

**DELAWARE RIVER MAIN CHANNEL DEEPENING
PROJECT
(PENNSYLVANIA, NEW JERSEY, AND DELAWARE)**

**INDEPENDENT TECHNICAL REVIEW REPORT
FEDERAL & ASSOCIATED NON-FEDERAL COSTS**

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Delaware River Main Channel Deepening Project
Independent Technical Review (ITR)
Federal and Associated Non-Federal Costs

Prepared by
Moffatt & Nichol Engineers
for
David Miller and Associates

1. INTRODUCTION

Moffatt & Nichol Engineers (M&N) was commissioned by the U.S. Army Corps of Engineers (USACE) Philadelphia District (District), under subcontract to David Miller & Associates (DMA), to conduct an ITR of initial/maintenance costs for the Delaware River Main Channel Deepening Project. The project concerns deepening the main navigation channel of the Delaware River from an existing Mean Low Water (MLW) depth of 40 feet to 45 feet MLW.

M&N's efforts included review of work prepared by the District for initial dredging, disposal area construction, and maintenance dredging costs. Additionally, M&N reviewed Non-Federal associated costs prepared by S.T. Hudson Engineers (STHE), who also served as a subcontractor to DMA. STHE evaluated the associated costs for initial dredging, maintenance dredging, and facility improvements needed in order for participating marine terminals to benefit from the deepening project.

The basic ITR review activities focused on:

- Federal Initial Dredging/Disposal Costs
- Federal Maintenance Dredging/Disposal Costs
- Associated Dredging/Disposal Costs
- Associated Facility Costs

Results of the ITR are discussed in this report.



2. FEDERAL DREDGING COSTS

2.1 Material Provided By District

The Philadelphia District provided the following material in order to facilitate M&N's review of the initial dredging costs:

- Delaware River Main Channel Deepening Project, Design Memorandum (DM), Philadelphia District, North Atlantic Division, May 1996.
- Delaware River Main Channel Deepening Project, Limited Reevaluation Report (LRR), Philadelphia District, North Atlantic Division, February 1998.
- Numerous Electronic Files Summarizing Project Cost Estimates including:
 - MCACES Cost Estimate Summary of Each Project Element Including Both Dredging and Dredge Material Placement Sites
 - MCACES-CDEP New Work Dredging Cost Estimates for Each Channel Segment in the Project
 - Large Maps Summarizing Material Quantities and Dredging Locations
 - Details on Existing and Future Channel Shoaling Rates (in connection with Maintenance Dredging)

2.2 Review of MCACES-CDEP Initial Dredging Cost Estimates

Moffatt & Nichol Engineers prepared an initial review of the District's June 7, 2002 estimate of first costs. Subsequent rounds of review were prepared as the District responded to M&N comments. M&N activities included both review of the District's work as well as independent estimates of dredging costs. The independent estimates were made using M&N's customized version of the Corps of Engineers' Dredge Estimating Programs (CEDEP).

2.2.1 Initial Comments/Independent Estimate

General Comments

Contractor's Overhead & Profit: After some initial discussions, we concurred with the District's suggestions for contractor's overhead and profit.

Mobilization: These costs were reviewed and adjusted during the latter stages of review.

Water Quality Monitoring: We accepted the unit price for this work and revised the duration, where appropriate, for M&N independent estimates.



Hopper Dredge Estimates

M&N revised the labor rates for hopper dredging based on our experience, however it made little overall difference. The District based their initial hopper estimates on a specific dredge, namely, the R.N. Weeks. While M&N agreed that this dredge was likely to perform some of the hopper work, it was felt that other hopper dredges should also be considered. For example, the R.N. Weeks is equipped for pump-ashore work and thus possesses pumping capabilities not found in the "average" dredge of this size. An alternative approach would be to use the "generic medium" dredge which more closely mirrors the capacities of the "average" dredge for this class. Another possibility would be to consider a larger dredge.

The USACE overrode the Effective Hopper Capacity in order to reflect no-overflow of hoppers. This is based on current restrictions against hopper dredge overflow.

M&N questioned the USACE's 90% Time Efficiency and considered lower values depending on the length of the project. We used an 80% value in our initial independent estimates.

The USACE did not use a booster pump for several estimates as a result of the greater pumping capacity of the R.N. Weeks. Additional booster pumps are necessary for the "generic medium" dredge. M&N suggested a monthly fee of \$300,000 for a booster pump, although this price may be a bit high if a lesser horsepower unit is used (<7,200-hp booster).

The USACE is not using a crane barge and one is likely necessary to handle pipeline. A monthly value of \$55,000 was used in the independent estimate along with a larger monthly cost for a Tender Tug. The independent estimate did not include the USACE \$150,000 monthly cost for Other Marine equipment. Similarly, it did not include the \$30,000 per month for other Monthly Costs. M&N reduced the \$80,000 per month for Shore Equipment to \$50,000 per month (adequate for a couple dozers, crane, front end loader, and pickups).

The USACE used their standard 10-months per year Availability rate. We adjusted this number according to our experience to match availability with project duration.

We used a frequency of travel of 21 days since the crews typically work 3 weeks on and 1 week off. A travel cost/trip of \$750 was used and the Provisions & Supplies value was adjusted to \$25/person-day.



Hydraulic Dredge Estimates

As in the case of the hopper dredge estimate, labor rates and crew sizes were adjusted and it made very little overall difference. The M&N independent estimate varies from the District's CDEP program on the issue of booster pumps. M&N's version includes new data production rates developed by Mobile Pulley. Consequently, the M&N modeled dredges are more powerful and able to pump greater distances than the USACE version in some cases.

We lowered the Time Efficiency slightly from the USACE value, decreased the monthly amount for shore equipment, and adjusted the dredge availability rate.

Clamshell Dredge Estimates

M&N's independent estimate used a different Bucket Size and Bucket Fill Factor than the USACE values. We used a longer Bucket Cycle Time of 70 seconds since the anticipated heavy bucket is multi-parted and closes/hoists/lowers slower than a mud bucket. We included a 5% downtime for weather and adjusted Time Efficiency as described above for the other dredge types. The independent estimate used a smaller tug (a larger one is not necessary for such a short haul). We used a 95% Towing Efficiency compared to the USACE value of 58.6%.

M&N used a smaller scow size (2,000-cy) in light of the short haul distance and adjusted the useable scow volume and percent solids. Only one dredge and tug was used for the independent estimate given the small size of this portion of the work.

Drillboat Estimate

We did not change the USACE labor rates materially, but did reduce crew size. Only one drillboat is necessary in our opinion. We lowered the Availability rate in accordance with the duration of the project. Minor revisions were made to the drilling and blasting estimate. The cost for this work is quite high and is a reflection of the large area coverage and 2.7-foot pay face.

Summary Round 1

M&N's independent estimate acted to reduce the USACE estimate in some areas and increase in others. Overall, the M&N independent estimate was a little higher than the USACE value. The increased price stems from the use of a medium hopper dredge rather than the R.N. Weeks and from M&N's lowered estimate of dredge availability. This



finding prompted further examination of the potential for using a large, rather than medium, hopper dredge.

2.2.2 Second Round Comments/Independent Estimate

Hopper Dredging

A Generic Large size hopper dredge was used for each estimate. An Effective Hopper Capacity override limitation of 1,900-cy was used for the A, D2 and KELLY Island portions of the project. No override was used for other estimates. For these same sections, the Annual Months Available was taken as the project duration. In short, M&N backed off on the lower availability values in recognizing that contractors would push to complete the projects for the reasonable project durations rather than stop work.

Hydraulic, Clamshell & Drilling/Blasting

Adjustments were made to overhead percentage. Annual Months Available for drilling and blasting were set to the estimated project duration.

Summary Round 2

The above changes lowered the independent dredging estimate to \$214 million compared to the USACE value of \$246 million. Most of this change is associated with the use of the large, rather than medium, generic hopper dredge.

2.2.3 Round 3 Comments/Independent Estimate

Estimates were prepared for "Generic Medium" class dredge in order to confirm the Round 2 results. Where project durations exceeded 10 months (BROADKILL, EGG ISLAND, HOPRA, HOPRD2, KELLY) the "USACE Standard" of 10 months was used. No other changes were made to the hydraulic, clamshell, or drilling/blasting estimates.

Summary Round 3

The round 3 changes increased the project cost from \$214 million back to \$246 million. This change emphasizes the efficacy of using a large, rather than medium, hopper dredge. The result validates the District's original June 2002 cost estimate.



2.2.4 Round 4 Comments/Independent Estimate

Hydraulic/Scow/Unloader

In the interest of further verifying the round 2 and 3 estimates, M&N examined the benefits of completing the BROADKILL, KELLY and EGG ISLAND project elements using a pipeline dredge (pumping into scows which would be emptied by a hydraulic unloader at the disposal site). The purpose of this exercise was to see if there was a less expensive alternative to hopper dredging.

This change has the effect of dropping the Round 3 Total Cost from \$246 million to \$240 million. While this option is slightly less than the Round 3 alternative, the "Generic Large" hopper dredge (Round 2) estimate is the least expensive option. Furthermore, this option assumes scow overflow (~45 minutes.) Without overflow, this option would exceed the Round 3 estimate.

2.2.5 Round 5 Comments/Independent Estimate (maintenance dredging)

M&N prepared independent estimates for all the Maintenance Dredging. M&N reviewed the basis for estimated existing and future shoaling rates for the project area. We found the shoaling analysis to be very sound as it is steeped in many years of dredging/survey data for regular and advanced maintenance dredging projects. The District extended its shoaling analysis to account for the time elapsed since the 1998 LRR. Based on this recent data, the District provided new, lower, incremental shoaling volumes for the channel deepening project. M&N performed a critical review of the new data and the rationale for using results based on the new data. The principle reason for the lower rate was the relatively recent adoption of a one-foot (rather than 2-foot) allowable overdepth. M&N concurred with this rationale and the resulting lower shoaling rates. M&N's independent cost estimate for maintenance dredging generally confirmed the USACE estimate.

2.2.6 Round 6 Comments/Independent Estimate

New work estimates were adjusted to match the original USACE values for Overhead and Profit. These values are acceptable to M&N and this approach allowed a more direct comparison to the USACE estimate. The following six (6) scenarios (which include examination of specific large hopper dredges, namely the Eagle I and Stuyvesant) were estimated:



- 6aa: R.N. Weeks w/Hydraulic, Clam and D&B estimates;
- 6ab: Clam/Scow/Unloader w/Hydraulic, Clam and D&B estimates;
- 6ba: Eagle I w/Hydraulic, Clam and D&B estimates;
- 6bb: Eagle I (all reaches except Reach A) and Clam/Scow/Unloader (Reach A) w/Hydraulic, Clam and D&B estimates;
- 6ca: Stuyvesant w/Hydraulic, Clam and D&B estimates;
- 6cb: Stuyvesant (all reaches except Reach A) and Clam/Scow/Unloader (Reach A) w/Hydraulic, Clam and D&B estimates.

Hopper loading limitations of 43% of the calculated capacity in sand and 84% of the calculated capacity in mud were used to simulate "no overflow" and are based on USACE field data. The results presented below again show a lower cost for a large hopper dredge. Mob/Demobs cost were also adjusted. A 1,618 nautical mile mob and a 1,618 nautical mile demob were used for the Eagle I and Stuyvesant hopper dredges (conservative assumptions.)

The following total project dredging costs were estimated:

- 6aa: \$287,309,000
- 6ab: \$239,550,000
- 6ba: \$230,819,000
- 6bb: \$226,206,000
- 6ca: \$222,519,000
- 6cb: \$219,560,000

Summary Round 6

The above alternatives show that in light of hopper dredge overflow restrictions, the large hopper dredge and the clam/unloader concept are quite attractive. The alternatives continue to validate the current USACE estimate although not strictly for the R.N. Weeks based approach. The other large hopper dredges (i.e., Eagle I and Stuyvesant) lower the price somewhat but due to the overflow restriction it is not as much as it could be. Price reductions associated with clam/unloader approach are hindered by low dig face (except Reach A) and large presence of sand (rather than mud which can be unloaded more economically). Additionally, the above work suggests that the job could be opened to both hopper or clam/unloader dredging. The potential for alternative dredge types would foster greater competition.



2.2.7 Round 7 Comments/Independent Estimate

The District prepared a new estimate after completion of round 6 efforts. This estimate again adopted the approach of using a large hopper dredge in lieu of a medium hopper dredge. There was considerable debate about the new approach prior to adopting it. Most of the debate centered on the likelihood that U.S. dredging companies would bid the projects with a large dredge. In this connection, the lower bay segments (i.e., Kelly Island, Egg Island and Broadkill Beach) were likened to beach nourishment projects, which are often completed using large hopper dredges. Additionally, M&N made independent inquiries with several dredging companies who confirmed their general interest in the project and the specific likelihood that they would approach certain elements with a large hopper dredge vis-à-vis a medium hopper dredge.

M&N's independent estimate for the new work hydraulic costs was \$31.4 million (before contingency, site preparation, etc.) vs. the USACE's \$33.1 million. With regard to the clam/drilling and blasting, our independent estimate was \$15.6 million (before contingency, site preparation, etc.) vs. the USACE's \$13.1 million. The increase and decreased estimates essentially negate each other.

Relative to the new work hopper dredging, M&N's estimate was \$105.8 million (before contingency, site preparation, etc.) vs. the USACE's \$93.3 million. The 13.4% differential amounts to a \$12.5-million increase. The cost difference stems from the use of booster pumps. M&N also had concerns regarding monthly costs for survey vessel, booster (where applicable), and tender tug. The USACE's use of the 1,900-cy Effective Hopper Capacity limitation (for no overflow) also has a substantial impact on project duration (as compared to percentages based on field measurements). The lower effective hopper capacity results in a difference of 7.3 months and \$16.3 million. This can be partially offset by using a clam/unloader on Reach A rather than a hopper and saves 4.5 months and \$2.0 million.

The USACE used a mob/demob distance for the Generic Large dredge of 150 nautical miles. M&N allowed for a mob distance of 1,618 nautical miles (Mobile to Philly) and demob of 150 nautical miles in recognition of the fact that these dredges are not normally positioned in the Northeastern U.S. The mobilization distance could be reduced to reflect a Miami or nearby departure point. This mob/demob difference amounts to a difference of \$1.0 million increase.



2.2.8 Round 8 Comments/Independent Estimate

The District revised the project cost estimate based on the Round 7 comments/estimates. M&N agrees with the District's final estimate of \$208.4 million inasmuch as the District resolved each of the issues raised by M&N. The following comments touch on the possibilities for further reducing project costs:

Although we have reviewed the field test data provided to us by the District, we do not understand why there is a requirement to completely prohibit overflow. The test data show no ill effects in terms of water quality or other potential impacts associated with overflow in sand or mud. The no-overflow restriction results in extra cost to the project. These monies could be better spent on other, more direct, environmental measures. Other areas in the U.S. allow for at least some overflow (e.g., 15 minutes). The existing data for Delaware Bay demonstrate that water quality requirements can be met while overflowing. Perhaps it would be possible to allow overflow through the hull rather than over the sides.

M&N also wonders if it is possible that the rock may already be fractured from prior blasting and could be excavated without, or with less, blasting. We communicated with an individual who worked on a 1959-1961 deepening project on the Delaware River above Florence, NJ where they successfully dug the rock with a cutterhead dredge although the rock was hard. Our independent estimates suggest that this would reduce project costs. This item can be further addressed by reviewing prior drilling and blasting records. It may also be desirable to perform additional field data collection to evaluate the potential cost reduction.

Overall, M&N is pleased with the approach, quality and final results of the District's updated new work and maintenance cost estimates. We have been over each aspect of the estimates and debated/resolved critical items with the District in a forthright and satisfactory manner. We are of the opinion that further opportunities exist to lower the cost of the project as outlined in the paragraphs above. The following section summarizes a sensitivity analysis that addresses the potential range of costs for the project.

3. FEDERAL DREDGING COSTS – SENSITIVITY ANALYSIS

Sensitivity analyses were conducted to analyze the effects of uncertainty on the project first costs. The sensitivity analysis considered potential impacts on the federal dredging cost estimate from differing assumptions concerning dredging efficiency, dredge



selection, and material composition. The sensitivity analyses conducted for this analysis include the following:

Sensitivity Test #1 - an increase in the effective hopper capacity of hopper dredges for no overflow conditions from roughly 25% of hopper volume to 35% of hopper volume;

Sensitivity Test #2 - economic loading allowing for overflow;

Sensitivity Test #3 - excavation of potentially pre-blasted/fractured rock with a cutter suction pipeline dredge; and

Sensitivity Test #4 - a 25% increase in the volume of rock quantity.

The results of the sensitivity analyses are shown below.

**Sensitivity Analyses on Project Costs
(\$ millions)**

Sensitivity Analyses	First Cost	Change from Base Estimate	Percent Change from Base Estimate
Base Estimate	\$208.4	\$0.0	0%
Test # 1	\$190.3	-\$18.1	-9%
Test # 2	\$180.0	-\$28.4	-14%
Test # 3	\$199.1	-\$9.3	-4%
Test # 4	\$211.6	\$3.2	2%

Tests #1, #2 and #3 act to reduce the cost compared to the base cost, Test #4 results in a cost increase. Test #1 is plausible inasmuch as existing field data support the increased hopper load for no overflow. Test #2 can only be achieved with hopper overflow, but there are good reasons to consider overflow as existing field data show that overflow in the Delaware would not adversely impact the physical environment. Test #3 considers the possibility that some previously blasted rock could be removed with another dredged type. Test #3 can be verified through further study. Test #4 is more hypothetical as the rock quantities are based on detailed geotechnical and survey information.

4. ASSOCIATED COSTS

The associated costs were prepared by S.T. Hudson Engineers. Draft reports summarizing the basis for associated costs were reviewed by M&N, addressing the following terminals:



- South Jersey Port Corporation, Beckett Street Terminal
- Philadelphia Regional Port Authority, Packer Avenue Marine Terminal
- Valero, Paulsboro Refinery
- Sunoco-Marcus Hook
- Sunoco-Fort Mifflin Refinery
- Sunoco-Hog Island Facility
- Phillips 66 Trainer Refinery
- Coastal Eagle Point Oil Company
- Wilmington Delaware
- Conrail Pier 122 & 124

M&N reviewed each of these reports in detail. This review was followed by a series of telephone conference calls that served to resolve specific issues. The following sections discuss associated dredging and associated facility costs separately.

4.1 Associated Dredging Costs

4.1.1 Initial Dredging Costs

STHE used a consistent approach to estimate associated dredging costs for each terminal. Recent bathymetric surveys were used to estimate material quantities. Quantities computed from the surveys were used with a unit cost (\$/cy) for dredging and dredge material disposal. The unit costs for non-rock material were based on quotes provided by Weeks Marine (a local dredging contractor). The unit costs include mobilization, demobilization, dredging and disposal at the Whites Basin disposal facility (owned and operated by Weeks Marine). This contractor apparently performs maintenance dredging for the various marine terminals located along the Delaware River for similar prices to those quoted for this project.

M&N expressed concerns regarding this approach. Specifically, the unit prices were not built-up in the same fashion as the Federal dredging estimates using the CDEP approach. Further, the unit costs depend on information provided by a single contractor, the unit cost does not vary significantly from terminal to terminal, and the costs are high compared to those computed for adjacent Federal Channel segments. After considerable discussion, STHE's approach was accepted inasmuch as the unit costs are judged to be conservatively high. It should be noted that considerable savings could be achieved by



combining associated new work dredging with dredging of adjacent Federal Channel segments.

Rock dredging is required at the Sunoco Marcus Hook terminal. STHE's approach was to extrapolate previous District estimates of unit costs. This approach also produced a conservative cost estimate and was eventually superseded by a more detailed and less costly estimate developed by the District. We concur with the District's approach.

4.1.2 Maintenance Dredging Costs

STHE based maintenance dredging costs on information provided by owners supplemented by STHE's knowledge of conditions (where applicable). The values are considered to be most reliable at terminals where the owners do not currently dredge, less reliable where they do. A more convincing case for terminal maintenance volumes would be based on comparative bathymetric surveys. In the absence of this information, M&N critically reviewed the existing maintenance volumes at those terminals providing project benefits and where maintenance dredging is or will be required. These include Beckett Street, Packer Avenue, Phillips 66, and Sunoco Marcus Hook.

Vertical shoaling rates were computed and volumes were compared to the total volumes for the adjacent Federal Channel segments. Finally, maintenance dredging permit records were reviewed for consistency. In the end, the existing rates were accepted inasmuch as the volumes were generally consistent with comparisons to other information.

Future projected maintenance dredging volumes for the deepened terminal areas are critical to project planning. Specifically, it is the difference between existing (40 foot channel) and future (45 foot channel) maintenance volumes that is key. STHE provided their professional opinion as to the incremental maintenance volumes. After considerable dialogue, M&N remained concerned that there was insufficient basis for the STHE incremental volumes. Accordingly, M&N prepared an independent assessment of future sedimentation rates at each of the relevant terminals. Results of this analysis (forwarded to the District) produced a slightly higher total incremental maintenance volume. The distribution of incremental volumes by terminals also varied from the STHE estimates. Nonetheless, M&N's independent maintenance volumes do not materially change STHE's annual maintenance costs estimates as the volumes are not substantially different and STHE uses a relatively uniform/high unit cost for dredging at each of the terminals.



4.2 Associated Facility Costs

STHE evaluated existing marine terminal infrastructure (principally marine structures) to determine modifications needed to implement the deepened channel. The project team took the approach that the existing pier, wharf and dolphin structures were in sound structural condition, and would continue to be maintained in that condition in the absence of the deepening project. At the request of M&N, STHE reviewed all existing structure inspection reports and structure maintenance history at their disposal. This review confirmed that the terminals providing benefits to the project are maintained by their respective owner/operators and are generally in sufficiently good repair to justify assumption of full structural integrity as shown on existing engineering drawings. The only exception to this finding is the Packer Avenue terminal where there are visible signs of structural deterioration. It is not clear that the present state of deterioration at the Packer Avenue is problematic (a condition inspection would be required to make a full determination). Nonetheless, maintenance of each of the terminals to full structural integrity is required for the existing channel depth.

Structural modifications will be required at several of the terminals in order to accommodate the channel deepening. Specifically, structural modifications are required at Beckett Street, Phillips 66, and Sunoco-Marcus Hook. The specific structural modifications presented by STHE were reviewed for reliability and cost. Overall, M&N concurred with the need for, the nature of, and the estimated costs for these modifications.

M&N had one fundamental technical concern regarding structural analysis of cellular sheet pile cofferdam structures located at Beckett Street and Packer Avenue. The analysis presented by STHE indicated that one facet of the cell structures had unacceptably low factors of safety. Using a conventional stability analysis supplemented by engineering experience, STHE provided an initial justification as to why this did not present a problem. Numerous discussions ensued before STHE provided a justification that was acceptable to M&N.

5. CONCLUSION

M&N has completed its independent technical review of the subject project. Through a combination of efforts (including comments, discussion, independent estimates/analyses, and issue resolution) M&N is satisfied that the Federal and Non-Federal cost estimates for the Delaware River Main Channel Deepening Project have been prepared in a rational and accurate manner.