CHAPTER 137

SELECTION OF DISPOSAL AREAS FOR SPOIL FROM BALTIMORE HARBOR

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ABSTRACT

Selection of sites for the diked disposal of 100 million cubic yards of spoil dredged from Baltimore Harbor presented a formidable problem Fifty percent of this spoil will be derived from harbor improvement in the next ten years The remainder will result from maintenance dredging and some private dredging over a 20 to 25 year period

The number of sites available for diked disposal areas, the various methods used for dredging and the fact that the dike material required transportation to site gave rise to a number of variables The decision making process was facilitated by an econometric model

Concentrations of metals such as chromium, cadium, zinc, lead, and copper have been found in the sediments of Chesapeake Bay An investigation as to the mode of their occurrence in the material to be dredged was made to appraise any possibility of toxic concentrations occurring in filter feeders such as oysters for shellfish constitute a sizeable industry in the Chesapeake Bay

Stabilization of the deposited dredged spoil was investigated in order to determine whether the unstable loosely-deposited fine grain material extending over a three to five square mile area could be economically converted to a firm foundation material suitable for industrial parks, harbor terminals or water-oriented parks

INTRODUCTION

Deepening the 25 miles of channel extending from Baltimore Harbor to a depth of 50 feet from its present depth of 42 feet and maintaining continuously that depth of channel will result in 100 million cubic yards of spoil in about twenty to twenty-five years

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Senate Bill No 623 approved by the Congress of the State of Maryland on May 2, 1969 provides for the funding of " the design and construction of one or more diked disposal areas and other and appurtenant facilities to receive dredging spoil from the harbor and the approach channels in the water and adjacent areas known generally as the Harbor of Baltimore City "

This paper deals with the method of the selection of candidate sites rather than the specific sites themselves Site selection involved the following overall considerations

1 Economy as it is related to the transportation of spoil and the material for the construction of the dike

2 Economy of dike construction from a standpoint of partitioning the overall diked area as well as consolidation of the underlying sediments

3 Ecology of the Bay as it pertains to oyster beds, sports and commercial fishing, and fish spawning areas

4 The various Federal and State regulations concerning the construction of diked areas

5 Possible utilization of the three to five square miles of land created

Disposal of dredged spoil in previous years was by open dumping in designated submarine disposal points within Chesapeake Bay, for the open ocean is more than 150 miles downbay However, the economic value of the fishing grounds and the lack of control of the deposition of the fine-grained sediments in the free fall through deep water has outmoded this method of disposal

Owing to the essentially free storage volume between the level of the Chesapeake Bay and its bottom, diked disposal areas within the Bay itself were the ones evaluated primarily At first view this may appear to be against the best interests of the bay, however, valuable real estate is created by filling the diked area Spoil dumped in a depth of water of 18 feet to an elevation of 9 feet above the bay level would produce about 3½ square miles of land

FUTURE DREDGING REQUIREMENTS IN BALTIMORE HARBOR

It is estimated that approximately ten years would be needed to dredge the channel from 42 feet to 50 feet without widening it Removal of some 50 million cubic yards of spoil would be involved From 1975 to 1983 there should be a steady increase in the total amount of spoil due to greater maintenance dredging and private dredging A slight decline should be realized after 1983, and should level off at

about 1985 to approximately 3 million cubic yards annually As maintenance is a continuing operation, more than one diked disposal area will be required in the long range picture

CURRENT DREDGING PRACTICES AND COSTS

Dredging in the vicinity of Baltimore Harbor and its approach channels is accomplished by means of bucket and scow, hopper dredge, and pipeline dredge The first is used for new dredging work, the second for maintenance dredging by the Corps of Engineers, and the third for special work

The cost projected in every dredging contract will be peculiar to the specific job to be performed and will be based on the following factors

1 Dredging Site Distance from disposal area and depth of water in disposal area

2 Type of material Sand, silt, and clay are dredged at different rates and have different effects on the equipment

3 Depth of water in the area to be dredged

4 Whether dredging is classified "maintenance" or "new work "

5 Volume of material to be dredged

6 Financial posture of the bidding firm

7 Mobilization and demobilization costs involved

8 Time of the year in which dredging is to be performed

Contact was made with a number of dredging firms and various districts of the Corps of Engineers and approximate cost ranges were determined for the three types of dredging These were used in the Econometric Model discussed later in this paper The total costs involved in bucket and scow and hopper dredging included mobilizing and demobilizing equipment and cutting, loading, transporting, and off-loading spoil Pipeline dredging costs, except for mobilization and demobilization, cannot easily be separated into component costs Accordingly, the figures used in the study represent the best estimates available from firms contacted

SITE SELECTION

Federal and State Regulations Important to Spoil Disposal

Any dredging project in navigable waters is affected by certain Federal and State regulations as well as by local interests and concerns Following is a resume of the basic Federal and State statutes and authority important to a spoil disposal project

1 Federal Jurisdiction

The Federal agency most critically involved in any dredging project is the U S Army Corps of Engineers Authority for this body's jurisdiction goes back to, and is still primarily based on, the Rivers and Harbors Act of 1899 Chief among the areas of jurisdiction are the following

a Dams and dikes across navigable waterways

b Piers, dredging, etc , in waterways Plans for wharves, piers, dolphins, booms, weirs, breakwaters, bulkheads, jetties, or other structures, and excavation or fill in navigable waters must be recommended by the Chief of Engineers and approved by the Secretary of the Army Section 10 of the River and Harbor Act of March 3, 1899 and Section 4(f) of the Outer Continental Shelf Lands Act of August 7, 1953, extend the authority of the Secretary of the Army to prevent obstructions to navigation by artificial islands and structures on the Outer Continental Shelf (Bridges and Causeways are now (1970) under Coast Guard jurisdiction.)

c Use of government works

d Harbor Lines

e Improvement of any navigable river

f Pollution Section 13 of the River and Harbor Act of 1899 states that, " it shall not be lawful to throw, discharge or deposit any refuse matter of any kind or description whatever other than that flowing from streets and sewers into any navigable water of the United States, or into any tributary of any navigable water " The River and Harbor Act of 1888 defines pollutants as "refuse, mud, sand, dredgings, sludge, acid or any other matter of any kind " Furthermore, Executive Order #11288 specifies the responsibilities of all Federal agencies to improve water quality through prevention, control, and abatement of water pollution

from Federal government activities in the United States The provisions of this Order are applicable to the pollutional aspects of all dredging operations including the disposal of dredged materials

2 State Jurisdiction

In any dredging project, the Maryland state agency most intimately involved at present is the Board of Public Works This body issues permits when state money is involved and also is the coordinating voice of all state groups involved While the Corps of Engineers' has the ultimate power in granting or refusing a permit, it will probably never override serious objections raised by the State's Board of Public Works In addition to the Board as a major voice of the State, the Submerged Lands Commission acts in an advisory capacity particularly in very large or controversial projects

As a coordinating body, the Board of Public Works gathers opinions from various state agencies in the process of considering an application for a permit Some of these agencies are

a Department of Water Resources

b Maryland Geological Survey

c Department of Chesapeake Bay Affairs

d Department of Health

e Department of Game and Inland Fish

f Department of Forests and Parks

g Department of Natural Resources

Selection of Potential Sites

In order to evaluate all possible spoil disposal sites available a comprehensive study was made of navigational charts covering the Chesapeake Bay area from the mouth of the Susquehanna River south to Tangier Island

Potential sites that were considered feasible for spoil disposal purposes were categorized as follows

° Island and shoreline sites which could border a diked area and serve as a base for eventual fast land recovery

- Marsh and swamp areas which could receive dredged harbor spoil providing eventual land recovery or possible nutritive enrichment of wetlands for wildlife use

- Relatively shallow open water areas suitable for diking for use as contained spoil disposal areas

- Deep bay areas such as trenches or holes where spoil disposal would not be subject to the spreading of spoil

Seventy sites were selected on this basis These were then critically examined on the basis of economic, ecological, and environmental factors These factors included site's proximity to oyster beds and other valuable seafood areas, the size and distance from the area to be dredged, the impact of the containment on water flow and navigation, the potential utilization as a reclaimed land area including accessibility to populated areas, and the present value as wetlands or wildlife refuge areas

Following this, a review of each site was made with personnel of various state, commercial, civic, and private interests to insure the fact that all groups were represented

Concurrently, the potential sites were examined from an economics standpoint by means of a mathematical model, hereafter termed Econometric Model Details concerning this model are discussed below

The Econometric Model

Input data to the Econometric Model were based on current dredging practices and costs Assumed constant in the model were (1) the cost of excavating the dike material, (2) the cost of off-loading the spoil, and (3) the cost of purchasing the dike material at $ 10 per cubic yard

Variables in the model included (1) transportation distance of the spoil to the disposal site, (2) cost of cutting channels to some sites, (3) transportation of dike material, (4) construction of the dike, (5) partitioning, and (6) compressibility of the bottom sediments Costs were computed for purposes of the comparison of sites on the basis of unit cost of cubic yard of dredged spoil

For convenience, the shipping channel to be dredged was divided into five zones As the bottom contour of the bottom varies, the centroid of the volume to be cut for each zone was located after the channel had been divided Navigable distances to the sites were computed from these centroids

One of the most important factors in choosing the site was the dike itself For comparisons and to enable certain conclusions to be drawn, a structural model had to be formulated early in the study The dike used for the model had a 1 4 slope on each face with elevation of +9 above mean low water (MLW) It was trapezodial in shape with 4 yards across the top The water depth at each of the sites was 15 feet or 18 feet MLW In order for the unit cost of constructing the dike to be incorporated in the model, the following equation was used

$$\text{Unit cost/yd}^3 = \frac{\text{Volume of Dike}}{\text{Vol of Spoil in Site}} \quad (\$2\ 77/\text{yd}^3)$$

The figure $2 77/yd^3 was the unit cost assumed for constructing the dike In keeping with the design of the model, the cost was divided by the amount of spoil in the site This gives a unit cost per cubic yard of spoil

The four most common horizontal configurations for the finished dike are the circle, square, rectangle, and equilateral triangle The following table gives the amount of dike material in cubic yards required to contain 100 million cubic yards of spoil at 18 feet MLW Calculations for the volume of the dike material are based on dimensions measured to the top inner edge of slope Furthermore it was assumed for the sake of simplicity that the volume of dike material underlying the face of the inner slope had a negligible effect on the storage capability of this enclosure

Circle	Square	Rectangle (3000 x 3740 yards)	Triangle
4 254 million yd^3	4 80 million yd^3	4 826 million yd^3	5 471 million yd^3

From the above table it is clear that the circle would be the best, since the dike required the least material This conclusion requires modification when partitioning is considered Details concerning this matter are discussed below

In the disposal of spoil in diked areas the question arises whether to build one continuous dike for the entire volume to be contained, awaiting a long period for filling and stabilization, or to partition the site into sections and thereby create stabilized acreage at a much faster rate In partitioning, however, extra dike material is required and the most economical dike shape may change Since the triangle was by far the most costly of the configurations, the effect of partitioning was examined only on the circle, square, and rectangle A table of unit costs for the three shapes with varying numbers of partitions is given below, assuming 100 million cubic yards to be placed in the site and the bay bottom to be 18 feet below mean low water

Number of Partitions	Circle	Square	Rectangle
4	$ 194/yd^3	$ 199/yd^3	$ 221/yd^3
5	$ 210/yd^3	$ 210/yd^3	$ 253/yd^3
6	$.229/yd^3	$ 233/yd^3	$ 283/yd^3
7	$ 248/yd^3	$ 243/yd^3	$ 314/yd^3
8	$ 266/yd^3	$ 255/yd^3	$ 344/yd^3
9	$ 285/yd^3	$ 266/yd^3	$ 375/yd^3
10	$ 303/yd^3	$ 277/yd^3	$ 406/yd^3

Although the circle does at times seem the best economically, the unit cost for a square is never more than one-half cent higher than that of a circle per cubic yard As the number of partitions increases, the square becomes the more desirable shape

Initially, the compressibility of the sub-bottom was assumed zero An analysis was pursued for the purpose of determining a multiplier to be applied to the unit cost for zero compressibility to adjust for the estimated compressibility of the bottom sediments When settlement takes place more dike material is required if a predetermined elevation of top of dike is to be maintained Thus, initially the dike must be built to a higher elevation. Once the amount and rate of settling is estimated from tests on bottom core samples, compensation for settling can be achieved by considering a pad of trapezodial cross-section with the same 1 4 side slope as existing beneath the dike The height of the cross-section would be equal to the estimated settlement As a result both studies may proceed simultaneously

Economic Projection

Selecting an area for a diked enclosure involves a decision whether to build for long range use at the present time or to build smaller enclosures filling them in shorter intervals All are aware of the diminishing value of the construction dollar with time, however, the more rapidly land is created the more rapidly its worth can be realized from both a sale and tax income standpoint

The Engineering News-Record Construction Cost Index, which is an aggregate combination of common labor cost and material cost, was examined to determine the effects of inflation on construction The Construction Cost Index in December, 1949, for Baltimore was 424 In December 1969, it was 1015 This is an increase of about 240 percent. A construction project in 1949 costing $10 million would cost $24 million today

Projections of the ENR Construction Cost Index were made to the year 2000 Three straight line projections were made maximum, median, and minimum rates of growth based on past recorded growth rates Median rates have been extrapolated from the average trend line between 1950 and 1970 Maximum rates are based upon the trend line between 1963 and 1970 and minimum growth rates upon the trend between 1949 and 1963 Projection of the costs for any project to some future date were obtained by multiplying today's estimated construction costs by a ratio of the estimated future cost index to the present cost index Space prevents further elaboration here of the studies made

SUB-BOTTOM INVESTIGATION

A program of sub-bottom investigation was undertaken for four purposes

1 To determine the types of sediment to be dredged

2 To determine the compressibility of the material underlying the dikes for dike design purposes

3 To obtain exact information as to the bathymetry in the candidate spoil areas

4 To obtain samples from the channel to be dredged for the chemical analysis of selected metal ions

The investigation was divided into two parts--a seismic survey and a test boring program

The seismic survey technique chosen for sub-bottom profiling employed a 3 5KH output frequency sub-bottom profiling device provided and operated by personnel from the Oceans International Company, Mystic, Connecticut

The profiling equipment used on this project emitted an acoustic signal strong enough to penetrate to approximately 30-50 feet of the sub-bottom About equivalent to the noise of a small sledge-hammer blow on a hard surface, the signal energy which is transmitted through the water and then absorbed and/or reflected by the sub-bottom in no way disturbed the bottom of the bay

The position of the vessel at any time during the seismic survey was automatically recorded by the Motorola Range Positioning System (RPS) RPS operates at line-of-sight ranges up to 50 nautical miles and the usual system range measurement accuracy is considerably better

than 50 feet The RPS was chosen for this project because of its 50-mile range, its all-weather capability, and its unique coding for non-interference with shipping or other communications in the congested harbor area

To eliminate the necessity for shifting the transponders to new line-of-site visible fixed reference stations, two high elevation sites were selected which could be "seen" electronically at all times from any planned position of the survey boat One of these, an outside observation-type terrace area of the Maryland National Bank Building in downtown Baltimore, which the Chesapeake and Potomac Telephone Company made available, is approximately 475 feet above sea level The other was atop one of the high towers on the suspension bridge of the Chesapeake Bay Bridge at an elevation of about 400 feet above sea level Each transponder and its antennas weighed approximately four pounds

The seismic data which were acquired in less than one week, when correlated with test boring data acquired at a slightly later date, and over a period of six weeks, gave an extended picture as to the composition and compressibility of the sub-stratum in the areas concerned

The test boring program consisted of basically taking continuous samples with a four-foot long 3" diameter piston corer according to ASTM Specification DI587-63T Twenty borings in 4" cased holes spaced 6600 feet apart to a depth of 15 feet in the various channels to be deepened formed the backbone of this phase of the program These were supplemented by 20 additional single four-foot piston cores (uncased) taken midway between the cased holes

Immediately upon removal from the drilling rig the sample tubes were placed in dry ice and frozen in preparation for chemical analysis and to preserve intact any samples with a high water content At the laboratory the long cores were cut laterally into 6-inch long cylinders and then longitudinally into hemi-cylinders One of the hemi-cylinders was used for grain size analysis of the sediments, the other was utilized for chemical analysis

The second part of the test boring program consisted of making piston core borings at each of the candidate sites to depths ranging from 36 to 50 feet below the bay bottom Samples from this phase were used to obtain a quantitative estimate of dike settlement

FUTURE USES OF THE FILLED CONTAINMENT AREA

Once filled to capacity and stabilized, the filled containment area will present the state with the pleasant dilemma of deciding upon one or even several of the many possible uses of this newly created piece of real estate If land were a goal, the State could expect to spend upwards of $25,000,000 for sandfill alone Where the area is located offshore some means of access must be provided in order to accomplish any of the uses Accordingly, sites adjacent to existing land where connections with the existing transit facilities are possible are particularly attractive

One often-proposed utilization for newly created waterfront land is the construction of an airport The location of an airport on or near water has a number of distinct advantages However, the problems and disadvantages of offshore airports must also be considered The proximity to water presents a weather problem in that fog is always more prevalent near the water This fog or haze enhances the risk commercial carriers must face in take-offs or landings

There will also be air traffic problems resulting from the proximity of Washington National, Dulles, Friendship, and Andrews Air Force Base to this offshore airport Even without a fifth major airport, air traffic controllers have claimed that the air space in this region is too crowded

Industries of various types might be attracted to new land on a waterfront site The end result is more employment opportunities for Marylanders and a general increase in the tempo of economic activity in the Baltimore area A shipping terminal would be another possibility The present Dundalk Marine Terminal in Baltimore, old and new sections, totals about 540 acres

Prices for industrially-zoned land in metropolitan areas start at about $6,500 per acre while industrial sites with all utilities and rail frontage range upward from about $15,000 per acre A conservative estimate of the worth of waterfront land in the large cities places its value in a range between $15,000 and $25,000 with the shoreline lots being the most valuable Assuming the most conservative price ($15,000) as an average sale price per acre, the state could consider the stabilized filled disposal area as an asset worth in excess of $30,000,000

Turning from industrial development, it can be advantageous to consider the new land in terms of a recreation area The State Department of Forests and Parks presently prefers at least 500 acres for a state park Each of the prime sites meets this requirement Along with a park, an 18-hole championship golf course (approximately 150

acres) could be scenically positioned on the Chesapeake Bay With golf and aquatic sports readily available, it would be logical to also construct marinas, hotels, and motels Athletic stadiums and wildlife preserves are other possibilities

The Federal Government, through the Bureau of Outdoor Recreation of the Department of the Interior, provides matching grants to states to help defray the costs experienced in the construction of recreation areas Funds for this type of outlay are authorized under the Land and Water Conservation Fund Act of 1965 As a result, this recreation benefit could be realized for only half of the actual cost

SPECIAL SITUATIONS STUDIED

Heavy Metal Content

In recent years brief investigations indicated that heavy metals exist in the bottom sediments of Chesapeake Bay Knowledge of the solubility and concentration of these metals is necessary for the proper evaluation of the possible disposal sites Concurrently, with the present investigation, a study is being made of the effect of these metals on shellfish This is being undertaken in a cooperative effort by the Chesapeake Biological Laboratory, the Chesapeake Bay Institute, the Department of Chesapeake Bay Affairs, and the Department of Water Resources

Chemical analysis of the sediments by Atomic Absorption Method for the Chromium, Copper, Cadmium, Zinc, Lead, Nickel, Cobalt, Mercury, Manganese, and Molybdenum was made Although other methods are available, Atomic Absorption Spectrometry was chosen as the method for making the desired analyses This method is generally accepted as the most desirable because it is rapid and inexpensive and requires the least interpretation to obtain actual concentrations In addition, standards used can be prepared to take into account amounts of interfering metals which may be included in the samples

Initially, several digestion procedures for the sediments were utilized One was acetic acid-sodium acetate buffer system Another was 1 0 Molar concentration of hydrochloric acid (HCL) at 70° C for 48 hours A third procedure used was digestion with aqua regia

There was little difference in the results obtained using HCL and aqua regia digestions The latter method was therefore discontinued A considerable difference between the other two digestion procedures was observed, however, and, therefore, a dual set of analyses was made

Digestion with the acetate buffer method would be expected to extract all of the soluble portions or lightly-bound particles while the HCL method would extract the more tightly-bound particles These two methods, then, probably enable distinction between the readily available or soluble metal ions and the more tightly-bound metal ions

Spoil Stabilization

During the initial period of spoil disposal the spoil, which is largely silt, will be covered by the water contained in the diked area A large lake within the Bay will be delineated by the dike Subsequent spoil disposal will cause the level of the spoil to rise above the water level within the dike Slow movement of water entrapped in the interstitial spaces of the fine-grained material, however, will preclude the soil from bearing safely superimposed loads, such as buildings, for a number of years In hopes of converting the created land into valuable real estate more rapidly, a search was made of the technical literature pertaining to soil stabilization by vibro-flotation, by electro-osmosis, and by chemicals Agencies concerned with this type of problem such as the Corps of Engineers in Buffalo and Detroit and those concerned with the dry land phase, such as the Highway Research Board, were contacted

The results of both parts of this investigation indicates that few inroads, if any, have been made into the problem and no satisfactory method of rapidly stabilizing the water-deposited dredged spoil is available

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