

GROUND WATER AND SURFACE WATER CONTAMINATION BY HYDROCARBONS -
A CASE HISTORY

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INTRODUCTION

The Bayonne Industries, Inc. Terminal, located on a reclaimed marsh area in Bayonne, New Jersey, U.S.A., encompasses 180 acres on a refinery site that had been in operation since the 1880's. The site is presently used only as a storage and transshipment facility for multigrade fuel oils. There are over 100 above ground tanks on the property, with a total storage capacity of about seven million barrels.

Accidental spills during fuel transfer, leaky or broken underground pipes, tank overflows, faulty valves, tank bottom rupture, etc. over the years has resulted in ground-water contamination. Eventually oil from the terminal has migrated into the adjoining surface water body called Kill Van Kull. The oil seepage control measures conducted by terminal personnel had included installation of a continuous boom along the waterfront area to contain and collect oil from the southern portion of the terminal property.

This paper summarizes the results of an ongoing study being performed by Roy F. Weston, Inc. since 1977 aimed at identifying, locating, and abating this surface and ground-water pollution problem.

FIELD PROGRAM

The main property of Bayonne Industries is located on a reclaimed marsh area in Bayonne, New Jersey with Kill Van Kull as the southern boundary and Platty Kill as the eastern boundary (Figure 1). The Newark Bay lies about 1.1 miles west of the property, and upper New York Bay is about one mile east of the property. The topography of the surrounding heavily industrialized area is generally flat-lying and poorly drained.

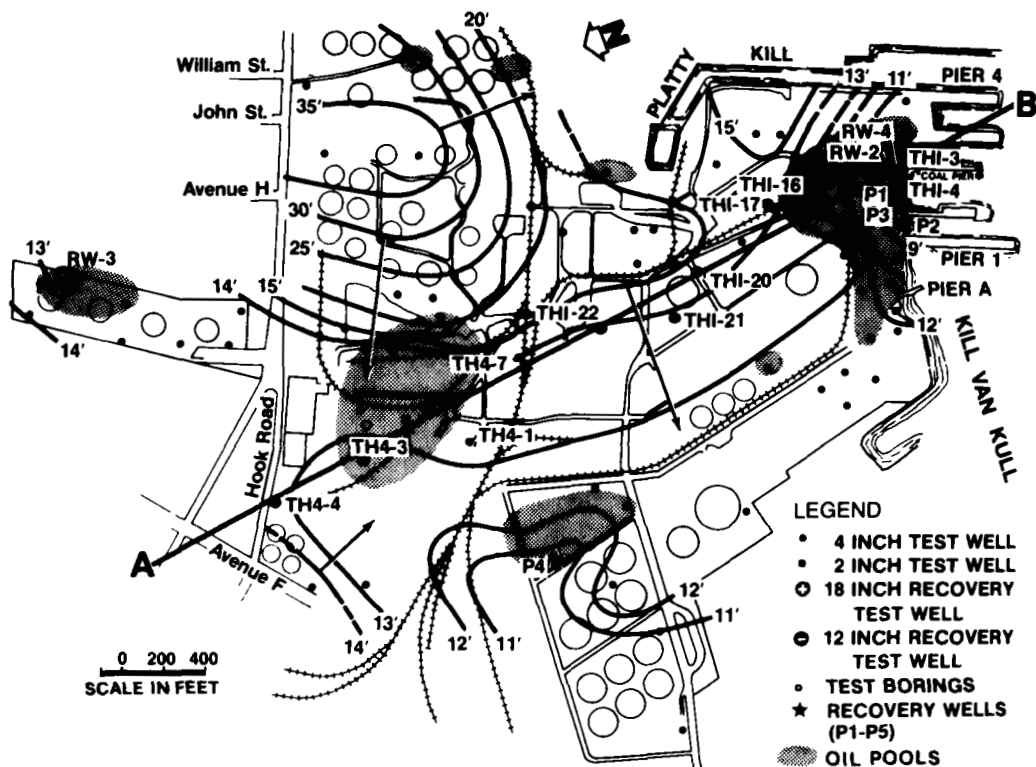


Fig. 1. Plot plan with water table map and oil pool areas.

A wooden crib bulkhead on pilings at the waterfront between Piers No. 1 and 4 is about 750 feet long, 25 feet wide, and 11 feet deep. Figure 2 shows the construction details of the bulkhead. The bottom of the horizontal piles is above the mean low-water elevation, which allows oil to seep into Kill Van Kull during low tide. A solid crib bulkhead approximately 20 feet wide and 25 feet deep covers about 275 feet at the western side of Pier 1 along the waterfront.

As part of the program, 60 backhoe pits were excavated. The samples from these test pits were examined to determine the distribution of the various sediments. Continuously-slotted monitor wells were constructed in each of these pits to monitor oil thickness and water level. The depth of these wells varied between 8 and 13 feet from grade. The locations of the monitor wells were selected to provide suspected areas of subsurface oil occurrence. An auger drill was used to construct the monitor wells in the waterfront. These wells ranged in depth from 20 to 24 feet and were cased with two-inch PVC pipes. The locations of all monitoring wells are shown in Figure 1.

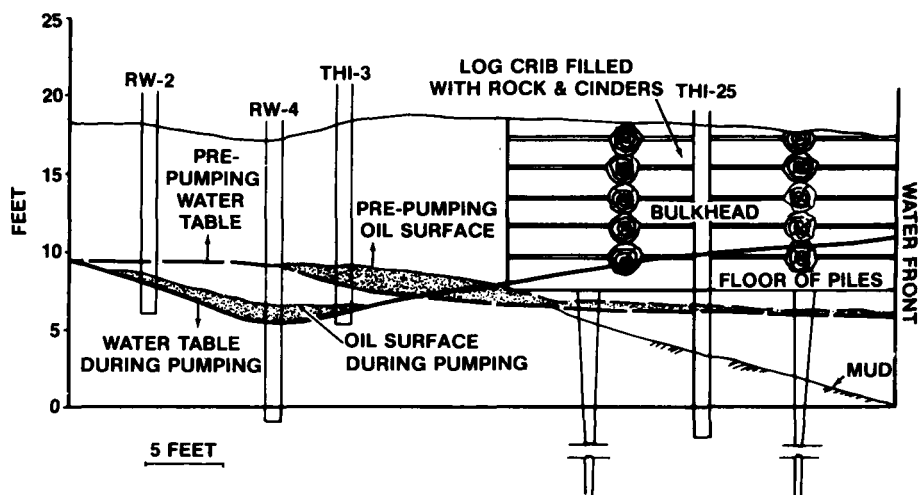


Fig. 2. Construction details of the bulkhead and oil/water levels before and during pumping of Well RW-4 - June 2, 1978

HYDROGEOLOGY

The main portion of the Bayonne Terminal is underlain by recent sediments of unconsolidated gravel, sand, silt and clay, varying in lens thickness from a few feet to as much as 45 feet. The cross section shown in Figure 3 portrays the nature and distribution of the subsurface materials. The upper surface to about 10 feet is composed of industrial fill material used to reclaim the swampy land. This fill material is underlain by about 10 to 15 feet of low permeability, gray, clayey silt peat or meadow mat, swamp muck, and marsh deposits. Beneath these deposits are alternating beds of fine to coarse grained sand or gravel and clay of varying thickness.

From measurements made in monitor wells, the average depth to water table varies between five to seven feet below ground surface. A representative water table contour map for this site is presented in Figure 1. As expected, the general flow of ground water is toward Kill Van Kull with several other minor ground-water flow directions within the property. The flow of oil is affected by this shallow ground-water flow system.

The tidal fluctuation in the Kill Van Kull averages about four to five feet. Automatic water level recorders installed on Wells TH1-3 and TH1-4 showed fluctuations in ground-water levels to be no more than 1.5 feet, indicating a relative impermeability at the bulkheads.

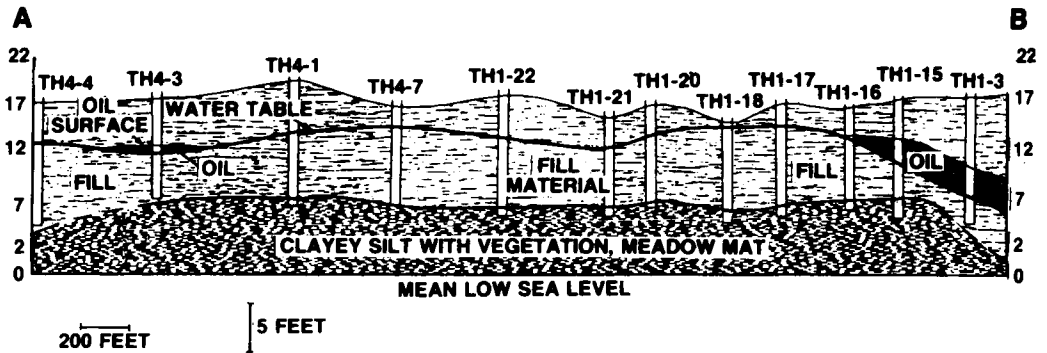


Fig. 3. Cross section A-B showing nature of subsurface material with oil and water levels for October 21, 1977

OIL DISTRIBUTION

Since September 1977, continuous measurements were made in all monitor points to measure the thickness of oil. Even though all test holes encountered oil-saturated and/or oil-stained sediments, only 27 of the 63 observation wells had "free-standing" oil with measurable thickness.

Based upon the product thickness measured in June 1978, five separate oil pools were identified. In addition, three other localized occurrences of subsurface oil were observed. The areal extent of each of the oil pools is shown in Figure 1. The largest pool in the southern part of the terminal is solely responsible for the seepage under a hydraulic gradient into the Kill Van Kull.

Maximum product thickness of 3.83 feet was observed in Well TH1-3 in the waterfront area in October 1977. Product thickness in the monitoring wells in the waterfront area varied from 0.01 to 3.83 feet; whereas it varied from 0.06 to 2.52 feet in the remaining areas. Oil in wells in the major pool on the northern part of the facility was light No. 2 oil; other areas tested indicated a mixture of No. 2, 4 and 6 oils. The total volume of subsurface oil was calculated to be 490,575 gallons.

OIL RETRIEVAL PROGRAM

Four oil recovery wells were installed on a test basis in different parts of the property. Figure 4 shows the construction details of test Well RW-4 in the waterfront. Figure 3 shows the relative locations of Wells RW-2, TH1-3, RW-4 and TH1-25 and the bulkhead in the waterfront. Oil and water levels in these wells

before and during pumping of RW-4 are also shown. As can be seen from this figure, free oil on the surface of the water table would naturally seep into Kill Van Kull during low tide. As shown in the figure, pumping reverses this natural gradient by creating a depression in the water table. Maintenance of this cone of depression allowed the continuous flow of oil to the pumping well during testing. Similar tests were conducted in three other test wells constructed in different parts of the facility.

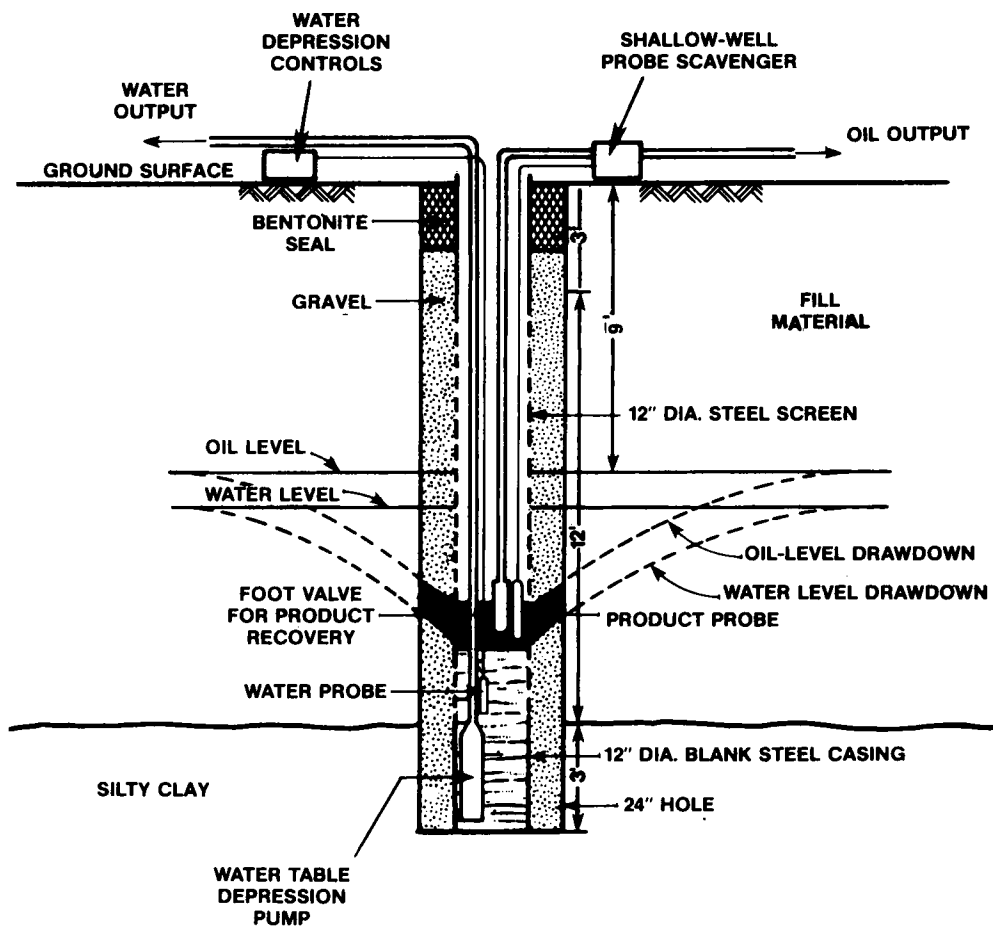


Fig. 4. Well installation sketch - RW-4

A pilot trench was constructed in the waterfront area between Pier 3 and Coal Pier about 15 feet north of the waterline. The buried pipes and logs of the crib bulkhead limited the total length

of the trench to nine feet and the width to three feet with maximum depth of 13.5 feet. An 18-inch diameter, corrugated pipe with overlapping slots was installed in the trench and the trench was then backfilled with crushed stones. The vacuum lines available at the site were used to test the trench method. Testing of this trench as well as the 25-foot long trench constructed in the northern part of the property did not prove to be an effective method of recovery.

Based on the analysis of the site geology, test pumping data, water and oil level measurements, and the thickness of standing oil in different wells, large diameter recovery wells were constructed in strategic spots. Test Well RW-4 was selected as a permanent recovery well location. Three additional recovery wells (P1, P2 and P3) were installed in the waterfront area (Figure 1). These wells are spaced 70 feet apart. Similarly, two other recovery wells were constructed: one in the western oil pool area (P4) and the other in the northern oil pool area (P5). In the central oil pool area, an existing buried tank was developed to act as a large skimming well, thus eliminating the necessity of additional recovery wells at this site.

In RW-4, a shallow probe scavenger system was installed with specially-designed probes that differentiate between hydrocarbons and water. This system has one water table depression pump set at its bottom. A shallow water probe scavenger is installed in the same well with the intake set above the top of the water table depression pump. The recovered oil is pumped into receivers that are periodically emptied by a vacuum truck. A schematic of the double pumping system is given in Figure 4. All other wells are equipped with single pumps which pump both oil and water to a single separator.

SYSTEM PERFORMANCE

The recovery system installed in June 1979 is still on-line except for Well P5. Well P5 was taken out of service since the oil thickness in the well was reduced to a sheen. Oil thickness in the wells in the western pool area was reduced from 2.5 feet to 0.60 foot. Similarly, oil thickness in the waterfront pool area was reduced to 0.59 foot from the original thickness of over a foot. A total volume of over 200,000 gallons of product has been removed based upon the oil thicknesses measured from the observation wells in each of the pool areas. Since the installation of the recovery system, the waterfront has been clean. The cost of the installations of this recovery system was about \$40,000.