USE OF GIS AND DIGITAL ORTHOQUADS TO SUPPORT INSPECTION AND OPERATIONS DURING OIL SPILL RESPONSE

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ABSTRACT: *Maps are essential tools of spill response. They are traditionally used in a variety of sizes and formats to report and show the location of oil, cleanup activities and, in later phases of the response, the status of beach inspections. Very precise maps are also needed by operations personnel to direct cleanup crews to the right location, along with specific cleanup instructions. Detailed aerial pictures provide the ideal type of representation for this specific task. Such pictures are now available in the form of one to six meter resolution digital orthophotos quadrangles (DOQ), which are georeferenced and may be used as basemaps within a Geographical Information System (GIS). We have designed a system using these aerial pictures that allows the provision, on a daily basis, of large scale representation used 1) by inspection teams as forms to report location and nature of areas of concern and 2) by cleanup supervisors to more efficiently direct the effort of cleanup crews. These maps incorporate all relevant information needed by their users such as location and identification of shoreline segments, nature of oiling conditions, or any other observation needed by operations personnel. These detailed representations are complemented by georeferenced 1/100 000 scale topographical maps, which prove to be very effective for general reporting and orientation purposes. This system was developed and implemented in the course of the Swanson Creek Incident (Maryland) oil spill response.*

Introduction

Spill response makes a large use of maps for various purposes. Cartographic representations are very useful to provide general orientation, such as maps showing the location of operational divisions or shoreline segments. Maps also greatly enhance the planning process, by providing means to represent and communicate the state of the situation at a glance. Representations of the extent of observed oiling from aerial overflights, oiling conditions from SCAT surveys, the location of cleanup or protection equipment and cleanup status from inspection teams have demonstrated their worth in the past (Lamarche *et al*, 1998).

Computerized tools, based on geographical information systems (GIS), have been developed to automate and speed-up the production of some of these maps (Lamarche and Owens, 1997), with the result of more timely response to the decision cycle. These computerized systems and their cartographic representations were developed primarily to support the earlier phases of response and cleanup (Lamarche *et al*, 1996). During these phases, shoreline surveys are done by specialized teams that assess oiling characteristic and determine cleanup techniques through standardized observation methods such as the Shoreline Cleanup Assessment Team (SCAT) approach (Owens and Teal, 1990).

The aim of this paper is to illustrate how new sources of cartographic data can be accessed to answer the needs of operations personnel during the later, restoration phase of the response of an oil spill. New data sources include georeferenced topographic maps now available for most of the coastlines in North America, at various scales, ranging from 1/25000 up to 1/250 000. In addition, one meter resolution aerial pictures, also georeferenced, are now available for many areas of North America. High resolution satellite imagery of up to 60cm resolution can also be acquired.

Methodology

Our cartographic system was developed and tested during the course of later inspection and restoration phases of the Swanson Creek Incident, a pipeline break which affected the Patuxent River shorelines (Maryland) in spring 1999 (See Gundlach, et al, in this IOSC proceedings). System development took advantage of the availability of two different types of digital information, georeferenced raster version of topographic maps and digital orthophotos.

Georeferenced topographic maps are produced by the United State Geological Survey, and are available for most of the United States. These were downloaded through the internet. Two scales of maps were used: 1/100 000 and 1/20 000.

Digital Orthophoto (Quarter) Quadrangles, also known as DOQs**,** were provided by the Maryland Department of Natural Resources for the entire work area. DOQs are rectified digital images of aerial photographs with distortion and displacements removed and corrected for aircraft pitch, yaw and altitude, camera tilt, and terrain relief, thus conforming to the properties of an orthographic projection. The finished product is a spatially accurate image with ground features represented in their true planimetric positions. A DOQ is, therefore, a computer-generated image of an aerial photograph that combines the image characteristics of a photograph with the geometric qualities of a map. Also, the digital image is a GIS product that can be overlaid and manipulated like any other coverage or layer, and offers significant flexibility.

DOQs are produced by digitizing aerial photographs, and processed to produce 3.75 x 3.75 minute tiles with 1-meter ground resolution, which are mapped to 1:12,000 scale accuracy specifications. The image transformations are cast on the Universal Transverse Mercator (UTM) projections based on the North American Datum of 1983 (NAD 83).

All digital imagery was imported within the Arcview GIS software version 3.2.

A task-based needs evaluation was performed using principles from Hierarchical Task Analysis (Annett and Duncan, 1967). This evaluation was used to analyze the task and interaction of work teams involved in the inspection and cleanup activities that characterized the later steps of the response. The analysis allowed the development of map specifications. Prototype maps were produced and their usefulness tested with people in charge of operations personnel. Once approved, these maps were distributed to cleanup and inspection crews via proper protocols within the Incident Command System.

Results

The daily planning cycle for inspection and cleanup activities is depicted in Figure 1, where each box represents teams performing a series of tasks.

Results form the HTA are provided in table 1, which lists the main tasks done by each of the teams.

This list indicates that maps can provide support personnel involved in operations for the following tasks:

1. Indicate where restorations activities need to be performed.
2. Show the location and indicate the nature of the problem to solve.
3. Provide indications as to what needs to be done at each of the identified locations.
4. Provide indications on how to get personnel where they need to be. In this case, a map with such things as access roads and place names is usually required.

One single type of map could not answer all of these needs. Topographic maps, for example, are very good tools to provide information about access, since they include both place names, topology and roads. It was found, however, that these maps, which are often based on aerial photographs taken many years ago, generally lack the necessary precision to locate exactly environmental or geological features in the field. For this latter purpose, one meter high resolution DOQs are much better tools.

The system that was developed and implemented makes use of three (3) distinct types of representation, using either topographical raster images or DOQs as basemaps, integrated within the ArcView GIS.

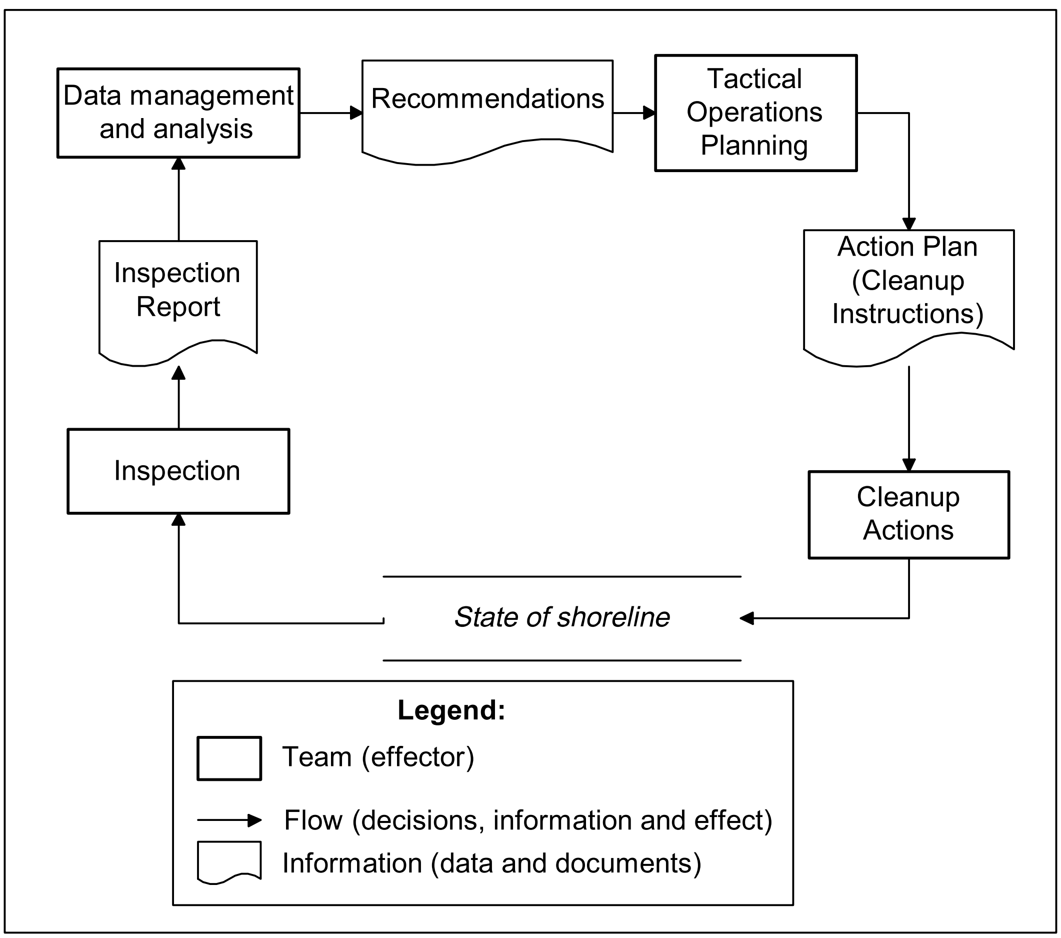

Figure 1. Daily planning cycle for the inspection and cleanup phases of the response.

Table 1. List of tasks performed by each of the teams involved in the later inspection and cleanup phase of a response.

Team	*Tasks*
Tactical Operations Planning	– Report findings of inspection crews
(Planning Section in coordination with Operations Section)	– Describe cleanup methods to be used
	– Input cleanup assignments (Form 204) with map into the IAP.
	– Upon Unified Command approval, transfer Form 204 and map to field crew leaders.
Data management and analysis	– Produce cleanup maps for reports
	– Produce cleanup instruction maps
	– Update status maps
	– Produce special types of maps on demand (for example, samples location maps)
Inspection	– Walk the beaches
	– Note any additional cleanup that needs to be done
	– Suggest cleanup method
Cleanup Operations	– Locate areas where cleanup completed and still needs to be done
	– Effect cleanup according to instructions

Division maps. The division maps shows the location of operational division overlaid on a topographical basemap (Figure 2). This representation

- Incorporates the higher level location of operational divisions
- Shows roads and place names.

These representations proved invaluable to all parties involved in spill response, as more than one hundred copies were produced and distributed.

Inspection maps. A type of map representation was developed specifically for the use of inspection teams, to allow them to report their observations during survey activities. These maps have the following characteristics:

- They use a 1meter resolution DOQ as a base
- Each map focused on a single area of operation
- They incorporate "finer" details such as the locations of shoreline segments, along with the segment codes (derived from the observations of SCAT survey teams).
- They were produced in black and white, to facilitate their reproduction.

Figure 3 shows an example of an inspection map which was produced for operational division E-4. Shoreline segment codes appear in smaller fonts along the delineation of the coastline.

"Hot Spots" maps. Observations from inspections teams were provided to operations personnel in the form of maps with the following characteristics:

- They used a 1 meter resolution DOQ as a base
- Each map focused on a single area of operation
- Each map identified the location of "hot spots", or areas that required the attention of cleanup crews
- For each area, a textual description of the nature of the "problem" was also provided.
- The shoreline segment code was used to identify each hot spot, in order to ensure uniformity in nomenclature.

Figures 4 and 5 show examples of a "hot-spot" maps which reports the results of inspections. Figure 5 is provided to demonstrate how the aerial map can be used to locate an otherwise hard to find tar patties.

Discussion

The developed system proved its effectiveness during the Swanson Creek incident. The division maps were quite effective as a mean to show all involved 1) where each geographic work division was located and 2) how to get there. These cartographic representation were extremely popular, as more than 100 copies were produced in the course of the response.

Using the higher resolution digital picture was also quite useful, since these were detailed enough to provide cleanup personnel with clear directions as to the location and nature of cleanup activities. Inspection reports will either signal that the state of the shoreline is acceptable, or that some additional cleanup is required. In this latter case, the cleanup effort was often quite small, such as picking-up a small tar patty, and involved work on a very limited area of the shoreline. A precise localization of the "problem", on a 1 meter resolution aerial picture, saved a lot of time to the cleanup crews.

In addition, the cartographic representation clearly and simply showed the work needed, and was considered a very useful communication and reporting tool.

The mapping representation could be made even better by incorporating latitude and longitude coordinates obtained through a Global Positioning System (GPS) apparatus. While such devices are now very common, they were not generally used during the Swanson Creek Incident, but their use is strongly recommended as a complement to the DOQs.

In short, the DOQ based set of maps developed to support the inspection and cleanup phases of the incident proved both effective and useful. These map tools ensured that the problem to solve was clearly identified and its location easy to find along a stretch of shoreline clearly. This saved both time and money.

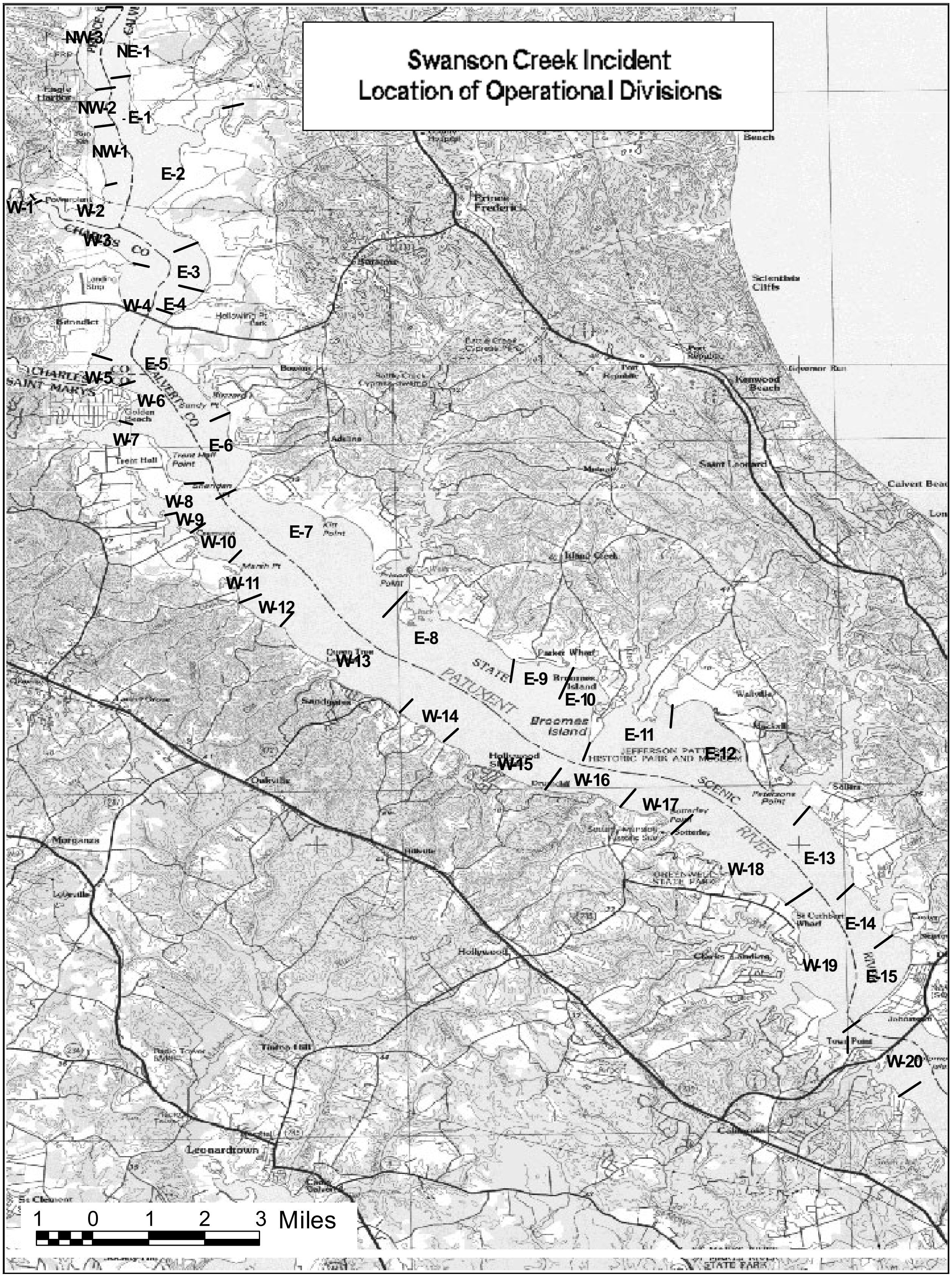

Figure 2. Topographic map showing the location of operational divisions.

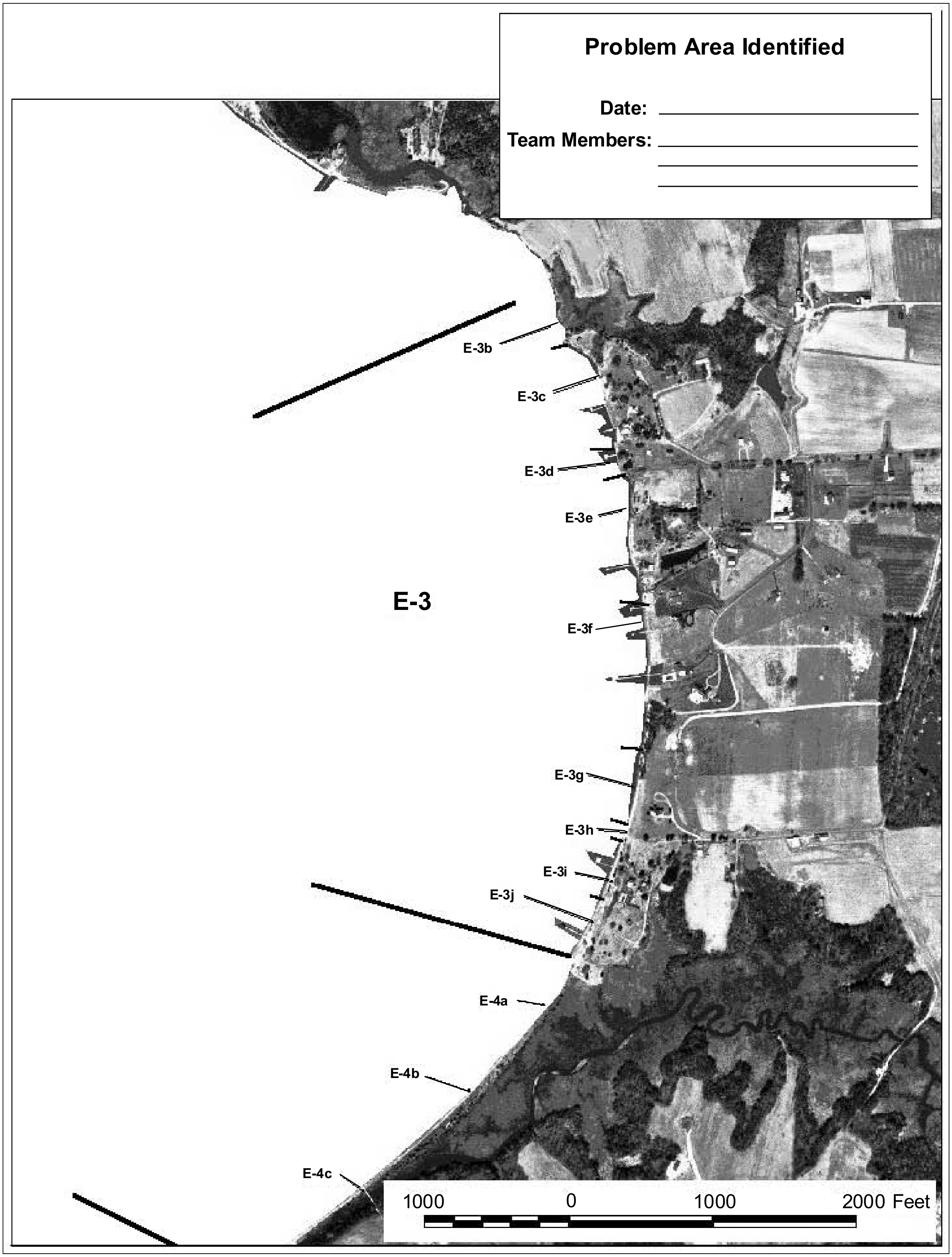

Figure 3. Inspection map for operational division E-3. The map uses a 1m resolution DOQ.

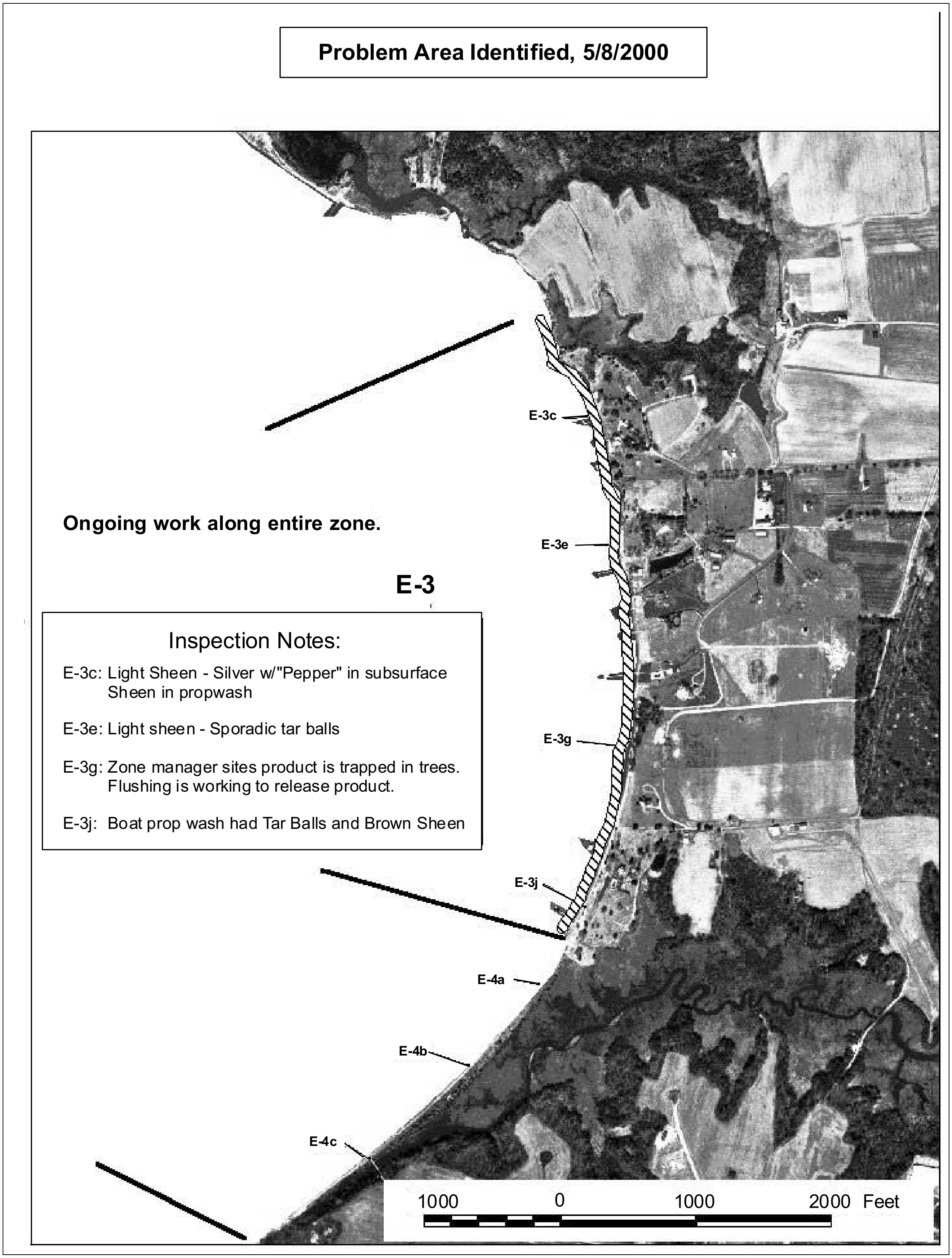

Figure 4. May 8 “Hot Spots” map for operational division E-3.

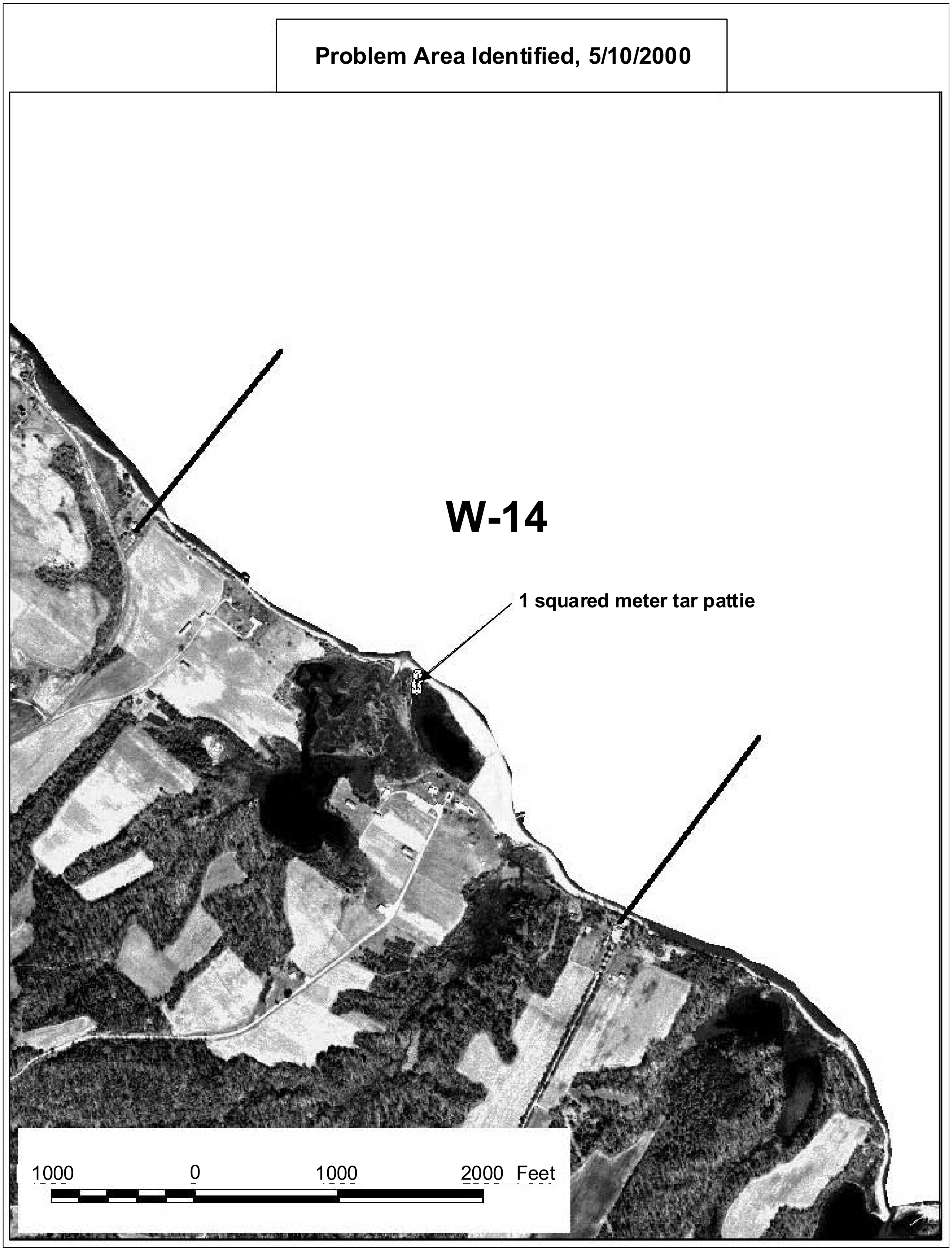

Figure 5. May 10 “Hot Spots” map for operational division W-14.

Biography

Alain Lamarche has been involved in the design, development, implementation and operation of many environmental management systems, including geographical information systems. His main research interests include performance and environmental decision support for emergency response.

Reference

1. Annett, J. and K.D. Duncan, 1967, Task Analysis and Training Design, *Occupational Psychology* 41:211-221.
2. Lamarche, A. and E. H. Owens, 1996, The Benefits of Computerized SCAT Data Management within an Incident Command System, *Proceedings of the 21th Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, Environment Canada, Ottawa*, p.157-166.
3. Lamarche, A. and E. H. Owens, 1997, Integrating SCAT data and Geographical Information Systems to Support Shoreline Cleanup Operations, *Proceedings of the 1997 International Oil Spill Conference.* Tampa, Florida, pp 499-506.
4. Lamarche, A., A.P. Varanda and P. Rubec, 1996. Geographical Information System (GIS) Support for Shoreline Cleanup Operations, *Proceedings of the 19th Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, Environment Canada, Ottawa*, p.1131-1143.
5. Owens, E.H. and A.R. Teal, 1990. Shoreline Cleanup Following the EXXON Valdez Oil Spill-Field Data Collection within the SCAT program, *Proceedings of the 13th Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, Environment Canada, Ottawa*, p.411-421.