Every Drop Matters

Global population and urbanisation is on the rise, so is the demand for water supply. With fast depleting water resources, counting and saving every drop is the only option left. Geospatial World explores how GIS is enabling water utilities across the world in plugging the leaks and quenching the thirst of global population

"A shortage of water resources could spell increased conflicts in the future. Population growth will make the problem worse. So will climate change. As the global economy grows, so will its thirst."

— Ban Ki Moon, UN Secretary General, World Economic Forum, 2008

Ban Ki Moon is absolutely right in predicting conflicts over water in the future as water is fast becoming the most stressed resources despite the fact that the planet is endowed with abundant water. A report by the US intelligence agencies even warns that beyond 2022, the use of water as a weapon of war or a tool of terrorism will become more likely, particularly in South Asia, the Middle East and North Africa. Access to clean drinking water is a critical issue that affects development and businesses around the world. In fact 22% of global GDP, or $9.4 trillion, was at risk owing to water stress by 2010, finds a study from Veolia Water. By 2050, this would swell to 45%. The growing focus on social responsibility and environment, regulatory pressures, aging workforce and failing infrastructure are all forcing water companies to reassess the impact of water management.

Use of geographic information by water supply companies started way back in the 1980s, perhaps even before it became a regular application. Denver Water first applied GIS to support network management. Since then, with advances in spatial data search and analysis, mapping and integrated GIS tools have become indispensable for water distribution and transmission companies.

Down the drain

The reasons are not difficult to guess. Utility companies are essentially about assets — assets spread over hundreds of kilometres over ground and underground. While accurate geolocation of underground assets remains a challenge worldwide, infrastructure leaks and ageing underground networks are further increasing the water woes.

Most underground water mains around the world are one hundred to several hundred years old. In US alone, about 40% of all water valves and 10% of hydrant valves are inoperable and 9% distribution valves are wrongly placed. "Globally, 30% of the water is lost before it gets to consumers," points out Malcolm S. Walter, Chief Operating Officer, Bentley Systems.

The Report Card on American Infrastructure 2013 has in fact assigned a 'D' grade to America's drinking water and wastewater infrastructure. Nearly 60% of the operating costs

700 Million people in 43 countries suffer from water scarcity

2.6 Trillion gallons of drinking water is lost through leaking pipes every year

310k Water lines burst each year in the US alone

relate to replacement of underground networks which have been out of sight and out of mind for decades, suggests the US Environmental Protection Agency. It is estimated that $277 billion is required to fix water infrastructure in US.

And this is only the US. Globally, at least $17.7 trillion will be needed for water/wastewater infrastructure over the next 25-30 years, according to OECD (Organization for Economic Cooperation and Development). "All this is happening at a time when local sources of revenues or state loan funds are near empty," says Terry Bennett, Senior Industry Manager, Civil Engineering and Construction, Autodesk.

Water, the new oil

The lifecycle of infrastructure is being compressed due to economic reality. Owners are concerned about the operations and maintenance (O&M) costs, and are looking at innovative approaches. "Over the lifetime of an infrastructure, these costs tend to comprise 90% of the total ownership costs. This is driving the need to look at opportunities afforded by spatial data and process integration," explains Bennett.

A typical water utility distribution cycle includes infrastructure planning, engineering, construction, O&M, and customer management. While technologies like GPS and surveying help accurate mapping of assets, a dynamic GIS platform allows utilities to store, manage and map spatial information, which can be accessed anywhere, any time, on any device. "This means that enterprise systems and information can be connected and leveraged in real-time, increasing collaboration and efficiency," says Lori Armstrong, Global Water and Wastewater Industry Manager, Esri.

» **Asset mapping:** Location of utility assets is essential for all aspects of operations, from planning and design to construction, O&M to customer service and emergency response. Managing facilities and widely distributed assets (pumps, pipes, culverts, valves, manholes, hydrants and meters) are mission-critical for water utilities. "Unless we have the precise location of our pipes and underground network, we cannot optimise our work force," says Vikram Singh, Superintending Engineer (Mapping), Delhi Jal Board (DJB), a water utility based in India.

Mapping of pipelines makes it easier for the crew to locate it and dig at the right spot. In addition to quickly correcting faults and restoring services, precise location is an imperative as faulty digging runs into huge losses besides ruining overground infrastructure. In the US alone, an underground utility is mistakenly hit every 60 seconds on an average.

For precise mapping of underground assets, utilities are taking to various technologies like GPS and sensors. For instance EPCOR, based in Edmonton in Canada, has integrated digital elevation models into its hydraulic network models. "GPS sensors are used to survey asset locations and this is integrated with our data recording applications, where the data is used in accurate placement of facilities," says Susan Ancel, P. Eng, Director of Water Distribution and Transmission, EPCOR.

DJB in coordination with the National Informatics centre took almost five years to prepare an accurate GIS map of its underground assets involving a process of aerial as well as manual surveys. "These maps are updated every time any new work is done," adds Singh.

RMSI, an India-based solution provider, used satellite images to create a digital terrain model at a contour of 0.2-metre intervals for the asset mapping project for a major city in North India. "Legacy maps with asset details and administrative boundaries were brought into a GIS environment. The details were further updated by field verifications as well by gathering information from the staff through their experience," says Sridhar Devineni, Head - Utilities Business Unit, RMSI.

Trimble has been helping its clients to accurately map new and existing facilities at decimetre-level. In addition, customers using its software can have field workers performing work orders on a combination of rugged handhelds, tablets, iPads and smartphones. "The same software can be used on handheld devices to precisely locate a buried water valve during an emergency shutdown, while new constructions can be directly mapped into GIS," adds Chris Stern, Director, Strategy and Portfolio Development, Water Division, Trimble.

» **Powered by GIS:** Besides assets, the spatial database contains — information about topography, height, soil types, zip codes, addresses, political boundaries, supply zones etc — that have to be maintained and kept up- to- date. Integration on a GIS platform cuts across traditional municipal delivery areas, to include infrastructure design and operations, land-use planning, public education and participation, emergency

30% Water is lost before it gets to the consumers

27% Urban population in the developing world does not have access to piped water

47% Global population will be living in areas of high water stress by 2030

45%

Global GDP at risk by 2050 due to water stress

$14 *bn/yr*

Total cost of water wastage through pipe leaks

$17.7 *trn*

Needed to fix global water infrastructure as of now

25

Million m³ increase in quantity of commercial water if NRW is cut by 2% a year

planning and response, pollution prevention, and habitat and shoreline restoration.

"GIS plays a critical role and adds value at each step of the distribution cycle. It provides a common platform for asset management, analytics, decision making and future planning," underlines Devineni.

The core functions of North East Water, which provides water and wastewater services in Victoria, Australia, revolves around the continuous operation of its underground infrastructure and the need to minimise service disruption. Michael Hardman, Geospatial and Business Data Manager, explains that the network trace functionality informs field crews in advance which valves or other infrastructure are involved in the outage and the number of customers affected. Also, address and map-building features enable quick outage information for customers.

Deploying GIS and mobile solutions, and moving to a cloud architecture for automated processes could enable a utility in achieving 25% productivity gain. The benefits also include reduced water loss and environmental damage, and better management of aging infrastructure, explains Stern. On the other hand, the cost of implementing GIS is just about 10% of the annual costs of preventive maintenance.

» **Not just GIS:** With new technology and applications, GIS is becoming an integral part of all hardware, software and mobile applications. "Although GIS has more engineering and IT is more to do with the services part, put together they can only complete the network," emphasises Atif Ahmed Karrani, Managing Director, IT Department, Sharjah Electricity & Water Authority (SEWA), which has GIS-based maps allowing for remote and instantaneous monitoring of water quality in the network.

Delhi Jal Board relies heavily on integration of GIS and IT. Its unique revenue management system monitors the revenues and billing in a spatial context. "We have digitised all the information about our customers and mapped them on a GIS platform so that we can identify the defaulters," says Singh. This method is useful in identifying the deficit areas too. "The system has increased our revenues and also helps us to keep a tab on our staff and their activities," he adds.

Integrating GIS in customer care and billing system has helped Manila Water in improving its customer relationship. "We integrated our network with GIS through business intelligence and identified customer location by using GPS coordinates. This helped us in addressing customer complaints," says Baltazar P. de Guzman, Head of Asset Management Department, Manila Water Company.

Such integration has also enabled a greater understanding of use of water based on different demographics, including age of the customers and their residence, household income levels, and owner versus renter occupancy. For instance, EPCOR claims to have been able to discern differences in low-rise versus high-rise properties. "We have conducted a detailed analysis on the ranges and volumes of water used in different business types," claims Ancel. This information has been used to target water conservation programmes and provide more information to customers on how their usage compares with their peer groups.

Alaska-based Anchorage Water and Wastewater Utility recognised that data integration is needed to go beyond connecting software platforms into developing "information value chains", so the best value information could be available at the lowest cost with highest accuracy. "The result is that processes rely on integration of analytics with various software platforms for each level of planning," explains Armstrong.

» **Automated solutions:** An operational view of water, right from the primary source through the storage and distribution to consumption links utilities at multiple levels. Automated solutions help water companies to optimise labour (cut down on regular mapping personnel, engineers, field crews and monitor their work); improve processes by eliminating duplication; and improve utilisation of assets by integrating accurate and timely asset information with mission-critical information systems.

In Dubuque, Iowa, IBM provided a pilot solution to more than 150 households that gave citizens and officials an integrated view of water consumption, improved water utilisation by 6.6% and encouraged long-term behaviour

changes. The pilot programme found eight times more leaks among pilot users than the city's average rate of leak discovery. Almost 90,000 gallons of water were saved. IBM's "rain-to-drain" operational view of water, from sources through storage and distribution to consumption and discharge provided a one-stop solution to utilities.

EPCOR has built automated tools to assign a replacement priority value to each pipe segment between valve stretches. "Pipes that meet a certain threshold are scheduled for replacement," says Ancel. Netherlands-based Brabant Water too has put in place a system which can identify which old pipes are due for change and how soon. "This helps utilities and municipal authorities save on unnecessary expenses and problems related to digging," says Daan vas Os, Advisor, Network Development, Brabant Water.

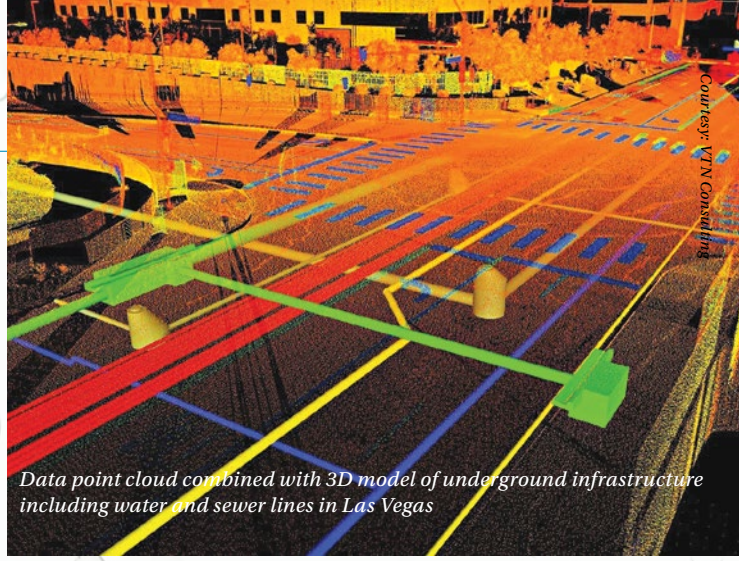
» **BIM & GIS:** As with all things related to construction, BIM is opening up a whole new world for water utilities too. "Although primarily known for large, complex facilities and plant design, BIM has become more prevalent in all aspects of both architectural and engineering design, including applicability for designing water, wastewater and storm water infrastructure," says Stern.

BIM enables planning and design professionals to use a variety of data, including social, political, economic, and environmental, to create 3D models that help explore and analyse various project proposals and make infrastructure a safe investment. "A complete and accurate water infrastructure model, including not only geospatial information but also treatment, pumping, and network facility models created using BIM, can be used to improve asset decisions, maintenance and customer communications," explains Bennett. Additionally, the geospatially accurate and complete BIM model of water utility facilities — whether underground pipes, treatment facilities or pumping plants — can be used to drive better asset management decisions.

Dewberry, a privately held engineering, architectural, and management consulting firm, installed a 5-mile-long reclaimed water pipeline in Fairfax County, Virginia using BIM. Advanced 3D visualisation and design software helped Dewberry increase design and construction efficiency, and communicate design intent to non-technical stakeholders. And, all this without impacting any existing utility infrastructure on the stretch.

In fact, maintenance and management of existing underground water pipelines by municipal agencies is slowly becoming a mainstream activity. Local authorities are looking for accurate 'as built' digital documents that can be used for future O&M activities for asset efficiency, public safety and predictive replacement models.

Also analysis software provides solution about how a certain network should perform by simulating some sort of pressure through the pipes. "We can then run that exact amount of pressure through the actual pipes and measure its performance," explains Walter from Bentley.


Courtesy: VTN Consulting

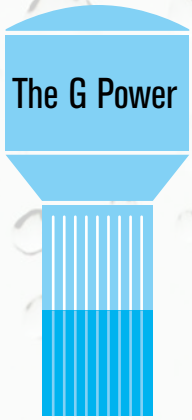
Data point cloud combined with 3D model of underground infrastructure including water and sewer lines in Las Vegas

Rough waters ahead

Worldwide utilities are plagued by a number of challenges, the primary being their high-maintenance assets. Also, lack of awareness about the technology and trained personnel are making the whole process slow and tardy.

» **Funding:** Water utility sector is chronically underfunded. Part of the problem is that water tends to be a local government responsibility, and not seen as a source of net revenue. The burden to finance the upgrades rests mainly on the local authorities, who do not have the requisite financial muscle. According to a paper by American Water on 'Challenges in the Water Industry', local governments in the US spent $93 billion in 2008 on water and wastewater systems. Despite that, there is an annual gap of $19 billion.

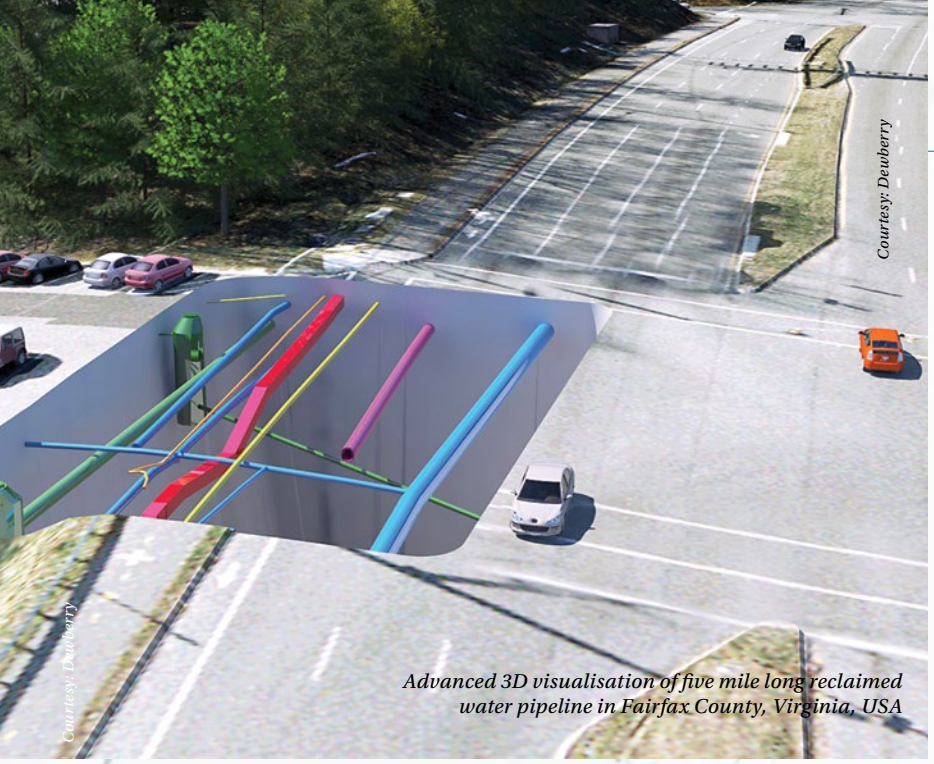
Public-private partnerships (PPP) have been touted as a panacea, whereby private sector water companies assist in designing, rebuilding and operating publicly owned systems. Experts say PPPs will play an increasingly critical role in overcoming water infrastructure challenges. EPCOR has delivered a number of positive results using PPP models, turning in major construction projects within the budget and time. Similarly, Manila Water is a globally acclaimed exam-



25%
Productivity gain and cost reduction for utilities

25%
Annual savings in operating cost for utilities

10%
Cost of implementing GIS as against annual costs of maintenance



Courtesy: Dewberry

Courtesy: Dewberry

Advanced 3D visualisation of five mile long reclaimed water pipeline in Fairfax County, Virginia, USA

ple of successful PPP and is recognised as among the world's best in terms of water efficiency.

» **Water management:** Non-revenue water (NRW) or water that has been produced but cannot be billed owing not only to leakage, but also due to overflowing, theft, inaccurate billing or free use, amounts to 25-30% of the world's water production. "More than water crisis, we are faced with water management crisis," says Rotem Shemesh, Marketing Manager, TaKadu, an Israel-based solutions provider.

Yarra Valley Water, a retail water company owned by the Victoria government in Australia, utilised TaKadu's solutions to reduce its water losses. "Yarra Valley witnessed a 50% increase in early awareness to water loss events as leaks are detected 14 days earlier," adds Shemesh.

The Vietnam Water Supply Association estimates that reducing NRW level by 2- 2.5% each year will increase quantity of commercial water by 25 million cubic metre a year. This is equivalent to the construction of a new water supply system with 100,000-cubic-metre-a-day capacity.

VidaGIS, a Vietnam-based GIS solution provider, developed a GIS-based Decision Support System to store, interpret and analyse data from the distribution systems and do network hydraulic modeling. With its help, the state of Seramban in Malaysia was able to reduce its NRW level from 39% to 24% within a year with the return on investment within two years from the saved NRW. Similarly, Manila Water was able to reduce its NRW from 63% to 11% in 2012 by deploying GIS.

Places like Singapore, which literally count every drop, operates a water supply system that is tightly managed — with an average of just one leak per day. Its Public Utility Board uses sensors in key parts of the network to detect issues immediately, so that the source can be shut down straight away.

» **Climate conditions:** A major challenge that Manila Water faces is natural calamities like storms, floods and droughts. "These result in major disruptions in our services," says Baltazar P. de Guzman, Head of Asset Management Department, Strategic Asset Management Group, Manila Water Company. GIS comes in handy in locating valves to quickly cut off the flow to reduce flooding, damages, and wastage.

In 2011, floods washed away key pipeline infrastructure and cut- off supplies of Queensland Urban Utilities. "With the help of up-to-date maps and accurate location of pipes, repair and replacement work was done in time," reveals Robin Lewis, Chief Operating Officer, Queensland Urban Utilities.

Canada-based EPCOR experiences extreme cold periods resulting in frozen hydrants, valves and water service lines. "GIS has been used to identify areas with a higher risk of freezing and hence requiring additional inspections. GIS is also used by our field crews during the response to main breaks which occur more frequently during severe weather events," says Ancel.

Geo-information and technology are also used to examine current climate variability and extremes, assess risks, investigate options, and project impacts of climate and sea-level change. "This allows evaluation of options for managing and developing reliable, adequate and sustainable water supplies," says Armstrong.

Courtesy: EPCOR

Renewing and installing new pipes in areas that are near critical infrastructure

Courtesy: Trimble

Handheld device for water leakage detection

The future of clean water

Evolving technologies like infinite computing, cloud-based analysis, crowdsourcing, social networking are opening whole new opportunities for the industry. "Future conditions and design models can be viewed during construction and cloud-based computing can run multiple analyses of different scenarios," underlines Bennett.

Armstrong sees an increase in the use of mobile technology (smartphones/tablets). "Utilities are moving into a real-time data collection; field crews are now able to access, change and create data without returning to the office."

Stern from Trimble points to the trend of consumer interest in mapping picking up. "Companies are continuosly evolving to support this demand for highly accurate, up-to-date maps and geospatial data," adds Stern.

Customers can now load the models and orient them over a city street in a virtual or augmented reality interface. "With cloud-based computing and project access, it is true 3D, rather than guesstimating with a metal detector," says Bennett. "It will be like X-raying into the ground as to where the pipes are installed, indicating critical components like age, maintenance history, condition and dependencies with other infrastructure."

An interesting trend is CitySourced, a real-time mobile civic engagement platform, which has been embraced by Los Angeles and San Francisco. CitySourced allows citizens to identify civic issues like water mains breaks and report them for quick resolution.

Now is the time to act

Why does water management continue to be such an acute problem? The answer lies in the callous attitude of both utilities and consumers. Since water is a widely available commodity and utilities don't have to manufacture or produce what they sell, they do not pay much attention to managing it. Similarly, thanks to ridiculously low taxes and tariffs, consumers find no reason to turn off their taps.

Perhaps water utilities need to take a cue from their peers in the power sector, and explore more tariff innovation, such as differential pricing and smart meters. This is again where geotechnology could play a significant role.

Also, it takes thousands of miles of pipes, hours of labour, new-age technology, and significant investment to produce a glass of clean drinking water. Stern claims the uptake of latest technology and improved business processes can help utilities save upto 25% annually on their operating cost. For all this, now is the time to act. Because, to quote National Geographic, "All the water that will ever be is, right now!"

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30%
of pipes are between 40 and 80 years old globally

700
water main breaks occur every day in the US

2,700
gallons of water wasted per year globally by a faucet that drips once per second

$335 bn
estimated cost to fix US water systems over 20 years

Source: IBM