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Abstract

The live without water is too difficult; water is one of the most important sources in the live, today with high development in technologies find out proper methods to conserve the water. One of those methods is GIS technology; this paper will discuss the relation between water industry and GIS technology. The discussion will show how GIS improve this type of industry around the world and how it manage the system perfectly with two reinforcement of case studies explain how the system reducing the cost, saving time, conserves the environment and improve customer services, such subject need hundreds of pages to cover totally.

Introduction

Industry it is not refer only to the factories sectors, it is also refers to producing services or materials, any specific type of service production could be called industry such as hospitality industry, culture industry and water industry. The water industry defined as all services and activities to producing, supplying, managing and all related work to water under or above the ground. Water industry consist of water (natural water, drinking water), west water, storm water and underground water, this type of industry need a huge effort to constructed and managed especially underground utilities. Underground utilities need updated data and as built drawings to get accurate information to managing the work within high production, short time and low cost "time is money". Thirty years ago, water industry did not have enough advance technology for new construction ,up grading net work or maintenance activities, numbers of pepper maps should be archived and need regular up dated for future plan. For example, suppose an agency which is responsible for maintenance in a city gets a call from customer X in 9:00 am, there is no water supplied to his house, the scenario will start by writing work order and submit it to the maintenance engineer, then he will start to find related drawings customer area for valves, manholes, pipes size and maintenance history. On the other hand all related drawing must be updated or as built drawings. Just, if we start to calculate time needed to this part of the work may exceeds 30 minutes, before the engineer reach the site for inspection. Same scenario will be done on other type of industries (wastewater, storm water,). Using advanced systems to follow up and control such type of data and information, will make the work moving smoothly with low cost, high quality, less time, more productivity and customer satisfaction. Most of water utilities agencies are start using GIS technologies in their work systems, GIS can be defined in more than one form, GIS is a special type of information system in which the data source is a database of spatially distributed features and procedures to collect, store, retrieve, analyze, and display geographic data (Shamsi, 2005). The user can add and edit required data as needed, the data in system added in layers, for example, the map contain network layers (water, storm water, and wastewater), type of soil layer, streets names layer and any related information. All data and features are stored in an attribute tables. All those will be explained through the report. GIS is a beneficial technology for water industry, in construction , planning, controlling ,engineering, mapping, maintenance, improving quality ,productivity, workability and management, all maintained cannot be covered in report in details. But we will explain and discuss about mapping, modeling, monitoring and maintenance.

Objective

The objective of this term paper to give the redder an idea about the benefits of using GIS technology in water industry, the report will contain history of GIS technology in water industry, mapping, type of models used with the system.

Limitations

- GIS technology is new since for me.
- I still learning about the GIS technology.
- Most of published papers are not accessible.
- Most of my experience as civil engineer in building.
- Most of sources start the subject with real country example as case studies.

History of GIS in Water Industry

The GIS Technology start in using in the 1960 as digital layering system, and updated up to today, but it involved in the water industry 20 years later. The system still new and it needs more experience and data, from 1990 to 1994, work-orders, operations and management plans, and models are developed when the paper maps converted to digital maps. In remaining years of nineties the GIS technology spread out, drinking water studies, investigation process about corrosion and chlorination, studies for network expansions and effect of water on human health usually done by using GIS technology . In the new century, the uses of the system have grown and the number increased sharply. According to the American Water Works Association (AWWA), approximately 90% of the water utilities in the U.S. were using GIS technology by the end of the year 2000(Shamsi, 2005). Now there are a number of GIS software companies improving and supporting the software and arranging conference and trying courses. The Environmental System Research Institute ((ESRI)) is one of the famous companies working on top of this technology and also it has a homepage in their web site for water and storm water applications.

GPS in Water Industry

GPS is the system use to determined the geographic coordinates position by receiving satellites (four satellites) signals that orbiting around the earth, the accuracy of GPS usually depending on the type of the instrument and if there are any restriction of signals (mountains, tree or buildings). The accuracy of GPS coordinates can be increased by applying differential corrections. Differential corrections move user points closer to their “actual” location. This is done by comparing the user’s new data on unknown locations with the data collected at the same time on a point with known coordinate values. The GPS receivers that can receive and apply the corrections in real time are called real time kinematic (RTK) receivers. Non-RTK receivers require post processing of raw GPS data in the office (Shamsi, 2005).

GPS application in for water industry:

1. Creating maps for new system and updating the existing maps.
2. Used to increase the accuracy of the system during the inspections or construction activities and also grantee the interface points for long pipe lines.
3. Used to gathering data for system attributes.

GIS Mapping

Mapping is one of the beginning processes to prepare database for GIS technology, and there are many types of maps that can be installed by many ways, for example, digital orthophoto (*scanning of aerial photos*), planimetric maps (*scanning of aerial photos and digitizing features from this photos*), scanned maps…etc. GIS maps divided into two categories vector (any objects represent on the map as point, line or polygon such as main pipe or odometers) and raster (regular grid images). By using a certain rules and specific models the map could be changed from curved surface to flat drawing, then the user can find out the coordinate system to measure vertical and horizontal distances. Low quality for data usually leading to wrong results and inaccurate GIS maps. The accuracy of the base map depending on the uses of GIS map, for example in engineering department they need high accuracy than location of building or mountains for cut and fill.

Figure 1. A water distribution system overlayed on a digital orthophoto base map.
Source: GIS Applications for Water, Wastewater, and Storm water Systems, Shamsi, 2005.

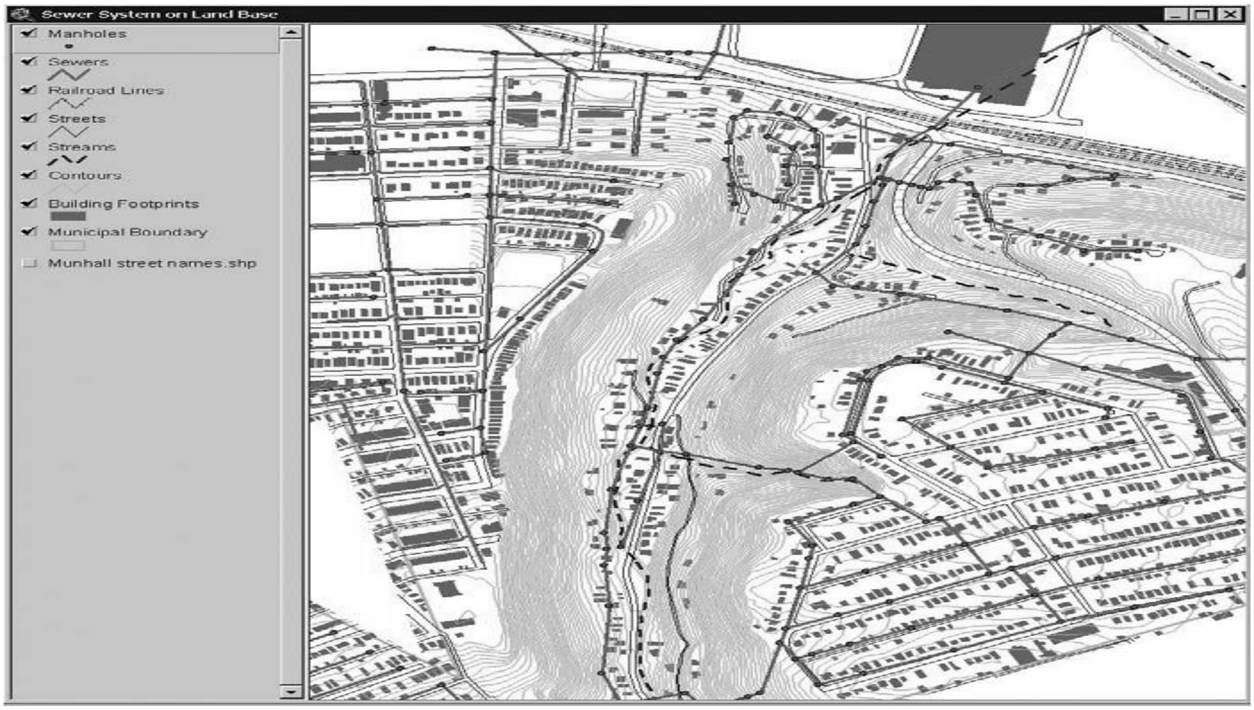

Figure 2. A sewer system overlayed on a planimetric base map.

Source: *GIS Applications for Water, Wastewater, and Storm water Systems, Shamsi, 2005.*

Figure 3. Data conversion using scanning.
***Source**: GIS Applications for Water, Wastewater, and Storm water Systems, Shamsi, 2005.*

GIS Monitoring

Managing any water system underground cannot be done without monitoring data and information, so the user need to monitor hydraulic characterizations data (monitoring velocity, flow rate, volume, bacteria) and physical characterizations data (pipes, manholes, valve condition).Monitoring is very important in expansion plan, water types investigations, collecting data for new studies and so on, in some new project monitoring data may cost around 25% of the total cost. On the other hand, GIS companied with remote sensing to collecting data in images that allow for the studies and investigation, for example for underground water. Usually used to determine the quality of water and the direction flow as shown in figure 4. And figure 5.

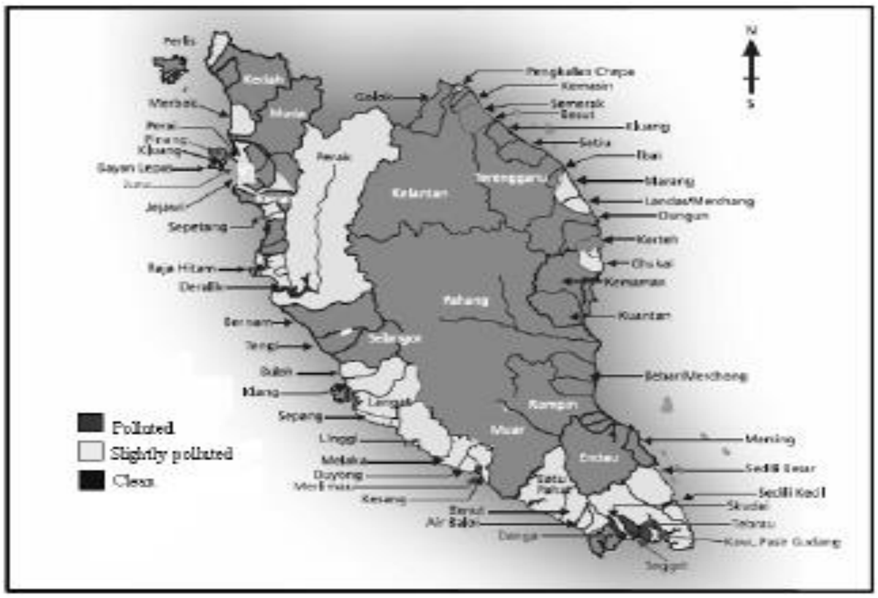

Figure 4. Categorization of water underground
Source: *Use of Remote Sensing and GIS in Monitoring Water Quality, Vol. 3, No. 3September 2010*

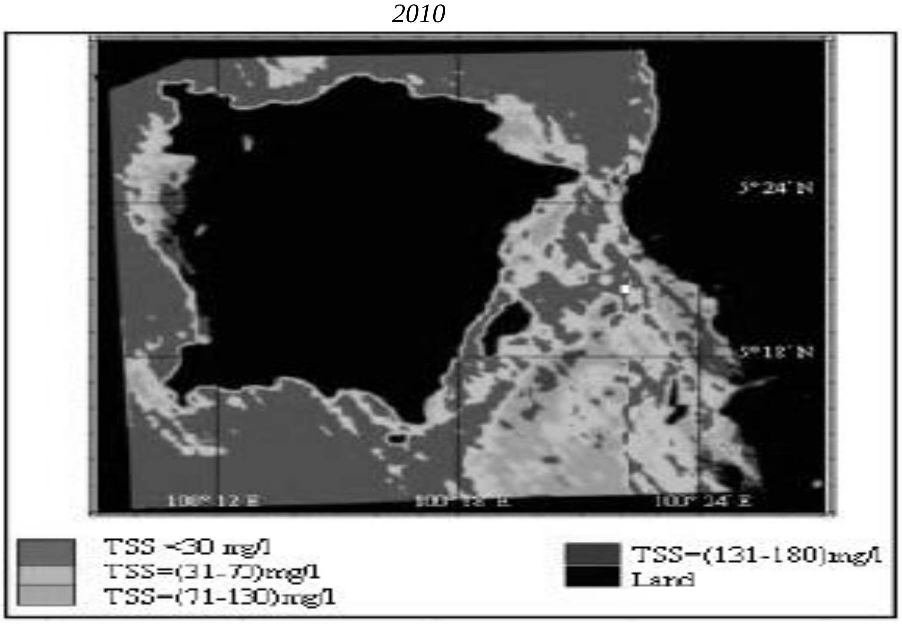

Figure 5. categorization of suspended participant in underground water
Source: *Use of Remote Sensing and GIS in Monitoring Water Quality, Vol. 3, No. 3; September 2010*

Modeling application in water industry

In water industry GIS technology is not working alone usually need to models to support the system for managing and controlling the work, GIS and moles can provide to the user more than one result and scenario for alternatives solution which leading to save time and cost. Models are structural of mathematical steeps software used to calculate specific results by input data. Models in GIS are useful for calculating pipe flow or need demands, this data is supporting the management to take action and make decisions. The most requirement are a suitable model and model input data, a complex model need a huge number of data, on the other hand a simple model not need to that much quantities of data. But the will influence the type of result, more data usually leading to accurate output. Also the cost of model and quantity of data is very important. There two types of hydrologic models:

Lumped parameter models lump the input parameters of a study area over polygons and use vector GIS applications. (Shamsi, 2005)

Distributed models distribute the input parameters of a study area over grid cells and use raster GIS applications. (Shamsi, 2005)

Now with advanced technology and software, GIS technology can be joined to other programs as resource such as CAD or Microsoft programs to facilitate the work. On other hand there are three methods to link GIS technology with model (Shamsi, 2005), see figure 6.

- Interchange method
- Interface method
- Integration method

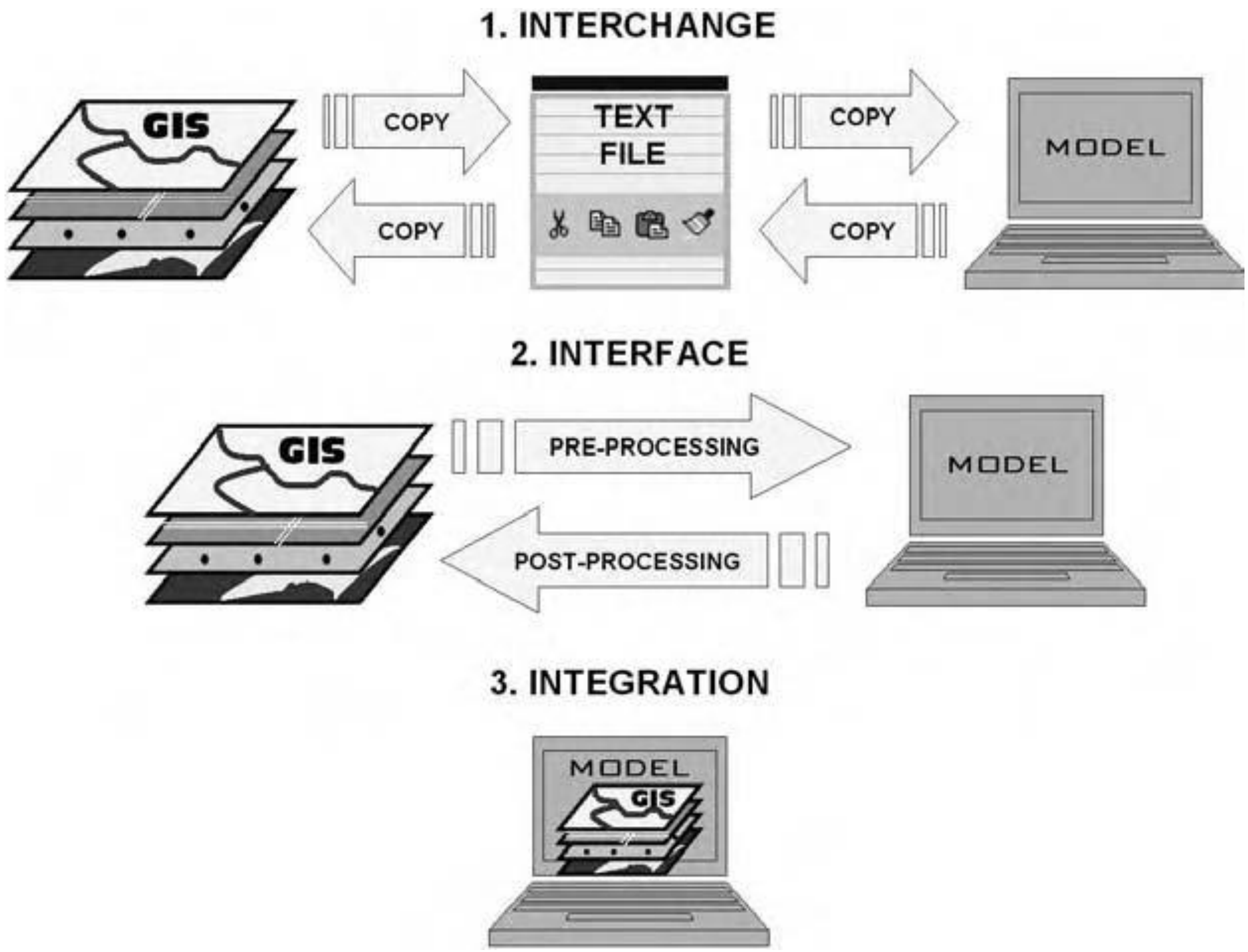

Figure 6: transferring data diagram
Source*: GIS Applications for Water, Wastewater, and Storm water Systems, Shamsi, 2005.*

Interchange methods

- No direct link between GIS and the model.
- Using separate input files.
- Using manual copying method.
- Input data copied manually from GIS.
- Output data copied manually to the model.
- Maps exposed in GIS as new spatial methods
- Vector and raster provides interchange options.

Interface Methods

There two important activities should be defined (Shamsi, 2005):

A preprocessor that analyzes and exports the GIS data to create model input files.

A postprocessor that imports the model output and displays it as a GIS theme

- Information changed directly from GIS to model automatically.
- Using GIS software's scripting language
- The input file created in GIS.

Integration Methods

In this method both GIS and model are companied together in one program that eliminate the gap and close out the relationship between them and only tow integration scenario allowed:

- GIS-based integration.
  - ✓ All activities (input, edit, running and output) for the model should be companied with GIS software.
  - ✓ No need to exit GIS to run the model or edit data.
  - ✓ Limited modeling power.
  - ✓ It is more public.
  - ✓ Need special program (SWMM,EPANET)
- Model-based integration
  - ✓ All activities of GIS done on software model.
  - ✓ Limited GIS functionality.
  - ✓ GIS used as mapping tools.
  - ✓ Difficult to visualize data.
  - ✓ Need special programs (FORTRAN, AML)

Case study (1): Economical Aspect of Using GIS Technology.

Of course using GIS technology made high change in water industry to the best; this improvement cannot be explained in one case study or examples. This case study will explain to the readers how the agency can start the system and showing all needs and requirements, moreover there is an example reflecting the benefits of the system in all management issues and specially in saving time and money. Elapse is a city located in Texas; in the southern region of U.S close to Mexico boundary and It contain 800,000 citizens in 2010 (Wikipedia). ELPaso Water Utility (EPWU) likes to find out a good GIS solution for the city, so it needs to have EPWU Enterprise GIS, ArcGIS, and EPWU GIS Viewer. All steeps will summarize in a diagram as shown in figure 7.

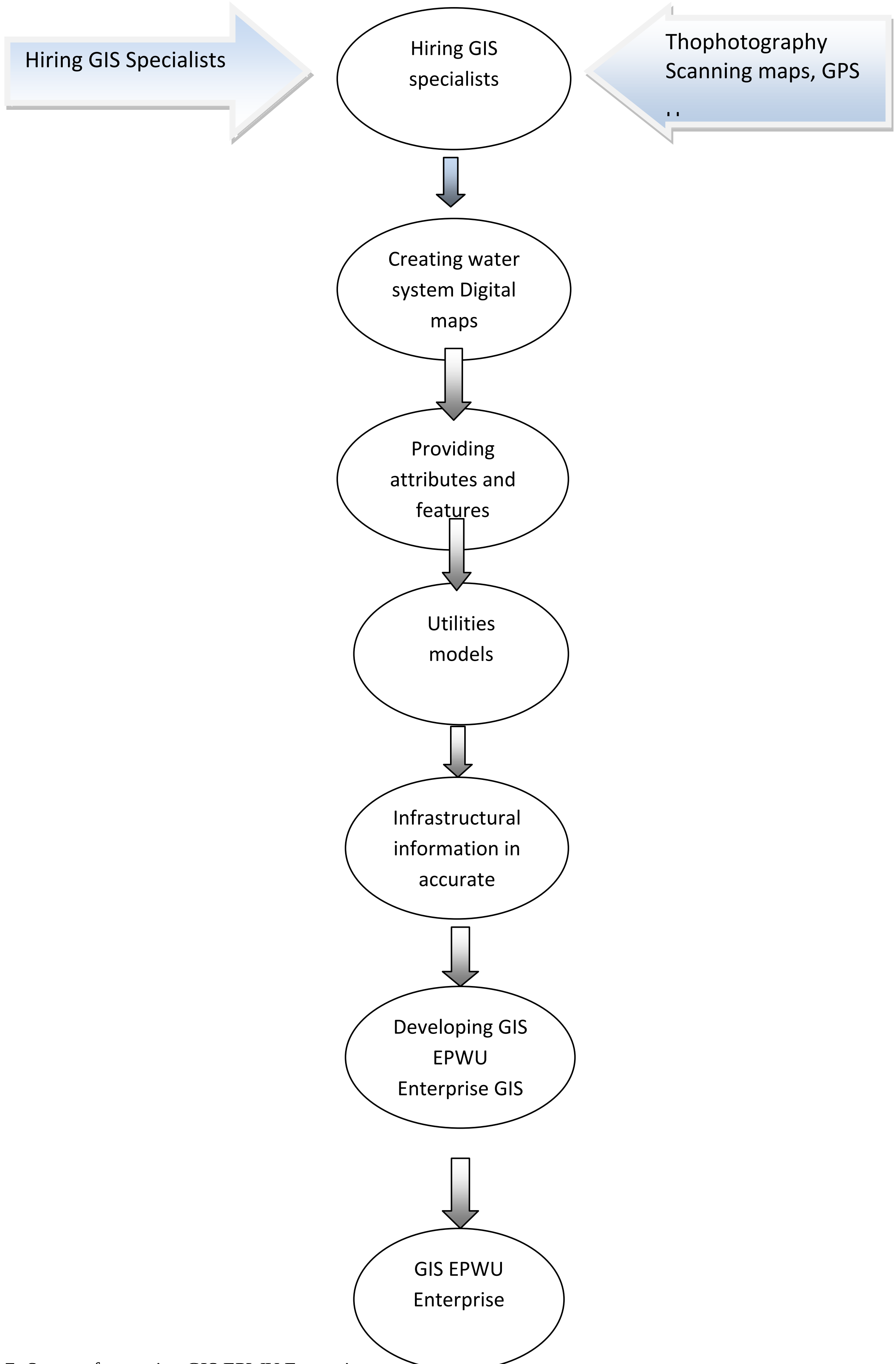

Figure 7: Steeps of preparing GIS EPWU Enterprise

EPWU GIS Viewer to view infrastructural information and open a chance to non GIS users to view, quairy, and print the updated map data without any running, so no needs for more paper maps or searching for as built drawing in the archives and it can be found on any laptop or advanced technology Mobil, see figure 8 and figure 9.

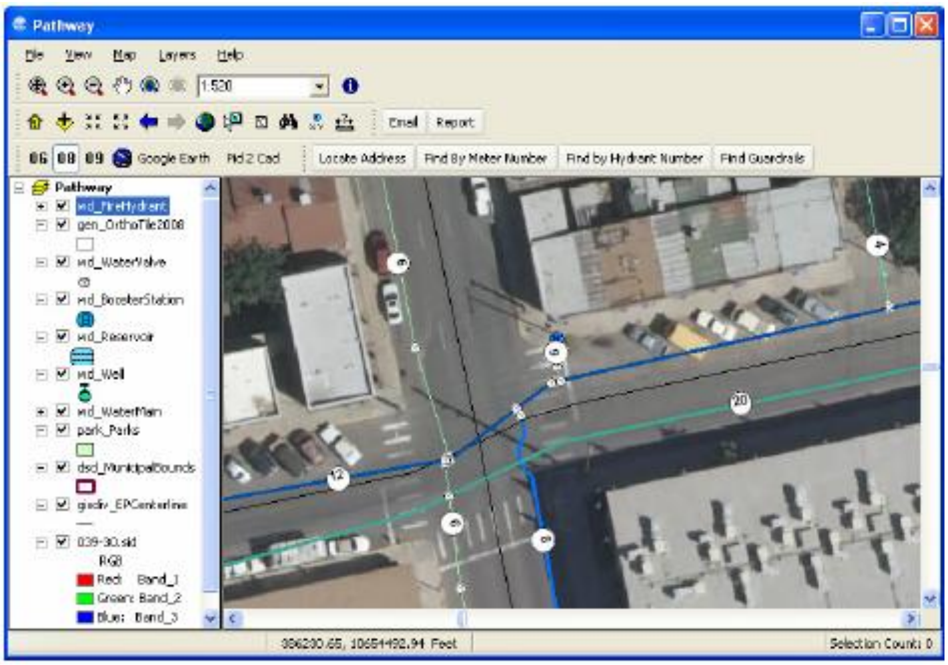

Figure 8. Close-Up Snapshot of the Water Distribution Infrastructure Using El Paso Water Utilities' GIS Viewer Application.
Source*: Water Resource Impact, Vol12, No1, p6*

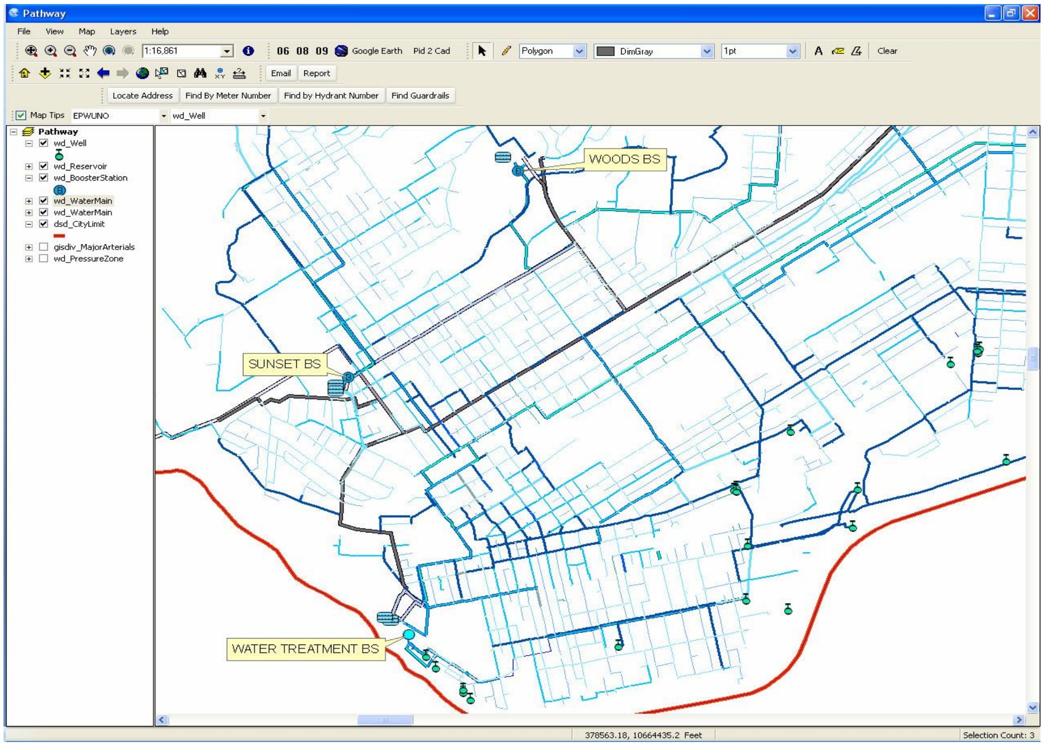

Figure 9. Extended View of the Water Distribution Infrastructure Using El Paso Water Utilities' Viewer Application.
Source: *Water Resource Impact, Vol12, No1, p6.*

On the other hand, table1 shows how the cost and time of manpower reduced after using the EPWU's GIS Viewer, for example to find intersection image in one use per day by using manual methods it take 548 seconds, but by using GIS Viewer it take 8 seconds $(((8 - 548) \div 548) \cong 98.5)$ the total saving per year is $567.

Mapping Operation	One Use Per Day	Manual Method in Seconds	GIS Viewer in Seconds	Time Savings Per Use (seconds)	Total Savings Per Use* ($15/hour)	Total Savings Per Use Per Year**
Find Street	1	180	13	167	$0.70	$175.35
Find Hydrant	1	188	9	179	$0.75	$187.95
Find Water Meter	1	258	9	249	$1.04	$261.45
Find Pressure Regulator	1	241	13	228	$0.95	$239.40
Find Intersect	1	248	13	235	$0.98	$246.75
Find Manhole	1	224	24	200	$0.83	$210.00
Find Liftstation	1	195	20	175	$0.73	$183.75
Find Well	1	211	20	191	$0.80	$200.55
Import Ortho	1	n/a	5	n/a	n/a	n/a
Identify	1	n/a	2	n/a	n/a	n/a
Measure	1	375	6	369	$1.54	$387.45
Water Genmaps	1	210	7	203	$0.85	$213.15
Sewer Genmaps	1	210	7	203	$0.85	$213.15
Intersection Images	1	548	8	540	$2.25	$567.00
Plan Profile Images	1	548	12	536	$2.23	$562.80
Total Savings for Utility Service Field Worker @ $15.00 Per Hour Wage						**$3,648.75**
60 Users at $15.00 Per Hour Wage						**$218,925.00**

*Total Savings Per Use ($15/hr = (Time Savings seconds/3600 seconds) * $15 per hour.
**Total Savings Per Use per Year = Total Savings per Use * 252 work days.

Table1. Illustrates Cost Savings Based on Manual Efforts to Retrieve Information vs. Using the EPWU's GIS Viewer.
Source*: Water Resource Impact, Vol12, No1, p7*

.In 2007 EPWU was responsible for storm water system operation and maintenance, with available information they started to identifying the infrastructural assets and deterring the assets layers needed in GIS, but since the underground system was too complicated, a lot of mapping work and gathering date finished to get accurate information for sotrmwater assets. High advanced system support EPWU make the management under control, pipes and channels can be cleaned and visualized by video. With a huge data collected and stored converted the system from old methods to high advanced system, more over the other department such as engineering department can make a plans and estimating for future demands depending on GIS population models, also accountant department can use the system for fees impacts. EPWU can make studies about an old underground pipe for improvement in futures.

Case study (2): Corporate GIS at Yorkshire water

Yorkshire water is a private company in Bradford, UK, it serve around 4.5 million domestic customer and150, 000 industrial customers. It is in charge for collection, treatment distribution and disposal of clean and wastewater, and managing over 60,000 km of mine pipe and sewers, 50 water treatment plant and more than 600 west water works, it fully responsible about management and operation. The company using 3500 PC's and laptop and 600 mobile Tough Book. This case study will reflect how GIS improve customer services, work delivery, management and environmental management.

The service system in the company consists of GIS, Customer Relationship Management (CRM) and work management system to form the Integrated Customers Operations Management system (ICOM). One call received about discoloration of water and directly displayed on the central control room GIS, on the other side, the in charged engineer visualize the case on the GIS in real time. The work order in progress for investigation, a concentric cercal exposed on screen as mush number of calls received. In the site, inspector or maintenance engineer using his 'Tough Book' to visualize all related information (construction details, maintenance history, age, pipe size etc.),when the problem is identified, the maintenance engineer contact the control room and explain the source of the problem and updating the history record. Now the CRM knowing all details about the problem and they can answer the customer about the proposed time to fix this problem, on the other hand, the action is taken to solve the discoloration water. From previous example, using GIS technology allow the company to have quick feedback in minimal time about the fault and increase their customer trust with good customer satisfaction.

For environmental uses of GIS at Yorkshire Water, the most enemy of sewer pipes system are roots trees which causing ether blockages or failure of the pipe. If any accident accurse it may cost up to around £15,000, but this mount may increased sharply if there is any water source around. GIS can identify the risky area of pipe, woodland and closest water polygon and keeping them under focusing as risky area. For more details, the investigation may use a CCTV 'mole' then starting engineering work to fix any leaking. Leaking in sewer system it has many effect on surrounded area such as underground water, wells, farms, foundations and tunnels, from previous, GIS can be considered as conservation tools.

Conclusion

Dissection

During the details in the report I think this technology makes a lot of change in the system of water industry, year of 1995 it will not be same as 2015 with such progress in technology. The infrastructure construction before need huge time and effort to determine the exact location for pipes, manholes and valve. Also for long pipe construction some time there is a severance in interface point. On the other hand, GIS can be save time and money by using remote sensing to control water contamination underground, and how solution determined before problems happened, this also may gives advance signals healthy issues .in maintenance, I think such system if it is fully workable, water company will get the customer and client satisfaction, with high quick accurate results of work.

The GIS improve the water industry, but usually there are strength and weaknesses in any technologies, so in the end of the repot I would like strength and weakness or limitations.

Strengthens:

- ✓ Increasing work productivities.
- ✓ Saving time and money.
- ✓ Improve the customer's satisfaction.
- ✓ Environmental conservation tool(monitoring water contamination in the pipes and underground water)

Weakness and Limitations

- Difficult to collecting data.
- Too expensive.
- Need specialist in GIS technology and modeling.

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GIS Technology for Water and wastewater, and Storm Water Utilities
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King Fahad University of petroleum and Minerals

Geographic Information system

Using GIS Technology in Water Industry

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