Shoreline Treatment during the Deepwater Horizon-Macondo Response

February 4, 2011

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ABSTRACT

The shoreline treatment program for the Macondo oil spill response following the Deep Horizon incident in April 2010 in the Gulf of Mexico involved the development of strategies and tactics for a range of oiling conditions on sand, wetland and man-made shore types. The response was characterized by three strategic phases: (1) spring/summer 2010 on-water operations to recover oil and prevent shoreline oiling; (2) 2010 Shoreline Cleanup Assessment Technique (SCAT) surveys, shoreline bulk oil removal and treatment to 2010 No Further Treatment (NFT) conditions, and (3) a 2011 SCAT resurvey and treatment to Stage 4 2011 NFT guidelines. To assist the shoreline response decision process within the Unified Command, two regional inter-agency Core Groups were created to develop treatment strategies and plans, response priorities and schedules. Technical working groups (TWGs) for sand beaches, wetland and man-made shorelines were established to develop specific treatment recommendations, Stage 3 2010 NFT conditions and Stage 4 2011 NFT guidelines. The foundation for the shoreline treatment program was the systematic SCAT survey program and the creation of a consistent data and knowledge base. Importantly, the same cadre of SCAT field team leaders was

maintained throughout the program to provide a professional, calibrated, high-quality knowledge base.

INTRODUCTION

The response to the Macondo oil spill involved the rapid establishment of a shoreline response and Shoreline Cleanup Assessment Technique (SCAT) program that is described elsewhere (Santner *at el*. in these Proceedings). A key feature of the program was the development of a long-term multi-phased strategy that could evaluate changing oiling situations and respond to these appropriately. A key component in maintaining consistency within the SCAT program and throughout the response theatre was the continuous communication between SCAT teams at each command center through daily debriefing sessions and discussions.

The Unified Command (UC) Nearshore and Shoreline Stage I and II Response Plan defined the three stages of the SCAT program:

Stage I On-water recovery of floating oil slicks in near shore waters

Stage II Initial cleaning of bulk oil from intertidal areas until the source is controlled

Stage III Removal of oil to habitat-specific cleanup endpoints once source control is achieved

Stage III began when the UC determined that there was "No recoverable oil on water".

Stage III.1 *Re-Baseline SCAT Survey, generation of STR/SIR Forms, shoreline treatment and inspection based on Stage 3 2010 No Further Treatment (NFT) guidelines developed by the Core Group*

Stage III.2 *Post-treatment Monitoring and Maintenance: Periodic SCAT surveys and monitoring supported by maintenance cleanup teams*

For the sake of simplicity, a new numbering scheme was applied with the spring 2011 SCAT resurvey. From this point onwards, each survey-treatment-inspection cycle would be numbered as a new stage.

Stage 4

- *Re-Baseline SCAT Survey in late-winte 2011r/spring 2011*
- *Preparation of Shoreline Treatment Recommendations (STR-4) to meet Stage 4 2011 No Further Treatment (NFT) guidelines*
- *Generation of a Shoreline Inspection Report (SIR-4) for a segment after completion of treatment*
- *Transition of segments that meet the Stage 4 2011 NFT guidelines out of the Stage 4 Unified Command shoreline response program to the National Response Center (NRC) reporting process.*

Future survey-treatment-inspection cycles, for example a planned post-2011 hurricane season survey, would be numbered Stage 5, etc.,

Oil did not reach the shorelines until the second week of May, by which time SCAT teams and Shoreline Operations were in place. The objective of shoreline operations in Stage II was the recovery of the larger amounts of stranded oil ("bulk oil") as quickly as possible. The Stage II plan was approved by the UC on 6 May and continued in effect until early September after the well was capped and when the determination was made by the UC that the risk to shorelines from recoverable oil on the water was no longer an issue.

This discussion focuses on the 2010 program as the 2011 response was still active at the time when this paper was prepared (February 2011).

2010 SCAT PROGRAM SUMMARY

The SCAT program was coordinated and logistics support provided through two bases at Command Posts in Houma LA and Mobile AL, each with a SCAT Coordinator, Logistics Coordinator, and Data Base Manager. These SCAT centers were maintained after the Command Posts were consolidated in New Orleans in the fall of 2010.

A key element of SCAT survey program was the systematic nature of the surveys and the creation of a consistent data and knowledge base. Importantly, the same cadre of SCAT field team leaders was maintained to provide consistency and continuity throughout the survey program. Standard SCAT terms and definitions were applied. A Combined Shoreline Oiling Summary (CSOS) form was created to merge the Shoreline Oiling Summary (SOS) and the Tar Ball Oiling Summary (TBOS) forms. Importantly, for this response a distinction was made between tar balls (TB) and oiled (sand) particles (Surface Residue Balls or Patties – SRBs/SRPs) as TBs were not from the Macondo spill. Typically the Macondo oil created oil-agglomerated sediments (up to 90% sand and 10% oil) rather than hard, sediment-poor, asphalt-like oil residues. The only significant change to the standard definitions was made in the Initial Surface Oil Cover Matrix as the "oiled area widths" of 6, 3, and 0.5 meters were replaced by 6, 3, and 1 feet to reflect the low tidal range within the study area.

A SCAT database was developed and was extensively revised and modified throughout the response to accommodate the unique situations and requirements of the Macondo SCAT surveys. An independent GIS component was developed to link to the database and allow for the production of mapping products, which were critical to situations updates for the UC and to the success of the field program.

The first ground survey was conducted on 4 May and, typically, between 15 and 20 SCAT teams were deployed each day. By the end of 2010, the SCAT survey data show that the total length of shoreline oiled at some point in time after April was 1,053 miles and that operational treatment (Stage III.1) had been recommended for 336.6 miles, of which 263.3 miles had been completed or were being treated or cleaned at the time this paper was prepared.

A summary of the maximum oiled shoreline lengths for each of the four affected states through 31 December 2010 is provided in Table 1. A significant point is to recognize that the length of the coastal wetlands in the affected area of Louisiana is more than 10,000 miles, based on GIS mapping conducted in this project, and that much of these are back-bay areas that were protected by the front-line wetlands and never oiled. A total length of 2,760 miles of wetland shorelines were surveyed on the ground and, due to the on-water response strategies and the outflow from the river, of this total only 15.6% (430.5 miles) was oiled and only 6.4 % (175.5 miles) was in the Heavy or Moderate

Oiling categories. In the Eastern States (Mississippi, Alabama and Florida), the degree of oiling was predominantly (79%) in the Very Light or Light Oiling Categories.

The level of effort in the 2010 SCAT program can be summarized by the following facts:

- >105,000 miles flown as part of the shoreline aerial reconnaissance surveys in Louisiana in May 2010
- SCAT teams completed more than 1,700 field days (not including aerial surveys, monitoring and other field activities)
- 4,223 miles of shoreline and 5,469 segments were surveyed
- >30,000 pits were dug or augured
- ~200,000 digital photographs are filed in the data base.

STAGE II – BULK OIL FREMOVAL

Stage II of the response plan consisted of removal of bulk oil which was defined as: 1) mobile oil in intertidal areas that poses a threat to adjacent habitats or resources, and 2) stranded oil on a segment or zone that is defined by a combination of surface oil thickness, % distribution and width (see matrix in Figure 1). Using this matrix, Stage II cleanup would remove bulk stranded oil defined as:

- Oil band at least 3 ft wide, greater than 10% distribution, and "Coat" or thicker (>0.1mm)
- Oil band at least 1 ft wide, greater than 50% distribution, and oil "Cover" or thicker (>1mm)

Stage II activities could be repeated if oil continued to be deposited in intertidal areas. Because some areas may have been (or became) sensitive to either repeated cleaning, or repeated oiling, those areas were monitored and the cleaning adjusted (either down or up) to minimize damage.

For some areas with bulk oil, it could be determined that any effort to remove the oil will likely cause significant impacts; thus, it would be appropriate to conduct cleaning once and only when there was little or no risk of repeated oiling. Examples include interior marsh oiling which was only accessible by vegetation cutting and/or use of boardwalks, and oil penetration into muddy tidal flats. Areas particularly sensitive to oiling required cleaning to a Stage III level on a repeated basis for the duration of the re-oiling period to minimize environmental damage until source control was achieved. Examples include areas of high environmental significance (e.g., turtle nesting areas, or high amenity value (e.g., high-use tourist beaches/waterfront parks, local residential areas).

STAGE III.1 - CORE GROUP AND TECHNICAL WORKING GROUPS

In late July the shoreline response team created multi-agency Core Groups: one for Louisiana and one for the Eastern States (Mississippi, Alabama and Florida), to coordinate the development of a draft Stage III shoreline treatment plan and to establish schedules for completion. Specifically the Core Groups were tasked to:

- Define shorelines that need treatment

- Set treatment priorities
- Develop shoreline treatment recommendations by habitat type
- Monitor the cleanup process to determine the effectiveness and impacts of treatment
- Develop 2010 No Further Treatment (NFT) guidelines by shoreline type so that SCAT teams would be able to determine when and where to recommend treatment/cleanup.

Three Technical Working Groups (TWGs) were established for Sand Shorelines, Coastal Marshes and Mangroves, and Man-made Shorelines to work on habitat specific issues, treatment recommendations, and 2010 NFT criteria. The reports generated by each TWG formed Appendices to the Core Groups' final reports – "The Stage III SCAT-Shoreline Treatment Implementation Framework."

The 2010 NFT guidelines for Eastern States sandy shorelines are summarized in Table 2, for Louisiana coastal marshes and mangroves in Table 3, and for Louisiana man-made shorelines in Table 4.

Waste minimization was a core principle for sand beaches with the intent to remove as little sediment as practical from the shore zone. Treatment methods for sand beaches comprised manual and mechanical removal, an on-site treatment plant, and sediment relocation. Mechanical removal involved a range of commercial self-propelled or towed machines designed primarily to sieve debris and litter on recreational beaches. Field trials were conducted to evaluate which specific mechanisms were more appropriate for the different oiling conditions. The beach cleaners were used as scrapers on the more heavily oiled beaches in Louisiana whereas the sieving function was more appropriate to recover oil particles on the beaches of the Eastern States.

Oiled wetlands included *Spartina* salt marshes and *Phragmites* ("roseau cane") brackish-freshwater wetlands in the Mississippi delta. Previous spills in this regional provided an understanding of the recovery potential for the oiled wetlands so that natural recovery was the preferred strategy in most cases based on the generally light oiling conditions. Natural attenuation was relatively rapid as the oil type had an API gravity of 35. A guiding principle for wetland treatment was to minimize physical intrusion and work from floating platforms, skiffs or shallow-draft barges, whenever possible. Floating mechanical flushing machines, using concrete pump arms, were used on a limited scale to reach into oiled fringe wetlands to wash and recover mobile oil.

Oiled rip rap, breakwaters, groins and jetties, were treated through manual removal of bulk oil and washed using a range of temperatures and pressure depending on the character of the oil.

The Stage III.1 concept was to achieve the 2010 NFT conditions as quickly as possible and transfer segments that had reached these standards to a winter monitoring and maintenance program (Stage III.2) prior to a spring 2011 SCAT resurvey and 2011 cleanup operation (Stage 4). Post-treatment inspection by the SCAT teams involved the land owner/manager and/or resource manager/trustee. If the segment met the 2010 NFT conditions a Shoreline Inspection Report (SIR) was signed and submitted to the Unified Command (UC) thereby transferring the segment to Stage III.2. Given that a number of shorelines continued to have recurring oil, either re-mobilized and re-deposited or exposed as wind and waves reworked the shoreline, most amenity beaches continued through winter with maintenance operations.

2011 SHORELINE SURVEY, CLEANUP ENDPOINTS, AND SIGN OFF

The Core Groups were reconvened in January 2011 to develop a Stage 4 plan and to propose Stage 3 NFTs. The strategy mirrored the 2010 Stage III program in many respects with a revision of treatment recommendations and Stage 4 2011 NFT guidelines to create STR-4s following SCAT surveys of all 1830 segments for which oil had been documented in 2010. The 2011 plan specified the process by which the segment would be inspected by the SCAT teams and the land owner/manager and/or resource manager/trustee so that a signed SIR would document that the treatment program had achieved the endpoint criteria. This program was still active at the time this paper was prepared (February 2011).

DISCUSSION

The character and organization of the shoreline response was controlled by the scale of the operation, both in space and time. The shoreline response was conducted through multiple Branch Operations centers, each of which was supported by embedded SCAT Operations Liaison teams. The SCAT program itself was divided geographically into two independent sectors, but with common and consistent documentation procedures and protocols. SCAT teams surveyed 4,223 miles of coast which, in 2010 alone, involved more than 12,500 miles of actual repetitive documentation effort, not including other activities related to non-SCAT post-treatment surveys or monitoring. Full-scale SCAT surveys were conducted in spring and fall 2010 and spring 2011. Due to the changing nature of the spill, the shoreline program was phased to take into account reoiling that continued through the summer of 2010, with continuous bulk oil recovery or treatment, followed by a program in fall-winter to meet 2010 NFT guidelines and a spring-summer cleanup program to meet 2011 endpoint criteria.

Two key elements in the development of shoreline treatment recommendations were the application of Net Environmental Benefit (NEB) concepts for oiled wetlands and waste minimization for the cleanup of sand beaches. The environmental benefit analysis was conducted based on experience and the well-established principle that cleaning beyond a certain level, particularly in wetlands, can delay rather than accelerate recovery. The 2010 NFT guidelines and Stage 4 2011 NFT guidelines were based on habitat use (human and biological)) and geomorphological concerns (particularly in Louisiana). Many field trials were conducted to evaluate treatment tactics or equipment, particularly for the sand beaches (see Owens *et al*. - these Proceedings). These principles were communicated through the STR process and interpreted for Operations by the SCAT Operations Liaison teams.

The STRs, through which the recommendations developed by the TWGs were incorporated into the ICS process as work assignment, and the post-treatment inspection surveys, which led to the generation of the Shoreline Inspection Reports (SIRs), are described in more detail elsewhere (Santner *et al*. – these Proceedings). The generation of STRs involved a complex decision and approval, and sometimes time-consuming process. The complications for STR sign-off were due in part to the multi-layer and multi-agency involvement of the many federal, state and local parties as well as having geographically distinct command and branch headquarters. All STRs were submitted to the appropriate agencies for consultation under Section 7 of the Endangered Species Act and Section 106 of the National Historic Properties Act. The U.S. Fish and Wildlife Service and the National Marine Fisheries Service, NOAA developed Best Management Practices (BMPs)

to minimize potential impacts to Threatened and Endangered species, which became part of the STR. Natural Resource Advisors (NRAs) were assigned to the operational branches to monitor for compliance with the BMPs and advise on methods to minimize impacts to protected resources. The Section 106 consultation included review by and concurrence of Federal, State, and Tribal representatives. Teams of archaeologists conducted field surveys (often as part of the SCAT team) of the entire impacted shoreline to locate known cultural resources and identify sites of potential cultural concern. Depending on the treatment method, an archaeological monitor was required to be present during operations, to provide direction on avoiding or minimizing impacts to cultural resources.

Though sand beaches are considered to be the easiest shoreline type to clean, several unique and challenging issues were encountered during the response to this spill:

1) recurring oiling, during the four months that surface oil continued to strand on the shoreline, re-oiling during storm events that exposed buried oil by beach erosion by waves and wind, and chronic deposition of new oil from oil/sediment mats located in the lower intertidal zone and nearshore subtidal zone;
2) stranding of oil during storm events (including Hurricane Alex) where the oil was deposited in the supratidal zone and on beaches that had been eroded, then buried as the sand returned, meaning that the buried oil was not within the normal erosion/deposition zone on the shoreline: oil was buried by up to 1.5 meters of clean sand, requiring removal and side-casting of extensive amounts of clean sand to access the buried oil, particularly on amenity beaches;
3) the need for mechanical auguring to delineate the buried oil over large areas, both along-shore and cross-shore, on beaches;
4) the widespread occurrence of oil/sediment mats in the lower intertidal zone that posed particularly challenging cleanup operations during the summer and fall because of high water conditions during daylight hours, as well as extensive removal of clean sand deposited on top of the mats over time;
5) restrictions on mechanical methods (including sediment relocation) on sand beaches on other than high-amenity use beaches in Louisiana because of geomorphological concerns that mechanical methods would increase the rate of beach erosion;
6) access restrictions on many of the remote barrier islands where mechanical equipment was not allowed or restricted;
7) requirements for archaeological monitors during “ground disturbing” activities, including auguring and pit digging to locate buried oil as well as mechanical treatment; and
8) an NFT guideline of no visible oil above background on amenity beaches, considering all the other above issues.

It would not be an understatement to describe the shoreline response to the Macondo spill as a complex operation. The geographic scale of the affected area and the changing oiling conditions posed many challenges, both administratively and logistically, for both the SCAT program and the Operations teams.

Table 1: Summary of 2010 Maximum Oiled Shoreline Lengths (miles) by Surface Oil Category, Shore Type and Region

SUMMARY OF 2010 MAXIMUM SURFACE OIL BY SHORE TYPE (miles)								
Louisiana Shore Type	Total Length Surveyed	SURFACE OIL CATEGORY					No Oil Observed	Maximum Oiled Length
		Heavy	Moderate	Light	Very Light	Trace (<1%)		
Beach	360.0	53.3	32.5	62.1	36.7	8.3	167.0	193.0
Wetland	2760.1	80.5	95.0	114.7	125.6	14.7	2329.6	430.5
Man-made	24.0	3.0	1.4	2.3	1.6	2.9	12.7	11.3
Totals	**3144.1**	**136.8**	**128.9**	**179.1**	**163.9**	**25.9**	**2509.4**	**634.7**

Eastern States Shore Type	Total Length Surveyed	SURFACE OIL CATEGORY					No Oil Observed	Maximum Oiled Length
		Heavy	Moderate	Light	Very Light	Trace (<1%)		
Beach	651.5	78.6	4.8	198.0	17.8	73.6	278.8	372.7
Wetland	317.4	0.7	3.5	16.7	10.5	3.4	282.7	34.8
Man-made	109.7	0.1	0.3	4.1	2.8	2.9	99.4	10.3
Totals	**1078.7**	**79.3**	**8.7**	**218.8**	**31.0**	**79.9**	**660.9**	**417.8**

TOTAL	**4222.8**	**216.1**	**137.6**	**397.9**	**194.9**	**105.8**	**3170.3**	**1052.5**

Table 2: 2010 NFT Guidelines for Eastern States Sandy Shorelines

2010 NFT Guidelines for Eastern States Sand Shorelines			
Beach Type	**Treatment Methods Recommended**	**Surface Oil NFT Guidelines**	**Subsurface Oil NFT Guidelines**
Oiled Residential/Amenity Beaches (e.g. Dauphin Island, Gulf Shores, Orange Beach, Pensacola)	Mechanical (sifting) Manual removal Tilling or Sediment relocation	No visible oil above background levels	No visible oil above background levels
Oiled Non-Residential Beaches (e.g., West Dauphin, Eglin AFB)	Mechanical (grooming - sifting) Manual removal Sediment tilling/mixing Natural recovery	< 1% visible surface oil and oiled debris; and no SRBs >5cm (2 inches)	No subsurface oil exceeding 3 cm (1¼ inches) in thickness and patchy (<50%) distribution that is greater than Oil Residue
Other Oiled Beaches in Special Management Areas (state and federal wildlife refuges, parks, wilderness areas, which may also have a mix of oiling conditions)	Mechanical (grooming - sifting) Manual removal Sediment relocation Natural recovery	< 1% surface oil and oiled debris; no SRBs >2.5cm (1 inch)	Subject to direction of Special Area Managers: No subsurface oil exceeding 3 cm (1¼ inches) in thickness and no more than patchy (<50%) distribution that is greater than Oil Residue

Table 3: 2010 NFT Guidelines for Louisiana Coastal Marshes and Mangroves

2010 NFT Guidelines for Louisiana Coastal Marshes and Mangroves	
Treatment Methods Recommended	**NFT Guidelines**
Low pressure ambient temperature flushing	No more flushable oil on the vegetation or soils
Sorbents	No more release of sheens that can affect sensitive resources
Manual removal Sorbents Vacuum	No more thick or pooled oil at the edges of - The marsh - The beach/shell berm/overwash areas No more thick or pooled oil in the marsh interior, including isolated oiling patches within the marsh
Vegetation cutting	No more pooled oil inside dense Roseau cane, that cannot be accessed by other means
Natural recovery	For all other oiling conditions

Table 4: 2010 NFT Guidelines for Louisiana Man-made Shorelines

2010 NFT Guidelines for Louisiana Man-made Shorelines	
Treatment Methods Recommended	**NFT Guidelines**
Low pressure ambient temperature flushing Sorbents Manual removal Shoreline cleaning agents Vacuum Vegetation cutting Natural recovery	No accessible oiled debris For non-amenity areas, no surface oil greater than Stain or Coat > 20 % distribution No oil on surfaces that rubs off on contact In high public use or high visibility areas, no surface oil greater than Stain or 10% Coat distribution on solid surfaces In inaccessible or remote areas where oil removal was not possible because of safety restrictions or ecological/cultural restraints, no longer generates petrogenic sheens that can affect sensitive resources under all weather conditions