Hazardous Waste Sites Characterizations using Geographic Information System in Newark, New Jersey

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ABSTRACT

The technology of the Geographic Information Systems (GIS) is used to map the potential hazardous waste site locations within the southeastern portion of Newark, New Jersey and to assess the potential risks of such sites to both human and environmental health. The study site is a densely populated section of the Newark metropolitan area with high concentrations of industries, predominantly chemicals, oils and paints. Varieties of geospatial data in both digital and analog forms were input for GIS database development and proximity analysis was performed using a GIS software--ArcView. This pilot study provided a baseline integrated GIS system which proved to be a cost-effective tool in gaining detailed information on waste sites and their impacts on both ecosystem and human welfare.

INTRODUCTION

The Newark Metropolitan area is a densely populated and highly industrial area. Various types of industry, currently active or inactive have produced and disposed of many potentially hazardous materials over past decades. Many of the plants have closed their operations after the US Environmental Protection Agency(USEPA) has set stricter regulations, but their former locations have remained contaminated. Some of the contaminants found are various liquids and vapors designated as Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Hazardous Substances. Many of the substances present potential threats to the public through direct contact and spillage or may cause fire and/or explosion through vapor emission (USEPA, 1993)[1]. Although the type of contaminations present and the level of risks to public health and the environment are not fully determined, the information provided by the USEPA and the New Jersey Department of Environmental Protection and Energy (NJDEPE) are important measures to protect the public health and the environment. The Toxic Release Inventory (TRI) published by the USEPA provides information about toxic chemicals that are being used, manufactured, transported, or released into the environment (USEPA Web Site)[2]. NJDEPE established the guidelines to protect the prospective buyer of any transactions made on the contaminated parcels. New Jersey offers the nation's model buyer protection program for a wide variety of manufacturing operations covered by the state's Industrial Site Recovery Act (ISRA). Under ISRA, any environmental contamination which poses a risk to public health and the environment are required to be identified and remediated by the sellers (NJDEPE Web Site)[3].

STUDY AREA

The study site is located within the Newark Metropolitan area in Essex County, New Jersey (Figure 1). This area is densely populated and located adjacent to a highly industrial zone. The predominant industries in this zone produce chemicals, paints, oils, and lubricants. These plants have historically produced and stored various chemicals and hazardous wastes at levels dangerous to human health and environment. Geologically, the study site is located in the Triassic Lowland Physiographic province, which is bordered on the west by the Ramapo fault and crystalline rocks of NJ Highlands, and on the east by the metamorphic rocks of New York City. The bedrock underlying Newark consists of red sandstone and shale deposited during the late Triassic Period. These formations weather rapidly and typically are not exposed in the city except at foundation excavations. The rocks strike northeast-southwest and typically dip about 15° northwest. The influence of bedding is manifested by subtle topographic differences throughout the city, (i.e., M.L. King Blvd). As Pleistocene glaciers receded from Newark about 12-15,000 years ago, they deposited a thin veil of glacial drift over the bedrock(Manspeizer, 1980)[4]. The drainage is generally good, the depth to water table is estimated to be 6-10 feet (Engineering Soil Survey, 1951)[5].

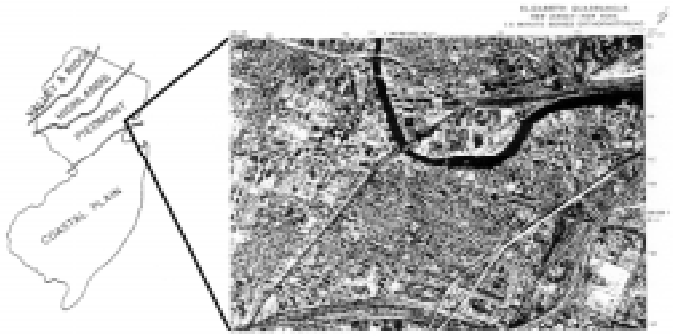

Figure 1. Portion of the Elizabeth Orthophoto Quadrangle Showing the Study Sites.

The objective of the project was twofold: 1) to identify and delineate the hazardous waste sites within the study area, and assess the location/proximity of the individual site to the residential and environmentally sensitive areas, and 2) to establish buffer zones and rank the sites for better management of the existing and incoming industries in order to prevent the further degradation of natural resources within the metropolitan Newark.

GIS AND HAZARDOUS WASTE SITE CHARACTERIZATION

Varieties of geospatial data in both digital and analog forms were input for database development and proximity analysis was performed using the GIS software -- ArcView. The characteristics of input data integrated into the GIS are listed in Table 1 and described as follows:

Data Source	Scale	Type
USGS Elizabeth Quadrangle (Orthophoto)	1:24,000	analog
USGS Elizabeth Quadrangle (Topographic Map)	1:24,000	analog
US Census Bureau Essex County, NJ Tiger 94	1:100,000	digital
USGS Digital Line graph (DLG)	1:24,000	digital
NJDEPE/ISRA[6] (attribute data only)		
USEPA/TRI (attribute data only)		

Table 1. Sources of Data Integrated into the GIS

1) The USGS Orthophoto Quadrangle map, which is a geometrically corrected airphoto with some cartographic annotations. The orthophotoquad was scanned as a (*.tif)file and transferred to a compatible format within ArcView (i.e., shape file) for use as a background image over which the other geocoded data were assembled. 2) US Census Bureau TIGER[7] (Topologically Integrated Geographic Encoding and Referencing) file, which is many files linked together using the integrated nature of the structure as the key. It relates all mapable features, address range information and geographic codes, and reflects in change to one item in all other files simultaneously. TIGER file was reprojected for georeferencing using the PC/ArcInfo Data Automation Kit for input into GIS(ESRI, 1996)[8]. 3) USGS Digital Line Graph (DLG-3)[9] structure, which is a data exchange format providing a fully topological data designed for integration into GIS. DLG-3 data of the study site containing the hydrography and boundary coverages were transferred into (*.Dxf) file format and used for delineation of hydrological features and wetlands within the study site. Orthophotoquad was then used for identification and delineation of hazardous waste sites in conjunction with the information derived from the ISRA and the TRI. The State's ISRA stores owner's name, address and the size of the individual site for public access. TRI, which was used as a complementary component to ISRA, stores facility name, address, latitude/longitude and the name of the parent company. Information derived from the ISRA and TRI attribute tables were linked to TIGER 94 file to generate new data layers using ArcView geocoding function and were used in combination with the orthophotoquad. The process of address matching was achieved by selecting a unique identifier from the TIGER attribute table (i.e., street address) and linking it with the location of it's corresponding toxic release/waste site identified on the TRI and ISRA data layers using the ArcView query builder. A query expression was specified from the attribute table in order to extract a common field for merging it with TIGER data. Table 2, 3 and 4 demonstrate, the results of the query operation.

SHAPE	FEATURE	COMPANY_NAME	ADDRESS	OWNER
Polygon	ISRA site	Scientific Chemical Processing	411 Wilson Avenue	Sigmund & Presto
Polygon	ISRA site	Courtesy Container Landfill	Rear 411 Wilson Ave	NHA
Polygon	ISRA site	Diamond Shamrock Site	Rear 86-102 Lister	
Polygon	ISRA site	N.J. Transport	701 Ferry Street	NJ Transit
Polygon	ISRA site	Arkansas Chemical Co.	185 Foundry Street	City

Table2. Portion of the ISRA Sites

SHAPE	LENGTH	FNAME	FTYPE	LEFTADD1	LEFTADD2	RGTADD1	RGTADD2	L_CITY	R_CITY
PolyLine	101.192400	Lister	Ave	122	162	119	159	Newark	Newark
PolyLine	76.741550	Lister	Ave	104	120	101	117	Newark	Newark
PolyLine	76.879800	Lister	Ave	90	102	85	99	Newark	Newark
PolyLine	163.844500	Lister	Ave	58	88	51	83	Newark	Newark
PolyLine	323.736000	Ferry	St	682	752	671	765	Newark	Newark
PolyLine	125.943000	Foundry	St	182	208	185	205	Newark	Newark

Table3. Portion of the TIGER

SHAPE	FACILITY	ADDRESS	CITY	AV_SIDE
Point	AUTOMATIC ELECTRO-PLATING	185 FOUNDRY ST.	NEWARK	R
Point	B. M. & CO.	134 LISTER AVE.	NEWARK	L
Point	BENNETT HEAT TREATING CO. I	690 FERRY ST.	NEWARK	L
Point	DARLING INTL. INC.	825 WILSON AVE.	NEWARK	L

Table4. Portion of the TRI Facilities

Additionally the locations of community services (e.g., school, hospital and playground) as well as environmentally sensitive areas (e.g., wetland, stream and canal) were delineated on the image map. All data were transformed to the same projection, ellipsoid, scale and datum as a basic requirement in a GIS database development and were converted to shape files for manipulation within the ArcView software. GIS analysis functions such as search and proximity operations were used to measure the proximity to the sites and assess their potential risks to both human and environmentally sensitive areas. Establishment of buffer zones (i.e., 500', 1000' and 2000') around the known hazardous waste sites were the basis for assigning the ranking criteria as unsatisfactory, marginal and satisfactory to assess the potential risk hazards to the areas of interests(i.e., school, hospital, park, etc.). Results of such analysis as a final output depicts the areal extents of various buffer zones for single and multiple sites indicating the severity of health hazards on human and natural resources (Fig. 2).

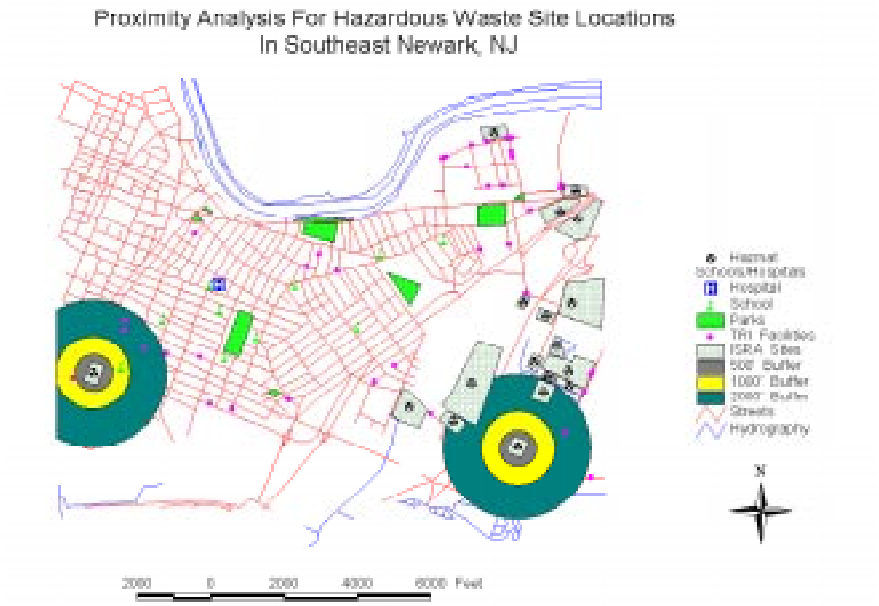

Figure 2. Final GIS map of the study site

This low cost pilot study provided a baseline integrated information system assisting the future remediation process which requires detailed data collection and chemical analysis of the field samples. Future work will focus on the generation of additional datasets--digital elevation model (DEM) and digital orthophoto quadrangle (DOQ) from high resolution aerial photographs. The stereo analysis of high resolution photographs will facilitate detailed measurement of size, depth and volume of contaminated soils within the individual buffer zone. A PC-based softcopy photogrammetry package--Digital Video Plotting (DVP) will be utilized to generate DEM at high resolution (characterizing 1 ft contour elevation) and to produce orthophoto at large scale. Integration of the DEM data layer into the GIS will help in remediation processes for removal of the contaminated soils from the selected sites.

Note: Based on the criteria set by NJDEPE waste disposal sites should not be within 2000 ft of human and natural resources (NJDEPE, 1984)[3].

ACKNOWLEDGMENT

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