GIS Applications in Site Remediation

Before the era of “environmental awareness,” few people were concerned about the harmful public health and environmental impacts of dumping, spilling, or burying chemical and radiological waste. On thousands of properties across the country where such practices occurred, the result was contaminated buildings, soils, sediments, surface water, groundwater, and landfills. Congress established the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980. Commonly known as Superfund, CERCLA authorizes response or cleanup actions that permanently and significantly reduce the dangers associated with releases of hazardous substances. The site cleanup process can take many years to complete and generally includes the collection of large amounts of environmental data to be used in making cleanup decisions about a site. Characterization and remediation activities at these sites are very expensive. But, it is not only large, Superfund sites that must deal with environmental cleanup and remediation. Smaller commercial and local-level sites must also remediate contamination from past and present activities. Environmental data management, analysis, and communication are essential components of environmental characterization and decision making. This is where GIS comes in.

A key project activity that impacts remediation decisions, cost recovery, and cleanup confirmation is data collection, analysis, and reporting. Data typically collected for contaminated sites include geologic information, such as lithology and soil characteristics; hydrologic information, such as groundwater levels and specific yields; and chemical information on the types, distribution, and concentration of contaminants.

Hardware and software improvements in the personal computing industry have enabled more people to utilize powerful data analysis and display tools such as GIS, 2-dimensional contouring, and 3-dimensional presentations of contaminant dispersion. Multiple data types are combined to provide a fullFeatured image including aerial photographs, utilities, parcel tracts, contaminant contours, land use and zoning, soil types, and digital elevations. GIS applications in site remediation can include environmental data management, contaminant fate and transport modeling, and the integration of GIS with three and four dimensional modeling and visualization.

One of the most notable uses of GIS in site remediation involves the development of large chemical databases that contain environmental, municipal, and engineering data. GIS enables users to access data from multiple sources and analyze changes in compound concentrations and spatial distributions over time with respect to surrounding environmental data. GIS-enabled mapping enables interactive assessments of subsurface contaminants and their surrounding environments.

GIS is still used in initial site investigation operations, such as historical document and aerial photograph review. Historical aerial photos obtained from flyovers are digitally georeferenced to a site map. The photographs can show the presence and location of former storage tanks, wastewater disposal beds, and other contamination sources which had been removed from the site prior to the discovery of the contamination. Analysis of spatial digital environmental data available from state and federal agencies is conducted
during initial site investigations. The data can include the locations and characteristics of present and former wetland areas (highly sensitive receptor), surface-water bodies, off-site contamination sources, and other potential sensitive receptors. Site maps can be generated in the GIS to include layers for utility lines, sample locations, building and structures, site features, and surrounding environmental features.

The overall impression of GIS in this field has been one of underdeveloped, under-utilized capabilities. GIS has been used in basic site investigations, mapping, and modeling functions. However, advanced GIS technologies, especially when used in combination with other technologies such as GPS and the internet, bring unique capabilities to environmental characterization and decision making that can result in reduced data-acquisition, management, and analysis costs while resulting in faster and better informed environmental decision making. Combining such technologies as GIS, expert systems, and simulation models into an “all-in-one” decision support system seems to be the future in this field. A comprehensive analysis in a “one-stop” setting will prove to be a powerful tool in environmental applications. It will result in a more powerful, complex, and interactive method for decision support.

The combination of cost-analysis with the application of GIS to visualize situations has the potential to garner consensus among users and constituents to address potential economically damaging problems in local governments. GIS provides visual representations of complex information as well as an integrated geospatial database for analysis, whereas cost-effectiveness approaches offer solutions in dollars. I believe this application of GIS will grow considerably in upcoming years.

GIS is a powerful tool and has many useful functions in environmental remediation. However, GIS can not be used alone. It must be used in conjunction with other technologies to be a comprehensive, environmental analysis tool. The key to applying them effectively lies mostly in their acceptance by decision-making personnel and appropriate funding to implement them.

BIBLIOGRAPHY


This paper discusses the benefits of integrating ESs, GISs, and simulations models (SMs) into a comprehensive DSS framework to solve complex environmental problems, specifically how such a system can improve landfill design and management. GIS has been applied in past analyses for landfill site selection and evaluation, mapping preferential transportation routes, and in monitoring the subsurface beneath the landfill. However, this paper conveys the powerful capabilities of a comprehensive framework for landfill design and performance, which would include the use of a GIS.

GIS tools are allowing municipal officials to prioritize maintenance schedules, streamline delivery of public services, improve resource allocation, and increase fiscal efficiency. Texas municipalities are using GIS to locate areas of concern for waterborne asbestos from deteriorating asbestos cement pipes. The asbestos can enter the drinking water supplies and place citizens at risk of exposure. Officials are using GIS to identify pipelines that pose the highest risk and would be the best candidates for replacement. This has allowed the city planners and other employees identify risk areas more effectively and efficiently, therefore decreasing overall costs to the city.


The redevelopment of brownfields by public and private investors is minimal. Innovative technologies, including GIS, could provide investors with critical information regarding site conditions, extent and nature of contamination, and economic development potential. A survey of EPA brownfields sites showed that only 6 out of 39 (15%) were using an “innovative technology”. The six sites were using GIS for their site assessments and several successful case studies were included in the report. This paper suggests that innovative technologies such as GIS are underutilized in brownfields redevelopment and gives several potential reasons why relatively little attention or funding has been given to this technology transfer by any of the federal or state agencies involved with national brownfields initiative.


Land used for the production of agricultural crops is often left contaminated by radioactive wastes. At the time this paper was produced, a GIS-based decision support system (SDSS) was being developed to assist decision-makers in the management of the radioactive contaminated land resources. The system would be used for evaluation and selection of remediation strategies. The assessment of the different remediation techniques would be based on the level of contamination, the land-use management, and a wide range of environmental parameters. The SDSS would produce maps depicting the appropriate remediation option for each grid cell. This paper discussed the need for SDSS in these environmental applications, their benefits, and how it can be implemented within the context of a GIS.


Chlorinated solvents were detected in the groundwater at a former chemical storage plant. The solvents were migrating in the general direction of groundwater flow in two distinct solvent plumes. Excavation of contamination “hot spots” was proposed followed by implementation of a groundwater remediation system. A GIS mapped the plumes using a triangular irregular network (TIN) and contaminant concentrations were assigned to each cell. Excavation areas were compared to the proposed excavation areas taking into account the percentage of the contaminant plume removed, the soil volume
removed, and related costs. Using GIS helped target the worst areas of contamination and provided a cost-effective solution.


Pollution of soil, surface water, and groundwater are often characteristic of large-scale chemical industry sites. The pollutants may spread to uncontaminated areas and endanger surface water, drinking water wells, and humans. Many of these large industrial sites are concerned with multiple contamination sources and/or pollutants, which require a multi-phase remediation approach. Since complete clean-up is neither economically feasible nor technically possible, GIS tools aid the remediation strategy by using a risk-based approach. A 3-D model was built at a large industrial site in Germany using GIS to analyze areas based on geology, contaminants, hydrogeology, land use, potential receptors, etc. This model identifies areas of greatest concern for the remediation process.


Industrially contaminated land is not limited to the borders of the United States. It is, in fact, a global problem. The enforcement of the 1995 Environment Act in the United Kingdom requires the local authorities to audit contaminated land within their boundaries and to establish an action plan to meet regulatory requirements at these sites. A system was developed within the framework of Arc/Info to map contaminated land within city boundaries. This system, CLASS [contaminated land assessment system], is a comprehensive database for the contaminated areas within Newcastle City. Additionally, CLASS has a modeling component that can classify each contaminated site in terms of the future pollution potential. This GIS tool will aid city employees prioritize future remediation activities for each site.


This presentation focused on the advances of environmental characterization of contaminated land sites which allow quicker, more informed remediation decisions to be made. Environmental data is being collected and analyzed at a remarkable speed due to the advancements of GPS, GIS, computer modeling, and the internet. Data can be collected in the field using GPS receivers and is sent directly to personnel in an office who can download the data into a GIS or modeling system. The data is immediately analyzed, reviewed by project managers, and informed decisions can be sent back to the field crew regarding the field work. The required technology and equipment are becoming cheaper and more readily available. The process is making site characterization easier, faster, and more cost-effective.

Gessaro, Jeremy.  GIS for Ordnance/Explosives Remediation, Formerly Used Defense Site, Camp Beale.  ESRI User Conference Presentation.
The Formerly Used Defense Site (FUDS) at Camp Beale has used geophysical, GPS, and GIS technologies to identify and locate unexploded ordnance (UXO). The site formerly had bombing, rifle, mortar, demolition, and machine gun ranges. During site closure, 64,000 acres were sold back to the public who now face the risk of exposure to UXO. Geophysical surveys are conducted to locate UXO and geographic coordinates are recorded. Data is compiled and passed on to a GIS, which creates color contour maps that visually identify anomalies detected by the geophysical survey instruments. These anomalies’ (potential UXO) coordinates are uploaded to the GPS, field crews find the location in the field, then they dig for each anomaly. GIS is used during archive searches of the area to analyze historic aerial photographs and maps. Certain features of interest are assessed and digitized. The GIS is used for topological analysis to identify high-risk exposure areas based on population densities, proximity to populations such as schools, churches, shopping centers, land parcel info, parcel owners, right-of-entry status, etc. GIS has proved to be a very useful tool in the remediation of the FUDS lands.