APPLICATION OF IN-SITU BURNING DURING THE MOSQUITO BAY OIL SPILL: OBSERVATIONS AND TRADE-OFF DISCUSSION

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ABSTRACT: *On 11 April 2001, the Unified Command received permission from the Regional Response Team (RRT6) to conduct a series of* in-situ *burns at an oil spill site in a remote coastal marsh adjacent to Mosquito Bay, Louisiana. Approximately 12 acres of marsh were contaminated with an estimated 1000 bbl of condensate crude oil. Because the spill was largely contained in low areas of remote interior marsh, conventional oil recovery techniques and mitigation would have caused unacceptable physical marsh impact; therefore,* in-situ *burning was considered the most environmentally friendly approach to minimize impact from the spill. Overall, the application of* in-situ *burning was considered a positive environmental trade-off since any manual response in such a sensitive marsh would involve greater negative environmental trade-offs. This paper focuses on an overview of the incident and the scientific and environmental issues that were evaluated and presented to the Unified Command in making the final decision to use* in-situ *burning as a mitigation technique.*

Introduction

In-situ burning oil stranded in coastal marshes as a mitigation technique has been used in response to several oil spills over the last decade (Clark and Martin 1999, Dahlin et al. 1999, Hyde et al. 1999, and Mendelssohn et al. 1995). Each time burning was considered and employed, the response and science community expanded technical and scientific knowledge of the process and the environmental trade-offs that must be considered when evaluating the option of *in-situ* burning. *In-situ* burning has the potential to remove large volumes of oil rapidly, however, it also has the potential to create adverse public safety and environmental damage. As with any emergency response, public safety is a priority. Secondly, the advantages and disadvantages to the impacted and adjacent ecosystem must be evaluated. If an *in-situ* burn is physically practical with no public safety concerns and a positive environmental benefit, burning meets the conditions of a best response option and should be considered.

Unlike conventional marsh burning as a management tool (also called prescribed burning), oiled marshes burn with a far greater intensity and generation of both heat and smoke than typical marsh fires supported only by the combustion of dead litter and living vegetation alone. As a result, many of the conventional guidelines for burning marshes must be modified to account for the addition of petroleum as the dominant fuel source.

One of the most difficult issues to evaluate in considering *in-situ* burning is control of the burn. For the most part, fire control actions by responders are severely limited once the oil is ignited – the oil and marsh will burn until environmental factors no longer support combustion. Firebreaks are not always effective. This paper focuses on the evaluation process at an oil spill in South Louisiana where *in-situ* burning was considered and employed.

Incident overview

On 11 April 2001, the Unified Command (UC) requested permission to conduct a series of *in-situ* burns at a pipeline spill in a remote coastal marsh. The location of the spill was approximately 29° 16.5' N Latitude, 091° 10.7' W Longitude and adjacent to Mosquito Bay, Louisiana. The location of the spill was extremely remote and could only be reached by boat or helicopter. Original estimates of the spill size were inaccurate because much of the affected area was within the heavy marsh and could not be accurately estimated from the air. Once the marsh had been ground-truthed, a more accurate estimate of 1000 bbl of condensate oil (crude oil co-produced in a primarily gas well) had been released before the source was completely shut in and controlled. The spill resulted from the failure of a 20-inch pipeline that carried natural gas and condensate oil. Approximately 12 acres of marsh were heavily oiled. Initial estimates suggested that a larger area, approximately 37 acres, was either oiled or within the immediate threat zone. The spill was largely contained in low areas of interior marsh where conventional oil recovery techniques and mitigation would have caused unacceptable physical marsh impact; therefore, *in-situ* burning was considered the most environmentally friendly approach to minimize impact from the oil spill.

After considerable discussions, the Unified Command presented a plan to the Regional Response Team (RRT6) on 11 April 2001 during an interactive conference call. RRT6 granted approval for the use of *in-situ* burning. The approved plan included an initial "test" burn in an area just west of the spill site where oil had escaped the main spill area and had been transported by wind and tides into the marsh. This second site was spatially separated from the main spill area, but on the same island. The test burn was to be followed by a second burn at the most heavily impacted area should the Unified Command deem the burn effective in reducing environmental impact from the spill. Criteria to evaluate the first burn was defined as follows: (1) The oil should burn readily and efficiently; (2) Unoiled areas should not burn beyond control efforts; (3) There should be no evidence of burn residue or soil impacts that would cause greater impacts than the oil alone; (4) The plume should not pose risks to downwind resources. It was expected that the burn would follow the pools of surface oil, but some adjacent drier marsh areas were expected to be burned as well. It was the consensus of the on-scene responders that burning was the proper course of action. The landowner's representative had no concerns about the burn progressing into adjacent unoiled areas since the marsh was often burned for management purposes.

Beginning at 0745 hrs on 12 April, preburn surveys, which included sampling and photo-documentation, were conducted in the test burn area. The time of the survey was about three hours before high tide. Oil thickness was as thick as 0.5 centimeters, but little water was observed between the oil and the marsh surface; the water level was expected to increase with the rising tide. A structural fire expert was contracted and deployed on-scene to provide fire protection to the nearby facility. The facility was located upwind and just offshore from the oiled area and considered at minimal risk. Just before 0900 hrs, the test area was ignited using a flare gun. The fire was slow to start, but eventually the pool of oil was fully evolved in flames. Although a firebreak was constructed using an airboat to wet and lay down the marsh grass prior to the burn, the fire progressed downwind and outside of the planned burn area. An estimated 40 acres of marsh was burned during the test—most of which was collateral damage to unoiled marsh.

Further burning was not conducted that afternoon because the wind speed had increased to 15-20 knots—above the upper limited presented in the plan. Airboats were used to control the edges of the grass fire beyond the test area to reduce accidental ignition of the main spill zone. The fire eventually burned out at the water's edge on the north side of the island.

While the marsh burned outside the test burn area and some birds (all thought to be rails) were observed killed, the Unified Command concluded that burning was still the preferred option should the wind diminish. Consultation with state and federal resource managers confirmed the identified environmental trade-offs. It was the general consensus that some birds are often killed during normal management prescribed burns and that these birds may have already been injured or would be injured by leaving the oil in place. The land manager restated that the entire island could be burned without his objection since the entire island was often burned for management purposes. However, the Unified Command preferred to minimize any collateral burns to the unoiled marsh.

During the evening debrief and planning meeting after the initial burn, the tradeoffs between burning at first light when the wind speeds would be lowest and burning at mid-tide when water levels in the marsh would be higher (predicted to be at about 1100 hrs on 13 April) were discussed. It was decided that the burn in the oil area should begin around 0900 hrs as a compromise between the expected higher winds and higher tide-driven water levels. During the second burn, a back-burn strategy was planned to minimize collateral burn damage. It was understood from the beginning that *in-situ* burning of oiled marshes was a developing science; new lessons were being learned during this response, which would be used for future responses. After the initial burn, the on-scene responders were reassured by the fact that the spill was on an island that provided it's own measure of burn control should the winds again drive the oil past the targeted burn zones.

On the morning of 13 April, the winds were less than 5 knots and a second *in-situ* burn was conducted at the main pipeline leak site. Back-burn or downwind fires were set north of the target burn area just before 0900 hrs, but these fires burned very poorly and were essentially ineffective in creating a fire-break or burning back and igniting the oiled zone. When the winds began to freshen, pools of oil on the up-wind side, near the pipeline leak were ignited using a flare gun and road flares. The oiled areas readily ignited. The winds never exceeded the 15-knot window authorized by the RRT approved plan and averaged less than 10 knots the entire day. Some collateral burn was observed, but no dead birds were observed due to the collateral burn. It was thought that reduced wind speed allowed better wildlife escape. A small oiled area outside of the heaviest oiled zone was identified. The Unified Command elected not to burn this area since the expected collateral burn would be great relative to the small amount of oil removed. An estimated 50 acres of marsh was burned on 13 April; most of this area was within the target burn zone, although collateral burn did occurred. Using post-burn aerial photography of the site, the final estimate of the burned, unoiled area was 98 acres (Michel et al., this volume).

Surveys at the end of the burn estimated that 90-95% of the recoverable surface oil had burned off. Oil was still observed subsurface in the thousands of fiddler crab burrows (some of which where burning like small lamps during the post-burn survey). A pit dug at the site where the pipeline repair was to be made, immediately reignited. Follow-up response plans were developed to contain and collect any released oil caused by subsequent rains. Post-burn recovery and monitoring studies were conducted and have been reported separately (Michel et al. 2002). Sediment sampling post-spill and burn showed that there was no residual sediment contamination six months later.

Trade-off discussion

When considering *in-situ* burning, a series of factors must be evaluated to determine if burning is the best response option. During the Mosquito Bay oil spill response, factors that were evaluated to assess the potential positive and negative effects of *in-situ* burning included: public safety, oil type, degree of oil pollution, marsh habitat, wildlife concerns, and fire control. When evaluating *in-situ* burning as a response option, two of these factors can be viewed as limiting—public safety and the combustibility of the oil. These factors alone will end any further discussion of burning as a response alternative. If the burn (or collateral burn) was expected to threaten citizens or private property near the site or if the oil was expected to be incombustible, any environmental trade-off discussion would be unnecessary. Only after public safety and the ignitability of the oil were evaluated were other factors investigated in the context of a trade-off discussion to determine if *in-situ* burning would provide a positive environmental benefit. Most environmental factors are interrelated and must be considered in the context of acute and chronic oil contamination risk, benefit and collateral damage from cleanup options, and the overall effect of anthropogenic response activities to the ecosystem.

Public safety. The public can be threatened both by the physical fire and downwind smoke inhalation during an *in-situ* burn. During the Mosquito Bay response, the spill site was located in a remote location and no public safety issues were identified. Several camps were located several miles to the north, but these were unoccupied and at what were determined safe distances regardless. There was no threat that the collateral burn would reach these camps since they were not on the island where the burn was being considered.

Oil type and degree of weathering. The oil must be combustible and ideally leave very little residual contamination after burning. Spilled oiled that has emulsified such that the water-in-oil concentration is greater than 25% may not support combustion when burned *in-situ* (McCourt et al. 1999). Oils with a relatively high asphaltene content often leave a thick oil residue that may have to be removed from the environment after the burn. The oil spilled in the Mosquito Bay incident was a light condensate crude with essentially no asphaltene content and an ideal candidate oil for *in-situ* burning. The spilled oil had been in the marsh for one week at the time of the burn. Although significant chemical compositional changes had occurred to oil composition due to evaporative loss of the light hydrocarbon fraction, the oil was still readily combustible. Little or no emulsification was observed in the spill area.

Oil thickness. To achieve an efficient burn, the oil must be at least several millimeters thick on the water surface to support sustained combustion. At the Mosquito Bay site, oil distribution was not uniform (neither was the marsh surface). Oil had seeped into the marsh from an underground pipeline. Free oil spread over the marsh by following surface contours and had spread by tides and winds during flooding. A large volume of oil escaped the primary spill site by way of a small tidal creek and was transported into the bay where winds and tide drove it into an adjacent marsh on the same island (it was this second impacted marsh area that was used for the initial or test burn). Oil distribution was centimeters thick in many areas and as thin as sheens in others. Only the heavy oil accumulations were the target of *in-situ* burning.

Habitat type. The marsh at Mosquito Bay was dominated by *Spartina pattens* (wire grass). Marsh managers have a second name for wiregrass, they call it paraffin grass because of how easy it ignites and burns. The thin leaves of *Spartina pattens* have a waxy protective covering such that even green *Spartina pattens* will easily burn. Also present was *Spartina alternaflora* (cord grass) and *Distichlis spicata* (salt grass). The marsh had been burned previously for marsh management, but managers reported that three growing seasons had passed since the last prescribed burn. Much of the impacted area was a relatively high marsh (marsh only flooded during higher tide events). Given the amount of residual fuel from past growing seasons in the adjacent marsh and the ignitability of both dead vegetation and *Spartina pattens*, some collateral burn was expected and factored to trade-off discussions.

A second concern was with the amount of water covering the marsh. For most prescribed burns the marsh sediment need only be saturated with oil to prevent root damage, but oil fires burn much hotter than typical marsh fires where the only fuel is vegetation. In-situ burns in marshes ideally would have a minimum water level of two centimeters to protect the sensitive subsurface roots and rhizomes from excessive heat (Bryner at al. 2001). This condition could only be partially achieved given the tide and conditions at Mosquito Bay. The heaviest oil accumulation, as might be expected, was in the shallow depressions of the marsh. Many of these depressions (or scars) were from the original installation of the pipeline. The marsh depressions containing the highest concentrations were mostly these small pipeline scars and several small ponds within the interior of the marsh.

Season is also a factor that must be considered. Marsh burns in the spring risk secondary ecological concerns. Plants would have to reestablish new growth with only limited below ground energy reserves. Given the high concentration of oil in the interior marsh and the direct contact of the oil with the marsh soils over 7-8 days of tidal fluctuations, the oiled plants were expected to die due to direct oil toxicity. In the past, *in-situ* burning was employed during the spring at a similar marsh at the Rockefeller Refuge in South Louisiana. Regrowth and natural succession after the fire occurred without any adverse habitat effects associated with the season of the burn (Pahl et al. 1999).

Wildlife concerns. There were no endangered species identified that would require additional consultations under the Endangered Species Act. Burning is generally viewed as having a positive effect relative to bird activities in and immediately adjacent to the spill (Hess et al. 1997). Oil in the marsh was a direct threat to birds in the area and the migration of the oil into adjacent marsh habitat would only increase the threat of wildlife impact. By burning the oil, the oil threat would be removed. The potential for collateral burn was weighed against the threat of leaving large amounts of oil in the marsh and the long-term exposure risk that might result.

Summary

After considering the trade-offs between leaving the oil for natural recovery (no additional response), intrusive egress into the marsh to attempt manual recovery, and application of a prescribed *in-situ* burn, the on-scene technical specialists recommended burning to the Unified Command. RRT6 approved the burn plan based on recommendations from the Unified Command and on 12 and 13 April 2002 the prescribed burning was used as the primary spill response countermeasure. Overall, the *in-situ* burn at the Mosquito Bay spill site was considered successful. Given that any other response alternative in such a sensitive marsh habitat would involve negative environmental trade-offs, the use of i*n-situ* burning was thought to have the least environmental impact and the highest removal efficiency for surface oil contamination.

Biography

Charlie Henry is the NOAA Scientific Support Coordinator (SSC) for Texas, Louisiana, Mississippi, Alabama, and the Florida panhandle. Henry has a Master of Science degree in Marine Science from Louisiana State University and 17 years experience related to oil and chemical spill response.

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