

Selected Spectral Imagery of the May 14, 1996 Pearl Harbor Oil Spill

A report submitted to:

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Abstract: Four-band, multispectral imagery of the May 14, 1996 Pearl Harbor oil spill obtained by TerraSystems, Inc., was examined for applicability to the U.S. Fish & Wildlife needs. Five areas of coastline in Pearl Harbor were selected for study: Hospital Point and the coast line immediately to the north of the point; the coastline at the Arizona Memorial Visitor Center, including the U.S.S. Bowfin; the Arizona memorial; and the coastline adjacent to the HECO Facility at Waiau. The imagery was obtained in four narrow bands at wavelengths of 450, 550, 650, and 770 nm at approximately 0.6 meters/pixel under cloud cover in the late afternoon (about 5:00 p.m. HST). Processing distinctly shows regions of oil, oil sheen and coastal impact.

I. INTRODUCTION

The purpose of this report is to document the collection (and subsequent processing) of multispectral imagery of an oil spill in Pearl Harbor resulting from a pipeline break located near the HECO Facility sometime during the night of May 13, 1996. The circumstances and particulars of the spill and cleanup can be found elsewhere.

TerraSystems, Inc., maintains and operates an airborne multispectral camera system (ASDMSV) that features four narrow spectral bands that can be selected for specific environmental applications. This system, which in some respects operates in a manner similar to nadir-looking aerial photography, can be flown in any light aircraft or helicopter as a self-contained unit. Because of this adaptability, the ASDMSV systems can be quickly configured for use for emergency response. Because of the digital nature of the imagery and the selectibility of the filters, the imagery can be used in many cases where true or false-color IR photography will fail.

On May 13, 1996, the ASDMSV system was crated in preparation for air shipment (on May 15th) to Massachusetts for work starting the on May 20th. On the morning of May 14th, TerraSystems, Inc. became aware of news reports of an oil spill, termed "major" in Pearl Harbor. At 3:00 p.m. Air Survey Hawaii (ASH) called TerraSystems to ask if we were interested in collecting ASDMSV imagery over the spill area even though there had been no requests from "official" sources. The low relatively thick cloud cover (base at 3,000 feet), lateness in the day and lack of suitable film in ASH's normal large-format aerial cameras precluded normal photographic flights.

TerraSystems responded by uncrating the ASDMSV, traveling to the ASH hanger on the south ramp of Honolulu International Airport and installing the ASDMSV in the 9-inch format camera mount of ASH's Cessna 210. The system was airborne at 4:45 p.m. HST.

II. DATA COLLECTION

The system as airborne was configured with wavelengths of 450, 550, 650, 770 nm with FWHM of 25 nm. Certain alignments in the system could not be checked before flight which meant that two of the cameras were not precisely co-aligned. This lack of alignment, apparent in the raw images, was easily corrected digitally (see processing). The ASDMSV system includes a video guide system. Video tape recording of all the flight lines was obtained as well.

The weather during the flights was not optimum for data collection. Cloud cover was almost 80% over Pearl Harbor but this combined with the lateness of the day (5:00 p.m. HST) ensured that the whole estuary was in cloud shadow. The base of the clouds was at 3,000 feet and dropped to 2,500 feet during the short time we were airborne. This low altitude forced us to collect imagery at 0.6 m/pixel rather than the preferred 2 meters/pixel. In addition, because Pearl Harbor is adjacent to Honolulu International Airport, our airspeed was higher than normal which induced some, but not relevant, image smear.

Our flight plan was, to say the least, impromptu since we had no guidance as to where the spill was, its severity, nor which regions were most important. However, once airborne, it

became apparent that we could not cover the whole spill in the short time (daylight) available. We concentrated on the coastlines, including several long flight lines from the entrance of the harbor, over Ford Island to the source of the spill. Not all areas of the harbor were covered. A map is included which shows some of the more relevant flight lines.

A total of 220 images along 12 flight lines were obtained between the 5:00 p.m. and 5:30 p.m. HST (see attached map). Not all of these images are of the harbor and some are redundant. Some flight lines contain only a few images. Some flight lines follow curvilinear paths as the aircraft was directed by the Honolulu control tower in response to aircraft landing at Honolulu Airport. However, through the cooperation of the HIA air traffic controllers, we were able to obtain good flight paths over the harbor entrance at 2,500 feet in a direction perpendicular to the main landing patterns -- no small feat.

III. DATA PROCESSING

A set of 24 images was selected as being most useful to the U.S. Fish & Wildlife Service in consultation with Kevin Foster. These images are from areas that the USF&WS deemed important. From this set a subset of 11 images was selected for further processing. The initial imagery set:

1. From Bishop Point to Hospital Point
PH2AH through PH2AQ (10)
PH5AK through PH5AN (4)
2. HECO Facility at Waiau
PH5AW, PH5AX, PH9AU, PH9AV (4)
3. Impact on mangrove forest
PH1AE (1)
4. Aeia region
PH8AK through PH8AN (4)
5. Arizona Memorial
PH9BL (1)

From this set a total of 11 images were selected for final processing and presentation. This final set was: PH9BL, PH8AN, PH5AL, PH5AM, PH2AL, PH2AM, PH1AE, PH5AW, PH5AX, PH9AU, PH9AW. Because of the wavelength position and the narrowness of the bands of the ASDMSV and the ubiquitous nature of the oil in these regions, only three bands (at 450, 550, 650 nm) needed to be used for the analysis. These three filters span the natural color range of humans (blue, green and red) so that the images could be displayed in near natural color to help interpret the location of the oil.

The images were first corrected for an effect called "offset" which is the result of the low altitude and higher than normal ground speed during acquisition. Next the images were corrected for "flat fields" and "dark signal". Finally the 4 bands were "co-registered" to correct for the mechanical misalignment of the cameras. This correction, although quite

substantial for the IR camera, affects only the area of coverage of the image, not the quality of the data. Instead of the normal 740 x 578 pixel image, we were left with a 700 x 500 pixel image. Artifacts of this co-registration process can be seen as red, green or blue stripping at the edges of some images.

The images were digitally enhanced to emphasize the oil on the water. Thicker oil appears as white or blue. Thinner sheens tend to have more vivid coloration. We did not process the images with a special digital technique used to identify extremely small amounts of oil on the water since it was deemed unnecessary for this project.

IV. RESULTS

Figure 1 is a mosaic of images showing the region around and adjacent to the HECO facility at Waiau. The color ASDMSV images were overlain on a B&W aerial image of the same area obtained in 1991 by ASH. The source of the spill is indicated as is the fresh water marsh adjacent to the spill source. Oil is seen as white and blue in the image. The oil was moving quite rapidly (due to tides, currents and wind) as can be seen by the discontinuities in the oil flow pattern between different flight lines. An oil stream can be seen impacting a mangrove forest on the shoreline.

Figure 2 (Hospital Point A) is a two image mosaic of the area just inside the harbor from Hospital Point. A large slick is seen between Ford Island and the Naval Reservation. A smaller slick is seen hitting the shoreline along Hospital Point.

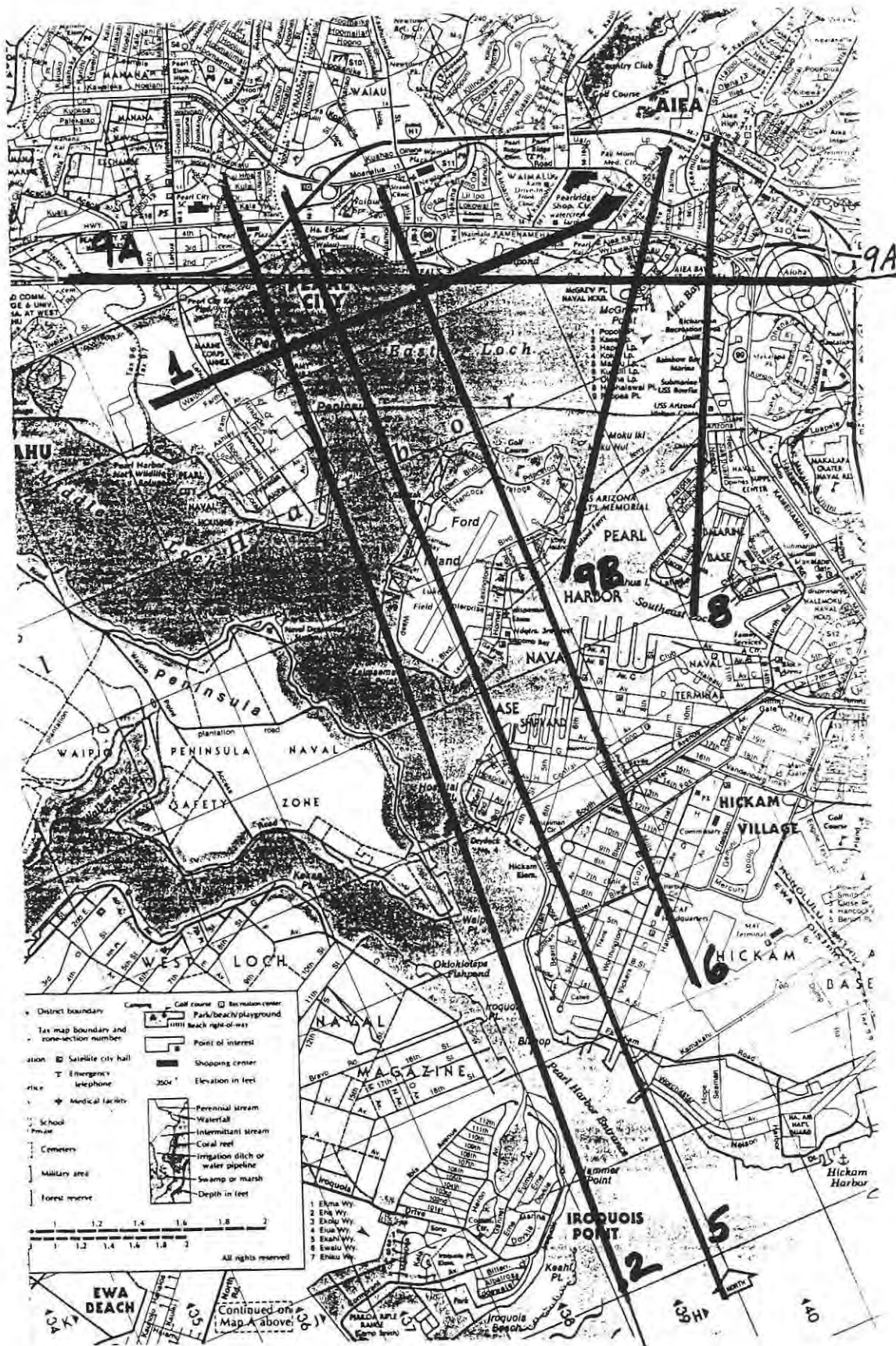
Figure 3 (Hospital Point B) is a two image mosaic of the oil at Hospital Point in the channel at the entrance to Pearl Harbor. The skimmer vessel is seen collecting oil. Oil has impacted a region near Waipio Point. A light sheen can be followed all the way to the shore at Hospital Point.

Figure 4 shows the shoreline adjacent to the Arizona Memorial Visitor's center. Oil sheens can be seen attached to the shoreline, the U.S.S. Bowfin and the Naval Reservation docks. Oil has moved upstream past the oil boom protecting Halawa Stream.

Figure 5 shows the Arizona Memorial and adjacent shoreline on Ford Island. Oil is seen on both sides of the booms set out to protect the memorial. Oil can be seen along the shores of Ford Island.

V. SUMMARY

The four-band, multispectral imagery of the May 14, 1996 Pearl Harbor oil spill obtained by TerraSystems, Inc., was examined for applicability to the U.S. Fish & Wildlife needs. Five areas of coastline in Pearl Harbor were selected for study: Hospital Point and the coast line immediately to the north of the point; the coastline at the Arizona Memorial Visitor Center, including the U.S.S. Bowfin; the Arizona memorial; and the coastline adjacent to the HECO Facility at Waiau. In all cases regions of distinct oil, oil sheen and coastal impact can be seen in the images.





HECO Facility at Waiau
May 14, 1996 ~5:10 pm

Arizona Memorial Visitor Center
May 14, 1996 5:16 p,m

N →

U.S.S. Bowfin

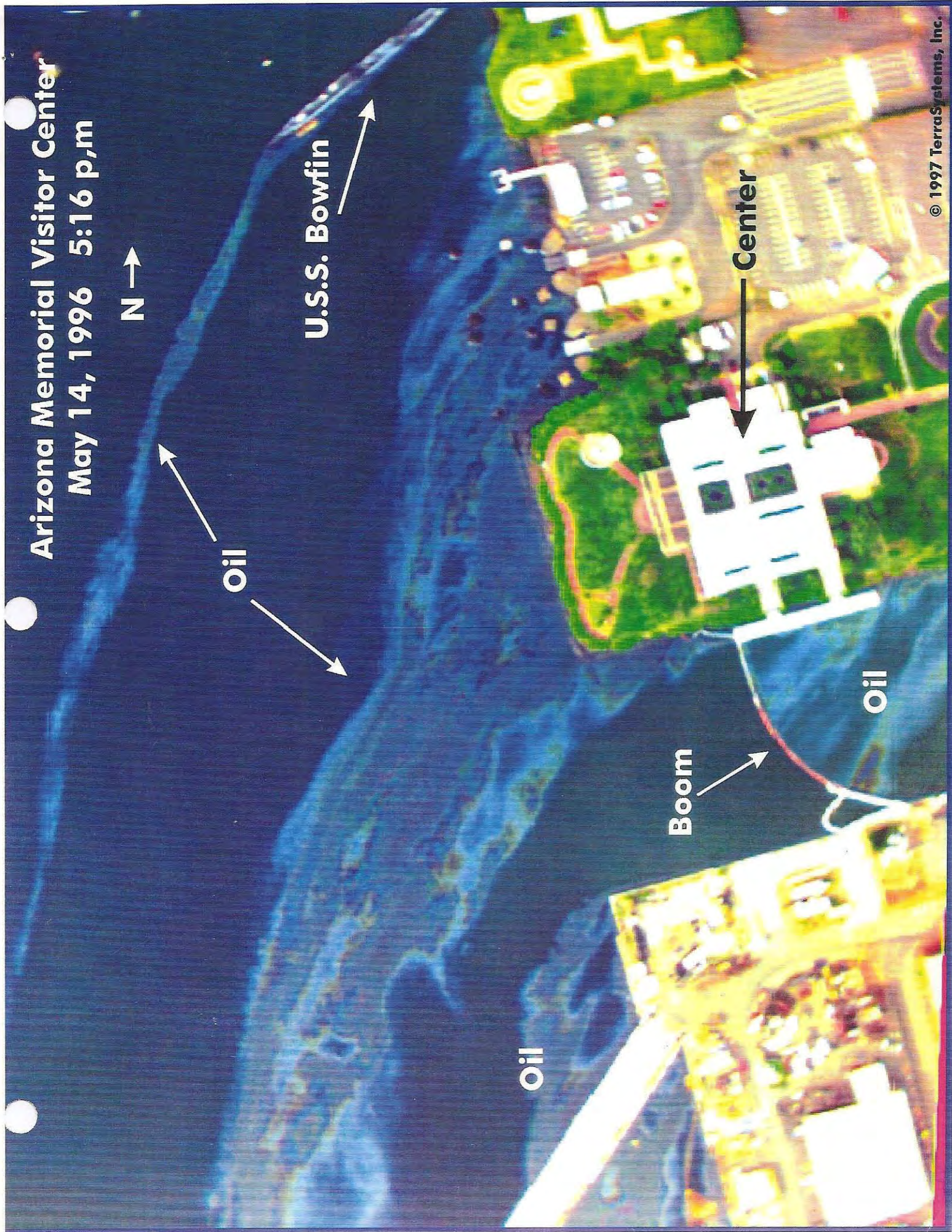
Oil

Center

Boom

Oil

Oil



Arizona Memorial
May 14, 1996 5:20 pm

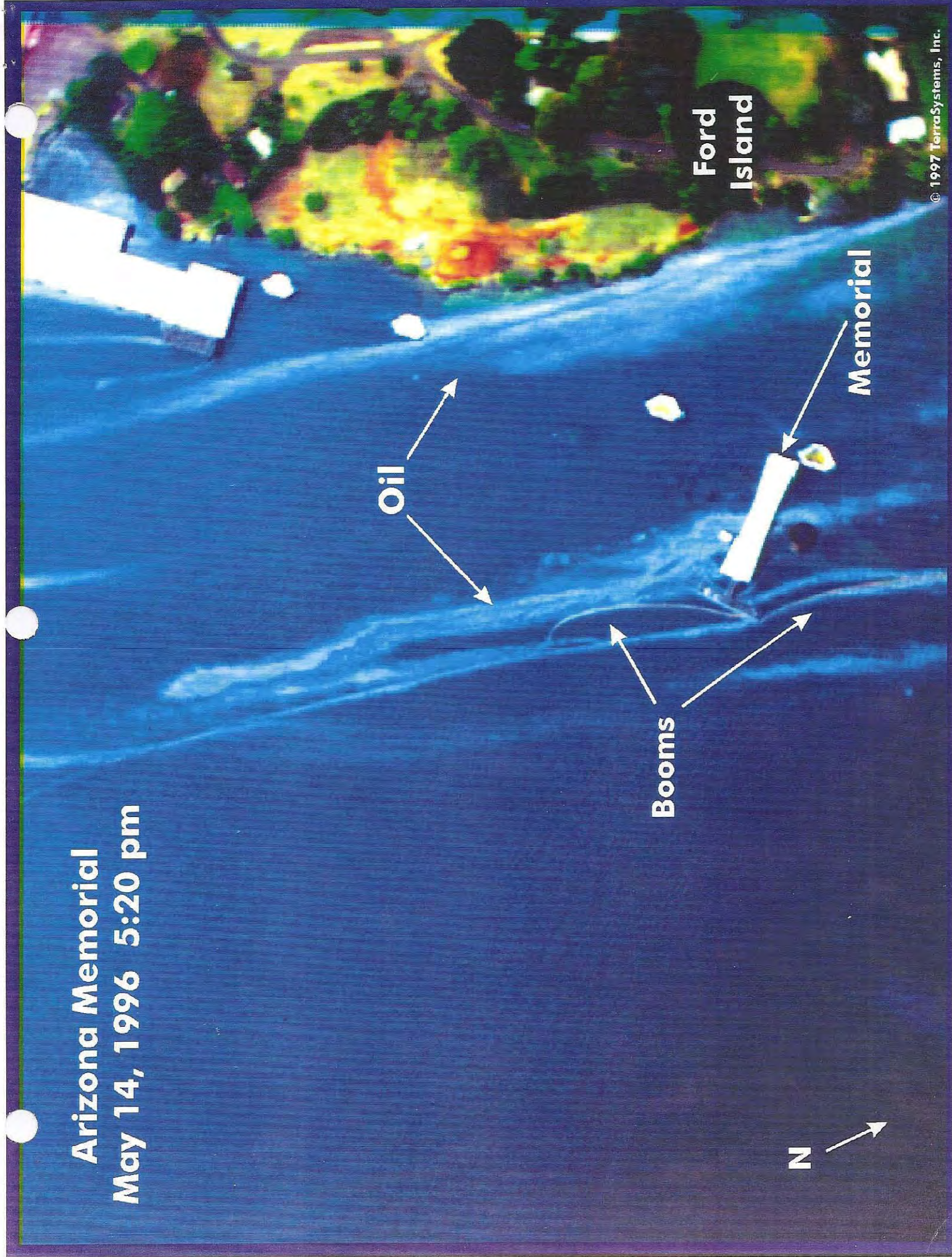
Oil

Booms

**Ford
Island**

Memorial

N





Hospital Point (B)
May 14, 1996 5:04 pm



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Naval Reservation

Hospital Point (A)
May 14, 1996 5:09 pm

Oil

Oil

← N

Ford
Island

