GIS for Agribusiness

ESRI • Summer 2009

In This Issue

Better Crop Estimates in South Africa

Integrating GIS with Other Business Systems

By Annalie Fourie, GIS Specialist, SiQ

More accurate and reliable crop estimates help reduce uncertainty in the grain industry. The South African Department of Agriculture Crop Estimates Committee was tasked with producing crop estimates for South Africa on a monthly basis. To perform this task, the committee receives data from various input suppliers.

SiQ, a member of the National Crop Statistics Consortium (NCSC), uses statistical methods to provide inputs to the committee. Since 2002, crop information provided by producers has been used for statistical analysis. However, problems caused by producers who don't provide complete information, combined with a greater emphasis on improving statistical accuracy and efficiency, led to the development of an alternative system.

South Africa is a large producer of the world's sunflower seeds.

An Example of Digitized Crop Field Boundaries and the SPOT Image Spot 5 Satellite Imagery Used for Digitizing the Boundaries

The Producer Independent Crop Estimate System (PICES) was developed in 2005. Implemented after a successful pilot study conducted in Gauteng Province, PICES uses crop field boundaries digitized from satellite imagery with a point frame sampling system to objectively estimate the area planted with grain crops.

The PICES process consists of the following steps:

1. Obtain satellite imagery.
2. Digitize crop field boundaries from satellite imagery.
3. Design the point frame and select random sample points.
4. Use aerial survey sample points to capture crop data.
5. Perform statistical analysis.

Obtaining Satellite Imagery

Satellite imagery for the project is made available by the South African government through the Department of Agriculture. SPOT Image Spot 5 satellite imagery with a 2.5-meter resolution is obtained from the department and used as the base layer for digitizing.

Comprehensive quality control measures are part of the digitizing process to ensure clean, accurate data of high quality. Detailed metadata is captured in a geographic information system (GIS) as soon as the dataset for a province has been finalized. This metadata is updated

continued on page 3

ESRI on the Road

ESRI Latin America User Conference
October 7–9, 2009
Bogotá, Colombia
www.esri.com/auc

ESRI European User Conference
October 14–16, 2009
Vilnius, Lithuania
www.esri.com/euc

National Future Farmers of America
Agricultural Career Show 2009
October 21–23, 2009
Indianapolis, Indiana, USA
www.ffa.org

ESRI Middle East and North Africa User Conference
November 10–12, 2009
Manama, Bahrain
www.esri.com/meauc

GIS for Agriculture Web Site

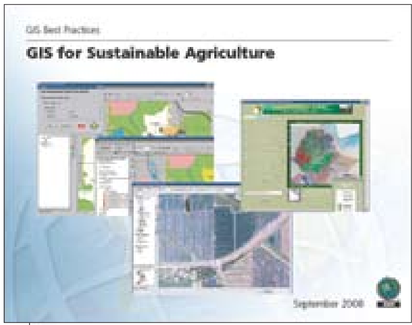
ESRI's GIS for Agriculture Web site is an information resource for applying GIS technology to agricultural needs. Read how GIS can help you better manage crops, rangelands, pests, and production operations. Learn how to bring different data resources together for insight that will help you improve crop yields and better plan production in changing markets.

Visit ESRI's GIS for Agriculture Web site at www.esri.com/agriculture.

ESRI News for Agribusiness

GIS Best Practices Online Booklet Series

Interested in learning more about how GIS can aid agricultural development? Check out these online booklets in ESRI's GIS Best Practices series. Download them for free at www.esri.com/bestpractices.



GIS for Sustainable Agriculture
This booklet highlights GIS projects that promote sustainable food production practices.

U.S. Department of Agriculture
These case studies provide government officials with examples of ways GIS is used to manage large volumes of agricultural data for a variety of purposes, from assessing nationwide land use to task automation.

World Development Report Recommends GIS to Aid Agriculture and Economic Development

The World Bank's World Development Report 2008: Agriculture for Development suggests that GIS can be used in the following strategies:

- Determining the spatial distribution of rural poverty in relation to agriculture
- Creating new collaboration between scientists, policy makers, and farmers
- Improving the practice of precision farming
- Identifying areas that can absorb higher livestock densities
- Filling the institutional vacuum in pasture management
- Monitoring carbon emissions

Natural resources that sustain agriculture are becoming increasingly sparse. The World Bank expects that the global demand for food will double within the next 50 years. The reports labels

GIS as an innovative technology required to help meet such demands.

To read more about World Development Report and its recommended use of GIS as a supportive technology in the economic development of agriculture, visit www.worldbank.org.

continued from page 1

Better Crop Estimates in South Africa

whenever changes are made to the dataset. All nine provinces of South Africa have been digitized—a total of approximately 12,965,000 hectares. The updating schedule and procedures ensure that the dataset remains current.

Designing the Point Frame

In the next step, sample points are randomly selected to represent potential cropped fields. These points will be surveyed in the field. A point grid of 45 meters by 45 meters is set up for the total provincial area. Grid points located outside field boundaries are removed from the sample population because these points are unlikely to locate crops.

Digitized fields are stratified based on the probability of finding a crop. The core strata used are high, medium, and low cultivation. High, medium, and low refer to the densities of fields within any given area as well as the presence of pivot irrigation and small-scale farming. Stratification is done to increase sampling efficiency. More sample points are used in strata where there is a higher likelihood of finding crops of interest. This will obtain the most useful data within budget constraints and keep the coefficient of variance (CV) as low as possible. [CV is the ratio of standard deviation to the mean; it is used when comparing datasets with different units or widely differing means.]

The grid points are selected per stratum and exported to a Microsoft SQL Server database. These points are sorted systematically from west to east and north to south. This is done to ensure an optimal geographic distribution of sample points. A random starting point is chosen and points selected at regular intervals according to the number of points needed in the specific stratum. The selected points are inserted into a new table in the database, and the process is repeated for each stratum. Finally, the SQL Server tables are added in ArcGIS Desktop and converted to shapefiles containing the sample points for each stratum.

Aerial Surveying of Sample Points

An aerial survey of the sample points is conducted. This aerial survey determines which crop is planted in the field represented by each sample point. These surveys are conducted by a field observation team that consists of a pilot and an observer in a very light aircraft. The observer is from the agricultural community and is very experienced at distinguishing between different crops and differentiating between dry land and irrigated cultivation. Typically, the number of sample points verified for each survey requires the use of more than one field observation team. This system of capturing field information for crop estimate purposes is believed to be unique in the world.

A Tablet PC connected to a GPS and running ArcPad is used to capture this data. ArcPad is customized with a user-friendly interface. The field observer notes which crop is planted at the sample point and whether it is dry land or irrigated cultivation. Additional information, such as growth problems or areas of double-cropping, is also captured. In addition to the data that is being captured, the observer also takes photos to provide more information on the conditions in the field during the specific survey. Each photo taken is automatically linked to a shapefile that indicates where it was taken.

A section of the 45- by 45-meter point grid after the removal of grid points outside the crop field boundaries. Crop field boundaries stratification is also shown.

Performing Statistical Analysis

The field data is captured and stored in the GIS shapefile format. This data is uploaded to a central server on a daily basis and imported into a SQL Server database. Expansion statistics are used to calculate estimates of the area planted in each grain crop on a provincial basis.

Conclusion

The need to objectively estimate area planted under grain crops prompted the development of PICES. The system uses crop field boundaries digitized from satellite imagery, together with a point frame sampling methodology and aerial field surveys, to objectively estimate the area planted for each grain crop. PICES has proved to be extremely cost-effective when compared with the previous system, which used information gathered from producers. An area of approximately 12 million hectares can be covered in a two-month period using three field observation teams. The accuracy has also been improved by 40 percent. The use of GIS has greatly improved crop estimates in South Africa and resulted in more cost-effective, accurate, and objective grain area estimates. For more information, contact Annalie Fourie, SiQ, at annalie.fourie@siq.co.za.

New Zealand's Animal Health Board Fights Bovine TB

To maintain its reputation as a supplier of high-quality, healthy meat and dairy products, New Zealand implemented a comprehensive nationwide program to control bovine tuberculosis (TB) in cattle and deer. GIS is now a tool for tracking and managing this disease.

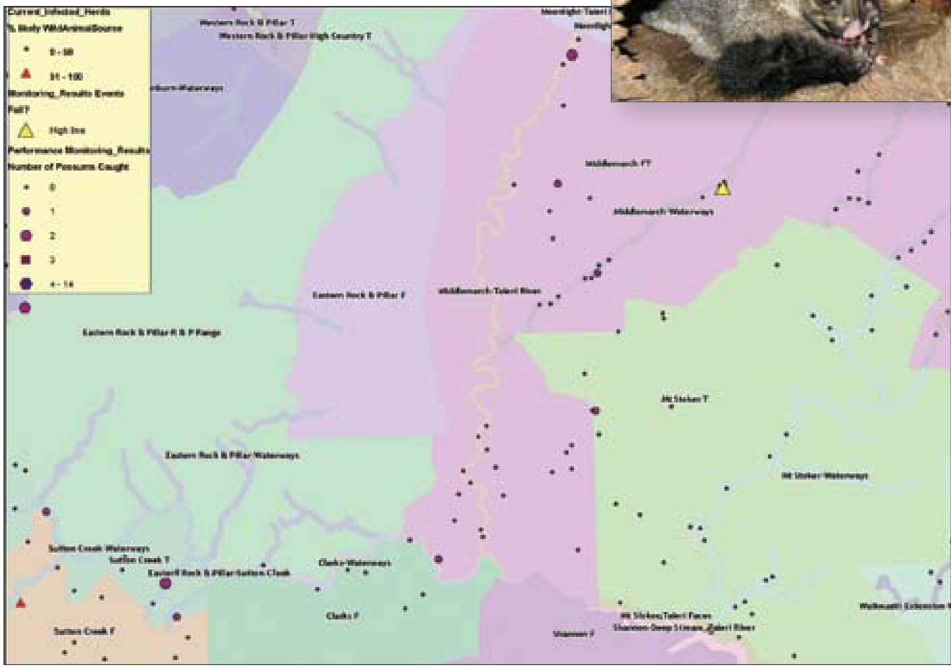
To decrease its livestock losses, New Zealand created the Animal Health Board (AHB). The board has initiated intensive large-scale possum control programs, since the major cause of TB in cattle and deer herds is contact with wild vectors, mainly the Australian brush-tailed possum.

New Zealand needed to set regional and national targets for TB vector control but was hampered by a lack of uniformity in recording prevention efforts and reporting methods. Before AHB assumed the management of the vector control process, more than a dozen regional councils used differing methodologies to try to achieve this task. AHB took the best practices from these councils to develop business rules, procedures, and interfaces for a geospatial approach to vector control that would be useful for all vector control sites. This new approach incorporated local knowledge at the regional level, then centralized it at the national level.

Using ESRI's ArcGIS technology, AHB created VectorNet, an application that uses a map-based interface to access, query, and report on all aspects of AHB's disease and vector control processes. Operation managers can visualize possum densities in different areas, then link this to performance and financial data.

Information sent by contractors in the field is uploaded to VectorNet. Managers then perform spatial searches to aggregate data, prepare summary reports, and manage contracts. The solution makes it easy for users to enter quality data and generate accurate reports.

VectorNet is built on .NET 2.0 and ArcGIS software provided by Eagle Technology Group, Ltd., ESRI's New Zealand distributor. VectorNet links more than a dozen previously uncoordinated regional systems, creating a consistent, accurate, and easy-to-manage geodatabase.



ArcGIS allows AHB to share information about the locations and quantity of possum captures as part of AHB's vector control programs.

Approximately 40 AHB staff members use VectorNet for contract management, strategic planning, and reporting. Field contractors update the database from the field with GPS-enabled handheld devices by uploading information through a Web browser. The data is validated and added to the geodatabase. Using a statistically based model to measure possum density, VectorNet generates exact locations within specific regions to implement control projects such as baiting or traplines. This geospatial approach, integrated with operational data, creates verifiable processes to better manage current projects and formulate future predictions.

Current spending on control of bovine TB is in excess of US$45.1 million (NZ$80 million) per annum. AHB estimates that VectorNet will save the country US$16.9 million (NZ$30 million) in its first decade. AHB also expects a net present value (NPV) of US$1.1 million (NZ$1.9 million) for the GIS project.

"A positive NPV shows that VectorNet is worth the investment of capital. We have calculated a payback period of 3.3 years," says William McCook, chief executive of AHB, "but that's just the beginning. For instance, we expect a 1 percent (US$310,000/NZ$550,000) efficiency gain on the overall vector program budget through consistent, accurate, complete, and timely information to make better decisions."

GIS links geospatial and textual data and publishes this information over the Internet. This gives AHB staff greater visibility of decisions and improved access to information. Data standardization also allows easier sharing with other organizations.

"The model we have developed is robust and could easily be modified for managing other invasive species or diseases," shares McCook. "Other organizations could benefit from linking geospatial, operational, and financial data."

AHB's VectorNet received New Zealand magazine *Computerworld*'s 2008 Supreme Award for Overall Excellence in the Use of Information and Computer Technology (ICT) and the Award for Innovative Use of ICT. The application's value was also recognized at the recent Asia-Pacific Spatial Innovation Conference in Canberra, Australia.

Inquire about VectorNet through an Eagle representative in New Zealand by calling 64-4-8021400 or visiting the Web site www.eagle.co.nz.

Precision Crop Management GIS Model Performs Bioenergy Assessments

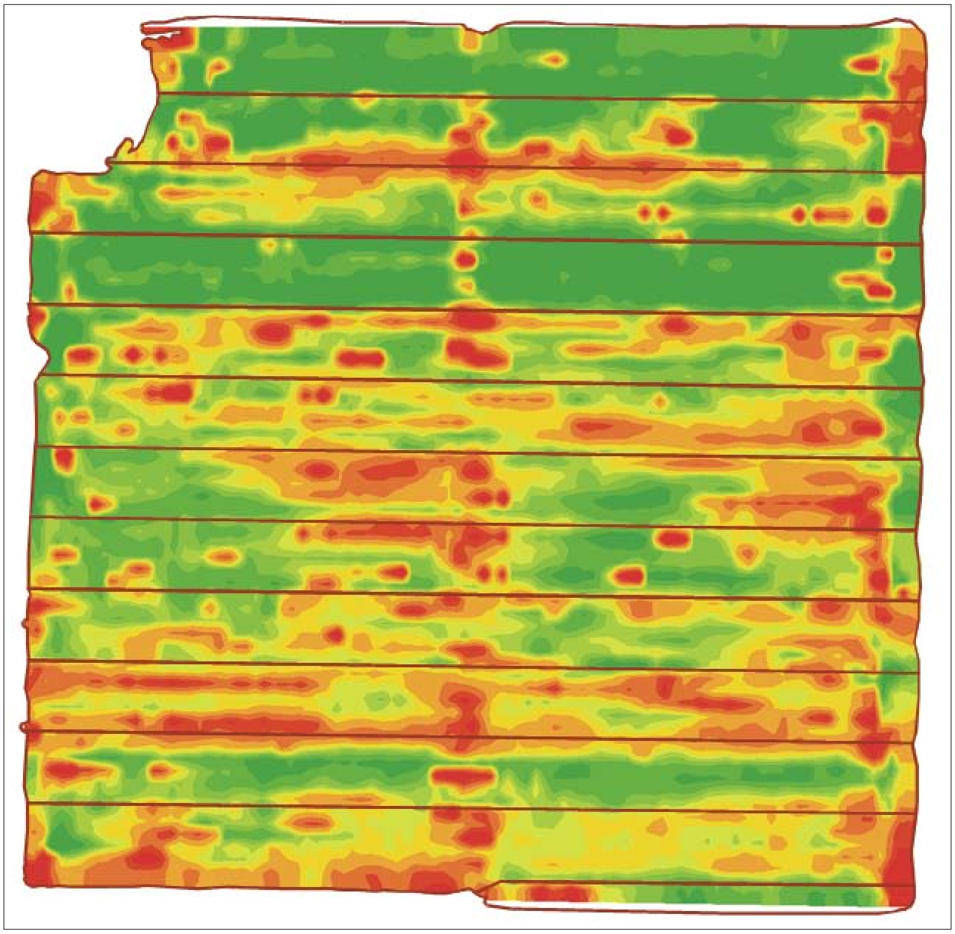
By Ronald Rope, Advisory Scientist, Idaho National Laboratory

Idaho National Laboratory (INL) is using GIS for conducting research and understanding economically optimum fertilization practices. The system supports the simultaneous production of grain and its straw biomass as well as the biorefinery infrastructure.

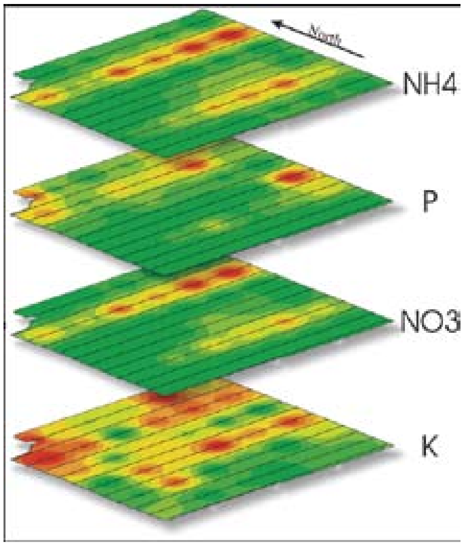
As part of its energy security research efforts, the U.S. Department of Energy (DOE) funds the INL Bioenergy program through the DOE Energy Efficiency and Renewable Energy, Office of Biomass programs. INL's Laboratory Directed Research and Development (LDRD) program has investigated whole-crop utilization, in which the entire agricultural crop is processed into products including food, feed, fiber, and energy.

INL scientists developed Decision Support System for Agriculture (DSS4Ag), a GIS-based crop model and methodology that provides an optimum, spatially variable fertilizer recipe. The spatial technology solution helps farmers make the best use of their land, whether for the production of agricultural food crops, biomass material, or both.

DSS4Ag uses ESRI's ArcGIS Spatial Analyst software to divide a designated field into cells or quadrants about 10 square meters in size and calculate the potential crop production for each cell based on variables including soil composition, required soil amendments, and irrigation needs. Soil samples are gathered before and after the growing cycle and compared with historic harvest data as part of the analysis and fertilizer recipe optimization processes. Analysts predict crop and biomass yields for specified cells over a given field. GIS generates maps that show the most profitable outcome for each cell in a field based on fertilizer costs and current or projected crop market values. This prescription map is then used to direct a variable rate fertilizer combine as it moves across the field.



Fertilization and irrigation variables factor into a yield calculation map, which can be used for everything from crop planning to harvesting.



GIS-based crop model generates a soil fertility value graph for analyzing soil potential.

The evaluation of fertilizer treatments is an important part of the analysis because it affects both the agricultural production costs and yields. Fertilizers such as urea, ammonium phosphate, ammonium sulfate, potash, and zinc sulfate are analyzed to estimate yield per acre versus the fertilizer costs. Based on fertilizer type, amount, and distribution, the difference in crop yield is included in the cost/productivity calculation. Including this information in the model allows the development of a map and a variable recipe that optimizes fertilizer distribution across the field. This prescription method results in lower consumption of petrochemicals and fuel for the vehicle applying the fertilizer, as well as a potential reduction in both nutrients leaving the field and contamination of surface or groundwater.

All this data can be included in the agricultural production process of planning, planting, growing, and harvesting crops. In addition, the application estimates grain and biomass yields and produces profit comparisons based on different scenarios.

Irrigation District Uses GIS for Water Bank Management and Piping Canal Modeling

By Garrett Lehman, Geospatial Services Manager at Geo-Spatial Solutions, Inc.

Three Sisters Irrigation District (TSID), an agricultural water user in central Oregon, is using GIS to identify water conservation opportunities, manage water bank reserves, support canal piping projects, and save money.

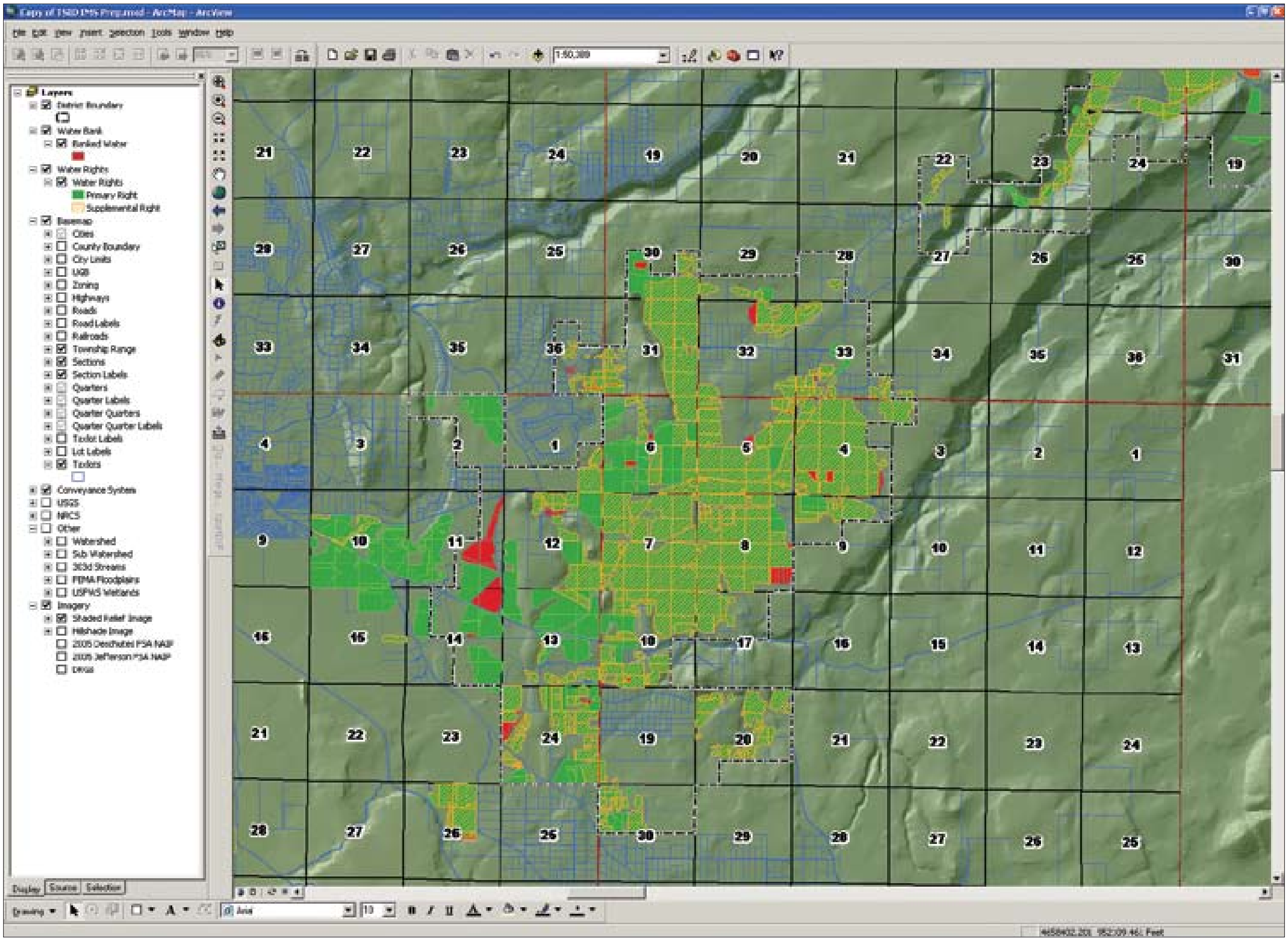
TSID has partnered with the Bureau of Reclamation and numerous local conservation groups through a System Optimization Review (SOR) Grant to help fund a GIS project. They employed ESRI business partner Geo-Spatial Solutions, Inc., to develop the SOR project using GIS.

"We chose GIS because it would help us identify conservation opportunities," explains Marc Thalacker, TSID manager. "GIS allows us to quickly respond to impending threats to our water supply. It also is an impartial tool that helps relieve some of the political tension caused by water use in the area. GIS has the capabilities to support management efficiencies well into the future."

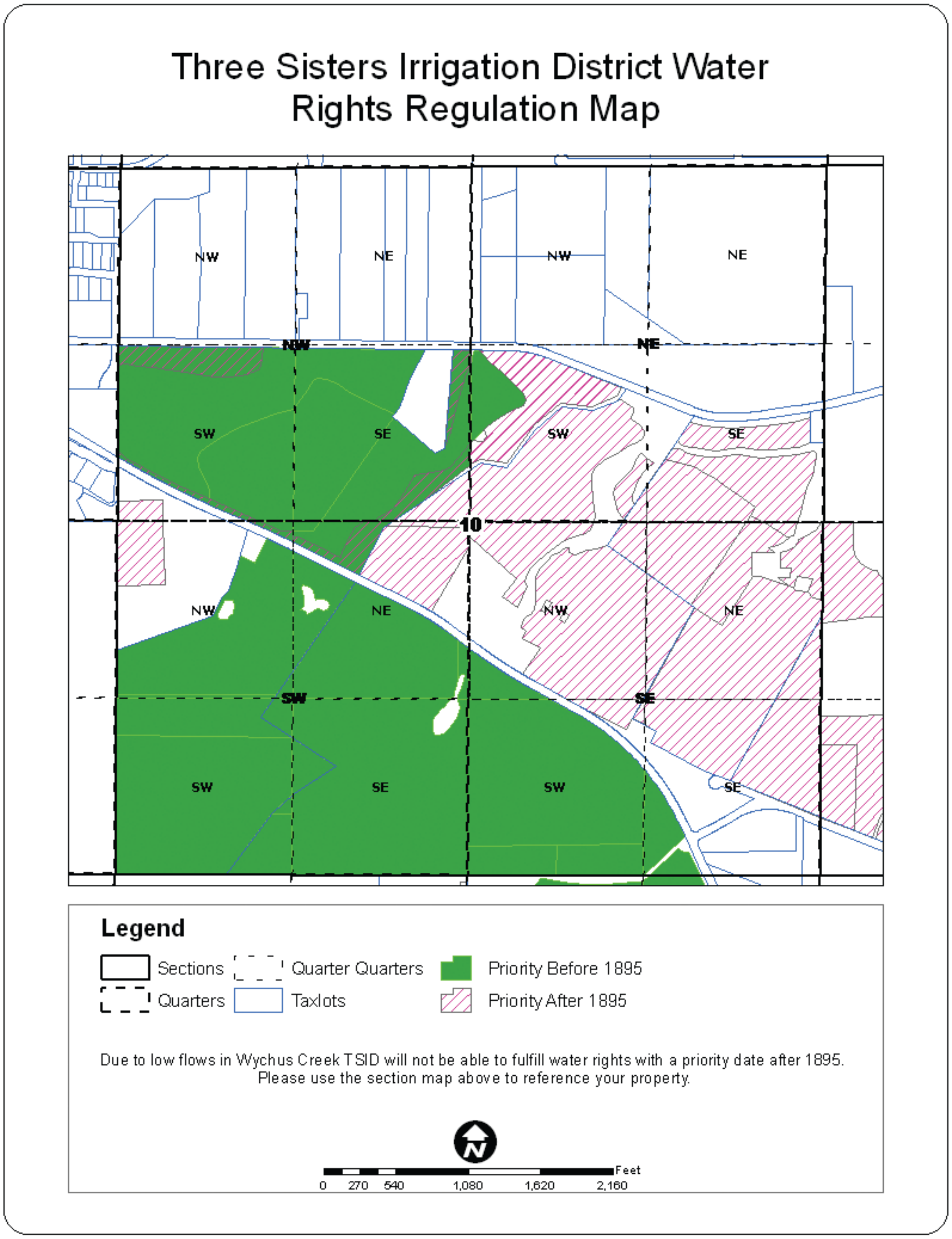
Using ESRI's ArcGIS software, TSID created a database compiled from state, local, federal, and TSID data sources. It then generated a basemap to identify, prioritize, and track conservation opportunities. It has been used to analyze different types of data from multiple sources (soil drainage and lengths of unlined canals), track the movement of water rights, and provide the district with access to critical information about land-use and environmental phenomena.

Water bank conservation assessment processes included an analysis of the water bank for TSID's branch of the Deschutes basin. A water bank is a transactional marketplace where water users can sell water rights or buy banked water rights to expand their farming operations. Water banks help reduce the stress on water supplies by allowing buyers to identify water for sale and by putting surplus unsold water rights in-stream on an annual or permanent basis.

TSID digitized its water rights information, then used GIS to understand how water rights



Three Sisters Irrigation District uses ArcGIS to identify water in its water bank. Banked water rights available for in-stream leasing are shown in red.



Water rights regulation maps provide Web site visitors with a resource for locating their properties' relationships to defined priority boundaries.

regulation would affect the delivery of water throughout the district. In addition, TSID was able to more easily convey water rights regulation issues by printing and distributing maps that showed district patrons how regulated water rights would look in low-water years.

Next, TSID created data layers to track the water right transactions that are critical for the management of its water bank reserves. TSID could then identify and distribute information about banked water rights and quickly prepare in-stream leasing information for unsold banked water. Traditionally, this process was tracked in a nonspatial database, and the district would hire an outside consultant to prepare the in-stream applications. Now, TSID can prepare lease applications and maps in-house.

The basin's terrain consists of very porous, fractured lava flows and does not convey water well, resulting in loss. Therefore, water is piped through open canals. GIS is used to identify and prioritize various canal piping projects. TSID used its existing GIS information, as well as field data collected using GPS units loaded with ArcPad, to create elevation, demand, and location inputs for a pipe modeling program.

Staff members input data into a GIS water modeling program created by the U.S. Environmental Protection Agency (EPA), EPANET2, that allowed them to assess the feasibility of piping projects. TSID modeled multiple pipe size and delivery scenarios. Staff and volunteers used GPS units and GIS to complete a piping assessment that included 24 miles of open canal in a matter of months and at a dramatically reduced cost.

"This was the part of the SOR project that I was most excited about," says Thalacker. "GPS data collection and GIS modeling are ways the district saved money, conserved water, and moved our operation into the twenty-first century."

TSID is now estimating piping costs and conveying piping priority by generating maps for its patrons and government agencies. The district estimates that the piping projects will conserve 10,000 to 12,000 acre feet of water, or a third of its average annual diversion. The district will then put 7,500 to 9,000 acre feet of water back into the Deschutes basin annually.

Geo-Spatial Solutions has been using GIS to serve irrigation districts throughout the West to reduce traditional costs, speed project implementation, manage district infrastructure and water rights, and create and track conservation opportunities.

Read more about Geo-Spatial Solutions and the GeoIrrigation solution at www.geospatialsolutions.com.

Read more about ESRI's ArcPad at www.esri.com/arcpad.

GIS for Agribusiness is a publication of the Agriculture Solutions Group of ESRI.

To contact the ESRI Desktop Order Center, call
1-800-447-9778
within the United States
or
909-793-2853, ext. 1-1235,
outside the United States.

View *GIS for Agribusiness* online at **www.esri.com/agriculture**.

To submit articles for publication in *GIS for Agribusiness,* contact the editor, Barbara Shields, at **bshields@esri.com**.

Advertisers can contact **ads@esri.com**.
To subscribe to ESRI publications, visit **www.esri.com/subscribe**.
To unsubscribe from ESRI publications, visit **www.esri.com/unsubscribe**.

Requests for back issues, missed issues, and other circulation services may also be requested by e-mailing **requests@esri.com**; by calling 909-793-2853, extension 1-2778; or by faxing to 909-307-3051.

To update your mailing address, visit **www.esri.com/coa** or use any e-mail, phone, or fax option.

If you are outside the United States, please contact your international distributor to subscribe, unsubscribe, or change your address. For a directory of distributors, visit **www.esri.com/distributors**.

Agriculture Solutions Group

Belinda LeSage
E-mail: blesage@esri.com
Tel.: 909-793-2853, ext. 1-2021

Peter Eredics
E-mail: peredics@esri.com
Tel.: 909-793-2853, ext. 1-2707

Matt Bechdol
E-mail: mbechdol@esri.com
Tel.: 317-459-5387

116853
12.9M7/09sp

My ESRI News keeps you connected with GIS users and events in your area. Sign up today at **www.esri.com/myesrinews**.

ESRI
380 New York Street
Redlands, CA 92373-8100

Presorted
Standard
U.S. Postage
Paid
ESRI