

RECOVERY OF FOUR OILED WETLANDS SUBJECTED TO *IN SITU* BURNING

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LIST OF ABBREVIATIONS

API	American Petroleum Institute
BTEX	benzene, toluene, ethylbenzene, xylene
cm	centimeter
LOSCO	Louisiana Oil Spill Coordinators Office
km	kilometer
LSU	Louisiana State University
m ²	square meter
mm	millimeter
PAH	polynuclear aromatic hydrocarbons
ppm	parts per million
RPI	Research Planning, Inc.
TPH	total petroleum hydrocarbons

EXECUTIVE SUMMARY

The primary objective of this study was to evaluate the use of *in situ* burning of oil spills in wetlands based on the assessment of the intermediate-term impacts at four case studies:

- Mosquito Bay, Louisiana spill of 1,000+ bbls of condensate in a salt marsh, 6 April 2001
- Lakehead Pipeline spill of 50+ bbls of crude oil in a ponded freshwater wetland at Ruffy Brook, Minnesota, 22 July 2000
- Louisiana Point, Louisiana spill of an unknown quantity of condensate in a high brackish marsh, 23 February 2000
- Chevron Pipe Line Milepost 68, Corinne, Utah spill of 100 bbls of diesel in a freshwater marsh and salt flats, 21 January 2000

These spills represent a range of oil types, volumes, time of year, habitats, and time between the spill and the burn. Follow-up field visits were made to these sites in July (Minnesota and Utah) and October (Louisiana) 2001, representing periods of 12 to 20 months post-spill and burn.

In all cases, the use of *in situ* burning was determined to be very effective, removing 80-100 percent of the oil remaining on the surface at the time of the burn. The best results were at sites where the oil was burned soon after the release, because the oil had the least spreading. The presence of a water layer reduced the risk of additional impacts to vegetation from thermal stress; however, plant survival was good in areas without a water layer but where the soils were water saturated.

Light oils (diesel and condensate) burned completely without any surface residue; however, there was a tarry burn residue after the crude oil burn that had to be removed. Burning did not remove oil that had penetrated into the soils via crab burrows, root cavities, and mud cracks at two of the sites. Also, burning did not prevent the toxic effects of the oil on vegetation that occurred before the burn. In the three cases where the burn was delayed by days to weeks, toxic effects to vegetation still occurred in areas of the heaviest oiling. Burning can, however, be very effective at reducing the extent and degree of additional impact by quickly and efficiently removing the remaining oil.

One of the most important lessons learned was that the window of opportunity for use of *in situ* burning in wetlands can extend for weeks to several months, depending on the spill conditions. Two condensate spills in Louisiana were very effectively burned 3 and 7 days after the spill. The diesel spill in winter in Utah was burned twice, with the first burn 7 weeks after the release was detected. The second burn was after the final spring thaw, an additional seven weeks after the first burn.

Another important lesson learned was that the area of the burn can greatly exceed the area of the oil. In three of the four case studies, the burned area was significantly larger than the oiled areas, and in two cases, the burn area was eight and ten times larger. Responders need to be aware that there is a risk of the burn spreading to unoiled areas, particularly at wetlands that have not been burned and thus contain abundant natural fuel.

RECOVERY OF FOUR OILED WETLANDS SUBJECTED TO *IN SITU* BURNING

1.0 INTRODUCTION

In situ burning of oiled inland and upland habitats is an alternate response technique that can minimize environmental impacts associated with oil spill cleanups. When used properly, it can be a relatively easy, low-cost response and reduce the time required for cleanup, compared to mechanical and manual removal. However, use of *in situ* burning in the United States varies considerably, and it often is not considered by the response community because there has not been sufficient information and experience to confidently make routine decisions on when to use it.

Oil spill planners and responders who are considering the use of *in situ* burning most need information concerning its potential ecological effects. Few efforts have been made to determine the environmental effects of past inland burns, and evaluations are needed of the environmental effects of *in situ* burning and the recovery of the burned habitats. In particular, studies are needed to assess the longer-term effects and recovery of burned spill sites so comparisons can be made to spill sites where burning was not used.

Published information on burning of spilled oil in inland and upland sites is very limited. A recent study sponsored by the American Petroleum Institute (API) (Dahlin et al., 1999) summarized information for 32 spill incidents where the use of *in situ* burning was documented as a response tool. Based on this study, a new project, co-sponsored by API and the Louisiana Oil Spill Coordinators Office (LOSCO), was initiated to select sites where follow-up field visits could be conducted to assess the efficacy of *in situ* burning on the medium-term recovery of the oiled habitats. The original 32 spills, as well as new events, were evaluated to select the most promising sites to visit. The following criteria were used in the evaluation:

- The area actually burned and similar unburned areas were well documented.
- The site should not be more than 10 years old, since it was likely that other events could have affected the site, and we would likely not be able to document these events.
- Sites where complete recovery had already been documented (including fields where farming commenced) were not considered.
- Sites that had already been well studied and the results published were not considered.
- Sites where only a few barrels were burned were considered too small for follow-up.
- A minimum amount of data post-burn was needed (e.g., description of the oil type and estimated volume, burn area, photographs of the post-burn area). Chemical analysis of sediment samples was desired but not required.
- Sites with a complicated spill/burn history were not considered to be good candidate sites because the burn effects could not be readily discerned separate from other effects (e.g., vegetation impacts resulting from brine released with the oil, other cleanup actions).
- A variety of habitats was desired.

Four sites were selected to include a diversity of oil types and habitats burned (Table 1-1). Site visits were conducted in July 2001 (Minnesota and Utah) and October 2001 (the two sites in Louisiana). All available data on each site were collected during meetings with the groups involved in the burns and the post-burn monitoring. In particular, photographs taken during and shortly after the spill and burn were obtained so that, during the site visit, the site could be photographed from the same position and perspective, creating time-series photography as a visual record of the use of *in situ* burning and vegetative recovery. Photography provides a powerful means of information transfer about the nature of the site, the spill and burn conditions, and the overall recovery. In combination with quantitative field measurements, such as percent vegetation cover in quadrats and chemical analysis of the residual oil in soils, photography allows the user to better understand the specific site conditions and how the results might apply to other sites. All of the sites were being monitored under agreements with state and/or federal agencies. These monitoring data were graciously shared and have provided much more information on the sites than the project was able to generate. The willingness on the part of the responsible parties to share their data has contributed significantly to the success of this study.

Table 1-1. Oil spill sites that were selected for monitoring in this study.

Spill Name/Location	Spill Type/Volume	Habitat Oiled	Spill and Burn Dates
Williams Energy Services, Mosquito Bay, Louisiana	Condensate/1,000 bbls spilled; 800+ bbls burned	Salt marsh	Spill: 6 April 2001; Burn: 11-12 April 2001
Lakehead Pipeline, Ruffy Brook, Leonard, Minnesota	Crude oil/50+ bbls spilled and burned	Ponded freshwater wetland	Spill and burn on 22 July 2000
Williams Energy Services, Louisiana Point, Louisiana	Condensate/Unknown volume spilled and burned	High brackish marsh	Spill: 23 Feb 2000; Burn: 25 Feb 2002
Chevron Pipe Line Milepost 68, Corinne, Utah	Diesel/100 bbls spilled and burned	Freshwater wetlands and salt flats	Spill: 21 Jan 2000; Burn: 10 March and 27 April 2000

Each case history is discussed separately in the following sections, with subsections on:

- Spill incident summary
- Burn evaluation (based on initial observations immediately after the burn)
- Post-burn monitoring and assessment
- Lessons learned

The final section includes a summary of the lessons learned from the use of *in situ* burning at these four sites.

2.0 MOSQUITO BAY PIPELINE RELEASE, TERREBONNE PARISH, LA

Date of Spill: 6 April 2001

Location: East of the Atchafalaya River mouth, Louisiana

Quantity Spilled/Burned: 1,000+ barrels spilled/800+ barrels burned

Oil Product/Type: Condensate (a light crude oil co-produced from gas wells)

Environmental Setting: Tidal salt marsh

2.1 Spill Incident Summary – Mosquito Bay

- The release occurred from a condensate pipeline located on Point au Fer Island, a salt marsh island in Mosquito Bay (Fig. 2-1). The vegetation consisted of mixed stands of salt cordgrass (*Spartina patens*), giant cordgrass (*S. alterniflora*), and salt grass (*Distichlis spicata*). Fiddler crab (*Uca spp.*) burrows reached densities of up to 100/m².
- Much of the oil was trapped in the dense vegetation and pooled in depressions and along small tidal channels. Some of the oil flowed out of the marsh via a main tidal channel and blew into a small adjacent bay to the west (Zone 1). Figure 2-2A shows the oil pocketed outside and in the small western bay.
- After the release was discovered on 6 April, manual recovery was conducted for 6 days using sorbents on pooled oil in open areas in the marsh vegetation and in small channels.
- The tidal range during this period was 0.6 m with 1-5 cm of water on the marsh surface at high tide, and the marsh surface dry at low tide, except for topographic lows that held pooled water. Marsh soils were mineral-rich (from the high sediment load introduced by the Atchafalaya River mouth just to the west) but had a dense root mat.
- Oil had penetrated up to 20 cm into the marsh soils via crab burrows and root cavities; free oil was up to 4 cm thick, pooled on the water surface (Fig. 2-3) and in burrows, though there were extensive areas where the oil thickness was on the order of 1 mm.

2.2 Burn Evaluation – Mosquito Bay

- On the day of the first burn, the oil on the water surface was 0.5-1 cm thick in low areas where the oil had pooled, to 1 mm thick over most other areas.
- The first burn was conducted in the small bay to the west of the release (Fig. 2B) on 12 April, 6 days after the spill was discovered. The water layer over the marsh surface was 0.1-5 cm. Winds were >10 knots from the south.



Figure 2-1. Location map of the Mosquito Bay burn site on Point Au Fer Island. The release was from a condensate pipeline on a marsh island located in Fourleague Bay, about 20 km east of the Atchafalaya River mouth (note the various plumes of suspended sediments in the water). Base image is a digital orthophotograph taken in 1998.



Figure 2-2. **A.** The small bay to the west of the original release site and the site of the first burn. Note oil accumulated against the outer bank and in the bay, taken on 9 April 2001. **B.** Zone 1 on 12 April 2001, 1 hour after the first burn ended. The firebreak is barely discernible as an arc around the small bay. The marsh burned to the downwind water's edge in most areas.

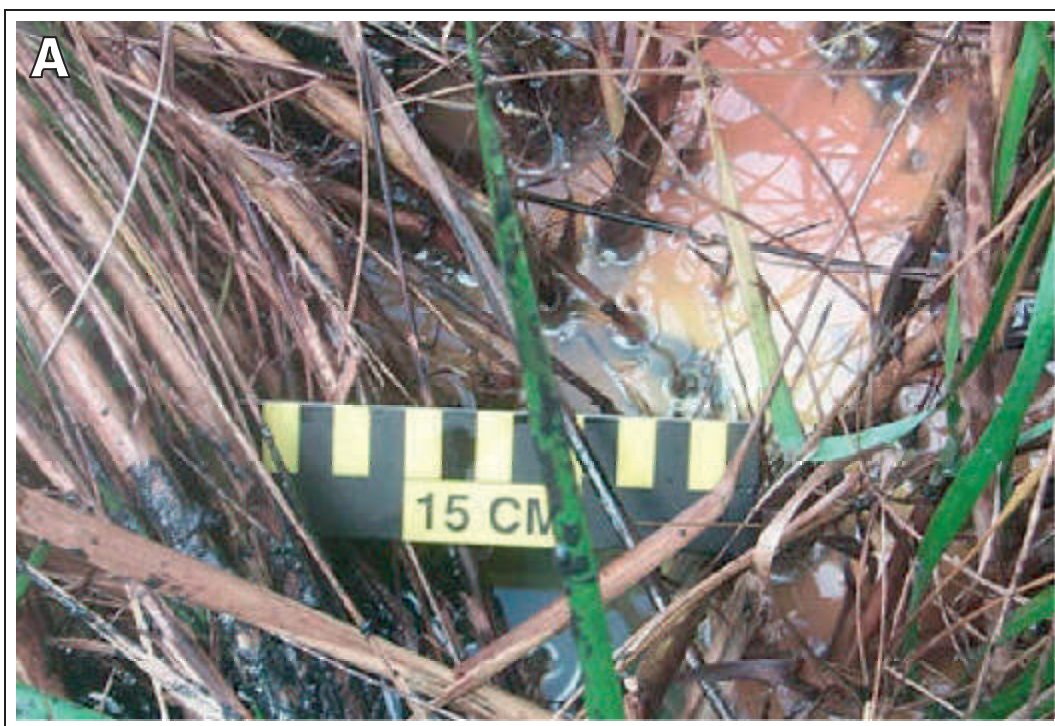


Figure 2-3. **A.** Condensate pooled to about 0.5 cm thick in dense vegetation, close to the release site. The dark material on the vegetation stems in the lower left corner is mud, not oil. The condensate is yellow in color. **B.** Condensate that accumulated in a small trench dug into the marsh soils adjacent to the release site. Within minutes, 1 cm of oil seeped out of adjacent sediments. At low tide, the oil penetrated the many crab burrows.

- A firebreak was placed around the burn site by repeated passes with an airboat. A flare gun was used to ignite free-floating oil held in a boom against the marsh (Fig. 2-2A).
- Once started, the fire burned quickly downwind, jumped the firebreak, and burned to the water's edge or to large patches of black rush or sedges. Figure 2-2B is an aerial photograph taken after the burn on 12 April. Note the edge of the burned areas. Twenty rails were observed to be killed by the flames.
- A second burn in the marsh near the release site was conducted early on 13 April (7 days after the spill was discovered), when the wind speed was expected to be lowest, but during mid-tide. Little to no water covered the marsh soils, except as isolated pools in the deeper depressions. Winds were 5-10 knots from the south.
- Road flares were used for ignition. Attempts to set a down-wind fire stalled, so fires were started in oil pools throughout the site. No attempt was made to create firebreaks.
- Once again, the fire burned both oiled and unoiled vegetation, stopping mostly at the water's edge. The smoke burned black in oiled areas, whereas in unoiled areas, the smoke was light gray to white (Fig. 2-4).
- Immediately after both burns, survey teams reported little to no free water remaining on the marsh surface, however the surface soils were wet and soft, with no evidence of soil or root burns. The marsh stems were burned down to 1-10 cm above the soil surface, indicating the localized depth of water or the point where the lowermost stems were too wet to burn. This marsh "stubble" was observed throughout the burned area, even where there was little to no water over the marsh surface. As such, stubble may be a poor indicator of water depth during a burn.
- There was no visible oil or burn residue on the marsh surface, however free oil remained in the sediments and on the water pooled in burrows. Approximately 90-95 percent of the surface oil was estimated to have burned (Henry, 2001).
- The oil remaining in burrows and pooled in footsteps after walking on the marsh surface would ignite, burning like small torches. Within 2 hours after the burn, during initial excavation of the soils above the release site in the pipeline to initiate repairs, the oiled soils immediately re-ignited. Oil pooled in the excavation area was repeatedly burned over several days.
- Some dead fiddler crabs were observed during inspection of the burn site, mainly in the most heavily oiled and burned areas. Many of the fiddler crabs appeared to have survived the burn in the lightly oiled and unoiled areas.
- There was concern that the free oil remaining in burrows after the burn would re-float during subsequent high tides, thus sorbents were deployed to pick up any mobilized oil.



Figure 2-4. The second burn was conducted in the morning on 13 April. Fires were started where the oil pooled on the surface. The oiled areas burned with black smoke, whereas the unoiled vegetation burned with lighter gray smoke.

2.3 Post-Burn Monitoring and Assessment – Mosquito Bay

A monitoring study was required by the Louisiana Oil Spill Coordinator's Office (LOSCO) as part of the burn approval. This work includes post-burn aerial photography (obtained on 5 May 2001), field surveys to measure percent cover, stem density, and crab burrow density, and sediment sampling and analysis. The results of the first post-burn survey (John Chance Land Surveys, Inc., 2001), conducted on 16 June 2001, were reviewed. Data on chemical analysis of soils from an on-going study by the landowner were provided (Coastal Environments, Inc., 2002). The study team visited the site on 17 October 2001, 6 months post-burn, to collect sediment samples and observe site conditions. The Trustees provided copies of aerial photography taken during an overflight on 31 May 2001. Figure 2-5A shows an oblique aerial photograph of the site on 26 April, taken 13 days after the burns, that can be compared with Figure 2-5B, a similar view taken on 31 May 2002, 13 months post-burn. These data are summarized below.

Ground surveys and the May 2001 post-burn vertical aerial photograph (Fig. 2-6) were used to estimate the area that was oiled and the total area that was burned. The oiled area covered an estimated 12 acres, whereas the burned area extended over 98 acres. Thus, the burned area was about eight times the oiled area.



Figure 2-5A. Oblique view of the Mosquito Bay burn site on 26 April 2001, two weeks after the burn. The oiled/burned areas look blacker in color than the unoiled/burned areas. Note that the fire burned downwind (toward the top of the photograph) until it reached the water's edge in most places.



Figure 2-5B. Oblique view of the Mosquito Bay burn site on 31 May 2002, 13 months after the burn. The arrows point to the areas where the vegetation has not recovered from east to west around the release site, the channel, open areas north of the dark patch of vegetation, which is black needle rush (*Juncus*), and the small bay to the west.



Figure 2-6. Vertical aerial photograph of the Mosquito Bay burn site on 5 May 2001. The oiled and burned areas are outlined. An estimated 12 acres were oiled; 98 acres were burned.

On the May 2001 vertical photograph (Fig. 2-6) and the May 2002 oblique aerial photographs (Fig. 2-5B), the unoiled and burned areas show the “greening up” that typically follows marsh vegetation burns. Based on field observations in 2001 and 2002, the unoiled and burned vegetation was recovering as expected after a burn.

On Figure 2-5B, there are several areas where the lack of vegetative recovery after 13 months is readily apparent, specifically:

- 1) The area around the release site, where the oil pooled on the surface and had penetrated deeply into the burrows and root cavities in the marsh soils. This area appears as an irregular, open patch in Figure 2-5B. As of May 2002, there was some evidence of spreading of shoots from live vegetation bordering the patch;
- 2) The edges of the channel in the center of the photograph where the bulk of the oil drained out of the marsh. The creek channel appears to be wider, comparing the two photographs in Figure 2-5. Ground photographs of the channel (Fig. 2-7) show that the vegetation bordering the channel was killed;
- 3) An area of open water just to the north of the dark patch of black needle rush (*Juncus*) that does not appear as open water in Figure 2-5A; and
- 4) The small bay to the west of the release site. Comparison of the two photographs in Figure 2-5 shows that a band of vegetation about 5 meters around the bay died back. Figures 2-8 and 2-9 show ground photographs at this site pre- and post-burn. In October 2001, it is clear that the vegetation was killed and did not recover. However, plugs of vegetation planted in May 2001 along the channel to the bay survived, indicating that the soils were no longer toxic (Fig. 2-10).

All of these areas were sites of pooled oil, as observed on the ground prior to the burn and indicated by the blackened patterns in Figure 2-5A, taken two weeks after the burn. The oil tended to pool at the release site, along drainage channels, and in depressions in the marsh surface. As discussed below, it is believed that these areas were exposed to high concentrations of condensate that penetrated into the soils during low tide, causing plant mortality prior to the burn.

More detailed delineation of the affected vegetation might have been possible if false color infrared aerial photography had been acquired in addition to the true color photographs. The color infrared photography would allow delineation of different levels of vegetative vigor, compared to what can be determined from the true color images.



Figure 2-7. Main creek channel along which the condensate flowed from the release site.
A. 26 April 2001, 14 days post-burn; lightly oiled/burned vegetation had started to re-grow.
B. 17 October 2001, six months post-burn; no re-growth of the heavily oiled vegetation along the bank, but good recovery for the lightly oiled adjacent vegetation.



Figure 2-8. First burn area (Zone 1). The condensate had pooled on the marsh surface and penetrated burrows during the 6-7 days between the spill and the burn. **A.** One hour after the first burn on 12 April. There were several cm of water on the marsh surface during the burn, as indicated by the plant stems. **B.** 17 October 2001, 6 months post-burn. All of the vegetation in the heavily oiled areas died, with no recovery.

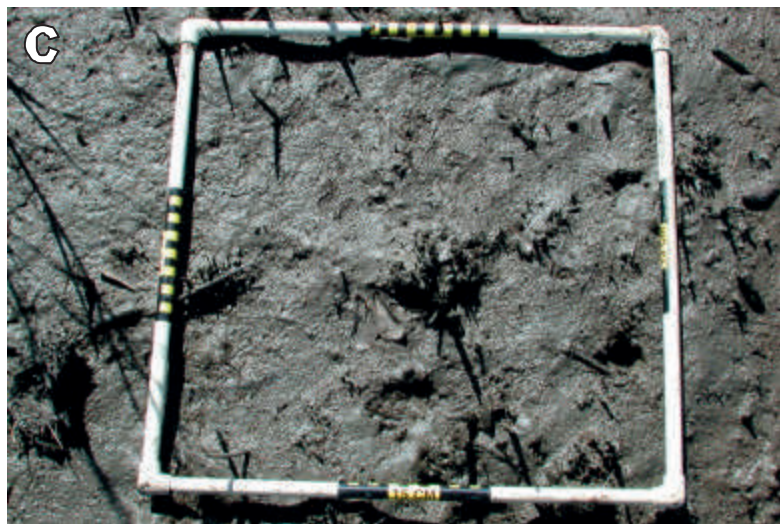
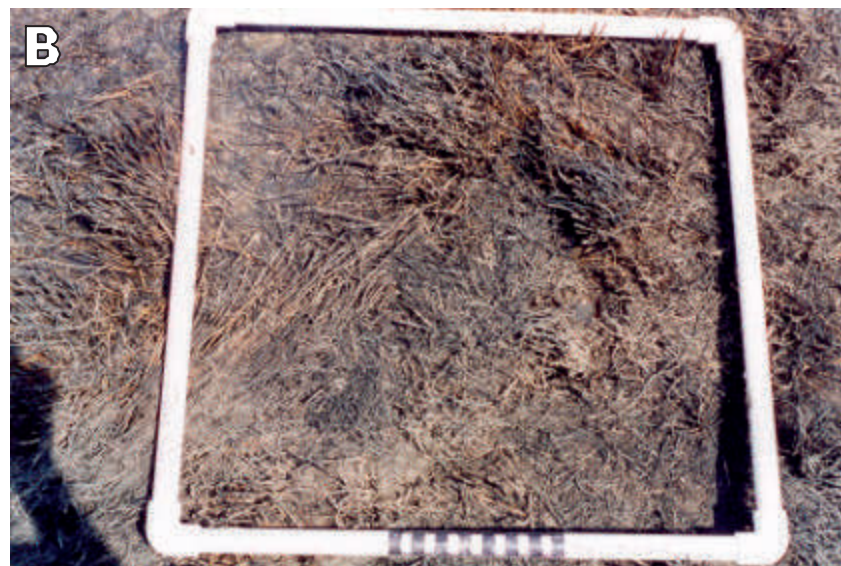


Figure 2-9. First burn area.

- A.** Heavily oiled vegetation (*Spartina patens*) immediately before the 12 April 2001 burn, starting to turn yellow after being in contact with the condensate for 6 days.
- B.** Same area hours after the burn. Note the lack of any oil residue.
- C.** Same area as in two previous photographs, taken on 16 October 2001, 6 months after the burn and at the end of the first post-burn growing season. The vegetation was dead with no recovery.