A Sediment Budget Study of Clamshell Dredging and Ocean Disposal Activities in the New York Bight

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ABSTRACT / The purpose of this study was to quantify the dry mass of dredged material involved in each stage of typical clamshell dredging and ocean disposal activities in order to identify and quantify "losses" of dredged material. Turbidity plumes generated at dredging sites were also observed. Approximately 2% of the dredged material was lost at the dredging site. Of this quantity 61% was due to the dredging itself and 38% was due to intentional barge overflow. Approximately 3.7% of the dredged material was lost at the Mud Dump Site during disposal. Total loss of dredged material during these clamshell dredging and ocean disposal operations was calculated to be 5.6%. Observations revealed that turbidity plumes were local features which traveled along the bottom for several hundred feet. These plumes only persisted while dredging was occurring, and ambient conditions were established within a relatively short time after dredging ceased.

Introduction

In the spring of 1980, approximately one-half million cubic meters of dredged material from six separate locations in the New York Harbor area was disposed at one previously unused location at the New York Bight Ocean Disposal Site for Dredged Material, the Mud Dump Site (Fig. 1). The dredged material was covered, or capped, with a layer of 193,000 m³ of fine-grained dredged material and 1,172,000 m³ of sand. This study was performed during and after the creation of the dredged material deposit in order to trace the total quantity of the capped dredged material from its pre-dredging to its post-depositional stages. Measurements of the dredged material involved in each stage were compared in order to determine a comprehensive sediment budget, showing if dredged material was "lost" (dispersed) in the dredging and disposal process as suspended sediment.

This study was initiated because of the recent trend for some state and federal regulatory agencies to restrict dredging and disposal activities out of concern over (a) dispersion of significant quantities of sediment- and particle-associated contaminants, such as PCBs and heavy metals, into the environment and (b) creation of levels of turbidity high enough to affect the survival of fish and shellfish or the migration of fish, especially anadromous varieties. The purpose of this study was to supply lacking basic data that could be used to help determine the environmental impacts of typical harbor dredging and disposal projects in light of these concerns. This study determined where and how clamshell dredged sediment and associated contaminants are dispersed into the environment, the quantity that is dispersed for each stage in the process, and the extent and magnitude of turbidity plumes in the vicinity of the dredging sites. All observations were made in areas of low current velocity (generally less than 0.5 knots) and for sediments that are predominantly silt and clay. This is typical of most dredging projects that occur in the Port of New York and New Jersey and is representative of many of the dredging projects that occur in other large estuarine ports in the United States.

Previous Research

Other authors have performed sediment budget studies at the Mud Dump Site and at other locations; however, the literature is not extensive (Freeland and Merrill 1976; Freeland and others 1976; Morton 1980; and Dayal and others 1981). The literature concerning resuspension of sediment during dredging and disposal operations is also not extensive. Most has been written within the last twelve years and concern U.S. Army Corps of Engineers projects (Gordon 1974, Brandsma and Divoky 1976; Wakeman 1976; Sustar and Wakeman 1977; Bokuniewicz and others 1978; Holiday and others 1978; Barnard 1978; Bohlen and others 1979; Conner and others 1979; Bokuniewicz and Gordon 1980; and Raymond 1983). Based on the previous literature, it can generally be stated that clamshell dredging causes turbidity plume to occur downstream from the dredging site with the major part of this plume occurring near the bottom. Concentrations of suspended sediment decrease away from the dredging site with distance travelled primarily dependent on current velocity. The concentration of suspended solids in the plume depends on a variety of factors, such as bulk density and grain size of dredged material, intensity of dredging, clamshell size, quantity of material overflowed, etc. During disposal, the dredged material descends through the water column as a dense mass (convective...
descent phase), impacts the bottom and spreads along the bottom for no more than several hundred meters as a dense surge (dynamic collapse phase). Estimates have been made that between 95 and 99% of the dredged material dumped will be deposited within several hundred meters of the discharge point. The remaining 1 to 5% remains in suspension and could potentially be dispersed from the disposal area by currents.

Methods

General Discussion

On various occasions during the dredging and disposal process, dredged material is resuspended into the water column. During dredging, sediment is resuspended when the clamshell impacts the bottom and is pulled off the bottom. Since the clamshell is usually not covered, more sediment is resuspended from the clamshell as it is pulled through the water column. When the clamshell breaks the surface of the water, more sediment is added to the water column as turbid water spills out of the clamshell or leaks through the jaw openings. When dredged material is intentionally overflowed to achieve an economic load, more sediment is resuspended into the water column. Finally, during the disposal of the dredged material, some sediment is resuspended as it descends through the water column and impacts the bottom.

Tidal current action will cause some of this resuspended material to be transported away, and some will resettle back to the bottom. In addition, oxidation of organic material can occur at many opportunities during the dredging and disposal process. What this study attempted to do is quantify and identify the losses of dredged material due to tidal dispersion and oxidation. Both the volume and the dry mass of the dredged material were compared and discussed, but the main emphasis was on the dry mass. Density changes occur because of the unavoidable addition of water during dredging and of the self-compaction that occurs to the dredged material after it is disposed, and this affects volumetric of measurements. The dry mass of dredged material was quantified before it was dredged (in-place measurements), in the barges before it was dumped (barge measurements), and after it was dumped (Mud Dump measurements). Differences in dry mass between successive stages was considered “lost” dredged material.

In-Place Measurements

Before-dredging bathymetry was subtracted from after-dredging bathymetry for all the areas dredged in order to construct “difference maps.” These maps show the areal distribution of the thickness of sediment removed from these dredging sites. To characterize physically the material dredged from each site, piston and gravity cores were taken. In cases in which it was not possible to take core samples in the exact area to be dredged, cores were taken in immediately adjacent areas with the assumption that hydrologic similarities would lead to similar sediment deposits. Average water content with depth and average percent organic content was determined for each location. Average water content was converted to dry density values using a conversion graph based on previous studies (Suszkowski 1978) and curves were extrapolated to the necessary depths using data supplied by Panuzio (1963).

Barge Measurements

In order to determine the dry mass of dredged material transported by barge to the Mud Dump Site, calculations from the earlier work of Bokuniewicz and others (1978) were used. They determined that the bulk density of dredged material