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Independent Technical Review of Navigation Studies

Final Report

Autoridad del Canal de Panamá

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Great Lakes Dredge & Dock Company

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PEER REVIEW

By

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Introduction.

Great Lakes Dredge & Dock Company (GLDD) was contracted to perform a peer review of ACP expansion plans focusing on dredging and dry excavation methods and techniques used to develop cost estimates and schedules.

As ACP continues its successful transition to operating more like a private business, it has proved willing to open itself up for critical review both internally and externally. With the encouragement of ACP, GLDD comments are intended to provide the same criticality and frankness that GLDD provides of its own operations and equipment on a regular and recurring basis. It is difficult to perform a "quick" review of any dredging operation, particularly of a successful operation that has been ongoing for many years with experienced and skilled personnel and equipment. GLDD does feel a significant commonality with the ACP given the historically open communications and similar equipment fleet. It is hoped that GLDD comments will prove of value to the ACP management team as well as our brethren in the ACP Dredging Division.

Acknowledgements

Ing. Gustavo Rivas has been extremely helpful and professional in his assistance to us on this study. His determination to provide as much feedback as possible as well as his ability to arrange site visits and meetings on short notice has allowed us to provide a wide scope of discussion in our presentation. Ing. Yolanda Chin has provided clear direction to keep the study focused on the task at hand while encouraging objective analysis based on available information. The Equipment Masters were all very open, helpful, and professional. Their's is a thankless job that receives little glory and much frustration with typically little more than an occasional atta-boy to show for it. Each of the Equipment masters had the obvious respect of their crews which is typically the desired reward for such men.

Project Sequence

In accordance with ACP requests, GLDD has reviewed four reports provided by ACP, made inquiries of ACP planning and operations personnel, and visited the equipment and field personnel.

The four reports were presented to GLDD by Ing. Gustavo Rivas of ACP on 18 November 2003 and preliminary review was begun immediately. An initial round of questions and requests for additional information were presented by GLDD to ACP the following week. ACP responded partially to the inquiries promptly as information became available.

This discussion was followed by a kick off meeting on 3 December 2003 in ACP offices attended by William Hanson of GLDD as well as Agustin Arias, Yolanda Chin, Luz De Pinzon, and Carmen Cano of ACP. Additional clarification meetings were held the same day between Hanson and Chin joined by Gustavo Rivas and Rolando Rivera of ACP. Much discussion focused on information requested by GLDD and its availability or applicability to this study. In summary, it was agreed that GLDD would limit the scope of the study to the information presented in the four studies with limited additional detail and information from ACP.

A site visit was made by Messrs. Hanson, James McNally, and Don Mackie of GLDD and Ing. Mario Matheu of Sococo. After orientation meetings with ACP staff, GLDD personnel were escorted to the Drill Boat Thor, Dredge RMC and Mindi where meetings were held with equipment staff and crew. Mr. Matheu was escorted separately to landside excavation sites by ACP personnel. Subsequent meetings were then arranged and held with other groups of ACP. Discussion were held with Dredging Division personnel regarding available daily report information. Survey Division personnel provided discussion of available bathymetry as well as a discussion of sequencing of surveys in relation to the dredge operations. Geotechnical Division personnel discussed available soils data, particularly the vast amount of information available on land and the limited data available for the marine portions of the canal.

ACP and GLDD personnel reviewing sample of drill boat reports.

Report Structure.

In response to the various tasks requested by ACP, this report is structured as follows:

1. Review and Comments Regarding ACP Report "Technical Analysis of the Deepening of the Atlantic Entrance to Drafts 41.5', 46', and 50'".

    a. Description of Work
    b. Working Environment
    c. Geotechnical Issues
    d. Quantities
    e. Equipment
    f. Disposal
    g. Production
    h. Costs

2. Review and Comments Regarding ACP Report "Technical Analysis of the Deepening of the Pacific Entrance to Drafts 41.5', 46', and 50'".

    a. Description of Work
    b. Working Environment
    c. Geotechnical Issues
    d. Quantities
    e. Equipment
    f. Disposal
    g. Production
    h. Drilling and Blasting
    i. Costs

3. Review and Comments Regarding ACP Report "Technical Analysis to Deepen Gatun Lake and Gaillard Cut to Design Channel Bottom of 27.5' PLD".

    a. Description of Work
    b. Geotechnical Issues
    c. Quantities
    d. Equipment
    e. Disposal
    f. Production
    g. Costs

4. Review and Comments Regarding ACP Report "Technical Analysis of Gaillard Cut Widening 1-Way Post-Panamax Traffic".

    a. Description of Work
    b. Geotechnical Issues
    c. Quantities
    d. Equipment
    e. Disposal
    f. Production
    g. Costs

5. Comments regarding Dry Excavation

6. Comments regarding Dipper Dredge Rialto M. Christiansen

    a. Equipment Design and Layout
    b. Support Equipment
    c. Labor
    d. Wear Part Inventory
    e. Equipment Utilization
    f. Equipment Maintenance
    g. Instrumentation
    h. Safety
    i. Comments on Suitability for Use in Expansion Efforts

7. Comments regarding Cutter Suction Dredge Mindi

    a. Equipment Design and Layout
    b. Support Equipment
    c. Labor
    d. Wear Part Inventory
    e. Equipment Utilization
    f. Comments on Suitability for Use in Expansion Efforts

8. Comments regarding Drill Boat Thor

    a. Equipment Design and Layout
    b. Labor
    c. Equipment Utilization
    d. Comments on Suitability for Use in Expansion Efforts

9. Comments Regarding Survey

10. Summary

Executive Summary

Great Lakes Dredge & Dock Company completed a review of four ACP canal expansion planning studies, an inspection of ACP dredging vessels, and interviews of ACP dredging personnel under contract to ACP. The purpose of the study was to conduct a review of the planned dredging studies and ACP dredging operations. GLDD's 114 years as an international dredging contractor and operator of similar equipment as well as its long-term relationship with ACP helped the process.

ACP equipment was found to be very capable and flexible. Crews were in good morale and professional. While there are always recommendations for improving dredge equipment (and GLDD does provide such recommendations) in general the equipment appears to function as designed. Additional operational planning prior to dredging would make the overall operation more efficient and can be accomplished by making geotechnical studies and utilizing the information in predetermining dredging equipment and methods. Tracking and cataloging actual dredge performance data will also provide opportunity to evaluate current operations as well as use said information in estimating future performance.

The reports themselves were found to be complete in scope, in terms of cost evaluation, production estimating, and technical issues. We note the following points further developed in the resulting report:

- Estimating dredging and excavation costs begins with real geotechnical information. A major information gap of the studies is a lack of available detailed geotechnical information in the canal waters. Assumptions made in relation to geotechnical conditions are mostly based on experience. In areas where the canal has dredging experience, this not an unreasonable approach, but in areas where there is little deepening experience such as the canal Pacific entrance, it is a difficult assumption.

- Estimated costs for Atlantic Entrance Deepening and Deepening of Gatun Lake and Gaillard Cut costs are believed to be conservative based on conservative estimates for dredge performance. Previous successful dredging efforts in these areas reduce risk in the estimates, and allow for further study to optimize costs.

- Lack of geotechnical information makes estimated costs for the Pacific Deepening unreliable. Without previous experience with new work dredging, or drilling and blasting in this area, risk factors in the estimates are dramatic. Therefore assumptions required to be made are not supported as in the other studies. The difficult material expected to be dredged and the difficult site conditions make extrapolation of data from dissimilar work elsewhere in the canal unreliable. Information from the seismic survey performed in the Pacific entrance give a snapshot, but are not reliable enough to make a value judgment as to the extent or quality of the required work.

- Daily costs developed for ACP equipment are reasonable reflecting the difficulty of working within the canal and are otherwise within industry standards. They are derived from historical data that while incomplete in detail, does allow a reasoned approach. Recent additional cost controls will hopefully allow for future tracking of detailed costs related to the operations.

- Operation of ACP equipment on site is reasonable and in accordance with industry standards. It is apparent that the ACP has a thorough and well implemented safety program. The equipment appears to be in good shape and well maintained.

- Historical records are accumulated in a reasonable format, but would be more useful if actual performance records were compiled and used. The equipment records summaries for this study are not adequate to analyze equipment or project performance. As this information is important in making judgment regarding previous production and costs, it is assumed that such information is available elsewhere.

- Important decisions to build new equipment are developed briefly in the reports, although it is unclear in these reports how final determinations were made. The need for the new build equipment is not clear based on information presented and perhaps should be reevaluated along with study of optimization of current dredging fleet or other sources of equipment such as existing inventory outside the canal or to private contractors. Data presented suggests that drill boat capacity will be stretched. Data also suggests that optimization of the dredge Mindi would be preferable to acquisition of a new CSD, while an additional dipper dredge type vessel could provide cost effective benefit.

- Dry Excavation costs result from historical projects where work is contracted to private companies. Accordingly, there is substantial historic price and scheduling data available. The ACP reports use this data in a correct manner, allowing for a high comfort level with the estimates.

- The sensitivity of the unit costs to the massive quantities to be moved given the magnitude of the project, makes review and optimization of every facet of the work important.

- As with all studies, there is recognized a need for additional detail. In addition, dredging questions are always best answered initially with "it depends". The ACP studies do raise important issues relative to the study, and if an opportunity exists to revisit raw equipment performance data, reports will be more conclusive. Full fledged geotechnical studies likewise will allow more defined conclusions. We do not pretend to predetermine the outcome of additional study or review of data, but would expect that such action will assure ACP that its determined course of action will result in best dredging value for the ACP.

Section 1. Review - Comments Regarding ACP Report "Technical Analysis of the Deepening of the Atlantic Entrance, Drafts 41.5', 46', and 50'".

Description of Work.

The Atlantic side dredging work will likely be the least difficult dredging work to be undertaken in the Canal expansion. Based on the synoptic information provided, ACP expects to encounter mud over gatun rock. All material will be pumped to upland sites adjacent to the dredging areas or pumped to the ocean disposal sites outside the breakwater. In any event pumping distances are expected to be within 3 km of the dredging area.

Major risks in assessing cost of work will be identification of quantities of gatun rock, existence of unexpected coral rock, and disposal of dredged material. These issues remain the same no matter the depth of the project.

Working Environment.

The working environment on the Atlantic side is in protected waters and therefore no issues are expected with sea conditions. It is noted that the Dredge Mindi will use the disposal area outside the breakwater for a portion of the work, but by pumping direct over the breakwater.

Geotechnical Issues.

In the ACP reports, Dredge Mindi Captain suggests that he expects most material to be softer except in the area of Station 7+700 to 9+900. Also based on his recommendations, geotechnical assumptions are made for 16% of the project area to be hard material in the 41.5' study, and 9% of the project area in the 46' and 50' study. Assumptions are made that the material is either 100% soft or 100% hard. This is rarely the case in a dredging environment where there is typically layer of mud of rock that effects production of both types of material.

The reports do note the lack of seismic and geotechnical data. A comprehensive geotechnical survey should be made of dredge areas to better define the materials to be encountered. This not only will allow in selection of proper dredging equipment, type of cutterhead and planning of dredge cuts, but also will allow for better management of the disposal areas. Reliance on prior experience to define the rock areas is particularly risky in the deeper options of –46 and –50 draft as the areas including rock could vary significantly from past shallower experience.

Quantities.

ATLANTIC STUDY VOLUMES 4/19/2004 JGM

GLDD 041304 results		GR	OD	Total	GR	OD	Total	GR	OD	Total
Area	Stationing	14.2 m	14.8 m		15.5 m	16.1 m		16.8 m	17.4 m	
#1	STA -2+700 TO -1+000	7	854	862	11,552	16,090	27,643	46,782	16,712	63,495
#2	STA -1+000 TO 3+300	342,069	243,349	585,418	1,132,624	539,776	1,672,401	2,323,986	568,871	2,892,856
#3	STA 3+300 TO 7+700	442,082	235,676	677,758	1,151,992	534,061	1,686,054	2,350,321	579,026	2,929,346
#4	STA 7+700 TO 8+800	175,035	109,129	284,164	441,280	137,481	578,761	740,365	139,581	879,946
#5	STA 8+800 TO 9+900	287,221	90,577	377,798			0			0
	subtotal 7+700--9+900	462,256	199,706	661,962	441,280	137,481	578,761	740,365	139,581	879,946
#6	STA 9+900 TO 10+750	345,326	59,523	404,849			0			0
		1,591,740	739,110	2,330,849	2,737,449	1,227,409	3,964,858	5,461,454	1,304,190	6,765,643
		25' & 10' overswing		521,857	25' & 10' overswing		596,865	25' & 10' overswing		780,004
		GLDD Total		**2,852,706**			**4,561,723**			**7,545,647**

ACP App No. 5		GR	OD	Total	GR	OD	Total	GR	OD	Total
Area	Stationing	14.2 m	14.8 m		15.5 m	16.1 m		16.8 m	17.4 m	
#1	STA -2+700 TO -1+000	128	9,330	9,458	90,020	188,475	278,495	379,229	206,462	585,691
#2	STA -1+000 TO 3+300	212,992	246,542	459,534	1,082,584	708,056	1,790,640	2,219,422	572,659	2,792,081
#3	STA 3+300 TO 7+700	290,357	245,393	535,750	1,067,959	525,992	1,593,951	2,165,139	559,643	2,724,782
#4	STA 7+700 TO 8+800			0	766,796	227,982	994,778	1,244,896	252,375	1,497,271
#5	STA 8+800 TO 9+900			0		0	0			0
	subtotal 7+700--9+900	280,901	202,417	483,318	766,796	227,982	994,778	1,244,896	252,375	1,497,271
#6	STA 9+900 TO 10+750	199,024	55,598	254,622			0			0
		983,402	759,280	1,742,682	3,007,359	1,650,505	4,657,864	6,008,686	1,591,139	7,599,825
		ACP Total		**1,742,682**			**4,657,864**			**7,599,825**
		% Difference		**64%**			**-2%**			**-1%**

Bathymetric survey data of the project area has been provided by ACP. Our calculations on the available dredge volume agree well in the 46' and 50' draft scenarios but we show substantially more quantity in the 41.5' draft scenario. The ACP appendix 5 volumes are shown in the ACP report as table 4 on page 7 of 26. Also in the ACP study is the volume by phase (table 5 on page 8 of 26). It is not clear why the dredging by phase totals more volume to be removed. In order to avoid confusion in comparison, ACP appendix 5 numbers are used in subsequent analysis.

Further quantitative analysis is based on ACP assumptions of 16% of the dredge area being considered as medium to hard dredging and in the 41.5' analysis, while 9% is used for the 46 and 50' alternatives.

In calculations of ACP dredge quantities, an overswing of between 10' and 25' was included based on the recommendation of the Mindi Vessel Master. It is not clear in the reports whether or not this overswing is a width outside the slope template taken as an advanced maintenance measure in response to high sedimentation rate or simply the with taken outside the channel limit necessary to achieve the template slope (box cut). From discussions with the Master, this has been historically included in the dredge plan as an advanced maintenance tool in softer materials. A contractor

would normally attempt to dredge a template as defined by the client based on their needs. Often these templates include some amount of advance maintenance, normally in the form of a pit (trap) or additional depth across the cut. It is noted that it is somewhat unusual to use channel widening as an advance maintenance measure. If on the other hand it is simply the box cut necessary to achieve the design slope, it should vary with cut depth (wider in 50' draft than 41.5') and would not be necessary to include as an additional volume in the volume calculations provided the volumes are run with a sloped template.

Equipment.

ACP anticipates use of a cutter suction dredge (CSD) for the work whether it be the Mindi or a new CSD. This is a reasonable assumption in that the Mindi has successfully dredged on the Atlantic side previously and also since no records exist of drilling and blasting being required. A further discussion of the dredge Mindi and a planned new CSD are provided in subsequent equipment section. Pumping distances are within previously achieved limits, however, ACP studies recommend the use of a booster to maintain production if pipeline lengths reach more than 3 km. While the 3km limit may be a reliable cut-off based on experience, the limiting economical pump distance without a booster is highly dependent on material type (i.e. much longer for mud than clay).

Operationally, ACP tends to use rock-style cutterheads for the Mindi in order to mitigate potential damage from unforeseen conditions. There are a variety of cutterhead types including sand, clay, and a variety of rock cutters available that can compliment a dredges performance. If detailed reliable geotechnical information were available, different cutter types could be used in different materials, i.e for mud versus clay versus gatun. Note that there have been great advances made in cutterhead design over the last 10 years and most manufacturers are more than willing to participate with dredge operators in studies to develop new designs. It is understood the ACP has routine contact with major cutterhead manufacturers in order to abreast of new technology

Given the fact that there is a significant quantity of mud to be removed, ACP may wish to consider use of a hopper dredge or clamshell dredge loading scows to remove this material. Offshore disposal would allow preservation of capacity in the upland sites near the dredge area.

Disposal.

There is a separate study of the ACP disposal areas underway by a consultant. ACP upland disposal areas typically are well constructed and well managed, although certainly the massive quantities to be pumped into them will require a comprehensive management plan. If geotechnical information were available prior to the dredging operation, optimization of the disposal operation could be studied. Should production increase as a result of increased efficiency of the Mindi or new CSD, additional labor or more intense management may be required to handle the increased delivery rates.

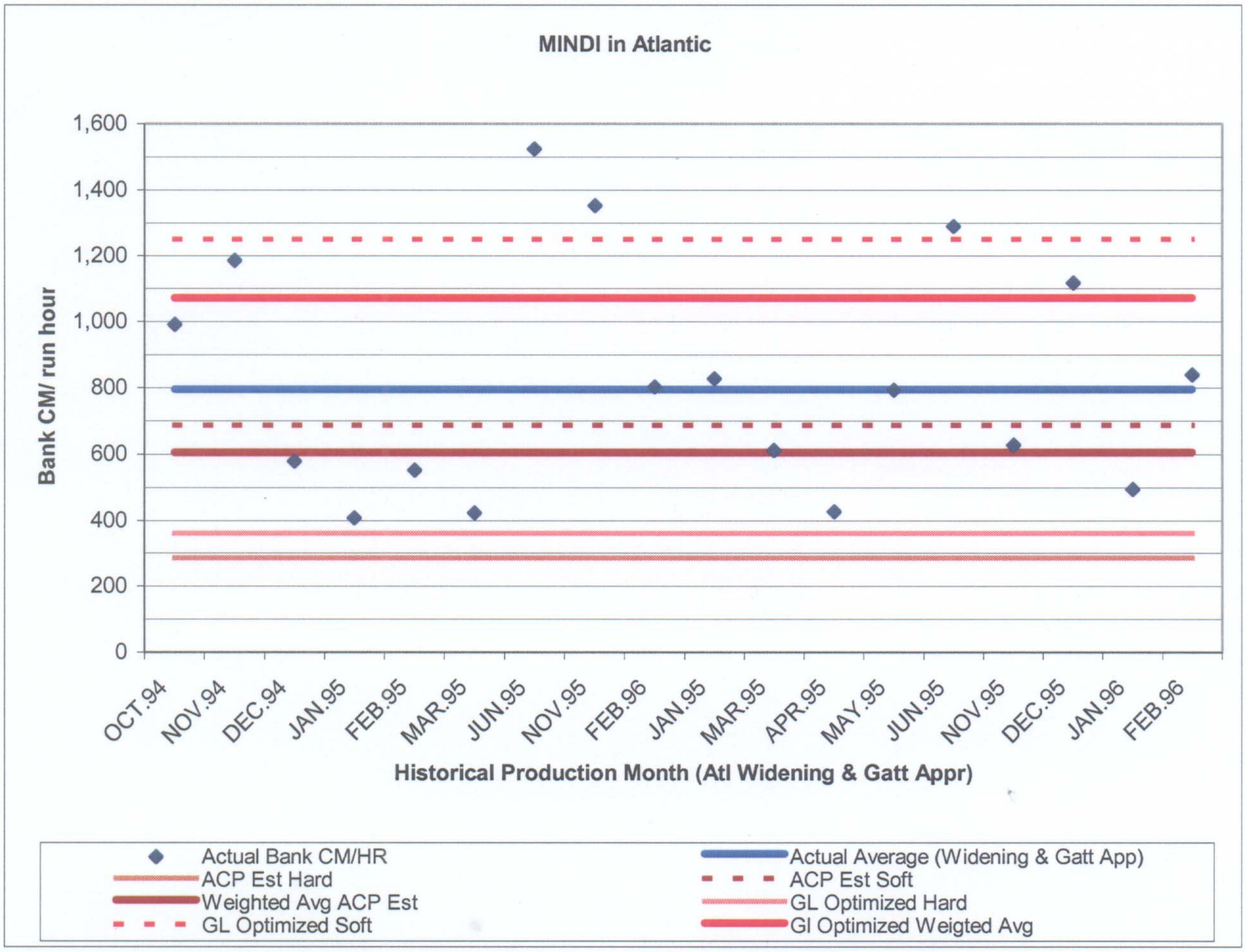
ACP has developed plans for use of the closest site available for each dredge area and thus is able to keep pipeline lengths below 3 km. This is practical and feasible. The length at which a booster is required is an important factor for cost estimation and project planning The 3km length is apparently based on ACP experience and appears to be a reasonable planning distance given the available pump horsepower of the MINDI. As discussed earlier, the actual distance at which the production vs. line length curves steepens sharply is highly dependent on material type (i.e. the MINDI could pump mud much further than clay).

Production.

ACP refers to historic productions and Vessel Masters suggestions in developing estimated productions. Upon initial review, historic and estimated productions appear extremely low for a dredge of the Mindi's specifications. Typically, a detailed review of dredge reports would give a hint of some of the reasons for the low production, whether it be delays to the operation such as marine traffic, disposal area delays, or repairs, or whether the equipment efficiency was reduced due to material type being dredged, cut geometry, available bank, type of cutterhead being used, or excessive pipeline lengths. Given the fact that the Mindi has worked in the Atlantic entrance under similar conditions previously, records may exist presenting some of this detail, however, this information is not presented nor is it referenced in the reports. If such records could be located, they should be cataloged and summarized in order to provide some explanation for the apparently low production.

Marine traffic is known to be an issue in any dredging project in any active waterway. Canal waters are no exception. A heavy impact of the MTC on ACP dredging operations is implied in discussions with ACP personnel, but documentation of the actual impact is not available. If the impact was significant, it should become the basis for ACP senior management discussion. Most major dredging projects take place in active waterways and it is very common for an ongoing dialogue to take place to assure that both of the owners desires are met: efficient prosecution of the capital improvement project and continuous safe operation of the waterway.

Monthly summaries of the Dredge Mindi's performance during the 1990's are provided. It is reasonable to use such information in this analysis as a basis to develop budget costs. It should be noted that dredge production is extremely dependent on material type, pumping distance, thickness of cut, width of cut and lift. Nonetheless, as the Mindi has dredged in this area previously, a case can be made that the dredge Mindi will be able to successfully complete the work and could easily exceed the planned production included in the study.



The graph above shows the actual average bank cubic meter per hour achieved by the Mindi on a monthly basis (the blue diamonds) during work on the Gattun approach (Jan 95'- Feb 96') and Widening of the Atlantic Entrance (Oct 94-Feb96). On average, the MINDI was able to move roughly 800 cubic meters per hour (solid blue line). The variation in monthly average production is dramatic with some months being as low as 400 and some as high as 1,450. This type of variation warrants further investigation of the records to understand the reasons behind the wide swing in average digging rate. It also demonstrates how records of more detail can be useful. Since average pipelength is included in the data, a review of the pipe length vs. production is possible and that review indicates that the variation is not linked to pipe length. The other likely possibilities included material type and bank height. It is assumed the most likely reason for the variation is bank height as some of this work was maintenance and a consistent bank of digging may not have been available to the dredge.

The solid brown line at 600 m3/wh is the average production from the ACP studies. This number is a weighted average of 80% soft digging (60,000 m3/wk) and 20% hard digging at (25,000m3/wk) and assumes 12.5 operating hours per day as discussed in the ACP estimates.

The solid red line is a weighted average of the "GL Optimized" estimate as discussed below. The graph also shows hard and soft production rates for the both the ACP estimate and "GL optimized" estimate. Since the available actual production rates do not distinguish between hard and soft areas of digging the actual productions are a composite of both hard and soft and as such should be compared to the weighted avg production of hard/soft for the ACP and GL optimized estimates.

It can be seen graphically that the ACP studies use an hourly production rate roughly 25% less than that achieved in past experience (600 vs. 800 m3/hr). The study explains that production is reduced from historical due to the deeper depths being dredged in the upcoming work. Since the MINDI has a ladder pump, a marginal increase in depth would not be expected to have a significant impact on production[1]. What would be expected based on past experience is spotty maintenance dredging and relatively narrow channel widening cuts. The wider and more consistent cuts of the upcoming deepening work should make a significant positive difference in production as compared to the historical experience.

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[1] The MINDI's ladder pump is believed to be underpowered, a situation discussed in separate section of this report. With an underpowered ladderpump, a dredge may be particularly sensitive to depth changes, however rectifying the ladder pump issue is preferred as opposed to reducing estimated productions with increased depth.

It is noted that based on our experience and records for a dredge with less power than the Mindi, a production of at least 42,000 m3 per week would be appropriate in Gatun rock (360 m3/hour for 16.8 hours per day), while in mud a production rate of some 150,000 m3 per week (1,275m3/hour for 16.8 hours per day) would be reasonable. Note further that the dredge, GL dredge Georgia, used for comparison was built in the 1930's , operates without a ladder pump, and has 700 hp on the cutterhead. The Mindi, of course, was built in the 1940's, but has a ladder pump and 1000 hp on the cutterhead. Therefore the hourly productions referenced should be achievable by the Mindi. Using the 80/20 split between soft and hard digging the GL weighted average production is 1,092 m3/wh and is shown as the solid red line on the hourly production graph.

The operating time more generally experienced is 70% of the day operating or 16.8 hours. The 12.5 used in the ACP estimates may be appropriate given the unique challenges of navigation coordination within the canal, but that assumption cannot be confirmed without more detailed records of why the dredge may have averaged 12.5 hours per day in the past.

ACP studies include a second scenario where the new CSD dredge is used to perform the deepening work in the Atlantic. ACP anticipates a 50% increase in production for the new CSD. It is unclear how this estimate is developed, whether it is a result of better running time, additional pumping power, cutting power, or pump size or other operational factors. Since no data is provided on the dredge, it is difficult to assess whether this is a reasonable assumption.

Costs.

The ACP report for the Atlantic Deepening relies on annual cost data through 1998 increased by inflation to develop annual costs for the dredge Mindi. For purposes of this study, this method is acceptable. In a similar fashion as to the production discussion, it would be helpful to have an analysis of important cost components affecting total costs such as length of pipeline, wear of pipeline and dredge equipment as a result of type of material being dredged, type of disposal, etc. ACP anticipates that recently implemented cost tracking methods will provide greater detail. The scope of this study did not include review of the new cost system, but it is assumed that it will allow for a more definitive analysis of operational costs. Cost data for equipment and pipeline wear, maintenance, and fuel can also be accumulated separately for each area dredged for each piece of equipment.

Utilization of 270 days per year is applied to develop the daily cost from the annual cost. The estimate assumes the dredges will be working 11 months a year with 6 months down every 5 years, so the dredges will average 9.8 operating months per year (+/-300 days). Using a rate developed with 270 days, the dredges would typically accrue +/- 10% more costs than the average annual fixed cost.

Hourly costs can vary by as much as 30% depending upon what type of material the dredge is working in due wear on the equipment. ACP rates appear to include this type of wear. Labor, support equipment, and fuel costs as percentage of total costs are also reasonable.

Division overhead is included at 12% which is realistic, however, no consideration is made for administrative overhead in support of the dredging division. Channel usage fees and transit fees are a significant part of contractors costs working in canal waters. It is assumed that as these fees are not included in this report, that they are included in ACP overhead elsewhere.

ACP assumes the same daily cost for the new CSD. No allowance for acquisition costs or other ownership costs is made even for the new equipment. As such records are not available as part of the scope of this review, no further study of this issue is made.

In developing a summary of costs for the Atlantic entrance, the dredge Mindi is the obvious basis since this dredge has successfully completed works in the area. Without detailed geotechnical work or detailed analysis of the Mindi' performance, it is difficult to develop estimates for other dredges. Based on the limited information available, the Mindi production estimates are significantly low and therefore the estimated costs are significantly high. For cost comparison purposes, the ACP estimated MINDI production in the attached spreadsheet is shown in comparison to a "GL optimized" estimate. The GL dredge Georgia production rate (m3/wh) is used as the basis of the optimized dredge in the analysis. The ACP estimated 12.5 hours per day is used although this could be improved significantly. Without detail on the types of delays and distribution of that delay time amongst various causes, it is not prudent to recommend use of a more typical operating efficiency (16-18hrs/day). Even with the 12.5 hours per day included in the GL optimized estimate, a 35% decrease in project cost and time is shown as compared to the ACP study.

Given the absence of any detail on the new CSD specifications or costs, no attempt is made to estimate cost or time using the new CSD.

Atlantic Entrance Cost Comparison Table

Atlantic Entrance	ACP Estimates			Optimized GL Estimates		
	41.5' Draft	46' Draft	50' Draft	41.5' Draft	46' Draft	50' Draft
Total Dredge Volume	1,742,682	4,657,864	7,599,825	1,742,682	4,657,864	7,599,825
Underwater Drill/Blast						
Total Budget	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000
Dredging						
% Soft	58%	79%	80%	58%	79%	80%
Soft M3	1,004,742	3,663,086	6,102,554	1,004,742	3,663,086	6,102,554
% Hard	42%	21%	20%	42%	21%	20%
Hard M3	737,940	994,778	1,497,271	737,940	994,778	1,497,271
CSD in Soft Material	MINDI	MINDI	MINDI	MINDI	MINDI	MINDI
CSD Soft M3	1,004,742	3,663,086	6,102,554	1,004,742	3,663,086	6,102,554
Work Hours/24 hour Day	12.5	12.5	12.5	12.5	12.5	12.5
Soft Prod (M3/Work Hour)	686	686	686	1,275	1,275	1,275
Soft Prod M3/Week	60,000	60,000	60,000	111,563	111,563	111,563
Dredge Weeks	16.7	61.1	101.7	9.0	32.8	54.7
Dredge $/M3	$5.86	$5.86	$5.86	$3.15	$3.15	$3.15
Total $	$5,889,392	$21,469,273	$35,776,223	$3,167,404	$11,546,500	$19,240,994
CSD in Hard Material	MINDI	MINDI	MINDI	MINDI	MINDI	MINDI
CSD Hard M3	737,940	994,778	1,497,271	737,940	994,778	1,497,271
Work Hours/24 hour Day	12.5	12.5	12.5	12.5	12.5	12.5
Hard Prod (M3/Work Hour)	286	286	286	360	360	360
Hard Prod M3/Wk	25,000	25,000	25,000	31,500	31,500	31,500
Dredge Weeks	29.5	39.8	59.9	23.4	31.6	47.5
Dredge $/M3	$14.07	$14.07	$14.07	$11.16	$11.16	$11.17
Total $	10,381,214	13,992,897	21,066,603	8,239,059	11,105,474	16,719,526
Dredge Weeks	46.3	101	162	32.4	64	102
Dredge $/M3	$9.34	$7.61	$7.48	$6.55	$4.86	$4.73
Total Dredge $	$16,270,606	$35,462,170	$56,842,826	$11,406,463	$22,651,974	$35,960,520
Total $/M3	$10.48	$8.04	$7.74	$7.69	$5.29	$4.99
Total $	$18,270,606	$37,462,170	$58,842,826	$13,406,463	$24,651,974	$37,960,520

If geotechnical information substantiated the existence of significant mud over the rock, it might prove interesting to consider the use of a hopper dredge or large clamshell to remove the mud prior to dredging the Gatun. For reference, such work is routinely performed by private dredging contractors at the nearby Coco Solo port facilities for prices between $2.50 and $3.00 per m3 with offshore disposal with 10 km.

In August 1999, ACP made inquiry of international dredging contractors for potential dredging work in the Atlantic in 1999. As no geotechnical data was provided for this effort either, GLDD presented a range of prices. Results of the inquiry were never made public and the tender was cancelled. ACP should review these studies to determine if in fact ACP costs are in line with industry standards.

Section 2. Review and Comments Regarding ACP Report "Technical Analysis of the Deepening of the Pacific Entrance to Drafts 41.5', 46', and 50'".

Description of Work.

The Pacific side dredging work is anticipated to be the most difficult dredging work to be undertaken in the Canal expansion. ACP anticipates that massive quantities of basaltic rock have to be removed. In addition, the Pacific Entrance exposes dredging operations to ocean swells. An extreme 6 meter tide differential challenges both survey engineers and equipment operators to pay strict attention to ever changing water elevations.

Major risks will be identification of quantities of basaltic rock and disposal of dredged material. These issues remain the same no matter the depth of the project, although the percentage of basaltic rock in the dredge quantity will likely increase with depth, and as a result overall dredge production will decrease and dredge unit costs will increase.

Working Environment.

A good portion of the working environment on the Pacific side is exposed and therefore care will have to be taken in the operation of all equipment. There will be periodic delays due to weather in offshore areas. It would be helpful to identify the Mindi's capabilities in working in open sea conditions. ABS or BV class vessels can dredge in up to 2 meter swells, but it is unknown what capabilities the Mindi has. In addition, the extreme tide differential will challenge both survey engineers and equipment operators to pay strict attention to ever changing water elevations. It would be helpful to review detailed daily logs from the periods when the Mindi has worked at the Pacific Entrance to determine if there have been significant weather related delays.

Geotechnical Issues.

A seismic study was performed in 1999 in an attempt to develop a sense of the materials expected to be encountered in the Pacific Entrance. While the scope of the original study is not mentioned, the documents made available as part of this report consist of selected bathymetry and geophysical drawings, and then finally a general description by geotechnical engineers of the results of the seismic survey. Results were correlated with previously made ACP borings in an initial attempt to understand the types of materials to be encountered in any dredging operation in the area.

There are extreme inconsistencies in the comparison of data, and unfortunately, original data is not available from ACP or the dredging contractor who performed the study in order to resolve the inconsistencies. A seismic report is typically a very preliminary study performed in order to help identify areas for further study. From a dredging perspective, GLDD experience is that geophysical studies are only suitable for indicative purposes, and useful only when supplemented by physical samples, usually a thorough campaign of borings. Included in the attachments is a technical information sheet that GLDD presents to clients to assist in developing geotech programs for dredging programs. Most importantly, it is imperative that original data and samples be retained and made available for planning and estimating purposes as well as comparison purposes while dredging is underway.

In general, the material anticipated for the Pacific entrance is mud over basalt rock. The basalt is reportedly of such strength that it cannot be dredged without pretreatment by blasting. USGS geological maps of the area confuse the issue by suggesting that the predominate geology in the area is the Boca formation which includes agglomerates and tuffs as opposed to the basalt.

A more detailed geotechnical survey is required of the dredge area to better define the materials to be encountered. Such information will allow confirmation of the extent of the required drilling and blasting as well as identify areas where blasting may not be required. The sensitivity of the dredging cost analysis based on the percentage of rock to be encountered is dramatic. Decisions to modify existing equipment or perhaps modify plans for the new build equipment are determined from this information. In addition, selection of proper dredging equipment, type of cutterhead and planning of dredge cuts, and also allowance for better management of the disposal areas will also result.

Quantities.

Bathymetric survey data of the project area has been provided by ACP and GL has run independent volume calculations. The results are shown below. In order to avoid confusion in comparison, ACP numbers are used in the subsequent analysis

PACIFIC STUDY VOLUMES (all quantities in cubic meters)

GLDD 4/13/04 Calcs Area	Stationing	41 Draft			46' Draft			50' Draft		
#1	STA 68+415 TO 70+000	335,707	162,822	498,529			0			0
#2	STA 70+000 TO 71+200	107,992	118,870	226,862			0			0
#3	STA 71+200 TO 74+000	282,127	277,314	559,441	1,024,860	362,935	1,387,795	1,755,697	371,080	2,126,777
	subtotal 70+00--74+00	390,119	396,184	786,303	1,024,860	362,935	1,387,795	1,755,697	371,080	2,126,777
#4	STA 74+000 TO 76+000	341,971	223,668	565,639	915,194	268,335	1,183,529	1,453,559	271,736	1,725,295
#5	STA 76+000 TO 78+000	63,312	167,900	231,212	570,021	263,623	833,645	1,099,027	267,041	1,366,068
#6	STA 78+000 TO 80+000	38,883	77,853	116,736	313,412	253,250	566,662	851,366	291,538	1,142,904
#7	STA 80+000 TO 82+000	164,558	155,829	320,386	650,418	348,953	999,371	1,375,080	373,819	1,748,899
#8	STA 82+000 TO 83+000	9,826	24,836	34,662	165,737	170,762	336,498	563,676	230,333	794,009
#9	STA 83+000 TO 85+920	0	1,079	1,079	48,606	101,584	150,190	357,911	337,675	695,586
		1,344,376	1,210,171	2,554,547	3,688,248	1,769,443	5,457,691	7,456,316	2,143,222	9,599,538
		50' overswing		1,536,817	50' overswing		1,578,872	50' Overswing		2,070,679
		GLDD Total		**4,091,364**			**7,036,563**			**11,670,217**

ACP App No. 5 Area	Stationing	41 Draft			46' Draft			50' Draft		
#1	STA 68+415 TO 70+000	408,134	203,720	611,854			0			0
#2	STA 70+000 TO 71+200			0			0			0
#3	STA 71+200 TO 74+000			0	1,129,205	435,121	1,564,326	1,908,139	463,203	2,371,342
	subtotal 70+00--74+00	576,075	361,947	938,022	1,129,205	435,121	1,564,326	1,908,139	463,203	2,371,342
#4	STA 74+000 TO 76+000	452,291	249,408	701,699	1,071,232	299,849	1,371,081	1,669,953	299,362	1,969,315
#5	STA 76+000 TO 78+000	158,012	179,735	337,747	691,987	298,920	990,907	1,288,852	298,431	1,587,283
#6	STA 78+000 TO 80+000	200,718	58,536	259,254	479,297	281,568	760,865	1,090,381	307,203	1,397,584
#7	STA 80+000 TO 82+000	298,098	207,059	505,157	834,118	443,572	1,277,690	1,692,906	416,141	2,109,047
#8	STA 82+000 TO 83+000	5,564	54,250	59,814	134,534	150,810	285,344	531,991	241,656	773,647
#9	STA 83+000 TO 85+920	0	289	289	51,135	58,523	109,658	282,214	355,875	638,089
		2,098,892	1,314,944	3,413,836	4,391,508	1,968,363	6,359,871	8,464,436	2,381,871	10,846,307
		ACP Total		**3,413,836**			**6,359,871**			**10,846,307**
		% Difference		**20%**			**11%**			**8%**

- The ACP volumes shown above are from appendix no. 5 of the Pacific Study and reportedly include a 50' overswing. The estimates in appendix no. 8 of ACP study have more quantity in the tolerance of reach 1 (71+700 – 74+000) at the –46 & -50 depths. Volumes from appendix 5 of ACP studies have been carried forward, assuming the tolerance volume in ACP estimates is an error.

- The ACP study shows a total of 10,846,307 cms above tolerance depth for 50' draft. In a separate table, the study shows total dredge volume if the dredging were to be performed in phases. That table shows a total of 11,739,568 cms above tolerance depth for 50' draft. The reason for this discrepancy is unclear.

An important calculation is the quantity of rock to be blasted. The seismic study is not adequate to make this judgment, but is the information available to date. ACP makes an estimate of approximately 60% of the area is to be blasted and this estimate is used in subsequent calculations.

After blasting, solid rock such as basalt on the Pacific side, is subject to a phenomenon called heave. By virtue of being broken by the blast, voids are created in the rock, and the blasted material actually rises in a heap above the previous sea floor level. This phenomenon is less pronounced in less dense rock where existing voids absorb most of the blast shock. The ACP Dredging Division and Survey division are aware of this issue and after each blast a "free boat" survey is run to detect the existence of heave. If heave is found, it can become a hazard to navigation and a more complete survey is run, and a dredge is mobilized to remove the heave to below required water depth. This issue has not historically been a major problem in the Gaillard Cut or in the current work in Gatun Lake where materials to be dredged tend to be fractured and much of the historical work has been performed outside the limits of the operating channel. However, in the Pacific entrance, the predominate rock type, basalt, when blasted, can be prone to significant heave. In our experience in such materials, as much as 2.5 meters of heave is possible. Heave can be controlled somewhat by reducing amount of blasting product in the drilled hole or by alternate drilling methods. In any event, it is a factor that needs to be addressed not only from a canal safety issue, but also from a quantity view.

When measuring quantities of materials to be removed, it is important to consider heave and "bulking" because the after blast volume is the volume being dredged. Given the fact that ACP anticipates drilling and blasting is anticipated over 60% of the total area to be dredged (including the existing channel) this would create the potential of an additional 6,500,000 m3. This quantity is not included in this analysis, but is an identified risk that to be addresses in discussion of final quantities.

Equipment.

ACP discusses the limitations of the Drill Boat Thor and RMC in light of the dramatic tidal conditions on the Pacific side as well as the exposure to swell conditions. For the Thor, existing spuds and drill towers limit the ability of the equipment to reach necessary grade. In the case of the RMC, the current dipper arm and spuds are too short to allow the RMC to work in the Pacific. While these specifications do cast doubt on the usefulness of this equipment in this environment, from a contractor's perspective, they are not in themselves rationale to disregard this equipment and construct new. In fact, as discussed in the following equipment sections, it should be quite simple to lengthen and strengthen spud systems. In addition, a longer dipper arm and rack system can be designed and built for the RMC and a modified drilling system can be provided for the Thor. These ideas may well have been considered by ACP, however, no discussion is provided in the reports.

Without the RMC for work in the Pacific Entrance, the solution offered by ACP is a new drill boat designed with capability to work in the Pacific conditions, followed by dredging with the CSD Mindi and/or a new CSD. An interesting point is that although the Thor has a spud reach problem which limit availability to 70% of the day (floats off spuds at high tide) as described in the ACP study, the estimates are based on the Thor doing roughly half the drill work on the Pacific side. It is presumed equipment modifications will be made to allow the Thor the work through high tide.

While the Mindi has limited cutter power, it does have an underwater pump which assists in pumping at deeper depths. Reference to use of a booster is made to enable the Mindi to pump up to 6 km is made. While this is feasible, it is unclear if this method has been used previously with the Mindi or if so what the performance was

The new CSD is reportedly being designed to be able to pump farther than the Mindi, but there are no specifications to review therefore, it is assumed that the new dredge has sufficient pump power in order to achieve the desired results. ACP costs are calculated using the new CSD at the same production rate as the Mindi. Cutter power will also be an important factor in evaluating the performance of the new CSD.

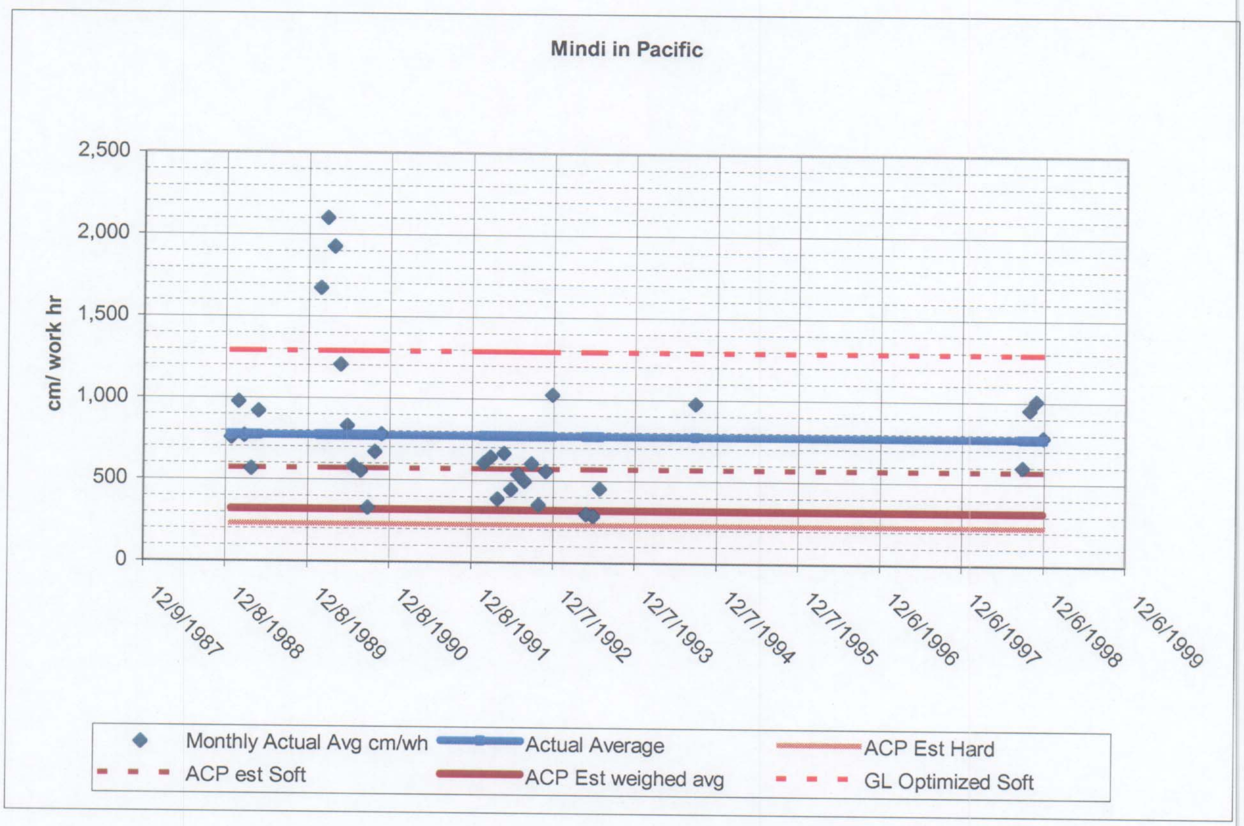
A booster is assumed to assist the Mindi in pumping up to 6 km. GLDD has extensive experience with booster pumps. There are several varieties that are used and spec sheets are attached to represent the different styles available. A study of potential uses of the boosters should be made to determine if a land based, or barge based, or jack-up based booster is the best alternative for ACP. A land based booster would be useful for much of ACP uses (and inexpensive). A barge based booster would also be useful for the ACP, and it is noted that a booster does not need to be a new build. CSD's themselves can serve as boosters. A jack up booster is an expensive option for use mainly in open sea conditions.

Disposal

A consultant is preparing a study of the ACP disposal areas. From the information reviewed for this study, the available disposal areas have adequate capacity for the volume to be dredged. The ACP upland disposal areas are well constructed and well managed. Should daily production increase in dredging of the mud as a result of increased efficiency of the Mindi or new CSD, additional labor or more intense management may be required. Care in the discharge of the blasted rock will have to be taken since this material will build quickly in the disposal area. Note that this material also has commercial value and should be stockpiled in a manner so as to allow removal of the material without impacting dredge filling operations.

The Pacific side does have an option for offshore disposal. As pipeline lengths increase, it is anticipated that a solution may be to load scows and haul material to sea. If so, the Mindi or new CSD will have to be modified for a barge loading system or a spider barge to load barges. Larger scows than currently operated by ACP would be considered although given the low production rate they are not necessary from a production standpoint, but from a convenience in terms of reducing barge change out time. Note however, that this type of capital spending will increase costs without long term benefit so the issue should be studied carefully.

Production.



The Pacific dredging is the area with the most uncertainty regarding dredge production. In the absence of the RMC, use of the CS Dredger MINDI would appear to be the most appropriate tool currently available for this project to dredge after blasting. The production estimates for the MINDI (and new CS) are based on previous MINDI experience in the Pacific entrance but it appears there has been no dredging other than maintenance in the Pacific side. The graph above shows the MINDI's actual average monthly m3/wh for the work history provided (Jan 89'- Dec98). On average it was 767 m3/wh. Also show is the ACP estimate of hard, soft and weighted average production (using 73.9% hard by volume in 50' scenario). The weighted average ACP estimated production is 318 m3/wh.

The ACP estimated weekly average productions for hard and soft digging are nearly the same as those used in the Atlantic entrance estimate but the anticipated running time per day is substantially higher in the Pacific, making the calculated m3/wh lower in the Pacific. The ACP estimated running time per day for the MINDI in the Pacific is 15 hours per day as compared to 12.5 hours in the Atlantic estimate. ACP records available do not explain why lower running time was experienced or should be expected in the Atlantic Entrance. Different results would be expected given the better swell protection in the Atlantic Entrance.

A contractors approach to estimating the Pacific side deepening would typically start with an analysis of past production that requires more details of the past production than have been made available. The critical information required is:

- Description of the material being dredged in the given production history (mud or basalt?)
- Description of the cut geometry like? Cut width, bank height etc.
- Explanation of large differences in monthly average productivity (300 to 2,100 m3/wh)

Since pipe length history is available (maximum was +/- 6,000, assumed to be feet), it is apparent that the pipe length was not the driving factor in the historical production variation.

It is assumed that the prior dredging in the Pacific was maintenance dredging and does not include basalt dredging (shot or unshot). It is also presumed that the production rates achieved were a result of the thickness and spatial distribution of the maintenance material being removed. Since future work being considered is largely dredging of shot basalt, this past production history is not useful in estimating MINDI production for the deepening.

What the ACP records do appear to show is that with enough material available to feed it, the MINDI is capable of achieving reasonably high rates of production when moving soft maintenance material. For several of the recorded months, the MINDI averaged over 1,500 m3/wh.

Given the uncertainty regarding the extent of rock, the dramatic production differences between dredging the basalt versus the overlying mud and the lack of new work experience in the area to rely on, it is apparent that additional geotechnical information is required before a reliable estimate for the Pacific entrance deepening can be generated.

Using GLDD dredge Georgia (a CSD of similar and somewhat lower specifications than the MINDI as discussed in the Atlantic Deepening section of this report), an estimate for production for the soft (non-rock) dredging of 1,286 m3/wh. This "GL Optimized" soft dredge production of 1,286 m3/wh is shown as the red dotted line on the above graph. For the hard digging, the ACP estimate of 229 m3/hr is left unchallenged as there is very little information available upon which to base a revised production rate for the basalt.

Drilling and Blasting

Drilling and blasting in basalt is quite different from D&B in conglomerate rock encountered elsewhere in the canal. As experienced in New York, where this rock type is predominate, the drilling is slow and results in extreme wear to the equipment. More detailed comments on the drilling and blasting costs are included in the equipment section, but there is more data in the reports provided for the Thor allowing for a better analysis. Much of the data came from a single test event over the course of several days. The crew on the Thor does keep very detailed records of their operation in accordance with industry standards. As with the dredges, it would be helpful to summarize this data rather than use a single event recording, particularly if another area in the canal could be identified where basalt has been drilled and blasted.

The new drill boat is being constructed using the same drilling system as the Thor. A discussion of this issue is included in the Thor equipment discussion, but a 25% increase in efficiency is expected. The reason for this increase is not known, but several options exist to improve production on the Thor that have been offered to the ACP previously including:

- Articulated drill frames to allow more than one row to be drilled each time the drill boat is setup on station. GL has noted a 20% increase in overall coverage with the articulated frames on the Apache.

- More efficient drilling systems are available using percussion drills that are faster particularly in harder rock. GL has noted a 20 to 30% increase in coverage as a result of these systems.

- Use of bulk product has also allowed reduce our product cost by some 25%. While the increase in drilling efficiency is easy to account for in our own operation, it is more difficult to quantify the savings ACP would generate for their own requirements.

The ACP reports evaluate the drilling production from this historical test and then applies it to the Pacific side, where admittedly, there is no drilling experience. A rate of 6,041 to 8,699 m2 per week is used in the DB production, depending on project depth. The Thor production ranges from 5,316 to 7,732 m2/wk while the new barge production ranges from 6,766 to 9,665 m2/wk.

A consultant study is included in the reports involving drilling and blasting. The study is laid out well, but presents confusing information regarding the use of bulk product. There is an indication in the consultants report that the use of bulk product in marine drilling and blasting applications is a novel and untried idea. This is an interesting conclusion in that GLDD has been using bulk product exclusively for its projects successfully and safely on projects around the world for over 15 years. It is recommended that recommend ACP revisit this issue with other consultants who are familiar with the products and can provide additional feedback and perhaps consider modifying the design of the towers for the new drill boat to accommodate different product and drills.

For comparison, GLDD drill boats utilize three separate drill frames with Atlas Copco hydraulic single pass drilling systems. The drill frames move laterally along a rail system covering the 110 feet of open drill deck. Drill hole diameter is 4.5 inch. The barge is configured to utilize ETI's Pourvex Extra HD bulk pumpable explosive product. The product is stored on board in 20-ton ISO tanks. The barge is held in position by four 6-foot square spuds and a four point anchoring system.

Several impacts need to be considered in the evaluation of DB production:

- Delays to due shipping. This issue is discussed later, but with much of the rock in the centerline of the channel, it will be very difficult to work with canal pilots responsible for the smooth flow of traffic.

- Weather impacts due to open ocean swells. The new drillboat is being designed with longer spuds which will be able to work in deeper depths and it is assumed also in light swell conditions.

- Tidal fluctuations. Severe tides on the Pacific side are a challenge to anyone working with them. Constant monitoring is required in order to assure proper elevations are being used.

- Harder rock. Experience shows that drilling production can decrease as much as 50% in basalt as opposed to less dense rock formations. Reduced drilling time equates to about 10% less overall efficiency in the daily operations.

- Drill pattern. ACP drill pattern works inside the canal, but if rock proves to be basalt, the drill pattern will likely need to be tightened up on the Pacific Entrance decreasing the efficiency. It would be worthwhile to calculate the powder-factor applied to the rock in historical ACP drilling and consider increasing the powder factor for the basalt.

- Drilling System. The system for making up the blast in the interior of the canal is fairly rudimentary involving a workman paddling a skiff to collect the blasting cords. While this system is not likely to be efficient in the Pacific entrance, it is assumed the new drillboat will have an alternate system in place and the Thor will operation will be modified as necessary.

- Impact on surrounding businesses. Our operations frequently involve intense seismic monitoring of third party properties for damage due to blast. Historically, there would not have been much to be concerned with except in Rodman and Balboa. With new facilities at Balboa and all along the Amador causeway, a public relations campaign will have to be instituted to respond to complaints during the course of the project. The rumble of nearby blasting often stimulates local property owners to inspect their structures for foundation or other cracking for the first time in years. The blasting is then takes the blame for any and all cracking discovered. A pre-blast survey of all the structures within a given radius of upcoming blasting is typically performed that includes a video or photographic survey of the structure to document preblast conditions . This operation also provides the opportunity to give impacted residents an indication of what to expect and where to get information on the project. This is a typical contract requirement for drilling and blasting in populated areas.

We have attached a copy of a specification from a Corps of Engineers project in San Juan Puerto Rico that provides a summary of typical environmental and seismic requirements for blasting projects.

- Performing the drilling and blasting in one phase as opposed to three is a very good idea. Projects in New York have experienced three different rounds of drilling and blasting in the same channel to accommodate Federal budget process in order to get to the current depth. The concept of drilling and blasting an additional 8.5 feet is technically challenging, but possible.

Using a theoretical drill boat with the articulated frame and percussion drills could result in increases of 20% and 25%, respectively.

Costs.

CSD.

The ACP reports utilize annual cost data through 1998 increased by inflation to develop annual costs for the dredge Mindi. For purposes of this study, this method is acceptable.

The developed estimated weekly cost of $351,750 is in line with industry standards for basic CSD equipment spreads for dredging of soft materials. Dredging of harder materials will not only decrease production, but cause additional wear and tear on the equipment, resulting in additional costs. A particularly expensive consumable cost in dredging rock blasted or unblasted is cutter teeth which must be replaced when broken or worn in order for the cutterhead to function as designed. GLDD has records of some 100 to 300 teeth per day in certain rock dredging situations. In blasted rock situations this tooth loss is reduced, but wear and abrasion cause continued high usage. For the work on the Pacific side, a reasonable estimate is that some 100 cutter teeth will be used per day. Costs per tooth will vary depending upon which cutterhead type is being used, particularly when speaking of the new CSD.

Division overhead is included at 12% which is realistic, however, no consideration is made for administrative overhead in support of the dredging division. Channel usage fees and transit fees are a significant part of contractors costs working in canal waters. It is assumed that as these fees are not included in this report, that they are included in ACP overhead elsewhere.

Utilization of 270 days per year is applied to develop the daily cost from the annual cost. The estimate assumes the dredges will be working 11 months a year with 6 months down every 5 years, so the dredges will average 9.8 operating months per year (+/-300 days). Using a rate developed with 270 days, the dredges would typically accrue +/- 10% more costs than the average annual fixed cost.

ACP assumes the same daily cost for the new CSD. No allowance for acquisition costs or other ownership costs is made for the new equipment. As such records are not available as part of the scope of this review, no further study of this issue is made.

ACP costs for the Mindi include a booster, while an assumption is made that the new dredge will not require a booster. Without details of the new dredge, it is not possible to understand this completely, other than to note that if the new CSD has that much power, then additional operating costs at a minimum for fuel would be required also. Also noted is the assumption that the new dredge will have less maintenance than the Mindi. Experience dictates that every new dredge goes through a break in period when many parts and pieces are replaced in order to make the system function properly. It may be prudent to assume that the new CSD works at reduced efficiency for the first year.

Drill Boat Costs.

In a calculation of cost per cubic meter drilled, the ACP reports estimate the Thor's weekly cost at $167,894 without explosives. Explosive costs are added to the unit price at the rate of $2.00 per m3 based on a separate calculation. Alternatively, costs were accumulated for the Gaillard Cut Widening in 2001 where weekly average costs of $251,084 were incurred, including explosives. The $251,084 cost per week including explosives is the number carried forward in the ACP cost estimates. The weekly costs for the Thor are reasonably close to rates for our drill boat 8.

Channel usage fees and transit fees are a significant part of contractors costs working in canal waters. It is assumed that as these fees are not included in this report, that they are included in ACP overhead elsewhere.

ACP assumes the same daily cost for the new Drill Boat. No allowance for acquisition costs or other ownership costs is made for the new equipment.

All things considered, the attached spreadsheet compares the anticipated costs from ACP equipment with modifications to productions suggested by GLDD in order to test the sensitivity of the costs.

Pacific Entrance Cost Sensitivities

Pacific Entrance	ACP Estimates			Optimized GL Estimates		
	41.5' Draft	46' Draft	50' Draft	41.5' Draft	46' Draft	50' Draft
Total Dredge Volume	3,413,836	6,359,871	10,846,307	3,413,836	6,359,871	10,846,307
Underwater Drill/Blast						
% Area Drilled	61%	56%	57%	61%	56%	57%
% Volume Drilled	86.50%	78%	74%	86.50%	78%	74%
Pay Cubic Meters Drilled	2,951,727	4,955,446	8,021,529	2,951,727	4,955,446	8,021,529
Area Drilled (m2)	2,597,273	2,085,323	2,133,824	2,597,273	2,085,323	2,133,824
Drill Weeks	299.1	299	356.3	271.4	270.5	321.1
M3 Drill/ Week	9,868	16,572	22,513	10,875	18,319	24,980
Approx Pay Drill Length (m)	1.14	2.38	3.76	1.14	2.38	3.76
Total Drill Length (m)	3.05	4.42	5.64	3.05	4.42	5.64
Approx M2/Wk	8,683	6,974	5,989	9,569	7,709	6,645
Approx 4 rng shots/week	18	14.4	12.4	19.8	16	13.8
$/M3 Pay	$25.44	$15.15	$11.15	$23.09	$13.71	$10.05
Total $	$75,104,193	$75,082,264	$89,463,930	$68,150,663	$67,919,476	$80,627,399
Dredging						
% Soft	14%	22%	26%	14%	22%	26%
Soft M3	462,109	1,404,425	2,824,778	462,109	1,404,425	2,824,778
% Hard	86%	78%	74%	86%	78%	74%
Hard M3	2,951,727	4,955,446	8,021,529	2,951,727	4,955,446	8,021,529
CSD in Soft Material	MINDI/New CS	MINDI/New CS	MINDI/New CS	MINDI/New CS	MINDI/New CS	MINDI/New CS
CSD Soft M3	462,109	1,404,425	2,824,778	462,109	1,404,425	2,824,778
Work Hours/24 hour Day	15	15	15	15	15	15
Soft Prod (M3/Work Hour)	571	571	571	1,286	1,286	1,286
Soft Prod M3/Week	60,000	60,000	60,000	135,030	135,030	135,030
Dredge Weeks	7.7	23.0	47.0	3.4	10.0	21.0
Dredge $/M3	$6.08	$6.14	$6.19	$2.70	$2.73	$2.75
Total $	$2,810,931	$8,627,010	$17,472,386	$1,249,025	$3,833,375	$7,763,779
CSD in Hard Material	MINDI/New CS	MINDI/New CS	MINDI/New CS	MINDI/New CS	MINDI/New CS	MINDI/New CS
CSD Hard M3	2,951,727	4,955,446	8,021,529	2,951,727	4,955,446	8,021,529
Work Hours/24 hour Day	15	15	15	15	15	15
Hard Prod (M3/Work Hour)	229	229	229	229	229	229
Hard Prod M3/Wk	24,000	24,000	24,000	24,000	24,000	24,000
Dredge Weeks	123	206	334	123	206	334
Dredge $/M3	$15.21	$15.36	$15.46	$15.21	$15.36	$15.46
Total $	44,887,179	76,099,973	124,040,940	44,887,179	76,099,973	124,040,940
Dredge Weeks	130.7	230	381	126.4	217	355
Dredge $/M3	$13.97	$13.32	$13.05	$13.51	$12.57	$12.15
Total Dredge $	$47,698,110	$84,726,983	$141,513,326	$46,136,204	$79,933,348	$131,804,720
Total $/M3	$35.97	$25.13	$21.30	$33.48	$23.25	$19.59
Total $	$122,802,303	$159,809,247	$230,977,256	$114,286,867	$147,852,824	$212,432,119

Issues Affecting Production and Costs.

Marine traffic is known to be an issue in any dredging project in any active waterway. The canal waters are no exception. The impact of the MTC on ACP dredging operations is implied in discussions with ACP personnel, but documentation of the actual impact is not available due to lack of operations reports. If such information could be provided, and if the impact was significant, it could become the basis for ACP senior management discussion.

In any event, work on the Pacific Entrance will require a very intense cooperative effort between the Dredging Division and MTC. It is assumed that the Mindi would be used for dredging the material including the blasted rock and positioned off the side of the canal and digging across as she does now in the Lake. While this will minimize delays due to traffic, it does not solve the problem of the new drill boat working in the center of the canal. Given the large area to be blasted according to the report, the position of the drill boat will be a very large concern for the MTC. Significant delays not accounted for in the estimated production will also occur.

Finally, removal of heaved material prior to ships being allowed to pass will be a prime safety concern. Experience and studies in the Kill van Kull waterway in New York indicate that it may be necessary to coordinate and use a reduced width channel during this operation. While it is an annoyance to ship traffic, New York has shown that such an operation can help the actual dredging proceed to conclusion while allowing the channel to remain open.

Section 3. Review and Comments Regarding ACP Report "Technical Analysis to Deepen Gatun Lake and Gaillard Cut to Design Channel Bottom 27.5' PLD".

Description of Work.

A portion of this work is actually already underway with the Drillboat Thor, Dredge Mindi, and Dredge Christensen (RMC) actively engaged in the Lake Deepening. This work will also include upland excavation. We understand the first contract for Gaillard Cut Straightening has already been let.

The Mindi and RMC are employed in deepening portion of the Gatun Lake and Gaillard Cut while the Thor is being used to blast portions of the project in advance of the dredges. Note that the Thor is not only blasting to allow for the deepening of the Lake for the currently approved project, but also overdrilling to elevations that would allow dredging without additional blasting for subsequent canal deepening operations. Although such records were not available as part of this study, it is important that records of this excellent planning and operational move, be made and used in future planning.

It would be interesting to evaluate this work in comparison to the last 10 years successful experience of ACP in widening the Gaillard Cut given the many similarities between the two projects. There has been much discussion of the fact that the Cut Widening Project was completed well under budget and ahead of schedule. An interesting comparison and basis for evaluation of this project would be a detailed comparison of the estimate versus cost for the various elements of the CWP as well as the performance of the equipment versus the estimated.

The historical performance of the Mindi has already been documented. In order for the GCWP to have been so successful, there must have been other factors that allowed early completion, ie, original estimate too low and costs too high; other equipment performed better than estimated, geotechnical conditions were not as difficult as estimated, costs were overestimated, or perhaps ACP developed better techniques than originally planned. One factor offered by ACP is that lower costs for land work were achieved as a result of competition in the private marketplace. In any event, when directly applicable historic data is available GLDD would tend to analyze in detail not only the historic performance of the equipment, but the performance against the original estimate. This allows a discussion so as to better estimate the costs, but also to avoid repetition of estimating assumptions not proved valid in the previous project.

The work is evaluated in two major phases. The first phase is the approved deepening to 34' PLD underway. The final phase would be to deepen the channel to 27.5' PLD.

Major difficulties and risks in the work to be accomplished in this phase will be identification of highly variable rock seams and disposal of dredged material. The Captain of the Dredge Mindi also mentioned that construction debris believed to be from the original canal construction is being encountered on a regular basis in their portion of the work.

GEOTECHNICAL ISSUES

A detailed geotechnical survey should be made of the dredge area to better define the materials to be encountered. At a minimum, a thorough survey and compilation of existing data that may be relevent to work being considered should be undertaken. This not only will allow selection of proper dredging equipment, but also will allow for better management of the disposal areas. There is much reliance on the Dredge Captains to have experience and knowledge of the material to be dredged. In this area, the general assumption is that the geology is so erratic that conservative digging techniques are employed. A comprehensive geotechnical study would allow better planning by all parties.

In addition, the RMC was dredging what GLDD describes as well shot rock. That being rock that is blasted into small pieces. Of course, having material blasted to this extent leaves no problem for the RMC, but does raise the question of whether or not the blasting effort should be reduced to save on time and blasting effort. The RMC is capable of handling much larger pieces.

QUANTITIES

Bathymetric surveys of the cut were provided as part of the study. Unfortunatley the complexity of the cut templates, the interface between dry excavation and dredging and lack of certainty regarding dredge overswing make generating a meaningful volume comparison impossible. Based on the previous confirmation of ACP quantities from the Atlantic and Pacific surveys, ACP quantities are used in the subsequent evaluation.

Volume in m3	Gatun Lake	Gaillard Cut	Total
Volume to 34' PLD	1,561,743	1,678,754	3,240,497
Tolerance to 32' PLD	2,477,712	1,384,385	3,862,097
Subtotal Phase 1	4,039,455	3,063,139	7,102,594
Volume 32' to 27.5' PLD	8,881,400	4,240,793	13,122,193
Tolerance to 25.5' PLD	4,483,839	1,830,511	6,314,350
Subtotal Phase 2	13,365,239	6,071,304	19,436,543
Total	17,404,694	9,134,443	26,539,137

Given the debris being encountered, a magnetometer survey of the area might also be appropriate in order to determine the extent of the debris. Such debris can cause severe damage to any of this equipment, or at a minumum will result in cautious operation of the equipment.

Equipment.

ACP utilizes all 3 pieces of equipment in its study and in practice. There are also plans to utilize the new drill boat and CSD in this area when they are available.

Dipper Dredge. The RMC is an ideal tool for work in this area as much of the material is well shot. The dipper type dredge has unique capabilities that make it an efficient and durable machine in dredging hard materials, including blasted rock. In some cases, the dipper type dredge can also be an effective tool in dredging unblasted rock. The RMC works with a fleet of 1,000 m3 split hull dump scows that are useful for operations in the canal. While the private industry tends to use scows from 2,800 m3 to 6,000 m3, the size and draft of these larger barges tends to make them cumbersome for canal operations. One also must consider the maximum light draft of a scow because the height the open dipper bucket can swing over is limited. It is not apparent from records available for this study that scow size has an impact on the efficiency of the current dredging operation. The RMC also works with 3,000 hp tugs towing scows to the disposal sites. The tugs are in excellent shape and appear to maneuver and handle well. Private industry would consider a 1,600 hp tug as adequate size for handling the

1,300 cy scows ACP uses with the RMC. Smaller tugs would theoretically be less expensive to operate. ACP does use the larger tugs for other purposes in the canal and so in fact higher costs would be mitigated if accounting were clarified for this expense.

CSD. The Mindi is discussed in previous sections detailing the dredge's successful history of completing work in the canal, but also limited cutter power for dredging rock. The dredge is supported by substantial attendent plant that also is well maintained. The new CSD is also discussed in previous sections, although no details are evaluated as part of the study, the dredge is planned to be employed by 2006.

DB Thor. The Thor is a capable proven machine that has recently undergone improvements and appears to operate very well in the current operation. A new drillboat is under construction and is also expected to be available in 2005. With the exception of the spud control system, the layout of the Thor is efficient. GLDD has comments about the drilling system and product type discussed in the equipment section.

Disposal.

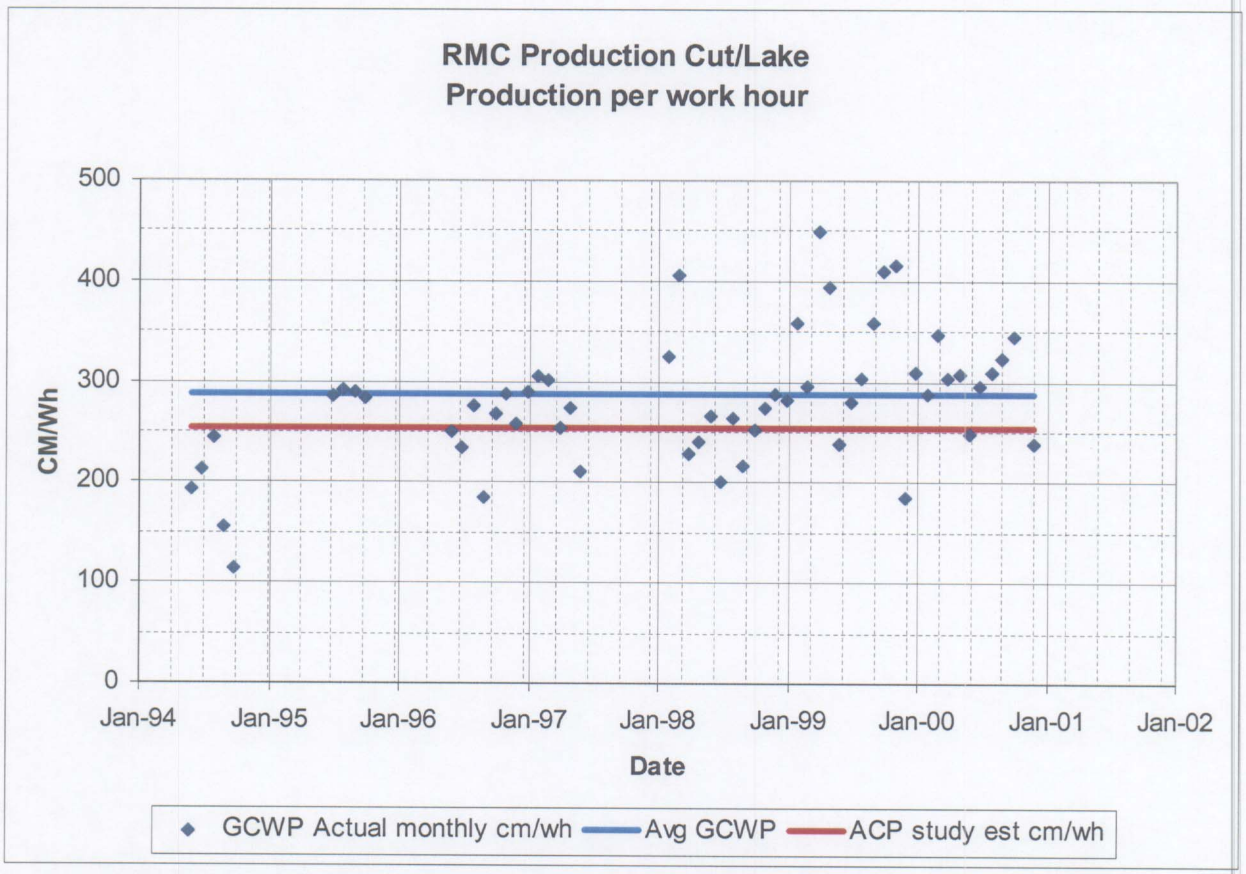
Dredge Mindi works with upland disposal sites while the Dredge RMC is using the lake disposal areas. Disposal of material will be a key issue for the Gaillard Cut works as capacities are reduced. A separate study is reportedly underway by a consultant regarding this issue.

Material excavated as part of this project, particularly rock has value in the commercial markets of Panama. No commercial credits are considered here, but there are numerous projects in and around Panama where such materials are marketed. Typically the marketing is on a much smaller level, but ACP should consider these options. Leaving this option to the contractors is not a viable option as this only clouds project commercial issues and does not leave ACP in control of its property.

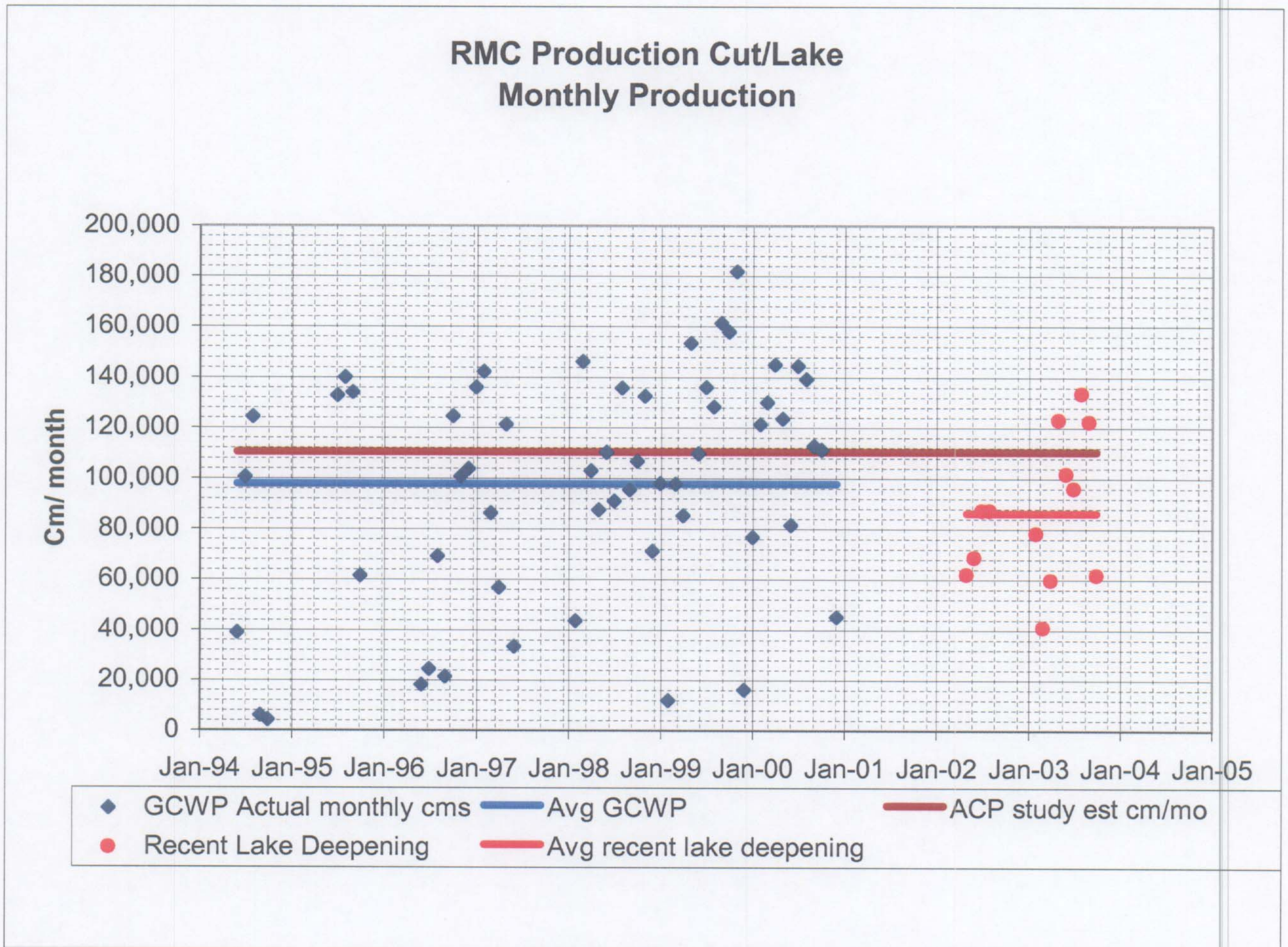
Production.

ACP reports utilize again the historic production data previously discussed for the Mindi and Thor, while the RMC is added for this section. RMC historical data provided is also summarized in a monthly format that while useful for budgeting, does not allow an analysis of equipment performance.

RMC



The graph above shows the m3/wh achieved by the RMC during the GCWP vs. that expected in the ACP study for the cut & lake deepening.



The graph above shows the monthly production achieved by the RMC during the GCWP (blue) as well as the monthly production achieved during the recent lake deepening work (red). It also shows the monthly production expected in the ACP study (brown).

GLDD has noted in previous visits with the RMC that is not being utilized to its maximum benefit in dredging overshot rock. It appears the dredge could handle much larger pieces of rock, meaning that blasting operations could be reduced by using less powder or larger drill patterns or areas could be dredged first by the RMC before blasting was attempted.

The RMC experience on the GCWP is an excellent starting point for estimating the production to expect in the cut/lake deepening. Based on the records provided, the

RMC dug at the average rate of 290 m3s per hour an average of 15.7 hours per day for a typical daily production of 4,500 m3/day. An average monthly production of 97,701 is the result of roughly 22 on-project operating days per month over the 56 months for of the RMC on the GCWP project (June 94'--Dec 00'). Note that this indicates an erratic operation that does not allow project engineers or operators to fine-tune their routine and cut patterns to optimize production.

This production appears low based on our experience using our dipper dredge Crest, which according to our records achieved 375 m3/wh in similar conditions using a similar size bucket.

The ACP study expects the dredge to move 4,000 m3s per day (presumably over 15.7 hours per day for an hourly production of 255 m3/hr). The monthly production anticipated is 110,000 m3s (28k week x 4.3 weeks per month x 11/12 for one month repairs per year).

Note also that consideration of the issue of whether or not larger size scows will effect the operation begins with a discussion of time efficiency. The 15.7 hours per day shown in the actual production for the RMC is satisfactory and does not point in the direction of the scow size unless there are operational considerations such as fuel efficiency and a desire to limit the number of trips per day. Given the satisfactory time efficiency, there is little to be gained from larger scows for this operation.

Presuming the material is not stiff enough to slow the dipper's cycle (a reasonably safe assumption in shot rock), the dredge's production is largely dictated by the bank available. This along with the additional traffic impact to be expected in the cut/lake deepening would lead one to expect somewhat lower production in the cut/lake deepening than what was experienced in the GWCP. This expectation is apparently confirmed by the recent production of the RMC is the cut/lake deepening.

The RMC production records for the on-going cut/lake deepening were not provided but total monthly productions from graphs on display in the dredging division office are used. Those monthly totals are shown in the graph above in red. Over the period of May 02' to Oct 03', the RMC has averaged 86,346 m3s per month, roughly 20% under the estimate used in the Study.

This points out a significant failing of the ACP estimate. The best information to rely on for estimating the cost and time of the project is the on-going project itself. The recent production records of the Thor on the cut/lake deepening project are included in the study and relied on but the RMC and MINDI records are not.

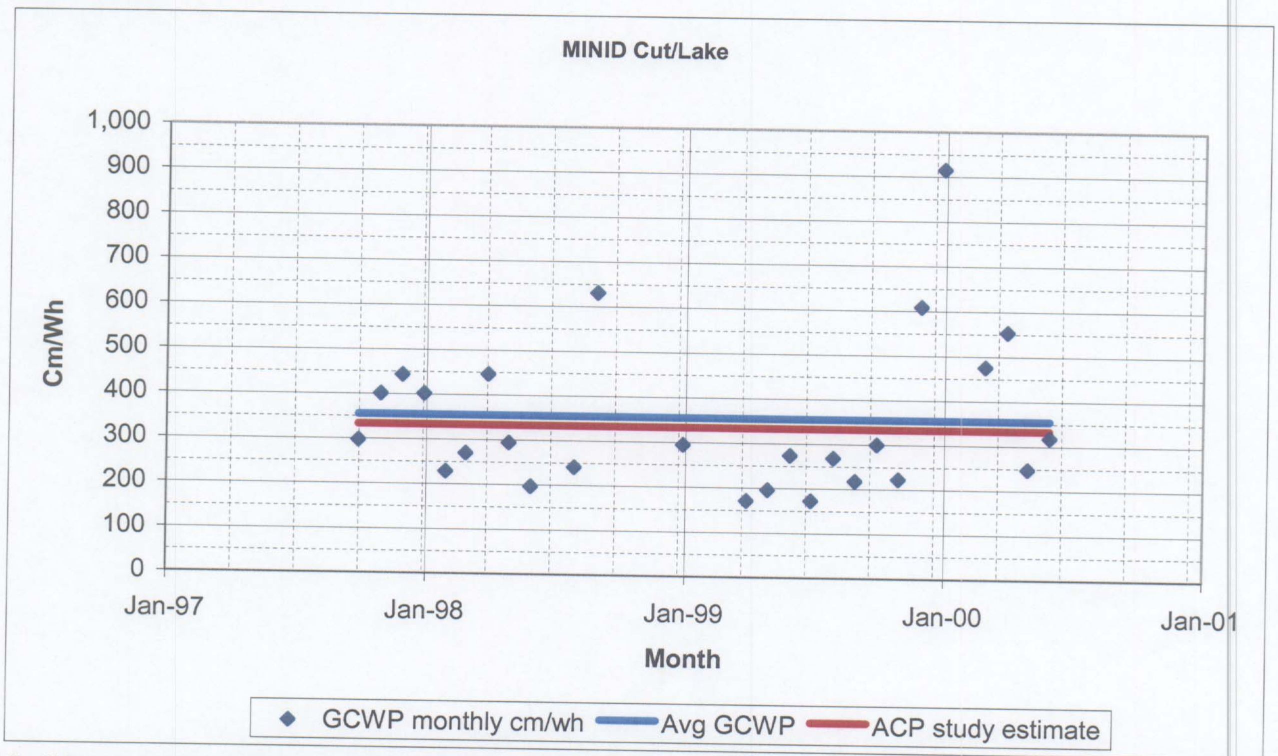
For comparison purposes, GL has used the actual production on the recent work when calculating a "GL Optimized" estimate. Since only monthly totals of the on-going work are available, 27 operating days a month are assumed and 15.7 hours per day (GCWP average) to back into a digging production rate of 196 m3/wh.

Determining whether or not the RMC could do better than the recent experience of +/- 90k m3s/month would require a detailed analysis of the current records. Questions to be answered include:

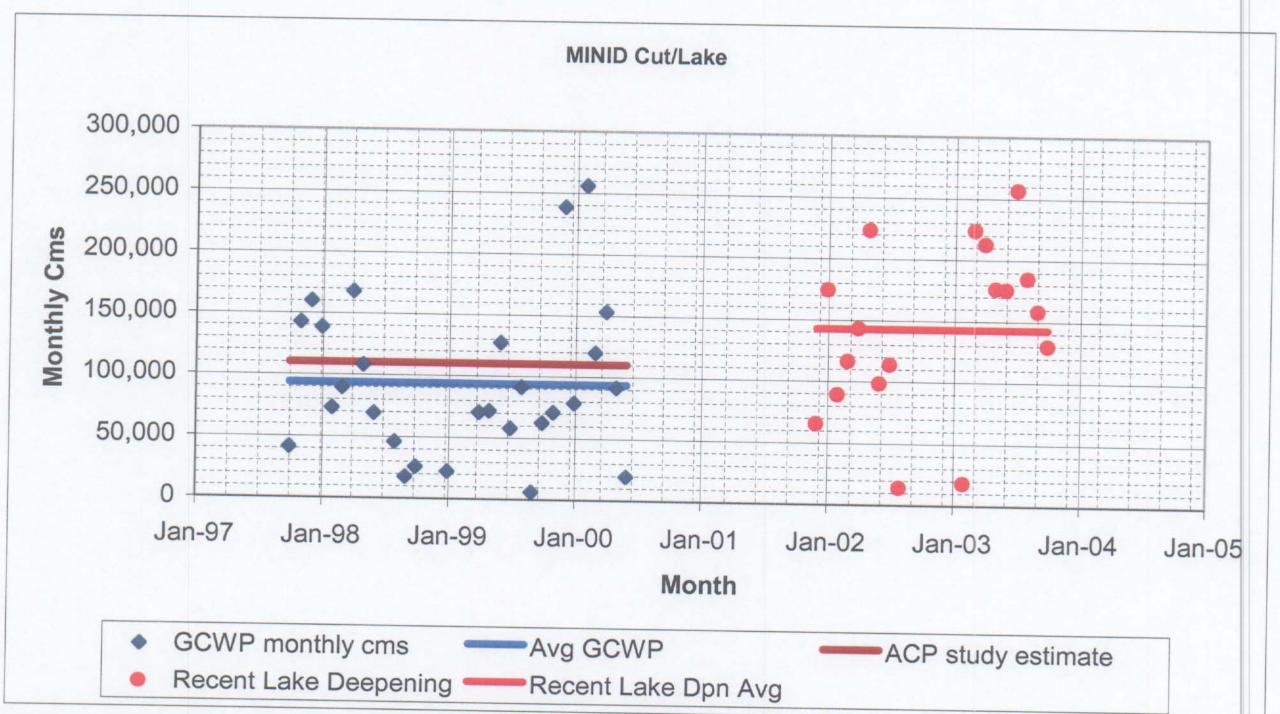
- Is the production decrease from the GCWP production rate the result of less operating hours per day?
- Less operating days per month?
- Scow delays?
- Slower cycle?
- Less available bank?

As these records are not available as part of this study , these questions are simply raised and for our sensitivity analysis the recent lower production in the GL revised estimate is used for comparison.

CSD Mindi



Mindi hourly production during GCWP (blue) vs. ACP study for cut/lake deepening (brown).



Mindi monthly production in GCWP (brown) and recently lake deepening (red). Also shown is the ACP study of cut/lake deepening estimated monthly production (brown).

The Mindi experience on the GCWP is an excellent starting point for estimating the production to expect in the cut/lake deepening. Based on the records provided, the MINDI dug at the average rate of 354 m3 per hour an average of 12.0 hours per day for a typical daily production of 4,268 m3/day. An average monthly production of 93,491 is the result of roughly 28 on-project operating days per month over the 56 months for the MINDI on the GCWP project (Oct 97'--Jun 00').

The ACP cut/lake deepening study expects the dredge to move 4,000 m3 per day (presumably over 12.0 hours per day for an hourly production of 333 m3/hr). The monthly production anticipated is 110,000 m3s (28k week x 4.3 weeks per month x 11/12 for one month repairs per year).

Discussion of the new CSD includes its production at the same level as the Mindi, while other ACP reports assume a 50% increase in production for the same machine. Without details of the new CSD, an evaluation of expected impact on production cannot be made, although clarification should be made as to why this theoretical production increase is not included in this section. Under the general conditions assumed for this study, a weekly production on the order of 49,000 m3/week for a vessel of the class of Mindi would be expected.

The production achieved by the MINDI during the GCWP appears very low. 4,268 cubic meters per day is a very low production rate for a 9,000 hp cutter suction dredge. It is unclear from the records why the MINDI averaged only 12 hours per day when presumably traffic was not a major issue during the widening. It is also unclear why the MINDI would have moved only 354 m3s per hour while digging since it is understood all of the material was shot. In the absence of any better information to base a production estimate, further investigation of the GCWP experience would be necessary.

In this case, there is better information available in the form of the cut/lake deepening dredging the MINDI has been performing since December of 2001. Between December

01' and October 03', the MINDI has averaged over 140,000 m3s of production, roughly 30% better than the ACP study has estimated. The records for this recent dredging were not included in the study and therefore there is no detail or technically based reason for the improved performance.

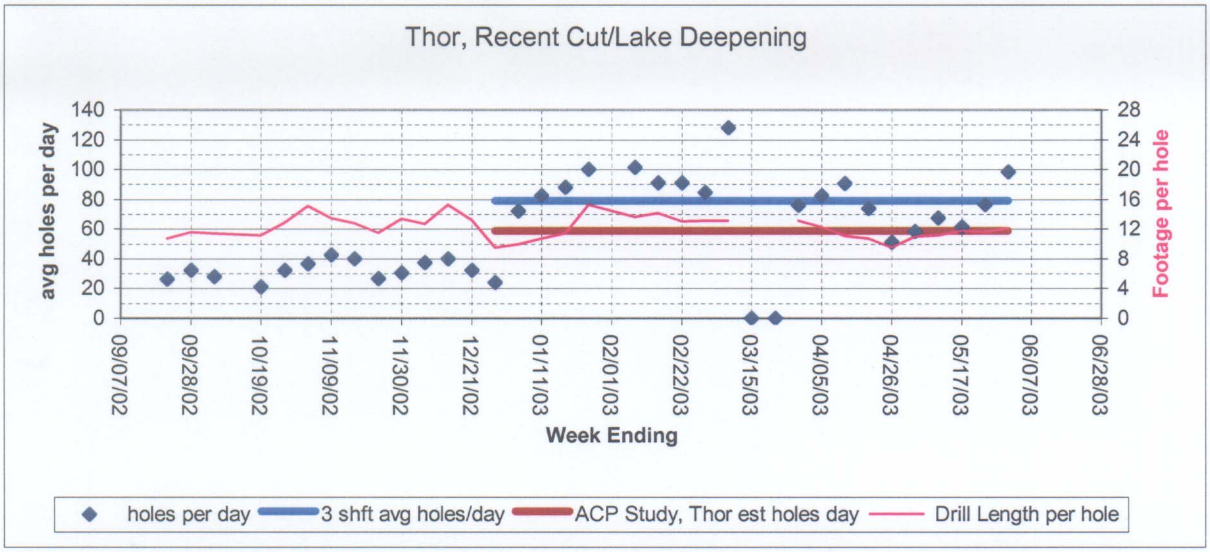
For sensitivity comparison purposes, GL has used the actual production on the recent work when calculating a "GL Optimized" estimate. Since only the monthly totals of the on-going work are provided as reference, the estimate assumes 27 operating days a month and 12 hours per day (GCWP average) to back into a digging production rate of 441 m3/wh.

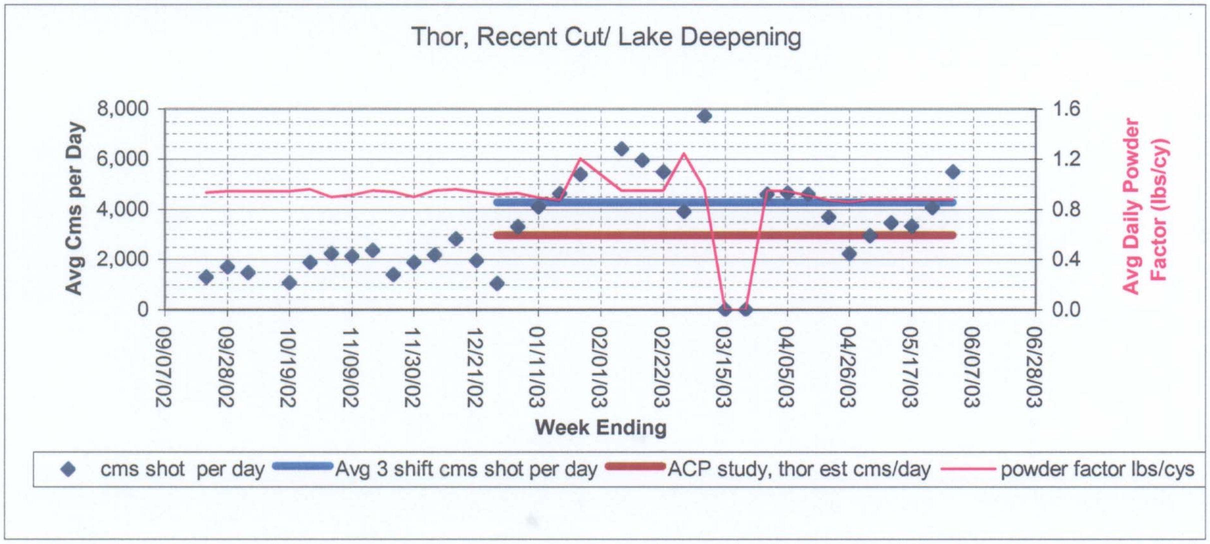
Even though the MINDI is doing 30% better than it did on the GCWP, 441 m3/hr is still a low production for a cutter of it's size and specifications. For example, in the Atlantic widening of 1994 to 1996, the MINDI averaged roughly twice this rate, achieving 850 m3/wh.

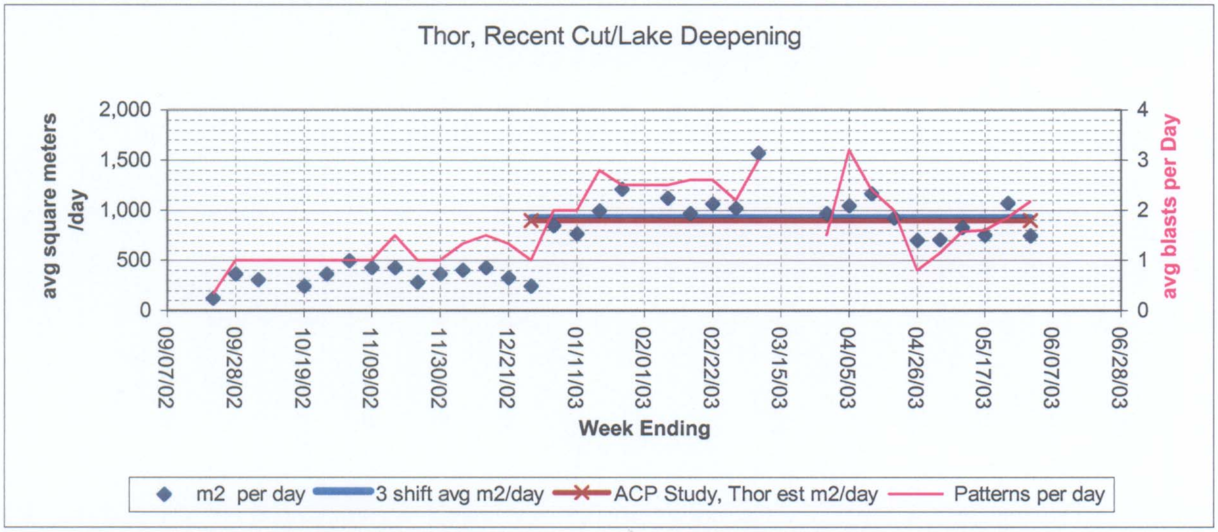
A detailed review of the records of the on-going dredging, along with observations of the dredge digging characteristics should be able to identify the factors limiting production. Modifications of equipment or operating procedures may then lead to significant improvement in the dredge's output.

Without geotechnical data, there is no ability to differentiate between soft dredging and hard dredging in the area, and therefore it is not possible to apply higher dredging rates for softer materials versus harder materials as would be desireable. Industry rules of thumb are that in areas of highly variable material types such as is suggested in this project area, hydraulic dredges such as CSD or hopper dredges have great difficulty achieving consistent production. Mechanical dredge types are typically more efficient in this scenario. It would appear that ACP experience also bears this out.

Thor


Thor, Recent Cut/Lake Deepening
avg holes per day
Footage per hole
Week Ending
holes per day
3 shft avg holes/day
ACP Study, Thor est holes day
Drill Length per hole


Thor, Recent Cut/ Lake Deepening
Avg Cms per Day
Avg Daily Powder Factor (lbs/cy)
Week Ending
cms shot per day
Avg 3 shift cms shot per day
ACP study, thor est cms/day
powder factor lbs/cys


Thor, Recent Cut/Lake Deepening
avg square meters /day
avg blasts per Day
Week Ending
m2 per day
3 shift avg m2/day
ACP Study, Thor est m2/day
Patterns per day

Detailed records for the Thor working on the current cut/lake deepening project were included in the study. Summary of key production parameters as compared to the ACP estimate are shown in the graphs above. Overall, the Thor is covering as much area as expected in the ACP study (+/- 6,300 m2/wk). It is observed that the records to date show an average of a 37 holes over 4,590 ft2. The estimate is based on a 32 hole pattern of 5,200 ft2, so the Thor is doing more holes and patterns than expected but roughly the same area expected per day.

The Thor is a capable proven machine that has recently undergone improvements and appears to operate very well in the current operation. A new drillboat is under construction and is also expected to be available in 2005. The new drillboat is assumed to achieve a 25% productivity increase over the Thor based on technology improvements. As discussed previously, other "recent" advances in DB technology employed by GLDD include articulating drill frames, newer design drills, and use of bulk product.

ACP estimates 7,293 m2 per week as an average using the two drill boats in tandem in Gatun Lake and 6,283 m2 per week for the Gaillard Cut. These are reasonable productions in accordance with industry standards for this type of vessel in this type of work. Should other enhancements as mentioned above be included in the technology, additional production increases would result.

Costs.

CSD. The developed estimated weekly costs of $351,866 are in line with industry standards for basic CSD equipments spreads for dredging of similar materials. Labor and fuel costs as percentage of total costs are also reasonable.

ACP assumes the same daily cost for the new CSD. No allowance for acquisition costs or other ownership costs is made even for the new equipment. As such records are not available as part of the scope of this review, no further study of this issue is made.

Channel usage fees and transit fees are a significant part of contractors costs working in canal waters. Even though MTC functions as a unit of ACP, it is somewhat independent and unclear how ACP accounts for interdivisional charges for pilotage and usage fees.

Dipper Dredge. The RMC's listed weekly package cost of $307,545 is high but within reason for a unique dredge of this type. Costs for the large support tug would appear to be the chief reason for the high day rate for the dipper dredge spread. As this tug is required for operating in ACP waters, it is a project requirement nonetheless. Since this vessel is also used for other activities within ACP, more detailed project accounting might show a reduced cost chargeable to the dredging division. In addition, it should be noted that private dipper dredges typically carry a crew of 6 people per day shift and 5 in the evening, plus crew for the dump scow and tug boats.

Drill Boat. The Thor's cost package is also within industry standards as discussed previously.

The attached spreadsheet indicates the sensitivity of ACP estimates compared to alternate scenarios. In this analysis, an "optimized" scenario is assumed wherein the drilling area is reduced by an arbitrary 10%. Note that the drill area assumptions are considered to be conservative given the lack of geotech data and the tendency of ACP to use their blasting capabilities liberally. Geotechnical investigations may in fact show that the area to be blasted is more than assumed, but it is suspected that the area is likely to be reduced more than 10% or at a minimum concentrated as a result of said studies. For this analysis, the Mindi production is maintained at 440 m3/wh, and the RMC is producing at a rate similar to our historic records.

An alternate estimate uses recent actual productions to extrapolate an estimate that closely mirrors the ACP estimate.

Summary of Cost Sensitivities for Gatun Lake and Gaillard Deepening to 27.5' PLD

Cut & Lake 27.5' PLD Deepening (includes 34' work)	ACP Estimate	Optimized Analysis	Estimate based on recent Performance
	Gaillard Cut & Gatun Lake Deepening 27.5'	Gaillard Cut & Gatun Lake Deepening 27.5'	Gaillard Cut & Gatun Lake Deepening 27.5'
Total Dredge Vol	26,539,137	26,539,137	26,539,137
Underwater Drill/Blast			
% Area Drilled	34% lake, 76% cut		34% lake, 76% cut
% of dredge Volume Drilled	58%	52%	58%
Area Drilled (m2)	5,750,877	5,175,789	5,750,877
Pay Cubic Meters Drilled	15,313,182	13,767,600	15,313,182
Drill Weeks	827	744	827
M3 Drill/ Week	18,516	18,516	18,516
Approx Pay Drill Leng (m)	2.66	2.66	2.66
Approx M2/Wk	6,954	6,954	6,954
Approx 4 rng shots/week	14.4	14.4	14.4
$/Pay M3	$13.56	$13.56	$13.56
Total $	$207,649,377	$186,698,346	$207,651,430
Dredging			
% Hard	100%	100%	100%
Hard M3	26,539,137	26,539,137	26,539,137
Cutter in Hard Mat'l	MINDI/New CS	MINDI/New CS	MINDI/New CS
Cuttter Hard M3s	17,404,694	$17,404,694.00	$17,404,694.00
Dig Hours/24 hour Day	12	12	12
Hard Prod (M3/Dig Hr)	333	441	441
Hard Prod M3/Wk	28,000	37,044	37,044
CDS Weeks	622	470	470
CSD $/M3	$12.57	$9.50	$9.50
Total $	218,718,578	165,320,165	165,320,165
Dipper in Hard Mat'l	RMC	RMC	RMC
Dipper Hard M3s	9,134,443	9,134,443	9,134,443
Dig Hours/24 hour Day	15.7	15.7	15.7
Hard Prod (M3/Dig Hr)	255	375	196
Hard Prod M3/Wk	28,000	41,213	21,540
Dipper Weeks	326	221.6425356	424
Dipper $/M3	$10.92	$7.42	$14.19
Total $	99,733,437	$67,769,422	$129,641,801
Total Dredge Weeks	948	692	894
Total Dredge $/M3	$12.00	$11.11	$11.11
Total Dredge $	$318,452,015	$233,089,587	$294,961,965
Total $/M3	$19.82	$18.94	$18.94
Total $	$526,101,392	$419,787,932	$502,611,342

Section 4. Review and Comments Regarding ACP Report "Technical Analysis of Gaillard Cut Widening 1-Way Post-Panamax Traffic".

Description of Work.

As part of the new Post Panamax project, widening and deepening of the Gaillard Cut in order to allow one way passage of Post Panamax vessels. This phase of the overall project requires massive dry excavation, as well as land based dredging, drilling and blasting and marine based dredging.

The dry excavation work is discussed in the Dry Excavation section of this report separately since this work is to be contracted out to private companies and there exists sufficient historical price data to achieve a comfort level with the costs.

The land based drilling and blasting and dredging is likely also to be accomplished by private contractors, but a complete cost analysis is provided by ACP based on historical records from the previous widening project, and supported by smartly detailed estimates. Calculations of land based operations are less risky than marine based particularly given the successful experience of ACP in such works. With the analysis provided as well as the well documented cost history for such works in the canal, the major risk factor from these costs is that quantities are based on a preliminary design requiring significant assumptions regarding rock quantities and strengths.

The work is evaluated in two alternatives. One is called the Contractors Hill Option and the other Gold Hill are under evaluation at this time to determine how best to accomplish the widening to 225 m in the straight legs of the Cut to 260 m in the cut. Major difficulties and risks in the work to be accomplished in this phase will be identification of highly variable rock seams and disposal of dredged material

As with the previous section regarding the Gatun Lake and Gaillard Cut Widening, it would be interesting to compare early estimates to actual performance based on the previous GCWP work. Based on its success in completing the previous Gaillard Cut project, ACP has exhibited its ability to complete the next phase.

GEOTECHNICAL ISSUES

All discussions regarding geotechnical issues are based on Dredge Masters experience. Given the massive amount of work involved in this project, it would seem prudent to undertake a geotechnical program designed to confirm this experience. As ACP has worked in much of the area previously, a program could be laid out to confirm both top of rock and rock quality throughout the area. This information could then be used to plan dredge movements in order to use the proper dredge in the proper sequence.

QUANTITIES

Bathymetric surveys of the cut were provided as part of the study. Unfortunatley the complexity of the cut templates, the interface between dry excavation and dredging and lack of certainty regarding dredge overswing make generating a meaningful volume comparison impossible. Based on the previous discussion of ACP quantities from the Atlantic and Pacific surveys, ACP quantities are used in the subsequent evaluation.

Equipment.

ACP utilizes all 3 pieces of equipment in its study and in practice. There are also plans to utilize the new drill boat and CSD in this area when they are available.

Dipper Dredge. The RMC is an ideal tool for work in this area as much of the material is well shot. The dipper type dredge has unique capabilities that make it an efficient and durable machine in dredging hard materials, including blasted rock. In some cases, the dipper type dredge can also be an effective tool in dredging unblasted rock. The RMC works with a fleet of 1,000 m3 split hull dump scows that are useful for operations in the canal. While the private industry tends to use scows from 2,800 m3 to 6,000 m3, the size and draft of these larger barges tends to make them cumbersome for canal operations. One also must consider the maximum light draft of a scow because the height the open dipper bucket can swing over is limited. It is not apparent from records available for this study that scow size has an impact on the efficiency of the current dredging operation. The RMC also works with 3,000 hp tugs towing scows to the disposal sites. The tugs are in excellent shape and appear to maneuver and handle well. Private industry would consider a 1,600 hp tug as adequate size for handling the 1,300 cy scows ACP uses with the RMC. Smaller tugs would theoretically be less expensive to operate.

CSD. The Mindi is discussed in previous sections detailing the dredge's successful history of completing work in the canal, but also limited cutter power for dredging rock. The dredge is supported by substantial attendent plant that also is well maintained. The new CSD is also discussed in previous sections, although no details are evaluated as part of the study, the dredge is planned to be employed by 2006.

DB Thor. The Thor is a capable proven machine that has recently undergone improvements and appears to operate very well in the current operation. A new drillboat is under construction and is also expected to be available in 2005. With the exception of the spud control system, the layout of the Thor is efficient. GLDD has comments about the drilling system and product type discussed in the equipment section.

Disposal.

Dredge Mindi works with upland disposal sites while the Dredge RMC is using the lake disposal areas. Disposal of material will be a key issue for the Gaillard Cut works as capacities are reduced. A separate study is reportedly underway by a consultant regarding this issue.

Material excavated as part of this project, particularly rock has value in the commercial markets of Panama. No commercial credits are considered here, but there are numerous projects in and around Panama where such materials are marketed.

Typically the marketing is on a much smaller level, but ACP should consider these options. Leaving this option to the contractors is not a viable option as this only clouds project commercial issues and does not leave ACP in control of its property.

Production.

ACP reports utilize again the historic production data previously discussed for the dredge equipment. It is anticipated that all material in this scenario will be blasted as in the previous phase. Anticipated production rates for the widening are very similar to those projected in the cut/lake deepening study. Therefore the previous discussion in the cut/lake deepening portion of this report applies as well to the cut widening. Rather than repeat that information, any specific differences connected with the widening are discussed below. Refer to the Cut/Lake Deepening portion of this report for a more detailed discussion of production.

RMC.

- The ACP study projects 30,000 m3/wk (4,290 m3/day) for the RMC in the planned widening. Actual production rates for the RMC during the Gaillard Cut Widening Project (GCWP) were roughly 4,500 m3/day.

- For cost sensitivity comparison purposes, GL experience indicates that 375 m3./wh is achievable and therefore is used "Optimized" estimate.

CSD Mindi

- Based on production data from previous work in the cut, an estimate of 30,000 m3 per week (4,290 m3/day) is also used for the dredge Mindi. Acknowledging this historic data is useful for budgeting purposes, however, as the productions appear quite low overall, a study of the detailed daily reports would be helpful to determine to cause, whether it be dredge performance, repairs, materials being dredged or site conditions, such as marine traffic.

- Discussion of the new CSD includes its production at the same level as the Mindi, while other ACP reports assume a 50% increase in production for the same machine. Without details of the new CSD, an evaluation of expected impact on production cannot be made, although clarification should be made as to why this theoretical production increase is not included in this section. Under the general conditions assumed for this study, we would expect a weekly production of 49,000 m3/week for a vessel of the class of Mindi.

- Without geotechnical data, there is no ability to differentiate between soft dredging and hard dredging in the area, and therefore it is not possible to apply higher dredging rates for softer materials versus harder materials as would be desireable. Industry rules of thumb are that in areas of highly variable material types such as is suggested in this project area, hydraulic dredges such as CSD or hopper dredges have great difficulty achieving consistent production. Mechanical dredge types are typically more efficient in this scenario. It would appear that ACP experience also bears this out.

DB Thor

- The Thor is a capable proven machine that has recently undergone improvements and appears to operate very well in the current operation. A new drillboat is under construction and is also expected to be available in 2005. the new drillboat is assumed to achieve a 25% productivity increase over the Thor based on technology improvements. As discussed previously, other “recent” advances in DB technology employed by GLDD include articulating drill frames, newer design drills, and use of bulk product.

- ACP estimates 30,000 m3/week (gross drill quantity including subdrill, 28,117 m3/week above design depth of 27.5’) with this vessel, which is a different analysis than used in previous reports in that the production is based on volume rather than area, but consistent in its results. It is difficult to evaluate this estimate as the exact nature of the drilling to be performed (the 16% of the quantity not blasted in the land drill operation) is not clear. Given the ACP experience in very similar circumstances, we assume this is a reliable estimate.

Should other enhancements as mentioned above be included in the technology, additional production increases would result.

Costs

CSD. The developed estimated weekly costs of $351,866 are in line with industry standards for basic CSD equipments spreads for dredging of similar materials. Labor and fuel costs as percentage of total costs are also reasonable.

ACP assumes the same daily cost for the new CSD. No allowance for acquisition costs or other ownership costs is made even for the new equipment. As such records are not available as part of the scope of this review, no further study of this issue is made.

Channel usage fees and transit fees are a significant part of contractors costs working in canal waters. Even though MTC functions as a unit of ACP, it is somewhat independent and unclear how ACP accounts for interdivisional charges for pilotage and usage fees.

Dipper Dredge. The RMC's listed weekly package cost of $307,545 is high but within industry standards for a dredge of this type. The costs for the large support tug would appear to the reason for this. As this tug is required for operating in ACP waters, it is a project requirement nonetheless. In addition, it should be noted that our dipper dredges typically carry a crew of 6 people per day shift and 5 in the evening, plus crew for the dump scow and tug boats.

Drill Boat. The Thor's cost package is also within industry standards as discussed previously.

In the following analysis, dredge quantities are split between the two dredge types in order to provide an analysis of each dredge. Idealized productions as discussed above are also provided. A similar treatment is provided for the drilling and blasting, where the

ACP coverage areas are assumed to be conservative and a potential reduction of 10% in drilling and blasting quantity considered assuming a geotechnical investigation is made.

Note that the ACP land based dredging analysis indicated a lower unit price than the marine dredging. Accordingly, all quantity that can be achieved from the land base is best handled in that fashion. If marine based dredging production improves as suggested, then the unit price may be lower and allow for this work to be handled from the water.

Summary of Costs for Gaillard Cut Widening 1-Way Post-Panamax Traffic

Cut Widening (Contractors Hill Option Only)	ACP Estimate	Optimized	Based on Recent Production
	Widening to 34' PLD, final dredging to 27.5' PLD	Widening to 34' PLD, final dredging to 27.5' PLD	Widening to 34' PLD, final dredging to 27.5' PLD
Total Dredge Vol	15,838,770	15,838,770	15,838,770
Land Drill Blast-Dredging M3	13,401,876	13,401,876	13,401,876
Land Drill Blast $	$60,308,442	$60,308,442	$60,308,442
$/M3	$4.50	$4.50	$4.50
Underwater Drill/Blast			
% Area Drilled	100% , 16% water	100% , 16% water	100% , 16% water
% Volume Drilled	100%	100%	100%
Pay M3 Marine Drilled	3,174,733	2,751,011	3,174,733
Drill Weeks	109	94	109
Pay M3 Drill/ Week	29,203	29,203	29,203
Approx Pay Drill Leng (m)	20.14	20.14	20.14
Approx M2/Wk	1,450	1,396	1,450
Approx 4 rng shots/week	3.0	2.9	3.0
$/Pay M3	$7.80	$7.86	$7.80
Total $	$24,774,641	$21,626,567	$24,774,641
Dredging			
% Hard	100%	100%	100%
Hard M3	15,838,770	15,838,770	15,838,770
CSD in Hard Material	MINDI/New CS	MINDI/New CS	MINDI/New CS
Cuttter Hard M3	7,919,385	7,919,385	7,919,385
Dig Hours/24 hour Day	12	12	12
Hard Prod (M3/Dig Hr)	357	450	450
Hard Prod M3/Wk	30,000	37,800	37,800
Dredge Weeks	264	210	210
Dredge $/M3	$11.00	$8.73	$8.73
Total $	87,113,237	69,137,490	69,137,490
Dipper in Hard Material	RMC	RMC	RMC
Dipper Hard M3	7,919,385	7,919,385	7,919,385
Dig Hours/24 hour Day	15.7	15.7	15.7
Hard Prod (M3/Dig Hr)	273	375	287
Hard Prod M3/Wk	30,000	41,213	31,500
Dredge Weeks	264	192	251
Dredge $/M3	$11.00	$10.48	$10.48
Total $	$87,113,237	$63,516,110	$82,964,988
Dredge Weeks	528	461	461
Dredge $/M3	$11.00	$8.38	$9.60
Total Dredge $	$174,226,474	$132,653,600	$152,102,478
Total $/M3	$16.37	$13.55	$14.97
Total $	$259,309,557	$214,588,608	$237,185,561

Section 5. Review and Comments Regarding Dry Excavation

Dry Excavation.

Dry excavation works under this study are more defined than dredging works. Wherein as a study of ACP costs for dredging involves evaluation of ACP internal costs, productions, and efficiencies, the dry excavation work is to be performed by private contractors. ACP used private contractors very successfully for the previous cut widening program. ACP has listed numerous contracts that were undertaken previously with competitive prices and results.

Our dry excavation expert, Sococo, participated in some of the earlier projects and noted that initially there were complications in dealing with the ACP including lack of geotechnical data, haul roads, and ACP experience in contracting this type of work. In addition, the early projects were new to the contracting industry as well and had a reputation of high risk. As contracting methods evolved, the work became more routine, other contractors became more interested, and prices declined.

For the Gatun Lake and Gaillard Cut report, 8 dry excavation projects are listed through 1997 showing a total average of $3.14 per m3 unclassified, with a range from $1.93 to $6.43. A unit of $4.00/m3 is developed in the reports and factoring in inflation is a reasonable assumption.

Our dry excavation expert confirms the validity of this cost. He also confirms that equipment to be used for this excavation with hauling distances from three to five kilometers would probably be mass excavators of medium size and matching off the road truck haulers or articulated dump trucks. Surface inspection show hard conglomerates and solid rock insinuate the need of large diameter crawler mounted drill for blasting.

Clarification of the material disposal areas that will serve each contract is most important since it will define haul routes, haul distances, and the feasibility of the operation of simultaneous contractors at the same time.

The cost analysis used seems to be solid, but it is to be remembered that the cost of the dry excavation will be determined by:

-The actual % of rock in the new widening.

-The actual haul distance to the assigned disposal areas.

The Dry Excavation included in the Deepening of the Lake and Cut amounts to 6,675,713 m3. Using the unit cost of $4.00 results in a cost for this work of $27,902,852.00 including incidentals and design work.

The Gaillard Cut Widening for 1 way Post Panamax traffic requires a great deal more design analysis but should prove as challenging as the previous phase. Using the preliminary assumptions, ACP derives a quantities ranging from 23 million m3 in the Gold Hill Option to 29 million m3 in the Contractor Hill option. Planning is being made to complete the work in a 5 to 6 year timeframe.

A detailed analysis of data is provided from records of contractors employed based on type of material and material type. This analysis is accompanied by a very appropriate analysis of land excavation and land blasting that cover all aspects of the operation.

Type of Work	Volumes in m3 Contractors Hill Option	Gold Hill Option
Dry excavation	29,319,174	23,215,243
Land based drilling & blasting	20,383,308	18,187,737
Land based dredging	3,265,474	3,690,689

Dry excavation: is unclassified and is the widening of the sides of the Canal above water level. From the progress chart it is the intention to divide the work in 8 contracts and be completed in 40 work months starting on the 9^{th}. month of the first year of the five year total time for completion of the entire project. The Contractors Hill option which is the most likely to be built, due to the high risks presented by the other option, requires the excavation of:

First Year	1.57 million m3	4 months.
Second year	10.76 million m3	12 months.
Third year	10.52 million m3	12 months.
Fourth year	6.35 million m3	12 months.

The peak of production requirements is in the second year in which the schedule shows at some time five contractors working simultaneously, totaling 52 contractor/months with and average production per contractor of 206,920 m3 per month. This is not considering the effect of the rains that will reduce the effective working months and increase the required production. For every dry excavation project lasting one year includes at least 2 summers.

The economic equipment for this type of excavation and haul distances ranging from three to five kilometers would probably be mass excavators medium size and matching off the road truck haulers or articulated dump trucks. Surface inspection show hard conglomerates and solid rock insinuate the need of large diameter crawler mounted blasthole drills and blasting.

The definition of the material disposal areas that will serve each contract is most important since it will define haul routes, haul distances, and the feasibility of the operation of simultaneous contractors at the same time.

The cost projection for the dry excavation was made based on the average of unit prices presented by contractors during the decade of 1990, combined with the average of a calculated Rock excavation prices for Gold Hill and Contractors Hill. The average of the two averages gave a unit price of $4.33/m3. To update this price it was raised to $ 4.50/m3 which gives an inflation factor of 3.92%.

The procedure used seems to be solid, but it is to be remembered that the cost of the dry excavation will be determined by:

-The actual % of rock in the new widening.
-The actual haul distance to the assigned disposal areas.
-The present costs of equipment, Fuels, lubricants, parts & materials.
-The present cost of labor.

The first two factors depend on the definitive design and the last two factors have suffered considerable increase in the last decade. Although fuel and labor costs have increased since the dry land projects were bid, competition seems to have muted this increase based on recent bids to ACP. As a result, our dry expert recommends a contingency factor of 10% be added to the dry excavation, land dredging, and land blasting costs.

	ACP	GLDD (+10%)	ACP	GLDD (+10%)
	Contractor Hill	Contractor Hill	Gold Hill	Gold Hill
Dry Excavation Qty	**29,319,174**	29,319,174	**23,215,243**	23,215,243
Unit Costs	**$4.50**	$4.95	**$4.50**	$4.95
Total Costs	**131,936,283**	145,129,911	**104,468,594**	114,915,453
Land Based D&B Qty	**20,383,308**	20,383,308	**18,187,737**	18,187,737
Unit Costs	**$4.50**	$4.95	**$4.50**	$4.95
Total Costs	**91,724,886**	100,897,375	**81,844,817**	90,029,298
Land Based Dredging Qty	**3,265,474**	3,265,474	**3,690,689**	3,690,689
Unit Costs	**$8.33**	$9.16	**$8.33**	$9.16
Total Costs	**27,201,398**	29,921,538	**30,743,439**	33,817,783

Note that in 1998, ACP utilized a dragline for a one month rental period. The local private company involved in this project, reports his price for the contract was $30,000 per month fully found (including fuel, lube, and labor) or $1,200 per day. He also reported single shift production on the order of 230 m3 per shift or 1,820 m3/day. Assuming similar production for a second shift yields a daily production of 3,640 m3/day or 21,820 per week. Note this is similar to what ACP has listed in Appendix 22. At 1,820 m3/day at the price reported results in a unit price of $0.66/m3 as opposed to the $2.01 listed in the Appendix 22 for the dragline and the $1.15 for the Liebherr 994. As this work will be tendered to private companies, ACP should make provision for contractors to select their appropriate equipment. Nonetheless it would appear again that ACP costs are conservative.

Section 6. Comments regarding Dipper Dredge Rialto M. Christiansen

The Dredge Rialto M. Christiansen is one of the few remaining dipper dredges in the world. As such the dredge has unique capabilities that are appreciated by very few companies. GLDD has a long and proud history of operating dipper dredges and appreciates the value of the RMC to ACP and specifically the work at hand in deepening Gatun Lake and eventually the canal expansion projects.

The dipper type dredge has unique capabilities that make it an efficient and durable machine in dredging hard materials, including blasted rock. In some cases, the dipper type dredge can also be an effective tool in dredging unblasted rock.

The RMC was visited by GLDD personnel in December 2003, it was operating in the Gatun Lake dredging well shot rock. Heaping buckets exceeding the capacity of the 15 cy bucket were being achieved and scows being loaded rapidly.

Equipment Design and Layout.

The RMC is of Japanese design, but most working and wear parts have been converted to more common components as possible. Ringer wear has been a problem over the last few years and minor repairs are made as required during the operation and major repairs are planned during next major down time.

Only major piece remaining unique are the main engines and generators. These are of Japanese manufacture and spare parts are not usually available requiring special build when repairs are required. This has been the source of major down time over the years.

Support Equipment.

The RMC is supported by a fleet of 1300 cubic yard split hull hopper barges that are towed by 3,000 hp tugs. 1600 hp tugs also assist in the effort to shuttle barges in some occasions.

Labor.

Crew appeared active and plentiful. GLDD was given a tour by the Chief Engineer who proudly showed off an immaculate below deck operation. Safety appeared to be a proper concern and morale appeared good. Captain Morotta was not available during the visit, but GLDD personnel have met with him previously and found him to be a personable and positive influence to his operation.

Wear Part Inventory.

The RMC has three spare 15 cy buckets, and three spare dipper arms. Also in inventory are several 13 cy dipper buckets that are no longer used.

Equipment Utilization.

The dredge currently is dredging well-shot rock. The dredge cut layout is efficient and familiar. Operators handle the dipper stick very well and are familiar with the means available to achieve full buckets. The operator and assistant captain were cognizant of one of the most difficult issues involved in dipper dredge work and that is the creation of pushed up berms at the end of each cut.

Equipment Maintenance

As mentioned, the RMC was clean and well maintained. This is typically a reflection of the positive attitude of the management and captain that carries forth to the morale of the crew.

Instrumentation

The dredging instrumentation on the RMC is familiar and effective.

Safety

The crew was in apparent full compliance with personal safety devices throughout the trip, with the RMC being no exception. Crew was cautious in moving about the crane and appropriately aware of barge movements.

Comments on Suitability of RMC for Use in Expansion Efforts

Equipment.

The RMC will prove valuable in completing the expansion work. Its flexibility and power are important, although historically poor mechanical performance are a continued cause for concern.

- Buckets

  If RMC was to be used for other applications such as deeper dredging or dredging unblasted rock, additional wear parts would be beneficial. For instance, smaller bucket and longer dipper arm would be helpful in deeper water, while for a smaller, heavier bucket would be helpful for dredging unblasted rock.

- Instrumentation

There is more modern instrumentation available for dipper dredges that would allow for positive positioning of the bucket that may prove valuable when overdredging becomes an issue. There is a new generation of production instrumentation that would be useful particularly on larger projects. Websites with information on such systems are at:
http://www.ihcsystems.com/acrobat/xpm.pdf; or
http://www.tbirdpac.com/shovelsmonitoring/docs/shovelpro.pdf.

- Scow Size

ACP utilizes a fleet of 1,300 cy split hull scows. These scows are small in capacity but also light in draft making them useful for disposing in confined areas of the Gatun Lake. From a contractors perspective, larger scows would seem to promote better overall production by reducing the number of scow trips per day and thus reducing tug costs and also reducing the time lost changing scows during the course of the dredge day. The major drawback of larger scows is that they tend to have deeper loaded drafts. While this is not an issue at the dredging end of the operation for ACP it is potentially a limiting factor in disposal management in the lake. A detailed review of current and future disposal management practices would indicate what operational limitations exist pertaining to scow size. Note GLDD uses a variety of scow sizes in its operations from 4,000 cy to 7,200 cy. While in general, GLDD uses the largest scows available, a calculation is made for each project to determine which size fits best. If smaller size scows are available and adequate for the job, they are used since they may allow for use of smaller tugs and be more efficient to handle.

- Tug Boats

ACP uses 3,000 hp tugs for operations particularly towing scows to the disposal sites. The tugs are in excellent shape and appear to maneuver and handle well. As contractors, a 1,600 hp tug would be considered to be more than adequate size for handling the 1,300 cy scows ACP uses with the RMC. Smaller tugs would theoretically be less expensive to operate. Should ACP decide to use larger scows in the future, the 3,000 hp tugs could prove useful, although in some case it should be noted that it may be necessary to raise the wheel house of the tugs to see over the larger scows when they are light loaded. While GLDD owns and operates some of its own tugs, frequently tugs from third parties are used to perform our towing. Long term charters are available from competent operators that allow for using properly sized boats for each project, i.e. a 1,600 hp boat when required or a larger boat if needed.

- Engine Delays

GLDD recommends a detailed study of major down time due to engine delays to ascertain its impact on operations. From a contractors perspective, replacement of the engines and gen sets with more common units should be a serious consideration. This would be a major undertaking, but should theoretically provide benefit in reducing major time from weeks at a time to a maximum of a few days for off the shelf repair parts. It could also be an opportunity to increase the amount of DC power available, which is currently limiting dredge operation.

Operations

The primary use for this dredge should be in unblasted and blasted rock areas. A program of test dredging the RMC in designated areas of lighter rock in order to determine if blasting can be avoided or reduced is recommended.

- Pretreating.

  GLDD has noted in previous trips that the RMC is not being utilized to its maximum benefit in dredging overshot rock. The dredge could apparently handle much larger pieces of rock, meaning that blasting operations could be reduced by using less powder or larger drill patterns or areas could be dredged first by the RMC before blasting was attempted. Finding the right balance between blasting and dredging effort often comes down simply trying various patterns in various rock formations and immediately test digging those trial areas to determine suitability of a particular pattern or powder factor.

- Overdredging.

  It was not clear whether overdredging was a concern in the current operation, but efficient use of the machine in canal expansion efforts will require more attention to this. Overdredging is a necessary part of any dredging operation, but limiting it through the effective use of instrumentation is a goal of any dredge operator in order to more quickly complete a projects.

- Maintenance Dredging

GLDD has read of reference to use of the RMC for maintenance dredging. GLDD would not recommend use of a dipper dredge for this purpose since it is simply not built for this purpose. GLDD understands that there is a wide definition of maintenance dredging materials in the canal, but a study of this issue would be beneficial to determine if this type of work is significant, perhaps purchase or leasing of a large clamshell dredge or small hopper dredge would provide more benefit.

- Impact of Marine Traffic

In verbal discussions, a common theme was that much time was lost in operations due to MTC. However, in order to document a review of the impact recorded in daily reports is required and such information is not available to us at this time.

- Survey/QC

The ACP survey program is discussed separately. In relation to the dipper dredge operation, it should prove useful to utilize surveys on a daily basis to confirm progress and depths left by the dredge. This information is helpful not only to the users of the channel, but also to the Captain and operators to know what depths they are leaving and whether or not modification to their digging methods are required.

- Scow Loading and Measurement discussion

It is unclear how production is actually evaluated. The RMC measures based on scow yardage, that is, since the scow is classed as a 1,300 cy capacity scow, when the scow is "full", the operator records an estimated volume of material in the scow, usually a fixed amount based on a loaded draft. This is a common recording method, but one that deserves further clarification, particularly in defining what is meant by a bank yard (volume removed from cut based on before blast bottom profile? Volume removed from cut based on after blast bottom profile? Volume in the scow? Does it include volume taken from outside the design prism? In any event, care needs to be taken when evaluating historic production versus future production given that many Dredge Captains use scow measure when speaking of production.

- Production

The historical production of the RMC appears reasonable for the days it operated on the GCWP in both hours per day and cm/hr. More detail of the cut geometry, bank heights, volumes being measured and excess dredging outside the prism would be required to determine if and how the hourly production of the Christiansen could be improved. The production records made available do not indicate when the dredge was down for repairs (how often, how long etc.) so there is insufficient information to evaluate the long term reliability of the dredge. Given the average 22 days per month of operation through the GCWP, it is suspected that the mechanical reliability of the RMC is somewhat low. However, it is unknown how much of this time down was due to mechanical problems with the dredge vs. other reasons such project delays etc.

- Daily Reporting and Measurement of Production/Efficiency/Equipment Utilization

There could be many reasons for lower production including mechanical downtime (both major and minor), traffic interference, but without documentation there is only conjecture. It is noted that it is unfair to rely on the dredge captain to forecast dredging productions. While the Captain is an important source, other information such as surveys and operators logs exist that would allow others to confirm and calculate dredge production more accurately.

Attached is a copy of a typical GLDD daily report. Much similar information is included in ACP reports also, but there are important differences. Probably the biggest difference though is what is done with the information provided. GLDD project engineers are tasked with the responsibility of compiling and completing these reports each morning. They receive operators logs and make their own surveys to confirm progress and achievement of project dimensions. They then compile the reports and submit them to the Dredge Captain and Project Manager for their review and approval. Subsequent to that, the information is faxed or emailed to our corporate office where it is further reviewed by operations, maintenance, mechanical engineering, and production engineering staff. Each person reviewing the report looks for trends in delays or production that may indicate a problem. From this information decisions can be made regarding means to improve the efficiency of the operation by modifying digging techniques or perhaps the equipment itself. Such reports are of little value if they are simply filed without review or study.

- Production Units

Also note one of the important distinctions as relates to the use of daily production numbers. When using averages, it is not uncommon to talk about a production of dredged material per day. However, when talking about productions it is important to speak in terms of production per work hour. This is a more accurate measure of the actual dredge efficiency, without considering delays to the operations such as marine traffic. This allows separate analysis of total production based on equipment running time versus other impacts.

- Planning Effort Prior to Dredging

One of the more important areas a private company focused on in thier dredging effort is planning. ACP apparently relies on the experience of the Dredge Captains for much of the decision making and planning including geotechnical, type of equipment to be employed and also anticipated production. In addition, there appears to be a frustration that since material in the canal is highly variable, that the most conservative tools and methods will be used.

The roles of the Captain and crew can be enhanced and productivity greatly increased by utilizing some of the following means typically used by making geotechnical studies and utilizing the information in the dredge planning process. In utilizing the resources of ACP survey and geotechnical group, proper dredge equipment can be deployed and used in the most effective manner. Documentation of some of the types of testing recommended is attached and GLDD would be pleased to provide examples of how this information is utilized by a contractor in planning a major dredging effort.

- Forecasted Daily Production (Theoretical)

A contractor uses a variety of means to forecast production. The previous discussion of how historical production is tracked and used, is followed by an investment in a good deal of time using theoretical models to both forecast future production and also model current production in order to help confirm efficiency.

Section 7. Comments regarding Cutter Suction Dredge Mindi

The dredge Mindi is a 28" cutter suction dredge manufactured by Ellicott with a major overhaul in 1992. The dredge also is outfitted with an underwater pump and a spud carriage. With these specifications the dredge is classified as a medium class cutter suction dredge, albeit a well equipped medium class CSD.

Despite the age of the vessel, the Mindi is in very good aesthetic shape. It should be noted that most CSD dredges in the world are relatively old, with most owners preferring to upgrade dredge components such as pumps and engineers with their capital investment dollars in lieu of new build. During the dredge visit, unfortunately, the dredge was being mobilized and not yet running. The Captain was supervising the installation of the cutterhead, which also meant that there was limited time to visit with the Captain.

Equipment Design and Layout

A CSD is a unique complicated machine, and the Mindi is no different. Each component is key and has an impact on the other. Each component typically has a history and a story behind its acquisition, installation, and use. While there was not enough time for a lot of details from the Captain, examples can be given based on experience with other similar situations.

For instance, the ladder pump was not part of the original installation because ladder pumps were not part of the technology when the dredge was built. As a result, the pump was added later, requiring structural modification to the ladder structure, and piping systems. Based on discussions with the Captain the ladder pump is not ideally suited for the dredge causing flow and suction problems in the pumping systems. There was some interest expressed in a variable speed ladder pump, but our impression based on a review of dredge specifications is that more power in the ladder pump, rather than variable speed would be very helpful. This issue requires further analysis as well as first hand observation of the pumping system in action.

Support Equipment

The dredge is supported by a large compliment of equipment including a large anchor handling barge, supply barges and launches. While such a compliment of equipment would be considered excessive in other applications, it is noted that in a remote location such as the canal, there is little alternative.

Labor

As with the RMC, the Mindi's crew is enthusiastic and professional. Although there appeared to be ample crew, an industry standard CSD spread crew would be on the order of 30 personnel.

Wear Part Inventory.

The Mindi uses chiefly rock type cutterheads based on their durability and ability to adapt to variety of conditions encountered. There are a variety of cutterheads for different applications that increase productivity dramatically. However, you can only use a sand cutter in sand, or a clay type cutter in clay. If the geology is changing constantly then it difficult to assess which cutter to use to avoid damaging the cutter. Since the Mindi has been working in the cut for so long now, it is accustomed to the conservative approach in that they have been blasted rock most of the time. If no geotechnical work is to be done, then this approach is logical to continue with. On the other hand if additional geotech is performed, then ACP should take advantage and maintain an inventory of a variety of cutterhead types.

Equipment Utilization.

Although the Mindi was not operating while the inspection was underway, our entire panel of experts was impressed with the upkeep of the equipment and the attitude of the crew.

Suitability for use on current project and in Expansion efforts

The Mindi is and should be a key tool for the expansion effort. Despite comments about the age of the dredge, age in dredging is not an issue unless pieces are falling apart. As long as the barge maintains its strength, everything else can be changed. Key is to change the cutting and pumping systems within the context of the system.

Key issues like cutterhead power and underwater pump modifications appear to be high on the Captains list of upgrades. The MINDI appears to have plenty of in-hull pumping power. The idler barge and walking spud are relatively modern in design. Where the dredge appears to be lacking is ladder pump power and general structural stength of the ladder. The magnitude of the expansion project warrants consideration of substantial investment in the Mindi such as a new ladder with new lp pump, cutter and swing machinery.

ACP should not rely on the Captain alone to undertake these upgrades, but enlist the aid of experts who are in the business of these upgrades and who have a proven track records in accomplishing such upgrades.

Productivity. It is not believed the Mindi is performing to standards. However, without detailed records or first hand observation of the digging, it is difficult to determine if this is the case or if operational problems such as site conditions are dictating reduced performance.

Daily Reporting and Measurement of Production/Efficiency/Equipment Utilization. From discussions with Dredging Division personnel and the Captain, it appears that appropriate reporting is being made but that this information was simply not available for this study. Dredging is a complex business and as long as key personnel in ACP are kept current with information, that is the point of the process.

Proposed new cutter. According to the reports, a new cutter suction dredge is being planned for delivery in 2005. Details of the dredge are not available, but it is apparently to be similar to the Mindi but with hoped for 50% increase in capacity, including increase cutter power and pumping distance. ACP has budgeted $40 million for this machine. It is noted that it is rare in the current business climate to build a new dredge. Options such as purchasing used equipment with similar characteristics or chartering a vessel should be considered. In any event, the Mindi should be upgraded and prepared for a long project.

Section 8. Comments regarding Drill Boat Thor

Equipment Design and Layout

The vessel it self appears to be in good shape considering the age of the hull. The size is adequate for working in the canal and would probably be okay if required for limited drilling on the Atlantic side. It is likely not a good vessel for working in exposed areas on the Pacific side area unless upgrading of the spuds is performed.

Labor

The crew is in good morale, safe and attentive to their duties. Crew size appeared to be within industry standards, although it was not apparent how many offsite personnel are involved.

Suitability for use on current project and in Expansion Efforts

The one modification the hull itself needs is an improved spud system. The current spuds are too small and light and the current operating system, each spud remotely and individually operated, is slow and cumbersome. Ideally the Thor would be well served with larger heavier spuds and a hydraulic winch system.

Two areas where the most significant improvement in production could be gained are the drilling and loading and engineering. The engineering is relative to the drill depth and spacing of the hole pattern. If the material being dug by the Christensen is an indication of the blasted rock from the THOR then an analysis of drill depth and pattern spacing needs to be done, the rock may be overshot.

An upgrade of the current drilling system is where the most significant improvement in production could be realized. The current system using six inch rotary bits and solid casings is slow and labor intensive. The rotary bits are expensive and not reusable whereas the button bits used on the Apache can be sharpened multiple times. The Captain has a concern regarding the problem of keeping a whole clean enough to load without using a solid casing, but GLDD uses a sandpot system in a variety of rock types with success. Also if the rock is so fragmented and non-incorporated that the holes won't stay open it is likely the RMC can dredge the area without blasting anyway.

By going to a smaller diameter hole, with a sand pot system versus solid casing and using a bulk product there would be an increase in efficiency and direct savings in a reduction of manpower required, less expense in bits and steel and a considerable reduction in costs for product. This would have to be weighed against the significant investment the ACP has in it's current size and style drill steel & bits. The current cartridge system being used of making up the shot, while it may be adequate working in the canal with no tide or current, would not work if any work were to be done in exposed areas on the approaches.

New Drill Boat

ACP has ordered a new drill boat of similar size and capacity as the Thor but with capability to drill in deeper waters than the Thor, particularly in the Pacific. In addition, the new drillboat is to have productivity of 25% greater than the Thor.

While the New Drill Boat will have more productivity, it is understood that drill frames and systems will be identical to the Thor. This misses quite an opportunity to convert to more modern and even more productive systems available on the market.
Bulk explosive have been used for 15 years now safely and economically around the world.

Section 9. Comments Regarding Survey

Four survey vessels are outfitted for service 24 hours per day 7 days per week. According to ACP, there is always at least one boat running available 24/7. The survey division is not dedicated to the Dredging Division but does provide service to all three pieces of dredging equipment. In general for RMC, before dredging and after dredging surveys are performed with a caution towards looking for berms created in initial and final cuts, as well as the end of each cut. For the dredge Mindi, survey division typically provides surveys every two week, although on occasion will run every week. For Thor, only services offered are "free-boat" surveys run after every blast looking for high spots as a result of after blast heave.

From a contractors perspective, more frequent surveys are recommended (GLDD performs such surveys daily) for quality control purposes. A contractor uses QC surveys to supplement operator knowledge to assure that he is leaving the minimum depth, but also that he is not overdredging and thus performing work he is not to be paid for. While ACP dredge operators are very aware of depths they are trying to achieve, it's not clear that minimizing overdredge is a high priority.

Survey equipment being employed by ACP is state of the art including software. From discussions with equipment vendors, it is understood that much of the multi beam equipment was purchased prior to 2000 and is now becoming somewhat dated. While the current setup remains adequate for the purposes intended, it will likely require upgrading in the next few years as technology continues to evolve and improve.

Quantity calculations are in general accurate and based on use of state of the art systems, INROADS and HYPACKS. These systems allow for quick compiling of data and also quick and accurate modifications to project limits, slopes, and depths.

Section 10. SUMMARY

The ACP dredging program has created a positive and professional attitude amongst its personnel. In order to allow the ACP to take advantage of this group, it will be necessary to support them with training and budgets to allow maximum efficiency possible. Accountability is required and when effectively made, it is also appreciated.

ACP's relies on the experience of the dredge captains to understand everything about their operations including geology and production. This is quite a heavy burden for a single person, particularly when very capable staff exists within the organization to make geotechnical investigations and provide the captain or his engineers with such information in advance of the dredging operation. Real production information is already generated by the dredge personnel, and some QC is available via survey, yet little of this information seems to make its way to management. Such information should be shared amongst the entire management team and actual dredge productions should be compared with theoretical. Shortfalls should be challenged and questioned, not to assess blame, but to allow for improvement by modifying operations, or perhaps making structural modifications to the equipment.

Building Program. Based on our accumulation of information related to this study, the following comments relative to the equipment are offered

In regards to ACP equipment , it should be emphasized that age is not an important factor in dredging equipment that is well maintained. ACP equipment is definitely well maintained and a resulting dividend in our opinion is that an upgrading of current equipment will allow completion of the lake deepening AND expansion without having to make investment in new equipment beyond the drillboat currently on order.

By making current equipment and operations more efficient and less redundant and with more planning through the use of existing staff, there may in fact be no need to construct a new cutter suction dredge. Several ideas have been presented that could be implemented or considered in order to achieve this efficiency. If additional study of methods and means to implement some of these ideas is desired, GLDD would be pleased to participate in said programs.

GLDD advises against building a new CS Dredger

GL recommends the ACP not build a new cutter suction dredge. As a worldwide contractor, GLDD admits that there is an inherent predisposition to advise against the entry of new capacity to the world dredging fleet. With this caveat, however, and regardless of this perceived bias ~~on this issue~~, these facts ~~are~~ need to be considered:

- Since the required schedule of dredging is unclear (3rd lock schedule is unclear and likely to drive the schedule for this project), a decision to invest $40 million dollars (which is believed to be unrealistically low) in additional dredge capacity to meet an as-yet undefined schedule seems premature.

- According to ACP studies, much of the planned dredging requires drilling and blasting, Accordingly, this operation appears to be the "pinch-point" and critical path, minimizing the schedule benefit of an additional more expensive CS dredge.

- The long term future of dredge disposal may be in water as pumping water up into the terrestial sites creates landslide concerns. Investing in a cutter with a potentially 50 year life may be imprudent if disposal sites for such a dredge are not clearly going to be available in the distant future.

- The ACP's historical experience in the GCWP show the cutter suction and dipper had similar productions. Given the substantially lower operating cost of a dipper (less crew/fuel), the dipper seems to have established itself as the low cost producer in the GCWP. Since a large dipper is a substantially smaller investment than a large cutter, a new dipper may make more long term sense for the ACP. Furthermore, dipper capacity is not readily available on the world market on either a used purchase or contracted basis, yet cutter suction capacity is.

- Most "for profit" dredge entities invest substantially in existing CS dredge upgrades rather than build new. Since many of the basic components of the MINDI are in good shape, a substantial upgrade of the MINDI would appear to warrant serious consideration.

- Most of the new cutter suction dredgers being built today are a substantially different tool than a standard cutter. The new builds are of enormous cutter power for dredging unblasted rock, which requires structural strength far beyond that of a standard dredge (hence the new build rather than retrofit). Presuming the ACP is not intending to try to build an unblasted rock digging cutter, the used market makes more sense than a new build. Standard cutter suction dredges are available on the market that would meet the general requirements of the ACP.

- Investing in a dredge with massive in-hull pumping power is less flexible than investing in a land based booster. A land based booster can be put together relatively cheaply and used as needed with either dredge (MINDI or new dredge).

- If ACP finds supplemental equipment of this type to be useful, GLDD would be pleased to assist ACP in evaluating modern dipper dredge technology or even hydraulic excavator technology. GLDD believes it shares unique common interests and experiences in such technology that would provide an interesting discussion.

SAMPLE DAILY REPORTS

GREAT LAKES DREDGE & DOCK COMPANY

DAILY PERFORMANCE RECORD FOR ______ 19 ____

G.L.3
3/78

REPORT # ______

COPIES OF THIS REPORT MUST BE SENT TO DIVISION OFFICE AND MAIN OFFICE DAILY. MAKE REPORT COMPLETE.

DIVISION ______ TIME STARTED ______ M TIME WORKED ______

LO[illegible]ION (INCL. STATE) ______ TIME FINISHED ______ M TIME IDLE ______

HYDRAULIC DREDGE ______ WEATHER ______ WIND ______ SEAS ______

DISPOSAL LOCATION ______ MATERIAL (Identify with %) ______

DELAYS	TODAY	CONTR. TO DATE
MOVE ON/OFF SITE - WEEKEND		
CHANGE CUT OR AREA		
WEATHER		
TRAFFIC		
SHIFT ANCHORS		
CLEAN LADDER PUMP		
CLEAN MAIN PUMP		
CLEAN CUTTER		
CHANGE CUTTER		
CHANGE TEETH		
GREASE		
ADD PONTOON PIPE		
DUMP		
ADD SHORE PIPE		
SURVEY		
SPILL BARGE		
BOOSTER PUMP		
BOOSTER ENGINES		
W. [illegible]OOSTER – OTHER		
MISC.		
REPAIRS: LADDER PUMP		
MAIN PUMP		
CUTTER & SHAFT		
WIRES		
PIPELINE		
MECHANICAL (spuds, winches, etc.)		
ELECTRICAL		
ENGINE ROOM		
OTHER		
TOTAL REPAIRS		
TOTAL TIME DELAY		
TOTAL TIME WORKED		
TOTAL REVENUE HOURS		
TIME EFFICIENCY %		
REVENUE DAYS		

PRODUCTION	UNIT*	TODAY	CONTR. TO DATE
TRAVEL			
WIDTH			
AREA			
AREA/REV. DAYS			
DIG QUANTITY			
PAY QUANTITY			
AVG. DIG FACE			
AVG. PAY FACE			
EXCESS (DIG FACE–PAY FACE)			
DIG QUAN./PAY QUAN. RATIO			
PAY QUANTITY/REV. DAYS			
PAY QUANTITY/RH			
PAY QUANTITY/WH			
DIG QUANTITY/WH			

*INDICATE UNIT USED FOR QUANTITY DATA (LF, SM, CYPL, CMPPL, ETC.)

PAY GRADE ______ O.D. GRADE ______ LADDER GAUGE @ ______

AVG. SOUNDING BEHIND DREDGE TODAY

1ST SHIFT ______ 2ND SHIFT ______ 3RD SHIFT ______

PAID IN CUT ☐ PAID IN FILL ☐ ON RENTAL ☐ L.S. JOB ☐ OTHER ☐

CUT # (S) ______ LOCATION

RANGE ______ TO ______ STA. ______ TO ______

RANGE ______ TO ______ STA. ______ TO ______

RANGE ______ TO ______ STA. ______ TO ______

RANGE ______ TO ______ STA. ______ TO ______

REFER TO KEY MAPS FOR NEW DISTRIBUTION
REFER TO GREEN CARDS FOR NEW PLANT NUMBERS

ITEM	CONTRACT	SUB-JOB	TASK	PLANT	REV HR

TECHNICAL DATA

PONTOON ______ FT. LIFT ______

SUBMERGED ______ FT. SPOIL AREA # ______

SHORE ______ FT. LANDING @ ______

TOT[illegible] ______ FT. FILL TO ______

IMPELLER DIA. ______ CUTTER TYPE ______

PUMP R.P.M. ______ BLADE/TEETH TYPE ______

AVG. VACUUM ______ # TEETH USED TODAY ______

AVG. PRESSURE ______ # TEETH TO DATE ______

ATTENDANT PLANT	RENTAL OR REV. HOURS TODAY	REV.HOURS THIS KEY # TO DATE

SUPT./CAPT. ______ TODAYS DATE ______

REPORT PROMPTLY ALL ACCIDENTS AND DAMAGES

OPERATOR'S LOG

ACTIVITY	TIME STARTED	TIME STOPPED	TIME DIFF.	ACTIVITY	TIME STARTED	TIME STOPPED	TIME DIFF.

TOTALS SHOULD EQUAL TOTAL REV. HOURS FOR TODAY. ________ *________

REMARKS ON TODAYS ACTIVITIES, DELAYS, OR PRODUCTION:

____

____

____

____

____

CREW TODAY:
(to be completed at least once/wk)

	DREDGE		SPIDER		BOOSTER		SPILL BARGE					
	US	Other	US	Other	US	Other	US	Other	US	Other	US	Other
SUPERINTENDENT												
FOREMAN												
CIVIL ENGINEER												
RODMAN												
CLERK												
CAPTAIN												
CHIEF ENGINEER												
OPERATOR												
ENGINEER												
MATE												
OILER												
FIREMAN												
DECKHAND												
DERRICK OPERATOR												
DERRICK D. H.												
WELDER												
COOK												
MESSMAN												
SHORE FOREMAN												
SHOREMAN												
EQUIP. OPER.												
TOTALS												

FUEL RECORD:

LOADER/UNLOADER/DREDGE

FUEL PREV. DAY USED TO DATE ________
DREDGE USED TODAY + ________
OTHERS USED TODAY + ________
TOTAL USED TO DATE ________

FUEL PREVIOUS DAY ON HAND ________
DREDGE USED TODAY – ________
OTHERS USED TODAY – ________
RECEIVED TODAY + ________
TOTAL ON HAND ________

BOOSTER

FUEL PREV. DAY USED TO DATE ________
BOOSTER USED TODAY + ________
TOTAL USED TO DATE ________

FUEL PREVIOUS DAY ON HAND ________
BOOSTER USED TODAY – ________
TOTAL ON HAND ________

GREAT LAKES DREDGE & DOCK COMPANY

DAILY PERFORMANCE RECORD FOR ______ 19 ____

G.L.2
3/78

COPIES OF THIS REPORT MUST BE SENT TO DIVISION OFFICE AND MAIN OFFICE DAILY. MAKE REPORT COMPLETE.

REPORT # ______

DIVISION ______

TIME STARTED ______ M TIME WORKED ______

LOCATION (INCL. STATE) ______ TIME FINISHED ______ M TIME IDLE ______

BK DREDGE ______ BKT. # ______ BKT. SIZE ______ WEATHER ______ WIND ______ SEAS ______

DISPOSAL LOCATION & RT MILES ______ MATERIAL (Identify with %) ______

DELAYS	TODAY	CONTRACT TO DATE
MOVE ON/OFF SITE - WEEKEND		
MOVE TO NEW CUT OR AREA		
TRAFFIC		
WEATHER		
GREASE		
WIND SCOWS		
CHANGE SCOWS		
WAIT SCOWS/TUG RETURN FROM DISPOSAL		
WAIT TUG BUSY ELSEWHERE		
SURVEY		
WAIT SCOW REPAIRS		
WAIT TUG REPAIRS		
DREDGE REPAIRS		
OTHERS		
TOTAL DELAY TIME		
TOTAL WORK TIME		
TOTAL REVENUE HOURS		
TIME EFFICIENCY %		
TOTAL REVENUE DAYS		

SCOW NUMBER(S)	TIME STARTED	TIME FINISHED	TIME TO LOAD	SCOW QUANTITY

______ (# SCOWS FINISHED TODAY) ← TODAY'S TOTALS → ______ ______

PRODUCTION	UNIT*	TODAY	CONTRACT TO DATE
SCOW QUANTITY			
TIME TO LOAD			
# SCOWS FINISHED			
TIME TO LOAD/# SCOWS			
SCOW QUANTITY/# SCOWS			
DIG QUANTITY/# SCOWS			
# SCOWS/REV. DAYS			
TRAVEL			
WIDTH			
AREA			
DIG QUANTITY			
PAY QUANTITY			
AVG. DIG FACE			
AVG. PAY FACE			
EXCESS (DIG FACE–PAY FACE)			
SCOW QUAN./PAY QUAN. RATIO			
DIG QUAN./PAY QUAN. RATIO			
PAY QUANTITY/REV. DAYS			
PAY QUANTITY/RH			
PAY QUANTITY/WH			
DIG QUANTITY/WH			
SCOW QUANTITY/WH			

*INDICATE UNIT USED FOR QUANTITY DATA (LF, CYPL, CMPPL, ETC.)

CREW TODAY: US ______ OTHER ______ TOTAL ______

___ SUPT.	___ CAPTAIN	___ OILER	___ COOK
___ FOREMAN	___ CH. ENGR.	___ DECKHAND	___ MESSMAN
___ C.E.	___ OPERATOR	___	___
___ RODMAN	___ ENGR.	___ SCOWMAN	___
___ CLERK	___ MATE	___ TUG CREW	___
___	___ WELDER	___ LAUNCH"	___

REFER TO KEY MAPS FOR NEW DISTRIBUTION
REFER TO GREEN CARDS FOR NEW PLANT NUMBERS

ITEM	CONTRACT	SUB-JOB	TASK	PLANT	REV HR

ATTENDANT PLANT	RENTAL OR REV.HOURS TODAY	REV.HOURS THIS KEY # TO DATE

PAY GRADE ______ O.D. GRADE ______ BKT.HELD AT ______

AVG. SOUNDING BEHIND DREDGE TODAY

1ST SHIFT ______ 2ND SHIFT ______ 3RD SHIFT ______

PAID IN CUT ☐ PAID IN FILL ☐ ON RENTAL ☐ L.S. JOB ☐ OTHER ☐

SUPT./CAPT. ______ TODAYS DATE ______ 19 ____

REPORT PROMPTLY ALL ACCIDENTS AND DAMAGES

OPERATOR'S LOG

ACTIVITY	TIME STARTED	TIME STOPPED	TIME DIFF.	ACTIVITY	TIME STARTED	TIME STOPPED	TIME DIFF.

TOTALS SHOULD EQUAL TOTAL REV. HOURS FOR TODAY. ________ *________

REMARKS ON DELAYS AND PRODUCTION:

LOCATION

CUT # ________ RANGE ________ TO ________ STATION ________ TO ________

FUEL USAGE

FUEL PREV. DAY USED TO DATE ________
DREDGE USED TODAY + ________
OTHERS USED TODAY + ________
TOTAL USED TO DATE ________

FUEL PREVIOUS DAY ON HAND ________
DREDGE USED TODAY − ________
OTHERS USED TODAY − ________
RECEIVED TODAY + ________
TOTAL ON HAND ________

GEOTECHNICAL INVESTIGATIONS

Geotechnical Investigations for Dredging Projects

GREAT LAKES DREDGE & DOCK COMPANY RIVER & HARBOR IMPROVEMENTS

geo

info on dredged materials from **GLD&D** 2002/1

The following is a list of recommendations regarding geotechnical investigations undertaken to determine relevant data for dredging projects.

1) **Investigate the areas to be dredged and reclaimed.** Place borings within the dredge areas! Borings outside the dredging area are of little value when estimating dredging works.

2) **Penetrate to, and collect information from, well below the required depth.** We suggest 5 ft (1.5 m) below dredging level for non-rock dredging projects and 8 ft (2.5 m) for locations where rock will be dredged.

3) **Space borings evenly throughout the dredge areas.**

4) **Pay particular attention to vertical control and tide correction.** A dredging estimate is much more sensitive to vertical errors than horizontal errors. Take advantage of DGPS and RTK technologies for cost effective and practical vertical control (eliminating the need for tide correction). For conventional control, use a lead line with a flat plate for a sounding rope with tide corrections from a tide gauge or a nearby a tide board.

5) **Use the standard hammer and drop for standard penetration tests (SPT).** The SPT is described in ASTM D1586-99 and BS1377:Part 9. The test requires a 140-lb (63.5-kg) hammer to drop 30 in (76 cm) in air for each blow. <u>Do not use non-standard hammers.</u>

6) **Do not continue SPT beyond refusal.** Refusal = 50 blows/6 in. Stronger materials (i.e., rock) must be cored.

7) **Be careful with RQD.** The field geotechnical engineer should identify drilling-induced fractures and discount them accordingly. Include an explanation of the method and measurements used to compute RQD.

8) **On rock dredging projects, augment borings with jet probes** to establish the top of rock surface over the entire dredging area. Taking jet probes is a fast and relatively inexpensive method to obtain refusal elevations over a large area thus defining the top of the rock surface.

9) **Tests of Interest.** In general, try to obtain samples for every 3 ft. (1 m) of boring and perform the tests cited in Table I as applicable.

10) **Provide color photo logs of rock cores and soil samples.** Photo logs should include a label with borehole number and depth of the sample, and a length scale. Rock photo logs should include TCR, RQD, and locations of core loss and/or tested samples.

11) **Keep sealed samples for prospective bidders' inspection.** Samples should be sealed to protect against moisture loss.

(continued on next page)

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Richard Adams, Graphics Engineer ♦ Richard Lowry, Editor

2122 York Road, Oak Brook, Illinois 60523 ♦ 630.574.3000 *fax* 630.574.2909 ♦ www.gldd.com

12) **Provide prospective bidders with complete geotechnical reports.** Borings, profiles, and lab tests often require a complementary narrative. Include to prospective bidders.

13) **Take as many borings as possible.** Borings are much less costly than unsuccessful dredging projects.

—Prepared with materials provided by Kyle Johnson & Greg Sraders

Table I - TESTS OF INTEREST

	Clay	**Silt**	**Sand**	**Rock**
Sampling Type	Undisturbed[1] & SPT	Undisturbed[1] & SPT	SPT	Coring
Moisture Content	Yes	Yes	No	Yes
Atterberg Limits	Yes	Yes	n/a	n/a
Unit Weight[2]	Yes	Yes	No	Yes
Grain-Size Analysis	No	Yes	Yes	n/a
Shear Strength[3]	Yes	Yes	n/a	No
Compressive Strength[4]	Yes	If compact	n/a	Yes
Total Core Recovery[5]	If cored	If cored	If cored	Yes
Rock Quality Designation[5]	n/a	n/a	n/a	Yes
Fracture Index[5]	n/a	n.a	n/a	Yes

NOTES

[1]Undisturbed samples are required for unit weight and some shear strength tests.

[2]Unit weight must be in the sample's natural state to extent possible. *Take care to seal the sample at site against moisture loss.*

[3]Field tests for undrained shear strength are Pocket Penetrometer and Torvane (hand vane). Lab tests are miniature vane (motorized vane) and UU triaxial shear.

[4]Compressive strength measured by unconfined compressive strength test. Use L/D=2.5 if possible. Avoid LD < 2.0.

[5] To be recorded at drilling time

Core box photo.

geo

geo
info on dredged materials
from **GLD&D** 2001/1

Site Investigations - 1: Introduction

Variety of Tools & Methods: *A rotary drilling rig and small cantilevered working platform are set up on a jack-up barge (above left). Test deployment of seismic reflection towfish is shown at right.*

Before Great Lakes can make any sort of reasonable estimate for executing a dredging project, estimators must have an idea of the ground conditions at the project site. Normally, the owner provides such information along with the tender documents. On occasion, the information provided is insufficient for our needs. Sometimes, we begin work on a project and find that subsurface conditions are different (to our disadvantage) from those presented in the bid documents. Other times, especially for international work, this information is not provided at all and we must assume all risk for ground conditions. In these instances, we often make the decision to gather our own subsurface information.

Many methods to obtain such information are available. The most common involve taking physical specimens of subsurface materials and subjecting them to laboratory tests. We typically use sample borings or vibrocore techniques for obtaining soil and rock specimens.

- **Sample Borings:** Sample borings are traditionally made with rotary or light percussion equipment with soil or rock sampling at discrete intervals.
- **Vibrocores:** Continuous samples of soil taken from a sample tube that is vibrated into the ground, vibrocores are referred to as direct methods of investigation because they involve direct examination of the actual subsurface materials.

Indirect methods may also provide subsurface information. Indirect investigation involves inferring some aspect of subsurface conditions (e.g., material type or strength, or boundaries between different materials) on the basis of observing the behavior of some other parameter (e.g., sound waves or penetration resistance) without the benefit of examining the material itself. Typical indirect methods include:

- **Hand Probings:** Probing the ground without sampling using hand tools. Typical methods include pushing a small-diameter rod into the sea bottom until refusal.
- **Wash Probings:** Jetting water through a small-diameter pipe with a small centrifugal pump through soft material to find top-of-rock level.

(Continued on next page)

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Photo courtesy of Conrad Stanen BV


Photo courtesy of A.P. Van den Berg, Inc.

Drilling Rigs: *1) Vibrocorer with no sample tube lying horizontally on a dock. Note that the leg beneath the corer is hinged, allowing the frame to be folded as shown for removal and attachment of sample tubes.* ***2)*** *Vibro corer with a 3-m-long barrel as it is deployed from a fishing vessel.* ***3)*** *A lightweight offshore cone penetration test unit being retrieved.* ***4)*** *A typical mobile light percussion drilling set-up.*

- **Wash Borings:** Driving casing in increments (say five feet), then washing out casing using jet pipe to bring up disturbed sample of material for each increment.
- **Cone Penetrometer Testing:** There are two categories of cone penetrometer tests. Static or quasi-static testing (CPT) involves probing by hydraulically pushing a 60-degree cone into the ground at a constant speed while measuring (mechanically or electrically) the force (tip resistance and side friction) required to do so. Dynamic testing (DCPT) involves driving a cone using

hammer free-falling some distance and recording the number of blows over measured increments of penetration.
- **Seismic Reflection:** A geophysical method that measures travel times of compression waves reflected from boundaries separating materials with different compression wave velocities. The method is similar in principle to conventional echo-sounding, and is used for broad geological profiling.
- **Seismic Refraction:** A geophysical method that measures the travel times of compression and shear waves critically refracted at boundaries separating materials with different wave velocities. The method is used to determine acoustic velocity of subsurface materials, which can then be related to hardness or rippability of materials.
- **Resistivity Surveys:** A geophysical method where an electric current is applied to the surface of the earth and a potential difference within the current flow is measured. The current, the potential difference, and a geometric factor that reflects the electrode configuration are combined to produce apparent resistivity of the geologic materials. From apparent resistivity values, an interpretation is made as to material type.

Each of these methods, direct and indirect, has particular applications for which it is best suited, and no single method will work well in all cases. Often, a combination of methods is required to obtain the desired information.

—Prepared with materials provided by Greg Sraders

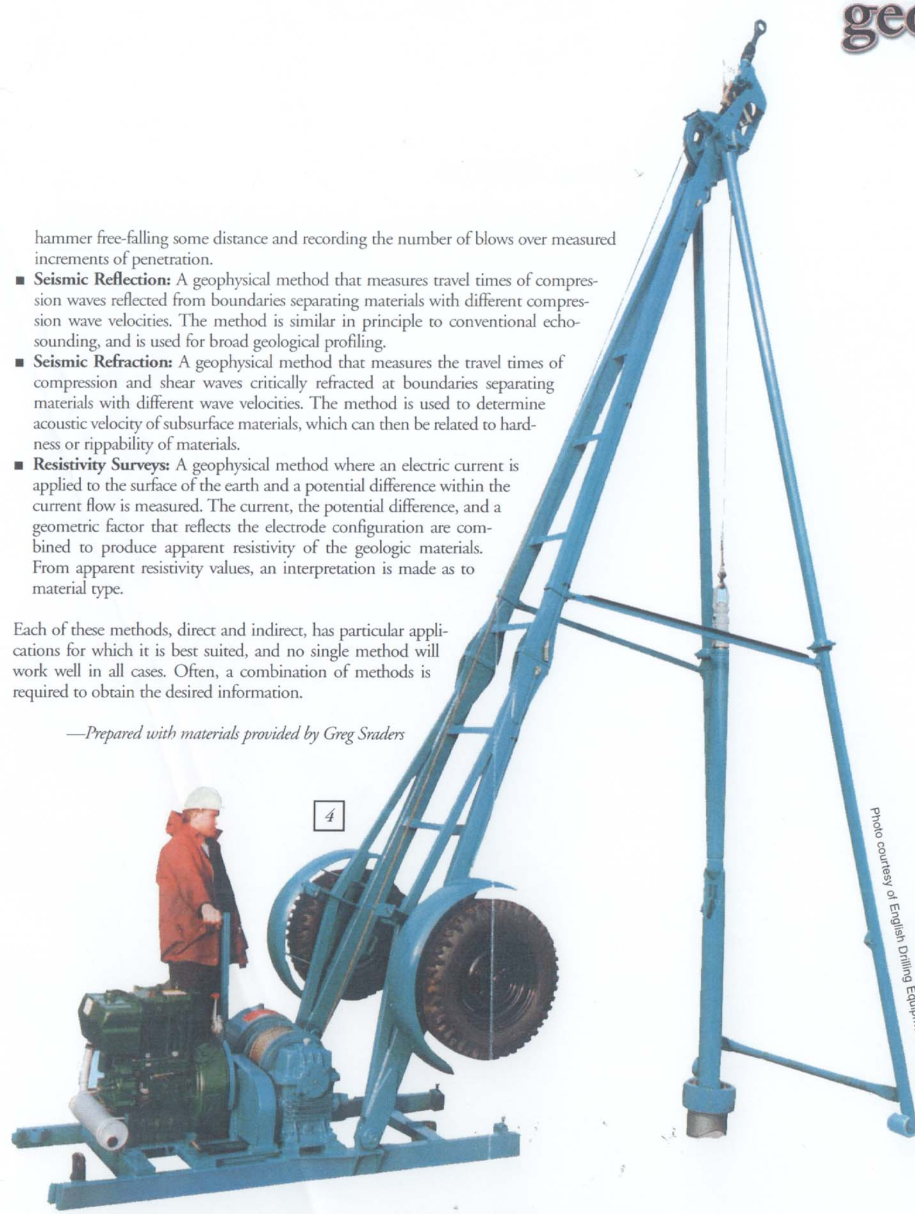
Photo courtesy of English Drilling Equipment Co.

GLDD BOOSTER SPECIFICATIONS

Jack-Up Booster No. 1


Jack-Up Booster No. 1 at full jack-up height offshore at Ocean City, Maryland

Jack-Up Booster No. 1 was constructed to provide a booster station that could be deployed in the open ocean and stand above the most severe wave conditions. The raised platform allows operations to continue in sea conditions in which a floating booster would have to shut down. Storms in the Atlantic can develop extremely quickly. In these conditions, dredges are the first equipment to be towed to safe harbor, followed by the booster and pipelines. Having a jack-up booster that can ride out a storm allows GLD&D to remove the crew to safety early, which in all cases is our highest priority.

Specifications

Hull Dimensions	42 x 80 x 8 ft
Outside of spud shoes	63 x 90.5 ft
Spuds	3 ft diameter, 84 ft long
Main Pump Power	3,600 hp @ 900 rpm
Discharge Diameter	30 in
Fuel Capacity	54,000 gal

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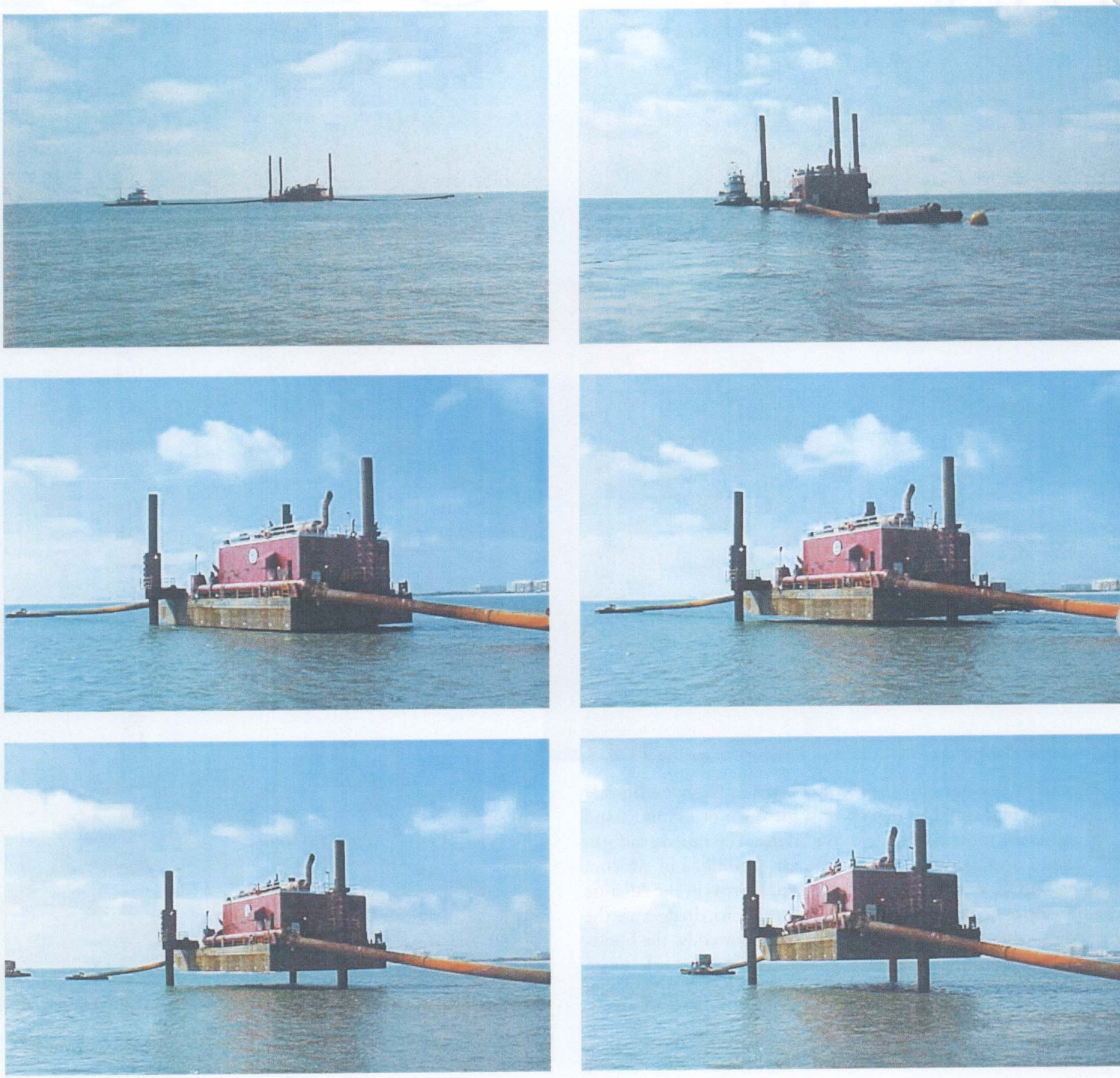

Jack-Up Booster No. 1 is raised out of the water to clear storm wave conditions.

Booster No. 2

Booster No. 2

Specifications

Hull Dimensions	50 x 140 x 12.5 ft
Anchoring/Mooring	Wire, 3-point mooring
Main Pump Power	7,200 hp @ 900 rpm
Discharge Diameter	30 in
Fuel Capacity	102,000 gal

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Booster No. 4

Jack-Up Booster No. 4 *offshore at Ft. Lauderdale, Florida. At right, the booster in service at Long Island, New York, with the cutter suction dredge* **Illinois.**
See photos on reverse.

Specifications

Hull Dimensions	56 x 113 x 6 ft
Anchoring/Mooring	6-ft-diameter x 101 ft spuds
Main Pump Power	3,600 hp @ 900 rpm
Discharge Diameter	30 in
Fuel Capacity	30,000 gal

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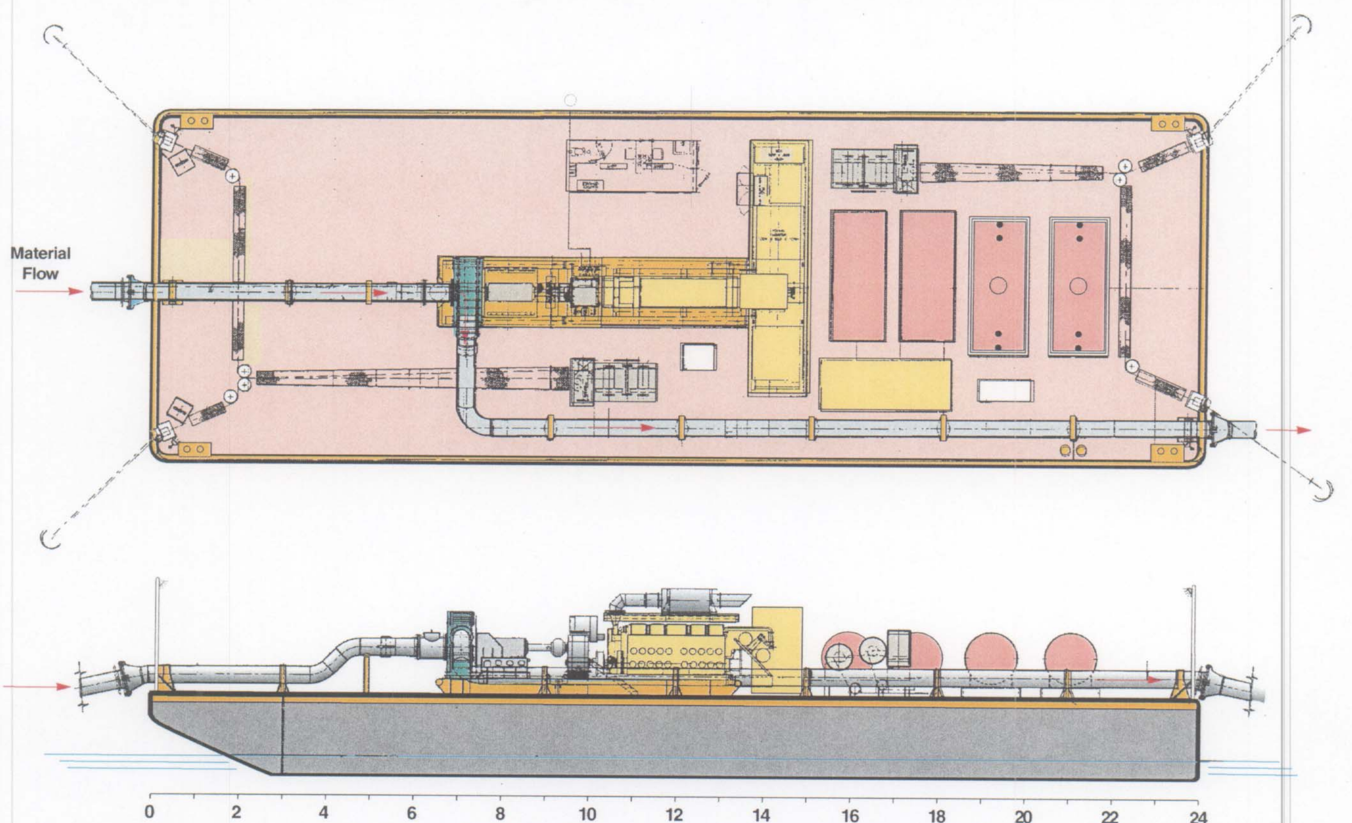
Booster No. 4 *pumps sand ashore at Ft. Lauderdale, assisting the trailing suction hopper dredge* Dodge Island *in renovating the beach.*

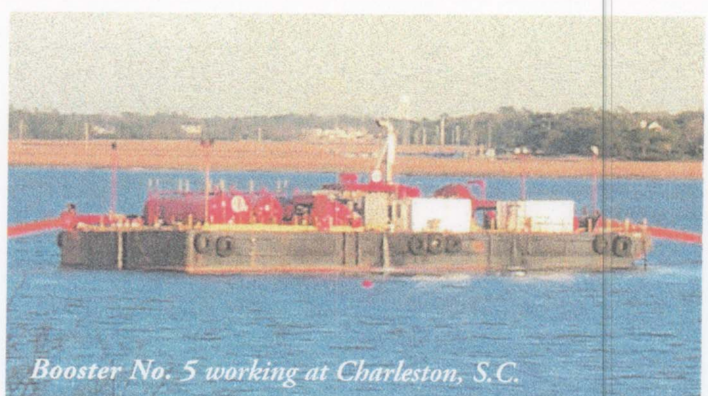
Booster No. 5



Booster No. 5: A portable booster with a 20-cylinder engine with 3,600 hp, a 30-in pump, four-point winch system, and on-deck fuel tanks, the modular booster concept has proven itself in the field. Her ocean hull is suitable for offshore work.

Specifications

Hull Dimensions	54 x 160 x 12.5 ft
Anchoring/Mooring	Wire, 4-point mooring
Main Pump Power	3,600 hp @ 900 rpm
Discharge Diameter	30 in
Fuel Capacity	28,000 gal

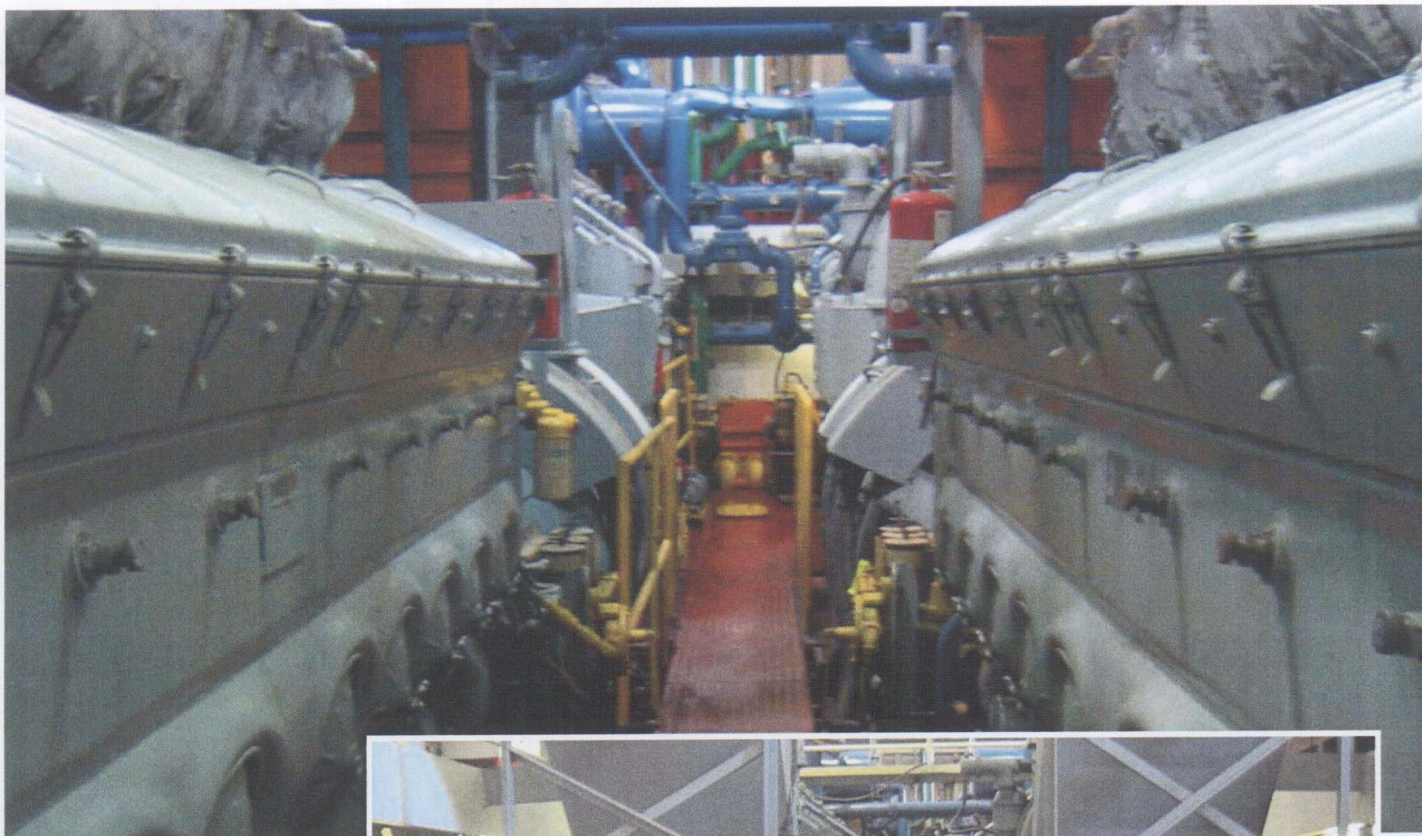


Booster No. 5 working at Charleston, S.C.

Booster No. 6

Specifications

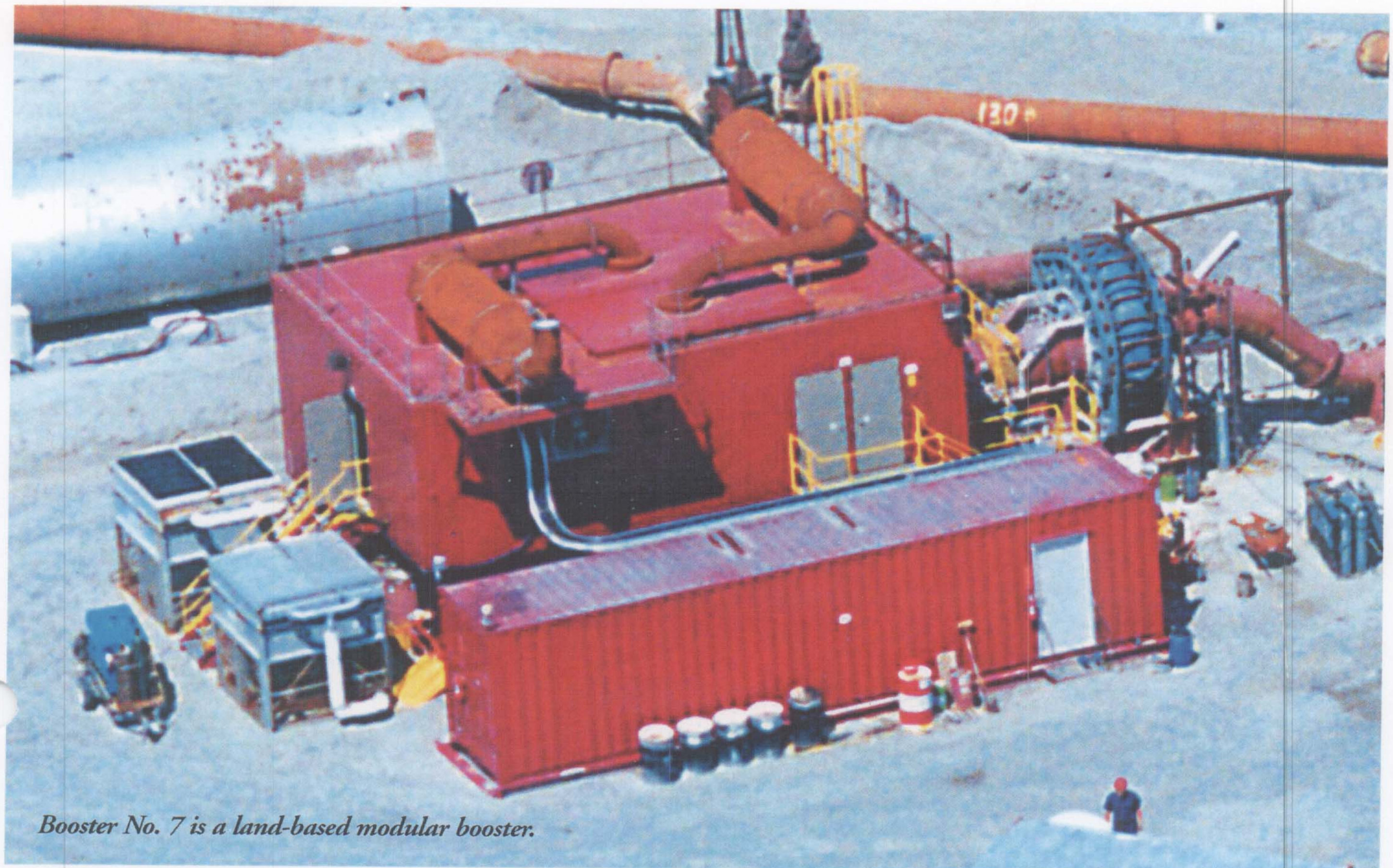
Hull Dimensions	45 x 215 x 13 ft
Anchoring/Mooring	42-in-diameter spuds
Main Pump Power	14,400 hp @ 900 rpm
Suction Diameter	34 / 30 in
Discharge Diameter	30 in
Fuel Capacity	100,000 gal



In the engineroom
of *Booster No. 6*

Booster No. 7

equipment info from **GLD&D** 2001/25



Booster No. 7 is a land-based modular booster.

Specifications

Main Pump Power	3,800 hp @ 900 rpm
Discharge Diameter	30 in

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CORPS OF ENGINEERS ENVIRONMENTAL AND SEISMIC SPECIFICATIONS

full-time (40 hours per week) Safety and Occupational Health person (Safety Officer) to manage the Contractor's accident prevention program. The Safety Officer shall be on duty during any work of a complex nature such as relocation of utilities; work on or around revetments; work on or around existing disposal area dikes; or when blasting will be performed. Duties which are not germane to the safety program shall not be assigned to the Safety Officer. The principal Safety Officer shall report to and work directly for the Contractor's on-site top manager (or a higher level official), or the corporate safety office. The Safety Officer shall have the authority to take immediate steps to correct unsafe or unhealthful conditions. The presence of the Safety Officer will not abrogate safety responsibilities of other personnel.

(b) Qualifications for Safety Officer:

(1) Shall have a degree in engineering or safety in a four-year, or longer, program from an accredited school; or

(2) Shall have legal registration as a Professional Engineer or a Certified Safety Professional and, in addition, shall have at least one year of experience in safety and occupational health work (see note below); or

(3) Shall have at least 3 years of experience in safety and occupational health work (see note below).

(Note: In order to be creditable toward satisfying the experience requirements specified in (2) and (3) above, at least 50 percent of the time during each year must have been devoted to safety and occupational health work. First aid work is not creditable.)

(c) Prior to the pre-work conference, the Contractor shall submit to the Contracting Officer, for approval, the name and qualifications of the proposed Safety Officer and a functional description of duties.

(End of paragraph number 52.223-4011 I)

12 52.223-4014 BLASTING

(a) Regulations and References. The Contractor shall comply fully with all applicable sections of the following regulations:

(1) Organized Crime Control Act of 1970, Title XI, Regulation of Explosives (P.L. 91-452) (obtainable from Internal Revenue Service as Publication 730).

(2) Commerce in Explosives, Part 181 of Title 26, Code of Federal Regulations (implements the provisions of Title XI, Regulation of Explosives, and is obtainable from the Internal Revenue Service as Publication 739).

(3) Safety and Health Regulations for Construction, Title 29, Labor Chapter XVII, Bureau of Labor Standards, Department of Labor, Parts 1910 & 1926 (published in Federal Register, Volume 36, Number 75).

(4) U.S. Army Corps of Engineers Safety and Health Requirements Manual, EM 385-1-1, edition in effect on the date the solicitation for this contract is issued, and changes and amendments thereto.

(5) Interstate Commerce Commission Regulations.

(6) Applicable U.S. Coast Guard regulations and state, county, municipal, or port authority codes, rules, regulations, and laws.

(7) Federal Register, Volume 36, Number 10, 15 January 1971, Department of the Treasury.

(b) Storage, Handling, and Security of Explosives.

(1) The Bureau of Alcohol, Tobacco, and Firearms (ATF) has enforcement, inspection, and investigative jurisdiction in all matters pertaining to explosives. The Contractor shall notify the appropriate office of the ATF in writing with copies to the local law enforcement authority and the Contracting Officer as to all related facilities, plans and procedures, prior to construction of explosives storage facilities,or receipt of explosives on the site. All transportation, storage, handling, and security of explosives shall be in strict accordance with ATF regulations.

(2) The Contractor shall be responsible for obtaining all licenses, permits, and approvals, and the keeping of accounts and records, as well as arranging the transportation and protection of all explosives on the project. Should the Contractor fail to comply with above requirements, the Contracting Officer may order a suspension of that part of work involved until the deficiencies are corrected. The Contractor's attention is also directed to subparagraphs (c)(2) and (c)(2)(i) for additional specific liability to be assumed by the Contractor.

(3) All personnel proposed for involvement with explosives, prior to any such involvement, shall be interviewed, their employee records checked, and

their history checked through local police records, for any indication of mental instability, criminal connection, or other factors which might render them a poor security risk. These records shall be made available to the ATF and the Contracting Officer for review. No person with any such risk indication shall be permitted any involvement with explosives, unless individually approved by law enforcement authorities.

(4) Any storage facilities for explosives shall be constructed, as a minimum, to conform to Type 2 Storage Facilities as specified in Part 181 of Title 26, Code of Federal Regulations, listed in the above references, subpart J, which includes requirements for hinges and hasps, and the locking system.

(5) Storage magazines/containers conforming to the referenced standards shall be inclosed by a 7-foot chain-link fence, with 3-strand barbed wire overhand mounted on steel arms facing outward at a 45-degree angle. The fence gate shall be secured at all times when not in actual use by 5-tumbler padlocks protected by 1/4-inch steel caps constructed so as to prevent sawing or lever action on the locks. The keys to the locks will be of a nonduplicating type and shall be strictly controlled by one approved individual.

(6) The explosives storage area shall be protected by security lighting installed in a manner that will provide illumination equivalent to normal daylight in the storage area.

(7) An approved armed security guard shall be posted at the storage site 24-hours per day while exlosives are stored at the job site. All security safeguards described above shall be implemented by the Contractor.

(8) The Contractor shall keep a daily record of transactions, to be maintained at each storage magazine. The inventory records shall be updated at close of business each day. Records shall show class and quantities received and issued, and total remaining on hand at end of each day. The remaining stock shall be checked each day, and any discrepancies that would indicate a theft or loss of explosive materials shall be reported immediately.

(9) Should a loss or theft of explosives occur, all circumstances and details of the loss/theft will be immediately reported to the nearest office of the ATF as well as to the local law enforcement authorities and the Contracting Officer's representative.

(c) Blasting Methods and Procedures.

(1) General. The Contractor's blasting program and methods shall be those necessary to accomplish the excavation shown on the contract drawings in accordance with the procedures specified herein. The Contractor will be required to make necessary plans, examinations, surveys, and test blasts to determine the quantity of explosives that can be fired without damaging property, and to thereafter control the quantity of explosives fired in any one blast to prevent injuries to persons or damage to structures, homes, utilities, vehicles, vessels moored or underway, or any property.

(2) Liabilities. The Contractor's attention is called to the PERMITS AND RESPONSIBILITIES and PROTECTION OF EXISTING VEGETATION, STRUCTURES, EQUIPMENT, UTILITIES, AND IMPROVEMENTS clauses of this contract which define the Contractor's responsibilities relative to the references listed in the subsequent paragraphs. The Contractor shall assume all liability and hold and save the Government, its officers, agents, and employees harmless for any and all claims for personal injuries, property damages, or other claims arising out of or in connection with handling of explosives under the contract. The Contractor shall, in addition, process any and all claims of private citizens arising out of said use of explosives promptly; in particular, all property damage claims shall be acknowledged by the Contractor (or his agent) immediately, and the claimed damage inspected within 30 calendar days following initial notification, and processed to a conclusion (honored, denied, or compromised) within 90 calendar days after cessation of all blasting on the contract; but, in no case shall the claim(s) remain unresolved for a period exceeding six months.

(3) Preparation.

(i) Public meeting. The Contractor shall make his specialists qualified in vibration and airblast control available for one day to prepare for and participate in a public meeting, conducted by the Contracting Officer to better inform the public about anticipated drilling and blasting operations. The specialists shall be prepared to answer any questions dealing with the magnitude of seismic motion or airblast overpressure expected and their impact on the public.

(ii) Preblast survey. The Contractor shall provide one person from his organization and his specialist on vibration control to work as a team with a representative of the Contracting Officer in making a preblast structural survey. A representative sample of structures (approximately 20 percent), as determined by the Contractor, that could receive seismic motion greater than 0.4 inch per second or airblast overpressure greater than 0.01 psi, will be inspected and their condition documented. Any existing outstanding architectural defects such as broken or fallen plaster or broken windows shall be photographically documented.

(4) Blasting Control.

(i) General. The blasting program and methods shall be those developed by the test blasting program and procedure to accomplish the excavation shown on the contract drawings in accordance with the procedures specified herein.

(ii) Blasting. Prior to the commencement of blasting operations, the Contractor shall submit a plan showing the location, size, spacing, type of explosives, sequence and pattern of delays (if any), and anticipated peak particle velocity and maximum peak positive airblast overpressure at the nearest structure to the blast, and description and purpose of special methods. Acceptance by the Contracting Officer of the blasting plan will not relieve the Contractor of responsibility to produce safe and safisfactory results as set forth by these specifications.

(iii) Vibration control. Where blasting is necessary, the Contractor shall employ a specialist qualified in vibration control methods capable of analyzing results obtained from seismograph readings. A minimum of 30 calendar days prior to commencement of blasting operations, the Contractor shall provide the Contracting Officer with bona fides of the seismic specialist to include, but not be limited to, past experience, training, and education. The acceptability of the specialist is subject to the approval of the Contracting Officer. The Contractor shall provide a minimum of four seismographs to measure and record ground movements caused by each blast detonated under the contract. Seismograph operators shall be qualified personnel capable of setting up instruments at designated locations and efficiently recording the blast. The seismographs shall be placed at locations to include, but not limited to, the nearest buildings, structures, or utilities, and such locations are to be approved by the Contracting Officer. Blasting shall be controlled in such a manner that the maximum ground vibration level at any structure which is vulnerable to damage shall not exceed a zero-to-peak particle velocity of 0.5 inches per second nor an energy ratio of 1.0. The instrumentation shall record three orthogonal components (vertical, radial, and transverse with respect to the location of the blast) of particle velocity direct (or shall have sufficient resolution of acceleration or displacement such that particle velocity can be readily and accurately determined from the records). The instantaneous vector sum of the three directional components of vibration will be used to compute the maximum vibration level. The record for each blast shall consist of seismograph records identified by instrument number, location of instruments positively identified, date and time and location of blast, amount of explosives used, peak particle velocity, and all other data necessary to adequately control blasting operations. A memorandum or telephone report on vibration intensity shall be submitted within 24 hours when specifically requested by the Contracting Officer or without request when such intensity exceeds a peak particle velocity of 0.5 inches per second. The Contractor shall submit a copy of the record in tabular form for each blast on a semi-monthly basis.

(iv) Airblast control. Where blasting is necessary, the Contractor shall employ a specialist qualified in making airblast overpressure measurements on selected detonations, analyzing the results obtained and making airblast predictions for succeeding detonations. A minimum of 30 calendar days prior to commencement of blasting operations, the Contractor shall provide the Contracting Officer with the bona fides of the airblast specialist to include, but not be limited to, past experience, training, and education. The acceptability of the specialist is subject to the approval of the Contracting Officer. The maximum peak positive airblast overpressure at any structures, vehicles, or vessels moored or underway, with glass windows shall not exceed 0.02 psi. Blasting operations shall not be conducted from 1 hour before sunset to 2 hours after sunrise or when a temperature inversion or heavy low-level cloud cover exists. The peak positive airblast overpressure as developed by the Test Blast Program shall be accurately measured (within +/- 10 percent) at three or more locations and to peak overpressure levels at or below 0.01 psi. The airblast overpressures from the test events should be monitored at ranges extending from the range of the closest structure to any planned detonation outward of an overpressure level of 0.01 psi or over a range from 500 to 3000 feet, whichever is greater. Results from the initial monitoring of the Test Blast Program shall be used to predict airblast overpressures for succeeding events and to insure peak positive overpressures do not exceed 0.02 psi at the closest structure or vessel moored or underway. One copy of the airblast records from each test blast identified, date and time and location of blast, amount of explosives used, peak positive overpressure shown, and all prediction curves necessary to adequately control blasting operations shall be furnished the Contracting Officer at the completion of the initial test blasts.

(5) Operational Blasting Plan.

(i) No later than ten calendar days after receipt of notice to proceed, the Contractor shall submit to the Contracting Officer 4 copies of the Blasting Plan for review and acceptance. The Contracting Officer shall have 14 calendar days for review and acceptance after receipt by the Contracting Officer's representative. If the plan is not acceptable, the Contractor shall revise and resubmit the plan. The Contracting Officer shall have 7 calendar days for review and acceptance of the revised plan.

(ii) No blasting shall be started until after the Blasting Plan has been reviewed by the Contracting Officer. Acceptance by the Contracting Officer will not relieve the Contractor of the responsibility for producing safe and satisfactory results.

(iii) The Blasting Plan shall include as a minimum requirement the following items:

(A) Proposed method of transportation, storage, and handling of explosives.

(B) Procedure for monitoring the blast operations and handling misfires.

(C) Location, size, depth, and spacing of blast holes, type of explosive and method of loading and detonating and maximum number of holes to be detonated per blast. Type of blasting machine to be used and when last tested.

(D) Type of instrumentation to be used, manufacturer, and when last calibrated and/or certified.

(E) List of licenses, permits and/or clearances required, when applied for, and date of approval or anticipated approval by federal, state, and local agencies.

(F) A format for maintaining a record of individual blasts throughout the life of the job designed to record pertinent data before, during, and after the blasting operation.

(G) Names and qualifications of specialists for vibration control analysis and airblast overpressure measurements. Refer to specifications for exacting requirements. Names and addresses of all certified blasters and users.

(H) Plan showing location of warning signs and signals to be used. Method of controlling vessel traffic and communications (if applicable).

(I) Name and address of Contractor's representative to which any claims for damage due to blasting should be addressed.

(J) A test plan which encompasses the requirements of the test blast program specified below. This plan shall also include the planned test patterns and weights of explosives of each test blast with anticipated peak particle velocities and peak positive airblast pressures at structures most likely to receive damage from the test blast.

(K) The plan shall be signed by an officer of the company.

(6) Test Blast Program.

(i) A test blast program shall be conducted by the Contractor consisting of up to 10 individual test blasts. The purpose of the test program is to allow the Contractor to establish safe limits of vibration and airblast overpressure. The test blast program shall be conducted and reported in strict accordance with procedures outlined in the sections of these specifications covering vibration control and airblast control.

(ii) Upon evidence of any damage to test structures, test blasting shall cease until the Contracting Officer has been notified, and adjustments made. The test events shall begin with a small number of charges and extend upward to the maximum yield to be used. The final test event shall simulate as close as practicable to the explosive charge type, size, overlying water depth, charge configuration, charge separation, initiation methods, and emplacement conditions anticipated for the largest detonations. One copy of the record for the test blasts shall be submitted in tabular form to the Contracting Officer daily.

(iii) After the test blasts, the Contractor shall examine the representative structures of the preblast survey as previously specified. All new damage resulting from the test blasting shall be reported in detail to the Contracting Officer, including photographs.

(iv) At the conclusion of the test blast program, the Contractor shall examine all reports, surveys, test data, and other pertinent information and conclusions reached shall be the basis for developing a completely engineered procedure for blasting. The procedure shall include sketches showing blasting patterns, weights of explosives, wiring, and charge emplacement. Four copies of the developed procedure shall be submitted for review to the Antilles Construction Office, and upon completion of the review and acceptance, it shall be appended to and become a part of the aforementioned operational blasting plan. A maximum period of seven calendar days will be required for review and acceptance by the Contracting Officer of the proposed procedure after receipt in the Antilles Construction Office. Such review period shall not be the basis for a claim against the Government for delay. In no event shall operational blasting proceed until the review of the developed procedure for blasting has been completed. If the procedure is not acceptable, the Contractor shall revise and resubmit the procedure. The Contracting Officer shall have 5 calendar days to review and accept the revised procedure.

(7) Where a Drill Boat or Barge is Used.

(i) Provisions shall be made for jettisoning explosives overboard in emergencies.

(ii) No high explosives shall be stored on the boat or barge deck in the open except for the one case that is to be loaded immediately into the bore holes. Any explosives remaining on deck shall be returned to the day magazine prior to the firing of any blast.

(iii) The firing line reel or spool shall be mounted on the rig in a manner that it cannot be lost overboard. An approved blasting machine shall be used for detonation regardless of the number of caps used.

(End of paragraph number 52.223-4014)

13 52.223-4015 SAFETY EQUIPMENT

(a) Lightning-Detection Equipment. The Contractor shall furnish, maintain, and operate lightning-detection equipment during the entire period of blasting operations and/or during the periods that explosives are stored at the site. The equipment shall be approved by the Contracting Officer, and shall be similar and equal to the Litton TSM/C Thunderstorm Monitor and Lightning Warning Instrument, as manufactured by Litton Industries, Inc., Environmental Systems Division, Camarillo, California. The equipment shall be installed where approved by the Contracting Officer. When the lightning-detection device indicates a blasting hazard potential, personnel shall be evacuated from all areas where explosives are present.

(b) Stray Ground Currents. Prior to blasting, a test shall be made for stray ground currents. The Contractor shall furnish both AC and DC voltmeters capable of reading 0.05 volts and shall employ the proper techniques in conducting the tests. Electrical blasting operations shall not be carried out when the maximum reading by the AC and DC voltmeters exceeds 0.05 ampere. The Contractor shall take all precautions outlined under "Stray Current", contained on pages 179 and 181 of DuPont's Blasters Handbook (16th Edition), to prevent premature detonation from stray ground currents.

(End of paragraph number 52.223-4015)

14 52.223-4020 HAZARD COMMUNICATION

(a) The Contractor shall comply with the requirements of OSHA 1910.1200, the Hazard Communication Standard.

(b) General requirements are as follows:

(1) Provide a written program describing implementation method of the above referenced standard.

(2) Ensure that Contractor's personnel are informed about health and physical hazards associated with materials to be used.

(3) Ensure that a hazardous material inventory is available to the Government upon request.

(4) Ensure proper labeling of hazardous material containers.

(5) Ensure availability of a Material Safety Data Sheet on site.

(End of paragraph number 52.223-4020)

3.1.12.1 Endangered Species Protection

Contractor is advised that manatees have been sighted in San Juan Harbor, in areas adjacent to and west of the Bar Channel and Anegado Channel, and in adjacent coastal waters between the Bar Channel and offshore disposal area. The West Indian Manatee is an endangered species. Endangered humpback whales and endangered sea turtles (green, hawksbill, or leatherback) may be present in water of the outer harbor channels and adjacent north coast of Puerto Rico, including the designated offshore disposal area (ODMDS). Transit of dredging vessels to and from the offshore disposal area, and disposal activities, will occur in these waters. Blasting may occur in areas where manatees and sea turtles have been observed. The Contractor shall instruct all personnel associated with the project of the potential presence of manatees, sea turtles, and whales in the Bar Channel, adjacent north coast waters, and offshore disposal area, and the need to avoid collisions with these animals. All construction personnel shall be advised that there are civil and criminal penalties for harming, harassing, or killing manatees, sea turtles, or whales which are protected under the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973. The Contractor shall be held responsible for any manatee, sea turtle, or whale harmed, harassed, or killed as a result of construction activities.

3.1.12.1.1 Siltation Barriers

If siltation barriers are used, they will be made of material in which manatees cannot become entangled, are properly secured, and are regularly monitored to avoid manatee entrapment. Barriers must not block manatee entry to or exit from essential habitat.

3.1.12.1.2 Blasting

In the Bar Channel or any area where blasting is required to obtain channel design depth, the following marine mammal and turtle protection measures shall be employed, before, during and after each blast:

a. For each explosive charge placed, detonation will not occur if a marine mammal is known to be (or based on previous sightings, may be) within a circular area around the detonation site with the following radius:

$$r = 260(\sqrt[3]{W})$$

(260 times the cube root of the weight of the explosive charge in pounds)

where:

r = radius of the danger zone in feet.
W = weight of the explosive charge in pounds (tetryl or TNT).

The area described by the above equation shall be known as the danger zone.

b. A marine mammal watch will be conducted by no less than 2 qualified observers from a small watercraft, at least 1/2 hour before and after the time of each detonation, in a circular area at least three times the radius of the above described danger zone (this is called the watch zone).

c. Any marine mammal(s) in the danger zone or the watch zone shall not be forced to move out of those zones by human intervention. Detonation shall not occur until the animal(s) move(s) out of the danger zone on its own volition.

d. In the event a marine mammal or marine turtle is injured or killed during blasting, the Contractor shall immediately notify the Contracting Officer as well as the following agencies:

Caribbean Stranding Network at 787-380-0025
Fish and Wildlife Service, Caribbean Field Office at 787-851-7297
National Marine Fisheries Service at 813-893-3366

3.1.12.1.3 Vessel/Boat Operation

All vessels associated with the project shall operate at "no wake/idle" speeds at all times while in waters where the draft of the vessel provides less than a four-foot clearance from the bottom, and vessels will follow routes of deep water whenever possible. Boats used to transport personnel shall be shallow-draft vessels, preferably of the light-displacement category, where navigational safety permits.

3.1.12.1.4 Manatee Sighting

If a manatee(s) is sighted within 100 yards of the project area, all appropriate precautions shall be implemented by the Contractor to ensure protection of the manatee. These precautions shall include the operation of all moving equipment no closer than 50 feet of a manatee. If a manatee is closer than 50 feet to moving equipment or the project area, the equipment will be shut down and all construction activities will cease to ensure protection of the manatee. Construction activities will not resume until the manatee has departed the project area.

3.1.12.1.5 Manatee Signs

Prior to commencement of construction, each vessel involved in construction activities shall display at the vessel control station or in a prominent location, visible to all employees operating the vessel, a temporary sign at least 8-1/2" x 11" reading, "CAUTION: MANATEE HABITAT/IDLE SPEED IS REQUIRED IN CONSTRUCTION AREA." In the absence of a vessel, a temporary 3' x 4' sign reading "CAUTION: MANATEE AREA" will be posted adjacent to the issued construction permit. A second temporary sign measuring 8-1/2" x 11" reading "CAUTION: MANATEE HABITAT. EQUIPMENT MUST BE SHUTDOWN IMMEDIATELY IF A MANATEE COMES WITHIN 50 FEET OF OPERATION" will be posted at the dredge operator control station and at a location prominently adjacent to the issued construction permit. The Contractor shall remove the signs upon completion of construction. Sample Manatee Caution Signs are appended to the end of Section 01130 ENVIRONMENTAL PROTECTION.

TEST BLAST PROGRAM

The purpose of the Test Blast Program is to determine the optimum drilling pattern and delay sequence with respect to rock breakage with tolerable vibration levels for productive excavation in the Bar Channel.

The Test Blast Program will begin with a single range of individually delayed holes and progress up to the maximum production blast intended for use in the harbor. Each Test Blast is designed to establish limits of vibration and airblast overpressure, with acceptable breakage for excavation.

The final test event will simulate the maximum explosive detonation as to size, overlying water depth, charge configuration, charge separation, initiation methods, and emplacement conditions anticipated for the typical production blast.

The results of the Test Blast Program will be formatted in a regression analysis with other pertinent information and conclusions reached. This will be the basis for developing a completely engineered procedure for production blasting.

Four copies of the Test Blast Results, Regression Analysis, and Scale Distance Charts will be submitted for review to the Antilles Construction Office and upon completion of the review and acceptance, it shall be appended to and become a part of the aforementioned operational Blasting Plan.

The progression of the Test Blast Program is so designed to allow for a realistic learning curve to familiarize all crewmembers with the products, safety procedure, and practical applications involved in operating in the San Juan Bar Channel.

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CAPTAIN MAROTTA'S COMMENTS

PEER REVIEW STUDY GLDD-ACP

COMMENTS BY CAPTAIN PETER MAROTTA, ACP February 5, 2004
RESPONSES BY GLDD 1 March 2004

Overall the report is well done.

1. ACP: Completely agree with you but additional planning should include Department of Engineering, Geotechnical Branch, and Department of Maritime Operations.

   GL: No doubt, planning should be a team effort.

2. ACP: Page vii, No geo-technical information is given to dredges, so assumptions based on experience are made which could lead to conservative estimates.

   GL: In many cases, our concern as contractors is that such assumptions might be aggressive resulting in potential cost overruns. In the case of ACP, we believe that most assumptions have been made on the conservative side. We understand that Dredging Division is in the process of compiling their historic data.

3. ACP: Page ix, first paragraph, could you indicate where is such information analyzed?

   GL: The cost and schedule data in each section are consistent in that the drilling capacity is insufficient to cover the work to be accomplished. In addition, the dipper dredge continually outperforms the CSD both new and old in costs and flexibility.

4. ACP: Page ix, second paragraph, if more contractors are required, then more equipment might be required. Also our dredges, THOR 54 years, RMC 27 years, CASCADAS 84 years before retiring in 1999, are all used and old equipment, which should be replaced for ACP modernization and expansion program challenge in the XXI century.

   GL: While we have some newer dredges, most of ours are 25 to 40 years old, so we do not have a lot of sympathy for the age discussion UNLESS it can be shown that existing equipment cannot be upgraded or maintained to efficiently complete the work at hand. The RMC is a great example of a tool that is in her prime now. From what we understand that is due to the investment made in improvements to the dredge. Many of the components of the MINDI are in good shape. The cost of a new dredge should be weighed against the cost of substantial upgrades to the MINDI along with the construction of a landside booster.

5. ACP: Page ix, second paragraph, please expand the statement: "Data also suggests that optimization of the Mindi would be preferable to acquisition of a new CSD"? Explain this issue.

   GL: From our brief discussions, we believe that some fairly simple changes to the underwater pump would provide benefit to the capabilities of the dredge. In addition, if the major reason for downtime is delay for marine traffic, then acquisition of a new dredge does nothing to solve that problem.

6. ACP: Page 2, second paragraph, the report implies that dredging volume calculations are OK for future dredging. The same calculation methodology was used to estimate dredging for previous Cut widening. Therefore why does the report imply that there could have been some volume miscalculation when Cut widening completion was ahead of schedule?

   GL: Touche and thanks for bringing this up. The point of this comment was that no explanation was given or attempted for the dramatic time and costs savings obtained in the GCWP. Some comparison of the actual results to the original estimate should be attempted based on this successful project to clarify if the original estimate was overly conservative or if ACP came up with a better plan than originally estimate. While bankers always appreciate cost and schedule savings, when the savings are overly dramatic as was the case in the GCWP, the results cast doubts on the viability of the original estimate. I think ACP needs to be prepared to answer these questions in detail for the next round of expansion.

7. ACP: Page 3, 1st paragraph, we do not consider a wasted effort to dredge 25' over-swing since the dredge would not require to go over again in a short time, thus increases our maintenance cycle, which in turn translates into savings.

   GL: We understand this idea now, although it would be helpful to have some data on specific areas where this is accomplished. We understand Dredging Division is compiling such data now.

8. ACP: Page 4, 2nd paragraph, I don't believe that a clamshell could efficiently do the dredging. CSD and hopper dredge are the adequate equipment to remove mud.

   GL: We successfully compete in the private market with large clamshell dredges and scows against hopper dredges. In each case, we analyze costs for each type of dredge to determine the best option. We only mention this as on option.

9. ACP: Page 5, 2nd paragraph, documentation is available through dredge captain's logbooks. Agree in discussing traffic impact with senior management. It would be advisable to discuss this issue of traffic impact with an external expert or international organization. The problem with traffic is mostly political, not operational.

   GL: We think it VERY important to quantify the actual impact of the delays. This information should be readily available from daily reports and can be translated directly to cost impacts. These are the parameters that Senior Management will want to know, so it is important to prepare the data in advance.

10. ACP: Page 14, 1st paragraph, are you implying a CSD to remove fragmented blasted rock? It is important to state size fragmentation for a CSD.

    GL: Agreed. This is an important issue for the CSD and is a function of pump vane gaps on both the underwater and main pumps. It is typical in the private industry to screen the inlet to the cutter at the mouth or cutter when dreding rock in areas that include significant amounts of rock too large to pass the pumps.

11. ACP: Page 15, 2nd paragraph, upgrading RMC for at least 79' reach is highly expensive. Would it be effective? The acquisition of a new dipper dredge is more reasonable.

    GL: Has the cost for modifying the RMC ever been estimated? How about the cost of a new dipper dredge? I can tell you that we constantly have a interesting discussion in our company about such matters, but such fact based discussion is required for Senior Management to make learned decisions.

12. ACP: Page 15, 3rd paragraph, CSD could not function in effectively blasted rock unless rock is "over blasted".

    GL: We understood that the RMC is the main tool used for dredging blasted rock, not the CSD. For sure the CSD should achieve better production in overly blasted rock, but perhaps more aggressive planning can reduce the areas where overblasting is required. To make this decision the basic technical question is how much tighter (if any) would the drill pattern have to be to prepare the rock for CS dredging as apposed to Dipper dredging and what production would result for each dredge. Once the answer to those questions is determined (either through estimation or real trials), the question is purely economical (which is cheaper). Therefore you may be right, it might have to be "overblasted", but until you know if it would and if so how much, you don't know what the cheapest overall plan is.

13. ACP: Page 15,4th paragraph, contradiction, it was said previously that CSD would follow THOR for dredging, and then it is said that CSD is not likely to be an efficient tool for dredging blasted basalt.

    GL: Good point of discussion. Here the issue is degree of efficiency. In this application, we believe the dipper type dredge to be a more efficient tool for dredging large quantities of blasted basalt.

14. ACP: Page 18, last paragraph, CSD is not appropriate but a clamshell, which would be better instrument unless the rock is "over shot".
    GL: Good point also. Upon further research, although we have used our large clamshells in dredging blasted rock, we agree it is not an efficient tool for this application.

15. ACP: Page 22, it is weekly cost.

16. ACP: Page 28, 1st paragraph, again information is contained in dredge captain's logbook.

    GL: We also understand that information is confirmed and compiled in some form in the Dredging Division office. However, this information has not been provided and thus is not being utilized in the studies.

17. ACP: Page 28, 2nd paragraph, THOR has to be allowed to complete its work because its production will affect RMC's productivity.

    GL: Agreed.

18. ACP: Page 28, Please include the statement that if it is done in NY, it could be done in the Panama Canal. Refer to item 17.

    GL: We should discuss before we include this. There are some issues in NY that are unique to NY and would not be helpful to the dredging operations in Panama.

19. ACP: Page 29, 2nd paragraph, there's also a phenomenon called "re-interlocking" which material will interlock itself so blasting might again be required for future dredging.

    GL: Agreed, although we do not have a lot experience with this, redrilling and blasting previously shot rock is VERY difficult.

20. ACP: Page 29, 3rd paragraph, there are no similarities between previous widening project and current deepening project. The dredging productivity for widening is higher than deepening because of less traffic interference and higher banks.

    GL: We note that ACP is also using the previous work in its estimates. At a minimum, the material in previous widening is likely to be very similar to current project. Although bank height may be higher, narrow cut widths of a relatively small widening can be very detrimental to production when it comes to a cutter suction dredge. We would also note there are in fact many similarities to be used in evaluating production, including use of bank factor (dig face). Other factors such as material type, cut width, bucket used, digging method, scow availability, etc. all play a role in the production and can be analyzed and used with some discretion in estimating the upcoming expansion work.

21. ACP: page 29, 4th paragraph, GCWP duration reduced because

    a. Initial estimates performed at 37.5' cuts for dredging
    b. It was discovered that 45' cuts for dredging were more effective for RMC progress

    Straight 130'/37.5' = 3.4 cuts reduced to 130'/45' = 2.8 cuts
    Curves 230'/37.5' = 6.1 cuts reduced to 230'/45' = 5.1 cuts

    GL: Great information to confirm that Dredging Division is proactive in trying to maximize production. However, cut width is not the only factor that reduced the schedule and cost of the GCWP by the dramatic amount it what we reduced. Some reports we have read mentioned the schedule and costs were reduced by 50% of the original estimate. The follow on question to this cut reduction program is that while the number of cuts were removed, how did production actually improve in comparison to what the dredge was doing previously??

22. ACP: Page 30, last paragraph, dredging has been very successful in the past with little geotechnical information. It could be more successful with more geotechnical information.

    GL: We would agree that the dredging program has been successful in completing the work set out for the equipment. Next step and part of this discussion is can it be made more efficient.

23. ACP: Page 32, 1st paragraph, How can you control "with scientific certainty" the size of rock after opening drilling pattern or reducing powder factor? With larger rock, bucket fill factor could lead to less efficiency because less material filling. Large boulders in bucket that require shot interrupt digging time. Also, RMC might need to dig deeper to remove larger boulders, bottom final profile will look rough, and dredging cycle time will increase.

    GL: Great observations by someone who has obviously been "in the trenches". Of course, there is no scientific certainty in dredging where you are working blindly underwater. Certainly a goal would be to minimize the amount of boulders too large to fit in the bucket. There is an additional component to the discussion about production, and that is costs. Our experience has been that the savings achieved by reducing blasting costs, more than compensates for occasional delays to dredge production. This is an unpleasant discussion for the group who has to answer for production, but nonetheless the final determination as to the efficiency of an operation is its COST effectiveness.

    From a practical perspective, we agree in general with these comments, but would respond that when we have used these same arguments in our various careers, we can always count on our respective bosses asking us to "prove it" and/or "lets try it and see what happens". We trust that Dredging Division will continue this tradition.

24. ACP: Page 32, last paragraph, if the material is unblasted and soft, the CSD is the ideal dredge. What type of material you are referring to when RMC can dredge unblasted material? Is it soft?

    GL: Yes, in this case, we have had some success with our dipper dredges in softer or weathered-rock. Not the ideal situation, but again if the material can be dredged "efficiently" without blasting there is a built-in savings.

25. ACP: Page 33, 1st paragraph, bigger scow when ballast could be too high for dredges and tugs.

    GL: Agreed, and would require study to assure the impacts were within the operational limits of Dredging Division Requirements.

26. ACP: Page 33, 1st paragraph, ACP Board of Local Inspectors (BLI) have already techno-statuatory (regulation) for tugs size based on horsepower to equipment displacement rate to move equipment in confined spaces such as the Cut thus so our tugs are acceptable for ACP scows. They are also intended for other use including assistance to transiting vessels.

    GL: Understood.

27. ACP: Page 34, 3rd paragraph, Again information is in the logbooks.

28. ACP: Page 34, 4th paragraph, refer to previous comment, number 25. Sometimes RMC does dredging before blasting with mixed results.

    GL: This information should be quantified, compiled and made part of the records for use in estimating and planning. It is important to not only analyze from production standpoint but from cost view.

29. ACP. Page 34, last paragraph, be careful how production is measured. Sometimes linear advancing is more important.

    GL: Agreed, as the available bank of material goes down, you can get to the point where the limiting factor is the dredges ability to cover ground. This is exactly why details such as the bank being dredged are important to include in production history for use in forecasting future work. We would expect that the 46' and 50' deepening programs would not have much coverage limited work.

30. ACP: Page 36, explain it is $307,545 per week. Explain also why a crew of 6 or 5.

    GL: Our standard day shift crew is one operator, one mate, one engineer, one deckhand, and one welder. The night shift is without the welder.

31. ACP: Page 51, 3rd paragraph, factors that contributed to early completion of GCWP. Bucket filling factor of 100% because of "overshot". RMC might not get this factor if blasting is not performed as it is now: "overshot".

    GL: Follow on questions will be, was the RMC waiting on the drill boat to "overshoot" the material, and what is the impact of less than 100% bucket fill factor? What is the fill factor of rock is shot less?

32. ACP: Page 53, 2nd paragraph, there are 3 dipper arm available.

    GL: Understood.

33. ACP: Page 53, last paragraph, no choice for RMC in order to dredge. Orders from MTC should be followed as per dump scow and RMC arrangement in the channel. Dredging in this configuration heaves material toward centerline. Thus berms are created sometimes.

    GL: Understood.

34. ACP: Page 54, 5th paragraph, in my opinion, the RMC won't gain anything by retrofitting. It is not cost effective because of age, previous investment. Refer to item 4.

    GL: Understood, again age is not an argument unless it can be proven that it impacts production and costs. RMC is performing well finally and is proving itself quite capable,

35. ACP: Page 55, last paragraph, 3,000 hp tugs are also intended to move ACP cranes, pipelines, MINDI, ships, etc.

    GL: Understood, again, while a 3,000 hp tug would be required to move ships, certainly not required to move dredge equipment.

36. ACP: Page 55, last paragraph, Dredging division does use other tugboats such as those from ACP Department of Maritime Operations, MR. Although there are 24 tugs available from MR, there are not sufficient crew. We are not optimizing our available resources.

    GL: Understood, and with this large project to complete, optimization will be a key concept

37. ACP: Page 56, 3rd paragraph, RMC has dredged blasted rock with success, and un-blasted rock unsuccessfully.

    *The success or failure of the dredge in unblasted rock has to take into account the **cost** savings of not drilling. This information should be quantified and compiled. Is there information as to what type of rock has not been dredged unsuccessfully? Was there complete failure or just low production?*

38. ACP: Page 56, 4th paragraph, please refer to previous comment, number 25.

39. ACP: Page 56, last paragraph, finer shots less overdredging. Larger boulders will cause more overdredging.

    GL: In concept this would appear to make sense, however, in our experience, we have never been able to prove this. Perhaps there is an occasional small hole left by a boulder, but in general, we have not been able to prove the impact. Perhaps this would be interesting for the ACP to perform tests in different areas of the canal to see if a reduction in drilling and blasting can be achieved.

40. ACP: Page 57, 2nd paragraph the leasing of clamshell or hopper dredge or backhoe with small bucket and long arm will depend on the type of material and depth of cut.

    GL: Agreed

41. ACP: Page 57, 3rd paragraph, again such info is documented in captain's logbook.

42. ACP: Page 57, 4th paragraph, in the Canal it is not wise to have survey every day since sometimes, only a small area is being dredged. Only when a specific amount of area has been dredged, the captain calls ACP survey boat.

    GL: We are suggesting use of the daily survey as a QC device, without relying on the operator to confirm he had achieved grade. If there are other means available, fine, but in general it only takes a short amount of time to run the daily QC survey and then the engineers can continue the rest of their routine.

43. ACP: page 58, 1st paragraph, barges are loaded to plimsoll mark load line. So, theoretically, volume should be OK based on dredged material specific gravity.

    GL: While we agree that if you load to a consistent draft (the load-line), you get a relatively consistent volume in the scow and that volume can be estimated, but it's not as simple as the dredged material specific gravity. There is typically a free surface of water on either end of the scow and that water is part of the scows tonnage load. There is also the question of what is the specific gravity after blasting, and does it change during the loading process (bulk). Lastly there are two densities of material in the scow, the saturated density below water line in the scow and the dry density in the material heaped above the hopper water surface.

44. ACP: page 58, again, dredge advance and accomplished channel depth must be considered to determine the degree of success, and not necessarily volumetric productivity.

    GL: We agree the available face has a significant impact on dredge productivity. The lower the face, the greater the impact. This is where more detail in the historical productions upon which the studies estimates are based would help enormously. A more detailed analysis of production would likely result in lower production estimates for the 41.5' draft option than the 50' draft option. Without the detail on the previous history, it's applicability to the current work cannot be made.

45. ACP: Page 59, I agree that it is a reflection of geotechnical investigation and should be helpful to ACP.

46. ACP: Page 52 of THOR, 2nd paragraph as explained in item 23.

47. ACP: Page 52 of THOR, last paragraph, what is sandpot system? Provide explanation on this system.

    GL: It is basically a casing that is of substantially greater diameter than the drilled hole. It is hammered through the overburden and seats on the top of rock, preventing overburden from falling into the hole as the drill advances. It also provides a path from the surface to the hole for loading purposes.

48. ACP: Page 55 of THOR, more overdredging leads to full bucket, therefore dredging is more efficient. Partially loaded bucket for less overdredging is not proved to be as efficient as more overdredging. Plus more overdredging does not require substantial effort and time consumption, and maintenance cycle is longer. Also by removing smaller fragmented rock ("overshot") produces a smooth bottom profile closer to the target design channel. By removing large boulder, there is rough bottom.

    GL: Again, efficiency needs to be measured in terms of equipment production AND costs. Overdredging is rarely a good thing in terms of cost efficiency.

49. ACP: Page 58, page 58, 2nd paragraph, current drillboat cannot keep up with RMC production. RMC dredges faster than the THOR can blast.

    GL: We assume this to be a specific comment based on a specific situation. As discussed earlier, there are so many factors affecting the production of this equipment that such a blanket statement cannot be made in terms of planning without supporting data.

SUMMARY AND CONCLUSION:

As per GLDD "Peer Review", there are certain areas in our operation that most definitely can be improved to increase our efficiency and lower our operating costs. Chief among these are better internal communication, more geologic investigation and more detailed record keeping. However as Captain of the dipper dredge, Rialto M. Christensen, the single most critical factor to enhancing production is the available access to portions of the channel that require dredging. AS long as no solution to the "classic" problem of transiting vessels and dredging operations is addressed, dredging productivity will suffer, and as a result when water levels go down shipping will be adversely affected.

As we continue to deepen, straighten and widen the existing Panama Canal, if no solution to this problem is enacted, it will not only affect dipper dredge operations, but CSD operations (because of digging spud positioning relative to centerline) nor will any contractor discover new and cheaper methodology. The problem with dredging operations and transiting operations is more political than technical (bow pilots, slide pilots, tug assistance should be explored).

One last thought: Dredging of the Panama Canal is not a luxury; it is a necessity (sooner or later).

GL: In our experience, a good dredge captain's priorities are:

- *The safety of his crew and vessel*
- *Keeping his dredge operating (not waiting on others)*
- *Seeing his dredge be productive, shipping scows to sea at a rate higher than expected.*
-

Obviously, the author of these comments is a good dredge captain. When you look at the operation of the dredge from the perspective of ACP Senior Management, the priority is safety and then economics. Is it cheaper to have the dredge wait for ships or ships wait for a dredge? Is it cheaper to push the RMC to the point where risks of damage are higher and save money on blasting or shoot to the point where the RMC is never inconvenienced by large rocks? Is it cheaper to modify existing and accept some downtime due to age or build brand new? There is no one person in our organization nor in any competing organization that we know of, who is solely responsible for answering there questions. We trust that these answers will be developed by the ACP team also.