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Guidance for USACE Dredging Projects Affected by Oil Spills

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PURPOSE: The U.S. Army Corps of Engineers (USACE) developed the guidance in this technical note to provide USACE districts with a streamlined process to assess and respond to the potential impacts from oil spills such as the *Deepwater Horizon MC 252* incident. This guidance includes procedures for engaging the Unified Command (UC), for establishing an administrative record, for assessing potential environmental impacts, and for communicating results to District leadership and resource agencies so that informed decisions can be made about dredging operations.

This guidance also provides a logical framework for USACE dredging operations in areas affected by oil spill incidents; it was developed after weighing relevant logistical and environmental considerations associated with ongoing routine, emergency or planned dredging operations. This technical note delineates the mechanisms for early and effective engagement with the United States Coast Guard (USCG) and/or the UC to minimize dredging downtime; it also establishes procedures for oil screening techniques of sites and dredged material, as well as for timelines, data collection and evaluation. Lastly, this guidance provides a decision hierarchy for actions to be taken subsequent to the identification of potentially newly oiled sediments at a dredging or disposal site.

BACKGROUND: On April 21, 2010, the USCG reported an ongoing fire after an explosion onboard a mobile drilling platform off the coast of Louisiana. The *Deepwater Horizon*, located approximately 65-80 km southeast of Venice, Louisiana, sank on April 22, 2010, resulting in a continuous release of oil from the damaged wellhead, 5000 feet below the surface. Approximately 4.9 million gallons of oil were estimated to have been released over an 87-day period, before the well was successfully capped (OSAT 2010). This is comparable in magnitude to previous oil spills in U.S. waters, including the Exxon Valdez (more than10M gallons spilled; National Response Team (1989)), the Mega Borg (3.9M gallons spilled; Canney 1992), and the Argo Merchant (estimated 7.3M gallons of fuel oil spilled[1]), but differs in that it was a deep subsurface release occurring over an extended period of time. Although dispersant use and warm environmental conditions were expected to facilitate biodegradation, the ultimate fate of the majority of the oil released by the Deep Water Horizon incident is still unknown. A vast area of the Gulf of Mexico stretching from Texas to Florida was impacted to various degrees. Multiple USACE dredging projects spanning the Gulf were anticipated to be potentially impacted from this incident (and perhaps future incidents) as well, requiring a reevaluation of dredging operations and coordination with the UC responsible for coordination and oversight of oil spill response.

1 http://www.uscg.mil/history/uscghist/Policy_Changes.asp

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While the magnitude of the *Deepwater Horizon* spill was significant, it was not an isolated incident. Oil spills occur due to releases of crude oil from tankers, offshore platforms, drilling rigs and wells. Spills of refined petroleum products (such as gasoline and diesel) and their by-products also occur, as do spills of heavier fuels (such as bunker fuel) used by large ships, or spills of oily refuse or waste oil. Between 2000 and 2009, there were an average of 32,630 oil spills per year along the coasts and in other navigable waters of the United States (NRC 2009). As previously mentioned, the *Deepwater Horizon* incident was one of four large oil spills occurring along U.S. coastlines from 1976 to 2010. Depending on the magnitude and location of a spill, the potential exists for USACE dredging operations to be delayed by spill response activities and the requisite reevaluation of potential environmental impacts associated with dredging operations in the affected area. Spill response activities, project area reevaluation, engineering controls necessary to manage contaminated sediments, and resulting downtime of dredges may all result in significant increases in project cost as well as other economic impacts associated with delays in project construction.

APPROACH: This guidance was developed for USACE dredging operations managers responding to potential project impacts associated with an oil spill. This guidance provides a framework that incorporates the oil spill incident UC structure; definitions that may be useful when communicating with the UC and relevant agencies are also provided. This guidance will help the dredging operation manager and other responsible parties to: (1) provide the most up-to-date information to District leadership so that command decisions can be made about dredging in areas affected by oil spills; (2) develop rapid guidelines for data collection and analyses; (3) provide resource agencies with data so that informed regulatory decisions can be made about dredging and disposal operations in the affected area; and (4) improve communication and information exchange with the UC to facilitate development of dredging operations and material management procedures (response actions or activities), thereby minimizing dredging downtime.

USACE DECISION FRAMEWORK FOR DREDGING OPERATIONS PLANNING AND RESPONSE IN OIL SPILL- IMPACTED AREAS

USACE Internal Priority Response Actions: The structure of the decision framework is outlined in the following flowcharts (Figures 1 to 3b). There are four parts to the framework, (1) those actions that position the agency to access available resources and information related to the spill and that facilitate coordination with other relevant agencies and the UC; (2) a decision structure for projects involving ongoing dredging activities classified as either emergency projects, in which dredging cannot readily cease or be postponed, or non-emergency projects, in which dredging cessation or postponement can be contemplated; (3) a decision structure for planned dredging projects, in situations where no contract has been awarded, so that dredging could be deferred if necessary; and (4) a post-contract award scenario, in which dredging deferral would likely have cost impacts.

The following sections elaborate on the major action items identified in the flowcharts. This approach was intended to provide a simplified and streamlined set of procedures that could be readily read and easily utilized by USACE personnel. It is not a comprehensive guideline for conducting the customary environmental evaluations necessary to permit dredging actions; that process is assumed to have been carried out previously. This framework augments that process with specific actions to be taken in the event newly oiled sediment is encountered or is anticipated to impact dredging projects in the area.

Check NOAA ResponseLINK: ResponseLINK is a web-based communications system for incident responders maintained by the National Oceanic and Atmospheric Administration (NOAA). Dredging operations managers or designated points of contact (hereafter referred to as Dredging Operations POCs) can request a user name and password by emailing the ResponseLINK administrator at *orr.incidentnews@noaa.gov*. NOTE: This request should be made as soon after an oil spill incident as possible in all areas affected – or having the potential to be affected – by the oil spill. ResponseLINK provides up-to-date information regarding the oil spill. Information that can be found includes – but is not limited to – overviews of the incident, situation reports, photos, maps, oil trajectories, water and oil chemistry, press releases and after-incident documents.

Identify Current/Future Dredging Operations: Once an oil spill is identified within a District boundary, the Dredging Operations POCs need to identify all current (on-going) dredging operations and future dredging operations. NOTE: Priority project identification should be given to current dredging operations.

Contact USCG: Dredging Operations POCs should contact the USCG as soon as possible after learning of an oil spill incident within District boundaries (Recommendation: Dredging Operations POCs should have an established relationship with the USCG within their District boundary – USCG Sector Directory and Map is located in Appendix A[1]). Alternatively, the Dredging Operations POCs should call the USCG National Response Center at (800) 424-8802 to request information regarding the incident.

Recommended inquiries (Additional recommended talking points can be found in Appendices E and F):

1. Who is the USCG POC for this incident?
2. What is the official name of this incident?
3. Where is the Command Center for this incident?
4. Can a USACE representative be placed in the Command Center?
5. When and where is the next UC meeting for this incident?
6. Will the USCG and/or UC develop a response plan (oil recovery personnel and equipment) in the event the USACE needs to resume dredging operations in impacted areas?
7. Request an orientation overflight of the oil spill area with the USCG (This will be a good opportunity to view the oil spill and see how it may impact dredging operations, and will provide the USCG with an aerial view of dredging operations).
8. Request funding from the USCG for USACE activities and participation in the UC (Funding requests are called PRFA - Pollution Removal Funding Authorization).

1Current USCG sector information and contact numbers can be found online, at: http://homeport.uscg.mil/mycg/portal/ep/home.do, under the Sector Directory link. There appear to be some differences between the online information and the information contained in the downloadable pdf file found on the site. Reportedly, the online information is the most current.

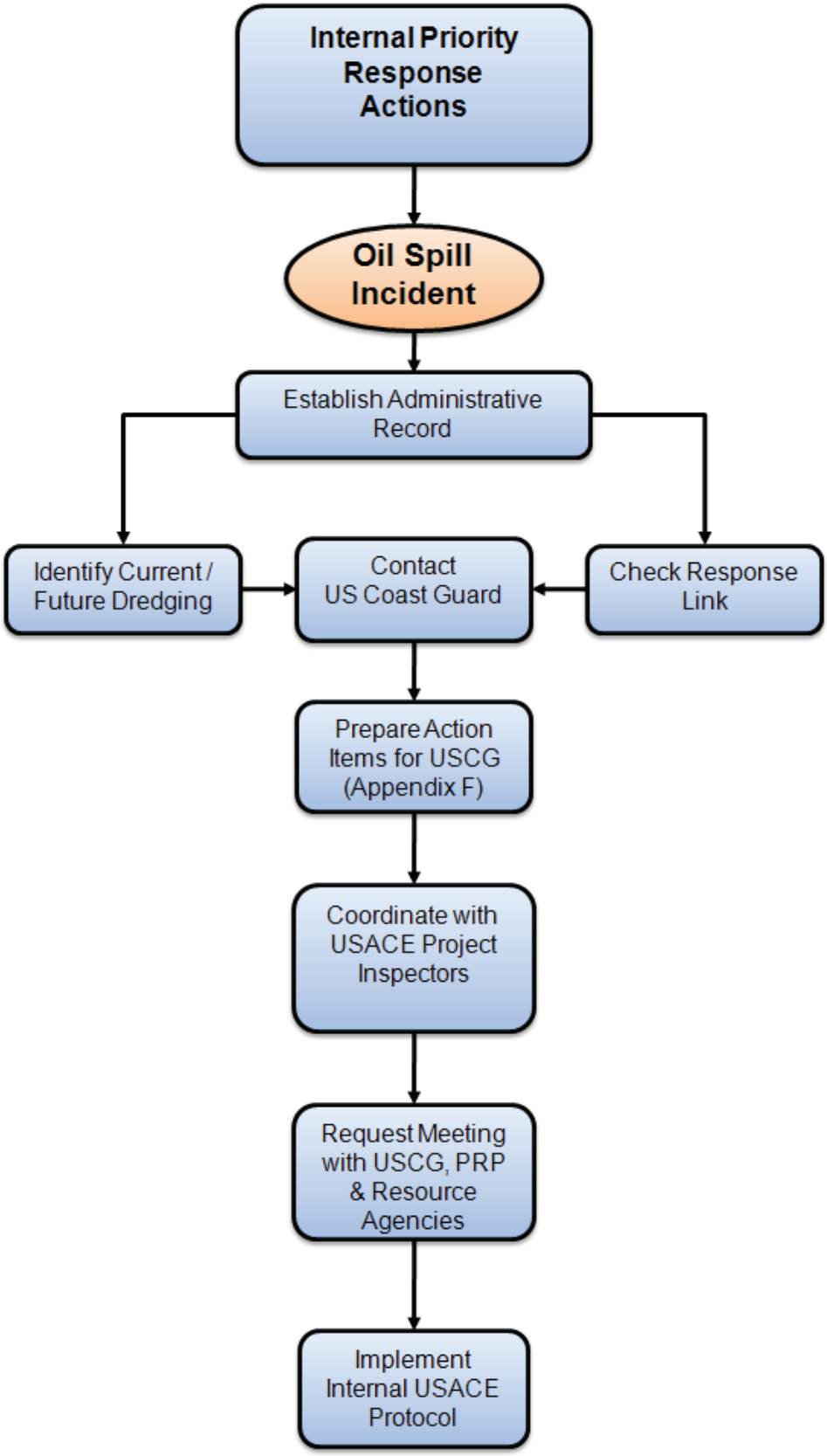

Figure 1. Decision Structure for Internal Priority Response Actions.

9. Request a source sample of the oil that has been released. (Depending upon the distance from the spill location to the dredging/disposal site, weathered samples taken from representative distances may also be recommended.)
10. Request that sediment samples (background samples and 1 year post-incident) be collected and analyzed in the dredging and disposal areas.

Coordinate with USACE Project Inspectors: Dredging Operations POCs need to coordinate with USACE Project Inspectors to address potential impacts to the dredging operations as a result of the oil spill.

Specific tools include:

1. Dredging Operations POCs will provide additional guidance by providing the "Open Water Oil Identification Job Aid[1] (NOAA 2007)" (Appendix B) to Project Inspectors to aid in the identification of oil, and the determination of the amount of oil observed in the dredge, barge, dredging area, and/or disposal area (collectively referred to as the project area). The Project Inspectors will be expected to provide an estimated surface area when reporting this information to the Dredging Operation POC, and to document characteristics of oil observed in the project area.

   To order an "Open Water Oil Identification Job Aid" laminated flip booklet designed to help oil spill responders complete spill response tasks, go to the following website:

   http://response.restoration.noaa.gov/topic_subtopic_entry.php?RECORD_KEY%28entry_subtopic_topic%29=entry_id,subtopic_id,topic_id&entry_id(entry_subtopic_topic)=265&subtopic_id(entry_subtopic_topic)=8&topic_id(entry_subtopic_topic)=1

2. Once the oil is characterized (sweet crude, bunker fuel, diesel, etc.) the Dredging Operations POC may request a "Field Screening Test Kit," which will provide a semi-quantitative determination of oil concentration (Appendices C and D).

   To request a Field Screening Test Kit through a Dredging Operations Technical Support (DOTS) request, contact the DOTS program manager either directly, or through the ERDC Environmental Laboratory (EL) executive office. The DOTS program is currently managed by:

   Douglas G. Clarke
   US Army Corps of Engineers
   Engineer Research and Development Center
   Dredging Operations Technical Support (DOTS) Program
   3909 Halls Ferry Road
   Vicksburg, MS 39180
   Phone: 601-643-3770
   Email: *Douglas.G.Clarke@usace.army.mil*

1 Reprinted with permission from NOAA.

The EL executive office can be contacted at:

US Army Corps of Engineers
Engineer Research and Development Center
Environmental Laboratory
Attn: Executive Office
3909 Halls Ferry Road
Vicksburg, MS 39180
Phone: 601-634-3111
Phone: 800-522-6937

3. An additional resource which may be useful to the Dredging Operations POC is the website for the US Army Corps of Engineers Dredging Operations and Technical Support (DOTS) program at: http://el.erdc.usace.army.mil/dots/. A number of informative technical presentations and reports are available on the DOTS website.

Prepare Action Items for the USCG and/or the UC: The Dredging Operations POC will need to prepare a list of action items in preparation for a meeting he/she will request with the USCG and/or the UC. A checklist of recommended documents, questions for the USCG and/or the UC, and action items can be found in Appendix E (example for illustrative purposes) and Appendix F (blank user copy for oil spill incidents).

Request Meeting with the USCG and/or the UC: The Dredging Operations POC will request a meeting with the USCG and/or the UC once the checklist in Appendix F has been completed. The purpose/objectives of the meeting with the USCG and/or the UC is to provide an overview of ongoing and/or planned dredging operations and how the USCG and/or the UC will address dredging operations with their response activities. It is anticipated that engaging the USCG and/or the UC early through effective coordination and communication will minimize dredging downtime.

Decision Structure for Ongoing Dredging Projects: This section addresses projects in which dredging is underway and there is either potential to encounter oil spill-impacted sediments or newly oiled sediment has already been encountered. The overall intent is to use the best available information to make informed decisions about any potential environmental impact associated with continued dredging operations, and to perform more detailed subsequent evaluations or establish routine monitoring activities to improve the body of information used to make District leadership command decisions. This will also allow necessary engagement with the regulatory community.

Background Data: One critical component of the decision structure involves examination of existing background data, and the adequacy of these data for determinations regarding subsequent oil impacts. For all dredging projects, if existing background data are not sufficiently recent or comprehensive to satisfy information needs, additional sediment samples should be taken prior to oil intrusion for baseline chemical and toxicity testing.

Ongoing Monitoring: Visual monitoring for evidence of oil will be conducted continuously while dredging within the sediment transport vessels and at the disposal site for all types of disposal operations (i.e. hopper, hydraulic or mechanical placement). It is recommended that upcoming dredging reaches be screened daily in advance of the dredge using the best available rapid screening methods to identify impacted areas where oil may not be visible. Open water disposal sites should also be screened prior to initiation of dredging if possible, and periodically throughout the active dredging season, to verify that the disposal site has not been impacted by oil. If evidence of new oil is found at the disposal site, a regulatory decision may be made to close the site until further evaluation has been completed. This may include a comparison between the concentration of oil-related compounds in current samples to that in previously characterized samples from the site. Note that it is not necessary to analyze sediment samples for a full suite of analytes where the only objective is to rule out oil impacts through comparison of chemistry to "pre-oil spill" data. A broad analyte list has the potential to unnecessarily complicate the comparison, with the result that a sediment may be determined to be "substantially different" in a regulatory sense due to non-oil-related compounds, and biological testing may then be required to further evaluate the significance of those differences. However, if biological testing is ultimately determined to be necessary for any reason, interpretation of the bioassay results may be considerably facilitated by a more complete analyte list. A stepwise approach may be appropriate, limiting analysis to oil-related compounds for initial data comparisons, and expanding that list to a full suite of analytes if biological testing is determined to be needed.

More definitive characterization of dredging reaches and disposal sites may be required where oil is identified visually (Appendix B), or by one of the following screening methods. The screening methods described here have been fielded at various sites, but use of these methods as evidence for the *absence* of oil may not be acceptable to regulatory agencies until further field validation has been conducted. Visual screening methods for identifying oil on the surface of the water at a site are described in Appendix B, and provide a means for consistent reporting of field observations. In some cases, qualitative estimates of the thickness of oil present can be made based on the appearance of the oil. From a regulatory perspective, even the presence of a sheen on the surface of a hopper bin is significant, and requires ruling out the presence of oil. There are a number of natural phenomena that can be mistaken for oil, however, and a sheen is not in itself definitive evidence of the presence of oil. Moreover, where oil is present, a sheen generally corresponds to minimal oil concentrations.

Weighted polypropylene, oil adsorbent snares or pompoms (available through a number of commercial sources, e.g. SpillTech Absorbent Pompoms[1], Berry Plastics Corporation[2], Spill 911[3] and others) have been used to screen for oil at other oil spill sites (e.g., for the 2004 Delaware River spill and for the 2007 San Francisco Bay spill). Reportedly, a single polypropylene pompom is capable of taking up 10 to 50 times its own weight in oil. The pompoms are dragged along the surface of the sediment to detect the presence of residual oil

1 https://www.spilltech.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10052&productId=11960&catalogId=10151&categoryId=10908&krypto=rHat%2BT0VaY02OE6xR9LU6edA1VJPtJ2o3B8%2BW%2Bb3IaJ6qmGJ4GFVmEUowA6cTCfWdVKQnnau%2Fjg%3D
2 http://www.berryplastics.com/catalog/content/?url=pages/oil-spill-clean-up-products
3 http://www.spill911.com/product/Individual-PomPoms,42678,2048.aspx

deposits. Detailed procedures are provided in Pacific EcoRisk (2008[1]). Pompoms provide a qualitative measure of the presence of oil; it is detected by examination of the surface of the polypropylene strands and by the presence of petroleum odor. However, pompoms may not be a particularly sensitive indicator of oil present at low concentrations. More definitive methods for determining whether the pompoms contain oil are being considered, such as use of the oil screening test kit (discussed below). Small pieces of the pompoms (or sorbents used to wipe down the pompoms) would then be analyzed by fluorescence. Due to the fact that the absence of obvious oil on the pompoms is not a definitive indicator that oil is not present in sediments or water at concentrations of concern, pompom screening should be used solely as a relatively crude, qualitative indicator of oil contamination.

To improve capabilities for rapid oil screening, an oil field screening kit was developed to provide a semi-quantitative evaluation of the amount of oil present, and is more fully described in Appendix D. The oil test kit can provide an indication of the approximate range of the oil concentration in sediment, sediment elutriate or water samples, and is presently the best semi-quantitative method available for oil screening. The principal disadvantage to using the test kit for advanced screening is that sediment samples must be obtained from the bottom of the channel; this is both costly and labor intensive. The kit is more easily used to assess the level of oil present in sediments and water contained in the more accessible dredged material transport vessels. However, it is preferable to identify oil in advance of the dredge and avoid it. When the costs of disposing of oil-contaminated material and decontaminating the dredge and other vessels are considered, the testing of in-channel sediments likely represents the least costly alternative available.

Another limitation of the oil screening test kit is that it has not yet undergone extensive analytical validation. Consequently, resource agencies may not accept a negative result obtained with the test kit as definitive evidence that oil is not present, particularly if oil-like substances are visible in sediments or water[2]. Unless it can be demonstrated that the dredged material intended for ocean disposal is not substantially different from materials previously characterized from the site and approved for ocean disposal, the presence of as little oil intrusion as a sheen of oil may require biological testing to evaluate toxicity. The timeline to perform a complete biological evaluation may require more than two months. Until more rapid biological assessment methods are available, assessments based on sediment chemistry will be most expedient where this provides sufficient information for a definitive determination. Based on draft guidance developed by EPA and ERDC[3], the comparison between oil-impacted sediments and previously characterized sediments

1 *http://www.spn.usace.army.mil/conops/07_Dec26_ACOE_REPORT.pdf*

2 The use of fluorescence for detection of oil is an established practice. Fluorescence was used to identify oil plumes in deep water following the Deep Water Horizon incident (OSAT 2010). Interferences from natural organic matter are acknowledged to be a limitation of the fluorescence tests (OSAT 2010); as a relatively inexpensive and portable testing method, however, the screening test kit is considered to have utility in a "weight of evidence" approach to site screening and monitoring. In some cases, duplicate analysis (test kit followed by conventional chemical analysis) may be required to obtain a more definitive result. Validation and improvement of the screening test kit will be aided by further refinement of the device, coupled with informed field use, appropriately supported with analytical testing.

3 USEPA and USACE August 2010. Approach for Evaluating Sediment for Proposed Ocean and Near Coastal Placement: Determining Oil Contamination from the Deepwater Horizon Spill, USAC Engineer Research and Development Center, Vicksburg, MS. *http://el.erdc.usace.army.mil/pdfs/10aug18-SedimentProposedOceanNearCoastalPlacement.pdf*

should be made on the basis of the concentration of relevant, oil-related compounds in each sample. If biological testing is determined to be needed, then a full suite of analytes is recommended to facilitate interpretation of the bioassay results, as previously discussed.

Because the Clean Water Act (CWA) provides more flexibility in interpreting the significance of contaminants present, placement of material in open water disposal sites regulated under the CWA may be possible, if it can reasonably be concluded that adverse impacts would not be unacceptable, or if impacts can be acceptably managed through engineering controls. The oil field screening kit may be sufficiently definitive for determining suitability for placement in CWA-regulated waters (if an acceptable threshold concentration has/can be defined); this will be a site-specific determination based on all available information regarding the degree of oil contamination present. Available engineering controls include carbon-containing silt curtains, submerged diffusers to limit water column losses, capping of the disposal site, and placement of the material in geotextile containers. These and other alternative disposal options are further discussed in Appendix H.

If oil impacts are suspected, based on the results of ongoing monitoring, the Dredging Operations POC should be immediately notified and dredging should cease until authorization is obtained to continue. The Dredging Operations POC will make an immediate determination as to whether dredging can resume, and will notify the UC and relevant regulatory agencies. The degree of contamination will be rapidly evaluated, and coordinated administrative and regulatory decisions made regarding an appropriate course of action. Results obtained with the crude oil screening test kit may be utilized initially to determine whether oil is present at concentrations above a pre-defined threshold, if one has been established. If no threshold has been established, or if the results obtained by the screening method employed are not considered sufficiently definitive to support a decision, sediment samples should be taken for customary chemical analysis and toxicity testing. It is also recommended that sediment samples be taken wherever oil is initially encountered in order to provide more definitive information to support decision making, and to develop a database from which such decisions can more rapidly be made in the future. Sediment samples should be taken for fingerprint[1] analysis wherever oil is encountered, in order to establish an administrative record regarding the source of the oil. Fingerprint analysis is a specialized analytical procedure that can be conducted by only a limited number of laboratories. It is recommended that the USCG and UC be contacted to identify approved laboratories and sampling, sampling handling, analytical and quality assurance (QA) requirements to ensure that the data will provide definitive and legally defensible information regarding the source of the oil. It is envisioned that the evaluation and decision-making process will evolve, and perhaps will become more streamlined as a body of evidence is gathered on which to base decisions regarding continued operations or changes to operations.

Procedures for deployment of rapid screening methods, visual identification of oil, and interpretation of sediment data, are described in Appendices B, C, D and G. None of these screening procedures should be considered a recommendation to depart from established guidance for the customary tiered testing and evaluations outlined in the Upland Testing Manual (UTM), Inland Testing Manual (ITM), Ocean Disposal Manual, and Technical Framework (USACE 2003,

1Fingerprinting is an analytical procedure whereby constituents of the oil in the sediment are compared to constituents in the crude oil from an identified source. Fingerprint analysis is crucial to proving responsibility for affected areas after a spill and should be part of the administrative record for the project. Techniques utilized to characterize and identify oil attributable to the Deep Water Horizon incident can be found in OSAT (2010).

USEPA/USACE 1998, USEPA/USACE 1991, USEPA/USACE 2004). However, this guidance is intended to facilitate rapid decision making based on an assessment of the change in conditions at a site, when this can be done definitively and to the satisfaction of the relevant regulatory agencies, and in a manner consistent with technical and regulatory guidance. This process should utilize the most comprehensive body of information that can be assembled through the combined use of semi-quantitative measures, expedited chemical analysis, comparison to historical or background data, and associated effects data where (or when) available.

Evaluating acceptability of existing disposal option: Once oil potentially attributable to the spill is encountered at the dredge or at the disposal site, the existing disposal option should be evaluated in light of the potential for unacceptable adverse environmental impacts associated with continued dredging and disposal. This evaluation should be based on the best available information, supported by multiple lines of evidence if possible, such as comparison of historical sediment data (background oil/polynuclear aromatic hydrocarbon (PAH) concentrations), to concentrations in sediment samples taken after oil is encountered (Appendix G).

Some engineering controls and alternatives to open water disposal are briefly outlined in Appendix H. It is envisioned that some rapid containment options may eventually be developed to address containment and dewatering of contaminated material where this is feasible and environmental impacts would otherwise require cessation of dredging. Use of geotextile structures to create a dewatering staging area or temporary disposal area may be feasible in some locations. Guidance and design parameters for such rapid containment measures will need to be evaluated and possibly developed to be applicable under site-specific conditions.

In the case of emergency dredging, continued dredging and disposal may be authorized by the appropriate authorities, but it is recommended that alternative disposal or management options be considered concurrently, if feasible and if adverse environmental impacts are anticipated with the existing disposal alternative. Characterization of dredged material (i.e., chemical and biological tests) removed during emergency operations should be performed to document contaminant levels present in the dredged material and to support determination of source.

Given that oil impacts can be considered to be an eventuality in at least some project locations, preliminary consideration of alternative disposal and management options should be taking place concurrently with dredging operations, even if oil has not yet been encountered. Available information and information gaps for potential options can be identified in advance of need and assembled to facilitate more rapid decision making and changes to dredging operations as needed.

Decision Structure for Planned Dredging Projects: This section addresses two cases of projects where dredging has not yet begun and oil impacts are reported, suspected, anticipated or possible:

- A time-critical project, for which the contract has been awarded and dredging must proceed within a specified time frame, or an emergency project that must be rapidly completed to address unanticipated shoaling in navigation channels
- A non-time critical project for which a contract has not yet been awarded, and dredging could be deferred and customary environmental evaluations completed if oil is identified in the dredging reach or at the disposal site

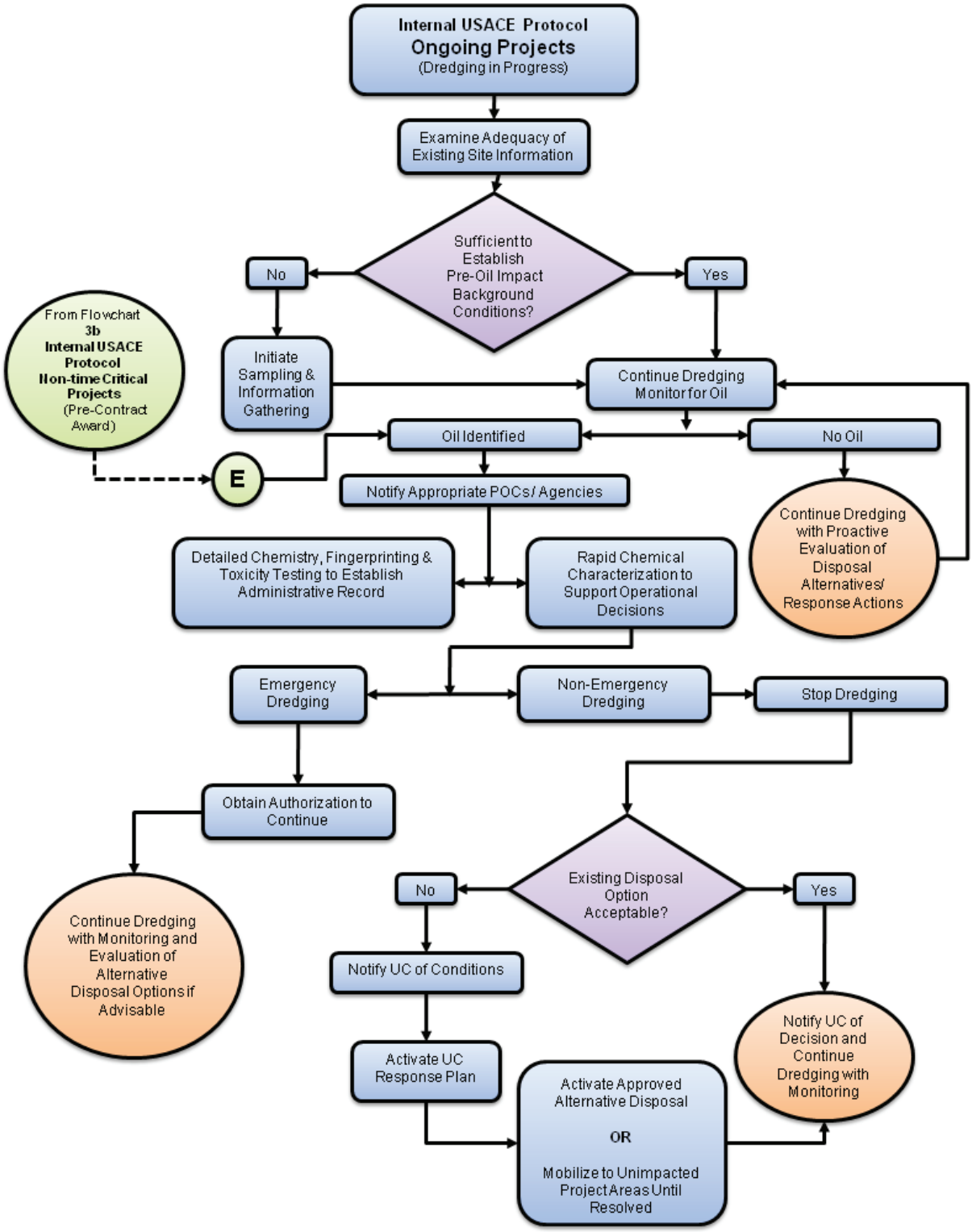

Figure 2. Decision Structure for Ongoing Dredging Projects.

Time-critical projects: This approach outlines rapid-response actions that must take place in the near term (i.e., days) in order to assess whether conditions have changed (i.e., oil has been identified) at the navigation dredging and disposal sites, and to assess whether the presence of oil is of such a magnitude that changes to the dredging or disposal plan need to be made. The rationale behind this approach is that it is crucial to rapidly generate the minimum amount of information needed to make this assessment, assuming deferring dredging is not an option, and alternative disposal options requiring extensive supporting environmental evaluation would not be feasible. This approach also assumes the project sediments were adequately characterized prior to contract award such that contaminants present prior to the oil spill were taken into account in developing the original dredging and disposal plan. Only the effects of the oil impacts on the existing dredging and disposal plan are taken into account, but all contaminants present would need to be taken into consideration when evaluating alternative disposal options.

Post-contract award, pre-dredging screening of sediment at the dredging and disposal sites will be conducted using rapid screening kits (or in the absence of kits, qualitative screening methods indicating presence/absence of oil, as previously described) to monitor for the presence of oil. If there are positive indications that oil may be present, such as a surface sheen on the water or shoreline impacts in proximity, qualitative screening methods may not be acceptable for regulatory determinations; expedited chemical analysis of sediment samples for oil–related compounds may be required to determine the extent and magnitude of contamination. In addition, the adequacy of existing pre-impact sediment data should be evaluated in order to enable comparisons to post-impact data, should that become necessary. This evaluation should also establish an administrative record sufficient to support future regulatory decisions pertaining to the dredging and disposal action, and claims for impact damages. If no oil is identified, monitoring will continue at specified intervals throughout the dredging project; monitoring intervals will be determined on a site-specific basis. In addition, a proactive evaluation of alternative disposal options and response actions will be prepared in the event that oil is encountered during the duration of the project. Periodic sampling for chemical analysis of oil-related compounds is recommended, even if oil is not detected by more qualitative screening methods, in order to support and verify field observations. This is further detailed later in this section.

If newly oiled sediment is identified, sediment chemistry should be obtained and toxicity testing initiated in order to:

- evaluate the magnitude of the contamination and the need for revision of the dredging and disposal plan;
- support future regulatory and environmental evaluations for this or related projects;
- facilitate more rapid future decision making through compilation of a supporting database of concentration and effects; and
- establish the source of the oil through chemical fingerprinting.

The dredging and disposal action may proceed in two cases:

- For emergency dredging, if authorized to continue by appropriate authorities
- The magnitude of oil contamination is limited and no change to the plan is required based on anticipated environmental effects.

The manner in which the magnitude of oil contamination is assessed will depend in part on the designated disposal alternative. Material intended for ocean disposal under Marine Protection, Research and Sanctuaries Act (MPRSA)/Section 103 regulations must be demonstrated not to be substantially different from pre-impact sediments from the site that was previously approved for ocean disposal. Material intended for disposal under the CWA may be evaluated on the basis of comparison to available sediment quality benchmarks, regulatory criteria, or other scientifically defensible evaluation of contaminant pathways and potential impacts. In both cases, coordination/notification of relevant federal agencies and the UC will be required. Note that at the present time the oil test kit may or may not be considered sufficient evidence that oil is not present if there is a visible sheen and the dredged material is intended for ocean disposal under MPRSA/Section 103 regulations; conventional chemical analysis for oil–related compounds may be required, but can be conducted within two or three days if samples are expedited.

For non-emergency projects, if it is determined that the magnitude of the oil contamination is such that changes to the dredging and disposal actions are required, alternative disposal and management options must be rapidly assessed. The UC should be notified that the material in the subject location has been determined to be contaminated, and that action is required by the UC and the Principal Responsible Party (PRP) to address the issue. Where possible, dredging may proceed in unimpacted areas of the project while necessary assessments and contaminated sediment removal is taking place.

Non-time-critical projects: This section addresses actions that must take place prior to contract award and prior to commencement of dredging, to monitor for oil impacts and to direct subsequent actions if oil potentially attributable to the spill is identified at either the dredging or disposal site. This approach outlines actions expected to take place in the mid- to long-term (weeks to years).

Prior to contract award, and similar to the time-critical projects, pre-contract site screening will be conducted using the oil field screening kits (or qualitative methods in the absence of rapid screening kits, as previously described) to rule out the presence of oil. If there are positive indications that oil may be present, such as a surface sheen on the water or shoreline impacts in proximity, and qualitative screening methods are not acceptable for regulatory evaluation, chemical analysis of sediment samples for oil-related compounds may be required to determine the extent and magnitude of contamination. In addition, the adequacy of pre-impact sediment data should be evaluated in order to enable comparisons to post-impact data should that become necessary; the administrative record should be sufficient to support future regulatory decisions pertaining to the dredging and disposal action, and potential claims for impact damages. If no oil is identified, monitoring will continue at specified intervals prior to and after contract award; monitoring intervals will be determined on a site-specific basis.

If no oil is identified in the initial pre-contract monitoring, contract award may proceed. However, a final pre-contract screening should be done two to three weeks before the contract award if a significant amount of time has passed, to verify that conditions at the dredging and disposal sites have not changed, and that work can proceed.

If oil potentially attributable to the spill is found in the pre-contract monitoring, dredging will be deferred, samples will be taken for analysis of oil-related compounds — if such compounds are

detected in the samples — and fingerprinting will also be done. Due to the change in conditions, the customary environmental analysis conducted for dredging and disposal actions will be reinitiated.

Additionally, if there is a significant time lapse between contract award and commencement of dredging, an additional rapid on-site screening of dredging and disposal sites is recommended to verify that the sites are still unimpacted (using oil field screening kits or oil absorbent pompoms). Again, if there are positive indications that oil may be present, such as a surface sheen on the water or shoreline impacts in proximity, qualitative screening methods may not be acceptable for regulatory determinations and expedited chemical analysis of sediment samples for oil related compounds may be required to determine the extent and magnitude of contamination. If no oil is found, dredging can proceed as planned, with visual monitoring taking place continuously throughout the period of dredging, coupled with rapid screening measures (oil field screening kits) if more definitive measures are needed. If new evidence of oil is found in the final screening before dredging commences, the decision structure for "time-critical projects" will be followed.

CONCLUSIONS AND RECOMMENDATIONS:

The decision framework outlined in this report is intended to provide guidance for dredging operations in areas affected by oil spills, or in areas at risk of being affected by a spill. The framework considers the time horizon and critical nature of the dredging operation impacted or potentially impacted. The overall intent is to:

- anticipate potential impacts to the dredging operations;
- develop an internal USACE pro-active response plan;
- utilize the best available information to make informed decisions about environmental risks associated with continued dredging operations; and
- perform a more detailed evaluation of environmental impact and establish routine monitoring activities to improve the body of information available for USACE leadership command decisions.

Major recommended actions:

- Access ResponseLINK and other available information sources to stay apprised of current incident status, available data, ongoing response actions and relevant resources
- Engage the USCG and the UC early
- Know and utilize the chain of command and points of contact (Appendix A)
- Create a defensible administrative record of all activities and relevant observations
- Conduct rapid assessments consistent with established guidance and environmental regulations, and in coordination with relevant agencies and the UC
- Conduct continuous and pro-active screening for oil at dredging and disposal sites, such that adverse environmental impacts and dredging interruptions can be avoided or minimized
- Request funding for USACE activities and participation in the UC from the USCG (Funding requests are called PRFA - Pollution Removal Funding Authorization)

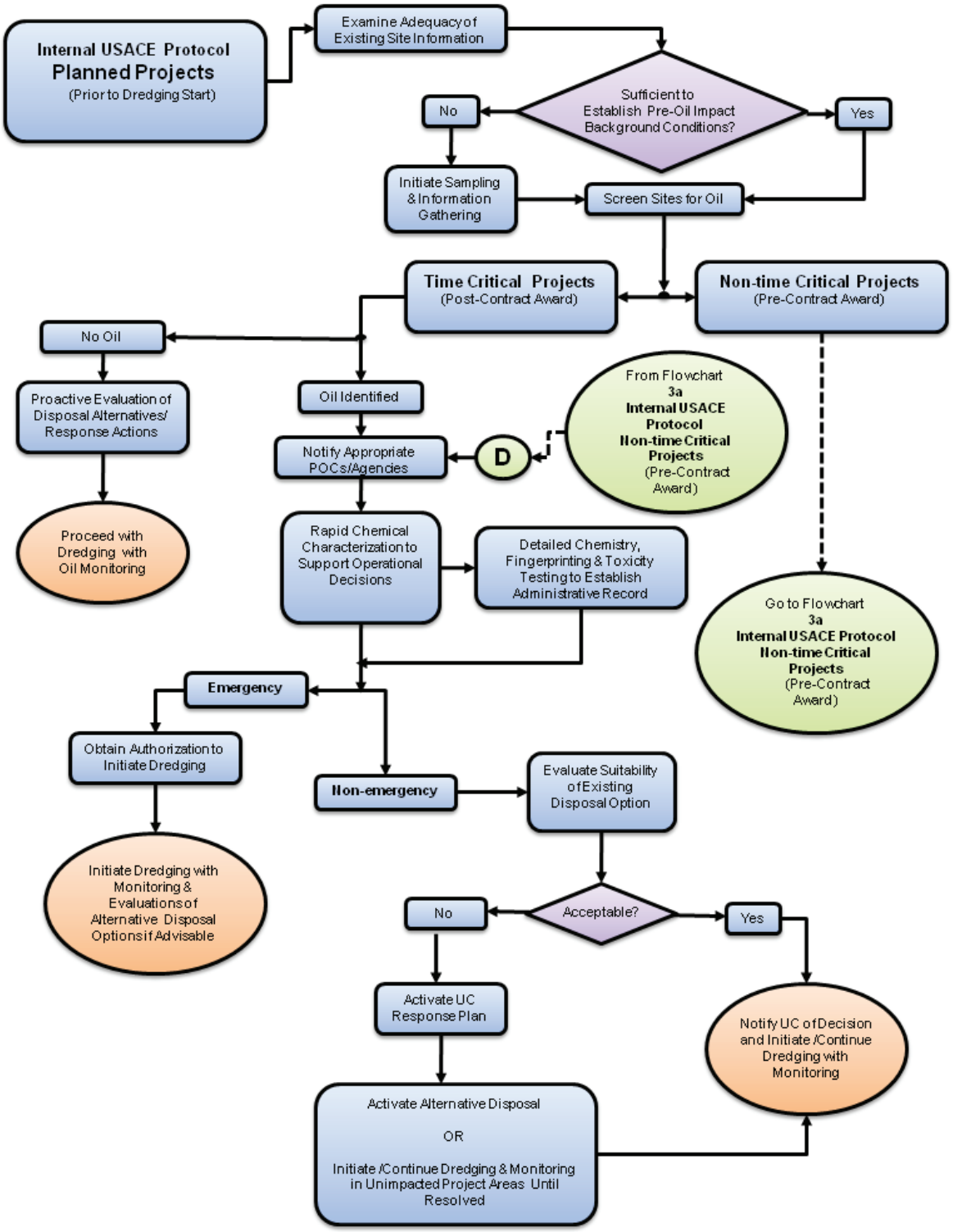

Figure 3a. Decision Structure for Planned Dredging Projects – Time Critical.

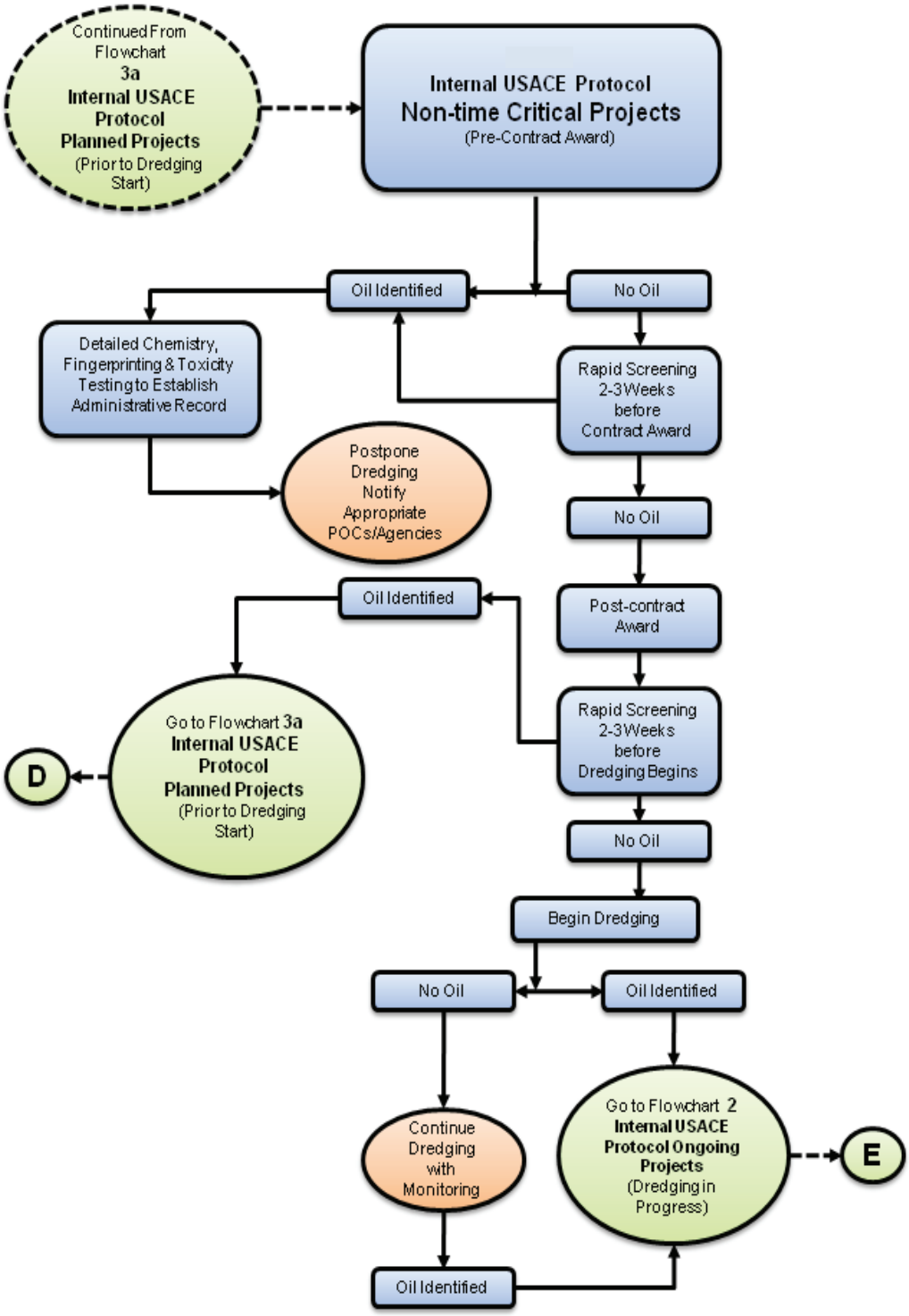

Figure 3b. Decision Structure for Planned Dredging Projects- Non-Time Critical.

Specific recommendations:

1. If non-critical dredging has not commenced, contract award and initiation of work should both be preceded by rapid assessment to verify site conditions; if site conditions have changed and new oil is found, work should be deferred and the customary dredged material evaluations conducted to assess environmental impacts of the dredging and disposal action.
2. Emergency dredging that must be performed may continue, once authorization is obtained, with increased monitoring; alternative disposal and management options may be considered concurrently— if necessary or advisable— to address potential unacceptable environmental impacts.
3. Ongoing dredging operations should employ pro-active measures to screen for oil and to prevent dredging in oil-impacted areas when encountered. Where newly oiled sediment is encountered, the protocol developed for ongoing dredging actions should be followed in order to develop appropriate documentation; assess the magnitude, extent and impact of the contamination; and to determine the need for engineering controls and alternative disposal or management options.
4. Increased monitoring for presence of oil, and rapid determinations for alternative disposal options should be developed. Alternative disposal and management options should be developed in advance of need to the extent possible; innovative, rapid-response options may need to be developed to provide alternatives to unconfined open water disposal where other alternatives are not in place.

POINTS OF CONTACT: For additional information, contact the author, Mr. Warren P. Lorentz, Chief, Environmental Engineering Division (601-634-3750, *Warren.P.Lorentz@usace.army.mil*) or the program manager of the Dredging Operations and Environmental Research Program, Dr. Todd S. Bridges (601-634-3626, *Todd.S.Bridges@usace.army.mil*). This technical note should be cited as follows:

> Lorentz, W.P., T.J. Estes, A.J. Bednar, G.R. Lotufo, S.E. Bailey. 2011. *Guidance for USACE dredging projects affected by oil spills.* ERDC/ EL TN-11-?. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

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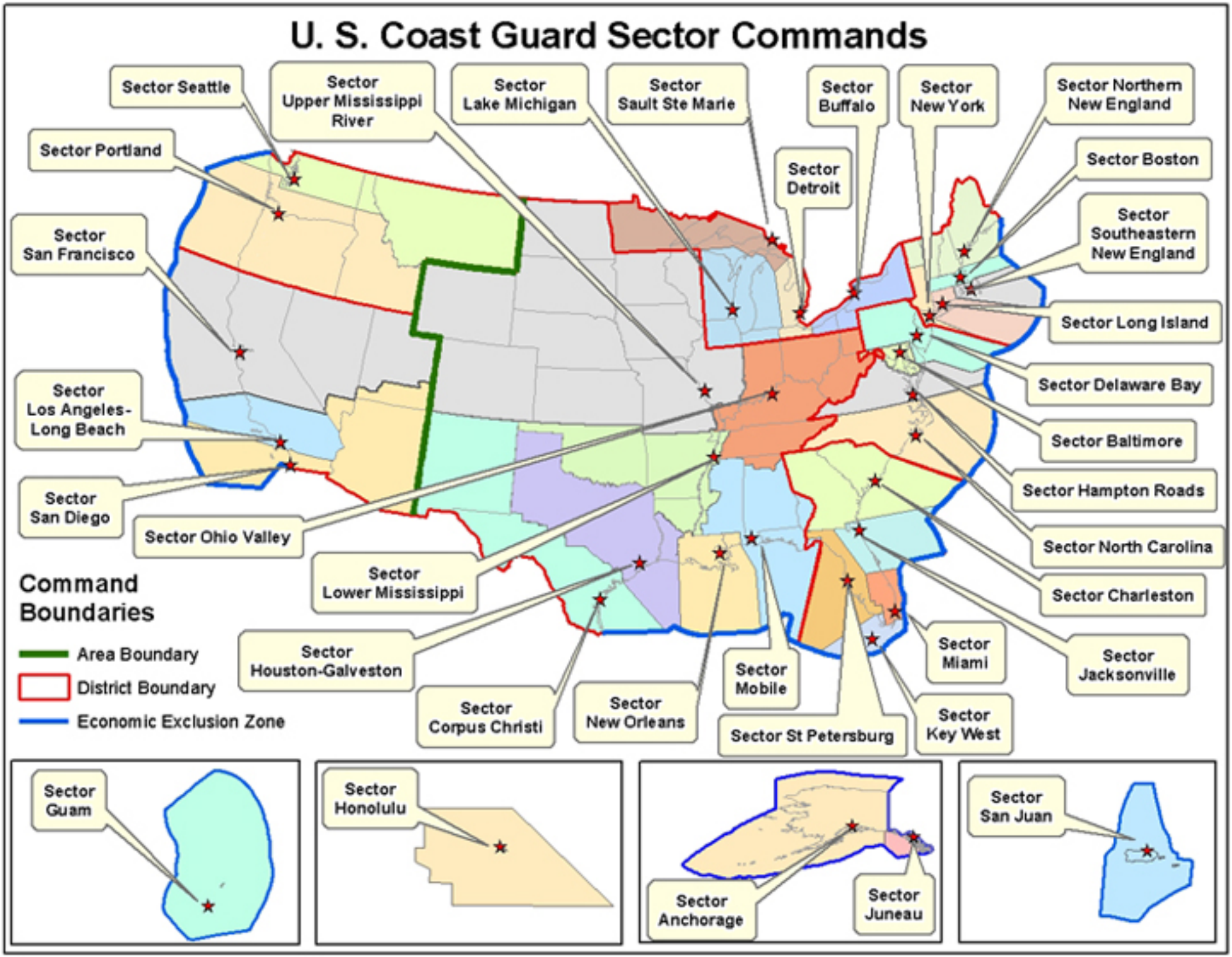
NOTE: *The contents of this technical note are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such products.*

Appendix A

U. S. Coast Guard Sector Commands



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SECTOR DIRECTORY

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers

FIRST DISTRICT

Sector Boston (01-37010)*
427Commercial Street
Boston, MA 02109-1027

Primary:	**617-223-3025/3123/3001**
Response:	**617-223-3318**
Incident Management:	**617-223-5762**
Enforcement:	**617-223-3117**
Prevention:	**617-223-3001**
Inspections:	**617-223-3031**
Waterways:	**317-223-5320**
Preparedness/Planning:	**617-223-3046**

Sector Northern New England (01-37000)*
259 High Street
South Portland, ME 04106-0007

Primary:	**207-767-0320**
Response:	**207-780-3675**
Incident Management:	**207-767-0333**
Enforcement:	**207-767-0342**
Prevention:	**207-767-0333**
Inspections:	**207-741-5431**
Investigations:	**207-741-5424**
Waterways:	**207-741-5421**
Preparedness/Planning:	**207-767-0328**

Marine Safety Detachment Belfast — Primary: 207-338-9865

Sector Southeastern New England (01-37020)*
Little Harbor Road
Woods Hole, MA 02543-1099

Primary:	**866-819-9128**
Response:	**508-457-3224**
Incident Management:	**508-457-3227**
Enforcement:	**401-435-2344**
Prevention:	**401-435-2311**
Inspections:	**401-435-2350**
Investigations:	**401-435-2362**
Waterways:	**508-457-2242**
Preparedness/Planning:	**401-435-2380**

Marine Safety Detachment Cape Cod — Primary: 508-968-6556

Marine Safety Detachment New Bedford — Primary: 508-999-0072

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers
	Sector New York (01-37040)* 212 Coast Guard Drive Staten Island, NY 10305		Primary: **718-354-4037** Response: **718-354-4075** Incident Management: **718-354-4353** Enforcement: **718-354-4104** Prevention: **718-354-4207** Inspections **718-354-4353** Investigations: **718-354-4227** Waterways: **718-354-2353** Preparedness/Planning: **718-354-4064**
	Sector Long Island Sound (01-37030)* 120 Woodward Avenue New Haven, CT 06512-3698		Primary: **203-468-4401** Response: **203-468-4414** Incident Management: **203-468-4433** Enforcement: **203-468-4580** Prevention: **203-468-4504** Inspections: **203-468-4547** Investigations: **203-468-4506** Waterways: **203-468-4596** Preparedness/Planning: **203-468-4474**
		Marine Safety Field Office Coram, NY	Primary: 631-732-0190
	Coast Guard Activities Europe PSC 72 Box 189 APO, AE 09709, Netherlands		Primary: 011-31-10-442-4458
FIFTH DISTRICT			
	Sector Delaware Bay (05-37050)* 1 Washington Avenue Philadelphia, PA 19147-4395		Primary: **215-271-4807** Response **215-271-4860** Incident Management: **215-271-4952** Enforcement: **215-271-4989** Prevention: **215-271-4850** Inspections: **215-271-4952** Investigations: **215-271-4923** Waterways: **215-271-4851**

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers
			Preparedness/Planning: **215-271-4802**
		Marine Safety Detachment Lewes, DE 802 Pilottown Road Lewes, DE 19958	Primary: 302-644-1909
	Sector Baltimore (05-37060)* 2401 Hawkins Point Road Baltimore, MD 21226-1797		Primary: **410-576-2561** Response: **410-576-2583** Incident Management: **410-576-2587** Enforcement: **410-576-2664** Prevention: **410-576-2506** Inspections: **410-576-2566** Investigations: **410-576-2558** Waterways: **410-576-2519** Preparedness/Planning: **410-576-2662**
	Sector Hampton Roads (05-37070)* 4000 Coast Guard Boulevard Portsmouth, VA 23703-2199		Primary: **757-668-5555 (opt. 1)** Response: **757-638-2703** Incident Management: **757-668-5535** Enforcement: **757-295-2043** Prevention: **757-668-5535** Inspections: **757-668-5552** Investigations: **757-668-5542** Waterways: **757-668-5581** Preparedness/Planning: **757-483-8443**
	Sector North Carolina (05-37080)* 2301 East Fort Macon Road Atlantic Beach, NC 28512-5633		Primary: **252-247-4570** Response: **252-247-4535** Incident Management: **252-247-4535** Enforcement: **252-247-4540** Prevention: **252-247-4520** Inspections: **252-247-4524** Investigations: **252-247-4520** Waterways: **252-247-4525** Preparedness/Planning: **252-247-4516**
		Marine Safety Unit Wilmington 272 N. Front Street	Primary: 910-772-2211 Response: 910-772-2217

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers
		Wilmington, NC 28401-3907	Incident Management: 910-772-2217 Enforcement: 910-772-2231 Prevention: 910-772-2231 Inspections: 910-772-2231 Investigations: 910-772-2231 Waterways: 910-772-2231 Preparedness/Planning: 910-772-2194
SEVENTH DISTRICT			
	Sector Miami (07-37110)* 100 MacArthur Causeway, RM 201 Miami Beach, FL 33139-5101		Primary: **305-535-8701** Response: **305-535-4302** Incident Management: **305-535-4531** Enforcement: **305-535-4312** Prevention: **305-535-8709** Inspections: **305-535-8732** Investigations: **305-535-8750** Waterways: **305-535-8724** Preparedness/Planning: **305-535-8715**
		Marine Safety Detachment Lake Worth	Primary: 661-848-8868
	Sector Key West (07-37140)* 100 Trumbo Road Key West, FL 33040-0005		Primary: **305-292-8809** Response: **305-292-8730** Incident Management: **305-292-8805** Enforcement: **305-292-7512** Prevention: **305-292-8808** Inspections: **305-295-1417** Investigations: **786-295-9057** Waterways: **786-295-9057** Preparedness/Planning: **305-292-8722**
	Sector Charleston (07-37090)* 196 Tradd Street Charleston, SC 29401-1817		Primary: **843-724-7600** Response: **843-724-7626** Incident Management: **843-720-3272** Enforcement: **843-740-3182 ext. 3909** Prevention: **843-720-3298**

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers
			Inspections: **843-720-3260** Investigation: **843-720-7600** Waterways: **843-720-3273** Preparedness/Planning: **843-724-7600 ext. 7762**
		Marine Safety Unit Savannah* 100 West Oglethorpe Avenue, Suite 1017 Savannah, GA 31401	Primary: 912-652-4353 Response:: 912-652-4353 ext. 205 Incident Management: 912-652-4053 ext. 212 Enforcement: 912-652-4053 ext. 238 Prevention: 912-652-4053 ext. 230 Inspections: 912-652-4053 ext. 205/230 Investigations: 912-652-4053 ext. 248 Waterways: 912-652-4053 ext. 237 Preparedness/Planning: 912-652-4053 ext. 235
	Sector Jacksonville (07-33231)* 4200 Ocean Street Atlantic Beach, FL 32233-2416		Primary: **904-564-7500** Response: **904-564-7537** Incident Management: **904-564-7606** Enforcement: **904-564-7514** Prevention: **904-564-7549** Inspections: **904-564-7653** Investigations: **904-564-7656** Waterways: **904-564-7653** Preparedness/Planning: **904-564-7546**
		Marine Safety Detachment Port Canaveral 9235 Grouper Road Port Canaveral, FL 32920	Primary: 321-784-6781
	Sector San Juan (07-37120)* 5 Calle La Puntilla Final San Juan, PR 00901-1800		Primary: **787-289-2041** Response: **787-289-5384** Incident Management: **787-289-4823** Enforcement: **787-289-2375** Prevention: **787-729-2378** Inspections: **787-729-2374** Investigations: **787-289-2060** Waterways: **787-289-2071**

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers
			Preparedness/Planning: **787-289-2062**
	Sector St. Petersburg (07-37130)* 600 8th Avenue SE St. Petersburg, FL 33701-5099		Primary: **813-228-2192** Response: **727-824-7674** Incident Management: **727-824-7598** Enforcement: **727-824-7672** Prevention: **813-228-2191 ext. 8121** Inspections: **813-228-2191 ext. 8102** Investigations: **813-228-2191 ext. 8111** Waterways: **813-228-2191 ext. 8130** Preparedness/Planning: **727-502-8743**
		Marine Safety Detachment Fort Myers, FL	Primary: 239-985-0560
EIGHTH DISRICT			
	Sector Mobile (08-37160)* South Broad Street Mobile, AL 36615		Primary: **251-441-5720** Response: **251-441-5962** Incident Management: **251-441-5018** Enforcement: **251-441-6005** Prevention: **251-441-5284** Inspections: **251-441-5282** Investigations: **251-441-5207** Waterways: **251-441-5940** Preparedness/Planning: **251-441-5031**
	Sector New Orleans (08-37150)* 201 Old Hammond Highway Metairie, LA 70005		Primary: **504-589-6196** Response: **504-846-6142** Incident Management: **504-846-5914** Enforcement: **504-846-6156** Prevention: **504-565-5046** Inspections: **504-565-5045** Investigations: **504-565-5059** Waterways: **504-565-5109** Preparedness/Planning: **504-846-6142**

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers	
		Marine Safety Field Office Galiano	Primary:	985-632-8676/8079
		Marine Safety Unit Baton Rouge (08-33268) 6041 Crestmount Drive Baton Rouge, LA 70809	Primary:	225-298-5400
			Response:	225-298-5400 ext. 230
			Incident Management:	225-298-5400 ext. 237
			Enforcement:	225-298-5400 ext. 230
			Prevention:	225-298-5400 ext. 292
			Inspections:	225-298-5400 ext. 292
			Investigations:	225-298-5400 ext. 292
			Waterways:	225-298-5400 ext. 230
			Preparedness/Planning:	225-298-5400 ext. 231
		Marine Safety Unit Houma (08-33278) 425 Lafayette Street, Room 205 Houma, LA 70360-4805	Primary:	985-851-1692
			Response:	985-857-1692 ext. 232
			Incident Management:	985-857-8507 ext. 231
			Enforcement:	985-857-1692 ext. 232
			Prevention:	985-581-1692 ext. 222
			Inspections:	985-851-1692 ext. 222
			Investigations:	985-851-1692 ext. 222
			Waterways:	985-857-1692 ext. 232
			Preparedness/Planning:	985-857-1692 ext. 232
		Marine Safety Unit Morgan City (08-33293)* 800 David Drive, Room 232 Morgan City, LA 70380-1304	Primary:	985-380-5320
			Response:	985-380-3254
			Incident Management:	985-380-5318
			Enforcement:	985-380-5378
			Prevention:	985-380-5352
			Inspections:	985-380-5353
			Investigations:	985-380-5308
			Waterways:	985-380-5334
			Preparedness/Planning:	985-380-5346
	Sector Houston-Galveston (08-37170)* 9640 Clinton Drive Houston, TX 77029-4328		Primary:	**713-671-5100**
			Response:	**713-671-5104**
			Incident Management:	**713-671-5111**
			Enforcement:	**713-971-5186**
			Prevention:	**713-671-5186**
			Inspections:	**713-671-5197**
			Investigations:	**713-671-5194**

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers
			Waterways: **713-671-5164** Preparedness/Planning: **713-671-5144**
		Marine Safety Unit Galveston 3101 FM 2004 Texas City, TX 77591	Primary: 409-978-2703 Response: 409-978-2754 Incident Management: 409-978-2719 Enforcement: 409-978-2754 Prevention: 409-978-2755 Inspections: 409-978-2718 Investigations: 409-978-2755 Waterways: 409-978-2707 Preparedness/Planning: 409-978-2749
		Marine Safety Unit Lake Charles (08-33267) 127 West Broad Street Lake Charles, LA 70601-5608	Primary: 337-491-7800 Response: 337-491-7803 Incident Management: 337-491-7803 Enforcement: 337-491-7803 Prevention: 337-491-7804 Inspections: 337-491-7809 Investigations: 337-491-7804 Waterways: 337-491-7819 Preparedness/Planning: 337-491-7813
		Marine Safety Unit Port Arthur (08-33274)* 2901 Turtle Creek Boulevard, Suite 200 Port Arthur, TX 77642-8028	Primary: 409-723-6500 Response: 409-719-5011 Incident Management: 409-719-5034 Enforcement: 409-719-5013 Prevention: 409-723-6564 Inspections: 409-723-6570 Investigations: 409-723-6591 Waterways: 409-719-5080 Preparedness/Planning: 409-723-6525
	Sector Corpus Christi (08-37180)* 8930 Ocean Drive Corpus Christi, TX 78419-5220		Primary: **361-939-6393/6349** Response: **361-939-6366** Incident Management: **361-888-3162 ext. 519** Enforcement: **361-939-6360** Prevention: **361-888-3162 ext. 200** Inspections: **361-888-3162 ext. 307**

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers
			Investigations: **361-888-3162 ext. 264** Waterways: **361-888-3162 ext. 534** Preparedness/Planning: **361-888-3162 ext. 512**
		Marine Safety Detachment Brownsville 1650 Paredes Line Road Brownsville, TX 78521	Primary: 956-592-0544
		Marine Safety Detachment Victoria	Primary: 361-533-0087
	Sector Ohio Valley (08-37200)* Martin Luther King Jr. Mazzoli Federal Building, Room 421 Louisville, KY 40202-2251		Primary: **502-779-5400** Response: **502-779-5413** Incident Management: **502-893-8186** Enforcement: **502-893-8186** Prevention: **502-779-5448** Inspections: **502-779-5323** Investigations: **502-893-8186** Waterways: **502-779-5301** Preparedness/Planning: **502-779-5418**
		Marine Safety Unit Huntington 95 Peyton Street Barbourville, WV 25504	Primary: 304-733-0198 Response: 304-733-0198 ext. 2106 Incident Management: 304-733-0198 ext. 2109 Enforcement: 304-733-0198 ext. 2105 Prevention: 304-733-0198 ext. 2105 Inspections: 304-733-0198 ext. 2128 Investigations: 304-733-0198 ext. 2105 Waterways: 304-733-0198 ext. 2123 Preparedness/Planning: 304-733-0198 ext. 2123
		Marine Safety Unit Paducah (08-33257) 225 Tully Street Paducah, KY 42003-0170	Primary: 270-442-1621 Response: 270-442-1621 ext. 2114 Incident Management: 270-442-1621 ext. 2114 Enforcement: 270-442-1621 ext. 2114 Prevention: 270-442-1621 ext. 2135 Inspections: 270-442-1621 ext. 2107 Investigations: 270-442-1621 ext. 2135 Waterways: 270-442-1621 ext. 2110 Preparedness/Planning: 270-442-1621 ext. 2109
		Marine Safety Detachment Cincinnati	Primary: 513-921-9033

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers
		3653 River Road Cincinnati, OH 45204-1153	
		Marine Safety Detachment Nashville 220 Great Circle Road, Suite 148 Nashville, TN 37228	Primary: 615-736-5421
		Marine Safety Unit Pittsburgh (08-33256)* 100 Forbes Avenue, Suite 1150 Pittsburgh, PA 15222-1371	Primary: 412-644-5808 Response: 412-644-5808 ext. 2116 Incident Management: 412-644-5808 ext. 2116 Enforcement: 412-644-5808 ext. 2116 Prevention: 412-644-5808 ext. 2107 Inspections: 412-644-5808 ext. 2107 Investigations: 412-644-5808 ext. 2107 Waterways: 412-644-5808 ext. 2108 Preparedness/Planning: 412-644-5808 ext. 2112
	Sector Lower Mississippi River (08-37190)* 2 Auction Avenue Memphis, TN 38105-1502		Primary: **901-544-3912** Response: **901-521-4747** Incident Management: **901-521-4753** Enforcement: **901-521-4827** Prevention: **901-521-4807** Inspections: **901-521-4845** Investigations: **901-521-4845** Waterways: **901-521-4825** Preparedness/Planning: **901-521-4742**
		Marine Safety Detachment Greenville 1801 Harbor Front Road Greenville, MS 38701-9586	Primary: 662-332-0964
		Marine Safety Detachment Fort Smith 12512 Forth Smith Boulevard, Suite 4 Fort Smith, AR 72923	Primary: 479-484-7021
	Sector Upper Mississippi River (08-37390)* 1222 Spruce Street, Suite 7.103 St. Louis, MO 63103-2832		Primary: **314-269-2500** Response: **314-269-2540** Incident Management: **314-269-2541** Enforcement: **314-269-2546** Prevention: **314-289-2568**

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers
			Inspections: **314-269-2560** Investigations: **314-269-2570** Waterways: **314-269-2575** Preparedness/Planning: **314-269-2591**
		Marine Safety Detachment Peoria Foot of Washington Street East Peoria, IL 61611	Primary: 309-694-7779
		Marine Safety Detachment Quad Cities Rock Island Arsenal, Building 218 Rock Island, IL 61204	Primary: 309-782-0627
		Marine Safety Detachment St. Paul 1 Federal Drive, Suite G-762 Fort Snelling, MN 55111-1875	Primary: 612-725-1871

NINTH DISTRICT

District Name	Sector Name	Unit Name	Phone Numbers
	Sector Buffalo (09-37210)* 1 Fuhrmann Boulevard Buffalo, NY 14203-3189		Emergency: **716-843-9527** Primary: **716-843-9315** Response: **716-843-9317** Enforcement: **716-843-9340** Prevention: **716-843-9324** Inspections: **716-843-9575** Waterways: **716-843-9573** Preparedness/Planning: **716-843-9579**
		Marine Safety Unit Cleveland (09-33259) 1055 East Ninth Street Cleveland, OH 44114-1003	Primary: 216-937-0111 Response: 216-937-0131 Incident Management: 216-937-0123 Enforcement: 216-937-0128 Prevention: 216-937-0131 Inspections: 216-937-0128 Investigations: 216-937-0128 Waterways: 216-937-0131 Preparedness/Planning: 216-937-0124
		Marine Safety Detachment Massena 180 Andrews Street	Primary: 315-769-5483

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers
		Massena, NY 13662	
	Sector Lake Michigan (09-37240)* 2420 South Lincoln Memorial Drive Milwaukee, WI 53207-1997		Primary: **414-747-7100** Response: **414-747-7145** Incident Management: **414-747-7145** Enforcement: **414-747-7145** Prevention: **414-747-7163** Inspections: **414-747-7159** Investigations: **414-747-7163** Waterways: **414-747-7188** Preparedness/Planning: **414-747-7139**
		Sector Field Office Grand Haven 650 South Harbor Drive Grand Haven, MI 49417	Primary: 616-850-2500
		Marine Safety Unit Chicago (09-33273) 16W215 83rd Street, Suite D Burr Ridge, IL 60527	Primary: 630-986-2155 Response: 630-986-2130 Incident Management: 630-986-2130 Enforcement: 630-986-2137 Prevention: 630-986-2137 Inspections: 630-986-2137 Investigations: 630-986-2137 Waterways: 630-986-2151 Preparedness/Planning: 630-986-2151
		Marine Safety Detachment Sturgeon Bay 57 N 12th Avenue, Suite 108 Sturgeon Bay, WI 54235	Primary: 920-743-9448
	Sector Detroit (09-37220)* 110 Mt. Elliot Avenue Detroit, MI 48207-4380		Primary: **313-568-9600** Response: **313-568-9521** Incident Management: **313-568-9501** Enforcement: **313-568-9615** Prevention: **313-568-9491** Inspections: **313-568-9619** Investigations: **313-568-9619** Waterways: **313-568-9508**

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers
			Preparedness/Planning: **313-568-9615**
		Marine Safety Unit Toledo (09-33263) 420 Madison Avenue, Suite 700 Toledo, OH 43604-1209	Primary: 419-418-6000 Response: 419-418-6023 Incident Management: 419-418-6023 Enforcement: 419-418-6023 Prevention: 419-418-6030 Inspections: 419-418-6030 Investigation: 419-418-6030 Waterways: 419-259-6023 Preparedness/Planning: 419-418-6023
	Sector Sault Ste Marie (09-37230)* 337 Water Street Sault Ste Marie, MI 49783-9501		Primary: **906-635-3340** Response: **906-635-3231** Incident Management: **906-635-3342** Enforcement: **906-635-3267** Prevention: **906-635-3220** Inspections: **906-635-3341** Investigations: **906-635-3341** Waterways: **906-635-3310** Preparedness/Planning: **906-253-2408**
		Marine Safety Unit Duluth (09-33262)* 600 South Lake Avenue, Canal Park Duluth, MN 55802-2352	Primary: 218-720-5286 Response: 218-720-5286 ext. 111 Incident Management: 218-720-5286 ext. 111 Enforcement: 218-720-5286 ext. 111 Prevention: 218-720-5286 Inspections: 218-720-5286 Investigations: 218-720-5286 Waterways: 218-720-5286 ext. 111 Preparedness/Planning: 218-720-5286 ext. 111
ELEVENTH DISTRICT			
	Sector Los Angeles/Long Beach (11-37260)* 1001 S. Seaside Avenue, Building 20 San Pedro, CA 90731-0208		Primary: **310-521-3600** Response: **310-521-3782** Incident Management: **310-521-3790**

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers
			Enforcement: **310-521-3656** Prevention: **310-521-3701** Inspections: **310-521-3702** Investigations: **310-521-3777** Waterways: **310-521-3861** Preparedness/Planning: **310-521-3846**
		Marine Safety Detachment Santa Barbara 111 Harbor Way Santa Barbara, CA 93109-2315	Primary: 805-962-7430 ext. 220
	Sector San Diego (11-37250)* 2710 Harbor Drive North San Diego, CA 92101-1028		Primary: **619-278-7033** Response: **619-278-7650** Incident Management: **619-278-7654** Enforcement: **619-278-7652** Prevention: **619-278-7230** Inspections: **619-278-7240** Investigations: **619-278-7255** Waterways: **619-278-7261** Preparedness/Planning: **619-278-7090**
	Sector San Francisco (11-37270)* 1 Yerba Buena Island San Francisco, CA 94130-9309		Primary: **415-399-3547** Response: **415-399-3474** Incident Management: **415-399-7332** Enforcement: **415-399-7332** Prevention: **415-399-7330** Inspections: **510-437-3133** Investigations: **510-437-3183** Waterways: **415-399-7401** Preparedness/Planning: **415-399-7337**
		Marine Safety Detachment Humboldt Bay	Primary: 707-269-2563

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers
	Sector Seattle (13-30506)* 1519 Alaskan Way South Seattle, WA 98134-1192		Primary: **206-217-6200** Response: **206-217-6126** Incident Management: **206-217-6214** Enforcement: **206-217-6127** Prevention: **206-217-6235** Inspections: **206-217-6075** Investigations: **206-217-6251** Waterways: **206-217-6042** Preparedness/Planning: **206-217-6085**
	Sector Portland (13-37310)* 6767 North Basin Avenue Portland, OR 97217-3992		Primary: **503-240-9310** Response: **503-240-9317** Incident Management: **503-240-2566** Enforcement: **503-240-9327** Prevention: **503-240-9316** Inspections: **503-240-9306** Investigations: **503-240-9339** Waterways: **503-240-2594** Preparedness/Planning: **503-247-4014**
FOURTEENTH DISTRICT			
	Sector Honolulu (14-37340)* 400 Sand Island Parkway Honolulu, HI 96819-4398		Primary: **808-842-2640** Response: **808-842-2661** Incident Management: **808-842-2656** Enforcement: **808-842-2655** Prevention: **808-522-8264 ext. 372** Inspections: **808-522-8260 ext. 261** Investigations: **808-522-8264 ext. 297** Waterways: **808-522-8264 ext. 271** Preparedness/Planning: **808-842-2687**
		Marine Safety Detachment American Samoa P.O. Box 249 Pago Pago, AS 96799-0249	Primary: 684-633-2299

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers
	Sector Guam (14-37350)* PSC 455 Box 176 FPO, AP 96540-1056		Primary: **671-355-4900** Response: **671-355-4837** Incident Management: **671-355-4842** Enforcement: **671-355-4815** Prevention: **671-355-4861** Inspections: **671-355-4862** Investigations: **671-355-4864** Waterways: **671-355-4872** Preparedness/Planning: **671-355-4941**
		Marine Safety Detachment Saipan P.O. Box 5644 Capitol Hill Saipan, MP 96950-5000	Primary: 670-236-2969
	Coast Guard Activities Far East Unit #5073 APO, AP 96328-5073		Primary: 011-81-311-755-8405
		Marine Safety Detachment Singapore PSA Sembawang Terminal Stores Road, Building 7-4 Singapore 759819	Primary: 011-65-6750-2449
SEVENTEENTH DISTRICT			
	Sector Juneau (17-37360)* 2760 Sherwood Lane, Suite 2A Juneau, AK 99801-8545		Primary: **907-463-2450** Response: **907-463-2475** Incident Management: **907-463-2430** Enforcement: **907-463-2449** Prevention: **907-463-2469** Inspections: **907-463-2444** Investigations: **907-463-2465** Waterways: **907-463-2465** Preparedness/Planning: **907-463-2461**

United States Coast Guard
U.S. Department of Homeland Security

District Name	Sector Name	Unit Name	Phone Numbers
		Marine Safety Detachment Ketchikan 1380 Stedman Street Ketchikan, AK 99901	Primary: 907-225-1048
		Marine Safety Detachment Sitka Lloyd Center 329 Harbor Drive, Room 202 Sitka, AK 99835-7554	Primary: 907-966-5480
	Sector Anchorage (17-37830)* 510 L Street, Suite 100 Anchorage, AK 99501-1946		Primary: **907-271-6700** Response: **907-271-6723** Incident Management: **907-271-6720** Enforcement: **907-271-1955** Prevention: **907-271-6726** Inspections: **907-271-6727** Investigations: **907-271-6709** Waterways: **907-271-6953** Preparedness/Planning: **907-271-6720**
		Marine Safety Unit Valdez (17-33283)* 105 Clifton Drive Valdez, AK 99686-0486	Primary: 907-835-7200 Response: 907-835-7261 Incident Management: 907-835-7214 Enforcement: 907-835-7261 Prevention: 907-835-7262 Inspections: 907-835-7223 Investigations: 907-835-7223 Waterways: 907-835-7209 Preparedness/Planning: 907-835-7266
		Marine Safety Detachment Kenai 150 North Willow Street, Suite #41 Kenai, AK 99611	Primary: 907-283-3292
		Marine Safety Detachment Kodiak P.O. Box 190055 Kodiak, AK 99615	Primary: 907-486-5915
		Marine Safety Detachment Unalaska Unalaska, AK 99692	Primary: 907-581-3466

*** Captain of the Port designation (Click on the name to be taken directly to Port Directory page on Homeport)**

Appendix B

OPEN WATER OIL IDENTIFICATION JOB AID

for aerial observation

New Standardized Oil Slick Appearance and Structure Nomenclature and Code

UPDATED November 2007

NOAA • Office of Response and Restoration • Emergency Response Division
Seattle, Washington

NOAA's Emergency Response Division (aka NOAA Hazmat) works to reduce risks to coastal habitats and resources from oil and chemical spills and hazardous waste sites. Hazmat draws on three decades of experience in responding with the U.S. Coast Guard to spill emergencies and resolving the often longer-term problems presented by hazardous waste sites. Hazmat's response to spill emergencies and waste site problems has gained us a reputation for rapid, yet carefully considered and cost-effective, environmental protection decisions.

This aid was originally a joint project of NOAA and the U.S. Coast Guard. This revision was pursued by the NOAA SSC group led primarily by John Whitney, NOAA SSC for Alaska. Photos were contributed by NOAA, U.S. Coast Guard, Washington Department of Ecology, the Alaska Department of Environmental Conservation, the oil industry, and Alan Allen of Spiltec who deserves special acknowledgement for sharing his knowledge and vast experience on how best to observe oil from the air.

This job aid may be ordered at http://www.response.restoration.noaa.gov/jobaid/orderform.

Carlos M. Gutierrez
Secretary, U.S. Department of Commerce

Vice Admiral Conrad C. Lautenbacher, Jr., USN (Ret.)
Under Secretary for Oceans and Atmosphere and NOAA Administrator

John H. Dunnigan
Assistant Administrator,
Ocean Services and Coastal Zone Management
NOAA Ocean Service

OPEN WATER OIL IDENTIFICATION JOB AID

Introduction

An important step in oil spill response is assessing color/appearance and structure/distribution of oil spilled on the water. This information is used by the Incident Command to prioritize response and direct cleanup resources. This aid was created to help you perform efficient assessments and communicate your findings effectively. It is intended that the terminology and codes presented in this Job Aid will promote consistency among observers nationwide.

When oil enters the water from a source (e.g., a vessel, pipeline, or facility), it initially spreads out and forms a continuous or cohesive patch on the water's surface. This layer or patch of oil absorbs energy and dampens out the surface waves making the area appear smoother or "slick" compared to the surrounding water. As the oil layer becomes thinner, it is more susceptible to being broken up by wave, wind, and current movement into smaller patches and narrow bands, or "windrows," oriented in the direction of the wind or current. Light oils, such as diesel and gasoline, may evaporate and disappear completely. Heavy oils, such as bunker fuels and crude oil, eventually spread out to form smaller, discrete patches or streaks, and may ultimately become tarballs.

The color, structure/distribution, and consistency of oil on water gives an indication of the type of oil spilled, how long the oil has been on the water, and our ability to contain and/or recover it. You are being asked to observe these properties and report them to the Incident Command. This Job Aid is designed to help you characterize the oil and describe what you see in standard terms. You should concentrate on observing the on-scene weather, the sea state conditions, the location of the spill, and the color and structure/distribution of the oil. In addition, you might be requested to report on other ancillary on-scene observations that pertain to the response (e.g., location of response equipment, presence of wildlife).

The observation platform — a helicopter (helo), a fixed-wing aircraft, or a vessel — will be determined by a number of different factors. Each platform has advantages and disadvantages. An aircraft (helicopter and fixed-wing) allows a greater overview of the area impacted by an oil spill. Aircraft allow you to reach the scene quicker and investigate the outer edges impacted by a large oil spill. A helo can generally fly slower and at a lower altitude, allowing you a better view of the spill. A vessel, on the other hand, allows a very close look at the oil itself, giving a better feel for its thickness and consistency. A vessel will also allow a closer look to verify whether the spill reported is actually oil or a natural occurrence that resembles an oil spill. Herring spawning, algal blooms, kelp or seagrass beds, and jellyfish are often mistaken for oil. Lastly, a vessel will allow you to sight tarballs formed during a spill, as these are not often visible from an aircraft.

This aid is organized in the following format designed to make it optimally useful to a field observer.

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- Oil structure/distribution terms
- Other oil slick terms

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- Bonn* thickness table and codes
- Photo examples of silver sheen, rainbow, metallic, transitional, and dark oil slicks on water

OIL SLICK STRUCTURE/DISTRIBUTION TYPES 23

- General types and codes
- Photo examples of streamers, convergence, windrows, patches, tarballs, and no structure for oil slicks on water

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- Photo examples of water and biological phenomena that may be observed and may tend to be mistaken for oil

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- Percent coverage charts
- Spill observation checklists

* The Bonn Agreement Oil Appearance Code (BAOAC) – research conducted by Alun Lewis and SINTEF.

OIL COLOR AND APPEARANCE TERMS:

Sheen: Sheen is a very thin layer of oil (less than 0.0002 inches or 0.005 mm) floating on the water surface and is the most common form of oil seen in the later stages of a spill. According to their thickness, sheens vary in color from **rainbows**, for the thicker layers, to **silver/gray** for thinner layers, to almost transparent for the thinnest layers.

Metallic: The next distinct oil color, thicker than **rainbow**, that tends to reflect the color of the sky, but with some element of oil color, often between a light gray and a dull brown. **Metallic** is a "mirror to the sky."

Transitional Dark (or True) color: The next distinct oil on water layer thickness after metallic, that tends to reflect a transitional dark or true oil color. At the "Transitional" stage, most of the oil will be just thick enough to look like its natural color (typically a few thousandths of an inch, or few hundredths of a millimeter), and yet thin enough in places to appear somewhat patchy.

Dark (or True) Color: Represents a continuous true oil color (i.e., its natural color), commonly occurring at thicknesses of at least a hundredth of an inch (or, a little over a tenth of a millimeter). Oil thickness at this "Dark" stage (especially in a calm and/or contained state) could range over several orders of magnitude. At sea, however, after reaching an equilibrium condition, most oils would not achieve an average thickness beyond a few millimeters. Heavy fuel oils and highly weathered or emulsified oils (especially on very cold water) could, of course, reach equilibrium states considerably greater than a few millimeters.

OIL STRUCTURE/DISTRIBUTION TERMS:

Streamers: Narrow bands or lines of oil (sheens, dark or emulsified) with relatively clean water on each side. Streamers may be caused by wind and/or currents, but should not be confused with multiple parallel bands of oil associated with "windrows," or with "convergence zones or lines" commonly associated with temperature and/or salinity discontinuities.

Convergence Zone: A long narrow band of oil (and possibly other materials) often caused by the convergence of two bodies of water with different temperatures and/or salinities. Unlike "windrows" and "streamers," commonly associated with wind, convergence zones are normally associated with the interface between differing water masses, or with the effects of tidal and depth changes that cause currents to converge due to density differences or due to large bathymetric changes. Such zones may be several kilometers in length, and consist of dark or emulsified oil and heavy debris surrounded by sheens.

Windrows: Multiple bands or streaks of oil (sheens, dark, or mousse) that line up nearly parallel with the wind. Such streaks (typically including seaweed, foam, and other organic material) are caused by a series of counter rotating vortices in the surface layers that produce alternating convergent and divergent zones. Sometimes referred to as Langmuir vortices (after a researcher in 1938), the resulting "windrows" begin to form with wind speeds of approximately six knots or more.

Patches: An oil configuration or "structure" that reflects a broad range of shapes and dimensions. Numerous "tarballs" could combine to form a "patch"; oil of various colors and consistency could form a patch or single layer 10s of cm to 10s (or even 100s) of meters in diameter; and a large patch of dark or rainbow oil could have patches of emulsion within it. Patches of oily debris, barely able to float with sediment/plants in them, might be called "tarmats," circular patches at sea might be called "pancakes"; REALLY BIG patches might simply be called "continuous" slicks. But, they are all "patches."

Tarballs: Discrete, and usually pliable, globules of weathered oil, ranging from mostly oil to highly emulsified with varying amount of debris and/or sediment. Tarballs may vary in size from millimeters to 20-30 centimeters across. Depending on exactly how "weathered," or hardened, the outer layer of the tarballs is, sheen may or may not be present.

No Structure: Random eddies or swirls of oil at any one or more thicknesses. This distribution of oil is normally the result of little to no winds and/or currents.

OTHER OIL SLICK TERMS:

Black oil: A black or very dark brown-colored layer of oil. Depending on the quantity spilled, oil tends to spread out quickly over the water surface to a thickness of about one millimeter. However, from the air it is impossible to tell how thick a black oil layer is. The minimum thicknesses for a continuous black oil layer would commonly be around a hundredth of an inch to about two tenth of a millimeter. Dark (or Black) oils just begin to look their natural color at around a thousandth of an inch (or, a few hundredths of a millimeter). See chart on page 10.

Dispersion: The breaking up of an oil slick into small droplets that are mixed into the water column as a result of sea surface turbulence. For response purposes, dispersed oil is defined as oil droplets that are too small to refloat back to the surface. The physical properties of the oil and the sea state are the main factors that determine how much oil is dispersed. Chemical dispersants can be used to change the chemical properties of the oil and enhance oil dispersion.

Emulsification: The formation of a water-in-oil mixture. The tendency for emulsification to occur varies with different oils and is much more likely to occur under high energy conditions (winds and waves). This mixture is frequently referred to as "mousse." Emulsification will impact the cleanup by significantly increasing the volume and viscosity of the oil to be collected.

Entrainment: The loss of oil from containment when it is pulled under a boom by a strong current. Entrainment typically occurs from booms deployed perpendicular to currents greater than 3/4 knot.

Recoverable Oil: Oil that is in a thick enough layer on the water to be recovered by conventional techniques and equipment. Only black or dark brown oil, mousse, and heavy Metallic layers are generally considered thick enough to be effectively recovered by skimmers. Thinner films may be recoverable with sorbents and/or concentrated with booms or chemical herders to enhance their recovery.

Slick: Oil spilled on the water that absorbs energy and dampens out the surface waves making the oil appear smoother or "slicker" than the surrounding water. "Slicks" refer to oil layers that are thicker than Rainbow and Silver "sheens". Natural slicks, from plants or animals, also may occur on the water surface and may be mistaken for oil slicks.

Weathering: A combination of physical and environmental processes such as evaporation, dissolution, dispersion, photo-oxidation, and emulsification that act on oil and change its physical properties and composition.

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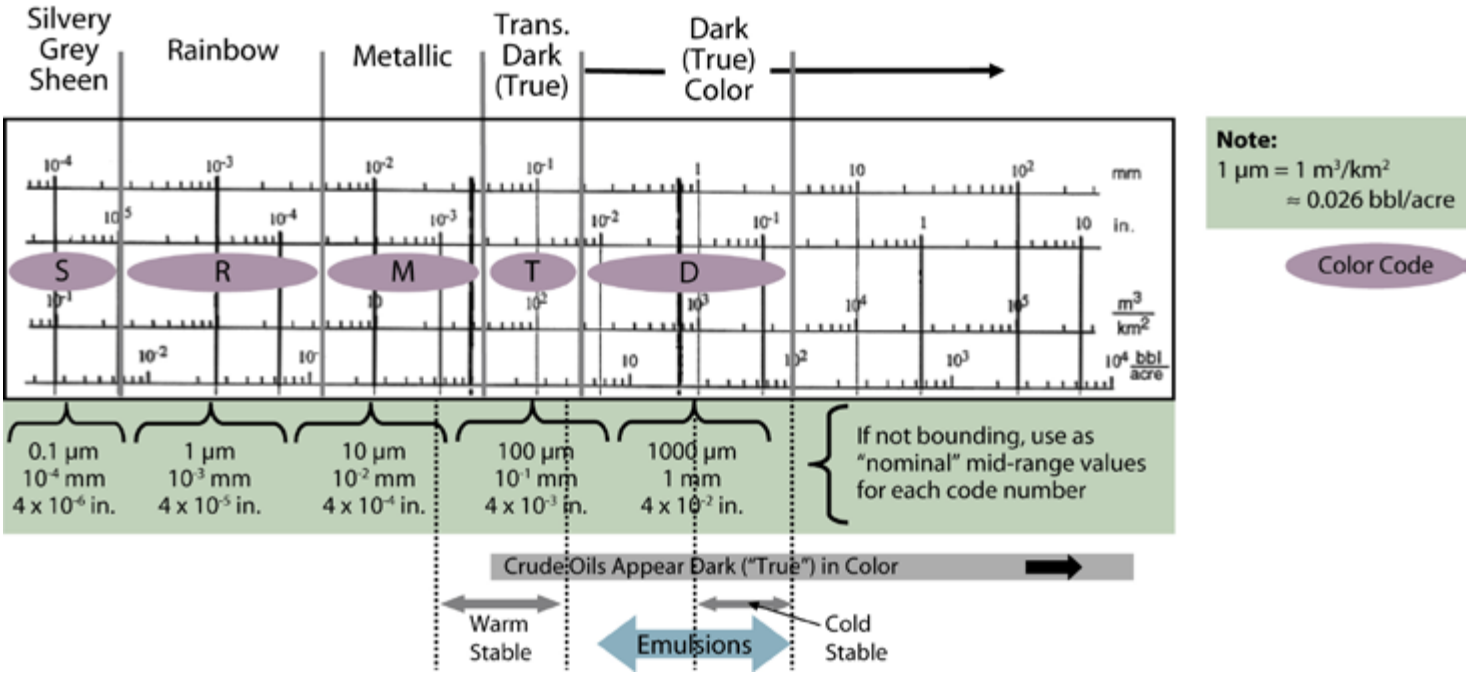
The BONN (BAOAC) Data – Metric & English Units

Code	Description	Layer-Thickness Interval		Concentration	
		microns (µm)	inches (in.)	m^3 per Km^2	bbl/acre
S	Sheen (silver/gray)	0.04 - 0.30	1.6×10^{-6} – 1.2×10^{-5}	0.04 – 0.30	1×10^{-3} – 7.8×10^{-3}
R	Rainbow	0.30 – 5.0	1.2×10^{-5} - 2.0×10^{-4}	0.30 – 5.0	7.8×10^{-3} – 1.28×10^{-1}
M	Metallic	5.0 – 50	2.0×10^{-4} – 2.0×10^{-3}	5.0 – 50	1.28×10^{-1} – 1.28
T	Transitional Dark (or True) Color	50 – 200	2.0×10^{-3} – 8×10^{-3}	50 – 200	1.28 – 5.1
D	Dark (or True) Color	>200	$> 8 \times 10^{-3}$	>200	> 5.1

Chart modified by A. Allen from Bonn Agreement Oil Appearance Code (BAOAC) 02 May, 2006.

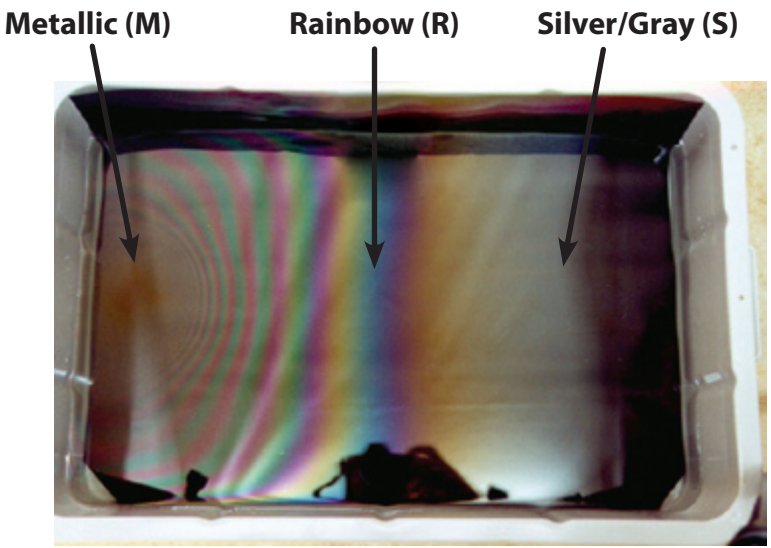
Note the use of Capital letters for thickness codes (S, R, M, T, & D); this will make it easier creating and interpreting sketches by aerial observers.

Oil Code Thickness and Concentration Values



Silver/Gray (S), Rainbow (R) Sheen, and Metallic (M) Oil Colors

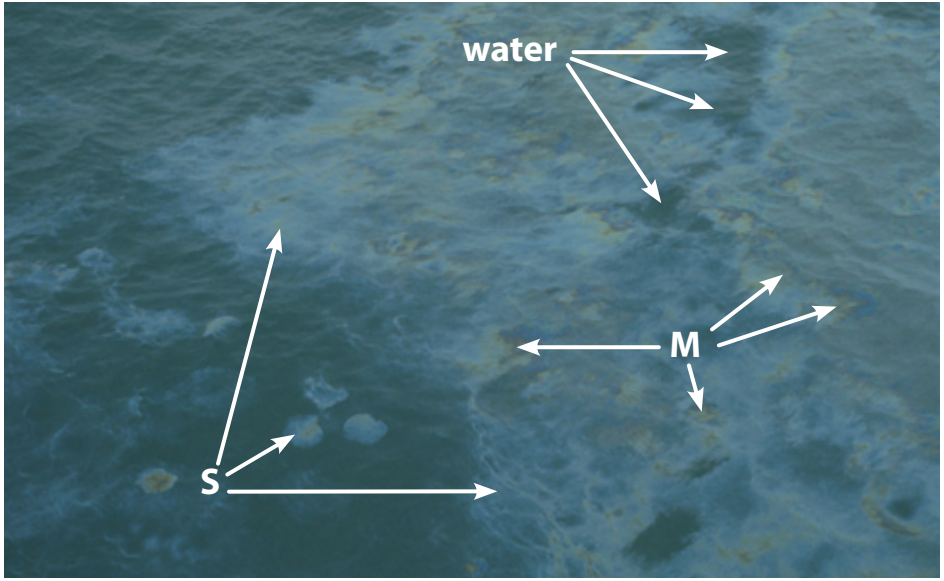
Patches of **silver/gray (S)**, **rainbow (R)**, and **metallic (M)** dull brown sheens.



Source: Alun Lewis & SINTEF (Dec. 2002)

SHEEN SURFACING FROM SUNKEN VESSEL

Patches of **silver/gray (S)** and minimal amounts of **rainbow (R)** and **metallic (M)** dull brown sheens.



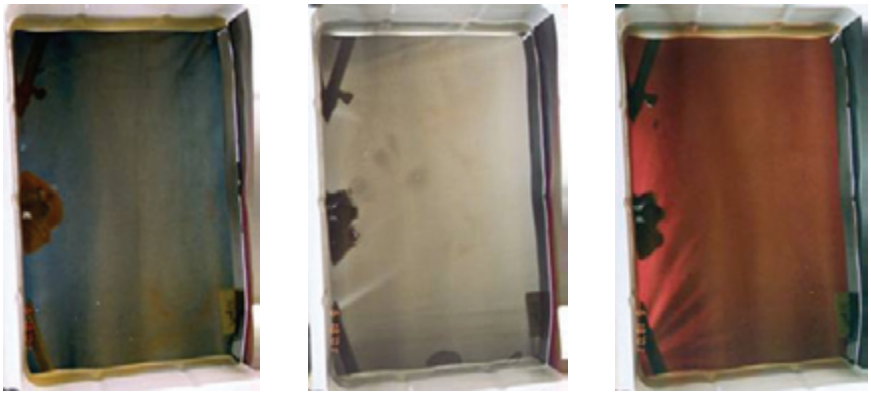
Observation altitude:
50 - 100 ft.

Platform:
Helo

Oil coverage:
60%

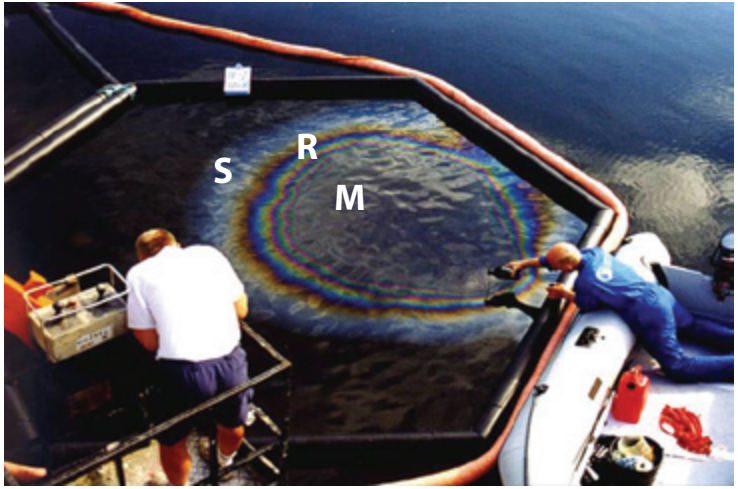
METALLIC (M) OIL SLICK COLOR/APPEARANCE

Oil layers that look metallic reflect the color of the sky, but with some element of oil color.



Source: Alun Lewis & SINTEF (Dec. 2002)

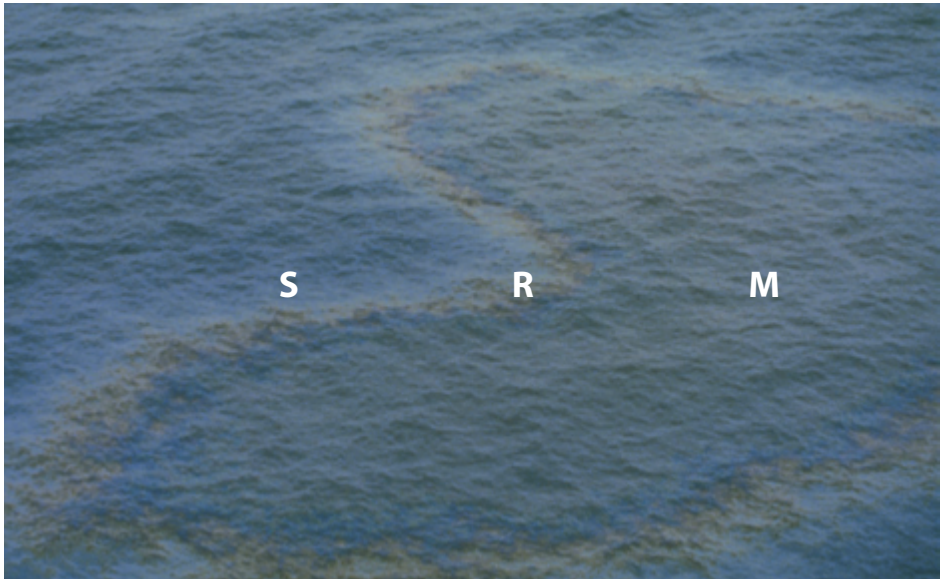
SILVER/GRAY SHEEN (S), RAINBOW (R), AND METALLIC (M) OIL COLORS



Source: Alun Lewis & SINTEF (Dec. 2002)

FRESH DIESEL SLICK

Metallic (M) dull brown slick in center fading to **rainbow (R)** and **silver/gray (S)** along the edges.



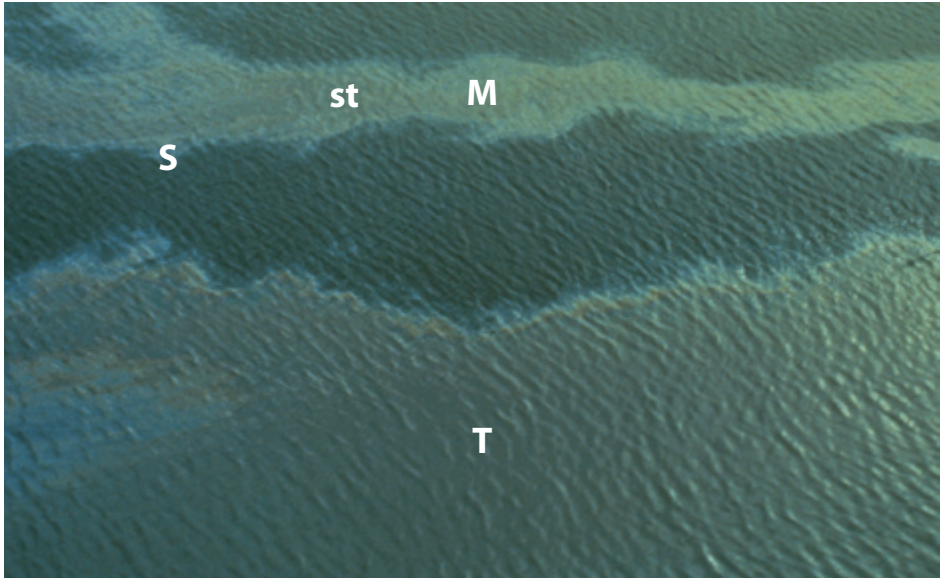
Observation altitude:
300 ft.

Platform:
Helo

Oil coverage:
70%

PATCH OF TRANSITIONAL (T) OIL

Transitional (T) oil color patch in bottom half of photo separated from **streamer (st)** of **metallic (M)** oil (top of photo) by clean water. Note light **silver/gray (S)** sheen along edges.



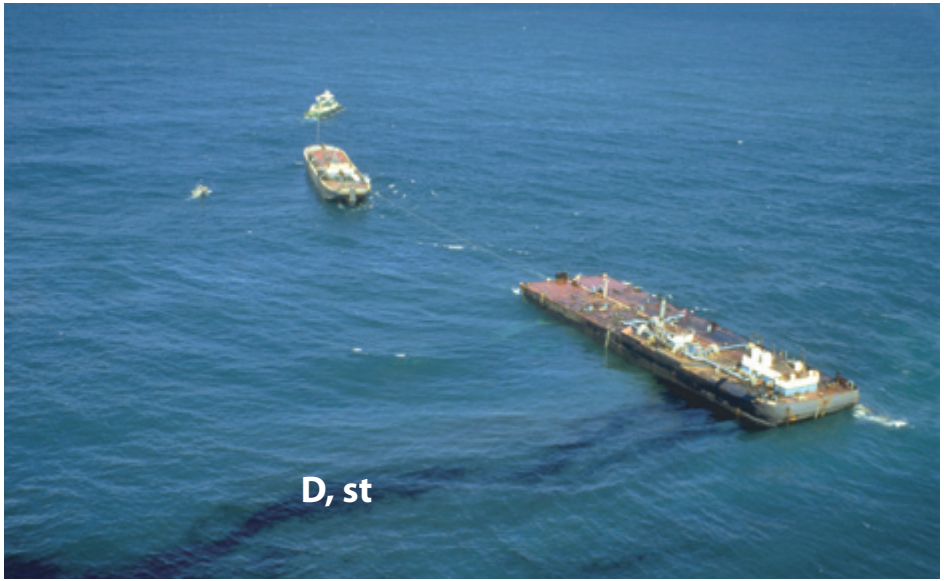
Observation altitude:
300 ft.

Platform:
Helo

Oil coverage:
60 - 70%

BLACK DARK (D) OIL LEAKING FROM BARGE

Black oil true color **dark (D)** forming **streamer (st)** from barge.



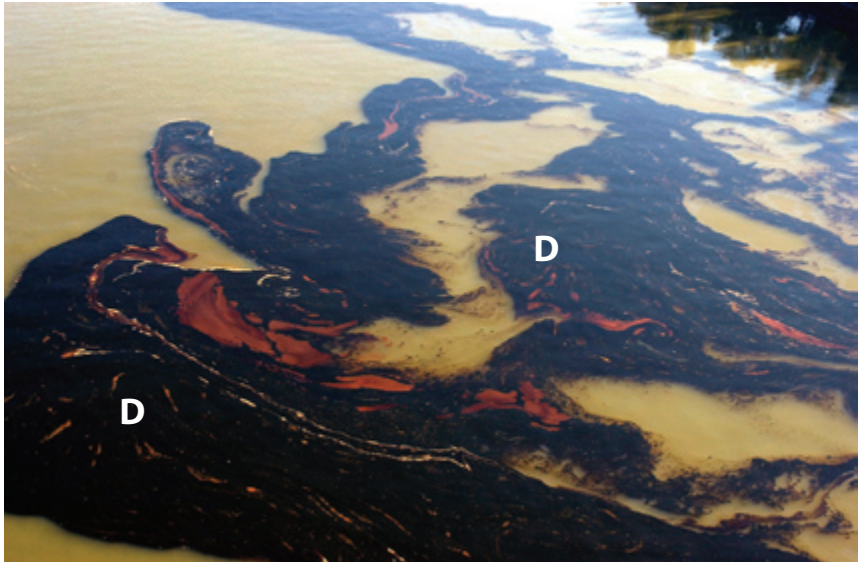
Observation altitude:
400 ft.

Platform:
Helo

Total slick dimension:
15 yds. x 500 yds.

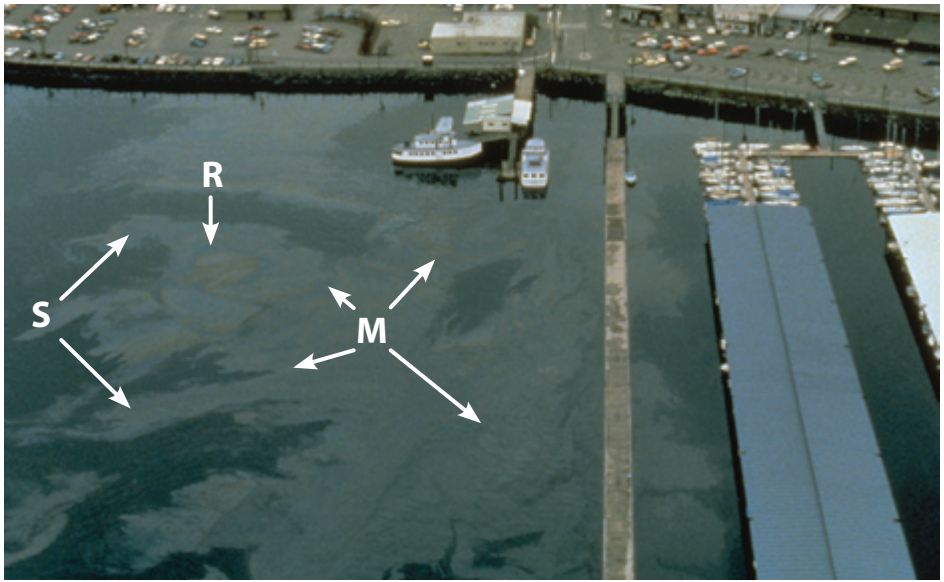
BLACK DARK (D) OIL ON THE MISSISSIPPI RIVER

Note the small orangish streaks and patches of emulsified oil. A true color oil can have a thickness greater than 200 microns, giving volume estimates a very large range. This has a **no structure (ns)** slick configuration.



DIESEL SPILL IN MARINA

Oil spreading out into **metallic (M)** or dull brown layer, **rainbow (R)** and **silver/gray (S)** sheens in and around piers. Very light wind and currents.



Observation altitude:
500 ft.

Platform:
Helo

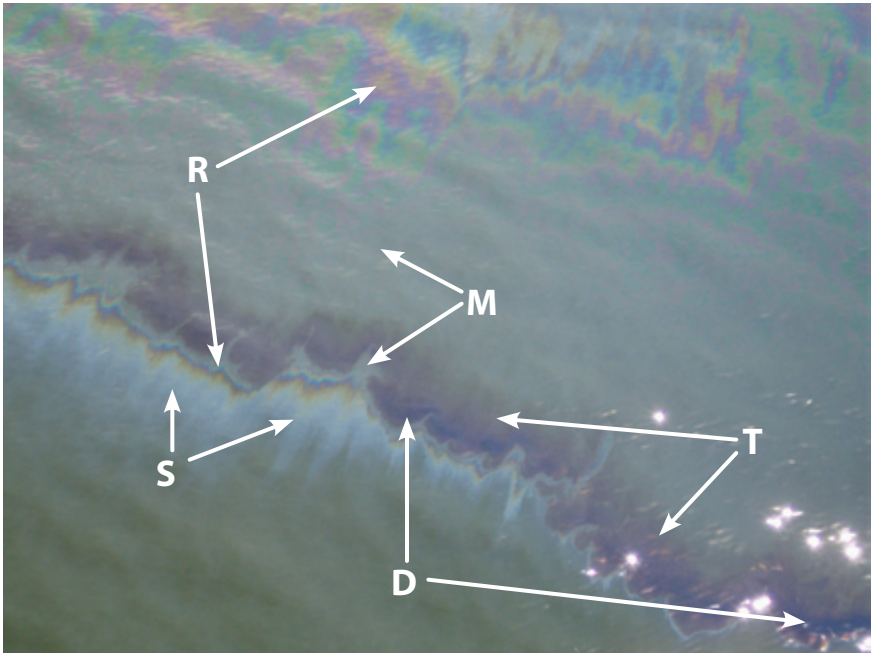
Oil coverage:
50% (with respect to entire water surface in photo)

RED-DYED DIESEL ON WATER

The U.S. has a two-tiered diesel system such that diesel used for highway vehicles has a special tax while diesel used for vessels, farm equipment, etc. is exempt from that tax. Often the latter is dyed red and can appear on water as shown by these two photos.

SUMMARY: FIVE PRIMARY COLOR CODES

Common Descriptors	Code
Silver Sheen	S
Rainbow	R
Metallic	M
Transition	T
Dark	D



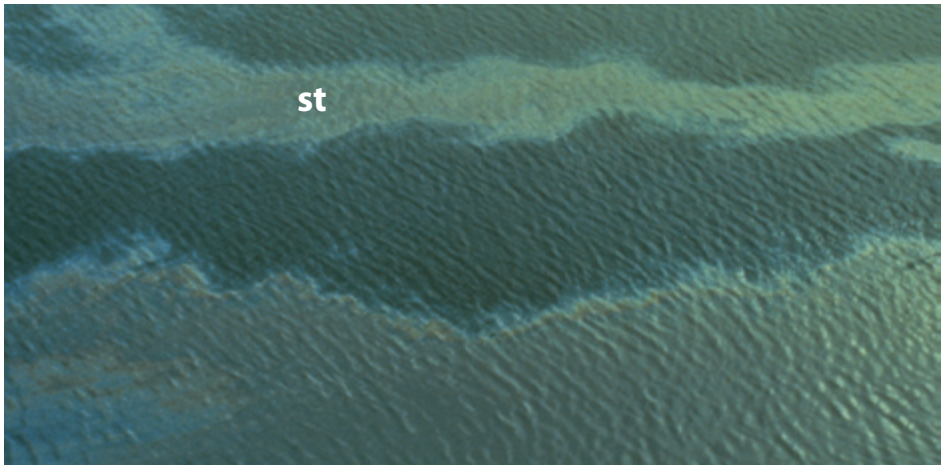
STRUCTURE/DISTRIBUTION TABLE

Common Descriptors	Code
Streamers	st
Convergence Line	co
Windrows	wr
Patches	pa
Tarballs	tb
No Structure (random eddies or swirls)	ns

Note: "Structure" uses two lower-case letters, and "Color Codes" use single-letter capitals (R, S, M, T, D).

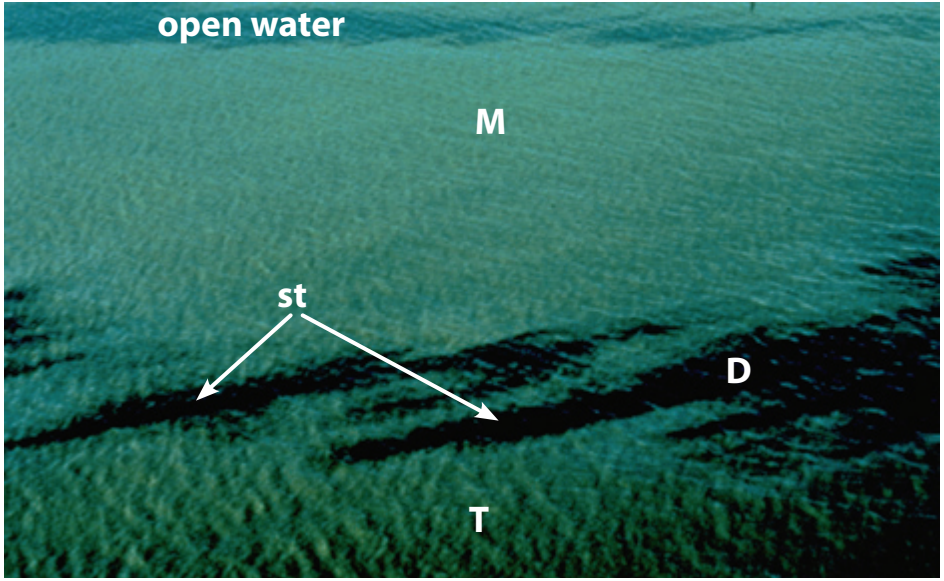
STREAMERS (st)

Narrow bands or lines of oil (sheens, dark or emulsified) with clean water on each side. Sometimes referred to as "fingers" or "ribbons." **Streamers (st)** may be caused by wind and/or currents, but should not be confused with multiple parallel bands of oil associated with "windrows," or with "convergence zones or lines" commonly associated with temperature and/or salinity discontinuities.



STREAMERS (st) OF BLACK OIL

Streamers (st) of **black oil (D)** are breaking up into **windrows (wr)**. Note transitional (T) and metallic (M) oil layers.



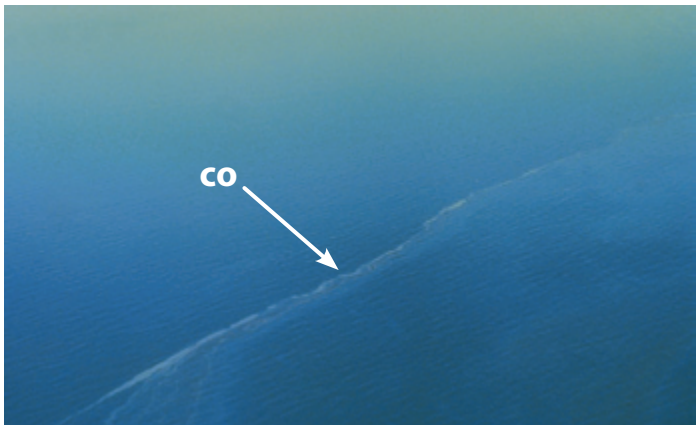
Observation altitude:
300 ft.

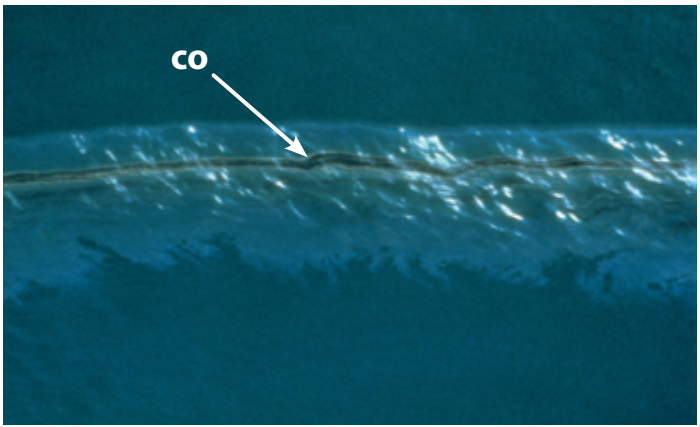
Platform:
Helo

Oil coverage:
15 - 20%

CONVERGENCE ZONE (co)

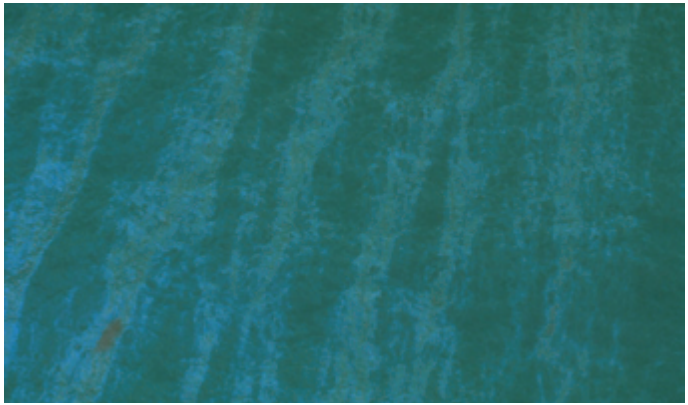
A long narrow band of oil (and possibly other materials) often caused by the convergence of two bodies of water with different temperatures and/or salinities. Unlike "windrows" and "streamers," commonly associated with wind, convergence zones are normally associated with the interface between differing water masses, or with the effects of tidal and depth changes that cause currents to converge due to density differences or due to large bathymetric changes. Such zones may be several kilometers in length, and consist of dark or emulsified oil and heavy debris surrounded by sheens.





WINDROWS (wr)

Multiple bands or streaks of oil (sheens, dark or mousse) that line up nearly parallel with the wind. Such streaks (typically including seaweed, foam, and other organic material) are caused by a series of counterrotating vortices in the surface layers that produce alternating convergent and divergent zones. Sometimes referred to as Langmuir vortices (after a researcher in 1938), the resulting "windrows" begin to form with wind speeds of ~6 knots or more. Bands are usually spaced a few meters to 10s of meters apart; however, windrows have been observed with spacings of 100 meters or more.

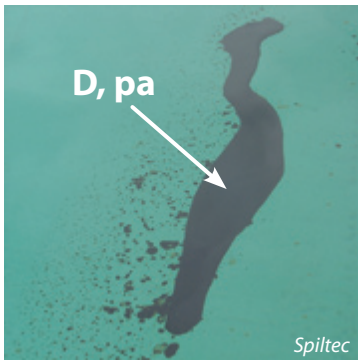


Al Allen, Spiltec

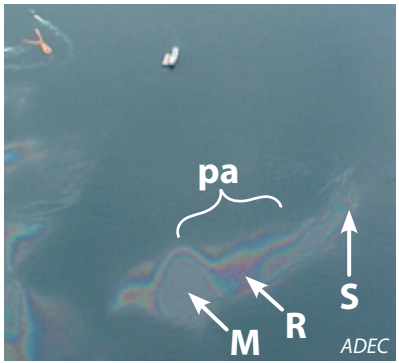
PATCHES (pa)

An oil configuration or "structure" that reflects a broad range of shapes and dimensions. Numerous "tarballs" could combine to form a "patch"; oil of various colors and consistency could form a patch or single layer 10s of cm to 10s (or even 100s) of meters in diameter; and a large patch of dark or rainbow oil could have patches of emulsion within it. Patches of oily debris, barely able to float with sediment/plants in them, might be called "tarmats"; circular patches at sea might be called "pancakes"; REALLY BIG patches might simply be called "continuous" slicks. But, they are all "patches."

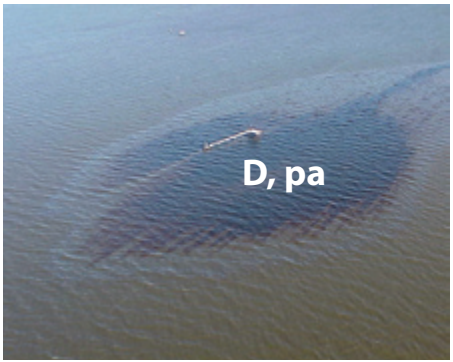
1 meter (crude oil)



50 meters (diesel)



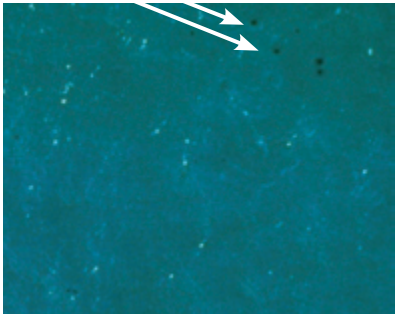
200 meters (crude oil)



TARBALLS (tb)

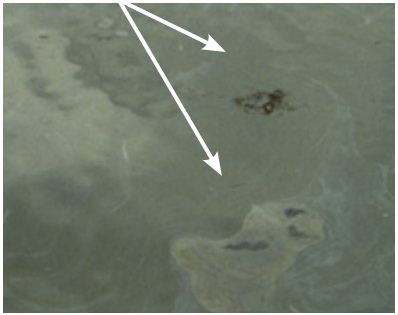
Discrete, and usually pliable, globules of weathered oil, ranging from mostly oil to highly emulsified with varying amount of debris and/or sediment. Tarballs may vary in size from millimeters to 20-30 centimeters across. Depending on exactly how "weathered," or hardened, the outer layer of the tarballs is, sheen may or may not be present.

Fist-sized tarballs



From helicopter (25-50 ft altitude)

Tarballs 1-5 cm



From boat

Tarballs 5 mm – 5 cm

From ground level on beach

NO STRUCTURE (ns)

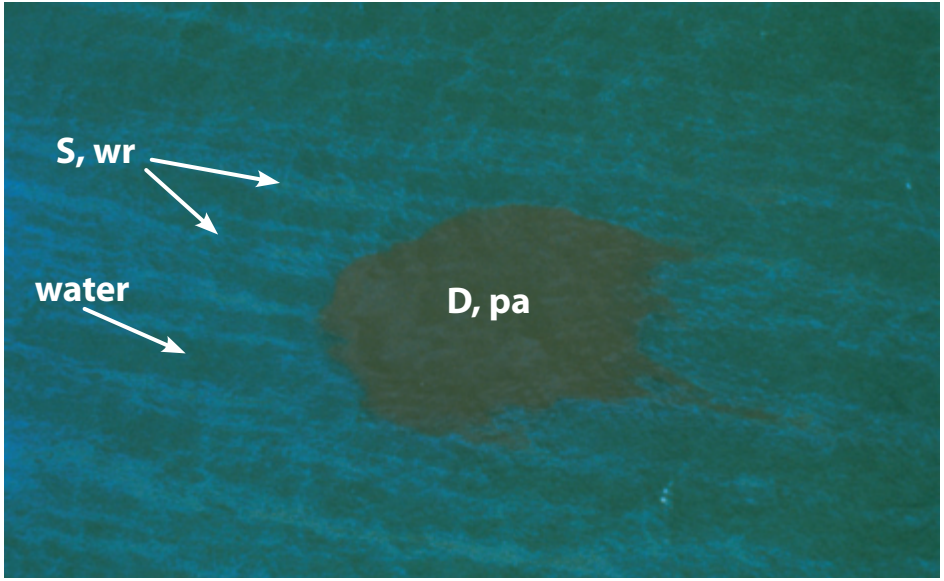
Random eddies or swirls of oil at any one or more thicknesses. This distribution of oil is normally the result of little to no winds and/or currents.

ADEC

ExxonMobil

PATCH (pa) OF EMULSIFIED OIL

Isolated **patch (pa)** or pancake of emulsified oil surrounded by **windrows (wr)** of **silver/gray (S)** sheen.



Observation altitude:
300 ft.

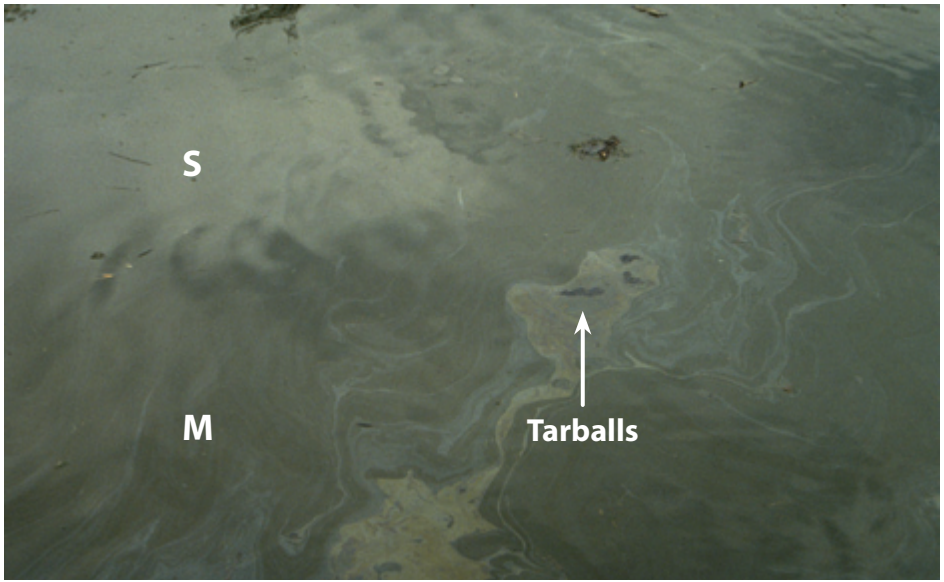
Platform:
Helo

Oil coverage:
40% total (sheen & emulsified oil)

Pancake 65 ft. in diameter

TARBALLS VIEWED FROM BOAT

Dime to silver dollar-sized **tarballs (tb)** surrounded by dull-brown or **metallic (M)** and **silver/gray (S)** sheen.



Observation altitude:
Surface

Platform:
Boat

Photo examples of water and biological phenomena that may be observed and may tend to be mistaken for oil. If in doubt, inspect more closely at a lower altitude. Most oil spills will have a sheen around the edges, as a method for helping sort out the spills from false positives.

KELP BED

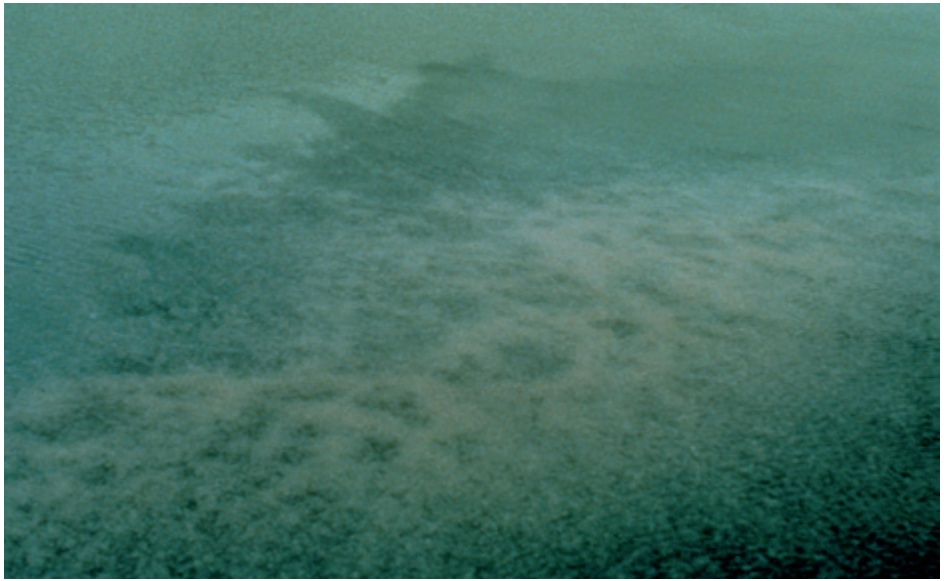
Kelp beds are frequently mistaken for oil. Sometimes kelp bulbs may be misidentified as tarballs.

Observation altitude:
800 ft. at very oblique angle.

Platform:
Helo

JELLYFISH

Large accumulations of jellyfish (spring/summer) are frequently mistaken for oil. If in doubt, take a closer look.



Observation altitude:
50 ft.

Platform:
Helo

RED TIDE

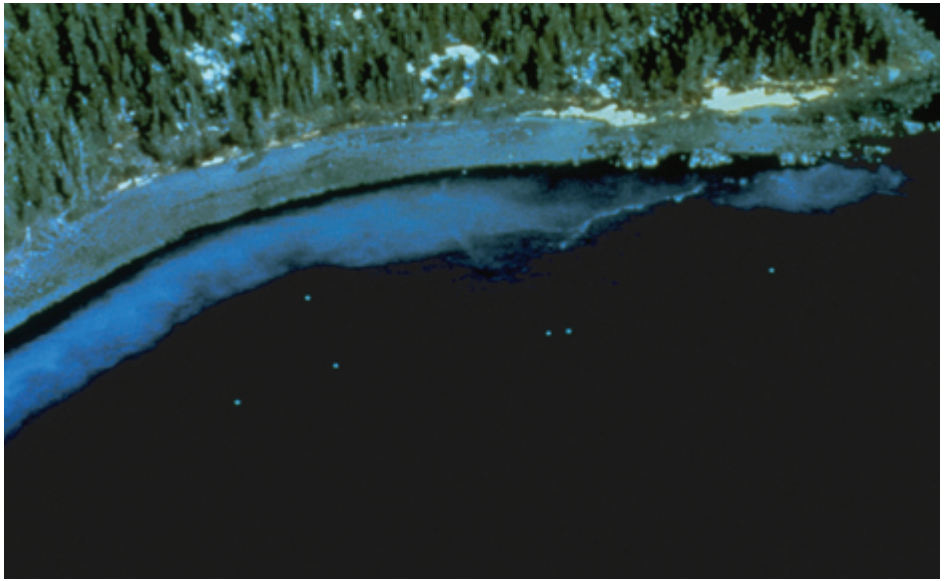
Red tide blooms are sometimes reported as oil.

Observation altitude:
1500 ft.

Platform:
Helo

HERRING SPAWN

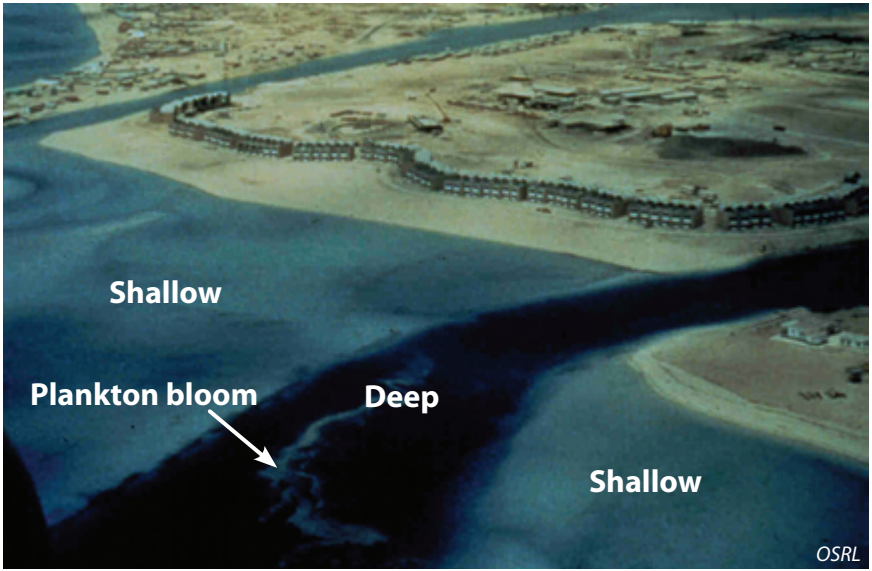
Herring spawn along shoreline can easily be mistaken for silver sheen.



Observation altitude:
1200 ft.

Platform:
Helo

WATER DEPTH CHANGE



CLOUD SHADOWS

At times cloud shadows on water may have the appearance of oil. Inspect more closely and check for sheens.

EFFECTIVE BOOMING AROUND DRY DOCK

Oil being contained within boom (without entrainment). This is possible with low currents until boom reaches holding capacity.

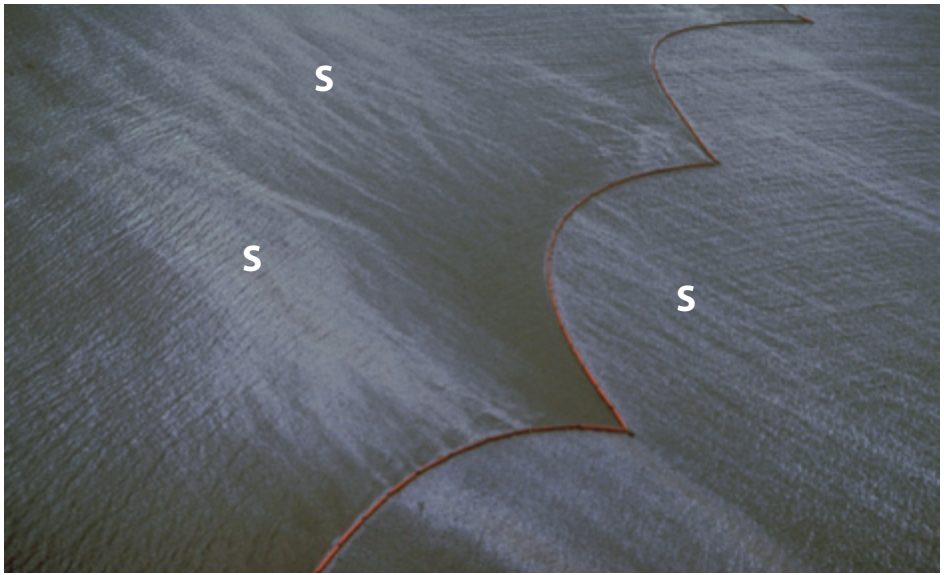
Observation altitude:
500 ft.

Platform:
Helo

Oil coverage:
n/a

ENTRAINMENT OF SILVER/GRAY (S) AND METALLIC (M)/DULL BROWN SHEEN

Entrainment of oil under boom deployed in high current.

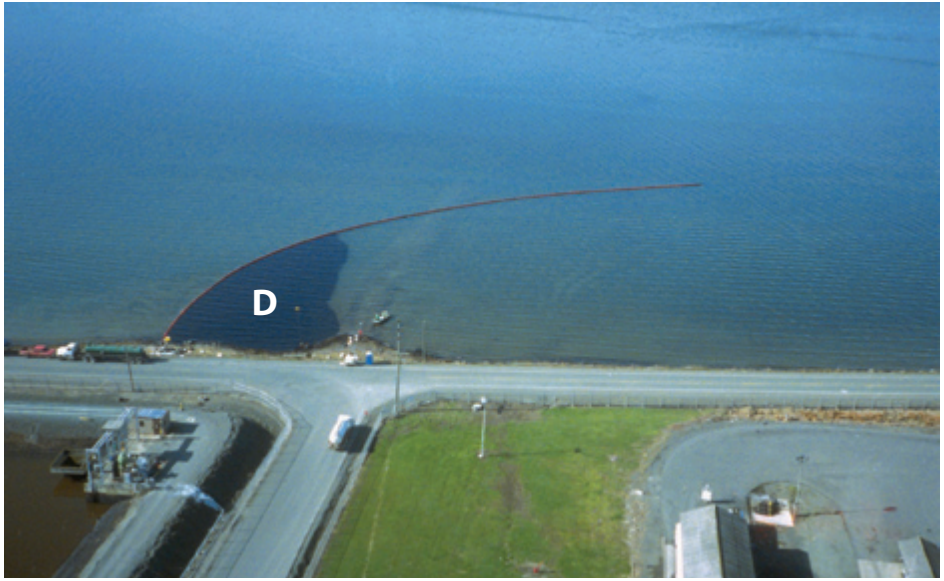


Observation altitude:
500 ft.

Platform:
Helo

EFFECTIVE CONTAINMENT OF BLACK DARK (D) OIL

Black dark (D) oil contained between boom and shoreline under very calm wind and current conditions.



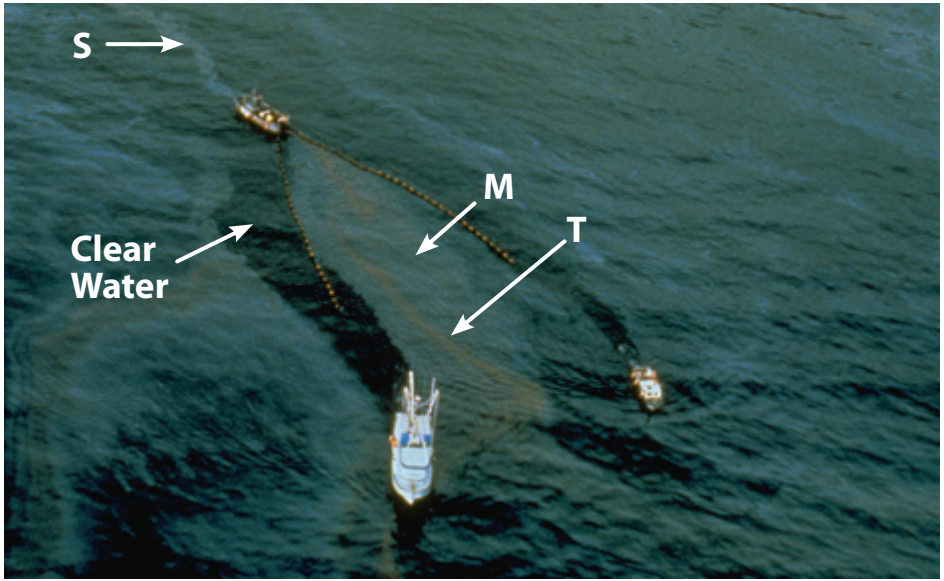
Observation altitude:
300 ft.

Platform:
Helo

Oil coverage:
n/a

ENHANCED SKIMMING

Boom towed in front funneling oil into skimmer. Note **transitional (T)** and **metallic (M)** oil in open boom and how thin **silver/gray (S)** sheen "passes through" skimming vessel.



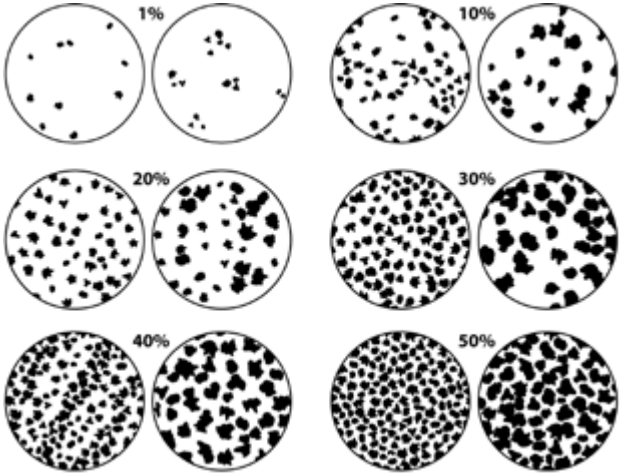
Observation altitude:
500 ft.

Platform:
Helo

Oil coverage:
n/a

PERCENT COVERAGE CHART

This chart is an aid to help you determine the percent of oil coverage in the area you are observing. When determining the coverage of an oil spill on the water, estimate the percentage of clean water and subtract from 100 to calculate the percentage of oil. Try to picture all the oil in one "corner" of the area you are observing and determine the clean water remaining.



OIL SPILL OBSERVATION CHECKLIST

Record information on chartlet of area being observed.

General Information

___ Date
___ Time (start/end)
___ Case Name
___ Information filled out by (name/phone)
___ Observers' names
___ Observers' affiliations
___ Location of source (if known)
___ Percent coverage
___ Stage of tide (flood, ebb, slack)

___ On-scene weather (wind, sea state, visibility)
___ Platform (helo, fixed-wing, boat)
___ Flight path/trackline (from GPS)
___ Altitude observations made from
___ Areas not observed
(fog, restricted air space, shallow water)

In planning flight path/trackline, plan the track so as not to take pictures looking into sun; get the best window seat; avoid midday light to minimize reflection; communicate with the pilot at all times, have access to GPS (lat/long), and go beyond impacted areas to ensure that there is not more oil beyond this area.

OIL SPILL OBSERVATION CHECKLIST

Record information on chartlet of area being observed.

Oil Observations

____ Slick location(s)
____ Slick dimension(s)
____ Orientation of slick(s)
____ Distribution of oil (tarballs (tb), convergence lines (co), no structure (ns), windrows (wr), streamers (st), patches (pa))
____ Color and appearance (silver/gray (S), rainbow (R), metallic (M), transitional (T), dark (D), mousse)
____ Percent coverage (estimate of area with oil. See Percentage Coverage Chart.)
____ Is oil recoverable? (black and transitional oil, mousse, heavy metallic slicks from diesel or oil)

Clearly describe (draw on map or chartlet) where oil is observed, or if the oil slick consists of a number of smaller slicks, consider flying the perimeter of both the entire slick and the smaller slicks with a GPS in Track mode. Also identify where no oil is observed.

OIL SPILL OBSERVATION CHECKLIST

Record information on chartlet of area being observed.

Other Observations

Response Operations...

___ Skimmer deployment (General locations. Are skimmers in highest concentration of oil?)

___ Boom deployment (General locations. Does boom contain oil? Is oil entraining under boom?)

___ Source (Status of source. Is oil still being released?)

Environmental Observations...

___ Location of convergence lines, rip tides, sediment plumes, coastal currents, and river/tidal estuary discharges

___ Location of kelp beds, seagrass (anything which might trap oil or be mistaken for oil)

___ Wildlife present in area (give location and approximate numbers of birds and marine mammals)

DOCUMENTATION GOALS

Simplicity: Use standard terms. Use Data Logs and Field Report Forms. Limit the number of tasks assigned to each observer.

Brevity: Use "codes" and keyed annotations. Avoid "photo-saturation" and lengthy videos.

Neatness: Print neatly. Use a pencil with eraser. Key lengthy annotations/notes on seperate form.

Accuracy: Be mindful of limitations and end-use. Ensure that Date/Time are "on" for cameras and other data logging equipment. Time-link everything!

Scale: Include common objects in images. Maintain and record desired altitude. Shoot close to vertical and note "dip" angles. Sketch to scale.

Redundancy: Periodically photograph notes and GPS with time. Hand-record key digital/electronic data.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NOAA

U.S. DEPARTMENT OF COMMERCE

Appendix C

ERDC TN-DOER-E26
September 2009

Analysis of Organic Contaminants in Dredged Material using a Field-Portable GC-MS

by Anthony J. Bednar, Robert A. Kirgan, Jeffrey M. Corbino, and Amber L. Russell

PURPOSE: This technical note describes the use of a field-portable gas chromatograph mass spectrometer for the in-field determination of organic contaminants in dredged material. During active dredging operations, sediment and water samples are collected as for traditional laboratory analysis of contaminants, however, in this case, field-portable instrumentation is used for quantitative analysis of certain organic contaminants, including Polycyclic Aromatic Hydrocarbons (PAHs).

INTRODUCTION: On July 23, 2008, a barge transporting fuel oil was involved in an incident that resulted in the barge sinking near Mile 96 above Head of Passes on the lower Mississippi River. The contents of the barge were discharged, and created a potential environmental hazard of unknown extent. Maintenance dredging activities being conducted by the U.S. Army Engineer District, New Orleans (MVN) downriver of the fuel oil spill were negatively impacted, necessitating that U.S. Coast Guard inspectors be present on dredges to detect 'sheen' on the water surface as the result of dredging operations.

In order to provide scientific data on which to base decisions about continuing or terminating dredging operations, MVN contacted the U.S. Army Engineer Research and Development Center (ERDC) for technical assistance. ERDC and MVN personnel developed a sampling and analysis plan to obtain definitive chemical concentration data on the extent of sediment contamination and the amount of contamination being disturbed by the dredging operations. The plan included collecting samples of sediment and water from active dredges for traditional laboratory analysis for a list of common, petroleum-related contaminants, including PAHs, diesel range organics (DRO), oil range organics (ORO), vanadium, and lead.

Additionally, the ERDC Environmental Chemistry Branch (ECB) deployed its Griffin 400 field-portable gas chromatography ion trap mass spectrometer (GC-MS). This instrument was developed as part of the Environmental Quality and Installations Long Term Monitoring Program for field analysis of explosives in groundwater (Kirgan et al. 2008). However, PAHs are commonly determined in laboratory methods using GC-MS following U.S. Environmental Protection Agency (USEPA) method SW-846 8270 (USEPA 2007), therefore, only minor modifications to the explosives detection method (temperature program, gas flows, ions monitored, etc.) were required to detect PAH compounds of interest in dredged material as a marker for petroleum contamination.

The investigation team, consisting of ERDC and MVN personnel, deployed to Venice, LA, for 4 days during August 2008 to collect samples and perform in-field analysis. The team collected

sediment and water samples from the dredge B.E. Lindholm during active dredging at various locations above Head of Passes on the lower Mississippi River. Samples were analyzed on the dredge during active operations, and sample splits were stored in coolers at 4°C and transported back to the Environmental Chemistry Laboratory in Vicksburg for further analyses.

MATERIALS AND METHODS:

Dredged Material Collection. Sediment and water samples were collected from the dredge's hopper while dredging was occurring using a 3-gallon galvanized bucket attached to a rope on the hopper catwalk. The bucket was allowed to sink as far as possible beneath the surface of the dredged material slurry while the water/sediment slurry was pumped in by the dredge pumps. The bucket was then retrieved and the slurry poured into precleaned 1-gallon glass jars; each sampling event yielded at least 2 gallons of material. A second bucket of material was then collected and allowed to settle for 10 to 15 minutes before decanting the water to collect the sediment in precleaned 8-ounce glass jars. A minimum of 16 ounces of sediment were collected for each sampling event. All sediment and water samples were then stored on ice in coolers until analyzed, either on the dredge with the field-portable GC-MS, or after transport to the ECB laboratory.

Field Extraction Techniques. Dredged material slurries were allowed to settle for about 15 minutes before the water was decanted for PAH extraction and analysis. The decanted water samples were extracted for PAHs using a modification of EPA method 3510C using Teflon separatory funnels (USEPA 2007). Briefly, 100 mL of dredged water was added to the 125-mL Teflon separatory funnel to which 20 mL of dichloromethane was added. The funnel was then hand shaken for 5 minutes with periodic degassing to prevent overpressurization. The dichloromethane layer separates and sinks to the bottom of the container because it is immiscible with the aqueous phase. The dichloromethane layer, now containing extracted PAHs from the sample, was then drained using the separatory funnel stopcock and collected in a 20-mL borosilicate glass vial containing 10 g of sodium sulfate to remove any residual water from the dichloromethane sample. This solvent sample was then spiked with internal standards and analyzed for PAHs using the field-portable GC-MS following modifications of EPA method 8270 as described below (USEPA 2007).

Sediments were extracted using a modification of EPA method 3550C (USEPA 2007). For this work, 2 g of settled sediment material was mixed with 2 g of sodium sulfate to help dry the sample and minimize formation of an emulsion with the 12 mL of dichloromethane extraction solvent. The sediment/sodium sulfate/solvent mixture was sonicated for 30 minutes using an ultrasonic bath. After sonication, the dichloromethane layer was decanted into a 20-mL borosilicate vial containing an additional 1 g of sodium sulfate to remove any residual water. This solvent sample was then spiked with internal standards and analyzed for PAHs using the field-portable GC-MS following modifications of EPA method 8270 as described below.

Field GC-MS Analysis. The instrument used for all field analyses was an ICx Griffin 400 gas chromatograph with a cylindrical ion-trap Mass Spectrometer (Kirgan et al. 2008). The instrument is shown in Figure 1. The GC column was a 5-m Restek-TNT II column with helium as a carrier gas. One microliter was injected for all calibration and check standards and sediment and water extract samples.

Figure 1. Field-portable Griffin 400 GC-MS instrument as deployed on the dredge B.E. Lindholm.

Briefly, the operation conditions of the GC-MS are as follows. The injection inlet was maintained at 200°C with a constant helium carrier gas flow of 1 mL/min. The column temperature ramp started at 40°C and was 1 min, before ramping at 10°C/min to 100°C, second ramp at 25°C/min to 280°C, with a final 5°C/min ramp to the final temperature of 300°C with a holding time of 3 min. The entire temperature program and sample analysis is approximately 21 min. A standard list of PAH compounds was determined, with the ions used for quantitation and confirmation taken from the published method (USEPA 2007). Mixed analyte calibration standards were purchased from Restek and used to calibrate the instrument from 100 to 50,000 μg/L using a minimum of four analyte concentrations with typical linear response correlation factors greater than 0.98. Figure 2 is an example chromatogram of a 5000-μg/L mixed analyte standard (Supelco, Bellefonte, PA) analyzed in the field by this technique.

The detection limits were determined based on the lowest calibration standard. The low standard was 100 μg/L, therefore concentrations greater than 20 μg/L (in water) are quantifiable, due to the concentration factor of five in the extraction process. The sediment detection limits were calculated based on sample mass (approximately 2 g each) and the solvent extraction volume (12 mL), yielding a detection limit of 600 μg/kg.

Field Analysis Results. Due to the low levels of contaminants present in the samples, no PAHs were detected in any of the sediment or water samples above instrumental detection limits. However, some low level concentrations were determined to be estimated values, either because the concentrations were below the low calibration standard, or the qualifier ion used to confirm the presence of an analyte was not detected. Table 1 lists the concentrations determined for several sediment and water samples determined in the field using the portable GC-MS. At the end of the table the average values for the detection limit divided by the values observed is given. This is a measure of the degree to which these compounds are below the calculated detection limits. All of the values given for the in-field results would be reported as not detected, but are given as estimated values to compare to the laboratory methods, which have somewhat lower detection limits due to the ability in the laboratory to concentrate the solvent extracts prior to analysis.

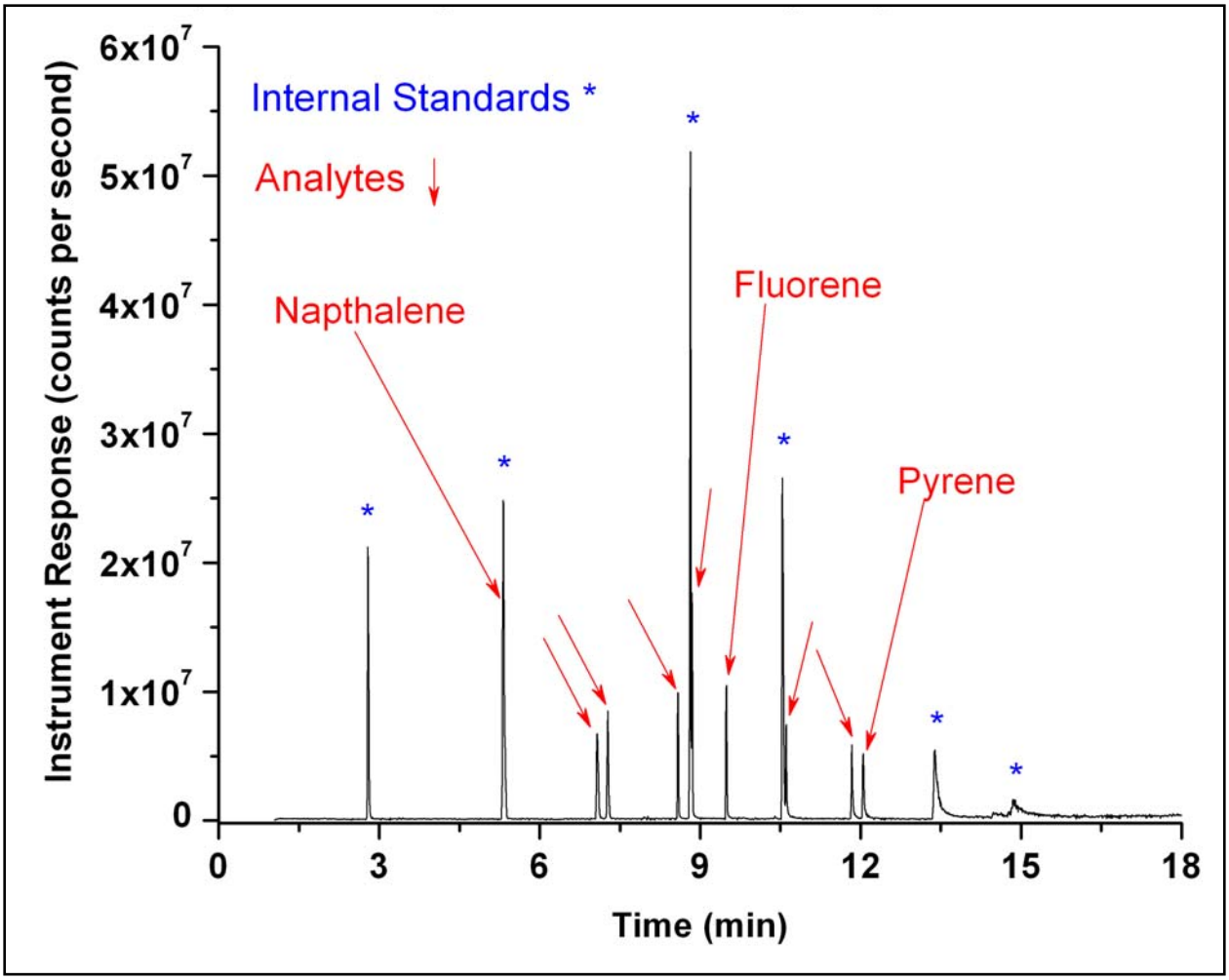


Figure 2. Example chromatogram of a 5000-μg/L PAH standard using the Griffin 400 GC-MS. Internal standard compounds are labeled with an "*", select PAH compounds are also indicated.

Comparison to Laboratory Results. Table 1 also lists concentrations of several PAH analytes in sediment and water samples analyzed by the Environmental Chemistry Branch laboratory in Vicksburg, MS. The analyte extraction efficiency of the fixed laboratory methods and the ability to concentrate the final solvent extracts allows the laboratory method to provide lower detection limits than the field techniques. However, the analyte concentrations measured by the laboratory and field methods do qualitatively agree, with no concentration measured in the laboratory analyses above that of the field method's reporting limit, indicating the field method does not produce false positives or negatives. The laboratory and field results for the water and sediment samples are plotted in Figures 3 and 4, respectively, showing generally consistent results between the two techniques considering the field values being compared are estimated concentrations well below the instrumental reporting limit (Table 1).

Table 1. Concentrations of PAH compounds in water and sediment samples determined by the field-portable and laboratory-based methods.
All concentrations reported are below the field instrument reporting limit.

Water Samples			Sediment Samples		
Compounds	**In-Field Results (µg/L)**	**Laboratory Results (µg/L)**	**Compounds**	**In-Field Results (µg/kg)**	**Laboratory Results (µg/kg)**
Naphthalene	0.548	0.200	2-methylnapthalene	0.181	3.679
Fluoranthene	0.005	0.017	Phenanthrene	11.790	11.958
Pyrene	0.023	0.017	Anthracene	1.040	2.760
2-methylnapthalene	0.001	0.013	Fluoranthene	0.199	19.317
Acenaphthene	0.017	0.013	Pyrene	0.054	16.557
Acenaphthylene	0.036	0.010	Acenaphthylene	0.687	3.766
Acenaphthene	0.013	0.010	Fluorene	4.906	7.517
Fluoranthene	0.134	0.010	Anthracene	0.372	15.092
Pyrene	0.024	0.010	Fluoranthene	0.305	111.566
Acenapthene	0.674	0.100	Pyrene	5.259	104.090
Athracene	0.307	0.130	Acenaphthylene	0.689	4.284
Fluoranthene	0.083	0.040	Acenapthene	3.152	11.402
Pyrene	0.356	0.220	Phenanthrene	4.092	102.687
Acenaphthene	0.107	0.05	Anthracene	1.079	27.015
Phenanthrene	0.131	0.210	Fluoranthene	4.135	167.164
Fluoranthene	0.16	0.010	Pyrene	4.770	142.537
Phenanthrene	0.024	0.012	Acenapthene	4.278	2.963
			2-methylnapthalene	3.272	3.763
Average DL / Concentration Measured					
	1880	4		1440	0.5

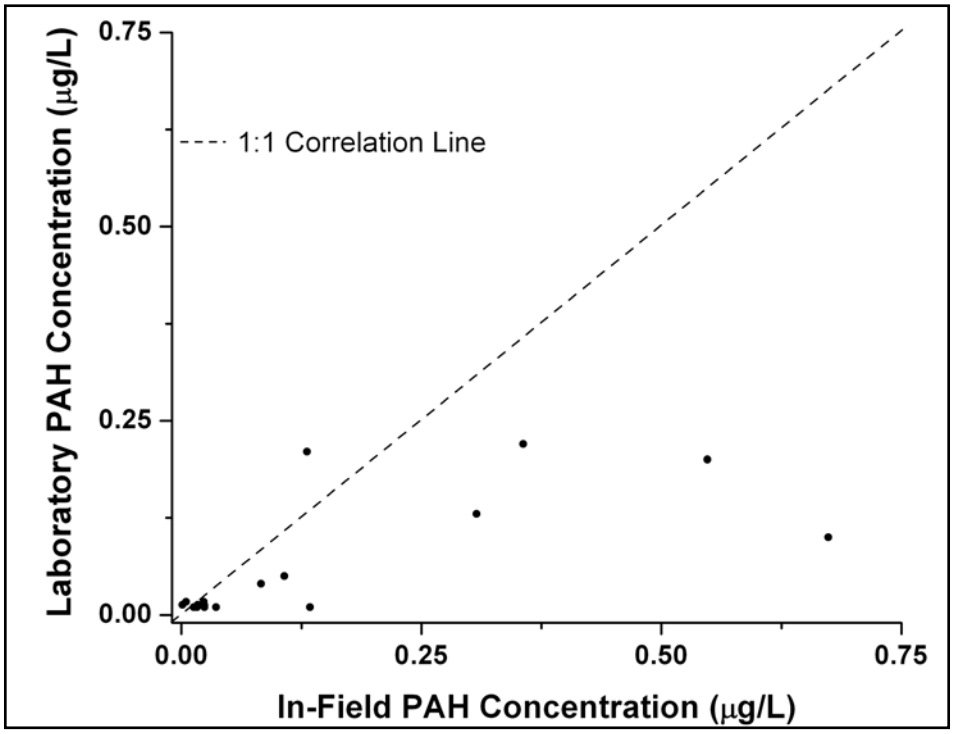


Figure 3. Comparison of field and laboratory PAH concentration data for water samples, all in-field concentration data is below the instrument detection limit, resulting in estimated values.

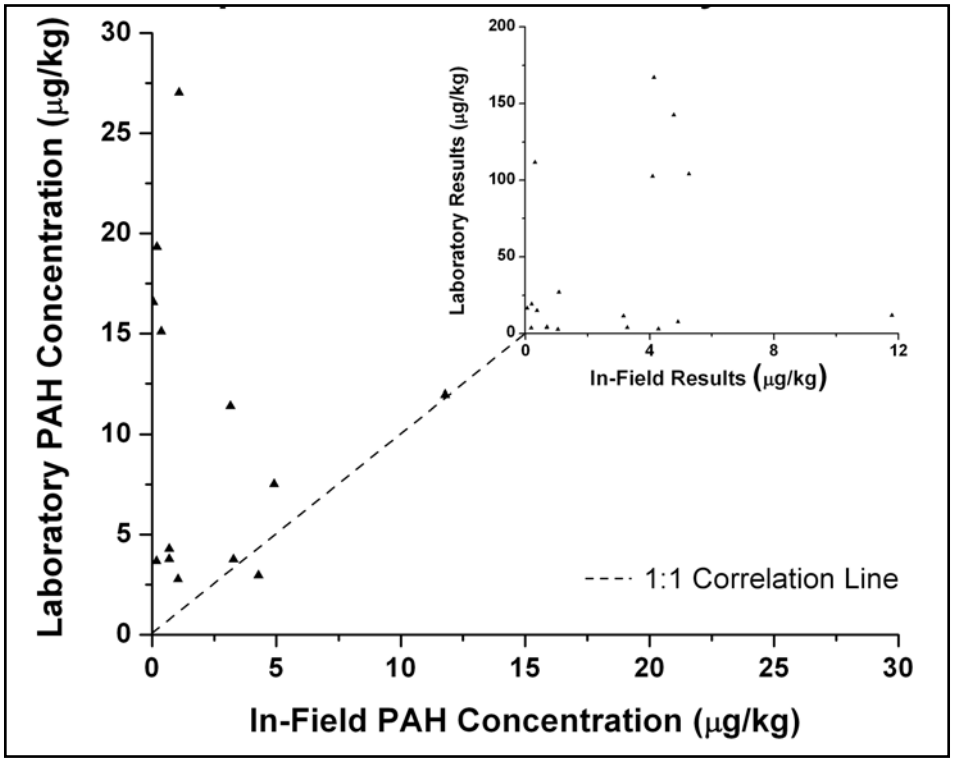


Figure 4. Comparison of field and laboratory PAH concentration data for sediment samples, all in-field concentration data is below the instrument detection limit, resulting in estimated values.

Qualitative Field Screening Kit. Due to the need to detect oil residue as dredging operations continue, a field screening test kit was also developed based on the slight color tint imparted to hexane extraction solvent when No. 6 fuel oil dissolves in it. This color change is proportional to the amount of fuel oil present, and therefore can be used as a qualitative indicator of the presence and relative amount of oil present. Figure 5 shows photographs of the field kit and example standards provided in each kit used to judge the amount of oil present in a sample. This field kit is being used by all active dredges on the lower Mississippi River during FY2009 dredging operations being conducted by MVN.

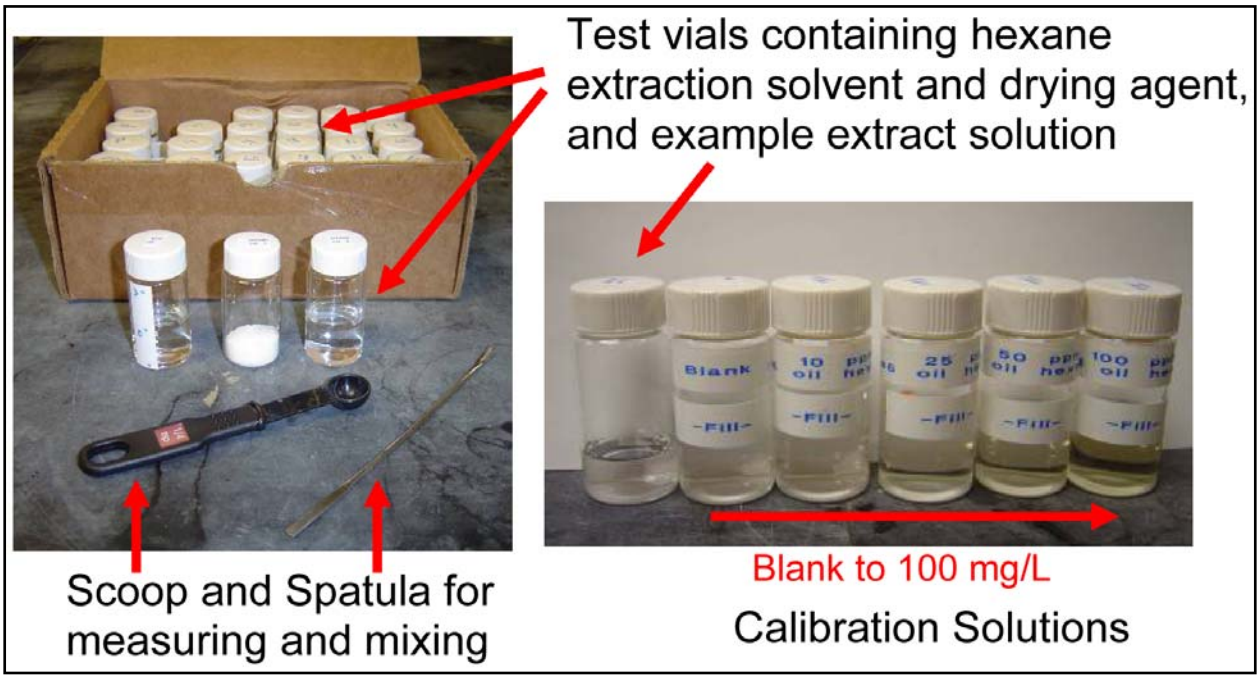


Figure 5. ERDC-developed field screening test kit for fuel oil #6 in dredged material (left). Dissolved fuel oil #6 in hexane standards used for calibration (right) in field screening test kit.

APPLICABILITY: The field-portable instrumentation described above has the capability to analyze for a wide variety of organic contaminants in complex environmental matrices. The Griffin 400 GC-MS weighs approximately 35 kg, has dimensions of approximately 40 × 40 × 40 cm, and can be operated on a 2-kW portable generator. Therefore the instrument can be deployed to any environment where this space and power is available. The only potential limitation is humidity. Previous work has shown that relative humidity levels above approximately 80 percent can cause electronic problems with the instrument, and therefore it is recommended that the instrument only be operated in conditions below approximately 75 percent relative humidity. However, the current work was successfully performed on an active dredge operating near the mouth of the Mississippi River during the summer, and humidity was not observed to cause any problems.

The work discussed above was specifically focused on PAHs; however, the technology was originally developed for explosives, and therefore can be modified to analyze for a wide variety of organic compounds. For example, during the instrumentation's original prove-out deployment for explosives in groundwater analysis, an unknown chromatographic peak in certain monitoring

wells was identified as a plasticizer compound because of the mass spectrometer's ability to detect and identify organic molecules based on their molecular weight and structure (Kirgan et al. 2008). Therefore, this technique can potentially be extended to other classes of organic compounds. Work is currently underway to expand capability to include polychlorinated biphenyls, and extension to pesticides is also possible.

SUMMARY: The use of a field-portable GC-MS is described for the near-real-time analysis of PAHs in dredged material. Although detection limits are not as low as traditional laboratory analyses, the data agree reasonably well between field and laboratory-based analyses considering the concentrations of analytes observed in the samples tested. The data provided by this research allowed real-time dredging decisions to be made based on sound scientific data, rather than subjective human observations. Future work is needed to improve detection limits through modified extraction techniques and real-time data processing through software modifications and upgrades; however, the current methods do allow for quantitative determination of PAHs in dredged material. Additionally, a qualitative field screening test kit was developed based on color changes in organic solvent used to extract fuel oil #6 from sediment and water samples. This test kit can be used as a rapid indicator for the need to collect samples for more quantitative and thorough laboratory analyses.

POINTS OF CONTACT: This technical note was prepared by Dr. Anthony J. Bednar, research chemist, Environmental Laboratory (EL), U.S. Army Engineer Research and Development Center (ERDC) (*Anthony.J.Bednar@usace.army.mil*), Dr. Robert A. Kirgan, research chemist, EL, ERDC, Jeffrey Corbino, Environmental Resources Specialist, U.S. Army Engineer District, New Orleans (MVN), and Amber L. Russell, Research Assistant, SpecPro, Inc. The study was conducted as an activity of the Dredging Operations Technical Support (DOTS) Program, and in support of MVN dredging activities. For information on DOTS, please contact the Program Manager, Dr. Douglas Clarke at *Douglas.G.Clarke@usace.army.mil*. This technical note should be cited as follows:

> Bednar, A. J., R. A. Kirgan, J. M. Corbino, and A. L. Russell. 2009. *Analysis of dredged material for organic contaminants using a field-portable GC-MS.* DOER Technical Notes Collection. ERDC TN-DOER-E26. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

REFERENCES

Kirgan, R. A., A. J. Bednar, A. L. Russell, and C. A. Hayes. 2008. The use of field deployable instrumentation for the monitoring of explosives in groundwater. *26th Army Science Conference, Orlando, FL, 1-4 December, 2008*.

U.S. Environmental Protection Agency (USEPA). 2007. *SW-846 methods for the analysis of hazardous waste.* Methods 3510, 3550, and 8270.

NOTE: *The contents of this technical note are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such products.*

Appendix D

US Army Corps of Engineers®

For additional information contact Anthony Bednar.

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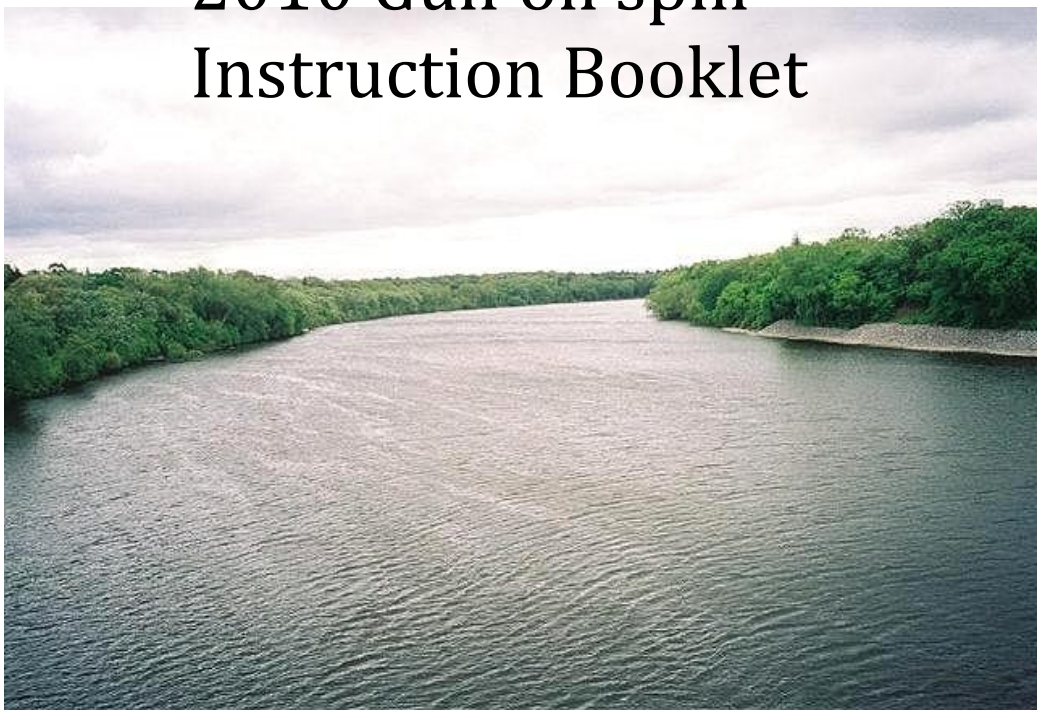
US Army Corps of Engineers®

Crude Oil Field Screening Kit: 2010 Gulf oil spill Instruction Booklet



Caution: Kit contains hexane (Flammable) and Sodium Sulfate (mildly toxic if ingested). Review MSDS sheet before using. Avoid Open Flames.

Kit contents:

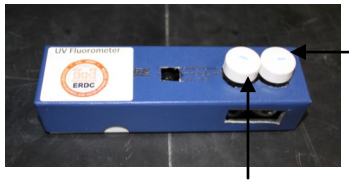
+ 1 Pen, Instruction Booklet and Labels

UV Fluorometer contents:

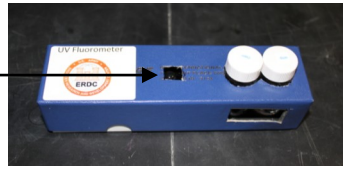
UV Fluorometer Instructions:

- Process sample
  -Water or Sediment sample analysis as shown previously.

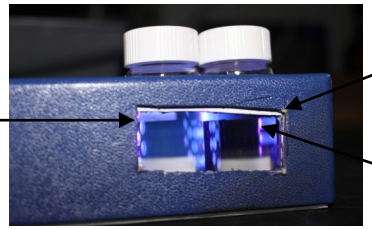
- Insert blank and sample to be analyzed into Fluorometer box, as shown.
  -Hexane blank should be on the right, furthest away from the light source.
  -Familarize yourself with the expected fluorescence by comparing the standards first with the hexane blank.



- Turn on Fluorometer
  -Press button on top of fluorometer box.



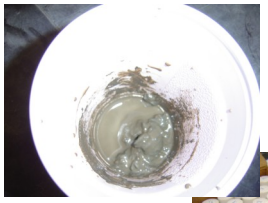
- Observe Fluorescence through viewing window.
  -Fluorescence is a positive indicator of the presence of oil in the sample.



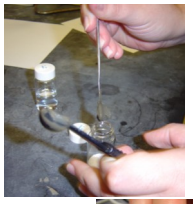
- *Fluorescence may be very faint.*
  -Therefore if fluorescence is suspected, remove sample and compare with several of the supplied standards always leaving the blank to the right for comparison.
  -If fluorescence is observed or suspected collect sample for laboratory analysis.

Sediment Sample Analysis Instructions:

- Pour off the water from the collected sample after the sample has settled.



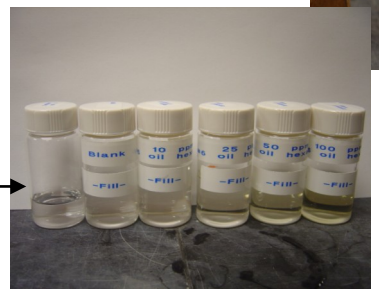
- Using the soil measuring device (1/4 teaspoon) and spatula, measure out 1 level 1/4 tsp of sediment.



- Transfer the sediment sample into sediment vial A using the spatula and mix thoroughly with the sodium sulfate.

- Transfer the contents of Sediment vial B (hexane) into sediment vial A shake for 5 minutes.

- Pour the liquid back into sediment vial B and compare with the standards using the UV fluorometer.



- Label vial with Date Time and location.

Sample →

The field detection method was laboratory tested with a commercially available South Louisiana crude oil. Interferences from environmental media have not been extensively tested to date, therefore, positive field results should be considered an indication of oil, necessitating laboratory samples be collected for confirmation.

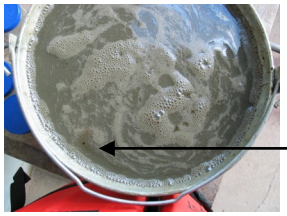
General Instructions:

- Follow all directions as written. Failure to do so will result in an incorrectly performed test and results will not be accurate.
- Clean all equipment after each use by rinsing with water.
- The comparison solutions are standards that have been calibrated to the concentrations shown on the label. Do not open these vials. If they are opened or tampered with the solutions will no longer be valid.
- UV Fluorometer contains a LED Black light flash light (light wave length 385-395 nm). Turn off when not in use.
- Do not look directly into the light, as eye damage could result.
- Holding the UV Fluorometer at a slight angle away from you will decrease the glare from the LED's making fluorescence observation easier.
- Operation under dim ambient light may make positive identification of faint fluorescence easier.

Sample Handling Instructions:

- Collect sample
  Images are sample collection from a dredge hopper.

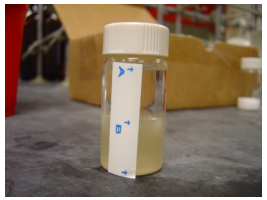
- Separate water from sediment by allowing to settle.



- Perform necessary analysis.
  -Water or Sediment sample analysis

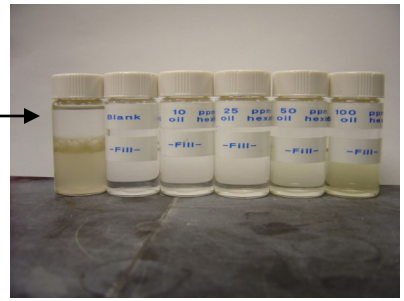
Water Sample Analysis Instructions:

- Slowly pour water from the settled sample into the water vial until the liquid level reaches the top arrow (A) .



- Replace the lid on the vial tightly and shake for 3 minutes.

- Compare the **<u>Top Layer</u>** with the comparison solutions (standards) using the UV Fluorometer.



- Label vial with Date Time and location.

Appendix E

Internal Spill Incident Action Checklist (EXAMPLE)

Incident Name:	Atlantis		**NRC Number:**	620210	
Incident Date/Time:	06/30/10	0815	**Responsible Party:**	ABC Oil Company	
Incident Location:	9231 Gulf Beach Highway		**USCG Contact:**	Keith Smith	
City/Parish or County:	Port Sulfur / Plaquemines		**USCG Contact #:**	504/567/1234	
Lat/Long:	N29°50'8	W93°30'34	**USCG Contact Cell:**	504/567/4321	
Product Released:	Crude oil		**Incident Type:**	Vessel breach	
Amount Released:	~9000 Barrels		**Media Affected:**	Mississippi River	
Approximate Size:	30-40 miles of waterways				
Command Center Location:	ABC Oil Company 1234 Oil Road East Venice, LA 01234		**RP Contact:**	John Doe	
			RP Contact #:	504/123/5678	
			RP Contact Cell #:	337/123/5678	
USACE Response:	Yes	**Response Date:**	07/05/10	**Arrived On-scene:**	0800
USACE Dredging Operator POC	Jeff Doe		**Contact #:**	504/527/9576	
			Contact Cell #:	504/720/1946	
USACE Responders:	Joe Smith- MVN		**Contact Cell #:**	504/528/5820	
	Heather Breaux-MVN		**Contact Cell #:**	504/528/1001	
			Contact Cell #:		
			Contact Cell #:		
Brief Description of the Incident:	During the evening of 28 November, the NOAA SSC was notified by MSO New Orleans of a 9000 bbl crude oil spill on the Mississippi River near Port Sulfur, Louisiana. The *MV Westchester*, an inbound tanker, lost main engines due to a crankcase explosion. With the loss of steerage, the ship's captain deployed the port anchor followed by the starboard anchor in an attempt to maintain control. Unfortunately, the vessel either struck its own anchor, struck a unidentified navigational hazard, or ran aground causing an oil release. Before the source could be controlled, the vessel lost 13,200 bbl of a Nigerian crude oil. At present, the source is under control and a salvage plan is under review. All of the key bayous and cuts have been boomed by either a deflection or collection strategy. Skimmers are working the heavy oil accumulations. NOAA is coordinating with the State of Louisiana, the USCG, and the RP's spill management team on shoreline assessments and spill cleanup strategies.				
Documents and Talking Points to Prepare Prior to Meeting with the USCG and/or Unified Command	Project area vicinity map.				
	Detailed map delineating the dredging and disposal area.				
	Project overview (dredging and disposal plan, volume of dredge material, and dredging duration schedule).				
	Phases of the project that could potentially be impacted.				
	Dredging operation 101 factsheets or powerpoint that will provide USCG and/or Unified Command with a dredging program overview.				
	Photographs of the vessels or dredging equipment.				
	Reasons why the USACE needs to dredge (commerce, economic impacts, etc.).				
	Contact the analytical lab for the minimum sample quantity required to perform designated chemical analyses on water, sediment or oil samples (for oil-related compounds, fingerprinting). Please note that this step must be completed prior to requesting a source sample from the USCG and/or Unified Command.				

Questions and Talking Points to Present to the USCG and/or the Unified Command	Request an overview of the oil spill incident.
	Offer to provide Dredging 101 and overview of current/planned dredging operations (dredging plans, pictures of vessels or dredging equipment). Explain why the USACE needs to dredge (commerce, economic impacts, etc.).
	How can the Unified Command support the phases of the Dredging Operation?
	Will the USCG and/or Unified Command develop a response plan (oil recovery personnel and equipment) in the event the USACE needs to resume dredging operations?
	What is the Unified Command's timeline for supporting the USACE dredging phases? Who is the POC for executing the response plan?
	How can USACE integrate staff into the Unified Command to facilitate coordination efforts?
	When and where are the Unified Command meetings?
	Who is the main POC for situation updates?
	Request an orientation overflight of the oil spill area with USCG. (This is a good opportunity to view the oil spill itself, to see how it may impact dredging operations, and to provide USCG with an aerial view of dredging operations.)
	Request funding for USACE activities and participation in the Unified Command from the USCG (Funding requests are called PRFA - Pollution Removal Funding Authorization).
	Request a source sample of the oil that has been released. NOTE: The analytical lab should be contacted prior to the USCG/UC meeting for the minimum sample quantity required to perform designated chemical analyses on water, sediment or oil samples (for oil-related compounds, fingerprinting).
	Request that sediment samples (background samples and 1 year post-incident) be collected and analyzed in the dredging and disposal areas.
Action Items from the Meeting with the USCG and/or Unified Command:	USCG and/or Unified Command will provide a response plan (oil recovery personnel and equipment) to the USACE by COB tomorrow.
	USCG and/or Unified Command will contact USACE when the source sample has been collected (ETA – 24 hours).
	USCG and/or Unified Command will provide USACE with an opportunity to be represented at Unified Command meetings.
	USCG and/or Unified Command will provide regular updates at their 1600hrs daily briefings.
	USACE will provide USCG and/or Unified Command with personnel contact information.
	USACE will keep USCG and/or Unified Command informed of any dredging operation schedule changes.

Appendix F

Internal Spill Incident Action Checklist

Incident Name:		**NRC Number:**	
Incident Date/Time:		**Responsible Party:**	
Incident Location:		**USCG Contact:**	
City/Parish or County:		**USCG Contact #:**	
Lat/Long:		**USCG Contact Cell:**	
Product Released:		**Incident Type:**	
Amount Released:		**Media Affected:**	
Approximate Size:			
Command Center Location:		**RP Contact:**	
		RP Contact #:	
		RP Contact Cell #:	
USACE Response:	**Response Date:**	**Arrived On-scene:**	
USACE Dredging Operator POC		**Contact #:**	
		Contact Cell #:	
USACE Responders:		**Contact Cell #:**	
		Contact Cell #:	
		Contact Cell #:	
		Contact Cell #:	
Brief Description of the Incident:			
Documents and Talking Points to Prepare Prior to Meeting with the USCG and/or Unified Command	Project area vicinity map.		
	Detailed map delineating the dredging and disposal area.		
	Project overview (dredging and disposal plan, volume of dredge material, and dredging duration schedule).		
	Phases of the project that could potentially be impacted.		
	Dredging operation 101 factsheets or powerpoint that will provide USCG and/or Unified Command with a dredging program overview.		
	Photographs of the vessels or dredging equipment.		
	Reasons why the USACE needs to dredge (commerce, economic impacts, etc.).		
	Contact the analytical lab for the minimum sample quantity required to perform designated chemical analyses on water, sediment or oil samples (for oil-related compounds, fingerprinting). Please note that this step must be completed prior to requesting a source sample from the USCG and/or Unified Command.		

Questions and Talking Points to Present to the USCG and/or the Unified Command	Request an overview of the oil spill incident.
	Offer to provide Dredging 101 and overview of current/planned dredging operations (dredging plans, pictures of vessels or dredging equipment). Explain why the USACE needs to dredge (commerce, economic impacts, etc.).
	How can the Unified Command support the phases of the Dredging Operation?
	Will the USCG and/or Unified Command develop a response plan (oil recovery personnel and equipment) in the event the USACE needs to resume dredging operations?
	What is the Unified Command's timeline for supporting the USACE dredging phases? Who is the POC for executing the response plan?
	How can USACE integrate staff into the Unified Command to facilitate coordination efforts?
	When and where are the Unified Command meetings?
	Who is the main POC for situation updates?
	Request an orientation overflight of the oil spill area with USCG. (This is a good opportunity to view the oil spill itself, to see how it may impact dredging operations, and to provide USCG with an aerial view of dredging operations.)
	Request funding for USACE activities and participation in the Unified Command from the USCG (Funding requests are called PRFA - Pollution Removal Funding Authorization).
	Request a source sample of the oil that has been released. NOTE: The analytical lab should be contacted prior to the USCG/UC meeting for the minimum sample quantity required to perform designated chemical analyses on water, sediment or oil samples (for oil-related compounds, fingerprinting).
	Request that sediment samples (background samples and 1 year post-incident) be collected and analyzed in the dredging and disposal areas.
Action Items from the Meeting with the USCG and/or Unified Command:	

Appendix G:

Considerations for Assessing Unacceptable Biological Impacts for the Unconfined Disposal of Dredged Material Suspected to Be Impacted by an Oil Spill

Technical guidance for determining the suitability of dredged material through physical, chemical, and biological evaluations, for discharge in waters of the United States (under section 404 of the CWA) or for dumping in ocean waters (under section 103 of the MPRSA) is provided in the Inland Testing Manual *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. - Testing Manual*, USEPA/USACE (1998)) or the Ocean Testing Manual (*Evaluation of Dredged Material Proposed for Ocean Disposal - Testing Manual*, USEPA/USACE (1991)). This guidance is also in accordance with the dredged material management technical framework (*Evaluating Environmental Effects of Dredged Material Management Alternatives - A Technical Framework*, USEPA/USACE (2004)).

This appendix recommends actions to expedite the evaluation for potentially oil spill-impacted sediments. These actions are intended to protect the environment and meet the requirements of applicable environmental regulations. This approach is intended to minimize the disruption to dredging operations in areas affected or potentially affected by oil spills. Although the recommendations made in this document involve a streamlined approach and rapid sampling methods for sediment contaminated – or suspected of having been contaminated – with oil, they are intended to be consistent with the overall aims of the national testing approach addressed above.

A sampling and analysis plan of the material to be dredged should be developed according to guidance provided in the above-referenced manuals. The need for biological testing of oil-impacted sediments may be determinable by straightforward chemistry comparison to oil-related compounds in previously characterized sediments from the same site. If found to be "substantially different," biological testing may be required to evaluate the significance of these differences. In order to perform the initial data comparison, at minimum, surface sediment should be collected using a grab sampler at various locations from the dredging site and properly stored and sent to a chemistry laboratory with the capacity to conduct and expedite analysis. In addition to surface samples, core samples collected to project depth is desirable. Chemistry data should be generated for polycyclic aromatic hydrocarbons (PAHs); minimally, the 16 USEPA priority PAHs (USEPA Method 8270) and measures of bulk petroleum products — namely TPH, oil and grease — (USEPA Method 1664) total organic carbon (USEPA Method 9060), as well as other constituents, if applicable, including those listed in the material safety data sheet. Sampling of the disposal and reference sites may be necessary if there is suspicion of contamination by oil. Hydrocarbon fingerprinting (e.g., USEPA Method 8015) is also recommended, if needed, to help identify the oil source.

Bulk chemistry data for all the sampled sites, including measured concentrations, non-detects, and laboratory reporting limits for sampling sites should be presented in spreadsheet format. Data from the latest evaluations and earlier ones, if applicable, as well as available Sediment Quality Guidelines (SQGs) (e.g., for certain individual and total PAHs) should be entered as additional columns in the spreadsheet. SQGs will provide an additional means for evaluating the environmental significance of the oil-related compounds if the sampled sites are found to be

"substantially different" from previously characterized material at the site. As previously mentioned, the initial analysis will involve a comparison of the relative oil-related contaminant levels in post-spill samples from the dredging or disposal site to corresponding data from sediment previously evaluated and approved for disposal. If the sediment concentration of oil related constituents appears to have increased as a consequence of oil contamination, the magnitude of the increase should be assessed to determine whether the post-spill sediment samples would be considered to be "substantially different." If replicate data are available, the determination of significant difference between present and previous evaluation results should be made using statistical comparison and should consider background concentrations of oil-related contaminants and analytical variability. If analytical results of present and previous evaluations are sufficiently similar, then the materials may meet regulatory requirements for disposal as previously determined.

If further evaluation is determined to be necessary, a screening-level evaluation of the potential impact of oil-related compounds to benthos at the disposal site may be performed by comparing the newly collected data and historical data on the dredging sites to SQGs. Those guideline values relate bulk chemical concentrations of sediment-associated contaminants to the potential for toxic effects in directly exposed benthic infaunal organisms. A comprehensive review of existing sediment quality guidelines, their limitations, and their potential and adequacy for application in the evaluation of dredged material is provided in Wenning et al. (2005) and Peddicord and Lee (1998).

In general, empirically based approaches for developing SQGs rely on statistical analysis of paired sediment chemistry and biological effect data to derive chemical concentrations intended to be predictive of either the presence or absence of biological effects in sediments. Some empirical guidelines have been in use for a number of years and are based on national databases. Other SQGs have been locally or regionally derived. Empirically based SQGs include Effects Range Low/Effects Range Median (ERL/ERM) (Long et al., 1995), and Probable Effects Level/Threshold Effects Level (PEL/TEL) (MacDonald et al., 1996). Under these approaches, there are lower, "threshold of effect" values (ERL and TEL, respectively) below which adverse effects are unlikely, and upper "probable effect" values (ERM and PEL, respectively) above which the probability of adverse effects increases. The latter SQG values can be found in the National Oceanic and Atmospheric Administration (NOAA) "SQuiRTs" (Buchman et al. 2008).

Further enhancements of the empirical SQGs include ERM quotients (Long et al., 2006). Consensus SQGs for PAHs, which use a mixture of mechanistic and empirical approaches, are available (Swartz 1999). MacDonald et al. (2000) developed a set of consensus-based SQGs for freshwater ecosystems, including threshold effect concentrations (TECs), below which adverse effects are unlikely to be observed, and probable effect concentrations (PECs), above which adverse effects are likely to be observed.

In some situations, comparisons with SQGs in conjunction with comparison with data from previous evaluations may be adequate to reliably assess whether oil-related compounds present in the dredged material may have an adverse impact on organisms in the receiving aquatic environment. If a definitive determination regarding the acceptability of the dredged material for open water disposal or beneficial use cannot be made based on this information, evaluation of the

water column and benthic toxicity and potential for benthic bioaccumulation for the dredged material may be necessary (biological testing).

The use of reference sediment is key to evaluating the benthic effects of dredged material. Reference sediment should reflect the conditions at the disposal site had no dredged material disposal ever occurred there. Reference sediment serves as a point of comparison to identify potential environmental effects of a disposal of dredged material. Toxicity tests and bioaccumulation potential evaluations of the reference sediment provide a point of comparison against which effects of dredged material are evaluated. Reference sediment should be collected: (1) to obtain physical characteristics, including grain size, as similar as practicable to the dredged material proposed for disposal; (2) to avoid areas in the immediate vicinity of — including depositional zones of — spills, outfalls, or other significant sources of contaminants; and (3) to be as close as practicable to, and subject to the same hydrologic influences as, the disposal site, but removed from areas which are subject to sediment migration of previous dredged material discharges.

If the project reference site has been impacted by the oil spill, or if evidence exists that it may have been, then a new reference site location may have to be pursued for sediment sampling and use in toxicity and bioaccumulation evaluations. If it is not possible to find reference sediment with physical characteristics similar to the dredged material proposed for disposal, toxicity and bioaccumulation tests should use organisms that are not sensitive to these differences. It should be noted that, in the absence of reference site material, interpretation of the toxicity test using a control sediment should be considered.

Guidance for performing toxicity testing bioaccumulation evaluation is provided in the testing manuals. Toxicity tests typically involve exposing test animals to sediment for 10 days and recording the number of survivors. If bioassays with shorter duration are desirable, alternative tests, such as amphipod sediment burrowing behavior tests (Kravitz et al., 1999; Scarlett et al. 2007) or sediment-water interface tests using bivalve embryos (Anderson et al. 1996) should be contemplated.

Potential for benthic impact related to bioaccumulation of oil-related compounds may be evaluated in an expedited fashion using the calculation of theoretical bioaccumulation potential (TBP) based on partitioning between the organic carbon in sediments and the lipids in organisms. If the TBP is lower from the dredged material than from the reference sediment, further testing for bioaccumulation of these nonpolar organic contaminants is not required. If the TBP of the dredged material exceeds that of the reference sediment, or if there are oil-related contaminants of concern that are not nonpolar organics, bioaccumulation testing in may be required.

The dredged material impact in the water column during disposal must be evaluated. Evaluation of state water quality standard (WQS) compliance using a numerical mixing model of the disposal site conditions is performed. However, state or federal WQS criteria are not available for most PAH compounds nor for TPH, oil and grease. Evaluation of water column impacts using effects-based testing that is generally more complex, costly, data intensive, and time-consuming may be necessary. Guidance for generating sediment elutriates and performing elutriate toxicity testing is provided in the testing manuals (USEPA/USACE 1991, USEPA/USACE 1998).

Whole-sediment, sediment-water interface, and elutriate tests require the transport of the sediment sample to a specialized laboratory for test performance. QwikLite™, a novel, self-contained portable instrument for performing toxicity assessments, may be a viable alternative for use as the sole source of toxicity evaluation or in conjunction with traditional sediment tests. QwikLite™ is commercially available from Assure Controls, Inc. The optical, mechanical and electronic measurement system, disposable test kits, and all supplies needed for measurement of samples with contaminants which may be in concentrations high enough to be toxic are contained in a convenient carrying case weighing approximately 6 lbs. Depending on shipboard conditions, it could be conducted aboard a dredge, or, more comfortably at a nearby shoreside location. QwikLite™ has demonstrated adequate capability to identify toxicity in sediment media within 24 h (Lapota et al. 2007. QwikLite™ was employed in onboard testing by the College of Marine Science, University of South Florida as an evaluation tool during extensive Gulf Oil Spill sampling during the Deepwater Horizon spill incident[1].

In conclusion, technical guidance for determining the suitability of dredged material, through physical, chemical, and biological evaluations, for discharge in waters of the United States (under section 404 of the CWA) or for dumping in ocean waters (under section 103 of the MPRSA) is provided in the cited testing manuals. This appendix recommends actions to expedite the evaluation while still maintaining an environmentally protective stance and meeting the requirements of applicable environmental regulations. This approach is intended to minimize the disruption to dredging operations in areas affected or potentially affected by oil spills.

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Appendix H:

Disposal Alternatives, Treatment Options and Engineered Controls

Alternative Disposal Options: In the event that evidence of newly oiled sediment is discovered during dredging, it may be determined that the material is unsuitable for the planned disposal alternative, and other options may need to be developed. Some type of temporary disposal may be required until necessary testing can be accomplished and a suitable disposal option can be identified.

Confined disposal facilities (CDFs) and confined aquatic disposal (CAD) have been used for containment of contaminated dredged material. The use of geotextiles to provide additional isolation in open water, to provide confined aquatic disposal, to temporarily hold and dewater the material, or to create a dredged material containment area may be considered. These alternatives are discussed in more detail in the following sections.

Contained Aquatic Disposal and Confined Aquatic Disposal (CAD): Contained aquatic disposal involves placing material in water, then covering it with clean cap material to provide physical stabilization and to isolate potential contaminants from benthic organisms and the water column. Contained aquatic disposal has been used at a number of sites to contain contaminated material (Palermo et al. 1998).

Confined aquatic disposal (CAD) involves the placement of dredged material in a subaqueous "cell," either a natural depression or manmade structure of some type (Figure H1), followed with a cap to stabilize the material and provide physical and chemical isolation. CAD cells have demonstrated effective chemical and physical isolation of contaminated sediments and offer a number of advantages over other disposal alternatives; in some cases, transport distances can be minimized with the use of CAD, and conventional dredging equipment can be used, resulting in cost savings. In addition, CAD has achieved regulatory acceptance and has been shown to be effective in minimizing the risk from contaminants (Fredette 2006, Palmerton et al. 2002). Detailed guidance on design of contained aquatic disposal sites can be found in "Guidance for Subaqueous Dredged Material Capping" (Palermo et al. 1998). Updated capping guidance is currently being drafted by EPA but is not expected to be published for some time. Major capping and CAD design elements include site selection, determination of appropriate cap material and thickness requirements, selection of equipment and placement techniques for both the dredged material and cap, and development of a post-disposal monitoring plan.

Contained aquatic disposal requires intensive engineering design to ensure long-term success, suggesting that CAD is unlikely to be implementable as a temporary disposal alternative. However, in the event that there is not sufficient time to fully characterize the dredged material and perform the monitoring necessary for full design, a non-engineered cap could be placed to provide immediate isolation, with additional cap material placed after completion of the full design. Geotextiles may prove useful to provide immediate isolation from the water column and benthos while cap design is being finalized. Potential issues with this approach could arise where underlying sediments are not strong enough to support a cap of the required materials and thickness. Some knowledge of the foundation materials would therefore be required before dredged material could be placed.

Considerations for selection of contained aquatic disposal locations: Confined aquatic disposal can be done by placing material in existing depressions, by excavating an area to contain the material and cap, or by creating berms on the bottom for lateral confinement. Also, level bottom capping can be achieved by capping mounds placed on the bottom (Figure H1).

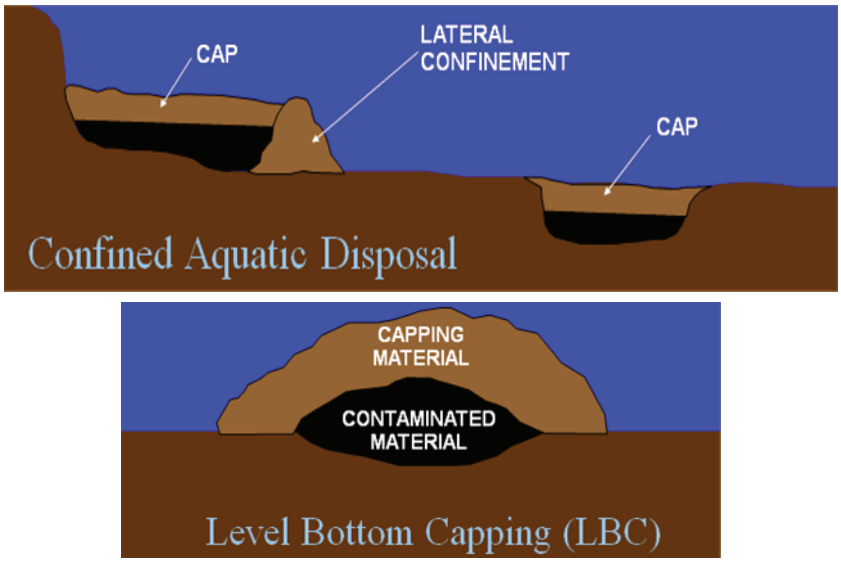

Figure H1. Types of CAD sites (modified from Palermo et al 1998).

Selection of a CAD location and type will depend on how the material is being dredged and site characteristics. In selecting a location, the following considerations are important:

Site bathymetry - Avoid steep slopes.

Water depth – There should be sufficient water depth to allow equipment access and the requisite storage and cap depth, and material should not be placed to a level that would impede navigation.

Currents – Dispersive sites should be avoided; strong bottom currents could cause excessive resuspension and cap erosion.

Proximity to sensitive resources – While caps typically recolonize relatively quickly with indigenous organisms, locations important to protected or sensitive species should be avoided.

Other considerations – Volumetric capacity, avoidance of nearby structures, haul distance, proximity to cap material, bottom shear due to ship traffic, groundwater flow.

Cap Design: Design of a cap involves selection of appropriate cap materials and thickness. Caps can consist of one material or multiple layers to provide different functions. Potential cap materials include sand, fine-grained material, soil, geotextile fabrics, armor stone, and amendments such as adsorbents or reactive materials. The cap material and thickness should be designed to account for:

- erosion – normal tidal currents as well as storm-induced, and ship scour;

- bioturbation – consider depth to which benthic organisms will penetrate and mix the cap;
- recolonization – materials can be placed to encourage or discourage recolonization or to enhance habitat;
- consolidation – will reduce thickness over time;
- contaminant transport – modeled after contaminant flux and sorptive capacity of cap are factored into consideration; and
- operational factors – penetration due to anchoring, as well as inability to place accurate layers.

Equipment and Placement Techniques: The dredged material should be placed in a controlled manner to minimize water column dispersion, lateral transport and resuspension. Minimizing the bottom footprint will reduce cap material requirements, if not otherwise contraindicated for the site conditions. Submerged discharge is one control method that can be used to improve the accuracy of placement and minimize water column contact. Submerged discharge can be accomplished using a submerged diffuser for pipeline placement, tremie tube for offloading a barge, or by pumping down through the drag arms of a hopper dredge. Placement of material in geotextile tubes which would then be offloaded at an open water, CAD or capping site might also be considered to minimize contact with the water column and reduce the dredged material footprint. The use and filling of geotextile tubes for dredged material disposal is discussed in more detail in later sections of this Appendix.

Placement of the cap material should be done in such a manner as to create a uniform cap thickness and avoid mixing or displacement of the underlying dredged material with the cap. Some methods used for controlled, even placement of the cap material are listed below:

- Submerged diffuser
- Sand spreader box
- Pipeline placement with a baffle plate
- Washing over the edge of a barge
- Spreading by cracking open the hull of a barge or hopper while under tow

Monitoring: A monitoring plan should be formulated to verify that the site has been constructed as designed, that contaminants are not being released into the environment by migrating through the cap, and that storm damage has not occurred following construction. The condition of the cap should be monitored periodically, and after storm events. Some maintenance of cap materials is expected due to erosion or navigation-induced damage (Palermo et al 1998).

Confined Disposal Facilities (CDFs): CDFs are typically earthen diked areas constructed to retain dredged material, facilitating gravity settling and dewatering of solids, and clarification of effluent that can then be discharged to a receiving water body, typically without further treatment. CDFs can be constructed in upland locations, nearshore, or in-water. Confined disposal may be suitable for either temporary or permanent storage of dredged material. If there is capacity available in existing CDFs, contaminated material may need to be segregated from clean or previously placed material so that it does not impair the quality of existing material and to facilitate management, treatment or material recovery for permanent disposal elsewhere. Cross dikes can be used to compartmentalize CDFs; cross dikes can often be constructed from material

in the CDF, or options such as geotextile tubes might be considered to provide temporary structures. Detailed design guidance on construction of CDFs — including cross dikes — can be found in EM 1110-2-5027 (USACE 1987). Most soil materials can be used for dike construction, with the exception of very wet, fine-grained soils and those containing a high percentage of organic matter.

Geotextile Tubes for In-Water Disposal, Water Treatment, Temporary Staging Areas and Rapid Construct Confined Disposal Facilities (CDFs):

Geofabric containers (GFCs) or geotextile tubes have been used to contain contaminated sediments and could potentially be used to create fast land to support containment and dewatering equipment. Case studies summarized in Table H1 were included to provide a brief operational overview of geotextile use. Geotextile containers have been used to dewater PCB-contaminated sediments from both OU1 of the Lower Fox River (Foth 2007) and Ashtabula River (Cieniawski 2008). Materials from both projects were landfilled after dewatering, and the filtrate water collected for treatment. Dredged material from Ashtabula River was loaded into geotextile tubes inside the landfill; the Lower Fox River sediments were dewatered using geotextile tubes, then excavated and trucked to a landfill. GFCs could provide either temporary or permanent dredged material storage, and may facilitate coupling dredged material disposal with restoration or marsh protection efforts in some cases.

Background: Geotextile tube projects are generally simple to construct (Davis and Landin 1997); geotextile tubes can be filled directly from the discharge line of a hydraulic dredge or with mechanically dredged material slurried in a hopper and pumped to the tube. Filling can be done from intermittently spaced access ports in the top of the tube, or from one end. Access points can be spaced further apart for fine-grained materials which are relatively flowable (e.g., 500 ft apart), but need to be closer for sandy materials (approximately 50-75 ft apart). The dredge discharge line is strapped into the filling sleeve, the slurry flows into the tube, and water is discharged out of the other ports (if left open) and through the fabric (if permeable). Much of the information that follows was taken from the proceedings of the National Workshop on Geotextile Tube Applications, held in 1995 (Davis and Landin 1997). Since that time, materials used in the construction of geotextile tubes have undoubtedly advanced, and there may be a broader body of experience from which to draw for design and filling parameters that could not be assessed within the scope of this effort.

Geotextiles are available in a variety of woven and non-woven materials, and can be constructed with a carbon layer within the textile in order to sorb dissolved contaminants in water passing through the tubes. Geotextile tubes are potentially suitable to provide containment on land or in an open water disposal site. Longevity of the tubes is a function of tensile strength of the material, exposure to UV light, and stability of the foundation upon which they are placed. Constructing structures with geotextile tubes by stacking them can be challenging unless the tubes are supported in such a way that they cannot roll or slide off one another. This construction has been done successfully (Cretens 2009, Foth 2007), however, and geotextile tubes therefore may be useful for rapidly constructing containment areas for dewatering of oiled sediments, or for construction of a staging area in wetland areas or shallow water where mechanical dewatering equipment could be set up, and loading and offloading operations performed. The suitability of any of these possible approaches will be site-specific and will require a certain

amount of pre-construction engineering in order to assure stability of the structures and adequate containment of the contaminated materials, as well as to assure materials are recoverable if necessary for permanent disposal elsewhere.

Geotextile Tube Installation and Filling Considerations: To maximize tube height, the tube must be pumped up to the desired shape during filling; however, pressure must be monitored and maintained at acceptable levels in order to avoid rupturing the tube. Non-permeable tubes may be easier to keep inflated than permeable tubes, but the former would not permit dewatering of the material within the tube. Flow velocity must be sufficient to transport material through the length of the tube; sand fill may be hand leveled from the top of the tube. Sand fill is preferable if a specific final elevation is required; fine materials will consolidate and tube height will gradually decrease with time. A rough rule of thumb given in Davis and Landin (1997) was a final to initial tube height ratio of 1:1 for sand and 1:4 for muds. An alternate rule of thumb given for determining final tube height is one-sixth to one-fourth the circumference of the tube. Final height is a function of the filling process and equipment, circumference of the tube, fabric permeability, filling sleeve spacing and fill material. Based on the limited evidence available, higher height to circumference ratios may be achievable with smaller circumference tubes. Non-woven fabrics result in lower permeability; woven fabrics tend to be higher strength (David and Landin 1997). The use of more filling ports reportedly resulted in less height variation along the length of the tube, although filling from just one port near the end of the tube has also been done. It may be helpful to spread an initial layer of sand in the tube to hold it in place (some tubing materials float).

An alternative to in-water or on-land filling of geotextile tubes involves placement of a tube in a hopper barge for filling. The tube can then be dropped from the barge at the selected placement site. A similar operation can be performed by lining the hopper with a geotextile, and then sewing it shut after filling.

Tubes appear to have a greater tendency to slide on each other than on the seabed; stacking therefore may require the tubes to be fastened together in some manner. Reported filling times ranged from 6 hrs for a 500–ft-long tube filled with sand, to 9 hrs for a 250-ft tube, but will vary depending upon equipment used, tube size and permeability and character of the fill material. Filling sleeves must be closed to prevent material losses from the tubes over time; abrasion from the sleeves moving back and forth over the surface of the tube can be problematic.

Costs reported in Davis and Landin (1997) were quite limited. For the Victoria Barge Channel project, a range of $50 to $150/lineal foot was reported at the time of installation (1994), with long tubes constructed in accessible areas and in conjunction with ongoing dredging being the least expensive. For the Victoria Barge Channel project, the tubes were less expensive than the rubble mound of rip-rap structures but more expensive than earthen dikes. In the Gulf Coast areas, however, geotextile tubes may be easier to fill and place in order to create containment structures than conventional dikes are, due to the low strength of marsh foundation materials.

Geotextile tube loading, including quasi-static, wave-induced pulsating, flow, buoyancy, impact and construction loads must all be taken into consideration and the results incorporated into the design. Loading is a function of the environment, manmade influences, and installation stresses

and varies both temporally and spatially. A load resistance factor design approach is briefly discussed in Davis and Landin (1997).

Barge Dewatering and Water Management: Another possible option for a mobile and temporary staging area would be to utilize a large barge float (e.g., 40 large barges) for the filling of geotextile tubes, as a stand-alone dewatering "basin" or for the management of effluent and runoff discharges from a temporary dredged material containment area. Material could be mechanically or hydraulically placed in a series of barges, clarified supernatant collected, and the water pumped to a barge or barges containing geotextile tubes filled with or constructed with activated carbon or other sorbents (such as carbonized bagasse). Flocculants may be needed to speed clarification of the supernatant given the limited effective "ponding" area, and slurried inflows would likely need to be split through a header or spider barge, such that flow rate to an individual barge could be handled without material and water losses. The operational feasibility, specifics and limitations of this approach remain to be developed at this time; the approach may be more applicable to hydraulic offloading of hopper barges than to management of discharge from a hydraulic dredge, given the high energy of a dredge discharge and the high associated production rates.

Assuming successful removal of dissolved contaminants, the treated supernatant could then be discharged to a receiving water body as is customarily done for upland disposal (if appropriately permitted). The dewatered dredged material could be transported for offloading at a CDF or other disposal site for temporary or permanent containment. Material dewatered in geotubes could potentially be sufficiently contained to permit open water disposal in areas regulated under the CWA, with appropriate evaluation of expected short- and long-term contaminant and material release. If determined to be suitable based on evaluation of contaminant levels in the material, beneficial use may be possible and geotextile tube or barge dewatering would facilitate stockpiling, rehandling and transport of the material. Reduced dredge production may be required in order to work within the limited ponding volume this option would provide, but one advantage is the ability to control release of untreated water and to mobilize the disposal "cell" to various locations. This option has not been fielded previously as far as could be determined, and preliminary engineering evaluations will be required to assess the logistical and technical feasibility.

Geotextile Tube Disposal and Staging Areas: Another possible option to provide temporary containment would be to construct a confined disposal area entirely of geotextile tubes, either in-water or in a wetland area. There are case studies cited in Table H1 where this was done for purposes of marsh restoration. This approach could be coupled with wetland restoration/stabilization efforts when the material is either not too contaminated to present an unacceptable risk, or when the material can be sufficiently isolated with clean layers of overlying sediment or by containment in the geotextile tubes. Alternatively, a layer of geotextile tubes could form a platform for deployment of mechanical dewatering equipment, and water containment and treatment equipment. As previously mentioned, water management could potentially be accomplished in adjacent barges containing carbon filled geotextile tubes or geotextile tubes constructed of fabric containing carbon.

Another alternative that reflects fairly recent technology development is the use of geotextile-encased sand columns (GEC) to provide a foundation for construction of dikes and fastland on

very soft soils (Kempfert et al 2002). This approach could be utilized to create staging areas in shallow water/wetland areas, or to support conventional dike materials for containment areas.

Geotextile tubes could also be used to construct temporary dikes in existing CDFs to segregate oiled material from non-oiled material, facilitating management of the more contaminated material.

Uncertainties/Site-Specific Investigations: There are some uncertainties remaining to be addressed with respect to the use of geotextile tubes for contaminated — particularly oiled — dredged material disposal. These questions may require site-specific evaluation of the appropriateness for a given sediment and contaminant of concern:

- How will oil affect the sorptive capacity of carbon in carbon-containing silt curtains and geotextile tubes? Will the oil preferentially sorb to the carbon to the exclusion of other contaminants, or will the oil, which is known to be a contaminant sink, simply form a relatively stable phase on the carbon that will also sorb contaminants?
- Can geotextile tubes used to construct staging areas using oil contaminated material be left in place? Will the geotextile tubes provide sufficient containment of mobile contaminants that unacceptable environmental affects would be prevented?
- How will the oil degradation rate of material disposed in geotextile tubes differ from that of unconfined oiled sediments? Will there be long-term leachate/filtrate issues? Is it likely the oil will degrade sufficiently that long-term material losses from degradation and weathering of the geotextile tubes would not be an environmental concern and the tubes could be left in place as a permanent disposal option?
- Can the tubes be successfully placed in soft sediments, such as a marsh area? How much will they sink? Can the sunken layer form a stable platform for processing sediments to be disposed off-site? Can the sunken layer be recovered later if it is considered undesirable to leave it in place?
- What changes have occurred in geotextile tube technology since the Davis/Landin workshop?
- Relatively low discharge pressures are required (based on Davis/Landin 1997). Are higher-tensile-strength materials now available? Is a header required to split the flow from a hydraulic dredge between multiple tubes and reduce discharge pressures? What is the optimum fill pressure, and what parameters determine optimum fill pressure?
- It might be possible to inject stabilizing materials along with the dredged material into the tubes such that the tubes would solidify prior to drop, so that material strength would ultimately not be such a critical factor (and also leaching would be less of a concern).
- Could geogrids be used in a similar manner for construction of a rapid dredged material containment area, or will they just crush, or lift, while filling? Could geogrids be used as a water treatment structure if constructed of permeable carbon impregnated materials?

Table H1. Geotextile Tube Case Studies

Case Study	References	Date	Diameter (ft)	Circumference (ft)	Length (ft)	Material	Strength
Bolivar Peninsula	Davis and Landin 1997	1972					
USACE	Davis and Landin 1997	mid-1980s	3		100	Geotextile	Low tensile strength
USACE	Davis and Landin 1997	early-1990s	20-45		100-2000		400 to 1000 test strength
Gailliard Island, AL		1991			500		
Avalon Beach, NJ	Davis and Landin 1997					Polypropylene	
Smith Island, MD	Davis and Landin 1997	1994		45	2000	Polypropylene	400 lb/in tensile
Atlantic City, NJ	Davis and Landin 1997	1995				Geotextile	
Destin, FL		1991			200	Geotextile	
Lake Peoria, IL	Davis and Landin 1997					Geotextile	
Barren Island, MD	Davis and Landin 1997	1995		30-37.5	200	Polyester	1000 lb/in
Port of Oakland, CA	Davis and Landin 1997						
New York District	Davis and Landin 1997						
West Bay Project	Davis and Landin 1997	1991-1992		22.5	1000	Polypropylene	
Arkansas National Wildlife Refuge Project	Davis and Landin 1997			15-22.5	3000		
Port O'Connor Project	Davis and Landin 1997	1993			400		
Victoria Barge Channel Project	Davis and Landin 1997	1994		22.5			
Ashtabula River	Cretens 2009, Cieniawski 2008	2006	~75	70 - 90	80 - 275		400 x 550 lbs/in and 600 x 640 lbs/in
Lower Fox River OU1	Foth 2007	2006		60	158 - 203	Geolon GT500	

Table H1. Geotextile Tube Case Studies (continued)

Case Study	Fill Material	Filling Method	Pipe Diameter	Operating Pressure	Fill Time	Fill Volume (yd^3)	Final Height (ft)
Bolivar Peninsula							
USACE	Water & sediment						
USACE							
Gailliard Island, AL	Fine grained mud	Direct pumping	8 in (attached to 30 in dredge discharge pipe)	4 psi (reduced from 18 psi from dredge discharge pipe)	90 minutes	1000	75% loss in tube height following dewatering
Avalon Beach, NJ							
Smith Island, MD							3.5-4 ft (design height 9 ft)
Atlantic City, NJ	Sand	Induction pump dredging sand off beach					
Destin, FL		Crest was slit open to allow sandbags to be placed inside.					
Lake Peoria, IL							
Barren Island, MD	Sand (20%)/silt mixture						
Port of Oakland, CA	Fine-grained contaminated sediments	Bucket-dredged sediments slurried using submersible hydraulic pump					
New York District	Contaminated material					4000	
West Bay Project	Sand						3.5
Arkansas National Wildlife Refuge Project	Mixture of sand and fines	Filling sleeves every 100 ft					
Port O'Connor Project							4
Project	Sand				9 hrs		
Ashtabula River	PCB-contaminated, fine-grained sediment, w/ polymer	Cutterhead dredges (8-in and 12-in)	12-in main header, to 10-in mini-headers				
Lower Fox River OU1	Thickened slurry (15-35%)						6 ft initial fill ht

Table H1. Geotextile Tube Case Studies (continued)

Case Study	Placement	Erosion Control Measures	Installation Method/Issues	Long-term Performance
Bolivar Peninsula	Marsh stabilization			As of 1995, tubes were deteriorated but still in place.
USACE	Underwater surge protection		Awkward design, difficult to fill	Unstable under tested conditions
USACE			Problematic placement, filling and handling	
Gailliard Island, AL	Used to raise the height of dikes around 1400 ac CDF in Mobile Bay	Blanket installed beneath tubes and extending to either side of tubes	Excess pressure can cause rupture, especially where fabric is already stressed or damaged (abraded) in transport	Over time, phragmites grew through the fabric
Avalon Beach, NJ	Shallow water parallel to waterline between rock groins to retain sand for beach augmentation			
Smith Island, MD	Shallow water adjacent to Smith Island as containment for sandy material		Difficulty filling tubes to heights greater than 4 ft. An 8-in dredge initially used, and switched to a 10-in dredge to provide greater filling pressure. Filling sleeves located 25 ft apart on tube crest. Tubes tended to twist n some locations during filling. Landward end of tubes was keyed into the shoreline to prevent flanking erosion at the end of the tube.	
Atlantic City, NJ	In front of boardwalk for shore protection	Tube placed in trench on top of impermeable fabric, then covered with sand and vegetated		Some exposure of tube expected due to wave erosion during storm events
Destin, FL	Installed as groins near East Pass inlet	Scour blanket		As of 1995, tubes had not deteriorated but had been partially covered by sand deposits.
Lake Peoria, IL	Planned as donut-shaped, in-lake dredged material containment			Unknown whether ever constructed
Barren Island, MD	Retaining dikes for sandy dredged material for erosion protection		Pumping distance for dredge varied from 6000 to 12000 ft; 1000 HP pump used with 14-in suction pipe and 12-in discharge pipe. The fabric of the first 6 tubes split when tubes reached a height of 3 ft; addressed by providing a relief outlet in the tube, using higher tensile strength tubes (1000 lb/in), and splitting the flow between the tubes and the containment area.	

Table H1. Geotextile Tube Case Studies (continued)

Case Study	Placement	Erosion Control Measures	Installation Method/Issues	Long-term Performance	Cost
Port of Oakland, CA			Tube fill tested on gradually sloped pier, tended to roll during filling.		
New York District					
West Bay Project	One thousand ft placed as the overflow structure for a ring dike to contain dredged material for creation of an island 5000 ft x 225 ft parallel to the Gulf Intercoastal Waterway	Fabric blanket 24 ft wide (2-12 ft sections sewn together) with 18 in diameter tube	Geotextile tube deployed; approximately 300 ft of the 1000 ft tube at a time, from the back of a barge. The in-water portion was then filled with sand. A 10-inch-diameter dredge pipe was used to reduce discharge pressures. Difficulty placing tube on a straight alignment and with a consistent crest elevation but still functional and resulted in a more random marsh edge behind the tube.	At 2.5 years, tube structure providing good protection, remaining in place with little subsidence	
Arkansas National Wildlife Refuge Project	Tubes extended bayward for 400 ft, then 2200 ft parallel to an existing open water dredged material mound.		Two failures due to seam rupture during construction. Erosion increased near the end of the geotextile tubes, which simply terminated on the shorline.	At 2 years, the tubes were in good condition, the fabric scour blanket and anchor tubes were covered with sediment, and marsh was establishing behind the structures.	
Port O'Connor Project	Placed as a groin in 1 to 2 ft of water, to protect marshes/seagrass beds from beach fill location.		Tube deployed off a roll mounted on the end of a barge. An 8-in-diameter dredge pipe used for filling.	Some deflation occurred during the first 18 months due to a cut in the top, apparently due to vandalism. The remainder has sustained the initial height. Some colonization of the tubes by barnacles and oysters noted.	
Victoria Barge Channel Project	Geotextile tubes used in place of earthen dikes for overflow section of dredged material containment area.	Placed on firm, relatively level substrate with underlying scour blanket		Tubes reported in good condition in 1995, though elevation lower than desired. Larger tubes reportedly may have been more effective. Life expectancy - decades, if UV degradation, vandalism and debris damage can be avoided.	$50-$150/lineal foot (at time of installation)
Ashtabula River	Placed in a landfill with leachate collection system; Tubes were stacked 10 high, allowing 15 days to air dry between layers.		Ten thousand lb capacity telehandlers with 56 ft vertical reach used to deply tubes on site. six-wheeled ATV used to unroll the tube; Partial filling of first layer used to level the sloped floor		
Lower Fox River OU1	Tubes stacked 4 high in pyramid fashion; Placed on dewatering pad with composite barrier beneath crushed limestone; Dewatered sediment excavated and trucked to landfill			Failure of one tube during operations.	

Engineering Controls: Depending on the disposal option selected, it may be necessary to employ controls during dredging and disposal to reduce potential impacts to the water column or benthos from release of oil and oil-contaminated particulates to the water column. The following are some structural and operational alternatives for reducing resuspension and limiting migration of oil, other contaminants and oil-contaminated particulates, and control and recovery of oil released into the water column.

Open Water Disposal: For open water disposal, engineering controls may be employed to control the release of contaminants to the water column during and after disposal, and to protect against benthic impacts. Contaminated materials can be capped with a clean layer of material to minimize diffusion of contaminants to the water column and to isolate dredged material from benthic organisms. Geotextiles may be used as part of a protective cap; geotextile tubes can be used as another form of in-water containment as previously discussed. Submerged discharge can be employed to minimize the release of dredged material into the water column above the disposal site. Oil booms can be used to contain and absorb floatable contaminants. Silt curtains can be used to reduce particulate transport in the upper water column; permeable silt curtains impregnated with sorbent are now available from some manufacturers and may be effective in capturing dissolved contaminants released to the water column during disposal. The use of silt curtains in this application is currently being evaluated in laboratory studies, but the curtains themselves are commercially available.

Confined Disposal Facilities (Upland Disposal): Upland disposal alternatives such as confined disposal facilities (CDFs) or geofabric containers (GFCs) may require some controls to restrict release of contaminants in any discharge (effluent or runoff) from the site. Control methods for treating effluent (the initial release of water from the dredged slurry) or runoff (water leaving the site following precipitation) may target particulate-associated contaminants or dissolved (or free) contaminants. For particulate-associated contaminants, control methods include the use of filtration at the point of discharge or addition of flocculants to settle out particulates. If long-term management is deemed necessary, after initial dewatering, establishment of vegetation on site or capping the site with clean material can help control release of particulate-associated contaminants. Oil booms placed prior to the weir discharge may be used to capture oil on the surface. Permeable silt curtains impregnated with sorbent material may be applicable for contaminant reduction from effluent and runoff of CDFs; as previously stated, use of silt curtains in this application is currently being evaluated in laboratory studies, but the curtains themselves are commercially available.

Dredging Site Controls: Controls may also be needed to minimize oil and associated contaminant releases resulting from resuspension of sediments at the dredging site and loss to the water column. Control measures used for environmental dredging of contaminated sediments (Palermo et al. 2008) are potentially applicable here.

Operational measures that can be used to reduce resuspension include:

- reducing the dredging rate;
- reducing bucket over-penetration;
- eliminating overflow;
- altering the operation based on changing site conditions (tides, winds, currents, etc.);

- modifying cutterhead depth;
- dredging from upstream to downstream; and
- using wash tanks or submerged trays to contain bucket spillage.

Engineering control measures for resuspension usually consist of physical barriers such as silt curtains or silt screens, pneumatic (bubble) curtains and coffer dams, which may be constructed of geotextile tubes or sheet piles, for example. These measures may not be applicable at all sites, depending upon water depth and velocity at the dredging site. Because release of oil due to sediment resuspension during the dredging process is a potentially significant concern, surface containment and oil recovery may be required in the dredging area. Oil-absorbent booms may be required around the dredge. Oil booms can be supplemented with sorbent materials such as polypropylene mats to sorb surface oil within the boomed off area, or oil skimmers could potentially be used to recover surface oil in the dredging area. Methods to encourage resettling of suspended sediments can be helpful in minimizing the associated contaminant release. Such methods include flocculation and quiescent settling to increase sedimentation.

Control of oil releases throughout the vertical profile of the water column might include the use of:

- filtering geotextiles applied with silt curtains (currently under development); and
- dispersing adsorbents (activated carbon or zeolite) inside the containment enclosure.

Lastly, control of volatile emissions may be a consideration when dredging in oil impacted areas. The following are operational methods to minimize volatile releases:

- Dredging during cooler weather or nighttime hours
- Using surface volatilization barriers
- Decreasing the surface area of the dredge enclosure
- Covering dredged material with a physical barrier during transport
- Degassing the pipeline before discharging to onshore facility.

Some residual contamination may remain after dredging. If needed, controls to address residuals include overdredging or capping the dredge area with clean material. Note that control measures can be expensive, may impact the production rate and can impact the project and environment; control measures should therefore be used judiciously and only where clearly needed and likely to be beneficial.

Treatment: Treatment of contaminated materials may be considered when contaminant levels are too high to permit conventional disposal alternatives, and when landfilling would be equally costly, space is not available, or transport logistics are infeasible. One benefit of treatment is that the treated materials may then be sufficiently decontaminated to be used beneficially. Various treatment options might be considered:

- Biological treatment (composting, landfarming)
- Thermal treatment (low temperature thermal desorption, high temperature contaminant destruction and immobilization)
- Sediment washing

Biological composting has been demonstrated to be effective in reducing organic contaminant levels in sediments, although some PAHs have proved recalcitrant to biodegradation. The effectiveness of this treatment alternative for the specific contaminants of concern would have to be demonstrated in the field; biological treatment cannot be used to remove or immobilize metals, but has been demonstrated on petroleum products. Some advantages of composting are that it is a low tech, low energy technique that could be implemented within a CDF by non-technical personnel. Costs of such treatment would be limited to associated equipment for mixing the sediment with appropriate amendments, such as leaf litter, labor to operate the equipment over the period of treatment, and analytical costs to demonstrate that adequate treatment has been achieved.

Thermal treatment has been demonstrated at large pilot scale for treatment of contaminated sediments. High temperature treatment such as that accomplished with a cement kiln or glass kiln adapted for the purpose is generally effective for destruction and immobilization of most contaminants, although some may remain minimally leachable in the resulting "aggregate." Thermal treatment is energy intensive, however, and the equipment is large and heavy, and therefore not mobile. Treatment cost is in part a function of the volume to be treated; unit cost for treatment of larger volumes will be lower than for that of small sediment volumes due to economies of scale. Based on recent sediment demonstrations, the economics of this type of treatment presumes a relatively large annual treatment volume (e.g. 250K - 500K $yd^{3/}yr$) over the useful life of the plant (e.g., 15-30 years). Estimated thermal treatment costs based on recent sediment treatment demonstrations were in the range of \$70-\$100/yd^3 (December 2009 values; Estes et al in publication), excluding any potential revenue that might be generated through the sale of the treated product. Cost is likely to be considerably higher for a temporary plant constructed for the treatment of a finite volume of sediment, and which has to be demobilized once treatment is completed.

Low temperature thermal desorption may be effective for reducing organic contaminants in oiled sediments sufficiently that they would be suitable for conventional disposal or beneficial use. With low temperature desorption, organic contaminants are removed from the sediment by volatilization. Metals are not removed unless they are relatively volatile, such as mercury. Current costs for low temperature thermal desorption were not available at the time of this report, but the technology would be expected to be less capital and energy intensive than high temperature thermal treatment and possibly more mobile.

Sediment washing may be effective in reducing the volume of contaminated material requiring treatment or confined disposal by separating more highly-contaminated sediment fractions from relatively clean fractions. A proprietary sediment washing/oxidation process has been demonstrated at large pilot scale and some contaminant reduction was achieved; oxidation of PAHs has proved to be problematic to date, however, and most contaminant reduction appears to be attributable to separation of more highly contaminated sediment particles and transfer of contaminants to the aqueous phase. Sediment washing is a relatively low energy process, but one disadvantage is the production of a large aqueous waste stream requiring management, treatment and disposal. Simple separation processes may be useful in segregating more contaminated materials for disposal or further treatment. Separation does require some bench scale assessment of contaminant distribution and sediment properties (particle size and density of expected target fractions), and careful selection of equipment such that the separation targets the appropriate

fractions, or the expected contaminant reduction may not be achieved. Costs for the proprietary sediment washing process were estimated to be in the range of $50/yd^3 treated (December 2009 values; Estes et al in publication), but also assume a minimum annual treatment volume and performance period that would not be met for short term projects. As for thermal treatment, unit costs for treatment of small volumes may be higher.

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