Based on a previous study of future dredging quantities in the San Francisco region (Gahagan & Bryant Associates 1994c), approximately 296.5 mcy of dredged material would require disposal over the 50-year planning period. The 20% of the material assumed to be NUAD would represent 59.3 mcy of this total volume, leaving 237.2 mcy of "clean" material (that is, material suitable for unconfined aquatic disposal).

A likely distribution of the dredged material among the placement environments was developed for each alternatives, based on the professional opinion of agency staff. These distributions were developed with the understanding that they needed to reflect the EIR/S alternatives, yet also bracket the range of disposal options and related costs associated with each alternative. The range of placement environments and capacities of environments available within each alternative, however, could result in a large number of combinations of disposal options for each alternative, especially when combinations of upland, wetland, and reuse (UWR) options are considered.

The distributions reflects fixed percentages falling within the percentage ranges established for the EIR/S alternatives described above. The total volume of clean material to be dredged and disposed of was held constant at 237.2 mcy over the 50-year planning period for the purposes of economic evaluation. Table 2 summarizes how this material was assigned to the various placement environments within each alternative.

Table 2: Assumed Distribution of Clean Material Among Placement Environments

No-Action (Current Conditions)	
In-Bay	70%
Ocean	15%
Upland/wetland/reuse	15%
Alternative 1: Medium In-Bay, Medium Ocean, Low UWR	
In-Bay (Medium)	40%
Ocean (Medium)	40%
Upland/wetland/reuse (Low)	20%
Alternative 2: Medium In-Bay, Low Ocean, Medium UWR	
In-Bay (Medium)	40%
Ocean (Low)	20%
Upland/wetland/reuse (Medium)	40%
Alternative 3: Low In-Bay, Medium Ocean, and Medium UWR	
In-Bay (Low)	20%
Ocean (Medium)	40%
Upland/wetland/reuse (Medium)	40%

These fixed percentages represent the target cumulative amount of dredged material assumed to be placed in each environment over the 50 year planning period. These distributions also are assumed to be evenly distributed over time: that is, the percentage of material going to a placement environment in year 1 will be the same as in year 50. In reality, total cumulative percentages will be lower than estimated here, as UWR placement sites, and policies removing economic disincentives to their use, are phased in. This would result in lower total costs for the alternatives, because aquatic disposal is generally less expensive overall.

Allocation of dredged material among the placement environments that constitute the UWR category (i.e., wetland restoration, levee rehabilitation, and landfill cover) was based on an assessment of the capacities of the UWR placement environments over the 50-year planning period prepared for LTMS by the San Francisco Bay Conservation and Development Commission. Allocations were developed for years 1-5, 6-15, and 16-50 of the planning period. The assessment was developed using three projected volumes of material going to UWR: Low (20% of all material), Medium (50% of all material) and High (80% of all material). Where the volume developed for an EIS/R alternative did not match the assessment assumption (e.g. Alternative 3 estimates 40% to UWR, as opposed to 50% in the assessment's Medium scenario), the relative percentages developed in the San Francisco Bay Conservation and Development Commission assessment were used to distribute material among the UWR placement options on a pro rata basis.

The distribution of dredged material over the 50 year planning period used in the economic analysis is summarized in Tables 3 and 4.

Table 3: Estimated Distribution of Dredged Material Among Placement Enviroment and Alternatives (mcy) \a

			Upland, Wetland, Reuse \b		
Alternatives	In-Bay	Ocean	Tidal Wetland	Levee	Landfill
No Action					
Years 1-5	16.6	3,6	2.8	0.7	0.0
Years 6-15	33.2	7.1	5.0	2.1	0.0
Years 16-50	116.1	24.9	12.4	12.4	0.0
Total	165.9	35.6	20.3	15.3	0.0
Alternative 1					
Years 1-5	9.5	9.5	3.8	0.9	0.0
Years 6-15	19.0	19.0	6.6	2.8	0.0
Years 16-50	66.4	66.4	16.6	16.6	0.0
Total	94.8	94.8	27.0	20.4	0.0
Alternative 2					
Years 1-5	9.5	4.7	8.7	0.8	0.0
Years 6-15	19.0	9.5	12.7	4.0	2.5
Years 16-50	66.4	33.2	37.8	15.9	12.6
Total	94.8	47.4	59.3	20.7	15.1
Alternative 3					
Years 1-5	4.7	9.5	8.7	0.8	0.0
Years 6-15	9.5	19.0	12.7	4.0	2.5
Years 16-50	33.2	66.4	37.8	15.9	12.6
Total	47.4	94.8	59.3	20.7	15.1

Source:
Gahagan and Bryant 1995 (Dredging Quantity Estimate) and Table 2

a\ based on 237.2 mcy of "clean" material
b\ based on estimates from SFBCDC (Larson memo, May 1995)

Table 4: Actual and Percentage Distribution of Dredged Material Among Placement Environment and Alternatives

Alternative	In-Bay	Ocean	Upland, Wetland, Reuse: Tidal Wetland	Levee	Landfill
No Action					
Volume (mcy)	165.9	35.6	20.3	15.3	0.0
Percentage	69.9%	15.0%	8.5%	6.4%	0.0%
Alternative 1					
Volume	94.8	94.8	27.0	20.4	0.0
Percentage	40.0%	40.0%	11.4%	8.6%	0.0%
Alternative 2					
Volume	94.8	47.4	59.3	20.7	15.1
Percentage	40.0%	20.0%	25.0%	8.7%	6.4%
Alternative 3					
Volume	47.4	94.8	59.3	20.7	15.1
Percentage	20.0%	40.0%	25.0%	8.7%	6.4%

Source:
Table 2 and 3, SFBCDC

Note: Percentages may not add up to 100 due to rounding

WORK CATEGORIES OF DREDGING

Dredging work can be generally allocated among three categories: new work, maintenance work, and small dredger work. The work categories have important implications for calculating dredging and disposal costs and identifying the sectors that will bear those costs. Several factors differentiate the costs faced by dredgers between the work categories: in many cases the volume of material dredged will provide conomies of scale for larger projects, and the composition of the dredged material may vary among the work categories, affecting the equipment and methods needed for dredging and disposal. In addition, the financing available for dredging and disposal differs among the work categories. For instance, the federal government does not finance most small dredging projects, so in most cases private sponsors bear the entire cost. The work categories are defined in more detail below.

"New Work" Dredging

New work is defined as dredging to create new moderate- to deep-draft channels, harbors, or other navigation facilities, or to deepen existing channels, harbors, and other navigation features to depths lower than historically maintained depths. New work, as defined for this analysis, is performed by major dredgers such as the U.S. Army Corps of Engineers, the U.S. Navy, major ports located within the San Francisco Bay and Delta, and freight and bulk shippers.

Maintenance Work

Maintenance work is defined as dredging projects that are undertaken to maintain the existing depths of moderate- to deep-draft channels and harbors. Maintenance work, as defined for this analysis, is performed by major dredgers similar to those listed above for new work projects.

Small Dredger Work

Small dredger work includes both new work and maintenance projects often (but not exclusively) undertaken by relatively small sponsors or involving relatively small amounts of dredge material. For the purposes of this analysis, the category of small dredgers is based on the Regional Water Quality Control Board criterion of channel depth. Small dredgers are considered to be those dredging to a channel depth of 12 feet or less. This definition includes dredging of federally authorized channels as well as dredging to construct or maintain public and private marinas, piers, utilities, and small ports.

Volumes of Dredged Materials by Work Category

The total dredging volume of 296.5 mcy can be divided into volumes relating to each of the new work, maintenance, and small dredger categories defined above. To estimate future dredging in the San Francisco Bay, Gahagan and Bryant Associates developed low-, mid-, and high-range estimates for new work. The high-range estimate of 48.4 mcy of material generated by new work is used in this analysis, consistent with the use of the high-range estimate of total dredged material.

After subtracting the 48.4 mcy from the total dredged volume, the remaining 248.1 mcy of dredged volume can be attributed to maintenance dredging of major facilities and small dredger new and maintenance work. (Gahagan & Bryant Associates 1994c). Future dredging volumes for small dredger work projects were estimated by analyzing historical data concerning the average annual dredged quantity generated by small dredging projects. Historic data indicates an average annual dredged quantity of 553,023 cy of both new work and maintenance was generated by small dredger projects in the San Francisco Bay Region during the years 1991 to 1993, the only years in which Corps records list individual small dredging projectes. Assuming that future volumes will be similar to historical volumes, it is estimated that approximately 27.65 mcy of dredging volume would be attributed to small dredger work projects during the future 50 year study period. Approximately 60% of this material is generated by federally authorized dredging, with the remainder attributable to public and private marinas, yacht clubs, and other maritime businesses.

Table 5a summarizes the allocation of estimated future volumes among the various work categories for all dredged material. For this analysis, the relative percentages from Table 5a were applied on a pro rata basis to estimate the distribution of clean material among the work categories (Table 5b).

Table 5a: Estimated Volume of Total Dredged Material by Work Category

Work Category	Estimated 50 yr volume (mcy) \a	% of total volume (%)
Maintenance	220.4	74.3
New Work	48.4 \b	16.3
Small Dredgers	27.7 \c	9.3
TOTAL	296.5	

Notes
a\ based on total dredged volume of 296.5 mcy
b\ based on high range estimate from Gahagan & Bryant 1994c.
c\ based on average annual small dredger work from Gahagan & Bryant 1994c

Table 5b: Estimated Volume of Clean Material by Work Category

Work Category	Estimated 50 yr volume (mcy) \a	% of total volume (%) \b
Maintenance	176.3	74.3
New Work	38.7	16.3
Small Dredgers	22.2	9.3
TOTAL	237.2	

Notes
a\ based on total volume of 237.2 mcy of clean material
b\ based on percentages in Table 5a.

This analysis assumes that material from each work category is distributed among the placement environments according to the relative volumes presented in Tables 3 and 4. For instance, if 40% of the all dredged material is slated for UWR, it is assumed that 40% of the material generated by each work category will go to that placement environment. In effect, this assumes that small dredgers will send an equal percentage of their material to higher-cost disposal sites (e.g. UWR) as the larger dredgers.

The actual distribution among placement environments by work category is likely to vary significantly. The actual choice of placement environment will depend on the economics of individual projects and the practicability of alternative placement sites at the time of the project's construction. For this analysis, no cost mitigation measures (such as allowing small dredge project to have first access to low-cost disposal sites) are assumed. Potential mitigation options will be explored at the end of this chapter and discussed in greater detail in Chapter 7 of the DEIS/R.

FACTORS AFFECTING DREDGING AND DISPOSAL COSTS

Dredging and disposal costs are dependent on a wide variety of factors. This section will explain the key factors and will outline how these factors generally affect dredging and disposal costs. The following section then explains how the specific unit and total cost estimates for this analysis were derived.

Dredging projects typically involve a number of discrete activities that can generally be grouped into activities required for dredging and placing materials at disposal sites and activities required for developing and managing disposal sites. The activities can be summarized as follows:

- Testing: Sediment evaluation and testing to determine its suitability for disposal

- Dredging and Placement:
  - dredging: mobilizing/demobilizing dredge equipment and dredging a project site
  - transport: hauling dredged material to a disposal or rehandling site and placing dredged material at the site
  - rehandling (for certain disposal sites): drying dredged material at a rehandling facility, excavating the dried material, and hauling the material to a final disposal site

- Site development and management
  - initial site preparation (e.g., initial site acquisition, environmental assessments and mitigation, planning, design, engineering, construction, and construction management)
  - site operations and maintenance
  - site monitoring

The unit costs for each activity vary among the placement environments based on factors such as transport distance to disposal sites, site preparation requirements, and disposal site operations and maintenance requirements. This section will define and explain the various factors that affect unit costs.

In general, unit costs for small dredger work differ from larger new work and maintenance project primarily because of differences in economies of scale. Small dredger work projects, which include both new and maintenance dredging, usually involve smaller quantities of dredge material. Unit costs for mobilizing equipment and dredging and transporting material are likely to be higher than maintenance dredging because costs are spread over smaller volumes of dredged material. In addition, the limited depths of small projects often necessitate small draft, lower-volume barges be used. The resulting increase in the number of round trips to the disposal site (per unit volume of dredged material) can also drive up unit costs for small dredge projects.

Testing

Sediments are usually sampled and tested prior to dredging to determine the existence of NUAD material. Testing costs include sediment sampling, extraction, analysis, and documentation. Project-specific testing costs will vary widely depending on the degree of existing sediment quality information, project size, project locations, special analyses, list versus contract rates for laboratory work, sampling techniques (e.g., pipe versus vibracore), the need for reference samples, and other project variables.

Testing costs also will vary among the different placement options. Disposal environments have different testing requirements which govern the tests needed, the number of tests required per dredged volume, and the number of samples; all factors which affect testing costs. For instance, the current tests required for in-bay disposal (PN93-2) are significantly less expensive than those for ocean disposal (Greenbook). The forthcoming Inland Testing Manual, however, will provide in-bay testing guidelines similar to those governing ocean testing. Testing costs for ocean disposal will continue to be more expensive, however, due the longer travel distance to the ocean site for reference sampling. The tests required for upland disposal are less expensive than those for ocean or in-bay.

The unit costs for sediment testing, however, depend on the quantity of material dredged. For the most part, unit costs for testing will decline as volume increases. Testing guidelines dictate a minimum number of samples and tests that must be conducted, which makes the unit cost significantly higher for very small projects. For instance, PN93-2 requires 1 test for dredge volumes between 5,000 and 20,000 cubic yards, so the unit cost for the 5,000 cy project will be 4 times more than for the 20,000 cy project.

Dredging and Placement

The following factors, discussed below, represent the key factors that define unit costs for dredging and placement:

- o volume of material,
- o type of material,
- o haul distance,
- o depth of access channel,
- o placement,
- o ownership costs, and
- o operating costs.

Unit costs associated with disposal (e.g., disposal site preparation, operations, maintenance, and monitoring) are not generally dependent on the factors listed above; these costs may be similar across work types for the same disposal sites but would vary across the various placement environments. Those costs are described below.

All of these factors dictate the type of equipment that will be used for dredging and placement. Different equipment configurations have different costs and production rates, which affect the total cost of a project.

Volume of Material. The volume of material is project dependent. A review of the *Dredging and Disposal Roadmap* (San Francisco Bay Conservation and Development Commission and U.S Army Corps of Engineers 1995) shows a wide range of volume dredged per project. Similarly, volumes of material vary substantially within each of the three work categories, affecting activities such as mobilization costs that are sensitive to economies of scale. For new work projects, dredge volumes can vary from 100,000 cubic yards to several million cubic yards of material. Individual maintenance projects vary from a few thousand cubic yards per year to more than a million. Samll dredging projects can range from very small quantities (hundreds of cubic yards) to several hundred thousand.

Mobilization and demobilization costs represent the preparation work needed to start actual production on a project. Included are costs associated with transporting the plant to the site and then preparing the plant for production (including operating and ownership costs) and associated engineering, surveying and administration costs. This cost also includes demobilization activities including breaking down the plant and removing it from the site. These are fixed costs for a given plant, and as such will not vary with volume of material dredged by that particular dredging plant. However, unit costs for mobilization and demobilization are very sensitive to economies of scale, as the fixed cost is divided by the total quantity dredged.

Type of Material. Dredged material from Bay Area projects generally falls into three categories: fine-grained silts and clay; unconsolidated sand; or hard-packed deposits of ancient muds or sands. Maintenance material is typically fine-grained silts and clays which is easily dredged. For new work projects, consolidated sandy material and/or stiff clay may be encountered that may require different kinds of equipment. This may translate into less production and higher unit costs than would be experienced by dredging maintenance material. Materials dredged during new work projects may also require additional slurrying or sieving prior to disposal to aquatic sites because the dredged material may need to be broken up more before disposal. Additionally, sand material may be more expensive to haul in scows traversing shallow channels. In channels less than 12 feet below MLLW (the definition of small dredge projects), the material dredged generally would not vary between new and maintenance work.

Haul Distance. Transport costs for projects vary in large part according to haul distance to disposal sites. Because of the nearness of the Alcatraz disposal site to many dredging project sites, transportation costs are generally low to this site. Similarly, transport costs would be relatively low for a project near an other disposal site (e.g. in Bel Marin Keys (Marin County) disposing materials at the nearby Redwood Landfill).

For most projects, transport costs would be relatively high for transporting materials to an ocean disposal site because of the long distance that materials must be hauled. Costs would also be high for projects in the South Bay transporting materials to Delta disposal sites.

Transport unit costs for small dredge projects may be higher to ocean and in-bay sites if the channel depth at the dredging site requires the use of shallow-draft small scows or partially loaded large scows (see below).

Depth of Access Channels. For disposal to non-aquatic sites, the cost of transporting material is affected by the depth of water access to an off-loading area and the effective distance from the off-loading area to the site. In the North Bay Area, dredged sediment would usually be transported to an off-loading area in a barge or scow, then removed from the scow by a hydraulic off-loader which pumps the material as a slurry through a pipeline to the site. Material used for levee maintenance, however, usually would be offloaded with a clamshell dredge.

Areas for off-loading dredged sediment are selected for safe anchorage, minimum obstruction of navigation, minimum ecological disturbance, and minimum distance to the parcel.

There are two basic kinds of water access to off-loading areas, deep water access and restricted water access. A deep water access has a minimum depth of 15 feet below Mean Lower Low Water (MLLW), and will accommodate a fully loaded large scow (3,000 cubic yards). A restricted or shallow water access has a minimum depth of 8 feet below MLLW, and will usually accommodate a fully loaded small scow, a partially loaded large scow, and may accommodate a fully loaded large scow if operations are timed with extreme high tides.

Transport unit costs for upland disposal sites are often higher than costs for aquatic sites because barges may be less than fully loaded or more trips with lower-volume shallow-draft scows may be needed because of access channel restrictions.

Placement. The placement requirements of a disposal site affect placement costs. For example, placing materials at aquatic sites typically requires no additional costs; however, placement at upland disposal sites usually is done using a hydraulic off-loader or mechanical rehandling (e.g. clamshell dredge into trucks or rail cars), which generates additional costs that are dependent on the distance from the off-loading area to the disposal site.

For hydraulic pipeline placement, the distance from an off-loading area to the discharge point at a wetland site or rehandling facility is typically not the shortest linear distance due to many constraints. Pipeline routes are constrained by numerous factors including:

- avoiding ecologically sensitive areas;
- avoiding long stretches of open water for floating pipelines due to the problems and costs associated with anchoring the pipeline to prevent wind and tidal current movement and damage;
- avoiding blocking or restricting navigation channels;
- avoiding costs and problems associated with crossing roads, railroads and other infrastructure;
- avoiding commercial or residential areas due to public safety and liability concerns, and;
- avoiding significant changes in elevation due to the effect on pumping costs.

Scows can be unloaded mechanically with clamshell dredges as well as hydraulically. Hydraulic off-loading is used for large volumes of material that is to be spread over a large area. Mechanical unloading is more likely to be used for smaller volumes of material, and for levee rehabilitation or for other uses (such as construction fill) where direct or precise placement is needed. The costs of mechanical offloading can be similar to the cost of initial clamshell dredging. The unit cost differences between mechanical and hydraulic placement will depend on the volume of material, the distance from the scow to the placement site, and the size of the area over which the material must be placed.

Ownership Costs. These expenses represent the costs of owning and maintaining dredge and haul equipment and include amortization of equipment (depreciation and interest on capital invested), major repairs, periodic dry docking, machinery overhauls, taxes, storage yard expense, "maintenance while idle" crew costs, and insurance. Ownership costs are affected by the size and configuration of equipment owned by individual dredgers. These costs may vary for dredgers bidding on large versus small projects.

It should be noted that the cost estimates depend on assumptions about the market conditions. Two types of market conditions can affect cost estimates for a project. A "standard" dredging market is one in which a contractor would be expected to earn a fair and reasonable return on the contract. Standard market conditions exist when there is an abundance of work in the industry that allows the contractor to be competitive and still include in his or her bid the following typical costs: 50% of monthly ownership costs; overhead at 15% of the total direct costs; 10% of total costs for contingencies; a 15% profit margin over total costs; and a bond at 0.5%.

A distressed market condition exists when there are few projects to bid on and competition is the greatest. The contractor would bid as low as possible without losing money just to keep the crew together, equipment utilized, and a cash flow occurring. In this market, contractor bids may be closer to the following: ownership costs at 0%, overhead at 15%, contingencies at 0%, profit at 0%, and a bond at 0.5%.

Market factors can account for much of the difference in costs between work performed by government and private dredgers because overhead costs for federal work remain relatively constant from year to year while private bid costs are more sensitive to profit margins and overheads rates supported by current market conditions.

Operating Costs. These expenses represent the costs of operating the equipment and include payroll costs, usage, repairs and maintenance, wear costs, marine insurance, fuel and other operating supplies, and engineering and supervision required for the operation of the various pieces of plant. Similar to ownership costs, operating costs may vary according to the type and amount of equipment used by individual dredgers that bid on large versus small jobs.

Rehandling
Transportation of dredged material to a landfill or other UWR disposal site often involves a two-step program. Materials are first transported by barge from the dredge site to a

rehandling facility where wet material is allowed to dry. Placement costs for offloading to the rehandling facility are likely to be similar to offloading to similar UWR sites. Dry dredge material is then excavated from the rehandling facility, trucked to the final placement site, and then offloaded. Rehandling costs include the cost to rent/lease the volume for drying at the rehandling facility itself, as well as the cost of subsequent excavation, loading, transportation, and offloading. Factors affecting the rehandling cost are the cost of loading and unloading the dry material and the haul distance to the final placement site.

Site Development and Management

Site development and management costs can be categorized according to costs associated with the initial preparation of disposal sites, ongoing site operations and maintenance costs, and ongoing site monitoring costs.

Site preparation costs include land acquisition costs; construction costs; and engineering, design, environmental, planning, and construction management costs. They also include public agency staff time spent on permit review and approval. These costs are not necessarily borne by the site's developers or the dredging community, but they represent a real cost to government.

The cost of developing ocean and in-bay sites have not been included in this analysis, as these site are currently developed and operating and there are no specific plans to develop new aquatic sites in the foreseeable future. These costs, borne primarily by the federal government and state agencies, are made up of direct site construction costs as well as agency staff overhead. Initial site preparation costs for the ocean disposal site have been estimated by EPA to total approximately $5.4 million, including $3.5 million for site designation costs and $1.9 million for agency staff costs, EIS preparation, and overhead.

Hypothetical development costs for an additional in-bay disposal site are estimated to be approximately $2 million, based on estimates from the Corps and the EPA. Costs include field surveys, modeling, engineering design, EIS/R document preparation, and designation activities.

Under the current regulatory framework, UWR sites will have signifcantly higher site preparation and development costs than ocean or in-bay sites. Habitat restoration and dredged material rehandling sites could incur significant land aquisition costs not associated with aquatic disposal sites. Acquisition costs will depend on area land values and alternative uses for the land. Several of the most feasible sites currently under consideration (e.g. Hamilton Air Base, Mare Island) are publicly owned, potentially reducing the cost of site acquisition. There would be no acquisition costs, however, for rehabilitation of existing levees. In most cases site construction and permitting costs also are likely to be higher for upland sites than for aquatic disposal, as upland sites typically require greater engineering, design and construction work. Construction costs will also vary among upland sites.

Site development costs will not necessarily vary between the dredging work categories, depending on the intended use of the site. UWR sites may be developed for the exclusive use of a single project or a specific group of projects, or may receive materials from many projects. It is not likely that small dredgers will develop an upland site as part of a small dredging project. If the site is developed by a public or non-profit entity (as in the case of the Sonoma Baylands), the dredging community may not bear the cost of land acquisition and site development, but rather will only face the incremental cost of disposing material at the site instead of in the bay or ocean.

Ongoing site operations and maintenance costs will vary depending on the disposal site. Ocean and in-bay sites will have no ongoing operations costs, other than monitoring activities described below. Site operations and maintenance cost for UWR sites include a wide variety of activities: upkeep of buildings or structures on site; dike and levee elevation and maintenance; engineering and equipment services for managing placed material and executing site management plans; and engineering and equipment services to ensure proper drainage and water management (Gahagan & Bryant 1994b). These costs are site specific, and will vary widely between sites. In general, site management and maintenance costs will not not vary by work category, unless a site is being managed for a particular project or group of projects.

Following the placement of dredged material, disposal sites may require ongoing monitoring to detect potential environmental effects. In general, monitoring for aquatic disposal will include water quality, turbidity, and the effects on aquatic biota. Monitoring plans for UWR sites will depend on the type of site. Restoration of tidal wetlands could require monitoring for effects on water quality and biota as well as the development of the site itself (e.g. sedimentation rate at the site, channel formation, revegetation and plant succession). Monitoring at levee rehabilitation and rehandling sites typically would involve monitoring runoff for dissolved metals, salinity, and suspended solids, among others (Gahagen & Bryant 1994b). Rehandling facilities may also have to monitor for potential groundwater contamination.

Monitoring costs for UWR are very dependent on both the placement environment and the specifications of a particular disposal site. The level and complexity of the monitoring, and therefore its cost, will depend on the characteristics of the particular site and the surrounding environment, existing structures (e.g. drains and runoff channels), regulations governing the particular region, and the existence of endangered species or other biota of concern. For instance, concern about groundwater contamination in the upper Delta may lead to more stringent monitoring for levee rehabilitation projects than would be required for tidal wetland restoration in the Bay.

DERIVATION OF ESTIMATED UNIT COSTS

In order to evaluate the potential, overall costs of the LTMS EIS/R alternatives, this analysis estimated a range of unit costs for the various dredging and disposal activities considered in the LTMS. These costs were further broken out by work category, to identify the potential share of costs borne by various sectors of the dredging community under each alternative. Where possible, a range of unit costs was developed, to capture the potential variation in the variables affecting dredging and disposal costs. Tables 6 and 7 summarize the unit costs estimated by this analysis.

Estimates of dredging and placement costs, including testing, are based on a Gahagan & Bryant model used to estimate dredging bid calculations and are summarized in Table 6. See Addendum A to this Appendix for a description of this model and the model output used to develop unit costs estimates for the high and low cost scenarios. Site development, site operations and monitoring costs were then estimated from other sources, and are summarized in Table 7.

The unit costs shown in Tables 6 and 7 attempt to capture the reasonable range of costs associated with each activity. Because costs vary extensively for each dredging project based on the location of the project and the specific placement environment used to dispose of dredged material, the unit costs may not represent extreme cases. These unit costs, however, should provide reasonable planning-level estimates of total costs. The sources used to develop unit cost estimates are documented below and in the notes accompanying Tables 6 and 7.

Dredging and Placement

Gahagan and Bryant used the dredging cost estimate model described in Addendum A to evaluate mobilization and dredging cost differences faced by project sponsors in the three work categories, and explored cost differences associated with transport and placement to different types of disposal environments. Factors included in this analysis were those costs included in Dredging and Placement (described above), except for the costs associated with rehandling.

Cost estimates were prepared for two project scenarios to represent the potential high and low end of unit costs for the various work categories and placement environments. The higher cost scenario (Scenario 1) simultaneously accounts for a longer transport distance, more expensive placement conditions (longer pumpout distance), a lower volume of material, and a shallower access channel than the lower cost scenario (Scenario 2). Costs affected by the type of material being dredged and ownership and operating characteristics were factored into the estimates prepared for the individual work categories.

Scenario Development

Addendum A contains the model output that served as the basis used to develop the scenarios. The following methods and major assumptions apply to the two scenarios used to develop the unit cost estimates for dredging and placement:

- The dredging volumes assumed for each scenario work category were selected to be

Table 6: Estimated Unit Costs for Testing, Dredging and Disposal ($/cubic yard)

Activity	In-Bay	Ocean	Upland, Wetland Reuse		
			Tidal Wetlands	Levee	Landfill \b
Maintenance (100% soft material) \a					
Testing \c	0.39-1.65	0.44-1.91	0.10-0.12	0.10-0.12	0.10-0.12
Mobilization \d	0.06-0.56	0.06-0.56	0.42-4.46	0.11-1.12	0.42-4.46
Dredging \e	1.74-1.79	1.68-1.69	1.69-1.66	1.68-1.74	1.66-1.69
Transport \f	1.21-2.18	5.04-5.99	2.12-4.96	2.18-5.99	2.12-4.96
Placement \g	0	0	2.19-3.44	2.00 \i	2.19-3.44
Rehandling \h	NA	NA	NA	NA	2.23-5.26
Total	**3.45-6.13**	**7.23-10.14**	**6.52-14.64**	**6.13-10.91**	**8.75-19.90**
New Work (50% hard/ 50% soft material) \j					
Testing	0.12-1.65	0.13-1.91	0.09-0.12	0.09-0.12	0.09-0.12
Mobilization	0.02-0.56	0.02-0.56	0.13-4.46	0.03-1.12	0.13-4.46
Dredging	2.29-2.35	2.22-2.23	2.19-2.22	2.23-2.29	2.19-2.22
Transport	1.58-2.87	5.38-6.62	2.79-5.27	2.87-5.38	2.79-5.27
Placement	0	0	2.88-4.54	2.00	2.88-4.54
Rehandling	NA	NA	NA	NA	2.23-5.26
Total	**4.07-7.37**	**7.76-11.31**	**8.11-16.58**	**7.28-10.85**	**10.34-21.84**
Small Dredge (100% soft material) \k					
Testing	3.30-8.25	3.81-9.53	0.17-0.49	0.17-0.49	0.17-0.49
Mobilization	1.68-8.40 \l	1.68-8.40	3.28-16.40	3.28-16.48	3.28-16.40
Dredging	1.74-1.79	1.68-1.69	1.66-1.69	1.68-1.74	1.66-1.69
Transport	1.21-2.18	5.04-5.99	2.12-4.96	2.18-5.99	2.12-4.96
Placement \m	0	0	2.00	2.00	2.00
Rehandling	NA	NA	NA	NA	2.23-5.26
Total	**7.98-20.57**	**12.22-25.60**	**9.26-25.51**	**9.37-26.56**	**11.49-30.77**

Notes for Table 6: (for complete explanation of sources and assumptions, see Appendix Q)

a\ Maintenance material is typically fine-grained silts and clays which is easily dredged.

b\ Represents costs associated with establishing a rehandling site. Costs based on assessment of Mare Island, Rio Vista Airport Borrow Pit, Leonard Ranch and Cargill rehandling sites (Gahagan & Bryant 1994a).

c\ Testing costs for ocean based on Green Book, for In-bay based on Inland Testing Manual, and for UWR on WET test. Ranges based on assumed volumes for low and high cost scenarios. See Tables 9 and 10 in Appendix Q for testing cost derivation.

d\ Based on Gahagan and Bryant bid model for a given set of equipment. See Appendix Q for explanation of bid model. Unit costs derived by dividing mobilization cost by assumed volumes for low and high scenarios listed in Table 4.

e\ Based on Gahagan and Bryant bid model for a given set of equipment. See Appendix Q for explanation of bid model. Unit costs derived by dividing dregding cost by average productivity of the particular equipment set. Slight variations in dredging costs due to differences in equipment assumed for each placement environment.

f\ Based on distances assumed in Low and High scenarios (see Table 4: Assumptions for Scenarios)

g\ Placement costs include cost of equipment and labor needed for placing dredged material at the disposal site. No placement costs were assumed for in-bay and ocean disposal, assuming the use of bottom-dump scows.

h\ Rehandling costs based on *Analysis of the Potential for Use of Dredged Material at Landfills*, San Francisco Bay Conservation and Development Commission 1994. Includes costs of excavating, loading, hauling and unloading dried material from rehandling facility.

i\ Placement cost based on use of clamshell dredge with similar cost characteristics to dredging operation.

j\ Accounts for inclusion of harder material (unconsolidated sand, or hard-packed deposits of ancient muds or sands). Hard material encountered in New Work projects may require different kinds of equipment, and less production and higher unit costs than would be experienced by dredging maintenance material.

k\ Includes dredging projects with channel depths of 12 feet below MLLW or less. Harder material is generally not encountered when dredging such shallow channels.

l\ Mobilization costs are very sensitive to dredging volumes, as they represent fixed costs than must be spread across the entire project volume.

\m Assumes the use of mechanical placement (clamshell dredge vs. hydraulic offloader and pipeline) at all disposal sites, with cost characteristics similar to levee placement. Assumes that small dredgers most likely will not be required to establish offloading facilities at any given placement environment due to the relatively small volumes offloaded.

Table 6: Estimated Unit Costs for Testing, Dredging and Disposal ($/cubic yard)

Activity	In-Bay	Ocean	Upland, Wetland Reuse		Landfill \b
			Tidal Wetlands	Levee	
Maintenance (100% soft material) \a					
Testing \c	0.39-1.65	0.44-1.91	0.10-0.12	0.10-0.12	0.10-0.12
Mobilization \d	0.06-0.56	0.06-0.56	0.42-4.46	0.11-1.12	0.42-4.46
Dredging \e	1.74-1.79	1.68-1.69	1.69-1.66	1.68-1.74	1.66-1.69
Transport \f	1.21-2.18	5.04-5.99	2.12-4.96	2.18-5.99	2.12-4.96
Placement \g	0	0	2.19-3.44	2.00 \i	2.19-3.44
Rehandling \h	NA	NA	NA	NA	2.23-5.26
Total	**3.45-6.13**	**7.23-10.14**	**6.52-14.64**	**6.13-10.91**	**8.75-19.90**
New Work (50% hard/ 50% soft material) \j					
Testing	0.12-1.65	0.13-1.91	0.09-0.12	0.09-0.12	0.09-0.12
Mobilization	0.02-0.56	0.02-0.56	0.13-4.46	0.03-1.12	0.13-4.46
Dredging	2.29-2.35	2.22-2.23	2.19-2.22	2.23-2.29	2.19-2.22
Transport	1.58-2.87	5.38-6.62	2.79-5.27	2.87-5.38	2.79-5.27
Placement	0	0	2.88-4.54	2.00	2.88-4.54
Rehandling	NA	NA	NA	NA	2.23-5.26
Total	**4.07-7.37**	**7.76-11.31**	**8.11-16.58**	**7.28-10.85**	**10.34-21.84**
Small Dredge (100% soft material) \k					
Testing	3.30-8.25	3.81-9.53	0.17-0.49	0.17-0.49	0.17-0.49
Mobilization	1.68-8.40 \l	1.68-8.40	3.28-16.40	3.28-16.48	3.28-16.40
Dredging	1.74-1.79	1.68-1.69	1.66-1.69	1.68-1.74	1.66-1.69
Transport	1.21-2.18	5.04-5.99	2.12-4.96	2.18-5.99	2.12-4.96
Placement \m	0	0	2.00	2.00	2.00
Rehandling	NA	NA	NA	NA	2.23-5.26
Total	**7.98-20.57**	**12.22-25.60**	**9.26-25.51**	**9.37-26.56**	**11.49-30.77**

Notes for Table 6: (for complete explanation of sources and assumptions, see Appendix Q)

a\ Maintenance material is typically fine-grained silts and clays which is easily dredged.

b\ Represents costs associated with establishing a rehandling site. Costs based on assessment of Mare Island, Rio Vista Airport Borrow Pit, Leonard Ranch and Cargill rehandling sites (Gahagan & Bryant 1994a).

c\ Testing costs for ocean based on Green Book, for In-bay based on Inland Testing Manual, and for UWR on WET test. Ranges based on assumed volumes for low and high cost scenarios. See Tables 9 and 10 in Appendix Q for testing cost derivation.

d\ Based on Gahagan and Bryant bid model for a given set of equipment. See Appendix Q for explanation of bid model. Unit costs derived by dividing mobilization cost by assumed volumes for low and high scenarios listed in Table 4.

e\ Based on Gahagan and Bryant bid model for a given set of equipment. See Appendix Q for explanation of bid model. Unit costs derived by dividing dregding cost by average productivity of the particular equipment set. Slight variations in dredging costs due to differences in equipment assumed for each placement environment.

f\ Based on distances assumed in Low and High scenarios (see Table 4: Assumptions for Scenarios)

g\ Placement costs include cost of equipment and labor needed for placing dredged material at the disposal site. No placement costs were assumed for in-bay and ocean disposal, assuming the use of bottom-dump scows.

h\ Rehandling costs based on *Analysis of the Potential for Use of Dredged Material at Landfills*, San Francisco Bay Conservation and Development Commission 1994. Includes costs of excavating, loading, hauling and unloading dried material from rehandling facility.

i\ Placement cost based on use of clamshell dredge with similar cost characteristics to dredging operation.

j\ Accounts for inclusion of harder material (unconsolidated sand, or hard-packed deposits of ancient muds or sands). Hard material encountered in New Work projects may require different kinds of equipment, and less production and higher unit costs than would be experienced by dredging maintenance material.

k\ Includes dredging projects with channel depths of 12 feet below MLLW or less. Harder material is generally not encountered when dredging such shallow channels.

l\ Mobilization costs are very sensitive to dredging volumes, as they represent fixed costs than must be spread across the entire project volume.

\m Assumes the use of mechanical placement (clamshell dredge vs. hydraulic offloader and pipeline) at all disposal sites, with cost characteristics similar to levee placement. Assumes that small dredgers most likely will not be required to establish offloading facilities at any given placement environment due to the relatively small volumes offloaded.

Table 7: Estimated Unit Costs for Site Preparation and Management ($/cubic yard)

Activity	In-Bay	Ocean	Upland, Wetland Reuse: Tidal Wetlands	Upland, Wetland Reuse: Levee	Landfill \e
Initial site prep \a	0.00 \b	0.00 \b	0.60-1.21 \c	1.84-2.21 \d	0.51-1.18 \e
Site operations/maintenance	NA \f	NA	0.02-0.03 \c	0.00	0.35-0.39 \e
Site monitoring	NA \g	NA \g	NA \h	0.27-0.34 \i	0 \j
Total	**0.00**	**0.00**	**0.62-1.24**	**2.11-2.55**	**0.86-1.57**

Notes and sources:

a\ Initial site preparation includes land acquisition, construction, mitigation, engineering, design, environmental, planning and construction management costs.
b\ No site preparations costs were assumed for the ocean and in-bay sites as these site are currently operational.
c\ Based on a cost associated with Hamilton Air Force Base and North Point properties (Gahagan & Bryant 1994a). See page X for more details.
d\ Site construction cost of $147,000 per levee mile based on Jersey Island levee rehabilitation project (Gahagan & Bryant 1994a). Planning, engineering, design and construction management costs estimated to equal $15,000 - $50,000 per levee mile based on Jersey Island project.
e\ Represents costs associated with establishing a rehandling site. Costs based on assessment of Mare Island, Rio Vista Airport Borrow Pit, Leonard Ranch and Cargill rehandling sites (Gahagan & Bryant 1994a).
f\ No site operations and maintenance costs associated with in-bay and ocean disposal.
g\ Site monitoring at ocean, and in-bay disposal represents a fixed cost that will not vary with volume. The cost of monitoring is included in the calculation of total costs. See page XX for details of monitoring cost estimates.
h\ See text for explanation of costs for site monitoring at tidal wetlands
i\ Based on costs of $24,000 - $30,000 per levee mile (Larson, BCDC, pers. communication)
j\ Monitoring costs for the rehandling facility are included in the site operations and maintenance cost

within the range that most projects fall into for each work category.

- For purposes of estimating haul distances, existing/proposed dredge project and placement sites/locations were used as case studies. Project sites assumed for each scenario were matched with the following disposal placement sites to create haul distances: the Alcatraz Disposal site for in-bay disposal; the 102 ocean site for ocean disposal; the City of Rio Vista area for disposal to levee maintenance areas; the Petaluma or Napa Rivers for disposal to a rehandling facility and wetland sites.

- For maintenance and new work projects, material was assumed to be initially placed at wetland restoration and rehandling facility sites using a hydraulic off-loader. Disposal at in-bay and the ocean sites would utilize bottom-dump scows.

- For all levee restoration projects, a clamshell was assumed to be used to place material. Cost for placement at levees was not derived with the cost-estimate model. Rather, the cost was extrapolated from the dredging unit costs for maintenance material, which also assumes clamshell dredging. Costs for levee placement are greater than those for dredging because it is assumed the clamshell dredge will take more time to place material along the levee, as compared with the initial dredging of a channel (i.e. levee disposal would be a less efficient operation per unit volume than initial channel dredging).

- For small projects placing material at wetland restoration and rehandling facility sites, material was assumed to be off-loaded mechanically using a clamshell, conveyor, etc. Costs were assumed to equal costs for placement to levee restoration, as the production process is similar to both operations. These unit costs are less than the hydraulic offloading assumed for maintenance and new work dredging. This simplifying assumption was made to capture the fact that most small dredgers would not be responsible for providing the offloading equipment (hydraulic boosters, pipeline, etc.) for upland sites. It is more likely they would offload through equipment already set up at the site.

- Dredge materials for maintenance and small dredger projects were assumed to be 100% soft fine-grained silts and clays, therefore allowing the same equipment for dredging and transport; dredged materials for new work projects were assumed to be 50% soft and 50% consolidated material.

- Production for a dredge is greatest when a full bucket load of material is retrieved in a cycle. This corresponds to a depth of cut (bank) greater than 5 feet. For this analysis, 50% of the work in each category was assumed to have a depth of bank greater than 5 feet.

- Ownership and operating costs were based on the use of a clamshell dredge with tugs and hopper scows transporting the material to either a hydraulic off-loader located at an upland disposal site or to an open water disposal site. Both ownership and operating costs are based on utilization of certain sizes and configurations of equipment for each of these systems. Other sizes or types of equipment might be used, but the system assumed for this analysis was considered to yield representative costs. The values used for the equipment are present-day purchase prices and represent current replacement costs.

Ownership costs were incorporated through the use of a "market factor", which indicates the degree to which ownership costs can be included in bid prices. For this analysis, a standard market factor was assumed, meaning that dredging bids would include 50% of the monthly ownership costs for the particular equipment used in the scenario.

- Mobilization and demobilization costs represent fixed costs that do not vary according to dredge volume. Unit costs for mobilization and demobilization are calculated by dividing the mobilization/demobilization cost by the total volume of the project in each scenario. Unit costs for dredging operations and equipment maintenance are derived by dividing the average monthly cost of running the equipment by the average monthly production rate (in cubic yards) of that equipment.

Scenario 1. Scenario 1 was developed as a "high" estimate of potential unit costs. It incorporates a longer haul distance, smaller volumes of dredged material, limited channel access, and more expensive placement conditions.

The following major assumptions, which are summarized in Table 8, were used to prepare Scenario 1 cost estimates.

- Dredge volumes were assumed to be 150,000 cy for both new and maintenance work projects and 10,000 cy for small dredger projects, representing relatively small projects within each work category.

- A South Bay dredge project location (Port of Redwood City) was assumed for Scenario 1, establishing a longer haul distance to disposal sites.

- A constricted channel (i.e., 8 feet below MLLW) is assumed to be used for access to offloading areas for upland disposal sites.

- Haul routes to a rehandling facility and wetland restoration sites were assumed to use the Petaluma River using lightly loaded or small-volume (shallow draft) scows.

- The pumping distance for off-loading to an upland disposal sites was assumed to be 26,000 feet. This distance is representative of the longest distance for an LTMS-proposed disposal sites (Hamilton Field). (Gahagan & Bryant Associates 1994b) This requires a hydraulic unloader and 2 booster pumps.

Scenario 2. Scenario 2 was developed to estimate the low end of the range of potential unit costs. It assumes relatively large dredging volumes, short haul distances, and optimal offloading conditions. The following major assumptions, which are summarized in Table 8, were used to prepare Scenario 2 cost estimates.

- Dredge volumes were assumed to be 1.5 mcy for maintenance work, 5 mcy for new work, and 50,000 cy for small dredger projects, representing relatively large projects within each work category.

Table 8: Assumptions Used to Develop High- and Low- Cost Estimates

	Scenario 1 - High End of Range				Scenario 2 - Low End of Range			
Work Type	Dredge Cut/Placement Site	One-Way Haul (nautical miles)	Pumpout Distance (feet)	Volume (000 cy)	Dredge Cut/Placement Site	One-Way Haul (nautical miles)	Pumpout Distance (feet)	Volume (000 cy)
MAINTENANCE (100%soft)								
In-Bay	Rort Redwood City/Alcatraz	22	N/A	150	Port Oakland/Alcatraz	5	N/A	1,500
Ocean	Port Redwood City/102 Ocean Site	80	N/A	150	Port Oakland/102 Ocean Site	62	N/A	1,500
Tidal wetland (fully loaded scow)	N/A	N/A	N/A	N/A	Port Richmond/Petaluma Riv.	20	4,000	1,500
Tidal wetland (lightly loaded scow)	Port Redwood City/Petaluma Riv.	43	26,000	150	N/A	N/A	N/A	N/A
Levee	Port Redwood City/Rio Vista	74	N/A	150	Suisun Bay/Rio Vista	22	N/A	1,500
Landfill (fully loaded scow)	N/A	N/A	N/A	N/A	Port Richmond/Napa Riv.	20	4,000	1,500
Landfill (lightly loaded scow)	Port Redwood City/Petaluma Riv.	43	26,000	150	N/A	N/A	N/A	N/A
NEW WORK (50% soft/hard)								
In-Bay	Port Redwood City/Alcatraz	22	N/A	150	Port Oakland/Alcatraz	5	N/A	5,000
Ocean	Port Redwood City/102 Ocean Site	80	N/A	150	Port Oakland/102 Ocean Site	62	N/A	5,000
Tidal wetland (fully loaded scow)	N/A	N/A	N/A	N/A	Port Richmond/Petaluma Riv.	20	4,000	5,000
Tidal wetland (lightly loaded scow)	Port Redwood City/Petaluma Riv.	43	26,000	150	N/A	N/A	N/A	N/A
Levee	Port Redwood City/Rio Vista	74	N/A	150	Suisun Bay/Rio Vista	22	N/A	5,000
Landfill (fully loaded scow)	N/A	N/A	N/A	N/A	Port Richmond/Napa Riv.	20	4,000	5,000
Landfill (lightly loaded scow)	Port Redwood City/Petaluma Riv.	43	26,000	150	N/A	N/A	N/A	N/A
SMALL DREDGER (100% soft)								
In-Bay	Port Redwood City/Alcatraz	22	N/A	10	Port Oakland/Alcatraz	5	N/A	50
Ocean	Port Redwood City/102 Ocean Site	80	N/A	10	Port Oakland/102 Ocean Site	62	N/A	50
Tidal wetland (fully loaded scow)	N/A	N/A	N/A	N/A	Port Richmond/Petaluma River	20	N/A	50
Tidal wetland (lightly loaded scow)	Port Redwood City/Petaluma River	43	N/A	10	N/A	N/A	N/A	N/A
Levee	Port Redwood City/Rio Vista	74	N/A	10	Suisun Bay/Rio Vista	22	N/A	50
Landfill (fully loaded scow)	N/A	N/A	N/A	10	Port Richmond/Napa River	20	N/A	50
Landfill (lightly loaded scow)	Port Redwood City/Petaluma River	43	N/A	10	N/A	N/A	N/A	N/A

- Projects located at the Ports of Oakland and Richmond and along the Suisun Bay Channel were assumed for Scenario 2, establishing shorter haul distances to disposal sites.

- Haul routes to rehandling facility and wetland restoration sites were assumed to use the Napa River using fully loaded, full-size scows.

- The pumping distance for off-loading to an upland disposal sites was assumed to be 4,000 feet. This distance is representative of shorter distances for LTMS proposed disposal sites (Gahagan & Bryant Associates 1994b). This requires the use of a single hydraulic unloader.

- A deep-water access channel is assumed to be available for access to offloading areas for upland disposal sites.

Rehandling

Costs for excavating, loading, hauling, and off-loading dry material are estimated to range from $2.23 to $5.26 per cubic yard, as shown by Table 6. Hauling dry material from a rehandling facility to a landfill site was estimated based on haul distances from potential rehandling sites to landfill sites. These haul costs were estimated to range from $1.03 to $4.06 per cubic yard of wet dredge material (San Francisco Bay Conservation and Development Commission 1994a). (Dry material is approximately 60% of the volume of wet material. The costs were calculated to be consistent with wet-material volumes.) The cost of excavating dry material at the rehandling facility, loading trucks, and off-loading material at landfill sites was estimated to total $1.20 per cubic yard, based on estimates from several landfill operators. (Olejniczak pers. comm.).

The costs shown in Table 6 and elsewhere in this report do not include tipping fees that landfills may charge to accept dredged material. Fees will vary from facility to facility, depending on the facility's need for material. Volume discounts are often given, and the discounts will vary. Depending on the composition of the material and the need of the landfill to acquire such material, landfills will either pay, or charge nothing or a discounted fee for dredged materials. (SFBCDC 1994a)

Testing

In-Bay and Ocean. Ocean and In-Bay testing will vary by volume. Testing cost estimates were developed for the dredging volumes associated with the two scenarios developed above. Actual testing costs will vary significantly by project, but these estimates represent a likely range of testing costs. These estimates were based on the following methods and assumptions. Tables 9 and 10 summarize the testing costs for ocean and in-bay disposal.

- Average test costs were based on estimates from five laboratories. Costs represent field collection for dredge site, reference, and control area sediment samples; laboratory testing and analysis; and documentation. Testing cost estimates are based on one composite and one set of tests.

- These estimates are conservative because the estimated cost per test was not assumed to decline as the number of tests increase (i.e. no economies of scale were assumed). Actual testing will likely be lower for volumes above 20,000 cy.

- The minimum number of tests required for a projected volume was taken from Public Notice 93-2.

- In-bay testing costs are based on the forthcoming Inland Testing Manual guidelines, which are similar to ocean testing guidelines.

- Ocean testing costs are based on the Greenbook guidelines. Ocean testing costs are higher than in-bay costs because of the travel distance to the ocean site for reference sampling.

- Both ocean and in-bay test costs include bioaccumulation tests.

These cost estimates for testing are conservative. There are a number of factors that could cause actual testing costs to be significantly lower than those estimated here. For instance, periodic sampling of the reference area could reduce the need to provide a reference sample for every disposal event. In addition, existing testing information on the area being dredged can reduce the need for testing in every case.

Table 9: Required Tests and Total Testing Costs for In-Bay and Ocean Disposal

Volumes \b (000 cy)	# of tests required \b	Average Total Testing Costs ($) \c
Ocean Disposal \a		
5-20	1	95,250
20-100	2	190,500
100-200	3	285,750
200-300	4	381,000
300-400	5	476,250
400-500	6	571,500
500+	7 /d	666,750
In-Bay Disposal /e		
5-20	1	82,500 /f
20-100	2	165,000
100-200	3	247,500
200-300	4	330,000
300-400	5	412,500
400-500	6	495,000
500+	7 /d	577,500

Notes:

a\ based on Greenbook guidelines

b\ based on Minimum Sediment Sampling guidelines in PN93-2, pg. 4

c\ Based on estimates from 4 labs for one test. Average estimate was $95,250. Actual test costs for volumes above 20,000 cy would be lower, as per test cost would decline with more tests.

d\ A minimum of 7 tests would be necessary. Testing required for volumes above 500,000 cy are decided on a case by case basis.

e\ based on forthcoming Inland Testing Manual

f\ Based on estimates from 4 labs for one test. Average estimate was $82,500. Actual test costs for volumes above 20,000 cy would be lower, as per test cost would decline with more tests.

Table 9: Required Tests and Total Testing Costs for In-Bay and Ocean Disposal

Ocean Disposal \a

Volumes \b (000 cy)	# of tests required \b	Average Total Testing Costs ($) \c
5-20	1	95,250
20-100	2	190,500
100-200	3	285,750
200-300	4	381,000
300-400	5	476,250
400-500	6	571,500
500+	7 /d	666,750

In-Bay Disposal /e

Volumes \b (000 cy)	# of tests required \b	Average Total Testing Costs ($) \c
5-20	1	82,500 /f
20-100	2	165,000
100-200	3	247,500
200-300	4	330,000
300-400	5	412,500
400-500	6	495,000
500+	7 /d	577,500

Notes:
a\ based on Greenbook guidelines
b\ based on Minimum Sediment Sampling guidelines in PN93-2, pg. 4
c\ Based on estimates from 4 labs for one test. Average estimate was $95,250. Actual test costs for volumes above 20,000 cy would be lower, as per test cost would decline with more tests.
d\ A minimum of 7 tests would be necessary. Testing required for volumes above 500,000 cy are decided on a case by case basis.
e\ based on forthcoming Inland Testing Manual
f\ Based on estimates from 4 labs for one test. Average estimate was $82,500. Actual test costs for volumes above 20,000 cy would be lower, as per test cost would decline with more tests.

Table 10: Total and Unit Testing Costs for Ocean and In-bay Disposal, by Scenario

	Scenario 1				Scenario 2			
Work Category	Volume (000 cy)	# of Tests	Total Cost	Unit Cost (per cy)	Volume (000 cy)	# of Tests	Total Cost	Unit Cost (per cy)
OCEAN DISPOSAL								
Maintenance	150	3	$285,750	$1.91	1,500	7	$666,750	$0.44
New Work	150	3	$285,750	$1.91	5,000	7	$666,750	$0.13
Small	10	1	$95,250	$9.53	50	2	$190,500	$1.91
IN-BAY DISPOSAL								
Maintenance	150	3	$247,500	$1.65	1,500	7	$577,500	$0.39
New Work	150	3	$247,500	$1.65	5,000	7	$577,500	$0.12
Small	10	1	$82,500	$8.25	50	2	$165,000	$3.30

Source: Tables 8 and 9

Upland, Wetland, and Reuse Sites. Testing costs for disposal to upland, wetland, and reuse sites were developed by EPA and are estimated to total approximately $0.09 - 0.49 per cubic yard. This estimate was based on the following methods and assumptions.

- Average test costs were derived from estimates from four laboratories.
- Testing costs are for the WET test, done only for Title 22 trace metal parameters.
- Costs include sediment sampling, extraction, analysis, and report writing. DI and acid extract costs are assumed to be equivalent.
- A regimen of one test per 3,000 cubic yards was assumed, with a minimum of three samples and tests.
- Very small projects (i.e., less than 3,000 cubic yards) will have higher per-yard costs because of the three-test minimum requirement.

These costs are summarized in Table 11.

Table 11: Unit Costs for Testing for Upland/Wetland Reuse

	Scenario 1			Scenario 2		
Work Category	Volume (000 cy)\a	Total Cost \b	Unit Cost (per cy)	Volume (000 cy)	Total Cost	Unit Cost (per cy)
Maintenance	150	18,000	$0.12	1,500	$150,000	$0.10
New Work	150	18,000	$0.12	5,000	$450,000	$0.09
Small Dredger	10	4,900	$0.49	50	$8,500	$0.17

Notes:
a. From Table 8
b. Costs based on estimates from 5 labs, with an average cost of $280.50 per test, $3375 for sampling, and $412.5 for report preparation. Assumes one test per 3000 cy of material, with a minimum of three tests.

Site Development and Management

Disposal costs represented by site development and management costs have been categorized according to costs associated with the initial preparation of disposal sites, annual site operations and maintenance costs, and annual site monitoring costs.

In-Bay Disposal: This analysis did not include site development costs for in-bay disposal, as the site is currently operational.