Illinois State Water Survey Division
WATER QUALITY SECTION
AT
PEORIA, ILLINOIS

SWS Contract Report 411

AN ASSESSMENT OF ILLINOIS RIVER BOTTOM SEDIMENTS IN THE VICINITY OF HAVANA COMBINED SEWER OVERFLOWS

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Prepared for the City of Havana
in cooperation with Randolph and Associates, Inc.,
Peoria, Illinois

January 1987

Illinois Department of Energy and Natural Resources

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INTRODUCTION

Many municipalities located along the banks of the Illinois River are served by combined sewers. Most of these sewers, when originally constructed, were designed solely to collect storm and surface water runoff from residential and commercial properties for discharge to the river. They were not intended for transporting wastewater. The connection of property sewers to existing storm sewer drainage systems became common practice with the advent of in-house plumbing. As communities expanded, separate sanitary sewers were constructed; however, the contents of these separate sewers eventually flowed into the storm sewer system in the older sections of communities. Thus a system originally conceived for handling only urban storm drainage became a dual-purpose utility, conveying a combination of surface water runoff and wastewater.

Generally, even relatively small rainfalls of short duration produce runoff which exceeds the hydraulic capacity of most treatment plants served by combined sewer systems (CSOs). Consequently, to prevent surcharging and damaging the system, overflows are provided at strategic locations to relieve the sewers of the excess flow. These overflows are contaminated with sewage, and they may create environmental problems when discharged directly to surface drainage areas.

Background

A large portion of the city of Havana, Illinois, is served by a combined sewer system in which four overflows are located ahead of pumping stations along a riverfront intercepter sewer. For over six years, the city operated the sewerage system without a National Pollutant Discharge Elimination System (NPDES) permit. The Illinois Environmental Protection Agency's (IEPA) reluctance in issuing the permit was due partly to an apparent lack of progress by the city in developing and instituting a plan to eliminate the overflows or in providing information on the pollutional effects of overflows on surface waters.

Nevertheless, on October 31, 1985, a permit was finally issued. However, IEPA stipulated that nine special conditions had to be met for the permit to remain effective through its expiration date of November 1, 1990. Pertinent to this study is SPECIAL CONDITION 8, "Combined Sewer

Overflows/S.T.P. Bypasses," in which the city is instructed to bring the CSOs into compliance with the applicable effluent limitations contained in the Illinois Pollution Control Board (IPCB) Rules and Regulations (1985). The possibility exists that the city might be granted a variance from the requirements set forth in the IPCB Rules and Regulations if the overflow pollutional effects can be shown to be insignificant or minimal.

During 1986, the consulting engineering firm of Randolph and Associates, Inc., Peoria, Illinois, instituted a monitoring program for assessing the frequency, quality, and quantity of the overflows at the four locations. Their work is limited to measuring the pollutional nature of the combined sewer overflows. The extensive river water quality data base generated during the 1983 Peoria CSO study CStaff of the Water Quality Section, Illinois State Water Survey, 1983) obviates the need to make a similar instream water quality study in the Havana area. The Peoria area study showed that Illinois River water quality deteriorated only slightly, in a very transient manner, even when very high combined sewer overflow discharge rates occurred during low river flows.

However, conclusions arrived at for the Peoria study relative to benthic or bottom sediment conditions cannot be readily applied to outfall areas at other locations such as Havana. A survey of stream bottom (benthic) conditions and stream morphology in the outfall areas at Havana was needed to identify the extent and nature of any short-term pollutional depositions and/or long-term chronic effects. The quality of bottom sediment can be a good indicator of chronic or long-term effects of persistent pollutional discharges. The Water Quality Section of the Illinois State Water Survey was given the task of making this analysis during the summer of 1986.

Study Area

The four outfall areas above the Havana wastewater treatment plant which were examined and evaluated are shown on figure 1. The outfalls are identified by the street locations at which the discharges occur. In downstream sequence, they are Tremont, Market, Washington, and Illinois. Note that the Tremont Street outfall discharges into a bay-like slough area (figures 1 and 2D. This outfall, a 15-inch welded steel pipe, is shown in figure 3; at low pool elevations, it is located approximately 38 feet back from the water's edge. Since late spring of 1986, the diversion regulator at the Tremont Street pumping station has been closed and overflows no longer occur at this location. However, sampling was conducted in the bay area to document if a historical buildup of pollutional sediments has occurred.

The Market Street outfall location is shown in figure 4. The exact location and pipe size are obscured since the opening is covered by riprap. The discharge runs over and through the riprap starting about 20 feet back from the water's edge in line with the left traffic cone shown in figure 4 and enters the river at a point marked by the right traffic cone.

The Washington Street outfall is a 36-inch reinforced concrete pipe discharging onto riprap about 9 feet back from the edge of the water Cfigure 5). The outfall is located in the middle of a grain-barge-loading operation. The outfall was overflowing when the photograph was taken. Rain might possibly have fallen several hours before the photograph was taken at 10:00 a.m. on August 4, 1986. By 10:30 a.m., the overflow had stopped.

Figure 6 shows the Illinois Street outfall area. The outfall extends about 25 feet into the river from the retaining wall face and is about half submerged under the boat dock in line with the traffic cones shown in figure 6.

Ackowledgments

This study was sponsored and funded by a grant from the City of Havana and was conducted in cooperation with the consulting engineering firm of Randolph and Associates. The work was performed under the general supervision of the Chief of the Illinois State Water Survey. Thanks are extended to Harvey Adkins, Eric Von Hoven, and Jud Williams, who assisted in the field work; Dana Shackleford, who helped prepare the study plan; Jud Williams, who prepared the illustrations; Linda Johnson, who typed the original manuscript; and Gail Taylor, who edited the report.

STUDY PLAN

Intermittent wastewater discharges, such as those originating from combined sewer overflows, have only a transient effect on the water quality of flowing streams and rivers. Even during periods of very high runoff, the effect of CSO discharges on the water quality of a large river like the Illinois is minimal. A conclusion reached as a result of the comprehensive Peoria CSO study was that, although the impacts of combined sewer overflows on water and sediments of the waterway were detectable, the only significant impacts that related solely to combined sewer overflow were a substantial increase in fecal coliform densities and transitory occurrences of floating debris (Staff of the Water Quality Section, Illinois State Water Survey, 1983). However, if certain physical conditions exist in outfall areas, the chronic effects of periodic overflows on benthic or bottom sediment quality often become readily evident. Sewer overflows discharging into sloughs, bays, side channels, or other still-water areas often cause a buildup of sludges or contaminate indigenous sediments with organic material in the immediate outfall areas. Consequently, the quickest and easiest way to ascertain if CSOs are causing significant instream pollution problems is to physically examine the sediments in the immediate outfall area. In this study, an extensive, orderly physical examination was made of the benthic sediments in each of the four outfall areas to ascertain if any sediments visually exhibited organic contamination typical of that known to occur in problem areas. Most of the results are, therefore, presented in a descriptive or subjective manner; however, some finite parametric measurements were made at selected locations.

Sediment Sampling Procedures

Two types of sediment samples were collected for physical examination. The majority were collected with a 9-inch Ponar sediment dredge; figures 7 and 8 show the dredge sampler in use. This sampler can collect up to a 9-inch-square by 6-inch-deep (depending upon substrate type) surface sediment sample. Also, attempts were made to obtain core samples at the various outfall locations. However, only the sediments in the Tremont Street bay area could be retained in the core sampler for visual examination. Figure 9 shows the core sampler in use at Market Street in a failed attempt to collect a sample near shore. This sampler is useful in obtaining historical information on the buildup of sediments in an area.

The Ponar sampler is a proprietary item, whereas the core sampler used was designed and constructed by State Water Survey personnel. It consists of a 2-1/2- inch-diameter by 60-inch-long copper coring tube equipped with a rod plunger to extract the core sample. The sampler is driven into the substrate by using a sliding, cylindrical weight attached to the top. Both samplers can be used either from a boat or by wading. The use of the core sampler is limited to certain types of sediments; it cannot be used in rocky or gravelly bottoms or where the sediments are very fluid or loose. In addition, clay-silt samples tend to be compressed and therefore somewhat distorted in the extraction process. The Ponar dredge is difficult to use on bottoms containing large gravel, rocks, and debris.

Extensive dredge samples were taken in the river channel proper at the Market, Washington, and Illinois Street outfall areas and in the outlet bay area which historically has received Tremont Street overflow discharges. The sampling locations are shown on figures 10, 11, 12, and 13. Samples in the Tremont bay area were taken along the centerline of the bay at 50-foot intervals up to a point 400 feet from the sewer outfall centerline (figure 14); an additional sample was taken in the river side of the bay entrance.

A grid system was used to establish sampling points at the other three locations. Baselines extending 100 feet upstream and 200 feet downstream of the centerline of each sewer discharge point were established, and fluorescent orange traffic cones were placed along the edge of the water at 50-foot intervals. The riprap on the shores at the Market and Washington Streets outfall areas precluded driving stakes. Transverse distances from the edge of the water to the sampling points were obtained by using a high quality rangefinder. The centerline sampling distance used in the Tremont bay area were also determined with the rangefinder by sighting the center white stake shown in figure 14.

Sediment oxygen demand (SOD) tests were made at two locations - one near the left bank of the river (looking downstream) above all outfalls upstream of the entrance to the Tremont Street bay area (figure 10), and the other at the Washington Street outfall (figure 12). The SOD sampler is shown in figure 15. The measurements were made by using standard procedures developed and routinely employed by the Water Quality Section of the Illinois State Water Survey (Butts, 1974; Butts and Evans, 1977) to aid in evaluating the pollutional nature of sediments.

The overall SOD analysis procedure includes collecting benthic macroinvertebrate (benthos) samples, plankton (suspended algae) samples, and sediment samples for laboratory analyses of total solids and volatile solids content of the sediments in which in situ SOD measurements have been made. In addition, a number of sediment samples were collected from the areas around each outfall for total solids and volatile solids determinations.

River Cross-Sectional Data

River cross-sectional data were obtained at transects located at the centerline of the Market, Washington, and Illinois Street outfalls and at a position approximately 65 feet below the tip of the island shown on figure 1. Traffic cones were placed at the edge of the water on both banks, forming a line perpendicular to the centerline of the navigation channel. Soundings were taken along this line at 25- to 50-foot intervals with a digital-readout, electronic depth sounder. Transverse distances were obtained by using therangefinder.

Data Generation

The field sampling program was designed principally to provide qualitative and subjective information on the pollutional condition of the sediments and the aesthetics in the outfall areas. Sediments were documented as to color, texture, and odor and were roughly quantified as to clay, silt, sand, and gravel composition. The core samples were dissected, and changes in composition were noted at incremental depths. Both dredge and core samples were photographed in black and white, with selected photographs included in this report. Those which have not been included in the report are on file in the Water Quality Section's laboratory in Peoria and are available for examination at any time:

The aquatic-related morphological factors in the immediate outfall areas are documented and described in terms of riverine or backwater habitat. Natural accumulations of logs and vegetative debris principally outside the navigation channel area are described and documented with black and white photographs.

A limited amount of quantitative data was also collected via the SOD, total solids, and volatile solids measurements and the benthos and algae identification and enumeration. The total solids content is indicative of the liquid or flocculent nature of sediments. Clay, silts, and sludge-like depositions contain a significantly larger fraction of water than do coarser materials like sand and gravel. Volatile solids content generally is indicative of the organic content of sediments. Raw sewage solids and sludges are composed of a high percentage of volatile material; consequently, a significant amount of volatile material in a sediment sample may be indicative of sewage contamination, depending upon certain conditions.

The sediment oxygen demand test in a stream principally measures benthic bacterial and macroinvertebrate respiration; i.e., the biological usage of dissolved oxygen (DO) by bottom-dwelling organisms. A high SOD rate in the absence of a large and diversified macroinvertebrate population generally indicates that the sediments have been polluted with sewage or other organic matter.

RESULTS

The results of this study are based on conditions which existed during sampling visits made on August 1, 4, 5, and 26, 1986. The river stage was two to three feet above normal but fell slightly during each of the first three dates. Persistent wet weather preceded the sampling, and sufficient rainfall occurred during the early morning hours of August 4 to cause the Washington Street outfall to overflow during a short period of sampling. The river water was dirty and silt-laden in early August, which is indicative of persistent high-flow conditions.

Morphological and Aesthetic Considerations

Each outfall area will be described in terms of stream morphology, aquatic habitat, and aesthetic and environmental conditions.

Tremont Street

This is the upstream-most of the four overflow sewers. It discharges into a shallow off-channel slough or bay-like area (figures 1, 2, 3, and 14). At the time of the survey, the shoreline of the bay was very wet and "mucky" due to the rapid drop in high pool levels caused by recent high-water conditions. The area around the outfall had grown up in willows, weeds, and bushes and had to be cleared to be examined (figure 3). No evidence of sludge or pollutional depositions of sewage origin existed on the bank above the edge of the water. The outfall area was totally free of undesirable odors and overflow trash and debris such as rags and paper products.

Market Street

The exact location of this outfall was not known at the start of this study, and it had to be established through use of a red fluorescent tracer dye. On two dates, dye was flushed down the diversion manhole at the top of the Market Street hill. The first flushing was made on June 11, 1986 and was unsuccessful in establishing the outfall location. At that time, this failure was attributed to the fact that the river flow and stage were much higher than normal, resulting in flooding of the lower quarter-section of the overflow pipe. The second dye flushing was made on July 31 when the river was just slightly higher than normal and the lower section of the overflow sewer was not surcharged. However, merely flushing the dye down the sewer did not reveal the discharge point.

Water was then run down the curb line of the pavement leading to the river and timed. This procedure indicated that the dye should have shown up at the edge of the water in less than five minutes, yet 15 to 20 minutes of sewer flushing produced nothing. Consequently, the water hose from the water truck was unreeled and forced down the overflow line-. At a point 300 to 400 feet into the sewer, the hose hit something firm and stopped. Repeated ramming with the hose caused a slight breakthrough, producing a distinctive red flow from the riprap about 15 to 20 feet from the water's edge. The beginning and ending discharge points are noted by the traffic cones shown on figure 4.

The outfall area displayed no evidence of chronic or recent overflow. No sewage or sewage-like odor could be discerned; overflow debris which commonly hangs up in riprap-receiving areas was totally absent. Only a persistent trickle of clear water was evident, indicating that ground-water infiltration into the overflow line was probably occurring. The overflow line blockage, the difficulty of breaking through it, and the total absence of any residual signs of overflow at the river indicate that the line probably has not overflowed into the river in the recent past. The steady clear water discharge may indicate a broken line in addition to a plugged one.

Washington Street

This sewer overflow is known to be active and, as noted previously in this report, it was observed to be overflowing once during a study visit Cfigure 5). The discharge point is a free drop onto riprap about 9 to 10 feet back from the edge of the water during normal pool levels. The riprap is clean; a sewage odor emanates from the 36-inch sewer pipe but not from the receiving area on the bank. The appearance of the overflow was one of very diluted or weak sewage free of floating debris and trash. No sludge deposits or accumulation of sewage debris were evident at any time during the study visits.

Illinois Street

The Illinois Street outfall, extending about 25 feet into the river, exhibited no evidence of sewage-related debris or solids accumulations in the area of the boat ramp.

The cross sections taken at the centerline of the Market, Washington, and Illinois Street outfalls and the one taken at the entrance to the bay into which the Tremont Street outfall discharges are shown on figure 16. All the cross sections were typical of debris- and snag-free sections occurring along the navigational channel in the lower Illinois River. The shallow 200-foot-wide left portion of the Tremont Street section represents the silted-in entrance to the bay area. The left bank of the Washington Street section drops off slightly more rapidly than those at Market and Illinois Streets because of the barge-docking facilities centered around the Washington Street outfall.

Dredge and Core Sediment Descriptions

The locations of the sediment sampling stations are shown on figures 10, 11, 12, and 13. Photographs of two core samples that were obtained in the Tremont Street area are presented in the text, and selected photographs of dredge samples are presented in the appendices. The dredge sample illustrations were selected to show the full range of substrate types encountered at each outfall location. Overall, 75 dredge samples were collected. None of the core or dredge samples examined displayed a sewage or sewage-like odor.

Tremont Street

The sampling locations in the Tremont Street outfall area are shown on figure 10. Core samples were collected at station 1 and at the water's edge in line with the outfall. Figures 17 and 18 show the core samples, and Appendix A shows two dredge samples which were selected for illustrative purposes for this area. Descriptions of the core and dredge samples are presented in tables 1 and 2, respectively.

Market Street

The sampling locations in the Market Street outfall area are shown on figure 11. Dredge samples were collected at all 24 locations shown except at station 4, where large riprap fragments prevented the sampler from closing. Photographs of 14 selected samples are presented in Appendix B and descriptions of all the samples are given in table 3. Core sampling was attempted here and at Washington and Illinois Streets but was unsuccessful because a major portion of the sediments consisted of loose, watery sand and gravel which could not be retained in the core sampler.

Washington Street

The sampling locations in the Washington Street outfall area are shown on figure 12. Dredge samples were obtained at the 23 locations shown except at station 4 where large riprap fragments made dredge sampling impossible. Photographs of 16 selected samples are presented in Appendix C, and descriptions of all the samples are given in table 4.

Illinois Street

The sampling locations in the Illinois Street outfall area are shown on figure 13. Dredge samples were obtained at all 18 locations shown. Photographs of 12 selected samples are presented in Appendix D, and descriptions of all the samples are given in table 5.

Measured Sediment Characteristics

The limited amount of quantitative sediment quality information (i.e., not of a descriptive or subjective nature) obtained is summarized in tables 6 and 7. Nineteen samples were collected from all four areas for total solids (TS) and volatile solids CVS) determinations. The selections were made on the basis of sediment type. Sediments representing various particulate makeup at each site were included, including those which appeared to be "worst case" conditions. Table 7 summarizes the results of the two in situ SOD measurements and the physical and biological measurements routinely made in conjunction with SOD testing.

DISCUSSION AND CONCLUSIONS

The sediments in the riverine outfall areas varied widely within each area and between areas. The Tremont Street bay area sediments were uniform throughout. These sediments displayed the same sterile-gray, watery, silt-clay characteristics of bottom substrates found in most Illinois River side-channel and backwater lake locations. None of the samples examined at any of the four sites showed any effects of chronic or acute sewage contamination. Sewage sludges of even a* superficial nature were totally absent. However, some of the sediments in the grain-loading area centered around the Washington Street outfall revealed evidence of chronic organic contamination and degradation.

The total and volatile solids makeups of selected samples from the four outfall areas are presented in table 6. The more watery (lower solids content) and higher volatile content of the Tremont Street bay samples, Washington Street samples 12 and 17, and Illinois Street sample 15 reflect the silt-clay composition of the samples rather than sewage contamination. The total and volatile solids content averaged 46.2 and 5.2 percent respectively for these six samples, whereas for the other 13 samples, composed primarily of coarser sediments, the respective averages were 78.4 and 2.9 percent. In contrast, sediments chronically contaminated by sewage pollution or having the appearance of sewage sludge often consist of less than 40 percent total solids, of which about 8 percent or more are volatile (Butts and Evans, 1978). A sample taken in a Pekin outfall location that appeared to be contaminated by periodic sewage overflows was composed of 59.8 percent solids, of which 6.9 percent were volatile (Butts, 1985). The maximum VS percentage observed at any location in the Havana area was 6.1 at Washington Street station 12; note from table 4 that this sample consisted of tan, watery silt-clay with no evidence of sewage contamination.

The results of the two SOD runs given in table 7 indicate that some degradation of the bottom sediments may be occurring in the area around the Washington Street outfall, albeit probably not from combined sewerage overflow. The degradation is more likely due to grain which has settled to the bottom during grain-loading activity and exists in various states of decay. The background SOD rate measured upstream of the city (figure 10) was 1.35 grams per square meter per day ($g/m^2/d$) of dissolved oxygen usage compared to a value of 3.02 $g/m^2/d$ in the Washington Street outfall area (figure 12). Also, the volatile solids content in the Washington Street measurement area was 2.5 times as great as that observed at the background measurement location (table 7).

Neither SOD-test location was biologically productive in terms of macroinvertebrate numbers (table 7). The upstream location contained a slightly higher number of organisms, but the Washington Street location contained a few mayfly larvae which are relatively intolerant of sewage pollution. Well-balanced, productive substrates contain tens of thousands of macroinvertebrates comprised of at least 8 or more taxa. Given in table 7 are the Illinois Environmental Protection Agency's (IEPA) macroinvertebrate biotic indexes (MBI) for both SOD sampling locations. The indexes were derived from information in the IEPA's Field Methods Manual - Biological Monitoring (1980). The biotic index is merely the weighted average (based on numbers) of values indicating an individual organism's tolerance to pollution. The tolerance values range from 0 for highly intolerant organisms to 11 for highly tolerant ones. Pollution tolerance in this case refers to tolerance to organic, oxygen-consuming wastes. The mayfly's tolerance is rated at 5, the midge's at 6, and the aquatic worm's at 10.

The data in table 8 place the SOD rates measured at Havana in perspective with those observed at other CSO locations along the Illinois River and with those associated with various degrees of pollution. The background rate at Havana is comparable with background rates observed above Peoria and Pekin CSOs (Staff of the Water Quality Section, Illinois State Water Survey, 1983; Butts, 1985). The Washington Street area rate is over 2.5 times as great as that observed in a similar area at Pekin and is near the maximum value measured in the extensive Peoria CSO overflow area. The Havana background rate can be categorized as slightly degraded, whereas the Washington Street area rate can be categorized as moderately polluted to polluted. The nature and cause of this higher demand appear to be related to bacterial stabilization of organic "pollutants" Cgrain spillage from barge loadings) contained in a clay-silt, fine to coarse sand substrate. An unsieved Ponar dredge sediment sample taken at the spot of the Washington Street SOD test run was described as gray-black silt-clay mixed with fine to coarse sand and small pebbles. After the sample was passed through a 30-mesh sieve, the residual was described as small bits of coal and shale, fine to coarse sand, leafy detritus, and pieces of corn in various states of decomposition. The small "pebbles" described in the unsieved samples turned out to be mostly corn seeds. A similar situation was observed around the Court Street outfall at Pekin, where grain loading facilities also are located CButts, 1985).

The fact that the sediments in the area below Illinois Street are very clean and free of even sterile silt and clay particles, except in the quiet water near the sheet-metal-piling retaining wall (figure 13 and table 5), is significant since this area is downstream of all four outfalls.

Conclusions drawn from this study are:

1. Discharges from the four combined sewer overflows at Havana do not appear to be creating either short-term or long-term sediment pollution problems. The bay-like area which historically received small discharges from the Tremont Street overflow is experiencing rapid siltation, but deep core samples taken in the area show no traces of sewage sludge or sewage-contaminated sediments. The sediment in the riverine areas around and below the Market, Washington, and Illinois Street outfalls consists of relatively clean sand and coarse material which show no evidence of sewage pollution.

2. Some sediments in areas around the Washington Street overflow exhibit organic contamination other than that originating from sewage discharges. A grain elevator and grain-loading facilities are centered around this outfall. Grain from spillage appears to settle to the bottom, raising the organic content of the sediments and causing relatively high sediment oxygen demand rates.

3. At no time during a study visit were aesthetic problems observed around any of the outfalls. No observations were made of accumulations of combined sewage overflow trash such as rags, condoms, styrofoam materials, etc., which are commonly observed on shores when CSOs chronically discharge above the water's edge, as do those at Tremont and Washington Streets.

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FIGURES AND TABLES

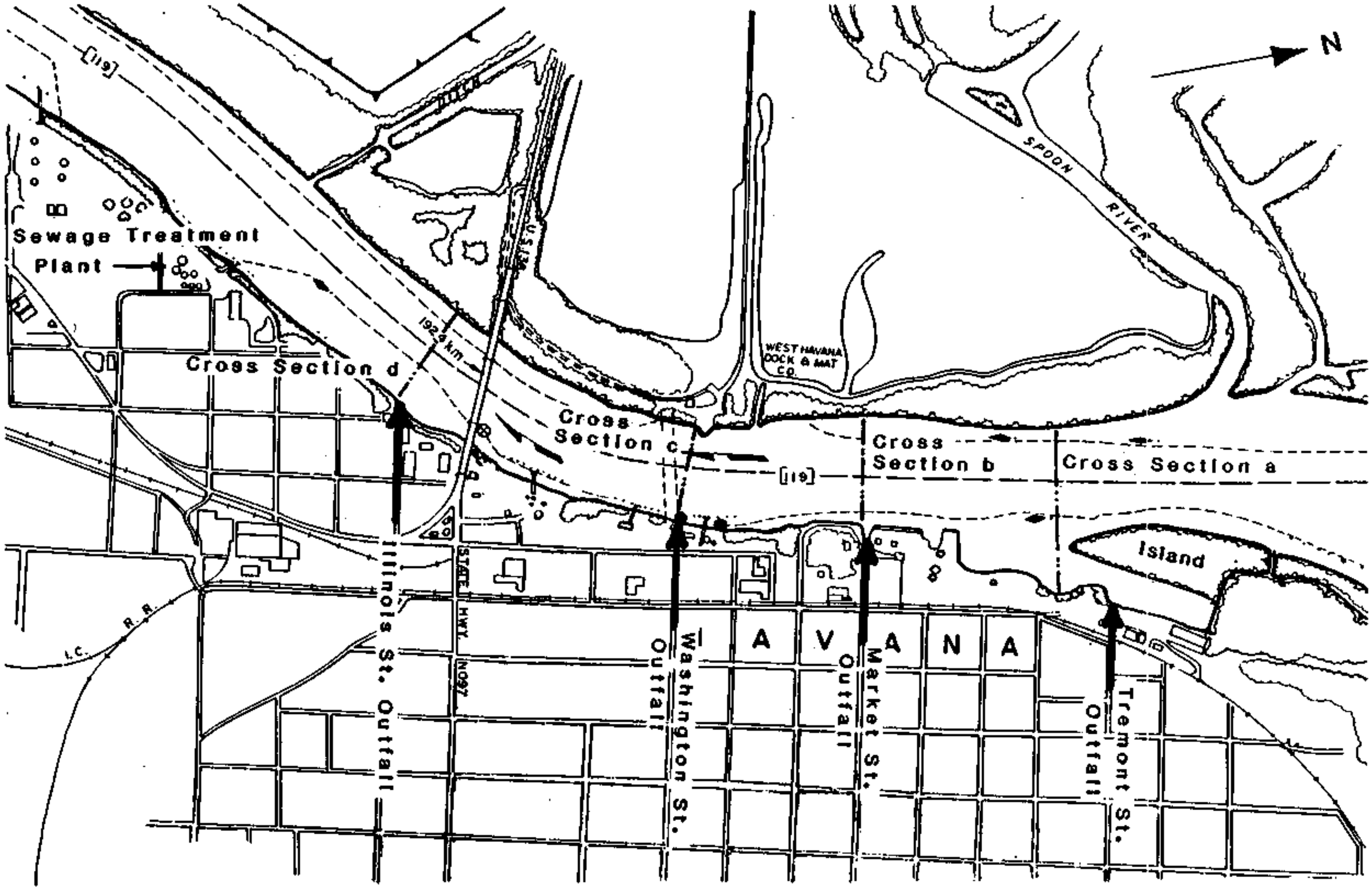


Figure 1. Havana combined sewer outfall locations

Figure 2. Tremont Street outfall bay looking toward river entrance

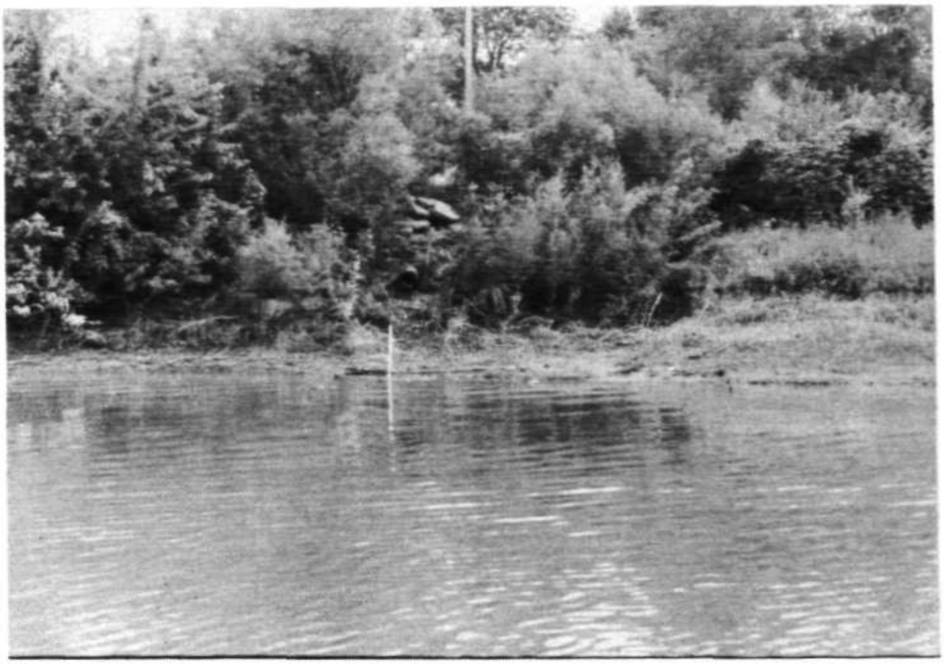


Figure 3. Tremont Street outfall

Figure 4. Market Street outfall area

Figure 5. Washington Street outfall

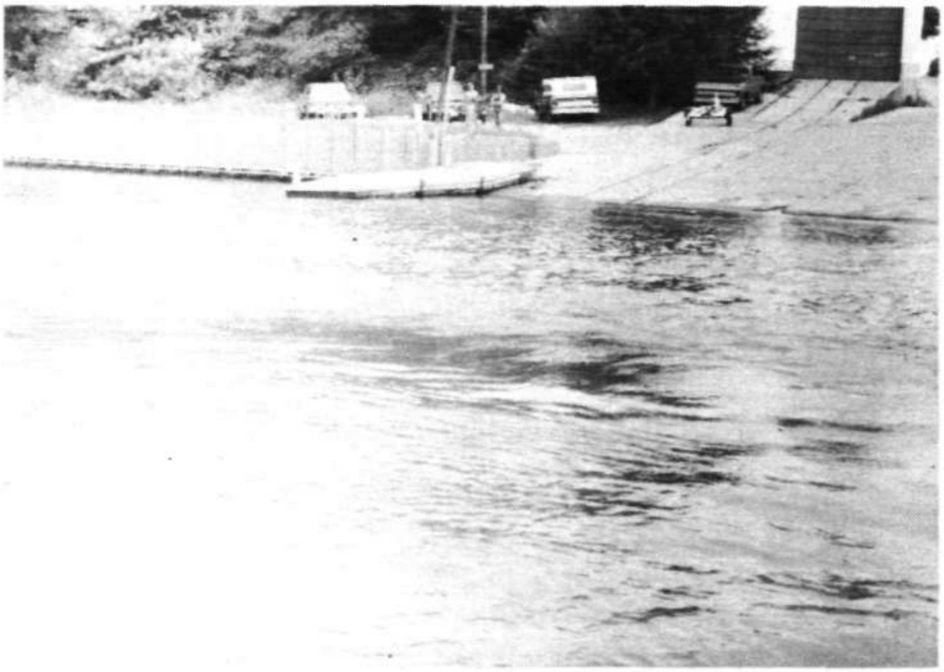


Figure 6. Illinois Street outfall area

Figure 7. Ponar dredge sediment sampler prepared for sampling

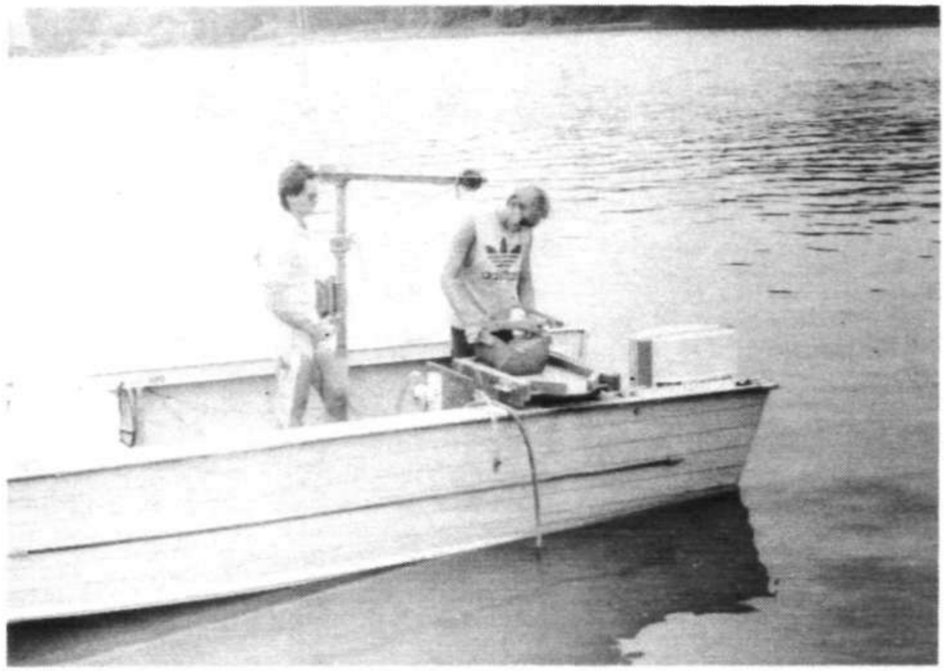


Figure 8. Releasing sediment from Ponar dredge sampler

Figure 9. Sediment core sampling attempt near shore at Market Street outfall area

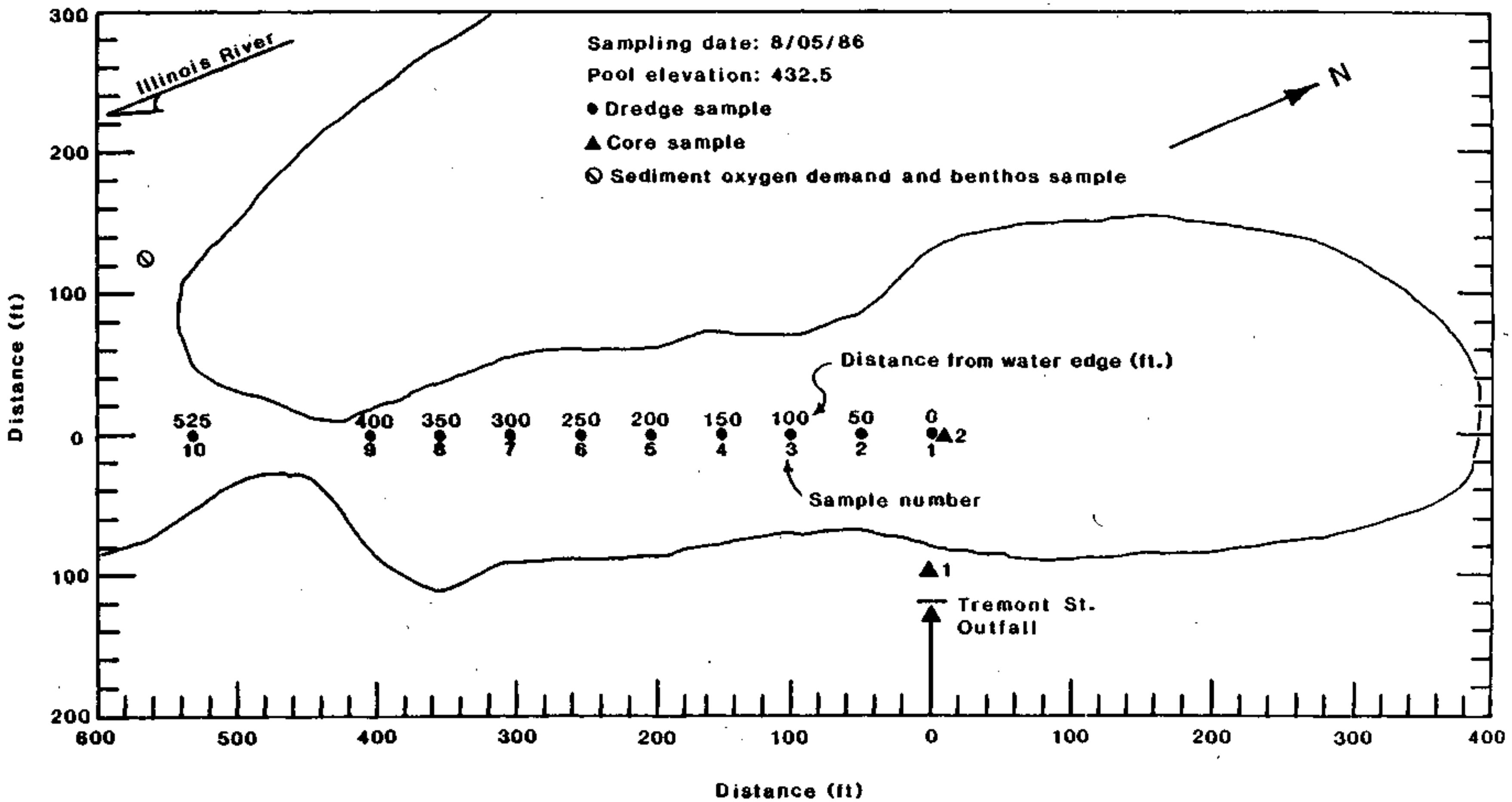


Figure 10. Sampling stations in the Tremont St. outfall area

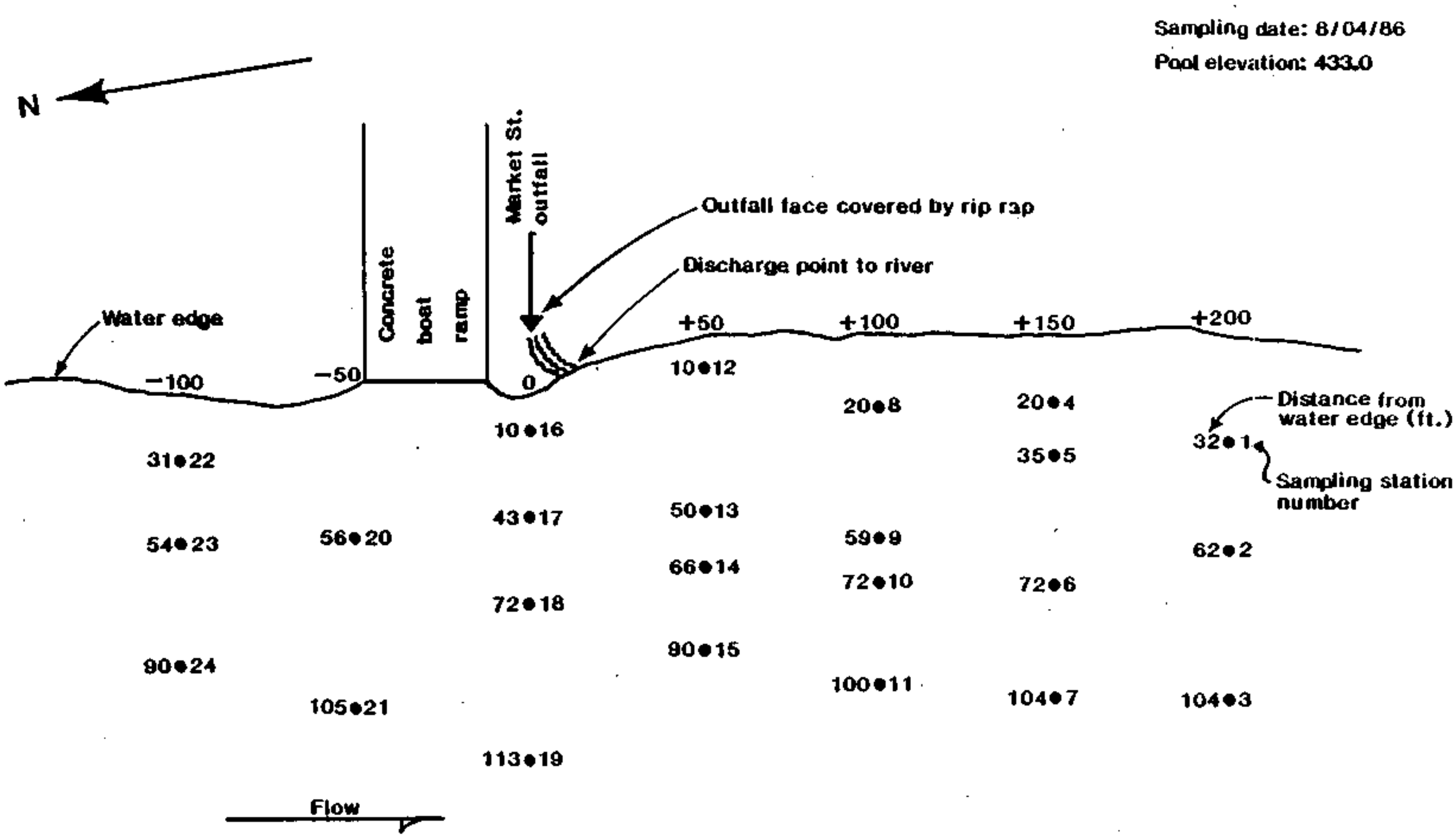


Figure 11. Market Street sewer outfall area sampling stations

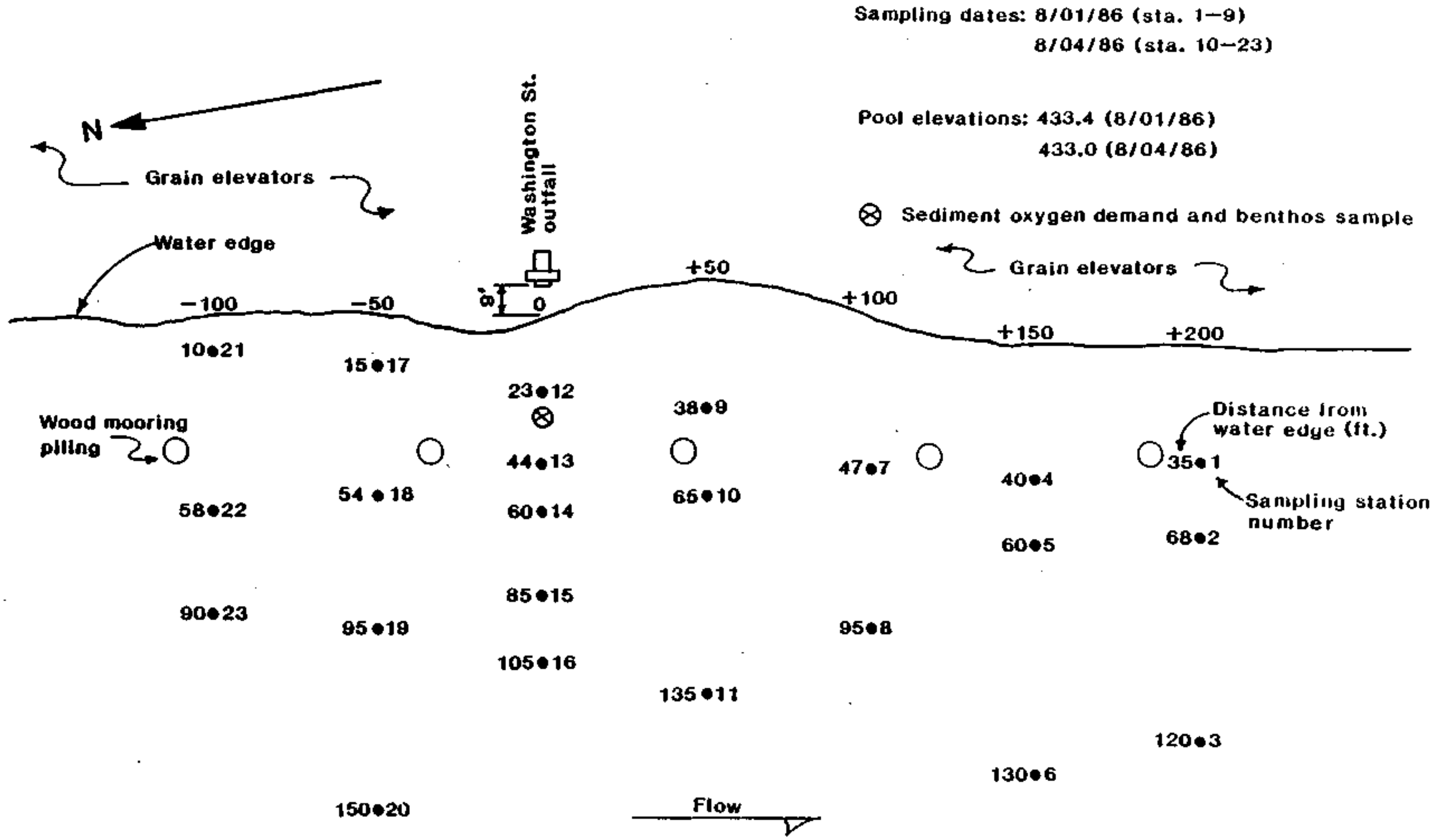


Figure 12. Washington Street sewer outfall area sampling stations

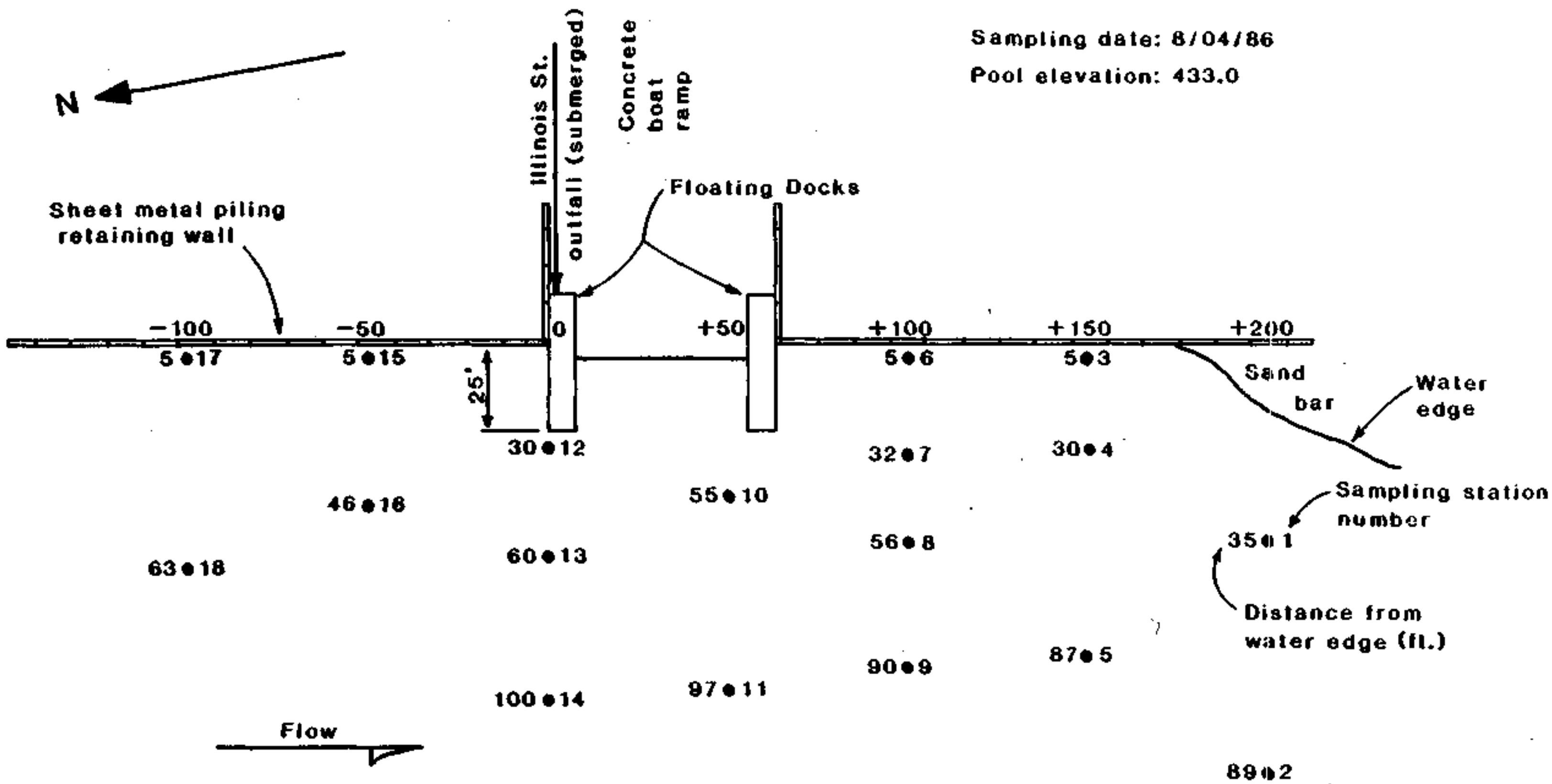


Figure 13. Illinois Street sewer outfall area sampling stations

Figure 14. Tremont Street bay area showing shoreline and sampling reference stakes

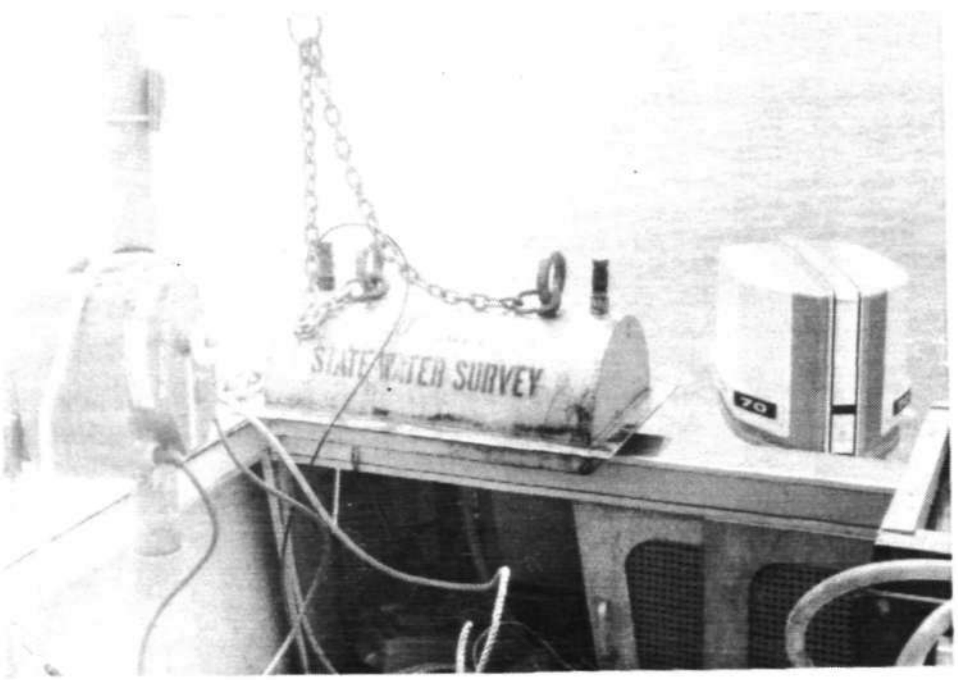


Figure 15. Sediment oxygen demand measurement chamber

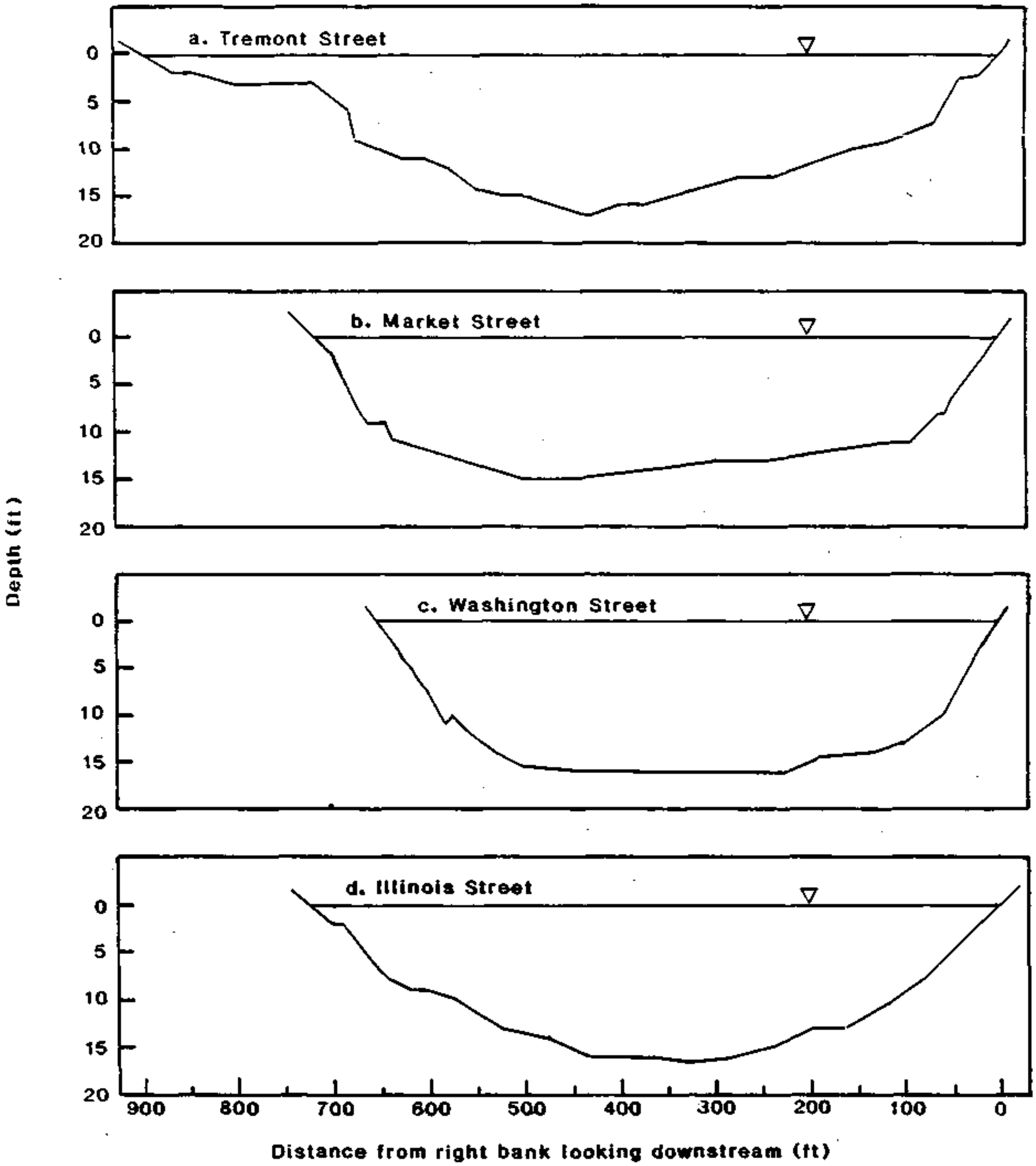


Figure 16. Illinois River cross sections at Havana combined sewer overflows at pool elevation of 432.5

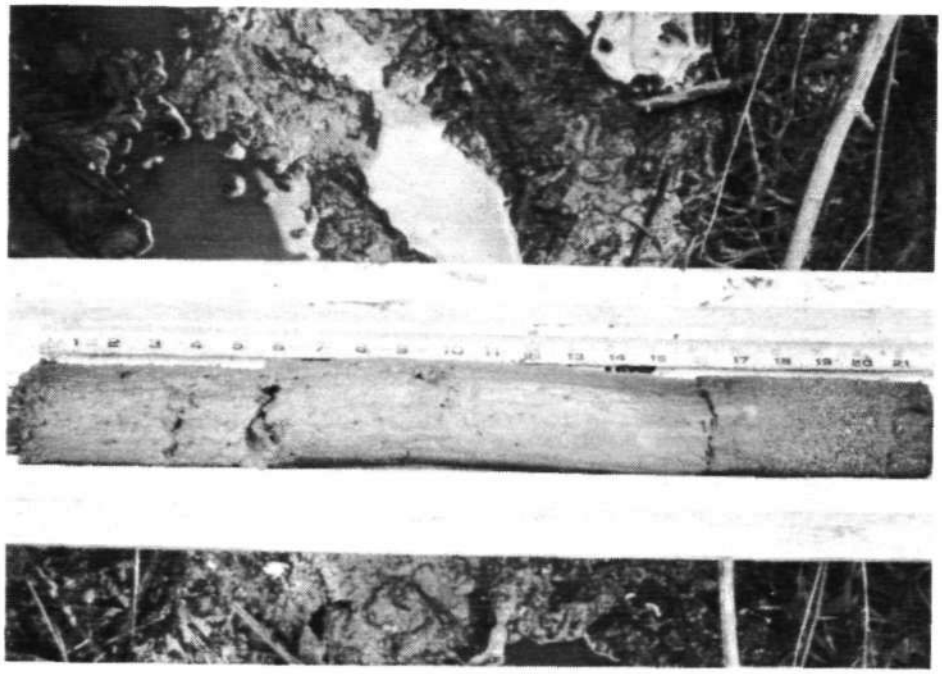


Figure 17. Tremont Street outfall area core sample 1

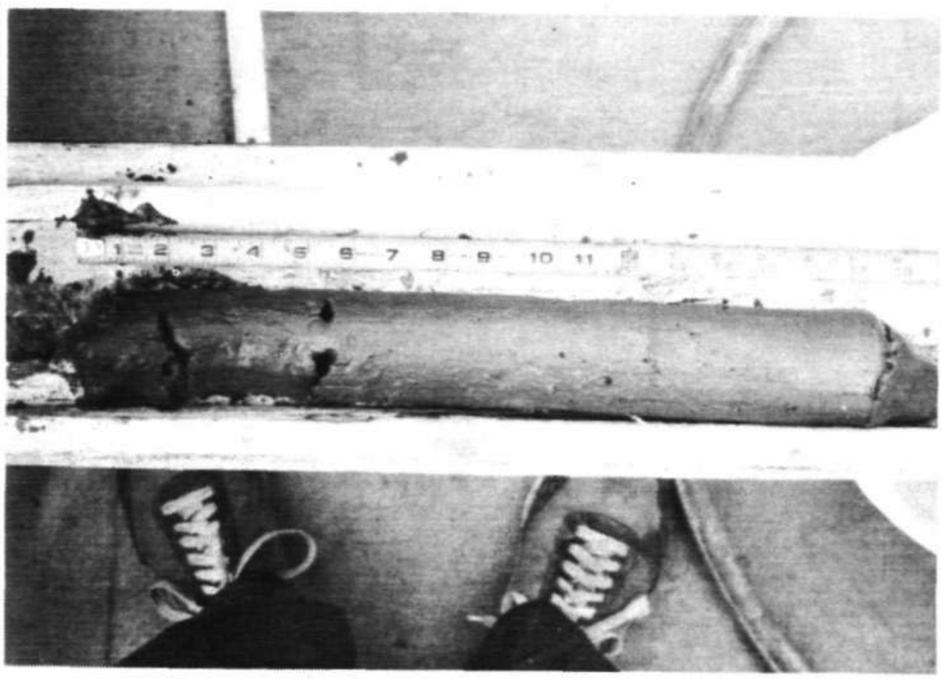


Figure 18. Tremont Street outfall area core sample 2

Table 1. Tremont Street Outfall Area
Core Sample Characteristics

Sample number	Depth interval (inches)	Description
1	0-2	Tan-gray, silt-clay mixed with coarse sand and fibrous detritus, no smell
	2-5	Tan-gray, silt-clay mixed with medium to coarse sand, small pea gravel, and medium gravel
	5-6	Gray medium sand to medium gravel
	6-8	Gray, tacky silt-clay
	8-13	Compact gray silt-clay interspersed with large gravel, some very fine fibrous detritus
	13-16	Clean, mixed silt and fine sand
	16-21	Uniform tan-brown fine to medium sand
2	0-2	Sterile-looking somewhat watery gray silt-clay
	2-19	Compact sterile-looking gray silt-clay

Table 2. Tremont Street Outfall Area
Sediment Characteristics

Sample number	Water depth (ft.)*	Description
1	2	Thin layer tan-gray silt on top of gray-black mucky silt and clay
2	2	Thin layer tan-gray silt on top of gray-black mucky silt and clay
3	2	Thin layer tan-gray silt on top of gray-black mucky silt and clay
4	2	Thin layer tan-gray silt on top of gray-black mucky silt and clay
5	2	Thin layer tan-gray silt on top of gray-black mucky silt and clay
6	2	Thin layer tan-gray silt on top of gray-black mucky silt and clay
7	2	Thin layer tan-gray silt on top of gray-black mucky silt and clay
8	1	Thin layer tan-gray silt on top of gray-black mucky silt and clay
9	2	Thin layer tan-gray silt on top of gray-black mucky silt and clay
10	2	Thin layer tan-gray silt on top of gray-black mucky silt and clay

* Pool elevation 432.5

Table 3. -Market Street Outfall Area Sediment Characteristics

Sample number	Water depth (ft.)*	Description
1	3	Tan silt and fine sand on top of clean coarse sand and small pea gravel
2	7	Tan silt and fine sand on top of pea and medium gravel mixed with silt-clay balls
3	11	Two inches of tan fine sand on top of gray compacted clay-silt interspersed with small rock fragments
4	1	Riprap extension from shore; a Ponar sample could not be taken
5	4	Medium to large gravel rocks
6	8	Thin layer of tan watery silt on top of black medium to coarse sand containing some clay-silt, shells and shell fragments
7	10	Very thin layer of tan fine sand on top of compacted gray-black clay, large rock fragments
8	2	Tan watery fine to coarse sand, small rocks on top of riprap, some sticks and woody detritus
9	7	Two inches of tan silt and fine sand on top of compacted gray-black silt-clay
10	8	Tan watery medium to coarse sand, pea gravel, whole clam
11	10	Thin layer of tan silt and fine sand on top of compacted gray silt-clay
12	1	Thin layer of clean coarse sand and pea gravel on top of riprap
13	4	Tan watery silt on top of medium to coarse tan sand, some pea gravel and slag type of gravel
14	7	Thin layer of tan watery silt on top of gray-black fine to coarse sand, pea to medium gravel, snail shells and shell fragments
15	10	Black compacted silt-clay, tan medium to coarse sand, a little pea gravel, shells and shell fragments
16	1	Thin layer of gray-tan silt on top of tan fine to medium sand
17	3	Two inches tan watery silt on top of tan fine to medium sand, small gravel
18	8	Two inches tan watery silt on top of tan fine to medium sand, small gravel
19	12	Tan silt balls, fine to coarse sand, pea gravel, snail and clam shells
20	7	Tan watery silt-clay mixed with pea gravel
21	11	Thin layer tan watery silt on top of tan fine to medium sand, slag type of gravel
22	3	Large rocks and riprap
23	7	Large rocks and riprap
24	9	Thin tan watery layer of silt on top of tan fine to coarse sand on top of compacted gray silt-clay

* Pool elevation: 433.0

Table 4. Washington Street Outfall Area Sediment Characteristics

Sample number	Water depth (ft.)*	Description
1	12	Thin layer of tan watery fine to medium sand on top of black sandy silt
2	16	Thin layer of tan watery fine to medium sand on top of black sandy silt
3	17	Thin tan watery layer of fine sand on top of uniform clean brown sand
4	13	Riprap bottom; a Ponar sample could not be taken
5	15	Thin layer of tan watery fine to coarse sand on top of a mixture of sticky gray-black silt-clay and coarse black sand
6	17	Thin layer of tan watery fine sand on top of compacted black silt-clay, a few clam shells
7	9	Tan watery fine sand on top of black medium to coarse sand mixed with some black silt-clay and slag type rocks
8	15	Thin layer of tan watery fine sand on top of tan-gray medium to coarse sand
9	4	Thin tan watery layer of silt on top of gray-black fine to coarse sand mixed with a little silt-clay and woody detritus
10	11	Tan watery silt on top of gray-black compacted silt-clay
11	10	Gray-tan clean fine to medium sand interspersed with compacted silt-clay balls
12	5	Tan, very watery silt-clay
13	7	Thin tan watery layer of silt-clay on top of gray-black compacted silt-clay
14	10	Tan, very watery silt-clay
15	12	Tan, very watery silt-clay
16	14	Thin layer of tan watery silt-clay on top of gray-black loose fine to coarse sand
17	3	Thin layer of tan watery silt-clay on top of compacted tan-gray silt-clay
18	8	Tan watery silt-clay on top of gray-tan compacted silt clay with sticks and wood detritus
19	12	Tan watery silt-clay on top of clean gray-tan loose fine to medium sand
20	14	Thin layer gray-tan watery silt-clay on top of gray-black compacted silt clay, sticks and woody detritus, red worms
21	1	Thin layer of tan watery silt-clay on top of compacted tan-gray silt-clay
22	11	Four inches of tan watery silt-clay on top of compacted tan-gray silt-clay
23	13	Tan watery silt-clay

* Pool Elevation: 433.4 (samples 1-9)
433.0 (samples 10-23)

Table 5. Illinois Street Outfall Area
Sediment Characteristics

Sample number	Water depth (ft.)*	Description
1	3	Clean tan fine sand to medium gravel
2	11	Clean pea to large gravel
3	2	Gray coarse sand to small gravel
4	7	Gray coarse sand to small gravel
5	12	Clean medium sand to pea gravel, clam shells
6	5	Clean tan medium sand to medium gravel
7	7	Thin layer tan sandy silt on top of gray-black silt-clay containing pea gravel
8	9	Clean tan medium sand to pea gravel on top of compacted black silt-clay
9	11	Uniform clean medium to coarse sand
10	6	Clean gray-tan fine sand to medium gravel
11	9	Clean tan coarse sand to large gravel
12	4	Clean tan fine sand to medium gravel
13	7	Clean tan coarse sand to medium gravel
14	9	Clean tan coarse sand to large gravel
15	6	Thin layer tan silt-clay on top of gray-black compacted silt-clay containing pea gravel
16	10	Clean tan fine sand to medium gravel
17	6	Compacted gray silt-clay
18	12	Clean fine sand to medium gravel

* Pool elevation 433.0

Table 6. Total Solids and Volatile Solids Content of Selected Sediment Samples

Sewer outfall area	Sample number	Solids content: % Total solids	Solids content: % Volatile solids
Tremont Street	1	54.7	5.7
	4	57.9	5.3
	10	58.2	4.5
	8	73.2	2.0
Market Street	14	76.2	2.0
	16	76.2	2.3
	17	64.3	3.2
	20	61.6	3.6
	1	72.7	3.1
Washington Street	6	70.4	3.1
	8	78.7	2.1
	9	62.6	4.0
	10	61.6	3.9
	12	43.9	6.1
	17	52.6	5.2
Illinois Street	4	74.6	2.4
	7	80.2	2.1
	12	88.1	1.1
	15	59.5	4.3

Table 7. Sediment Oxygen Demand (SOD) Results and Supporting Physical and Biological Data

Outfall	Sampling station location: Above Tremont Street bay entrance	Sampling station location: 30' out from Washington St. outfall
Sediment data		
SOD $g/m^2/day$ @ 25°C	1.35	3.02
% total solids	73.1	53.0
% volatile solids	1.9	4.7
Biological data		
Benthic organisms Cno./m^2)		
Hexagenia limbata (burrowing mayfly)	0	57
Chironomidae (true midge)	191	0
Oligochaeta (aquatic worm)	497	364
Benthos summary		
Total number of organisms	688	421
Number of taxa	2	2
IEPA Macroinvertebrate Biotic Index	8.9	9.3
Plankton algae (no./ml)	2846	3833

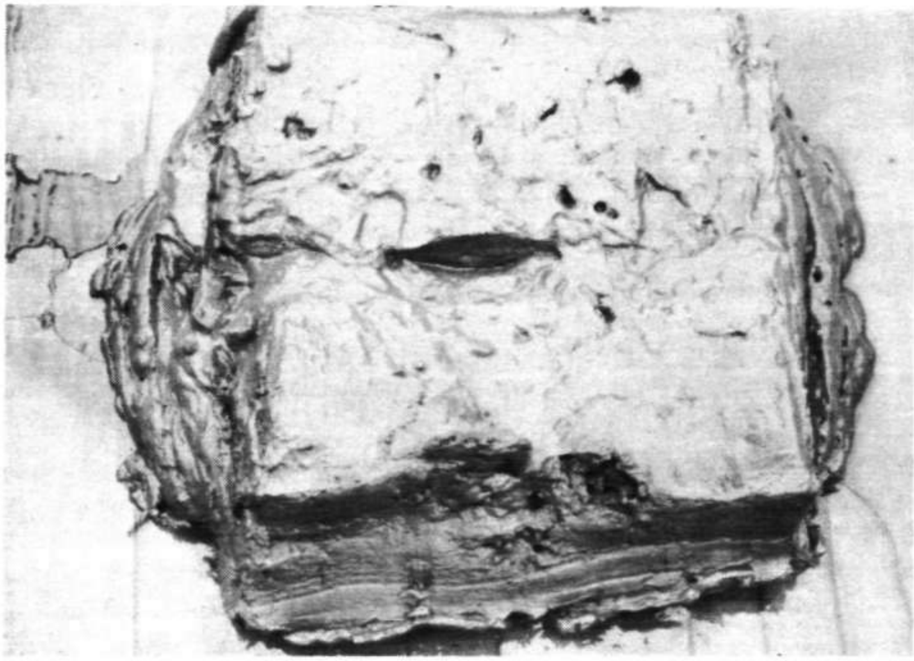
Table 8. Comparison of Havana SOD Rates with other Illinois River CSO Area Measurements (a) and Generalized Criteria (b)

(a) Location	SOD rates ($g/m^2/day$ at 25°C) for sampling: Above CSOs	In CSO area
Peoria	1.52 - 2.86	0.99 - 3 . 12
Pekin	0.84	1.15
Havana	1.35	3 .02

(b) Generalized benthic sediment condition	Expected range of SOD rates (g/m /day)
Clean	0 - 0 . 5
Moderately clean	0.5 - 1.0
Slightly degraded	1.0 - 2.0
Moderately polluted	2.0 - 3.0
Polluted	3.0 - 5.0
Grossly polluted	5.0 - 10.0
Sewage-sludge like	> 10.0

APPENDIX A

Photographs of Selected Ponar Dredge Samples in Tremont Street Outfall Area



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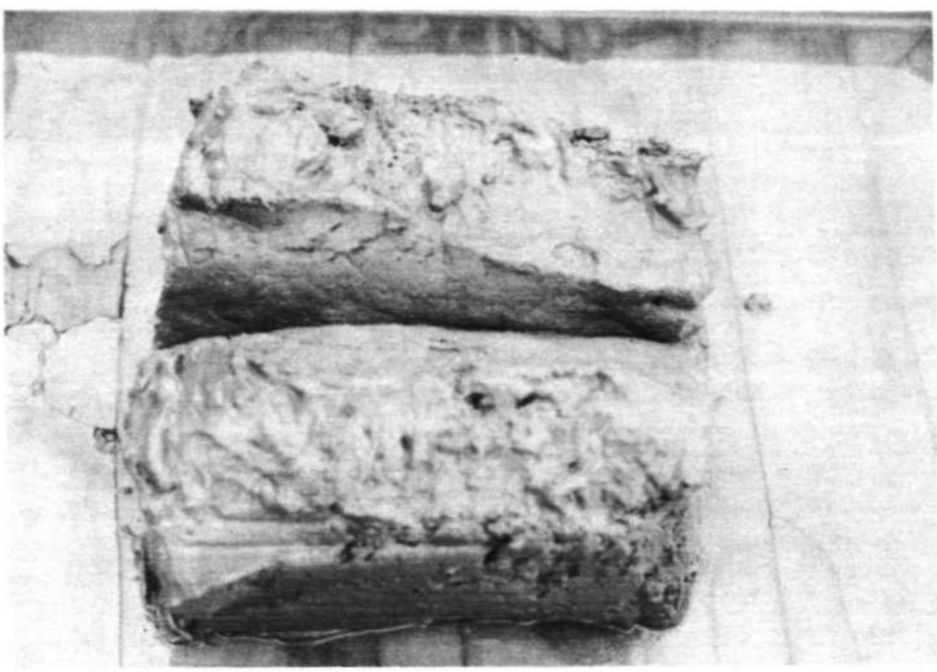

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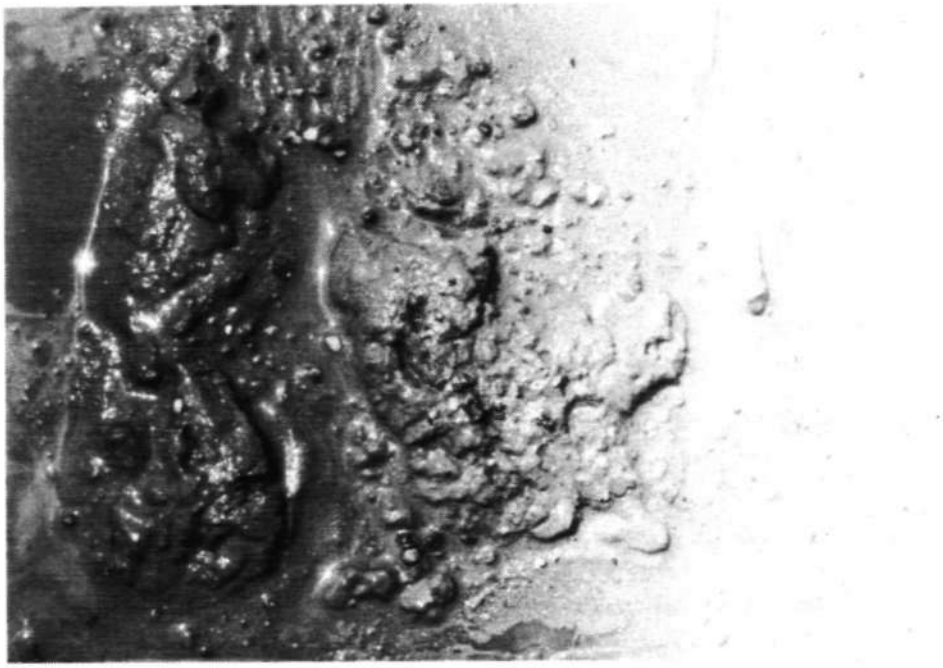
APPENDIX B

Photographs of Selected Ponar Dredge Samples in Market Street Outfall Area



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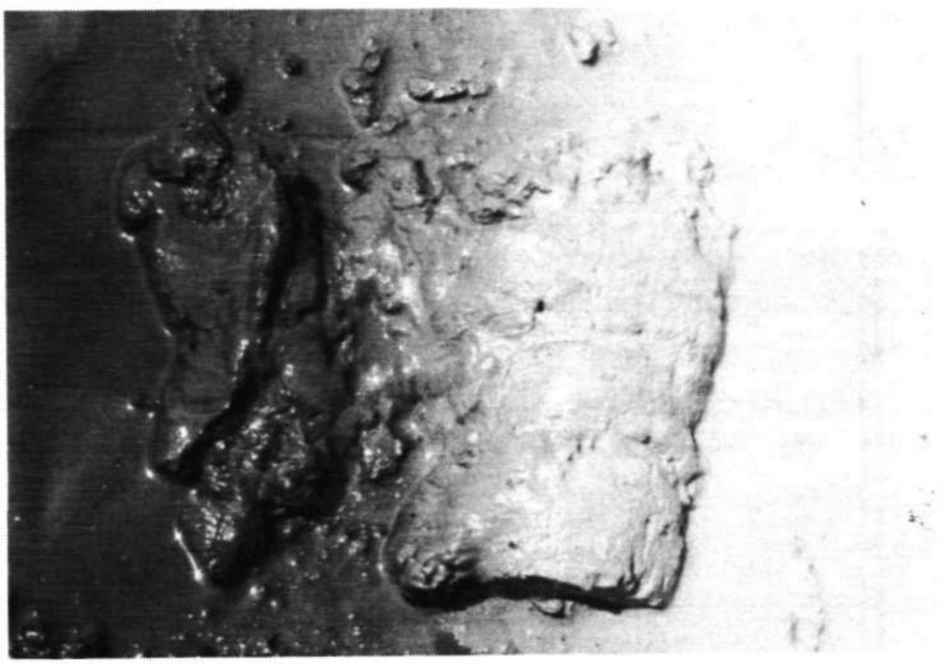

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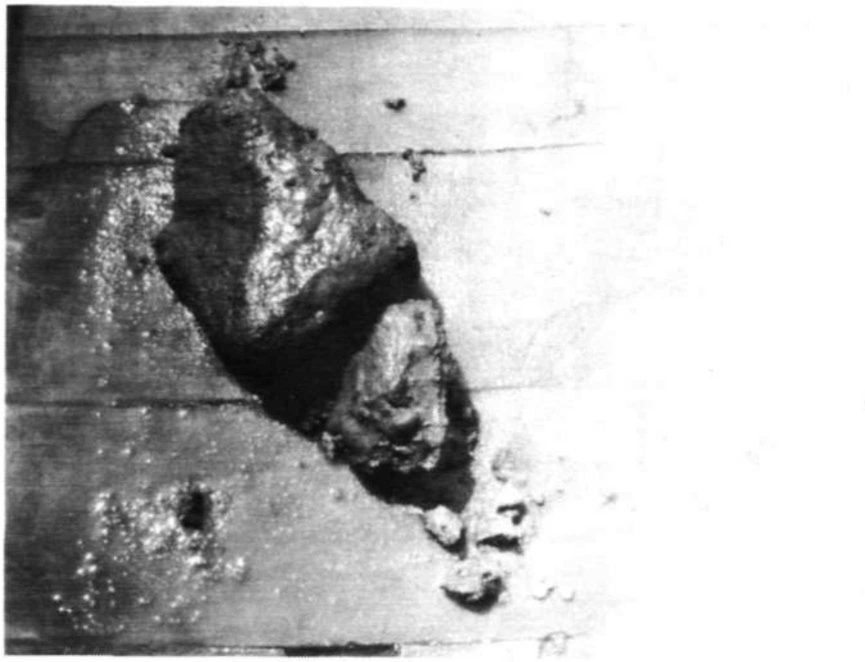

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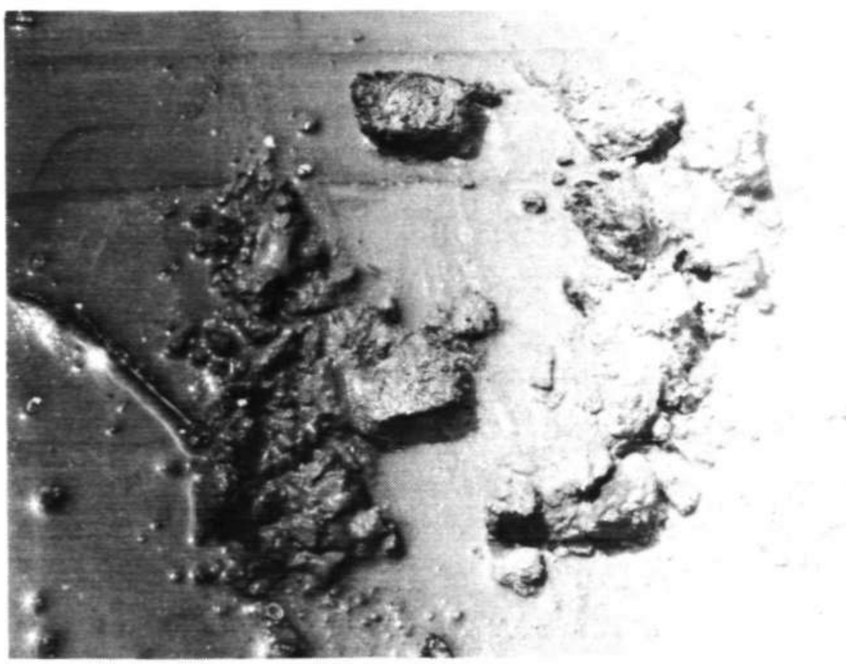

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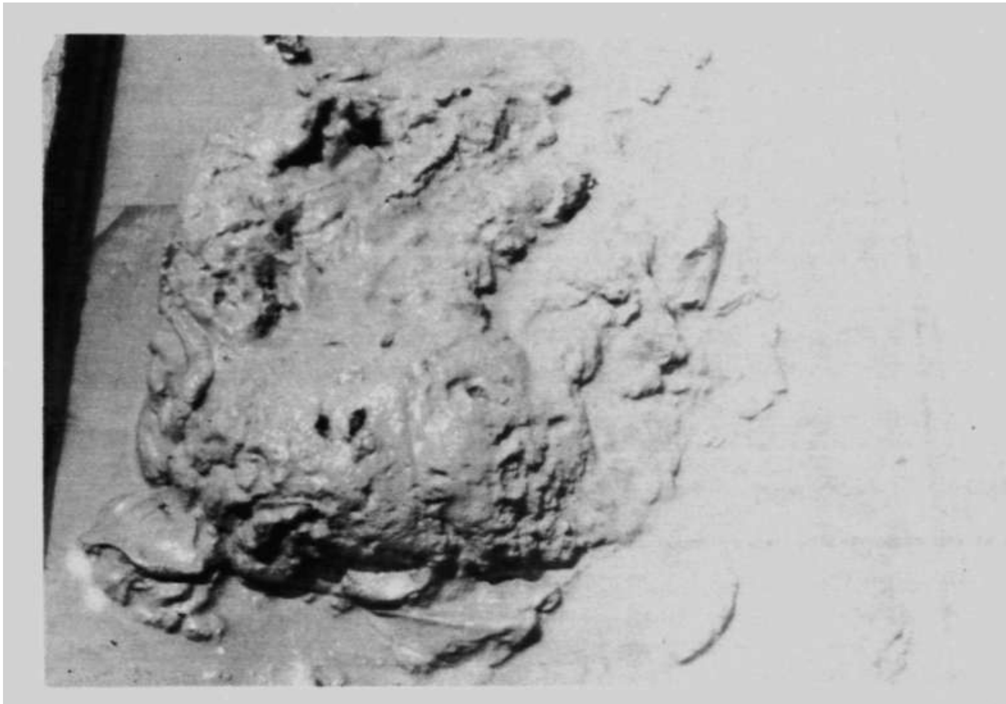

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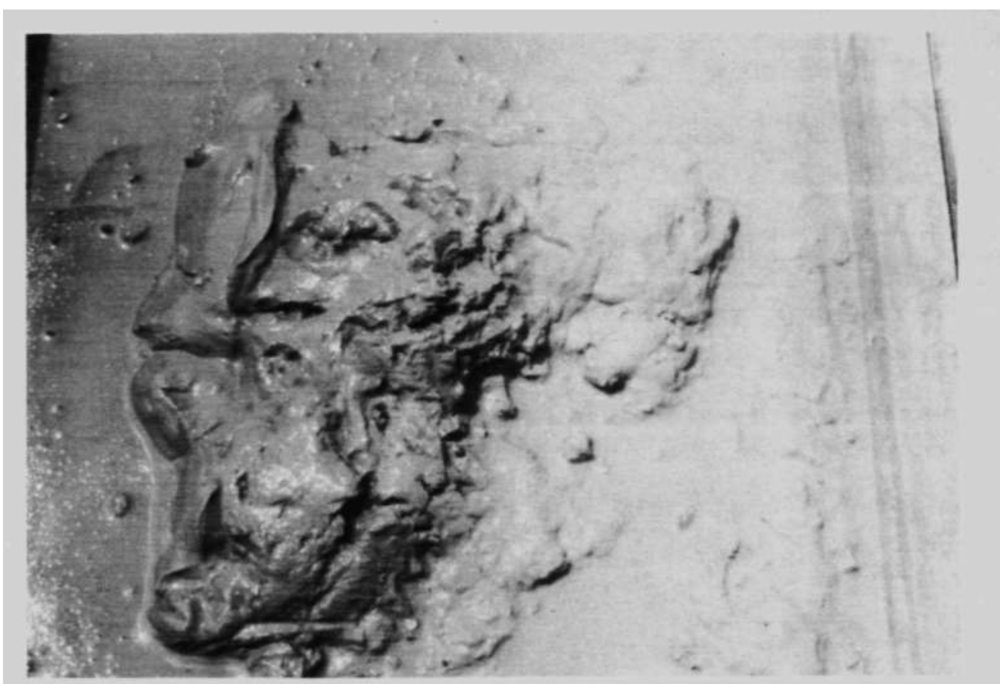

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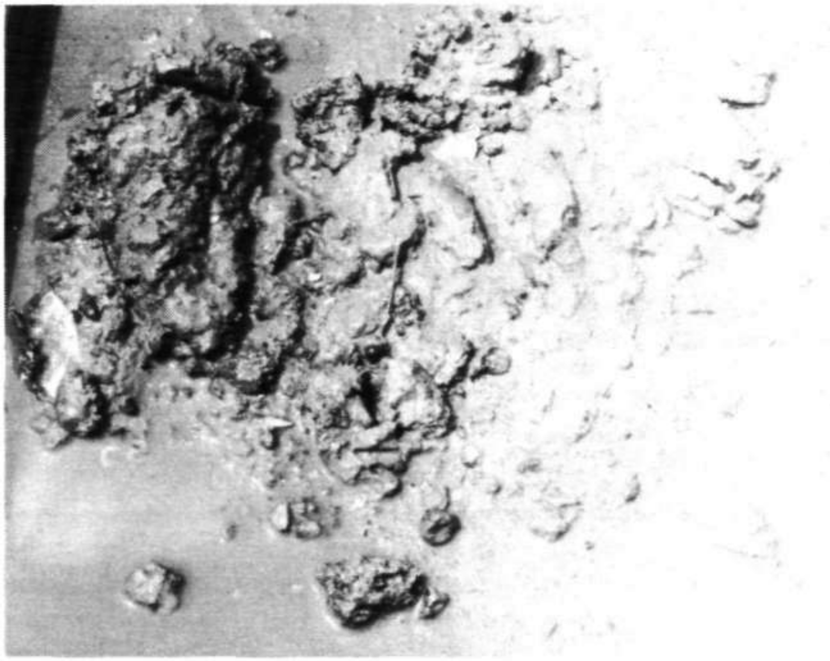

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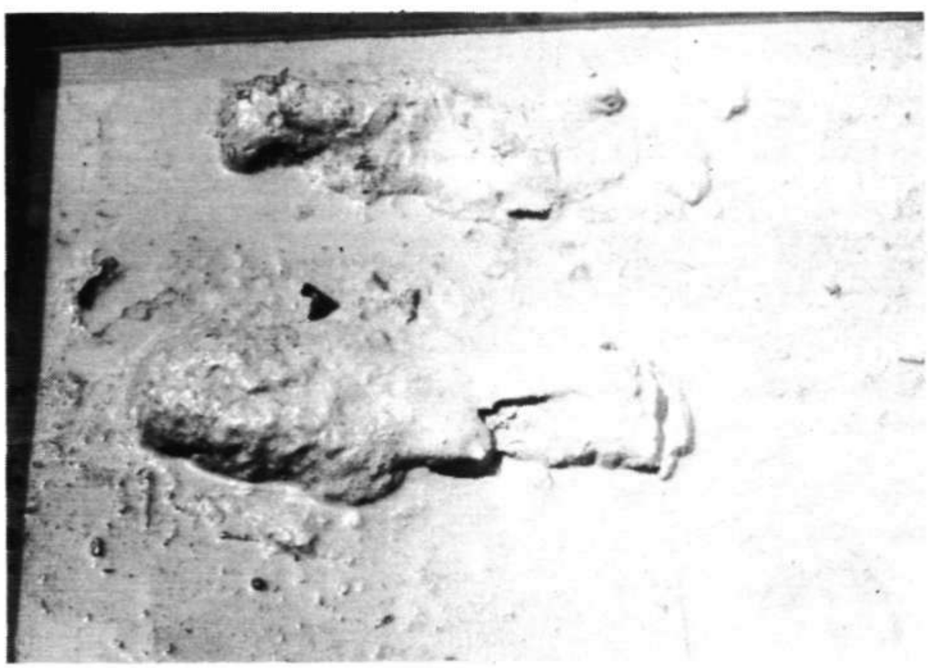

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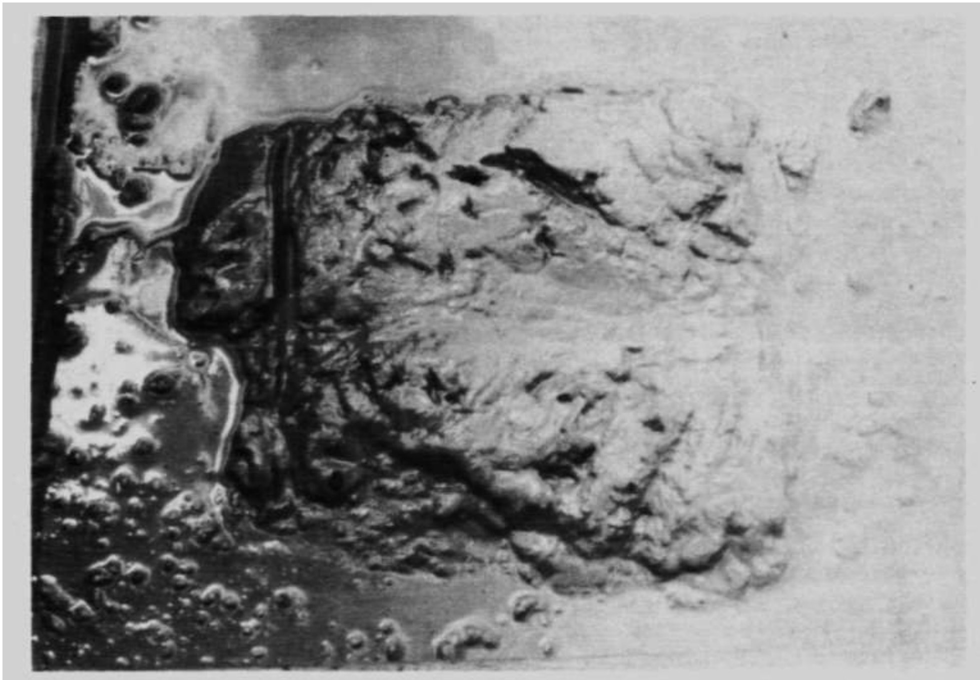

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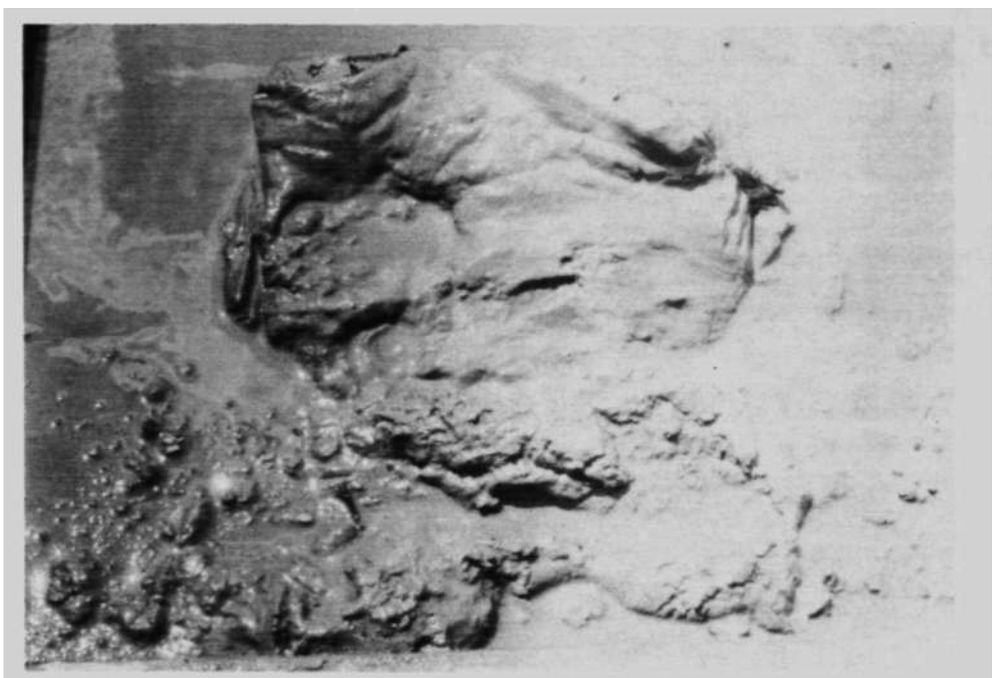

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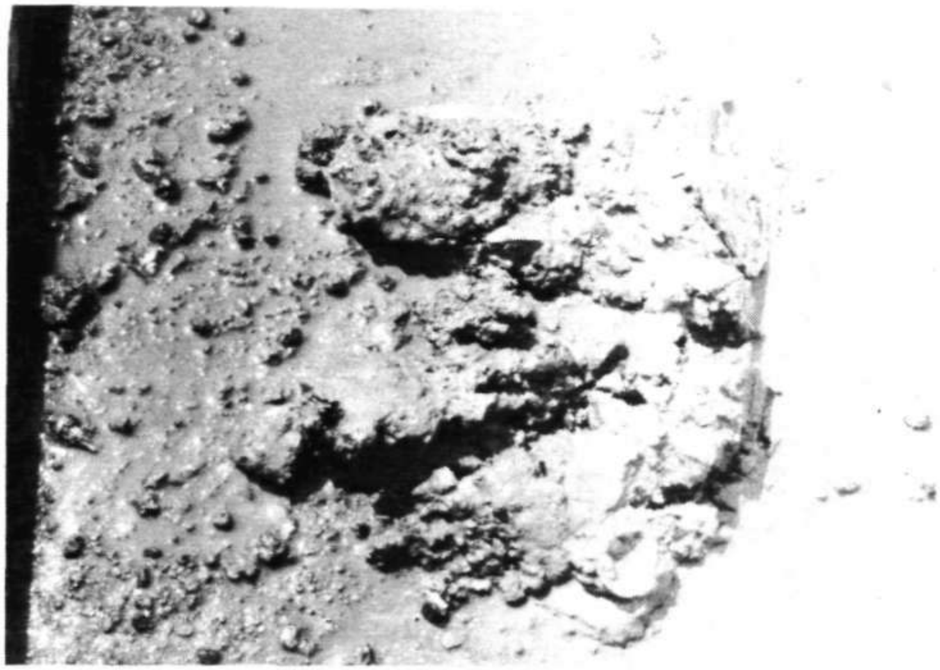

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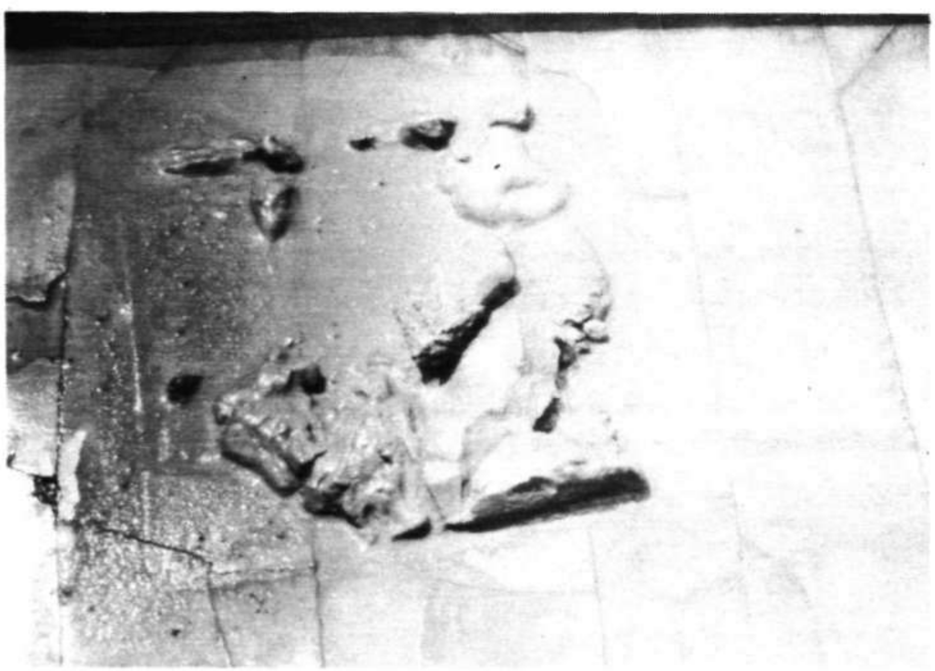

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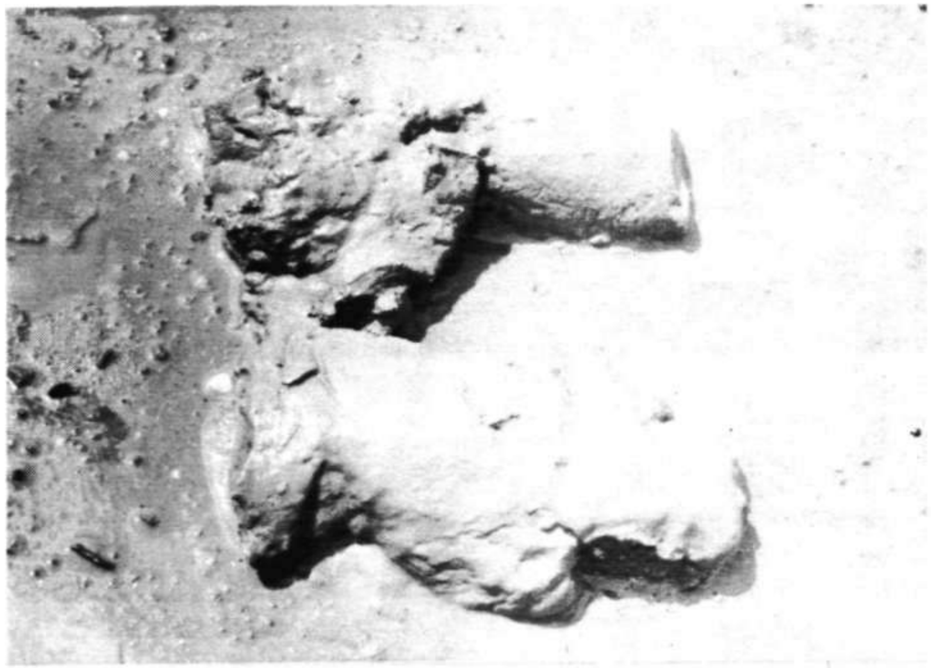

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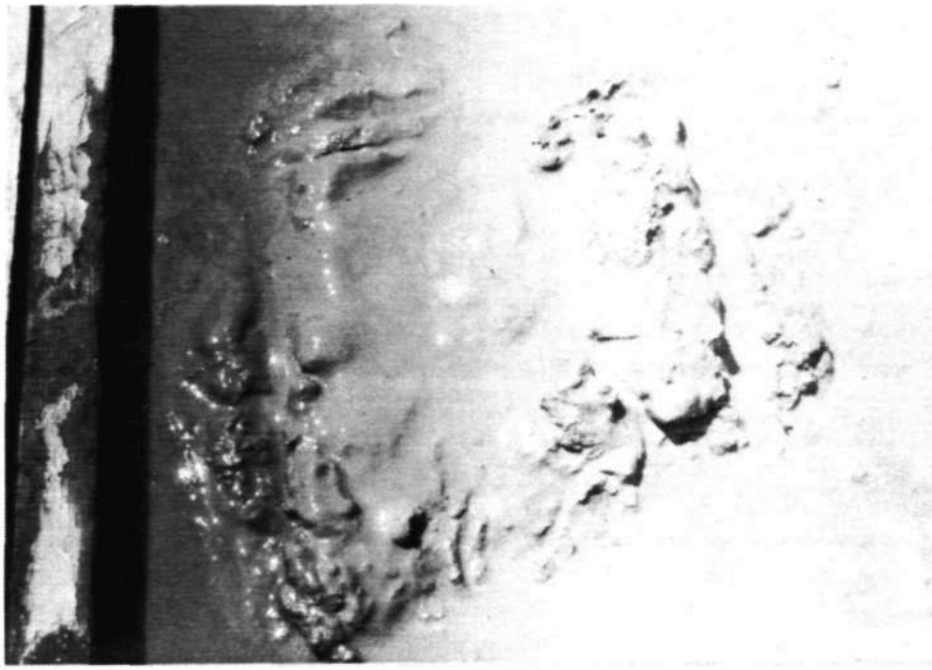
APPENDIX C

Photographs of Selected Ponar Dredge Samples in Washington Street Outfall Area



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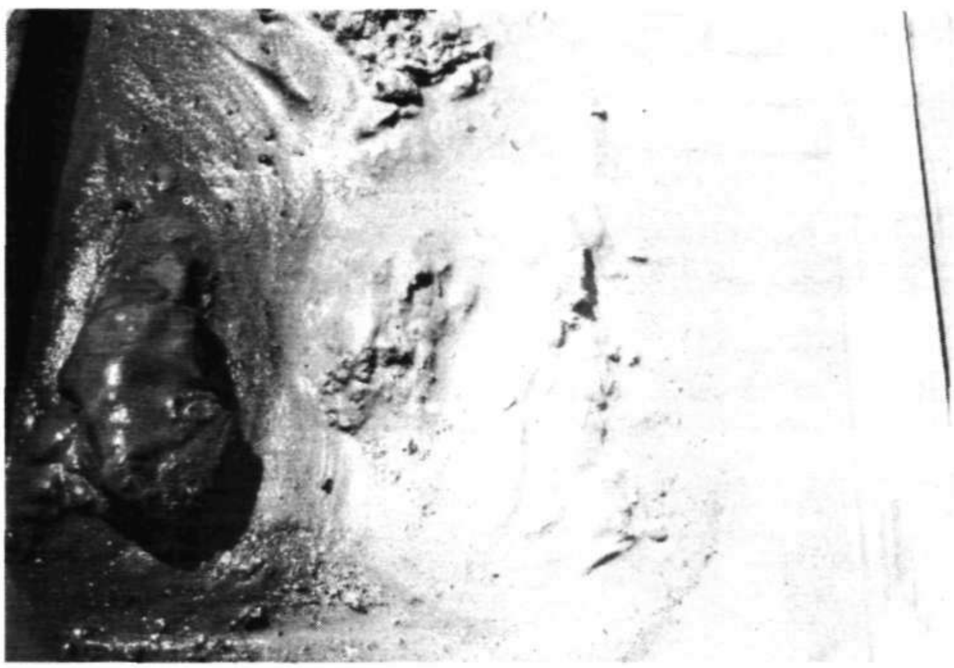

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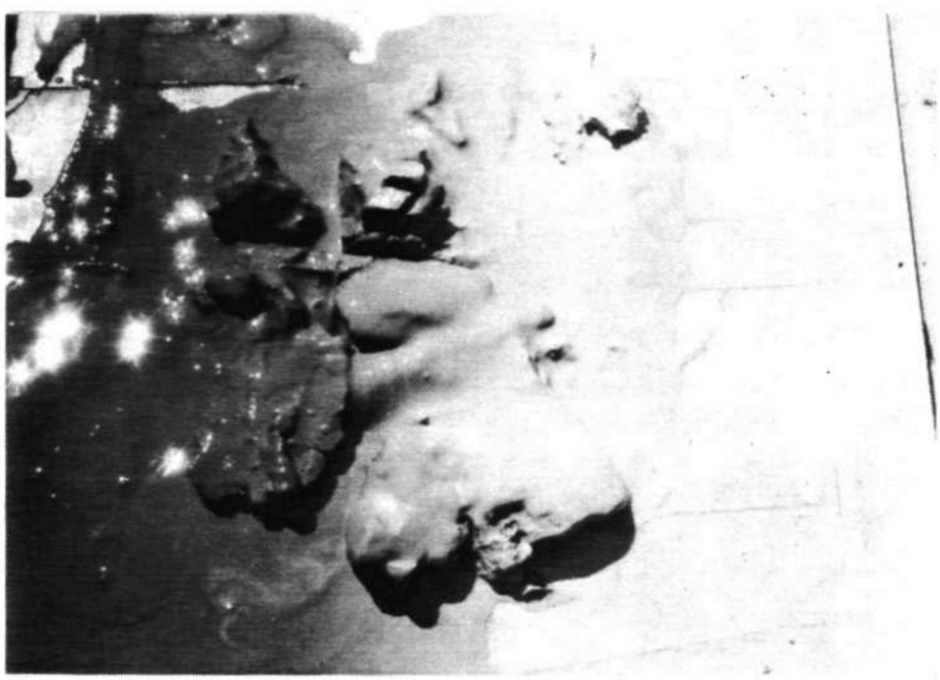

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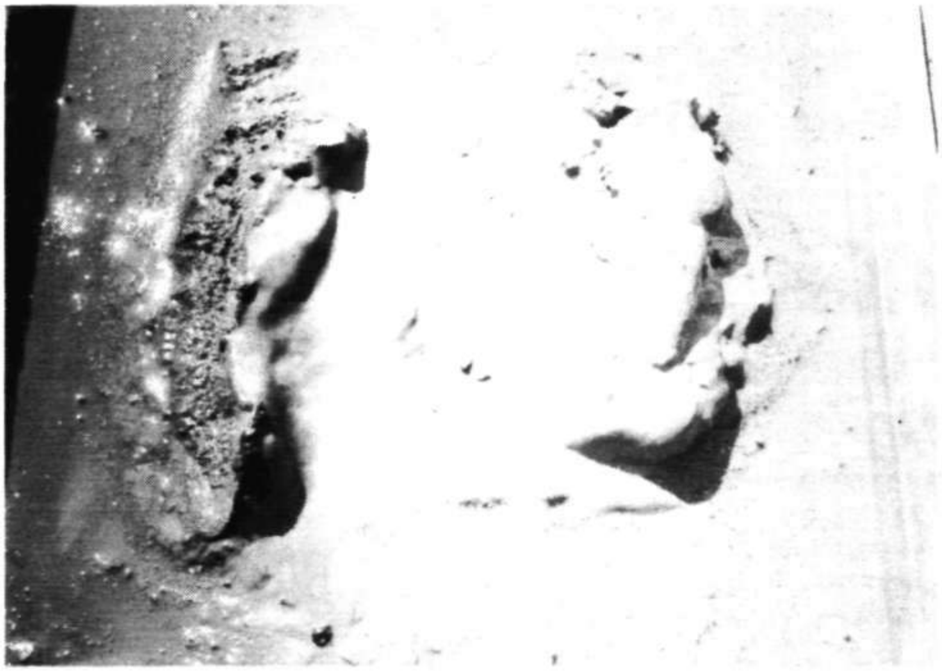

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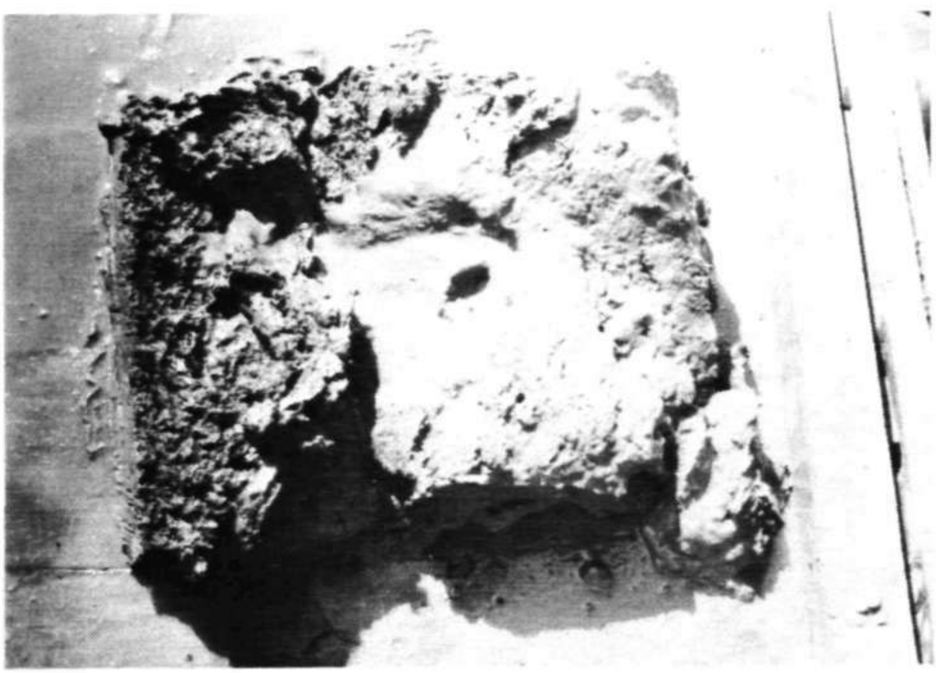

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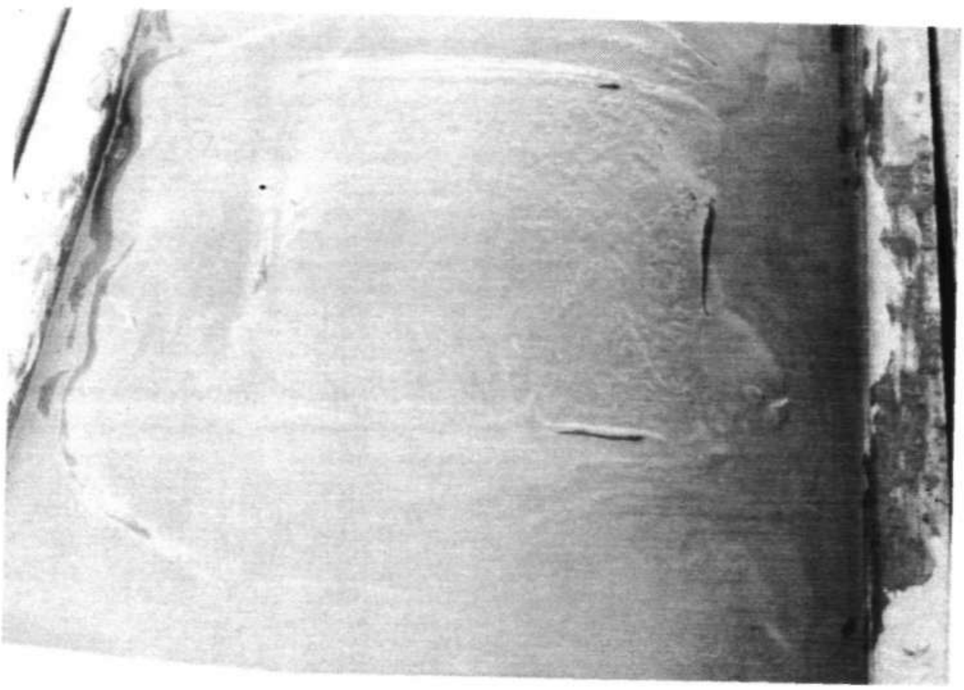

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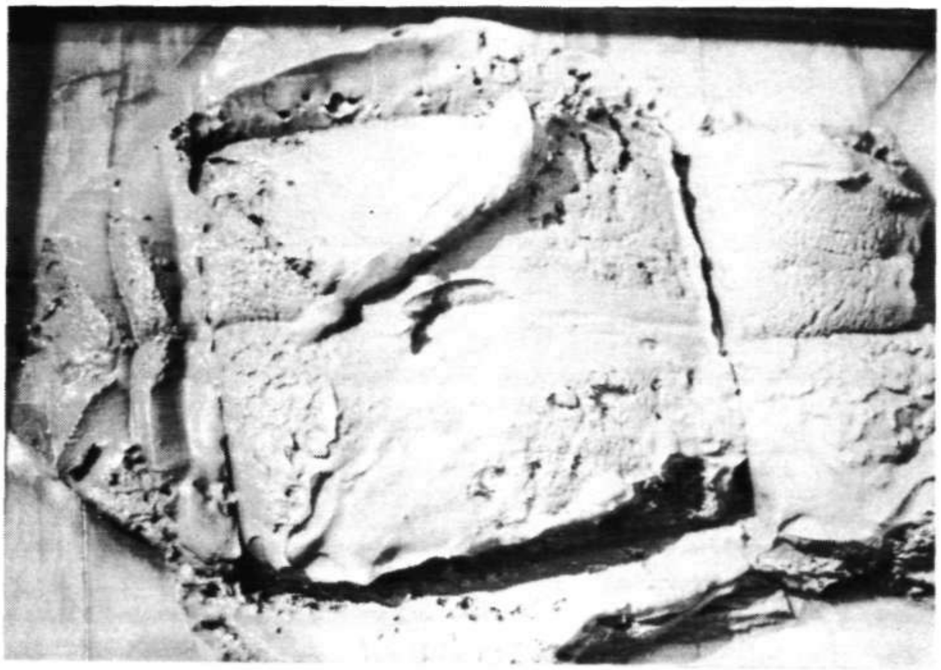

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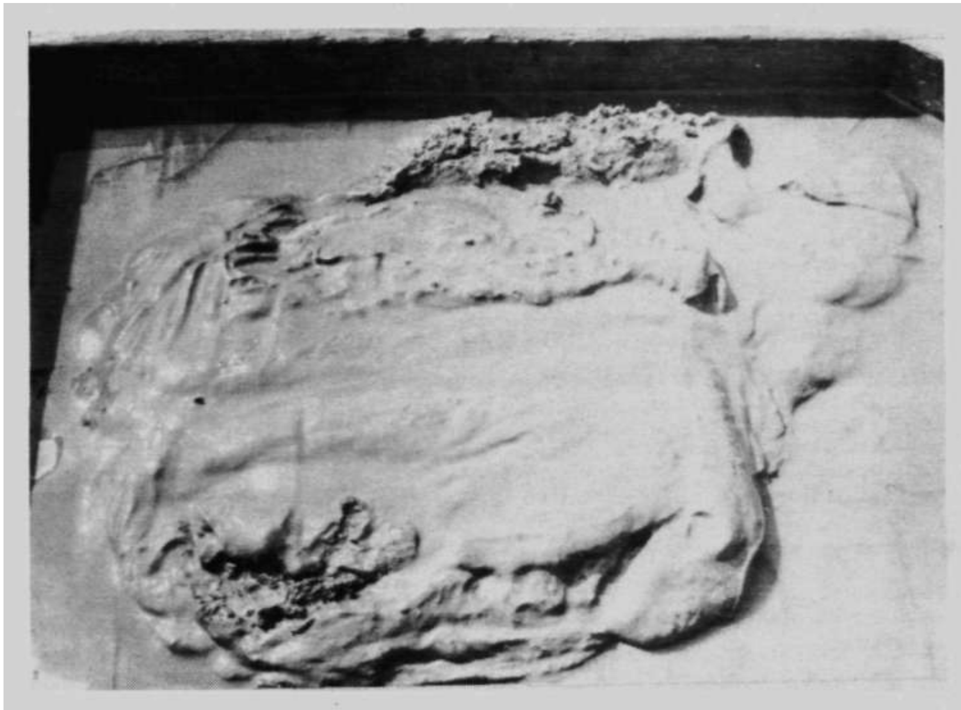

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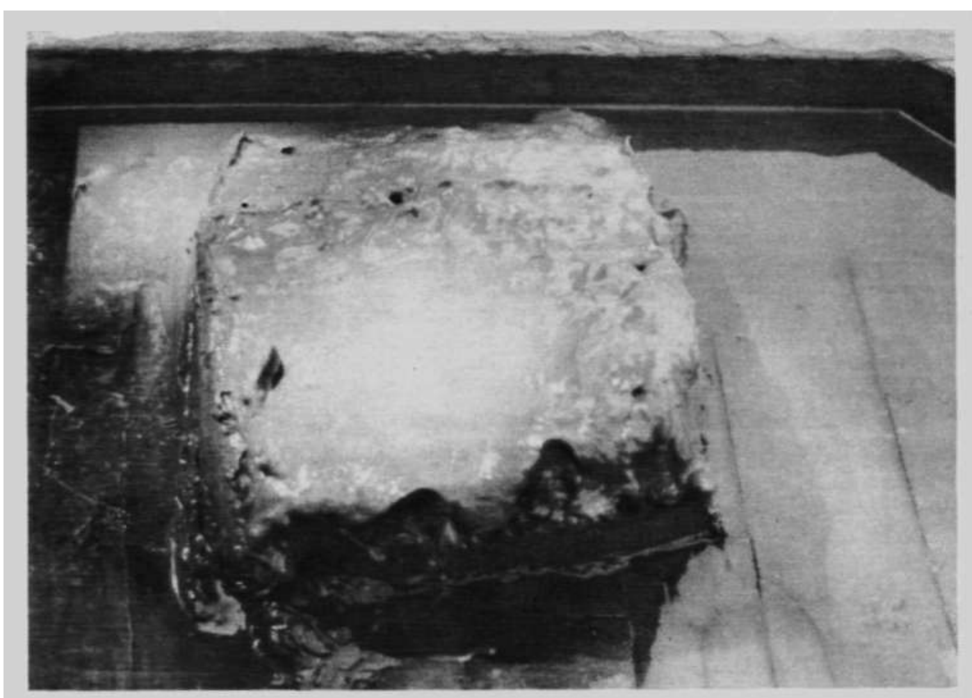

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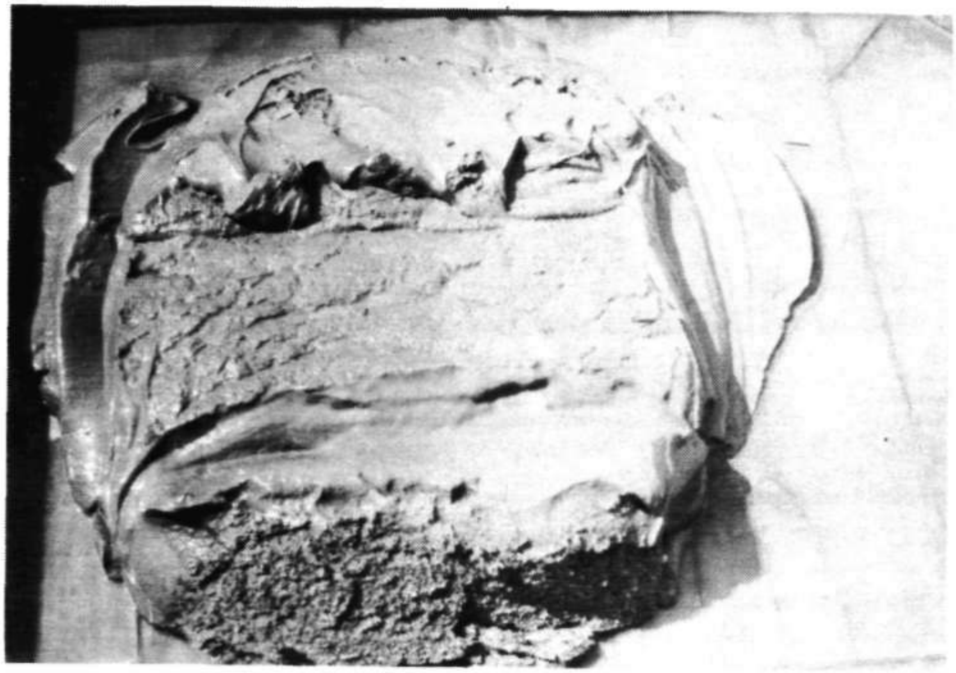

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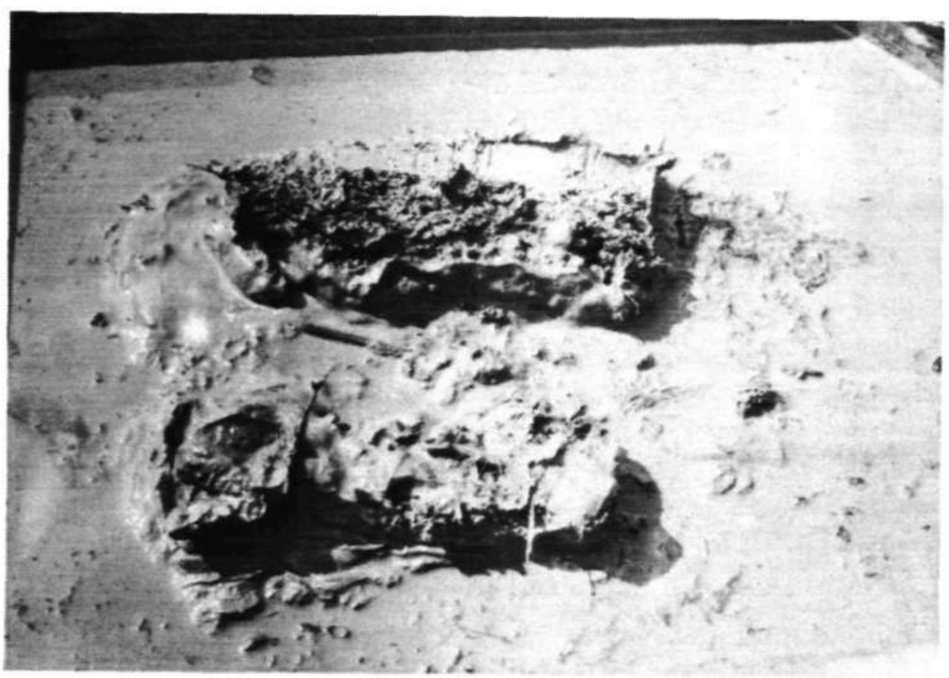

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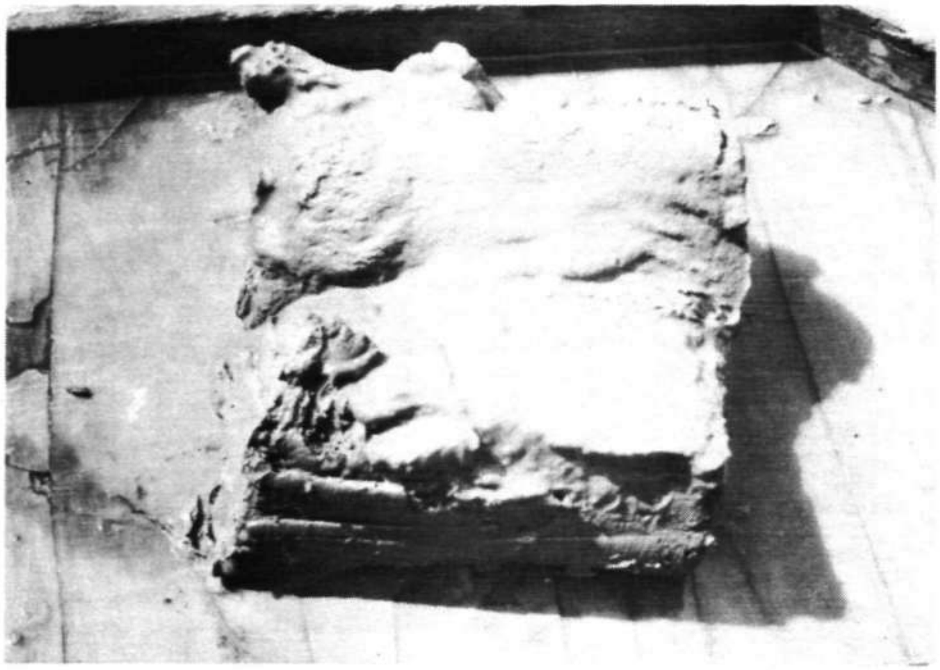

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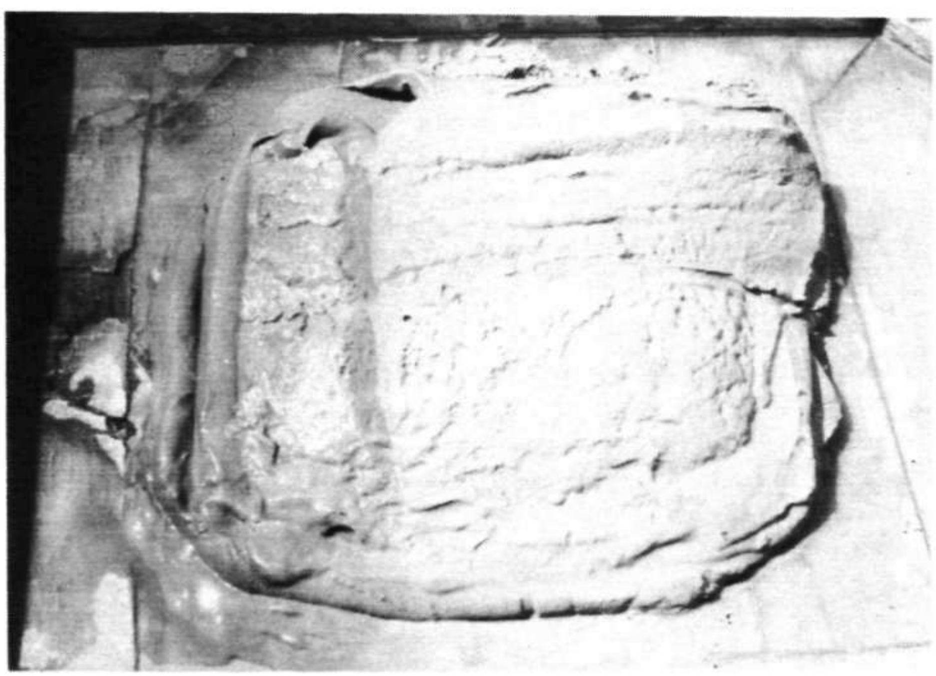

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APPENDIX D

Photographs of Selected Ponar Dredge Samples in Illinois Street Outfall Area

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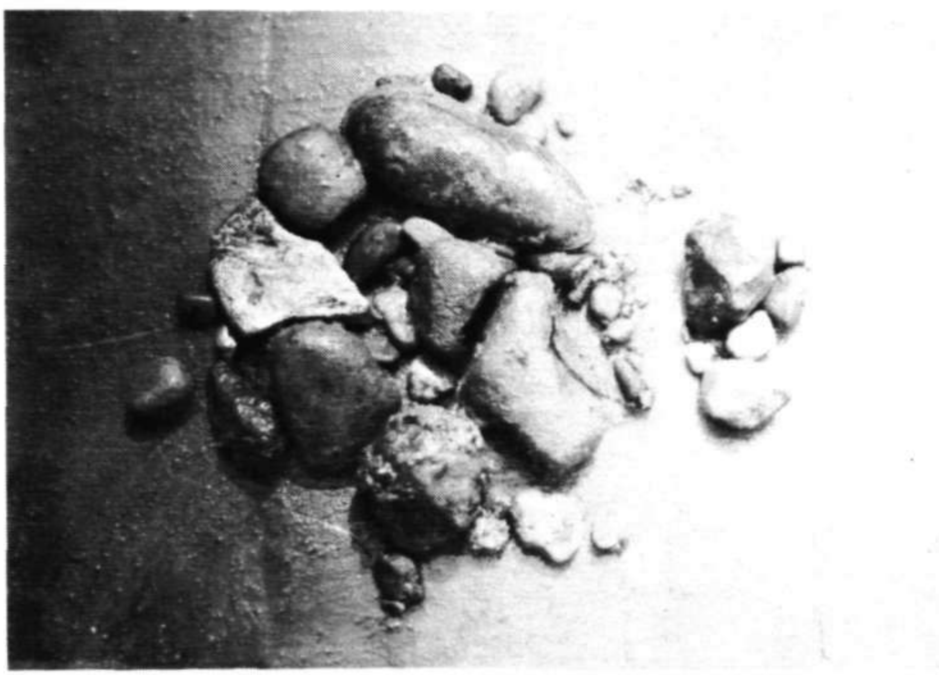

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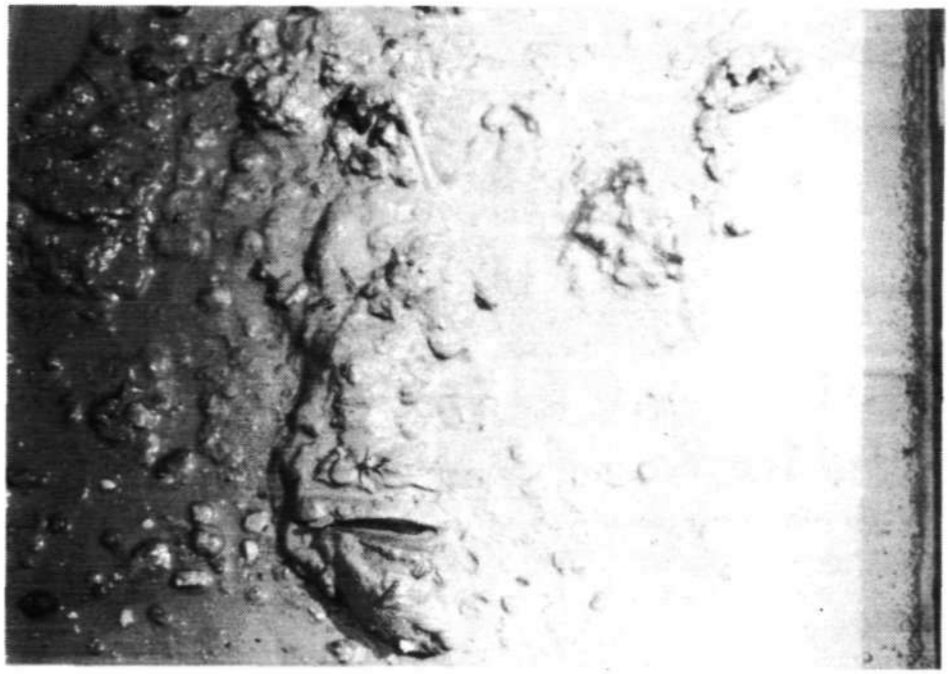

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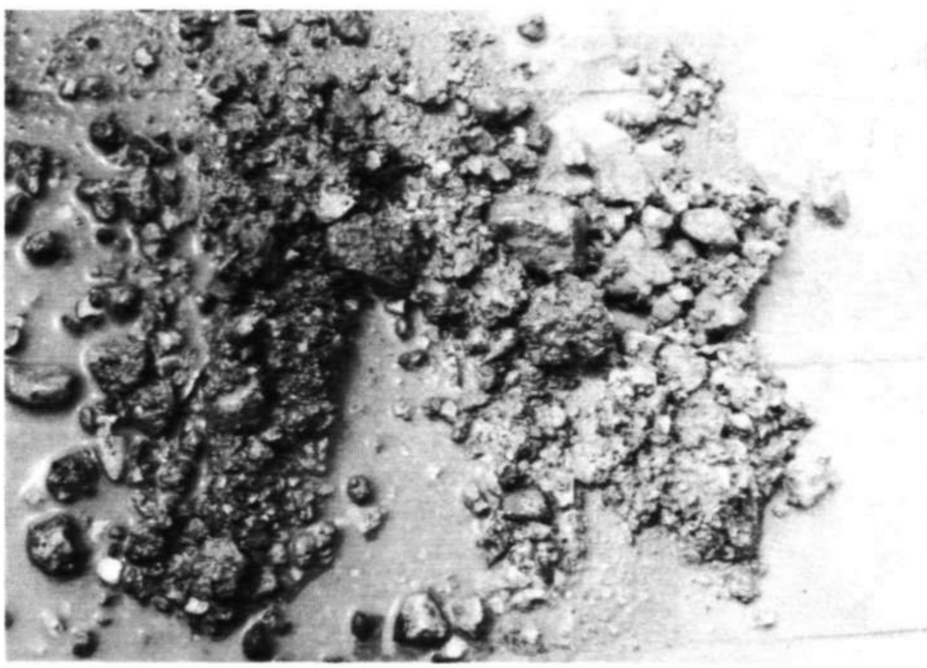

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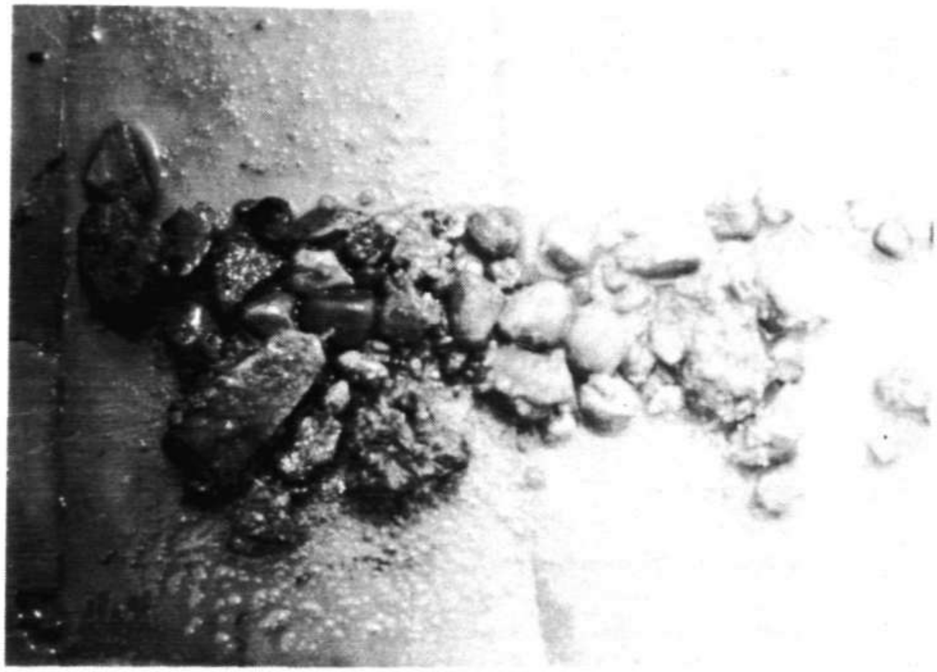

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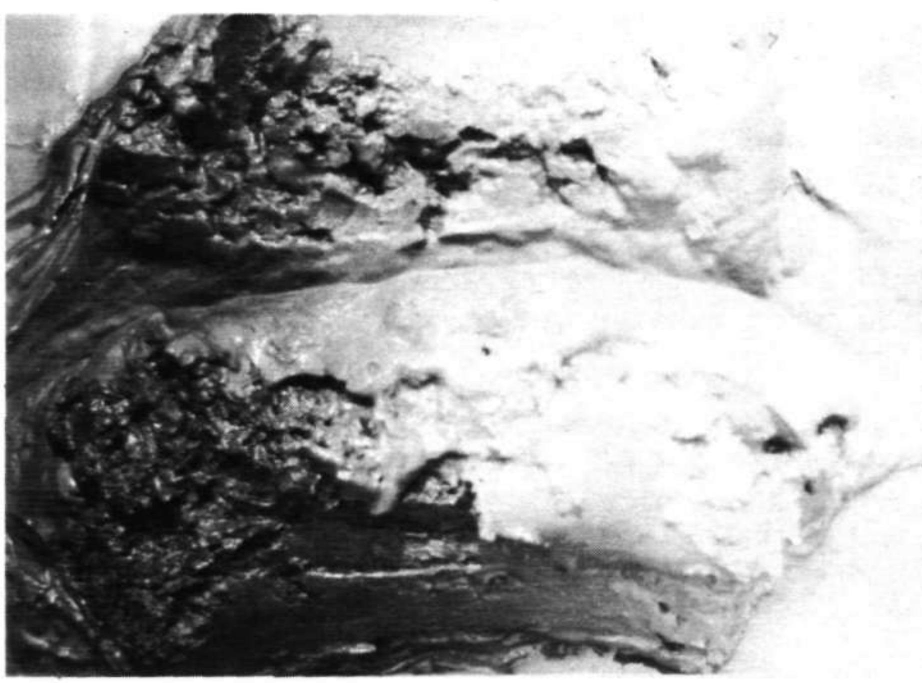

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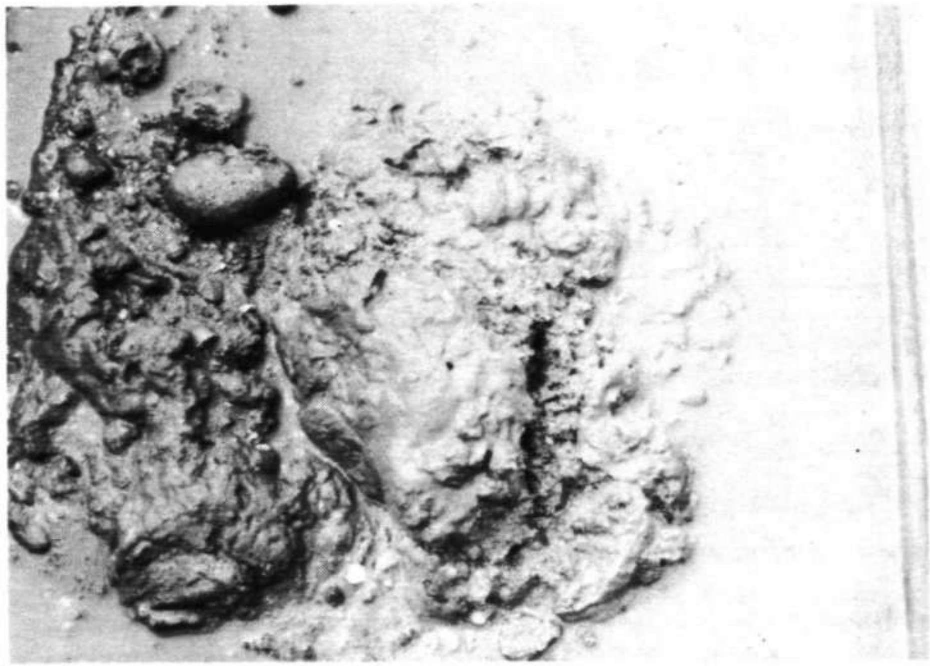

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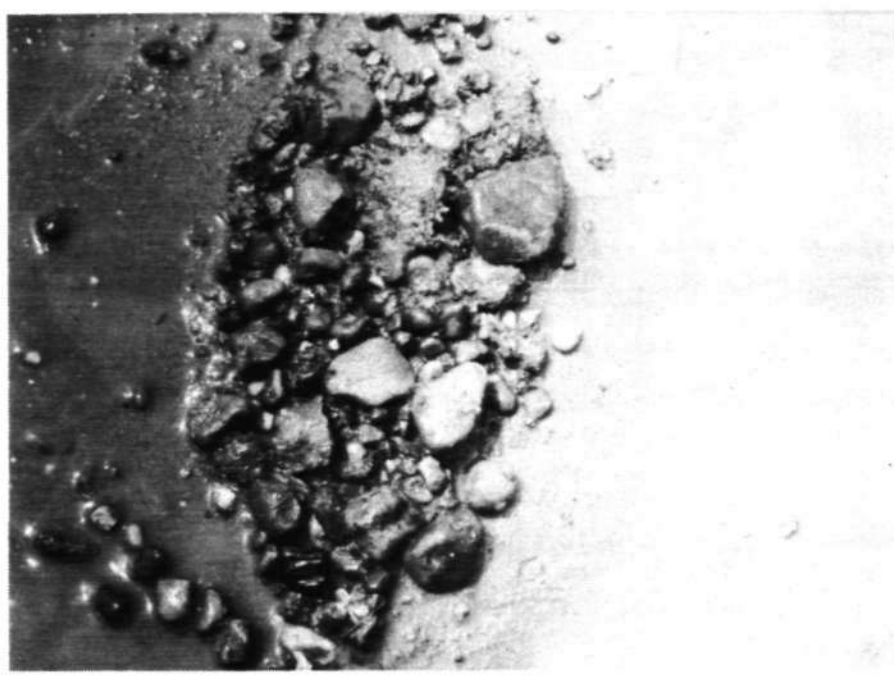

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