International Association of Dredging Companies

- IMPACT OF MEGAPROJECTS on the dredging workforce
- UNCERTAINTY ANALYSIS of maintenance dredging volumes
- ENVIRONMENTAL PLAN for an in-water containment facility

Maritime Solutions for a Changing World
Terra et Aqua is a quarterly publication of the International Association of Dredging Companies, emphasizing “maritime solutions for a changing world.” It covers the fields of civil, hydraulic and mechanical engineering including the technical, economic and environmental aspects of dredging. Developments in the state of the art of the industry and other topics from the industry with actual news value will be highlighted.

- As Terra et Aqua is an English language journal, articles must be submitted in English.
- Contributions will be considered primarily from authors who represent the various disciplines of the dredging industry or professions, which are associated with dredging.
- Students and young professionals are encouraged to submit articles based on their research.
- An exception is made for the proceedings of conferences which have a limited reading public.
- In the case of articles that have previously appeared in conference proceedings, permission is required.
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COVER

Baltimore Harbor, Maryland, urgently needed a dredged material containment facility (DMCIF) as all previous areas were closing in December 2009. With unusual speed, approvals and permits were received in 28 months and work could begin. Please refer to: An area view of the direct placement of hydraulically dredged cut-benchmark into the dike section at the new Baltimore DMCIF.

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EDITORIAL

THE CHANGING MARITIME INDUSTRY: THE IMPACT OF MEGAPROJECTS ON THE WORKFORCE
KEES D’ANGREMOND

As the demands on global dredging projects have increased, so have the demands on personnel, crew members, engineers and others in the industry. How has this impacted education and the professional requirements of the workforce?

UNCERTAINTY ANALYSIS OF THE MUD INFILL PREDICTION OF THE OKLNG APPROACH CHANNEL: TOWARDS A PROBABILISTIC INFILL PREDICTION?
SUZE ANN BAKKER

To take well-founded financial decisions, help manage risks and reduce uncertainty, a model for calculating the probabilistic assessment of maintenance dredging volumes was developed using the Olokola LNG project near Lagos, Nigeria, as an example.

MASONVILLE DREDGED MATERIAL CONTAINMENT FACILITY: ENVIRONMENTAL PLANNING, COMPLIANCE AND COMPENSATORY MITIGATION
KAITLIN E. McCORMICK

Planning a new confined disposal facility at the Baltimore, Maryland, Harbor was easy, but building it required extensive permits, environmental licenses and collaboration with the public, other stakeholders and regulatory agencies.

SEMINARS/CONFERENCES/EVENTS

Two important events in November: The 35th IADC International Seminar on Dredging and Reclamation in Singapore, and the CEDA-IADC Environmental Aspects of Dredging Training Course in Africa.
As summer draws to a close and students return to schools and universities, our focus turns to the subject of finding and educating the next generation of dredging experts. And the question arises, “what are we doing to draw young people toward our industry?” And once they have joined our ranks, how do we hold onto them? What qualities are we looking for and, vice versa, what are young people today seeking in a career and profession? What makes dredging such an attractive industry that it has held us captive, fascinated and challenged?

Dredging awakens curiosity and inventiveness. Dredgers are explorers “finding” new lands of their own creation. State-of-the-art dredging equipment and vessels are busy worldwide. And whilst dredging is a hands-on profession, it has an idealistic side – a side that looks to the future to improve the lives and well-being of people by creating new infrastructure that betters their economic and social circumstances. Over the years, the demands for expertise have widened considerably as the work, and the environment within which dredgers work, has grown ever more complicated. As Professor Kees D’Angremond writes in his article in this issue of Terra, projects are bigger, ships are bigger and dredging companies also need to think ‘bigger’ when looking for their workforce: “Society expects a larger span of control from its engineers, a vision of the consequences of the project, a rapid an adequate response if something unwanted or unexpected occurs”.

At a recent dredging conference, the discussion arose with a group of people about how they had ‘found’ dredging, or had dredging ‘found’ them? Several agreed that a career in dredging was not an obvious choice. For some it was a family business, generations before them had been in the industry. For most, however, it was serendipitous – an encounter with a stimulating professor or an enthusiastic acquaintance. The ‘wet’ side of engineering usually came to their attention only years after their studies had commenced. But once they had discovered dredging they were hooked. And with dredging in the news more often than ever – playing a major role in land reclamation projects in Singapore, Dubai and Abu Dhabi, as well as restoration work after the tsunami in Southeast Asia, Hurricane Katrina and the Gulf of Mexico clean up – the industry is drawing more and more positive attention.

Each dredging project represents the hard work of hundreds of people: Engineers, dredging masters and their crews, project managers, scientists, researchers, specialists in all areas of maritime construction. Local people who have been employed and trained on site and employees who, sometimes at the drop of a hat, are deployed all over the world. Each project reflects expertise, enthusiasm, imagination, and professionalism. Recently IADC has taken the initiative to assist young people in finding appropriate studies in the maritime sector, as well as to ultimately guide them in finding employment within the industry (see http://www.iadc-dredging.com/index.php?option=com_content&task=view&id=66&Itemid=90).

IADC also recognises the importance of rewarding younger members of the dredging community and some years ago initiated the “IADC Award for the Best Paper written by a Young Author” to be presented at selected conferences. In this issue of Terra two papers that received this award are published: One at the PIANC MMX Conference in Liverpool, UK and the other at the WEDA / TAMU Conference in San Juan, Puerto Rico. In both cases, the intelligence, dedication and insights of these young researchers shine through. And we as an industry must be encouraged by their contributions.

Koos van Oord
President, IADC
ABSTRACT
Over the course of the last 40 years the face of dredging has changed dramatically, with coastal engineering projects completed in much shorter time frames. It is widely recognised that the technological changes in maritime construction and the ever-increasing magnitude of projects, so-called megaprojects, have resulted in increased demands on personnel, crew members, engineers and others in the dredging industry. This article addresses these demands and how they have impacted the education and professional requirements of the workforce.

INTRODUCTION
In recent years so-called megaprojects in coastal engineering have increasingly been in the spotlight. It is not clear at all, however, which criteria place any project in that category. Is it the impact on the economy or the environment? Is it the area covered by the project, the volume of material handled, the turnover or the profit associated with the execution? These questions seem rather academic since almost everybody in the coastal engineering community considers projects like Tuas reclamation and other projects in Singapore, Chek Lap Kok airport in Hong Kong, the reclamation projects in the Gulf region (Dubai and Qatar), and most recently the extension of Maasvlakte in Rotterdam to belong to this category. Surprisingly, hardly any mention is made of similar sized projects in the past: construction of the Suez Canal and Panama Canal, the closure of Lake IJssel and the subsequent reclamation of 165,000 ha of land, the Delta Project in the Netherlands, including the storm-surge barriers in the Eastern Scheldt and the Rotterdam Waterway.

WHAT CONSTITUTES A MEGAPROJECT?
From large to extra-extra large
A critical analysis of similarities and differences between the older megaprojects and the more recent ones demonstrates that these older projects should not be excluded from the category megaproject. The most important distinction between the older projects such as the Suez and Panama Canals or the Lake IJssel Reclamation and Delta Project in the Netherlands (Figure 1) and the projects today such as in Dubai (Figure 2) is the construction time. Where the projects of the past took decades to be completed, the recent ones are completed in a few years. For a more elaborate analysis, see Table I, Figures 1 and 2, and K. D’Angremond, “Scale effects of megaprojects”, Shore & Beach, (Vol. 76, No. 4, Fall 2008). More interesting than a discussion about which projects qualify for the mega-size category is the analysis of the faster execution of these projects: What are the causes and what are the effects of the faster execution? One cannot limit this discussion to the world of the contractors only, but one should incorporate designers and owners as well.

BACKGROUND OF THE FASTER EXECUTION
The faster execution of mega-dredging projects has several reasons including economic and social motivations. But of course neither of these would matter nor be possible if technology had not kept pace.

Rate of return
One of the major reasons why faster execution of large projects is attractive is certainly the wish to enhance the rate of return on investment. More and more projects are scrutinised by economists on
the basis of a calculation of the net present value (NPV). Interest payments on the capital investment during construction reduce the NPV and earlier revenues increase the NPV. All good reasons to attempt a reduction of the construction time. An additional reason might be the fear that competitors “borrow” the ideas and run away with potential customers.

Whatever the economic drivers to reduce construction time, from a technical perspective this acceleration was only possible because of a tremendous increase in the capacity of the construction equipment.

As the focus here is on coastal engineering projects, this means mainly the capacity of the dredging equipment.

The increased production capacity is partly the result of increased understanding of the physical processes involved, like mixture formation, pumping sand water mixtures and deposition of granular material. In fact, one may conclude that the co-ordinated research efforts that started in the late 1960s now fully contribute to the output.

Supply and demand
A second aspect is a mutual influence between supply and demand in the market. Technological innovations facilitate the construction of ever larger equipment, the larger equipment facilitates larger projects and the larger projects in their turn create a demand for larger equipment. This effect can best be explained by comparison of some older and more recent dredgers.

Effects of faster execution
Whatever the background of the faster execution, contemplating the consequences is interesting and crucial. Obviously, the faster execution and the shorter duration of the projects must have a large impact on organisations and individuals involved, whether the owner of the works, the designers, the contractors or the supervisors.

Starting on the purely technical side, the time available to run in on a project is less. Small deviations of the work plan will have immediate and large consequences. There is less time to re-consider and optimise working methods. Preparations, therefore, have to be more elaborate, but also the project management must be more alert than ever to notice differences between the anticipated work method and the actual course of events. There is very little time to allow for a learning curve on the project.

The same applies to the representatives of the employer. If the works cause unforeseen and unwanted side effects (technically, environmentally or even socially or politically), in the past time was ample to reconsider and adapt the original set-up. This is not merely a hypothetical remark; many such adaptations took place during the execution of the Lake IJssel reclamation and the Delta Project in the Netherlands where time to rethink a

<table>
<thead>
<tr>
<th>Project name</th>
<th>Country</th>
<th>Year of Completion</th>
<th>Construction Time (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suez Canal</td>
<td>Egypt</td>
<td>1869</td>
<td>11</td>
</tr>
<tr>
<td>Panama Canal</td>
<td>Panama</td>
<td>1914</td>
<td>22</td>
</tr>
<tr>
<td>Lake IJssel Reclamation</td>
<td>The Netherlands</td>
<td>1968</td>
<td>48</td>
</tr>
<tr>
<td>Delta Project</td>
<td>The Netherlands</td>
<td>1986</td>
<td>30</td>
</tr>
<tr>
<td>Palm Jumeirah</td>
<td>UAE</td>
<td>2005</td>
<td>3</td>
</tr>
</tbody>
</table>

An interesting comparison is of two vessels, both named W.D. Fairway. The older one was constructed in the 1960s, the newer one in 1996 and extended in 2002. This coincidence became to light at the National Dredging Museum, when during a search for a picture of the new vessel, a picture of the older one came to light. Although the newer vessel was lost after a collision in 2007, it remains unusual to find two vessels with the same name which are so extremely different (see Figures 3 and 4 and Table II). The remarkable point is that, roughly speaking, although the strength of the crew on both vessels is equal, productivity is not. Despite the tremendously increased hopper capacity on the newer vessel, the filling time for both hoppers remained almost the same. This once again demonstrates that supply and demand and technological innovation have gone hand in hand.
The introduction of the Alliance Contract has provided a way for contractor and client to share responsibilities and risks and find solutions together, but this too requires elaborate planning and teamwork. At the end of the day, people on the work floor have to cope with the more complicated conditions. When the scene on the work floor changes, making changes to the workforce must be considered as well. Successfully completing a large project remains the work of people, in spite of the power of our tools. The conclusion is that the changes in the scale of present-day projects will have a major impact on the quality and quantity of the human resources we engage.

The effects are not restricted, however, to the technical side of the projects. A shorter project duration also means compaction of all financial and administrative procedures. This starts with financing, intermediate surveys, issuing of payment certificates, and so on. It ends with reduced times for contractual notifications and formulation of claims, to name a few aspects.

The overall picture is clear: Faster execution leads to a need for increased alertness, shorter lines of communication and a better understanding of all processes during execution. The staff on site must consist of well-trained observers who can distinguish and interpret even the slightest signals that indicate deviations from the anticipated plans. It means that they must be able to observe and to reflect quickly on the meaning and background of what they have observed.

Where communication between designer, owner and contractor is involved, one of the solutions is a change in the contractual relations. Design and Build contracts or even Design, Build and Maintain contracts solve part of the problem for the owner, but increase the exposure of the contractor. The introduction of the Alliance Contract has provided a way for contractor and client to share responsibilities and risks and find solutions together, but this too requires elaborate planning and teamwork.

At the end of the day, people on the work floor have to cope with the more complicated conditions. When the scene on the work floor changes, making changes to the workforce must be considered as well. Successfully completing a large project remains the work of people, in spite of the power of our tools. The conclusion is that the changes in the scale of present-day projects will have a major impact on the quality and quantity of the human resources we engage.

**THE EFFECTS ON INDIVIDUALS**

When attempting to formulate what effect these changes have for the staff on dredging work, the introduction of the Alliance Contract is perhaps the most prominent of all. The concept is to share responsibilities and risks with the client, so as to reach a better understanding of what is expected. The contractor will be more involved in design, cost control, quality assurance, and more. This will improve the contractor’s ability to handle unexpected situations, as well as the satisfaction of the client. Furthermore, the contractor’s exposure to the project will increase. This will require more planning, teamwork, and dedication, but it will also provide more opportunities for the contractor.

**Table II. Comparison of main characteristics of the old and new TSHD “W.D. Fairway”**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Unit</th>
<th>W.D. Fairway (old)</th>
<th>W.D. Fairway (new)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>m</td>
<td>69.19</td>
<td>232.35</td>
</tr>
<tr>
<td>Width</td>
<td>m</td>
<td>11.85</td>
<td>32.00</td>
</tr>
<tr>
<td>Loaded draught</td>
<td>m</td>
<td>5.47</td>
<td>13.68</td>
</tr>
<tr>
<td>Sailing speed (fully laden)</td>
<td>knots</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Hopper capacity (sand)</td>
<td>m³</td>
<td>1,236</td>
<td>33,800</td>
</tr>
<tr>
<td>Cargo capacity</td>
<td>tons</td>
<td>1,605</td>
<td>56,800</td>
</tr>
<tr>
<td>Suction tubes</td>
<td>-</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Suction tube diameter</td>
<td>mm</td>
<td>850</td>
<td>1200</td>
</tr>
<tr>
<td>Max. dredging depth</td>
<td>m</td>
<td>18.29</td>
<td>55/120</td>
</tr>
<tr>
<td>Total installed power</td>
<td>kW</td>
<td>1,660</td>
<td>27,500</td>
</tr>
</tbody>
</table>

Figure 2. Reclamation projects in Dubai were completed in a few years.
projects, the conclusion in the first place must be that all involved have a much larger responsibility than in the past. And larger responsibility leads to more stress. Society expects a larger span of control from its engineers, a vision of the consequences of the project, a rapid and adequate response if something unwanted or unexpected occurs. These skills are important, and somewhat new, but we can prepare engineers by education and training, and by putting an adequate human resources selection process in place.

Employees are subject to changes in the social field as well. In the past, the duration of the projects was such that it often paid to take the family along for several years. The companies were used to providing housing, schooling and medical facilities for large groups of staff. Since many of the projects of the past took place in remote areas, the project manager was not only manager of the project proper, but also director of the project school and the project hospital.

With the shorter execution times, taking the family along is usually not reasonable, which adds to the personal stress. Fortunately, part of these effects is mitigated by the modern means of communication and the improved living conditions on board of the dredgers. At the same time, the world is shrinking and remote areas are few and far between. In cities like Hong Kong, Singapore and Dubai, setting up a company school or a company hospital is no longer necessary. International schools and adequate health care services already exist independently of, though sometimes supported by, the companies. Still, in spite of this, this new class of mega-projects demands an increased flexibility not only from the staff, but certainly also from their families.

**CHALLENGES IN A BROADER PERSPECTIVE**

All these changes take place in an environment where coastal engineers are facing broader challenges in general. There is a growing need for fresh water as a result of a growing world population. Moreover, the effects of climate change and sea level rise present threats for a large (and growing) part of the world population that lives in low-lying coastal areas. Any solutions that are proposed must not only meet technical specifications, but must be sustainable as well.

The coastal engineering community can only cope with these challenges if it is able to apply innovations to the profession. That is easier said than done. Looking at coastal engineering in general, it means that the industry has to consider more elements than just the coastal stability; it must incorporate considerations about climate change in a realistic way; it must introduce elements from the biosciences and ecology; it must consider spatial planning and zoning and pay more and more attention to the latest macro-economic insights. Last but not least, as engineers, the dredging industry will have to convince the broader public about the justification of these ideas.

The same applies to dredging as the toolkit for the coastal engineer. Over the last decades, the knowledge of the dredging process has so much improved that it is difficult to optimise further in this direction. Innovations have to be introduced from different disciplines like electronics, materials science, remote sensing and logistic planning. Here, dredgers will have to demonstrate that dredging can improve the environment and does not destroy it.

Considering these options for innovation, it becomes clear that most opportunities are opening up at the interface between disciplines, disciplines that are sometimes far away from the traditional fields of interest of today’s coastal engineer. The prospective interfaces, however, are not only present in the scientific subjects; they are also found in the relation between (competing) companies, between employer, consultant and contractor and between nations and even cultures.

If one recognises the need for such open innovations beyond the traditional borders to integrate the best ideas into feasible new concepts, the need for new business models becomes obvious as well. Such new models...
must combine a borderless strategy and a very dynamic business concept.

This is quite a challenge for an industry that used to shield its own knowledge from the outside world to such extent that even the application for a patent was considered to be a breach of confidentiality.

For this reason the industry must expect joint ventures that are not only aimed at the execution of a single project, but also that address more general issues.

Partners in such joint ventures can be commercial companies, non-profit organisations, government agencies and research institutes.

**THE NEW GLOBAL COASTAL ENGINEER**

The changes in the work environment of the “new” coastal engineer must have an effect on their education as well. To operate successfully, today’s coastal engineer must have specific skills to work in a global environment.

– They must still master the traditional technical abilities
– They must master more than one language
– They must have a broad cultural awareness
– They must be innovative and creative
– They must have entrepreneurial skills
– They must be flexible
– They (and their families) must be mobile

The easiest solution is to say that it is the task of universities and colleges to develop these skills. There is no doubt that during the education process more emphasis should be placed on the independence and individual responsibility of the students in relation to the required skills.

However, adding more and more aspects to the curriculum cannot go on indefinitely. There are limits in time, but there are also limits by the nature of the academic environment. In order to prepare the students for their new role, an open exchange with the professional field is necessary to establish a clear link between the abstract scientific background and the actual behaviour of water, sediments, machines and human beings. This exchange can have different shapes: traineeships by students and lecturers, internships at large dredging companies and consultancies, but also lectures by professionals, embedded in the curriculum.

This exchange is not a panacea; the professional world must realise that education is continuing and should obtain the shape of “lifelong learning”. To a certain extent, this attitude has been taken up by the large companies that have trainee programmes for inflowing students (Figure 5). In general, however, the aspect of lifelong learning has hardly found a place in the civil engineering society. This is surprising since, for instance, the medical and the legal professions have accepted “continuing education” as part of their professional accreditation. More recently some changes in this attitude seem to be on the horizon.

**ANSWERING THE CRY IN THE WILDERNESS**

Some of the ideas presented here have been voiced by several colleagues and presented a few years ago at conferences and in articles. At the time a few years ago, it felt like “a cry in the wilderness”. Today however, it is amazing to see that many of these ideas are being implemented rapidly and are starting to show some first results.

In the USA, recognition of the need for specialty certifications programmes in engineering, such as exist for doctors and other professionals, has recently led the American Society of Civil Engineers to start a new academy, known as the Academy of Coastal, Ocean, Port & Navigation Engineers (ACOPNE) (www.acopne.org). ACOPNE was created to offer a voluntary, post-license credential that provides professional engineers an opportunity to gain further recognition in the field of coastal engineering and related disciplines. The goal of ACOPNE is to improve the practice, elevate the standards and advance the COPNE profession and provides recognition to those individuals who have excelled in the sub-disciplines embraced by COPRI (Coastal, Ocean, Port and River Institute).

Figure 5. Two views of cutter suction dredger simulator: Simulators are part of in-house training to prepare personnel before they take over the tasks onboard.
started a programme to intensify the ties between the industry and the educational institutes. This initiative is still being expanded. In spite of the economic downturn, the industry has pledged to maintain the opportunities for students to complete their thesis work during an internship. The industry has further entered into formal financial and professional support to the Faculty of Civil Engineering of TU Delft. Although the main reason for this support was a regrettable shortfall in the budget of the faculty, the agreement between the industry and the University opens new and unprecedented options for exchange.

Furthermore, the research programme “Building with Nature” of EcoShape, based on the research by Ronald Waterman and his book of the same name, has made a start and constitutes a cooperation between employers, contractors, consultants and research institutes. The programme is not restricted to Dutch participants, but constitutes an international framework.

The main employers of recently graduated professionals all have their own trainee programmes. Some of them have received special recognition for their excellence as the best trainee programmes in their respective country. As a follow-up, they try to boost the mutual exchange between the young professionals by creating chapters within their organisations. In this way, “Young PIANC” and “Young Rijkswaterstaat” as well as “Young Management Days” of IADC are becoming increasingly active (Figure 6). The professional associations attempt a move in the same direction. CEDA (Central Dredging Association) has taken a similar initiative.

In an international context, it is reassuring that the continued existence of COPEDEC is safeguarded now under the umbrella of PIANC, and that after the successful conference in Dubai, a new one is planned in India (2012).

In the field of education joint MSc programmes are being established, such as a new initiative by Delft University of Technology (TU Delft, the Netherlands) and the National University of Singapore (NUS). There is also a new programme under the umbrella of the EU: CoMEM. The Erasmus Mundus Master in Coastal and Marine Engineering and Management is a two-year, English-language international Master’s programme, in which five highly rated European universities participate. Students will familiarise themselves with key issues involved in providing sustainable, environmentally friendly, legally and economically acceptable solutions to various problems in the CoMEM field.

During the programme, students study at universities in three different countries. Students spend the first semester in Trondheim, Norway, the second semester in Delft, the Netherlands; during the third semester in the second year, students choose a specialization in Barcelona (Spain), London (UK) or Southampton (UK). Semester 4 is devoted to doing the MSc thesis at one of the three universities previously visited.

In the Netherlands, the Vereniging van Waterbouwers (the Association of Hydraulic Engineers, formerly VBKO), an organization of contractors in coastal engineering, has started a programme to intensify the ties between the industry and the educational institutes. This initiative is still being expanded. In spite of the economic downturn, the industry has pledged to maintain the opportunities for students to complete their thesis work during an internship. The industry has further entered into formal financial and professional support to the Faculty of Civil Engineering of TU Delft. Although the main reason for this support was a regrettable shortfall in the budget of the faculty, the agreement between the industry and the University opens new and unprecedented options for exchange.

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ABSTRACT

The costs of capital and maintenance dredging can be a significant part of the total capital and operating costs of a port. Although dredging methodologies become more and more optimised, which leads to more economic dredging, there is a large uncertainty in the estimation of maintenance dredging volumes for new “green field” ports and major expansions. On the basis of the Olokola LNG (OKLNG) project in Nigeria a tool was developed to make a probabilistic assessment of maintenance dredging volumes in order to better understand and quantify uncertainties involved. At the project location, the main infill is caused by mud and fines in suspension. Infill scenarios and data that were collected for the study suggest that at the specific project site the fines in suspension may not be flocculated which normally is the case for fine material in suspension.

Although this was not subject of further study here, it was decided to develop two models for the prediction of sedimentation to develop maintenance dredging volume estimates for both flocculated and non-flocculated sediment.

For the purpose of the study a relatively simple sedimentation formula was used in which the various parameters could be expressed with probabilistic distributions.

By use of Monte Carlo simulation the infill rate was computed several ten thousand times, each time with input parameters drawn from their assigned probability distributions. The results of the study were presented in two probability distributions for channel sedimentation volumes for both flocculated and non-flocculated sediment. These results illustrate how such methodologies can be used in project development planning and in risk analysis as part of investment planning.

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INTRODUCTION

Morphology and the resulting sedimentation of access channels is a key feature for the design of port and harbour developments. Often, morphological predictions are expressed deterministically with perhaps indicative “upper and lower bound” values to indicate uncertainty. This uncertainty is caused by the fact that relatively little is known about the exact processes behind morphology and that the driving processes are dynamic and may show significant variation in time.

For the project used as an example here, the Olokola LNG (OKLNG) port project, channel sedimentation predictions were presented in a wide range with an expected high average resulting from the persistent swell waves in the area. Without probabilities
related to the sedimentation range, a conservative approach to dredging costs should still be adopted when applying a financial decision model. In order to take a well-founded investment decision and to improve the planning of maintenance dredging, the probability distribution of the sedimentation rate should be known. Therefore Shell was very interested in the development of a probabilistic model for the calculation of the probability distribution of the channel sedimentation rate. The expectation was that such an approach may, for example, enable investment on surveys, data collection and trials to be better targeted and provide an early opportunity to select marine concepts, which minimise morphological risks and life-cycle costs.

A probabilistic approach is useful to apply to channel infill, because input parameters such as currents and sediment concentrations in the water column are inherently uncertain (subject to "randomness or variations in nature" (Van Gelder, 2000)) and can be characterised with a probability distribution, and major uncertainties regarding the physical processes and the modelling of the infill exist. These uncertainties are not properly represented in a deterministic calculation.

The objective of the study was to use a simple morphological model that can provide a probabilistic estimate of the channel infill and to give an overview of the uncertainties when calculating channel infill. This will lead to strategies to manage risks and reduce uncertainty. The model has been kept simple on purpose; the objective of this study was to identify and, if possible, quantify the uncertainties. A simple model shows more clearly which parameters, processes and uncertainties influence the infill most. Secondly, a probabilistic module cannot be added to more sophisticated models, such as DELFT 3D or MIKE 21, since these models cannot be run a large number of times, each time with different input parameters in order to create a probability distribution of the infill rate.

It should be noted that this study was carried out as an MSc thesis for Delft University of Technology by (Bakker, 2009). The information here will focus on the infill modelling and uncertainty analysis to show the possibility of applying a probabilistic method to predict channel infill in the design phase of a project in order to improve the planning of maintenance dredging.

**PROJECT CHARACTERISTICS**

**Site location**

The study was based on the OKLNG project, located some 100 km east of Lagos, Nigeria, along the muddy open coastline west of the Niger Delta (see Figure 1).

**Approach channel design**

In the proposed design, LNG and LPG carriers will access the new marine export terminal through an approximately 10.5 km long approach channel. The approach channel is this long because the foreshore is gentle. The channel layout is presented in Figure 2.

**Sediment and metocean data**

Measurements of waves, currents and sediment were carried out during a period of 12 months for the project and made available for this study. Figure 3 presents the predominant wave and current directions. The seabed in the area is muddy. This mud layer can be over 6 m thick near the shore. In the breaker zone the seabed is sandy. However the breakwaters run through the breaker zone, so the channel infill will consist of mud.
An IADC Best Paper Award for a Young Author was presented to Suze Ann Bakker. Ms. Bakker received her M.Sc. cum laude from Delft University of Technology in the fall of 2009. During her studies she did a three-month internship at Van Oord Dredging and Marine Contractors at the Palm Deira Project in Dubai. During a second internship she spent three months in Lagos, Nigeria as part of an engineering consultancy team from Royal Haskoning. After her studies, in March 2010, she joined Shell as a civil and marine engineer. Her award-winning paper is part of her MSc thesis and the research was conducted for Shell. The paper is based on the fact that the costs of capital and maintenance dredging are often a significant part of the total capital and operating costs of a port. Although dredging methodologies have become more and more optimised, leading to more cost-efficient dredging, great uncertainty in the estimation of maintenance dredging volumes for new “green field” ports and major expansions remains an important issue. On the basis of the OKLNG project in Nigeria, a tool was developed to make a probabilistic assessment of maintenance dredging volumes in order to better understand and quantify the uncertainties involved. Each year at selected conferences, the International Association of Dredging Companies grants awards for the best papers written by younger authors. In each case the Conference Paper Committee is asked to recommend a prizewinner whose paper makes a significant contribution to the literature on dredging and related fields. The purpose of the IADC Award is “to stimulate the promotion of new ideas and encourage younger men and women in the dredging industry”. The winner of an IADC Award receives €1000 and a certificate of recognition and the paper may then be published in Terra et Aqua.

The predominant waves are unidirectional \((185^\circ < \theta_{\text{swell}} < 200^\circ)\) swell waves \((T_p = 14 \text{ s})\). These waves induce large orbital velocities near the bottom and keep fine sediment such as mud in suspension. The governing currents are geostrophic currents, the ESE Guinea Current and the WNW Ivorian Undercurrent (Svasek Hydraulics and Royal Haskoning, 2007). Although these currents are only 0.15 m/s on average near the bottom, it is still more than enough to transport the fine mud particles.

**PROBABILISTIC APPROACH CHANNEL INFILL MODELLING**

**Set-up of the model to predict the channel infill**

As explained in the introduction, a simple model is needed for a probabilistic infill prediction. To create a probability distribution for the channel infill, the model should be run many times, each time with different input parameters based on the probability distribution of each input parameter. The calculation time increases as the model becomes more complicated. Additionally, a simple model will provide more insight into the influence of each parameter on the uncertainties.

The model needs to have reasonable predictive capacity. More complicated models are based on the schematisation as presented in Figure 4.

This schematisation subsequently leads to the equation for the infill rate of the channel \(S\) in kg/s as depicted in Figure 5. Simply said,
the amount of sediment that is trapped in a channel is the transport velocity of the currents multiplied by the amount of sediment integrated over the water column multiplied by the percentage of the sediment that is trapped.

Note that well-known simple formulas such as the CERC- and Bijker-formula are only applicable for non-cohesive sediment infill such as sand. In the case of OKLNG, the infill consists of mud – cohesive sediment – making these formulas inapplicable.

The infill rate depends on 4 parameters: the current velocity \( u \), the sediment mass integrated over the water column \( c \cdot z \) (the sediment concentration \( c \) integrated over the water depth \( z \)), the trapping efficiency \( p \) and the channel length \( L \). After all important parameters were identified, a probability distribution was developed for every parameter based on available data, literature and expert opinions (Van Gelder, 2000). As opposed to a deterministic calculation where an average value for each of these parameters would be used, the probability distribution of each parameter was taken into account to be able to investigate the uncertainties and the spread in the infill. This modelling approach is presented in Figure 6.

By use of Monte Carlo simulation the infill rate was computed several ten thousand times, each time with input parameters drawn from their assigned probability distributions. If enough possible outcomes are generated, the probability distribution of the infill rate can be developed. Not all sedimentation processes were modelled in-depth with this equation, but this approach does show the uncertainties in the prediction, in line with the objective of this study. The model was set-up in Excel. The Monte Carlo simulation was run with the software package Crystal Ball. The probability distribution of the infill rate \( S \) and the probability distribution of the yearly infill \( M \) were generated. To obtain a prediction for the yearly infill, or the amount of sediment in the channel \( M \) in kg, integration over time was carried out, which will be explained in section below entitled “Integration over time”.

### Infill mechanisms

With a sandy seabed, day-to-day channel infill is caused by suspended sediment infill. When passing the approach channel, part of the suspended sediment will settle in the channel depending on channel parameters such as depth, width and slope, on sediment characteristics as settling velocity and on the current velocity. In case of suspended mud, sedimentation is low because of the small particle size and subsequent low settling velocity.

In the marine environment, mud particles normally flocculate and hence form larger flocs, i.e. mud shows cohesive behaviour. However, strong swell waves can break the bonds between the mud particles or prevent flocs from being formed, causing a mobile mud layer to be present on the seabed. In case the density and thickness of the layer are large enough – which is always the case if a mud layer is present as demonstrated in Bakker (2009, section 4.2.1) – the weak current at OKLNG is unable to transport the mud layer up the opposing slope and all sediment will remain in the channel. Mobile mud layer infill will therefore cause large infill quantities in a short period of time, since the trapping efficiency is 100%.

Day-to-day mud infill is thus a combination of suspended sediment infill and mud layer infill. Both infill mechanisms can be modelled with the equation in Figure 5.

### Infill scenarios

The sediment behaviour largely determines if the above-mentioned mobile mud layer is permanently present or only generated by waves during storm conditions. Flocculated mud particles normally lead to settling velocities in the order of 0.1-1 mm/s.
However, while analysing the sediment at OKLNG, several indications were found that the sediment in the water column at OKLNG is unflocculated to poorly flocculated and subsequently has a very low settling velocity. Such unflocculated conditions in the marine environment have not been found in literature and experts consulted for this study have not encountered these conditions before (i.e. Winterwerp and Van Kesteren, 2004).

For an in-depth analysis of the OKLNG sediment and the analysed measurements which led to the conclusion that it is possible that the sediment at OKLNG is not flocculated and infill due to a permanent mobile mud layer be investigated as well, the reader is referred to Bakker (2009, section 3.8). This report focuses on the probabilistic approach and will therefore not address the mud behaviour any further, even though it is quite interesting and novel.

The question of whether or not the sediment is flocculated introduces an important uncertainty into the upcoming infill calculation, since it determines how the sediment is distributed over the water column. This is demonstrated in Figure 7. Since exact measurements of the settling velocity at the project site have not been conducted and since other measurements do not exclude either scenario, this introduces an important uncertainty in the infill calculation. In the framework of this study both scenarios were investigated as the flocculation aspects were beyond the scope of the study. Summarising, these scenarios are with reference to Figure 7.

1. Scenario 1: the sediment is fine and unflocculated to poorly flocculated, yielding very low settling velocities (i.e. ~0.004 mm/s). The sediment concentration in the water column is not directly related to the wave climate, but a mobile mud layer is present near the bottom, which concentration and thickness vary in time. A clear bottom cannot be defined as also sketched in Figure 7. Sedimentation of the channel under day-to-day conditions is caused by transporting the mobile mud layer in the channel and being trapped there. The amount of suspended sediment that is present in the water column above the mobile layer is negligible in comparison to the large quantities of sediment in the mud layer (Bakker, 2009, section 5.3.2).

2. Scenario 2: the sediment is flocculated and yields settling velocities in a range normally encountered in the marine environment (i.e. ~0.5 mm/s). The amount of sediment in the water column is directly related to wave action. Continuous sediment infill is a result of suspended sediment settling in the approach channel. Only during storm events a mobile mud layer may be formed on the seabed, which is subsequently transported by the currents into the channel. Infill is thus a result of suspended sediment infill most of the time and mud layer infill a small percentage of the time.

**Input parameters**

The input parameters and their probability distributions required to predict the channel infill will now be discussed in the order of appearance in the model equation as shown here in Figure 8.
The difference between the two scenarios lies in the sediment mass and the trapping efficiency. The schematisation for the sediment mass and trapping efficiency is different for the suspended sediment infill and the mobile mud layer infill. The current velocity and channel length are the same for both scenarios.

1. **Current velocity \( u \) in m/s**: The currents were modelled perpendicular to the channel, since the current velocity perpendicular to the channel equals the infill velocity. As already shown in Figure 2 the channel is divided into 4 sections, since the orientation of the channel varies along the axis. The probability distribution of the current velocity is shown in Figure 9. The high percentage of zero infill velocity in section A1 is caused by a breakwater, which shelters this section from eastern directed currents.

2. **Sediment mass \( c \cdot z \) in kg/m\(^2\)**: the amount of sediment in the water column depends on the sediment characteristics, the waves, which stir up the sediment and the currents, which mix it over the vertical. Often, the sediment distribution over the vertical is modelled using these parameters. Fortunately, at OKLNG the sediment concentration was measured at different heights above the bottom using an optical backscatter device during an extensive measuring campaign. The probability distribution of one of those measurement locations is presented in Figure 10. Based on Vinzon and Mehta’s (1998) equation, a most likely specific mass of 4 kg/m\(^2\) was adopted.

The probability distributions of the sediment higher in the water column were positively skewed. Therefore the lower limit was estimated to be half of the most likely value, 2 kg/m\(^2\), and the upper limit was chosen to be twice that value at 8 kg/m\(^2\).

3. **Trapping efficiency \( p \) as a percentage of the total sediment mass**: In the case of mud layer infill, the trapping efficiency is 100%. The low currents cannot transport a thick layer of mud up the slope of a channel once it has flown into the channel under the influence of gravity. This is sketched in Figure 12.

For suspended sediment infill, calculating the trapping efficiency is more complicated, since it depends on the sediment characteristics,

![Figure 10. Sediment concentration distribution at 0.10 m above the seabed.](image)

In case of suspended sediment infill, this schematisation is suitable. Unfortunately, a mobile mud layer may well be smaller than 10 cm in the OKLNG area based on Vinzon and Mehta’s (1998) mud layer height equation (see section 4.4.2.1 and appendices C and D of Bakker (2009) for the equation and calculation). If a mud layer is permanently or occasionally present on the seabed in the project area, the measurements may very well not show any indication of it. This means that the sediment mass in case of a mud layer needs to be estimated with a separate probability distribution.

Since little is known about the specific mass of the mud layer, the expected lower limit, upper limit and most likely value were estimated. The triangular distribution was used to model the parameter. Based on Vinzon and Mehta’s (1998) equation, a most likely specific mass of 4 kg/m\(^2\) was adopted.

![Figure 11. Schematisation of the sediment mass.](image)
the flow regime, the channel configuration and wave action. Unfortunately no simple equation exists that properly takes relevant processes, such as floc formation and break-up, into account and gives a reliable prediction of the trapping efficiency of a sediment-laden flow passing a channel.

More importantly, these processes are still not well understood and the formulas always require validation with field measurements. Therefore numerical models such as DELFT 3D, MIKE 21 and FINEL 2D are almost always used to compute the trapping efficiency for suspended sediment infill.

In this case, trapping efficiencies calculated with FINEL 2D by Svasek Hydraulics and Royal Haskoning (2008, Table 4.4) were used as input for the infill computation.

This also points to another difficulty when modelling scenario 2. A small part of the time, infill is caused by mud layer infill and a different trapping efficiency should be applied.

A criterion to decide which of the two infill mechanisms should be applied is required additionally.

In this study a criterion was formulated based upon the sediment mass. Above a certain sediment mass, the sediment cannot be kept into suspension and a mud layer is formed. The sediment mass distribution as depicted in Figure 10 thus represents both infill mechanisms; the tail with the high concentrations represents the incidental mud layer infill and the rest of the distribution with the low concentrations represents the suspended sediment infill that occurs the majority of the time.

4. Channel length $L$ in m: The channel length is a given design parameter and of a deterministic nature. For the computation $L = 10,550$ m is used.

Concluding, the current velocity and sediment mass are modelled probabilistically. The current velocity distribution is based on measurements. The sediment mass distribution for scenario 2 is also based on measurements.

For scenario 1, the unflocculated sediment scenario, this was not possible, since in case a mud layer would be permanently present on the seabed the measurements would not show this. A sediment mass distribution was therefore estimated.

The trapping efficiency for mud infill is 100% and is of a deterministic nature. In case of suspended sediment infill – only relevant for scenario 2, the trapping efficiency is modelled based on the outcome of the FINEL 2D model and varies along the channel axis. The channel length is a deterministic parameter.

All in all, this leads to a semi-probabilistic result for the channel infill, since not all parameters could be modelled properly and estimations were adopted.

Integration over time
In order to calculate the annual infill $M$ in kg, the infill rate $S$ in kg/s must be integrated over the period of one year. The timescales of the relevant infill processes result in the time step, which should be adopted.

The time step is such that the parameters from different time steps are independent, i.e. the outcome of the first draw at $t = t_i$ does not influence the outcome of the next draw at $t = t_{i+1}$ as schematically shown in Figure 14.

In that respect a large time step should be chosen. However, too large a time step causes overestimation of the variance and standard deviation of the yearly infill quantity.
The mean infill value does not change if the number of time steps is increased, but the standard deviation decreases. The standard deviation of the yearly infill distribution decreases with a factor $\sqrt{n}$ when the number of time steps $n$ increases.

Ideally, the choice of the length of a representative time step should be based on an analysis of the correlation and the time scales of the relevant physical processes. Autocorrelation functions can be used to determine this time step (Van Gelder, 2000).

In this study a pragmatic time step of one week was adopted for each scenario, based on the time scale for current reversals.

The assumption was that the input parameters vary on a weekly basis, so the number of time steps in one year is 52.

**SET-UP OF THE UNCERTAINTY ANALYSIS**

Figure 15 shows the set-up of the uncertainty analysis. To gain insight in the order of magnitude of the yearly infill quantity the approach channel infill was first determined deterministically and as indicated in Figure 6.

Next a sensitivity analysis was conducted to identify which parameters have the largest influence on the infill quantity and to determine the importance of each parameter.

The objective of a probabilistic infill prediction is to gain insight in the uncertainties and spread around the mean, which is the average or expected value of all predicted values. The result of a probabilistic analysis is a probability distribution of the yearly infill quantity. Also the dependency of parameters is included in this study. Figure 16 shows the influence of correlated parameters on the predicted probability density function.

To compute the probability density function of the infill rate $S$ in kg/s the model as depicted in Figure 5 was run 1 million times (without integration over time) in this study. From the resulting 1 million different realisations of the channel infill rate the probability distribution was then determined. The yearly infill quantity $M$ in Mton was computed based on the infill rate $S$ multiplied by the time step as explained in section 0. The 52 realisations of the infill quantity were randomly generated by running the model 52 times. Each of these realisations was representative for one time step.

So by averaging the 52 infill quantities, one realisation for a yearly infill quantity $M$ in Mton is obtained.

This is repeated 10,000 times for each scenario. From these 10,000 realisations of the infill quantity a probability distribution is constructed.

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**Figure 15.** Set-up of the uncertainty analysis of the mud infill prediction.

**Figure 16.** The influence of correlated parameters on the probability density function of the variable of interest.
RESULT AND DISCUSSION OF THE MUD INFILL PREDICTION AND UNCERTAINTY ANALYSIS

Scenario 1 – unflocculated to poorly flocculated sediment

The largest uncertainty in the mud infill prediction in case of unflocculated to poorly flocculated sediment is the sediment mass. As already noted in section “Input parameters” above, the mud layer mass had to be estimated, since measurements were not available. A moderate estimate was made for the probability density function of the sediment mass with a most likely mass of 4 kg/m². This results in the blue cumulative probability distribution of the infill rate S seen in Figure 17. Additionally, the cumulative distribution was constructed with a much higher mud layer mass and a much lower, with a most likely sediment mass of 6 and 2 kg/m² respectively. The mean infill rate subsequently varies between 2.6 and 0.8 Mton dry sediment per week, indeed showing that the uncertainty in the mud layer mass results in a large uncertainty in the infill prediction. All other parameters influence the infill rate to a much lesser extent.

It may seem that this outcome does not help to design a proper maintenance strategy, since the spread is quite large. However, when taking the amount of sediment the approach channel can accommodate into account, this outcome is very useful.

The nautical bottom for OKLNG was defined for preliminary planning purpose at a density of 1,100 kg/m³, in which case the channel can accommodate 5.2 Mton of sediment.

Below the set depth for navigation of –15.5 m CD, the channel can accommodate 2.3 Mton of sediment. This is based on a soil density of 1,370 kg/m³, which is the average in situ density of the muddy seabed (based on GEMS, 2008a, 2008b, 2008c; GEMS, 2008d).

Scenario 2 – flocculated sediment

For scenario 2 additional assumptions had to be made; for the trapping efficiency of the suspended sediment other model outcomes had to be used and a criterion to decide which percentage of the time mud layer infill takes place was introduced.

The uncertainty analysis shows that the infill mechanism criterion is robust: varying this criterion with a factor $10^2$ influences the predicted mean infill quantity with only 13%. Apparently most of the concentration data of the layer near the bottom was well below the threshold criterion and causes suspended sediment infill.

The more extreme concentrations that cause large infill quantities were well above the criterion. This suggests that where the exact boundary between suspended sediment infill and mud layer infill is placed does not influence the infill quantity to a large extent.

Secondly and surprisingly, the trapping efficiency in case of suspended sediment infill does not influence the prediction much either. A reliable estimate of this parameter was therefore not essential for a reasonable infill prediction either.

Again for this scenario, the overall uncertainty is a result of the uncertainty in the sediment mass: the concentration at 10 cm above the seabed could only be measured up until a concentration of 8 kg/m³. Roughly 14% of the time no concentration data are available, due to the concentrations being higher than 8 kg/m³. The tail of the probability density function of the sediment concentration therefore had to be estimated using the least square method, which introduced an uncertainty.

Figure 17. Cumulative probability distribution of the infill rate $S$ in case of scenario 1 - unflocculated to poorly flocculated sediment.

Figure 18. Probability density distribution of the yearly infill quantity $M$ in case of scenario 2 - flocculated sediment.
CONCLUSIONS

The following conclusions and recommendations are in respect of the adoption of the described methodology of probabilistic modelling to predict infill rates of an approach channel and to support designing a proper maintenance strategy in an early stage of a project. The conclusions do not relate to the actual circumstances of the OKLNG project.

The purpose of the research was to increase insight in sedimentation behaviour and assess the sedimentation quantities. For this a simple model was developed to make estimates of the channel infill and to provide an overview of the uncertainties when calculating channel infill, which will lead to strategies to manage risks and reduce uncertainty.

This was in contrast to the alternative of using more sophisticated models, which incorporate the infill processes and hydrodynamic flow into more detail and give a deterministic prediction.

The applied approach proves to be a powerful tool to gain insight in the uncertainties and spread around the mean. Figure 18 clearly shows the added value of this analysis compared to a deterministic prediction. In the case of a validated model and sufficient data on the input parameters the P10, P50 and P90 can be computed.

The selected probabilistic approach heavily relies on site environmental data, so quality measurements are needed if one wishes to use this method. This method would therefore be useful in the design phase after the wave climate, current climate and sediment characteristics are investigated and/or after measurements have been conducted.

Based on present study, this method requires further development and validation of the used model as given in Figure 5. Information from existing channel dredging operations in similar environments would be valuable for this purpose.

This study showed that mud could possibly exist in an unflocculated state in the marine environment. Further testing is needed to confirm this but, if this is the case, this influences the infill rates of nearby channels and preferable maintenance strategy to a large extent.

REFERENCES


The Masonville Dredged Material Containment Facility (DMCF) was designed to accommodate Baltimore Harbor dredged material, which is statutorily required to be placed in a confined disposal facility. Limited options for placement facilities in Baltimore Harbor led the Maryland Port Administration (MPA) to develop an in-water facility that required the fill of 141 acres, including 130 acres of tidal open water, 10 acres of upland within the Chesapeake Bay Critical Area, and one acre of wetlands. The project required permits or licenses from the U.S. Army Corps of Engineers, Maryland Board of Public Works, and Maryland Department of the Environment, approval from the Maryland Critical Area Commission and U.S. Environmental Protection Agency, and consultation with the U.S. Fish and Wildlife Service, Maryland Department of Natural Resources, National Marine Fisheries Services, and Maryland Historical Trust.

To evaluate project impacts, an Environmental Impact Statement was prepared in accordance with the National Environmental Policy Act (NEPA) and a compensatory mitigation plan was developed to offset identified impacts. The mitigation plan incorporated both in- and out-of-kind mitigation projects vetted through the Bay Enhancement Working Group, a technical advisory body established by MPA. A site-specific habitat condition analysis was developed to assess the sufficiency of the compensatory mitigation package, which included substrate improvement, wetland creation and enhancement, stream restoration, and trash interceptors. The project also faced regulatory challenges related to air quality and required the purchase of credits to offset construction-related emissions. Despite the many regulatory challenges, the approvals and permits necessary to begin construction were obtained within 28 months of public scoping as a result of the Port’s collaborative decision-making process which incorporated numerous stakeholders and regulatory agencies.

Additional permitting activities are ongoing to support the operation of the DMCF, including application for a National Pollutant Discharge Elimination System (NPDES) Permit. Lessons learned from this project will be used as MPA assesses future DMCF development within the Baltimore region.

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INTRODUCTION

The Port of Baltimore’s geographic location as the most inland port on the Atlantic Coast and its proximity to railroads and other methods of ground transportation allow
for rapid transportation of materials to the midwest and central portion of the United States. Safe passage at the Port of Baltimore is ensured by regular maintenance dredging of Baltimore Harbor’s federal navigation channels and new work projects to support upgrades and changes to the Port. The Maryland Port Administration (MPA) and the U.S. Army Corps of Engineers (USACE) are responsible for maintaining the navigation channels within Baltimore Harbor.

Baltimore Harbor maintenance and new work dredging projects generate approximately 1.1 million cubic metres (mcm) (1.5 million cubic yards (mcy)) of dredged material annually. Maryland law requires all sediments dredged within Baltimore Harbor to be placed in a confined facility (Annotated Code of Maryland – Environmental Article §5-1102). A shortfall of annual placement capacity will begin in 2010, as a result of the mandatory closure of an existing placement site by state law. To address the predicted dredged material placement capacity shortfall, the MPA worked with the State Dredged Material Management Program (DMMP) committees to identify and screen potential placement options (Figures 1 and 2). The State DMMP screening process is described in detail by Hamons and Wilson (2010) and resulted in the selection of the Masonville Dredged Material Containment Facility (DMCF) as a preferred option to address the shortfall of annual placement capacity in the near term.

The screening of potential alignments for the Masonville DMCF, resulted in the selection of an alternative with a total footprint of approximately 57 hectares (140 acres), of which, 53 hectares (130 acres) was tidal open water (Figure 3). The remaining 4.5 hectares (11 acres) of DMCF footprint consisted of 4 hectares (10 acres) of upland and 0.4 hectares (1 acre) of vegetated wetlands.

The 53 hectares (130 acres) of open water included 1.2 hectares (3 acres) of existing unauthorized fill in the form of a dry dock.

MPA’s preferred alternative would provide 11.8 mcm (15.4 mcy) of dredged material placement capacity with an annual storage capacity of 0.4 mcm (0.5 mcy) to 0.8 mcm (1.0 mcy) for a 19-year site life (Table I). The DMCF is composed of two sections, the wet basin and the main DMCF.

To date, only the main portion of the DMCF has been constructed. The main DMCF structure is composed of cofferdam cells, an armored rock dike, a fringe wetland, and a shoreline dike (Figures 4 and 5).

The wet basin will be enclosed by a rock dike. The cofferdam portion of the DMCF containment structure was designed to support a future pier, to be known as Masonville Berth 3. The DMCF, including the wet basin area, will have an ultimate end use as a port facility, such as a roll-on/roll-off cargo terminal.

**REQUIRED PERMITS, CONSULTATIONS AND APPROVALS**

Prior to construction of the DMCF, multiple permits, consultations, and approvals were required. These included: Section 10 and Section 404 permits from the USACE, tidal wetlands license from the Maryland Board of Public Works, a nontidal wetland permit from the Maryland Department of the Environment (MDE), plus approval from the Critical Area Commission for the Chesapeake and Atlantic Coastal Bays. Because the project required a federal permit, compliance with National Environmental Policy Act (NEPA) was required. Because of the potential for significant impacts associated with the fill of 53 hectares (130 acres) of open water, an environmental impact statement (EIS) was required. To comply with NEPA and to support the required federal permits, consultation in accordance with other federal regulations were required. These included: endangered species (Section 7) consultations with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS), essential fish habitat (EFH) consultation with NMFS, and Section 106 (National Historic Preservation Act) consultation with the State Historic Preservation Officer (SHPO). A list of major permits and approvals required for construction and operation is included as Table II.

The MPA employed numerous time-saving measures throughout the permitting and NEPA process in order to meet the Masonville DMCF project’s expedited schedule. These measures were:

- Completing cultural resource surveys prior to project scoping
- Incorporating the biological assessment (BA) and essential fish habitat (EFH) assessments into the draft environmental impact statement (DEIS) to allow a single review by NMFS rather than requiring two separate reviews, one for the BA and one for the DEIS
- Concurrently preparing the DEIS with and coordinating with the Joint Evaluation Committee (JE) regarding potential mitigation requirements associated with the MPA’s preferred project alternative
- Integrating a review of the preliminary DEIS by other state and federal agencies prior to issuance of the DEIS, which allowed MPA to work on comment resolution during the public comment period

Figure 1. Baltimore Harbor waterways: Areas shaded in black were unavailable for use/development.
FAST-TRACKED ENVIRONMENTAL COMPLIANCE PROCESS

After identifying Masonville as the preferred site for a DMCF and as the next DMCF alternative to be constructed, the MPA initiated the permitting process by meeting with the JE for a pre-application meeting. The JE is a group of federal and state regulatory and resource agencies within the State of Maryland that meets monthly to discuss projects requiring extensive or multiple permits within the Chesapeake Bay and provides recommendations to permitting agencies. These recommendations are often related to project alternatives, methods to minimize potential project impacts, and mitigation requirements. Agencies that regularly participate as part of the JE are: USACE, MDE, NMFS, FWS, U.S. Environmental Protection Agency (EPA), Maryland Department of Natural Resources (MDNR), Maryland Historical Trust (MHT), and Maryland Board of Public Works (BPW).

The first meeting with the JE was held prior to submission of the Joint Permit Application (JPA), which is a joint federal/state application for the alteration of any floodplain, waterway, tidal or nontidal wetland in Maryland. This pre-application meeting provided an opportunity for participating agencies to identify concerns related to the project and to discuss potential mitigation requirements. The JE confirmed the need for an EIS under NEPA.

After the first meeting with the JE, the MPA met with the USACE and MDE to develop a schedule for site permitting. This schedule changed and evolved as the project developed, and the final permitting schedule is listed below. To the extent possible, tasks were completed concurrently to optimize the project schedule.

The duration of the environmental compliance process from Notice of Intent (NOI) to issuance of permits necessary for construction was only 28 months for a complex project with major impacts:

- Publish Notice of Intent: May 2005
- Agency Pre-application Meeting: May 2005
- Consultation Letters: June 2005
- Conduct Scoping Process: June 2005
- Public Meeting: June 2005
- Comments Due: July 2005
- Draft EIS (DEIS): May 2006
- DEIS/Permit Application: May 2006
- USACE/MDE Public Notice: May 2006
- USACE/MDE Joint Hearing: June 2006
- DEIS Supplement: June 2006
The permitting schedule for the proposed project (Figure 6) was driven by the MPA’s need to meet an annual dredged material placement capacity shortfall after the closure of the Hart-Miller Island DMCF, which closed December 31, 2009. The identification of this capacity shortfall presented an urgent need to study, select, and construct a new placement option capable of accepting an annual volume of 1.5 mcy of material. The Masonville DMCF was identified as the only viable placement option that could be brought online in time to assist in meeting the dredged material placement capacity need. The need for a placement site, beginning in 2010, required permitting to be completed to allow sufficient time to construct the DMCF before the placement capacity shortfall began.

SCOPING AND CONSULTATION
A public scoping meeting was scheduled following the publication of the NOI for the Masonville Project. This meeting was held, in accordance with NEPA, to obtain public input on the proposed project prior to the selection of alternatives for analysis. A public meeting was held where concerned citizens, port stakeholders, and other concerned entities were invited to learn about the project and provide input.

Concurrently with the public scoping process, informal coordination letters were sent to state and federal resource agencies to obtain input on the proposed project. These letters were sent to FWS, NMFS, MDNR, and SHPO. The letters sent to FWS, NMFS, and MDNR requested information on the presence of state and federally listed threatened and endangered species present within the vicinity of the proposed Masonville DMCF. Prior to submitting a coordination letter to Maryland’s SHPO, a submerged cultural resources survey was completed. The results of this survey were submitted to the SHPO along with a request for concurrence with the determination that the proposed project would not affect cultural resources.

Comments made during the public scoping meeting addressed both the proposed DMCF project and the proposed mitigation package (to be described in detail in the following sections). Prior to public scoping, MPA had identified the Masonville DMCF as a placement site and had identified the adjacent Masonville Cove as a site for a potential restoration project as mitigation to offset the potential impacts of the proposed project. The placement site and mitigation had been identified as part of an extensive screening and planning process (detailed in Hamons and Wilson 2010) that integrated the public through an organization called the Harbor Team, which is composed of Port of Baltimore stakeholders, private citizens, local officials and agencies.

Many of the local community members spoke out in support of the project because of their strong support of the restoration of Masonville Cove and plans to develop a community environmental education site adjacent to the Cove. Multiple comments were received noting the economic importance of the Port of Baltimore and speaking out in support of MPA’s efforts to maintain safe passage through the Harbor. Finally, there was a comment noting the overall condition within the Patapsco River and the need to continue restoration of the River, as well as concerns about the changes to water circulation in the Harbor as a result of the proposed project.

None of these comments raised concerns that would cause the MPA’s preferred alternative to change substantially.

Prior to the release of the DEIS responses were obtained from FWS, NMFS, MDNR, and SHPO. NMFS initially responded to the request by identifying the following federally listed species as those that may occur within the vicinity of the proposed project: shortnose sturgeon (Acipenser brevirostrum), loggerhead sea turtle (Caretta caretta), leatherback sea turtle (Dermochelys coriacea), Kemp’s ridley sea turtle (Lepidochelys kempii), and green sea turtle (Chelonia mydas). NMFS further noted that a “Species of Special Concern” also had the potential to occur within the project area, Atlantic sturgeon (Acipenser oxyrinchus

Table I. Site characteristics

<table>
<thead>
<tr>
<th>Site Characteristic</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dredged Material Placement Capacity</td>
<td>11.8 mcm (15.4 mcy)</td>
</tr>
<tr>
<td>Anticipated Annual Usage</td>
<td>0.4 – 0.8 mcm (0.5 – 1.0 mcy)</td>
</tr>
<tr>
<td>Footprint Area</td>
<td>57 hectares (141 acres)</td>
</tr>
<tr>
<td>Affected Tidal Open Water</td>
<td>53 hectares (130 acres)</td>
</tr>
<tr>
<td>Affected Upland Area</td>
<td>4 hectares (10 acres)</td>
</tr>
<tr>
<td>Affected Wetland Area</td>
<td>0.4 hectares (1 acre)</td>
</tr>
<tr>
<td>Site Life</td>
<td>19 years</td>
</tr>
</tbody>
</table>

Table II. Major permits and approvals required for the Masonville DMCF

<table>
<thead>
<tr>
<th>Permit or Approval</th>
<th>Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal Wetland License</td>
<td>Board of Public Works</td>
</tr>
<tr>
<td>Nontidal Wetland Permit</td>
<td>MDE</td>
</tr>
<tr>
<td>Water Quality Certification</td>
<td>MDE</td>
</tr>
<tr>
<td>Coastal Zone Consistency Determination</td>
<td>MDE</td>
</tr>
<tr>
<td>Section 10/404 Permit</td>
<td>USACE</td>
</tr>
<tr>
<td>Federal Conformity Determination</td>
<td>USACE</td>
</tr>
<tr>
<td>National Environmental Policy Act Compliance (EIS)</td>
<td>NMFS, FWS, MDNR</td>
</tr>
<tr>
<td>Section 7 Consultation</td>
<td>SHPO</td>
</tr>
<tr>
<td>Critical Area Approval</td>
<td>Critical Area Commission</td>
</tr>
<tr>
<td>National Pollutant Discharge Elimination System (NPDES) Permit</td>
<td>MDE</td>
</tr>
</tbody>
</table>
oxyrinchus). While this was a species of concern for NMFS, there was no regulatory authority to require any mitigation measures to protect this species.

FWS’s response noted the presence of the federally listed bald eagle (Haliaeetus leucocephalus) within a quarter of a mile of the project footprint within adjacent Masonville Cove. No other federally listed species within the jurisdiction of the FWS were documented within the vicinity of the proposed project.

MDNR identified two state listed bird species of concern that were not documented within the project area. However, the range for these species included the project area. If the habitat for these species were present within the project area, then further measures to protect these species, such as time-of-year restrictions would be recommended. These species were: hooded merganser (Lophodytes cucullatus) and common moorhen (Gallinula chloropus). MDNR also noted in their letter that the area adjacent to the proposed DMCF is a known historic waterfowl concentration area.

SHPO responded and issued their concurrence with the findings of the cultural resources survey completed by MPA’s contractors. No further coordination on cultural resources was required.

Coordination was also completed with NMFS related to essential fish habitat (EFH), which is designated under the Magnuson Stevens Fishery Management Act (MSFMA). The MSFMA (16 USC 1801 et seq. Public Law 104-208) establishes the Secretary of Commerce and Fishery Management Council authority and responsibilities for the protection of EFH. The Act specifies that each federal agency shall consult with the Secretary with respect to any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by such agency that may adversely affect any EFH identified under this act. EFH is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” MPA’s coordination with NMFS regional office identified two EFH species likely to occur within the project area: adult and juvenile summer flounder (Paralichthys dentatus) and adult and juvenile bluefish (Pomatomus saltatrix).

**DRAFT ENVIRONMENTAL IMPACT STATEMENT**

After identifying all resource concerns, the MPA and its contractors, hereafter referred to as the Masonville Project Delivery Team (PDT) began preparation of the DEIS in consultation with the USACE. The USACE was determined to be the lead federal agency for the project and the EIS was completed to meet the USACE regulatory requirement for an EIS under the NEPA. As previously stated, the EIS was required because the project required a federal permit and had the potential for significant adverse impacts to aquatic resources. Preparation of the DEIS identified resources within the project vicinity of particular concern. Some of these concerns were identified by other regulatory agencies through the scoping and consultation processes, such federally listed species; others were identified by analyzing site-specific data.

The greatest area of concern identified during coordination with the JE, was the loss of 53 hectares (130 acres) of open water habitat. This area would result in the loss of a significant amount of aquatic habitat that had the potential to support species of concern. This loss of open water was identified in the DEIS as the most substantial impact of the project, and was described in detail, including a description of effects to resources that are dependent upon open water habitat. These include, federally listed aquatic species, such as shortnose sturgeon and sea turtles, and essential fish habitat (EFH) species, such as summer flounder and bluefish. Coordination with NMFS had identified a need to complete a biological assessment (BA) for shortnose sturgeon and sea turtles, which was completed concurrently with the DEIS to streamline the review process. This allowed for a single review and single submission of both the DEIS and the BA by NMFS, FWS, and DNR. MPA also completed an EFH assessment, in accordance with the guidance received from the NMFS regional office.

The EFH assessment was included as an attachment to the DEIS and was summarized within the EIS. As with the BA, this allowed NMFS to review both documents concurrently.

The Masonville PDT first prepared a preliminary DEIS for internal review and review by the USACE to verify the document was sufficient for use as the USACE EIS as part of NEPA compliance. The document was initially reviewed by technical staff at the USACE and key contributors within the Masonville PDT.
All comments were consolidated and integrated into the document, prior to formal submission to the USACE for supervisor and legal review. At this time, a meeting between the USACE and MPA occurred and the USACE determined that it would be prudent to incorporate MDE as an informal cooperating agency on the EIS, because of its jurisdiction over the fill of open water and wetlands.

Both agencies were considering the potentially significant impacts of the proposed project relative to the permit request and could most efficiently work together by partnering in the development of the EIS and determination of project impacts and required mitigation.

Concurrently with the development of the DEIS with USACE and MDE, MPA coordinated with the JE regarding potential mitigation requirements associated with the MPA’s preferred project alternative. This mitigation package, discussed further in the following subsections, was incorporated into the mitigation and impacts sections of the DEIS, to comprehensively document the project impacts and mitigation. MDE and USACE both had regulatory authority to require the MPA to offset document impacts associated with the fill of wetlands and open water.

Additional mitigation was required for compliance with Maryland’s Critical Area Act, which is discussed further below.

After integrating MDE and USACE’s predicted mitigation needs into the DEIS, MPA provided a revised preliminary DEIS to both agencies for their review and comment. The initial review process for the DEIS was time consuming, with many rounds of review and comment. During this review and comment process, MPA was cognizant of the need to expedite the internal review of the DEIS, so that the overall project schedule could be met. After addressing all MDE and USACE comments on the preliminary DEIS, MPA worked with USACE and MDE to allow review of the preliminary DEIS by other state and federal agencies prior to issuance of the DEIS to the public. MPA desired to proactively address agency concerns early in the process, by identifying agency concerns upfront, which would allow MPA additional time to address and respond those concerns. Any minor comments received as part of the preliminary DEIS review were addressed prior to the issuance of the DEIS. More substantive comments that could not be resolved prior to issuance of the DEIS, were resolved during the public comment period. By having agency comments prior to the issuance of the DEIS, MPA gained the public comment period as time to work on a resolution to those comments rather than awaiting comments.

The DEIS was issued by the USACE in May 2006, which initiated the public comment period for the project.

PUBLIC COMMENT PERIOD AND HEARINGS

MPA worked with MDE and USACE to schedule public hearings on the proposed project in advance of the issuance of the DEIS. These public hearings were not required, but could be requested by the public. If a member of the public requests a public hearing of MDE or USACE during the public comment period, then a hearing must be held. To avoid potential delays associated with scheduling a hearing that would occur after the closure of the comment period, a public hearing was planned to occur during the public comment period. If the hearings were not planned in advance, then the schedule could have been delayed for weeks or months as a result of the need for additional public hearings after the comment period closed. The public meeting was held in the community adjacent to the Masonville DMCF project site during evening hours to be convenient to area residents.

Public comments on the DEIS were noted by the USACE, MDE, and MPA and were addressed, as appropriate. Comments were made in support of the Masonville DMCF project and in support of the Masonville Cove restoration component. There were comments from area residents requesting changes, modifications, or additions to the proposed compensatory mitigation package and some requests for additional detail about the potential impacts of the DMCF to specific
resources, such as changes to Patapsco River hydrology and hydrodynamics. Most of the comments received were from private citizens and community organizations. Other commenters included state and federal agencies issuing their formal comments on the project, a representative from a private marine terminal, and local non-profit organizations, such as the Living Classrooms Foundation and the National Aquarium in Baltimore.

All comments were recorded and integrated into a comment and response table, for integration in the FEIS.

**CHANGES TO THE PROJECT DESIGN AFTER FINALIZING THE DEIS**

During the public comment period for the DEIS, a new alternative to the existing MPA preferred alternative was identified by MPA. The new alternative linked the Masonville DMCF project to the Seagirt-Dundalk Marine Terminal Deepening and Widening project (Seagirt Project). The Seagirt project was expected to generate approximately 380,000 cubic meters (cm) (500,000 cubic yards (cy)) of dredged material consisting of sand and gravel and potentially suitable for construction of the Masonville DMCF. The linking of the projects eliminated the need to purchase construction material for the DMCF and the need to place that material from the new work project at Seagirt-Dundalk Marine Terminals in a confined placement facility. The linking of the projects provided a significant cost savings to MPA and also produced environmental benefits associated with regional air quality by reducing the transport and offloading emissions associated with the Seagirt project and by reducing the need to transport clean construction material for Masonville from an upland location.

This new alternative changed the impacts and alternatives identified in the DEIS and resulted in the need to either reissue the DEIS or issue a supplement to the DEIS. To lose as little time as possible from the project schedule, while still gaining the cost savings associated with the new Seagirt alternative, MPA prepared a supplement to the DEIS (supplement) that described the new alternative and its potential impacts. MPA timed the release of the supplement to be the same date as the public hearing for the DEIS. USACE, MDE, and MPA also determined that it would be prudent to schedule a public hearing related to the new alternative during the required public comment period for the supplement. This required MPA, USACE, and MDE to have the supplement prepared more than one week prior to the public meeting, so that the notice of availability for the supplement could be published prior to the hearing. The USACE and MPA arrived at the public hearing with copies of the supplement, information on the upcoming public hearing, and posters and informational material describing the new alternative. All participants at the DEIS hearing were invited to attend the public hearing on the supplement.

Only four individuals spoke at the second public hearing. These individuals were residents of the surrounding communities and included representatives of the community groups. These individuals raised concerns about crime and safety at the site, oversight of the facility, viewsheds in the project vicinity, and public access of the Masonville Cove restoration area. No comments were made opposing the new project design and the public comment period officially closed at the end of the second public hearing.

**AIR IMPACTS – FEDERAL CONFORMITY DETERMINATION**

The U.S. Environmental Protection Agency (USEPA) has set National Ambient Air Quality Standards (NAAQS) for six pollutants: ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter, and lead. Any area where a pollutant does not meet the air quality standards set by the USEPA is considered to be in non-attainment. Non-attainment categories for ozone range from sub marginal to extreme. It was determined the proposed project was in a region in moderate non-attainment for ozone standard and in non-attainment particulate matter 2.5 (USEPA 2010). The entire State of Maryland is part of the Northeast Ozone Transport Region (OTR), which was established in the 1990 Clean Air Act Amendments in recognition of the long-standing ozone non-attainment problems in the northeast.

Figure 5. Construction of the cofferdam portion of the Masonville Dredged Material Containment Facility.
Screening-level calculations of project emissions were completed and compared to de minimis thresholds as identified under the authority of the federal conformity provisions of the Clean Air Act. If the total of direct and indirect emissions from a proposed federal action in a non-attainment area are below the de minimis thresholds specified in 40 CFR 93.153(b)(1) and the total emissions are not “regionally significant,” comprising 10 percent or more of the region’s total emissions of that pollutant, as specified in 40 CFR 93.153(i), the Federal Action is exempt from the requirements of the general conformity provision. Because these screening calculations indicated that the project would exceed the de minimis thresholds, a general conformity analysis was completed for the project. The general conformity provision requires mitigation to be completed for all project emissions of a pollutant, if the project exceeds the de minimis thresholds for that pollutant or precursor. The Masonville DMCF project emissions of NOx exceeded the thresholds and required mitigation to offset those emissions. MPA and its contractors worked closely with MDE and USEPA to identify credits to offset the impacts of the proposed project. NOx credits were leased from another project that would not be releasing its full allocation of emissions. This was a unique, one-time arrangement with MDE and USEPA. MDE and USEPA stated that in future, MPA would be required to develop emissions offsets for its air quality impacts.

The federal conformity analysis was prepared and extensive negotiations took place between MDE, USEPA, and the USACE regarding the calculations of impacts and the measures identified to offset those impacts. Because these determinations are made so infrequently, it was unclear at first which federal agency was responsible for issuing the required federal conformity determination. Though initially it was thought that this determination would be made by the USEPA, it was eventually decided that the lead federal agency for the project (USACE) was responsible for issuing the determination.

MPA prepared the conformity analysis and worked with MDE, USEPA, and USACE to gain concurrence from all three agencies for the project. USACE used MPA’s conformity analysis to prepare a draft conformity determination. Because the MPA and USACE did not want to delay the issuance of the DEIS, it was determined that the federal conformity determination would be finalized during the public comment period and would be incorporated, as draft, into the upcoming final environmental impact statement (FEIS). This ensured that the project schedule was not delayed as a result of the federal conformity process.

**WATER AND WETLAND IMPACTS – MITIGATION SUFFICIENCY**

Concurrent with the development of the DEIS, SEIS, and preliminary phases of the FEIS, MPA continued to meet with the JE to develop a sufficient compensatory mitigation package to offset the impacts of the proposed project. USACE required MPA to provide a detailed alternatives analysis of all efforts to avoid and minimize impacts in the DEIS and supplement. After impacts were avoided and minimized to the extent possible, the overall project impacts were considered. MPA solicited recommendations from state and federal resource agencies, Baltimore City, and other participants on the JE. The mitigation projects focused on the restoration of the adjacent Masonville Cove, but also incorporated offsite and out-of-kind mitigation projects. Because of many out-of-kind or unusual mitigation components incorporated into the project, the JE and USACE required a mechanism to determine the overall sufficiency of the mitigation package to offset the total project impacts.

In order to demonstrate that the proposed mitigation options would replace the open-
The benthic, stream and estuarine habitat and fisheries community definitions are derived from various published multi-metric approaches. The general approach is a multi-metric scoring technique following the IBI work of Karr and others. Note: To the extent possible, these definitions follow standard ecological measures for sediment quality, water quality, B-IBI, etc. The benthic, stream and estuarine habitat and fisheries community definitions are derived from various published multi-metric approaches.

The project-specific HCA involved a multi-metric evaluation of the loss of functions as a result of project impacts and functions gained by implementation of the mitigation package. The condition factors derived for the analysis (Table III) came from commonly used, regionally appropriate and broadly accepted measures of environmental quality, such as sediment quality criteria and the Chesapeake Bay Benthic Index of Biotic Integrity. These factors were reviewed by the regional Bay Enhancement Working Group and the JE. A consensus building approach was used to gain support for the HCA process from regional experts and project stakeholders.

As part of the evaluation, initial and final condition factors were assigned for the project area and the proposed mitigation options.

The difference between the initial and final conditions of the project was scaled by the acreage affected to determine the required mitigation to offset project impacts. The same calculation was then completed for each of the components of the mitigation package based on pre- and post-mitigation activities. The gain in habitat functions as a result of mitigation components was balanced against the calculated loss (Table IV).

Community enhancements and other environmental benefits associated with the proposed project were also evaluated using the HCA but were not included in the balance sheet for mitigation of aquatic impacts.

The HCA estimated that the mitigation package would generate approximately 15 mitigation credits in excess of those needed to compensate for the loss of open water and wetlands. The analysis and results were reviewed by the BEWG and JE and demonstrated that the lost habitat functions would be replaced within the watershed by the proposed mitigation package. The HCA was then incorporated into the FEIS to demonstrate the sufficiency of the mitigation package.

**Table III. Condition factors used in the HCA**

<table>
<thead>
<tr>
<th>Condition</th>
<th>POOR (Eutrophic backwater)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>IDEAL (Barren island)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chesapeake Bay Index of Biological Integrity (B-IBI)</td>
<td>Severely degraded (poor abundance and diversity)</td>
<td>Degraded</td>
<td>Fair (meets restoration goals)</td>
<td>Good</td>
<td>Excellent (good diversity; stable community)</td>
<td></td>
</tr>
<tr>
<td>Fish (community)</td>
<td>Little or no fish</td>
<td>Poor diversity; abundance in one species</td>
<td>Moderate diversity and abundance</td>
<td>Good diversity; abundances across several species</td>
<td>High diversity and good abundances in all seasons</td>
<td></td>
</tr>
<tr>
<td>Fish (population)</td>
<td>Populations not sustainable; on verge of extirpation</td>
<td>Population marginally sustainable; poor recruitment relative to available habitat</td>
<td>Population struggling with wide variations in recruitment success</td>
<td>Population strong; recruitment successful in most years</td>
<td>Population fully sustainable and at full carrying capacity for available habitat</td>
<td></td>
</tr>
<tr>
<td>Contaminants</td>
<td>Many exceed effects range median (ERM); some more than two times</td>
<td>Several &gt; ERM; many &gt; probable effects level (PEL) or ERM-Q</td>
<td>Some exceed PEL of ERM-Q; many greater than TEL</td>
<td>Several greater than threshold effects level (TEL); few other exceedances</td>
<td>Few or none &gt; TEL</td>
<td></td>
</tr>
<tr>
<td>Aquatic Habitat (estuarine)</td>
<td>No cover; bulkheaded; poor water quality and forage</td>
<td>Little cover; low dissolved oxygen (DO) seasonally; degraded forage</td>
<td>Moderate cover; some submerged aquatic vegetation (SAV); DO usually supportive; adequate forage</td>
<td>Good cover; soft shorelines; SAV present; good DO; stable forage</td>
<td>Diverse cover; stable SAV; good DO; abundant forage in all seasons</td>
<td></td>
</tr>
<tr>
<td>Aquatic Habitat (stream)</td>
<td>Highly entrenched; very low width to depth ratio; low sinuosity; riffles highly embedded; poor instream cover and benthic habitat</td>
<td></td>
<td></td>
<td></td>
<td>No enchtement, width to depth ratio very high; high sinuosity; little riffle embeddedness; excellent instream cover and benthic habitat</td>
<td></td>
</tr>
<tr>
<td>Wetland and Riparian vegetation</td>
<td>Dominated by pioneer or invasive species; lots of human debris</td>
<td></td>
<td></td>
<td></td>
<td>Dominated by stable balanced communities of native species; little trash of debris</td>
<td></td>
</tr>
</tbody>
</table>

**CONCLUSION OF CONSULTATIONS**

During the public comment period, comments were received from MHT, MDNR, NMFS, and the U.S. Department of the Interior (on behalf of FWS). MHT’s comment resulted in the conclusion of Section 106 with no additional comments beyond the determination that the proposed project would not adversely affect historic resources. MDNR noted that it would not request TOY restrictions for the bald eagle, but that it would request TOY restrictions to protect spawning anadromous fish. No other substantial comments were made about the protection of habitat or species.

NMFS responded with a letter stating its concurrence with the determination that the Masonville DMCF project was unlikely to adversely affect listed sea turtles or shortnose sturgeon, but requested additional consultation on large whale species when the end use of the DMCF site is developed. No further consultation was required for the construction and operation of the Masonville DMCF. DOI responded on half of FWS and had no further comments specific to listed species or habitat under the jurisdiction of FWS. No further consultation was required with FWS. The Chesapeake Bay Field Office of...
NMFS responded with comments related to the EFH assessment and concluded that the Masonville DMCF project “should not adversely affect managed species and their EFH”. No further coordination related to the MSFMA was required.

**PREPARATION OF THE FEIS**

Completion of the FEIS (USACE 2007) first required MPA and its contractors to integrate the DEIS and the supplement. This integration was completed first to ensure that comments on all of the alternatives and resources were consistent throughout the FEIS. The new project alternative integrating dredged material with construction grade properties from the nearby Seagirt Marine Terminal project was incorporated into the FEIS. All sections of the impacts chapter of the document were revised to include the new alternative. The new alternative changed the preferred alternative for the project to the alternative that incorporated dredged material from the Seagirt project. After the new alternative was fully integrated into the document, the project-specific studies and consultations completed after the issuance of the DEIS were integrated into the FEIS. These included the federal conformity analysis, the HCA, and the concurrences obtained from resource agencies. The mitigation chapter of the FEIS was expanded to add the HCA and justification of the sufficiency of the compensatory mitigation package.

All comments received during the public comment period were also compiled and summarized in a comment response table. These comments and the accompanying table were integrated into a new appendix for the FEIS. After summarizing all of the comments into a comment response table, edits were incorporated to the relevant sections of the EIS, which were then cross-referenced in the comment response table. This table was completed to demonstrate due diligence with regard to addressing public comments.

The FEIS was revised and updated and submitted to the USACE for review, including legal sufficiency review to ensure that regulatory requirements were satisfied.

After several tiers of review by USACE, the FEIS was adopted and was publicly issued.

---

**Table IV. Masonville DMCF HCA balance sheet**

<table>
<thead>
<tr>
<th>Description</th>
<th>Hectares or Hectare Equivalents</th>
<th>Acres or Acre Equivalents</th>
<th>Initial Condition (score 1-5)</th>
<th>Final Condition (score 1-5)</th>
<th>(Final condition - initial condition) x hectares</th>
<th>Mitigation Balance Credit</th>
<th>Notes or Existing Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Impact</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affected Area</td>
<td>53.0</td>
<td>131</td>
<td>1.7</td>
<td>0</td>
<td>-90</td>
<td>-90</td>
<td>Initial conditions of 1.7 x 53 hectares (131 acres) (52.6 hectare (130 acre open water) and 0.4 hectare (1 acre) vegetated tidal and notidal wetlands)</td>
</tr>
<tr>
<td><strong>Mitigation Options: Aquatic Projects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetland Enhancement</td>
<td>0.8</td>
<td>2</td>
<td>2</td>
<td>3.5</td>
<td>1</td>
<td>-89</td>
<td>Current wetlands dominated by Phragmites sp.</td>
</tr>
<tr>
<td>Wetland Creation</td>
<td>1.3</td>
<td>3.1</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>-86</td>
<td>Shallow areas with little to no vegetation</td>
</tr>
<tr>
<td>Non-Tidal Wetland</td>
<td>4.0</td>
<td>10</td>
<td>1</td>
<td>4</td>
<td>12</td>
<td>-74</td>
<td>Non-tidal area not currently a wetland. Devoid of plants and/or dominated by pioneer species</td>
</tr>
<tr>
<td>Reef and Fish Habitat (subtotal)</td>
<td>38.8</td>
<td>95.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fish community current conditions: outside cove are 2 (poor diversity with abundance in single species); Current conditions inside cove (shoreline) are 4 (good diversity diversity with abundance across several species).</td>
</tr>
<tr>
<td>Reef Balls and Fish Habitat (Inner Cove)</td>
<td>12.5</td>
<td>31</td>
<td>3.5</td>
<td>4</td>
<td>6</td>
<td>-68</td>
<td>Some instream cover (artificial), natural shoreline and SAV present</td>
</tr>
<tr>
<td>Reef Balls and Fish Habitat (Outer Cove)</td>
<td>17.0</td>
<td>42</td>
<td>2</td>
<td>3</td>
<td>17</td>
<td>-51</td>
<td>Little cover and poor substrates and benthic conditions</td>
</tr>
<tr>
<td>Shallow Water Substrate Improvement</td>
<td>9.2</td>
<td>22.8</td>
<td>2.5</td>
<td>3</td>
<td>5</td>
<td>-46</td>
<td>Benthic conditions poor in some shallower parts of Cove; much debris</td>
</tr>
<tr>
<td>Fringe Wetland Creation (along dike)</td>
<td>0.8</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>-45</td>
<td>Current beaches small with little natural cover and poor substrates</td>
</tr>
<tr>
<td>Eel Passage (Bloede/Simpkins Dam, Daniels Dam, Sawmill Creek, Deep Run)</td>
<td>2.3</td>
<td>5.6</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>-40</td>
<td>The populations of herring/shad and eels in the Patapsco drainage are at record low levels and sustainability is questionable</td>
</tr>
<tr>
<td>Shad and Herring Restoration</td>
<td>2.4</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>-35</td>
<td>Abundant trash which is a large problem for habitat quality</td>
</tr>
<tr>
<td>3 Trash Interceptors</td>
<td>8.1</td>
<td>20</td>
<td>1.5</td>
<td>3</td>
<td>12</td>
<td>-23</td>
<td>Poor channel stability and instream habitat</td>
</tr>
<tr>
<td>Biddison Run Reach O (926 meters (3,039 linear feet) of stream)</td>
<td>2.5</td>
<td>6.1</td>
<td>1.5</td>
<td>4</td>
<td>6</td>
<td>-17</td>
<td>Poor channel stability and instream habitat</td>
</tr>
<tr>
<td>Biddison Run Reach P (1,737 meters (5,700 linear feet) of stream)</td>
<td>5.7</td>
<td>14</td>
<td>2</td>
<td>4</td>
<td>11</td>
<td>-6</td>
<td>Poor channel stability and moderate instream habitat</td>
</tr>
<tr>
<td>2 Trash Interceptors</td>
<td>5.4</td>
<td>13.3</td>
<td>1.5</td>
<td>2.5</td>
<td>5</td>
<td>0</td>
<td>Abundant trash which is a large problem for habitat quality</td>
</tr>
<tr>
<td>Western Run (6 reaches, totaling 1,450 meters (4,758 linear feet) of stream)</td>
<td>6.2</td>
<td>15.2</td>
<td>1.5</td>
<td>4</td>
<td>15</td>
<td>15</td>
<td>On average, poor channel stability and poor to moderate instream habitat</td>
</tr>
</tbody>
</table>

_Acreage for items having 'project' units are calculated by dividing the item by $30,400 (per hectare cost for MD Wetland restoration; per acre is $75,000). Totals indicated in Green._

Source: Boraczek et al. 2008
MDE AND USACE PERMIT PREPARATION AND ISSUANCE
Prior to issuance of state and federal permits, two key regulatory documents were required. The MDE Water Quality Certificate required the preparation of a “report and recommendations” for the BPW prior to their issuance of a tidal wetland license. The USACE permit process required the preparation of a record of decision (ROD) that identified its preferred alternative with a decision to either issue or deny the permit. The ROD also incorporated the final conformity determination.

Under normal circumstances, the MDE report and recommendations are prepared internally by MDE staff; however, for this project, MPA provided staff support to MDE to initiate the preparation of this document. MPA contractors drafted documents for MDE to revise and finalize as appropriate to the agency’s requirements. MPA further expedited MDE’s generation of the report and recommendations by making one of its contractors available to MDE to modify and revise the permit application figures for use in the report and recommendations. This contractor was available onsite as the document was finalized so that there was no delay between modification requests and delivery of the figures. It should be noted, that MDE was solely responsible for the generation of the recommendation text and that MPA contractors did not provide input to MDE’s internal decision process.

The MDE permit process also included the preparation of a state water quality certification which was required for the USACE permit, and the issuance of a nontidal wetland permit. No report and recommendations or equivalent document is required for the nontidal permitting process. MDE also integrates the coastal zone consistency process into the tidal permit process. In Maryland, the coastal zone consistency determination is typically incorporated as a condition of both the tidal wetlands license and the water quality certification.

The USACE ROD was prepared internally by USACE with support from MPA contractors. MPA contractors assisted USACE staff by summarizing conclusions and other content from the FEIS and providing a succinct summary of the project actions. The decision to issue the permit was made solely by USACE.

With both USACE and MDE, MPA provided contractor support to expedite the preparation of the ROD and report and recommendations, respectively. This contractor support kept the project moving steadily forward through the regulatory review process by allowing regulators to focus on the analysis and decision/recommendations rather than on the summarization of facts and the project description. MPA further coordinated with USACE, MDE, and BPW to keep both permit schedules synchronized so that the Maryland tidal wetlands license and the USACE permit were issued simultaneously. MPA first assisted MDE with the generation of its report and recommendations so that it would meet the deadline for review by the BPW prior to one of its regularly scheduled meetings. MPA then shifted its focus to the ROD so that it was prepared for release concurrent with the BPW decision. The coordinated actions resulted in the issuance of the tidal wetlands license on the same day as the BPW decision, which reduced processing time by several days.

While both MDE and USACE issued permits for the proposed project, both agencies, as well as other participants in the JE, indicated that this would most likely be the last in-water placement site approved for MPA. The agencies stated that all future placement sites would need to be upland. MDE, USACE, and the JE encouraged the further development of innovative reuses of dredged material as part of MPA’s innovative reuse committee.

CRITICAL AREA APPROVAL
The Chesapeake Bay Critical Area is defined as all tidal waters and all land within 300 m (1,000 ft) of tidal waters and wetlands (COMAR 27.01.01.01). The critical area buffer is the first 30 m (100 ft) landward from the mean high water (MHW) line of tidal waters, tributary streams, and tidal wetlands (COMAR 27.01.09.01).

The Masonville DMCF project is entirely within the Chesapeake Bay Critical Area. The project area is owned by the State of Maryland and falls under the jurisdiction of the State Critical Area Commission rather than the Baltimore City department normally responsible for enforcing Critical Areas Regulations within the boundaries of the City. The site is also within an Intensely Developed Area (IDA) of the critical area. IDAs are areas of concentrated development where little natural habitat exists. As required by Maryland law, new development and redevelopment of an IDA must be accompanied by techniques to decrease water quality impacts due to storm-water runoff, by greater than 10 percent. Construction of a containment site or beneficial use project involved shoreline impacts and required review and approval by the Critical Area Commission.

MPA filed its request to develop the Critical Area with the Commission and followed up with detailed information on the project. MPA was then required to present the project to the Commission. This process was completed concurrently with the joint permit application for MDE and USACE permits. MPA worked with the Critical Area Commission to develop mitigation measures to offset the potential impacts to the Critical Area Buffer and redevelopment of the land portion of the Critical Area. Mitigation measures to offset the impacts to the Critical Area Buffer included planting areas of the DMCF containment structure, where feasible, and plantings within Masonville Cove. Redevelopment of the land portion of the Critical Area was mitigated through MPA’s Institutional Plan for reducing nutrient loads within (or from) the Critical Area.

OPERATIONAL PERMITTING
The Clean Water Act requires states to develop lists of its impaired waters. Impaired waters are those waters that are too polluted or degraded to meet state water quality standards. The Act requires that states establish priority rankings for waters on the lists and develop total maximum daily loads (TMDLs) for these waters. The TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards. The Patapsco River is impaired for dissolved oxygen (caused by nitrogen and phosphorous), metals, PCBs, trash, bacteria, total suspended solids, and pesticides (MDE 2010).

The operation of the Masonville DMCF requires a national pollutant discharge elimination system (NPDES) permit that regulates point source discharges to surface waters. MPA began the NPDES permitting process by meeting with MDE, which administers the
NPDES program, to identify issues and concerns associated with discharges from the Masonville DMCF. The first meeting was held soon after the construction permits were issued. These pre-application meetings included the submission of several draft permit applications to MDE for review prior to the formal application to MDE in August 2008.

MPA has another DMCF within the Harbor, Cox Creek. This facility was assigned load allocations for nitrogen and phosphorus in the TMDL modeling for discharges. Discussions were held with MDE regarding use of the Cox Creek DMCF load allocation under a “bubble permit” that would cover multiple DMCFs within Baltimore Harbor. MDE requested additional information on the potential for localized impacts associated with a shift of a portion of the Cox Creek allocation to the Masonville facility. A study was funded by MPA and completed by the Virginia Institute of Marine Science (VIMS) to model potential water quality impacts to dissolved oxygen that could potentially be caused by a discharge from the Masonville facility. Initial modeling utilized the existing Baltimore Harbor model used for that TMDL. Future scenario runs of the model will be updated to include the most recent revisions to the USEPA Chesapeake Bay model. Initial modeling indicated no localized impacts as a result of the Masonville DMCF’s operation. MPA and its contractors have also calculated acute and chronic mixing zones for selected toxic pollutants and provided that information to MDE for the use in developing the draft permit for the project.

An individual discharge permit will be established for the Masonville DMCF. A public notice related to the Masonville discharge permit was released by MDE in May 2010 and a public hearing was held in June 2010. MDE is currently addressing the public comments provided during the public comment period. The permit issuance is anticipated in Fall 2010.

After the release of the draft permit, there will be a public comment period, during which the public can provide comments and request a public meeting or hearing. MPA, in keeping with its policy of transparency in the development of DMCFs, is planning to request the scheduling of a public meeting in anticipation of public interest in this project. Scheduling of public hearings for draft permits at the time of their issuance can shorten the timeframe for permit approval rather than waiting for those requests during the formal comment period. The issuance of the NPDES permit is the last step required to support the operation of the DMCF and the permit award is anticipated in late 2010.

**CONCLUSIONS**

Despite the many regulatory challenges, the approvals and permits necessary to begin construction were obtained within 28 months of public scoping because of the Port’s collaborative decision-making process. The ability to move multiple project and permitting components forward simultaneously provided evidence of the benefit for proactive outreach efforts. MPA took advantage of every opportunity available to streamline the permitting process so that all necessary permits and approvals were obtained in the shortest period of time. Time savings were realized by measures such as:

- scheduling public hearings and meetings during the public comment period,
- interacting early and often with the JE and BEWG,
- providing agencies with the opportunity to comment on the project as a preliminary DEIS rather than awaiting the public comment period, and
- using the public comment period as an opportunity to concurrently complete additional studies and information requests associated with the preliminary DEIS.

It is noteworthy that the MPA managed to obtain permits for the project in just over two years despite concerns with open water fill and multiple resources of particular concern, such as listed species and EFH.

The Masonville DMCF had a unique permitting and approval process that integrated many agencies and stakeholders in the project development. Statements by the agencies that no additional in-water placement sites would be allowed have shifted future development considerations to upland sites around the Harbor, which makes the approval process for future sites different from the process used for the Masonville DMCF. MPA developed a valuable understanding of the NEPA process for large, complex projects. In particular, MPA gained an understanding of the cooperating agency process and will use its knowledge to integrate additional partners in future efforts.

MPA also developed a valuable project specific HCA process, which will also be incorporated into future projects to determine the sufficiency of compensatory mitigation packages. If additional DMCF facilities are developed with the potential for substantial impacts, the HCA process will allow MPA to simultaneously present potential mitigation options and demonstrate their sufficiency.

**REFERENCES**


Coast Expo  
**SEPTEMBER 21-23, 2010**  
**FERRARA, ITALY**

This First Exhibition on the Protection of the Coast and Sea will be held within the 4th RemTech Expo 2010 - RemediationTechnologies and Requalification of the Territory Exhibition. Coastal areas represent a unique asset in terms of environment, economics and socially. Coast Expo 2010 will provide a focus on the areas of management, dredging, nourishment and remediation of port areas and the coasts and a total use of resources towards the possibility of bilateral meetings between stakeholders (operators, industry, public authorities, port authorities). The Scientific Committee with national delegates (and representatives of the Ministries) and international delegates (including representatives of the European Commission) are supporting the exhibition as well as the following Congresses: a conference on dredging, a symposium on monitoring and risks and a symposium on applications of speech cases, studying or monitoring. Parallel projects at the RemTech Expo 2010 are currently being finalised.

**For further information contact:**  
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Tel: +39 0532 909495, Fax: +39 0532 976997  
Email: gpiva@ferrarafiere.it

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Optimising Port Development  
**OCTOBER 5-6, 2010**  
**DUBAI, UAE**

Optimising Port Development 2010 will showcase the latest infrastructure and management strategies that growing ports need to be aware of in order to expand successfully. The event is committed to bringing together ports though leaders from across the world to discuss some of the most pressing issue facing the industry. Emerging markets in EMEA, Asia and Latin America need to match greater capacity and better services in ports to facilitate the rising volumes of trade. This event presents information to prepare you to develop your port to a world class standard. It will allow regional and international key decision makers to discuss the future of ports development. An exclusive site visit will take place at the Port of Fujairah on Monday October 4th. Delegates at this conference will be drawn from a range of organisations including: Port Authorities, Port Operators, Terminal Operators, Logistics companies, Shipping Lines, Ship Managers, Ship Agencies, Governmental Transport and Logistics Departments, Marine Engineering and Construction Companies, Project Manager, Port and Terminal Equipment Providers, Lawyers, Banks and financial institutions.

**For further information please contact:**  
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Tel. +44 (0) 207 981 2506  
Email: jhermans@acieu.net

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Port & Terminal Technology 2010  
**OCTOBER 5-6, 2010**  
**LONG BEACH, CALIFORNIA, USA**

Now in its 7th year, Port & Terminal Technology has established itself as a “must-attend” key industry event. Because of the success in 2009 in the USA, the 2010 event will return there, delivering a diverse and in-depth conference programme complimented by an impressive lineup of industry experts and market leaders. Exploring the latest developments, issues, trends and technology affecting ports and terminals around the globe, the conference will provide delegates an invaluable learning opportunity as well as an excellent platform for discussion, debate and networking. The event will be complimented by an additional one-day workshop on Ports and the Environment. The conference is especially designed for representatives from operations, maintenance and engineering.

**For further information, please contact:**  
Claire Palmer – Event Manager  
Tel: +44 (0)1628 820 046, Fax: +44 (0)1628 822 938  
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35th IADC International Seminar on Dredging and Reclamation  
**NOVEMBER 8-12, 2010**  
**GRAND PARK CITY HALL HOTEL, SINGAPORE**

More than ever dredging is in the news. Be it the land reclamation projects in Dubai and Abu Dhabi or the cleanup actions in the Gulf of Mexico and China, or the urgency of coastal protection against rising sea levels in this time of climate change. All are reasons why governments continue to invest in maritime infrastructure projects. Since dredging is an indispensable, but often misunderstood, tool in these projects, the International Association of Dredging Companies (IADC) decided some years ago to develop an “International Seminar on Dredging and Reclamation”. The seminar is continually updated and is given by recognised experts from the world’s leading dredging companies. It is aimed at (future) project managers, project staff and decision makers in governments, port and harbour authorities, offshore companies and other organisations.

The five-day course provides an understanding of dredging through lectures by experts in the field and workshops. Some of the subjects covered are: land reclamation, the development of new ports and...
maintenance of existing ports; project phasing (identification, investigation, feasibility studies, design, construction, and maintenance); descriptions of types of dredging equipment and boundary conditions for their use; state-of-the-art dredging techniques as well as environmentally sound techniques; pre-dredging and soil investigations, designing and estimating from the contractor’s view; costing of projects and types of contracts such as charter, unit rates, lump sum and risk-sharing agreements.

In addition, in each country a visit to a dredging project is planned, if possible combined with a trip on a working trailing suction hopper or cutter dredger.

The cost of the seminar will be €2,950,-; this fee includes all tuition, seminar proceedings and workshops and a special participants dinner during the week. Register before 15 September and enjoy a €250,- discount. Fees are exclusive of travel costs and accommodation. IADC assists as needed with finding accommodation in the conference hotel or at another facility.

For further information please contact:
Frans-Herman Cammel
Tel: +31 070 352 3334
• Email: cammel@iadc-dredging.com.

COPIRI Congress
NOVEMBER 13-17, 2010
MEMPHIS MARRIOTT & CONFERENCE CENTER, TENNESSEE, USA

Coasts, Oceans, Ports & Rivers Institute will hold its inaugural congress to celebrate its 10th anniversary, entitled, COPIRI: A Decade of Progress, A Future of Opportunities featuring sessions by all of COPIRI’s technical committees, as well as plenary speakers, an awards luncheon, founder’s gala, student and young professional job fair, short courses, general membership meeting and an opportunity for committee meetings.

Short courses on Sunday, Nov. 13, will address:
Conference tracks Monday and Tuesday will include four parallel sessions: Can This Be The Last Storm – Learning From Disaster Investigations To Prevent Negative Impacts Within Coastal Areas; Use Of Composites In Commercial Ports; Climate Adaptation and Sustainability in Ports; E-Navigation; Federal Policy Issues; Living Behind A Levee; Lifecycle Management Of Navigation Facilities; Legal Issues For Engineers; Marine Renewable Energy And Ocean Engineering; New Developments In Coastal Engineering Practice; Sediment Management On Riverine Systems; Sustainability; Research Needs, and Water Resource Policies & Authorities - Incorporating Sea Level Change Considerations in Civil Works Programs

For further information please contact:
Tom Chase, COPIRI Director for volunteering
• Email: tchase@asce.org
Sean Scully for sponsorships or exhibits
• Email: ssully@asce.org
Elaine Watson, Conference Manager
• Email: ewatson@asce.org
Steve Curtis, Congress Organizing Committee Chair
• Email: sac63chevy@hotmail.com

CEDA–IADC Training Course
“Environmental Aspects of Dredging”
NOVEMBER 22-23, 2010
PORTS TRAINING INSTITUTE (IFP), CASABLANCA, MOROCCO

This well-respected two-day course, being presented in Africa for the first time, provides an overview of the environmental aspects of dredging, the latest technologies and equipment that apply to dredging and the management of dredged material. The seminar includes presentations and workshops and is given by two renowned industry professionals, Gerard van Raalte and Pol Hakstege.

The registration fee is €950, which includes the presentation slides, the CEDA-IADC book Environmental Aspects of Dredging edited by Nick Bray, published by Taylor and Francis (a €125 value); as well as lunches, coffee breaks and participation in the gala dinner.

For further information please contact:
Permanent Secretary of CEDA-AS, Ms Khadija Legliti
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www.ceda-africa.com

Ports & The Environment 2010
DECEMBER 2, 2010
AMSTERDAM, THE NETHERLANDS

With the environment being a vital issue for ports and terminals worldwide, this conference will return in December 2010 to examine key issues and topics such as noise, dust and exhaust emissions, environmental dredging, port expansion and development, ballast waste management, cold ironing, hazardous cargo, congestion, legal framework, terminal capacity and social-economic development issues affecting ports and terminals worldwide.

For further information, please contact:
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www.millenniumconferences.com
Terra et Aqua is a quarterly publication of the International Association of Dredging Companies, emphasising “marine solutions for a changing world”. It covers the fields of civil, hydraulic and mechanical engineering including the technical, economic and environmental aspects of dredging. Developments in the state of the art of the industry and other topics from the industry with actual news value will be highlighted.

- As Terra et Aqua is an English language journal, articles must be submitted in English.
- Contributions will be considered primarily from authors who represent the various disciplines of the dredging industry or professions, which are associated with dredging.
- Students and young professionals are encouraged to submit articles based on their research.
- Articles should be approximately 10-12 A4. Photographs, graphics and illustrations are encouraged. Original photographs should be submitted, as these provide the best quality.
- Digital photographs should be of the highest resolution.
- Articles should be original and should not have appeared in other magazines or publications.
- An exception is made for the proceedings of conferences which have a limited reading public.
- In the case of articles that have previously appeared in conference proceedings, permission to reprint in Terra et Aqua will be requested.
- Authors are requested to provide in the "Introduction" an insight into the drivers (the Why) behind the dredging project.
- By submitting an article, authors grant IADC permission to publish said article in both the printed and digital version of Terra et Aqua without limitations and remunerations.
- All articles will be reviewed by the Editorial Advisory Committee (EAC). Publication of an article is subject to approval by the EAC and no article will be published without approval of the EAC.

Reference to: www.iadc-dredging.com +31 (0)70 351 2654

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MEMBERSHIP LIST IADC 2010

Through their regional branches or through representatives, members of IADC operate directly at all locations worldwide.