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Phase II Final Project Report Paso del Norte Watershed Council Coordinated Water Resources Database and GIS Project

New Mexico Water Resources Research Institute
Technical Completion Report No. 341

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Texas Agriculture Experiment Station
Texas A&M University

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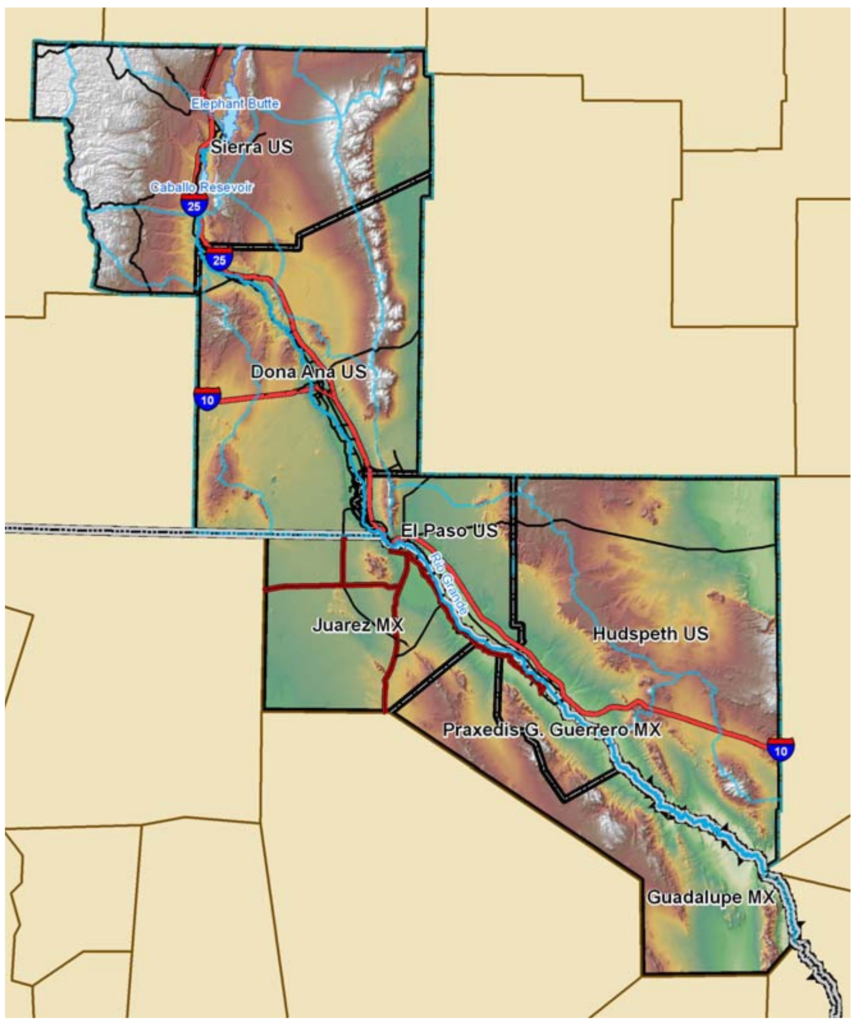

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Phase II Final Project Report
Paso del Norte Watershed Council
Coordinated Water Resources Database and GIS Project

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http://www.pdnwatershed.org

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Abstract

The Coordinated Water Resources Database and GIS Project (Project) was developed to provide improved access to regional water resources data in the Paso del Norte region for regional water stakeholders to make timely decisions in water operations and flood control. Tasks accomplished in Phase II include the complete migration of the Project Website and related databases to the ArcIMS software, which provides a better spatial query capacity. The database was enhanced by incorporating more gauge stations, limited groundwater data (well information, water levels, water quality, and pumpage) and other new data, and strengthened data sharing by implementing FGDC classic metadata. Protocols were explored for data sharing and spatial queries and opportunities for more active participation of volunteer regional data providers in the Project. The linkage of the PdNWC database with future groundwater and surface water model development was also assessed. Based on the experiences gained in the Project, the following recommendations for future Project work include:

- Continued compilation of new data sources not yet included in the Project to enhance data sharing,
- Installation of additional new monitoring stations and equipment and inclusion of these monitoring sites in future ArcIMS map products to fill data gaps and provide additional real-time data,
- Strengthening the links with the Upper Rio Grande Water Operations Model (URGWOM) being advanced by the USACE. Special focus will be given to serving DEM and orthophoto data recently transferred from the USACE to NMWRRI and enhancing direct Web linkages with USACE and URGWOM project activities to improve model development capacity and enhance sharing of modeling results,
- Development and implementation of a user needs survey focusing on new data sets of interest, enhanced access mechanisms, and other suggestions to improve the Project Website,
- Development and making available online for download a Microsoft Access database of Project water resource data to provide search and query functions,
- Development of an online help tutorial that would support online searches of the database, making the site easier for end users to navigate and utilize, and
- Continuity in the exploration of future funding opportunities for Project activities, especially through linkages with other regional data compilation and modeling projects.

Part I of this report presents major historical and technical components of the Phase II development of the Database and GIS prepared by C. Brown, Z. Sheng, and M. Bourdon. Groundwater elements of interest, relevant to the development of the coordinated database and to the integral comprehension of the watershed’s mission and planning are also included as Part II of this report. This part, prepared by Z. Sheng and others, presents the sources of regional groundwater resources data compiled by different federal and state entities and outlines suggestions for regional groundwater data to be implemented with an ArcIMS interface so that this data can be shared and accessed by all Paso del Norte Watershed Council stakeholders. Part III, prepared by R. Srinivasan, presents the technical challenges posed to data sharing by multiple data collectors and sources and summarizes the different protocols available for an

effective transfer and sharing of data through a GIS ArcIMS interface. Part IV, prepared by Z. Sheng and D. Zhang, explores the possibility to link the Database Project to a comprehensive development of regional hydrological models within the Rio Grande reach between Elephant Butte Dam, in New Mexico, and Fort Quitman, Texas. Finally, Part V, prepared by C. Brown, Z. Sheng, and M. Bourdon, presents closing comments as well as a summary of the recommendations made throughout the document. Dr. Hanks provided assistance in summarizing preliminary user survey results.

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PART I

Historical and Technical Components of the Coordinated Water Resources Database and GIS Project-Phase II Paso del Norte Watershed Council

C. Brown, Z. Sheng, and M. Bourdon

Introduction

The Rio Grande is the only major source of renewable water in the Paso del Norte region within which Las Cruces, New Mexico; El Paso, Texas; and Ciudad Juárez, Chihuahua, Mexico, lie. To assist water resource managers and researchers, Project staff developed a prototype system for compiling data on river flow and water quality and made data available via Web-based query tools in Phase I of the Project. Several organizations have either responsibilities or research interests concerning the monitoring, use, and management of the river, and the goal of the Phase I work was to provide better access to data compiled and served by these agencies and institutions. These organizations include the U.S. Section of the International Boundary and Water Commission (USIBWC), the U.S. Bureau of Reclamation (USBR), the U.S. Geological Survey (USGS), Elephant Butte Irrigation District (EBID), El Paso County Water Improvement District #1 (EPCWID #1), the El Paso Water Utilities (EPWU), City of Las Cruces (CLC) Water Utilities, The University of Texas at El Paso (UTEP), Texas A&M University/Agricultural Research and Extension Center at El Paso (TAMU/TAES), New Mexico State University (NMSU), New Mexico Water Resources Research Institute (NMWRRI), La Universidad

Autónoma de Ciudad Juárez (UACJ), regional health departments, and other water resource management organizations. Many of these entities monitor or gather other data on the river, canals, and drains so that they can effectively meet the responsibilities of providing accurate assessment of regional water resources to water data users, water resources managers, and municipality planners. In some cases, this information is gathered using near real-time technology, with each organization compiling and using the information it collects solely for achieving its mission. Limited sharing of data does occur in the region, but this transfer and exchange of data is on an ***ad hoc*** basis that frequently lacks coordination. This absence of real-time data sharing and related coordination frequently leads to unnecessary duplication of effort and inefficient use of agency and institutional resources. For example, several sites within the study area see the exact same parameter (e.g., flow) being measured by three different entities.

In the past, data collection and compilation of water quantity and quality data lacked coordination or a single point of contact that served the region. Accordingly, it is very difficult to coordinate data collection and compilation to assess water movement through the Paso del Norte region, from Elephant Butte Reservoir through Southern New Mexico and into El Paso and Hudspeth counties in Texas. This problem is particularly acute during storm events when floodwaters enter the river below Caballo Dam. During these flash flood episodes, the USBR and USIBWC are often faced with reacting to cresting of flood control levees and related spills. The present method of dealing with flood surges involves reaction to these flood flows based on historical evidence. Enhanced collection and coordination of data sharing on the Rio Grande during these events would allow for enhanced preventive actions at diversion dams and spillways to insure containment of floodwaters.

The monitoring and management of year-round flows in the Rio Grande, which served as the basis to propose changes in the operation of the Rio Grande Project (RGP), would pose special data access issues. The El Paso-Las Cruces Regional Sustainable Water Project, the focus of collaborative efforts of the New Mexico-Texas Water Commission (NMTXWC), considered year-round releases of some of the water stored in Elephant Butte and Caballo reservoirs. Since the completion of Elephant Butte Dam in 1916, very little water has been released to the river during the non-irrigation season – typically from November to March. Consequently, delivering water from Caballo Dam to El Paso for use in the City of El Paso's water treatment facilities or any other proposed surface water treatment facilities in the region during the non-irrigation season will require close monitoring of flows to ensure that proper amounts of water with appropriate quality are delivered at the prescribed times.

Real-time, continuous monitoring of water quality parameters will also be useful for both agricultural and municipal planning and for general watershed management activities. However, a comprehensive and coordinated dataset of flow and conductivity data along the Rio Grande is not currently available. This makes it impossible to predict accurately the flow regimes along gaining/losing stretches of the river as water travels more than 100 miles from Caballo Dam to El Paso. It also prevents tracking changes in salinity prior to, during, and after a reservoir release or a storm event. An up-to-date system of water flow and real-time water quality monitoring would support the efficient delivery of specific amounts of water to the end users within acceptable water quality limits. Ready and seamless access to flow and conductivity measurements at existing monitoring stations is a logical step in the effort to manage and monitor the passage of Rio Grande flows more efficiently.

With respect to benefits, flood mitigation and water quality management strategies will become more responsive and less reactionary with enhanced coordinated water resource data, making it possible to control flood surges better or bypass lower quality pulses. This new ability to retrieve flow and quality data for the stretch of the Rio Grande Project (RGP) area will allow for the development of an integrated management plan by the USBR and USIBWC to handle cresting of levees resulting from storm events more effectively. The Federal Emergency Management Agency can utilize this information in their disaster response plans. Surface water treatment diversions can be more carefully planned and controlled. These and many other benefits will result from the open sharing of water quantity and quality information among the primary recipients of RGP water (Mexico, EBID, EPCWID #1, and EPWU).

During the past several years, different proposals for an integrated database management system for water resource data in the Paso del Norte region have been advanced by different stakeholders, water resource managers, and researchers (Keyes 2001a, 2001b). During the time these proposals were being discussed within the New Mexico-Texas Water Commission, the Paso del Norte Watershed Council (PdNWC) came into existence to provide guidance on environmental mitigation and enhancement activities related to the El Paso-Las Cruces Regional Sustainable Water Project. The PdNWC is a quasi-governmental organization that serves in an advisory capacity to the New Mexico-Texas Water Commission regarding the selection, planning, and implementation of environmental enhancements and mitigations associated with the El Paso-Las Cruces Regional Sustainable Water Project. The PdNWC recommends policies for cooperation, coordination, and the sharing of information concerning planning and management activities of projects affecting the Paso del Norte Watershed, this being defined as the RGP area between Elephant Butte Dam/Reservoir in southern New Mexico, and Fort Quitman, Texas.

Past advocates of such a database management system proposed that the PdNWC undertake such an effort, and a Technical Committee representing the Watershed Council, including technical expertise from the region, developed a series of proposals. In August of 2002, the EPWU granted the funds necessary to undertake Phase I of the development of a Coordinated Water Resources Database Project, and a coalition of staff members from regional universities executed Phase I of the Project (Brown, Sheng, and Rich 2004). In February of 2004, the EPWU generously provided funding for Phase II of the Project, and work has been conducted on Phase II from February of 2004 until March of 2005.

Methods and Data Employed in the GIS Implementation – Phase I

In Phase I of the Project, we studied the general framework of how to best provide water resource data to interested parties, and this involved questions including how data were stored, how they were served, how spatial queries were handled, what range of metadata[1] was provided, and how tabular data were served. Based on this research, the Technical Committee established a set of protocols by which the Project would be developed. These included project data being housed on a central server (this changed to a hybrid portal model in actual Project work), tabular data being served as Excel files, the use of ESRI’s ArcIMS as a means to provide an Internet Map Server (IMS), and the provision of basic metadata elements, these being data source, spatial extent, date of data capture or update, variables or data elements involved, format of data, and access information.

[1] Metadata are ancillary information about the core data elements, including date of data collection and update, source of data, and type of data. These elements will be discussed in greater detail later in this document.

With the above protocols in place, Project staff at NMSU and TAMU/TAES began working with regional data providers to identify data holdings of interest to the Project to determine how best to access the data and to make arrangements for such access, either via a direct link to existing webpages or though the actual transfer of data. At this point in the Project, members of the Technical Committee realized that it would be more efficient to employ a portal and distributed database storage model, as opposed to the data warehouse model identified previously. Using this data model, Project staff compiled a range of data and access points to data housed elsewhere and served these data through a combined IMS and image map protocol involving GIS maps as a graphical and spatial gateway to access data of interest.

With the underlying ArcIMS front end and smaller GIS map tiles in place, Project staff worked with regional data providers to ensure all of the desired data were accessible via HTML calls to other websites or loaded into the Project server. Considerable efforts were extended to clarify irregularities among the data elements, check the general positional accuracy of the spatial elements on the map, and ensure that the correct linkages to data elements were in place. We also worked with researchers at La Universidad Autónoma de Ciudad Juárez (UACJ) and UTEP to include data holdings that were housed at these institutions. The final stage of work on the Project was to document Project tasks through the hosting of a PdNWC Coordinated Database Project Workshop and to complete of the Phase I Final Project Report (Brown, Sheng, and Rich 2004). The workshop and review of the final Project report has provided valuable input for Phase II of the Project.

Methods and Data Employed in the GIS Implementation – Phase II

The following set of recommendations for future work emerged from Phase I of the Project, and these guidelines have driven development of the Scope of Work for Phase II and the specific tasks we have undertaken:

- Complete migration of the Project website and related databases to the ArcIMS software (EPWU/TAMU)
- Installation of new monitoring stations and equipment as detailed in the Phase I Final Report and inclusion of these monitoring sites in future ArcIMS map products (Original EPWU/TAMU Scope of Work Task Three)
- Enhanced levels of funding to support more active participation of volunteer regional data providers and to bring new providers into the project (Original EPWU/TAMU Scope of Work Task Seven)
- Exploration of scripting and automated FTP routines or a batch mode of data transfer to provide more seamless access to data across numerous servers (Original EPWU/TAMU Scope of Work Task Four)
- Inclusion of groundwater data into future phases of the project (Original EPWU/TAMU Scope of Work Task Six)
- Linking the EPWU-funded project to USACE-supported database efforts (Original EPWU/TAMU Scope of Work Task Five)

Based on these recommendations and ongoing input from the Technical Committee, Phase II activities have focused on the above areas. Specific activities undertaken include those detailed below.

Migrating the Project website from image maps to ArcIMS

As noted above and discussed in more detail in the Phase I Final Report, one of the biggest "lessons learned" from Phase I was to migrate the website user interface from the combination of image maps and ArcIMS to a fully supported ArcIMS application. This was done in the first stages of Phase II work and provides more flexibility serving GIS data via maps on the website; this also makes updating the actual water quality and quantity data much, much easier. Figure 1 is a graphic showing the ArcIMS map from the Project website.

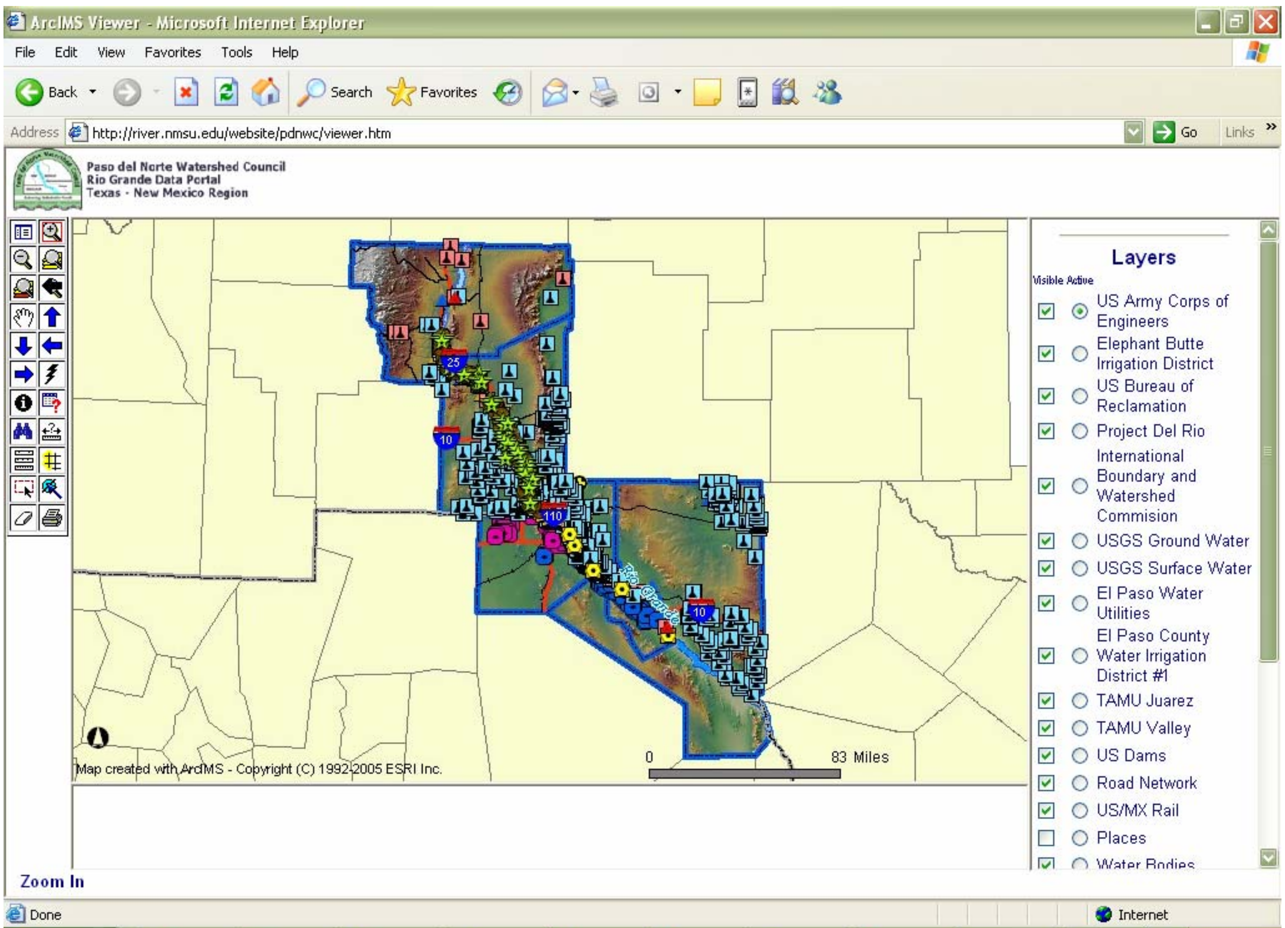

FIGURE 1. ArcIMS Map of the Study Area

Migrating from ArcIMS 4.1 to ArcIMS 9.0

Coincident with the above migration, we learned that Environmental Sciences Research Institute (ESRI – the company that develops and sells the ArcInfo and ArcGIS software) was moving to a new version of their desktop mapping program, ArcGIS, and the related ArcIMS module. In order to be able to incorporate map products from the newest version of ArcGIS (ArcGIS 9.0), we also needed to update the ArcIMS application we were running on our client machines used in development and on our servers. Project staff upgraded machines and servers in the NMSU Department of Geography's Spatial Applications and Research Center (SpARC) where development work was done, and staff at the New Mexico Water Resources Research Institute (NMWRRI) upgraded all NMWRRI clients and servers to ArcGIS 9.0. The longest learning curve for ArcIMS 9.0 was becoming familiar with all the different components that make it operate and understanding how they work together.

Resolution of inoperative hyperlinks in ArcIMS

In Phase I of the Project, a major problem was encountered whereby many spatial features mapped in the ArcGIS and ArcIMS applications would not link to hyperlinked internal data files or external Internet sites. This problem was caused by an erroneous internal setting that limited the number of hyperlink fields resident in ArcIMS files from functioning, and the problem was solved by extensive research into how the ArcIMSparam.js file was configured. The number of hyperlinks used must be specified in this file. This specification was set in our files, but some other programming code was causing a certain section of the file to be skipped. Through information provided by on-line forums supported by ESRI and conversations with the technical staff at ESRI, this problem has been rectified, allowing additional hyperlinks to the ArcIMS files involved.

Customizing the ArcIMS portion of the website

Users of the Phase I website noted several areas of the ArcIMS interface that were problematic, including problems with map aesthetics and integration and removal of certain function buttons (notably, the hyperlink and overview map buttons). These problems were resolved through customizing the ArcIMS site using ArcXML.[2] Changes were implemented by modifying pertinent variables within the files that directed specific actions to a desired section of the page; these commands included variations like "bottom.htm" and "top.htm" to direct actions to the top and bottom of HTML files.

Changes in the functionality of the ArcIMS interface of the website were also linked to map aesthetics (presentation of map graphical output). Project staff employed a Digital Elevation Model (DEM)[3] to create a hillshade that was combined with the original elevation data to depict contouring relief. Simulating sunlight falling on the earth's surface creates hillshades, providing a three-dimensional representation of the landscape portrayed, often highlighted with the use of color. This use of a DEM and hillshade provides visual robustness to the IMS website and gives a more concise sense of place to those who view the map products on the website. Figure 2 provides samples of a DEM and the hillshade produced from elevation data included on the Project website.

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[2] ArcXML is ESRI's **Arc** e**X**tensible **M**arkup **L**anguage, a "programming language used for sending requests and receiving responses through ArcIMS' spatial server" (GISLounge 2005).
[3] A Digital Elevation Model or DEM is a cell based digital file where the average height of the location represented by a given cell above the earth's surface is indicated by a numeric value.

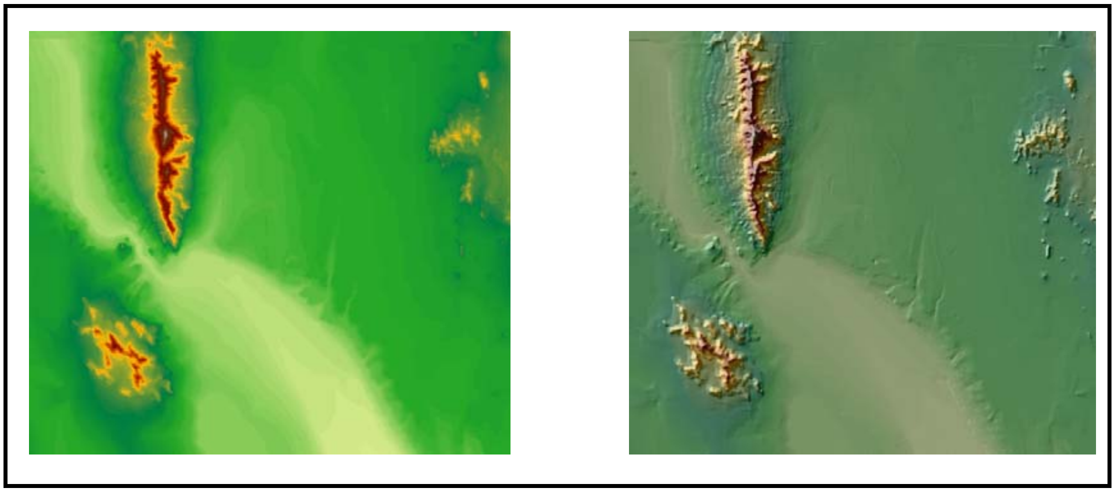

FIGURE 2. Sample Digital Elevation Model and Hillshade Datasets

Creation of front end for the website

One of the comments we frequently heard from members of the Technical Committee and other people who had used prototype versions of the Phase I and Phase II website was the need for a “user friendly” and informational “front end” to the website that provided a project description, list of participants and funding agencies, a general map of the study area, a link to Project metadata, and the PdNWC logo and related identifying information. Project staff created an HTML file for the front end of the project website with parallel aesthetics to the IMS site. The front end consisted of much of the same information and content as the original Phase I website, but this content is repackaged to match the enhanced IMS graphics and updated with current data about the project. See Figure 3 for a detail of this front-end HTML file. At the time of initial drafting this report, problems still existed with viewing the website with Internet browsers other than Internet Explorer (i.e., Netscape and Firefox), but these problems had been resolved by the time of the final drafting of this document. Users have suggested that we also need to include a transparent logo that will allow more freedom with aesthetic design.

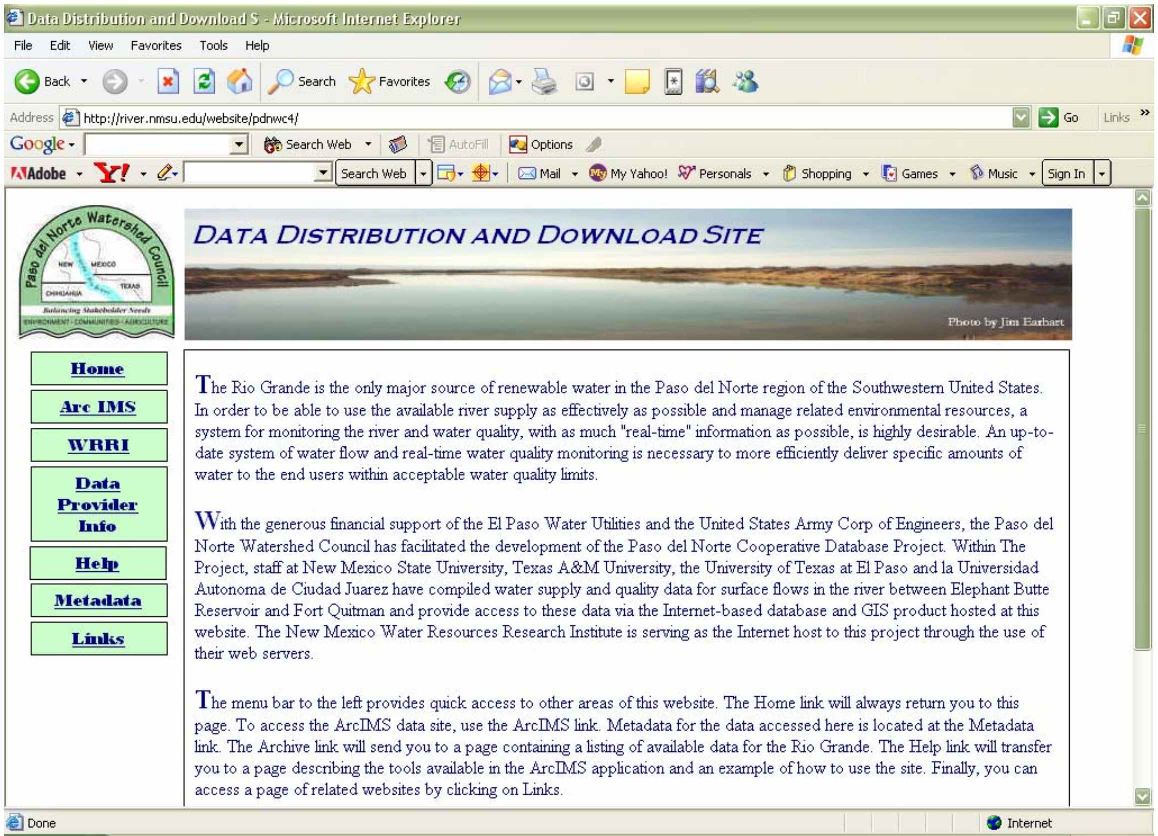

FIGURE 3. Front Page of ArcIMS Project Website

Addition of new data sources and enhanced data management

One of the more prominent tasks detailed in the Scope of Work for the Phase II Project is the addition of new data sources to the Project. Based on input from the Technical Committee and assistance of Project cooperators, several new data sources were added for the second phase of the project, including well data from Texas obtained with the assistance of staff at TAMU/TAES, Junta Municipal de Agua y Saneamiento de Ciudad Juárez (JMAS) public supply data, Distrito Riego 009 irrigation well data, elevation and hypsography, transportation, hydrography and land information system records provided by UACJ, updated location data for EBID gauges for which data are served on the EBID website, historical flow data obtained under the USACE Phase I funding, well and irrigation flow data for EPCWID #1, and well and river flow data obtained from EPWU. In order to provide access to the USACE data, the location data for the gauge stations had to be manually converted from individual files to a single table. These locational data were then linked internally to the tabular data files served on the NMWRRI server, and hyperlinks were established in the ArcIMS maps to connect the user to these data files on the NMWRRI server.

As work continued on the above data integration activities, we became aware that data needed to be consolidated and restructured on the NMWRRI servers to insure stability of the data management environment and to facilitate a secure backup of Project data. All files pertaining to the ArcIMS site were relocated from their distributed locations to a central data drive on the NMWRRI River server, and backup routines with the central computing staff at NMSU were initiated.

Development and serving of metadata

As detailed in the earliest work on the Phase I Project, serving metadata is an important facet of the Project. In Phase I, we employed a "low tech" and what appeared to be straightforward method to do this, namely populating Word files with metadata elements and then posting these on the Project website and in the Project report documents. When we were incorporating these metadata elements in the final Phase I Project deliverables, we encountered formatting problems that made it extremely difficult to provide consistently formatted documents for posting. For Phase II, we took advantage of the ability of ArcGIS to produce consistently formatted HTML files of metadata that are also consistent with the Federal Geographic Data

Committee (FGDC)[4] standards for the development of metadata documents. This outcome is also important as we incorporate data from the USACE-funded projects, as all GIS projects funded by federal agencies must produce metadata consistent with FGDC standards.

During the period of time the Project was being conducted, Project staff in the NMSU SpARC Laboratory undertook a large-scale data restructuring effort for the lab, with the goal that all projects (including the Phase II PdNWC Coordinated Water Resource Database and GIS Project) are archived in such a manner as to make metadata consistent with the FGDC standards readily available for all projects. Staff members revised Project data files to ensure that all attribute data fields on the ArcIMS site have at least the minimal metadata requirements that were designated in Phase I. These metadata have been exported to HTML files that are consistent with the FGDC standards, and these relevant HTML files are served to Project users through access on the front-end webpage for the Project.

Miscellaneous user interface issues – the "problem with pop-ups"

The installation of Microsoft Service Pack 2 to client computers using Windows XP allowed for a pop-up blocker plug-in for Internet Explorer to be installed along with that update. This plug-in poses serious problems when accessing hyperlinked pages or using identity tools that are important elements for accessing IMS applications. When the IMS application attempts to open new windows to internal data files or external website URLs on client machines, this pop-up blocker prevents the new window from opening and stalls the user in accessing these data.

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[4] The Federal Geographic Data Committee (FGDC) is a U.S. federal committee composed of numerous agencies dealing with geo-spatial data issues, and the FGDC has developed a set of standards for archiving and transferring geo-spatial data and related metadata.

Most solutions to this problem must occur on the client side of the application, either through a minimal alteration in the Internet options of Internet Explorer to add our site to those that allow pop-ups or through users holding down the **ctrl** key when accessing a pop-up. On the server side, we have moved the output of users requesting identity information from a pop-up back to an onscreen display. This move has decreased the areal extent of the map frame, making the map smaller, at least upon original display. However, the hyperlink tool that users employ to access internal data files and external websites still requires a pop-up, which generates the problem with the pop-up blocker detailed above. At the time of the drafting of this report, this problem was still being studied to determine the best means to resolve it.

Ongoing modification of the Project website and ArcIMS application

We have provided regular updates to the Technical Committee and representatives of EPWU through regular meetings and conference calls with the Technical Committee on the Project's progress**.** Several very useful suggestions were offered by EPWU staff regarding the structure and functionality of the website, and we have implemented many of these suggestions. One suggestion was to repackage the data so various subsets of Project data of interest to the user could be viewed separately and turned "on" or "off." Another suggestion was to change the color and shape of the symbols so they could be more easily recognized, and Project staff worked with EPWU staff and other users to enhance the symbology of the map elements to improve aesthetics and make the meaning behind the symbols as clear as possible.

PART II

Groundwater Data in the Paso del Norte Watershed

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Introduction

Groundwater is a major source for municipal and industrial water supply in the Paso del Norte watershed extending from Elephant Butte Reservoir in New Mexico to Fort Quitman, Texas. The Hueco Bolson is the sole source of potable water for Ciudad Juárez's municipal and industrial water supply, and provides 30 to 40% of the water supply for the City of El Paso in an average year. The City of Las Cruces relies completely on groundwater from the Mesilla Basin and Jornada del Muerto Bolson for its municipal water supply. To have a better understanding of the regional aquifer system, water utilities and state and federal agencies have collected groundwater data. Data collected includes information such as location (latitude and longitude), depth, diameter and screen of the well, and initial water level, water level measurements, water quality (general chemical analysis and trace metals), and pumpage.

However, not all the groundwater data and information are readily available through one single point of contact, and the inclusion of groundwater data is an improvement to the Project that was advanced in the Phase II work this report provides. In addition, data are kept in different formats, which further complicates data sharing across different computer platforms and applications. As part of the PdNWC Coordinated Database and GIS Project, this section of the Phase II report summarizes data elements, sources of data, hyperlinks to data sources, and metadata. Part of the data has been incorporated in the Coordinated Database and GIS website.

It also provides recommendations for further database development and for data sharing on-line.

Groundwater Data Elements of Interest

Even though elements of groundwater data vary from one agency to another, data collected can be classified under the following categories: well information, water levels, water quality, and pumpage. Some agencies such as New Mexico Office of the State Engineer (NMOSE) and the Texas Water Development Board (TWDB) also maintain water rights records and numerical models such as Groundwater Availability Models (GAMs) for major and minor aquifers. The following sections will describe each category in detail.

Well Information

Well information usually includes geographical locations (latitude and longitude); well numbers; owners; well design parameters such as depth, elevation, diameter, screen, and casing; initial water level; uses of well (irrigation, domestic and public supply, injection, or monitoring); completion date; and other parameters. Figure 4 shows an example of a well location and limited information from the TWDB. Table A1 in the Appendix shows the details of more extensive well information that is provided by the TWDB for its wells.

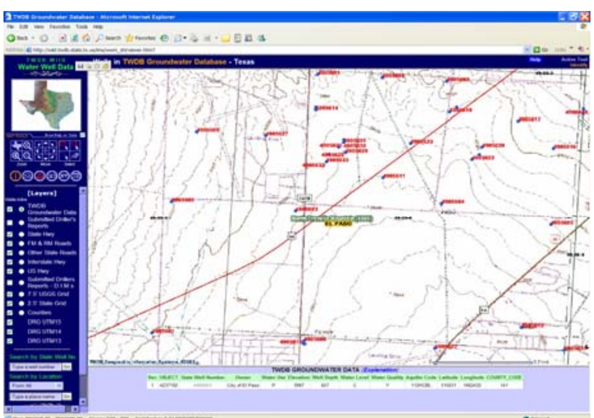


FIGURE 4. An Example of TWDB (2005)
Well Information for JL-49-05-603 (EPWU well 32)

Water levels

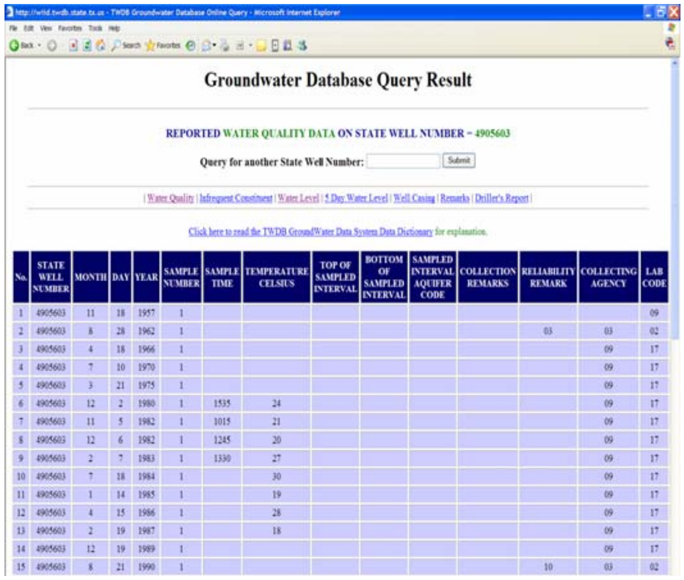
Water level data can be classified into two types: historic measurement/monitoring data and real-time monitoring data. The USGS maintains a real-time water level monitoring network around the nation as well as historic records of water levels at selected sites. Other agencies keep all the initial water level data and periodic water level measurement records. Figures 5 and 6 show examples for historic and real-time data maintained by the USGS.

FIGURE 5. USGS Historic Groundwater Level Data for the Texas Well JL-49-13-301 (EPWU MR-3) (USGS 2005)

FIGURE 6. USGS Real-time Groundwater Level Data (USGS 2005)
for the Texas Well JL-49-13-301 (EPWU MR-3)

Water quality

Two sets of water quality data from lab analyses exist: one for general chemical analysis and the other for trace metal assessments. EPWU, JMAS, and CLC maintain both hard copies and electronic format archives of historic water quality records. TWDB also provides historic water quality data in its website (TWDB 2005). Figure 7 provides examples of water quality data from TWDB.



Groundwater Database Query Result

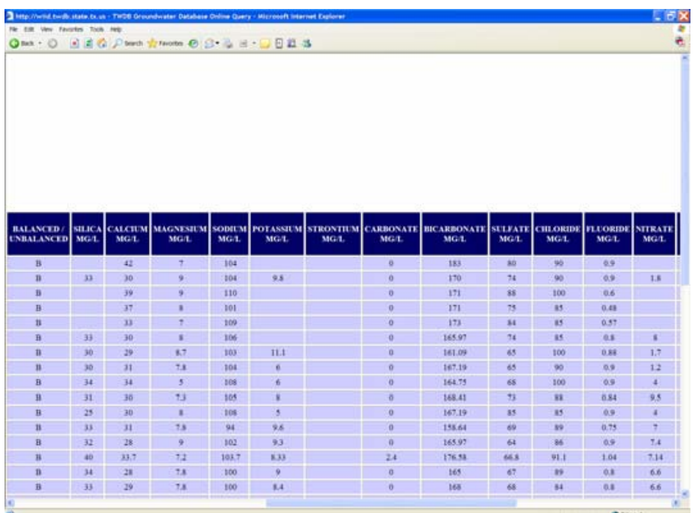
REPORTED WATER QUALITY DATA ON STATE WELL NUMBER = 4905603

Query for another State Well Number: Submit

| Water Quality | Infrequent Constituent | Water Level | 5 Day Water Level | Well Casing | Remarks | Driller's Report |

Click here to read the TWDB GroundWater Data System Data Dictionary for explanation.

No.	STATE WELL NUMBER	MONTH	DAY	YEAR	SAMPLE NUMBER	SAMPLE TIME	TEMPERATURE CELSIUS	TOP OF SAMPLED INTERVAL	BOTTOM OF SAMPLED INTERVAL	SAMPLED INTERVAL AQUIFER CODE	COLLECTION REMARKS	RELIABILITY REMARK	COLLECTING AGENCY	LAB CODE
1	4905603	11	18	1957	1									09
2	4905603	8	28	1962	1							03	03	02
3	4905603	4	18	1966	1								09	17
4	4905603	7	10	1970	1								09	17
5	4905603	3	21	1975	1								09	17
6	4905603	12	2	1980	1	1535	24						09	17
7	4905603	11	5	1982	1	1015	21						09	17
8	4905603	12	6	1982	1	1245	20						09	17
9	4905603	2	7	1983	1	1330	27						09	17
10	4905603	7	18	1984	1		30						09	17
11	4905603	1	14	1985	1		19						09	17
12	4905603	4	15	1986	1		28						09	17
13	4905603	2	19	1987	1		18						09	17
14	4905603	12	19	1989	1								09	17
15	4905603	8	21	1990	1							10	03	02



BALANCED / UNBALANCED	SILICA MG/L	CALCIUM MG/L	MAGNESIUM MG/L	SODIUM MG/L	POTASSIUM MG/L	STRONTIUM MG/L	CARBONATE MG/L	BICARBONATE MG/L	SULFATE MG/L	CHLORIDE MG/L	FLUORIDE MG/L	NITRATE MG/L
B		42	7	104			0	183	80	90	0.9	
B	33	30	9	104	9.8		0	170	74	90	0.9	1.8
B		39	9	110			0	171	88	100	0.6	
B		37	8	101			0	171	75	85	0.48	
B		33	7	109			0	173	84	85	0.57	
B	33	30	8	106			0	165.97	74	85	0.8	8
B	30	29	8.7	103	11.1		0	161.09	65	100	0.88	1.7
B	30	31	7.8	104	6		0	167.19	65	90	0.9	1.2
B	34	34	5	108	6		0	164.75	68	100	0.9	4
B	31	30	7.3	105	8		0	168.41	73	88	0.84	9.5
B	25	30	8	108	5		0	167.19	85	85	0.9	4
B	33	31	7.8	94	9.6		0	158.64	69	89	0.75	7
B	32	28	9	102	9.3		0	165.97	64	86	0.9	7.4
B	40	33.7	7.2	103.7	8.33		2.4	176.58	66.8	91.1	1.04	7.14
B	34	28	7.8	100	9		0	165	67	89	0.8	6.6
B	33	29	7.8	100	8.4		0	168	68	84	0.8	6.6

FIGURE 7. TWDB (2005) Water Quality Data for JL-49-05-603 (EPWU well 32)

Pumpage

Most municipal wells have comprehensive records of water pumpage; however, pumpage for domestic and agricultural irrigation wells has generally not been well documented. Table 1 is an example of groundwater pumpage data provided by EPWU (2004). The pumpage data will be incorporated as future phases develop.

TABLE 1. Examples of Pumpage Data from the EPWU Wells in 2001 (EPWU 2004)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	01PROD																
2																	
3		Canutillo Shallow Monthly Production in Thousands of Gallons												Canutillo Shallow Accumulative Production in Th			
4																	
5	Well No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
6	101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	104	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	106	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	109	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	115	0	0	13,264	17,312	16,709	16,048	16,090	15,038	0	0	1,290	0	0	0	13,264	30,576
18	116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	117	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	118	0	247	29,425	35,759	37,491	34,549	36,573	36,857	35,919	12,318	0	0	0	247	29,672	65,431
21	Subtotal	0	247	42,689	53,071	54,200	50,597	52,663	51,895	35,919	12,318	1,290	0	0	247	42,936	96,007
22																	
23		Canutillo Deep Monthly Production in Thousands of Gallons												Canutillo Deep Accumulative Production in Thou			
24																	
25	Well No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
26	201	0	0	0	0	0	80,315	48,106	57,350	79,412	97,606	79,678	0	0	0	0	0
27	202	85,549	66,771	44,410	20,216	41,981	46,369	72,574	33,027	19,825	35,940	27,745	0	85,549	152,320	196,730	216,946
28	203	32,802	27,684	18,566	26,150	68,623	56,011	42,968	38,232	40,760	72,398	17,238	10,274	32,802	60,486	79,052	105,202
29	204	0	0	9,260	10,820	50,089	25,314	17,882	5,017	19,497	59,526	46,639	18,482	0	0	9,260	20,080
30	205	0	42,732	20,584	13,776	21,181	28,997	55,188	30,960	0	20,116	71,105	0	0	42,732	63,316	77,092
31	206	24,514	75,590	0	0	29,460	79,675	40,648	70,205	40,055	104,906	87,045	91,106	24,514	100,104	100,104	100,104
32	207	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	Subtotal	142,865	212,777	92,820	70,962	211,334	316,681	277,366	234,791	199,549	390,492	329,450	119,862	142,865	355,642	448,462	519,424
34																	
35		Canutillo Intermediate Monthly Production in Thousands of Gallons												Canutillo Intermediate Accumulative Production i			
36																	
37	Well No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
38	301	0	72,384	81,777	81,076	81,830	75,359	79,053	80,045	79,854	80,591	77,632	74,829	0	72,384	154,161	235,237
39	302	0	29,296	45,932	49,961	49,142	46,741	37,768	35,092	27,696	50,201	39,844	42,039	0	29,296	75,228	125,189
40	303	68,517	56,701	63,051	67,532	59,824	45,313	63,107	70,067	35,092	61,142	65,070	59,509	68,517	125,218	188,269	255,801
41	304	44,302	29,988	37,923	0	25,162	56,703	22,509	39,246	5,059	14,491	0	0	44,302	74,290	112,213	112,213

Water Rights

In New Mexico, the integration of Geographic Information Technologies (GIT) into the New Mexico Office of the State Engineer's enterprise system design for Water Rights Administration is currently being developed. The system will provide access to a map illustrating individual water rights information, including places of water use, points of water diversion, and water conveyances. Currently, the technology is supporting historical water rights analyses, hydrological modeling of ground and surface water resource quantities, and legal descriptions of water rights holdings. The linkage to the NMOSE website will be established in future phases.

Others

Other information related to groundwater includes the data associated with the TWDB groundwater availability models (GAMs) for major and minor aquifers in Texas, and NMOSE delineation of closed basins. The linkages with these sites will be built in future phases.

Data Sources – Metadata Hyperlinks to Data Sources

This section presents data sources under different provider categories, metadata for some data sources, and their hyperlinks, if available. Three major categories of agencies that collect data are water utilities, state agencies, and federal agencies.

Water Utilities

EPWU – El Paso Water Utilities maintains well information for over 173 public supply wells, historic annual water level measurements for the period between 1903 and 2000, periodic water quality data (general chemical and trace meter analysis) up to 2002, and monthly and annual well pumpage data from 1967 to 2003. Well information, annual water level measurement, and water quality data are available through the TWDB groundwater database for most of these wells. However, pumpage data were not included in the TWDB groundwater database. A well location shapefile was created by the Texas A&M University (TAMU) project team based on the spreadsheet data provided by EPWU. Other datasets are in the spreadsheet format.

JMAS – The Technical Department of the Junta Municipal de Agua y Saneamiento of Ciudad Juárez maintains a data set containing geo-referenced locations of the municipal and domestic wells in the city of Cd. Juarez. This coverage also includes water chemistry (quality) from 1985 to 1999 and water levels from 1975 to 1995. UACJ provided a copy of shapefiles for inclusion in the project website of the PdNWC (2005). UACJ has worked on updating metadata of the different digital coverages created for the Project. For each of the different layers incorporating data from the Paso del Norte region (US – Mexico), a description on some of the layers combined the attributes (allowed for different fields from different tables to be queried, cross-referenced and joined), which defined each physical characteristic on the data set. Although this has been done within a tabular format, some layers have digital files included on the GIS project (see Appendix B for type of data).

CLC – The City of Las Cruces Department of Water Resources maintains records of well information, water level, water quality, and pumpage. New Mexico State University (NMSU) collects and maintains some of the CLC data. The data will be incorporated in future phases.

State Agencies

TWDB – Texas Water Development Board maintains two groundwater data sets: TWDB Groundwater Database and Submitted Driller's Reports using ArcIMS (http://wiid.twdb.state.tx.us/IMS/wwm_drl/viewer.htm). The hyperlinks will be established in future phases. The groundwater database stores information on approximately 128,000 registered wells out of the approximately 1,000,000 water wells drilled in Texas statewide in the last century. This web service provides external users with reported water well information. Besides the well information as listed in Appendix A, it also provides historic water quality data, historic water level measurements, and a hyperlink to the USGS real-time monitoring website. A submitted driller's report is created by the online Texas Well Report Submission and Retrieval System (A cooperative Texas Department of License and Regulation [TDLR] and TWDB system) that registered water-well drillers use to submit their required reports. Appendix C shows steps for accessing the TWDB Groundwater Database.

NMOSE - New Mexico Office of the State Engineer maintains records of wells and associated water rights authorized at the following website http://iwaters.ose.state.nm.us:7001/iWATERS/. A registered user can search well data, depth of water, water column, and water rights by Township, Range and Section, by XY coordinates, by County, water basin, database file number, or owner name. Users can then select their desired report format, and all reports can be downloaded as a text file. The hyperlinks will be established in future phases.

Two sets of GIS data are also available for download at the following website http://www.seo.state.nm.us/water-info/gis-data/index.html. The first is OSE well data as of October 2004; Water Well data from W.A.T.E.R.S. (Water Administration Technical Engineering Resource System) have been converted into a GIS database and are now available for download from the NMOSE website. Metadata are included within the compressed zipfile (9.5MB) which, when uncompressed, expands to over 380MB. Please note these data have NOT been validated or checked for spatial accuracy.

The second database deals with declared groundwater basins - A declared groundwater basin is an area of the state proclaimed by the State Engineer to be underlain by a groundwater source having reasonably ascertainable boundaries (http://www.seo.state.nm.us/water-info/misc-maps/Groundwater Basins.html). By such proclamation, the State Engineer assumes jurisdiction over the appropriation and use of groundwater from the source. This dataset is to be used as a guide for where the actual boundaries exist. Please refer to the Rules and Regulations Governing Drilling of Wells and Appropriation and Use of Groundwater in New Mexico for boundary location.

Federal (National) Agencies

INEGI – National Institute of Statistics, Geography and Information of Mexico provides data in both digital and analogical formats. Locations of agricultural wells in the lower valley on the Mexico side of the study area were digitized from INEGI maps containing data for groundwater in the area. These wells need to be geo-referenced and their attributes included in the database pending further efforts to have a more comprehensive dataset of wells and water resources on the lower valley (see Appendix B for type of data).

USGS – U.S. Geological Survey Groundwater Database contains groundwater site inventory, groundwater level data, and water-quality data. The groundwater site inventory consists of more than 850,000 records of wells, springs, test holes, tunnels, drains, and excavations in the United States. The site descriptive information includes well location information such as latitude and longitude, well depth, and name of the relevant aquifer (http://waterdata.usgs.gov/nwis/gwsi).

The USGS annually monitors groundwater levels in thousands of wells in the United States. Groundwater level data are collected and stored as either discrete groundwater level measurements or as a continuous record (http://waterdata.usgs.gov/nwis/gw). Data from some of the continuous record stations are relayed to USGS offices nationwide through telephone lines or by satellite transmissions providing access to real-time groundwater data. Only one USGS real-time groundwater level monitoring site is located in El Paso within the Paso del Norte Watershed (http://waterdata.usgs.gov/nwis/current/?type=gw). However, historic water level measurement data through time are available at a total of 614 well sites in the region: Doña Ana (308 sites), Otero (52), and Sierra (17) counties in New Mexico, and El Paso (236) and Hudspeth (1) counties in Texas (http://nwis.waterdata.usgs.gov/usa/nwis/gwlevels). Query results are displayed in hydrographs.

The USGS also collects and analyzes chemical, physical, and biological properties of water, sediment, and tissue samples from across the nation (http://waterdata.usgs.gov/nwis/qw). The NWIS (National Water Information System) web discrete sample database is a compilation of over 4.2 million historical water quality analyses in the USGS district databases through September 2003. The discrete sample database is a large and complex set of data that has been collected by a variety of projects ranging from national programs to studies in small watersheds. It includes a total of 311 well sites within the PdN watershed: Doña Ana (150 well sites), Otero (20), and Sierra (9) counties in New Mexico, and El Paso (132) and Hudspeth (0) counties in Texas.

At selected surface-water and groundwater sites, the USGS maintains instruments that continuously record physical and chemical characteristics of the water including pH, specific conductance, temperature, dissolved oxygen, and percent dissolved-oxygen saturation. Supporting data such as air temperature and barometric pressure are also available at some sites. At sites where this information is transmitted automatically, data are available from the real-time data system. No USGS real-time monitoring sites are identified within the PdN watershed.

Others

Local universities, other government agencies, and industries also collect and maintain groundwater data. They include New Mexico Water Resources Research Institute (NMWRRI), the Center for Environmental Resources Management (CERM, http://www.cerm.utep.edu) at UTEP, UACJ, TAMU, EPCWID #1 (http://www.epcwid1.org), Hudspeth County Water Conservation and Reclamation District, and others. For example, UACJ identified other well locations that were obtained from el Instituto Municipal de Investigación y Planeación (IMIP) in Juárez, México, and consisted of databases based on raster GIS maps. These wells need to be geo-referenced and their attributes included on the database on further efforts to complete the information regarding wells and water resources on the lower valley. El Paso County Water Improvement District #1 maintains irrigation well information and pumpage records for wells drilled in 2003 and 2004. All locations of these wells were surveyed using Global Positioning System (GPS).

Recommendations for ArcIMS Implementation

In summary, multiple local, state, and federal agencies collect and maintain groundwater data. Currently, data access and data sharing are not well coordinated. With the development of this website for the Coordinated Water Resources Database and GIS Project by the PdNWC, users will be able to more easily access well information, water level, water quality, and pumpage in a timely manner.

Based on the nature of source data, the following recommendations are made for development of linkages to other existing database websites and establishment of data access through the PdNWC coordinated water resources database and GIS website (http://www.PdNWC.org) for the archived data that are not readily accessible through other websites:

1. Create an integrated point shapefile or coverage for all well sites and incorporate them with well location information such as well number, latitude, longitude, and aquifer.
2. For well sites with information available in other existing websites, such as with the NMOSE, TWDB, and USGS, develop linkages with existing source data using hyperlinks through ArcIMS. Users will link to appropriate source data per their interests by clicking the well site. Data will be updated and maintained by agencies that host and maintain QA/QC (quality assurance and quality control) programs for the data.
3. For a well site with information not readily available through other websites (such as EPWU well pumpage, and JMAS/INEGI groundwater data), archive relevant data from data collectors and conduct QA/QC of the data as needed. If the well site is not included in the shapefile yet, such well site information will be added into the integrated point shapefile/coverage. If a shapefile exists, it can be loaded through ArcMap or ArcIMS. A query function to link information/data related to this well site will then be developed using the similar ArcIMS protocol as the TWDB groundwater database website (Appendix C). With such implementation the PdNWC coordinated water resources database and GIS website will eventually provide improved access to data that are not readily available yet.
4. Evaluate alternative methods to compile all the data collected by different agencies and resolve formatting differences. An especially promising area of future work is to collaborate with the USGS Border Environmental Health Initiative; USGS staff members working on this initiative are currently addressing the issue of data comparability

between TCEQ, USGS, and CNA with the objective of creating one water quality database.

PART III

DATA SHARING AND SPATIAL QUERY

Raghavan Srinivasan

Introduction

With multiple data collectors and multiple data sources, efficient data sharing is essential for development of the coordinated database. This section of the Phase II Final Report explores the options for data transfer and sharing, such as FTP, HTTP, WGET, ArcSDE, and ArcIMS with DDE extension, which will eventually be implemented in the Paso del Norte Watershed Council's (PdNWC) Coordinated Water Resources Database and Geographical Information System (GIS) Project. With the current PdNWC ArcIMS, a simple one-layer query is already included, and we discuss some of the specifics of how this single layer query is handled. For future applications, multi-layer query is desired by regional water resources planners and managers and recommended for implementation.

Data Transfer and Sharing

Many ways exist to advance data transfer and sharing. Researchers usually refer to FTP, HTTP, and WGET for spatial data sharing. The ESRI ArcIMS Data Delivery extension enables GIS data publishing for ArcIMS. It allows ArcIMS users to make their data available in a wide variety of standard spatial formats. The definitions of each follow:

FTP

File Transfer Protocol, or FTP, is a protocol used to upload files from a workstation to an

FTP server or download files from an FTP server to a workstation. FTP was one of the first efforts to create a standard means of exchanging files over a TCP/IP network, so FTP has been around since the 1970s. The key functions of FTP are:

- to promote sharing of files (computer programs and/or data),
- to encourage indirect or implicit use of remote computers (via programs),
- to shield a user from variations in file storage systems among hosts, and
- to transfer data reliably and efficiently. Although FTP can be invoked directly by a user at a terminal to initiate file transfers, it is designed mainly for use by programs.

FTP enables the user to transfer files between a client host system and a remote server host system. On the client system, a file transfer program provides a user interface to the FTP; on the server, the requests are handled by the FTP daemon, FTPD. FTP control frames are TELNET exchanges and can contain TELNET commands and option negotiation. However, most FTP control frames are simple ASCII text and can be classified as FTP commands or FTP messages.

HTTP

Hypertext Transfer Protocol (HTTP) has been in use by the World Wide Web (WWW) global information initiative since 1990. HTTP is based on a request/response paradigm. The communication generally takes place over a TCP/IP connection on the Internet. HTTP is an application-level protocol with the lightness and speed necessary for distributed, collaborative, hyper media information systems. It is a generic, stateless, object-oriented protocol that can be used for many tasks, such as name servers and distributed object management systems, through extension of its request methods (commands). A feature of HTTP is the typing and negotiation of data representation, allowing systems to be built independently of the data being transferred.

The innovations that Berners-Lee added to the Internet to create the WWW had two fundamental dimensions: connectivity and interface. Using HTTP, a computer that asked for a file from another computer would know when it received the file and whether it was a picture, a movie, or a spoken word. With this feature of HTTP, the Internet began to reflect an important truth - retrieving a file's data is almost useless unless the users know what kind of data it is.

Difference between FTP and HTTP

HTTP is a protocol used to transfer files from a Web server onto a browser in order to view a webpage that is on the Internet. Unlike FTP, where entire files are transferred from one device to another and copied into memory, HTTP only transfers the contents of a webpage into a browser for viewing. FTP is a two-way system, as files are transferred back and forth between server and workstation. HTTP is a one-way system, as files are transported only from the server onto the workstation's browser. When *http* appears in a URL, it means that the user is connecting to a Web server and not a file server. The files are transferred but not downloaded, therefore not copied into the memory of the receiving device. FTP and HTTP are both essential tools for the Internet; however, FTP's upload ability is still one of the most wanted and most commonly deployed.

GNU WGET

WGET is a network utility used to retrieve files from the Web using HTTP and FTP, the two most widely used Internet protocols. It works non-interactively, so it will work in the background, after having logged off. The program supports recursive retrieval of web-authoring pages as well as FTP sites. The users can use WGET to make mirrors of archives and home pages or to travel the Web like a WWW robot.

WGET supports a full-featured recursion mechanism, through which the users can retrieve large parts of the Web, creating local copies of remote directory hierarchies. Of course, maximum level of recursion and other parameters can be specified. Infinite recursion loops are always avoided by hashing the retrieved data. All of this works for both HTTP and FTP.

WGET has the following features to make download easier:

- WGET is non-interactive, meaning that it can work in the background, while the user is not logged on;
- WGET can follow links in pages and create local versions of remote web sites, fully recreating the directory structure of the original site;
- File name wildcard matching and recursive mirroring of directories are available when retrieving via FTP. This ability can be extremely useful for automated updating of real-time data that may or may not have changed since the previous time a given data site was searched and accessed;
- WGET has been designed for robustness over slow or unstable network connections; if a download fails due to a network problem, it will keep retrying until the whole file has been retrieved;
- WGET supports proxy servers, which can lighten the network load, speed up retrieval, and provide access behind firewalls;
- Built-in features offer mechanisms to tune the links the user wishes to follow;
- Most features are fully configurable, either through command line options or via the initialization file.

ArcIMS and DDE

ArcIMS (Internet Mapping Server) is a server-based product that provides a scalable framework for distributing GIS services and data over the Web. The ESRI ArcIMS Data Delivery Extension (DDE) enables GIS data publishing for ArcIMS. It allows ArcIMS users to make their data available in a wide variety of standard spatial formats. End users can translate the data being viewed to a desired spatial output format and projection, and then download the translation results to their desktop. The results include feature attribute data supported by the chosen output format.

DDE uses Web-based technologies to provide this real-time distribution of spatial data. It performs translation requests using proven Feature Manipulation Engine (FME) technology from Safe Software.[5] DDE is an extension product to ArcIMS. It is architecturally independent of ArcIMS but can be configured to work with ArcIMS. The integration requires minor modifications to the ArcIMS HTML Viewer.

The DDE consists of four components: Translation Servlet, QServer, FME Server, and Process Monitor. DDE supports variable downloadable formats: Adobe Illustrator (Encapsulated PostScript [EPS], Autodesk AutoCAD DWG/DXF, Autodesk MapGuide SDL, Design Files [DGN], Bentley/Intergraph), Design Files (V8), EPS, ESRI ArcInfo Coverage, ESRI ArcInfo Export (E00), ESRI ArcInfo Generate, ESRI GML, ESRI Shapefile, Geographix CDF, GML 2, MapInfo MID/MIF, MapInfo TAB, PenMetrics GRD, Raster Image (PNG/GIF), Scalable Vector Graphics (SVG), VML, and VRML. DDE also supports these data sources: ESRI ArcSDE

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[5] Safe Software is a private vendor of data interoperability software that offers considerable capability to transfer and use GIS software across a wide range of formats. See http://www.safe.com/ for additional detail, especially for the FME product detailed above.

8.x/Spatial Database Engine (SDE) 3.x, ESRI Personal Geodatabase, ESRI Multi-user Geodatabase, and ESRI Shapefile.

There are a number of benefits to using DDE to solve data distribution problems:

- ***Scalable:*** As the load increases on a server that is hosting DDE, more FME translation Servers can be added on different machines over a network. This allows many processing resources to be added to the system to meet peak demands.
- ***Real-Time Translation:*** DDE performs real-time translations using Safe Software's industry-leading FME Translation Server.
- ***Customizable:*** The DDE QServer and FME Server APIs are published, flexible, and robust. As a result, third-party components easily integrate, allowing for full exploitation of DDE's capabilities.
- ***Data Independence:*** DDE can be configured to distribute data from any format or system supported by its underlying FME Translation Server.
- ***Data Security:*** All data access is specified through configuration and FME mapping files. These files define which data is accessed and made available to the client applications. Users of the remote applications have no direct access to the data.

Spatial Query

When ArcIMS is launched, query functions are launched as well. Querying a dataset can be done in one of three ways:

- A tabular query based on the value of attributes
- A spatial query based on features selected on a map
- A combination of a tabular and spatial query

QUERY, SPATIALQUERY, and STOREDQUERY are used in ArcIMS, but it is recommended to use SPATIALQUERY for all query statements with the exception of stored queries.

- QUERY handles only attributes, while SPATIALQUERY handles both attribute and spatial queries.
- QUERY must be used when setting up a stored query.
- Joined tables cannot be used with a QUERY in STOREDQUERY.
- SPATIALQUERY is also used to join DBF files to shapefiles and to relate tables in ArcSDE.
- The main element used around one or more STOREDQUERY expressions is a stored query EXTENSION, for example: extract extension.

Without SPATIALFILTER, SPATIALQUERY works exactly the same as QUERY when querying database attributes. A spatial filter defines the envelope for a spatial query. The envelope can be a rectangle, point, line, polygon, or buffer.

Although ArcIMS only provides querying one layer at a time, the user can develop a code algorithm to do multi-layer query, pre-processing of spatial data queries, and set up interface for accessing to these spatial data queries. This is not implemented in the current ArcIMS configuration. The users need to develop algorithms and write programs to achieve the same.

In addition to the current implementation of ArcIMS, the one-layer query can be implemented in simple HTML interface or in a more advanced Java client interface. Add-on packages are available to perform the multi-layer drill down operation. That is, if a user clicks on a map in the ArcIMS client interface, the program queries all the layers of interest and returns the information for one location from each layer. However, if an overlay operation between two layers or a conditional query between two or more layers needs to be performed, it is not possible in the current implementation of ArcIMS. These need more advanced programming.

Besides the spatial query, ArcSDE is based on standards for managing spatial data in an SQL database that have been defined by both international standards bodies and industry organizations. A good database management system with ArcSDE will also greatly improve the query efficiencies.

Discussion and Recommendations

The above discussion reviews a range of spatial data transfer and query tools that are either already implemented in commercial off-the-shelf software or that can be implemented through the development of custom scripts that users can develop. To date in the Project, we have used a combination of the geo-spatial data serving capabilities of ArcIMS and automated FTP calls that allows users to easily access multiple data platforms and transfer both GIS and aspatial water resource data. Project partners have fielded these calls in a variety of ways, depending on how they are serving data of interest for their own purposes, and this method of accessing data has provided good utility for a majority of users. However, input received at the users workshop conducted near the end of the Project period indicates that future work toward making access more seamless would be a useful direction to proceed.

From a general perspective, it is best to automate the transfer of datasets between the various data collectors to the maximum extent possible. Once the data are collected, a small script could be developed to automatically upload it to the main central server to host the data in real-time (hourly or within a day). There are various ways to accomplish this, as discussed in this document, and future research could address the technical issues involved. Putting such a process in place would also require permission on behalf of data providers and Project partners, and future discussion with Project partners would need to pursue such permission.

Concerning the use of ArcIMS, development of scripts would facilitate customization that would add flexibility to the ArcIMS implementation, including a new feature that allows users to download data. A site can also be developed to distribute metadata along with each data layer. With add-on packages and additional advanced programming, multi-layer queries can be implemented to allow users to perform the multi-layer drill down operation, interlayer operations, or conditional queries between two or more layers.

As future Project efforts esplore alternate means to serve geo-spatial data, we also suggest exploring the use of ArcGIS Server that is a module of ESRI's ArcGIS software suite as an alternate means to serve geo-spatial data.[6] Although the Project website currently deploys the ArcIMS technology to successfully serve these data, research conducted recently indicates that this tool may offer considerable utility for future Project activities.

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[6] ArcGIS Server 9.2 has enhanced geoprocessing capabilities, an additional developer framework for both the J2EE and .NET 2.0 environments, the ability to serve data to mobile users that allows field editing and upload, and an improved out-of-the-box Web application development framework. For addtional detail on ArcGIS Server, please see http://www.esri.com/software/arcgis/arcgisserver/index.html.

PART IV

Potential to Link the PdNWC Coordinated Database to Future Model Development

Z. Sheng and D. Zhang

Introduction

This part of the Phase II report documents the potential to link the PdNWC Coordinated Water Resources Database to the model development within the Rio Grande reach between Elephant Butte Dam in New Mexico and Ft. Quitman, TX. In addition to the expansion of the existing Upper Rio Grande Water Operations Model (URGWOM) Planning version for flood control assessment for the reaches below Elephant Butte Dam using RiverWare (version 4.5.1) developed by the Center for Advanced Decision Support for Water and Environmental Systems (CADSWES) at the University of Colorado in Boulder, CO, water quality will also be considered in future model simulation. The spatial information and historic records of river flow at gauge stations, canal diversions, wasteway spills and drain return flows from the Coordinated Database Project (CDP) will be used for configuration and calibration of the planning version model. The current water quality component of the RiverWare model only covers temperature, Dissolved Oxygen (DO), and Total Dissolved Solids (TDS). Even though historic water quality data are limited, the coordinated database will provide some data for temperature, DO, and TDS needed for water quality model configuration. In addition, groundwater data will not only provide information needed for the groundwater availability model configuration, but will also furnish data needed for coupling groundwater and surface water models.

Data collection and compilation are very important factors for a successful development of a numerical model. With continued expansion, the Paso del Norte Watershed Council Coordinated Water Resources Database Project will not only establish more links to data sources, especially for real-time data, but will also help archive more historic flow and water quality data that otherwise would not be accessible through the Internet. With spatially referenced data, the Coordinated Database Project will provide a convenient framework for delineation of the model boundaries. Historic data can be used for model calibration and verification. In this part of the report, we explore expansion of the URGWOM to cover the Rio Grande reaches between Elephant Butte Dam and Ft. Quitman as a potential linkage of the Coordinated Database Project. We are especially interested in numerical model development such as extracting data from the database for model configuration and storing the model simulation results into the database. In addition to spatial information, several hydrological datasets will be evaluated in terms of their application in model development.

Data Needs for the URGWOM Development in the Paso del Norte Watershed

Several models have been developed to simulate river flows and water quality for the Paso del Norte watershed. For example, BESTSM (Boyle Engineering Stream Simulation Model) was used to simulate the river flow and water quality (TDS, chloride, and sulfate) between San Marcial, New Mexico, and the Riverside Dam in Texas (Boyle 1998 and 2000). Specifically, BESTSM simulates the operation of surface water reservoirs, the routing of daily surface water flows, and attendant water quality for given time periods (CH2MHill 2000). The SWAT model (Neitsch et al. 2002) was developed to predict the impact of land management practices on water, sediment, and agricultural chemical yields in large complex watersheds with varying soils, land use, and management conditions over long time periods. It requires weather, soil properties, topography, vegetation, and land management practices (climate, Hydrological Response Units, ponds/wetlands, groundwater and main channel) as input and simulates water movement, sediment movement, crop growth, nutrient cycling, and other outputs (flow, TMDL, sediment load, BMP alternatives for control of non-point source loading) as output.

Compared to SWAT and BESTSM, RiverWare as implemented in URGWOM employs better hydrological routing approaches and has a better user-interface for input/output. RiverWare also allows users to add water resources components, simulates flood control operations, and simulates short-term and long-term planning for reservoir operations better than BESTSM. In the area of data needs, RiverWare also departs from SWAT and BESTSM. RiverWare does use some of the data elements that BESTSM and SWAT require (for example, hydrologic data and spatial data), but RiverWare also needs new data for model configuration. Specifically, RiverWare requires data on river flow routing parameters, a better assessment of return flows, and other data sets. This report will focus on the data needs for development of the URGWOM incorporating a water quality component as well as coupling with a groundwater model and its potential linkage to the coordinated database.

URGWOM

URGWOM was created based on the consensus and mutual interests of six federal agencies: U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. Bureau of Indian Affairs, the International Boundary and Water Commission (U.S. Section), and the U.S. Army Corps of Engineers in developing a unified water operations model for the Upper Rio Grande Basin to assist regional water managers (http://www.spa.usace.army.mil/urgwom/). URGWOM was designed to simulate water storage and delivery operations in the Rio Grande from the headwaters in Colorado to below Caballo Dam in New Mexico and for flood control modeling from Caballo Dam to Fort Quitman, Texas (Figure 8). It was developed using RiverWare modeling software (RiverWare), which was developed by CADSWES at the University of Colorado in Boulder, CO. RiverWare is a generalized river basin modeling environment that can integrate the analysis of power system economics with other purposes of reservoir systems such as flood control, water supply, recreation, water quality, and navigation (Zagona et al. 2001). RiverWare is designed to provide river basin managers with a tool for scheduling, forecasting, and planning reservoir operations. RiverWare's solutions can be either supply or demand driven at time steps ranging from hourly to monthly. It can simulate processes, such as mass balance water budgeting for reservoirs, river reach routing, diversions, water quality (temperature, DO, and TDS), and hydropower system economics.

The primary purpose of the URGWOM is to facilitate more efficient and effective management of water in the Upper Rio Grande Basin. Historically, the water of the Rio Grande has been used primarily for crop irrigation. However, rapid population growth in the Basin and urbanization in some areas has resulted in increasing and diversifying demands on the hydrologic system. Water management decisions are becoming increasingly complex and difficult due to the broad range of interests and issues that must now be considered. A greater variety and a large number of official entities and interest groups are asserting influence over water management decisions. As water supply limits are approached, higher levels of precision and reliability in water accounting and forecasting are required.

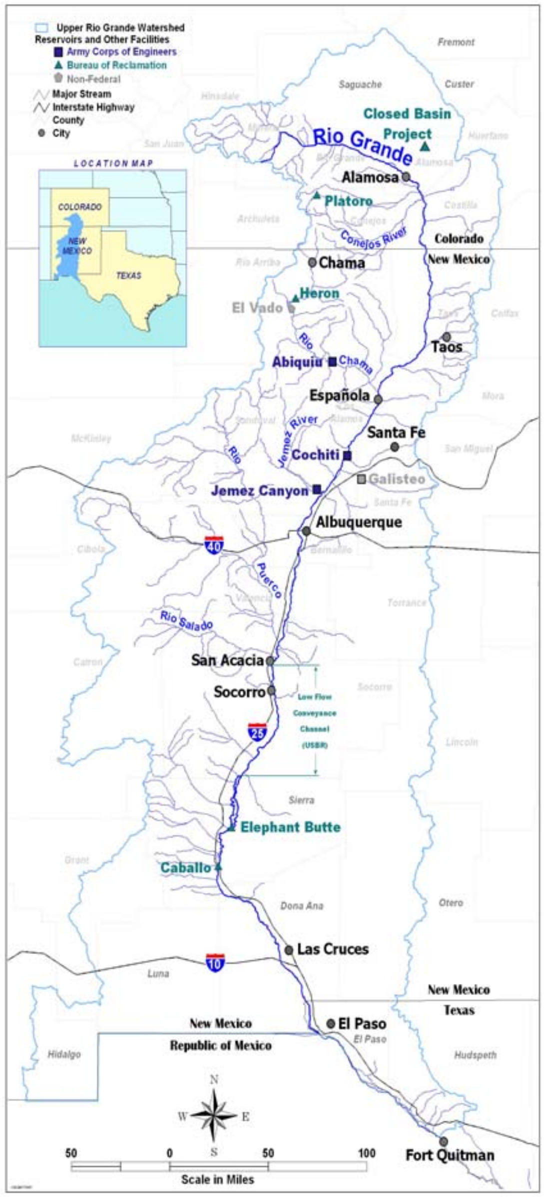

FIGURE 8. Modeling area of the URGWOM (from Stockton et al. 2004)

Among the considerations involved in contemporary water management decisions are flood regulation, irrigation demands, municipal and industrial demands, Indian water rights, compact and treaty obligations, water quality parameters, riverine and riparian habitat protection, endangered and threatened species protection, recreational uses, and hydropower generation. A reservoir and river simulation model will improve the availability, timeliness, completeness, and accuracy of information and data related to water storage, deliveries, depletions, flood control operations, and other related operations. It will provide real-time status information as well as the capability to evaluate proposed “what if” operation scenarios.

The current URGWOM configuration (accounting version) allows users to track the status of water for Compact deliveries, international treaty obligations, Indian water rights, various private rights, and contracts. Several of the major metropolitan areas in the Rio Grande Basin are moving toward a conjunctive use of their available water resources. This water use strategy allows municipal water managers to meet increasing water demand by using both groundwater and surface water supplies. These conjunctive use strategies require detailed and reliable accounting to ensure that groundwater pumping effects are offset by reservoir releases that “keep the river whole” for downstream users.

In addition to water accounting functions, the model (forecasting version) will provide better capability to forecast river and reservoir operations. Snowmelt runoff forecasts jointly provided by the National Weather Service and the Natural Resources Conservation Service would be the basis for these projections. The model will more accurately enable water managers to project system operations through a number of months and share the information more readily with all water stakeholders in the Basin. Better ability to forecast water operations will result in reduced waste, reduced unnecessary reservoir spills, and more equitable distribution of available water supplies. The model will also provide a better tool for optimizing the regulation of flows resulting from summer thunderstorm activity.

Short-, mid-, and long-range forecasts prepare water users and managers with information and data needed for more timely decisions and fewer crisis response scenarios. The model's forecasting capability (planning version) will provide an enhanced tool for water resources planning in the Basin. With improved tools available, planners can more easily formulate and evaluate proposals for infrastructure projects and management options.

Data needs

Information sharing is essential to maintaining communication throughout the water management community. The management of hydrologic data to meet the ever-increasing needs of water user communities requires increasingly sophisticated data management capabilities. In addition to providing accounting and forecasting functions, the model will also function as a central repository for information on system status, characteristics, and projected operations. The efficient and timely sharing of this information is necessary to help water managers make more fully informed decisions.

The RiverWare model provides a graphic-user interface (GUI), which allows a user to construct a model by selecting river reaches, reservoirs, confluences, diversions, and other objects and linking them to define the basin topology. Data associated with each object are entered or can be imported from other data sources. Operating parameters are added via constraint or rule-based editors. To aid in modeling the Upper Rio Grande, a database was developed to store the vast amount of data necessary to develop and maintain the model.

To expand the URGWOM for the reaches below Elephant Butte Reservoir, additional data are required. The Project provides a framework to feed data into or extract data from the URGWOM's database in addition to the data the USACE has acquired through other means. Data required for the model configuration and simulation range from spatial data – such as river mileage, gauge station locations, return flow discharge points, and others – to hydrologic data, such as river flow, diversions, reservoir storage, seepage losses, and other associated parameters.

In addition, water rights should be considered in the model simulation as well as constraints set by the Rio Grande Compact and 1906 Convention between the United States and Mexico on the Equitable Distribution of the Waters of the Rio Grande.

Potential Linkage of the Coordinated Database to URGWOM Using the RiverWare DMI

The Project currently provides linkages to various data collectors' websites, such as historic and real-time flow data from USIBWC and EBID, and maintains some data sets such as historic drain flows not available from other websites. With enhanced development of the data transfer protocol, such as FTP, HTTP, GNU WGET, and ArcIMS DDE as discussed in Part III of this report prepared by Srinivasan, the CDP can download data needed from other sources, compile it, and store it in the CDP data files. The data can then be fed into the URGWOM (planning version) through the RiverWare data management interface (DMI). In addition, data generated by the URGWOM can also be transferred back to the CDP for sharing with end users using the data transfer protocol as described in Part III of this report. The following sections list types of data available in the CDP and its potential linkage to the URGWOM.

Spatial information

With the Coordinated Database and GIS Project, spatial information for gauge stations, reservoirs, diversions, wasteways, and drain discharge points can be easily extracted from the GIS coverage. The river mileage can also be calculated. These data can be fed into the URGWOM through the DMI of the RiverWare. In general, there is no need to transfer these data back to the CDP from the model.

Hydrologic data

Flow – With further development of the coordinated database, historic and real-time flow data at gauge stations along the Rio Grande can be extracted from the host websites, USIBWC, USGS, and irrigation districts; compiled according to requirements of the URGWOM database; and integrated with data hosted within the CDP. Flow data includes river discharge, diversions for agricultural irrigation and/or municipal water supply, wastewater discharge into the river, wasteway spills and return flow from drains. Once compiled with quality assurance/quality control, data can then be transferred into the URGWOM for simulation. The simulated results for flow can also be transferred back to the CDP for users to view and analyze.

Reservoir storage – Reservoir storage records are maintained by and are available through USBR. Historic records can be transferred either directly from the host (USBR) or the CDP with compilation to the URGWOM database. The simulated reservoir storage information can be transferred back to the CDP. Specifically, short-term forecast data will be very useful for making timely decisions on flood control and water releases.

Water quality

Currently, URGWOM does not have a water quality component. However, regional water planners and managers have expressed considerable interest in water quality. It is anticipated that water quality component will eventually be incorporated in the URGWOM. The data available through the CDP will eventually be used for model simulation. The same protocol for data sharing as the flow data can be applied.

Groundwater water data

It is anticipated that URGWOM will be coupled with a groundwater flow model to address surface water and groundwater configuration. The groundwater component of the CDP will provide well locations, well depth, screen lengths, historic water level data, and pumpage for production wells (Sheng et al. 2005) needed for groundwater model configuration and simulation. The data need to be pre-processed according to the requirements of the groundwater model input before data can be used for the model simulation. The groundwater data can also be used for a stand-alone groundwater model simulation, such as TWDB (2005), and groundwater availability model (GAM) for major aquifers in the region including the *Hueco Bolson* (Heywood and Yager 2002 and EPWU 2002) and the Mesilla Basin (Ch2MHill 2002, Hutchison 2004, Weeden and Maddock 1999).

Discussion and Recommendations

The above-listed data sets are only examples to demonstrate how the coordinated data can be used in the expansion of the URGWOM for the reaches between Caballo Dam and Fort Quitman in Texas. In fact, the CDP can provide portions of data needed for watershed scale model simulation too, such as gauge station flow data and boundary of the watershed. Great potential exists for linking the CDP to the hydrologic model development by providing data as input for the model. Moreover, information generated from the model will further enhance the CDP.

To enhance utility of the coordinated database, the following recommendations are made:

1. Further assessment of data needs; for example, water rights in New Mexico for conjunctive management of surface water and groundwater as well as watershed/basin delineation and incorporation of additional data needed for different model development projects within the watershed
2. Further exploration of methods – for example, ArcHydro – that can efficiently process the data to meet the requirements of the model development and provide a good linkage between the coordinated database and hydrologic model

3. Further exploration of protocol for effectively sharing simulation results in the Coordinated Water Resources Database and GIS Project website. One or multiple data transferring methods, such as FTP, HTTP, GNU WGET, and ArcIMS DDE, discussed in Part III of this report can be implemented for the efficient data transfer and sharing

PART V

Closing Comments and Recommendations for Future Work

C. Brown, Z. Sheng, and M. Bourdon

Preliminary Survey

A preliminary survey was conducted during workshops at the URGWOM meeting on March 10, 2005, and the Paso del Norte Coordinated Database and GIS Project workshop March 11, 2005. This survey provides us information about user groups who are interested in the Coordinated Database and GIS. It also covers data and information that regional water stakeholders are most interested in and the best way to present that data. All the survey data collected have established a base of information for additional user-need surveys in the next Phase. Survey results are summarized in Appendix E. The results indicated that regional water stakeholders are interested in data collection and sharing. They are not only interested in water quantity, but also interested in water quality for both surface water and groundwater.

Closing Comments

The activities described in this Phase II Final Project Report for the Paso del Norte Watershed Council Coordinated Water Resources Database and GIS Project have generated outcomes and results of considerable interest and usefulness to water resource managers and researchers in the Paso del Norte region. Specifically, an enhanced operational website has been produced based extensively on the ArcIMS application that serves a wider range of water resource data more flexibly than was offered in Phase I of the Project. We have also contributed to the knowledge base of how to serve regional water resources in the Paso del Norte region more effectively, with these "lessons learned" being documented in this Phase II Project Final Report and workshop held on March 11, 2005, at New Mexico State University. These accomplishments, while notable, also point to opportunities for improvement in areas already identified for future database development and GIS interface work.

One area for continued effort is broadening the participation of data providers in future work. To varying degrees with certain providers, the volunteer nature of the participation of regional data providers limited the degree to which these organizations could participate. We believe that the continued participation of the regional data collectors in future phases of the Project would greatly improve the comprehensiveness and utility of the Project, and we recommend that this effort be continued to capture datasets of interest that we have not yet been able to obtain. To the degree possible, we also suggest that funds be sought in future stages of the Project to compensate other regional data providers for their time and effort in working with Project staff.

As this database project progresses and the Upper Rio Grande Water Operations Model (URGWOM) being developed by the U.S. Army Corps of Engineers extends further into reaches of the Rio Grande below the Elephant Butte Reservoir, Project efforts should continue to explore linkages with URGWOM. To date, the data collected under the USACE Phase I funding for the URGWOM project have been loaded into the Paso del Norte Watershed Council Collaborative Water Resources Database through links to the NMWRRI server discussed above. In future work, we will be putting up the DEM data and orthophotos that the USACE staff has provided to NMWRRI staff on the Project server at NMWRRI. In the future, the Project Database could also be linked directly to the URGWOM project website to provide real-time monitoring data once the URGWOM flood control model is in operation for the Rio Grande below Elephant Butte

Reservoir. Such configurations will allow interested parties to manage water operations more efficiently with real-time monitoring and model projection and help to cement the separate but related Project activities that have been funded to date by the EPWU and the USACE through its URGWOM project into a more cohesive whole.

Summary of Recommendations

The following summary of recommendations for future work has emerged from Project work and discussion with Project staff and the Technical Committee, and we recommend that these guide future proposals for Project work:

- Continued work on compiling new data sources not yet included in the Project to enhance data sharing,
- Installation of new monitoring stations and equipment and inclusion of these monitoring sites in future ArcIMS map products to fill data gaps and provide more real-time data,
- Strengthening the links with the Upper Rio Grande Water Operations Model (URGWOM) project being advanced by the USACE. Special focus should be given to serving DEM and orthophoto data recently transferred from the USACE to NMWRRI and enhancing direct web linkages with USACE and URGWOM project activities to improve model development capacity and enhance sharing of modeling results,
- Development and implementation of a user needs survey focusing on new data sets of interest, enhanced access mechanisms, and other suggestions to improve the Project website,
- Development and making available an on-line downloadable version of a Microsoft Access database of Project water resource data, and
- Development of an on-line help facility to support on-line searches of the database.

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List of Acronyms

CADSWES: Center for Advanced Decision Support for Water and Environmental Systems, University of Colorado, Boulder

CERM: Center for Environmental Resources Management, University of Texas, El Paso

CLC: City of Las Cruces

DEM: Digital Elevation Model

EBID: Elephant Butte Irrigation District

EPCWID #1: El Paso County Water Improvement District #1

EPWU: El Paso Water Utilities

ESRI: Environmental Sciences Research Institute

FGDC: Federal Geographic Data Committee

FTP: File Transfer Protocol

GAMS: Groundwater Availability Model

HTML: Hyper Text Markup Language

IBWC: International Boundary and Water Commission, United States and Mexico

IMIP: Instituto Municipal de Investigación y Planeación, Mexico

IMS: Internet Map Server

INEGI: National Institute of Statistics, Geography, and Information of Mexico

JMAS: Junta Municipal de Agua y Saneamiento

NMOSE: New Mexico Office of the State Engineer

NMSU: New Mexico State University

NMTXWC: New Mexico-Texas Water Commission

NMWRRI-NMSU: New Mexico Water Resources Research Institute, New Mexico State University

NWIS: National Water Information System

PdNWC: Paso del Norte Watershed Council

RGP: Rio Grande Project

SpARC: Spatial Applications Research Center, NMSU Department of Geography

TAMU: Texas A&M University

TDLR: Texas Department of License and Regulation

TWDB: Texas Water Development Board

UACJ: Universidad Autónoma de Ciudad Juárez

URGWOM: Upper Rio Grande Water Operations Model

USACE or USCOE: U.S. Army Corps of Engineers

USBR: United States Bureau of Reclamation

USGS: United States Geological Survey

UTEP: University of Texas at El Paso

Appendices

Appendix A: Attributes/Field of Well Information from Different Agencies

Table A1 shows the attributes of TWDB well information table as an example. EPWU uses the same fields as TWDB to document wells in a spreadsheet format. Table A2 shows the description of USGS monitoring well sites. Table A3 shows the fields of the NMOSE well information.

Appendix B: Metadata Developed by UACJ

These tables provide detail on the metadata related to the water well data compiled by researchers at UACJ, specifically the meaning of the various attributes in the shapefiles that UACJ has contributed to the Project.

Appendix C: Protocol of the TWDB Water Well Data

These tables and related text provide detail on how to access TWDB data on the Web and also provide screen shots of the Web output that various routines will yield at the TWDB website.

A**ppendix D: Glossary of Terms Used**

This Appendix provides a list of technical terms employed in this report and also some basic definitions of these terms to aid a lay audience in understanding various technical issues.

Appendix E: Results of Preliminary User-Need Survey

This Appendix provides preliminary results from the User Needs Survey conducted at the Users Workshop detailed earlier in the document.

Appendix A

TABLE A1. Explanation of Fields of the TWDB (2005) Well Data for JL-49-05-603 (EPWU well 32)

Field	Value	*Explanation
STATE WELL NUMBER	4905603	Click on the well number for well location map (*Please be patient while your map is being prepared - It may take up to 2 to 3 minutes until the map is ready*).
COUNTY CODE	141	El Paso County, Texas
BASIN	23	Rio Grande Basin
ZONE	1	
REGION NUMBER	1	
PREVIOUS WELL NUMBER	R-68	
LATITUDE	315631	DMS (in decimal degrees: 31.941944)
LAT DEC	31.941944	
LONGITUDE	1062432	DMS (in decimal degrees: -106.408889)
LONG DEC	-106.408888	
OWNER 1	City of El Paso	
OWNER 2		

DRILLER 1	City of El Paso	
DRILLER 2		
SOURCE OF COORDINATES	1	
AQUIFER CODE	112HCBL	HUECO BOLSON
AQUIFER ID1	1	Hueco-Mesilla Bolson Aquifer
AQUIFER ID2		
AQUIFER ID3		
ELEVATION	3987	feet

TABLE A1. Explanation of Fields of the TWDB Well Data for JL-49-05-603 (EPWU well 32) (cont.)

ELEVATION MEASUREMENT METHOD	M	INTERPOLATED FROM TOPO MAP
ALPHA CODE	260300	CITY OF EL PASO C/O PUBLIC SERVICE BOARD
DATE DRILLED	09211957	
WELL TYPE	W	Withdrawal of Water
WELL DEPTH	657	feet
SOURCE OF DEPTH	D	DRILLER'S LOG
TYPE OF LIFT	T	TURBINE PUMP
TYPE OF POWER	E	ELECTRIC MOTOR
HORSEPOWER	200.00	
PRIMARY WATER USE	P	PUBLIC SUPPLY
SECONDARY WATER USE		
TERTIARY WATER USE		
WATER LEVEL AVAILABLE	C	Click here for water level data

WATER QUALITY AVAILABLE	Y	Click here for water quality data
WELL LOGS AVAILABLE	DE	
OTHER DATA AVAILABLE	AC	
DATE COLLECTED OR UPDATED	09081995	
REPORTING AGENCY	01	TWDB or Predecessor Agency
WELL SCHEDULE IN FILE	Y	
CONTRUCTION METHOD	H	Hydraulic Rotary
COMPLETION	F	Gravel Pack w/Perforations
CASING MATERIAL	S	Steel
SCREEN MATERIAL	S	Steel

TABLE A2. Site Description of the USGS Well Data (USGS 2005)

LOCATION

Latitude 31°58'17", Longitude 106°35'25" NAD27,

El Paso County, Texas, Hydrologic Unit 13030102

WELL DESCRIPTION

The depth of the well is 310 feet below land surface. Altitude of land surface datum 3,850 feet above sea level NGVD29. The depth of the hole is 310 feet below land surface.

This well is completed in MESILLA BOLSON AQUIFER (112MSBL)

AVAILABLE DATA:

Data Type	Begin Date	End Date	Count
Groundwater levels	1987-12-09	2004-02-03	11

OPERATION:

Record for this site is maintained by the USGS office in Texas

CONTACT INFORMATION

Email questions about this site to Water Webserver Team

TABLE A3. New Mexico OSE Well Data (NMOSE, 2005)

(quarters are 1=NW 2=NE 3=SW 4=SE)
(quarters are biggest to smallest)

POD Number	Tws	Rng	Sec	q q q	Zone	X	Y
LRG 11632 S	18S	04W	27	3 2	C	336226	624601.

Driller Licence: 578 MAULDIN DRILLING & PUMP SERVIC

Driller Name: **Source:** Shallow
Drill Start Date: 02/20/2004 **Drill Finish Date:** 02/22/2004
Log File Date: 07/13/2004 **PCW Received Date:** 07/13/2004
Pump Type: **Pipe Discharge Size:**
Casing Size: 18 **Estimated Yield:** 1200
Depth Well: 68 **Depth Water:** 15

Water Bearing Stratifications:

Top	Bottom	Description
15	63	Sandstone/Gravel/Conglomerate

Casing Perforations:

Top	Bottom
28	68

Meter Number: 7896
Meter Serial Number: 04-8-1082 **Meter Make:** MCCROMETER
Number of Dials: 6 **Meter Multiplier:** 100
Unit of Measure: GALS **Meter Type:** Diversion
Usage Multiplier: **Return Flow Percent:**

Meter Readings (in Acre-Feet)

Read Date	Year	Mtr_Reading	Flag	Rdr	Comment	Mtr_Amount	YTD_Amount
06/23/2004	2004	47578	A	mm		0	
07/14/2004	2004	66115	A	mm		5.689	
10/15/2004	2004	143498	A	mm		23.748	29.437

Appendix B: Metadata Developed by UACJ

(Granados et al. 2004)

Wells in Cd. Juarez: Pozos_jz.shp

FID	Internal feature number.
Shape	Feature geometry.
POZOS_	Identificador
POZOS_ID	Identificador/ id
ELEVATION	Elevacion/ elevation
NUM_POZO	Numero de pozo/ well number
COOR_Y	coordenada en Y/ coord y
COOR_X	coordenada en X/ coord x
LATITUD	Latitud/ latitude
LONGITUD	Longitude/ longitude
EL_BROCA	elevacion broca// curbstone elevation
N1975	nivel piezometrico 1975/ groundwater levels 1975
Continued through	… groundwater levels
N1995	nivel piezometrico 1995/groundwater levels 1995
A85_E	Temperatura 1985/ temperature 1985
A85_F	pH 1985
A85_G	Sales disueltas 1985/ Dissolved salts 1985
A85_I	Calcio 1985/ calcium 1985
A85_J	magnesio 1985/magnesium 1985
A85_K	sodio 1985/ sodium 1985
A85_M	ortofosfatos 1985/ othophosphate 1985
A85_N	carbonato 1985/ carbonate 1985

A85_O	bicarbonato 1985/bicarbonate 1985
A85_P	sulfato 1985/ sulphate 1985
A85_Q	cloruro 1985/ chloride 1985
A85_U	dureza total CaCO3 1985/ total hardness
A85_V	dureza calcica 1985/ calcium hardness
A85_W	dureza de carbonatos 1985/ carbonate hardness
A85_Y	alcalinidad t 1985/alkalinity (T)
A85_Z	solidos totales 1985/ total solid
Continued through	… with some variations in parameters
A99_1A	fecha muestra 1999 primer semestre/ sample date first semester 1999
A99_1E	Temperatura 1999 primer semestre/ temperature first semester 1999
A99_1F	PH 1999 primer semestre/ Ph first semester 1999
A99_1G	Sales Disueltas 1999 primer semestre/ dissolved salts first semester 1999
A99_1I	Calcio (Ca) 1999 primer semestre/ calcium first semester 1999
A99_1J	Magnesio (Mg) 1999 primer semestre/ magnesium first semester 1999
A99_1K	Sodio (Na) 1999 primer semestre/ sodium first semester 1999
A99_1L	Potasio (K) 1999 primer semestre/ potassium first semester 1999
A99_1M	Ortofosfatos 1999 primer semestre/ orthofosphates first semester 1999

A99_1N	Carbonato (CO3) 1999 primer semestre/ carbonate first semester 1999
A99_1O	Bicarbonato (HCO3) 1999 primer semestre/bicarbonate first semester 1999
A99_1P	Sulfato (SO4) 1999 primer semestre/ sulphate first semester 1999
A99_1Q	Cloruro (Cl) 1999 primer semestre/ chloride first semester 1999
A99_1R	Fluoruro (F) 1999 primer semestre/ fluoride first semester 1999
A99_1S	Nitratos (NO3) 1999 primer semestre/Nitrate first semester 1999
A99_1T	Nitritos 1999 primer semestre/Nitrite first semester 1999
A99_1U	Dureza Total $CaCO_3$ 1999 primer semestre/ total hardness first semester 1999
A99_1V	Dureza Calcica Como $CaCO_3$ 1999 primer semestre/$CacO_3$ first semester 1999
A99_1X	Alcalinidad (F) 1999 primer semestre/ alkalinity first semester 1999
A99_1Y	Alcalinidad (T) 1999 primer semestre/ alkalinity first semester 1999
A99_1Z	Solidos Totales 1999 primer semestre/ total solids first semester 1999
A99_1AA	Conductividad 1999 primer semestre/ conductivity first semester 1999
A99_1AB	Silice 1999 primer semestre

A99_2A	Fecha muestra 1999 segundo semestre/ sample date second semester 1999
A99_2E	Temperatura 1999 segundo semestre/ temperatura second semester 1999
A99_2F	pH 1999 segundo semestre/ pH second semester 1999
A99_2G	Sales Disueltas 1999 segundo semestre/ dissolved salts second semester 1999
A99_2I	Calcio (Ca) 1999 segundo semestre/ calcium second semester 1999
A99_2J	Magnesio (Mg) 1999 segundo semestre/ magnesium second semester 1999
A99_2K	Sodio (Na) 1999 segundo semestre/ sodium second semester 1999
A99_2L	Potasio (K) 1999 segundo semestre/ potassium second semester 1999
A99_2M	Ortofosfatos 1999 segundo semestre/ orthofosphates second semester 1999
A99_2N	Carbonato (CO3) 1999 segundo semestre/ carbonate second semester 1999
A99_2O	Bicarbonato (HCO3) 1999 segundo semestre/bicarbonate second semester 1999
A99_2P	Sulfato (SO4) 1999 segundo semestre/ sulphate second semester 1999
A99_2Q	Cloruro (Cl) 1999 segundo semestre/ chloride second semester 1999

A99_2R	Fluoruro (F) 1999 segundo semestre/ fluoride second semester 1999
A99_2S	Nitratos (NO3) 1999 segundo semestre/ Nitrate second semester 1999
A99_2T	Nitritos 1999 segundo semestre/Nitrite second semester 1999
A99_2U	Dureza Total CaCO3 1999 segundo semestre/ total hardness second semester 1999
A99_2V	Dureza Calcica Como CaCO3 1999 segundo semestre/$CaCO_3$ second semester 1999
A99_2X	Alcalinidad (F) 1999 segundo semestre/ alkalinity (f) second semester 1999
A99_2Y	Alcalinidad (T) 1999 segundo semestre/ alkalinity (t) second semester 1999
A99_2Z	Solidos Totales 1999 segundo semestre/ total solids second semester 1999
A99_2AA	Conductividad 1999 segundo semestre/conductivity second semester 1999
A99_2AB	Silice 1999 segundo semester/Silica second semester 1999

Appendix B: Metadata Developed by UACJ (cont.)

(Granados et al. 2004)

Well in the valley: Pozos_valle.shp

FID	Internal feature number.
Shape	Feature geometry.
POZO	Identificador/Id
NUMERO	numero de pozo/wells number
OBRA	Tipo de Obra/ construction type
FECHA	fecha de analisis quimico/ date of chemical analysis
CA	niveles de calcio/ calcium levels
MG	niveles de magnesio/magnesium levels
NA	niveles de sodio/sodium levels
K	niveles de potasio/potassium levels
D_CACO3	dureza de carbonato de calcio/ calcium carbon hardness
RAS	Relacion de absorcion de sodio/ adsorption of sodium relation
PH	Metodo de lectura con potenciometro/ method of reading with potentiometer
CE	Conductividad electrica/ electric conductivity
SO4	Niveles de sulfato/ sulphate levels
HCO3	niveles de bicarbonato/ bicarbonate levels
NO3	nivel de nitratos/ nitrate levels
CO3	Carbonato/carbonate
CL	cloro/ chloride
TSOLDIS	Total de solidos disueltos/TDS

C_AGRIEG	calidad de agua para riego/quality of water for irrigation
A_AGUA	agresividad del agua/aggressiveness of the water
DTD	Diametro de tuberia de descarga en cm/Diameter of the unloading pipe
PTO	profundidad de la obra en mts./depth of the well
NE	nivel estatico en mts./ static level
T	temperatura en grados centigrados/ temperature in Celsius degrees
ND	nivel dinamico en mts./ dynamic level
Q	gasto en lt/s / discharge or well capacity lt/s
USO	Uso del agua/ water use
FUNCIONAMI	Funcionamiento / Function
O_OBS	observaciones/ observations
O_OBS2	otras observaciones/additional observation
TIPO	Tipo de pozos/ well type

Appendix C: Protocol of the TWDB Water Well Data

1. Search the Internet at **http://wiid.twdb.state.tx.us/index_explain.asp** to access water use survey and water planning website (Figure C1).

FIGURE C1. TWDB Water Use Survey and Water Planning Website

1) Select TWDB Groundwater Database (ArcIMS) and bring up a new interface.

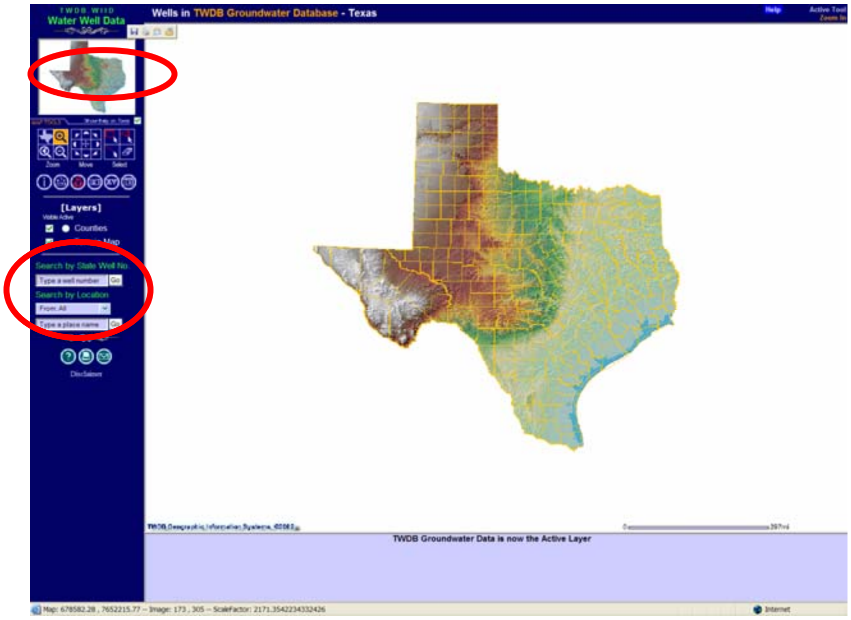


FIGURE C2. TWDB groundwater database website

2) Choose one of the two search methods; locate information by map (under top ellipse), or locate information by text (under large ellipse).

<u>Locate Information by Map</u>

1. Click on an area of the map to zoom in.
2. In the detailed map, click on desired location to search that region.
3. Continue to zoom in until well numbers are shown on the map.
4. Use identify button  to select the well of interest, and a table will indicate well information (Fig. C3).
5. Click the well number in the table, which will bring up the full screen of well information (Fig. C4).
6. From the table, users can view water levels and water quality data if available.

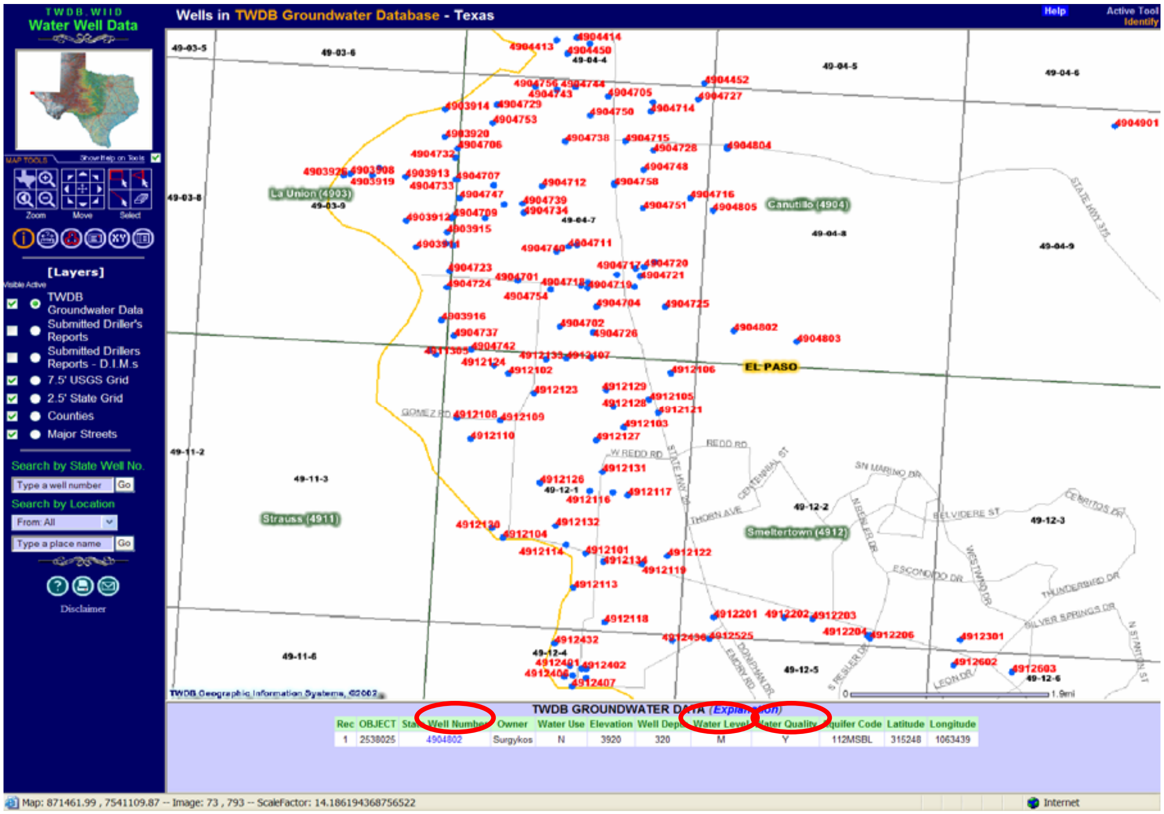
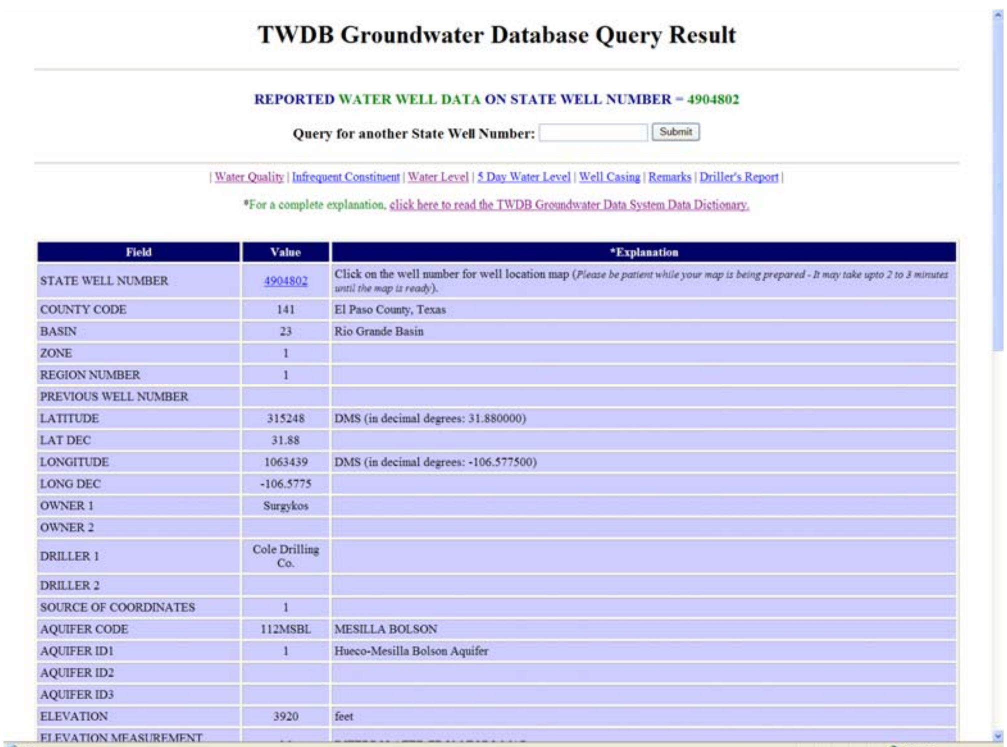


FIGURE C3. Well Locations and Information Table



TWDB Groundwater Database Query Result

REPORTED WATER WELL DATA ON STATE WELL NUMBER = 4904802

Query for another State Well Number: Submit

| Water Quality | Infrequent Constituent | Water Level | 5 Day Water Level | Well Casing | Remarks | Driller's Report |

*For a complete explanation, click here to read the TWDB Groundwater Data System Data Dictionary.

Field	Value	*Explanation
STATE WELL NUMBER	4904802	Click on the well number for well location map (*Please be patient while your map is being prepared - It may take upto 2 to 3 minutes until the map is ready*).
COUNTY CODE	141	El Paso County, Texas
BASIN	23	Rio Grande Basin
ZONE	1	
REGION NUMBER	1	
PREVIOUS WELL NUMBER		
LATITUDE	315248	DMS (in decimal degrees: 31.880000)
LAT DEC	31.88	
LONGITUDE	1063439	DMS (in decimal degrees: -106.577500)
LONG DEC	-106.5775	
OWNER 1	Surgykos	
OWNER 2		
DRILLER 1	Cole Drilling Co.	
DRILLER 2		
SOURCE OF COORDINATES	1	
AQUIFER CODE	112MSBL	MESILLA BOLSON
AQUIFER ID1	1	Hueco-Mesilla Bolson Aquifer
AQUIFER ID2		
AQUIFER ID3		
ELEVATION	3920	feet
ELEVATION MEASUREMENT	[illegible]	[illegible]

Done Internet

FIGURE C4. Groundwater Database Query Results

Locate Information by Text

1. Enter a name of a city, town, or county in the text field. Click the Search button to open a preview map.
2. Zoom in to get into next level where well locations are shown on the map.
3. Follow the same procedure outlined above to select the well of interest.
4. Or simply enter the state number of wells, which brings the user to the well site map with information table (Fig. C5).

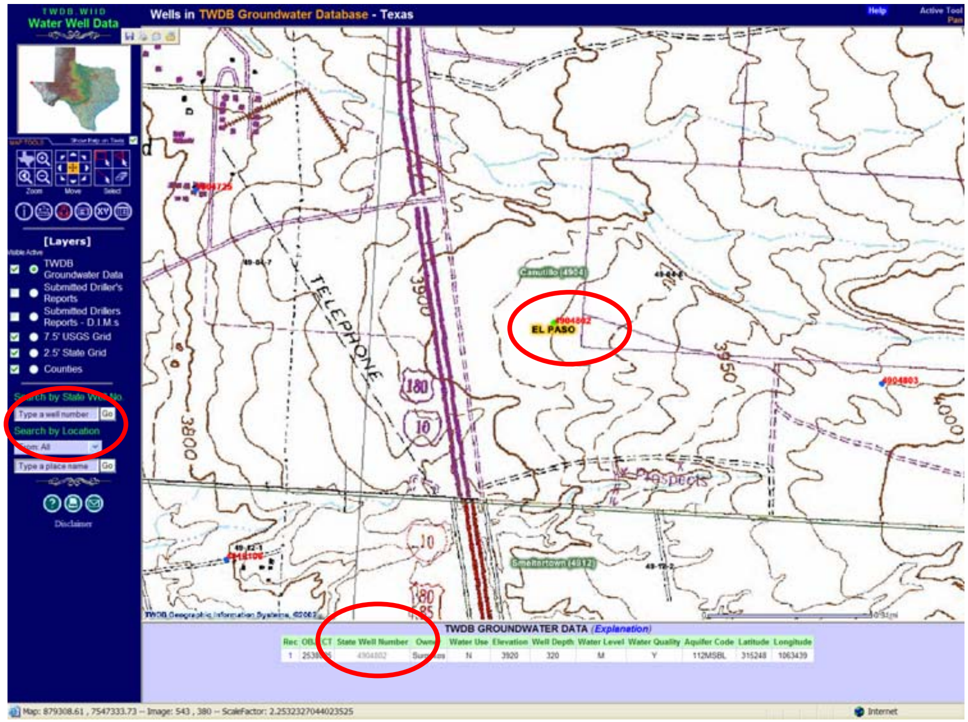


FIGURE C5. Detail Well Location Map and Information Table

Appendix D: Glossary of Terms Used

API

Abbreviation of application program interface, a set of routines, protocols, and tools for building software applications. An API is defined at source code level and provides a level of abstraction between the application and the kernel (or other privileged utilities) to ensure the portability of the code. An API can also provide an interface between a high level language and lower level utilities and services which were written without consideration for the calling conventions supported by compiled languages.

ArcIMS

The solution for delivering dynamic maps, GIS data and services via the Web. It provides a highly scalable framework for GIS Web publishing that meets the needs of corporate Intranets and demands of worldwide Internet access. ArcIMS services can be used by a wide range of clients including custom Web applications, the ArcGIS Desktop, and mobile and wireless devices. Using ArcIMS, city and local governments, businesses, and other organizations worldwide publish, discover, and share geospatial information.

ArcSDE

A server software product used to access massively large multi-user geographic databases stored in relational database management systems (RDBMSs). It is an integrated part of ArcGIS and a core element of any enterprise GIS solution. Its primary role is to act as the GIS gateway to spatial data stored in a RDBMS.

DDE

The Data Delivery Extension is an extension product to ArcIMS. It is architecturally independent of ArcIMS but can be configured to work with ArcIMS. The integration requires minor modifications to the ArcIMS HTML Viewer. The ESRI ArcIMS Data Delivery extension enables geographic information system (GIS) data publishing for ArcIMS. It allows ArcIMS users to make their data available in a wide variety of standard spatial formats.

FME

FME (Feature Manipulation Engine) is an intelligent translator for spatial data and does not stop at the simple translation of one GIS or CAD format to the other. Using the FME 'factories' it is possible to define rules to handle very complex models. The FME Suite consists of three main components: a translator, a transformation editor, and a viewer. FME Suite also includes developer tools and coordinate conversion support.

FTP

File Transfer Protocol, or FTP, is a protocol used to upload files from a workstation to an FTP server or download files from an FTP server to a workstation.

GIS

A system of hardware and software used for storage, retrieval, mapping, and analysis of geographic data. Practitioners also regard the total GIS as including the operating personnel and the data that go into the system. Spatial features are stored in a coordinate system (latitude/longitude, state plane, UTM, etc.), which references a particular place on the earth.

HTTP

Abbreviation for HyperText Transport Protocol (HTTP), the protocol for moving hypertext files across the Internet. Requires an HTTP client program on one end, and an HTTP *server* program on the other end. HTTP is the most important protocol used in the World Wide Web (WWW).

JAVASCRIPT

A scripting language developed by Netscape to enable Web authors to design interactive sites. Although it shares many of the features and structures of the full Java language, it was developed independently. JavaScript can interact with HTML source code, enabling Web authors to spice up their sites with dynamic content. JavaScript is endorsed by a number of software companies and is an open language that anyone can use without purchasing a license. It is supported by recent browsers from Netscape and Microsoft, though Internet Explorer supports only a subset, which Microsoft calls Jscript.

HTML

Abbreviation for HyperText Markup Language, the authoring language used to create documents on the World Wide Web. HTML defines the structure and layout of a Web document by using a variety of tags and attributes. The correct structure for an HTML document starts with <HTML><HEAD<BODY> and ends with </BODY></HTML>. All the information the users would like to include in their Web page fits in between the <BODY> and </BODY> tags.

WGET

WGET is a network utility to retrieve files from the Web using HTTP and FTP, the two most widely used Internet protocols. It works non-interactively, so it will work in the background, after the user has logged off. The program supports recursive retrieval of web-authoring pages as well as FTP sites.

TCP/IP

Abbreviation for Transmission Control Protocol/Internet Protocol, two interrelated protocols that are part of the Internet protocol suite. TCP breaks data into packets. IP routes packets. TCP enables two hosts to establish a connection and exchange streams of data. IP specifies the format of packets, also called datagrams, and the addressing scheme. TCP/IP was originally developed by the U.S. Department of Defense.

URL

Abbreviation of Uniform Resource Locator, the global address of documents and other resources on the World Wide Web. The URL contains the protocol of the resource (e.g., http:// or ftp://), the domain name for the resource, and the hierarchical name for the file (address).

Appendix E: Results of Preliminary User-Needs Survey

1. Affiliation?

Category	URGWOM	WORKSHOP	TOTAL
General public			
Water supply/management organization		5	5
Agriculture industry		1	1
State/federal agency	6	7	13
University		5	5
Consultant	5	1	6
Environmental group			
Other			
Total	11	19	30

2. Aware of the PdNWC Coordinated Water Resources Database and GIS before the workshop?

Category	URGWOM	WORKSHOP	TOTAL
Yes	10	14	24
No	1	5	6

3. Important for water managers and the public to have this access and a comprehensive source of flow and water quality information for the Paso del Norte region?

Category	URGWOM	WORKSHOP	TOTAL
Yes	11	19	30
No	0	0	0

4. Interested in using and learning more about this database?

Category	URGWOM	WORKSHOP	TOTAL
Yes	10	18	28
No	1	1	2

5. What information in the database and GIS are you most interested in?

Category	URGWOM	WORKSHOP	TOTAL
Gauge station locations	3	9	12
Historical River flows	4	11	15
Real-time river flows	3	9	12
Maps	5	12	17
Surface water quality	2	11	13

Diversion location/quantity	4	9	13
Sources & types of information available	2	10	12
Well locations	3	11	14
Groundwater levels	4	10	14
Groundwater quality	1	11	12
Pumpage	2	8	10
Other	All (3); Metadata; References; Aquifer	All; Comprehensive Flow; Water Quality	
	Physical property data; Climatic data (2); Land use (3); Drought map; Vegetation	Water levels on a regional basis; DOQs on ARCIMS site; Plots of the data available; Population; RS data; Long range; Cover the entire Mexican border; Water use, by sector; Delivery/infrastructure; Watershed info; Wildlife abundance and distribution; Surveys; Raster data sets available in satellite, DEMs, grids; Strip out unnecessary fields	

6. Have you used the Coordinated Database and GIS website before?

Category	URGWOM	WORKSHOP	TOTAL
Yes	2	10	12
No	8	8	16
No response	1	1	2

6a. If yes, please rate the organization of materials on the database/website:

Category	URGWOM	WORKSHOP	TOTAL
Excellent	2	6	8
Good	0	3	3
Acceptable	0	1	3

6b. If yes, were you able to download/copy data from the website?

Category	URGWOM	WORKSHOP	TOTAL
Yes	0	5	5
No	0	1	1
NA	1	0	1
No response	1	4	5

6c. Which features of the database/GIS do you find most useful?

Category	URGWOM	WORKSHOP	TOTAL

Answer	0	5 responses: Historical river flows; Spatial data; Streams and gauges; Hyperlink; Who supplies the data	5
No response	11	14	25

6d. Which features would you like to see expanded or improved?

Category	URGWOM	WORKSHOP	TOTAL
Answer	4 responses: More social/ economic information; Compiled US actual data graphs; Sorting data provided and US data compiled; Metadata	5 responses: Less toggling; Different compiled sets for different locations; Massive availability of historic data-matrix; Binational data sets; Search and apportion data and be able to download (.shp files), also seamless availability and download historic data	9
No response	7	14	21

7. Did the workshop provide valuable information on water resources data availability and access?

Category	URGWOM	WORKSHOP	TOTAL
Yes	6	12	18
No	0	0	0
No response	5	7	12

8. Was the information provided on database/website access and content useful?

Category	URGWOM	WORKSHOP	TOTAL
Yes	6	12	18
No	0	0	0
No response	5	7	12

9. How would you rate the overall workshop today?

Category	URGWOM	WORKSHOP	TOTAL
Excellent	5	15	20
Good	4	4	8
Acceptable	0	0	0
No response	2	0	2

10. Comments/Suggestions

Category	URGWOM	WORKSHOP	TOTAL
Answer	1 response: Multilayer queries will be important in the future	4 responses: What is the long term plan for this project? Grant funds have started it, how will it be maintained/updated? Where is the funding coming from? Compiling similar data sets into one database table for water quality, etc. would be more meaningful than separate, unrelated tables; The topic is interesting and the workshop was good; Would like to link with state agency like TNRIS; I wanted to see more of the tabular info available using your website, I'll be investigating it, good pres.; Goals should include greater interoperability, data fusion	5