DEVELOPMENT OF A GEOGRAPHIC INFORMATION SYSTEM FOR THE COMMONWEALTH UTILITY CORPORATION, SAIPAN WATER DISTRIBUTION SYSTEM

by
Dr. Leroy F. Heitz P.E.
Dr. Shahram Khosrowpanah P.E.

WATER AND ENVIRONMENTAL RESEARCH INSTITUTE
OF THE WESTERN PACIFIC
UNIVERSITY OF GUAM

Technical Report No. 132
September 2011

DEVELOPMENT OF A GEOGRAPHIC INFORMATION SYSTEM FOR THE COMMONWEALTH UTILITY CORPORATION, SAIPAN WATER DISTRIBUTION SYSTEM

by

Dr. Leroy F. Heitz P.E.
Dr. Shahram Khosrowpanah P.E.

University of Guam
Water and Environmental Research Institute
of the Western Pacific
UOG Station, Mangilao, Guam 96923

Technical Report No. 132
September 2011

The work reported herein was funded, in part by the Department of the Interior, via the Water Resources Research Institute Program of the U.S. Geological Survey (Award No. 06HQPA0002), administered through the Water and Environmental Research Institute of the Western Pacific (WERI) at the University of Guam. The content of this report does not necessarily reflect the views and policies of the Department of the Interior, nor does the mention of trade names or commercial products constitute their endorsement by the United States Government.

ABSTRACT

The US Environmental Protection Agency (EPA) has recently stressed that the water distribution system in Saipan, Commonwealth of the Mariana Islands (CNMI) is still in need of improvement. The EPA has acknowledged that the lack of safe drinking water has been among the top environmental challenges that the EPA found to be facing the CNMI, particularly Saipan. In a previous assessment, the EPA found Saipan to be the only municipality of its size in the United States without 24-hour water delivery. The agency reported that the water on the island is not drinkable due to its high salinity, and water flows through the pipes only a few hours per day for almost half of the island's residents.

In March of 2009, the CNMI, Commonwealth Utilities Corporation (CUC) entered into a stipulated order (STO) for preliminary relief under an agreement with the Government of the United States. The order provided for a long list of compliance items that CUC must complete in order to satisfy the stipulated order. One major item that CUC must prepare is a master plan for their water supply and wastewater systems. A part of this master plan is the "Development of a Geographic Information System (GIS) of the CUC drinking water and systems to facilitate better management of the CUC's system". As mentioned in the STO, the CUC will locate, map, and develop GIS layers for all of the following: treatment facilities, wells, water lines, storage tanks, collection systems, pump stations, and CUC's and Department of Environmental Quality (DEQ's) water quality monitoring stations.

A healthy water system that can perform its essential functions requires a good record of system inventory, location, connectivity, and maintenance practices. This information should be easily available to the water managers and field operators. Prior to this study, the water and inventory and maintenance data were being entered manually and stored in file folders. This created excess paperwork and it made it very difficult to track the frequency of maintenance, hard to provide information to the field operator groups, and created a lack of close communication between system managers and field operators. Additionally, there was no link between the physical hydraulic model of the water system that was previously created by WERI and the maintenance and system inventories. What this study accomplished was to initiate the creation of a GIS that contains the system description and system maintenance schedules and that can be made readily available to system managers and field operators. This project concentrated on the drinking water side of the CUC operation. It is anticipated that in the future the data base will be extended to include the system and the data from water meters that are being installed. The benefit of this project will be to provide an improved and more efficient management and operation of the Saipan water system.

ACKNOWLEDGMENTS

We thank the Engineering Staff of the Commonwealth Utility Corporation (CUC) for their support and assistance on this project. Special thanks goes to Mariano Iglecias and Larry Manacop who spent many hours working with the principal investigators improving the data that was input into the original water system models. We thank Commander Kenneth Esplin, Capt. Robert Lorenz, and Capt. Derek Chambers for their guidance, comments, and data.

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Page

INTRODUCTION

The US Environmental Protection Agency (EPA) has recently stressed that the water distribution system in Saipan, Commonwealth of the Northern Mariana Islands (CNMI) is still in need of improvement. The EPA has acknowledged that the lack of safe drinking water has been among the top environmental challenges that the EPA found to be facing the CNMI, particularly Saipan. In a previous assessment, the EPA found Saipan to be the only municipality of its size in the United States without 24-hour water delivery.[1] The agency reported that the water on the island is not drinkable due to its high salinity, and water flows through the pipes only a few hours per day for almost half of the island's residents.

In March of 2009, the CNMI, Commonwealth Utilities Corporation (CUC) entered into a stipulated order (STO) for preliminary relief under an agreement with the Government of the United States[2]. The order provided for a long list of compliance items that CUC must complete in order to satisfy the stipulated order. One major item that CUC must prepare is a master plan for their water supply and wastewater systems. A part of this master plan is the "Development of a Geographic Information System (GIS) of the CUC drinking water and systems to facilitate better management of the CUC's system". As mentioned in the STO, the CUC will locate, map, and develop GIS layer for all of the following: treatment facilities, wells, water lines, storage tanks, collection systems, pump stations, and CUC's and DEQ's water quality monitoring stations.

A healthy water system that can perform its essential functions requires a good record of system inventory, location, connectivity, and maintenance practices. This information should be easily available to the water managers and field operators. Prior to this study, the water and inventory and maintenance data were being entered manually and stored in file folders. This created excess paperwork and made it very difficult to track the frequency of maintenance, hard to provide information to the field operator groups, and created a lack of close communication between system managers and field operators. Additionally, there was no link between the physical hydraulic model of the water system that was previously created by WERI and the maintenance and system inventories. What this study accomplished was to initiate the creation of a GIS database that contains the system description and system maintenance schedules and that can be made readily available to system managers and field operators. This project concentrated on the drinking water side of the CUC operation. It is anticipated that in the future the database will be extended to include the system and the data from water meters that are being installed. The benefit of this project will be to provide an improved and more efficient management and operation of the Saipan water system.

OBJECTIVES

The specific objectives of this project were to:

1. Install GIS software on a newly purchased computer and provide three days training on the use of GIS and data entry to one or two personnel from CUC.
2. Export the information from Saipan's Haestad water system model into GIS layers.
3. Identify and create new data layers for features not included in the Haestad model but important for management of the CUC system.
4. Integrate the maintenance schedule and system inventories into GIS layers.
5. Make the database available to the system managers and system operators.

The development of the GIS database not only meets the requirements of the recently imposed Stipulated Order by US EPA, but also will assist CUC in providing improved operation and maintenance of the water system and will assist the CUC in meeting its goal of improved water quality and 24-hour water to all its customers.

STUDY AREA

Geographic and Hydrologic Setting

The Island of Saipan is located in the Commonwealth of the Northern Marianas Islands (CNMI) which is part of the Marianas Chain of the Islands of Micronesia. As shown in Figure 1, Saipan is located at approximately 15° 11' North Latitude and 145° 45' East Longitude, or approximately 1500 miles south of Japan and approximately 3500 miles west of the Hawaiian Islands. Its closest neighbors are Tinian and Rota in the CNMI, and the Territory of Guam which is located approximately 135 miles south.

Elevations on the island range from sea level to approximately 1400 ft on Mount Takpochao. The geology of the island varies from Limestone karst structures to structures of volcanic origin.[3] Ground water is a major source of water for the municipal water distribution system. Since the geo-hydrology of the island is highly complex, finding and developing groundwater successfully presents a great challenge to water managers. There are a few spring sources that have been developed for municipal use, and there are a few small streams on the eastern side of the island which presently are not used by the municipal water supply system.

Average rainfall in Saipan is approximately 77 inches per year at the airport. The rainfall is not evenly distributed over time. Approximately 67 percent of the rainfall occurs during the wet season months (July through December) and approximately 33 percent occurs during the dry season months (January through June).[4]

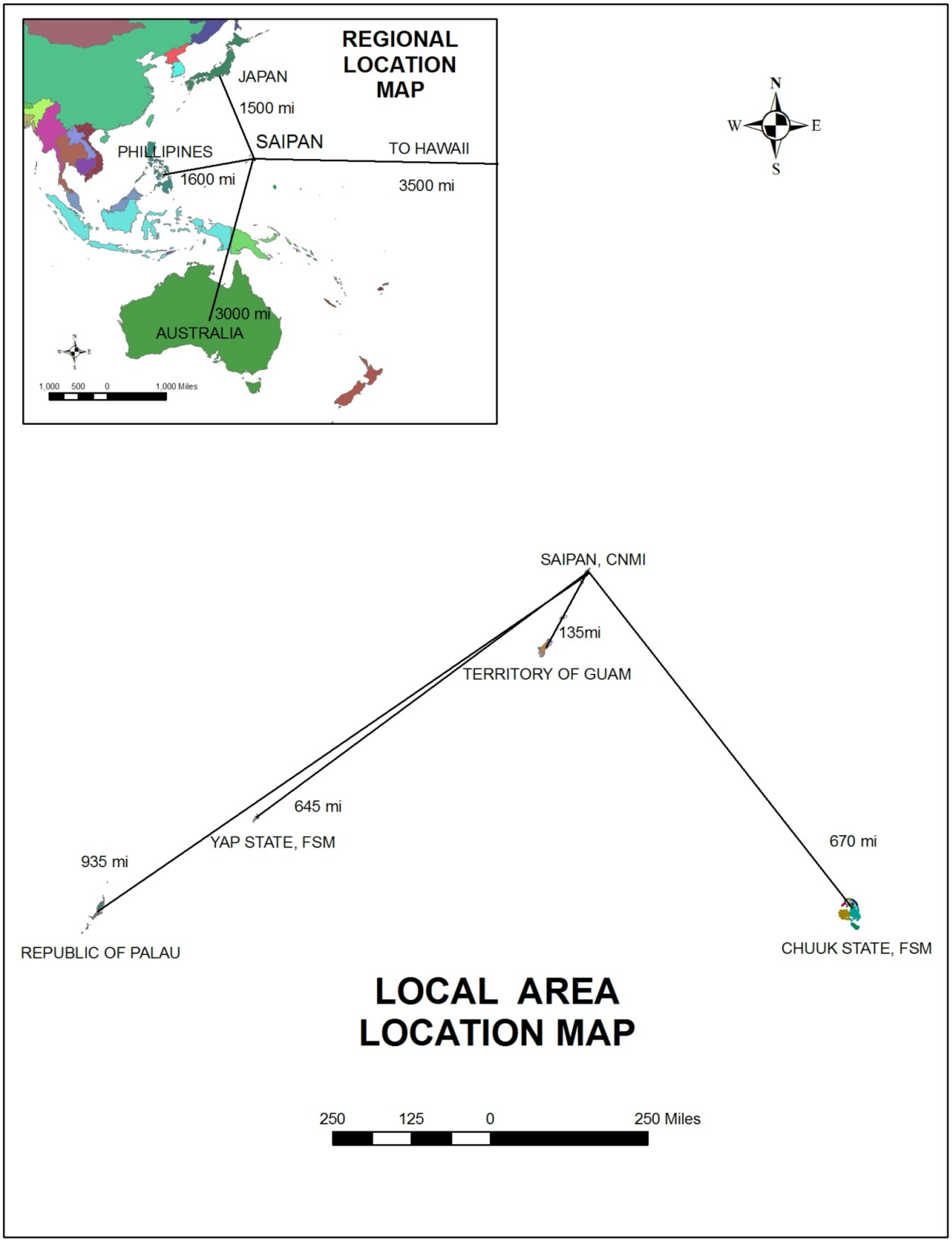


Figure 1. Location of Saipan, CNMI

WATER SYSTEM DESCRIPTION

Saipan's water distribution system, which is operated by the Commonwealth Utility Corporation (CUC), is divided into 15 sub-regions as shown in Figure 2. Each sub-region (I.D. numbers shown in red on Figure 2) can be operated as a separate entity or connected with adjacent regions. Each sub-system consists of well or spring sources, transmission piping, tanks for storage of water, and distribution system piping to deliver water to the CUC customers. The Saipan water system serves a population of 62,400 people. In 2006, CUC served a total of 14,600 customer accounts.

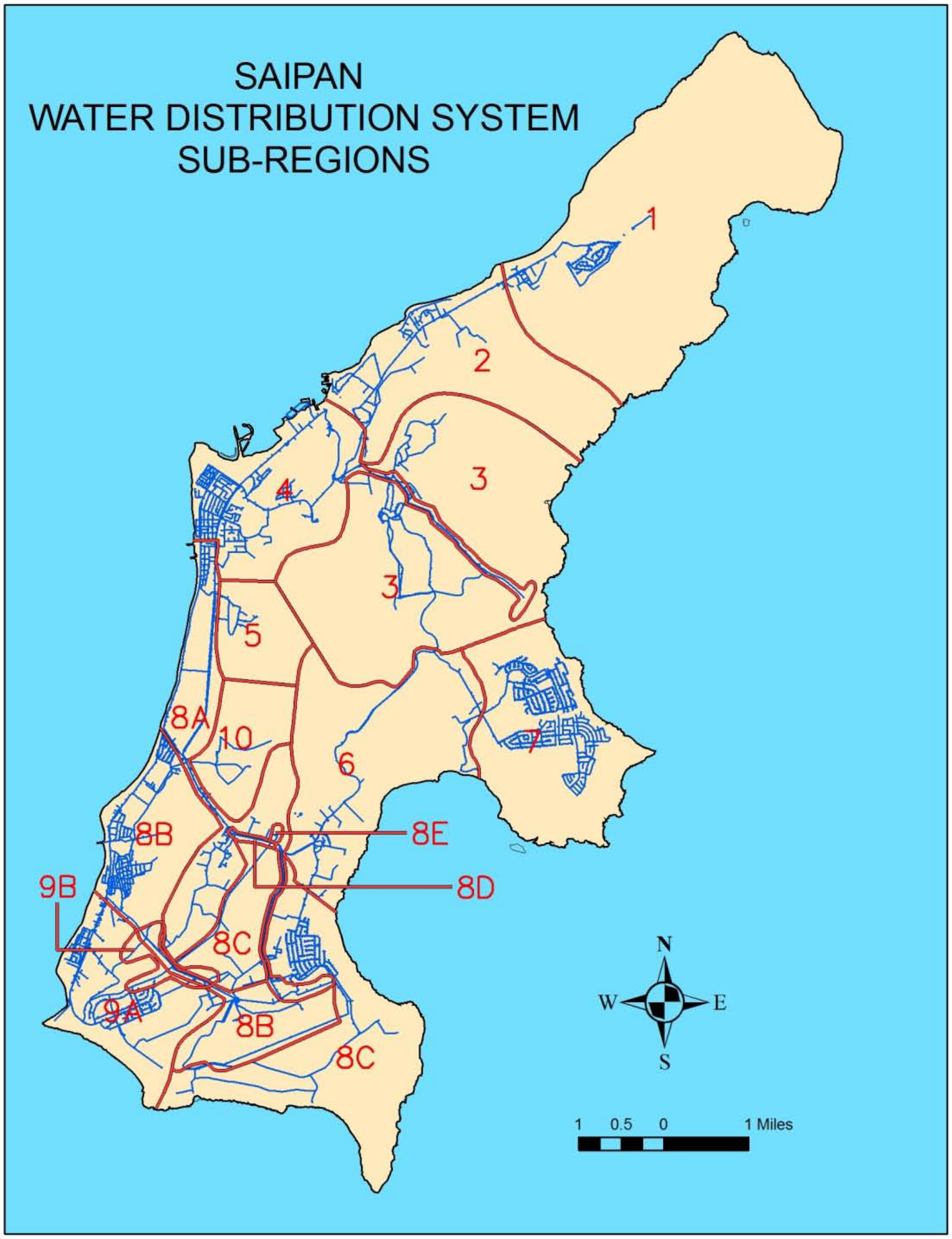


Figure 2. Saipan Water Distribution System, Water Delivery Sub-Regions

BACKGROUND

In earlier studies separate water distribution system models, using the Haestad WaterCAD for AutoCAD program, were developed by WERI engineers for each of the fifteen sub-systems in the Saipan water distribution system. Engineers from the CUC Water Divisions and the Governor's task force were provided instruction on how to operate the models.

One important parameter that was required by the model is the customer demands. These demands are input at the junction points in the models. WERI researchers embarked on a study to better quantify these demands. Using GIS techniques applied to US Census data coupled with known CUC water use rates they were able to quantify the number of users and water demands at each junction node in the model. [5]

The major goal of this study was to export the information from CUC's Haestad model described above into GIS layers usable in the ESRI ArcMap program.

METHODS AND PROCEDURES

This project was divided into five phases. Each of these phases is described below.

Phase I.
Installation of Compatible GIS software

A copy of the Latest version of ArcMap software and a compatible computer that works with this GIS and CUC's Haestad Computer model was purchased for CUC. CUC now has a designated workstation that is compatible with CUC's GIS, database, and water system model and that will be available to the water division staff.

Phase II
Exporting Model Data into GIS Layers

This step was carried out in close consultation with CUC water division staff. In planning meetings with CUC staff it was decided that the new GIS that was to be developed should not be segregated by region as was the original Haestad hydraulic models that were developed for each sub region.

To accomplish this de-segregation each of the regional models was turned into what is termed a "sub model" in the Haestad program. This process is shown in Figure 3. The user first chooses the "Export Sub-Model" command from the file menu. Next, the user chooses the components to be included in the sub-model using windowing. The final step is to assign a name and storage location of the sub-model that will be created. This process was created for each of the regional sub-models.

Next the original Sub Region 1 model was saved with a new name titled, "Entire System Model". Each of the sub-models was combined with the entire system model to create a new model containing all of the sub regions. This process is described in Figure 4. The user selects the "Import Sub-Model" command from the file menu. Next the sub model file to be added is chosen. Step 3 involves allowing the program to re-label any duplicate labels that may occur. This is important since the regional sub-models were developed separately and are quite likely to have duplicate labels. Step 4 in Figure 4 shows the new model that incorporates the original data plus the new data from the sub-model that was imported. After repeating this process for all of the sub-models a new model is created that contains all the data for the entire system. This "Entire System Model" will be used in the later described exportation steps to create most of the GIS data layers.

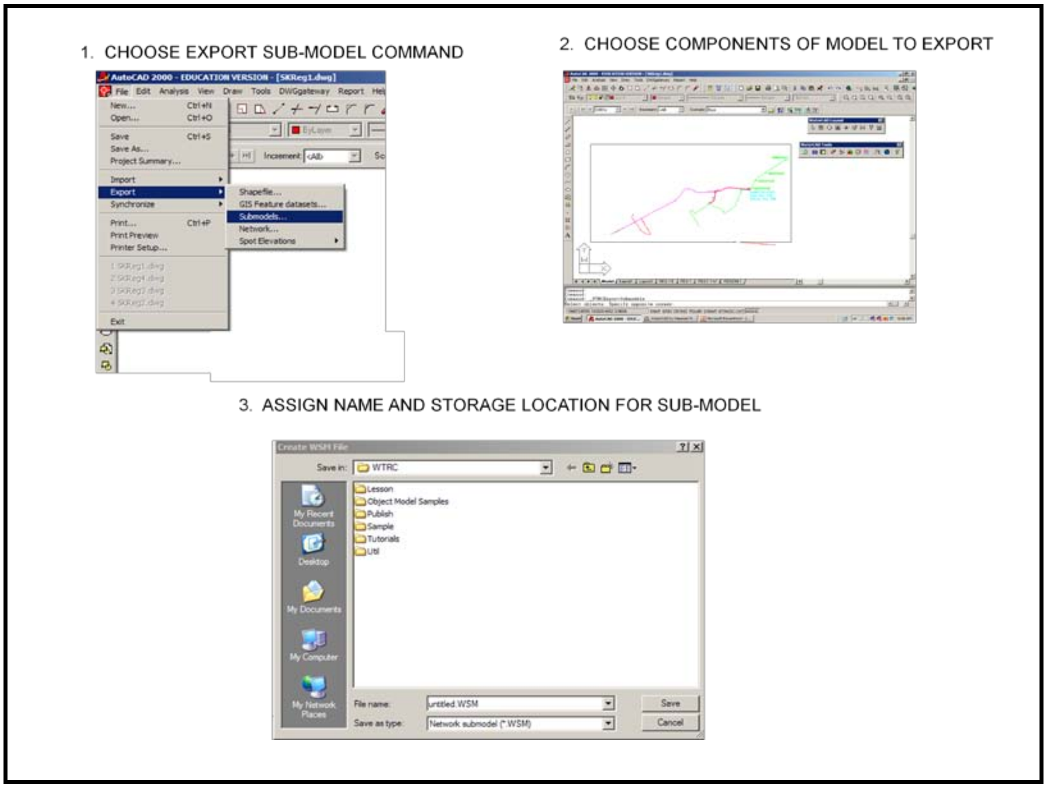


Figure 3. Using the Haestad model Export Sub-Model command

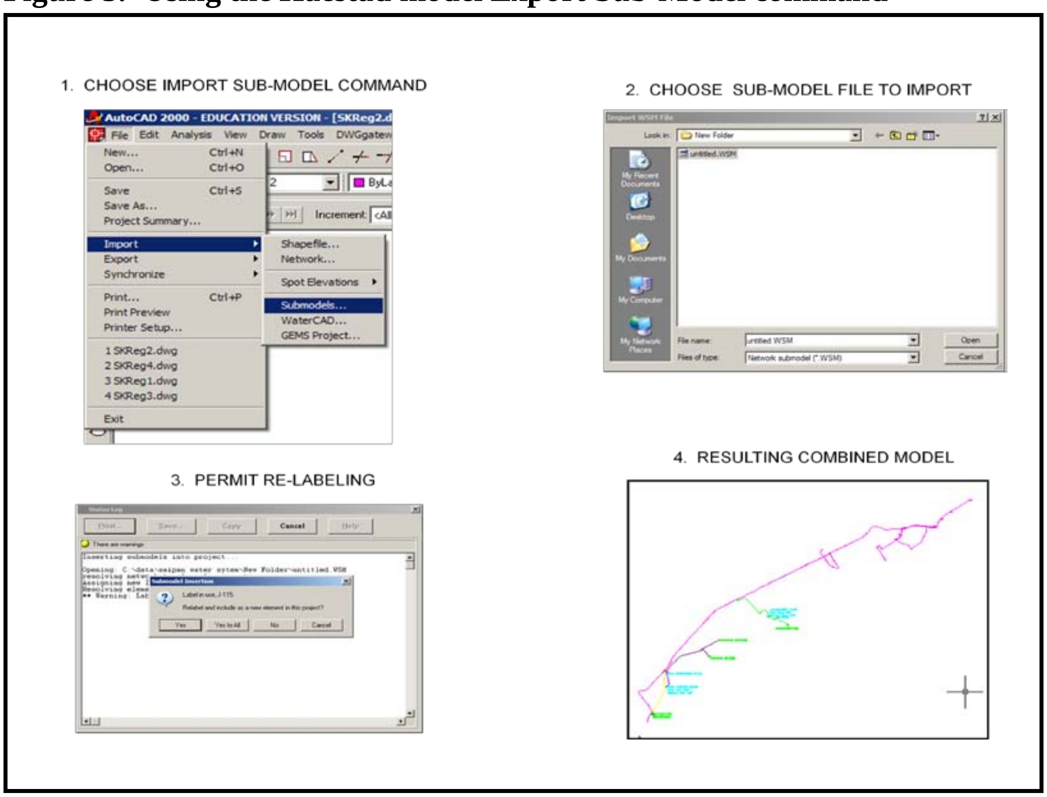


Figure 4. Using the Haestad Model Import Sub-Model Command

The next step was to determine what data layers were to be included in the GIS Data layers and what attributes were to be included for each different layer. This again was accomplished with consultation with the CUC water division staff. Table 1 on the following page provides a list of the layers that are included in the database along with a list of the management attributes that are included in the database.

The Haestad Software export tool was used to export the required feature data that was available in the model. This tool allows for any or all of the data available in the data table for a particular feature to be exported into ESRI shape file format. Figure 5 illustrates the steps in the process. The user first chooses the "Export Shape File" command from the file menu. Next the Haestad model element, such as a pipe or pump, to be exported is selected. In step 3 the attributes to be attached to the shape file are selected. The final step is to attach a name and storage location for the shape file. This procedure is repeated for each of the Haestad model elements to be exported to shape files. After exporting the shape files additional attribute fields that were requested by the CUC management team were added to the shape file attribute tables. Figure 6 below shows the completed GIS as viewed in the ArcMap program. Figure 7 shows sample attribute files for CUC Tanks, Pumps, and Pipes that are available in the GIS database.

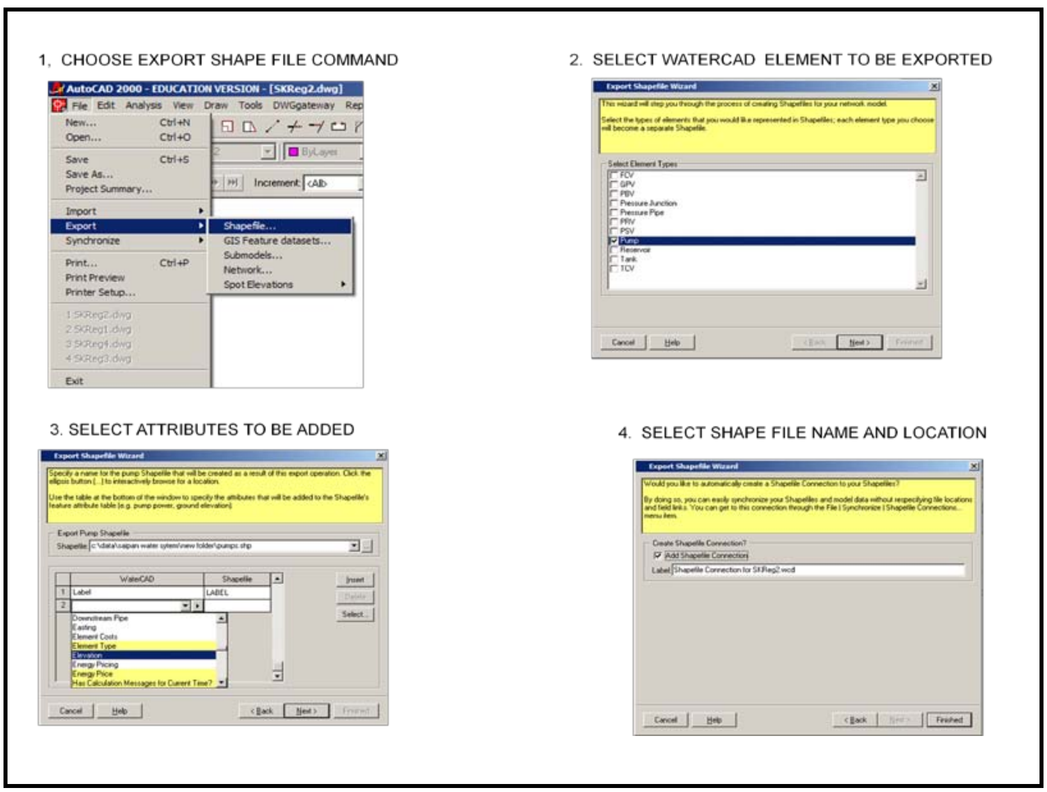


Figure 5. Using the Haestad Model Export Shape File Command

TABLE 1. GIS layers and management attributes from available Haestad water system models

LAYER NAME	LAYER TYPE	ATTRIBUTE 1	ATTRIBUTE 2	ATTRIBUTE 3	ATTRIBUTE 4	ATTRIBUTE 5	ATTRIBUTE 6	ATTRIBUTE 7	ATTRIBUTE 8
Gate Valves	Point	Serial Number	Diameter	Elevation	Maker	Working			
Pressure Reducing Valve	Point	CUC Number	CUC Name	Diameter	Elevation	Set Pressure	Model	Status	
Pipes	Line	Label (Model Pipe ID)	Diameter	Length	Material	CH Value	Start Node	End Node	Installed Date
Tanks	Point	Label (CUC-Name and Model Tank ID)	Base Elevation	Maximum Elevation	Minimum Elevation	Total Active Storage	Tank Diameter	Picture *	
Well	Point	Label (CUC-Name and Model Well ID)	Elev (Ground Water Elevation)						
Pump	Point	Label (CUC-Name and Model Pump ID)	Pump Curve ***	Pump Maintenance Data **	Direct Feed To Customers (yes or no)				
Junctions	Point	Label (CUC-Name and Model Junction ID)	Elevation	People Served	Type of Fitting				

*Hyperlink to Picture of Tank **Hyperlink to CUC Excel Maintenance Data Base *** Hyperlink to Pump Curve pdf
Underlined data layers were not available in the Haestad Model therefore next layers were constructed for these features

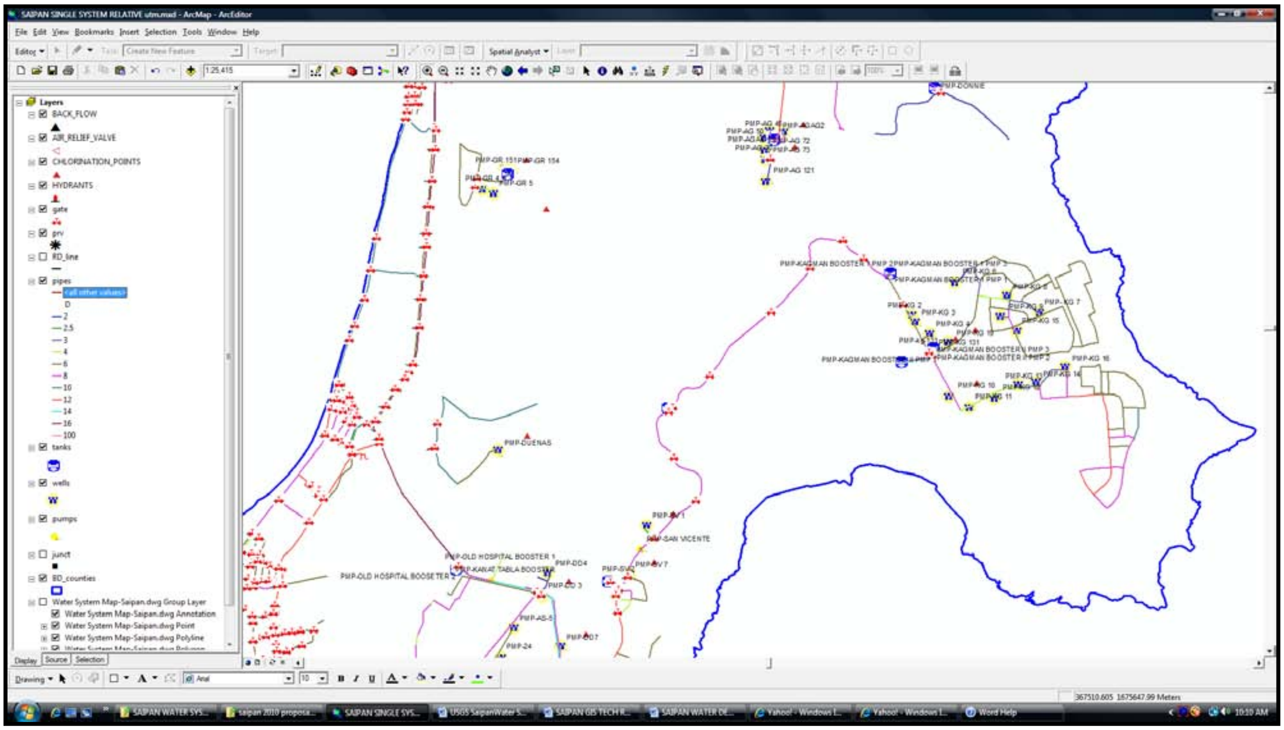


Figure 6. CUC Water System GIS Data Base as viewed in the ArcMap Program

TANK ATTRIBUTE FILE

OBJECTID *	Shape *	LABEL	LABEL_1	DESC_	TOT_ACT	BASE_ELEV	H_MIN	INIT_HGL	MAX_ELEV	H_MAX	MIN_ELEV	H_MIN_1	VI	TANK_D	X	Y	
1	Point	T-ACHUGAO SUMP		ACHUGAO SUMP TANK	23937.66	233	0	237	241	8	233	0	0	0	183722.72	190116.68	
2	Point	T-MAUI		MAUI TANK	999369.17	255	0	256	276	21	255	0	0	90	174982	181420	<Null>
3	Point	T-TASA SUMP		TASA SUMP TANK	14362.6	34	1	42.9	43	9	35	0	0	0	177626.12	186800.31	<Null>
4	Point	T-AGAG TANK		AGAG TANK	103403.28	609	6	620	626	17	615	0	0	40	178847	173820.64	<Null>
5	Point	T-CAPITOL HILL			1000558.89	870	10	885	890	20	880	0	0	130.5	177905	178543	PICTEST1.JPG
6	Point	T-ISLEY TANKa			1000558.89	184	2	190	196	12	186	0	0	130.5	168867.36	148898.48	<Null>
7	Point	T-HOSPITAL			1007594.43	142	5	152	182	40	147	0	0	70	168319.35	159412.02	<Null>
8	Point	T-GUALO RAI		GUALO-RAI TANK	200012.27	303	7	315	327	24	310	0	0	44.75	169951.58	172601.73	<Null>
9	Point	T-ACHUGAO		ACHUGAO TANK	200111.78	221	4	229	233	12	225	0	0	65.25	183301.63	190235.53	<Null>
10	Point	KOBBLER NSUMP 0120			14961.04	125	0	127.5	130	5	125	0	0	0	166236.79	150315.55	<Null>
11	Point	T-SAN VICENTE		SAN VICENTE TANK	500132.32	320	5	330	352	32	325	0	0	56.15	173382.25	159029.02	<Null>
12	Point	T-2			1081322.14	370	0	390	411	41	370	0	0	67	183134.51	166418.85	<Null>

Record: 1 Show: All Selected Records (1 out of 27 Selected) Options

PUMP ATTRIBUTE FILE

LABEL	LABEL_1	PUMP_DEFIN	DESC_	ELEV	X	Y	PUMP_CURVE	PUMP_DATA	PUMP_MAIN_DATA	DIRECT_FEED
PMP-AS-5		AEROMOTOR 50-500 (PMP-24) (PMP-AS-5) (PMP-AS-2)		0	170231.39	157434.51	<Null>	<Null>	<Null>	<Null>
PMP-KUMOY 3		AERMOTOR 6A80-10 (PMP-KUMOY 3)		-14	164613.33	153139.81	<Null>	<Null>	Pump Data-Region 8A.xls	<Null>
PMP-AS-2		AEROMOTOR 50-500 (PMP-24) (PMP-AS-5) (PMP-AS-2)		-5	169112.56	155904.09	<Null>	<Null>	<Null>	<Null>
PMP-KAGMAN B		PEERLESS 3PV11 50 HP (PMP-KAGMAN BOOSTER 1 PMP 1) (PMP-KAGMAN BOOSTER 1 PM		364	182684.57	169310.08	<Null>	<Null>	<Null>	<Null>
PMP-KV 25		AERMOTOR 75-500 (PMP-KV 22) (PMP-KV 25) (PMP-KV 11) (PMP-KV 12) (PMP-KV 17) (PMP-M		-5	161297.16	148113.62	<Null>	<Null>	Pump Data-Region 9A.xls	<Null>
PMP-SQ 11		Aermotor 75-750 (PMP-SQ 6) (PMP-CL 5) (PMP-SQ 12) (PMP-SQ 149) (PMP-PR 164) (PMP-SQ 7)		-2	177228.98	180290.41	TEST PUMP CURVE.pdf	<Null>	Pump Data-Region 4.xls	<Null>
PMP-KG 13		AERMOTOR 35-300 (PMP- KG 7) (PMP-KG 9) (PMP-KG 13) (PMP-KG 14) (PMP-KG 11) (PMP-KG		-4.25	187044.46	165593.94	<Null>	<Null>	Pump Data-Region 7.xls	<Null>
PMP-SQ 150		AERMOTOR 230S250-9BB (PMP-SQ 150)		-2.5	177007.1	183672.21	<Null>	<Null>	Pump Data-Region 4.xls	<Null>
PMP-KAGMAN B		PEERLESS 4PV8A (PMP-KAGMAN BOOSTER II PMP 2) (PMP-KAGMAN BOOSTER II PMP 3) (P		0	184114.4	166842.4	<Null>	<Null>	<Null>	<Null>
PMP-MQ 9		GRUNDFOS 40S75-21		-8	190882.01	195806.22	<Null>	<Null>	Pump Data-Region 1.xls	<Null>
PMP-KV BOOSTE		GRUNDFOS 200-800 9PM (PMP-KV BOOSTER PMP 1) (PMP-KV BOOSTER 1 PMP 2)		131	166229.57	150254.48	<Null>	<Null>	<Null>	<Null>
PMP-IF 206		AERMOTOR 75-500 (PMP-IF 23) (PMP-IF 208) (PMP-IF 206) (PMP-IF 106) (PMP-IF 202) (PMP-IF		-2	171590.87	150069.74	<Null>	<Null>	Pump Data-Region 8A.xls	<Null>

Record: 1 Show: All Selected Records (0 out of 151 Selected) Options

PIPE ATTRIBUTE FILE

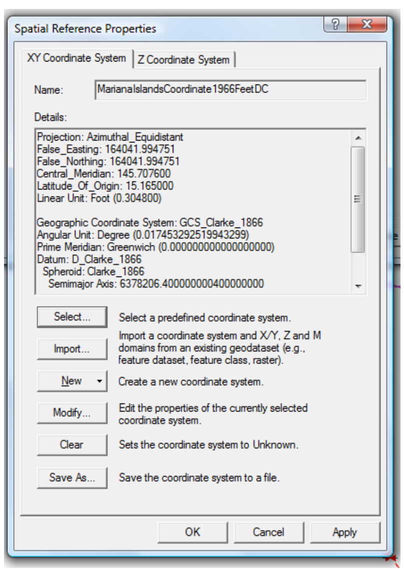
OBJECTID *	Shape *	LABEL	LABEL_1	DESC_	L	MATERIAL	MAT_DESC	C	KM	START_NODE	STOP_NODE	D	Shape_Length	INSTALLED_DATE
1	Polyline	P-47a			15	PVC	PVC	150	0	PBV-3	J-31a	16	15.000001	<Null>
2	Polyline	P-172b			261	Asbestos Cement	Asbestos Cement	140	0	J-70b	J-71b	6	260.553234	<Null>
3	Polyline	P-137b			785	PVC	PVC	150	0	J-54c	J-57c	6	785.084823	<Null>
4	Polyline	P-406			349	Asbestos Cement	Asbestos Cement	140	0	J-194a	J-205a	8	349.155325	<Null>
5	Polyline	P-43f			1209	PVC	PVC	150	0	TCV-12e	J-19g	10	1209.376496	<Null>
6	Polyline	P-441			389	Asbestos Cement	Asbestos Cement	140	0	J-225b	J-227c	8	388.70772	<Null>
7	Polyline	P-290d			1324	PVC	PVC	150	0	J-152b	J-136c	8	1323.700223	<Null>
8	Polyline	P-499a			14	PVC	PVC	150	0	FCV-185a	J-58e	8	13.967846	<Null>
9	Polyline	P-13a			173	PVC	PVC	150	0	J-9b	FCV-4a	12	172.999798	<Null>
10	Polyline	P-715			374	PVC	PVC	150	0	J-344	J-345	4	373.855044	<Null>
11	Polyline	P-252a			11	PVC	PVC	150	0	J-115b	FCV-122	10	10.56104	<Null>
12	Polyline	P-217a			26	PVC	PVC	150	0	T-TASA SUMP	PMP-TASA SUMP	12	26.100281	<Null>
13	Polyline	P-446b			2797	PVC	PVC	150	0	J-233c	J-94d	6	2796.872055	<Null>
14	Polyline	P-561a			22	PVC	PVC	150	0	J-281	FCV-216	6	21.837231	<Null>
15	Polyline	P-579			54	PVC	PVC	150	0	J-287	FCV-226	6	53.560594	<Null>

Record: 1 Show: All Selected Records (0 out of *2000 Selected) Options

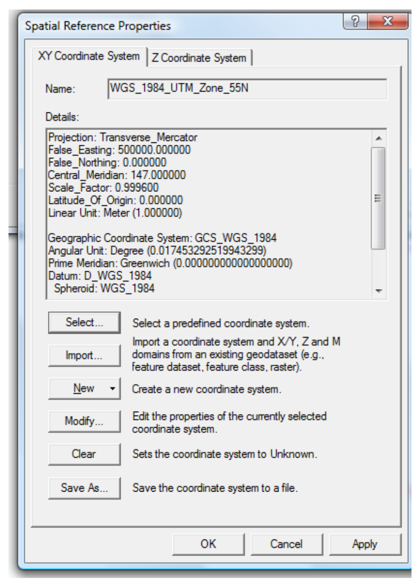
Figure 7. Sample Attribute files for CUC Tanks Pumps and Pipes that are available in the GIS data Base

MAP DATUMS AND TRANSFORMATIONS

All of the data layers that were developed for this project were developed in the local coordinate system that is used by the CUC. This coordinate system uses an Azimuthal Equidistance Projection based on the Clark 1866 Geographic Coordinate System. In order to maintain compatibility with other coordinated systems and with Global Positioning System (GPS) data the coordinate system that was used within the GIS data frame was a Universal Transverse Mercator Projection (UTM) based on the World Grid System (WGS) 1984 Geographic coordinate system. The definitions for these two systems are shown in figure 8. In order to use the local coordinate system a transformation is required between the Clark 1866 to the WGS 1984 system. The transformation values that seemed to work best in matching existing satellite data and other UTM maps was provided by Mr. Paul Camacho of the CNMI Department of Land Management.[6] He is their GIS Administrator and has vast experience in surveying and GIS in the CNMI. The required transforms he suggested were dx = +59.935 dy = +118.40 and dz = +10.87. These transformation units are all in meters.



Local Coordinate System Definition



UTM Coordinate System Definition

Figure 8. Spatial reference properties for the layers and data frames used in the CUC GIS System

PHASE III
Designating new layers and their attributes

Additional layers other than those available from the Haestad water system model data were determined by a series of meetings with CUC Water Division staff and DEQ who have an interest in the GIS system. Table 2 shows the GIS management layers and their accompanying attributes that were added

TABLE 2. GIS layers that were not available in the Haestad water system models

LAYER NAME	LAYER TYPE	ATTRIBUTE 1	ATTRIBUTE 2	ATTRIBUTE 3	ATTRIBUTE 4	ATTRIBUTE 5
Backflow Preventer	Point	CUC Number	Serial Number	Manufacturer	Customer Number	
Air Relief Valve	Point	CUC Number	Diameter	Manufacturer	Model	Status
Chlorination Point	Point	Treatment ID Number	Common Name	Region	Status	
Hydrants	Point	CUC Number	Serial Number	Manufacturer	Flush Date	

PHASE IV
Integrate the maintenance schedule and system inventories into GIS layers

CUC Water Division provided the pump maintenance spreadsheet workbooks that were incorporated into the GIS layers. This was the only data available that was in a format that could be readily used by the GIS. Hyperlinks are provided in the GIS for each well and pump site to access this data base. A data attribute called "Pump Curve" was also added to the pump data. CUC engineers will be able to input the names of scanned pump images in the data base and they will be easily accessible from the GIS. Special hyperlink fields were added so that pictures of the tank features could also be viewed directly from the GIS program. Any new maintenance files or scanned images must reside in the same folder as the "GSI.mxb" file for the CUC GIS.

Figure 9 shows how by using the "Identify" command a particular pump is chosen. Then by selecting the hyperlink for the maintenance data base the maintenance data for that particular pump is made available. Figure 10 shows Pump Curve Data accessed directly from the ArcMap Program. Please note that only a sample pump curve is shown. The actual pump curves will be added to the data base by CUC Water Division engineers. Figure 11 shows a photograph of the Capital Hill water storage tank accessed directly from the ArcMap Program.

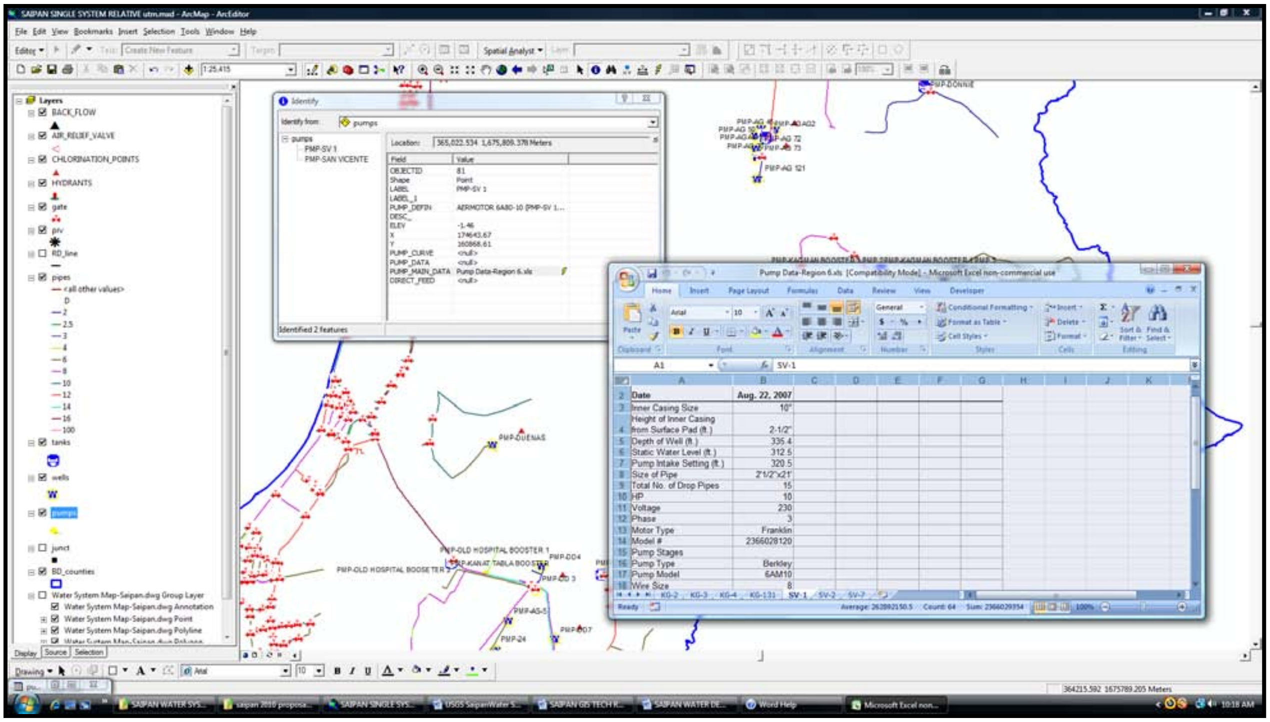


Figure 9. Pump Maintenance Data for Well Pump SV-1 accessed directly from the ArcMap program

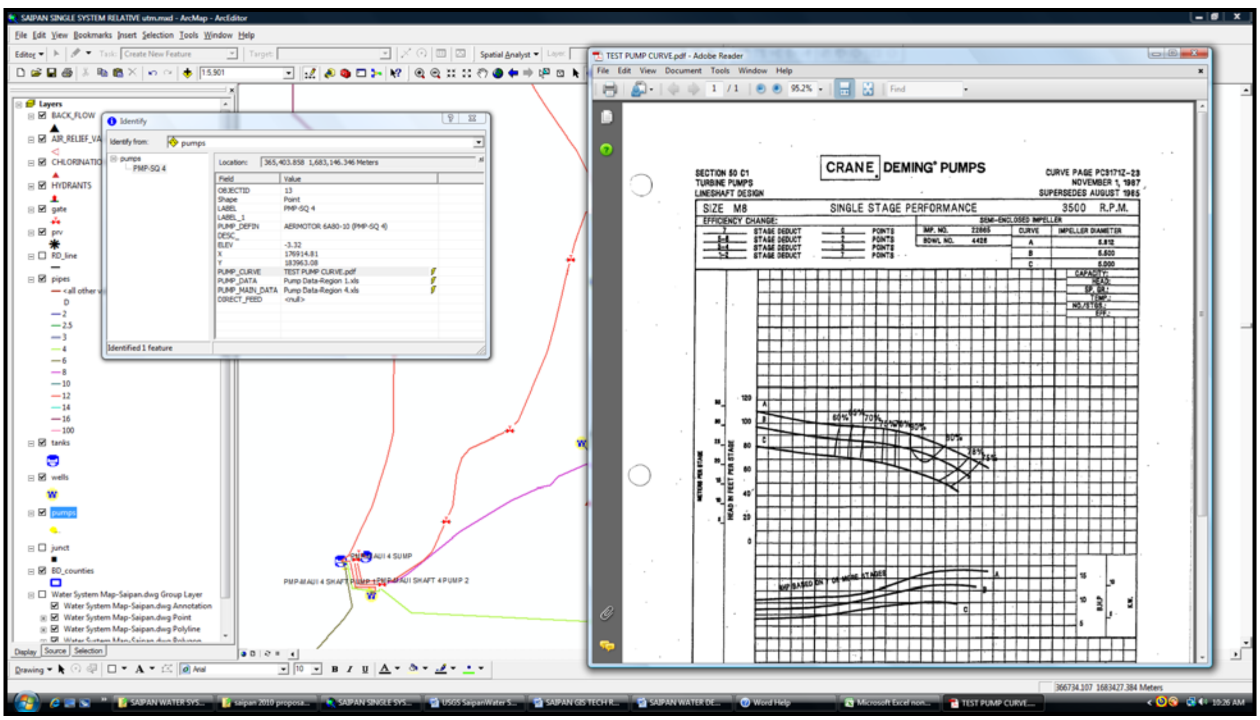


Figure 10. Pump Curve Data accessed directly from the ArcMap Program. Please note that this is only a sample pump curve. The actual pump curves will be added to the data base by CUC Water Division engineers

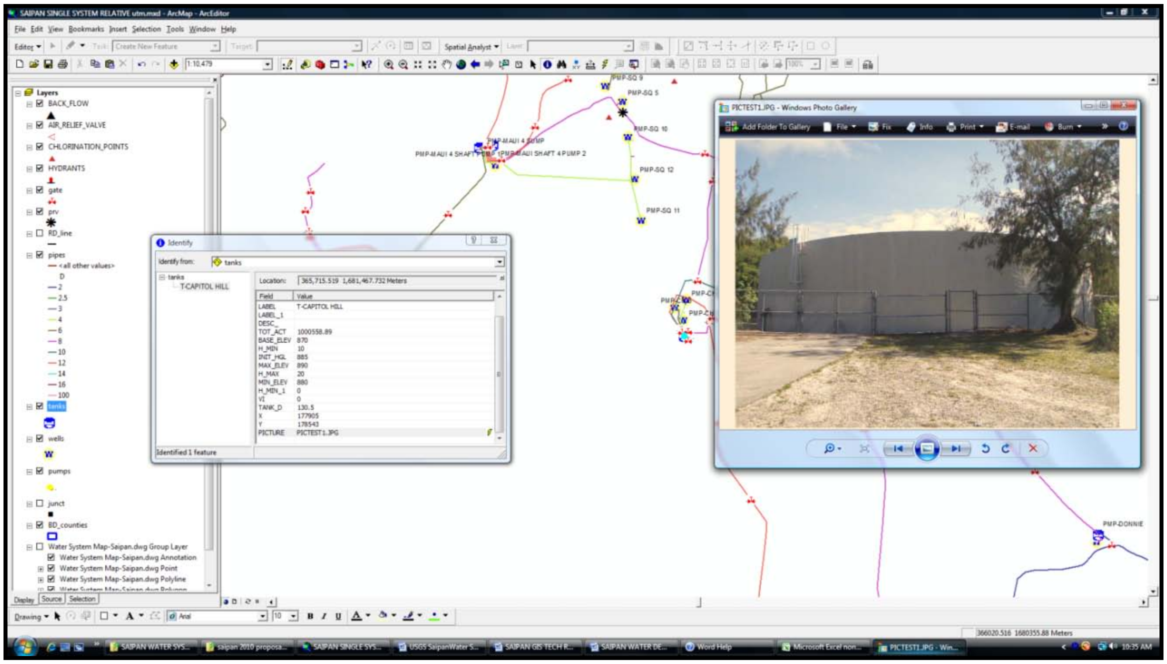


Figure 11. A photograph of the Capital Hill water storage rank accessed directly from the ARC View program

PHASE V
Make the data base available to the system managers and system operators

The final phase of the study was to make the GIS available to CUC water division. A new computer was purchased for the CUC water division and the computer was loaded with ArcMap and the Haestad Water system model during the first Phase of this project. All of the GIS management data was combined into one common ESRI geo. This allows for easy maintenance and exchange of all the required GIS files. These files along with the GIS Management System "MXB" file and other auxiliary files were loaded onto a CD for transport and loading onto the CUC water system computer. The files were transferred and the entire system was checked to be sure that it was operating properly on the CUC computer. A class on use of the GIS was carried out by WERI researchers for all interested CUC staff.

RESULTS

What this study accomplished was to initiate the creation of a GIS data base that contains the system description and system maintenance schedules. Now this information will be readily available to CUC water system managers and field operators. This is an important first step in meeting the US EPA Stipulated order requirement of developing a water system master plan and a comprehensive GIS management tool. Beyond satisfying the stipulated order this project will help CUC to provide an improved and more efficient management and operation of the Saipan water system and improved service to their customers.

FUTURE STUDIES

As the Saipan water system is expanding by normally occurring upgrades and system extensions, it will be necessary to also update the GIS data base to reflect the system expansion. In addition, the information about the water meters, location of fire hydrants, chlorinators need to be added to the data base. A similar study needs to be done for the wastewater system. Finally, training on the use of the GIS data base, review of the water system hydraulics, and Haestad model needs to be conducted for those that will be responsible for running the model and inputting data to the GIS data base.

LITERATURE CITED

[1] Erediano, Emmanuel, "EPA: NMI Water Needs Improvement" Marianas Variety, Vol 34, No, 192, December 11, 2006.

[2] Stipulated Order, Civil Case No. CV08-0051, United States District Court, Commonwealth of the Northern Mariana Islands. March 1, 2009.

[3] Jenson, John W. et al, "Karst of the Marianas Islands: The interactions of tectonic, glacio-eustasy, and freshwater mixing in Island Carbonates", Geological Society of America, Special Paper 404, 2006.

[4] Lander, Mark A. Personal Conversations, Water and Environmental Resources Research Institute of the Western Pacific, University of Guam, August 2007.

[5] Heitz, Leroy, S. Khosrowpanah and M. Iglecias Development of Junction Water Demands for the Saipan Water Distribution System Numerical Mode, Technical Report No. 122, University of Guam, Water and Energy Research Institute, August, 2008

[6] Camacho, Paul. Personal Conversations, CNMI Department of Land Management, Saipan, CNMI, February 2010.