Section III

CASE HISTORY: THE AMOCO CADIZ

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THE *AMOCO CADIZ* OIL SPILL CLEANUP OPERATIONS—AN OVERVIEW OF THE ORGANIZATION, CONTROL, AND EVALUATION OF THE CLEANUP TECHNIQUES EMPLOYED

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ABSTRACT: *The organization used for work on the* Amoco Cadiz *oil spill, and the changes in this organization required by the size of the disaster, are explained and details are provided on the techniques used in the cleanup. These techniques had as their goals: protection of selected areas; pumping of oil where possible; and cleanup of the beaches, the shingle shores, rocky areas, and harbors, and disposal of the oily debris. The spill involved some 223,000 tons of oil spilled along 400 kilometers of coast. Almost 10,000 persons worked on the project during the busiest period. As a result, almost 200,000 tons of oil and debris were pumped and gathered. However, less than 20,000 tons of oil was finally retrieved after separation from the total mass of material obtained from the coastal zone.*

The cleanup organization

When the *Amoco Cadiz* went on the rocks on March 16, 1978 (Figure 1), it soon became evident that her 223,000 tons of light crude oil would spoil a large part of the Brittany coast. What administrations were concerned and on what organization could the French authorities rely to coordinate and manage all the cleanup operations?

Based on previous experiences which we had to deal with in France (*Torrey Canyon, Olympic Bravery,* and *Boehlen* having been the most important), it had been previously decided in the "Polmar Plan" that the French Navy would be responsible for the fight against pollution at sea, and Civil Safety Services would be responsible on shore. However, a few days after the grounding of the *Amoco Cadiz,* it became obvious that the onshore cleanup operations would require a great deal of people from different administrations, particularly from the Army. An overall national coordinator was therefore needed for the operations, which were conducted in the following way:

(a) The Navy kept the responsibility for all the offshore operations; and

(b) A Civil Safety Representative had the responsibility for all the onshore operations which utilized firemen from the Civil Safety Organization, civil officers from the Ministry of Equipment who have, in France, the responsibility for harbors and other public works along the coast, and different Army corps (military engineering, communications, transportation, and, of course, infantry).

Weather conditions did not permit use of one or more of the numerous kinds of devices which have been successfully used elsewhere in the open sea. If the weather had been more favorable, the Navy would have decided which of these to use. As it turned out, adverse meteorological conditions and weathering of the oil reduced these options very quickly to the use of only a few types of dispersants complying with the recommendations of the Ministry of Environment. The Institut Scientifique et Technique des Pêches Maritimes (ISTPM or Scientific and Technical Institute for Marine Fisheries) had conducted dispersant toxicity tests and was able to indicate those dispersants which were as harmless as possible. All told, less than 3,000 tons of dispersants was used; some chalk, used as a sinking agent, was also employed but only to protect the Bay of Brest which was threatened by some oil patches a few days after the spill.

The onshore operations organizations for the Departments of Finistère and Côtes du Nord were different because the responsibility came under the "Prefet" (the Government's representative) in each department. After a few days of reflection, hesitation, and improvising, the Finistère Department became organized in this way: a managing staff set up in Ploudalmézeau, a small town near Portsall, while a technical team worked in Brest. This team gathered people belonging to the Ministry of Equipment, to the Institut Francais du Pétrole (IFP, the French Petroleum Institute) and to the Centre Oceanologique de Bretagne (Research Center of the French National Agency for Ocean Exploitation). This team tried to find appropriate answers to the numerous questions coming in from the people working on the coast who faced difficulties and problems never encountered before.

The prevailing winds for a month after the disaster were from the southwest to the northwest (except for the two first days after the accident during which it had been blowing from the north) and spread the oil to the east of Portsall. Less than one week after the accident, the oil reached the Côtes du Nord Department area which, of course, had been forewarned. In this department, the headquarters were in Lannion and included both technical and operational teams, thereby allowing these specialties to work more closely than in the Finistère Department. However, even though the solutions found and techniques used differed in some details, cleanup operations between the two departments were accomplished by a small staff at Rennes. This unit provided and distributed wagons and trucks used to evacuate the wastes from the theater of operations, and provided all types of items which had to be shared between Finistère and Côtes du Nord as necessary.

Attempts to minimize the spill and protect the shore

The first ideas entertained immediately after the accident were to burn the oil, to lighten the wrecked ship, and to protect the most vulnerable parts of the shore. Burning the oil seemed too dangerous, because the smoke and unburned oil carried by the smoke would have polluted a large inland area. A lot of oil would not have burned and would have remained to pollute the sea. In addition, the experts thought that the part of the oil which would burn would eventually evaporate anyway. Lightening the ship by pumping the oil ashore was not feasible because the 2.5 kilometers (1.5 mile) pipe needed for this would be almost impossible to lay down due to the roughness of the sea. Pumping the oil into a smaller tanker would have been difficult, dangerous, and a very long process. In fact, the *Amoco Cadiz* was completely broken up and almost empty before lightening operations could have been attempted eight days later.

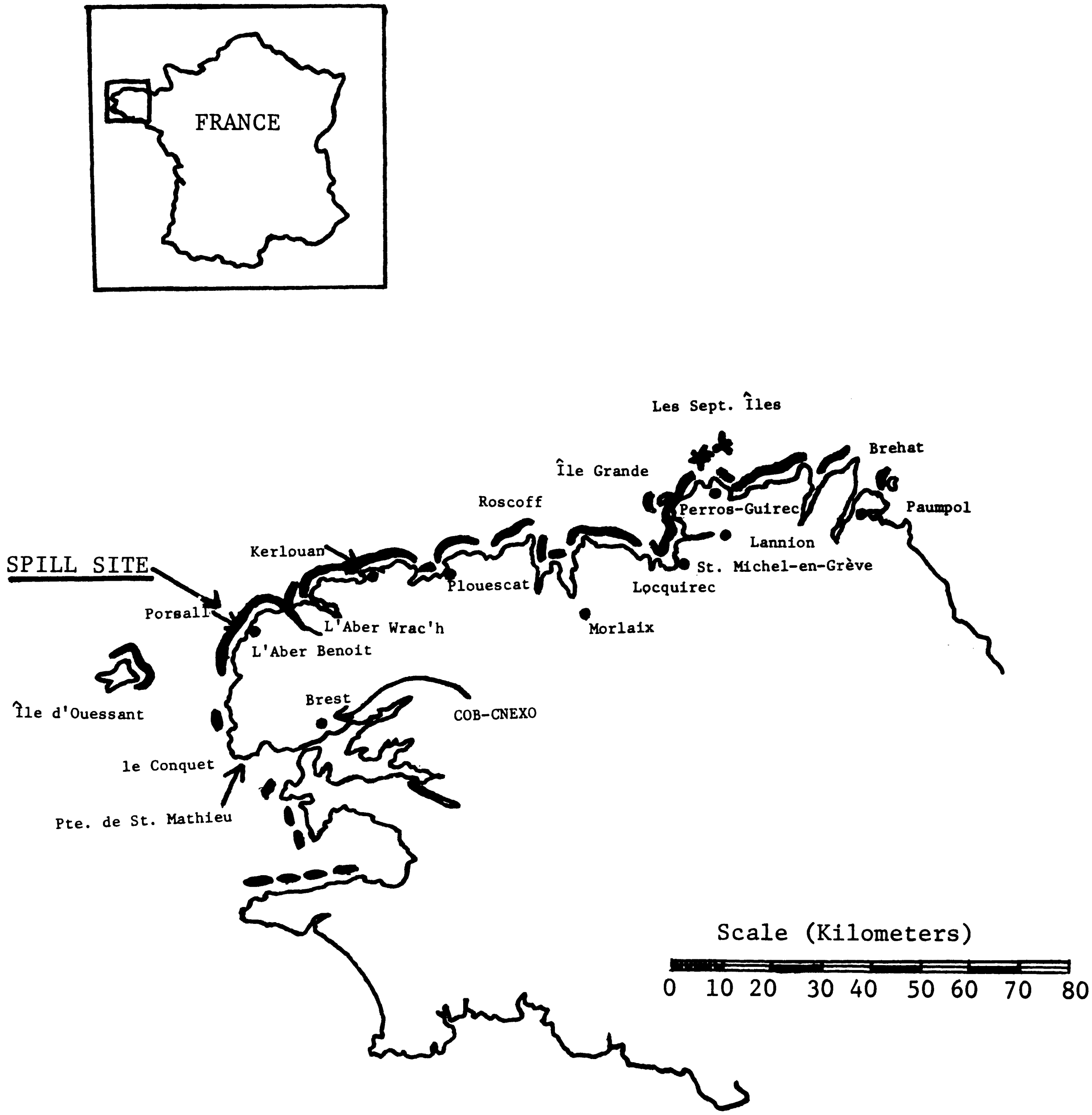

Figure 1. Chart showing place names associated with the *Amoco Cadiz* oil spill of March 1978; heavy offshore lines indicate the approximate distribution of beached oil

The most vulnerable parts of the shore were the places where oysters were grown, especially in the rivers called Aber Benoît and Aber Wrach, the Carantec River and the Morlaix River. These places also seemed, to many people, the easiest to protect. In fact, booming across these rivers proved useless because of the speed of the tidal currents. The whole Bay of Morlaix was protected by a 4 kilometers (2.5 miles) long boom, the maintenance of which required a number of persons under almost permanent alert. This action was considered as successful. It should be noted that the Bay of Morlaix was rather sheltered, both from severe weather conditions and from the arrival of excessive quantities of oil. The boom was laid far enough from the mouth of the river so as not to be exposed to strong currents and therefore work efficiently.

This situation did not exist across the Aber Benoît and Aber Wrach Rivers, where the booms that were deployed were very quickly broken up by strong winds and waves during the two weeks after the accident. It would certainly have been possible to protect some places by using the booms in the deflector mode, but this would have required a very large amount of boom to protect all the places needing protection. Sufficient boom was not available, and the time left for deploying and mooring before the oil arrived would have been too short. In addition, by so using the booms, only a few places could have been protected, thereby making it difficult to explain to the people concerned and requiring a political decision for which the public was not prepared.

Pumping operations

The other obvious idea was to try to pump as much oil as possible from the shore. Some skimmers were used in the harbors and protected areas (Figure 2). Whatever type they were (and a lot of different kinds of devices were used), their efficiency was limited because of the seaweed which blocked the pumps and hoses. Layers of weed two inches thick or more were observed; in fact, in some places pumping was possible only with vacuum devices. Vacuum cleaning tanks came from everywhere in France and even from Belgium and The Netherlands. These trucks did a good job, but were limited by their weight which obliged them to work from piers, boat slips, or roads (Figure 3).

Figure 2. ACME skimmers being used in Portsall Harbor during the first few days after the spill incident

Figure 4. Pumping the oil trapped in a small beach pond by use of a "honey wagon's" vacuum pump

Figure 3. Pumping oil from the surface of the water using vacuum trucks near Portsall.

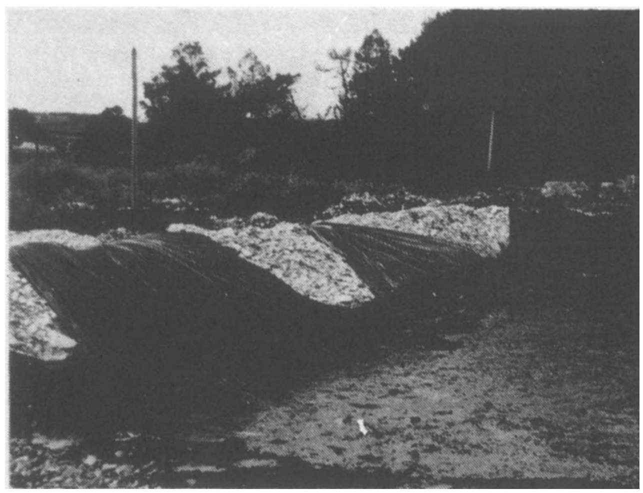

Figure 5. Temporary storage of oily residue in a lined dug pit near Roscoff

Often, when a pumping possibility existed, that is, when the oil was gathered in a bay, access was rather difficult. The farmers, driving their tractors pulling vacuum tanks designed to handle liquid manure (called "honey wagons" in the U.S.A.) would come and pump out the "chocolate mousse" water-in-oil emulsion which spoiled every place along approximately 400 kilometers (250 miles) of the Brittany coast (Figure 4).

These vacuum tank trailers pumped everything—oil, water, and seaweed. The water was separated as much as possible in the vacuum tanks; the tanks were then emptied through filter-buckets into interim storage of 10-to-20 cubic meter capacity. Regular vacuum trucks then transferred the emulsified oil from these storage tanks into large tank trucks, railway tank cars or even into small tanker ships moored in Roscoff harbor for further transport to refining plants. To make the oil transfer easier, some chemical products were used to break the emulsions. Good results were achieved, but it was difficult to make people realize that they must add the product either in the "honey wagons" before pumping, or in the interim storage tank whenever a vacuum tank was emptied into the storage tank. In some places, where intermediate storage capacity was lacking, we dug large holes in the earth which were lined with plastic sheets in order to be oil tight (Figure 5). This type of work extended for about one month, during which up to 300 pumping machines, 150 road trucks and more than 1,500 persons were engaged in the pumping operations. About one month after the accident, the surface oil layers became very thin and dispersed. The emulsified oil was so viscous in the very few places where it remained in heavy concentrations that vacuum trucks could no longer pick it up. All in all, the total quantity of pumped liquid almost reached one hundred thousand tons. In all this product, less than twenty thousand tons of oil were to be found after treatment in refining plants.

Removal of oil and oily debris stranded along the shore

The last stage of the cleanup operation could begin in an efficient way once there was no longer any oil floating on the sea in appreciable quantity. The risk of further pollution in these areas was rather small, even if high spring tides were able to wash ashore some oil from the still-polluted rocky areas. In any event, the final phase of cleanup operations could not be delayed, as these operations had to be completed in the tourist areas before summer.

There were four main types of shorelines, each presenting different problems, which had to be cleaned, namely: sandy beaches, shingle strands, rocky areas and stone or concrete construction in harbors, and muddy or marshy areas.

In removing the oil from beaches, the first operation was gathering and removing the stranded oily seaweed. In part, this was done manually by a great number of soldiers. More than seven thousand men worked along the coast picking up the seaweed and putting it in plastic bags. These bags were then collected on the beaches by farmers' tractors and trucks, and transported to dump sites in Brest and Tregastel. In some sections, front end loaders and trucks were used (Figure 6).

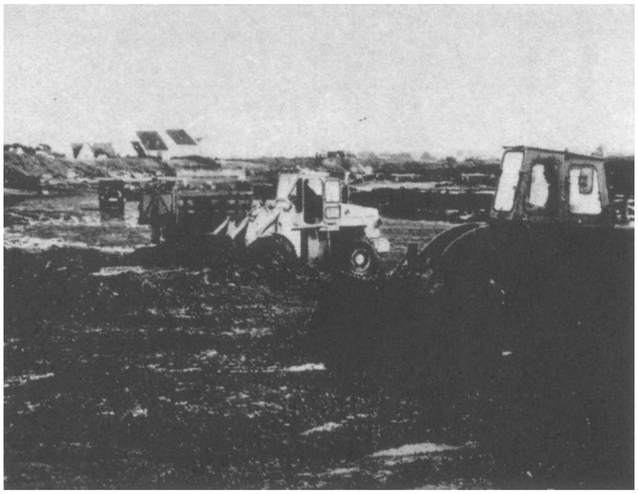

Figure 6. Front-end loaders removing oily sea weed from a beach near Portsall

The thick layer of mousse which still spoiled the upper part of the beaches was picked up, mostly by men with shovels and buckets, but sometimes with public works loaders (Figure 7). Some attempts were made to thicken the mousse layers by scraping and gathering the oil with public works scrapers or by twenty meter long booms dragged over the sand behind two tractors. These two techniques required flat beaches without any rocks, but were sometimes very helpful, specially when the wind pushed mousse into a corner of the boom. This mousse, when collected, contained a large amount of sand and was kept, as was the oily seaweed, for further treatment.

Figure 7. Hand removal of emulsified oil covering a beach

Some attempts were also made to use a sorbent to facilitate oil removal. Sawdust, straw peat, shredded paper, leather powder, and rubber powder were all tested. The light products flew away with the wind and were not at all efficient. It had been hoped the rubber and leather powders would be efficient and rather cheap, but a difficulty arose in that the powder needs some energy for mixing with the oil or mousse. In such a case, only manual agitation was available. As a result, these procedures needed more energy than appeared feasible and accordingly were not used.

When all the visible oil had been removed, it was still necessary to try to clean the sand, the spoiled depth of which sometimes reached fifty centimeters (20 inches) with two or three oil layers sometimes deeply buried in the beaches where extensive sand transfer had occurred during each gale. Ploughing and harrowing the beaches to allow the sea to clean the sand were the most commonly used techniques. We tried in some places to mix with the oily sand a mixture of talc, water, and dispersant to make removal of the oil by the sea easier. Some attempts were also made to increase the natural biodegradation of oil. Both artificial (soluble and insoluble) fertilizers and bacterial cultures were poured on the oily sand before harrowing.

In some places where we had observed up to two kilograms per square meter (0.4 pounds per square foot) of oil mixed with the sand down to thirty centimeters depth (12 inches), much smaller oil quantities were observed three months later (about 0.5 kg/m^2, or 0.1 pound per square foot). Our laboratory analysis is not yet sufficient to be sure to what extent the applied agent assisted or accelerated the natural biodegradation process.

In the case of shingle strands, cleanup was very difficult because the oil passing between the shingles is able to reach great depths where large amounts of it can be trapped. As these strands were not popular tourist areas, cleanup operations were conducted only in the places where the oil picked up by the sea would be able to re-pollute some cleaned beaches. In these areas, polluted shingles were pushed down by bulldozers to the level of low tide; the waves and the incoming tide then carried these shingles back toward the upper parts of the strand. The shingles actually scrubbed each other clean—or almost clean—from the wave action after a few high tides. Some attempts were also made to pour pure dispersant on the shingles and to let the tide then clean them up; in this case, however, the dispersant appeared to be non-effective.

In all the small harbors, from Porspoder to Brehat Island, piers and slips were covered with oil, as were the beautiful pink granite rocks of Tregastel and Perros-Guirrec. The economic impetus to cleanup the piers and slips for use by fishermen was as great as the economic impetus for cleaning the rocks of Perros-Guirrec or Plougasnou for the tourist business. At all these places, extensive and meticulous cleanup was required. Fire hoses were used first. When this low pressure (7 bars, or 100 psi) equipment proved no longer effective, very high pressure pumps (up to a limit of 400 bar or 1,000 bar, 5,800 psi to 13,000 psi) were tried. These pumps had to be washed with fresh water each evening; in addition, use of this very high pressure was dangerous to the concrete parts of the structures, as well as to personnel. It was also expensive.

Such processes were effective between the sixth and ninth weeks after the *Amoco Cadiz* grounding. After that, high pressure, hot water pumps working at a pressure of 140 bars (2,000 psi) with a relatively low flow rate of fresh water heated to between 80° to 140°C, were used with very good efficiency under all circumstances for the next few months (Figure 8). One man could clean more than 500 square meters (about 5,000 square feet) of rocks per day at the begin-

Figure 8. Cleaning of rocks using high pressure, hot water hosing technique

ning, but four months later, the efficiency was much lower, 20-50 square meters per day. To prevent the oil from sticking again on the cleaned-up rocks after the next high tide, the best method appeared to be to add a small amount of dispersant to the water. The initial amount (0.5 percent) of dispersant was not adequate to provide a steady dispersion so the percentage was increased to 3 percent.

Where piers had been built out over sandy flat ground, trenches were dug in which the oil and water collected and from which the oil could be pumped or absorbed by rubber powder for manual collection. However, this method proved slow, tedious, and inefficient. For the most part, dispersants were added to the water of the washing machines (0.5 percent of concentrated dispersant in the water), the flow rate of which was about one thousand liters per hour (about 4.5 U.S. gallons per minute). Use of dispersants in this case had to be considered from the ecological point of view as well.

Because some of the rivers contained oyster beds, marshes had to be cleaned. Cleaning the marshes, especially the Ile Grande marsh near Tregastel which had been covered with oil, was done by removing the oil manually; in fact, in some places, 30 centimeter (one foot) thick layers of mousse could be found. To do this, some paths had to be built across the marsh. Unfortunately, we cannot yet say how long it will be before the marsh looks like it did before the spill.

As of October, 1978 the cleaning of the river banks is not complete and certainly is the most difficult problem yet to be solved. These banks are covered either with shingles or with mud. In both cases, they are rather soft, yet we are obliged to wash off the oil without burying it. Because of the ecological vulnerability of the rivers, use of dispersants was not recommended. Instead, the oil was pushed down by low pressure water streams to the river for collection there. The oil in this instance is collected by a particular device, "Egmolap", developed by a local firm. This device is able to collect any kind of floating matter in a sheltered area.

In the muddy areas, which are often very flat and impossible to walk on, it is also almost impossible to wash out the small amounts of oil which appear on the surface of the mud. In fact, after six months it is still possible to find oil one foot inside the mud due to later depositions of oily mud. The best way to remove this oil so far is to wash the muddy areas drastically with a mixture of water and a very light inorganic sorbent. The polluted sorbent is then collected in the same way as noted above. This sedimentation of oil by muddy particles is one of the major continuing problems because the process helps maintain a high concentration of oil on the bottom of the rivers.

Disposal and treatment of the oily debris

As the result of all the cleanup operations, many thousands of tons of oily debris accumulated in Brest and in Tregastel. The disposal of this debris created yet another set of problems. The oily debris was divided into different storage areas according to its fluidity and its oil content. The most liquid products (some 30,000 tons) were stored in five large ponds dug near the merchant harbor of Brest in an embankment area. These pools were lined with very strong plastic sheets carefully welded together to be oil tight (Figure 9). After a very careful study, it now seems that the best treatment for these products would be water plus dispersant washing to separate the oil, which could then be sent to the local refining plant. The washed, but still oily, debris would then be treated along with the second type of debris which primarily originated from the beaches and rocky areas, and contains sand and seaweed, with less than 5 percent oil. About one hundred tons of this material was stored in Brest and forty thousand tons in Tregastel. The quickest and cheapest way to dispose of this debris has been to mix it with quick-lime, thereby creating a sort of material that, although it cannot be used for public works fill, still remains quite inert (Figure 10). However, this stability may not be a long-term one; nevertheless, the oil concentration in the material is low enough to be absorbed by the quick-lime.

Other possibilities, because of the huge amount of debris which had to be eliminated, have been considered. These are:

1. To burn the debris in the place where it was collected as many persons actually suggested—However, this would have required a great number of small incinerators, each having a poor efficiency and using a large quantity of fuel oil to burn a small quantity of oily debris containing considerable water.
2. To burn the debris in a large incineration plant to be built at Brest for this purpose and afterwards used by the Brest tanker ship deballasting facilities at a few percent of its capacity—This approach would have been much more expensive than the first and was not further studied.
3. To treat the debris with chemical products in order to separate oil and debris, then washing in devices specially-built or adapted for this purpose—This approach also appeared to be much more expensive than the first approach.

Many difficulties have also been encountered in dealing with the products found at the bottom of the "honey-wagons", the trucks, and the ships. These residues are actually deposits that cannot yet be demulsified. Carriage of these residues also appears quite impossible for they are too viscous for pumping, yet not solid enough for free-standing in trucks.

Figure 9. Artificial pond near Brest Merchant Harbor being filled with the more liquid portions of oily waste from the *Amoco Cadiz* spill

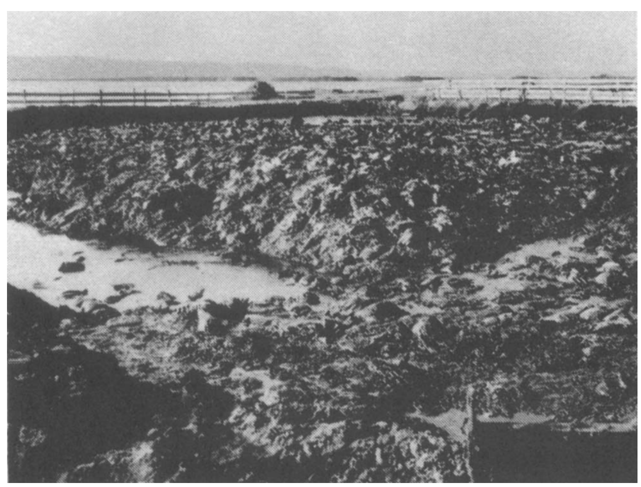

Figure 10. Artificial pond near Brest Merchant Harbor filled with oily debris which has been treated with quick lime

Conclusion

Those administrators facing this very large oil spill have tried to find quickly the most efficient solutions. Because of the size of the spill, it provided the opportunity to try a number of various solutions in a great variety of circumstances. Some of the solutions appeared to be the right way to go, but that was not necessarily so in other cases. The lay of the land was such that we were obliged to find effective ways to remove the oil and to clean the beaches without using heavy equipment or a great amount of dispersant.

Some problems still remain as a result of the initial cleanup effort. For example, the problem of oily waste disposal is complicated by the large amount of material having a very low content of oily debris. To avoid this problem in the future, we are also studying all sorts of scenarios in order to find the best way to fight a major new oil spill should one ever occur again.

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