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DOER: A Major Dredging Research Programme

Abstract

Much like the Public Works Ministries in many other countries, one of the major responsibilities of the US Army Corps of Engineers Civil Works Directorate is supporting the nation's infrastructure. A vital part of this infrastructure is the construction and maintenance of 25,000 miles of navigable waterways. These waterways serve over 400 ports, including 130 of the nation's 150 largest cities.
There is a huge difference in geological, meteorological, environmental, morphological and physical differences from waterway to waterway and port to port.
The diverse range of conditions makes it difficult, if not impossible, to set up programmatic standards or develop solutions that apply equally to all sites and situations. To meet these needs, the United States Government under the auspices of the US Army Corps of Engineers has authorised a new major multi-year dredging research programme called the Dredging Operations and Environmental Research (DOER) Programme.

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Introduction

A major element of any waterway construction and maintenance programme is the extensive dredging requirement. The Corps national dredging programme involves an average of 250 to 300 million cubic metres annually at a cost of US$400 million. Dredging is the single most costly element of the Corps of Engineers budget. The Corps also grants permits to the private sector for dredging and disposing of an additional 100 million cubic metres of sediment annually.

Sediments in many urbanised and industrialised harbours are severely contaminated from years of unregulated discharges and runoff. This situation is made more difficult by the rapidly diminishing capacity of present disposal facilities and by high levels of resistance to constructing new facilities in traditional locations. Non-controversial disposal options are quickly disappearing, and dredging options are increasingly constrained by environmental windows and other restrictions for the protection of sensitive aquatic resources and wildlife.

Today's dredging managers are faced with complex situations in which they must achieve a cost-efficient operation while simultaneously considering the risks associated with various types of dredging equipment, timing of dredging and disposal operations, selection of an appropriate disposal alternative, and other important factors.

Research Tailored to Demonstrated Needs

The DOER programme recognises the necessity of balancing the operational and environmental requirements and is intended to develop tools and techniques to meet this challenge. The programme was developed from the bottom up; that is, a survey of needs of the Corps far-flung field offices served as a basis for identifying what needed to be done and the priorities for the various aspects of the programme. The use of a continuing involvement of field dredging managers in an advisory role has been successful in past research programmes and will be an integral part of the manage-

ment of this new programme. A major advantage of this approach is to accommodate changes in direction as new needs evolve and other research initiatives prove impractical.

Technology Transfer a Primary Emphasis

Research results only realise a true value when they are publicised to potential users. Therefore aggressive technology transfer to the field operators and managers is a critical element of the programme from the outset. In addition, the Corps of Engineers is including other Federal and state agencies in the planning and implementation of the programme. These partnering agencies include the Environmental Protection Agency (EPA), the US Fish and Wildlife Service and the National Marine Fisheries Service.

Bridge to the Next Century

DOER is the latest in major dredging-related research spearheaded by the Corps of Engineers. It is intended to address a full array of research needs related to dredging and dredged material disposal and the research will span into the new millennium. The first major research programme was the Dredged Materials Research Programme (DMRP) that started in the early 1970s as the sensitivity to environmental issues gave impetus to finding environmentally sound solutions to dredging problems. The next research programme was the Dredging Research Programme (DRP) which was more attuned to research and development of innovative operational solutions to problems. The current programme, DOER, is envisioned as an 8-10 year $48 million programme and it will have amore eclectic set of objectives, ranging from operational, engineering and technical to environmental.

DOER is divided into six specific applied research focus areas each with work tasks describing objectives, research methodologies, user products and time/cost schedules. These focus areas are:
– Nearshore placement of dredged materials
– Environmental windows for dredging operations
– Contaminated sediment characterisation and management
– Instrumentation for dredges and site monitoring
– Innovative dredging technology
– Ecological risk management for dredging disposal projects.

Nearshore and offshore placement of dredged materials
Nearshore and offshore locations present a variety of challenges and opportunities for the cost-effective, environmentally acceptable placement of dredged material. In addition to being costly, conventional disposal practices usually remove the sandy and silty materials required to build and replenish beaches, barrier islands, and other land features. In the case of contaminated dredged material, the demand for offshore capping and confined disposal projects is bound to increase as upland and other traditional options become scarcer.

Placement options for contaminated and non-contaminated materials are now constrained by a lack of predictive tools, assessment capabilities, and operational guidance for the physical aspects of placement/environment interactions. DOER nearshore research focusses on predicting the time-dependent movement of sand/silt mixtures, including material sorting and the fate of finer fractions. Such predictions are essential for estimating long-term benefits from repeated placement of maintenance dredged material and for assessing risks to nearby resources. In addition, guidance will be developed to further enhance beneficial uses, to determine impacts to key species, and to minimise effects on fishery resources. For offshore confined disposal facilities (CDFs) and capped mounds, research will focus on developing siting and configuration criteria, predicting the performance of various construction techniques, evaluating long-term behavior and integrity, and providing integrated design guidance.

Benefits from nearshore work in this area will include:
– improved use of maintenance dredged material for shoreline stabilisation,
– increased acceptance by regulatory agencies of nearshore placement as a viable long-term disposal alternative, and
– lower costs for overall maintenance dredging operations.

For offshore placement of contaminated material, benefits will include improved design capabilities and confidence, and significantly expanded options for safe, cost-effective disposal.

Environmental windows for dredging operations
Environmental windows impose serious constraints on dredging operations. Although widely applied, they are often based on little technical information. There is a lack of consistency for recommended windows, even when protecting the same resource, and they typically result in limited scheduling and equipment options, increased costs, and potential for navigation safety hazards. Specific categories of windows (e.g., to protect salmon runs and nursery habitat in New England) will be identified that pose severe impediments and significantly increase project costs impact moderate to large volumes.

A survey of existing and proposed environmental windows will quantify the relationships between each category of window and impacts. Only those high profile

windows that maximise return of research funds into the dredging programme will be selected for further study.

DOER is synthesising the state-of-knowledge of individual issues, evaluate their technical basis, and produce guidance for resolvable issues, given existing information. Issues needing further research are being prioritised based on probability of resolution with reasonable investment of funds and potential benefit. The effectiveness of equipment and/or operational measures in reducing the need for environmental windows will be documented.

DOER is developing partnerships with the Corps field offices and environmental resource agencies to evaluate current environmental windows and implement research necessary to resolve seasonal restrictions. Where windows are technically justified, guidelines for implementation that optimise resource protection while retaining flexibility for project contracting and scheduling are being developed. Benefits will include:
– technical basis for appropriate application of environmental windows,
– improved inter-agency coordination by removing speculative arguments,
– increased efficiency in contracting and equipment, scheduling, and
– reduced project dredging costs.

Contaminated sediment characterisation and management

The presence of chlorinated hydrocarbons (dioxins) and other man-made contaminants in sediments is a potential threat to the environment and human health that results in significant project delays and management cost increases. Contaminated sediments unsuitable for conventional disposal may be confined, contained, or not dredged.

CDFs are located on land or in areas of relatively sheltered water. Many CDFs are approaching capacity for which replacement is required. Future CDF locations will include non-traditional areas such as offshore sites. Capping contaminated sediment with clean dredged material is a related option for open water disposal. It has significant potential to increase disposal capacity, but application to deeper waters or high-energy environments requires additional environmental investigation.

DOER will develop risk-based effects assessments for contaminated dredged material that include contaminant control, treatment, and removal technology and reuse of marginally contaminated sediments from existing CDFs. The risk process for contaminated sediments includes hazard assessment, contaminant pathway testing, exposure assessment and identification of contaminant controls and treatment (Figure 1).

Research will develop low-cost, rapid, and interpretable biological screening methods. These will also reduce the number of chemical analyses and quickly identify contaminated sediments and marginally contaminated dredged material in existing CDFs that can be reused.

Figure 1. As part of contamination sediment characterisation and management, a researcher is using a pipette to add cells to wells in microtitreplate for the H4IIE dioxin screening assay.

CDF research will develop and validate contaminant controls, treatment methods, and management techniques. Design of CDFs as treatment structures, groundwater and surface water control, and overall contaminant retention will be emphasised. Design criteria for treatment and/or control of high-profile contaminants in CDFs will be developed. Tools for predicting capped material chemical migration will be refined. Environmental aspects of capping and CDFs will be developed jointly with physical aspects under the Nearshore and Offshore Placement focus area. Benefits will include the ability to:
– improve the cost-effectiveness of identification and assessment procedures,
– reuse existing disposal capacity for contaminated materials, and
– design and manage disposal facilities for enhanced capacity, treatment, and containment objectives.

Instrumentation for dredges and site monitoring

Improvements in instruments to make measurements are needed to meet increasingly stringent environmental monitoring requirements and to expand automated operational monitoring and characterisation capabilities. The DOER Programme will help bridge the gap between present instrumentation needs and the tendency of commercial firms to direct their product development resources toward broader, non-dredging market segments.

Figure 2. Experimental teeth on a California-style draghead is an example of innovative dredging technology which has improved productivity.

Research will augment domestic and internationally available commercial products where feasible and will support specialised product applications. By developing system standards and specifications and demonstrating prototypes, the DOER Programme will facilitate achieving an overall objective of product implementation and support through the commercial sector. Research in the instrumentation focus area is directed toward developing systems and standards to achieve these goals:
– pay hopper-dredge contracts on a dry-weight basis,
– precisely locate dredging transport and disposal, and
– verify compliance with environmental requirements.

In each case, instrument and system development will be preceded by a thorough requirement analysis to ensure that quantified performance goals are set based on verifiable needs. Where competing technologies are involved, independent screening procedures based on these performance goals and on existing technology, theory, and data will be used to assess which candidates, if any, warrant further development. Benefits from work in this area will include:
– tools for compliance with environmental requirements,
– positive incentives for increased dredging efficiency, and
– reduced potential for sustainable contractor claims.

Innovative dredging technology

During a multi-year research programme, technological opportunities may be encountered that are outside the initial scope of work. This focus area will serve as a coordination and evaluation center for such opportunities. These future advances may emerge from other DOER focus areas, related R&D activities, or private industry both in the US and abroad. The capability to recognise these opportunities, evaluate their potential, and facilitate their demonstration and implementation will provide timely additional options for removing and disposing of dredged material. Examples of candidate technologies include equipment and procedures for capping and systems for dredging contaminated materials (Figures 2 and 3).

A clearinghouse for innovative dredging and disposal technologies is being established. Recent advances in equipment, operational methodologies, and environmental compliance will be catalogued. These advances will be matched to Corps needs articulated by field representatives and Corps headquarters. A screening and evaluation process will identify items with the greatest potential for implementation, high return and increased efficiency.

The next step will be to develop funded demonstration opportunities for high-potential candidates. Some demonstrations may be of sufficient scope and potential to warrant an autonomous proposal. Regardless of the source, all demonstrations will be accompanied by a detailed plan to implement successful technologies into Corps in-house, contractor and permitting practices.

This focus area will promote the evaluation and implementation of innovative dredging and disposal technol-

ogies. Promising technologies will be matched to needs, and the process from identification to operational integration will be fully planned and coordinated. This rapid process will provide more immediate benefits in the form of improved operations, reduced costs, and environmentally acceptable dredging operations.

Ecological risk management for dredging disposal projects

Fiscal constraints are making the already difficult task of managing the field managers' maintenance dredging/disposal programme even more difficult. Risk management can promote the more effective use of limited funds through evaluation of critical factors (such as cost, equipment, windows, contaminants, disposal options, shoaling and channel navigability) as well as the consequences of not dredging. A repeatable and defensible framework to quantify this process is missing. Lack of an internally developed framework increases the probability of having one imposed by external sources (e.g., EPA) that does not fit dredging needs.

Risk-based analyses will be required for a wide variety of activities and functions integral to managing dredging and disposal projects. These include:
– facilitate long-term management continuity,
– support decisions or requests,
– choose among closely ranked alternatives, and
– negotiate environmental, engineering and economic issues

A framework for risk-analysis techniques and engineering reliability methods for dredging and disposal processes are being developed. Researchers will identify and rank critical factors and define data collection requirements to evaluate them (e.g., the probability of a given reduced channel depth). Many aspects of the dredging and disposal process have considerable uncertainty; the risk framework will allow a consistent approach to dealing with these uncertainties. Existing risk-analysis techniques are being examined for their potential application to maintenance dredging.

A risk framework integrating dredging and disposal management will be developed. The framework will demonstrate the usefulness of risk-analysis to a dredging manager making difficult decisions on controversial, closely ranked alternatives.

Integration of the International Experience

One objective of the DOER Programme is to capture the successes and promising on-going research existing in the international sector. A conscientious effort will be made to interface the Corps researchers with their counterparts on the international scene. This could mean research projects will be awarded to universities or other research agencies in Europe or elsewhere around the world and/or partnerships could be established with other Corps researchers.

Figure 3. Another example of innovative technology for a project-specific environmental problem is the turtle deflection device developed by the US Army Corps of Engineers. Mounted on a TSHD draghead, it is used to avoid the entrapment of sea turtles (an endangered species) through the suction pipe of a TSHD during maintenance dredging in Florida (USA).

Contacts through the Corps expanding Internet presence can greatly assist in reaching out to utilise these international capabilities (the Corps Dredging Operations Technology Support Home Page at http//:www.wes.army.mil/el/dots/). Information on the Corps dredging programme in particular (including the major contracts advertised and awarded), is available as well as information on ports, navigation projects, waterway commerce and navigation statistics.

Conclusion

The DOER programme demonstrates a commitment to meaningful research in the essentials of dredging technology ranging from operational, engineering and technical to environmental. The objectives and results of this research should provide innovative, cost-effective solutions for dredging operations and environmentally responsible disposal techniques.
These may ultimately be utilised to great advantage by any nation where navigation, waterway transportation and dredging issues constitute an important part of their national interests. Likewise, recognising the on-going research and activities in other parts of the world, there may be some opportunities for substantial international participation in this major research effort.