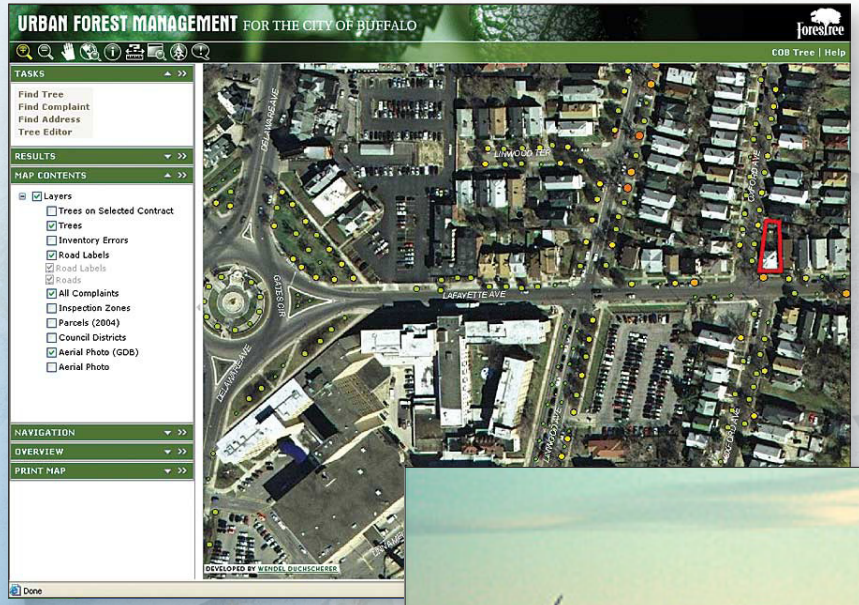
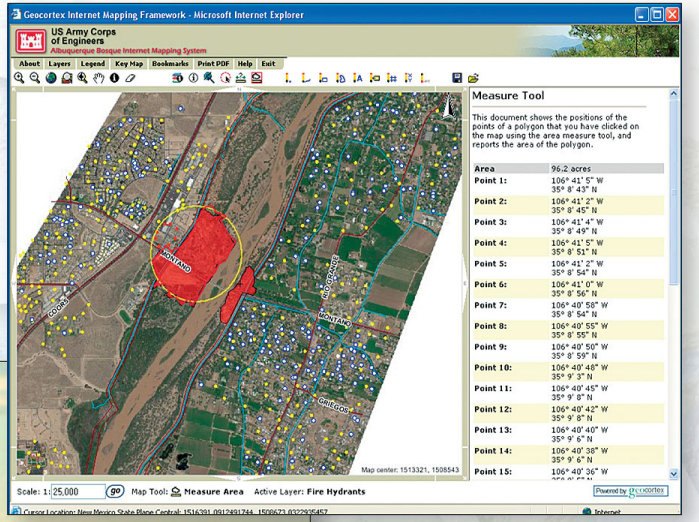
GIS is a Green Technology





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ESRI

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GIS Supports Global Green Initiatives

With the growing unease and awareness among large segments of the population that remedial action must be taken to resolve the many environmental crises we now face, GIS solutions are currently being implemented around the world that provide the technological and scientific support necessary to create programs and processes designed to return our planet to a more sustainable and balanced level of use.

Whether increasing the efficiency of fleet vehicles by optimizing standard routes and subsequently reducing fuel consumption or determining the optimum location for a wind farm to produce energy with minimal pollution, GIS provides the quantified information and analytical capabilities necessary to make decisions that can both support growth and reduce consumption.

The visualization capabilities of GIS afford a unique way of examining things that promotes creative out-of-the-box thinking, providing insight and solutions that are not so apparent in written reports and tabular data. Often, an existing GIS implementation stimulates the need to modify existing business practices or apply new ones that lead to savings in both costs and resources.

The stories included in this e-book detail GIS-based applications for innovative, sustainable solutions to many of today's common environmental problems. Cascade County, Montana, uses GIS to map the optimum locations for wind farms and promote investment in this "green" energy source. Buffalo, New York, known as the City of Trees, maintains its urban forest inventory with GIS. Air pollution in Jakarta, Indonesia, is severe; in 2004, 46 percent of all illness in the city was respiratory related, but backed by GIS-based scientific studies, the government has implemented an ambitious plan to improve air quality. The release of carbon dioxide (CO_2) into the atmosphere is the fundamental cause of global warming; GIS is being used in the study and implementation of CO_2 sequestration programs, which either capture the pollutant at its source or absorb it through the planting of vegetation. The U.S. Army Corps of Engineers used GIS to restore the natural habitat of the Middle Rio Grande in New Mexico, and the City of Boston, Massachusetts, is implementing an ambitious solar energy program by using GIS to calculate the solar radiation available on city rooftops.

As ESRI president Jack Dangermond has often said, "The application of GIS is only limited by the imagination." *GIS Is a Green Technology* provides an introduction to the powerful capabilities of the software when applied to environmental and sustainability issues as well as the ingenuity of those developing these innovative applications.

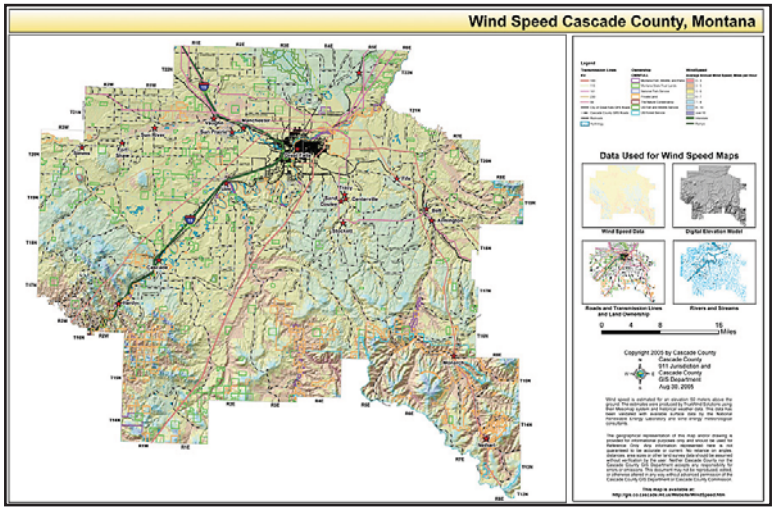
The Big Sky State Taps Wind Resources

Cascade County, Montana, Visualizes and Maps Data with GIS

Highlights

- ArcGIS Desktop is used to create a wind map book combining wind, transmission, parcel, and road data.
- GIS data helps investors and developers locate best wind power resource areas.
- The county can visualize wind speeds and transmission lines with the functionality in ArcGIS.

Cascade County, Montana, has its county seat in Great Falls and lies in an area on the eastern slope of the Rocky Mountains known for its powerful chinook winds. Cascade County commissioner Peggy Beltrone has coined the area south of the Canadian border the Don Quixote Canyon after the fictional character who had notable encounters with windmills. Beltrone, who also serves on the Department of Energy (DOE) Wind Powering America steering committee, has been the force behind a unique wind marketing program for the county that is receiving attention around the globe.



A wind speed map created with GIS.

"There is a tremendous wind resource in Montana," Beltrone says, "but wind is generic, and the way to differentiate the wind that crosses through your county and the next county is to draw attention to it and make it easier for developers to explore your wind resource and see its value over wind in other areas."

Cascade County is using GIS to help developers interested in investing in wind power easily research parcels available for lease and the wind resources that exist on those parcels. In addition to regional developers, interest has come from business people as far away as Japan and Ireland internationally and Florida in the United States.

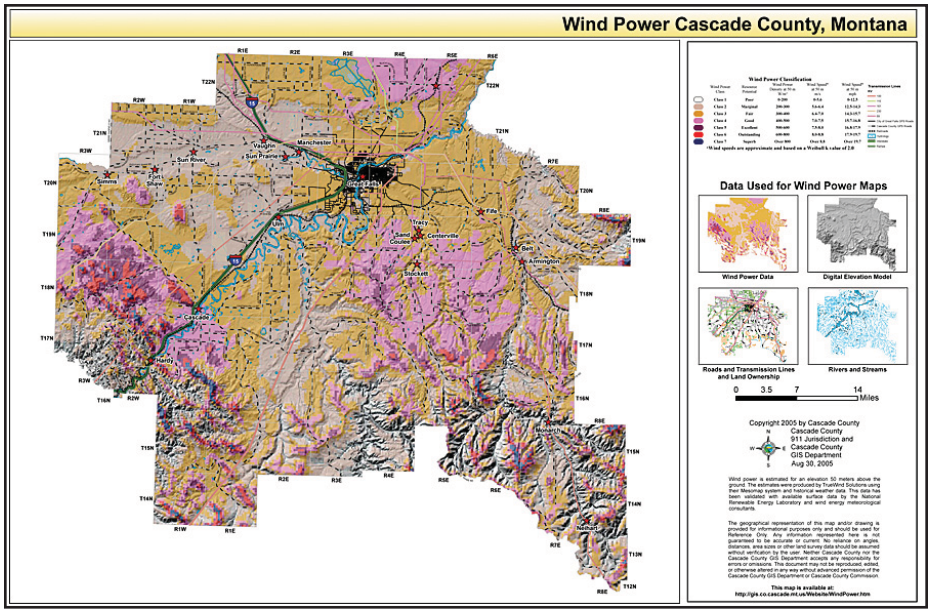
"We have a lot of people coming into our office looking for data on wind," notes Tom Mital, GIS manager for Cascade County. To better serve these interested parties, Mital used his county's ArcGIS Desktop software to create a wind map book that combines wind, transmission, parcel, and road data. The wind speed estimates for an elevation of 50 meters above the ground were produced by TrueWind Solutions LLC (Albany, New York) using its Mesomap system and historical weather data. The data was then validated with surface data from the National Renewable Energy Laboratory and wind energy meteorological consultants.

Horseshoe Bend Wind Farm in Cascade County, Montana (source: John Godwin).

A PDF version of the map book is available on the Cascade County GIS Department Web page at www.co.cascade.mt.us. The Web page also includes links to a Wind Power Map and Wind Speed Map that visitors can download in PDF format. When someone requires more detail about a specific area, Mital creates a custom map.

ArcGIS allows the county to show developers wind speeds across the county and locations of transmission lines. "Along with that, we have data such as topography, so it's very easy for someone to see that a wind farm would not be on the top of a pristine mountain," Beltrone notes. "This saves developers from having to fly in and be on the ground to see these things for themselves, and it saves them from having to go to the courthouse to search for landownership documents. Instead, they can access all of this information in one place on a computer anywhere in the world."

Once a developer leases property from a landowner, typically a farmer, the investor installs a commercial-grade anemometer to measure the wind speed at 50 meters. Measurements are taken for approximately 18 months to verify the wind speed before installing wind turbines and connecting to a transmission line.



A wind power map.

"The nation is thirsty for wind power," Beltrone says. "Today, wind power supplies 1 percent of the nation's electricity. Under a plan by DOE's Wind Powering America, that number could climb to 20 percent by 2030."

In Cascade County, anemometers are showing up on land throughout the area, and there is currently one wind farm, Horseshoe Bend, that has six wind turbines producing nine megawatts of energy.

In addition to the positive environmental impact of generating green energy, wind farms allow the county to expand its tax base. During the first year of taxation, Beltrone estimates that each commercial wind turbine brings $25,000 into the community.

For the investors, the wind farms generate revenue when they sell the energy the turbines generate. Additionally, investing in green energy helps states meet renewable energy portfolio standards. Twenty-nine states have adopted renewable energy portfolio standards.

"The advantage of using GIS in the marketing of wind is that it gives developers a lot of information that they need to decide whether or not placing a wind turbine in this area is going to work for their power needs and their budgets," Beltrone adds. "One executive told me that the information we provided saved his staff months of work, since we did all the work for them. If he can take a look at our resources without having to invest time and money in preliminary research, it's a big draw."

(Reprinted from the Summer 2008 issue of *ArcNews* magazine)

Wind data from sensors on this rural anemometer is sent to remote computers for analysis.

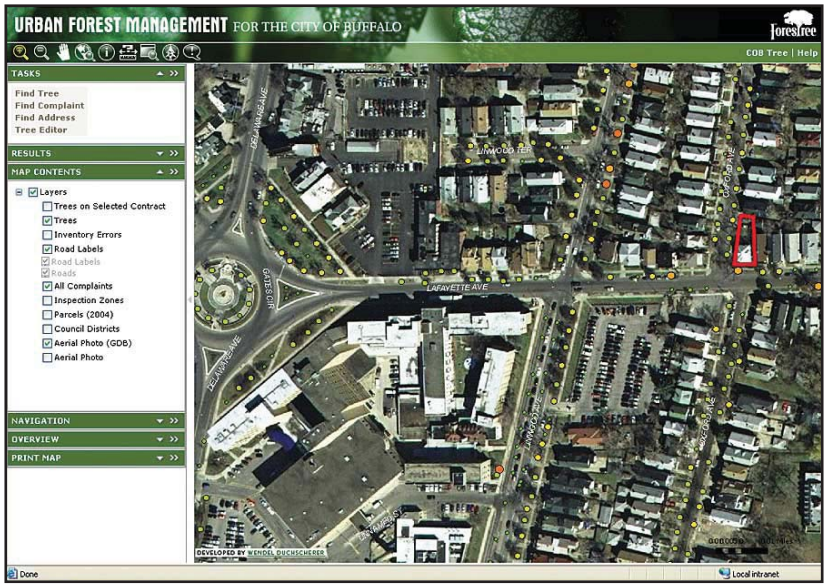
Buffalo, New York, Urban Tree Management Evolves from Surprise Storm

Web-Based GIS Helps "City of Trees" Recover

Highlights

- Errors caused by lack of information or delayed communication are prevented.
- Real-time display of completed work helps decison makers.
- Program saves the city money, which is being used to plant new trees.

On October 13, 2006, a historic lake-effect snowstorm surprised the city of Buffalo, New York, dumping more than two feet of snow overnight. Two days later, president George W. Bush issued a major disaster declaration for the city and surrounding areas. Federal aid was made available to assist in recovery efforts.



The tree management Web-based GIS allowed full editable access to instantly update tree records and complaint information.

Located on the northeast shore of Lake Erie, Buffalo sees an average of more than 93 inches of snow each year. This particular storm event was unique because it happened in early October; most major snowfall does not occur until late November or early December. As a result of this snowstorm, there was widespread damage to roughly 85 percent of the area's trees. This damage was a result of vertical snow loading on fully canopied trees, causing limbs to structurally fail. The falling branches caused excessive damage to cars, houses, and power lines, leaving nearly 400,000 residents in more than 100,000 homes without power for several days.

Known as the "City of Trees," the city of Buffalo has maintained a complete urban forest inventory since 2001. This inventory includes all city-owned trees that reside in the public rights-of-way between the curb and sidewalk and also all trees in the city parks. There are 68,000 trees and 108,000 locations included in the tree inventory.

After the October storm and the initial clearing of fallen trees and tree branches from the roadways, the city started assessing the condition of the urban forest. Within the first few days after the storm, the city realized that a new system would have to be implemented to assess and inventory all damaged trees throughout the city. The existing tree inventory management system in place at the time of the storm was not capable of supporting the effort needed to assess and update the inventory on such a large scale. Before the October storm, many of the tasks needed to manage the tree inventory were completed using a paper-based system involving the use of paper tickets. Hours of data entry into a central database was necessary after information was recorded on paper forms out in the field. Another consideration for the development of a new system was to improve the city's chances to qualify and receive maximum funding from the Federal Emergency Management Agency (FEMA) for the several-month-long poststorm cleanup effort.

Urban Forest Specialists and GIS Professionals

Wendel Duchscherer Architects & Engineers, with headquarters in Amherst, New York, has been the city's urban forest manager since 2005, responsible for day-to-day maintenance and management of the tree inventory. This includes the issuance and management of annual trimming, planting, and removal contracts; handling citizen complaints regarding street trees; inspecting contractor work; and inspecting and updating information on each individual street tree in the inventory.

The firm's urban forest specialists and GIS professionals collaborated to develop a GIS-based tree management program to answer the urgent and comprehensive needs of the city resulting from the weather disaster. The program was called Urban ForesTREE Management

and was developed utilizing a combination of ArcGIS Server and ArcIMS technologies. When the initial development started two weeks after the storm, four separate groups were identified as primary users of the program: contractors, inspectors, city officials, and the urban forest manager. Each group had a customized Web-based GIS site developed to fit the particular needs and requirements of the work that was completed. By having each site use the same central database, work that was completed on one group's site instantly updated the information on the other three sites. This prevented errors caused by lack of information or delaying communication to the decision makers.

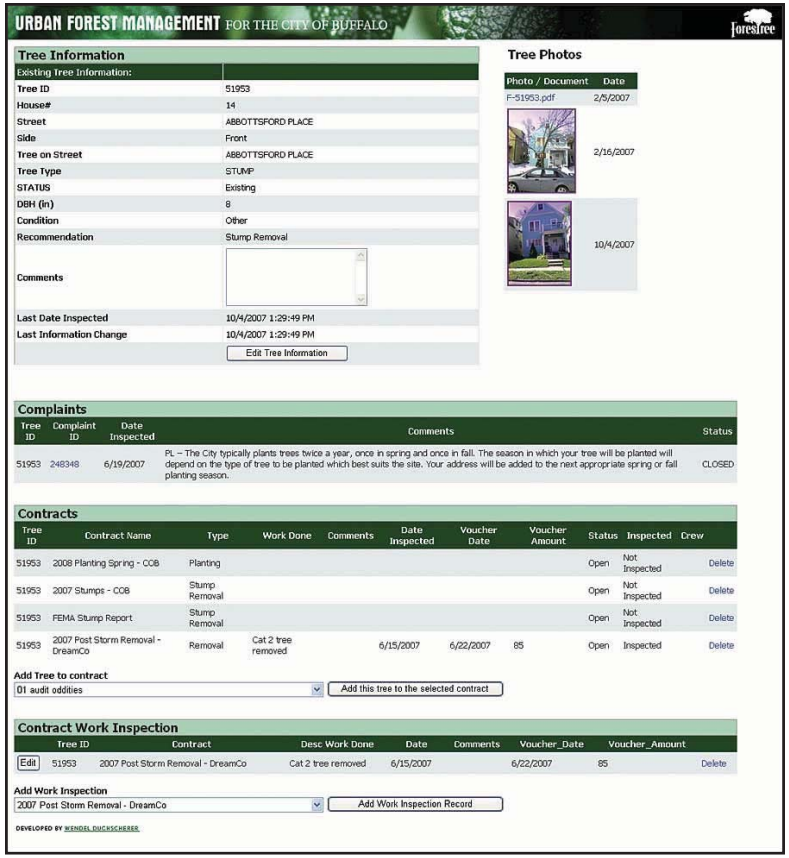
The city's tree population was devastated by the surprise storm.
This shows one of the many city streets blocked by fallen tree limbs.

The first task after the storm cleanup was to inventory all the damaged trees of the 68,000 existing trees owned by the city. An ArcIMS application was developed by Wendel Duchscherer to run on a Pocket PC that inspectors used in the field to enter data. One of the main considerations when development started was the elimination of paper forms. These forms

were re-created as editable Active Server Page (ASP) forms and integrated into the ArcIMS site. This not only helped the field-workers with organization, it also eliminated the need for office personnel to enter the data into the central database. General reference layers (e.g., parcels, aerial photography, roads) were added to the application to help inspectors reference their location when in the field. Through this application, inspectors were able to select a tree on the map and enter updated information directly into the central database. There were up to 10 inspectors in the field at one time after the storm. Another benefit of this system was the real-time display of completed work. Project decision makers and city officials were able to view daily progress and all detailed field information.

Once the damaged trees were assessed, they were added to either trimming or removal contracts. The firm then developed another ArcIMS application to help contractors mobilize their crews and track and locate the trees on each particular contract. Organization of the individual contractor information was critical, as more than 100 field crews were working throughout the city at any one time. The ArcIMS site provided the contractors with a map and list of the trees for each of their individual contracts. When work on a tree was completed, the contractor was able to request inspection of the tree through the Web site; the inspection request would be instantly added to the Web application, allowing inspectors already mobilized in the field to visit and inspect completed work sites on a more timely basis. This not only automated the scheduling and work assignments for the inspectors but also expedited the verification and payment process for the contractors.

The most complex parts of managing the city of Buffalo's urban forest is editing tree locations and attributes, along with handling complaints submitted by the public. Wendel Duchscherer developed an ArcGIS Web Mapping Application (WMA) designed to efficiently meet these challenges. The urban forest manager needs the ability to edit the location and associated attributes of every tree in the inventory. A tree information tool allows viewing and editing of each tree simply by selecting the tree through the mapping interface. Individual trees can also be added to selected contracts while in the field, eliminating the need to create the contract information at a later time.



Detailed view of customized ASP Web forms allowing updates while out in the field.

The city's Web site has a citizen Call and Resolution Center where residents can submit complaints related to city services. Any complaints about city trees are entered into the system by geocoding the address entered on the Web complaint form. These geocoded locations are populated on the WMA site through a nightly automation process. A custom tool was developed that allows the urban forest manager to select an individual complaint and enter the various attributes recorded for response to the complaint.

The October storm caused unprecedented damage to the city of Buffalo's tree population and, at the same time, changed the management of its urban forest. The GIS-based Urban

ForesTREE Management program now provides the city with an innovative system to manage and maintain its urban forest more effectively and efficiently than ever—and saves the city money, which is being reallocated to repopulate the trees that were lost as a result of the storm.

(Reprinted from the Fall 2007 issue of *ArcNews* magazine)

Addressing Ambient Air Pollution in Jakarta, Indonesia

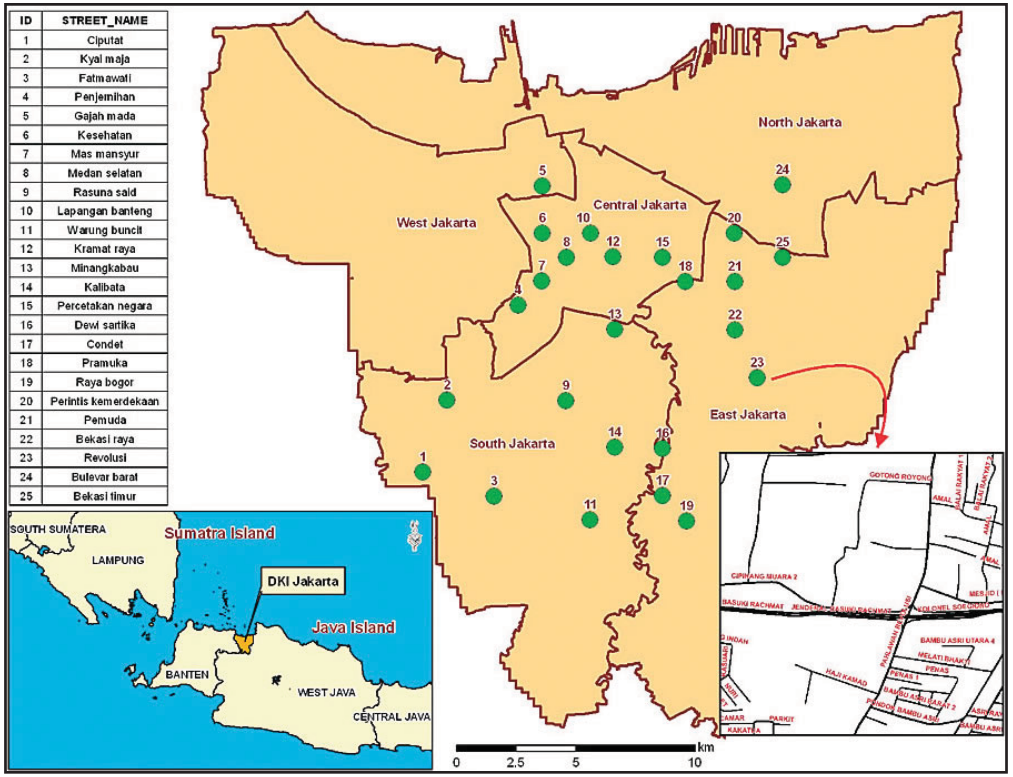
GIS and GPS Help Isolate Problem Areas

Highlights

- Sampling data was mapped with ArcView.
- GIS was used to describe and visualize the current air quality conditions.
- GIS helped efforts to define and resolve the problem.

Air pollution is a problem in big cities, including Jakarta province, the capital of the Republic of Indonesia. The pollution is due to increased human activities, population growth, the increasing number of industries, and transportation. Monitoring of ambient air quality parameters, such as total suspended particles (TSP), sulfur dioxide, nitrogen oxide, carbon monitrogen oxideide, hydrocarbons, and lead, in Jakarta indicates that the condition is concerning.

Transportation is the main source of ambient air pollution in Jakarta, which has 10 million people. It is larger than any other municipality in Indonesia with 15,000 people per square kilometer. According to the Statistic Central Agency, the number of vehicles in Jakarta in 2003 was 3.4 million motorcycles, 1.99 million passenger cars, 467,000 trucks, and 392,000 buses. Meanwhile, oil fuel consumption increased. In 2003, oil fuel use was 68 percent of total energy consumption. In 2004–2005, the demand for gasoline in Jakarta rose, resulting in increased air pollution. Ambient air pollution has a significant impact on the health and economic sectors. Health care costs increase by US$3.8 million per year. On average, people have only 18 "good air" days in a year. In 2004, 46 percent of all illness cases in Jakarta were respiratory related.



ID	STREET_NAME
1	Ciputat
2	Kyai maja
3	Fatmawati
4	Penjernihan
5	Gajah mada
6	Kesehatan
7	Mas mansyur
8	Medan selatan
9	Rasuna said
10	Lapangan banteng
11	Warung buncit
12	Kramat raya
13	Minangkabau
14	Kalibata
15	Percetakan negara
16	Dewi sartika
17	Condet
18	Pramuka
19	Raya bogor
20	Perintis kemerdekaan
21	Pemuda
22	Bekasi raya
23	Revolusi
24	Bulevar barat
25	Bekasi timur

Ambient air quality sampling locations in the DKI Jakarta area.

Recent Measurements

In June 2006, the Center for Health and Status Ecology Research and Development, National Institute of Health Research and Development, Ministry of Health, conducted research on this pollution. The aim of the study was to measure pollutant concentration, including TSP, nitrogen oxide, and lead. The measurements were conducted at 25 sampling points in five cities—West Jakarta, North Jakarta, Central Jakarta, East Jakarta, and South Jakarta. TSP was measured using a high-volume sampler, and nitrogen oxide was measured using a gas sampler. Lead concentration was measured using the atomic absorption spectrum. Sampling locations were chosen based on the density of vehicle traffic, and the measurement period was 24 hours at each sampling point. The sampling locations were recorded in GPS and moved to an attribute table to be visualized on a map using ArcView. The map also included information about the

density of people in relation to building density; location of parks, which help minimize pollution; and road information, such as major roads and artery roads.

Data was mapped in two categories, threshold and upper threshold. The upper thresholds were defined as TSP concentration higher than 230 micrograms/m3, the standard quality determined by the government; nitrogen oxide concentration higher than 92.5 micrograms/m3; and lead concentration higher than 2 micrograms/m3.

The results show that the TSP and lead concentrations at some sampling points were upper threshold. Meanwhile, the nitrogen oxide concentration at all sampling points was under threshold. Specifically, TSP concentration ranged between 74.07 and 416.26 micrograms/m3, nitrogen oxide concentration ranged between 23.61 and 55.36 micrograms/m3, and lead concentration ranged between 0.00 and 3.88 micrograms/m3. The highest TSP concentrations were found in Central Jakarta and East Jakarta, which was consistent with Central Jakarta being an office area and East Jakarta being an industrial area.

The main purpose of the GIS was to describe and visualize the data, showing the current air quality conditions. The visualization and analysis of data using GIS are very useful for environmental researchers and the government, quickly providing pollution information and locations, and helping with the evaluation of air pollution reduction strategies in Jakarta.

As a result of this study, the government has carried out various efforts to overcome the problem, including producing the integrated *Local Strategy and Action Plan for Urban Air Quality Improvement in DKI Jakarta, 2006.* The action plan has focused on implementation of lead phaseout and low sulfur and on development of public transportation to decrease the number of private cars.

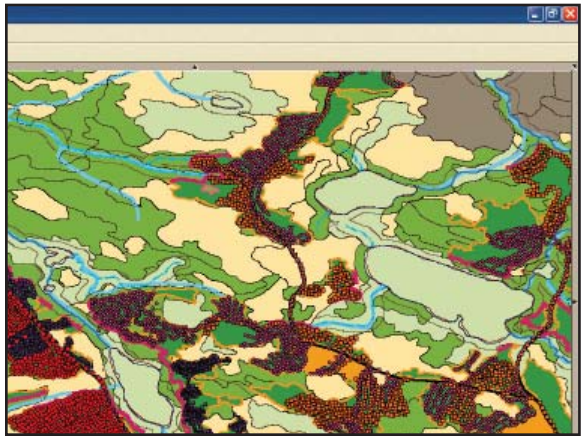
(Reprinted from the Fall 2007 issue of *ArcNews* magazine)

Harvesting Efficiently Using Mobile GIS

Kruger Publication Papers

Corner Brook Pulp and Paper (CBPP), a division of Kruger Publication Papers, has been using GIS since 1987 when they had a direct link to the Newfoundland Forest Service GIS located at Herald Towers, in Corner Brook. Today, they use ArcPad for pre-harvest planning field work by capturing the necessary terrain and tree stand attributes required for inventory analysis and operations planning. They also use ArcPad to help navigate harvesters in the woods and record harvesting activity.

Each harvester is equipped with a GPS recorder that tracks location and activity.



Harvest boundaries are defined as digital shapefiles and downloaded to the computers on the harvesters. This enables them to see where they need to cut and track where they have already been.

CBPP currently employs approximately 400 people for their harvesting and silviculture programs and another 500 in their newsprint mill and Deer Lake Power operations. Their operations typically run 24 hours a day, five days a week and naturally must work within seasonal time constraints.

Pre-harvest planning is an intensive and rigorous activity that requires collecting accurate block boundaries for harvest digitally to reproduce operational maps. CBPP uses ESRI's ArcPad

software, running on Thales and Trimble GPS units, to create and manipulate shapefiles of harvest blocks in the field, then adds this data to the company's corporate GIS. This data is used to create an accurate representation of a harvest block, an accurate volume determination, and the minimum road requirements for passage along with other valuable attributes affecting navigation such as slope and hydrology.

To further improve harvesting operations, CBPP installed simple electronic service recorders (Multidats) on five harvesters in September 2006. Each Multidat is equipped with an internal GPS unit and exterior antennae mounted on the roof of each machine. Once an operator has entered his three digit code into the Multidat, the system senses the machine's motion and begins to record activity data and GPS coordinates. When a machine is sitting idle for longer than five minutes the operator is prompted to enter a stop code which explains the reason the machine is not working.

They also equipped the harvesters with a Tablet PC running ArcPad. A customized application was built to show the information captured from the GPS Multidat system in ArcPad so that the operators could visualize their current location along with other information previously downloaded from the corporate databases. With the track logs turned on the operator can see the areas they have harvested in order to most efficiently navigate to new harvest locations within their defined block. Prior to using ArcPad for navigation, a foreman would tie ribbons around trees, marking the boundaries for harvest to guide machine operators. The foreman's job has changed significantly now that he can show the operators on a screen where he expects them to harvest so that and they can navigate directly to these locations. Today, before each harvester begins work, the computer in each harvester machine is loaded with a shapefile of the harvest boundary.

All harvesting activity is tracked, logged, and uploaded to the company's central database at the end of each day. These data logs are then sent to a download station in the foreman's vehicle through a short range RF modem connection. The download station then connects to the Internet via a cell phone modem when the foreman's truck is within range of a cell tower, and the shapefiles are uploaded to the company's FTP site. From there the data is incorporated into the company's GIS and displayed through the use of an ArcGIS Server system so field supervisors back in the office can visualize the track logs of their harvesting equipment over the operating area.

Since installing a navigation and tracking system in each harvester, CBPP has realized the following benefits:

- Increased productivity through targeted direction to identified stands for harvesting
- Reduced environmental incidents as operators now see the buffer zones and streams on the maps in the cab
- The technology helps attract and retain employees (the tools are not only interesting for the operators to work with, but also provide increased safety and personal satisfaction through productivity gains)
- Easier to communicate with contractors who have navigation systems
- Better monitoring tools help create the most economically efficient harvest plans

"We have been successfully using the navigation portion of this system since May 2007 and we are in the process of automating the upload and display of the shapefiles in our ArcGIS Server application," said Deon Hamlyn, Operations Superintendent, Corner Brook Pulp and Paper. "My hope is to automate the entire process. I also envision transferring harvest tracking data between machines, so that forwarders know where harvesters have cut. We have realized fantastic productivity gains by digitally capturing and displaying our operations. It seems clear, the greater our field communication becomes, the greater the economic return."

"We have realized fantastic productivity gains by digitally capturing and displaying our operations."
Deon Hamlyn,
Operations Superintendent,
Corner Brook Pulp and Paper

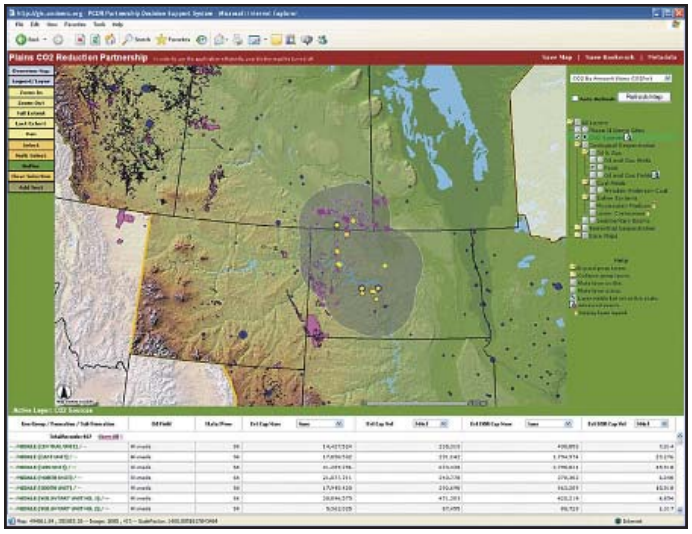
(Reprinted from the Vol. 11 No. 1, 2008 issue of *ArcNorth News* magazine)

Carbon Dioxide Sequestration Communications Supported by GIS

A Study of the Great Plains of North America

Affordable energy not only fuels our vehicles and electrical plants, it also fuels our economy and our quality of life. However, most of today's energy technologies release carbon dioxide (CO_2) into the environment, and there is growing concern that CO_2 in the atmosphere might affect global climate and weather.

The University of North Dakota Energy & Environmental Research Center (EERC) is leading an international team to develop opportunities for CO_2 sequestration in the Great Plains of North America. This team, the Plains CO_2 Reduction (PCOR) Partnership, is one of seven regional partnerships established by the U.S. Department of Energy/National Energy Technology Laboratory (DOE/NETL) to determine the most suitable technologies, regulations, and infrastructure needs for carbon capture, storage, and sequestration in different areas of the United States and Canada.



The Plains CO_2 Reduction Partnership Decision Support System showing the selection of oil pools (potential CO_2 sequestration sites) within 75 miles of selected CO_2 sources.

Through the collaboration of more than 50 government, industry, and environmental groups, the PCOR Partnership is currently characterizing CO_2 sources and sequestration opportunities in nine U.S. states and three Canadian provinces—in all, nearly 1.4 million square miles.

A major component of this characterization is creating an inventory of large stationary sources of CO_2, identifying and mapping geologic and terrestrial targets, or sinks, for CO_2 sequestration across the PCOR Partnership region. Knowledge of the character and spatial relationships of sources, sinks, and regional infrastructure is basic to developing and assessing approaches to economical CO_2 sequestration.

The most efficient way to communicate this information to the partners has been through a GIS-enabled Web site built with ArcIMS software, which was selected following competitive evaluation because of its versatility in both the GIS and Web environments. This site is a major component of a larger Web-based decision support system (DSS) that provides the research team with a single point of access to a wide variety of research data for the evaluation of sequestration data and the development of potential scenarios. This password-protected Web-based platform contains the tools and capabilities designed to deliver functional and dynamic access to data acquired through the project. The data is housed in a relational database and accessed through a map-based portion of the Web site. More traditional Web pages provide access to relatively static data, such as links to reports, CO_2-related Web sites, terrestrial maps, and snapshots of regional data.

The Web-based GIS portion of DSS is designed using ArcIMS, which provides a scalable framework for GIS Web publishing.

GIS technology enhances the users' understanding of regional opportunities by allowing them to visualize the spatially distributed nature of the data. DSS contains several analysis methods that allow members of the research teams to browse, query, analyze, and download data regarding CO_2 generation and sequestration in the PCOR Partnership region. Researchers can use the GIS to

- Examine attributes of individual features or groups of features and their spatial relationships to other features.
- Query the underlying data to analyze the region and export selected data for manipulation in other software.
- Explore the nature of the data through thematic maps.

In addition to enabling the user to directly select features on the map, the site allows the user to employ advanced selection methods. The attribute query option is a powerful tool for finding and examining features and data based on specific data attributes. An alternative feature selection process allows for sink/source proximity analysis that can be employed through a spatial query. This approach uses the buffer tool to identify features that are located within a user-specified distance of currently selected features.

The Web-based GIS interface of DSS contains several themes of georeferenced data that are considered crucial for the PCOR Partnership project. This data includes detailed source and sink characterization information that has been collected or generated by the research team. Several base layers and associated characteristics are also available, including political boundaries, cities, regional geology, road and rail transportation, shaded relief, and land use.

The majority of the source characterization data was gleaned from public data sources, such as U.S. Environmental Protection Agency (EPA) Web sites. The database currently contains information regarding all stationary CO_2 sources in the PCOR Partnership region. Stationary sources include heat and power generation (utility, industrial, institutional, and municipal) and industrial facilities representing the food, fuels, chemicals, minerals, metals, paper/wood, manufacturing, and waste-processing industries.

Largely, CO_2 emissions were estimated using fuel utilization data or unit production emission factors (e.g., tons CO_2/gallon ethanol). Sulfur and nitrous oxide emission data was included wherever available. Emission data is initially displayed in tons CO_2/year (mass) and million cubic feet (mmcf) CO_2/year (volume); however, the ArcIMS interface has a converter for users to select different units, such as tons CO_2/year or mmcf CO_2/day.

The petroleum-related data (well and field locations along with associated management, production, and stratigraphic data) was provided by state agencies or gleaned from publications; however, the level, or detail, of available data was not always consistent from state to state. The database currently contains information on more than 400,000 wells with various attributes, including operator name, well name, total depth, well type, and well status. Reservoir characteristic data was obtained by researching state agency case files for fields with a cumulative oil production greater than 800,000 barrels. This data pertains to reservoir characteristics that are necessary to perform detailed field studies with respect to CO_2

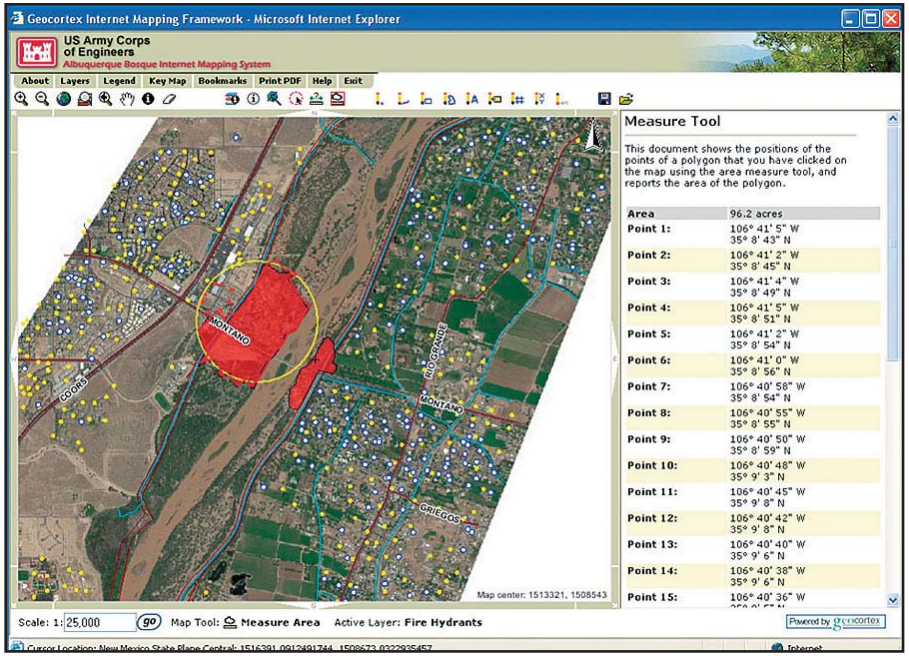
sequestration, including porosity, permeability, reservoir thickness, surface area, original oil in place (OOIP), cumulative production data, and water and oil characteristics.

(Reprinted from the Winter 2006/2007 issue of *ArcNews* magazine)

Middle Rio Grande River Being Restored Using GIS

In Albuquerque, New Mexico, Shared Geographic Information Is Key to Project Success

The future looks cleaner and greener for Albuquerque, New Mexico. A legion of federal, state, and local government agencies; tribal communities; conservation groups; and nongovernment organizations, funded by the U.S. Congress and led by the U.S. Army Corps of Engineers, has embarked on a massive restoration project of the Middle Rio Grande River. The project group today guides the modern course of the Middle Rio Grande River as it bisects the city of Albuquerque, New Mexico.



Digital orthophotos are used for the basemap.

Water is at the heart of this project. For centuries, the Middle Rio Grande has been the cradle of life in New Mexico. River damming calmed destructive flooding but also narrowed and deepened the river channel, resulting in environmental loss for indigenous cottonwood stands. The bosque, defined as a small wooded area, is a natural habitat for endangered species, such as the southwestern willow flycatcher. Floods served to germinate new cottonwood stands; clear dead brush; and carve out small, shallower riverbeds. The once wide river channel was an ideal breeding ground for the silver minnow, another now endangered species. Times changed, as did the river.

Population growth intensified in the 20th century—most notably in the city of Albuquerque. Houses, apartment complexes, streets, railroad tracks, freeways, bridges, and dams slowly encroached on the river bosque. The stabilized river led to closer human habitation and, subsequently, more pollution—a common story of ecological destruction.

Increased human habitation brought significant structural changes to the river. The aggradation of the channel, a result of downriver damming, reduced the surrounding water table as the channel deepened and narrowed. Many of the adjoining cottonwood stands, starved of water, withered and died and were replaced by exotic plants and brush, which fueled wildfires. Albuquerque's number one natural hazard risk is fire. Modern water control measures prevent the natural brush-clearing effect of floods, which increases the risk of wildfires leaping from the bosque to adjacent residential communities.

Restoring the Natural Order

The U.S. Army Corps of Engineers, with its legions of supporting agencies and organizations, aims to restore a natural order in accord with a modern urban lifestyle; this is no easy feat, but work so far has been positive. One core project objective was to secure both interorganizational and community consensus, a cardinal reason why the U.S. Congress assigned the corps project responsibility.

According to John Peterson, GIS developer for the bosque project and a corps employee, GIS assumed a new role as not only an analysis tool but also an information dissemination tool. Following an evaluation process, the corps teamed up with Latitude Geographics, a Victoria, Canada, company and ESRI Canada Limited Business Partner that specializes in Web-based GIS, to implement a dynamic and interactive online mapping system using ArcIMS. As the project entailed constant communication among varied stakeholders, the corps needed a tool that would enable nontraditional GIS users to access a plethora of geospatial information.

The Middle Rio Grande River.

"The functionality of ArcIMS coupled with Latitude Geographics' Internet cartographic and technical applications and services," says Peterson, "empowered the corps to engage its stakeholders and community advocates to use the Middle Rio Grande River Bosque GIS program. The Internet-based GIS moved project information from being centrally organized to a self-service orientation."

The bosque river map, accessed from the project Web site (www.bosquerevive.com), includes tools that can measure area; draw points, lines, and polygons; add text and labels; and spot coordinates. The power of the system is the ability to amend maps, save them, e-mail them to colleagues, and receive adjustments from colleagues. This process is all accomplished via the Internet and without the need for training or acquiring various site licenses. This Internet-based GIS tool promotes dynamic interaction and consensus building.

Peterson says, "The scenario might be that you bat an idea around using the saved session format. After the idea stabilizes, you create a PDF that encompasses the final static decision based on a consensus."

One example of information dissemination is an application created by the corps using Latitude's Geocortex Internet Mapping Framework (IMF) software. The application identifies fire hydrants within a radius based on a fire location. By adding layers to the Internet map, firefighter dispatchers quickly relay information to field units to determine the nearest hydrants and closest access points to a fire. Coupled with analysis conducted by the Native Communities Development Corporation, firefighters may also locate nearby swimming pools as an extra water supply.

The Internet map hosts a number of key layers that the community may access and freely use. A key to reaching an ecological balance is to achieve community buy-in for restoration efforts, not only in terms of greater environmental awareness but also to support development efforts.

"All ends of the economic bracket are positively impacted by all this work being done," Peterson explains. "You also have more wildlife habitat created with more recreation areas." The Internet map assists in communicating these efforts.

Latitude's Geocortex Statistics product allows the corps to track community site hit rates and usage patterns. Popularity for the site is growing. One powerful function is the ability to map the areas that are most commonly visited on the Web site. A red to green color schematic overlaid on top of the map indicates areas of high visit activity (red). This not only informs the corps

where additional maps or information may be added but also indicates which spatial areas are most interesting to community visitors.

"Overall, there is enthusiasm up and down the river as you affect whole neighborhoods through these revitalization efforts," Peterson explains. For the bosque river project, information is the glue that binds the multifaceted and multitalented project group. The information dissemination tool is GIS software, which is helping restore ecological harmony to the Middle Rio Grande bosque.

In 2004, the Corps of Engineers won the prestigious American Association of Landscape Architects' Honor Award in Analysis and Planning for the Middle Rio Grande Bosque Restoration Project.

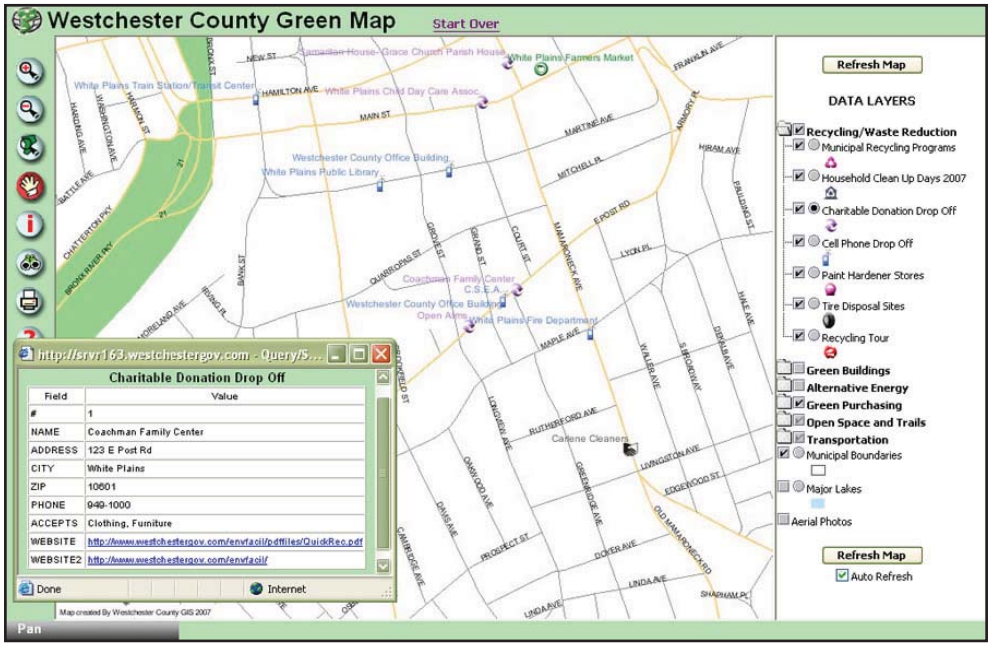
(Reprinted from the Winter 2005/2006 issue of *ArcNews* magazine)

Westchester County's Green Map Aids County Global Warming Task Force Plans

By Maggie Jones, ESRI Writer

Environmentally conscious staff members of Westchester County GIS in New York State have found a way to raise awareness about global warming in their community. They have created an online Green Map (http://greenmap.westchestergov.com/) that allows residents to see resources that support green practices such as recycling centers, tire disposal sites, and farmers' markets.

The map service utilizes ESRI's ArcIMS software along with technology from Green Map System, Inc. (GMS), an organization devoted to developing sustainable communities with mapmaking tools that increase awareness of local conservation opportunities.



Users can query the features using the Identify tool. Links to relevant Web sites can be accessed for more information.

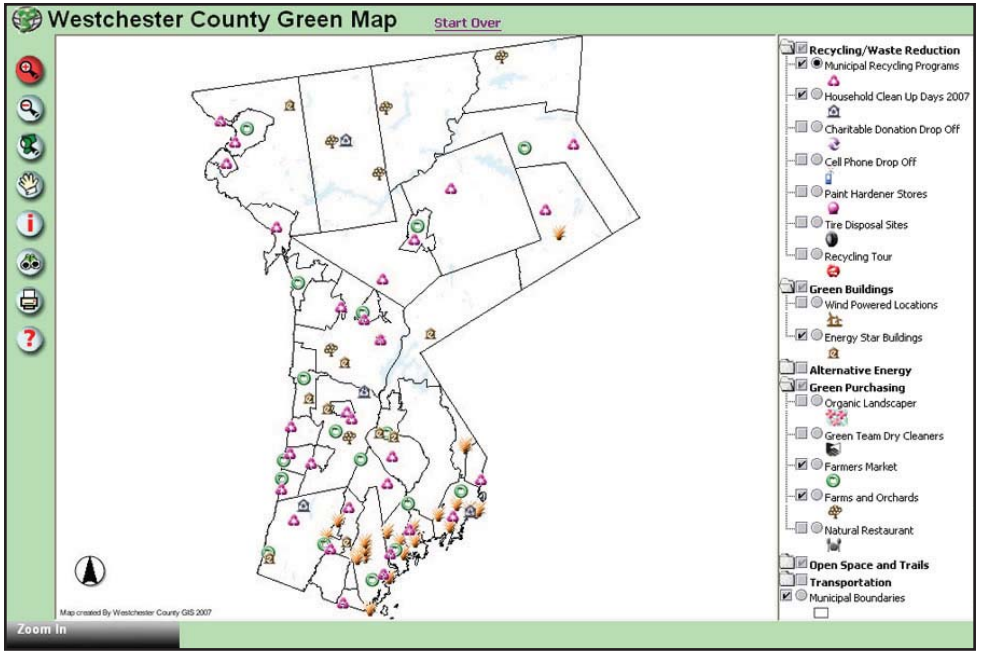
More than 900,000 people live in Westchester County, which borders New York City. As a densely populated county, it finds following environmentally friendly practices necessary for sustainable living. The county's interactive Green Map was launched as part of county executive Andy Spano's Global Warming Task Force, whose mission is to create a countywide action plan to reduce greenhouse emissions and promote sustainable development through awareness and education.

The Green Map helps residents find environmentally friendly and green resources that are available in their own community. Viewers can select the category they want, such as bus stops, tire disposal sites, farmers' markets, or green buildings, and find the nearest and most accessible locations.

Users also have the option of viewing aerial imagery on the map.

Designed for easy navigation, the map lets users simply select the resources they wish to see labeled, find the most convenient location, and zoom in until they can see the exact place (e.g., intersection or street name). Users can display or hide features on the map, as well as find out more about anything that interests them, by clicking a link to source Web sites. Residents frequently visit the site to find the closest farmers' markets, cell phone recycling locations, or hazardous household chemical disposal sites. If county residents would like to spend time outdoors, they can also use the Green Map to search for local parks and nature reserves.

The Web site supplies community members with downloadable datasets for each of the categories represented on the map. The site provides detailed information about the dates and locations for household cleanup days and other green activities, which are also displayed on the map. The ArcIMS software-based application enables users to browse, query, and print their maps. In contrast to traditional Green Map publications that usually appear in either hard-copy format and/or Adobe Acrobat PDF, the online map gives users a more accessible, intuitive, and interactive look at the county and its local resources. Additionally, Westchester County's GIS specialists can easily add or update features as needed and are able to display any amount of data without crowding the map or simplifying the data, which often occurs with printed maps.



Westchester County's Green Map application highlights facilities, programs, and services that encourage greener living within the county. Here, the pink triangles represent municipal recycling programs, the green circles are farmers' markets, the trees are farms and orchards, the houses represent locations for household cleanup-day events, and the orange flora represents the locations of the county's aquatic restoration sites.

"It is a resource for anyone who wants to find out how to make their household and community more environmentally friendly places to live, work, and play," said Cynthia Louie, GIS specialist for Westchester County, adding that public involvement in conservation practices has increased since its implementation. By taking climate change issues into its own hands, Westchester County is leading the way for other local and regional governments that want to find a way to develop more sustainable practices.

(Reprinted from the August 2008 issue of *ArcWatch* magazine)

Idaho Power Company Protects the Lifeblood of the State

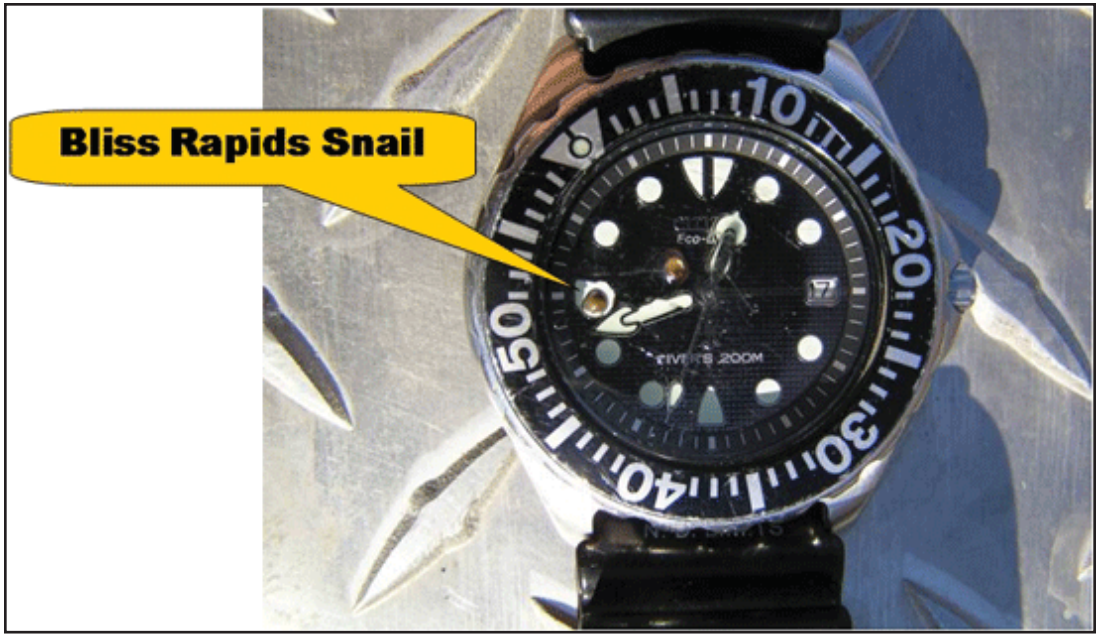
Written by Jessica Wyland
Monday, 15 September 2008

For much of Idaho, the Snake River is the lifeblood. The 1,040 mile tributary of the Columbia River provides water for drinking, irrigating, and generating approximately 50 percent of the state's energy through hydropower. The Snake River flows from Yellowstone National Park through a series of mountain ranges, canyons, and plains in Wyoming, Oregon, Idaho, and Washington. For Idaho Power Company, owner and operator of 17 hydroelectric power plants, preservation of the river is of utmost importance.

Idaho Power is involved in the generation, purchase, transmission, distribution, and sale of electric energy in a 24,000-square-mile area in southern Idaho and eastern Oregon with an estimated population of 982,000. It is one of the nation's few investor-owned utilities with a predominantly hydroelectric generating base in addition to two gas-fired plants and shared ownership of three coal-fired generating plants.

"Since we use the river system for power generation and for public recreation, we are committed to being good stewards of our natural resources and environment," said Mike Butler, GIS expert with Idaho Power.

Each of the 17 dams Idaho Power operates along the Snake River is subject to a federal license through the Federal Energy Regulatory Commission (FERC). Each license is for a specified term and must be renewed over time. Idaho Power is in the process of relicensing dams throughout its system and complying with new licenses received in 2004 for Bliss Dam and Lower Salmon Dam, where a study is under way to ensure the viability of the Bliss Rapids snail, a species listed as threatened under the Endangered Species Act.



The Bliss Rapids Snail is listed as a threatened species under the Engangered Species Act.

FERC is not allowed to grant licenses that might adversely affect any listed species without consulting with the U.S. Fish and Wildlife Service (USFWS). This formal consultation with the USFWS occurs when an action is likely to adversely affect a listed species.

If Idaho Power restricted operations of its Snake River Dam, the utility could potentially lose substantial revenues and would need to seek costly alternate sources of energy to meet the needs of its customers. Instead, Idaho Power takes a proactive approach to relicensing its dams by employing a large staff of experts in biology, engineering, and geographic information system (GIS) technology. The team primarily studies and monitors hydraulic, recreational, aquatic, and terrestrial resources within the utility's service territory as defined by FERC.

Looking at Impact on Bliss Rapids Snails

In 2004, Idaho Power began its five-year study of the Bliss Rapids snail. The gastropod may be considered an indicator species, one that defines the overall health of its habitat and the river system. Invertebrate biologists and hydraulic engineers at Idaho Power are charged with trying

to locate and study habitats including the hydraulic environments of threatened or endangered snail colonies in the middle Snake River reach.

"We want to learn where and under what hydraulic and environmental conditions do we find listed snails," Butler said. "We need to be able to answer questions related to snail reactions as the water levels change during seasonal river flows and normal flow fluctuation from power generation."

Idaho Power's team of experts had to answer important questions. What are the habitats the snails occupy and what environmental conditions do they need? What hydraulic variables impact the snails? If the water level goes up or down, are the snails able to migrate to the new environment? Does the utility's operation cause harm to the snails? If so, how will the utility alter operations to minimize its impact?

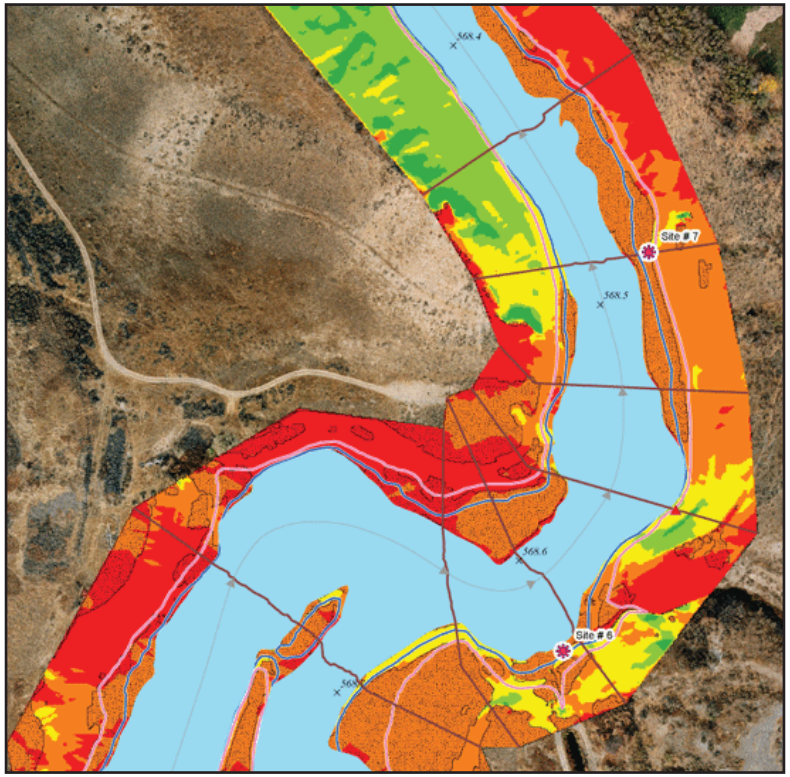
"Our mission is to collect the data necessary to accurately model the river flows and locate snail habitats," Butler said. "From there, we will be able to determine how best to minimize possible operating impact to the snails—if any impact is found."

Idaho Power has a boat equipped with a wide range of sensors to measure and monitor the health of the Snake River.

Here you can see the data returned from the sonar instrument and thermal sensors for water temperature and bathymetry.

Determining Data Layers

The utility's GIS houses a comprehensive set of layers for studying the river. A substrate layer identifies changes in the riverbed surface from boulders, cobbles, gravels, sands, silt, and muck. A channel classification layer distinguishes each region of the river as a bar, pool, riffle, glide, or rapid. Water temperature is tracked with a temperature data logger. Solar radiation tools in the ArcGIS Desktop Spatial Analyst extension help determine places on the ground within the river system where temperature changes need to be understood and monitored.



This detailed map of the Snake River shows the effect of solar radiation on water temperature for this stretch of the river.

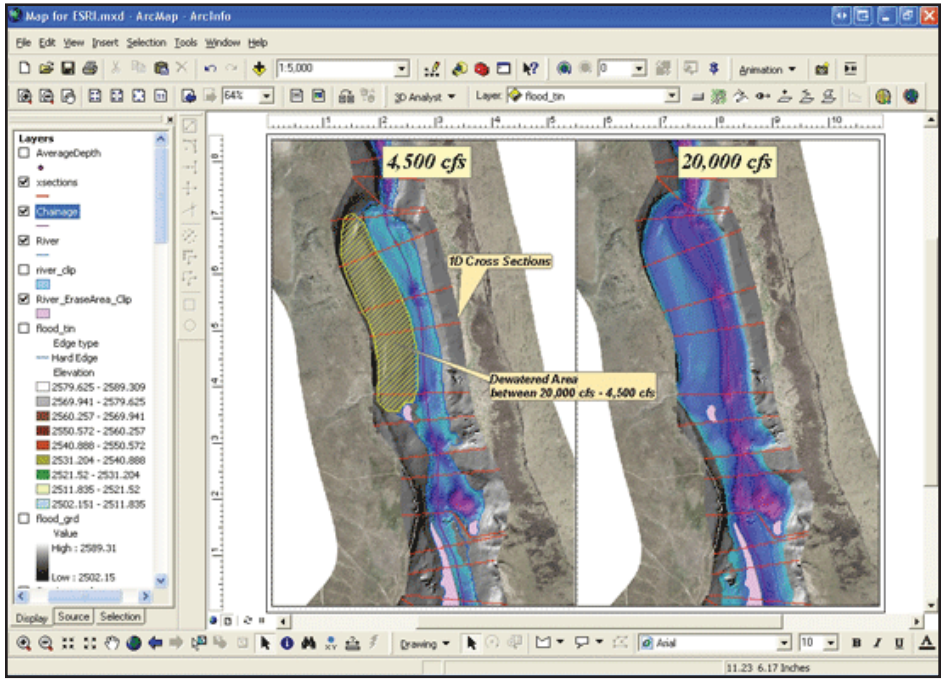
Since Bliss Rapids snails are approximately the size of a pinhead, or 2 to 3 mm, and therefore difficult to spot, the team used Global Positioning System (GPS) techniques to locate the

populations. Population locations are stored in the enterprise geodatabase along with data for substrate layers, channel classification, water temperature, and water velocity.

"GIS allows us to look at the potential area of impact by flow and even duration of wetting and drying so we can try to minimize that area and simultaneously maximize operating potential," Butler said. "This is essential to our company not only during the relicensing process, but as we continue to produce affordable, renewable energy for the rate payers."

Mapping and Modeling the Snake River

By linking GIS-based 3D terrain models with results from Danish Hydraulic and Water Institute (DHI) 1D hydraulic models, the Idaho Power team is able to simulate through animation and portray with maps all flow regimes the company may encounter through normal operations. Researchers are able to overlay inundation polygons with known snail locations, mapped habitats, and channel classification polygons to quantify how much area of preferred snail habitats are wetted or dewatered at different operational flows.



This flood simulation shows the water flow potential at a low stage of 4,500 cubic feet of water per second (CFS) versus a flood stage at 20,000 CFS.

With ESRI's ArcGIS Desktop Spatial Analyst and 3D Analyst extensions, the team created a series of triangulated irregular networks (TIN) and surface grids that combine underwater topography, aerial photogrammetry, and various ground surveys into a seamless physical representation of the riverbed. Sonar devices are used to collect underwater topography, or bathymetry. Ground surveys are conducted by engineers who map the bed surface and water surface elevations using sonar, Real Time Kinematic (RTK) GPS, and traditional survey techniques. Pressure transducers were also installed in the river to log water surface elevations related to discharge. The river stage data was used to calibrate several one-dimensional hydraulic models that are ultimately used to simulate water flows.

"Now we have the physical environment mapped in GIS and modeled with hydraulic modeling software," Butler said. "We import results from our modeling work into our GIS to create inundation flood maps for specific dam discharges."

GIS analysts at Idaho Power developed a series of Visual Basic models to streamline the flood mapping process and geodatabase design and implementation. When the inundation polygons are compared with the channel classification and substrate layers, suitable and unsuitable snail habitats are identified for each operating flow.

"We are now able to visualize the inundation area versus discharge relationships for the entire river reach and how they relate to snail habitats," Butler said. "Laboratory studies have determined that the snails being studied have high mortality above certain temperatures and under freezing conditions. So if we can alter operations to minimize exposing critical snail habitats to ambient air temperature and solar radiation, then we can benefit the snail populations by reducing potentially harmful conditions, improve our stewardship in the river system and still generate electricity at some of the lowest energy rates in the country."

(Reprinted from the September 2008 issue of *V1 Magazine*)

Ethanol Buzz Fuels GIS Planning by Colonial Pipeline Company

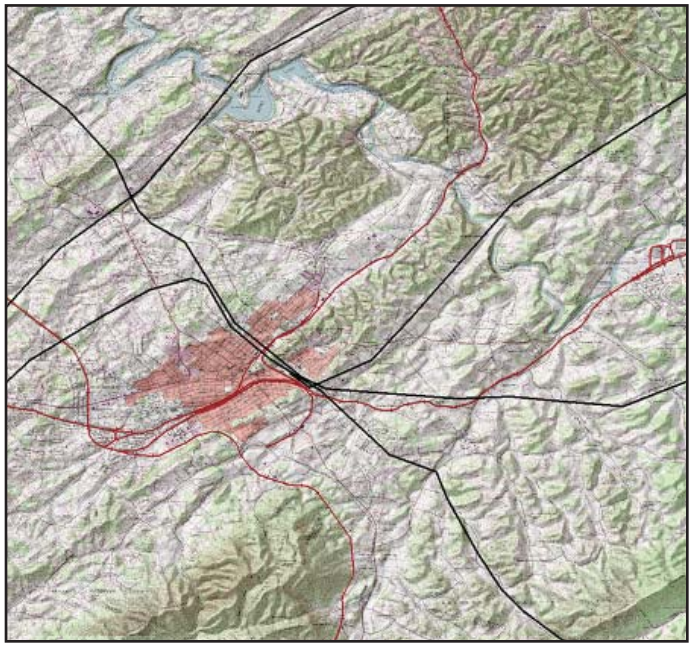
Highlights

- GIS is used to find the best opportunities for tying producers to pipelines; to terminals; and, eventually, to retail gas stations.
- With ArcGIS software, Colonial can identify infrastructure locations incompatible with ethanol.
- Spatial queries identify which ethanol producers connect to railroads, then in turn connect to Colonial's pipelines.

Amid the clamor of national debate over how best to reduce reliance on oil, the call to replace petroleum with ethanol made enough noise to attract government and industry attention.

A federal mandate, passed in December 2007, requires that the United States produce 15 billion gallons of corn-based ethanol by 2015. In response, a major U.S. pipeline company, Georgia-based Colonial Pipeline Company, began its study of the feasibility of introducing alternative fuels, such as ethanol, to pipeline shipments.

"Ethanol is now transported on railways and roads, but there is growing interest in the use of pipelines," says Chad Zamarin, who spent eight years in the natural gas industry working on new



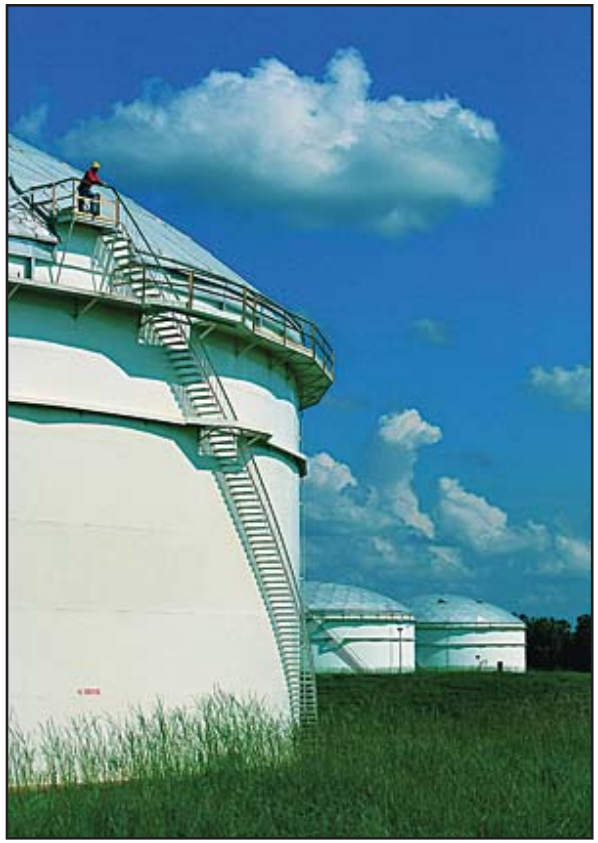
This screen shot shows some current pipeline routes with topology.

pipeline construction, failure investigation, and pipeline integrity management before joining Colonial in 2004. "We want to be able to safely ship any and all types of fuel."

Colonial has been in the pipeline business for 45 years and delivers a daily average of 100 million gallons of different fuels to markets across the southern and eastern United States. The company's 5,500-mile network of underground pipelines extends from Houston, Texas, to the New York harbor and carries gasoline, home heating oil, aviation fuel, and other refined petroleum products.

Even for a company with as much experience and infrastructure as Colonial, the task of shipping ethanol brings new concerns that must be addressed, such as protection of the steel pipe and the integrity of the fuel being shipped. Despite obstacles, Colonial is pushing ahead with system integrity and business case studies for carrying alternative fuels, including biofuels.

"We are moving in the direction of alternative fuels because we want to be ready to ship not only the fuels of today but also the emerging and still unknown fuels of tomorrow," Zamarin says. "Pipelines are by far the safest, most reliable, and most efficient mode of transportation. We are trying to figure out how to use our infrastructure and technology to address the nation's energy needs."



The efficiency of pipeline distribution makes new cross-country lines a viable investment.

The Challenge of Moving Ethanol

The first step in addressing the ethanol issue was to perform an analysis of our existing pipeline system to see if we are capable of shipping ethanol," Zamarin explains.

Colonial and other pipeline industry experts have learned that ethanol is not directly compatible with existing systems. Ethanol is water soluble and prone to absorbing moisture that may accumulate in a pipeline. The addition of water to ethanol can render the ethanol unusable as fuel. Additionally, ethanol differs from petroleum-based fuels in that in the presence of certain impurities it can potentially cause cracking of steel pipelines. Ethanol can also have a damaging effect on a steel pipeline's equipment and seals.

A second consideration to the idea of shipping ethanol through existing pipelines is location. Ethanol production centers are mostly in the Midwest—far from consumers and not in direct reach of many existing pipelines. Ethanol would still have to be shipped to a pipeline injection facility by train, barge, or truck.

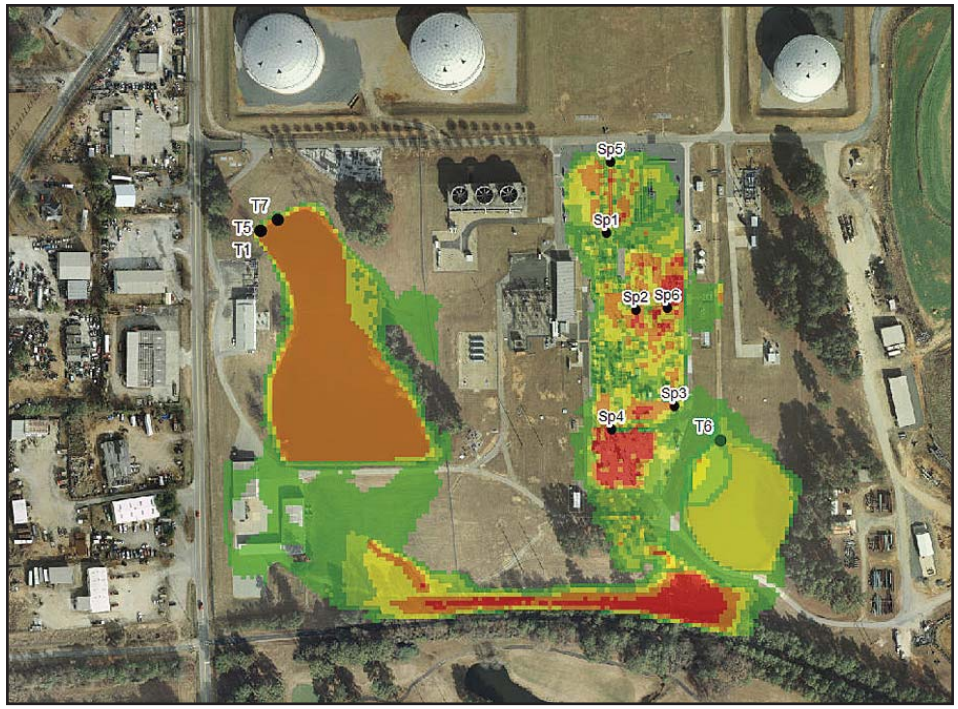
Zamarin says that the biofuels industry faces many complex issues that revolve around geospatial questions. In today's complex regulatory and operational environment, GIS is an important asset to help effectively manage a pipeline system.

To manage the large and growing number of contingencies and considerations, Colonial uses GIS technology. GIS software by ESRI was selected because it provides a framework for understanding every element of a particular situation based on geographic location and relationships. In the pipeline industry, GIS is used to find the best opportunities for tying producers to pipelines, to terminals and, eventually, to retail gas stations.

Using GIS, pipeline companies layer infrastructure data with natural resources and population information. For Colonial, GIS provides an integrated account of the company's assets and infrastructure. The system tracks the location of pipelines, tanks, equipment, and other components. With the modern geospatial tools found in ArcGIS software, Colonial can analyze its infrastructure to quickly identify locations that may not be compatible with ethanol. By building a computer model of proposed plans, Colonial is able to identify risks and analyze the use or modification of its pipeline system.

Working with GIS technology, Colonial has been able to build business models for shipping ethanol via pipelines. Within the business model, Colonial can weigh the costs associated with various railroads, production capacity for each ethanol plant, and various transit times from producer to pipeline. Colonial engineers map and model possible scenarios of transporting

ethanol from producer to train, barge, or truck to pipeline to terminals and back to trucks. Concurrently, the company can analyze population data within the GIS to determine where the greatest demand for ethanol exists.



This image of a refinery incorporates spatial analysis for detailed planning purposes.

"If I want to know what ethanol producers are closest to Colonial pipelines or what railway systems connect us," Zamarin says, "I'd have to use a lot of maps and I still might not figure out which combination of producer and railroad is best. "When we put all the information into the GIS. we solved the tedious process of shuffling through paper maps and relying on manual interpretation. Now, it has become an efficient process of spatial analysis. We run spatial queries to identify which ethanol producers connect to railroads and then in turn connect to our pipeline and integrate that analysis into our business models to identify the best opportunity."

Colonial stores its data in an enterprise geodatabase based on the ArcGIS Pipeline Data Model (APDM) industry template. Data is stored in Oracle9*i* with ArcSDE 9.2. Integration, sharing, and analysis of the data are performed through ArcGIS Server and a suite of out-of-the-box applications from ESRI and third-party business partners. For operations and project development, Colonial leverages a variety of purchased, publicly available, and company-collected and -owned data.

The Debate over Ethanol

While Colonial prepares to respond to the demand for biofuels—ethanol or otherwise—the discussion of U.S. ethanol policy has intensified. For decades, the U.S. oil and natural gas industry has blended ethanol with petroleum to add octane and oxygen, which reduces certain kinds of fuel emissions.

In 2007, U.S. farmers harvested a little more than 13 billion bushels of corn, according to reports by the United States Department of Agriculture (USDA). Before floods overran much of the Corn Belt, this year's projected yield was a record 14.6 billion bushels with 3.2 billion bushels designated for ethanol and 2.35 billion bushels for export. More recent estimates lower total projected yield to 11 billion bushels, while corn used for ethanol is expected to jump 30 percent.

Meanwhile, as opportunities are emerging, pipeline companies such as Colonial have begun route selection and planning for new pipelines. Routing of new pipelines requires consideration for property owners, water bodies, environmental issues, impact to other utilities, types of vegetation, fault lines, and topography. All this information can be represented as layers in a GIS.

(Reprinted from the Fall 2008 issue of *ArcNews* magazine)

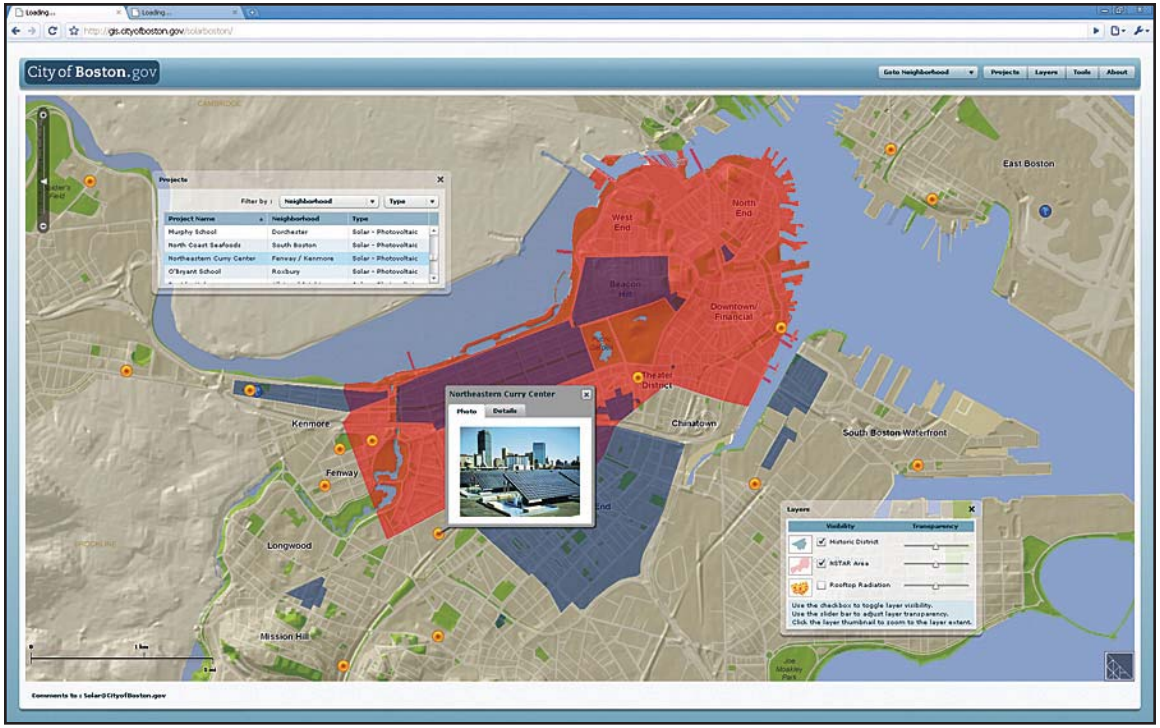
Boston Showcases Solar Power Potential with Web GIS

Highlights

- Web GIS helps track the progress of citywide solar installations.
- Solar radiation tools in ArcGIS Spatial Analyst calculate the solar energy potential of building rooftops.
- The ArcGIS API for Flex wraps the application in a user-friendly format.

In 2007, Boston mayor Thomas Menino issued an executive order on climate change that set greenhouse gas reduction goals and outlined city strategies for recycling and renewable energy. That order was decisive in the formation of Solar Boston, a two-year $550,000 project designed to expand the use of solar power throughout the city. Solar Boston is part of the Solar America Initiative, a campaign launched by the U.S. Department of Energy (DOE), to make solar electricity cost-competitive with traditional electricity production by 2015. To help meet the city's greenhouse gas reduction targets and support the goals of DOE, Mayor Menino set a target of 25 megawatts of solar power installed by 2015. To support the Solar Boston program, Boston is using Web GIS technology to map current solar installations, track progress toward the mayor's goal, and allow Bostonians to analyze their rooftop solar energy potential.

Solar Boston builds on the City of Boston's leadership in promoting green buildings. Green building is the practice of maximizing the use of a building's resources while reducing the environmental impact throughout its life cycle. In 2004, Mayor Menino created a Green Building Task Force, and in 2007, based on the task force's recommendations, Boston became the first major city in the United States to require all large, private-sector buildings to conform to the Leadership in Energy and Environmental Design (LEED) green building standards. Outfitting Boston's largest residential and corporate structures with solar panels is in keeping with the city's green building and energy conservation objectives.



The ArcGIS Solar Radiation tool gives users the ability to research solar power capacity.

Renewable energy is a solution for reducing the demand on and air pollution from traditional energy systems. As on-site sources of clean power, solar energy systems can reduce greenhouse gas emissions and air pollution, increasing energy security and creating local jobs. Solar electricity systems (also called photovoltaics [PV]) also have the potential to generate power when it is needed most—on hot summer days—thereby relieving strain on the electricity system and reducing the risk of blackouts. By encouraging solar energy, Boston hopes to not only capture these benefits but also prepare for the market explosion likely to occur when solar power becomes competitive with fossil fuels.

To promote the use of PV to investors, the Boston Redevelopment Authority (BRA) needed a system to showcase solar energy potential in a user-friendly format—one that lets users investigate locations of interest and perform preprocessed analysis. GIS was the obvious tool to

achieve this end because it started with a visual reference—a map of the entire city showing the buildings that had solar installation potential. Says Wilson Rickerson, Solar Boston coordinator, "We needed a baseline, because you can't really get anywhere if you don't know where you are. Without GIS, we'd have no concept of the size of the city's solar industry, how fast had it grown, and what potential it had."

GIS analysts at BRA started on the project by using ArcGIS Desktop software's ArcGIS Spatial Analyst extension to calculate the solar radiation available on building rooftops. To do this, they built a digital elevation model (DEM) of the city. "We took the bare earth DEM and 'burned' into that the building heights using attributes available in the building footprints, which resulted in a three-dimensional surface model of the city," says Greg Knight, senior GIS applications developer with the Boston Redevelopment Authority. "We proceeded with this prepared surface and utilized the solar radiation tools available in Spatial Analyst to calculate what the solar radiation availability would be for each rooftop." The solar radiation tools allowed the analysts to model incoming solar radiation and take into account numerous factors, including variation in elevation, orientation (slope and aspect), the shadows cast by topographic features, and changes with time of day or year.

After completing the analysis in ArcGIS Desktop, the solar radiation map was published, along with a basemap, other layers of interest (e.g., historic and local electric utility districts), an address locator, and geoprocessing tools, to ArcGIS Server for use by the Solar Boston Web application. "The application was originally built using a geoprocessing service, which calculated the solar radiation on the fly," continues Knight. "Because the calculations took about 30 seconds to complete, we preprocessed the analysis in order to deliver a more responsive Web application."

Wrapping the analytics in an easy-to-use Web GIS application was the next step. GIS developers at BRA saw great potential in ESRI's new ArcGIS API for Flex, which is a client-side technology rendered by Flash Player 9 or Adobe AIR. Flex gives developers the capability to combine GIS-based Web services from ArcGIS Server with other Web content and display it in a fast, visually rich mapping application that can be deployed over the Web or to the desktop. It was the ideal medium to show investors the logistics of solar energy investment. "We gathered market data to get a baseline, but we knew it was equally important to publicize the information via the Web," says Bradford Swing, director of energy policy for Boston. "We knew Solar Boston needed a map, and this map is a simple, powerful tool to chart what we've accomplished and where we want it to go in the future."

Thanks to Boston Solar's Web application, Boston's real estate sector can easily start learning about the feasibility of its solar projects.

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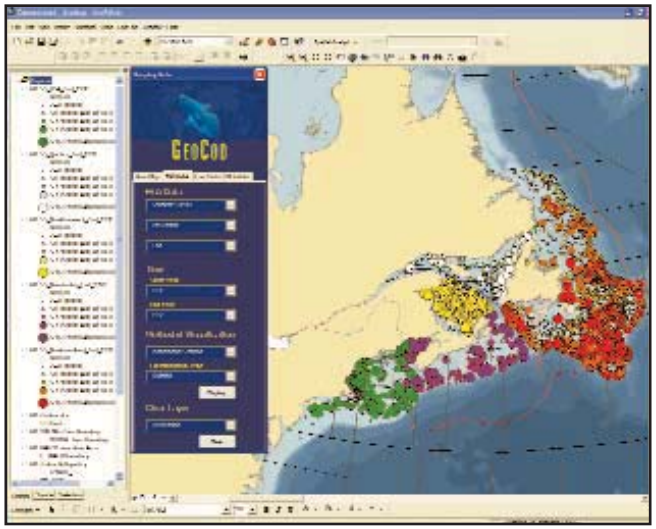
GIS for the Sustainable Management of Fish Stocks

With nearly 18,000 students, Memorial University of Newfoundland is the largest university in Atlantic Canada. Its department of Geography offers bachelor, master's, and PhD degrees where students can specialize in GISciences (GIS, Cartography, and Remote Sensing). In addition to these degrees, Memorial University offers an undergraduate diploma in GISciences where students can add practical experiences to their academic training. GIS technology is utilized extensively for teaching and research purposes. Research in GIS within the department of Geography ranges from modelling the impact of climate change on vegetation, supporting conservation of endangered marine species, and analyzing the seabed morphology to identifying structures related to oil and gas reservoirs.



Proportional symbols map produced by the GeoCod system showing the abundance of Cod in Atlantic Canada in 1992.

The marine environment plays an important role in Canadian society. More than 71% of the world's surface is covered by oceans. Canada has the world's longest coastline, the second largest continental shelf, and about 23% of the population lives in coastal communities, many depending on the sea to make a living. Worldwide, more than 1 billion people rely on the ocean for food. Canada's oceans generate a considerable number of jobs and economic activity.

However, the United Nations has estimated that more than 75% of the world's fish stocks are either fully exploited or overexploited. Eastern Canada, and more specifically Newfoundland and Labrador, is one of the major world regions that has experienced extensive overfishing. In addition to overfishing, it has been suggested that climate change has also had a negative impact on fish stock dynamics. To date, more than 40,000 jobs have been lost due to the closure of the Northern cod fishery in Newfoundland in the 1992 moratorium. This has been compared to the effect of closing every manufacturing plant in Ontario.

The GeoCod project is a 2-year research project spearheaded by Memorial University and cofunded by the Canadian GEOIDE Network of Centres of Excellence and the Canadian Center for Fisheries Innovations (CCFI) that began in January 2006. The project is focused on the North West Atlantic region of Canada and aims to provide a comprehensive picture of marine fish and invertebrate distribution and abundance for these biological species, cod, capelin, shrimp, and crab, through the use of GIS.

A major part of this project focuses on the development of a GIS-based decision support tool that has been developed as an extension to ArcGIS. The prototype of the extension will be made available to the different partners of the project, which include Fisheries and Oceans Canada, Fisheries and Aquaculture Newfoundland, and the World Wildlife Fund. In turn, these partners will be able to use this GIS-based tool to analyze and visualize the database compiled to better understand fish dynamics in the study area over the last few decades.

"Decision-makers in fisheries management traditionally relied upon statistics, tables, charts, and other data sources, and haven't fully utilized the power of GIS to conduct spatial analysis which provides the framework for a more comprehensive understanding of fisheries data," said Dr. Rodolphe Devillers, GeoCod Project Leader, Memorial University.

The Department of Fisheries and Oceans Canada (DFO) has been collecting data in Canadian waters for decades to assess the state of fish stocks. The database compiled in the GeoCod project to date includes oceanographic data (temperature, salinity, and nutrients), biological data (Canadian and US Fisheries scientific surveys as well as Fisheries observer program information) for the four biological species, and remote sensing data (sea-surface temperature and biological productivity). Prior to leveraging GIS to analyze these data, analysis was done by employing traditional statistical techniques that do not have a spatial dimension. Project stakeholders decided that GIS and its associated spatial characteristics offer more effective means by which the spatial context of fisheries-related data can be most rigorously examined.

"GIS allows us to integrate heterogeneous fisheries and environmental data into a single data model that has made it suitable for subsequent analyses and visualization," said Dr. Devillers.

Original datasets have been delivered in various formats (Excel spreadsheets, text files, etc.) and have been integrated in a common data model. All of the fisheries data have been integrated into a single geodatabase, storing both the data and the associated metadata. Many other datasets related to the environment and fisheries management units were also collected. Fisheries data typically include observations made at sea at a specific location and at a specific time of the year. The kriging tools available with ArcGIS Spatial Analyst and Geostatistical Analyst have been used to interpolate the sample locations to generate continuous surfaces of the fish abundance. An extension for ArcMap was developed in Visual Basic and adds several functions that allow users to select the data they want to visualize (fish species, region, year), choose between the sample locations or the interpolated surfaces, produce thematic maps of fish distribution and abundance, and produce animated maps of changes in abundance through time. Users are also able to compare spatial and temporal changes in fisheries data, explore the data for potential relationships between changes in fish occurrence/abundance and changes in the physical environment.

"Our application is so user-friendly that almost anyone can analyze and visualize fisheries information geographically," added Dr. Devillers. "The spatial analysis characteristics of the application represent a significant leap forward with respect to being able to more effectively communicate fisheries information. We expect that it will be a powerful decisionsupport tool that will contribute to the fight against declining fish stocks in our oceans."

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