



GIS TECHNOLOGY TRENDS, STATUS, AND BEST PRACTICES IN WATER AND WASTEWATER UTILITY ORGANIZATIONS

Results of research and survey responses from
water and wastewater utility organizations

Author:

Peter Croswell, President
Croswell-Schulte IT Consultants, Inc.
pcroswell@croswell-schulte.com



Fostering Excellence in GIS

www.URISA.org

Image provided by
The Schneider Corporation, Indianapolis, IN
www.schneidercorp.com

PREFACE

This special publication is designed to provide water and wastewater utility organizations with information to support planning for GIS implementation and operations. It is based on research conducted by the author which includes a Web-based survey and analysis of information from responding organizations.

We would like to thank the organizations which responded to the survey (see Appendix B) summarized in this publication. Their responses provided a good summary of current GIS status, technology and management issues impacting use of GIS, and a picture of trends driving future GIS implementation and use in water and wastewater utility organizations.

Recognition is also extended to the City of Winnipeg Water and Wastewater Department. Much of the research on which this project is based was carried out by the author in connection with work on a GIS Strategic Planning project being conducted by the Department.

Published by:

The Urban and Regional Information Systems Association
701 Lee St, Suite 680
Des Plaines, IL 60016
Phone: 847-824-6300 Fax: 847-824-6363
info@urisa.org
<http://www.urisa.org>

Copyright ©2014 by the Urban and Regional Information Systems Association (URISA)

All rights reserved including the rights of reproduction and use in any form or by any means, including the making of copies by any photo process or by any electronic or mechanical device (printed, written, or oral), or recording of sound or visual reproduction, or for use in any knowledge or retrieval system device, unless permission in writing is obtained from the copyright proprietor.

This ebook is sold on condition that it shall not be lent, resold, hired out, or otherwise circulated without the copyright proprietor's consent, and without a similar condition being imposed on a subsequent purchaser.

Published in the United States of America

ISBN #: 978-0-916848-06-4

TABLE OF CONTENTS

1. Technology Trends Impacting GIS	4
2. Overview of GIS Use in Water and Wastewater Utility Organizations.....	5
3. GIS Applications.....	6
4. GIS Integration with External Systems and Databases	7
4.1 Overview of Integration Concepts and Scenarios.....	7
4.2 Status of GIS-External System Integration—Responses from Survey	8
4.3 Specific GIS Integration Scenarios	8
5. GIS Program Management and Organizational Structure	11
6. Survey Responses on GIS Best Practice Areas.....	13
6.1 User/Technical Staff Training and Professional Development.....	13
6.2 Keeping Senior Management Engaged	13
6.3 User Group/User Engagement.....	14
6.4 Helpdesk/User Technical Support Services	14
6.5 Deploying GIS to the Field	14
6.6 Web-Based vs. Desktop Software Use	15
6.7 Database Update/Quality Control	15
6.8 Application Configuration/Customization.....	16
6.9 Management Practices	16
6.10 Publicly-Accessible Web Applications/Services	16
6.11 Other Ideas and Observations	17
7. Lessons for GIS Development and Operations in Water and Wastewater Utility Organizations	18
Appendix A: GIS Survey Form	19
Appendix B: Survey of GIS Practices-List of Responding Organizations	22

1. TECHNOLOGY TRENDS IMPACTING GIS

GIS technology has been an established tool for both public sector and private utility companies with a history going back over 30 years. GIS software and equipment vendors have responded to user needs and have capitalized on overall information technology advances. These areas of advancing GIS and related IT products and capabilities include processing power, increases in wired and wireless network speeds, improvements in GIS data capture methods (lowering cost and shortening delivery time), enhanced functional capabilities of GIS software, improved approaches for system integration, and better access driven in large part by Web-based tools.

Some good references on technology status and trends include:

- <http://www.esri.com/products/technology-topics>
- <http://www.ikegps.com/blog/bid/56311/Hot-New-Trends-in-Mobile-GIS-Technology-and-Applications>
- <http://gis-centric.net>
- http://www.pobonline.com/ext/resources/Issues/2013-8/pob0813_trends.pdf

The key areas of IT and GIS technology trends and advances that are particularly important for GIS operations and applications are:

- Higher network bandwidth and wireless access.
- Cross platform software and data accessibility with interfaces and applications for desktop computers, tablets, and smart phones.
- Move away from desktop GIS software use (except for processing-intensive tasks) toward a server-centric model with Web-based management tools and user access via Web-browsers (including internal Web-based networks and publicly accessible Web-based GIS services).
- “Open GIS” which encompasses accepted standards for GIS data and services led by the OpenGIS Consortium (OGC), government and independent standards organizations including the Federal Geographic Data Committee (FGDC), the Canadian General Standards Board (CGSB), the Canadian Council on Geomatics (CCOG), and the International Organization on Standardization (ISO). Open GIS trends and formal standards have motivated commercial GIS software vendors to improve interoperability and data integration with other systems and it has been the basis for a number of open GIS software products.
- Real-time GPS/GNSS positioning incorporated into field operations, handheld devices, and GIS applications. Advances in real-time GIS networks (Web-based services supporting real-time positioning), improvements in GNSS receivers and software, and expansion in GNSS satellite constellations (U.S., European Union, Russia, and China) greatly enhance position speed and accuracy.
- Cross-platform tools, more robust wireless networks, and real-time GPS/GNSS positioning technology has, in recent years, driven the wide adoption of field based applications for GIS data access capture, and update.
- Public access to GIS data and services through well-designed Web portals.
- Seamless access to a wide range of GIS-related external Web services (with internal GIS data and applications).
- Improved and lower cost capabilities and services for aerial data capture including high-resolution imagery and elevation data (from satellites, aircraft, and unmanned aerial vehicles). Coupled with real-time GNSS positioning and better software for processing the data, data can be processed and delivered to users in much shorter timeframes.
- Cloud-based hosting and service delivery—including platform-as-a-service (PaaS) and software-as-a-service (SaaS). This cloud service trend offers opportunities for more flexible access to server and storage resources and hosting of software and data.
- CAD-GIS integration and digital engineering drawing submission. This includes better tools for georegistration of CAD files and GIS tools that can directly access, display, and allow analysis of CAD data from the GIS software (without requiring steps for CAD file translation and import).
- More flexible and transparent GIS integration with other enterprise systems (e.g., asset management/maintenance, document management, and hydraulic modeling). The trend is to eliminate time-consuming steps for extract, transformation, and loading (ETL) to move data from one system to another so it can be used in that system.
- Tools for “crowd-sourcing” of GIS data delivery. For utility and public works organizations, such tools and custom applications allow the public or businesses to submit information about infrastructure problems (with location information and often a tagged photo).
- Easier-to-use and broader set of capabilities for spatial analysis and “business intelligence” integration. This includes better tools for designing and running network tracing applications, suitability modeling, and a range of geostatistical analysis.
- 3D data capture, visualization, and modeling with improved capabilities to include a third dimension with traditional x,y coordinates in GIS databases. This offers some additional opportunities for geodesign, terrain/drainage analysis, and 3-D modeling and visualization for build-out, surface structures, and underground infrastructure..

2. OVERVIEW OF STATUS OF GIS USE IN WATER AND WASTEWATER UTILITY ORGANIZATIONS

Today, it is estimated that at least 89% of water and wastewater utility organizations in the USA and Canada are using GIS technology (see Baird, 2012)—at least to support digital mapping but also GIS software capabilities for query, map visualization, and a wide range of spatial analyses. This includes water and wastewater utilities operating as a department in a City or County government, independent water and sewer districts and authorities, and private water companies.

Footnote Citation---**Baird, Gregory. "Heating the Spot GIS Helps Improve U.S. Water Infrastructure". Waterworld, Volume 26, Issue#5, 2012. <http://www.waterworld.com/articles/www/print/volume-26/issue-5/regional-spotlight/north-america-caribbean/heating-the-spot-gis-helps-improve-us-water-infrastructure.html>

Croswell-Schulte conducted a survey of selected water and wastewater utilities to get a comprehensive picture of current uses of GIS and best practices for GIS implementation and operation. This was a Web based survey which can be found at the URL below and pages of the Web-based form are included in Appendix A: www.surveygizmo.com/s3/1344608/Survey-GIS-Use-in-Water-and-Wastewater-Utility-Organizations

Croswell-Schulte contacted, via email, approximately 200 water and wastewater utility organizations (focusing on those organizations serving medium and large urban areas in the USA in Canada and invited them to participate in this survey. The survey asked questions about: a) current and planned applications in use, b) integration between GIS and external systems, c) GIS program governance and management practices, and d) ideas on "best practices" in GIS implementation and operations. A total of 62 responses were received. While this is only a small percentage of all water and wastewater organizations using GIS, it included utilities making effective use of GIS technology and was sufficient to draw conclusions about GIS use. The responses break out as shown in Table 1.

Table 1: Main Characteristic of Responses from Web-based Survey

Canadian vs. US Respondents:	Responses by Organization Type:
- United States: 41 responses - Canada: 21 responses	- Utility part of local government: 39 responses - Independent authority or district: 11 responses - Private company or co-op: 12 responses

Responses by Utility Service Type:	Responses by Number of Customers:
- All services (Water, Sanitary Sewer, Stormwater): 28 responses - Water Only: 12 responses - Sanitary Sewer Only: 6 responses - Stormwater Only: 0 responses - Water and Sanitary Sewer: 12 responses - Water and Stormwater: 2 responses - Sanitary Sewer and Stormwater: 2 responses	- Under 10,000: 5 responses 10,000 to 49,999: 23 responses 50,000 to 199,999: 18 responses 200,000 to 499,999: 6 responses 500,000 to 1 million: 3 responses - Over 1 million: 7 responses

A list of the utility organizations responding to this survey is in Appendix B.

Out of the responses, software for GIS, CAD mapping activities, as distributed among the following vendors with an identification of the percentage of responses for different software products:

- Esri: 60 responses including ArcGIS for Server (68%), ArcGIS Desktop (50%), ArcPAD (12%)
- Intergraph: 2 responses representing use of GeoMedia and Geomedia Pro
- AutoDESK: 17 responses representing various version of AutoCAD*

*The survey did not ask a specific question about CAD software use so this figure may not fully take into account level of use of AutoCAD for engineering design and mapping along with other GIS software.

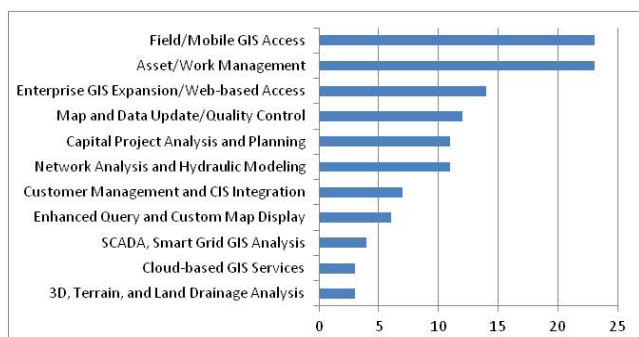
A small number of responses cited the following additional GIS and mapping software products ArcFM (Televent), MicroStation (Bentley), GenaMap, PostGIS (open source software), and MapInfo (Pitney Bowes).

3. GIS APPLICATIONS

There is an active community of GIS users in the water and wastewater industry sector and a substantial body of literature describing GIS applications, program structure, and best practices. One way to gauge GIS application focus is a literature review of recently published materials and formal conference presentations. Croswell-Schulte conducted research which identified 55 papers and presentations from 2009 to the present. Key sources of this literature were: a) Esri User Conference papers and presentations, b) presentations at meetings of Esri Water/Wastewater user group (www.esri.com/industries/water/community/team-water), c) Arc-News articles, d) Newsletters from GIS vendors, e) Published pieces in Waterworld.com (magazine and Web service), and f) publications of the American Water Works Association. A classification of GIS application topics covered by the 55 references is shown in Figure 1.

Figure 1: Applications Identified in Literature Review

(From Croswell-Schulte literature review)



The Web-based survey conducted by Croswell-Schulte for this project asked for responses regarding current or planned GIS application use. Table 2 summarizes these responses.

Table 2: GIS Application Status from Survey

GIS Application	Status of Application Use		
	Current Use	Planned Use	No Current or Planned Use
Standard map update and production	100%	0%	0%
Custom map design and production	100%	0%	0%
Underground Utility Location	92%	6%	2%
Field crew GIS access	77%	21%	2%
Field crew redline/data update	33%	57%	10%
Preliminary engineering design	68%	11%	21%
Detailed engineering design	41%	21%	38%
Asset inventory/condition monitoring	76%	21%	3%
Construction plan review	48%	16%	36%
Permit review and tracking	32%	40%	28%
Work order issuance and field support	43%	47%	10%
Project tracking	68%	24%	8%
Financial/regulatory compliance and reporting	46%	27%	27%
Call complaint response and tracking	36%	45%	19%
Network tracing	36%	48%	16%
Hydraulic modeling	61%	24%	15%
Capital project planning and budgeting	65%	27%	8%
Drainage/runoff analysis	25%	29%	46%
Customer alerts and notification	27%	47%	26%
Special engineering or planning projects	60%	14%	26%

Not surprisingly, the survey shows very high usage of GIS technology for standard and custom mapping applications and to support underground utility location. It is somewhat unexpected that nearly all of the application categories showed a significant amount of use by respondents with about half of the application categories showing current use by 60% or more of the respondents. A very high percentage (98%) are currently providing field access to GIS or are planning to do so and 90% currently support or are planning to deploy field-based mark-up capabilities. Current or planned use of GIS to support asset inventory, condition monitoring, and work order management is very high. Of note is the relatively high reported use of GIS to support various spatial analyses (e.g., network tracing, hydraulic modeling). Also of interest is a significant amount of current or planned use of GIS for financial management and regulatory reporting (73%) and capital project planning and budgeting (92%).

4. GIS INTEGRATION WITH EXTERNAL SYSTEMS AND DATABASES

4.1 Overview of Integration Concepts and Scenarios

It has become commonplace and a critical technical component of GIS to put in place useful integration with external systems and databases. These external systems (e.g., CAD systems, asset management, hydraulic models, etc.) often contain or use geographically-referenced data. Integration with GIS delivers business value by supporting one or more of the following:

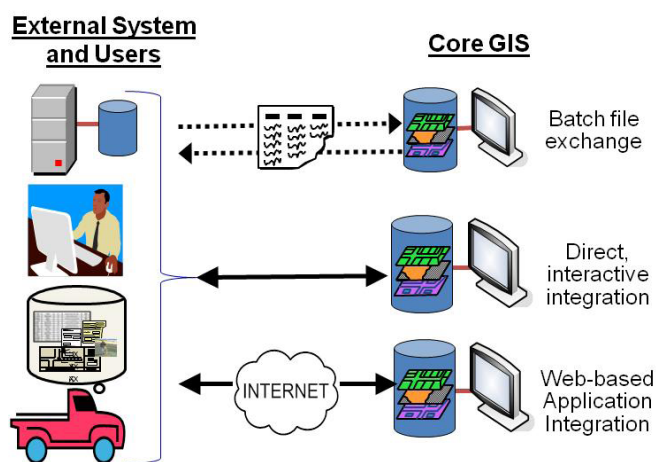
- Graphic or attribute data captured in the external system is used to update selected attribute fields in the GIS database. Example: CAD data for an as-built drawing is used for GIS database update.
- The external system captures data that can be used by the GIS for geographic queries, map display, or analysis. Example: The GIS access work order or maintenance history data from an asset management system for map display—supporting maintenance work or spatial analysis for maintenance history.
- The GIS is used as a front-end to support query and access to documents which are associated with a location—engineering drawings, mechanical drawings, reports, photos, etc. Example: A map-based GIS selection is used to access and view an as-built drawing for a specific water main segment.
- The GIS provides data in a specific format for further analysis in an external system. Example: Selected GIS data for the sanitary sewer network is extracted for use by a hydraulic modeling software package.
- Data prepared by a query or analysis in an external system is used by the GIS for further analysis, map display, or visualization. Example: Data on historical water consumption from a customer billing system is used to project future water demand for areas of likely growth.

Key concepts of GIS integration are explained well in a number of publications including the ones listed below which present practical integration issues and approaches for GIS integration in utility and facility management environments:

- The ABCs of Integration, Kathryn Browning, Esri Water/Wastewater Group, <http://www.esri.com/industries/water/>.
- Hydraulic Modeling and GIS, Esri Press, Lori Armstrong, 2011 (see <http://esripress.esri.com/display/index.cfm?fuseaction=display&websiteID=204&moduleID=1>).
- GIS for Facility Management, Stuart Rich and Kevin Davis, IFMA Foundation, 2010 http://www.ifmafoundation.org/documents/public/GIS_WP_FINAL.pdf.

At a conceptual level, typical environments for GIS integration with external systems are shown in Figure 2.

Figure 2: Environments of GIS Integration with External Systems



From a functional perspective, integration between GIS and external systems may take one of two main forms:

- **“Loosely coupled” integration** in which case the external system would be maintained and operated independently with a process set up for periodic transfer of data to and from the GIS to support applications that do not require real-time or near real-time integration. This periodic transfer could be a regularly scheduled batch transfer and data loading (e.g., monthly, annually) or a more sophisticated data replication process that is set up to run automatically on a frequent basis (e.g., daily or even more frequently). In the information technology industry today, formal “data warehouse” technology has become a prominent approach to loosely-coupled integration. The data warehouse serves as a central repository of selected data which is copied on a regular schedule, using formal extract-transform-load (ETL) procedures from source databases which remain operating separately.
- **“Tightly coupled” integration** could mean one of the following—a) the external system is fully incorporated within the core GIS, or b) systems remain independent, but an interactive process is set up to support applications (data update, viewing, query, analysis) on a real-time transaction basis. This real-time integration between two systems may use any of a variety of technical methodologies including direct SQL queries into an external database, commands sent to-from the external system enabled by an established messaging protocol, or the use of Web-based tools for integration of data or services. Today, many software packages have “application programming interfaces” (APIs) to enable GIS integration. These APIs can eliminate or greatly reduce the amount of custom programming and technical configuration needed to set-up a real-time, tightly coupled integration environment.

Tightly-coupled integration between separate systems or databases usually tends to be more technically complex to implement than loosely-coupled integration approaches. The tightly-coupled approach should be considered under the following circumstances:

1. When there are benefits to eliminating an external system and incorporating its functionality and/or data fully into the core GIS.

OR

2. When there are requirements for real-time, transaction-level connections for application and data access between the GIS and the external system.

Loosely-coupled integration approaches are most appropriate and effective when it makes sense, from a business and technical standpoint, for the external system to remain separate from the core GIS and where a periodic batch transfer of data meets all users' needs (i.e., user needs not dependent on a transaction level integration or frequent exchange of data).

4.2 Status of GIS-External System Integration—Responses from Survey

The Web-based survey asked for responses about current or planned GIS application use. Table 3 summarizes the responses

Table 3: Status of GIS Integration from Survey

GIS Integration with External System	Status of GIS Integration with External Systems		
	Current Use	Planned Use	No Current or Planned Use
Asset/Work Management System	62%	33%	5%
Document Management System	32%	42%	26%
Hydraulic Modeling-Sewer	38%	21%	41%
Hydraulic Modeling-Water	57%	18%	25%
Televised Inspection System	40%	21%	39%
Customer Account Billing/Management	28%	39%	33%
Automated Call/Complaint Management	18%	47%	35%
Runoff/Drainage Analysis System	26%	16%	58%
Dispatch/AVL System	21%	28%	51%
Computer Aided Design (CAD) System	73%	13%	14%
Pan/Permit Review and Tracking System	29%	36%	35%
Customer Notification/Alert System	24%	44%	32%

In addition to the responses to the specific survey questions shown in Table 3 above, some additional information on GIS integration with external systems was provided:

- 3 respondents identified current or planned GIS integration with Supervisory Control and Data Acquisition (SCADA) systems.
- 5 responses indicated current or ongoing projects for GIS integration with Enterprise Resource Planning (ERP) systems.
- 2 respondents reported integration with data warehouse or business intelligence system.

In response to the question about best practices for implementing and managing GIS integration with external systems, respondents voiced the following concerns and suggestions:

- Integration problems are complicated by legacy software or software compatibility problems as versions change
- System and database integration with GIS may involve changes to the data structure and content to support needed applications and to define a unique, stable key field on which integration is based
- Complications in database integration arise when it is not clear which database is the "master" or how to reconcile changes to the multiple databases
- The need and design for GIS integration with external systems should be based on business requirements
- Not all cases require a real-time integration—sometimes batch file transfer is sufficient
- Involve IT staff in designing and developing GIS integration with external systems and databases
- Investigate the availability of existing integration tools, software features, and Application Programming Interfaces (API) for integration development

4.3 Specific GIS Integration Scenarios

Based on our literature review and the results of the Web-based survey, there are three critical integration areas that receive the most focus and very likely deliver the greatest benefits among all possible GIS-external system integrations: a) GIS integration with document databases, b) GIS integration with asset/work management systems, and c) GIS integration with plan/permit review and tracking systems. These are discussed in more detail below.

GIS Integration with Document Databases

This integration may involve third-party document management packages with direct access to and from the GIS or this integration may just employ standard tools in the GIS and database management package. GIS-document management integration is useful and may be employed for any type of document, (stored in a range of file types) and is associated with a location. Common GIS-document integration scenarios include engineering plan and as-built drawings, inspection forms, field notes, site photos,

engineering project specifications, and schematics (e.g., internal pump station details).

In some cases, document integration involves georegistration of scanned engineering drawings—perhaps storing these drawings in GeoTIFF format. There is a trend to submit plans and as-built drawings in a vector format (usually AutoCAD) which is the WWD current practice. However, Adobe PDF format is becoming very popular—particularly with an expanded set of tools for plan review and mark-up offered by Adobe and third party vendors. GIS-document integration may also involve CAD files (usually AutoCAD) through a file translation and import to GIS or direct viewing from the GIS software. There is a trend to provide tools in CAD and GIS software for a tightly-coupled integration in which GIS and CAD data is spatially-referenced and may be viewed and used together for mapping, query, and analysis applications.

Effective integration, using the GIS as a platform for document access, requires functionality for attribute-based queries as well as map-based selection. The document database must include a set of index fields (drawing number, project name and number, type, date, etc.). Map-based queries (select a feature or location interactively on the map and retrieve documents for the location) requires that the documents be spatially referenced. If the document itself is not spatially referenced (e.g. GeoTIFF format). This may be done by including document index fields to store key GIS “feature/asset IDs” to support direct attribute queries. Another approach is to create a new GIS feature layer with point or polygon features representing the location or area extent (engineering drawing sheet) for the documents.

GIS Integration with Asset/Work Management Systems

Today, most of the popular asset/work management software packages used by utility and public works organizations have application program interface tools that support GIS integration—reducing the need to design and build custom interfaces. At least this is generally true for direct integration with Esri ArcGIS software. Esri ArcGIS, being the dominant GIS software platform for local governments and utility organizations, has been a focal point for multiple asset management software vendors to add integration features for ArcGIS geodatabases. There has also been work done by asset management system vendors to build integration features for Intergraph Geomedia but to a much less extent than Esri ArcGIS. The Web-based survey showed a significant use and interest in GIS integration and asset management. While the survey did not specifically ask respondents to identify asset management software packages being used, many did provide this information and the most prominently mentioned packages were Cityworks, Infor Hansen, and Maximo.

A 2012 publication from the Water Finance Research Foundation (WFRF) entitled, *Municipal Maintenance and Infrastructure Asset Management Systems*, (see www.waterfinanceRF.org) reviews and compares functionality, price, and GIS integration of the main commercial asset/work management packages available today. This publication, “The 2012 Comparative Review—Municipal Maintenance and Infrastructure and Asset Management Systems”, examines the following software packages: Accela, Agile Assets, Azteca System’s Cityworks, Cartegraph, City View, Energov, IBM’s Maximo, Infor Hansen, Lucity/GBA, Maintenance Connection, Novotx’s Elements, Oracle Asset Management, Pubworks and Viewworks. The summary scores in this report’s comparison taking into account all functionality and price factors examined is shown in Table 4 below.

Table 4: Overall Functionality and Cost Scores

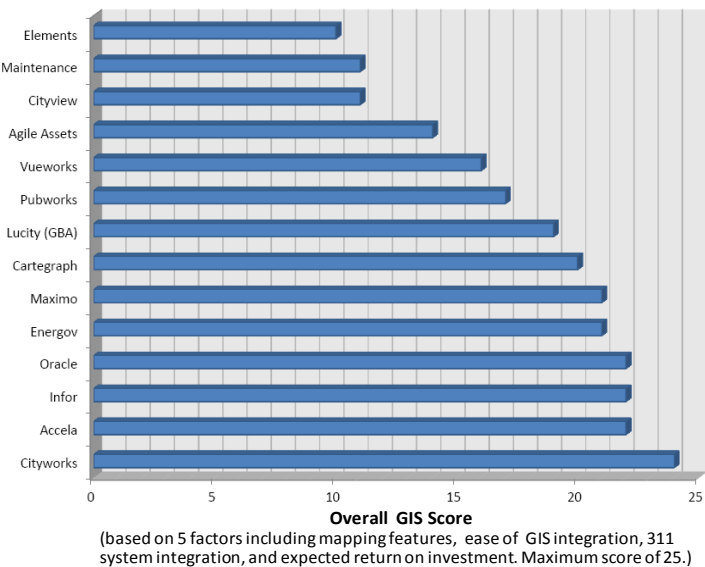
From the WFRF Comparative Review-Maintenance and Infrastructure Asset Management Systems. Maximum Score of 100 in each category.

Software	Functional Score	Price Score*
Cityworks	99	91
Oracle	94	79
Maximo	93	78
Accela	92	82
Infor/Hansen	89	79
Energov	88	82
Cartegraph	87	81
Lucity (GBA)	82	78
Pubworks	65	68
Maintenance	61	61
Viewworks	61	61
Agile Assets	52	58
Elements	50	56
Cityview	33	42

The WFRF examined the capabilities and tools of the infrastructure asset management software packages to support integration between GIS and the asset/work management software. The results of this assessment are summarized in Figure 3 below.

Figure 3: Overall GIS Capability Scores

(From the WFRF Comparative Review-Maintenance and Infrastructure Asset Management Systems.)



GIS Integration with Plan/Permit Review and Tracking Systems

The Web-based survey showed that about 30% of the respondents are currently using integration between their GIS and a plan/permit review and tracking system and that about 35% are in the planning stage to implement integration. GIS integration is designed to provide very easy access to maps and GIS data by streamlining the review process. In many cases, plan/permit review and tracing software packages include functionality for inspection support and tracking which also makes use of GIS integration.

There are numerous vendors providing software packages for plan/permit review and tracking. As is the case with asset/work management systems, some of the vendors provide functionality for easy integration with GIS databases. The survey did not specifically ask for information about plan/permit review and tracking software packages in use but additional research has identified several companies. Some of these companies also provide asset/work management software. The most prominent vendors in the plan/permit review and tracking software market are: Accela, Infor Hansen, CRW Systems, MS Govern, and Azteca-Cityworks. Recent software capabilities provided in many of these software packages include functionality to support automated document routing, mark-up, and reviewer collaboration.

5. GIS PROGRAM MANAGEMENT AND ORGANIZATIONAL STRUCTURE

Through the 1990s when GIS implementation was becoming prevalent in utility organizations, it was typical for the management of these programs to reside in a line departments—such as an engineering or planning group and often without formally de-

fined GIS management positions and roles. As GIS use expanded throughout organizations and as GIS integration with external systems became a dominant theme, there has been a trend toward more formal GIS practices and organizational structures for enterprise GIS programs. Figures 4(a) to 4(e) illustrate survey responses in answer to questions about GIS management.

Figure 4(a): Does the organization have an assigned GIS Manager and/or formal GIS office

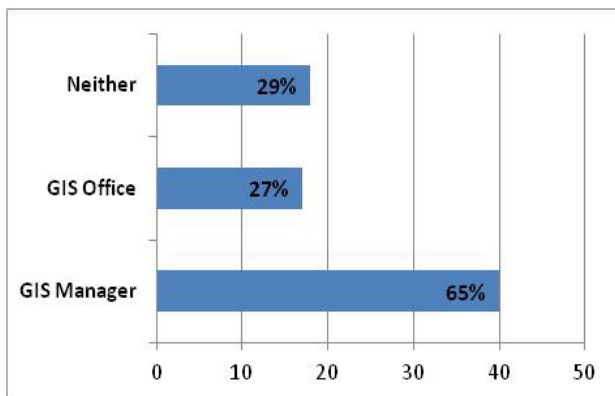


Figure 4(b): Where in the organization does GIS management reside?

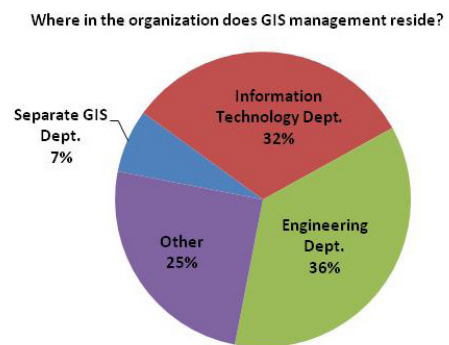


Figure 4(c): Does the organization's GIS program operate in coordination with or under the management of a GIS program in a parent organization (e.g., Citywide GIS office)?

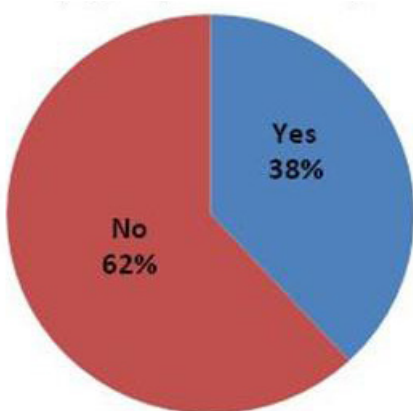


Figure 4(d): Does the organization have in place any committees, formal body, or user group to support GIS coordination and operations?

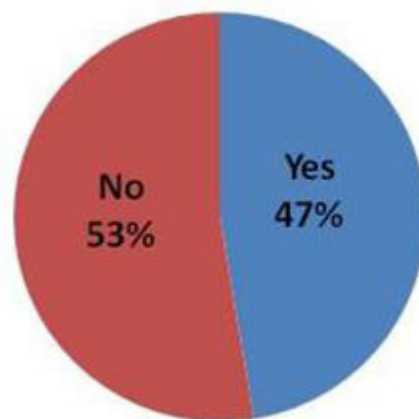
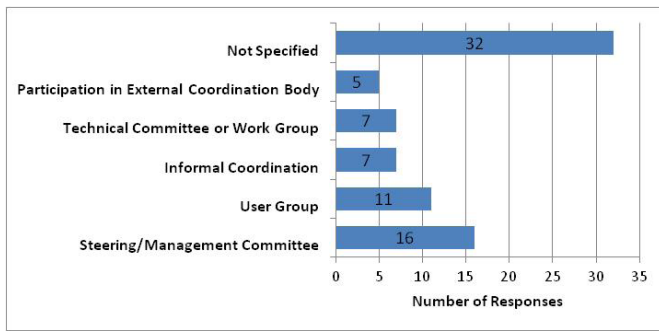


Figure 4(e): Type of GIS Coordination Body



There is no single best organizational structure for GIS management inside a utility organization. While there has been a trend over the past 15 years for creation of a formal GIS Office or role inside the utility organization IT Departments or Divisions, many successful utility GIS programs have the main GIS management role placed in Engineering or other departments or divisions. Whatever choices are made for organizational placement, some critical management structure best practices for utility organizations were clearly revealed by the survey and literature review:

- Formally and clearly designate GIS management roles and responsibilities to a specific office in the organization.
- Identify a GIS manager and his or her role for GIS coordination and operations in the organization.
- Ensure that the GIS management office has an organizational location which allows it to coordinate and provide services to ALL users in the organization.

6. SURVEY RESPONSES ON GIS BEST PRACTICE AREAS

The Web-based survey asked respondents to provide comments on a number of best practice areas that influence GIS management, coordination, and use. A summary of responses for the following GIS best practices is presented in this section.

- User/Technical Staff Training and Professional Development
- Keeping Senior Management Engaged
- User Group/User Engagement
- Helpdesk/User Technical Support Services
- Deploying GIS to The Field
- Web-Based vs. Desktop Software Use
- Database Update/Quality Control
- Application Configuration/Customization
- Management Practices
- Publicly-Accessible Web Applications/Services
- Status Monitoring/Reporting
- Other Ideas and Observations about GIS Best Practices Or Lessons Learned

6.1 User/Technical Staff Training and Professional Development

Most respondents stressed the need for ongoing training programs for users and technical staff. In many cases, respondents indicated that not enough resources are allocated to training and that it is difficult to train technical staff to keep pace with technology changes. Specific observations and suggestions that multiple respondents voiced include:

- Maximize use of online training programs and services
- Involve users and technical staff in GIS conferences as a means to advance skills and support professional development
- Create a formal in-house training program including “train-the-trainer” and mentoring of younger employees.
- Increase level of professional networking inside and outside the organization
- Involve staff early in software migration and new application development to prepare them for operational use
- Use formal vendor-provided instructor-led training as resources permit
- Provide more effective orientation to senior and mid-level management on the business value of GIS technology and how it is used to deliver real benefits to the organization

- The best user and technical training uses local data and context specific scenarios so that users can more easily connect the technology tools and applications with actual use in the organization

6.2 Keeping Senior Management Engaged

Respondents emphasized the importance of keeping senior management and officials (elected officials or appointed board members) engaged, interested, supportive of the GIS program. Some expressed that this is difficult to do and that lack of engagement had negative impact on GIS operations as revealed by the following comments:

“...it is difficult to engage senior management in local government because management changes frequently. Also getting money set aside in budgets was difficult because of these management changes”

“Early attempts to “sell” GIS did not go well. It was only when we could integrate development of a GIS with an accelerating capital improvement program that we were successful. GIS quickly became “mission critical”, both in support of field operations and supplying data to other internal systems”

But many respondents report success in getting active engagement and even use of GIS by senior management by using the following approaches:

- Prepare and conduct well-designed management-level briefings with summary documents and presentation materials
- Find ways to demonstrate and communicate real use and business value to the organization
- Engage senior management through their support staff build applications that address management needs (e.g., support for capital project planning and budgeting)
- Involvement of senior management works well when there is a formal GIS Steering Committee
- The GIS Manager must actively promote the GIS program and communicate directly with senior management.

The following comments illustrate and elaborate these ideas:

“GIS has become a core technology throughout the county with multiple system integrations so senior management is very engaged. Showing them the power of GIS technology will get their attention quickly and they will support funding for GIS projects.”

"The GIS manager needs a platform to keep management up to date and manage expectations. The GIS manager needs to be an ambassador for GIS to the organization - beyond just having advanced GIS skills. Quarterly updates to senior leadership; utilizing communication tools like monthly newsletters; anything that enables the GIS manager to share updates is beneficial."

"Explaining the process and merits of the GIS to senior management is important so that the information and GIS tools can be efficiently utilized."

"We try to involve senior management as much as they are willing to keep them engaged but also to engage their staff more."

"Department Directors are encouraged to be familiar with GIS. My Director uses the GIS regularly himself, as well as assigning work to subordinates that involves GIS."

"Form a Steering Committee. Keep meetings short and to the point. These are your Champions to the cause and will be needed to make sure staff are using the GIS as expected. If they don't buy-in, their staff won't."

"It is a must to inject GIS into the fabric of an organization. To keep senior managers engaged support from the top down (i.e. CEO, or President) is mandatory."

"It is important to communicate the business need, and the realized gains in efficiency. An often overlooked benefit that should be emphasized is the improvement in data analysis that can be produced. This can assist with high level decision making."

6.3 User Group/User Engagement

Respondents indicated the importance of regular communication with users and identified the following suggestions and themes:

- Holding regular meetings and, for 11 of the respondents, maintaining a formal user group
- A supportive user base critical for overall success of the GIS program
- keep users a part of design and implementation of GIS applications and keep those applications user-friendly with direct benefits for the users
- There is sometimes a problem with support of older workers who have difficulty or resistance to changes
- When there are changes to the GIS database, software, procedures, etc., keep users informed to avoid disruptions or negative reactions
- Support user involvement in GIS conferences, professional events, and professional networking

6.4 Helpdesk/User Technical Support Services

Almost one-fourth of the respondents indicated that there are formal helpdesk systems and procedures in place (sometimes as part of overall IT operations) that allow users to submit questions and requests and to coordinate and track responses. These respondents indicated general satisfaction with these formal systems. Some respondents expressed the need to keep technical support procedures as simple as possible—avoid adding administrative overhead. Several respondents also reported success with user Web-based tools (project Web sites, FAQs, Wiki sites, BLOGs) to provide information and help answer user questions. Also, the need for an efficient and clear process for submitting requests about software problems or functionality to vendors is very important. One respondent mentioned the value of creating an effective "peer-to-peer" environment in which users can communicate and help each other with GIS software and data use—a very insightful observation probably applicable to all organizations.

6.5 Deploying GIS to the Field

The results of the survey show that about three-fourths of the responding organizations have deployed GIS in the field and most of the others are planning to do so. Observations about best practices in developing and deploying field-based GIS applications are summarized as follows:

- Pay attention to and make wise decisions about field-based hardware—looking at cost, screen format, need for ruggedized units (or not), and functionality. Decisions on hardware will directly affect usability and acceptance by field personnel. There may not be a need to buy expensive, ruggedized computers for the field as opposed to commodity devices (notebook and tablet computers) which may be purchased for 25% or less of the cost of ruggedized devices.
- Determine the need for location identification and the device's capability for positioning and its accuracy level (impacted by type of GPS/GNSS receiver and software)
- Involve field users in the design and development of the applications. Make sure field-based applications have simple interfaces and are designed for field use and device type.
- To the extent possible, use off-the-shelf field-based applications with as little customization as necessary
- Conduct a pilot project prior to operational deployment
- Determine the level of need for real-time wireless connectivity with GIS host relative to wireless communication technology and services available in area of operation. Consider allowing for disconnected use without real-time connection.
- When field applications support data capture in the field, it is best not to configure the applications for direct GIS database update. Data should be directed to a temporary location for office-staff check and QA prior to posting to GIS database.

Some specific comments about field deployment are:

“A properly developed mobile GIS application should be dead simple to operate so that the operator requires no specialized GIS knowledge.”

“Local copy of the PUC database are stored on field laptops and tablets. A main pitfall is keeping data current as some are in remote locations and network/internet connectivity is low.”

“Involve your stakeholders early in the process. Get them excited about the technology and let them sell the concept to senior management.”

“Deploying GIS to the field is a very sensitive subject. The organization needs to be very careful of not overloading the field personnel. A well-planned, smooth transition is best.”

“Deployment in field should provide clear benefits and enhancements over traditional paper-based processes such as GPS and camera integration. Develop GIS based processes to facilitate data collection (i.e. inspection) and improve data quality and visibility.”

“We originally deployed “GIS” to field users by publishing distribution system maps as pdf files that could be accessed in the field. One thing we did that helped build user confidence (particularly as the GIS data was still being refined) was to publish each pdf as two pages. The first page was the map published from GIS. The second page was the corresponding “old” map the field crews were used to seeing. That allowed them to easily compare the GIS to their trusted source if they had any doubts. Once we deployed a GIS web viewer the pdfs were theoretically unnecessary. However, we continue to publish the pdfs (it is all automated) because it is a good backup in case the GIS is down.”

“Carry out multiple field trials and support and backup of field staff supervisor. Simple system that is easy to update. Try to do one system for everyone if possible.”

6.6 Web-Based vs. Desktop Software Use

Based on the responses to this question, over 2/3 of the respondents indicated the importance of deploying internal Web-based GIS applications and most of these also expressed the need for both desktop (non-Web) and Web-based applications for internal use. It was recognized by many respondents that current Web-based applications and tools are not sufficient to support all users—particularly those involved in intensive database update and spatial analysis. There were a substantial number of respondents indicating the ease of maintenance and support that comes from a properly configured and well-managed server-based Web GIS environment.

6.7 Database Update/Quality Control

The majority of respondents expressed the importance of setting

up a clear, efficient process for regular database update with the following themes being voiced by multiple respondents:

- Users who are primarily involved in utility operations should have GIS update responsibilities
- Database update should be based on sound and thoroughly documented, database content, format, and quality standards. Clear organizational and personnel responsibilities should be identified
- It is important to make effective use of automated tools for data update and quality control in order to streamline the update and ensure quality data population
- Data update should be a continuous process with efficient workflows for making updates soon after changes occur.
- There should be a formal mechanism for database versioning to store transaction history and to allow the retrieval of database history.
- Metadata should be updated along with GIS database updates

Several comments from users illustrate these key points:

“We have a robust process for capturing new data. Costs are borne by developers but work is conducted by vendors under contract to Authority. Finished survey data are fed directly into GIS ensuring high accuracy.”

“Quality and accuracy are very important to use since engineering drawing are created from the GIS data we capture.”

“We update the utility database daily. Limited number of staff can update and this helps with quality control.”

“Most important function in GIS. Every GIS program should have its number one priority to be the data. Must base this off 3 principles of Position Accuracy, Timeliness Accuracy and Content Accuracy.”

“Use versioning and have assigned personnel responsible for the data accuracy.”

“Use versioning when available. This provides an opportunity to QC data prior to it being distributed or made available to general staff. Having a trained DBA who understands GIS can be beneficial.”

“Provide an easy means of communication between field personnel and data entry personnel for tracking changes to the GIS and databases.”

“Recommend implementing update and QA processes using versioning and replication functionality. Also use QA software to automate review processes.”

“The County has an extensive quality control program for data produced internally and externally. For most of our large-scale data, we have feature level metadata that identifies who and

when the edits were made, what technology used and the type of source material. We also have an application that allows the general users to provide feedback on data issues. Users are highly encouraged to use this mechanism to report issues in the data.”

“Have GPS correction projects to locate and verify location of services. Long term this will provide more accurate data for users. Takes a long time due to large area to cover and having limited resources available.”

“All GIS is based upon data integrity; without data integrity, the GIS will never gain its true respect in the client environment.”

“Changes are automatic within our department. Toughbooks would only receive updated GIS info when I update the Geo-databases. In GIS, we use information regarding the source of quality of the data. For example: As-Built info, GPS data, Issued for Construction, Field update, etc.”

6.8 Application Configuration/Customization

Ideas offered by the respondents about GIS application development best practices are summarized below:

- To the extent possible, use off-the-shelf applications and vendor-provided templates and avoid custom coding
- For Web-based applications, use programming tools (JavaScript, HTML5) that are not platform dependent and can be used in different browser and platforms
- Keep the application interface as simple as possible
- Employ a standard methodology for application design and development that involves users and includes formal testing, usually with a pilot deployment
- Prepare user and technical documentation

6.9 Management Practices

As indicated above (see Figure 4(a)), almost 2/3 of the respondents indicated that their organization has a formally designated “GIS manager” position and over ¼ have established a formal GIS office. In many organizations, there is some type of management, technical, or user coordination body (see Figure 4(d)). Respondents expressed the advantages and disadvantages of different levels of GIS management “centralization” but, for the most part, there was a consensus toward some level of centralization for coordinating applications, data management, and user support. Some important management concerns and suggestions are summarized below:

- High user demand/challenges keeping up
- Keep connection with users and have a process for change management. Keeping up with user demands with limited staff is difficult
- Maintain good documentation of practices and procedures

- Document a long-term strategy for GIS development and operations
- Cross-training GIS technical support staff is very important
- Treat the GIS database as a critical asset
- Funding is always a challenge. Maintaining good support from users and senior management engagement helps.

The following respondent comments on GIS management and coordination practices illustrate these key points:

“Our GIS program needs to improve more on documenting GIS best management practices or documenting standard operations procedures.”

“Right now with GIS technology moving as quickly as it is and our users’ demands being so high we are in a survival mode. We are trying to meet as many needs as possible with too little money and too little staff.”

“Develop a long-term strategy about how your organization will use GIS. Don’t try to hit the ground running without a plan or ultimate goal.”

“Implement change controls. The more that relies on the GIS the greater chance of interruption when GIS is updated or changed.”

“Consider a centralized body to manage your GIS data. This allows more control over standards and workflows.”

“Closer collaboration on business models should lead to better alignment of data collection and maintenance across departments. This requires close communication through some kind of governance structure. Nice to have in the past, is essential for future success.”

6.10 Publicly-Accessible Web Applications/Services

A review of responses indicate that there is a hesitancy in the deployment of publicly accessible Web-based GIS applications. Only about 15% of the respondents were strongly supportive of public Web-based applications with over 60% expressing concerns and reservations about moving too quickly in this direction. These concerns had to do with issues of liability or online security as well as the need for additional software and services to build public Web-based applications. Most of the utility organizations now providing public access (about 8 respondents) concentrate on data or pdf map downloads as part of a municipal or county GIS services. Four respondents indicated interest and active consideration of using cloud-based GIS services for public GIS access.

6.11 Other Ideas and Observations about GIS Best Practices from Survey Respondents

In addition to the survey questions on specific best practice areas, respondents were asked to provide any general ideas or suggestions for effective GIS operations. These responses include:

“Join users groups such as the Esri Water/Wastewater industry group.”

“Asset management and condition monitoring is becoming more widely recognized as a significant need that GIS can support and enhance.”

“Construct a master map template document and work off it every time a new project is created which requires standard map display. Include all your facility data.”

“Lessons learned...The more the GIS is supporting in terms of external systems the more difficult it becomes to change your GIS as its needs grow. Items like schema changes and version upgrades become very difficult because a business system is relying on the GIS. Any change could impact that application.”

“Never stop improving.”

“Develop proof-of-concept and pilot new applications to expose users/stakeholders to capabilities of GIS. Develop data model based on standard industry models. Identify integration requirements including standardization such as asset naming

convention and key data domains. For projection(s) recommend use separate projection for edits versus general user access: use Web Mercator for integration with external data sources including external maps and Google/Bing Maps to avoid on the fly reprojection on devices such as tablets.”

“GIS is a very useful tool but it needs to be shared and utilized. It is important that agencies share their GIS data.”

“Listen to your end users and communicate about GIS in terms of how it can benefit the business. GIS managers should have an advocate(s) in upper management to sponsor projects.”

“The whole field is clearly headed towards free and open-source software. I get all the productivity I need from PostGIS, a free GIS database, than I do from Oracle/Esri-SDE. The free competitor to ArcMap, Quantum GIS, is about as good as the ArcView of 1999, but is improving rapidly. The field needs to be democratized, taken away from the GIS specialists.”

“Put a policy in place that any technology acquisitions must have both a core IT and GIS signoff for RFPs and contracts and acquisition. - Encourage user departments to include GIS staff at early moments in projects and acquisitions. - Encourage user departments to contact the GIS group when they are looking for solutions. GIS staff are often very up to date on software solutions out there.”

“Changing technology requires more individuals who have a programming background with GIS knowledge.”

7. LESSONS FOR GIS DEVELOPMENT AND OPERATIONS IN WATER AND WASTEWATER UTILITY ORGANIZATIONS

While every utility organization is different and any major IT or GIS initiative needs to focus on the organization's business needs and resources, the research conducted for this project provides some important lessons that will help to guide future GIS development and operations for water and wastewater utilities. Key conclusions from this research are summarized below:

- Take advantage of expanded wireless coverage and a wider array of mobile devices and applications to further deploy GIS capabilities in the field—including access to work management systems and field-based data entry/update.
- In support of wider field-based deployment, examine and compare different mobile device types based on cost and functionality. Consider consumer-grade devices when acceptable to avoid costs of ruggedized devices which can be four or more times the cost.
- Look closely at new software offerings from GIS vendors and evaluate adoption and deployment based on the software capabilities to support business needs. Consider the use of other open-source software and Web-based GIS services (including GoogleMaps, GoogleEarth, StreetView, BingMaps, etc.) where these software products and services provide needed capabilities to augment vendor software.
- Expand internal Web-based software and applications for users not requiring desktop software. This server-centric Web-based access approach is easier to administer and usually delivers a reduction in software license costs (compared to adding additional desktop software licenses).
- Explore but move slowly toward deployment of public Web-based GIS applications taking into account the needs of external organizations and the public, security concerns, and the time and cost for maintaining external and public Web-based access.
- Move deliberately to implement IS integration with key external software and databases—primarily infrastructure asset management systems, document management systems, and permit/plan review systems. GIS software and external software packages provide tools and application program interfaces (API) to streamline setting up integration.
- In GIS application development, avoid custom coding to the greatest extent possible. Use off-the-shelf functions and configuration tools in the GIS software to build custom interfaces for specific user groups. For more complex applications, explore and use add-on software packages (from the GIS software vendor or a third-party).
- Assign a single GIS manager and selected staff to oversee the GIS program, communicate with and support users, support GIS integration efforts, and ensure that GIS operations are responsive to the organization's business needs.
- Examine and select an appropriate organizational position for GIS program management. Following the practice in place in most utility organizations, consider placing GIS management inside the organization's information technology department or engineering department. Assign the necessary role and authority to a GIS office so that it can support users throughout the organization and position GIS as one part of an overall information technology program.
- Evaluate current GIS training approaches and make decisions to expand and improve training and professional development activities making best use of time and resources for instructor-led training, computer-based and on-line training, in-house training programs, and greater involvement by users and technical staff in professional associations.
- Put in place improved approaches for responding to user needs and requests for technical help and for examining opportunities for expanded use. This has several elements that include more formal "helpdesk" environment, employee mentoring, peer-to-peer support, and GIS user group activities.

APPENDIX A. GIS SURVEY FORM

This pages that follow show the format of the Web-based survey in which information on GIS status, use and best practices was gathered from water and wastewater utility organizations in the USA and Canada.

Survey--GIS Use in Water and Wastewater Utility Organizations

Page One

CONTACT PETER CROSWELL, pcroswell@croswell-schulte.com, if you have questions

IDENTIFICATION AND ORGANIZATION BACKGROUND INFORMATION

1. Organization/Dept. Name: *

2. Respondent Name(s): *

3. Email address(es):

4. A1. Organization Type: *

- ☐ Municipal/County Dept. ☐ Independent District or Authority
☐ Private Company or Co-op

5. A2. Utility Services: *

- ☐ Water ☐ Sanitary Sewer ☐ Stormwater ☐ Other

6. A3. Service Area (provide a brief description mentioning cities, counties, or region served):

7. A4. Number of Customers

GIS SOFTWARE USE (B1, B2)

8. B1. GIS Software Use

- ☐ Esri ☐ Intergraph ☐ Bentley ☐ AutoDesk
☐ Other

9. B2. Identify specific GIS software packages:

GIS APPLICATION USE:

For questions C1 to C21 below, please indicate the status of your use of GIS applications

10. C1. Standard map update and production

- ☐ Current use ☐ Planned use ☐ No current or planned use

11. C2. Custom map design and production

- ☐ Current use ☐ Planned use ☐ No current or planned use

12. C3. Underground utility location

☐ Current use ☐ Planned use ☐ No current or planned use

13. C4. Field crew GIS access

☐ Current use ☐ Planned use ☐ No current or planned use

14. C5. Field crew redline/data update

☐ Current use ☐ Planned use ☐ No current or planned use

15. C6. Preliminary engineering design

☐ Current use ☐ Planned use ☐ No current or planned use

16. C7. Detailed engineering design

☐ Current use ☐ Planned use ☐ No current or planned use

17. C8. Asset inventory/condition monitoring

☐ Current use ☐ Planned use ☐ No current or planned use

18. C9. Construction plan review

☐ Current use ☐ Planned use ☐ No current or planned use

19. C10. permit review and tracking

☐ Current use ☐ Planned use ☐ No current or planned use

20. C11. Work order issuance and field support

☐ Current use ☐ Planned use ☐ No current or planned use

21. C12. Project tracking

☐ Current use ☐ Planned use ☐ No current or planned use

22. C13. Asset tracking and reporting

☐ Current use ☐ Planned use ☐ No current or planned use

23. C14. Financial/regulatory compliance/reporting

☐ Current use ☐ Planned use ☐ No current or planned use

24. C15. Call/complaint response and tracking

☐ Current use ☐ Planned use ☐ No current or planned use

25. C16. Network tracking (e.g., services impacted by shutoff)

☐ Current use ☐ Planned use ☐ No current or planned use

26. C17. Hydraulic modeling

☐ Current use ☐ Planned use ☐ No current or planned use

27. C18. Capital project planning and budgeting

☐ Current use ☐ Planned use ☐ No current or planned use

28. C19. Drainage, runoff analysis

☐ Current use ☐ Planned use ☐ No current or planned use

29. C20. Customer alerts and notification

☐ Current use ☐ Planned use ☐ No current or planned use

30. C21. Special engineering or planning projects

☐ Current use ☐ Planned use ☐ No current or planned use

31. C22. Please provide more comments about current or planned applications:

GIS INTEGRATION WITH EXTERNAL SYSTEMS, SOFTWARE, AND DATABASES:

For questions D1 to D13, indicate the status integration between GIS and external systems

32. D1. Asset/work management system

☐ Current use ☐ Planned use ☐ No current or planned use

33. D2. Document management system

☐ Current use ☐ Planned use ☐ No current or planned use

34. D3. Hydraulic modeling-sewer

☐ Current use ☐ Planned use ☐ No current or planned use

35. D5. Hydraulic modeling-water

☐ Current use ☐ Planned use ☐ No current or planned use

36. D5. Televised inspection equipment/data

☐ Current use ☐ Planned use ☐ No current or planned use

37. D6. Customer account billing/management system(s)

☐ Current use ☐ Planned use ☐ No current or planned use

38. D7. Automated call/complaint management

☐ Current use ☐ Planned use ☐ No current or planned use

39. D8. Runoff/drainage modeling/analysis systems

☐ Current use ☐ Planned use ☐ No current or planned use

40. D9. Dispatch/AVL system(s)

☐ Current use ☐ Planned use ☐ No current or planned use

41. D10. Computer aided design (CAD)

☐ Current use ☐ Planned use ☐ No current or planned use

42. D11. Plan/Permit review and tracking system

☐ Current use ☐ Planned use ☐ No current or planned use

43. D12. Customer notification/alert system

☐ Current use ☐ Planned use ☐ No current or planned use

44. D13. External Web service

☐ Current use ☐ Planned use ☐ No current or planned use

45. D14. Other system/database integration with GIS:

GIS ORGANIZATIONAL STRUCTURE AND MANAGEMENT QUESTIONS (E1 to E5)

46. E1. Does the organization have a GIS office and/or an assigned GIS manager?

☐ GIS manager ☐ GIS office ☐ Neither

47. E2. Where in the organization does GIS management reside?

☐ Separate GIS Dept. ☐ Information Technology Dept. ☐ Engineering Dept.

☐ Other:

48. E3. Does the GIS program operate in coordination with or under the management of a GIS program in a parent organization (e.g., Citywide GIS office)?

☐ Yes ☐ No

49. E4. Does the organization have in place any committees, formal body, or user group to support GIS coordination and operations?

☐ Yes ☐ No

50. E5. Please provide more information about committees, coordination bodies, or user groups:

LESSONS LEARNED/BEST PRACTICES

In questions F1 to F13, please provide comments about your experiences in GIS implementation, lessons learned, suggestions about pitfalls or optimal approaches, etc. Provide suggestions useful for other utility organizations implementing a new GIS or enhancing current GIS capabilities.

51. F1. User/tech staff training and professional development

52. F2. Keeping senior management engaged

53. F3. User group/user engagement

54. F4. Helpdesk/User/tech support services

55. F5. Deploying GIS to the field

56. F6. Web-based vs desktop software use

57. F7. Database update/quality control

58. F8. Application configuration/customization

59. F9. Management practices

60. F10. Coordination or technical committee operations

61. F11. Integration with external systems or databases

62. F12. Publicly-accessible Web applications/services

63. F13. Status monitoring/reporting

64. F14: Provide other ideas and observations about GIS best practices or lessons learned:

65. If applicable, provide a Website URL to access information about your GIS program:

66. Provide any additional comments about GIS use or best practices:

APPENDIX B. SURVEY OF GIS PRACTICES-LIST OF RESPONDING ORGANIZATIONS

American Water / Enterprise GIS Department (Operations in 16 states)	City of London (ON) Environmental and Engineering Services
Aqua America, Inc. (HQ in PA and operations in 10 states)	Lakehaven (WA) Utility District
Avon (CT) Water Company	Loudoun Water (VA)
Anchorage (AK) Water & Wastewater	City of Medicine Hat (ON) Environmental Utilities Dept. (Water & Sewer)
Baltimore County (MD) Department of Public Works	Mid-South Synergy (TX)
City of Barrie ON) - IT Department	Village of Mundelein (IL)
City of Bloomington (IN) Utilities	City of Nanaimo (BC) Department of Engineering & Public Works
City of Boulder (CO) Utilities	Madison Water Utility (WI)
City of Brandon (MB) Engineering	Mohawk Valley Water Authority (NY)
County of Brant ON)	Village of Mount Prospect (IL) Public Works Department
The City of Calgary (AB) Water Resources Asset Management	Niagara Region Water/Wastewater (ON)
California Water Service Company (HQ in CA with operations in 4 states)	Orange County (CA) Sanitation District Information Technology
Chatham-Kent (ON) Public Utilities Commission	City of Ottawa (ON)
Charleston (WV) Water System - GIS	Village of Orland Park (IL) Public Works Department
Cobb County (GA) Water System	Peachtree City (GA) Water and Sewerage Authority
City of Cranbrook (BC) Engineering Department	Region of Peel (ON) Public Works Department
Denver (CO) Water Engineering Division	City of Rockford (IL) Engineering Division
Region of Durham (ON)	City of St Albert (AB) – Information Technology
City of Duluth (MN)	Santa Clara Valley (CA) Water District
Easton(PA) Suburban Water Authority	San Gabriel Valley Water Company (CA)
EPCOR Water (USA), Inc (operations in AZ and NM)	San Jose/Santa Clara (CA) Regional Wastewater Facility
Erie (PA) Water Works	Shakopee (MN) Public Utilities Commission
City of Evanston (IL) Utilities Department	Shorelands Water Co (NJ)
Fairfax County (VA) Wastewater Management	Town of Stony Plain (AB) - Corporate Services
Fairfax (VA) Water / Planning and Engineering	City of Tuscaloosa (AL) Water
City of Fargo (ND) IS Department	United Water (HQ in NJ with operations in 21 states)
Region of Halton (ON)	United Water Idaho Division Operations
The City of Hamilton (ON) Public Works Department	City of Vancouver (BC)
City of Hayden (ID) Public Works Department	Valencia Water Company (CA)
City of Kenora (ON)	City of Waterloo (ON) Integrated Planning and Public Works
City of Lauderhill (FL) Dept. of Environmental & Engineering Services	City of Windsor (ON) Geomatics Division