PUBLIC VERSION

The U.S. Trade and Development Agency

The U.S. Trade and Development Agency (USTDA) advances economic development and U.S. commercial interests in developing and middle income countries. The agency funds various forms of technical assistance, early investment analysis, training, orientation visits and business workshops that support the development of a modern infrastructure and a fair and open trading environment.

USTDA's strategic use of foreign assistance funds to support sound investment policy and decision-making in host countries creates an enabling environment for trade, investment and sustainable economic development. Operating at the nexus of foreign policy and commerce, USTDA is uniquely positioned to work with U.S. firms and host countries in achieving the agency's trade and development goals. In carrying out its mission, USTDA gives emphasis to economic sectors that may benefit from U.S. exports of goods and services.

Mailing and Delivery Address: 1000 Wilson Boulevard, Suite 1600, Arlington, VA 22209-3901
Phone: 703–875–4357 • **Fax:** 703–875–4009 • **Web site:** www.ustda.gov • **email:** info@ustda.gov

1. Executive Summary **1**

2. Report Structure **4**

Technical Memorandum Tasks 1 & 2 ..... **6**

1. Introduction **6**

2. Water Audit Methodology **7**

3. Detailed Background Review **11**
3.1 Mabalacat Water District 13
3.1.1 General Information 13
3.1.2 Management Information Systems 14
3.1.3 Logistics and Communications 14
3.1.4 GIS/HM Data 15
3.1.5 NRW Data 15
3.1.6 Staff and Equipment 16
3.2 Angeles City Water District 16
3.2.1 General Information 16
3.2.2 Management Information Systems 17
3.2.3 Logistics and Communications 18
3.2.4 GIS/HM Data 18
3.2.5 NRW Data 19
3.2.6 Staff and Equipment 19
3.3 City of San Fernando Water District 19
3.3.1 General Information 19
3.3.2 Management Information Systems 20
3.3.3 Logistics and Communications 21
3.3.4 GIS/HM Data 21
3.3.5 NRW Data 22
3.3.6 Staff and Equipment 22
3.4 Batangas City Water District 22
3.4.1 General Information 22
3.4.2 Management Information Systems 23
3.4.3 Logistics and Communications 24
3.4.4 GIS/HM Data 25
3.4.5 NRW Data 25
3.4.6 Staff and Equipment 25
3.5 San Pablo City Water District 26
3.5.1 General Information 26
3.5.2 Management Information Systems 27
3.5.3 Logistics and Communications 27
3.5.4 GIS/HM Data 28
3.5.5 NRW Data 28
3.5.6 Staff and Equipment 29
3.6 Butuan City Water District 29
3.6.1 General Information 29
3.6.2 Management Information Systems 31
3.6.3 Logistics and Communications 31
3.6.4 GIS/HM Data 32
3.6.5 NRW Data 32
3.6.6 Staff and Equipment 32
3.7 Calbayog City Water District 33
3.7.1 General Information 33

3.7.2 Management Information Systems 34
3.7.3 Logistics and Communications 34
3.7.4 GIS/HM Data 35
3.7.5 NRW Data 35
3.7.6 Staff and Equipment 36

4. Study Management Plan 36
4.1 Pilot Area Selection 37
4.1.2 Logistics 37
4.1.3 Communications 37
4.1.4 GIS Data 38
4.1.5 Hydraulic Modeling Data 38
4.1.6 NRW Data 38
4.1.7 Staff 39
4.1.8 Equipment 39
4.2 Selected Pilot Area: Mabalacat Water District 39
4.3 GIS Development 40
4.4 Hydraulic Model Development 41
4.5 SCADA development 42
4.6 Residential Water Meter Testing Program 43
4.6.1 Meter Selection Process for Testing 43
4.6.2 Meter Brand Distribution 44
4.6.3 Meter Age Distribution 45
4.6.4 Test Meter Selection 46
4.6.5 Meter Testing Procedures 48
4.6.6 Performing the Test 49
4.6.7 Reading The Test Meter 50
4.6.8 Meter Test Form 53
4.7 District Metering Area Flow Metering Study 54
4.7.1 DMA Design and Selection 55
4.7.2 DMA Flow Monitoring Program 58
4.8 Socio-Economic and Demographic Data Collection 60
4.9 Responsibilities and Expectations of Water District 60
4.10 Pilot Project Equipment Identification 61
4.10.1 Large Scale Flowmeter 61
4.10.2 Residential Meter Testing Unit 62
4.10.3 Pressure Data Loggers 63
4.10.4 Data Conversion Software - AutoCAD 63
4.10.5 GIS Software – ESRI ArcInfo, ArcGIS, and GeoViewer 64
4.10.6 Hydraulic Modeling Software – WaterGEMs and EPANet 64
4.11 Project Schedule 65

Attachments

Attachment A - Pilot Area Selection Matrix

Attachment B – Socio-Economic Survey Form

Attachment C – Project Schedule

Index of Figures

Figure 1: Mabalacat Water District 14
Figure 2: Angeles City Water District 17
Figure 3: City of San Fernando Water District 20
Figure 4: Batangas City Water District 23

Figure 5: San Pablo City Water District 27
Figure 6: Butuan City Water District 30
Figure 7: Calbayog City Water District 34
Figure 8: Mabalacat Water District Pilot Area 40
Figure 9: Reading of 34.111 Cubic Meters 51
Figure 10: Reading of 34.167 Cubic Meters 52
Figure 11: Reading of 57.985 Cubic Meters 53
Figure 12: Meter Test Form 54
Figure 13: MWD DMAs 55
Figure 14: Flowmeters 1 & 2 56
Figure 15: Flowmeter 3 57
Figure 16: Flowmeter 4 58

Index of Tables

Table 1: IWA/AWWA Water Balance 8
Table 2: NRW Loss Types 9
Table 3: Water Balance Performance Indicators 10
Table 4: Meter Brand Distribution 45
Table 5: Meter Age Distribution 46
Table 6: Test Meter Sample Sizes 47
Table 7: Badger Meter Accuracy Table 50

Technical Memorandum Task 3 71
GIS/HM/SCADA Evaluation

Introduction 71

Subtask 3.1 Establishing GIS/HM/SCADA Framework 73
Subtask 3.1.1 GIS Framework 76
3.1.1.1 MWD GIS Data Model Development 77
3.1.1.2 GIS Data Conversion 79
3.1.1.3 GIS Operational Costs 80
3.1.2 Hydraulic Model Framework 82
3.1.2.1 MWD Hydraulic Model Development 83
3.1.2.3 Hydraulic Model Operating Costs 85
3.1.3 SCADA Development 86

3.2 Pilot Phase 88
3.2.1 Pilot Focus: Unauthorized Consumption 89
3.2.2 Pilot Focus: Customer Meter Inaccuracies and Data Handling Errors 92
3.2.3 Pilot Focus: Physical Losses 94

Appendix A: DMA Metering Project 97

Appendix B: Residential Water Metering Project 101

Technical Memorandum Task 4 111
Feasibility Analysis of the GIS/HM/SCADA Project

Introduction 111

Pilot Study Results 113
GIS Development 116

Hydraulic Model Development 119
Residential Water Meter Testing Program 121
SCADA Evaluation and Design 123
Socioeconomic Survey 125
District Metering Area (DMA) Flow Study and NRW Calculation 129

Pilot Study Conclusions 134

Subtask 4.1 Technical Assessment 135
Systems Engineering and Design Parameters, Complexities and Limitations 135
Constructability and Identification of Major Problem Areas 138
Operability and Operating Costs 139
Maintenance Requirements 140
Long Term Adaptability and Effects on Existing Water Supply System 142
Life Cycle Costs 143

Subtask 4.2 Economic Analysis 145
GIS Costs 146
Hydraulic Model Costs 148
SCADA Costs 149
Cost Benefit Analysis 151

Subtask 4.3 Financial Analysis 155

Subtask 4.4 Human Health and Environmental Impact Analysis 159

Subtask 4.5 Water Supply System Impact Analysis 161

Subtask 4.6 Ecological Impact Analysis 161

Subtask 4.7 Socioeconomic Impact Analysis 162

Subtask 4.8 Developmental Impact Assessment 164
Infrastructure 164
Human Capacity Building 165
Technology Transfer and Productivity Improvements 166
Market Oriented Reform 168

Index of Tables

Table 1: Meter Brand Distribution 122
Table 2: Meter Accuracy Results 123
Table 3: Income per DMA 127
Table 4: Active and Inactive Meters by DMA 128
Table 5: Are You Willing to Pay More for Better Service? 128
Table 6: Apparent Water Loss per DMA 130
Table 7: Three DMA Results 131
Table 8: Adjusted Water Loss 132
Table 9: MWD GIS Costs 146
Table 10: 10 Year GIS Operating Costs 147
Table 11: HM Development Cost 148
Table 12: HM 10 Year Operating Costs 149
Table 13: SCADA Development Costs 150
Table 14: SCADA 10 Year Operating Costs 150
Table 15: NPV of Recovered Water @ 50% Recovery 153

Table 16: Break Even Water Recovery Point 154
Table 17: Cost Recovery for GIS/HM Only 154
Table 18: Increased Revenues at 10.58% NRW Reduction 157
Table 19: Debt Recovery at 10.58% NRW Reduction 158
Table 20: Debt Recovery at 21% NRW Reduction 158

Index of Figures

Figure 1: MWD Staff Planning Meter Tests 114
Figure 2: MWD Management Planning Meeting 114
Figure 3: DMA Flow Meter Installation Team 115
Figure 4: DMA01 Flowmeter Installed 115
Figure 5: GIS Source Data 117
Figure 6: Finished GIS 117
Figure 7: GIS with Aerial Image 119
Figure 8: Hydraulic Model Elevations 120
Figure 9: Hydraulic Model and Demand Nodes 120
Figure 10: PDEIF NRW Goals 156

Appendix A: GIS Report 169

Appendix B: Hydraulic Model Construction Report 205

Appendix C: SCADA Design Report 222

Technical Memorandum Task 5 246
Overview of US Manufacturers

5.1 Introduc tion 246
5.2 Geographic Information Systems 246

5.2.1 Introduction 246

5.2.2 Data Conversion and Editing Software 247
5.2.2.1 AutoCAD 247
5.2.2.2 Microstation 248

5.2.3 GIS Database Software 249
5.2.3.1 ESRI 249
5.2.3.2 Intergraph 250
5.2.3.3 AutoDesk 251

5.3 H ydraulic Modeling 251

5.3.1 Introduction 251
5.3.1.1 MWH Soft 252
5.3.1.2 Haestead Methods 252
5.5.1.3 KY Pipe 253

5.4 Residential Water Meters 253

5.4.1 Introduction 253
5.4.2 Types of Residential Water Meters 254

5.4.3 Sensus Metering Systems 255
5.4.4 Hersey Meters 258
5.4.4 Neptune Technology Group 259

5.5 Supervisory Control and Data Acquisition (SCADA) Systems 261

5.5.1 Introduction 261

5.5.2 Instrumentation Equipment 262
5.5.2.1 Pressure Monitoring Equipment 262
5.5.2.1.1 Rosemount Inc. 263
5.5.2.1.2 Omega Engineering, Inc. 263
5.5.2.1.3 Ashcroft Inc. 264
5.5.2.1.4 Honeywell 264
5.5.2.2 Flow Measurement 264
5.5.2.2.1 McCrometer Inc. 265
5.5.2.2.2 SeaMetrics, Inc 265
5.5.2.2.3 Badger Meter 265
5.5.2.3 Level Measurement 266
5.5.2.3.1 Rosemount Inc. 266
5.5.2.3.2 Omega Engineering, Inc. 267
5.5.2.3.3 Babbit International 267

5.5.3 Programmable Logic Controllers 268
5.5.3.1 Rockwell Automation 268
5.5.3.2 General Electric Fanuc 269
5.5.3.3 Opto 22 270

5.5.4 SCADA Communications Systems 271
5.5.4.1 Cisco Systems 271
5.5.4.2 Synetcom Digital Inc. 272
5.5.4.3 Teledesign Systems 272
5.5.4.4 Nota Bene Technology (NBT) 272
5.5.4.5 CalAmp Inc 272

5.5.5 SCADA Software 273
5.5.5.1 Wonderware 273
5.5.5.2 Open Automation Software 274
5.5.5.3 GE Fanuc 274
5.5.5.4 Rockwell Automation 275
5.5.5.5 Opto 22 275

5.6 List of Contractors & Sub-Contractors used in this Study 276

Technical Memorandum Task 6 278
Project Implementation Plan

6.1 Introduction 278

6.2 Phased Implementation Plan 279

6.3 Review of Pilot Study Results 279

6.3.1 Distribution System Evaluation 280
6.3.2 Existing Data Sources 281

6.3.3 Staff Capacity 282
6.3.4 NRW Characteristics Evaluation 283

6.4 Adaptation of Pilot Study Process to Local Conditions 284

6.4.1 GIS Development 284
6.4.2 Hydraulic Model Development 285
6.4.3 Residential Meter Testing Program 286
6.4.4 District Metering Area Monitoring Program 286
6.4.5 Hydraulic Modeling of NRW 287

6.5 Validation of Results of Pilot Study to Local Conditions 288

6.6 Development of Localized Implementation Plan 290

6.6.1 Develop Localized Procurement Documents 291
6.6.1.1 GIS Procurement Documents 291
6.6.1.2 Monetary Savings for Water and Wastewater Agencies Using GIS 292
6.6.1.2.1 Rapid Access to Plans Using Scanned As-Builts 293
6.6.1.2.2 Up To Date Maps for Project Planning 294
6.6.1.2.3 Map Making for Presentations 295
6.6.1.2.4 Development of Accurate Valve, Hydrant, and Appurtenance Databases 296
6.6.1.2.5 Capital Asset Replacement Planning 297
6.6.1.2.6 Visualization of Issues in the System Using Work Order and Customer Data 298
6.6.1.2.7 Training Tool with GIS And Aerial Photos 298
6.6.1.2.8 Line Location 299
6.6.1.2.9 Easement Identification and Encroachment Control 300
6.6.1.3 Hydraulic Model Procurement Documents 302
6.6.1.4 SCADA Procurement Documents 302
6.6.2 Identification of Capital Asset Replacements 304

6.7 Estimated Implementation Costs 305

Appendix A – GIS Procurement Documents

Appendix B – Hydraulic Model Procurement Documents

Appendix C – SCADA Procurement Document

Executive Summary

With a broad mandate to improve the lives of the residents of the Philippines by bringing safe water supplies to their homes, the Local Water Utilities Administration (LWUA) faces many challenges. One of these includes how to deal with the excessive rates of Non-Revenue Water (NRW) among the local agencies under LWUA's umbrella. NRW rates of up to 40% are routinely reported by LWUA member agencies. This results in a massive loss of income for the utilities.

This feasibility study was developed to determine if the use of Geographic Information Systems (GIS), Hydraulic Modeling (HM), and Supervisory Control and Data Acquisition (SCADA) technologies could be a cost effective way to help control NRW. This report describes the development and implementation of this feasibility study.

At the outset of the study, a detailed background review of seven water districts selected by LWUA for inclusion in the project was conducted. From this list, Mabalacat Water District (MWD) was selected for the pilot project based on a variety of factors including the configuration of their infrastructure and availability of data sources. An area within MWD representing about 13% of its total system was selected for a detailed pilot study.

This pilot area was analyzed further in a number of areas. First, a detailed GIS was developed for the pilot area. This provided the mapping data needed to divide the pilot area into four District Metering Areas (DMAs). The use of DMAs for NRW control is a proven technique that has been applied with success all over the world. The effort at MWD was no exception.

In order to rule out the residential water meters as the source of NRW due to under registration of water flowing through the meters, a comprehensive meter accuracy analysis was performed along with the physical testing of a representative sample of the installed meters. A total of 297 meters were tested using a standardized testing technique and a certified testing meter. Overall, the results of this testing program showed that on

average the meters at MWD registered 96% of the water going through them. This result indicates that the water meters are a contributor to the overall NRW but not the primary source.

A thorough review of MWD leak history records indicated that there was no history of main line leaks that would indicate that this was a substantial source of NRW. The makeup of the piping in the pilot area – primarily newer PVC pipes – would also indicate that main line leaks should be rare. There were a small number of water service line leaks but all were controlled rapidly with insignificant water loss.

At this point portable flow meters were installed at the inlet to each of the DMAs in order to record the amount of water flowing into each area. A week long testing period was scheduled where all the residential meters in each DMA was read at the start and end of the week. The DMA flow meters were read at the same time so that an accurate comparison could be made between the two to identify the actual water loss in each DMA.

After normalizing the meter reads to the same point in time and adjusting the data to reflect average meter inaccuracy rates, the pilot area showed an overall water loss of about 21%, which is consistent with MWD data for this area. The raw data, once analyzed with the hydraulic model, showed that there was movement of water between DMA 2 and DMA 3. These two DMAs have interconnections that were supposed to be closed, but either the valves were not closed or they do not close fully to prevent the movement of water between the DMAs. In either event, this demonstrated the value of the model to help find areas of water loss.

The amount of NRW in DMA 1 was much lower, about 6%, than the other DMAs which were over 20%. Since the piping systems and leak histories are similar across the entire pilot area, the explanation of this striking change was found to be socioeconomic. As part of the study, a detailed socioeconomic survey was conducted in the pilot area. This study showed that the residents of DMA1 were more affluent than the other areas. They

also had a lower rate of disconnection than the other DMAs. This data indicated that water theft based on inability to pay could be a major part of the NRW problem.

The study suggested that MWD use the GIS data and the DMA metering results to target the areas where water theft is most likely. The GIS included information on water service laterals and many laterals serve multiple properties and are located above ground and on private property. Focus on illegal connections should be on those laterals that serve "disconnected" meters.

The study also suggested that water affordability may be a causal factor in the rate of water theft. The billing rates at MWD are such that the lowest monthly water bill is greater than the upper limit of water affordability, which has been established at 2% of monthly income in various studies by the American Water Works Association (AWWA). The study suggests that MWD could implement new rate structures to allow for lower income residents to apply for reduced water rates so that they can pay some portion of the regular bill for water that they are taking now without paying anything.

The study also did a detailed review of the cost to implement a GIS/HM/SCADA system in order to manage NRW. The benefits of the system were limited to the fiscal benefits of reducing NRW, even though the implementation of these technologies would have sometimes significant operational benefits outside of NRW for MWD. The cost benefit analysis showed that SCADA systems, installed for the sole purpose of NRW control, are not cost effective. The cost to implement SCADA was high and the study concluded that SCADA was not a particularly useful tool for NRW control, even though it may have large benefits in other aspects of the operation of the water system.

The study concluded that implementing GIS and HM is cost effective, even when the cost of the LWUA loan program is added to the capital and operating costs of these technologies. In order to return the entire capital, operating, and debt costs over 10 years, the use of the GIS and HM would only need to reduce NRW by 21%. In the case of the MWD pilot area, this would mean reducing NRW from the measured 21% down to

16.6%. It was determined that this is a very achievable goal if a system of illicit connection enforcement and possible rate structure modifications were to be implemented.

Report Structure

This report consists of a series of reports and technical memorandums that were prepared in accordance with the Tasks identified in the Terms of Reference. These reports are as follows:

Task 1 and 2 Report – describes the detailed background review and study management plan that was developed for the study

Task 3 Report – Describes the development and implementation of the water meter testing and DMA metering process as well as a detailed evaluation of SCADA implementation

Task 4 Report – Describes the outcome of the pilot study performed as part of Task 3 as well as a series of specialized subsections:

4.1 Technical Assessment
4.2 Economic Analysis
4.3 Financial Analysis
4.4 Human Health and Environmental Impact Analysis
4.5 Water Supply System Impact Analysis
4.6 Ecological Impact Analysis
4.7 Socioeconomic Impact Analysis
4.8 Developmental Impact Analysis

Task 5 Report - Describes the range of US manufacturers of GIS/HM/SCADA technology

Task 6 Report – Describes a GIS/HM/SCADA project implementation plan that can be used by other LWUA agencies to evaluate the results of the pilot study as they relate to their particular situation and provides guidance on how to implement this project full scale. This report also includes procurement documents including specifications and RFPs.

Technical Memorandum: Tasks 1 & 2

1. Introduction

Representing over 600 Water Districts throughout the Philippines, the Local Water Utilities Administration (LWUA) has broad oversight responsibilities in the area of effective utility operations. As part of this responsibility, LWUA monitors the performance and efficiency of water District operations and has found that the rate of Non-Revenue Water (NRW) is much higher than would be desired. NRW rates of up to 40% are not common among some of the utilities under LWUA's umbrella.

As part of its oversight duties, LWUA contracted with Nobel Systems to conduct a feasibility study on the use of Geographic Information Systems (GIS), Hydraulic Modeling (HM), and Supervisory Control and Data Acquisition (SCADA) systems to locate and control NRW within its member utilities. The goal of this study is to evaluate the existing conditions at the water utilities and determine how the application of GIS/HM/SCADA can help them reduce NRW.

The use of such technologies within water agencies is well established over the last decade or so. These systems have improved productivity, enhanced control, and provided better information to decision makers within the organizations. Harnessing the combined power of the three in a comprehensive NRW analysis effort is a newer concept although not without precedent.

This study will evaluate 7 of LWUA's member agencies to determine an appropriate candidate for further study. Within that selected agency, a smaller pilot area will be selected upon which intensive analysis will take place to determine how GIS/HM/SCADA can be deployed in such a way as to control NRW. This study will also include an evaluation of the overall accuracy of the residential water meters in the

pilot area. It should be noted that there is rarely one single cause of NRW and the reduction of this problem generally takes a multifaceted approach. The methods to be evaluated as part of this study are just such an approach.

2. Water Audit Methodology

Together with the American Water Works Association, the International Water Association's Water Loss Task Force developed the international standard for the evaluation of water loss in municipal water systems. Known as the IWA/AWWWA Water Balance, this standard carefully describes each of the components of water deliveries, including NRW. Table 1 below displays the Water Balance table.

Table 1: IWA/AWWA Water Balance

System Input Volume (corrected for known errors)	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption□(including water exported)	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Non-Revenue Water (NRW)
			Unbilled Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorized Consumption	
			Customer Metering Inaccuracies	
			Data Handling Errors	
		Real Losses	Leakage on Transmission and Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to point of Customer metering	

In Table 1, each of the categories of water that contribute to NRW is shaded in yellow – note that the majority of the categories of water are NRW. It is just this complexity of causes of NRW that makes the approach to dealing with NRW so complicated.

Table 2 below summarizes the main types of NRW and how each technology can address each issue.

Table 2: NRW Loss Types

Water Loss Type	Description	Technology
Unbilled Metered Consumption	Water used by the District or other approved parties at no charge	N/A
Unbilled Unmetered Consumption	Unmetered water used by authorized parties such as Fire Departments	SCADA can document peaks from fire flows
Unauthorized Consumption	Unmetered water used by unauthorized individuals – water theft	GIS and SCADA can locate areas where excess flows originate allowing for surveillance and investigation
Customer Metering Inaccuracies	Failure of water meters to record the precise volumes of water sold	Meter testing program will determine overall average accuracy of meters
Data Handling Errors	Errors made during the meter reading and billing process	GIS can help develop more accurate customer databases
Leakage on Transmission and Distribution Mains	Leaks of any type on all pipes that are not customer service laterals	GIS and HM can evaluate specific areas for leaks. SCADA can warn operators of unusual flows when leaks start so they can be controlled sooner.
Leakage and Overflows at Utility's Storage Tanks	Loss of water in storage and pumping systems	SCADA can accurately monitor tank levels and report any unusual events
Leakage on Service Connections up to point of Customer metering	Smaller leaks on small diameter pipelines serving customer meters	GIS and HM can evaluate specific areas for leaks or abnormal water use patterns

Another component of the IWA/AWWA Water Balance methodology are the performance indicators. These indicators are standardized benchmarks that utilities can use to evaluate where they stand in terms of water losses. It also includes standard measures such as Unavoidable Annual Real Losses, which are based on system

characteristics to give a baseline for what utilities may expect from system performance. Table 3 below outlines these performance indicators.

Table 3: Water Balance Performance Indicators

Performance Indicator	Function	Comments
Volume of Non-revenue water as a percentage of system input volume	Financial - Non-revenue water by volume	Can be calculated from a simple water balance; good only as a general financial indicator
Volume of Non-revenue water as a percentage of the annual cost of running the water system	Financial - Non-revenue water by cost	Allows different unit costs for Non-revenue water components
Volume of Apparent Losses per service connection per day	Operational - Apparent Losses	Basic but meaningful indicator once the volume of apparent losses has been calculated or estimated
Real Losses as a percentage of system input volume	Inefficiency of use of water resources	Unsuitable for assessing efficiency of management of distribution systems
Normalized Real Losses - Gallons/service connection/day when the system is pressurized	Operational: Real Losses	Good operational performance indicator for target-setting for real loss reduction
Unavoidable Annual Real Losses (UARL)	UARL (gallons/day) = (5.41Lm + 0.15Nc + 7.5Lp) x P where Lm = length of water mains, miles Nc = number of service connections Lp = total length of private pipe, miles = Nc x average distance from curbstop to customer meter P = average pressure in the system, psi	A theoretical reference value representing the technical low limit of leakage that could be achieved if all of today's best technology could be successfully applied. A key variable in the calculation of the Infrastructure Leakage Index (ILI) It is not necessary that systems set this level as a target unless water is unusually expensive, scarce or both
Infrastructure Leakage Index (ILI)	Operational: Real Losses	Ratio of Current Annual Real Losses (CARL) to Unavoidable Annual Real Losses (UARL); good for operational benchmarking for real loss control.

As the pilot phase of this study produces data about water uses in the selected pilot area, an analysis of NRW and water losses will be conducted. As part of this study, the AWWA Water Loss Control Committee Water Audit Software (V 3.0) will be used to estimate the performance factors outlined above, including the Infrastructure Leakage Index (ILI).

Since this is a pilot study only and the data collection period will be over a limited time, the results may not be exactly representative of the overall performance of the pilot area or the District as a whole. However, this will provide specific insight into the nature of the NRW issue and point toward the methods needed to develop a comprehensive control strategy using GIS/HM/SCADA.

3. Detailed Background Review

From its ranks of over 600 Water Districts in the country, LWUA selected the following seven water agencies to participate in this study.

1. Mabalacat Water District
2. Angeles City Water District
3. San Fernando City Water District
4. Batangas City Water District
5. San Pablo City Water District
6. Butuan City Water District
7. Calbayog City Water District

In August 2008, a kickoff meeting was held at the LWUA headquarters office, led by LWUA Administrator Orlando C. Hondrade. The purpose of this meeting was to

introduce the project team from Nobel Systems to the members of the seven selected water agencies. Subsequent meetings were held with each of the water districts in order to obtain information that is specific to each of those utilities.

The purpose of the background review is to familiarize the study team with the operational details of each water agency. There are several factors that make this familiarization necessary. First, since this project will consist of a pilot of a small area of one of the districts, it is necessary to obtain detailed background information in order to make the selection of the pilot area. Second, even though the project is going to do detailed pilot work in only one of the districts, the results from this pilot work will be extrapolated, to the extent possible, to the other districts. Having some standardized information about each district will allow this extrapolation to have some meaning even though it may not be fully accurate.

Finally, in subsequent tasks, this project will review some of the institutional and environmental obligations and duties that these districts face. There are quite a number of overlapping regulatory and financial systems that are woven into the commercial operations of the districts. This information will be necessary for making cost benefit analyses later in the project as well as identifying potential funding sources for projects. This technical Memorandum will not duplicate these efforts, as they will be reported in the deliverable for Task 4 of the Terms of Reference.

For each water district, a standard list of information was developed to satisfy the needs of the project. The main categories include:

1. General Information – Size of agency, location, year of formation, Distribution system data, upcoming projects, etc
2. Management Information Systems (MIS) – type and status of any MIS used by each water district
3. Logistics and Communications – accessibility of pilot area, travel time, Internet access, etc

4. GIS/HM Data – Availability and condition of any existing GIS data such as attribute data, landbase data, or HM data such as system pressure and flow data, pump curves, etc
5. NRW Data – Availability of historical data on water loss, leakage, etc
6. Staff and Equipment Information – Capabilities of district staff members, availability for the project, etc

Many of these sets of information will then be used in a comprehensive pilot area selection process that will be detailed in Section 3 below. It should also be noted here that there was not exactly the same type of information available for every district, so there is some variation in the information to be presented here. Note also, that unless otherwise stated, all cost data will be in Philippine Pesos.

3.1 Mabalacat Water District

3.1.1 General Information

Mabalacat Water District (MWD) was formed in 1978 and the office is situated at Mac Arthur Highway, Mabiga, Mabalacat, Pampanga 2010. MWD is recognized as a Large Category Water District with approximately 31600 Service Connections and service area covering about 120 Sq. Km.

MWD at present has 2 ongoing projects one is the 100M project of building the ground reservoir, which is expected to start by 2nd quarter of 2009, and finished by last quarter of 2010. The other project is 2.7M for Phase-1 of building a GIS and acquiring ESRI software Arc Editor and Arc View for in house use.

Figure 1 below is a satellite image of the district and its immediate surroundings.

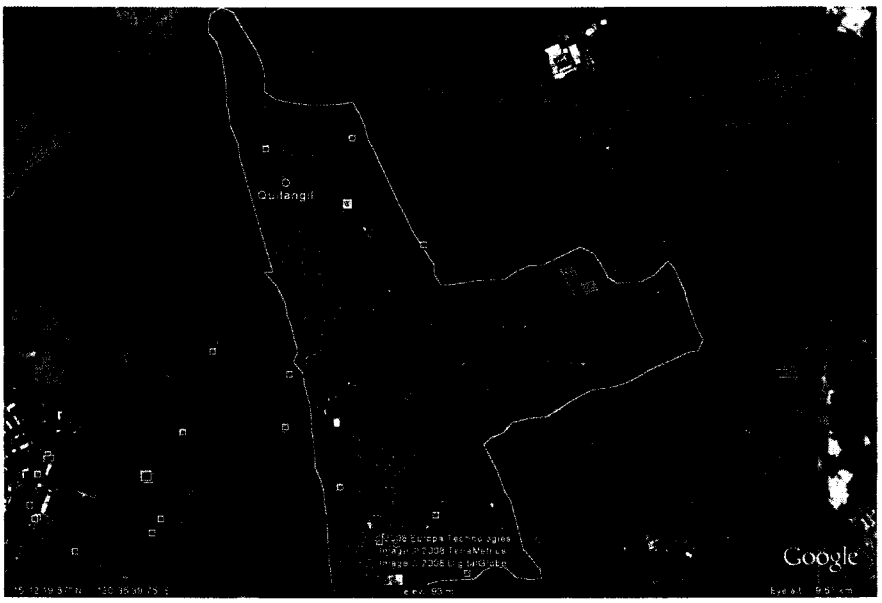


Figure 1: Mabalacat Water District

3.1.2 Management Information Systems

MWD has three sub-offices spread over its service area, and has a fully developed MIS system in place. The MIS extends to their warehouse operations, which are also tied into the main data centers. MWD is using SQL database as the backend for storing their data of billing and collection.

MWD has a very advanced meter reading and customer billing system in which field employees use handheld computers to take the meter readings and small portable printers to generate the bill for the customer on the spot. This process saves on repeat visits to the customer site to deliver bills. Upon returning to the office, the data from the handheld computer is uploaded into the main billing database

3.1.3 Logistics and Communications

MWD is conveniently located near Manila and the pilot area under consideration here is also well located for the purpose. The pilot area is confined within one pressure zone, which is ideal.

MWD has an excellent Internet connection of 1 Mbps with plans to upgrade this connection to 3 Mbps in the near future. District staff has field radios and the main officers of the District have cellular phones. This sort of communications capability is important to the success of the project.

3.1.4 GIS/HM Data

MWD has their mainline network already mapped in the soft copy AutoCAD format except for 2 resettlement areas, which were handed over to the WD. The soft copy format is not to scale and is not in the real world coordinates but it is color-coded for the diameter of the mains. Pipe material data is also indicated.

There are no attribute information encoded in the AutoCAD data and the installation year is yet to be ascertained. There was no digital Centerline data and Parcel/property data available at the time of the first visit. Service Map locations are also not in place at this time. MWD only elevation data is the 1:50000 NAMRIA 20 meter contour maps.

MWD has Digital Flow meters for all the pump stations and an analog pressure-monitoring device installed beside it. There are no data/pressure loggers, but low-pressure issues have been observed at peak times at some areas due to hydraulic constraints in the distribution system.

3.1.5 NRW Data

MWD has an Isolatable area for the Pilot project area, which has a NRW of about 40% in the Pilot area. There are no ACP mainlines in the proposed Pilot area. Historic records of customer-billed v/s Paid is submitted for this Pilot area are available. Leakage and burst

history of mainlines and service connections in this pilot area are also documented and have been submitted to Nobel.

3.1.6 Staff and Equipment

MWD has the personnel with skill sets that could work on AutoCAD and ESRI products. MWD has adequate drivers and can afford to provide the security necessary for the equipment installed (if selected as the Pilot project WD). MWD staff is experienced with water meter removal as well as the operational details of the proposed pilot areas. As noted above, the pump station in the proposed pilot area has a digital flow meter that will be essential in the evaluation of this area if it is selected for the pilot. No GPS equipment is available.

3.2 Angeles City Water District

3.2.1 General Information

Angeles City Water District (ACWD) was formed in the year 1987 and the office is situated at Pampang Rd., LNW, Brgy. Pampang, Angeles City 2009 and is recognized as a Large Category Water District with approximately 44025 Service Connections and service area covering about 100 Sq. Km.

ACWD has two sub-offices spread over its service area and has future plans to build up a separate warehouse, at present the warehouse is attached to the ACWD main office. ACWD at present is planning to take over the Balibago Barangay Water works to its control and are working with the private institutions for additional funds required to acquire the same. ACWD has already built up a very good Booster station, which hosts 7

pumps and 10 wells. The booster station site also has a Laboratory, which tests the water quality.

Figure 2 below is a satellite image of the district and its immediate surroundings.

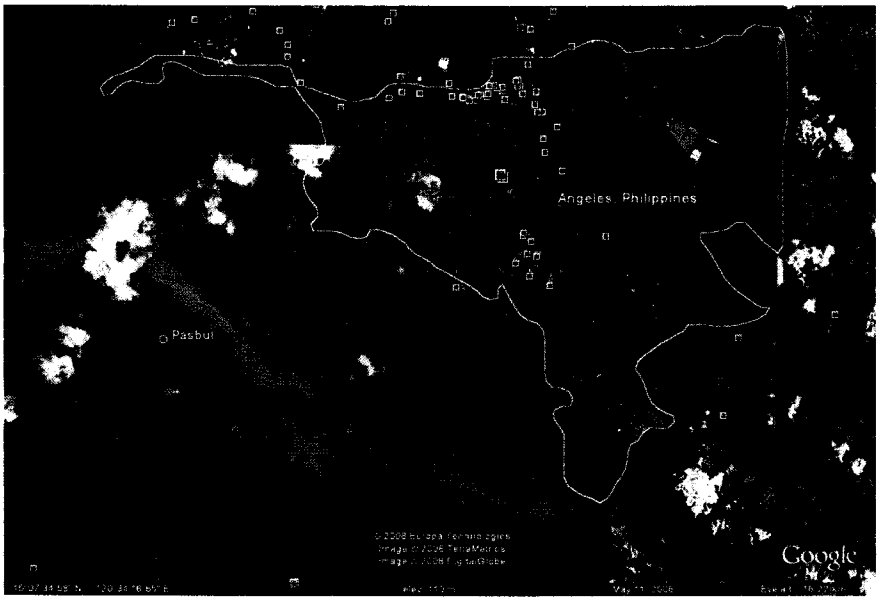


Figure 2: Angeles City Water District

3.2.2 Management Information Systems

MIS at ACWD is not as advanced as at some other districts. The main office houses the MIS but it has not been extended to the sub-offices. ACWD is using SQL database as the backend for storing their data of billing and collection. There is no in-house IT person on staff, which makes the deployment of an MIS more challenging.

MWD has a very advanced meter reading and customer billing system in which field employees use handheld computers to take the meter readings. Meter readers then return to the office where the data is uploaded and bill printed. Bills are then taken to the customer in a second trip.

3.2.3 Logistics and Communications

ACWD is conveniently located near Manila and the pilot area under consideration here is also well located for the purpose. The pilot area is confined within one pressure zone, but it is not easily isolated from other areas, which make this pilot area more difficult to consider.

ACWD have a very low speed Internet line of about 512 KBPS and has no plans to upgrade it. Internet speed at ACWD is very low as the 512 KBPS bandwidth is shared to all managers thus making the Internet very slow. District staff has field radios and the main officers of the District have cellular phones. This sort of communications capability is important to the success of the project.

3.2.4 GIS/HM Data

ACWD has their mainline network already mapped in the soft copy AutoCAD format. The soft copy format is said to be to scale but is not in the real world coordinates. It is color-coded for the diameter of the mains. Pipe material data is also indicated.

There are no attribute information encoded in the AutoCAD data and the installation year is yet to be ascertained. There was no digital Centerline data and Parcel/property data available at the time of the first visit. Service Map locations are also not in place at this time. MWD only elevation data is the information contained in the construction drawings developed during the initial construction of the distribution system.

ACWD has Digital Flow meters for all the pump stations and an analog pressure-monitoring device installed beside it. There are no data/pressure loggers, but low-pressure issues have been observed at peak times at some areas due to hydraulic constraints in the distribution system.

3.2.5 NRW Data

ACWD does not have an Isolatable area for the Pilot project as the pump station in the area, which ACWD has proposed, also serves two more areas and thus it is not possible for them to calculate the NRW at this area alone. There are no ACP mainlines in the proposed Pilot area and historic records of customer billed v/s Paid for this Pilot area have been submitted. Leakage and burst history of mainlines and service connections at this pilot area is being documented and yet to be submitted.

3.2.6 Staff and Equipment

ACWD has the personnel with skill sets that could work on AutoCAD and ESRI products. ACWD has adequate drivers and can afford to provide the security necessary for the equipment installed (if selected as the Pilot project WD). ACWD staff are experienced with water meter removal as well as the operational details of the proposed pilot areas. As noted above, the pump station in the proposed pilot area has a digital flow meter although the fact that it cannot be isolated to serve only the pilot area is a major drawback

3.3 City of San Fernando Water District

3.3.1 General Information

City of San Fernando Water District (CSFWD) was formed in the year 1977 and the office is situated at B. Mendoza St., City of San Fernando, Pampanga 2000, and is recognized as a Big Category Water District with approximately 22238 Service Connections and service area covering approx. 100 Sq. Km.

CSFWD has one sub-office at the Buloan area and has future plans to build up more sub offices. CSFWD at present have an on going project of building their website which is 80% complete and also features the customer to know their billing details. One

more on going project is the construction / expansion of the pipelines / more wells / pump stations in order to serve the new areas.

Figure 3 below is a satellite image of the district and its immediate surroundings.

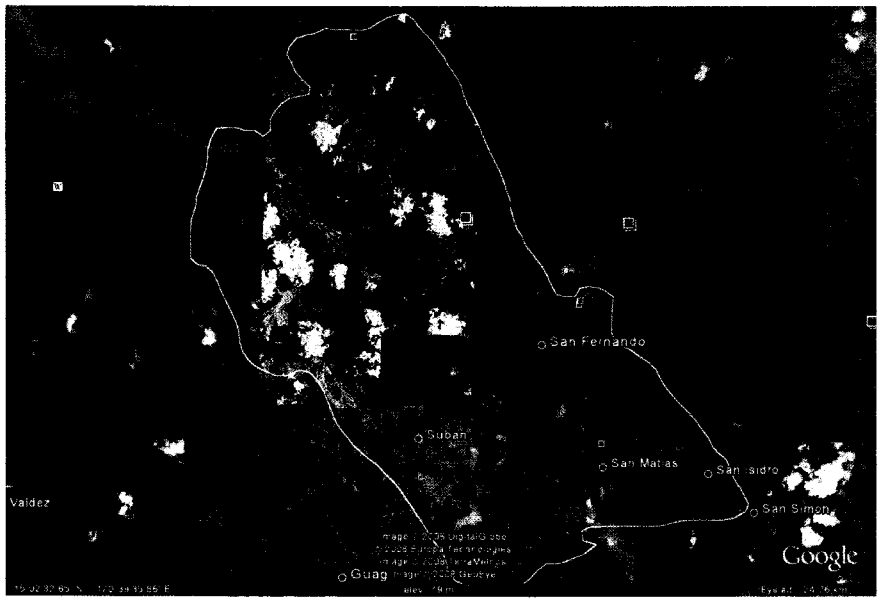


Figure 3: City of San Fernando Water District

3.3.2 Management Information Systems

CSFWD has an advanced MIS that handles their billing and is has a robust web site with many useful features. CSFWD has awarded a project to upgrade their MIS and the contractor has already finished 50% of the work on it. CSFWD is using SQL database as the backend for storing their data of billing and collection.

CSFWD has a very advanced meter reading and customer billing system in which field employees use handheld computers to take the meter readings. Meter readers then return to the office where the data is uploaded and bill printed. Bills are then taken to the customer in a second trip.

3.3.3 Logistics and Communications

CSFWD is conveniently located near Manila and the pilot area under consideration here is also well located for the purpose. The pilot area is confined within one pressure zone, and is fully isolated from other parts of the system.

CSFWD have a very good speed Internet as they have 4 DSL wireless internet access lines one each for the department and the speed is most likely to be over 700 KBPS for each DSL connection. CSFWD already has a very good Intranet in place and at present there is no IT person to solve issues (if any) they are planning to have an IT person as they are working on upgrading the MIS. District staff has field radios and the main officers of the District have cellular phones. This sort of communications capability is important to the success of the project.

3.3.4 GIS/HM Data

CSFWD has their mainline network already mapped in the soft copy AutoCAD format. The soft copy format is not to scale but is not in the real world coordinates. It is also considered by CSFWD staff to be out of date. It is color-coded for the diameter of the mains. Pipe material data is also indicated.

There are no attribute information encoded in the AutoCAD data and the installation year is yet to be ascertained. CSFWD has plans to make use of the Centerline data and Parcel/property data, which is already available with the City hall office. Service Map locations are already being created and ready for the submission

CSFWD at present do not have Digital Flow meters for any of the pump stations but they do have the analog Flow meters and analog pressure-monitoring device installed beside it. CSFWD has awarded the contract of Digital Flow Meters and are yet to install the Flow Meters at all there pump station location. There are no data/pressure loggers, but

low-pressure issues have been observed at peak times at some areas due to hydraulic constraints in the distribution system.

3.3.5 NRW Data

CSFWD do have an area, which is best suited for the Pilot project as the area is not connected to any of their main water system and it has one pump station serving the entire area of about 3000 dwellings. There are no ACP mainlines in the proposed Pilot area and historic records of customer billed v/s Paid for this Pilot area have been submitted. Leakage and burst history of mainlines and service connections at this pilot area is being documented and yet to be submitted.

3.3.6 Staff and Equipment

CSFWD has the personnel with skill sets who could work on AutoCAD and no personnel who could work on ESRI products. CSFWD has adequate drivers and can afford to provide the security necessary for the equipment installed (if selected as the Pilot project WD). CSFWD staff are experienced with water meter removal as well as the operational details of the proposed pilot areas.

3.4 Batangas City Water District

3.4.1 General Information

Batangas City Water District (BCWD) was formed in the year 1974 and the office is situated at Km. 4 National highway Alangilan, Batangas City 4200 and is recognized as a Large Category Water District with approximately 25000 Service Connections and service area covering approx. 113 Sq. Km.

BCWD has only one collection centre that is at the BCWD main office and has a central Pump Station unit which is beside the ground reservoir and only control switch out of seven are working good. BCWD has to plan for rehabilitating the Pump Station with new ECB's and any other pumping needs. BCWD also has a sophisticated laboratory beside its ground reservoir and there is a warehouse for the water fittings at the same location.

Figure 4 below is a satellite image of the district and its immediate surroundings.

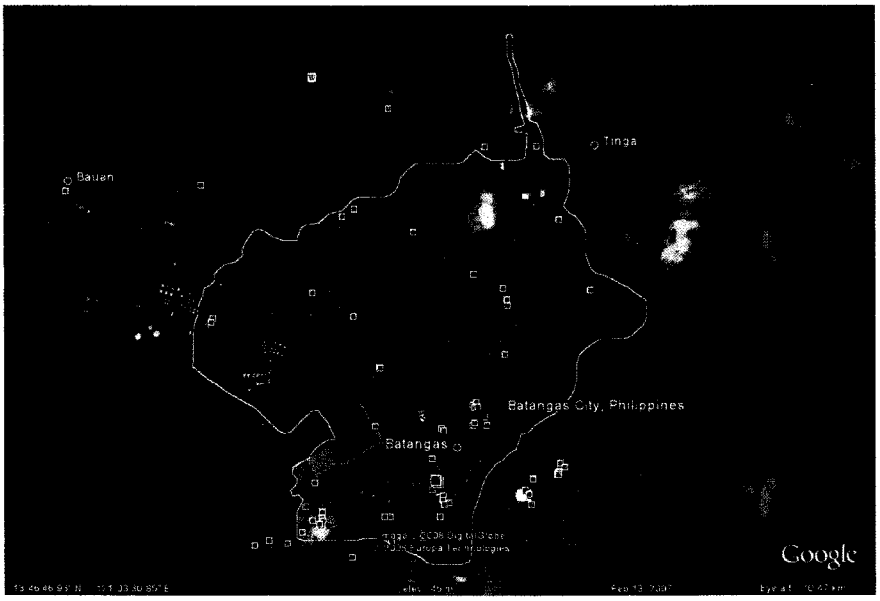


Figure 4: Batangas City Water District

3.4.2 Management Information Systems

BCWD has a very limited MIS in place at this time. There is limited internal network capacity and most business processes are paper based yet reliable. BCWD is using FoxPro database for their Billing and collection. FoxPro was supported by Microsoft but the last release was version 9 in 2004. Microsoft will not be making a version 10.

BCWD had deployed a field handheld computer meter reading system but the hardware failed and the readers reverted to manual meter reading and logging on paper. These reading logs are returned to the main office for data entry at which points bills are produced. A second trip to the customer site is necessary to deliver the bill.

3.4.3 Logistics and Communications

BCWD is located quite far from Manila making daily round trips impractical. The pilot area is confined within one pressure zone, but it is not easily isolated from other areas, which make this pilot area more difficult to consider.

BCWD have a very limited Internet as there is only one department who is authorized to have the internet and only one line of less than 700 Kbps. BCWD has no plans to increase the speed. BCWD does not have a good Intranet and at present the Intranet is working only for two or three systems, which are interconnected to billing and collection. District staff has field radios and the main officers of the District have cellular phones. This sort of communications capability is important to the success of the project.

3.4.4 GIS/HM Data

BCWD has their mainline network already mapped in the soft copy AutoCAD format. The soft copy format is not to scale but is not in the real world coordinates. It is considered by BCWD staff to be up to date. It is color-coded for the diameter of the mains. Pipe material data is also indicated.

There are no attribute information encoded in the AutoCAD data and the installation year is yet to be ascertained. There was no digital Centerline data and Parcel/property data available at the time of the first visit. Service Map locations are also not in place at this time.

BCWD at present do not have Digital Flow meters for any of the pump stations but they do have the analog Flow meters and analog pressure-monitoring device installed beside it. There are no data/pressure loggers, but low-pressure issues have been observed at peak times at some areas due to hydraulic constraints in the distribution system.

3.4.5 NRW Data

BCWD does not have an isolatable area for the Pilot project as pump station in the area, which BCWD has proposed, also serves two more areas and thus it is not possible for them to calculate the NRW at this area alone. There are many ACP mainlines in the proposed Pilot area. Historic records of customer billed v/s Paid have been submitted for this Pilot area. Leakage and burst history of mainlines and service connections (without account numbers) at this pilot area have been submitted but the lack of account information diminishes the usefulness of this data.

3.4.6 Staff and Equipment

BCWD has the personnel with skill sets who could work on AutoCAD and no personnel who could work on ESRI products. BCWD has adequate drivers and can afford to provide the security necessary for the equipment installed (if selected as the Pilot project WD). BCWD staff is experienced with water meter removal as well as the operational details of the proposed pilot areas.

3.5 San Pablo City Water District

3.5.1 General Information

San Pablo City Water District (SPCWD) was formed in the year 1973 and the office is situated at Maharlika Highway, Brgy San Gabriel, San Pablo City 4000. SPCWD is recognized as a Big Category Water District with approximately 32000 Service Connections and service area covering about 214 Sq. Km.

SPCWD has one collection center and has future plans to build up more sub offices. SPCWD is planning to build a new bigger office for its daily usage over the coming years, at present the existing building sports ware house, collection centre and meter testing department.

SPCWD at present has an on going expansion project which also has as a goal the reduction of the number of asbestos cement water mains in their network. There are only a few ACP pipes remaining in their network, which they are planning to rehabilitate in a few years from now. SPCWD is also planning for the GIS project with already a million pesos budgeted for it.

Figure 4 below shows the general layout of SPCWD – no good quality satellite imagery was available for this area.

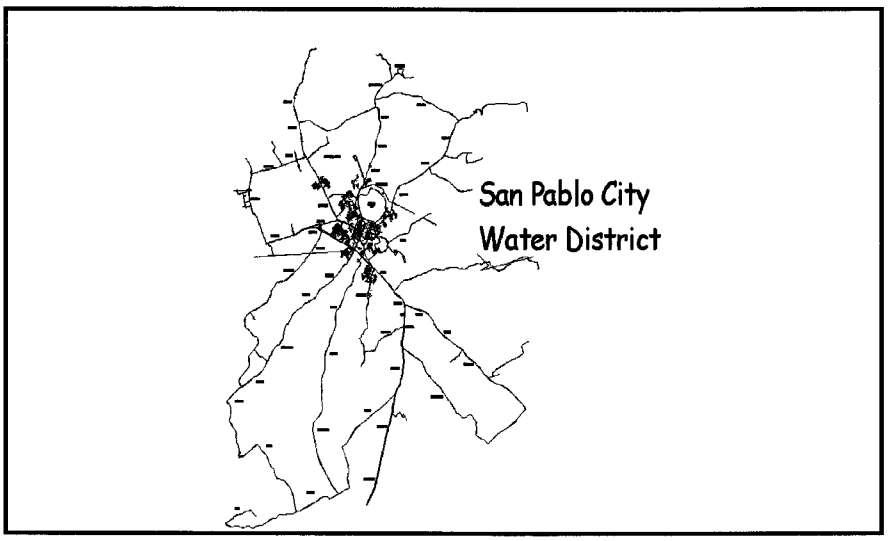


Figure 5: San Pablo City Water District

3.5.2 Management Information Systems

SPCWD has a very limited MIS in place at this time. There is limited internal network capacity and SPCWD is using FoxPro database for their Billing and collection. As noted earlier, Microsoft supported FoxPro but the last release was version 9 in 2004. Microsoft will not be making a version 10.

SPCWD has a very advanced meter reading and customer billing system in which field employees use handheld computers to take the meter readings. Meter readers then return to the office where the data is uploaded and bill printed. Bills are then taken to the customer in a second trip.

3.5.3 Logistics and Communications

SPCWD is located quite far from Manila making daily round trips impractical. The pilot area is confined within one pressure zone, but it is not easily isolated from other areas, which make this pilot area more difficult to consider.

SPCWD have a very limited and slow Internet access of less than 512 KBPS. SPCWD has plans to increase the speed. SPCWD does not have a good Intranet and at present the Intranet is functional only for the Billing section and the Collection section. SPCWD is planning to have the MIS and an IT person as future projects. District staff has field radios and the main officers of the District have cellular phones. This sort of communications capability is important to the success of the project.

3.5.4 GIS/HM Data

SPCWD has their mainline network already mapped in the soft copy AutoCAD format. The soft copy format is not to scale but is not in the real world coordinates. It is also considered by SPCWD staff to be out of date. It is color-coded for the diameter of the mains. Pipe material data is also indicated.

There are no attribute information encoded in the AutoCAD data and the installation year is yet to be ascertained. There was no digital Centerline data and Parcel/property data available at the time of the first visit. Service Map locations are also not in place at this time. SPCWD staff has collected quite a few data points using Magellan GPS devices

SPCWD has Digital Flow meters for all the pump stations and also an analog pressure-monitoring device installed beside it. There are no data/pressure loggers, but low-pressure issues have been observed at peak times at some areas due to hydraulic constraints in the distribution system.

3.5.5 NRW Data

SPCWD does not have an Isolatable area for the Pilot project, as there is no pump, which is serving only one area. All pumps in service are serving two or more areas. SPCWD has proposed not to isolate but to install a Digital Flow Meter at the start of the area, which has dead end and can monitor the water flowing in the area by the Flow Meter. This can be done but it is not possible for them to calculate the NRW for this area alone. There are no ACP mainlines in the proposed Pilot area and historic records of customer billed v/s Paid have been submitted. Leakage and burst history of mainlines and service connections (without account numbers) at this pilot area have been submitted but the lack of account information diminishes the usefulness of this data.

3.5.6 Staff and Equipment

SPCWD has the personnel with skill sets who could work on AutoCAD and no personnel who could work on ESRI products. SPCWD has a person on staff who has some experience in Hydraulic Modeling software who has already transferred the GPS points collected into the Hydraulic Modeling software and doing some research on how could they use it. SPCWD has adequate drivers and can afford to provide the security necessary for the equipment installed (if selected as the Pilot project WD). SPCWD staff is experienced with water meter removal as well as the operational details of the proposed pilot areas.

3.6 Butuan City Water District

3.6.1 General Information

Butuan City Water District (BCWD) was formed in the year 1974 and the office is situated at Gov. J.A. Rosales Avenue, Butuan City 8600. BCWD is recognized as a Very Large Category Water District with approximately 38280 Service Connections and service area covering about 333 Sq. Km.

BCWD has only one collection centre that is at the BCWD main office. BCWD is planning to expand its office as they have acquired few more land adjacent to the exiting land now. At present the existing building sports warehouse and collection centre.

BCWD at present have an on going expansion project. BCWD has already attempted and completed a GIS conversion Pilot Project for a small area by its own and have linked their Billing and customer database. Budgetary constraints and competing priorities have placed the GIS conversion project on hold.

Figure 6 below shows a satellite image of the District and surrounding areas.

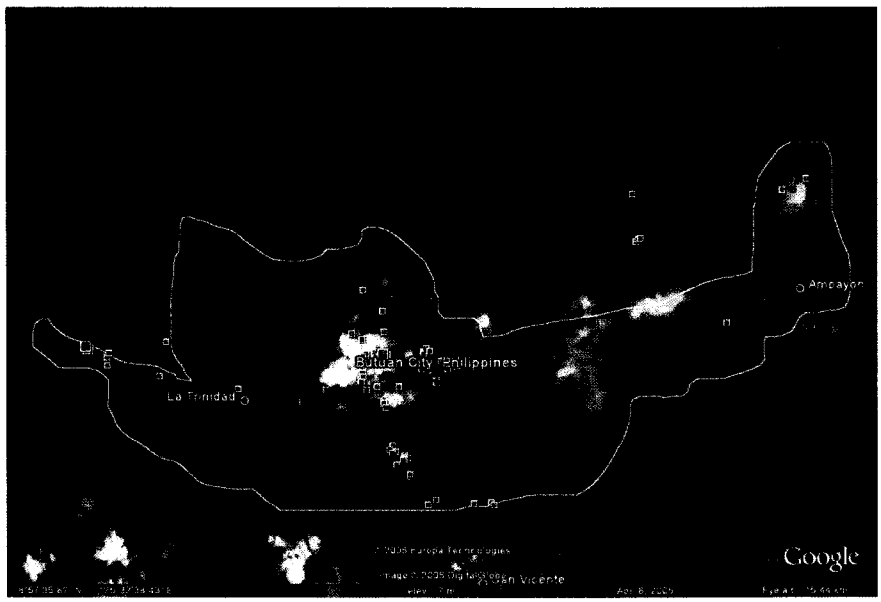


Figure 6: Butuan City Water District

3.6.2 Management Information Systems

BCWD has an advanced MIS in place along with dedicated IT staff to support it. BCWD is using the Foxpro database along with software, which is developed by in-house programmers for their Billing and collection. BCWD was the only Water District who has given the billing data or customer data along with the billing history in the format requested by Nobel as they already have in-house programmers who could easily create queries/code to extract this information.

SPCWD has a very advanced meter reading and customer billing system in which field employees use handheld computers to take the meter readings. Meter readers then return to the office where the data is uploaded and bill printed. Bills are then taken to the customer in a second trip.

3.6.3 Logistics and Communications

BCWD is located on a separate island from Manila, making an air flight a requirement for reaching the District. This makes traveling back and forth on a daily basis impractical. The proposed pilot area is very accessible and in a single pressure zone.

BCWD have a very good speed Internet as they have 3 DSL wireless internet access lines one each for the department and the speed is most likely to be over 700 Kbps for each DSL connection. BCWD already has a very good Intranet in place and has developed an IT department who takes care of editing/updating the billing and collection software; also they take care of the other computers. District staff has field radios and the main officers of the District have cellular phones. This sort of communications capability is important to the success of the project.

3.6.4 GIS/HM Data

BCWD is in the process of updating their mainline network in the soft copy AutoCAD format and Nobel also have given some inputs on how to maintain the layers and points in the AutoCAD file. The soft copy format is not to scale and is not in the real world coordinates. It is color coded for the diameter of the mains and material also is indicated.

There are no attribute information encoded in the AutoCAD data and the installation year is yet to be ascertained. There was no digital Centerline data and Parcel/property data available at the time of the first visit. Service Map locations are also not in place at this time.

BCWD has Analog Flow meters for all the pump stations and an analog pressure-monitoring device installed beside it. There are no data/pressure loggers, but low-pressure issues have been observed at peak times at some areas due to hydraulic constraints in the distribution system.

3.6.5 NRW Data

BCWD has isolated an area for the purpose of competing to be selected as Pilot project WD and have computed the NRW to be around 35% in the Pilot area. There are no ACP mainlines in the proposed Pilot area and historic records of customer billed v/s Paid has been submitted for this Pilot area. Leakage and burst history of mainlines and service connections at this pilot area is also documented and submitted to Nobel.

3.6.6 Staff and Equipment

BCWD has the personnel with skill sets who could work on AutoCAD and no personnel who could work on ESRI products currently but in house IT capacity would lend itself to training in this area. BCWD has adequate drivers and can afford to provide the security necessary for the equipment installed (if selected as the Pilot project WD). BCWD staff is experienced with water meter removal as well as the operational details of the proposed pilot areas.

3.7 Calbayog City Water District

3.7.1 General Information

Calbayog City Water District (CCWD) was formed in the year 1973 and the office is situated at J.D.Avelino St., Calbayog City 6710. CCWD is recognized as a Medium Category Water District with approximately 10000 Service Connections and service area covering about 25 Sq. Km.

CCWD has only one collection centre that is at the CCWD main office. CCWD is has already ongoing project of rehabilitating the front look of their existing old building. CCWD plans to build a new PVC pipeline from their existing source of water to the water system, but due to financial constraints the project has been delayed for 4-5 years. This project is intended to replace the ACP pipelines that have failed and this failure has limited the access of a source of water for the District

Figure 7 below shows a satellite image of the District and surrounding areas.

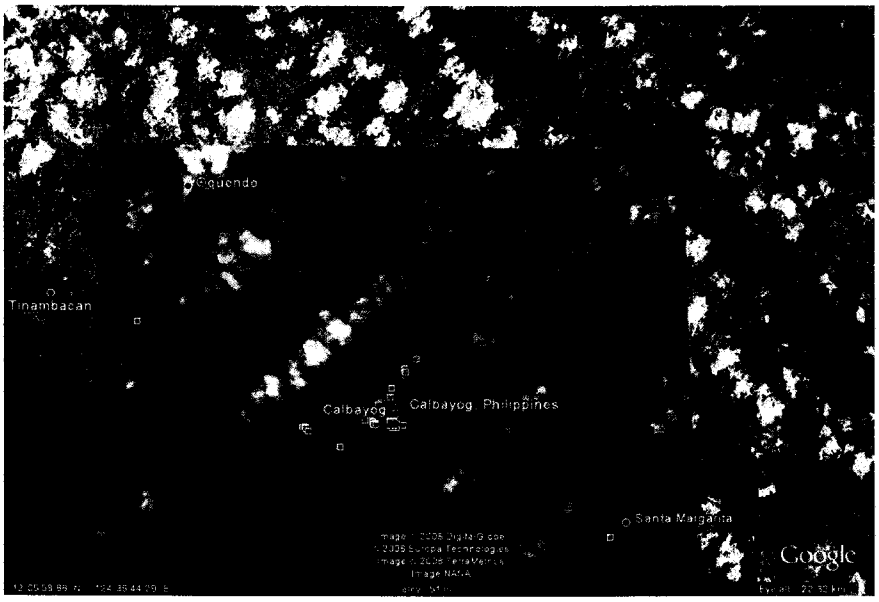


Figure 7: Calbayog City Water District

3.7.2 Management Information Systems

CCWD has an MIS in place along with dedicated IT staff to support it. CCWD is using the Foxpro database along with software, which is developed by external parties. CCWD staff does not have the capability to edit the database internally. The main office has a functioning network for office computers.

CCWD has a very advanced meter reading and customer billing system in which field employees use handheld computers to take the meter readings. Meter readers then return to the office where the data is uploaded and bill printed. Bills are then taken to the customer in a second trip.

3.7.3 Logistics and Communications

CCWD is located on a separate island from Manila, making an air flight a requirement for reaching the District. This makes traveling back and forth on a daily basis impractical. The proposed pilot area is very accessible and in a single pressure zone.

CCWD have a very limited and slow Internet access of less than 512 KBPS. CCWD has no plans to increase the Internet speed. CCWD has a good Intranet in place and is working fine. CCWD already has a person who takes care of their IT related problems. District staff has field radios and the main officers of the District have cellular phones. This sort of communications capability is important to the success of the project.

3.7.4 GIS/HM Data

CCWD has their mainline network in the soft copy AutoCAD format. The soft copy format is not to scale and is not in the real world coordinates. It is color coded for the diameter of the mains and material also is indicated.

There are no attribute information encoded in the AutoCAD data and the installation year is yet to be ascertained. There was no digital Centerline data and Parcel/property data available at the time of the first visit. Service Map locations are also not in place at this time.

CCWD has Analog Flow meters for all the pump stations and an analog pressure-monitoring device installed beside it. There are no data/pressure loggers, but low-pressure issues have been observed at peak times at some areas due to hydraulic constraints in the distribution system.

3.7.5 NRW Data

CCWD does not have an isolatable area for the Pilot project, as there is no pump, which is serving only one area. All pumps in service are serving two or more areas. CCWD has proposed not to isolate but to install a Digital Flow Meter at the start of the area, which has dead end and can monitor the water flowing in the area by the Flow Meter. This can be done but it is not possible for them to calculate the NRW for this area alone. There are

no ACP mainlines in the proposed Pilot area and historic records of customer billed v/s Paid has been submitted for this Pilot area. Leakage and burst history of mainlines and service connections (without account numbers) at this pilot area have been submitted but the lack of account information diminishes the usefulness of this data.

3.7.6 Staff and Equipment

CCWD has the personnel with skill sets who could work on AutoCAD and no personnel who could work on ESRI products currently but in house IT capacity would lend itself to training in this area. CCWD has adequate drivers and can afford to provide the security necessary for the equipment installed (if selected as the Pilot project WD). CCWD staff is experienced with water meter removal as well as the operational details of the proposed pilot areas.

4. Study Management Plan

The main objective of the pilot study is to evaluate the benefits that GIS, hydraulic modeling, and SCADA have on identifying and quantifying NRW in a selected sector of the study area. The information obtained from the pilot study will be used to identify technologies and corrective measures that could be deployed in an effort to reduce the NRW in the other water districts in the region.

In addition to the specific development of GIS/HM/SCADA for the pilot area, another important part of NRW evaluation has been included – residential water meter testing. Even though this topic is not directly related to GIS/HM/SCADA, it is an important factor in NRW and needs to be evaluated as part of the study.

4.1 Pilot Area Selection

The task of selecting an appropriate pilot area from within the 7 selected water districts required careful consideration. There are many variables that will either enhance, or degrade a particular area's suitability for this project. There were 7 categories of criteria that were evaluated for each proposed pilot area and each of these has several sub criteria. Each category was weighted as to its relative benefit to the study overall and based on interviews with staff at the various water districts, scores from 1 to 10 were given in each sub criteria.

The following subsections define the categories and how they influence the overall selection of the pilot area:

4.1.2 Logistics

This category evaluates the location of the proposed pilot area with respect to Manila with closer areas being favored over distant ones or those that require air travel to reach. This is not to say that districts that are further afield will not benefit from GIS/HM/SCADA, only that for the purposes of the pilot there are impractical. In addition, this category looked at the relative size of the pilot area based on the size of the district as a whole, as the pilot area should not be too small or large. Another important factor is accessibility of the features within the pilot area as there will be interactions with pipelines and other equipment during the study. Finally, the ideal pilot area is all contained within one pressure zone.

4.1.3 Communications

This category evaluated the ability for the local water district to maintain reliable communications, especially Internet connectivity. Since there will be sometimes large amounts of data transferred during the study, those districts with higher bandwidth connections were favored over those with limited connectivity. Also, the internal

network capacity was an important factor followed by the general security of the host district's IT infrastructure.

4.1.4 GIS Data

Since the development of a GIS is part of the pilot study, the availability of high quality source data is an important factor in the selection. This does not mean that the selection would be hinged on whether a district already had digital maps, as the presence of digital maps that lack proper attribution can sometimes be of less value that high quality paper sources. Additionally, the availability of street centerline, landbase, and service location maps were considered to be desirable.

4.1.5 Hydraulic Modeling Data

As with the GIS, having a certain amount of data in an accessible format will enhance the development of the hydraulic model for the pilot area. Customer demand and billing history is important along with demographic information where available. Details on the tanks and pumps that are part of the pilot area will be essential along with any flow or pressure monitoring equipment. Finally, a source for good elevation data will be important.

4.1.6 NRW Data

In order to do an NRW study and do some of the HM testing and calibration that may be required, it is important that the pilot area have operable valves that can isolate the pilot area and in certain cases isolate certain sections of the pilot area. Pilot areas with documented rates of NRW of over 25% were favored over those with less information. Information about pipeline leaks is also necessary to develop some of the background information needed to complete a thorough NRW review. In addition, the pilot areas need to be isolatable with one master flowmeter entering the pilot area.

4.1.7 Staff

As part of this study, a fair amount of specialized, and very expensive, equipment will be put in place. It is critical that the host water district have the capacity to secure this equipment against damage or theft. In addition, it is desirable to have skilled personnel who are available to perform certain tasks, including driving, as part of the project. The skill sets for handling water meters will be more important that specific GIS or CAD skills for the purposes of doing the study.

4.1.8 Equipment

Those districts whose proposed pilot areas already were outfitted with high quality flow meters were considered to be more suitable than those without as they would be better able to document flows into the pilot area. The availability of radios for field communications was an important factor, as this type of communication will be needed during certain phases of the study. Finally, the availability of GPS equipment was considered to be a plus.

4.2 Selected Pilot Area: Mabalacat Water District

Each of the water districts was evaluated for all of the criteria listed above. The results are shown in the charts included in Attachment A at the end of the report. With a combined total score of 84.63%, the pilot area proposed by Mabalacat Water District was selected. This pilot area is comprised mainly of the Mauaque Resettlement Area, a community that was constructed in the aftermath of the Mt. Pinatubo eruption in 1991. With about 3400 active services total, this area is well suited for this pilot.

A single well source feeds the entire area and the layout of the pipelines will allow further segregation into smaller District Metering Areas (DMA). These smaller DMAs

will allow for high precision measurement of water flows into each DMA and through each meter. There are four DMAs in the Mabalacat pilot area.

The selected pilot area is nearly 100% constructed with PVC pipelines, giving a consistent material type for the model and the NRW calculations. Meters are accessible and above ground to facilitate the removal for meter testing.

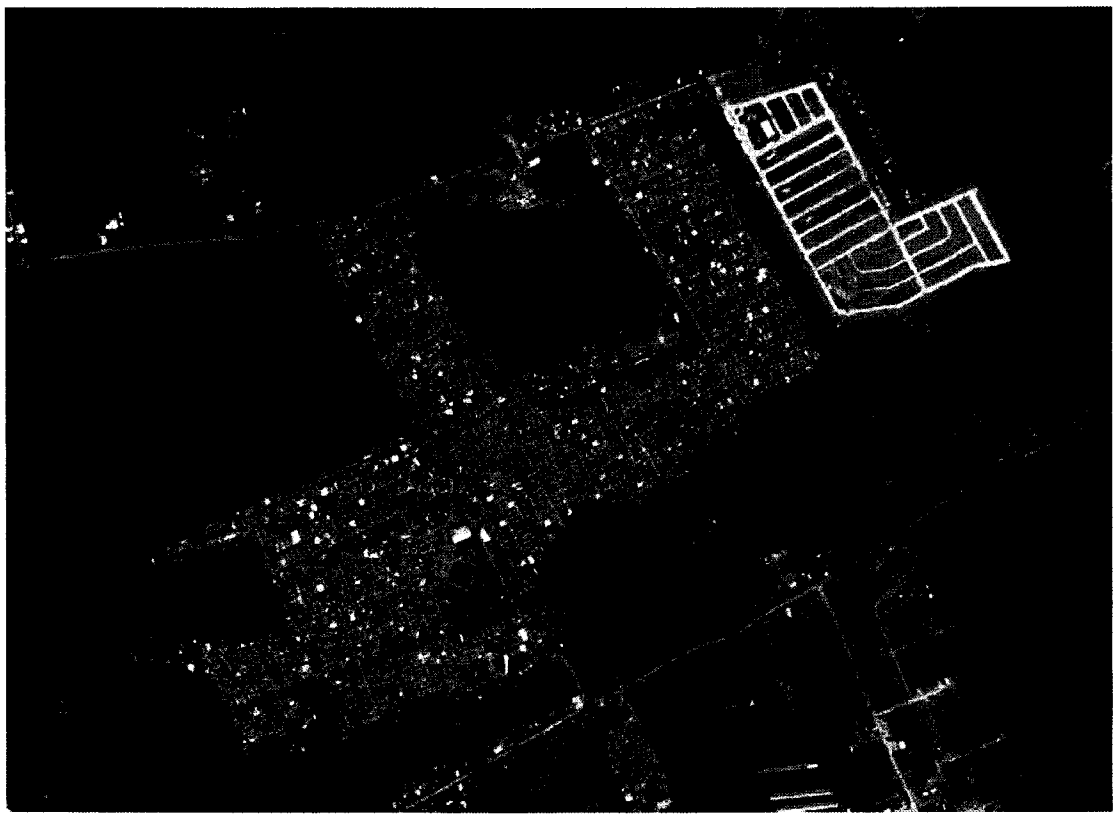


Figure 8: Mabalacat Water District Pilot Area

4.3 GIS Development

A full-featured GIS will be developed for the pilot area. The source data for this project is a series of atlas type maps that display the water mains and meters in separate sheets.

This data will be obtained from MWD by Nobel staff and conversion will commence immediately. Layers to be included in the GIS will be:

- Street Centerlines
- Parcels
- Meters
- Service Laterals
- Distribution Mains
- Transmission Mains
- Hydrants
- Misc Appurtenances
- Aerial Photos
- Wells/pump stations

Upon completion of the GIS development, the GIS data will be available using Nobel Systems' GeoViewer web based GIS application. This will allow authorized users to view, query, and print maps from the GIS data. The source maps will be scanned and linked to the GIS data for viewing via GeoViewer.

In addition, the meter layer will be linked to the billing and customer service data from MWD. This will allow users to search for and query non-GIS data that is held in external tables.

4.4 Hydraulic Model Development

Once the GIS data is developed, the task of creating the HM will begin. By creating the HM from the GIS data and maintaining a 1:1 relationship between the two systems, a

single database can be used to manage both systems. When a change is made in the GIS, it can be easily reflected in the HM, this maintaining both in the most current and up to date state.

Part of the model development process will be an initial evaluation during which the best places for subsequent pressure and/or flow monitoring should take place. Also, the initial model will point the way toward a flow and pressure-testing program that will be used to calibrate the model to reflect real-world conditions. Based on an initial review of water main sizes in the pilot area, it is expected that significant hydraulic restrictions are present due to small main sizes. It is expected that system pressure will drop off significantly during periods of peak flow demands or fire hydrant use. These assumptions will be verified through field-testing.

4.5 SCADA development

The report in Task 4 covering the pilot testing in Task 3 will outline the results of this effort in some detail. The main goal of this process is to determine how best to deploy SCADA within the pilot area to meet the needs of an NRW control program. There are two main components to this effort.

First, the study will include the temporary installation of flow and pressure monitoring equipment in the pilot area. These instruments will be used to demonstrate how such tools can help control NRW. They will simulate what could be available were the utility to install such features on a more permanent basis and connect them using SCADA.

Second, the study will include a preliminary design of a SCADA system for the pilot area as well as a review of the regulatory and institutional frameworks identified in Task 3. This report will include suggestions for the type of instrumentation that will be needed, potential software vendor choices, and possible control strategies for the pumps in question. Of particular interest will be the evaluation of communications systems for linking the remote monitoring and control systems to the headquarters SCADA.

4.6 Residential Water Meter Testing Program

In order to determine the contribution to the overall Non-Revenue Water (NRW) that has its origin in the residential metering program at Mabalacat Water District (MWD), a comprehensive analysis and testing program will be conducted on the residential meters. The goal of this study is to clearly identify the overall accuracy rate of the thousands of residential water meters in the pilot area. Based on the results of this testing program, assessments can be made on the cost effectiveness of any residential water meter retrofit programs.

All water meters register water use with varying levels of accuracy. Differences in manufacturer, type of meter, and meter age can all factor into the meter's overall accuracy. In this study, we will try to control for these variables to determine how the performance of meters in the MWD Pilot Area contributes, or does not contribute, to NRW.

4.6.1 Meter Selection Process for Testing

As noted above, the three major variables that are controllable for this project are meter manufacturer, meter type, and meter age. Nobel Systems staff has collected meter data from MWD staff and an analysis shows that all of the meters for which information is known about their brand indicate that they are all multi-jet type meters. This will narrow down the testing regimen to only meter brand and age.

In addition, since we are interested in determining how meters are contributing to NRW now, as opposed to at some period in the past, we will be considering only those meters listed in MWD's data as being currently active. This will correlate the information more

closely with other aspects of the distribution system modeling, since the mass flowmeters will presumably only be feeding meters that are on during the study period.

4.6.2 Meter Brand Distribution

In the data set provided to Nobel by MWD, there are 3817 accounts listed total. This number includes both active and inactive meters as well as a large number of meters for which no brand name was known (1623). Of the total number of meters, there are currently 1606 for which both the brand name is known and the meter is listed in MWD's data as being active or in service.

There are twelve total brands of meters in this data set of 1606 meters as shown in Table 4 below. The vast majority of these meters (over 86%) are one of three brands: E-Jet, Aqua-jet, and Arad. The remaining 9 brands have very small representation in the total meter population and therefore will not be part of the meter testing program; these 9 brands have such small numbers that if any meter replacement program is suggested as part of this project they will simply be included in the program.

Table 4: Meter Brand Distribution

Brand	Count	Percent of Total
E-Jet	689	42.90%
Aqua-jet	453	28.21%
Arad	246	15.32%
Jitsui	77	4.79%
evjet	49	3.05%
Excel	42	2.62%
Artic	31	1.93%
Asahi	7	0.44%
Shang-shu	6	0.37%
Ever	3	0.19%
Andrae	2	0.12%
YT	1	0.06%
Total	1606	100%

4.6.3 Meter Age Distribution

As a critical component of meter performance, advanced meter age can result in meter underperformance through inaccuracies and underreporting of water passing through the meter. The meter data provided by MWD was reviewed to determine the age distribution of meters. Again, only active meters with known brand names were included,

As Table 5 below indicates, over half of the meters in the pilot area are under 5 years old and over a third are over 10 years old. There is a smaller number of meters in the middle aged portion, indicating that meter installations were not even distributed over time, but

were performed in bunches at different times. This is a fairly typical distribution of water meter ages.

Table 5: Meter Age Distribution

Brand	Under 5 Years Old	5 to 10 years old	Over 10 Years old
E-Jet	335	269	82
Aqua-jet	261	144	48
Arad	130	86	30
Jitsui	45	25	7
evjet	28	14	7
Excel	24	14	4
Artic	9	18	4
Asahi	2	3	2
Shang-shu	0	4	2
Ever	2	1	0
Andrae	1	0	1
YT	0	1	0
Total	837	579	187
% of Total	52.1%	36.1%	11.6%

4.6.4 Test Meter Selection

In order to reduce the impact on labor resources needed to perform the test, a sliding scale of test samples will be used. This is due to the fact that most meters wear with age and are expected to be most accurate at a young age. Since most of the meters in the total population of meters are relatively young, a smaller sample set of each will be used for the initial meter-testing program. Once data is received from the initial testing program it

will be evaluated to determine if additional testing is needed in order to achieve a reliable result.

Normally, a sample size is related to the total number of meters in the sample group to be evaluated. This will be the case in this study, but we will deploy a sliding scale of test sample size based on age. For meters that are over 10 years old, we will test 20% of the meters. For those between 5 and 10 years old we will test 15% of the meters. For those under 5 years old we will test 10% of the meters as we predict that these meters will be very close to their factory state and should not exhibit excessive wear at this young age.

These sample sizes will give good indicators of the average performance of the meters in the pilot area as a whole. Table 6 below shows the number of meters that will be tested for each brand and age group. A total of 180 meters will be tested altogether.

Table 6: Test Meter Sample Sizes

Brand	Under 5 Years Old	5 to 10 years old	Over 10 Years old
E-Jet	34	40	16
Aqua-jet	26	22	10
Arad	13	13	6
Total	73	75	32

A map showing the location of each of the meters to be tested will be provided to the test personnel along with the test data collection sheets.

4.6.5 Meter Testing Procedures

A total of three meter testing rigs will be provided to the testers for this project. It is expected that each tester should be able to complete at least 10 meters per day and potentially several more than that. With 180 total meters to test, the testing should be completed in 6 days, barring unforeseen situations.

In order to test each customer meter, the cooperation of the customer will be needed. The water will need to be shut off to the residence for the test period. If this is not possible for some reason, the test will have to be called off and an alternative site selected. Depending on local practice, advance notification of the customer may be needed.

Once the tester has contacted the residents of the property and informed them of the water shutdown, the valve service the meters shall be turned off. Once the pressure has been removed from the line the meter shall be removed from the service and connected to the test rig. A flexible hose will then connect the meter on the test rig to the service connection on the utility side. This hose should be as short as possible to prevent excessive head loss.

Care should be taken on the location of the test rig so that the discharge of water will not cause damage to property in the area. If needed a hose can be connected to the outlet of the test rig. It should be kept as short as possible to prevent excessive head loss in the hose.

4.6.6 Performing the Test

Once the meters are connected and before any water flows through the meters, it is important to record data to the data collection sheet provided. The following data shall be recorded:

- Verify the serial number of the meter
- Record the read of the customer meter
- Record the read of the test meter (Badger)

Once the data has been recorded and the tester has made all the connections and ensured that the discharge location is appropriate, the test can begin. For this size meter, the test protocol will be for a single flow rate of 0.25 m^3/hr or about 1 GPM. It is important that this flow rate be consistent from test to test as variations in flow can have impacts on the accuracy of the test. It is recommended that the testers practice on sample meters using known volume buckets and stopwatches so they can get a sense for what the 0.25 m^3/Hr flow looks and feels like. It is not critical to be exact, but the flows need to be close.

The tester should then run the water for 15 to 20 minutes at a consistent flow rate. Care should be taken not to open our close valves too quickly when starting and stopping the test – gradual flow changes are best. After the time has elapsed, the outlet valve should be closed followed by the customer's service valve. Before disconnecting the meters the tester shall record the reads of both meters on the test form.

Once the meter data is properly recorded the customer meter can be disconnected from the test rig and replaced into service. If for some reason the meter registers no flow or is

obviously recording incorrectly, the tester may choose to replace the meter at the time of the test with a new meter.

4.6.7 Reading The Test Meter

The Badger M25 test meter has been tested by the factory and the accuracy of the meters is certified as shown in the table below. This tag indicates what the percentage of actual flow is recorded by the meter at a given flow rate. This number will be used in the final calculation of the customer meter accuracy. For the purposes of this study we will only be using the mid-flow accuracy shown below.

Table 7: Badger Meter Accuracy Table

Serial Number	Low Flow Accuracy (0.25 GPM/0.0625 M^3/HR)	Mid Flow Accuracy (1.0 GPM/ 0.25 M^3/HR)	High Flow Accuracy (25 GPM/6.25 M^3/HR)
08739778	100.2	100.6	98.9
08739777	100.3	100.4	99.3
08739776	100.1	100.3	98.9

The Badger M25 meter has six live register digits and a 0.1cubic meter test circle. Five of the six digits are white and one black. The black digit reads tenths of cubit meters. Using the register digits and the test circle hand, the tester can record water use down to the thousandth of a cubic meter.

Figure 9 below shows a read of 34.111 cubic meters. The 5 white digits are 00034, indicating 34 cubic meters and the black digit is 1, indicating 0.1 cubic meters. To get the hundredths and thousandths the reader needs to look at the hand, which is at 0.011. Added together the overall read becomes 34 + 0.1 + 0.011 = 34.111

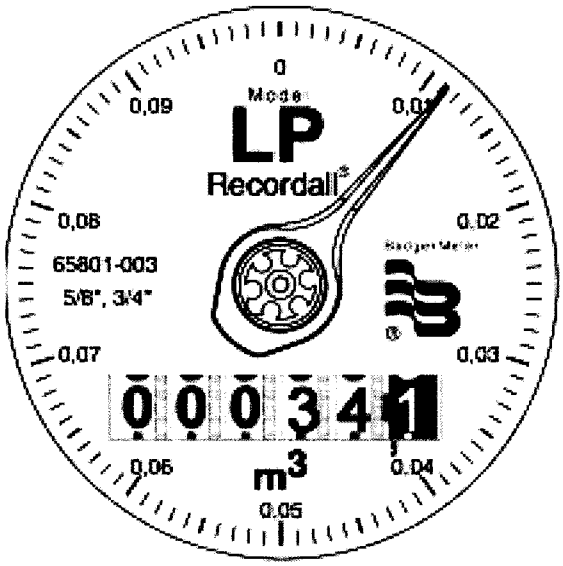


Figure 9: Reading of 34.111 Cubic Meters

Figure 10 below shows a read of 34.167 cubic meters. The 5 white digits are 00034, indicating 34 cubic meters and the black digit is 1, indicating 0.1 cubic meters. To get the hundredths and thousandths the reader needs to look at the hand, which is at 0.067. Added together the overall read becomes 34 + 0.1 + 0.067 = 34.167

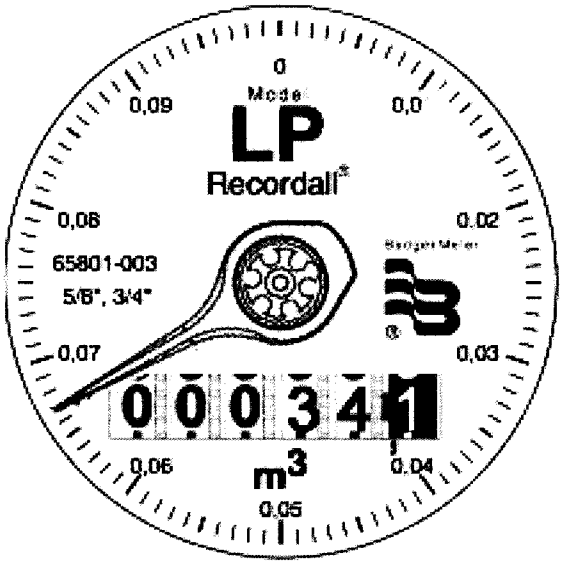


Figure 10: Reading of 34.167 Cubic Meters

Finally, Figure 11 below shows a read of 57.985 cubic meters. The 5 white digits are 00057, indicating 57 cubic meters and the black digit is 9, indicating 0.9 cubic meters. To get the hundredths and thousandths the reader needs to look at the hand, which is at 0.085. Added together the overall read becomes 57 + 0.9 + 0.085 = 57.985

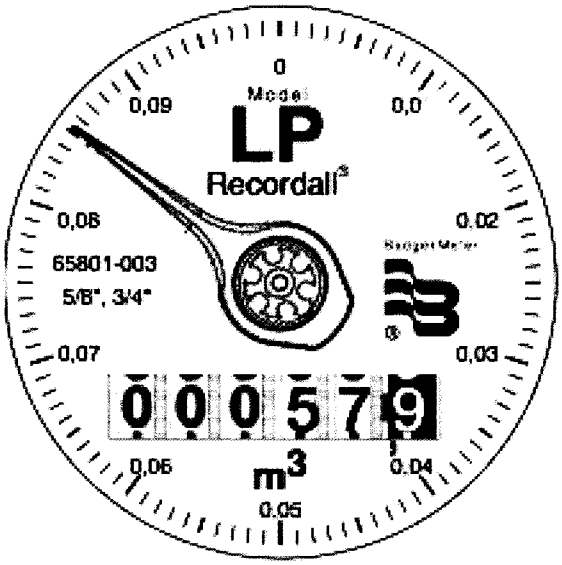


Figure 11: Reading of 57.985 Cubic Meters

4.6.8 Meter Test Form

The meter test form has a place to record all the information needed to determine the accuracy of each meter tested. The tester will record the read of the customer meter before and after the test and log this in for billing accuracy so that the customer does not get charged for the test water. MWD staff will need to deduct the test water from the test customers' bills at the next billing period. A sample of the meter test form is shown in Figure 12.

After the meters are connected, the tester must record the read from the Badger test meter in the "Start" column of the Test Meter area and the start read of the customer meter in the "Start" column of the Customer Meter area. The customer meter should be read to the closes one thousandth of a cubic meter. At the conclusion of the test the end reads should be read and entered into the respective columns. The tester should also record the

accuracy given as a percent on the tag on the meter. This will not vary from test to test based on the small number of tests being done in this project.

Nobel staff will then calculate the volumes from each meter and the gross accuracy of the customer meter. To get the true accuracy the gross accuracy is multiplied by the certified accuracy of the test meter.

Nobel Systems / LWUA

Meter Test Form

METER NO 0621952 **ACCOUNT NO** 321-0039 **BRAND** Arad

CONSUMER PASCUAL, DIOSDADO

ADDRESS B- 42 L-08 38TH ST. MRC

Read (Before Test) _____ Read (After Test) _____

Test Rate	Customer Meter Being Tested			Test Meter (Badger)			Gross Accuracy	Test Meter Accuracy	Final Accuracy
M3/HR	End	- Start	= Volume C	End	- Start	= Volume T	Vt / Vc	%	=(Vt/Vc) x %
0.25									

Notes.

Figure 12: Meter Test Form

4.7 District Metering Area Flow Metering Study

In order to isolate areas of higher water leakage, unauthorized consumption, or other facets of NRW, even the small pilot area may not provide sufficient detail to allow for an accurate analysis. This part of the study is designed to demonstrate the relative benefits of having multiple flowmeters installed in specific areas of a distribution system. Such

flowmeters will allow the users to determine if there are variations in the rate of NRW and allow for more detailed investigations to find the root cause and correct the situation.

4.7.1 DMA Design and Selection

For the MWD pilot area, a total of four DMAs have been developed. Figure 13 below shows the selected locations for the in-line temporary flowmeters.

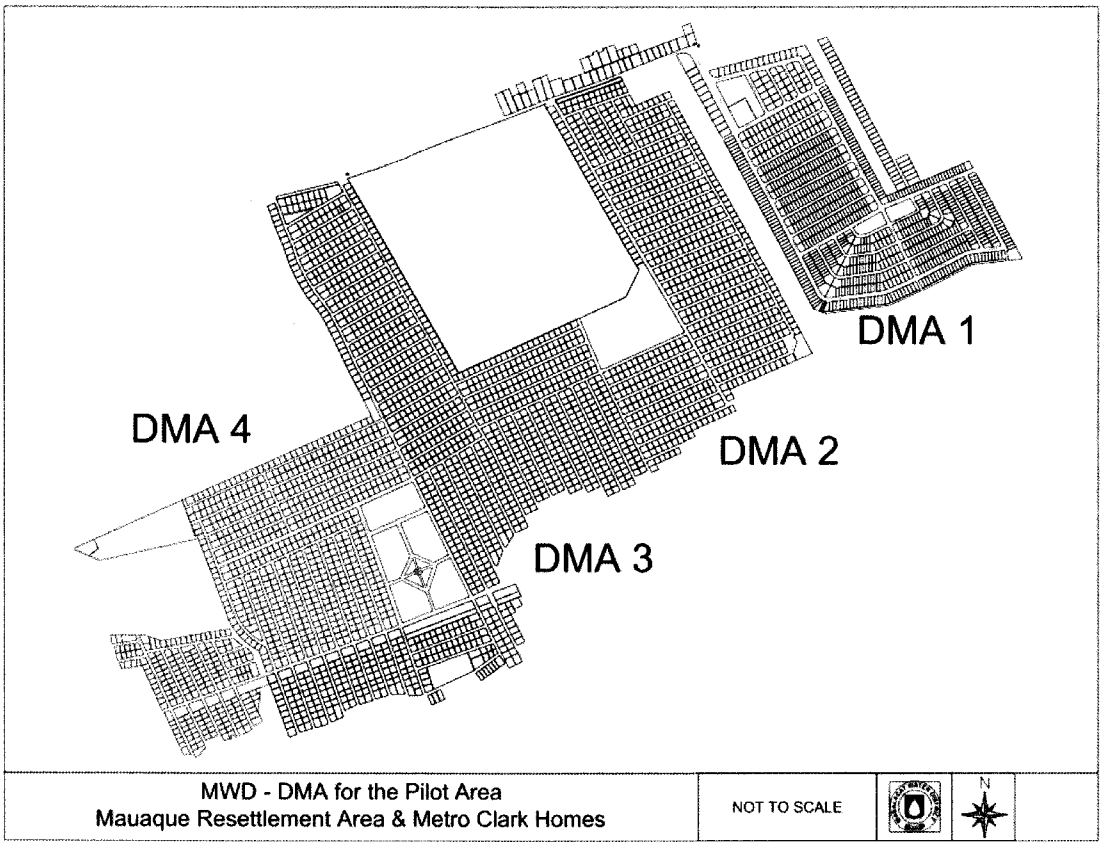


Figure 13: MWD DMAs

As shown above, there are four DMAs and 4 flow metering locations, designated as Q1 through Q4. The flow meter designated as Q0 is the main flowmeter at the local pump station. The use of these portable flowmeters can provide an important cross check for meter accuracy, both for the portable test meters and the main production meter, Q0.

In this study, each of the flowmeters will be installed and a then checked for proper operation. Careful attention needs to be paid to securing these devices as they are very expensive and are also sensitive to damage. Staff at MWD has indicated that they have the capacity to secure these facilities. A more detailed description of the flowmeters themselves is included in a subsequent section.

Precise flowmeter locations are shown in Figures 14 through 16 below

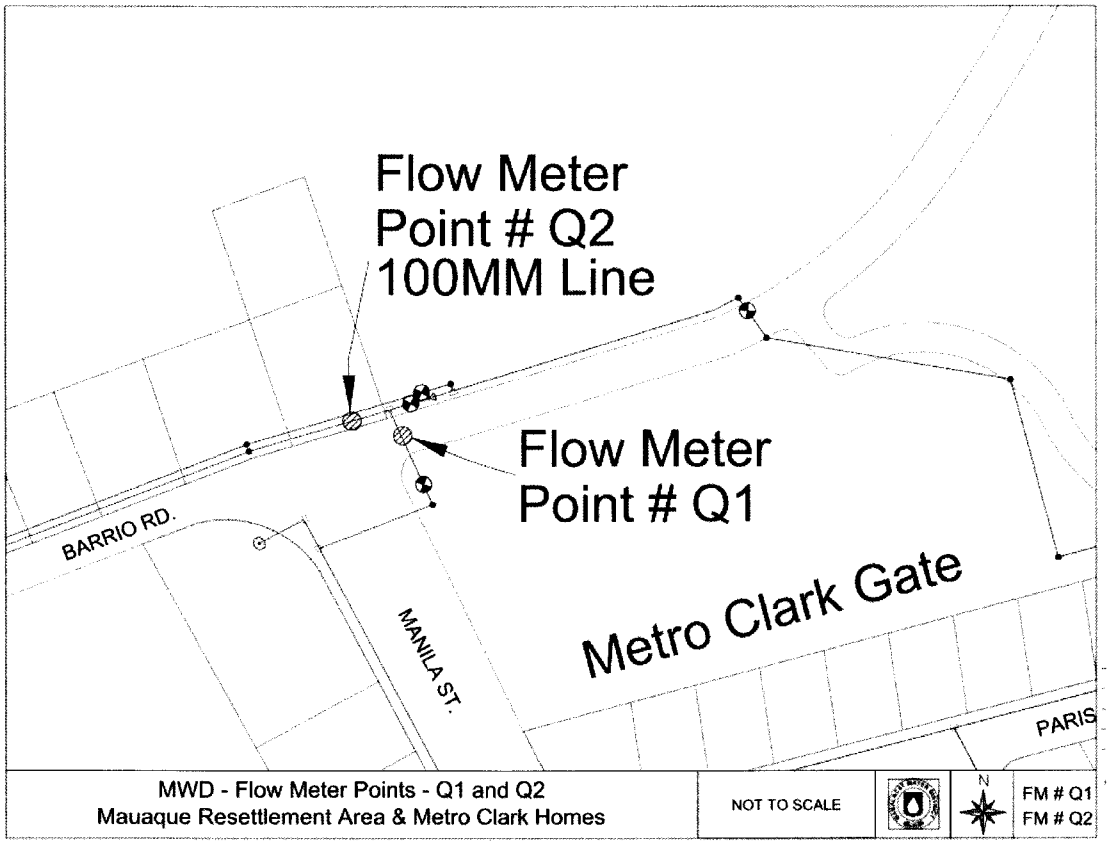


Figure 14: Flowmeters 1 & 2

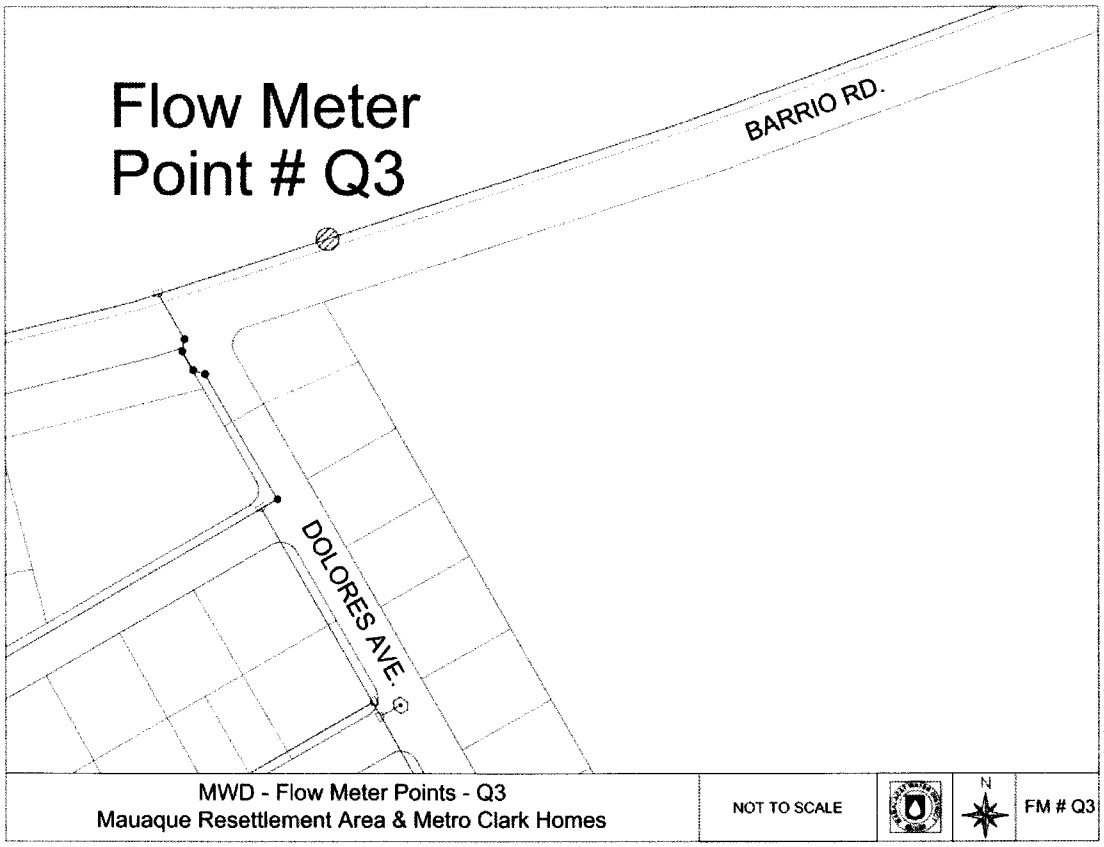


Figure 15: Flowmeter 3

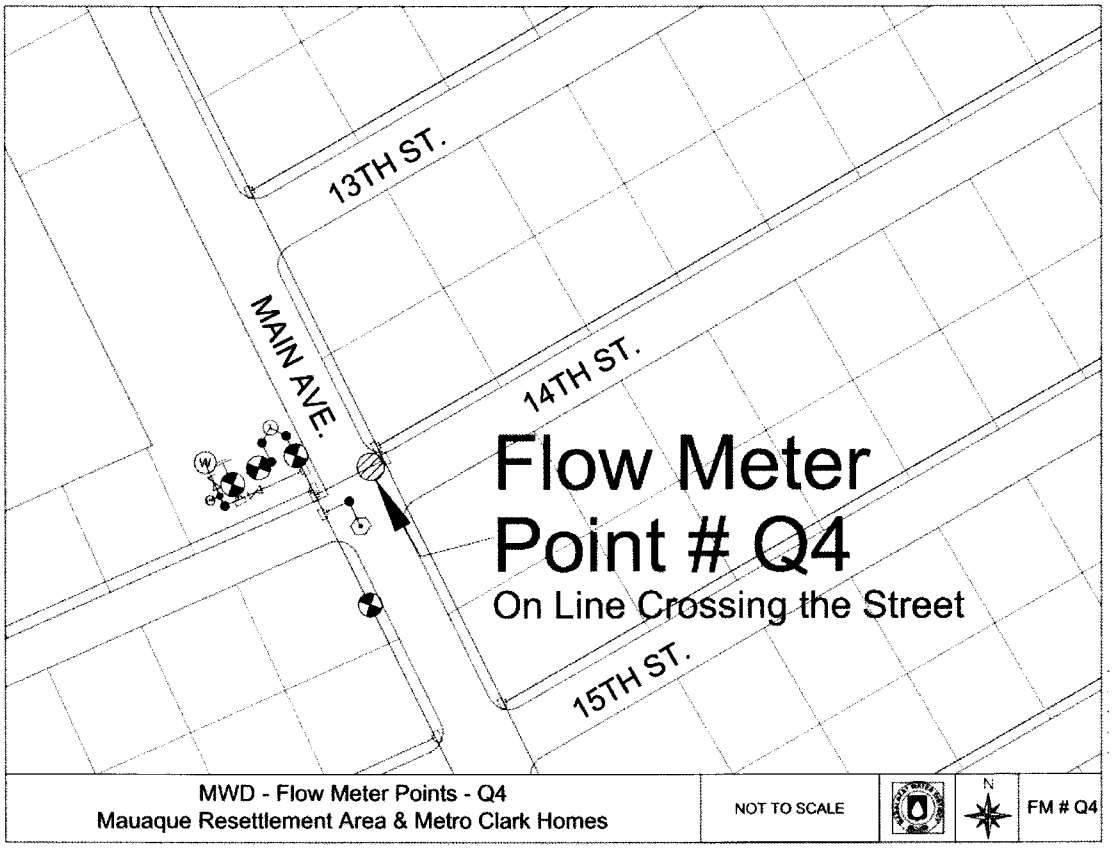


Figure 16: Flowmeter 4

4.7.2 DMA Flow Monitoring Program

Once all flowmeters are installed and validated as operational, the flow-monitoring period can begin. The concept here is to record the total water measured into each DMA along with the total water going through the residential meters within each DMA at the same time to determine how much water is leaking or leaving the system through unmetered connections.

It is important to note that it is not physically possible to manually read every meter at the exact same time. For this reason, it is critical that both the residential meter reads as well as the individual flow meter readings are accompanied by the date and time of the read.

With this information, the reads can be normalized to a common instant in time by determining the average flow and adjusting the measured total to the given time chosen.

For instance, if a water meter is read at 4:00 PM and the target time is 10:00 PM, the data will be adjusted by determining the average flow per day and then per hour and adding 6 hours worth of flow to the total for that meter. This normalization of flow records introduces a small factor of error, but it is much smaller than leaving the reads non-normalized.

The totalizer on each of the zone flowmeters should be read every day and the log of minute-by-minute flow readings downloaded. The instantaneous flow data will not be used for the overall calculation of NRW, but it will be very useful in gaining insight into the diurnal patterns of water use as well as for the hydraulic model.

For each of the DMAs, a concerted effort by MWD staff must be made to read the meters as close to the same time as possible. This is dependent on availability of meter reading staff, but the goal is to try to get the reads done within a short a time period as possible so that the error introduced by the normalization of flow readings is minimized. Depending on staff availability, only one DMA may be able to be read per day, although it would be best to do more than one if possible followed by the others the following day.

Once the data is collected, it will be processed by Nobel Systems to first normalize the data for each DMA to a common point in time. At this point accurate determinations will be able to be made as to the extent of unmetered water in each DMA.

The exact duration of this monitoring period should last for at least two weeks for each DMA. Care should be taken to avoid taking reads on days where local or national holidays may disrupt typical water use patterns as this can induce errors in the read normalization process.

4.8 Socio-Economic and Demographic Data Collection

Task 4 of this project includes required investigations into the socio-economic impacts of this project on the residents of the area. Nobel will conduct a door-to-door survey in the pilot study area with assistance from LWUA, including preparation of the survey questionnaire and personnel training. The questionnaire will include: demographic and socio-economic questions such as: number of people per dwelling, sex, ages, annual income per household, amount spent in utilities and water, level of satisfaction with the water service, and willingness to pay more for a better service based on quality of water (drinkable), quantity, and pressure. A copy of the proposed survey form is included in Attachment B.

Data from this survey will be compiled into a database for analysis and reporting in Task 4 of the project.

4.9 Responsibilities and Expectations of Water District

This comprehensive project cannot succeed without a close partnership with the host water district. The local knowledge held by district staff is an invaluable resource for the project team. The cooperation of the local officials has been excellent during the opening phases of the project and it is expected that the roles that they are required to play should have minimal impact on day-to-day operations.

The local agency will be expected to provide the following:

- Staff labor to perform the residential meter-testing program as described above. Accuracy is very important here so experienced staff are requested.
- Labor to prepare the pipelines for the temporary flow meter installations. This will include excavation of the mains as well as the development of systems to protect the flowmeter and associated datalogger from physical damage and theft.

- Staff labor to check on a read the temporary flowmeters on a daily basis.
- Staff labor to read the residential meters in DMA batches as described in the DMA Flow Monitoring Program above. It is critical that these reads are done quickly within each DMA so multiple staff members may be needed at once.
- Construction of the three meter testing rigs as defined by local Nobel staff.

For Task 4 additional information will be needed:

- Average of design costs as a percentage of overall project costs locally
- A set of data that includes the labor trades available locally as well as average hourly rates of pay
- Average electrical costs paid by the water districts
- An estimate of the availability of skilled labor in the region
- Identification of prospective funding sources per Subtask 4.3
- The expected rate of return on money expected locally
- Any information that the Grantee or districts feel would be pertinent as it relates to local laws and environmental regulations related to this project.
- Identification of the local water supplies used by the districts
- Estimation of regional demographic data including median incomes, unemployment rates, etc
- Estimates of total build-out potential for each district in terms of current number of services and estimated maximum number of services in the future.
- Additional information may be needed and requests for this information will be forwarded to the Grantee or districts as needed.

4.10 Pilot Project Equipment Identification

4.10.1 Large Scale Flowmeter

For the measurement of water moving to various areas of the pilot study area, Nobel has selected a portable transit time flowmeter from Dynasonics. The Series TFXP flowmeters will be attached to the distribution system pipelines at carefully selected locations. On board data loggers will track water flows through these pipelines so that total water used in particular sub areas of the pilot area can be determined. Reads of all domestic water meters in the pilot areas will be taken concurrently so that the amount of water that is measured at the water meters can be compared to the amount of water flowing into any particular sub area of the pilot area.

Installation of this equipment will require the pipeline to be exposed so that the flow measuring devices can be attached to the pipeline. No cutting or tapping of the pipe is required. A power source will be needed for extended data logging. It is important to note that these units are expensive and some sort of enclosure needs to be provided for the electronics so that they are not stolen.

4.10.2 Residential Meter Testing Unit

In order to evaluate the overall accuracy of residential water meters, a randomly selected group of meters will be tested for accuracy. The selection of the meters will be based on the brand of meter and the meter age. Individual meters will be selected randomly from these groups for testing. There are 12 different brands of meters in the pilot area, however four brands compose the vast majority of meters so the brands will smaller representation will be omitted from the study.

In order to test the meters, Nobel has a portable meter-testing rig using Badger T-25 water meters. This system will allow the meter tester to do all the testing at the customer's site and will allow the meter to be placed back into service after testing rather than having to bring the meter to a centralized test facility. A total of three of these units will be assembled for the testing process.

4.10.3 Pressure Data Loggers

A critical part of developing the hydraulic model of the distribution system is an accurate representation of system pressures. Combined with actual data from flowmeters, changes in system pressures can point to hydraulic bottlenecks as well as other distribution system issues. In order to obtain the bet result, it is important to select pressure recorders that are rugged, dependable, and simple to use.

For this project, Nobel Systems has selected the Dickson Model PR-100 Pressure Logger. These units are very compact, giving the installer a wide range of options for locating them in the system. They are very rugged and self-contained – the batteries can last for up to 5 years of operations between replacements. The housing is all stainless steel and is water resistant. Finally, the system is very simple for the user to install and operate.

4.10.4 Data Conversion Software - AutoCAD

Nobel Systems has extensive experience in the conversion of paper-based information into full-featured Geographic Information Systems (GIS). Once the source data is obtained, the documents are scanned into the PDF format for use by the data conversion team. These electronic versions of the original plans serve as an excellent reference for users of the GIS who can access these documents through links to the GIS.

The data conversion team then uses AutoCAD, along with a data conversion extension to AutoCAD developed by Nobel Systems, to perform the data conversion. This special software tool, called DataWorks, the conversion team can leverage the power of AutoCAD in the drafting arena to produce data sets that are seamlessly imported into ESRI geodatabases. This software increases accuracy while reducing the time and cost of producing GIS data sets.

4.10.5 GIS Software – ESRI ArcInfo, ArcGIS, and GeoViewer

As the industry leader in GIS software, ESRI's flagship product, ArcInfo has the full suite of data editing and analysis tools needed to produce the final geodatabase. Using DataWorks, the Nobel conversion team will export data from AutoCAD directly into ArcInfo in order to complete the geodatabase. Any further refinement of the feature classes and the representation of the data through symbology will be performed here.

For publishing GIS data over the web using Nobel's GeoViewer web based GIS application, GIS data will be stored on ESRI's ArcGIS Server. This robust, enterprise class application allows large data sets to be efficiently stored and securely shared among users, either via desktop applications or using web based clients such as GeoViewer. In this method, advanced users with full-featured desktop applications can access the same data sets that more casual users access over the web.

4.10.6 Hydraulic Modeling Software – WaterGEMs and EPANet

Bentley's WaterGEMS modeling software is a full-featured product that features total interoperability with AutoCAD, ESRI and Microstation data files. WaterGEMS has many robust features that allow the full range of modeling including leak detection systems. Bentley's Darwin Calibrator software is specially designed to assist in the use of hydraulic modeling to control NRW.

In addition to WaterGEMs, the Nobel team will create a model in the free EPANet software. This is the lowest cost hydraulic modeling software available, but it lacks some of the enhanced user interface tools that are part of the commercial package. By building

a model in both environments, it will make it easier for LWUA to make a determination about which is better for their environments.

4.11 Project Schedule

A revised project schedule is included in Attachment C

LWUA WATER DISTRICTS
NRW Pilot Study
Weighting Matrix

		BENEFICIAL VALUE TO PILOT STUDY	WATER DISTRICT (SCORE 1 - 10)						
			San Fernando	Butuan	Mabalacat	San Pablo	Angeles	Batangas	Calbayog
1	**LOGISTICS**								
	ACCESS TO ALL LOCATIONS WITHIN THE PILOT AREA	30%	10	10	10	10	10	10	10
	PILOT AREA TO BE <=10% CONNECTIONS (+/- 5 COMPLETE BARANGAYS)	25%	9	10	10	10	10	10	10
	TRAVEL TIME TO WD	15%	10	8	10	9	10	9	8
	ACCESS TO FACILITIES	15%	10	10	7	7	7	7	7
	PILOT AREA TO BE CONTAINED WITHIN 1 PRESSURE ZONE	15%	10	10	10	10	6	6	6
	SUBTOTAL SCORES	100%	9.8	9.7	9.6	9.4	9.0	8.8	8.7
2	**COMMUNICATIONS**								
	INTERNET ACCESS 24/7	50%	10	10	10	5	10	5	5
	INTRANET ACCESS 24/7	30%	10	10	10	5	10	5	10
	IT SECURITY	20%	10	10	10	2	10	2	10
	SUBTOTAL SCORES	100%	10.0	10.0	10.0	4.4	10.0	4.4	7.5
3	**GIS DATA**								
	DIGITAL DATA (SATELLITE IMAGES)	20%	9	0	0	0	0	0	0
	MAINLINES (ACAD, PAPER, ETC.)	10%	10	7	7	7	7	7	7
	ACCURATE & UP-TO-DATE	10%	10	10	10	10	10	10	10
	ATTRIBUTES FOR DIAMETERS	10%	10	10	10	10	10	10	10
	ATTRIBUTES FOR MATERIAL	10%	10	10	10	10	10	10	10
	ATTRIBUTES FOR YEAR OF INSTALLATION	10%	10	10	10	10	10	10	10
	STREET CENTERLINE	10%	8	0	0	7	0	0	0
	TAX MAPS (PARCEL DATA, OR PROPERTY BOUNDARY MAPS)	10%	8	7	7	7	7	7	7
	SERVICE LOCATION MAPS	10%	8	8	0	0	0	0	0
	SUBTOTAL SCORES	100%	9.2	6.2	5.4	6.1	5.4	5.4	5.4
4	**HYDRAULIC MODELING DATA**								
	CUSTOMER BILLING DATA	15%	7	10	7	7	7	7	7
	HISTORY OF BILLING DATA	15%	3	10	0	0	0	0	0
	CENSUS DATA	10%	10	10	10	10	10	10	10
	ELEVATION DATA	10%	7	3	3	7	7	7	7
	TANK AND/OR PUMP DETAILS / MANUALS	10%	10	10	10	10	3	10	10
	DIGITAL FLOW MONITORING DEVICE	10%	6	0	8	3	8	3	3
	PRESSURE MONITORING DEVICE	10%	6	6	6	6	6	6	6
	NO LOW PRESSURE ISSUES (0-10 PSI)	10%	10	10	10	10	8	8	10
	DATA LOGGERS	5%	0	0	0	0	0	0	0
	NO INTERMITTENT SERVICE	5%	10	10	10	10	10	10	10
	SUBTOTAL SCORES	100%	6.9	7.4	6.3	6.2	5.8	6.0	6.2

LWUA WATER DISTRICTS
NRW Pilot Study
Weighting Matrix

NOBEL SYSTEMS

iDModeling
observe . model . improve

		BENEFICIAL VALUE TO PILOT STUDY	WATER DISTRICT (SCORE 1 - 10)						
			San Fernando	Butuan	Mabalacat	San Pablo	Angeles	Batangas	Calbayog
5	NRW DATA								
	ISOLATABLE AREA USING OPERABLE VALVES	20%	10	10	9	6	5	8	6
	EXISTING WATER LOSS > 25%	20%	9	4	8	0	0	0	0
	WATER MAIN MATERIAL FEEDING AREA = PVC, HDPE OR METALLIC - NO AC PIPE	15%	10	10	10	10	10	10	10
	HISTORIC RECORDS OF CUSTOMERS BILLED VS. PAID	15%	10	10	10	10	9	9	10
	ANNUAL PRODUCTION REPORTS	10%	10	7	10	0	0	0	0
	METERING REPLACEMENT AND FLOW VERIFICATION PROGRAM	10%	5	5	5	5	5	5	0
	LEAKAGE AND BURST HISTORY	10%	10	10	10	9	9	9	9
	SUBTOTAL SCORES	100%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	STAFF								
	SECURITY PERSONNEL	50%	10	10	10	10	10	10	10
	AVAILABILITY (INC DRIVER)	25%	10	10	10	10	10	10	10
	APPLICABLE SKILL-SETS	25%	5	7	7	7	5	5	5
	SUBTOTAL SCORES	100%	8.8	9.3	9.3	9.3	8.8	8.8	8.8
7	EQUIPMENT								
	FLOW METERS	30%	10	10	10	10	10	10	10
	PRESSURE LOGGERS	30%	0	0	0	0	0	0	0
	GPS	25%	0	0	0	10	0	5	0
	FIELD RADIOS	15%	10	10	10	10	10	10	10
	SUBTOTAL SCORES	100%	4.5	4.5	4.5	7.0	4.5	5.8	4.5
	CATEGORIES		%	%	%	%	%	%	%
1	LOGISTICS	10%	9.75	9.70	9.55	9.40	8.95	8.80	8.65
2	COMMUNICATIONS	5%	5.00	5.00	5.00	2.20	5.00	2.20	3.75
3	GIS DATA	25%	23.00	15.50	13.50	15.25	13.50	13.50	13.50
4	HYDRAULIC MODELING DATA	25%	17.25	18.50	15.63	15.38	14.38	14.88	15.38
5	NRW DATA	25%	23.25	20.00	22.25	14.00	13.13	14.63	12.75
6	STAFF	5%	4.38	4.63	4.63	4.63	4.38	4.38	4.38
7	EQUIPMENT	5%	2.25	2.25	2.25	3.50	2.25	2.88	2.25
	TOTAL WEIGHTED BENEFIT (%)	100%	84.88%	75.58%	72.80%	64.35%	61.58%	61.25%	60.65%

MABALACAT WATER DISTRICT – SOCIOECONOMIC SURVEY

Account Number_____ **# of People living in the house:** 1 2 3 4 5 6 7 8 9

Last Name:_____**First Name:** _____**Middle Name:**_____

House #: _____**Building Name:**_____ **Street Name:**_____

Number of Stories: 1 2 3 4 5 **House Make:** Nipa / Wood / Concrete **Customer Status:** Active / Deceased / Transferred / Abroad

Landuse: Residential/Commercial/Industrial/Vacant/Agriculture **Commercial Class:** BulkSale/Commercial/A/B/C_____

Residence Type: FullyOwned / With Relatives / Renting / Loaned-Mortgaged **Employment Status:** Casual / Job Order / Permanent

Employer Sector: Government / Private **Years of Occupancy:** 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 >15

Monthly Income: <10000 <15000 <20000 <25000 <30000 **Wage Schedule:** Monthly/Semi-Monthly/Daily **Sex:** Male / Female

Barangay:___Mawaque / Camachiles_____**Municipality:**___Mabalacat_____**Province:**____Pampamga_____

Marital Status: Single/Married/Widowed/Separated **Birthday:** _____ **Occupation:** _____

Landline #:_____ **BroadBand:** Yes / No_____

Cell Phone #:_____ **Cable Connection:** Yes / No **WasteWater (Sewer):** Yes / No **Electricity:** Yes / No___

Water: Yes / No **Satisfied with Water Service:** Yes / No **Monthly Average Broadband Bill:** < 500 < 1000 < 1500_____

Monthly Average Landline Bill: < 300 < 500 < 750 < 1000 < 1250 < 1500 < 2000 Others, Please specify_____

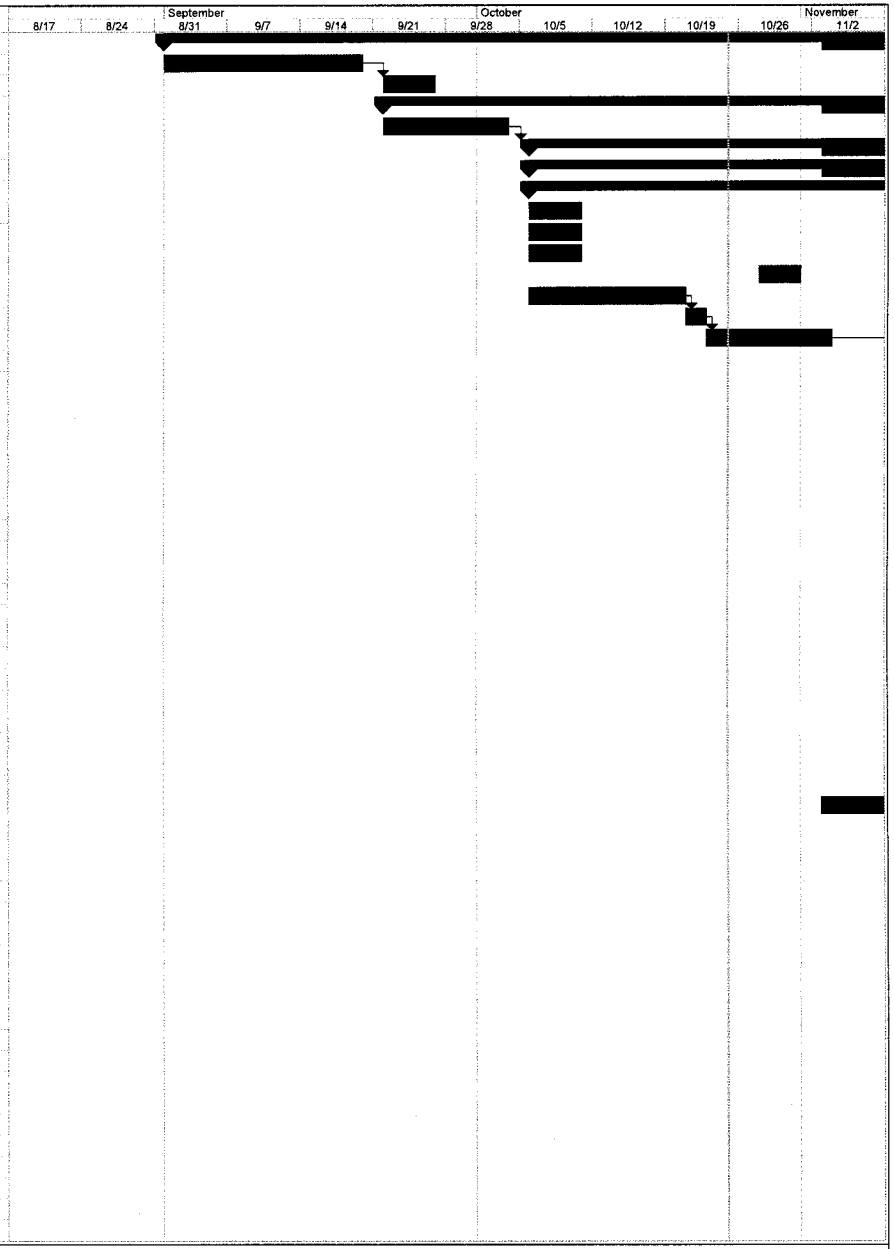
Monthly Average Cell Phone Bill: < 500 < 1000 < 1500 < 2000 < 2500 **Monthly Average Cable Bill:** <500 <750 <1000_____

Monthly Average Electricity Bill < 500 < 1000 < 1500 < 2000 < 2500 Others, Please Specify: _____

Monthly Average Water Bill < 500 < 1000 < 1500 < 2000 < 2500

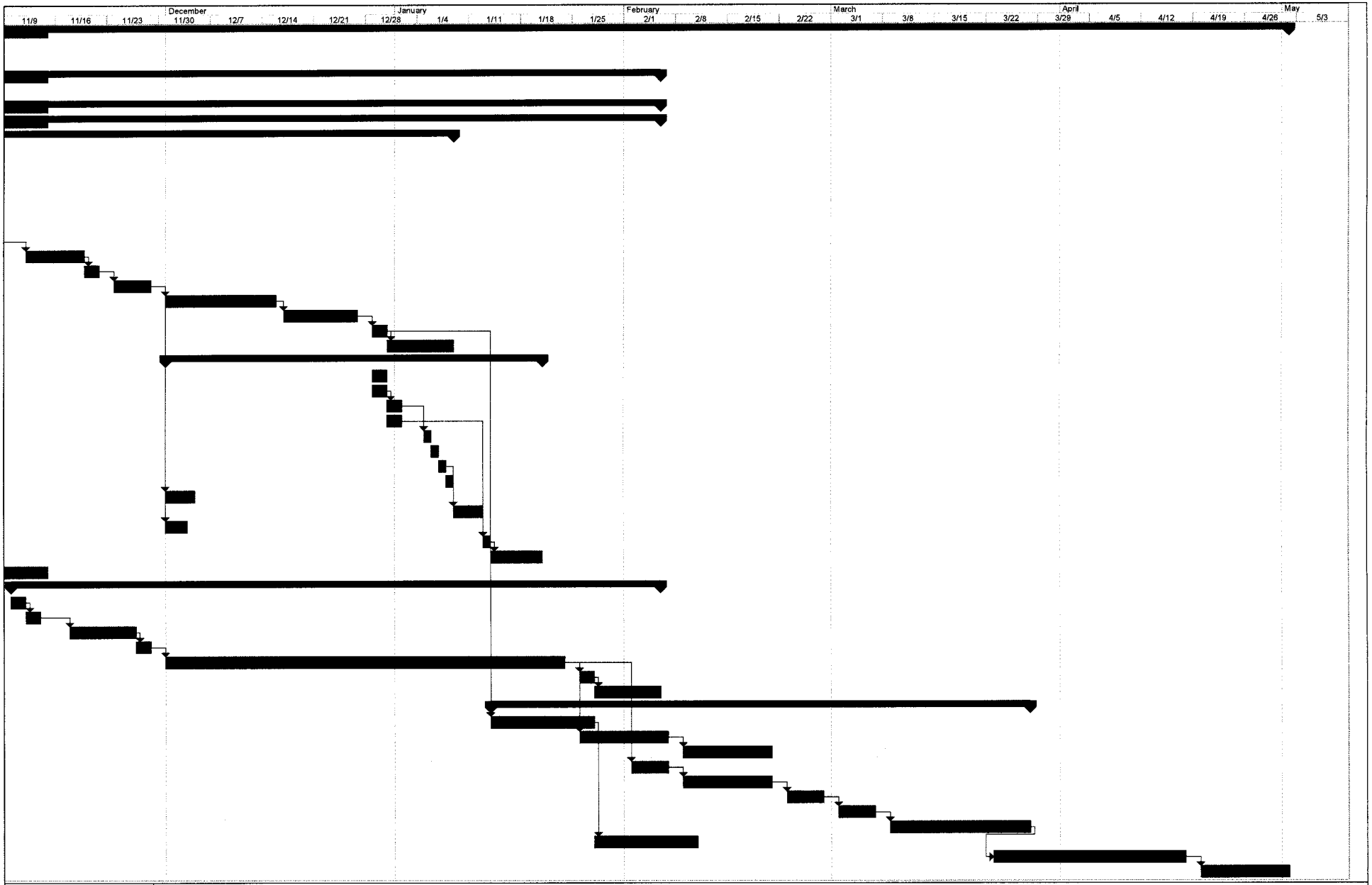
Will you pay more for Better "Quality, Quantity, Pressure of Drinkable/Potable Water" service: Yes / No_____

ID	Task Name	Duration	Start	Finish	Predecessors
1	**LWUA Project**	**175 days**	**Mon 9/1/08**	**Fri 5/1/09**	
2	Task 1 - Detailed Background Review	15 days	Mon 9/1/08	Fri 9/19/08	
3	Task 2 - Study Management Plan	5 days	Mon 9/22/08	Fri 9/26/08	2
4	**Task 3 - GIS-HM-SCADA Technology Evaluation**	**99 days**	**Mon 9/22/08**	**Thu 2/5/09**	
5	Subtask 3.1 - GIS-HM-SCADA Framework	10 days	Mon 9/22/08	Fri 10/3/08	
6	**Subtask 3.2 - Pilot Phase - Evaluating GIS-HM-SCADA Technology**	**89 days**	**Mon 10/6/08**	**Thu 2/5/09**	**5**
7	**GIS - HM - SCADA Data Development**	**89 days**	**Mon 10/6/08**	**Thu 2/5/09**	
8	**GIS for Pilot Area**	**69 days**	**Mon 10/6/08**	**Thu 1/8/09**	
9	Acquire Source Data	5 days	Mon 10/6/08	Fri 10/10/08	
10	Inventory	5 days	Mon 10/6/08	Fri 10/10/08	
11	Scanning of As-builts and Documents	5 days	Mon 10/6/08	Fri 10/10/08	
12	Data Model Preparation	4 days	Tue 10/28/08	Fri 10/31/08	
13	Acquire Satellite Image	11 days	Mon 10/6/08	Mon 10/20/08	
14	Ortho Rectify Satellite Image	2 days	Tue 10/21/08	Wed 10/22/08	13
15	Buildup Landbase	8 days	Thu 10/23/08	Mon 11/3/08	14
16	Creating Service Location Map	6 days	Wed 11/12/08	Wed 11/19/08	15
17	Checking the Parcel Landbase	2 days	Thu 11/20/08	Fri 11/21/08	16
18	Data Capture	5 days	Mon 11/24/08	Fri 11/28/08	17
19	Data Attributation Tasks	11 days	Mon 12/1/08	Mon 12/15/08	18
20	QA/QC	8 days	Wed 12/17/08	Fri 12/26/08	19
21	Data Migration to Geo Database	2 days	Mon 12/29/08	Tue 12/30/08	20
22	Annotation Placement	7 days	Wed 12/31/08	Thu 1/8/09	21
23	**Hydraulic Model of the Pilot Area**	**37 days**	**Mon 12/1/08**	**Tue 1/20/09**	
24	Data Collection & Review	2 days	Mon 12/29/08	Tue 12/30/08	
25	Piping Network Conversion from GIS	2 days	Mon 12/29/08	Tue 12/30/08	
26	Hydraulic Model Model Connectivity, Topology, and QA/QC	2 days	Wed 12/31/08	Thu 1/1/09	25
27	Facility Creation - Creation of Tanks, Pumps, Valves, Zone Valves	2 days	Wed 12/31/08	Thu 1/1/09	
28	Elevation Assignments	1 day	Mon 1/5/09	Mon 1/5/09	26
29	Pipeline Roughness Coefficient Assignments	1 day	Tue 1/6/09	Tue 1/6/09	
30	Model Service Node/Non Service Node Assignments	1 day	Wed 1/7/09	Wed 1/7/09	
31	Project Queries, Named Views, and Selection Set Development	1 day	Thu 1/8/09	Thu 1/8/09	
32	Demand Development using Landbase and Meter Records	4 days	Mon 12/1/08	Thu 12/4/08	18
33	Demand Loading & Allocation	2 days	Fri 1/9/09	Mon 1/12/09	30
34	Diurnal Curve Development	3 days	Mon 12/1/08	Wed 12/3/08	18
35	Facility Control Assignments	1 day	Tue 1/13/09	Tue 1/13/09	27
36	Multi-day Extended Period Flow Meter Calibration	5 days	Wed 1/14/09	Tue 1/20/09	35
37	**Procurement of Equipment and Implementing SCADA Test Process**	**10 days**	**Mon 11/3/08**	**Fri 11/14/08**	
38	**SCADA for Pilot Area**	**64 days**	**Mon 11/10/08**	**Thu 2/5/09**	
39	Divide the Pilot Area into 3 to 5 SubAreas or District Metering Areas (DMA)	2 days	Mon 11/10/08	Tue 11/11/08	
40	Identify Monitoring Points for Measuring Flow	2 days	Wed 11/12/08	Thu 11/13/08	39
41	Install Equipments (Meters and Flow Devices)	7 days	Tue 11/18/08	Wed 11/26/08	40
42	Check if all devices and the system is working fine	2 days	Thu 11/27/08	Fri 11/28/08	41
43	Weekly Readings for 8 weeks	**40 days**	**Mon 12/1/08**	**Fri 1/23/09**	**42**
44	Existing Meter v/s Multijet Meter readings	2 days	Mon 1/26/09	Tue 1/27/09	43
45	NRW Analysis by DMA for Pilot Area	7 days	Wed 1/28/09	Thu 2/5/09	44
46	**Task 4 - Feasibility Analysis of GIS-HM-SCADA Project**	**53 days**	**Wed 1/14/09**	**Fri 3/27/09**	
47	Subtask 4.1 - Technical Assessment	10 days	Wed 1/14/09	Tue 1/27/09	21FS+10 days
48	Subtask 4.2 - Economic Analysis	**10 days**	**Mon 1/26/09**	**Fri 2/6/09**	**43**
49	Subtask 4.3 - Financial Analysis	**10 days**	**Mon 2/9/09**	**Fri 2/20/09**	**48**
50	Subtask 4.4 - Human Health & Environmental Impact Analysis	5 days	Mon 2/2/09	Fri 2/6/09	43FS+5 days
51	Subtask 4.5 - Water Supply System Impact Analysis	10 days	Mon 2/9/09	Fri 2/20/09	50
52	Subtask 4.6 - Ecological Impact Analysis	5 days	Mon 2/23/09	Fri 2/27/09	51
53	Subtask 4.7 - Socioeconomic Impact Analysis	5 days	Mon 3/2/09	Fri 3/6/09	52
54	Subtask 4.8 - Developmental Impact Assessment	15 days	Mon 3/9/09	Fri 3/27/09	53
55	**Task 5 - Analysis of US Manufacturers of GIS-HM-SCADA Technology**	10 days	Wed 1/28/09	Tue 2/10/09	47
56	**Task 6 - GIS-HM-SCADA Project Implementation Plan**	20 days	Mon 3/23/09	Fri 4/17/09	54FS-5 days
57	**Task 7 - Final Report**	10 days	Mon 4/20/09	Fri 5/1/09	56



Project: LWUA_ProjectPlan_v3_03OC
Date: Sat 10/25/08

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone



Project: LWUA_ProjectPlan_v3_03OC
Date: Sat 10/25/08

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Page 2

Task 3 Report

GIS/HM/SCADA Technology Evaluation

Introduction

As described in the beginning of the Terms of Reference for this project, the goal of this project is to determine the feasibility of using GIS/HM/SCADA systems specifically for the control of Non-Revenue Water (NRW) for the water districts that are part of LWUA. GIS/HM/SCADA systems comprise a wide-ranging variety of technologies, hardware, and implementation options with the selection of the appropriate mix for any given situation being highly variable based on local conditions. It is precisely this dizzying mix of options that spawned the need for this analysis.

During the course of this study, the staff at Mabalacat Water District (MWD), in conjunction with Nobel System staff, has made a series of efforts to gather information about the nature of NRW at MWD. These efforts were substantial, from gathering customer and billing data from MWD computer systems, to testing residential water meters, all the way to participating in some detailed water loss measurement efforts in the field. The project proceeded slower than originally projected due to certain unforeseen delays, the longest of which was due to some equipment getting caught up in Customs for three months! Nevertheless, all of the data gathering goals of the project were met and a sufficient amount of data to make an evaluation of the pilot area was developed.

It is important to note here that there is no single "silver bullet" solution to the problem of NRW. Table 1 below shows the variety of components that make up the IWA/AWWA Water Balance system.

Table 1: IWA/AWWA Water Balance System

System Input Volume (corrected for known errors)	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption□(including water exported)	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Non-Revenue Water (NRW)
			Unbilled Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorized Consumption	
			Customer Metering Inaccuracies	
			Data Handling Errors	
		Real Losses	Leakage on Transmission and Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to point of Customer metering	

The focus of this study was the application of GIS/HM/SCADA to the reduction in NRW, particularly those in the Water Losses section of Table 1. Unbilled Authorized Consumption is water than the utility authorizes its staff or other parties to use at no

charge, either metered or unmetered. Based on the information that we have collected during this study, this is an insignificant source of the water losses.

The study had two main phases: the establishment of a GIS/HM/SCADA framework followed by a pilot study to test the concepts identified in real-world conditions. An important consideration is that while the various capabilities of each water district was reviewed in a general sense, the development of the pilot program was specific to the area chosen by MWD. Its design and implementation is unique to the circumstances present at this location and the assumptions and designs may not globally apply. The report for Task 6 contains guidance on how each of the 7 LWUA agencies can take the detailed work done for MWD and apply it to their local circumstances.

Subtask 3.1 Establishing GIS/HM/SCADA Framework

As discussed in the report for Tasks 1 and 2, there are a variety of ways that GIS/HM/SCADA can help water utilities control NRW. The exact tools that could be used by any given utility are dependant on the conditions faced by each utility. The selection of the appropriate mix of approaches to NRW will vary and it is up to the people who understand the local system the best to make this selection based on which sets of approaches will likely produce the best result.

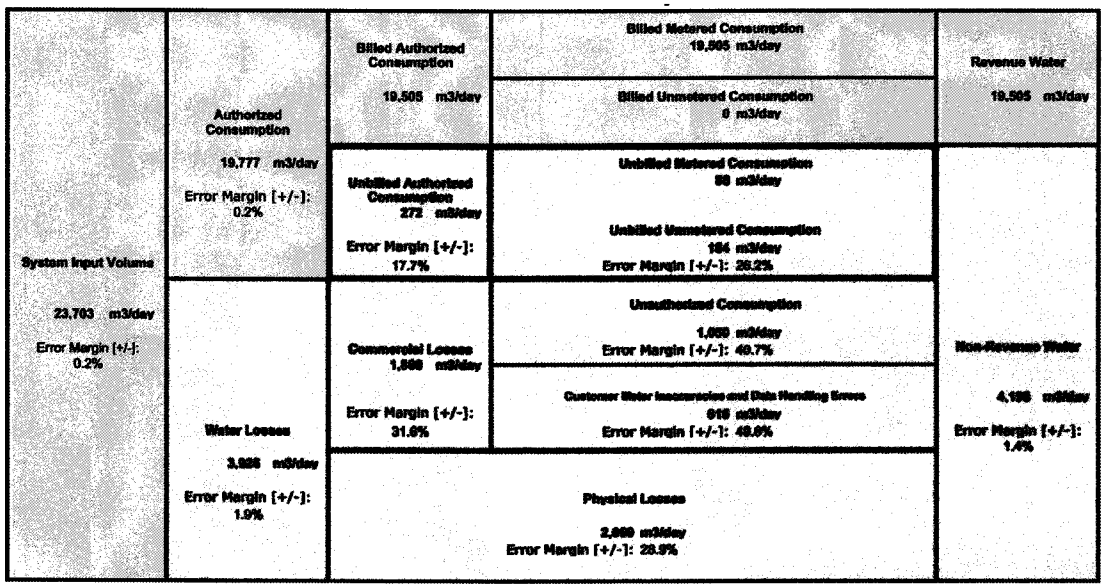
In the situation where money is no object and unlimited funds are available, the selection process is simple – do it all and see what happens. In the real world of shrinking resources and competing priorities, utility managers have to make hard choices about how to use their resources. In this case, which is the norm rather than the exception, the use of resources must be evaluated carefully with an eye toward results.

In the case of MWD, a Water Balance calculator was provided to Nobel Systems by MWD staff for calendar year 2008 (See Table 2 below). This water balance was created by MWD staff using the WB-EasyCalc software from Liemberger and Partners (www.liemberger.cc) which is a very good tool for evaluating water loss types. This software produces reports that follow the IWA Water Balance system described in Table 1 very closely. There is another water balance software system similar to this that is provided by the American Water Works Association called the AWWA Water Loss Control Committee Water Audit Software (http://www.awwa.org/Resources/Content.cfm?ItemNumber=589). Both pieces of software do essentially the same thing, although the WB-EasyCalc includes tools for measuring the relative accuracy of the information provided.

By evaluating the range of water losses estimated in the MWD data shown below, it becomes clear that there is a significant NRW of a bit over 17%. About 6.5% of this NRW is classified as Unbilled Authorized and is made up of MWD staff use as well as fire flows and system flushing activities. As was noted earlier, since MWD has control over these losses, they will not be a subject of this study.

The true water losses total 3926 cubic meters per day. This water, if billed out at the average tariff of P16.80 per cubic meter amounts to a financial loss of P9029 per day. Taken over the course of an entire year, this loss amounts to nearly P24 Million – a considerable sum.

Table 2: MWD Water Balance for 2008



A review of the sources of the losses provides more insight into the problem at MWD. There are two main types of losses – Commercial Losses and Physical Losses. Physical losses are represented by water that actually leaks out of pipes, overflows tanks, and other wise escapes out of the transmission and distribution system. The WB-EasyCalc software estimates this amount using an algorithm that is based on the total length of pipes, the size and material of the pipes, the system pressure, and other factors. This is not a direct measurement, which, of course, would be impossible for this type of water loss.

The Commercial losses in this case are more interesting. Over half of the commercial losses have been attributed by MWD staff to unauthorized consumption or stated more simply - water theft. This represents about 25% of the total non-revenue water – a large amount. According to MWD staff and the experience of Nobel System staff that are in Mabalacat, there are somewhat widespread illegal connections to the water system.

The other component of commercial losses is from the estimated under recording of residential meters at 96% of the actual volume of water passing through the meters. This

is not a particularly bad value, as most water meters average plus or minus 2% when brand new.

The goal of the pilot project is to measure, using GIS/SCADA/HM technologies, each of these water loss types to either validate the estimates made by MWD staff, or alter them using these technologies in order to have as accurate an understanding as possible of the relative contributors of water loss to the whole NRW picture. From there, MWD managers can make decisions as to which areas of water loss to focus on most.

The next three subtasks will describe the detailed framework selection process for each of the technologies and how they will be applied in this project.

Subtask 3.1.1 GIS Framework

A GIS is a lot of things all at once. It is maps – the graphical representation of the world around us. For water agencies, these maps include not just roads and rivers, but also pipelines, valves, hydrants, meters and all of the other things that make up the water transmission and distribution system. A GIS is also a database. It has a data model, a collection of tables and fields, and a variety of queries and other very technical components all designed to keep track of the thousands of things that together make up the water distribution system.

Alone, each of these is great, but is hindered in its use by their own nature. Maps are great, but only a limited amount of information can be displayed on the map and searching for that one thing can be tough. Imagine a road map of all of Luzon with every single road on it. It would be impossible to see many of the roads, much less read the name of the road, unless the map covered a whole wall. A database of all the roads may make it easy to find a given road, but in the list form, it would be hard to trace a route from one place to another.

Put together, the maps and the database give the GIS its true power. By marrying the special dimensions of the map to the analytical power of the database, GIS serves as the foundation for many of the commercial activities of water agencies worldwide. The GIS serves as a complete list of every component in the water district transmission and distribution system; for most agencies the GIS will be the most complete list of assets ever created because every pipe, fitting, valve, hydrant, and appurtenance can be captured in the GIS.

The GIS can also have a wide variety of other non-water system components, with the primary one being a landbase. The landbase generally is based on the property lines of the parcels in the subject area. This allows the water system data to be displayed in reference to property ownership. Another useful non-water data set is the road network, although this is sometimes described within the parcel database as well. Finally, aerial photos allow for a "real world" view of the GIS data on top of actual images of the area.

3.1.1.1 MWD GIS Data Model Development

For the purposes of this study, Nobel Systems developed a data model for MWD based on ESRI's ArcGIS Potable Water Distribution UML Model. This data model is an industry standard model and was developed in a partnership with water agencies as well as third party software companies. The goal of using a standardized model is three fold. First, by using a standard model, the data produced will be more easily shared between agencies. If MWD needs to add data from a neighboring or overlapping jurisdiction, if they are both using the same data model, the integration of the data will be greatly simplified. Second, by using a standard data model, MWD ensures that its data will be something that any qualified GIS technician who is familiar with the industry standard models can use without having a lengthy training period to learn a custom data model.

Finally, and perhaps most importantly for this project, the participation of third party software developers in the data model development process allows for a level of software

integration efficiency that would be impossible without such standardization. There are a variety of third party software applications that use the GIS data for their operations. Many vendors of Computerized Maintenance Management Systems (CMMS), Enterprise Asset Management Systems (EAM), and Hydraulic Modeling Systems (HM) integrate with GIS based on these standard models. In this case, the HM was built directly from the GIS data and the HM software understood exactly where to find every bit of information that it needed in the model with out any customization needed. By using the standard model to develop the GIS, the utility then has an asset that can be leveraged across many applications, serving as a multiplier effect on the return on investment in GIS.

The specific UML model for MWD is attached in Appendix C. This model was adapted from industry standard models specifically for MWD. The model consists of three core packages:

- **Water Network Subsystem Classes** – this part of the model defines all of the fields that will be included in the model for all of the components of the water distribution network. This covers pretty much anything that has water flowing through it.
- **Water Feature Subsystem Classes** – this part of the model describes parts of the water system that are not part of the piping system, such as pump station sites, casings, as well as a specific layer for tracking leak sites. This leak site layer is intended to be used by the utility to spatially record leaks for future replacement analysis work.
- **Domains** – the domains are where each agency customizes the terminology that will be used in the model to describe things. Each field in the model can be assigned a domain table, which defines what sort of valid data is allowed in that field. Consistency of data across the database is critical for maximum benefit of the database. A common field to assign a domain table is pipe material. Each agency defines how they want materials to appear in the database, such as "STL" for steel, "PVC" for poly vinyl chloride, etc. It is important that one person

entering data does not use "Steel" and another "STL" as this will make future queries very difficult. By setting a domain table and establishing all of the naming conventions in advance, the GIS will only accept values that match a corresponding value in the domain table for each field.

Each water agency must review the data model and make the determination of what fields to include and what domain tables to create. There are hundreds of available fields that could be included in a GIS, but many may have no viable use for the water district and as such may just clutter up the GIS. For this project, the fields selected were those that were needed to develop the information needed to perform the NRW analysis and build a hydraulic model.

3.1.1.2 GIS Data Conversion

Once the data model had been developed and domain ranges established, the team could focus on the data conversion process. Data conversion is the task of gathering information from various sources and converting it to GIS format. There are a number of steps in the data conversion process, with the first being data model development. The failure to properly design the data model prior to data conversion will generally lead to a unsatisfactory result because unless you know in advance exactly what data you need for the GIS, you will have a hard time identifying the proper sources for the data.

The selection of data sources for conversion is also a critical step. With an understanding of the requirements of the data model, an analysis of existing data sources must be undertaken to determine where the required data resides. It is uncommon for all data to reside in a single source prior to GIS development. For instance, there may be information about the main line configurations on an as-built for the construction of the water mains, but often service line and meter information is on a separate form that may have been developed at a later date. It is not uncommon for many of the services to be

installed years after the water mains. The GIS team must identify in advance what documents are needed and proceed from there.

In the case of MWD, the water main data was contained in As-builts and this data was converted from this source. Water service locations were gathered by direct observation by Nobel staff in conjunction with MWD meter readers. Service lateral information was also gathered at this time as well as street names. MWD had the base parcel data needed for the project in a format that was ready to use. An aerial photograph of the area was obtained and orthorectified to match the GIS data set.

The GIS data conversion process was carried out by Nobel using techniques that Nobel has honed over many hundreds of data conversion projects. It is not the purpose of this report to describe this process in detail, but information about the process can be obtained in the sample RFP provided in the Task 6 report.

A critical component of this project was the attribution of the customer account number to each meter in the system. This single feature is essential for the use of the GIS data for this project because it provides a built in way to link the GIS with the MWD billing system and any customer demands with great accuracy. Quite a bit of the analysis included in this study was based on the metering information and being able to spatially link customers to places and identify trends that may have spatial elements is essential.

3.1.1.3 GIS Operational Costs

For the pilot area, the cost to perform the GIS data conversion was about P1.3 Million. Based on this experience, it is estimated that a full conversion of the entire MWD service area will be about P6.5 Million. This cost includes all of the data included in the pilot area as completed in this project. There may be ways to reduce costs through utility participation, such as developing some of the customer and meter links in advance, but such costs savings would have to be evaluated on a case-by-case basis.

The GIS data, once completed, requires a GIS application in order to view, edit, and use the data. The GIS for this project was created in the ESRI ArcGIS format, so the data can be read by any of ESRI's wide range of applications, including the free ArcReader available at http://www.esri.com/software/arcgis/arcreader/download.html . This version of the software has substantial limitations and ESRI offers higher-level software systems for advanced viewing, editing, and map making. Single seat costs for this range from P72,000 for ArcView to P720,000 for ArcInfo, the gold standard for GIS software.

Another way to access GIS data is through web based GIS services that allow users to access GIS data over the Internet via a web browser. These sorts of arrangements can be a much more inexpensive way to give larger numbers of people access to GIS data at more reasonable costs. Nobel Systems has made the MWD data available on its web-based GIS application, GeoViewer, at www.geoviewer.net . MWD staff have been given passwords to access this system and may choose to share those with other study participants and LWUA.

Once a GIS data set is created, the data needs to be maintained. Just as a vehicle will eventually fail to operate as intended if routine maintenance is not performed, the GIS data needs to be maintained as well. There will be changes and modifications needed in the data every time someone adds or removes a feature from the water system. In addition, since non-web based GIS software requires considerable training, there will need to be someone on staff who is skilled in the use of the software to make maps and other analyses for other staff members.

For an agency the size of MWD, at least one GIS technician will be needed to edit and maintain the data and provide GIS services for other MWD staff members. The amount of GIS update work required will be highly dependant on the pace of change at any given agency. Agencies that have high growth or change will require considerable technician time to manage the updates. Agencies that are closer to final build out will have a slower pace of change and thus less need for map updates.

This technician could be one of the AutoCAD operators that may be on staff as the data conversion training for GIS is similar to CAD work. The CAD technician, if available, could be assigned part time to manage GIS updates. Further, depending on the CAD package used, the data from CAD can be imported directly into the GIS, thus saving time and money.

A second GIS database specialist would be required to manage the GIS database and produce advanced reports and maps for internal and external use. This person would be required to have detailed knowledge of the GIS data model and the database structure and application.

A review of salaries for GIS technicians and database specialists indicates that the cost of a full time GIS technician is about P375,000 per year and the cost for the GIS Database Specialist would be about P675,000 per year. These costs must be adjusted for fringe benefits based on each agency's benefit package to arrive at the total cost.

3.1.2 Hydraulic Model Framework

Hydraulic Models (HM) are virtual representations of reality using computer simulations. These simulations allow users to evaluate the conditions in the water distribution system through the model rather than through direct measurement. This allows the water utility manager to simulate various scenarios to analyze conditions in a wide variety of ways.

For the purpose of controlling NRW, the hydraulic model is used to monitor the flow of water within the system that would be expected of a water system that had no unexplained losses against measured values from the actual water system itself. By comparing the measured versus modeled results, the water manager can make determinations about where the possible sources of NRW are. In addition, this form of

modeling will allow the water manager to simulate various types of NRW in order to replicate the measured conditions and develop testing programs to validate these simulations.

HM databases are very similar to GIS databases. They contain information about each pipe segment including length, diameter, material, etc just like the GIS. HM databases are not, however, required to be constructed from the GIS. In the past, computing power was not quite sufficient to manage large databases, so HM models were generally skeletonized versions of the water network, as opposed to the totally detailed systems used in GIS. Modern computers can handle larger data sets, so now the only barrier to using GIS is generally the cost of the modeling software, which is generally sold by the number of records in the pipeline database. These costs will be discussed in a subsequent section.

3.1.2.1 MWD Hydraulic Model Development

For this study, the HM was developed as a one-to-one match to the GIS database. This has several distinct advantages:

- It takes advantage of the investment made in the GIS and leverages this data to create a larger return on investment over making a separate HM database
- It allows for the model to be updated easily when GIS updates are performed so that the model can be brought up to date at low cost when changes are needed
- It allows the use of GIS based modeling software that is available from various vendors
- It allows for other spatial data such as aerial photos to be used when displaying model run outputs

A key part of the HM database that may or may not be part of the GIS database is elevation data. While the GIS does not really use elevation data for anything other than

to provide users of the GIS some additional information, HMs are aware of the elevation of each pipe, tank, pump, or any other element in the system. The model needs to know this information so that it can accurately reflect system pressures and the impact on the hydraulic grade lines of the system based on the various tank elevations and pump curves. The elevation data is generally introduced to the model using Digital Terrain Model (DTM) that is available commercially in digital form, or from using paper based topographic maps during the GIS data conversion period.

HMs also require detailed information on the various pumps and pressure regulating stations deployed in the water transmission and distribution system. Pump curves from the manufacturers are entered into the model so it can simulate the operation of pumps. The total pressure drop across pressure regulating stations as well as the sizes of the pressure control valves and pressure relief valves that are part of these stations are entered into the model as well. Along with the elevation data of the pipelines and tanks, these data sets allow the model to operate.

From there, the modelers need to obtain information on system demands and some of the various seasonal and diurnal flow and pressure characteristics of the system in question. These serve as the baseline for setting up the model for the initial run and evaluation. Upon initial model operation, the results are checked and adjustments made until the model appears to run properly. Adjustments are generally made by modifying the coefficient of friction for water pipelines until the expected data matches actual data.

If the model is expected to perform extended period simulations with great accuracy, a process of model calibration must take place. In this process, the modelers will place pressure-recording devices in many parts of the system and then systematically flow water from hydrants and other large sources to create pressure fluctuations in the system. The flows are measured carefully along with the pressures and these flows are simulated in the model and the resulting pressures compared to see how the model does. If there are inaccurate results, the model is adjusted until the results mirror the real-world

conditions. For the purposes of this study, extended period simulations were not required, so no calibration was performed.

3.1.2.3 Hydraulic Model Operating Costs

The primary costs of the hydraulic model are its development/calibration and its subsequent operation. Since the model is generated primarily from the GIS database already completed, the level of effort to create the model is greatly diminished. For the pilot area at MWD, the total cost of developing the model was a bit under P500,000. Since a large part of the model development is setting up the GIS/HM linkages, the costs to perform the whole district at MWD is estimated to be only about 50% more or about P750,000. This demonstrates the economic advantage of leveraging the GIS dataset described above.

Once a HM is developed, the user must have the appropriate software licenses in order to operate the model. For this study, we used MWHSoft's InfoWater application, which has full interoperability with ESRI GIS products. This software is expensive, with an unlimited node license costing about P720,000 for the InforWater Suite 6.0. MWH has a module that is specifically designed to help agencies that have leak issues pinpoint leak locations using the HM through its InfoWater LDM software. The cost for this license is about P380,000. Together, these software packages could cost over P1 Million.

The United States Environmental Protection Agency (USEPA) has a free version of HM software known as EPANET. This can be downloaded by anyone and used for free. It has a reputation for being able to perform the basic functions of the products from commercial firms but has a greatly reduced feature set. For instance, there is no direct tie in to GIS databases – users must create custom text files for moving data between the model and the GIS – a process that can generate many errors.

If an agency chooses to purchase the modeling software or use EPANET, they will also need someone who is skilled in the operation of the model. This is a very specialized and

highly trained individual who must have a deep understanding of the practical use of HM software. It would be expected that this person would have a degree in civil engineering or some other similar vocation. It would be expected that the salary of such an individual would be in the range of P1 Million per year without benefits. IF EPANET is chosen, this cost may go up as the person must also be very skilled in the more "manual" manipulation of data required by EPANET.

For an agency the size of MWD, the large cost to operate the HM in house may be more than the budget can manage. In fact, only the largest of water utilities generally employ full time modelers on staff. Most smaller and mid sized agencies who wish to have hydraulic modeling analysis done simply hire a consultant who can spread the cost of the software and the specialist to operate the software across many clients. Quite often, the need for modeling services are short term and the expense of having dedicated modelers and modeling software can be many times the cost of using a consultant. The viability of this option may be limited by the availability of modeling firms in any given area.

3.1.3 SCADA Development

The term SCADA covers a huge range of possible systems under a massive technological umbrella. There is no one-size-fits-all SCADA system anywhere. Each and every SCADA system is custom developed to meet the particular needs of the client, whether that client be a water utility or a factory producing jelly beans. Each needs to monitor and control the various pieces of equipment that allow them to get their job done.

In the water utility industry, SCADA systems are used for a few key items:

- Monitoring the status and condition of mechanical equipment such as pumps remotely

- Monitoring the pressure, flow, and level of water in the system in various places remotely
- Sending out alarms if any of the above items strays outside of "normal" ranges
- Logging data for reporting and analysis on system performance

In terms of NRW control, SCADA systems can be useful in identifying large leaks by alarming on unusually high flow rates. They can also show flow into areas that should have little to no flow at certain times of day, thus indicating smaller leaks. SCADA systems are particularly adept at managing the level of water in tanks to prevent spills by automatically shutting off pumps when the tanks reach a given level.

The greatest benefit from SCADA in NRW control can be the monitoring of flow in and out of designated DMAs so that these flows can be compared against the actual measured use in those areas. This is one of the best tools for narrowing down the sources of NRW because it allows the users to spot variances between NRW rates of different parts of the system.

SCADA systems are expensive to design, configure, and install. So for the purposes of this study there was no effort to design and install a full SCADA system. A detailed report on SCADA system design for this project along with a detailed cost estimate is included in the report on Task 4 of this project.

In the case of MWD, we found that while a SCADA system would be particularly useful as an operational tool and had the potential to be used for the future control of NRW, the primary benefit of the system would not be realized from an NRW perspective. The reason for this is that in many cases the installation of remotely monitored flowmeter systems is much more expensive that installing manually read mechanical meters at the same location. In a water system whose residential meters are manually read, such as MWD, there is no particular benefit to having a SCADA-read DMA meter, as the meter readers can simply read the DMA meter while they are on their rounds. These meters can

generally be installed at a fraction of the cost of a SCADA system and produce similar results.

This is not to say that other operational benefits of SCADA would tilt the decision in favor of SCADA for MWD. The labor savings on monitoring and controlling pumps and tanks alone could justify the expense as they have in many systems. The fact is that if NRW control is the only condition that the SCADA is to be used for there are lower cost alternatives that should be explored.

For the purposes of this NRW study, we focused on simulating a SCADA system that monitors the flow in and out of the four DMAs that were established as part of this project. A detailed explanation of this process is included in the next section.

3.2 Pilot Phase

Since the goal of this study is the evaluation of the use of GIS/HM/SCADA technologies to control NRW, the pilot project design was focused on the primary components of water loss identified in the IWA Water Balance system. In addition, the pilot design was influenced by the water balance work done by MWD staff as reported earlier since their historical knowledge of local conditions pointed toward certain areas of water loss as being higher probabilities than others.

There are five main contributors to NRW:

- Unbilled Metered Consumption
- Unbilled Unmetered Consumption
- Unauthorized Consumption
- Customer Meter Inaccuracies and Data Handling Errors
- Physical Losses (leaks)

As noted earlier, the first two categories fall into the general class of Unbilled Authorized Consumption. Data provided by MWD indicates that they have a good handle on the nature and quantity of this NRW and these components of NRW are not the main focus of this study. The bulk of the work will focus on the relative contribution of the other three areas of concern. The following sections will identify the facets of the pilot project that apply to each area of NRW.

3.2.1 Pilot Focus: Unauthorized Consumption

In the water balance provided by MWD staff, as well as in the direct interaction with MWD meter reading staff, unauthorized consumption was identified repeatedly as a likely candidate for a large component of MWD's NRW problem. There are a number of theories as to why unauthorized consumption is so rampant, but it appears to be a systemic problem at several of the other agencies – not just MWD. The results of the socioeconomic survey point toward some interesting facts regarding water affordability that may be a factor. A more complete discussion on this topic will be provided in the Task 4 report.

The first technology to be used for this effort is the GIS. For the first time, a detailed map of this system was developed showing every pipeline and meter in the system. Since each meter was linked to the customer account, it was a straightforward manner to then evaluate customer data based on billing history and water service. This also allows the location of inactive or disconnected meters to be identified with respect to location with great precision. Figure 1 below shows the relative distribution of active and inactive accounts.

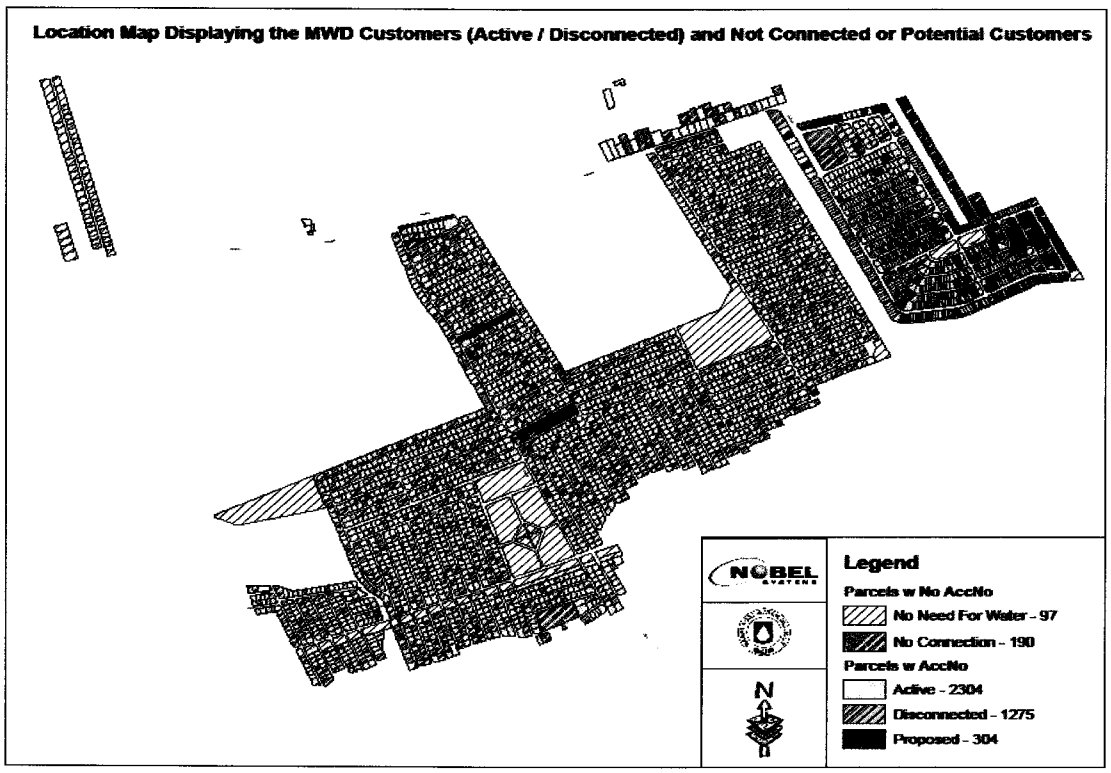


Figure 1 : Meter Location Map

When reviewing this map with an eye toward unauthorized consumption, the number of meters in this area that are actually active represents only about 65% of the parcels with account numbers and only about 53% of the total number of meters. Based on our inspection of the area, nearly every residential parcel is occupied and all of these people need water in some sort or another. There are some public wells and other private wells in the area, but these are considered to be insufficient to meet the needs of the population. It is presumed that some percentage of these homes has unmetered connections to the water system.

The process of determining just how many will be accomplished using both our simulation of possible SCADA technology and the hydraulic model. For SCADA, District Metering Areas (DMAs) were established with individual flowmeters as described in the report for Task 1 & 2. These four flowmeters will record the flow into

each of the DMAs with great precision. We will be reading these meters manually, as opposed to from a central station because the cost to install a central station for such a short period is not cost effective.

The DMA metering process is described in detail in both the Task 1 & 2 report as well as in Appendix A: DMA Metering Project. This process measured very carefully the amount of water that entered each DMA through the temporary flowmeters and the amount of water that was registered through the residential water meters. The difference is the amount of NRW.

During this period, Nobel staff communicated with MWD staff about any observed leaks or other uses of water such as tank overflows and hydrant flushing. No significant activity was reported during the monitoring period. Also, historical records at MWD indicate a low instance rate of main line leaks which is to be expected of a system with relatively new PVC piping systems.

For these reasons, it is predicted that a large percentage of the NRW identified during this process will be from unauthorized consumption. Special attention will be paid to the relative ratio of active to inactive accounts within each DMA to look for any differences in the rate of NRW. If the rate of unauthorized use of water by inactive accounts is relatively constant across this group, this should result in a variance in NRW across DMAs.

Finally, we will deploy the hydraulic model to incorporate the actual demands from each meter along with simulated demands from unmetered connections to make an estimation of the number of unauthorized connections within each DMA. Further refinement of this process could be provided by installing additional DMA meters and breaking the system down into smaller and smaller areas, but the cost of going any smaller than we have here may not be effective.

It should be noted that mechanical, manually read DMA meters can work just as well as SCADA for this application

3.2.2 Pilot Focus: Customer Meter Inaccuracies and Data Handling Errors

According to the 2008 Water Balance report supplied by MWD, customer meter inaccuracies and data handling errors account for about 3.4% of the NRW water. A deeper review of the background information reveals that MWD staff felt that the losses due to data handling errors was minimal and that most or all of this loss was due to inaccuracies in the residential water meters.

Since a great deal of the other NRW work in this study relies on the accuracy of this estimate, a program of residential water meter testing was developed for MWD in order to validate this estimate. In this program, a statistical review of the installed water meter base was performed. The distribution of meters based on size, age, and brand was determined so that a meter-testing program could be established. A detailed description is included in Appendix B of this document.

As a review of Appendix B will indicate, the installed base of meters at MWD consists of relatively new meters of the multi-jet type, which are considered to be more accurate in general than older types of meters, especially in systems where fine sands from groundwater may be present. In agencies that have a different mix of water meters, the same process should be conducted although the sample sizes and range of meters tested may vary from agency to agency.

With respect to data handling errors, there are a number of ways that these errors can be introduced into a meter reading system. The first would be during the actual meter reading itself – are the meter readers properly trained in how to read the water meters. Advances in water meter technology over the years have made this process easier and a

review of the capabilities of MWD staff revealed that in general they are able to read the meters correctly.

One issue that did surface is that the water meters have dials that allow them to be read to the thousandth of a cubic meter, but MWD staff read meters only in whole cubic meters, rounding down to the next cubic meter. This process relies on billing the partial cubic meter that is not included in one month's read on the next month's bill. With an average use in the District of a bit over 18 units, the amount of the under read in any give month would range from 0% (if the meter read on the cubic meter exactly), to 5% (if the meter read XX.9 cubic meters). However, when this process is extended out over a whole year the capturing of the lost fragments of use in subsequent months shaves the average overall error down to a fraction of one percent. It is recommended that agencies take advantage of the capabilities of their meters to resolve use more finely, but it is not mandatory.

Another factor in meter reading errors is dependant on how the data is entered. System that are subject to the highest levels of inaccuracy are those that depend on people to manually read meters and then hand write the results in a log for later transcription into the billing system. Assuming that the meter reader writes the reads down precisely, this process can introduce errors in two other ways. First, the person who does the transcription may mis-read the handwriting of the meter reader. A "1" may look like a "7" or a "6" may be confused for a "8", etc. From there, the person entering the data may make a keystroke error when entering the data.

In the case of MWD, meter reads are conducted using handheld computers, so these transcription errors are not present. Based on a review of the meter reading capabilities of the meter readers, it appears that they are very capable of correctly reading meters. If an error is made in the read of a meter one month, it can generally be corrected the following month when the two reads, once compared by the billing system, show unusual – or negative – use.

For these reasons, meter reading errors were not considered to be a meaningful part of the NRW situation at MWD, so no specific pilot activities were conducted to measure them.

3.2.3 Pilot Focus: Physical Losses

The Physical Loss component of NRW is water that actually leaks out of water mains through the various pipes and fittings. These leaks can be small or large and the range of causes includes corrosion, material failure, impact from people digging in the street, among many others. In some cases, leaks are a major cause of NRW.

Many leaks make themselves visible readily and the larger ones can create huge sinkholes. These leaks are generally attended to immediately by the water agency who can, by attending to the leak, make an estimate of the amount of water lost in the incident. This loss is added to the NRW but the fact that it is accounted for allows the utility to make more accurate estimates for the relative contributions of NRW categories to the total. It is important for water agency staff to keep track of every substantial leak for eventual use in NRW calculations.

The GIS is the foundation for the application of technologies to NRW as it creates a complete database of all of the piping elements in the system along with their materials and ages. When estimating water leakage rates, most of the Water Balance models (such as the WB-EasyCalc referenced earlier) use pipe material and age as a significant factor in whether or not a particular pipe is expected to leak. Newer pipe of more modern materials, such as PVC, generally leaks a lot less than older steel or galvanized piping systems. Average leak rates for various piping systems are included in these models and the rate of leakage is calculated based on material, size, age, length, and system pressure. The GIS allows for accurate information to be fed into these models.

Hydraulic models can also be effective tools for helping to control NRW. Specialized software packages such as MWHSoft's InfoWater LDW is designed specifically for this

purpose. This software allows for detailed review of water loss using a technique that involves breaking an area with excessive leakage into DMAs with a flow meter installed on the input main to each zone. Starting from the farthest valve away from the meter, the DMA is systematically reduced in size by closing valves to isolate different pipe sections in succession (so that less and less of the test area is supplied through the meter), at the same time recording changes in flow rate at the meter. The sequence of closing valves is followed until the flow meter is reached (when the flow becomes zero). A significant drop in flow rate indicates a leak in the section of pipe that was last shut off. The sequence is repeated by opening valves in reverse order. This sort of testing, known as step testing, is normally carried out at night before the morning high demand to minimize supply interruption and reduce inconvenience to customers.

SCADA systems can also be used to control NRW by constantly monitoring the level of water in tanks to prevent overflow of these tanks. By installing flow-monitoring equipment throughout the system, water operators can be alerted to unusually high flow rates that may indicate a main break, allowing crews to respond quickly to the event and reduce the amount of water lost significantly. The SCADA can also be used to monitor and record the nighttime flow for various areas so that utility managers can determine if an area has higher than normal minimum flows for a given area as these flows may indicate a leak.

For the purpose of the pilot, a review of MWD leak history data was undertaken. All of the leaks reported by MWD staff were small and contained to service laterals. Leaks were repaired promptly and MWD staff did not report any areas where they suspected leaks to be present in the pilot area. In addition, the pipe age (under 20 years old), material (primarily PVC), and pressure (low) classifies this system to be one where leakage rates are expected to be very small.

Combined with the system data gathered through the GIS as well as the reports from MWD staff, it was determined that physical losses from leaks would be a small percentage of the problem and that taking measures such as implementing the step testing

system described above would not be cost effective unless other parts of this study indicated that such a review would be warranted.

Appendix A: DMA Metering Project

LWUA DMA Metering Project

Data Collection Protocols

Introduction

In order to evaluate the net volumes of water moving into each of the DMAs of the pilot area, four flowmeters will be installed at key points in the distribution system. These flowmeters will record the total amount of water going into the zone. In order to exactly determine the amount of unmetered water, this total influent volume will be compared to the total amount of water metered through residential meters over the same period. This data will also provide input for the hydraulic model.

Flowmeter Setup

There are several things to consider when installing the four transonic flowmeters:

1. Follow the instructions for installation carefully – the relative position of the transducers is very important.
2. Great caution must be used when installing these items in order to ensure that they will not be damaged or stolen. These are very expensive pieces of equipment and must be protected carefully.
3. Follow the manufacturer's instructions on the installation location with respect to pipe direction changes or other items like system valves. The goal is to have a good deal of straight pipe on either side of the meter.
4. If possible, install the flowmeter near a valve (but not too close – see above) so that the technical could create a zero flow situation. Some models of flowmeters require the installer to "zero out" the flowmeter by taking a measurement at a known flow rate of zero.
5. Make sure that the totalizer is set for cubic meters and that the time intervals are appropriate for this application.
6. If possible, test the flowmeter function by turning the supply pump on and off to induce flows to the storage tanks in the system. You should see changes in the flowmeters during these conditions.
7. There is a valve between DMAs 2 and 3 at the southern end that needs to be closed – make sure it is closed before we start.

Residential Meter Reading

This process ideally would have each and every residential meter read at the exact same instant as the four portable flowmeters. Regrettably, this would require thousands of people and is not practical. In order to simulate this process, we will take the meter readings as quickly as possible at the start and end of the measurement period. It is expected that it will take 8 hours to read all the meters in each DMA. An important part of each meter read will be not only the reading on the meter, but the exact time to the minute that the read is taken. Using this information we will normalize the reads to match the time the main DMA flowmeter was read. The greatest accuracy will be obtained by keeping the adjustment period as small as possible. In this case, we will try to limit the adjustment period to a maximum of four hours.

Here are the steps to follow to start the monitoring period:

1. Make sure all DMA portable flowmeters are installed and operating properly.
2. Brief the meter reading crew on the goals of the program and emphasize the need for both speed and accuracy. Meters should be read to the thousandth of a cubic meter.
3. Make sure that each meter reader has a timepiece and that these timepieces are all showing the same time.
4. Make sure that the meter readers have a form that includes the account number and a space to record the read and the time.
5. Commence the meter reading at the start of the day.
6. At mid-day, or halfway through the reading process, have someone take the totalizer reading at the portable flowmeter. Again, record the read and the time to the minute.
7. Continue reading the remaining meters in this DMA and logging the time for each read.
8. Check the work of the meter readers to ensure that the correct information was collected
9. The following day, repeat this process at the next DMA, and continue until all four DMAs are done.

Here are the steps to complete the monitoring period:

1. Start with the first DMA that was read above at least 7 days from the start date.
2. Brief the meter reading crew on the goals of the program and emphasize the need for both speed and accuracy. Meters should be read to the thousandth of a cubic meter.
3. Make sure that each meter reader has a timepiece and that these timepieces are all showing the same time.
4. Make sure that the meter readers have a form that includes the account number and a space to record the read and the time.
5. Commence the meter reading at the start of the day.

6. At mid-day, or halfway through the reading process, have someone take the totalizer reading at the portable flowmeter. Again, record the read and the time to the minute.
7. Continue reading the remaining meters in this DMA and logging the time for each read.
8. Check the work of the meter readers to ensure that the correct information was collected
9. The following day, repeat this process at the next DMA, and continue until all four DMAs are done.

Data Processing

Once the data is collected, each reading must be entered into a spreadsheet or a database. Using this information, the total volume metered at each customer will be calculated by subtracting the beginning read from the end read. Once the total volume is known we will calculate the total interval in minutes between the reads by using the time stamps collected with each read. This information will be used to calculate the average flow in cubic meters per minute for each account.

In order to normalize the reads, we will then compare the residential meter read time with the main DMA flowmeter read time for the area where each meter is located. We will calculate the total number of minutes each reading was either before or after the DMA. If the reading happened before the start of the monitoring period, that is if the meter reading for the start was taken before the DMA meter was read, we will subtract a volume equal to the average flow rate for that meter multiplied by the number of minutes difference between the two reads.

If the residential flowmeter was read after the DMA flowmeter, we will add a volume equal to the average flow rate multiplied by the difference in minutes between the reads. This will most easily be achieved using a spreadsheet or a database. This process will be repeated for each DMA and each meter within each DMA.

The adjusted reads will then be as good an approximation as we can get of the actual metered volume and the actual input volume. The difference between these values will be the actual water loss.

Appendix B – Residential Water Meter Testing Program

Residential Water Meter Testing Program

Mabalacat Water District

Introduction

In order to determine the contribution to the overall Non-Revenue Water (NRW) that has its origin in the residential metering program at Mabalacat Water District (MWD), a comprehensive analysis and testing program will be conducted on the residential meters. The goal of this study is to clearly identify the overall accuracy rate of the thousands of residential water meters in the pilot area. Based on the results of this testing program, assessments can be made on the cost effectiveness of any residential water meter retrofit programs.

All water meters register water use with varying levels of accuracy. Differences in manufacturer, type of meter, and meter age can all factor into the meter's overall accuracy. In this study, we will try to control for these variables to determine how the performance of meters in the MWD Pilot Area contributes, or does not contribute, to NRW.

Meter Selection Process for Testing

As noted above, the three major variables that are controllable for this project are meter manufacturer, meter type, and meter age. Nobel Systems staff has collected meter data from MWD staff and an analysis shows that all of the meters for which information is known about their brand indicate that they are all multi-jet type meters. This will narrow down the testing regimen to only meter brand and age.

In addition, since we are interested in determining how meters are contributing to NRW now, as opposed to at some period in the past, we will be considering only those meters listed in MWD's data as being currently active. This will correlate the information more closely with other aspects of the distribution system modeling, since the mass flowmeters will presumably only be feeding meters that are on during the study period.

Meter Brand Distribution

In the data set provided to Nobel by MWD, there are 3817 accounts listed total. This number includes both active and inactive meters as well as a large number of meters for which no brand name was known (1623). Of the total number of meters, there are currently 1606 for which both the brand name is known and the meter is listed in MWD's data as being active or in service.

There are twelve total brands of meters in this data set of 1606 meters as shown in Figure 1 below. The vast majority of these meters (over 86%) are one of three brands: E-Jet, Aqua-jet, and Arad. The remaining 9 brands have very small representation in the total meter population and therefore will not be part of the meter testing program; these 9 brands have such small numbers that if any meter replacement program is suggested as part of this project they will simply be included in the program.

Table 3: Meter Brand Distribution

Brand	Count	Percent of Total
E-Jet	689	42.90%
Aqua-jet	453	28.21%
Arad	246	15.32%
Jitsui	77	4.79%
evjet	49	3.05%
Excel	42	2.62%
Artic	31	1.93%
Asahi	7	0.44%
Shang-shu	6	0.37%
Ever	3	0.19%
Andrae	2	0.12%
YT	1	0.06%
Total	1606	100%

Meter Age Distribution

As a critical component of meter performance, advanced meter age can result in meter underperformance through inaccuracies and underreporting of water passing through the meter. The meter data provided by MWD was reviewed to determine the age distribution of meters. Again, only active meters with known brand names were included,

As Table 2 below indicates, over half of the meters in the pilot area are under 5 years old and over a third are over 10 years old. There is a smaller number of meters in the middle aged portion, indicating that meter installations were not even distributed over time, but were performed in bunches at different times. This is a fairly typical distribution of water meter ages.

Table 4: Meter Age Distribution

Brand	Under 5 Years Old	5 to 10 years old	Over 10 Years old
E-Jet	335	269	82
Aqua-jet	261	144	48
Arad	130	86	30
Jitsui	45	25	7
evjet	28	14	7
Excel	24	14	4
Artic	9	18	4
Asahi	2	3	2
Shang-shu	0	4	2
Ever	2	1	0
Andrae	1	0	1
YT	0	1	0
Total	837	579	187
% of Total	52.1%	36.1%	11.6%

Test Meter Selection

In order to reduce the impact on labor resources needed to perform the test, a sliding scale of test samples will be used. This is due to the fact that most meters wear with age and are expected to be most accurate at a young age. Since most of the meters in the total population of meters are relatively young, a smaller sample set of each will be used for the initial meter testing program. Once data is received from the initial testing program it will be evaluated to determine if additional testing is needed in order to achieve a reliable result.

Normally, a sample size is related to the total number of meters in the sample group to be evaluated. This will be the case in this study, but we will deploy a sliding scale of test sample size based on age. For meters that are over 10 years old, we will test 20% of the meters. For those between 5 and 10 years old we will test 15% of the meters. For those under 5 years old we will test 10% of the meters as we predict that these meters will be very close to their factory state and should not exhibit excessive wear at this young age.

These sample sizes will give good indicators of the average performance of the meters in the pilot area as a whole. Table 3 below shows the number of meters that will be tested for each brand and age group. A total of 180 meters will be tested altogether.

Table 5: Test Sample Sizes

Brand	Under 5 Years Old	5 to 10 years old	Over 10 Years old
E-Jet	34	40	16
Aqua-jet	26	22	10
Arad	13	13	6
Total	73	75	32

A map showing the location of each of the meters to be tested will be provided to the test personnel along with the test data collection sheets.

Meter Testing Procedures

Test Preparations

A total of three meter testing rigs will be provided to the testers for this project. It is expected that each tester should be able to complete at least 10 meters per day and potentially several more than that. With 180 total meters to test, the testing should be completed in 6 days, barring unforeseen situations.

In order to test each customer meter, the cooperation of the customer will be needed. The water will need to be shut off to the residence for the test period. If this is not possible for some reason, the test will have to be called off and an alternative site selected. Depending on local practice, advance notification of the customer may be needed.

Once the tester has contacted the residents of the property and informed them of the water shutdown, the valve service the meters shall be turned off. Once the pressure has been removed from the line the meter shall be removed from the service and connected to the test rig. A flexible hose will then connect the meter on the test rig to the service connection on the utility side. This hose should be as short as possible to prevent excessive head loss.

Care should be taken on the location of the test rig so that the discharge of water will not cause damage to property in the area. If needed a hose can be connected to the outlet of the test rig. It should be kept as short as possible to prevent excessive head loss in the hose.

Performing the Test

Once the meters are connected and before any water flows through the meters, it is important to record data to the data collection sheet provided. The following data shall be recorded:

- Verify the serial number of the meter
- Record the read of the customer meter
- Record the read of the test meter (Badger)

Once the data has been recorded and the tester has made all the connections and ensured that the discharge location is appropriate, the test can begin. For this size meter, the test protocol will be for a single flow rate of 0.25 m^3/hr or about 1 GPM. It is important that this flow rate be consistent from test to test as variations in flow can have impacts on the accuracy of the test. It is recommended that the testers practice on sample meters using known volume buckets and stopwatches so they can get a sense for what the 0.25 m^3/Hr flow looks and feels like. It is not critical to be exact, but the flows need to be close.

The tester should then run the water for 15 to 20 minutes at a consistent flow rate. Care should be taken not to open our close valves too quickly when starting and stopping the test – gradual flow changes are best. After the time has elapsed, the outlet valve should be closed followed by the customer's service valve. Before disconnecting the meters the tester shall record the reads of both meters on the test form.

Once the meter data is properly recorded the customer meter can be disconnected from the test rig and replaced into service. If for some reason the meter registers no flow or is obviously recording incorrectly, the tester may choose to replace the meter at the time of the test with a new meter.

Reading The Test Meter

The Badger M25 test meter has been tested by the factory and the accuracy of the meters is certified as shown in the table below. This tag indicates what the percentage of actual flow is recorded by the meter at a given flow rate. This number will be used in the final calculation of the customer meter accuracy. For the purposes of this study we will only be using the mid-flow accuracy shown below.

Table 6: Test Meter Accuracy

Serial Number	Low Flow Accuracy (0.25 GPM/0.0625 M^3/HR)	Mid Flow Accuracy (1.0 GPM/ 0.25 M^3/HR)	High Flow Accuracy (25 GPM/6.25 M^3/HR)
08739778	100.2	100.6	98.9
08739777	100.3	100.4	99.3
08739776	100.1	100.3	98.9

The Badger M25 meter has six live register digits and a 0.1cubic meter test circle. Five of the six digits are white and one black. The black digit reads tenths of cubit meters. Using both the register digits and the test circle hand, the tester can record water use down to the thousandth of a cubic meter.

Figure 1 below shows a read of 34.111 cubic meters. The 5 white digits are 00034, indicating 34 cubic meters and the black digit is 1, indicating 0.1 cubic meters. To get the hundredths and thousandths the reader needs to look at the hand which is at 0.011. Added together the overall read becomes 34 + 0.1 + 0.011 = 34.111

Figure 2: 34.111 Cubic Meters

Figure 2 below shows a read of 34.167 cubic meters. The 5 white digits are 00034, indicating 34 cubic meters and the black digit is 1, indicating 0.1 cubic meters. To get the hundredths and thousandths the reader needs to look at the hand which is at 0.067. Added together the overall read becomes 34 + 0.1 + 0.067 = 34.167

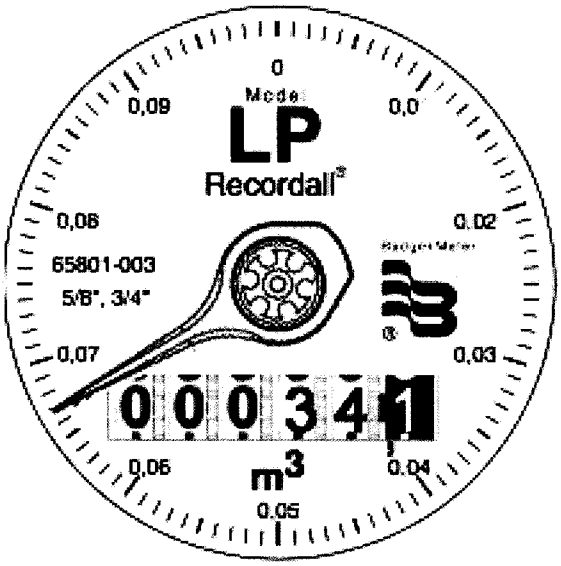


Figure 3: 34.167 Cubic Meters

Finally, Figure 3 below shows a read of 57.985 cubic meters. The 5 white digits are 00057, indicating 57 cubic meters and the black digit is 9, indicating 0.9 cubic meters. To get the hundredths and thousandths the reader needs to look at the hand which is at 0.085. Added together the overall read becomes 57 + 0.9 + 0.085 = 57.985

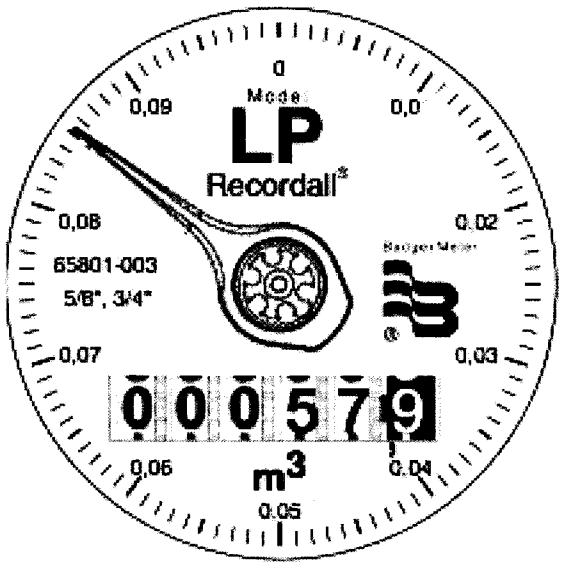


Figure 4: 57.085 Cubic Meters

Meter Test Form

The meter test form has a place to record all the information needed to determine the accuracy of each meter tested. The tester will record the read of the customer meter before and after the test and log this in for billing accuracy so that the customer does not get charged for the test water. MWD staff will need to deduct the test water from the test customers' bills at the next billing period. A sample of the meter test form is shown in Figure 4.

After the meters are connected, the tester must record the read from the Badger test meter in the "Start" column of the Test Meter area and the start read of the customer meter in the "Start" column of the Customer Meter area. The customer meter should be read to the closes one thousandth of a cubic meter. At the conclusion of the test the end reads should be read and entered into the respective columns. The tester should also record the accuracy given as a percent on the tag on the meter. This will not vary from test to test based on the small number of tests being done in this project.

Nobel staff will then calculate the volumes from each meter and the gross accuracy of the customer meter. To get the true accuracy the gross accuracy is multiplied by the certified accuracy of the test meter.

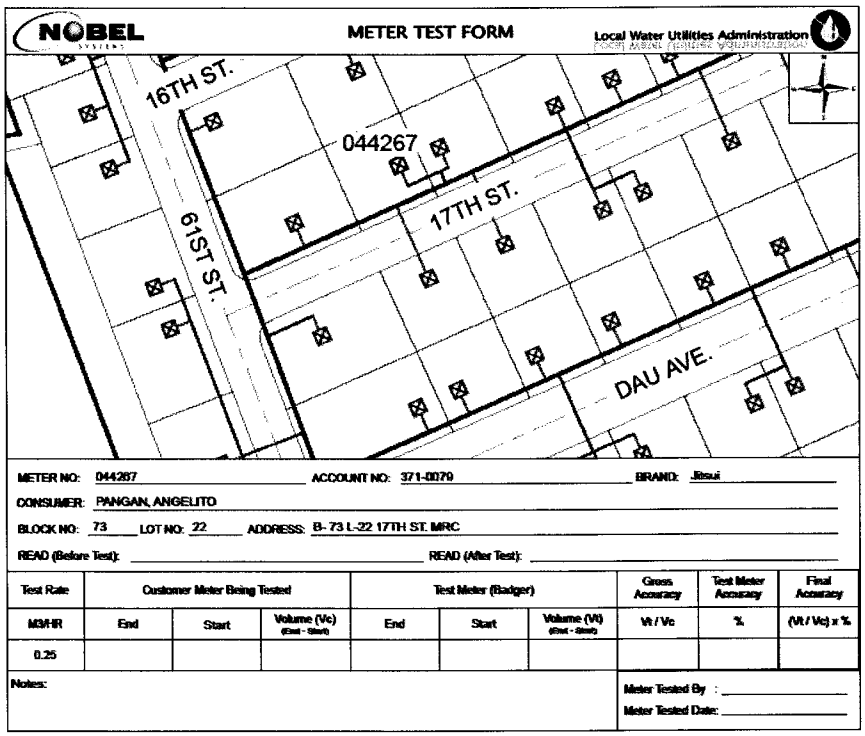


Figure 5: Meter Test Form

Task 4 Report

Feasibility Analysis of the GIS/HM/SCADA Project

Introduction

The impact of Non-Revenue Water (NRW) on water utilities is enormous. Even if local water supplies are plentiful, the costs to collect, treat, pump, and distribute water to customers is increasing over time. In areas where the supply of water is limited, responsible water agency managers must focus on every drop of water to ensure that none is wasted. For these, and many other reasons, the control of NRW is mandatory.

Traditional methods for NRW control focused mainly on two areas. First, a big part of NRW for many systems can be due to metering inaccuracies. If the precise volume of water going into a system is not accurately metered, it is difficult or impossible to determine whether or not there is a significant NRW problem. Conversely, if the meters used at the customer delivery site are inaccurate, it is difficult to know how much water was actually used. In these cases, there can be large variances in system input and output that lead to NRW. A system with zero leakage could have massive NRW simply due to metering inaccuracies.

The second major focus is on water leaks. Depending on the age, pipe material, and pressure of a system, there can be widely varying levels of leakage in distribution systems. Generally, newer lower pressure systems leak less than older higher-pressure systems, but that is not an absolute rule. Finding leaks in the past relied mainly on direct observation of leaks at the ground surface, or through listening for leaks acoustically at valves and other appurtenances.

So if an agency has some level of NRW and has already deployed these two methods and finds itself still saddled with high NRW, the decision on how to proceed gets more difficult. New approaches need to be developed and evaluated in order to determine how to proceed.

This study was conceived to evaluate the use of Geographic Information Systems (GIS), Hydraulic Modeling (HM) and Supervisory Control and Data Acquisition (SCADA) systems in the effort to control NRW. These technologies, taken individually or together as in this case, each possess certain qualities that allow water agency managers to gain insight into the root causes of NRW.

The use of these technologies differs from the two traditional methods of NRW control in that they tend to take a system level approach rather than focusing on one meter or one leak at a time and trying to aggregate these into a comprehensive program. These technologies require detailed information about the water system to be fed into software than can perform calculations that are impractical for humans to do standing at a leak site or meter vault.

The detailed review of data from these systems can provide insight that would be difficult or impossible to obtain using traditional methods. These systems are not a guarantee that NRW can be controlled perfectly if they are deployed – far from it. These systems on their own have little capacity to actually control NRW. What they can do is provide insight to water utility managers as to the appropriate courses of action that could be taken over time to reduce NRW. As the results of this study will show, some of the methods for controlling NRW have little to do with meters or leaks, but more with how the community interacts with its water providers.

Also, the results of the study provided in this report are geared toward information gathered in the selected pilot area of the Mabalacat Water District (MWD). Any conclusions drawn from this data apply only to this area and may not apply to the rest of

the Mabalacat Water District or any of the other 7 Districts that are part of this study. This study simply outlines the process that each agency can take when considering using GIS/HM/SCADA in an effort to control NRW. The report on Task 6 includes some guidelines on how to use the results of this pilot study and apply it to other areas. There is no one-size-fits-all solution to NRW – each agency must make its own evaluation of the particular situation it faces before proceeding.

Pilot Study Results

Before describing the results of the pilot study, Nobel Systems wishes to express its gratitude for the efforts of MWD management and staff in the implementation of the pilot work. This process required a great deal of cooperative planning in order to set up the data collection programs. There was also a lot of old fashioned work involved in the installation of temporary meters, residential meter testing, and DMA meter reading. Numerous MWD staff members participated and without their cooperation this project would not have been possible. The images below show just a small glance into the efforts that were made.

Figure 1: MWD Staff Planning Meter Tests

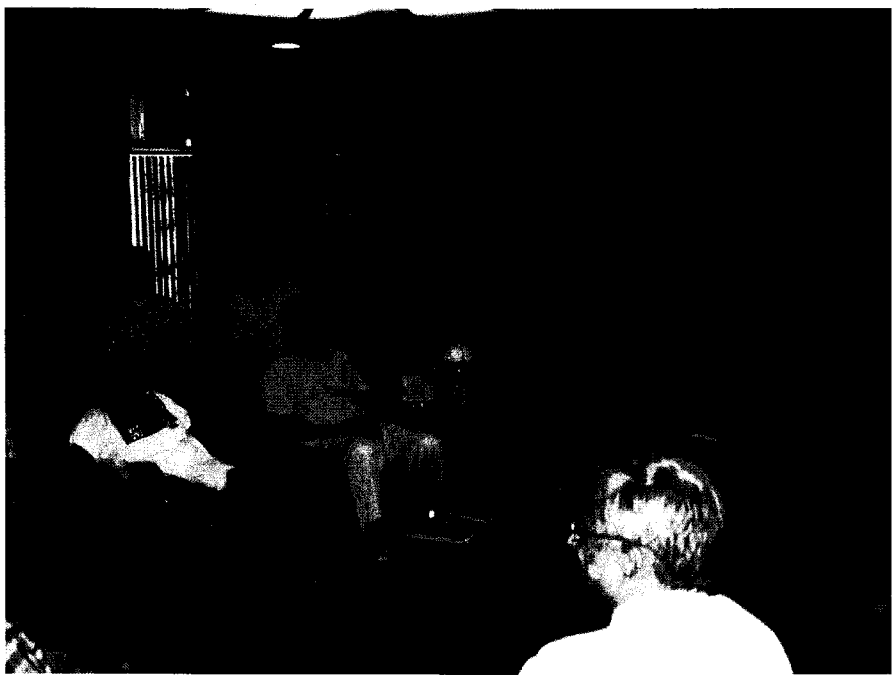


Figure 2: MWD Management Planning Meeting

Figure 3: DMA Flow Meter Installation Team

Figure 4: DMA01 Flowmeter Installed

There were several areas of concentration of this study for which results are available:

GIS Development
Hydraulic Model Development
Residential Meter Testing Program
SCADA Evaluation and Design
Socioeconomic Survey
District Metering Area (DMA) Flow Study and NRW calculation

GIS Development

The development of the GIS was the first phase of this project, commencing immediately after kickoff. A data model was developed as described in detail in the Task 3 report. Source data was collected for the data conversion process and scanned so that it could be linked to the GIS data in the software. Additional sources of information included records from MWD staff as well as service lateral information gathered via site visits and other MWD records.

Figure 5 below is an example of the source data for the GIS and Figure 6 shows the completed GIS. Note the additional detail available in the GIS, particularly the meter and lateral locations along with account numbers. This additional information is what makes GIS particularly useful for NRW control because with this data actual water use rates can be spatially analyzed. Also note that the water meters coded red in the GIS are disconnected meters.

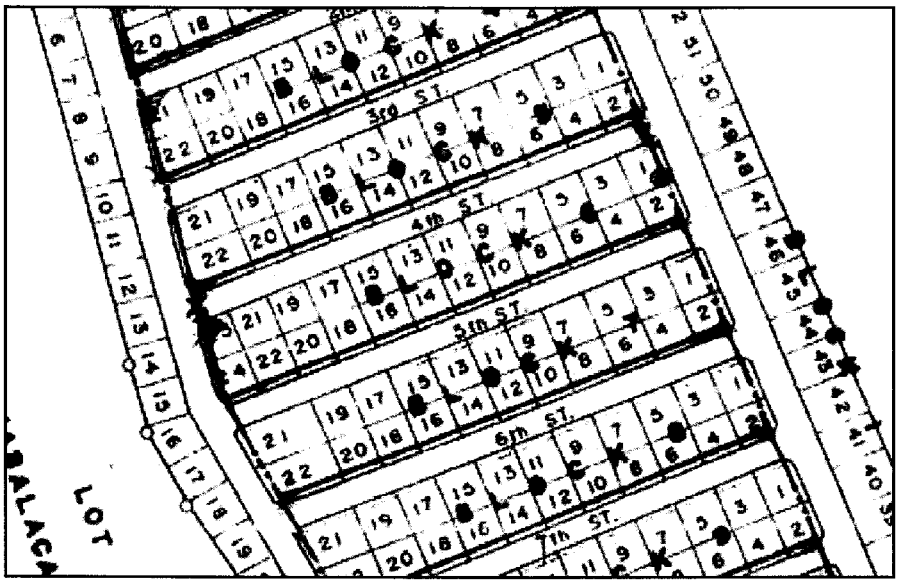


Figure 5: GIS Source Data

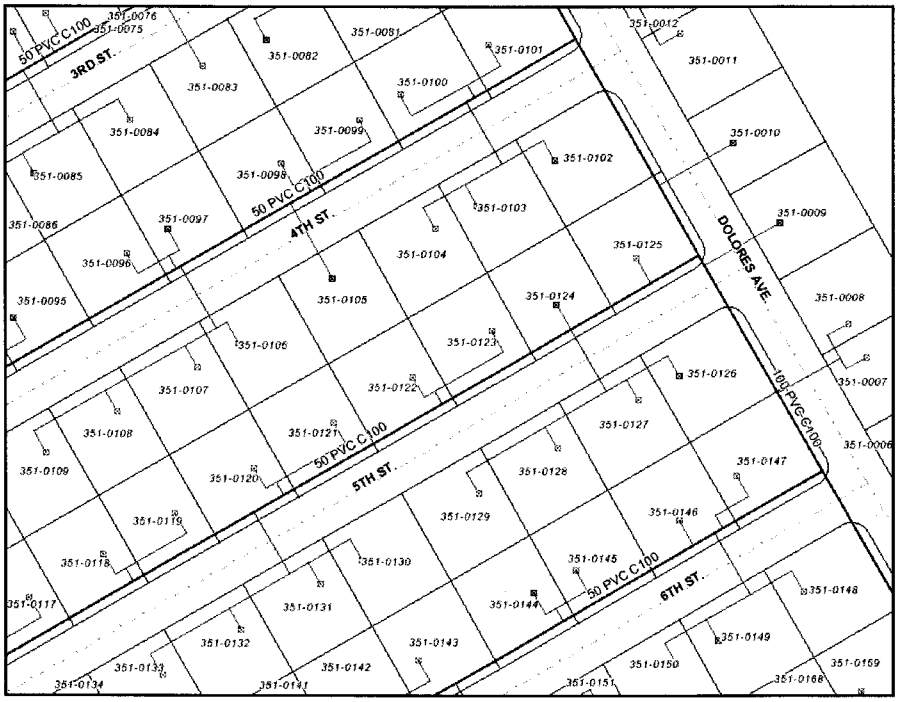


Figure 6: Finished GIS

As completed, the GIS now consists of the following information:

Feature	Record Count
Control Valves	36
Fittings	5810
Hydrants	8
Lateral Lines	6685
Main Lines	503
Meters	3897
Valves	92
Pump Stations	2
Tanks	4
Parcels	4170

In addition, aerial photograph data is integrated into the GIS, which provides water managers the ability to reference GIS data across "real world" imagery without having to repeatedly travel to a site to gather some small bit of information that might be on the aerial photos. Figure 7 below demonstrates how the GIS can overlay the Aerial image.

When combined with the customer data in the GIS, information about a property is readily available. For instance, in this image it is clear that some of the disconnected meters are serving residences. Using this information, MWD staff could compile a report on how many of these residences are occupied and then make some assessment on how many occupied properties have disconnected meters. These properties would be prime targets for unauthorized water use and the use of GIS simplifies the process of finding this source of NRW.

Figure 7: GIS with Aerial Image

Hydraulic Model Development

For this project, the HM was developed using the GIS data as both a matter of convenience and a matter of overall model accuracy. As noted in Task 3, HMs can be constructed based on skeletonized representations of the water network, as opposed to the detailed network shown above. This makes for simpler, but potentially less accurate models. For this project, we used the GIS data to construct a model using MWHSoft's InfoWater.

A complete report on the HM construction is provided in Appendix A. Figure 8 below shows the relative elevations of the various components that are included in the HM. Figure 9 shows how the GIS data seamlessly integrates into the HM.

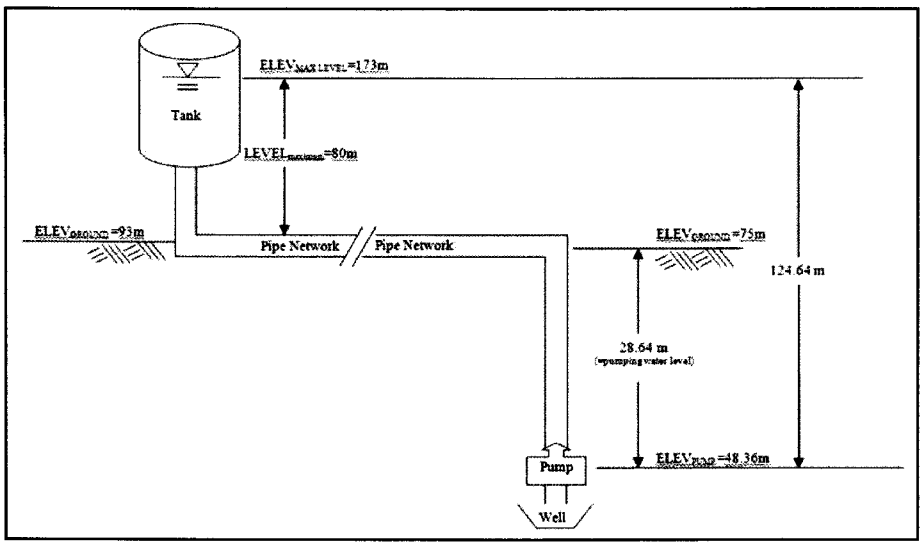


Figure 8: Hydraulic Model Elevations

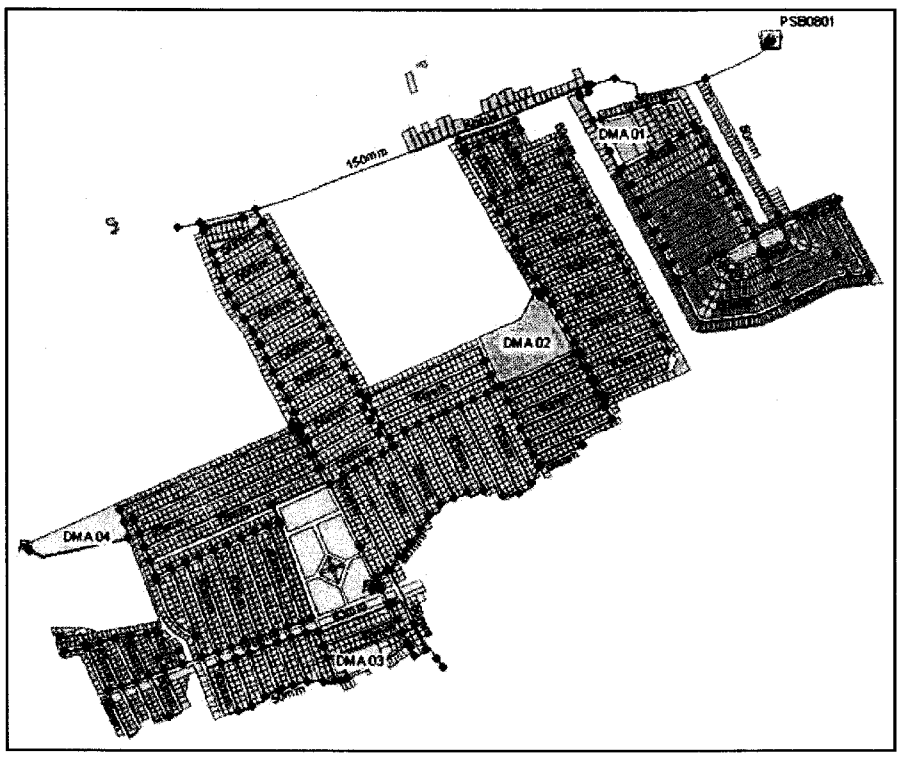


Figure 9: Hydraulic Model and Demand Nodes

In Task 3, the process of Step Testing was described that uses the HM to pinpoint water leaks in distribution systems by systematically reducing the size of each DMA by closing valves and monitoring water flow as you go. The HM software then analyzes the data and reports the most likely location of the leak. In the pilot area for MWD, the initial DMA metering data indicated that main line leaks were not an issue. For this reason, a decision was made not to bring MWD staff in to isolate valves in the middle of the night as such efforts were not expected to reveal any significant leaks. It should be noted that this may not be the case for all water districts.

Residential Water Meter Testing Program

The customer water meter is one of the most important parts of the water accounting system used by water districts worldwide. It serves as the basis for projecting water demands, establishing rates, and collecting revenue. These meters serve as the cash register for water district revenues and thus are critically important.

For the purposes of using GIS/HM/SCADA for NRW control, it is critical to understand the overall accuracy of the meters installed in the system. Since these meters will be used to calculate overall NRW in conjunction with the DMA flowmeters, it is important to know the actual volume of water that passes through them, irrespective of what the meter register reads.

In preparation for this testing event, an effort was made to classify the various types of meters in the pilot area. Data was collected from MWD's billing system through a query that provided a list of accounts with meter information such as size and brand name. A full description of the process of evaluating this information is included in the Task 1 & 2 report.

The breakdown of meters by brand is shown in Table 1 below. E-Jet meters are by far the most prevalent, followed by Aqua-Jet and Arad. Together, these three brands make up 85% of the installed meter base and thus became the focus on the meter testing program. Note that the total meter count is low because the MWD data set was incomplete with respect to brand names.

Table 1: Meter Brand Distribution

Brand	Count	Percent of Total
E-Jet	689	42.90%
Aqua-jet	453	28.21%
Arad	246	15.32%
Jitsui	77	4.79%
evjet	49	3.05%
Excel	42	2.62%
Artic	31	1.93%
Asahi	7	0.44%
Shang-shu	6	0.37%
Ever	3	0.19%
Andrae	2	0.12%
YT	1	0.06%
Total	1606	100%

The meters were then classified by age and a testing sample was identified to test more of the meters as they age in order to evaluate whether or not there was any sign of performance degradation over time. A total of 297 meters were tested. A review of the test results was undertaken to spot any irregularities. There were a handful of tests that were invalidated, as they were obviously incorrect due to errors in meter reading.

The results of the testing are provided in Table 2 below. Overall, the installed meter base at MWD performs well. There is minor variation between the brands of meters. Interestingly, the overall accuracy of the meters appears to increase over time. This is somewhat counterintuitive and may be a result of the somewhat small sample set chosen for this test. For a more complete picture of meter accuracy, a larger sample set and more controlled testing conditions could be considered.

Table 2: Meter Accuracy Results

Brand	All Ages	>5 Years	>10 years
E-Jet	96.0%	98.8%	99.4%
Aqua-Jet	94.3%	92.5%	95.4%
Arad	95.2%	95.5%	96.6%
Average	**95.2%**	**95.6%**	**97.1%**

These results mean that for every 100 cubic meters that enter the pilot area, the district must pump just over 105 cubic meters. These meter inaccuracies represent about 5% of the NRW at MWD.

SCADA Evaluation and Design

SCADA can play an important role in the operation of any water system. Having the ability to monitor and control all of the various components in a water distribution system allows operators to be more effective in their work. SCADA systems can optimize pumping efficiency, make system pressures more consistent, and prevent tank overflows. SCADA also logs a great deal of data on the system that can be used later for detailed analysis.

In terms of NRW control, SCADA systems can be useful in identifying large leaks by alarming on unusually high flow rates. They can also show flow into areas that should have little to no flow at certain times of day, thus indicating smaller leaks. SCADA systems are particularly adept at managing the level of water in tanks to prevent spills by automatically shutting off pumps when the tanks reach a given level.

Another benefit from SCADA in NRW control can be the monitoring of flow in and out of designated DMAs so that these flows can be compared against the actual measured use in those areas. This is one of the best tools for narrowing down the sources of NRW because it allows the users to spot variances between NRW rates of different parts of the system. Since MWD did not report any problems in controlling tank levels, this was the part of the SCADA that was implemented for the pilot.

Four transonic flowmeters were installed in key locations that were identified using the GIS. These recorded the flow into each of the four DMAs in the pilot study. These flowmeters had digital dataloggers attached locally and were not connected to a main SCADA system via radio as a permanent DMA meter would have been because this was simply a demonstration of the concept rather than a permanent installation.

It should be noted here that if the only reason a water district is considering SCADA is for DMA metering, the use of SCADA based meters may not be the most efficient method. DMA metering relies heavily on accurate reads of the residential meters in the DMA, so by design, teams of meter readers will be in the DMA reading meters. If this is the case, a standard meter, albeit a large one, could be installed at the DMA metering point and it could be read manually. This would save on the complexity and cost of a SCADA based DMA metering system.

The Terms of Reference for this project required a series of detailed analyses to be done regarding SCADA and the regulatory framework surrounding its use in the Philippines. A detailed study of implementing an Opto-22 based SCADA system for the pilot area

was conducted and the full report is included in Appendix B. This system focused primarily on pump control and tank level control and did not include options for SCADA based DMA meters.

One of the main concerns of the TOR was the range of regulatory requirements that might affect the implementation of a SCADA system. The only regulation existing is outlined in the National Telecommunications Commission Memorandum Circular 09-11-2005 allocating the 481.250-481.475 MHz and 486.250-486.475 MHz for use by telemetry and related data system. This regulation however does not apply to this particular study specifically because it was designed to use Wireless I.P. radios instead of the conventional analog radios.

Socioeconomic Survey

In order to evaluate the impact of any actions contemplated by MWD as a result of this study, it is important to have a good understanding of the population affected. For this reason, a detailed socioeconomic survey was conducted within the pilot area. This survey captured a wide range of information about each household including the number of people in the house, employment status, income levels, monthly utility costs, among other things.

A total of 3787 surveys were prepared and efforts were made to collect information on each one of these. The account number for the property was included on each survey so that the data could then be sorted out by DMA or in any other way. Of these, a number of surveys could not be completed for a variety of reasons. Some individuals refused to be surveyed, no resident was located, the property was unoccupied, etc. A total of 2972 surveys were collected.

There were 47 fields total in the survey, some of which were pre-populated from the customer data such as account number, address, customer name, etc. The respondents completed the rest voluntarily. High pressure tactics were not used to compel answers – if a person did not wish to give a particular piece of information it was marked as "Unknown" in the survey. The goal was to get good data from those willing to give it rather than force unwilling participants to give information that was less reliable. It is possible that survey respondent self-selection has impacted the quality of the data.

It should be noted that this survey data was not designed nor conducted in a manner that would withstand rigorous statistical analysis. There were many variables in the collection of the data that were this a socioeconomic survey project rather than an NRW project, could have been controlled to produce a result with a higher degree of confidence. This survey methodology is intended to gather information to cross reference against other information collected as part of this project. It is not intended to stand alone. With that said, the broad inferences that will be drawn from this data should be considered generally reliable. If a given agency wishes to have more detailed information along these lines, a more detailed survey instrument design process should be undertaken prior to collecting the data.

The survey data was analyzed to see if there were any significant differences between DMAs for the purpose of determining if there were any socioeconomic causal factors that influenced the NRW for a given DMA. Since unauthorized use of water was identified by MWD as being one of the leading causes of NRW, there could be a socioeconomic link that would help resolve NRW issues. One area of interest was the average income of the population. This information could lead to possible links between income and NRW. Table 3 below summarizes the average income (in Pesos per month) data sorted by DMA

Table 3: Income per DMA

DMA Average	Income
1	10805
2	7521
3	8007
4	11075

This result demonstrates that the average income in DMAs 1 and 4 are significantly higher than the other two. The average income across the entire survey was P9352 per month. In reviewing the data gathered in the survey, it became clear that average income levels had an influence in many areas, some unexpected. The data showed that income had little influence in others where it might have been expected.

The income data suggests that the income for DMA 4 was higher than DMA 1, but it is expected that this information is skewed by the nature of the sample. The reported incomes for DMA 4 included many that were apparently high, but a review of the housing stock and general conditions of the neighborhood clearly indicate that DMA 1 is a more affluent area.

Table 4 below is the results of an analysis that looked at the ratio of active vs. disconnected accounts and looks at them sorted by DMA and with the average income associated with each group of responses. This data represents only information from survey respondents.

Table 4: Active and Inactive Meters by DMA

Active			Inactive		
DMA	Number	Avg Income	Number	Avg Income	% Inactive
1	380	10773	5	7736	1.3%
2	132	7948	29	5578	18.0%
3	607	8137	151	7193	19.9%
4	240	11075	81	8809	25.2%

This table suggests that a factor in whether a given meter is active or inactive is related to the income of the household. In each case, active meters had significantly higher income than inactive meters. An inference that could be made from this information is that inactive meters, which are generally locked off due to non-payment, are disproportionately found among those households with lower incomes in their DMAs. This is not universally true – there are many active meters that have incomes less than the average of the inactive meters in each DMA. It does, however, suggest a possible trend.

Another question in the survey related to whether or not a customer would be willing to pay more on their water bill if it meant getting better service. The results of this question are shown in Table 5 below:

Table 5: Are You Willing to Pay More for Better Service?

	Yes		No	
DMA	Number	Avg Income	Number	Avg Income
1	347	10481	28	10525
2	143	7568	3	6290
3	530	8238	119	7719
4	239	10773	60	8724

As with the results in Table 4, income plays a factor in the answer to this question. Respondents who answered "Yes" to this question on average earn more than those who

replied "No" – except in DMA 1. DMA 1 is, according to in-country personnel, the most "posh" of the 4 DMAs. There is clear evidence in the neighborhood of higher income. While the percentage of those in DMA 1 who would not pay more was not huge, those who said they would not pay more actually earned more on average than those who would in DMA 1. Compared against the other groups, all of whom had higher incomes for the "Yes" group, this is an interesting result.

In the next section, the results of the DMA metering and NRW calculations will be provided. When those results are compared against the results of this socioeconomic survey, it will become hard to separate the two. There appears to be a relationship between the average income of a group and the rate of NRW. Whether or not this relationship can be said to be statistically significant is not part of the scope of this project. It is, however, hard to overlook and could deserve more in depth study by MWD before embarking on any subsequent NRW projects.

District Metering Area (DMA) Flow Study and NRW Calculation

The utility managers at MWD, as well as most other agencies, have been tracking NRW for some time. The method of calculation is generally dependant on the monthly reading of residential water meters balanced against the inlet flowmeters from pump stations and other sources. These sorts of calculations can be very useful – they let agency managers know what the scope of their problem is in no uncertain terms. If they put 40% more water into the system than they billed customers for, they know they have a problem.

The calculations, however, do little more than define the scope of the problem. They have limited capacity to provide insight to possible solutions to the problem. They do not indicate anything about the range of the sources of NRW – they just tell you that put

together, all of these sources adds up to whatever the percentage of water loss is for a given agency. That is where this study comes in.

With a GIS that defines the system in great detail, utility managers can divide the system into DMAs. The pilot area was selected because it had a pipe configuration that made DMAs easy to set up. Other agencies may need to embark on specific pipeline realignment of valve installation projects in order to establish DMAs. In any event, a high quality mapping system, generally provided by a GIS, is indispensable in this task.

The DMA flow metering project was conducted between April 21 and April 29, 2009. the excellent efforts of MWD staff made this project possible because without the combined efforts of the meter readers this sort of data collection is impossible. The data was collected and all of the volumes read were normalized to the same instant in time that each DMA flowmeter was read, as described in the Task 3 report. There were a few readings of residential meters that were obvious errors (one read nearly 2500 cubic meters in one week through a 13 mm meter) and these were adjusted to the annual average consumption for that account based on historical records. Table 6 below provides the results of this analysis:

Table 6: Apparent Water Loss per DMA

DMA	Inlet Vol	Reads	Water Loss	Loss %
1	2904	2620	284	9.8%
2	8427	3837	4590	54.5%
3	3369	4717	-1348	-40.0%
4	4180	3142	1038	24.8%
Totals	**18880**	**14316**	**4564**	**24.2%**

Table 6 shows an obvious error in the data set, as DMA 3 shows a net gain of water and DMA 2 shows a larger than expected loss of water. A review of the data confirmed the input data and the hydraulic model was used to check for the error. When the model was

adjusted to show that the valves separating DMAs 2 and 3 were open, thus creating three rather than four total DMAs, the numbers worked out much better.

Table 7: Three DMA Results

DMA	Inlet Vol	Reads	Water Loss	Loss %
1	2904	2620	284	9.8%
2&3	11796	8554	3242	27.5%
4	4180	3142	1038	24.8%
Totals	**18880**	**14316**	**4564**	**24.17%**

This information demonstrates the value of using DMAs to break the overall water loss calculation down into ever-smaller areas because there is a clear difference between the rate of water loss among the DMAs. DMA 1 has fairly low apparent water loss, with the remaining DMAs showing water losses in the expected range based on historical records. Total water loss in the whole pilot area was 4564 cubic meters in one week, which represents a 24.2% water loss.

During the testing period there were three small service leaks reported, 2 in DMA 4 and one in DMA 3. Each leak was repaired promptly with a total leak time of 30 minutes combined. This is an insignificant quantity of water loss.

This result also demonstrates the capability of the process to spot issues such as the non-isolation of DMAs 2 and 3. Hydraulic models can be used to evaluate and locate many unseen distribution system conditions. They are frequently used to find partially closed valves such as this by flowing hydrants and measuring residual pressure drops in various areas. In this case, the operators reported that there was no open connection between DMAs 2 and 3 but the data suggest otherwise.

Table 7 does not take into account the inaccuracy of the residential water meters. As demonstrated earlier, different brands of water meters have inaccuracies that affect the amount of water actually registered by the meters. These accuracy rates were in the 95% to 96% accurate range. If the residential water meter reads are adjusted upward 4% based on the average inaccuracy rates, the resulting water losses are what is shown in Table 8 below.

Table 8: Adjusted Water Loss

DMA	Inlet Vol	Reads	Water Loss	Loss %
1	2904	2729	175	6.0%
2&3	11796	8910	2886	24.5%
4	4180	3273	907	21.7%
Totals 18880		**14912**	**3968**	**21.02%**

This table provides a wealth of information about NRW at MWD. The results from DMA 1 show a difference between inlet volumes and outlet volumes of 6%. Assuming that there are other variables at play. This result also indicates that the piping infrastructure in this DMA has little leakage.

Leak history data for this area from MWD confirms this as there were very few and only minor leaks reported in the last year. It should be noted here that there are a host of potential sources for errors in this data that could swing this result several percentage points in any direction – these will be discussed later. When reviewing this information, it is important not to focus on the specific numbers, but what these numbers mean relative to each other and relative to other data sets that relate to them.

A review of the GIS data reveals that there is no significant difference between the piping systems used in DMA 1 versus those used in the rest of the pilot area. Therefore, there is no reason to suspect that there will be a significant difference in the leakage rate in the

other DMAs. What this suggests is that there is little to no leakage in any part of the pilot area. This information has some interesting ramifications.

First, the estimates for water losses from leaks given by MWD staff in Table 2 of the Task 3 report are likely much too high. This estimate, made using the WB-EasyCalc software placed leaks at about half of the total water loss. These results indicate that leaks are a small part of the problem. If leaks are not the problem, and the residential meters are performing at a known accuracy, then there is only one likely source for the large majority of the water loss – unauthorized consumption.

Unauthorized consumption is known to be widespread in not only the pilot area, but in many other nearby areas and districts as well. Nobel staff was made aware of the problem from MWD staff and a review of other agencies in the area indicates that they share similar problems. What is most striking is the magnitude of the problem and the fact that it varies by DMA. Why is it that DMA 1 has relatively lower water loss when compared to the others?

The answer to this question may be found in the socioeconomic survey data. There appears to be a direct relationship between the magnitude of water loss and the average income of a DMA. The higher income DMAs exhibit much lower water loss. The information collected was analyzed from many directions and this is the nearly inescapable conclusion.

This seems to indicate that water loss here could be related to water affordability more than anything else. It is true that there are numerous examples of customers with low incomes that remain connected and pay their bills, but as this study progressed there was an increasing amount of evidence pointing toward a relationship between income and water loss. A detailed discussion on this topic and some suggested remedies is provided in Subtask 4.3 – Financial Analysis as well as in Subtask 4.7 – Socioeconomic Impact Analysis.

Pilot Study Conclusions

Before making any conclusions about the data collected as part of this project, it is important to consider the fact that all of the data gathered has some certain level of error. Every effort has been made to contain errors in this data and steps have been taken to mitigate those that were found as noted above. This was a wide-ranging study that had many facets. For those agencies that are part of LWUA who wish to use this study to evaluate their own systems, they should focus on those parts of this study that are likely to have the most benefit to them and refine the methods or control the variables to the greatest extent practicable.

For instance, one known potential error is the fact that the initial reads of residential meters in the DMA metering project were rounded down to the nearest cubic meter, as this is the normal practice of the meter readers. Instructions for higher accuracy reads were provided in advance but the word was not disseminated effectively. The end reads were captured to the thousandth of a cubic meter as asked. The beginning reads were adjusted by .5 cubic meters to account for the fact that all reads were somewhere between .1 and .9 cubic meters above what was registered. Were we to embark on this effort again, a more rigorous effort to inform the meter readers would take place.

Irrespective of any actual or perceived errors, the data collected as part of this study infers the following general conclusions as it relates to the use of GIS/HM/SCADA in the control of NRW:

- The development of a GIS is a particularly effective tool in allowing a wide range of analyses to be made that relate consumption data from billing records to spatial data in the real world.

- The GIS is indispensable in setting up DMAs as it would be very difficult to do without a very accurate map that includes all valves and water services.
- Hydraulic Modeling can be an effective tool for NRW control, but many of the benefits of HM only become apparent if the source of the NRW is due to uncontrolled leaks in the distribution system
- SCADA is an excellent technology for the overall management of a water utility and is in place at most "modern" water systems, but its efficiency in dealing with NRW is limited.

Subtask 4.1 Technical Assessment

The development and implementation for GIS/HM/SCADA for NRW is a very complex task. Many disciplines are required, from mapping experts to computer programmers, to electrical technicians. Each has a role to play in a highly integrated system. This subtask will summarize some of the technical details and challenges of deploying GIS/HM/SCADA for NRW.

Systems Engineering and Design Parameters, Complexities and Limitations

As demonstrated by the pilot study, there are a myriad of different things to consider when contemplating the use of GIS/SCADA/HM in the control of NRW. The decision as to whether this technology will be a worthwhile investment for NRW will be different for each agency that considers the issue. There are also many benefits from GIS/HM/SCADA technologies that will be enjoyed by a water district that are not NRW

related, so even if a particular technology does not show a perfect return on investment in NRW alone, adding in some of the other benefits may tip the scale in favor of deployment.

For the GIS and HM, the most important consideration with respect to design parameters is that the use of industry standard data models is important. These standards make the interaction of the GIS and HM work, and set the stage for this data to be shared easily with other third party applications. Further, in many regions around the world there are local GIS groups that establish even finer standards, such as domain ranges that are specific to a country or language. Prior to commencing the development of the GIS a review of any local standards should be undertaken.

When considering the design of a SCADA system for any given district, the main focus should be on solving a particular problem rather than reducing NRW. As the pilot study demonstrated, unless a utility has a problem with NRW that is related to the control of their system, such as tank overflows or wells pumping to drain for too long, the role of SCADA in NRW is limited. For these reasons, the use of the SCADA for NRW would be considered to be an accessory use rather than a primary use of the SCADA. The vast majority of NRW control techniques can be accomplished without the use of SCADA.

The use of GIS/HM/SCADA technology has its share of limitations. Some of these limitations are due to the technology itself and some are related to how an agency is able to leverage the technology to its benefit. These limitations include:

- The accuracy of the GIS is limited to the accuracy of the source documents that make up the GIS. The higher quality the source documents, the better the GIS data. The absence of source documents do not make the construction of a GIS impossible – they just make it a lot more expensive due to the need to actually excavate pipes in order to determine key attributes such as size and material.

- The use of DMAs is limited by the configuration of the distribution system. In the pilot area there were very convenient places to excavate and install DMA flowmeters. However, this may not be the case in every water district. DMAs are most effective when they have a single source of supply that can be metered. If there are multiple sources of supply or there are system operational characteristics that would make the water flow in and out of a DMA, the use of DMAs is not impossible, it simply requires additional hardware in the form of bidirectional meters and more complex analysis. As was shown in this study, even when DMAs are designed using valves to separate DMAs, there may be problems with valves being operated properly or the fact that even if an operator "closes" the valve it might not be fully closed and will allow water to pass.
- The use of DMAs is highly dependant on accurate residential water meters. The meters in the pilot area averaged about 96% accurate, but if they were highly inaccurate it would have been very difficult to do the DMA analysis. In this case, however, the utility will have a clear mechanism to reduce NRW – replace the water meters.
- The practical application of DMA metering requires the utility meter reading teams to be very accurate. They need to use the full accuracy of the meters, not just read in cubic feet as was the case in the first read of the pilot study. Errors in meter reading can and will affect the accuracy of the results.
- As noted above, the use of SCADA for NRW is limited to a few specific uses. This is not to say that SCADA is not a worthwhile investment for a water agency to make – it is just that NRW control is not the driving factor for its installation.

Constructability and Identification of Major Problem Areas

The constructability of GIS is nearly entirely dependant on the availability of source data. Sources can take many forms, from engineered as builts, to old hand drawn wall maps, to a map drawn on the back of a napkin in extreme cases. If the various bits of information that is needed to build the GIS database is available in one form or another, the GIS can be built.

Since it can be based on the GIS, the constructability of the HM follows the same lines with a couple of additional challenges. Elevation data is needed for the model, along with pump curves and control set points for the pumping systems. This data is generally available in most areas, so obtaining it is not usually a problem. In the absence of a GIS, the HM can be simplified and constructed using a skeletonized representation of the distribution system. This can be of some use, but in the control of NRW the HM is most useful in doing the step analysis described earlier, so the more detail the HM has the better.

The other problem area highlighted by this study is the fact that the task of establishing DMAs can be very challenging. Very accurate maps are needed to start, with the GIS serving as the best source of information. After that, the exact field conditions must be verified carefully. The status of open and closed valves should be checked and double checked. The selection of the locations for flowmeters should be driven first by the required placement for the DMA to work right and then by the convenient placement for reading and maintenance. In this case, the meters were installed under heavy plates, but for a permanent installation some sort of secure vault would be needed. The use of standard water meters rather than the portable transonic meters used for this study will also prevent theft of instruments, as this meter will be just like any other and will be difficult to remove.

There are many challenges that could pose constructability problems for SCADA systems. Depending on terrain and other obstructions, some radio links may not work well at high frequencies and will need to be shifted to other forms of communications.

There may be issues on having power available at all sites. The complexity of developing and operating a SCADA system can be much more challenging than GIS or HM. Finally, the fact remains that SCADA is not necessarily the most effective tool for NRW management.

Operability and Operating Costs

The operation of a GIS requires individuals who understand how the software works and the related data structures that support this data, the computer hardware to run the software, and finally the software and data itself. Once the main data conversion is completed, which is a very large task, the personnel needs are limited. Depending on the size of the District, at least one person will be needed to support the GIS.

GIS supports many business activities of water agencies in areas such as capital planning, project planning, asset management, map making, etc. The use of the GIS for NRW is only a small part of its overall capabilities and from an operating cost standpoint the NRW function of the GIS has very low operating costs, primarily the labor of the specialist who reviews the DMA flow data and performs the analysis.

More GIS experts could be added to the staff, but more and more agencies are deciding to have both a single or small number of GIS experts as well as a simplified GIS interface using standard web browsers to allow non-experts to access the GIS for non-NRW purposes, although these can be used effectively for this as well. During the course of this project, Nobel team members located in the US and the Philippines used the Mabalacat data on GeoViewer Online effectively while performing the data analysis.

Similar to the GIS, the operating cost of a HM is strictly limited to the experts who operate the model. It is conceivable that the same expert who operates the GIS for an agency could also operate the HM. HMs are generally used for specific short term

purposes and studies and do not generally require daily interaction. If an in house staff member cannot be found with the requisite knowledge to run the model, outsourcing the work to a local vendor who can is sometimes a much lower cost option for specific projects such as an NRW study. Conceivably, the cost of the model software could be avoided by using a license owned by a contract modeler.

The operation of a SCADA system involves many more factors. There are power costs to run the PLCs and radios. These devices are not particularly power intensive, but the cost should be evaluated during the design phase based on the expected loads from the equipment. For pump stations this amount of power is negligible when compared to the pumps themselves, but for flow metering or tank control sites, the SCADA may be the only power draw for the site. SCADA systems are also made up of hundreds and sometimes thousands of interconnected pieces of equipment, from pumps to sensors, to PLCs.

Operating a SCADA system generally falls to the System Operators who currently control the pumping and tank levels in the system. These individuals will need extensive training in the system including its basic components, how these components are connected, and how the software interface works. It generally takes some time for individuals who have done things manually for years to become accustomed to sitting down to a computer to turn pumps on and off, so an adjustment period should be expected.

Maintenance Requirements

A GIS is only as accurate as the last time it was updated, so it is critical that the map be updated as frequently as required to keep pace with changes in the system. The rate of change to a system varies greatly from district to district. High growth districts make a

lot of changes to the GIS related to development. Low growth districts may only make map changes infrequently, although as a system ages there are more and more replacement projects that require map changes. Agencies should carefully consider the rate of change expected as they plan out the GIS.

Another way to manage large changes to the GIS from large developments is to create a development impact fee structure that includes fees specifically for map updates. Many municipal GIS users who cannot afford to hire large in-house teams of GIS technicians outsource the map updates to local vendors and pass the costs off to the developer. This process is favored because the existing ratepayers are protected from costs that are directly attributable to developers.

For MWD, it is expected that at least one full time GIS technician will be needed to manage the GIS. In the Philippines, these sorts of positions command an annual salary of up to P350,000 depending on level of skill and years of experience. Fringe benefits must be added based on each agency's structure, so the bottom line cost can be as much as double this cost per year. If this GIS technician also has HM skills, the cost may increase, but may also be offset by the need to hire one person for the GIS and another for the HM.

Personnel costs are not the only maintenance cost for GIS – the software also has annual licensing fees from ESRI. These fees are not mandatory, but staying current on maintenance fees is the only way to get updates and certain technical support. The fees are generally 15% of the purchase price of the software per year.

The maintenance cost for the HM is limited in that as long as the GIS is updated, the HM will be easily updated as a byproduct of building the two systems so that they are using the same database of pipelines. Again, HM software has annual licensing fees depending on the vendor.

SCADA systems require extensive maintenance. Sensors must be calibrated routinely in order to ensure proper reporting on conditions. Users of SCADA systems deal frequently with SCADA communications glitches and sensor failures that keep SCADA technicians quite busy. Depending on the nature of the SCADA system, at least one full time technician, and more than likely two will be needed to support a SCADA system for an agency the size of MWD. SCADA technicians earn up to P350,000 per year again depending on specific skill sets and experience. It is important that if there is only one technician that this person be quite capable as there is a long learning curve. This is why many agencies choose to have two technicians on the job with one journeyman or master level person and the other a trainee.

SCADA systems are also comprised of a lot of computer hardware and software. These systems have shorter useful life spans than the pumps and tanks that they monitor, requiring replacement every 7 years and in some cases more frequently. There is also the issue of replacement availability. Most hardware vendors are always updating their product lines – adding features (and costs). In these cases, they phase out support and parts for legacy equipment in such a way that forces agencies to convert whole systems when certain individual components are no longer available. In some circles this is known as planned obsolescence, and while no-one will admit it, it is a fact of life. It is virtually a guarantee that any SCADA hardware that is purchased today will not be available as a replacement in 10 years.

Long Term Adaptability and Effects on Existing Water Supply System

GIS and HM systems are highly adaptable by design. They are intended to be modified as conditions change and are sometimes the source of the inspiration for system changes. In the effort to establish DMAs, the GIS and HM data may point toward the logical places for new isolation valves or interconnections. HM data may also demonstrate areas of concern for water quality or system pressures.

SCADA systems also adapt to changing conditions. When compared to the older relay based control systems, SCADA provides a massive amount of flexibility to adapt to real-world conditions. In fact, it is unusual for operators of SCADA systems not to make a series of changes in both SCADA inputs and controls after a project is first commissioned. There is sometimes information that comes to light when first using the SCADA that drives a desire for some additional information. SCADA systems are highly adaptable in this regard, although there can be sometimes significant costs related to wiring in new hardware.

The only effects that GIS/HM/SCADA would have on existing water supply systems are positive. These effects include, but are not limited to:

- Better mapping of assets and systems
- Better information about the functional hydraulics at play in the system
- Better control over pumps and motors
- Better alarms for when things are not operating correctly
- Better data on overall operations that can be used for efficiency efforts
- Lower water loss

Life Cycle Costs

Subtask 4.2 will provide detailed cost estimates in these areas, so the following is just a general discussion about life cycle costs of GIS/HM/SCADA systems.

The useful life of GIS data generally follows the useful life of the asset that it describes. For instance, if a given pipe is installed in the ground in 1990 and has an expected life span of 50 years, it will need replacement in 2040. If that same pipeline is entered into

the GIS in 2008, it can be expected that it will remain in the GIS until 2040 as well, thus it will have a useful life of 32 years. The great thing about the GIS data is that it is digital, not physical, so its replacement in 2050 may just be an alteration rather than a full replacement. Perhaps the size and material attributes would change along with the installed date, but many of the features could remain constant, especially if the new pipe is laid in the same position as the old pipe.

The life cycle cost of the GIS will be the sum of:

- GIS software purchase price and upgrade every 5-7 years
- GIS software maintenance fees (annual)
- GIS technician salary – total to be dependant on the number of positions
- GIS computer hardware costs – for small systems just a robust PC – replacement every 3-5 years
- GIS data hosting costs (if any)

HM life cycle costs are low and since the HM will be based on the GIS, the cost to update the HM as the GIS is updated is minimal. Additional savings can be realized if the HM operator is also the GIS tech at an agency. This may not always be possible, so the cost of either a dedicated HM technician or outside consulting services must be factored into the cost of the system. The life cycle cost of the HM is the sum of:

- HM software purchase price and upgrade every 5-7 years
- HM software maintenance fees (annual)
- HM technician salary – total to be dependant on in-house or consultant
- HM computer hardware costs – for small systems just a robust PC – could be shared with the GIS costs – replacement every 3-5 years

SCADA systems have different components that have different life spans. For instance, when a SCADA system is installed, there is generally a metal electrical cabinet that is dedicated to the SCADA system. This cabinet is where all the conduits from the various instruments are connected so that the wiring can be performed. As the SCADA ages, the internal components such as PLCs need to be replaced, but the built in hardware components such as conduits and wires can be reused. Thus the initial capital cost of the SCADA will not be an excellent predictor of the cost to replace individual components of the system later on. The life cycle costs of the SCADA system will include:

- Cost of initial installation of system including all hardware and software
- SCADA Technician salary – dependant on the number of people
- SCADA software maintenance costs (dependant on vendor – none for Opto22)
- SCADA hardware replacement – every 7-10 years
- SCADA technician laptop – replacement every 3-5 years
- SCADA technician tools and supplies (electrical testing and calibration gear, etc)
- SCADA Technician vehicle (depends on agency)
- SCADA Operator Computer – robust PC with hot swappable backup system – replacement every 3 years

Subtask 4.2 Economic Analysis

In this subtask, an effort will be made to make an economic analysis for the implementation of GIS/HM/SCADA for the Mabalacat Water District. This analysis will be made based on the work done in the pilot area and extrapolated to the whole District. Since a detailed study of the entire District was not undertaken as part of the scope of work for this project, the analysis provided here serves more as a general guidance rather than a firm financial prediction. The results should be used as a catalyst for whether or

not to pursue a more detailed study prior to implementation. Some guidance on how to proceed with the full project is included in the Task 6 report.

Wage and salary estimates made for these studies are based on a salary survey done by Nobel staff, but individual agencies could experience different rates locally depending on the labor market. For the cost analysis, an effort was made to err on the high side of the salary estimates.

GIS Costs

During the course of this study, a detailed GIS cost proposal was provided to MWD covering the whole service area. This cost estimate was made based on the experience in doing the pilot work, so these estimates are considered to be very accurate. The GIS costs are given in Table 9 below:

Table 9: MWD GIS Costs

Task	Description of Tasks	Cost (Php)
1	Project Setup and Design of Database	15,175.07
2	Programming (Conversion Programs / GDS setup / Checking routines)	10,795.28
3	Scanning, Barcoding & Inventory of As-builts & Documents	257,801.49
4	Procurement of Satellite Imagery	551,330.21
5	Digitizing Parcels	535,384.04
6	Clean-Up of AutoCAD Drawing	484,668.48
7	Capturing Missing Features and Attribution (Including Leak Point Data)	826,173.36
8	Digitize Meters	1,606,948.43
9	QC, Conversion, Annotation Placement, Anno. QA/QC, Final QA	570,308.69
10	AtlasBook Creation and Hyperlinking of Atlas Book	100,667.88
12	Web Hosting / Commissioning / Turn Over	578,318.40
13	Testing / Parallel Run	77,109.12
14	Training	231,327.36
15	Project Management	491,211.23

16	Travel and Expenses	374,621.81
	Total Cost	**6,711,840.85**

This cost includes the first year of an online GIS system from Nobel. The ongoing operating costs did not include this cost as it is not directly related to NRW , but it may be something that an agency would want to consider to take advantage of GIS for other productive endeavors.

An analysis of the 10 year costs to operate the GIS was undertaken, using the cost centers described in Task 4.1. This assumes one GIS technician and no GIS softare upgrades other than those offered under the ESRI maintenance agreement:

Table 10: 10 Year GIS Operating Costs

Description	Cost
Initial Acquisition	6,711,840.85
GIS Tecnician Cost (P350,000 for 10 years)	3,500,000.00
GIS Software Costs (ArcEditor)	850,000.00
ArcEditor Annual Maintenance	1,275,000.00
GIS Hardware (100K replaced every 3.33 years)	300,000.00
GIS Depreciation	2,237,280.00
Total Cost (Php)	**14,874,120.85**

These costs apply to the situation at MWD. There are a number of variables that affect the price of the GIS, so if these variables are the same at other agencies, the relative costs could be about the same. Using the ratio of service connections can be a good way to

estimate the total cost, but it is not precise. The Task 6 report explains in some detail the methodology for reviewing local conditions when evaluating this data.

Note that the last line item is the depreciation of the initial conversion. This assumes a straight line depreciation at 30 years and the cost for this line item represents 10 years worth of depreciation. Depreciation is an operating expense that is overlooked in many cases, but it is a significant component of the overall cost and must be accounted for.

Hydraulic Model Costs

As noted repeatedly, in this project the HM was constructed from the GIS. This leverages the investment in the GIS and allows the HM to be constructed at a much lower cost than it would be without the GIS. MWHSoft provided a cost estimate for a GIS based HM for MWD as shown in Table 11 belos:

Table 11: HM Development Cost

Task	Description of Tasks	Cost (Php)
1	GIS Data Import	194,400.00
2	Pump and Tank data entry	201,600.00
3	Elevation Extraction	216,000.00
4	Demand Allocation	72,000.00
5	Test Run	36,000.00
	Total HM Cost (Php)	**720,000.00**

The operating costs of the HM are primarily the cost of the staff in the form of a HM Technician and the cost of the hardware and software needed to run the model. It is possible that an agency could find an individual that could handle both the GIS and the

HM, but for the purposes of this comparison a full time HM Technician is assumed. Depreciation for this is also at 30 years.

Table 12: HM 10 Year Operating Costs

Description Cost(Php)	
Initial Acquisition	720000.00
HM Model Tech (P400,000 for 10 years)	4,000,000.00
HM Software	576,000.00
HM PC (75K every 3.33 years)	225,000.00
HM Depreciation (30 year depreciation)	240,000.00
Total 10 year cost	**5,761,000.00**

The salary for the HM Technician is a bit higher than that for the GIS Tech. It would be advisable to make sure that the selected candidates were familiar with both systems to some degree as the work of the GIS Tech can influence the effectiveness of the HM Tech and vice versa.

SCADA Costs

The pilot area project covered roughly 13% of MWD service area. The complexity of developing a cost estimate for a SCADA for the entire district was not possible given the scope of this project, so the cost for the pilot area SCADA was extrapolated based on the 13% figure to arrive at the entire cost. This is certainly not the most accurate way to arrive at a total cost, but since SCADA plays only a limited role in the control of NRW in this study, there does not seem to be a financial motivation to study this in great deal as part of an NRW effort.

A detailed SCADA cost breakdown is given in Appendix B – the table below is a summary of this detailed breakdown. Depreciation is a very difficult process for SCADA

because some of the components should last 30 years and others perhaps as few as five. For the purposes of this study, the depreciation will be set at 15 years for the entire system.

Table 13: SCADA Development Costs

Task	Description of Tasks	Cost (Php)
1	Pump Station Automation	507,908.00
2	Elevated Storage Tank Automation (4)	1,070,864.00
3	Wireless Communications Devices	689,000.00
4	Central Monitoring System	414,500.00
	Total Cost for pilot Area	**2,682,272.00**
	Total Cost for Whole District	**20,632,861.54**

SCADA operating costs are related to the cost of the personnel required to maintain the system as well as some of the software and hardware needed to support the SCADA Technician. The cost for SCADA tools and supplies is an estimate and may vary from agency to agency depending on the nature of the final SCADA and the types of instrumentation systems installed. A vehicle is essential as SCADA technicians have to travel from site to site frequently.

Table 14: SCADA 10 Year Operating Costs

Description Cost(Php)	
Initial Acquisition	20,632,861.54
SCADA Technician (P350000 for 10 years)	3,500,000.00
SCADA tech laptop (50000 replaced every 3.33 years)	150,000.00
SCADA Tech tools and supplies	250,000.00
SCADA Tech Vehicle	1,250,000.00
SCADA System Depreciation (assume average 15 year life)	13,755,241.03

Total 10 year cost	**39,538,102.56**

The total 10 year costs for the SCADA system is considerably larger than the total for the GIS and HM combined, representing about 2/3 of the total GIS/HM/SCADA costs. This is an important factor to consider when contemplating installing SCADA for NRW control. SCADA is a fantastic technology for many uses at a water district, but it is not critical in the control of NRW based on this study.

The total cost of the GIS/HM/SCADA system over 10 years is P60,173,223.

Cost Benefit Analysis

The first step in performing a cost benefit analysis is determining the costs, which were completed above. The next step, and sometimes more challenging step, is to determine the benefit of the project. There are many benefits that GIS/HM/SCADA technology can bring to a water agency. GIS can bring better information to operators about pipeline locations and conditions so that better decisions will be made in the field. The GIS data can help system planners work through system improvement designs. HM can play a critical role in system design as well as in water quality management. SCADA systems are now a standard part of system operations in most water agencies because they allow for much more accurate control of the water system and its components.

For this study, the benefits of the project are limited only to the benefits of NRW control. The benefit of NRW control is the increased revenue from the water that is now being produced and not being paid for by any customers. The results of the pilot study indicate that the major factor in the water loss is due to unauthorized use of water. The lack of leak reports and any other evidence of system leakage, as well as the differences in water loss across socioeconomic groups indicates that water theft is the primary culprit.

The pilot study, having identified not only this root cause, but also mapping out some of the most likely properties to be involved in this activity, should be used by MWD to aggressively pursue unauthorized connections with the goal of gaining revenue from these sources. The benefit from pursuing the project will be the net gain in revenue from bringing this unauthorized water consumption to a halt and recovering the water rates from customers who now steal the water.

Since we know how much the GIS/HM/SCADA will cost over 10 years, we now need to know what the net present value (NPV) of this increased revenue will be over the same period. In order to calculate this, we need to estimate the amount of increased revenue.

During the pilot study, a total of about 4000 cubic meters was "lost" over the period of a week. From this value, the total water loss per week comes to 208000 cubic meters for the pilot area. If the pilot area represents 13% of the District, the total water loss at the District per year becomes 1,600,000 cubic meters. This result corresponds well to MWD's 2008 Water Balance report where they reported a total of 1,532,360 cubic meters of water loss. For the purposes of the remainder this study, the value from MWD will be used in order to be conservative, as it shows about 4% lower water loss than the extrapolated result of the pilot.

In order to realize the benefit of increased water revenue, the District must overcome the problem of water theft. Using the DMA studies, the District can focus its efforts to those areas with the highest water loss as the most potential for gain resides there. There are a number of steps that can be taken:

- Increased physical surveillance of properties with disconnected meters. It appears that the practice of hanging multiple meters off a single service lateral and placing

the meters inside private property has complicated the matter of inspection. A sincere effort to find and eliminate these users must be undertaken.

- A bounty program could be developed – some of the water districts in the area already do this. The message to neighbors is that people who steal water are making those who do not steal pay more, so it is in their self interest to report water theft.
- The MWD Board could increase fines and penalties for water theft and begin aggressive enforcement. Sometimes once a few people get caught and penalized heavily, with corresponding media attention, other people will reconsider their actions and sign up for water service.
- There are additional options that will be discussed in the socioeconomic survey section in Subtask 4.7

In order to determine the net present value of the gain in water sales, this study presumes that the water revenue will remain constant over the 10 year period and the rate for the cost of money will be set at 5%. This is a very conservative approach as it is unlikely that water rates will not rise over a 10 year period.

It is also unlikely that MWD will be able to recover all of the lost water simply by aggressively pursuing water theft. To start, Table 15 below assumes a 50% rate of recovery of the lost water through the theft management programs.

Table 15: NPV of Recovered Water @ 50% Recovery

Annual Water Loss	1,532,360.00
% Water Loss Recovery	50%
Increased Water Sales	766,180.00
Increased Revenue @ P16.5/m3	12,641,970.00
Net Present Value of water over 10 years	**97,617,941.32**

So when the net present value of the project benefits is compared to the total cost of the project, the result is a positive cash flow of P37,444,717. This is an excellent return on the investment and when a NPV calculation is this positive, the recommendation is that the project should proceed.

One complication is that this project benefit is based on the 50% recovery level. The next question is at what recovery level will this project simply break even. Table 16 below shows that the break even point is at a water recovery of 30.83%

Table 16: Break Even Water Recovery Point

Annual Water Loss	1,532,360.00
% Water Loss Recovery	30.83%
Increased Water Sales	472,349.97
Increased Revenue @ P16.5/m3	7,793,774.51
Net Present Value of water over 10 years	**60,181,460.83**

The problem here is that to expect to rapidly recover 31% of the lost water in order to break even on the project poses certain difficulties. As has been discussed in several places here, the SCADA system does not play a critical role in the NRW solution. If the SCADA costs, which represent nearly 2/3 of the total, are removed from the total cost, the 10 year cost of the project drops to P20,635,120. From there the break even point drops down to just over 10% recovery of lost water.

Table 17: Cost Recovery for GIS/HM Only

Annual Water Loss	1,532,360.00
% Water Loss Recovery	10.58%
Increased Water Sales	162,123.69
Increased Revenue @ P16.5/m3	2,675,040.85

Net Present Value of water over 10 years	**20,655,956.38**

This result indicates that if MWD chooses to only implement the GIS and HM, which were the most effective of the technologies tested for NRW, they would only need to recover a bit over 10% of the lost water in order to recover the cost of the system over 10 years. Note that this is not a net change in 10% in NRW overall, this is a change of 10% of the lost water. If MWD's overall NRW rate is 18%, recovering 10% of the lost water would reduce the overall NRW down to 16%.

This also assumes that all of the benefits of the GIS will be realized through the NRW process, but many agencies find the GIS to be an effective operational tool even without an NRW problem.

This study will not attempt to extrapolate this data to the other 7 water agencies, as the number of assumptions that would need to be made would certainly compromise the results. The report on Task 6 provides an outline that agencies can use to compare these results to their own situations. In most cases, some sort of detailed study will need to be undertaken at each district in order to come to meaningful results.

With that said, this cost benefit analysis demonstrates conclusively that the benefit from deploying GIS and HM outweighs the cost easily.

Subtask 4.3 Financial Analysis

Access to capital to embark on a project as described in this study is one of the key factors in whether or not the project is viable. Many water agencies in countries like the

Philippines have limited access to capital, and the support of agencies like LWUA and funding institutions such as the Asian Development Bank (ADB), the World Bank, and the Development Bank of the Philippines is critical.

Each of these financial firms could be a potential source of funding for the project(s) but the ADB stands out as the prime opportunity. The ADB states includes in it 2009-2010 Country Operations Business Plan (COBP) that providing funding for water infrastructure projects is one if its priorities and it specifically mentions partnerships with LWUA in this area.

Since LWUA is very familiar with the nature of this relationship, there is little benefit to rehashing this in this document. LWUA has a system for providing funding for such projects based through its Project Development and Efficiency Improvement Fund (PDEIF). This program includes specific goals for precisely these sorts of NRW projects in section 4.1.2 which is excerpted in Figure 10 below:

1) Non-Revenue Water Reduction Program

This program aims to assist WDs in reducing their technical and commercial losses of water, which are key contributing factors to the financial weaknesses of the WDs. The program will also build the capacities of the WDs in monitoring and accounting for real and apparent water losses. The program promotes good metering practices, leak detection and control, detection and regularization of illegal connections, accuracy in meter reading, and best practices in the installation and rehabilitation of the supply networks.

This program may support implementation of the following activities:

- Setting up district metering zones (DMZs);
- Developing a leak detection and control system;
- Rehabilitating pipes and pipe fittings;
- Establishing a public awareness campaign for illegal connections; and,
- Training meter readers and monitoring of readings.

Figure 10: PDEIF NRW Goals

In order to qualify for such funding, the recipient of the funding must demonstrate that the proposed project is viable from a cost recovery standpoint. This has been done in

Subtask 4.2. In addition to being able to recover the capital and operating costs, the recipient must demonstrate that they can cover the debt burden of the loan program as well. Interest rates for loans in this program will range from 8.2 to 8.7 percent with a term of 10 years.

Since it will take some time to build the GIS/HM infrastructure before some of the operating benefits will be realized, this evaluation will assume that it will take three years to reach the full increase in revenue, with half of the increase appearing in year 2. Table 18 below demonstrates this concept based on a reduction in NRW of 10.58% - the break even point for the GIS/HM project. SCADA will not be considered here as the returns on that require much too high a reduction in NRW to be practical.

Table 18: Increased Revenues at 10.58% NRW Reduction

Year Increased	Income
1	0
2	1,337,520.43
3	2,675,040.85
4	2,675,040.85
5	2,675,040.85
6	2,675,040.85
7	2,675,040.85
8	2,675,040.85
9	2,675,040.85
10	2,675,040.85
Total	**22,737,847.24**

If the loan is amortized over 10 years at 8.7% per LWUA guidelines, the payments come to P3,173,033.36 per year. In addition to this there are the increase operating costs for the GIS/HM system of P1,320,328.00 per year. When these costs are combined with the

increased revenues at the 10.8% water recovery level, Table 19 below demonstrates that this level of NRW reduction will not support the debt obligation.

Table 19: Debt Recovery at 10.58% NRW Reduction

Year	Increased Income	Debt Payment	Operating	Total Expense	Net Income
1	0	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	(4,493,361.36)
2	1,337,520.43	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	(3,155,840.93)
3	2,675,040.85	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	(1,818,320.51)
4	2,675,040.85	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	(1,818,320.51)
5	2,675,040.85	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	(1,818,320.51)
6	2,675,040.85	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	(1,818,320.51)
7	2,675,040.85	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	(1,818,320.51)
8	2,675,040.85	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	(1,818,320.51)
9	2,675,040.85	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	(1,818,320.51)
10	2,675,040.85	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	(1,818,320.51)
Total	**22,737,847.24**	**(31,730,333.60)**	**(13,203,280.00)**	**(44,933,613.60)**	**(22,195,766.36)**

It is clear that if this project is to be financed at the published rate from LWUA and at a 10 year term, then the project needs to yield a greater reduction in NRW in order to be viable. An analysis of the break even point for NRW reduction to have an increase in revenues that will offset both the debt load and the capital and operating costs, reveals that the increase in NRW must rise to 21% in order to meet the total obligation.

Table 20: Debt Recovery at 21% NRW Reduction

Year	Increased Income	Debt Payment	Operating	Total Expense	Net Income
1	0	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	(4,493,361.36)
2	2,654,813.70	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	(1,838,547.66)
3	5,309,627.40	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	816,266.04
4	5,309,627.40	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	816,266.04
5	5,309,627.40	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	816,266.04
6	5,309,627.40	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	816,266.04
7	5,309,627.40	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	816,266.04
8	5,309,627.40	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	816,266.04

9	5,309,627.40	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	816,266.04
10	5,309,627.40	(3,173,033.36)	(1,320,328.00)	(4,493,361.36)	816,266.04
Total	**45,131,832.90**	**(31,730,333.60)**	**(13,203,280.00)**	**(44,933,613.60)**	**198,219.30**

What Table 20 shows is that the debt load basically doubles the rate of NRW recovery required to make the project viable. This situation also will require MWD to self finance the fist two year's of debt payments and operating expenses, but these will be recovered by a net positive income by year three.

This situation assumes that water rates will be the same for the entire period. It also assumes that the NRW reduction can be accomplished in year three. It is possible and in many cases likely that the NRW control efforts will reduce NRW by more than 21%. In this case, the net positive income increases. Further, after year 10 the net income rises by over P3M per year.

When the SCADA capital and operating costs are included in this analysis, the required reduction in NRW rises to 58% in order to cover the debt and operating costs. While it is possible that an NRW program could achieve that level of success, it is not likely.

This analysis demonstrates that the GIS/HM Project – without the SCADA element – is a viable project under the funding guidelines established by LWUA.

Subtask 4.4 Human Health and Environmental Impact Analysis

The successful implementation of this project will have generally positive effects on the environment and on human health. It could be possible that radio towers for SCADA systems could require some environmental review based on local regulations, since it is

not the recommendation of this study to pursue a SCADA for this purpose this will not be investigated.

The development of the GIS is something that is done primarily in an office setting with a certain amount of field survey work. Assuming that there are paper based source documents there should be no need to perform any excavations. If there are any excavations needed these will be merely potholes not unlike those created by MWD staff on a regular basis. The image in Figure 4 gives a good idea of the maximum extent of such an excavation. No environmental permitting is needed for this type of effort.

The development of the HM is similarly an office-based project. If an agency chooses to calibrate their HM, there will be a requirement to flush some hydrants while collecting pressure data. This flushing, however, is no different than routine flushing undertaken by water district staff all over the world, and is generally not subject to environmental regulation. Care should be taken to de-chlorinate the discharge and ensure that the flowing water does not cause any erosion issues.

There is a small potential health issue for some customers who now take water from the system illegally and who may be disconnected. If these people truly cannot afford the water bill, they will have to use one of the shallow public wells in the area. This water is generally considered to be less safe than the chlorinated water distributed in the MWD piping network.

A review of the requirements of the Philippines National Water Resources Board did not reveal any sort of regulation that would apply to this project. Similarly, a review of regulations from the Department of the Environment and Natural Resources also found no regulatory framework that would cover this project as depicted here.

Subtask 4.5 Water Supply System Impact Analysis

If implemented at full scale, this project will result in either the same or less water supply required for the district. The goal would be for water supplies to remain the same, and to obtain more revenue from this supply. It is possible that some customers, once confronted with fines for unauthorized use of water, will simply take no water from the MWD system. There are 53 active shallow public water wells in the pilot area that can meet the needs of those who cannot afford even the minimum monthly fee from MWD. There may be increased use of these wells by people whose illegal connections have been capped.

The increased use of these shallow wells may have a negative impact on human health. Shallow water wells are considerably more at risk from contamination than are deep wells. Also, public wells with exposed outlets can be breeding grounds for bacteria. We have no data to suggest that the water from these wells poses a specific hazard, but the water from the piped system is chlorinated at the source, providing an additional measure of protection.

In short, there will be no negative water supply impact from this project. In fact, the only impact of this project for water supply will be positive.

Subtask 4.6 Ecological Impact Analysis

In the case of a system that had an NRW problem that resulted from large scale leaking of pipelines, it is conceivable that the "lost" water would find its way into the environment and begin supporting some sort of community of plants and animals that could become dependant on that water source. Based on the climatic conditions in the Philippines it is unlikely that the removal of this one source of water would impact the

community of organisms because there is ample frequent rainfall to support any sort of aquatic organisms.

Further, since this study demonstrated that there are no large scale leak problems at MWD, the reduction of NRW will not have an ecological impact. As will be described in Subtask 4.7 below, this project may have a socioeconomic impact, but there will be no ecological impact.

Subtask 4.7 Socioeconomic Impact Analysis

The results of this study indicate that there may be a link between the relative income levels of the various areas of the pilot study and the rate of unauthorized use of water. While the data is not conclusive enough to make an iron clad pronouncement about the relationship, there is a good chance that income levels affect the status of customers, as the data show that disconnected customers tend to be at lower income. This is not to say that all low income customers are disconnected – most of these customers remain connected in good standing.

A good resource for this topic can be found in a book from the American Water Works Association titled "Water Affordability Programs". Published in 1998, this book delves into the complex issue of water affordability and draws a fairly universal standard at which water is affordable. According to the authors (Saunders, Kimmel, Spade, and Brockway), water is affordable when the monthly cost is under 2% of the monthly income.

At MWD, the lowest water bill you can get is about P150 for the first 10 cubic meters. If you use less than 10 you get the same bill anyway. Using the 2% standard, this means that on average people need to earn P7,500 in order to be able to afford the smallest possible water bill. In the socioeconomic data from MWD, the average income for disconnected customers was below this amount for 90% of the disconnected users. For

connected users the rate of un-affordability was 70%. This demonstrates that the affordability of the water rates have some impact on whether or not a person gets disconnected.

This also suggests that there are many customers for whom the water bill is over the affordable threshold by the 2% standard. The burden of the water bill could be a significant one in these households. It is also possible that the income per household was underreported. However, with the magnitude of the water theft issue, some evaluation of the water rates should be considered.

The average income for all customers was P8564, which amounts to a maximum affordable water bill of P171 per month. Unfortunately, the average user takes about 18 cubic meters per month, which comes to a bill of about P287. On average, people can't afford the water rates.

Most people seem to do fine, but the data suggest that the likely cause of the water theft is the fact that the bills are more than they can afford and the configuration of the meter and lateral system makes stealing water somewhat easy. Even if massive efforts are made to either disconnect these users permanently or bring them into the bill paying column, it is possible that they simply cannot afford the bill even if they wanted to pay it.

In other areas, agencies have successfully implemented lifeline rates for lower income residents so that they can get the minimum amount of water at a lower cost. The idea here is to get as much revenue from each individual as they can afford. For example, if we assume that 80% of the NRW is from water theft, which is a likely number in the case of MWD, and if half of these customers could be brought on at a rate that has a 50% subsidy for the first 10 units, they could get the water at P75 per month and would only need an income of P3750 per month.

In this scenario, 40% of the NRW would be recovered at 50% of the "normal" cost of water for an increased revenue of 20%, or just about what is needed to fund this project. This concept does not return as much money as trying to compel each user to pay at the full rate, but there are users who simply can't afford the full rate and this program would get 50% of the revenue rather than 0% of the revenue.

Some normal rate paying customers may complain that they are subsidizing others at their expense, but the fact is that they are subsidizing 100% of the stolen water now, and this program would reduce that subsidy in half. The decision as to whether to implement such a program should only be undertaken after a more detailed income analysis and price elasticity study to see what the appropriate subsidy levels would be. There would be a process where people could apply for the subsidy and prove their income level is below some threshold for participation.

The goal of the water district is to provide clean, safe water to the communities it serves and to do so in a fiscally responsible manner. This type of program meets the needs of the population by providing fresh water in the home rather than at a public well. It also meets the fiscal needs of the agency by recovering at least some of the revenue that is now being lost to water theft.

Subtask 4.8 Developmental Impact Assessment

Infrastructure

This project will result in a modest amount of physical infrastructure being constructed but will result in a tremendous asset being developed for the agencies that is information based. Information assets such as the GIS and HM are substantial tools for the water

agency that help in the production and distribution of water. Much like a new pipeline or some other physical improvement, the GIS and HM will serve the District for decades.

There may be several dozen DMA meters installed in a full-scale application of this project. These meters will generally be mechanical, manually read meters unless a SCADA system is installed. The procurement and construction cost for each of these meters would be expected to be under P300,000 per location with about P200,000 of that being the meter itself.

If a SCADA system were to be installed, and the findings of this report are that it is not economical to do so in order to control NRW, then there is the potential for a significant amount of infrastructure to be build. Consisting primarily of radio communications and monitoring systems, this infrastructure would be installed at dozens of sites with an estimated total cost of over P20,000,000.

Human Capacity Building

During the development of the GIS, there will be a need for one additional employee at the subject district, the GIS Technician. If the District were to choose to take on the data conversion project in house, the total number of man hours required for a project such as MWD amounts to about 10,000 hours, so if the goal was to finish the project in one year it would take 5 to 6 people working full time to get the job done. This presumes that all of these people have GIS data conversion experience, as if they are learning on the job, the process is likely to take much longer. There are also data quality issues that arise when small number of staff members is given such an enormous task to complete. These sorts of large conversions are generally better left to contractors with the GIS Tech doing quality control checks and providing source documents.

GIS technicians will require training on the use of the GIS software. This training is generally arranged through the software vendor locally. It takes some time to become experienced in the use of GIS, as applications such as ArcEditor have a steep learning curve. One way to quickly realize the benefit of the GIS is to deploy a simplified web based GIS, such as the GeoViewer product prepared to MWD as part of this project. This allows a much shorter learning curve and quicker timelines to productivity improvements from better information.

The installation of DMA flowmeters would most likely be handled in house, but they could also be contracted out. These jobs would be short term as each installation should take only a day or two to complete.

The development of the HM will produce just the one job for the HM Tech. This is not a labor intensive process, and it is conceivable that an agency could combine the GIS tech position with the HM tech in order to save money. Again, training on the software would be arranged through the vendor. HM training is extensive, and could take a number of months before a user becomes moderately proficient.

The installation of a SCADA system as contemplated in this report would create about a dozen jobs that would last anywhere from one to three months to install all the systems. This is a complex process that would also result in one full time job to maintain the systems after construction is complete. As noted above, the cost to deploy this technology would not be reasonably supported by the expected increase in revenue, so in reality there would be no jobs created for SCADA.

Technology Transfer and Productivity Improvements

When deploying the GIS, there are software license agreements from the GIS software provider, in this case ESRI. The software licenses include requirements for annual

maintenance fees to be paid in the area of 15% of the purchase price. These fees maintain the user's access to support and software patches and updates. In some cases, aerial photographs must be licensed from the vendor along with topographic data. Licenses for these sorts of software are not universally required, so it really depends on the vendor selected. For this project, no binding licenses were required. HM software is similar to GIS software in terms of licensing.

The implementation of this project, by design will result in a more efficient use of water resources by reducing NRW. Less water will be "lost" and more revenue will result. The GIS and HM will also improve efficiencies in a number of other areas:

- Water crews will have better location information for planning excavations, thus leading to more effective job planning and execution. In the absence of GIS, some construction crews search around for piping by digging holes, rather than consulting maps that show where the lines are.
- Customer service people will have better maps to respond to customer issues since now they will be able to relate the customer to the various facilities operated by the agency.
- By mapping out all customer locations accurately, dispatchers can more effectively create routes for field personnel to reduce the time and cost of excessive travel to work sites.
- Utility crews will have better information to mark out underground systems, thus resulting in fewer main leaks caused by other contractors digging in the area.
- By using the HM to evaluate residence time of water in the system, the utility managers can spot water quality problems in their systems and plan out corrective action using the model as opposed to using the "trial and error" method.

There are numerous other benefits to GIS and HM that apply to nearly every water agency.

Market Oriented Reform

One of the ways that market reforms could facilitate this project is a way to reduce the cost of capital on the project. The interest rates and term put a large burden on the project and if the term were lengthened or the rate reduced, the rate of NRW reduction would also go down. As it stands, the estimate of a 20% reduction in NRW, from 18% to 15% in the case of MWD, is very achievable, so this financing burden is not something that cannot be overcome.

Another concept of market reform was discussed in Subtask 4.7 and this related to the pricing of water. It seems that there is a breakpoint in the price elasticity for certain income groups that makes failure to pay their water bill not a decision, but an economic necessity. They just can't afford the water. The District should have a goal to serve the greatest number of people in their service area with clean, potable water from their deep well systems. By developing subsidized pricing systems as described in Subtask 4.7, they may find a way to meet both the fiscal goal of recovering lost revenue, and their social goal of providing clean and safe water for all of their citizens.

DATA CONVERSION STANDARDS FOR WATER UTILITIES

VERSION 1.0

MABALACAT CITY WATER DISTRICT

PREPARED BY: NOBEL SYSTEMS, INC.

1. OVERVIEW

1.1 Objective

The following features shall be digitized from the Engineering Drawings and Atlas:

- Air Release
- Blow Off
- Brass Ball Valve
- Cross
- Elbow
- End Cap
- Filtration Plant
- Gate Valve
- Hydrant
- Lateral Line
- Mainline
- Meter
- Pressure Gauge
- Production Assessment Area
- Pump Station
- Reducer
- Saddle
- Tank
- Tee
- Water Structures
- Well
- Address Annotations
- Control Valve Annotations
- Hydrant Annotations
- Meter Account Annotations
- Miscellaneous Annotations
- Pipe Annotations
- Pump Station Name Annotations
- Reducer Annotations
- Street Name Annotations
- Valve Annotations

After completion of digitization work, the attribute data of the Water System is entered into the Object Data table. A form developed that replicates the database design for all fields included in the data conversion. This form shall be used to capture and input the water attribute data. A series of lookup (domain) tables that are also developed containing valid values for all appropriate fields such as size and material type.

The development of the data model and the symbols used were based on the existing water system and inputs gathered from Water District personnel.

A new grid system has been created to generate atlas maps at 1:14 metres scale.

Deliverable: GeoDatabase with feature linked annotation and data on Geo Viewer Online.

1.2 Drafting Rules

1. Use the Engineering Drawing sheets as a guide for capturing water features as per data model. The symbols are presented in the succeeding pages.

2. All features is captured as per standards from the Engineering Drawing or Atlas.

3. If any existing data is not found in the Engineering Drawing but is available in the Atlas, then the data in the Atlas shall be used.

4. If any existing data does not have any information either from the Atlas or the Engineering Drawing, then a Problem And Resolution (PAR) needs to be raised.

5. If the surveyed distances on the graphical source and relative positions do not match the Engineering Drawing or Atlas, modify as per Engineering Drawing or Atlas.

6. Digital centerlines or land bases should be matched and digitized with respect to the satellite image.

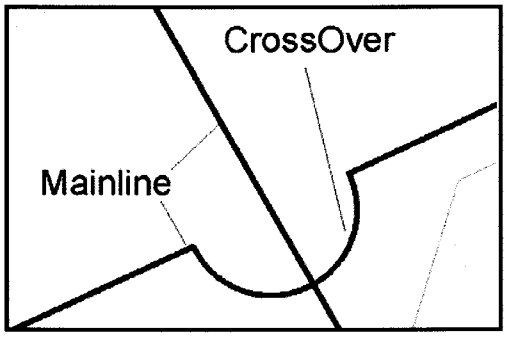
7. The relative location of the water mainlines and other features with relation to the parcel edge should be maintained.

8. Whenever offset distances are provided in the source, use this distance to construct features. If offset distances are not shown, heads-up digitizing techniques should be used.

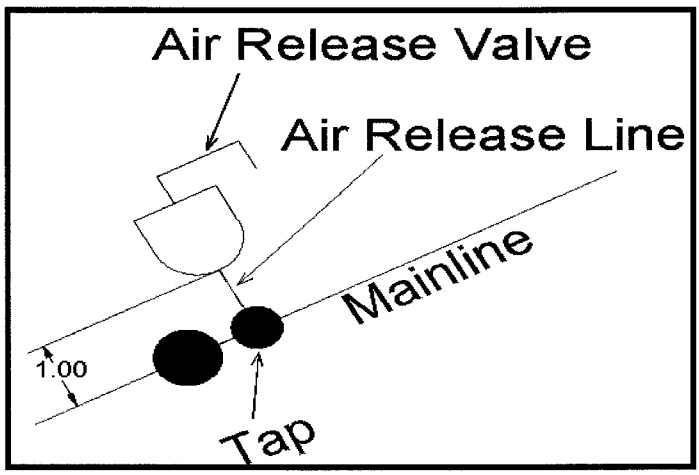
9. Each point feature should be digitized as a block in AutoCAD. The block should be rotated to align with the mainline on whose end it is placed. (This is necessary so that the "Rotation Angle" field may be coded correctly.)

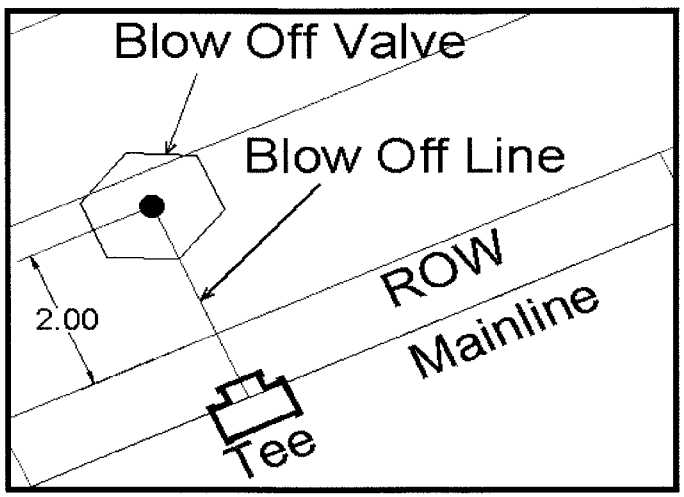
10. Wherever details are shown they must be referred to while digitizing the features.

11. Cross Over should be added where 2 lines that are not connected are crossing each other. This is for cartographic purposes only.



12. Blow off and air release assemblies should be captured as follows:

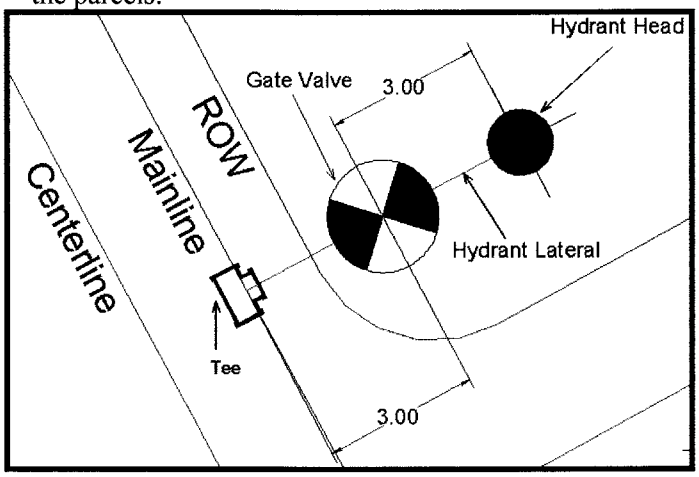




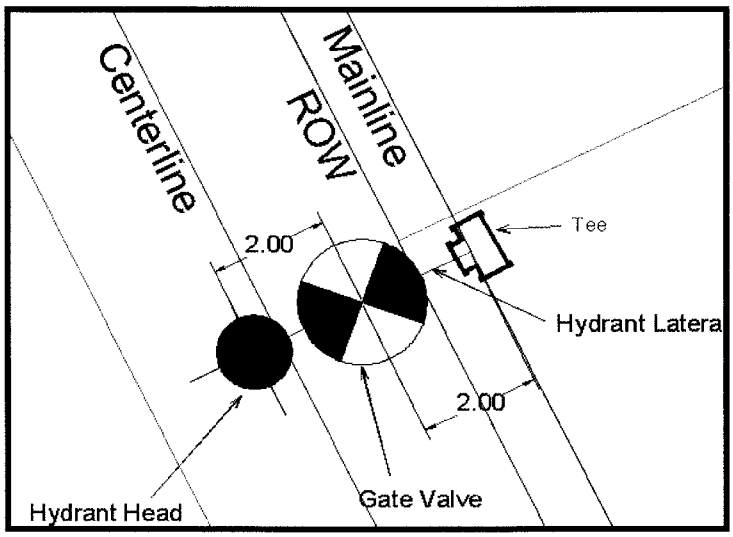
All units mentioned above are in metres

13. Hydrant assemblies shall be captured as follows:

a. Valves associated with hydrant assemblies should be placed at a distance of 3.00 meters from the main line. The hydrant head should be constructed 3.00 metres outside the Right Of Way (ROW) inside the parcels.

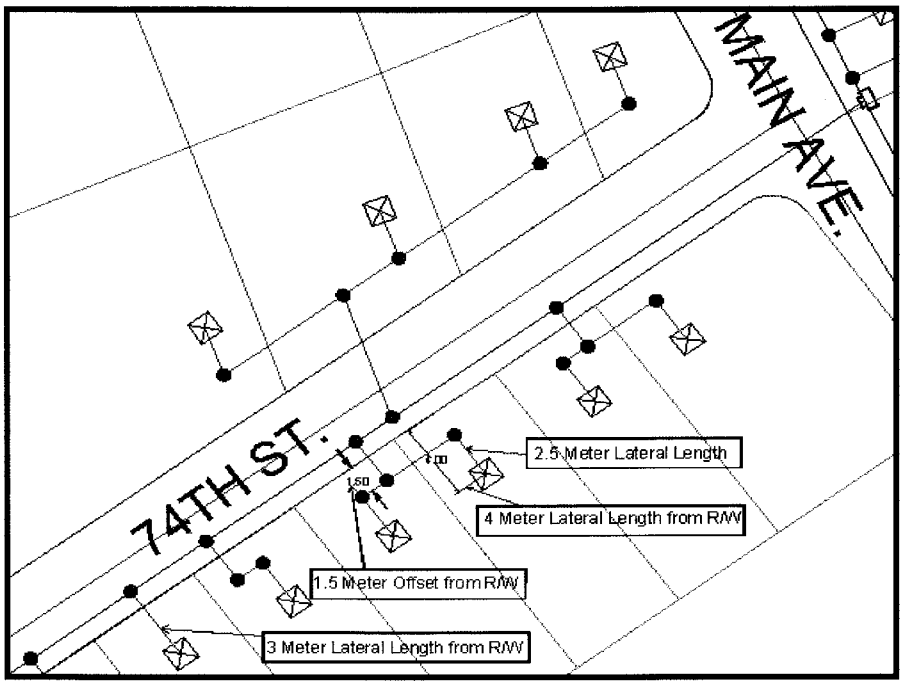


b. If the Hydrant falls inside the ROW then the Valve should be captured at a distance of 2.0 metres between the pipeline and the valve. The hydrant head is placed at a distance of 2.00 metres from the valve. (The same distance will also be used in 'Open Space'.)

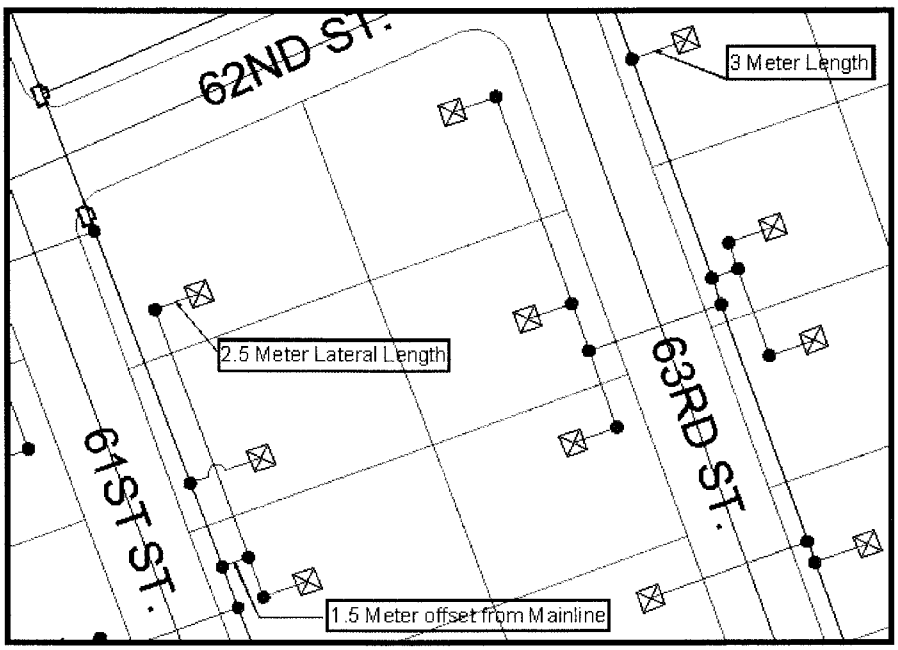


14. Meter assemblies shall be captured as follows:

a. Mainlines aligned within the ROW

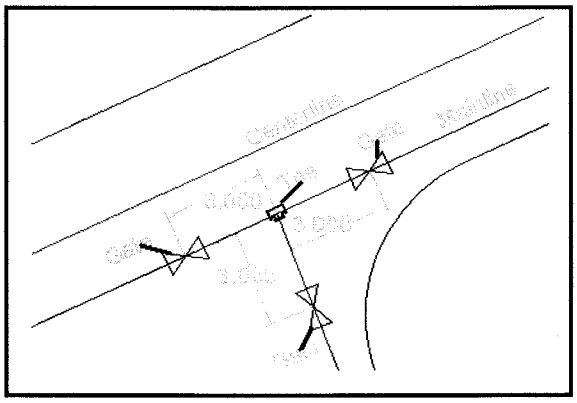


b. Mainlines aligned inside the Parcels.

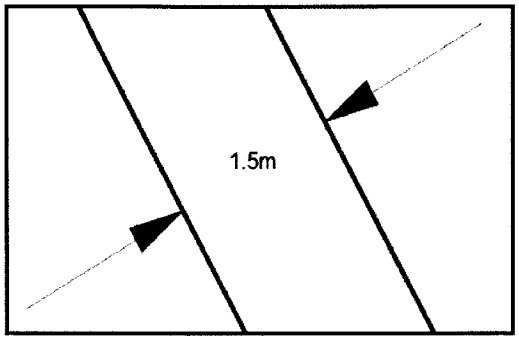


15. Break the pipelines at all fittings (tee, cross, elbow and reducer) and valves.

16. Features should be constructed as shown below. The minimum distance of 3 metre between two features should be maintained to avoid overlapping of features.



17. Maintain a minimum 1.5 metre distance between pipes, when pipes run parallel to each other.



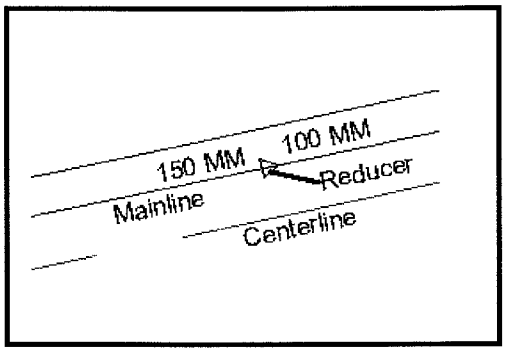
18. Wherever the material, pipe class and installation year changes in the mainline, break the mainline and add a coupling.

19. Tee fitting should be added at the intersection of mainline when three (3) mainlines are intersecting each other.

20. Cross fitting should be added at the intersection of mainline when four (4) mainlines are intersecting each other.

21. Elbow/Bend fitting should be added when the mainline has a sharp bend.

22. Reducers should be added wherever diameter changes in the mainline.



23. At the intersection of main pipeline and fire hydrant laterals a tee node feature must be provided. Mainline should be broken at the hydrant lateral intersection.

24. End Plug should be added where the water main is terminated.

25. For air release assembly, "fitting" should be added at connecting point of mainline and air release line and mainline should be broken at "fitting".

26. Lateral placement should be at the center of the property normally.

Case (i) If meter is close to the property line, then lateral should be maintained 1.5 metre from the property line.

Case (ii) If meter is little far from the property line then lateral should be 2.5 metre from the property line.

Case (iii) If meter is mid of the property then lateral should be mid of the property.

27. Saddle/Service tee fitting should be added at the intersection of lateral with mainline and mainline should not be broken at the "fitting".

28. Hydrant valves will be added only when the "fire hydrant assembly" is mentioned in the Engineering Drawing.

2. ATTRIBUTE CODING STANDARDS

2.1 General Rules

The following standards shall be used to code some of the common fields which are present in all features.

Facility Id - This is the unique identifier within the grid and a concatenation of Feature Class name, grid number and unique identifier. Feature

class name for fitting should start from 'FT' like other feature classes are given as "HYD", "MTR" The number should start from 01 for each grid/feature class. The order of assigning ID's to features will be left to right and top to bottom in a grid. Ex: - 'B07' is the grid number and the number which will be concatenated is '1'. FacilityId is **'FTB0701', 'HYDB0701' 'MTRB0701'.**

Grid No - This attribute stores the grid number in which it resides.

Status - This attribute stores the functional status of the water features. The source for capturing this attribute is the Engineering Drawing and should be picked from the following list.

- Active
- Stand By
- Abandoned
- Inactive
- Proposed

YearInstalled - This attribute stores the information on what year the pipe or feature was installed. This information should be obtained from the Water District personnel. Year is attributed as provided by Water District personnel and if year is not available code as NULL

Owner - This attribute stores the information on Who is the Owner? of the specific feature. By default it is 'Mabalacat City Water District' unless otherwise noted

Source - This attribute stores the information from which type of source was the feature referred to for digitization. It will be picked from the following list:

- As-built (Engineering Drawing)
- Atlas
- Others
- QC_Plots

As-built Name- This attribute stores the Engineering Drawing name of the facility. Source for capturing this attribute is sourced from Engineering Drawing. Ex: Mauaque Services

Angle - This attribute captures the rotation angle for map symbol purpose based on the orientation of the point feature relative to the line. This should be coded using a program in AutoCAD – the data capture technician should leave it blank.

2.2 Specific Rules

Following is the list of features available in the Water Data Model along with standard of coding for different fields. It will be noted that the following information is shown after omitting some of the common fields, which has been explained in the previous section.

2.2.1 Mainline

Mainline Type Name - This attribute stores the alphabetic display of the subtype number to make it easy for the user to interpret the Main Type. This should be picked from the following domain list:

- Distribution Main
- Transmission Main

Main Type - This attribute stores the numerical type of water main. This should be picked from the following domain list:

- Distribution Main
- Transmission Main

Diameter - This attribute stores the diameter of pipe in millimeter. Data source for encoding this field is the Engineering Drawing or Atlas. This should be picked from the following domain list:

Description		Coded Value
13 mm	-	13
50 mm	-	50
63 mm	-	63
75 mm	-	75
100 mm	-	100
150 mm	-	150

Material - This attribute stores the material of the feature. The source for capturing this attribute is the Engineering Drawing or Atlas. This should be picked from the following domain list:

Description		Coded Value
Asbestos Cement Pipe	-	ACP
Cast Iron	-	CastIron

Clay	-	Clay
Concrete	-	Concrete
Ductile Iron	-	DuctileIron
Galvanized Iron	-	GalvanizedIron
High Density PolyEthylene	-	HDPE
PolyEthylene Polyvinyl Chloride	-	PolyEthylene PolyvinyChloride
Steel	-	Steel
UnPlasticised Polyvinyl Chloride	-	UPVC
Unknown	-	Unknown
Wood	-	Wood

Offset - This attribute should be coded as shown in the Atlas/Engineering Drawing. All offset values should be measured from Right-of-Way. If there is no offset value given, the default value to be coded is 1 metres. If the Water Main is not parallel to Right-of-Way or centerline, offset should be coded as "999".

Depth - This attribute stores the depth of the water main in metres under the ground from ground surface. This should be coded as "0.76" unless otherwise noted.

Pipe Class - This attribute stores the class of the water main. Below are the standards to be followed to encode the same:

Pipe Class	Material	Diameter
Class 100	Polyvinyl Chloride	All diameters
Class 150	Polyvinyl Chloride	All diameters
SDR 11	PolyEthylene	1 – 1.5"
SDR 13.5	PolyEthylene	2 – 4"
SDR 17	PolyEthylene	6"

2.2.2 Lateral Line

Lateral Type Name - This attribute stores the alphabetic display of the lateral type number to make it easy for the user to interpret the lateral type. This should be picked from the following domain list:

- Air Release
- Blow Off

- Cluster
- Hydrant
- Service Lateral

Lateral Type - This attribute stores the numerical type of service lateral. This should be picked from the following domain list:

- Air Release
- Blow Off
- Cluster
- Hydrant
- Service Lateral

Diameter - This attribute stores the diameter of lateral line in millimeter. Source for encoding this field should be referred from meter diameter. Diameter for hydrant should be the same as that of the main line.

Description		Coded Value
13 mm	-	13
19 mm	-	19
25 mm	-	25
50 mm	-	50

Material - This attribute stores the material of the feature. The default attribute for the laterals is polyethylene, unless otherwise noted. Material for hydrants should be the same as that of the main line.

Description		Coded Value
Asbestos Cement Pipe	-	ACP
Cast Iron	-	CastIron
Clay	-	Clay
Concrete	-	Concrete
Ductile Iron	-	DuctileIron
Galvanized Iron	-	GalvanizedIron
High Density PolyEthylene	-	HDPE
PolyEthylene	-	PolyEthylene
Polyvinyl Chloride		PolyvinyChloride
Steel	-	Steel
UnPlasticised Polyvinyl Chloride	-	UPVC
Unknown	-	Unknown
Wood	-	Wood

GroundSurface Type - Should be coded as "Concrete" unless otherwise mentioned.

BrassBallValve - Should be coded as "Yes" unless other wise mentioned.

2.2.3 System Valve

Valve No - This attribute stores the number of the valve's occurrence in a Grid. This will be coded by a program.

Diameter - Should be coded same as that of the connecting mainline, unless otherwise mentioned.

System Valve Type Name - This attribute stores the alphabetic display of the system valve type number to make it easy for the user to interpret the valve type. This should be picked from the following domain list:

- Gate
- Butterfly
- Check
- Plug
- Float
- Brass Ball
- Cone
- ByPass

System Valve Type - This attribute stores the numerical type of valves. This should be picked from the following domain list:

- Gate
- Butterfly
- Check
- Plug
- Float
- Brass Ball
- Cone
- ByPass

Valve Purpose - This attribute stores the purpose of the valve serving in the system. This should be picked from the following domain list:

- Mainline
- Hydrant
- Reservoir
- Lateral

Manufacturer- This attribute stores the manufacturer of the valve. Code it if the information is given on Engineering Drawing otherwise code it as 'Makati Foundry'.

Turns To Close - Should be coded as "Null" unless other wise mentioned.

Turns To Open - Should be coded as "Null" unless other wise mentioned.

Currently Open - This attribute stores the status of the valve if it is open or closed. Code it as 'Yes', unless otherwise mentioned in the Engineering Drawing as 'Normally Closed'.

Motorized - Should be coded as 'No' unless otherwise mentioned.

Normally Open - Should be same as that of currently open.

Percent Open - This attribute stores the percentage open of the valve should be coded as '100' if the valve is 'open' and '0' if the valve is 'closed'.

Regulation Type - Should be coded as 'Flow' unless otherwise mentioned.

Flange Adapter - This attribute stores information on whether or not a valve is fitted with Flange Adapter. Should be coded as 'Yes' unless otherwise mentioned

2.2.4 Control Valve

Valve No - This attribute stores the number of the valve's occurrence in a Grid. This will be coded by a program.

Diameter - Should be coded same as that of the connecting mainline, unless otherwise mentioned.

Control Valve

Type Name - This attribute stores the alphabetic display of the control valve type number to make it easy for the user to interpret the valve type. This should be picked from the following domain list:

- Air Release
- Blow Off
- Pressure Relief
- Pressure Reducing

Control Valve Type - This attribute stores the numerical type of valves. This should be picked from the following domain list:

- Air Release
- Blow Off
- Pressure Relief
- Pressure Reducing

Flange Adapter - This attribute stores information on whether or not a valve is fitted with flange adapter. Should be coded as 'Yes' unless otherwise mentioned

2.2.5 Fitting

Fitting Type Name - This attribute stores the alphabetic display of the fitting type number to make it easy for the user to interpret the fitting type. This should be picked from the following domain list:

- Cleanout
- Coupling
- Cross
- Reducer
- SaddleCamp
- Elbow
- Tee
- End Cap
- Tap

Fitting Type - This attribute stores the numerical type of fittings. This should be picked from the following domain list:

- Cleanout
- Coupling
- Cross
- Reducer

- SaddleCamp
- Elbow
- Tee
- End Cap
- Tap

Fitting No - This attribute stores the number of the fitting's occurrence in a Grid. This will be coded by a program.

Reducer Size - This attribute stores the diameter of the connecting pipes at both ends of the reducer. Should be coded only for the reducer fitting.

Material - This attribute stores the material of the feature. Code the same as that of the mainline material unless otherwise mentioned.

2.2.6 Hydrant

Fire Hydrant No - This attribute stores the number of the fire hydrant's occurrence in a Grid. This will be coded by a program.

Manufacturer- This attribute stores the manufacturer of the hydrant. Code it if the information is given on Engineering Drawing otherwise code it as 'MakatiFoundry'.

Diameter - Should be coded same as that of the connecting mainline, unless otherwise mentioned.

Blow Off Valve - This attribute stores information on whether or not a blow off valve is fitted with the hydrant. Should be coded as 'Yes' unless otherwise mentioned.

2.2.7 Meter

Address - This attribute stores the address information of the concessionaire. This will be extracted from the customer database programmatically.

Account Number - This attribute stores the unique account number assigned to a concessionaire. This has to be picked up from the property map's which meter readers have marked the account numbers.

Maintenance Order - Should be coded as "Null" unless other wise mentioned.

Construction Order - Should be coded as "Null" unless other wise mentioned.

Meter Classification - This attribute stores the information of classification of the meters as listed below:

- Residential
- Commercial
- Semi-Commercial
- Commercial A
- Commercial B
- Commercial C
- Government
- Concessionary
- Bulk
- ClusterPoint

This will be extracted from the customer database programmatically.

Meter Brand - This attribute stores the information of the brands of meter as listed below:

- Ace
- Anchor
- Aqua Jet
- Arad
- Asahi
- Asiam
- Ever
- Evjet
- Excel
- Great Volume
- Kuhmo
- LWUA
- Miller
- Test Brand
- Tianjin
- Zacchi

Meter Number- This attribute stores the unique meter number which is on the meter feature. This will be extracted from the customer database programmatically.

Meter Size - This attribute stores the size of the meter. This will be extracted from the customer database programmatically.

Material - This attribute stores the material of the meter. This will be extracted from the customer database programmatically.

Barangay - This attribute stores the name of the area in which the meter is located. This will be extracted from the customer database programmatically.

Telephone Number - This attribute stores the landline phone number of the concessionaire. This will be extracted from the customer database programmatically.

Cellphone Number - This attribute stores the cell phone number of the concessionaire. This will be extracted from the customer database programmatically.

2.2.8 Reservoir

Reservoir No- This attribute stores the number of the reservoir's occurrence in a Grid. This will be coded by a program.

Reservoir Name - This attribute stores the name of the reservoir. This should be picked from Engineering Drawing.

Capacity - If the information is given in Engineering Drawing then code it, otherwise leave it blank.

Material - If the information is given in Engineering Drawing then code it, otherwise leave it blank.

Lining - If the information is given in Engineering Drawing then code it, otherwise leave it blank.

Address - This attribute will store the location information of the reservoir.

ImageLink - This attribute will store the hyperlinked picture name of the reservoir.

2.2.9 Well

Well No - This attribute stores the number of the well's occurrence in a Grid. This will be coded by a program.

Well Name - This attribute stores the name of the well. This should be picked from Engineering Drawing, unless otherwise mentioned by the Water District staff.

Depth - This attribute stores the depth of the well. This should be picked from the well design document.

Maximum Yield - This attribute stores the maximum yield of the well. This should be picked from the well design document.

Casing Size1 - This attribute stores the inner diameter of the well. This should be picked from the well design document.

Casing Size2 - This attribute stores the outer (casing) diameter of the well. This should be picked from the well design document.

Casing Material - This attribute stores the material of the casing used for the well. This should be picked from the well design document.

Image Link - This attribute stores the hyperlinked picture name of the well.

Well Design Drawing Link- This attribute stores the information of the hyperlinked design document.

2.2.10 Tank

Tank No - This attribute stores the number of the tank's occurrence in a Grid. This will be coded by a program.

Tank Name - Should be coded same as that of the well name.

Tank Type - This attribute stores the information on the type of tank at the location. Should be picked from the following list:

- Under Ground
- Ground Level
- Elevated

Material - This attribute stores the material of the tank. This should be picked from the tank documents, unless otherwise mentioned.

Capacity - This attribute stores the capacity of the tank. This should be picked from the tank documents, unless otherwise mentioned.

Maintenance Type - Should be coded as "painting" unless otherwise mentioned.

Height - Should be coded as "Null" unless otherwise mentioned.

Bottom Water Level - This attribute stores the bottom water level of the tank. This should be picked from the records or from Water District staff.

Upper Water Level - This attribute stores the upper water level of the tank. This should be picked from the records or from Water District staff.

Image Link - This attribute stores the hyperlinked picture name of the well.

2.2.11 Production Meter

Meter Number- This attribute stores the meter number of the feature. Should be picked from the Engineering Drawing.

Maintenance Order - Should be coded as "Null" unless otherwise mentioned.

Diameter - This attribute stores the diameter of the production meter. Should be picked from the Engineering Drawing.

PMeter Type - This attribute stores the type of the production meter. Should be picked from the Engineering Drawing.

Meter Brand - This attribute stores the brand of the production meter. Should be picked from the Engineering Drawing.

Model - This attribute stores the model name (year) of the production meter. Should be picked from the Engineering Drawing.

Material - This attribute stores the material of the production meter. Should be picked from the Engineering Drawing.

Initial Reading- Should be picked from the Engineering Drawing, unless otherwise mentioned by the Water District staff.

Image Link - This attribute stores the hyperlinked picture name of the production meter.

2.2.12 Filtration Plant

Filtration Plant No - This attribute stores the number of the filtration plant's occurrence in a Grid. This will be coded by a program.

Filtration Plant Name - This attribute stores the name of the filtration plant. This should be picked from the Engineering Drawing unless otherwise mentioned.

Maintenance Record - This should be coded as "Null" unless otherwise mentioned.

Type Of Treatment - This should be picked from Engineering Drawing or from Water District staff.

Chlorination - This should be coded as "Others" unless otherwise mentioned.

Capacity - This attribute stores the capacity of the tank. This should be picked from the tank documents, unless otherwise mentioned

Image Link - This attribute stores the hyperlinked picture name of the filtration plant.

2.2.13 Pump Station

Pump Station No - This attribute stores the number of the pump station's occurrence in a Grid. This will be coded by a program.

Pump StationName - This attribute stores the name of the pump station. Should be picked from the Engineering Drawing unless otherwise mentioned

Description - Should be coded as "Null" unless otherwise mentioned

Electric Board Type - This attribute stores the electric board type in the pump station. This should be referred from the pump station document and picked from the following list:

- Auto Transformer
- Wye Delta
- Variable Speed Drive
- Others

Electric Board Amperage - This attribute stores the current amperage of the Electric board in the pump station. This should be picked from the pump station.

Image Link - This attribute stores the hyperlinked picture name of the pump station.

Operations Manual Link - This attribute stores the information of the hyperlinked Operation Manual document of the pump station.

2.2.14 Sampling Point

Date Sampled - This attribute stores the date of tested sample water.

Date Last Sampled - This attribute stores the date of previously tested sample water.

2.2.15 PressureGauge

Pressure Gauge Type - Should be coded as "Analog" unless otherwise mentioned.

Date tested - This attribute stores the date of tested the pressure of water.

2.2.16 Flowmeter

FMeter Type - This attribute stores the type of the flow meter.

- ElectroMagnetic
- Mechanical

Meter Brand - This attribute stores the brand of the production meter. Should be picked from the Engineering Drawing.

Model - This attribute stores the model name (year) of the production meter. Should be picked from the Engineering Drawing.

Material - This attribute stores the material of the production meter. Should be picked from the Engineering Drawing.

Initial Reading- Should be picked from the Engineering Drawing, unless otherwise mentioned by the Water District staff.

Image Link - This attribute stores the hyperlinked picture name of the production meter.

2.2.17 Casing

Casing Type Name - This attribute stores the alphabetic display of the casing type number to make it easy for the user to interpret the casing type. This should be picked from the following domain list:

- Steel Casing
- Concrete Encasement

Casing Type - This attribute stores the numerical type of casings. This should be picked from the following domain list:

- Steel Casing
- Concrete Encasement

Casing Size - This attribute stores the size/diameter of the casing. Should be picked from Engineering Drawing unless otherwise mentioned

2.2.18 Water Structure

Structure Type Name - This attribute stores the alphabetic display of the structure type number to make it easy for the user to interpret the structure type. This should be picked from the following domain list:

- Pump Station Site
- Reservoir
- Well Site
- Filtration Plant building
- Tank
- Production Assessment Area

Structure Type - This attribute stores the numerical type of structures. This should be picked from the following domain list:

- Pump Station Site
- Reservoir
- Well Site
- Filtration Plant building
- Tank Site

Operational Date - Should be coded as "Null" unless otherwise mentioned.

Production Assessment Area Name - Should be coded as "Null" unless otherwise mentioned.

2.2.19 ProductionAssessmentArea

Production Assessment Area Name - Should be coded as "Null" unless otherwise mentioned.

Number Of Wells - This attribute stores the number of wells present in the ProductionAssessmentArea. This should be picked from the Wells document.

2.2.20 Leak Points

Account Number - This attribute stores the unique account number of the concessionaire. Code the same account number as that of the meter feature.

Date Reported - This attribute stores the information of the reported date regarding the leakage.

Date Repaired - This attribute stores the information of the repaired date regarding the leakage.

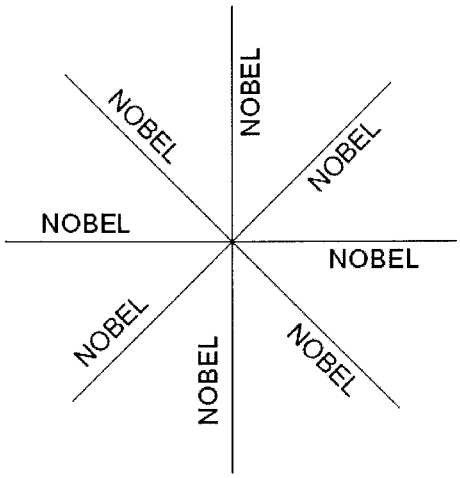
Leak DetectedON - This attribute stores the information of the leakage detected date.

Leak FixedBy - This attribute stores the information of the leakage fixed by whom.

Leak Address - This attribute stores the information of the address of the leakage.

2.2.17 Annotations

1. Mainline Annotations and Street Name Annotations should be placed and aligned bottom to top and left to right.
2. Leader line should be used to place the annotation where there is a space constraint.
3. All the point feature annotations should be in 0° angle (except meter account numbers).
4. Below mentioned standards should be followed for annotation placement.



Mainline Annotation - Annotations of diameter and material are to be generated. The size of annotations is 4, 5 & 6 points accordingly. Vary the annotation sizes based on the space availability. Do not duplicate the annotations at the Grid Boundary. Annotation font style should be Arial.

Meter Annotation - Annotation of Account Number has to be generated. The size of annotation is 4 points accordingly. All meters should have the annotations generated and placed neatly. Annotation font style should be Arial.

Hydrant Annotation - Hydrant number (FireHydrantNo) annotation should be generated. The size of the annotation is 6 point. The color is Red for fire hydrant annotation and hydrant valve annotation should also be placed near to the respective feature. Annotation font style should be Arial.

System Valve Annotation - Valve number (ValveNo) annotation should be generated. The size of annotation is 6 point. The color is Blue for valve annotation. Annotation font style should be Arial.

Control Valve Annotation - Diameter and control valve type should be generated for air release and blow off. The size of annotation is 6 point. Annotation font style should be Arial.

Reducer Annotation - Reducer size annotations should be generated for reducer. The size of the annotation is 6 point. The color is Black for reducer annotation. Annotation font style should be Arial.

Pump Station Annotation - Pump station name annotations should be generated for pump stations. The size of the annotation is 12 point. The color is Green for pump station annotation. Annotation font style should be Arial .

Miscellaneous Annotation - Annotations such as schools, reservoir names, area names, etc should be added. The size of annotation can vary from 4 to 20 point, based on the annotations shown on the Atlas. Annotation font style should be Arial.

Street Name Annotation - Street names should be captured from Engineering Drawing and Atlas sheets. Each street will be annotated with at least one annotation depending on the length of the street. If a street is crossing at the edge of the grid boundary, two annotations will be shown appropriately on either side of the grid. Generally all the street name annotations will have the readability from bottom to top and from left to right. Street names should be placed 3 meters away from ROW, unless otherwise for the space constraint.

Casing Annotation - Casing size and type annotation should be generated (example: 40m - 20" STL CASING). The size of annotation is 6 point.

GRID INDEX

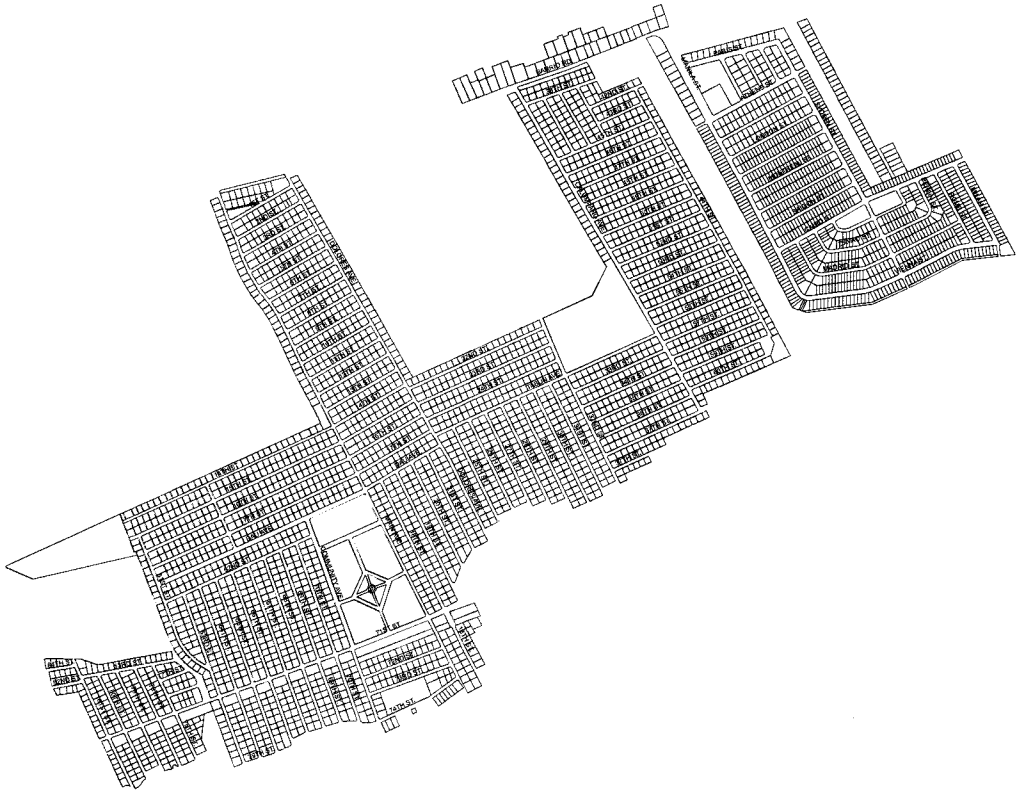
Mabalacat Water District

- Grid
- Right of Way
- Mauaque Resettlement Area
- Metro Clark Homes Area

N
W E
S

DISTRICT METERING AREA

Mabalacat Water District



DMA 01
DMA 02
DMA 03
DMA 04

N
W E
S

Legend

Control Valve:

- Air Release
- Blow Off

Fitting:

- Clean Out
- Coupling
- EndCap
- Reducer

Meter:

- Active
- Disconnected
- Proposed

System Valve:

- Butterfly Valve
- Check Valve
- Gate Valve

Other Points:

- Flow Meter
- Hydrant
- Pressure Gauge
- Pump Station
- Tank
- Shallow Well
- Well

Main Line:

- 13 mm
- 19 mm
- 25 mm
- 50 mm
- 63 mm
- 75 mm
- 100 mm
- 150 mm
- 200 mm
- 250 mm
- Transmission Main
- Inactive Main

Lateral Line:

- Air Release
- Blow Off
- Hydrant
- Active Cluster
- Active Service Lateral
- Disconnected Service Lateral
- Proposed Cluster
- Proposed Service Lateral

Casing Type:

- Steel Casing
- Concrete Encasement

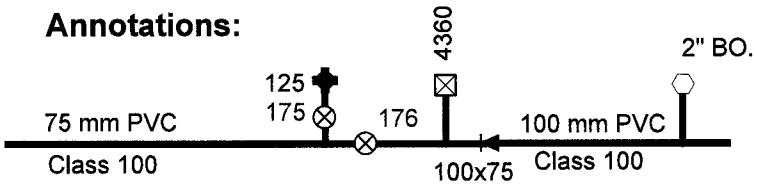
Structure Type:

- Filtration Plant Building
- Pump Station Site
- Tank Site
- Reservoir
- Well Site

Landbase:

- Building
- Lake
- Mauaque Resettlement Area Boundary
- Metro Clark Homes Area Boundary
- Right of Way
- Stream
- Parcel
- Grid

Annotations:



100 mm PVC	Pipe Diameter & Material
Class 100	Pipe Class
125	Hydrant Number
175	Valve Number
4360	Meter Account Number
2" BO.	Blow Off Diameter
100x75	Reducer Size

Note:- All Inactive point features are shown in Gray color

Mabalacat - Street Name Index

STREET	GRID
1ST ST.	D04
2ND ST.	D04
3RD ST.	D04
4TH ST.	D04
	E04
5TH ST.	E04
6TH ST.	E04
7TH ST.	E04
	E05
8TH ST.	E04
	E05
9TH ST.	E04
	E05
10TH ST.	E04
	E05
11TH ST.	E05
12TH ST.	E05
	F05
13TH ST.	F05
14TH ST.	F04
	F05
	G03
	G04
15TH ST.	F04
	F05
	G03
	G04
16TH ST.	F04
	F05
	G03
	G04
17TH ST.	F04
	F05
	G03
	G04
18TH ST.	F05
	G05
	H05
	H06
19TH ST.	F05
	G05
20TH ST.	F05
	G05
21ST ST.	F05
	G05
22ND ST.	E05
	E06
	F05
23RD ST.	E06
	F05
24TH ST.	E06
	F05
	F06
25TH ST.	F05
	G05
26TH ST.	F05
27TH ST.	F05
	F06
28TH ST.	F06
29TH ST.	F06
30TH ST.	F06
31ST ST.	F06
32ND ST.	E06
	F06
33RD ST.	E06
	F06
34TH ST.	F06
35TH ST.	F06
	F07
36TH ST.	F06

STREET	GRID
	F07
37TH ST.	F06
	F07
38TH ST.	C06
39TH ST.	C06
	D06
40TH ST.	C06
41ST ST.	C06
42ND ST.	C06
43RD ST	C06
44TH ST.	C06
	D07
	E07
45TH ST.	C06
	D06
46TH ST.	D06
47TH ST.	D06
48TH ST.	D06
49TH ST.	D06
	D07
50TH ST.	D06
	D07
51ST ST.	D06
	D07
52ND ST.	D06
	D07
	E06
53RD ST.	D07
	E06
	E07
54TH ST.	E06
	E07
55TH ST.	E06
	E07
56TH ST.	E06
	E07
57TH ST.	E07
58TH ST.	E07
59TH ST.	E07
60TH ST.	E07
	F07
61ST ST.	G03
	H04
62ND ST.	G04
63RD ST.	G04
	H04
64TH ST.	G04
	H04
	I04
65TH ST.	G04
	H04
	I04
66TH ST.	G04
	H04
	I04
67TH ST.	G04
	H04
68TH ST.	G04
	H04
69TH ST.	G04
	H04
	H05
70TH ST.	G04
	H04
	H05
71ST ST.	H04
	H05
	I03
72ND ST.	H05

STREET	GRID
73RD ST.	H05
74TH ST.	H05
75TH ST.	H03
	H04
	I04
76TH ST.	H04
77TH ST.	H04
78TH ST.	H03
	I04
79TH ST.	H03
	I03
80TH ST.	H03
	I03
81ST ST.	H03
	I03
82ND ST.	H03
83RD ST.	H03
	H04
84TH ST.	H03
A	
ATHENS ST.	C07
B	
BARRIO RD.	C05
	C06
	D03
	D04
BERLIN ST.	D08
BERN ST.	D08
BRUSSEL ST.	D08
C	
CAIRO ST.	D07
	D08
CALUMPANG AVE.	C06
	D06
	E06
	F07
COMMUNITY AVE.	G04
	G05
	H05
D	
DAU AVE.	F05
	G04
	G05
DAVAO ST.	D07
	D08
DOLORES AVE.	D04
	E05
	F05
	G05
F	
FRUNKFURT ST.	D08
L	
LONDON ST.	C07
	D07
M	
MADRID ST.	E07
	E08
MAIN AVE.	D04
	E04
	F05
	G05
	H05
MANILA ST.	C06
	C07
	D07
MILAN ST.	D08
MONTREAL ST.	D07
MOSCOW ST.	C07
P	
PARIS ST.	C07

STREET	GRID
R	
ROME ST.	D08
S	
SAIGON ST.	D07
	D08
SINGAPORE ST.	D07
STOCKHOLM ST.	C07
SYDNEY ST.	C07
	D08
	E08
T	
TABUN AVE.	E06
	F05
	F06
TOKYO ST.	C07
V	
VANCOUVER ST.	D07
VIENNA ST.	D08
	E07
	E08
Z	
ZURICH ST.	C07

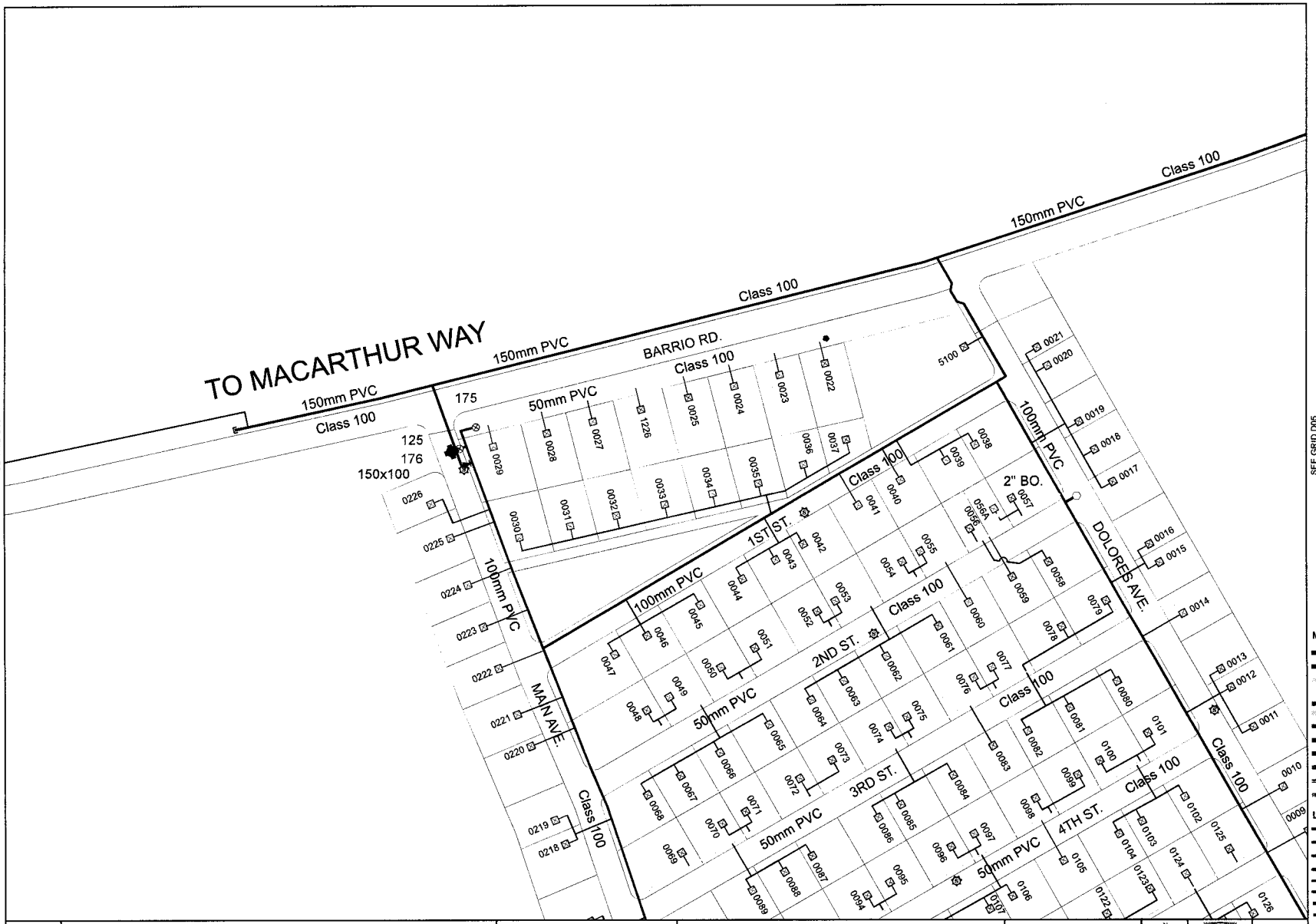
C06	SCALE: 1 CM = 7 METRES PAPER SIZE: 11"x17"	14 7 0 14 METERS	WATER ATLAS BOOK	This Map and accompanying Datasheet represent a visual aid intended to assist Mabalacat Water District personnel with the management of Water system facilities. Data provided hereon is not a guarantee of actual field conditions nor a substitute for record drawings and field verification.	May 2009		C06

Valve and Hydrant Data of Tile C07

System Valve				
VALVE NUMBER	VALVE DIAMETER	VALVE PURPOSE	CURRENTLY OPEN	VALVE DESCRIPTION
175	150	Mainline	Yes	BARRIO RD. VALVE
176	100	Mainline	Yes	BARRIO RD. VALVE
177	100	Mainline	Yes	BARRIO RD. VALVE
178	50	Mainline	Yes	PARIS ST. VALVE
179	75	Hydrant	Yes	SYDNEY ST. VALVE
180	50	Mainline	Yes	SYDNEY ST. VALVE
181	75	Hydrant	Yes	MANILA ST. VALVE
182	75	Mainline	Yes	ATHENS ST. VALVE
183	100	Mainline	Yes	MANILA ST. VALVE

Hydrant			
HYDRANT NUMBER	NOZZLE DIAMETER	BARREL DIAMETER	HYDRANT DESCRIPTION
125	75	75	SYDNEY ST. HYDRANT
126	75	75	MANILA ST. HYDRANT

C07	SCALE: 1 CM = 7 METRES PAPER SIZE: 11"x17"	14 7 0 14 METERS	WATER ATLAS BOOK	This Map and accompanying Datasheet represent a visual aid intended to assist Mebelacat Water District personnel with the management of Water system facilities. Data provided herein is not a guarantee of actual field conditions nor a substitute for record drawings and field verification.	May 2009		C07



D04	SCALE: 1 CM = 7 METRES PAPER SIZE: 11"x17"	14 7 0 14 METERS	WATER ATLAS BOOK	This Map and accompanying Datasheet represent a visual aid intended to assist Mabalacat Water District personnel with the management of Water system facilities. Data provided hereon is not a guarantee of actual field conditions nor a substitute for record drawings and field verification.	May 2009		D04

DRAFT TECHNICAL MEMO 1

WATER DISTRIBUTION SYTEM MODELING SERVICES
NOBEL SYSTEMS

WATER SYSTEM MODEL BUILD PROCESS MANUAL

Prepared By:

MWH Soft
370 Interlocken Blvd., Suite 300
Broomfield, CO 80021

April 10, 2009

1.0 PURPOSE

The MWH Soft (Soft) project team has reviewed the existing ArcGIS database of the Malabacat water system, detailed requirements, and made recommendations for the creation and GIS integration of an InfoWater hydraulic model. Steps taken and assumptions made to build the water model from the ArcGIS database and other data provided by Nobel are presented in this document to assist in future model updates and model management.

2.0 GIS EXCHANGE

Specific fields for some attributes in the GIS database that will be imported into the model do not exist in the default InfoWater model and must be created before data is imported. The fields imported into the model from the GIS database and the standard and custom fields that were used in the model database can be found in Appendix A. Any field with a "Yes" in the Custom Field column was created on top of the default InfoWater database.

After the custom fields were created, exchange clusters were set up in the GIS Gateway to import data from the geodatabase to InfoWater. This was done by mapping fields from the geodatabase to fields in the InfoWater database. Details on what fields were transferred between each database can be found in Appendix A. The spreadsheet "Field Details.xlsx", provides details on each field in the GIS. There may be data stored in the geodatabase that is unnecessary for GIS-hydraulic model integration, as noted in the spreadsheet.

The following exchange clusters were created for the initial data import:

- Pipes: Imported data from MainLine,
- Pressgage: Imported data from PressureGauge,
- Tank: Imported data from Tank,
- Well: Imported data from Well, and
- Pumps: Imported data from PumpStation

3.0 NETWORK CONNECTIVITY FOR INTEGRATION

After the GIS data was imported, the geometric network and InfoWater networks and databases were reviewed. The configuration based on the GIS dat was nearly fully connected. All relevant information pertaining to connectivity and geometric network design are covered in Appendix B and the spreadsheet "Geometric Network Breakdown.xlsx". This can be used as a guide for designing geometric networks in the future.

4.0 ELEVATION EXTRACTION

A hard copy contour map of elevation data was provided. However, this information was difficult to use and so digital elevation data was found through research. This digital elevation data was used with the InfoWater Elevation Extraction tool to automatically assign elevations to each model node.

5.0 PUMP/TANK/RESERVIOR/CONTROL VALVES DATA

5.1 General

Pumps, Tanks, Wells, Pressure Gauges, and Pipes were imported from the GIS into the hydraulic. General details on each feature are given below.

5.2 Pumps

Pumps in the model simulate the operation of both wells and booster pumps. There is only one active pump in the GIS, and this pump was included in the model. The pump characteristic curve defining the pump operation was obtained from Nobel's GeoViewer of the area information.

5.3 Tanks

Tanks in the model simulate the operation of elevated water storage. There are a total of four tanks in the GIS reflecting a total storage volume of 120,000 units. All information needed to model a tank was obtained from GeoViewer.

5.4 Wells

There is one well in the system that is the water supply source for the pump described above. Four other reservoirs are in the GIS data set, but were all inactive and not included in the model. There is assumed to be an infinite amount of water that can be pumped from the well. The water level of the well was obtained as closely as possible from GeoViewer data.

5.5 Control Valves

Control valves in a model regulate flow or pressure. There are no control valves in the model. Any Pressure Regulating Valves (PRV's) added to the GIS at a later date will require a new GIS exchange cluster to import them into the model.

5.6 System Valves

System valves in the model stop or allow flow. There are seven check valves in the GIS data set, only one of which is active. The active check valve is downstream from the active pump and, as the model incorporates a check valve in every pump automatically, there is no need to include the check valve in the model.

5.7 Pressure Gauges

Pressure Gauges in the model can be used to compare model results to field measurements. As the GIS data set has the pressure gauge as a non-breaking element, it was decided to leave it out of the model build process.

6.0 DEMAND ALLOCATION

Demands were allocated to the junctions in the model using billing record data and the InfoWater Demand Allocator module. The GIS data set included the location of each meter, including both active and inactive meters. The InfoWater Allocator module was run to assign the demand for each active meter to the closest pipe in the model. From the pipe the demand was automatically assigned to the connected junctions.

7.0 MODEL TEST RUN

By assuming the missing data, the model ran successfully. Full details will be provided with the final model build.

Appendix A

GIS Exchange Field Mapping

PIPES

Feature Class/Shape File Name: MainLine (470 Records)
Where Clause Used: STATUS = 'Active'
Imported As: Pipe
ID Mapping Field: FACILITYID
Fields Imported: See "Field Details" Spreadsheet for full details

GIS Field Name	GIS Field Type	InfoWater Field	InfoWater Field Type	Custom Field in InfoWater?
PIPECLASS	Text	Class	Text	Yes
FACILITYID	Text	ID (MOID)	Text	No
YEARINSTALLED	Long Integer	YR_INST	Long Integer	No
PZONE	Text	Zone	Text	No
MAINLINETYPENAME	Text	Description	Text	No
DIAMETER	Double	Diameter	Double	No
MATERIAL	Text	Material	Text	No
LINELENGTH	Double	Length	Double	No

JUNCTIONS

Feature Class/Shape File Name: **PressureGauge (1 Record)**
Where Clause Used: **STATUS = 'Active'**
Imported As: **Junction**
ID Mapping Field: **FACILITYID**
Fields Imported: **See "Field Details" Spreadsheet for full details**

GIS Field Name	GIS Field Type	InfoWater Field	InfoWater Field Type	Custom Field in InfoWater?
ENABLED	Short Integer	ID (MOID)	Text	No
DESCRIPTION	Text	Description	Text	No
PRESSUREGAUGETYPE	Text	Type	Text	Yes

PUMPS

Feature Class/Shape File Name: **PumpStation (1 Record)**
Where Clause Used: **STATUS = 'Active'**
Imported As: **Pump**
ID Mapping Field: **FACILITYID**
Fields Imported: **See "Field Details" Spreadsheet for full details**

GIS Field Name	GIS Field Type	InfoWater Field	InfoWater Field Type	Custom Field in InfoWater?
FACILITYID	Text	ID (MOID)	Text	No
YEARINSTALLED	Long Integer	YR_INST	Long Integer	No
ELEVATION	Double	Elevation	Double	No
PUMPSTATIONNAME	Text	Description	Text	No

TANKS

Feature Class/Shape File Name: **Tank (4 Records)**
Where Clause Used: **STATUS = 'Active'**
Imported As: **Tank**
ID Mapping Field: **FACILITYID**
Fields Imported: **See "Field Details" Spreadsheet for full details**

GIS Field Name	GIS Field Type	InfoWater Field	InfoWater Field Type	Custom Field in InfoWater?
TANKTYPE	Text	TankType	Text	Yes
MATERIAL	Text	Material	Text	Yes
CAPACITY	Double	Capacity	Text	Yes
PUMPSTATIONID	Text	PumpID	Text	Yes
FACILITYID	Text	ID (MOID)	Text	No
YEARINSTALLED	Long Integer	YR_INST	Long Integer	No
TANKNAME	Text	Description	Text	No
BOTTOMWATERLEVEL	Double	MIN_LEVEL	Double	No
UPPERWATERLEVEL	Double	MAX_LEVEL	Double	No
DIAMETER	Double	Diameter	Double	No
PZONE	Text	Zone	Text	No

RESERVOIRS

Feature Class/Shape File Name: **Well (1 Record)**
Where Clause Used: **STATUS = 'Active'**
Imported As: **Reservoirs**
ID Mapping Field: **FACILITYID**
Fields Imported: **See "Field Details" Spreadsheet for full details**

GIS Field Name	GIS Field Type	InfoWater Field	InfoWater Field Type	Custom Field in InfoWater?
DEPTH	Double	Depth	Double	Yes
MAXIMUMYIELD	Double	MaxYield	Double	Yes
DRAWDOWN	Double	Drawdown	Double	Yes
SPECIFICCAPACITY	Double	SP_CAP	Double	Yes
WEL_TYPE	Text	Class	Text	Yes
PUMPSTATIONID	Text	PumpID	Text	Yes
ENABLED	Short Integer	ID (MOID)	Text	No
STATUS	Text	YR_INST	Long Integer	No
WELLNAME	Text	Description	Text	No
STATICWATERLEVEL	Double	Head	Double	No
IN_MODEL	Text	Material	Text	No
PZONE	Text	Zone	Text	No

Appendix B

Geometric Network Integration with Hydraulic Models

The geometric network designed by Nobel was received in the data sent on April 3, 2009. The following are assumptions and comments and were made after reviewing the geometric network and its rules.

Designing the breaking of pipes is critical for integrating the GIS with a hydraulic model. Complex Edges in the GIS provide the mode flexibility for integration. A spreadsheet included with the delivery of this report details all aspects of the geometric network. The information here is provided as a list of key points for review and comment.

- **Hydrants** – Including hydrants in the model as junctions will provide more accurate fire flow results. This will also increase the number of nodes in the model with no benefit for standard hydraulic simulations. Under the current GIS configuration, hydrants will not be included in the model. As no fire protection is envisioned, the usefulness of these points will be that a pressure gauge can be attached to each hydrant to get a pressure reading that can be usefull during the calibration effort.

- **PumpStations** –The current configuration of the GIS stores pumps as point elements, and is configured correctly for seamless model integration.

- **Tanks** –The current configuration of the GIS stores tanks as point elements, and is configured correctly for seamless model integration.

- **Wells** –The current configuration of the GIS stores wells as point elements, and is configured correctly for seamless model integration.

- **PressureGauges** - The current configuration of the GIS stores pressure gauges as point elements, and is configured correctly for seamless model integration. However, the main lines connected to these 4 features do not split the main line to which they connect. This will need to be corrected in the GIS so that the pressure gauges can be included as model elements.

- **Control Valves** – Control valves vary based upon type:

- **Blowoff** –Many blowoffs are located at pipe end points, so breaking is often not an issue. Blowoffs are not used for hydraulic modeling. Breaking pipes at blowoffs is not recommended.
- **Air Release** – Air release valves are not used for typical hydraulic modeling, but are useful for transient modeling. Since there are typically a low number of air release valves compared to the number of pipes in a system, breaking pipes at these points has little impact on the size of the hydraulic model.
- **Pressure Reducing Valves** – Pressure Reducing Valves are important for hydraulic modeling, as is any valve that regulates flow or pressure. Breaking pipes at these valves is recommended.
- **Pressure Relief Valves** – Pressure relief valves are not used for typical hydraulic modeling, but are useful for transient modeling. Since there are typically a low number of these valves compared to the number of pipes in a system, breaking pipes at these points has little impact on the size of the hydraulic model.

- **System Valves** – System valves vary based upon type:
  - **Check Valves** – Check valves are an attribute of a pipe in the hydraulic model. Integrating these between the GIS and hydraulic model is easiest using a spatial selection from check valves to pipes. Currently pipes in the GIS are broken at check valves. Breaking pipes at check valves is not recommended.
  - **Other Valves** – All other system valves in the hydraulic model only open or shut off pipes. Integrating these features into the hydraulic model has little or no benefit. Since geometric network analyses can be performed using complex edges regardless of breaking convention, breaking pipes at other valves is not recommended. An external valve layer can always be used for UDF analysis.

- **Other Nodes** – All other nodes (fittings, etc) in the hydraulic model only require elevation and demand as an input. Since this data is not typically stored inside a GIS, integrating these features into the hydraulic model has little or no benefit, and often leads to network connectivity issues when the model is updated from the GIS. Breaking pipes at other nodes is not recommended. Demands are assigned from the meter layer using demand allocator and elevations are assigned from an elevation dataset using the elevation extractor.

Sample Suggested Rules

Rules can be created in a geometric network to ensure the network is broken as desired. A rule that says "pressure reducing valves valves must be connected to exactly 2 mains" can be created in the geometric

network. This will simplify finding valves that do not split pipes in the GIS after the geometric network is edited. Another rule that says "a blowoff can only be connected to 1 main line" can be created in the geometric network. This will simplify finding blowoffs that split pipes in the GIS after the geometric network is edited.

Water Lines

The following section summarizes the connectivity issues found with the GIS dataset "MainLine" that will prevent a seamless integration between the GIS and model databases from being created for Nobel.

The following SQL Query was used to prevent inactive elements from being imported:

STATUS = 'Active'

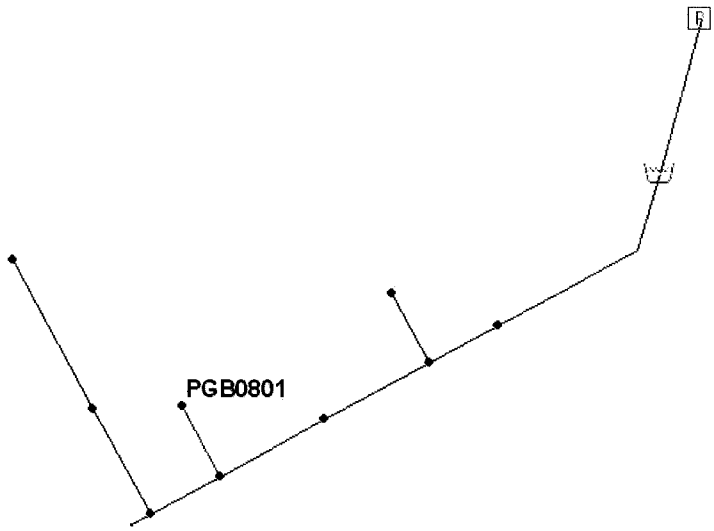
Unique ID's

There are no duplicated ID's.

Connectivity

The only connectivity issues were pipes that are not split at tees to the pressure gages, and pipes that are split at check valves.

- Pipes split by check valves
  - See System Valves section for details
- Pipes that need split
  - 1 Pipe (3 inactive pipes need split also for future use)
  - This can be split in the GIS
  - Asset Code reference given in figure below



Wells

The following section summarizes the connectivity issues found with the GIS dataset "Well" that will prevent a seamless integration between the GIS and model databases from being created for Nobel.

The following SQL Query was used to prevent inactive elements from being imported:

STATUS = 'Active'

Unique ID's

There are no duplicated ID's.

Connectivity

No connectivity issues were associated with wells.

Pumps

The following section summarizes the connectivity issues found with the GIS dataset "Pumps" that will prevent a seamless integration between the GIS and model databases from being created for Nobel.

The following SQL Query was used to prevent inactive elements from being imported:

STATUS = 'Active'

Unique ID's

There are no duplicated ID's.

Connectivity

No connectivity issues were associated with pumps.

Tanks

The following section summarizes the connectivity issues found with the GIS dataset "Tanks" that will prevent a seamless integration between the GIS and model databases from being created for Nobel.

The following SQL Query was used to prevent inactive elements from being imported:

STATUS = 'Active'

Unique ID's

There are no duplicated ID's.

Connectivity

No connectivity issues were associated with tanks.

Control Valves

The following section summarizes the connectivity issues found with the GIS dataset "ControlValves" that will prevent a seamless integration between the GIS and model databases from being created for Nobel.

No control valves were imported as there was no pressure reducing valve in the dataset.

Connectivity

No connectivity issues were associated with control valves.

System Valves

The following section summarizes the connectivity issues found with the GIS dataset "SystemValves" that will prevent a seamless integration between the GIS and model databases from being created for Nobel.

No system valves were imported as they do not provide any information required by the model and pipes are not split at most of these features.

Connectivity

Pipes in the MainLine feature class are broken at check valves in the GIS. In the hydraulic model, a check valve is an attribute of a pipe. This attribute is typically tagged using a spatial selection between check valves in the GIS and pipes in the model. Connecting pipes at check valves is recommended.

Pressure Gauge

The following section summarizes the connectivity issues found with the GIS dataset "PressureGauge" that will prevent a seamless integration between the GIS and model databases from being created for Nobel.

The following SQL Query was used to prevent inactive elements from being imported:

STATUS = 'Active'

Unique ID's

There are no duplicated ID's.

Connectivity

The pressure imported gauge is disconnected as the main line attached to it does not split the main line where it connects. See the figure in the pipes section for details.

Hydrants

The following section summarizes the connectivity issues found with the GIS dataset "Hydrants" that will prevent a seamless integration between the GIS and model databases from being created for Nobel.

No hydrants were imported in this initial build.

Connectivity

Hydrants were disconnected from the system as hydrant laterals were not imported. If hydrants are desired to be included in the hydraulic model, hydrant laterals will be imported. However, main lines will need split at each of the eight hydrant laterals in the system.

Meters

Demands will be assigned using the meter feature class, which typically gets consumption values from a billing system. Demands are assigned from the meters to the model using the InfoWater Demand Allocator. Ideally, the pipe ID (main line) to which each meter connects is stored inside a field in the meter database. The InfoWater Demand Allocator will use this information to assign demands. If this data is unavailable, meters can be assigned to the closest pipe, the assignment QA/QC'd, then demands assigned to connected junctions. Actual usage values will be needed prior to allocating demands.

TECHNICAL FEASIBILITY STUDY

TO DETERMINE THE TECHNICAL REQUIREMENTS AND IMPACT OF THE APPLICATION OF A SCADA SYSTEM ON THE DAPDAP METRO CLARK PUMPING STATION LOCATED AT MABALACAT, PAMPANGA, PHILIPPINES

MARCH 23, 2009

BY:

East Asia
TECHNOLOGIES CORPORATION

TABLE OF CONTENTS

A. Introduction
B. Existing Telemetry System
  B.1. Soft Starter
  B.2. Generator Set
  B.3. Flow Meter
  B.4. Pressure Transducer
  B.5. Submersible Pump
  B.6. Chlorine Dosing Pump

C. SCADA System Features & Functionalities
  C.1. Remote Telemetry Units
  C.2. Pumping Station Automation
    C.2.1. Pressure Monitoring
    C.2.2. Flow Meter Reading
    C.2.3 Pump Motor Controls
    C.2.4. Chlorine Dosing Pump
    C.2.5. Generator & ATS Status Monitoring
    C.2.6. Energy Consumption Monitoring
    C.2.7. Water Well/Pumping Station Energy Efficiency
  C.3. Elevated Storage Tank Automation
    C.3.1. Water Level Monitoring
    C.3.2. Pressure Monitoring
    C.3.3. Motorized Valves
  C.4. Central Monitoring and Control Interface
  C.5. Data Acquisition & Publishing
  C.6. SCADA Communications Topology
  C.7. Estimated System Cost

D. Regulatory Considerations & Compliance
E. Project Impact Assessment & Conclusion
F. Attachments
  F.1. Bill of Materials
    F.1.1. Dapdap Metro Clark Pumping Station Components
    F.1.2. Elevated Tank Automation Components
    F.1.3. Wireless Networking Components
    F.1.4. Central Office Monitoring Components
  F.2. Single Line Diagrams
    F.2.1. Dapdap Metro Clark Pumping Station Single Line Diagram
    F.2.2. Elevated Tank Automation Single Line Diagram
    F.2.3. Wireless Network Signal Propagation Path
    F.2.4. Network & Server Systems Single Line Diagram
    F.2.5. General RTU Architecture
  F.3. Implementation schedule
  F.4. Product Brochures
    F.4.1. OPTO 22 SNAP System Brochure

A. INTRODUCTION

The residents of Mauaque Resettlement Area and Metro Clark Homes located at the town of Mabalacat in the province of Pampanga have been enjoying the piped water supply system since XXXX where water is typically drawn from the ground, chlorinated then dispatched to the distribution system. The distribution system employs the use of 4 smaller pumping stations each of which has a 30,000 gallons capacity elevated storage tanks located around the resettlement area up until the year 2003 when the pumping operation was centralized into one pumping facility.

Today, the four smaller pumping stations have ceased to operate while retaining the use of the elevated storage tank facilities. Water to the area is now being supplied by the Dapdap Metro Clark pumping station located northeast of the resettlement area. The pumping station is operated by the Mabalacat Water District.

B. EXISTING TELEMETRY SYSTEM

The pumping station has been fitted with the minimum required control systems to operate the various pumping equipment, however, there is no existing SCADA/RTU system at the Dapdap Metro Clark Pumping Station site that enables remote monitoring and control functions of the pumping station. Existing equipment are primarily sensor devices to measure flow (flow sensor), pipe pressure (pressure transducer), soft starter system, pump motors and a generator set. The following devices are currently installed at the Dapdap Metro Clark Pumping Station:

B.1. Soft Starter	Danfoss SoftStarter & Standby Auto-Transformer designed for 50HP, 440VAC, 3 Phase, 60 Hz with thermal overload, thermal inverse time limit, manual reset push button, phase angle protection, over/under voltage protection, Voltage, ammeter Gauges with Manual switches, five digit run hour meter, indicator lamps, auxiliary contacts, circuit breakers, run start, wye contactor, pneumatic timer, lightning arrestor, control relay, auto current transformer, tend and Diazed fuse all fitted inside NEMA 3R Enclosures
B.2. Generator Set	Stationary type Cummins PS Tech naturally aspirated combustion system made in Singapore. 440V 3 Phase rated output voltage, 60 Hz Star Delta Alternator topology.
B.3. Flow Meter	The existing device is a Euromag flow meter model MUT 2200EL. It's a 6", electromagnetic flow meter fitted with MC308 transmitter that sends the data to an ARAD totalizer.
B.4. Pressure Transducer	Mechanical Pressure Gauge fitted with a separate pressure switch.
B.5. Submersible Pump	Made in USA 440VAC, 3 Phase, 50 HP, 60Hz, 3450 RPM submersible motor fitted with a 2 stage, 600 liters per minute capacity submersible pump

B.6. Chlorine Dosing Pump	Model P15-2-398i, 220VAC, 60Hz Single Phase Solenoid Pump with pumping capacity of up to 3.8 liters per hour operating at a maximum pressure of 7.6 Bar/110 PSI drawing Chlorine Dioxide from a 100 Liter tank.

There is also no resemblance of a central controller that will provide remote monitoring and control functions for all the equipment installed at the pumping station. There also no form of communication link between the pumping station and the Water District office.

C. SCADA SYSTEM FEATURES & FUNCTIONALITIES

An important challenge to the commercial success of a given Water Distribution Utility organization is to harness the data collection power of the SCADA/RTU systems to provide a wealth of operational information to all levels of the organization. The selection of the SCADA system features should incorporate a readily scalable, open systems based platform with GUI-based flow chart programming/logical controls with tools available that will enable the system to either read or write to open standards database systems. This way, the wealth of data collected can be easily shared to all levels of the organization either via local graphical interface (mostly designed for operations engineers tasked to monitor the system) or web based reporting for easy access to operational data anywhere anytime and equally important is the ability for the same set of information to be shared with hydraulic modeling systems and other enterprise applications.

The platform of choice for this particular study is the OPTO22 PAC suite of products and PAC Project Professional Suite software tools manufactured by OPTO22 (www.opto22.com) out of Temecula, California USA. The platform was selected for its state of the art "openness", scalability and the unique snap-on design features which will enable the utility to "start small" while the level of sophistication is minimal while maintaining plenty of room for expansion as the required sophistication increases. The distributed architecture allows the individual remote telemetry units to run individual automation sequences (i.e. turn on/off pumps depending on pressure or closing/opening of control valves for the water tanks depending on water levels) without the need to communicate to a central server like what most DCS/PLC architecture employs.

The suite of software tools that comes with the hardware controllers will enable the water district to design custom graphics interface application to suite their everyday needs. Also, the control software suite which is used to develop the automation sequences incorporates a self documenting flow chart based high level programming tools that will likewise enable the water utility engineers to maintain the system using in house skills with very little dependence on outside contractors.

C.1. Remote Telemetry Units

Each of the monitored facility (1 pumping station & 4 elevated storage tanks) will be fitted with individual Remote Telemetry Units (RTU). The individual RTUs will be fitted with the appropriate signal modules that will be connected to the individual sensor heads (flow meters, level meters, pressure gauges, etc). Data will be collected and processed at site by the individual RTUs and transmitted back to the central database server for Graphical display, Web Interface and database processing. The general SCADA/RTU architecture is shown on the diagram below.

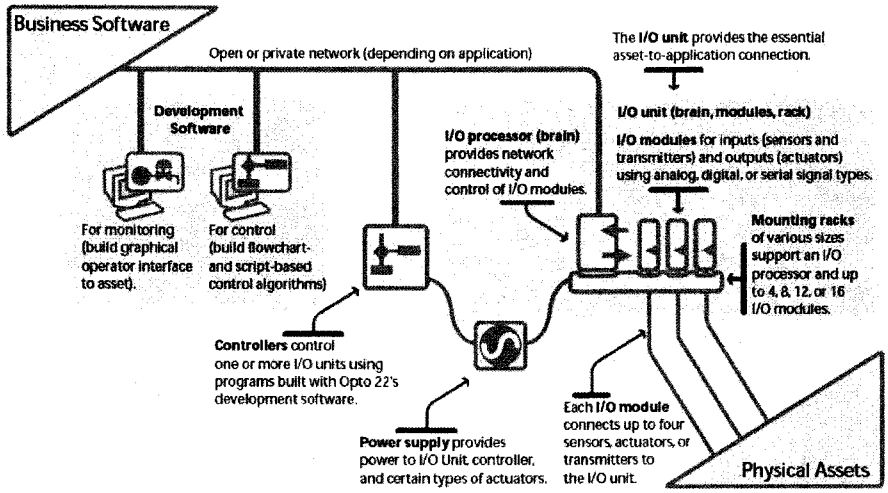


Figure 1: General RTU Architecture

Generally, each physical asset (pumps controls, flow sensors, pressure transducers, etc) will be connected to the RTU using the appropriate SNAP-Modules. Please refer to the OPTO 22 product brochure in Section F.1.4 of this document.

C.2. Pumping Station Automation

Critical to the overall water supply system of the Mauaque Resettlement Area a Metro Clark Homes is the Dapdap pumping station. This is where the various equipment critical to the operations is housed and operated. Much of the operational data will come from the pumping station equipment and the overall efficiency of any water utility can be determined on how each of the pumping stations are operated. At the minimum, each pumping should be monitored for system pressure, flow meter readings, pump motor status (and remote start/stop operation), status of the chlorine dosing pump, generator status, fuel levels and overall energy consumption.

C.2.1. Pressure Monitoring

System Pressure monitoring shall be accomplished by utilizing a 4-20mA pressure transducer. Currently the system is fitted only with a mechanical pressure gauge in tandem with a pressure switch. The pressure transducer will be connected into the analog input module of the OPTO22 PAC Controller. The frequency at which the pressure data will be read and recorded will be based on the data refresh time that will be set at the control station.

C.2.2. Flow Meter Reading

In order to acquire the flow meter readings, we will interface with the existing MC308 ARAD totalizer via the RS485 interface. Alternatively, we can also read the pulses generated directly by the flow meter.

C.2.3. Pump Motor Controls

Remote pump controls will enable the utility to start/stop the pump motor from the central station without the need to send any personnel to the pumping station physically.

The remote start/stop function can also be used to control the pump motors based on schedules. Since the RTU is the one controlling the pump operations, the system can take note of the total time (hours) the motor pumps were operational. This data can be used to trigger an automatic preventive maintenance ticket and also for measuring overall pump efficiency.

For pump motor monitoring, each pump motor will be fitted with current transformers (CT) to determine both the pump status and current drawn from the electrical system. This data can determine the health of the pumping equipment and can also be used to measure the pump efficiency over time. The said CT will be interfaced with the analog Current Module on the RTU.

To control the pump operation remotely, the system will interface with the soft starter system using the existing control buttons (ON/OFF). The said control buttons will be interfaced with the Digital Output module on the RTU.

C.2.4. Chlorine Dosing Pump

The chlorine dosing pump currently installed is set to inject a maximum of 3800cc of Chlorine per hour. The issue in this particular setup is that the flow rate is not usually linear. This non-closed loop setup between the flow meter (providing the flow rate data) and the chlorine dosing pump can result in either under or over dosing of the supplied water.

The SCADA/RTU system that will be installed at site will be able to provide the near-real time flow rates. Using variable injection devices to control the amount of chlorine injected into the system, the amount of chlorine can now be better controlled and will be directly proportional to the amount of water actually drawn by the system. This will result in better quality water for the residents of the resettlement area and potentially lower amounts of chlorine required over time.

C.2.5. Generator & ATS Status Monitoring

Generator & ATS Status should also be monitored. In the event of a power outage, central station personnel should be immediately alerted. Prolonged power outages can cause the generator fuel to run out and thereby stopping the water supply to the resettlement area.

Most Generators and ATS systems are fitted with digital status relays. The RTU will simply read the status of the said relays to determine the current status of the generator equipment. The system will also monitor the total engine runtime to determine fuel efficiency which can also be later on used for automated preventive maintenance planning.

C.2.6. Energy Consumption Monitoring

Energy conservation starts by profiling the energy consumption of the pumping station over a period of time. Although each of the wells are already equipped with the energy meters provided by the utility company, the utility company however is not capable (or most of the time unwilling) to provide the rest of the electrical & power quality data (Demand, THD, Voltage, Current, Frequency, Energy, Power Factor) overtime.

This scenario then calls for the installation of an electronic energy meter. The electronic energy meter will be programmed to provide data on demand. This means that the frequency whereby the required data (Demand, THD, Voltage, Current, Frequency, Energy, Power Factor) are collected will be determined by a user defined parameter (default will be every 15 minutes) at the central station.

Data collected from the energy meter will be displayed using the graphical application and saved into the appropriate database. The RTU will interface with the energy meter using the RS485 Communication module.

C.2.7. Water Well/Pumping Station Energy Efficiency

The use of soft-starter systems does have a direct impact on energy efficiency of any given pump motor. It does so by reducing the amount of spike-current required to start the motor. The use of Variable Frequency Drives or VFD's also reduces the amount of energy used by a given motor by reducing the frequency (making the motor turn slower) at which the pump motor operates. The use of the soft-starters should be standard but the use of VFDs needs a careful study.

Energy efficiency can be defined as a measure of electricity used per cubic meter of water drawn from the ground. This can be measured directly by dividing the total energy used and the total volume of water drawn from the ground assuming that the target system pressure is maintained within acceptable levels over a period of time.

Energy consumption can be continuously measured by an electronic energy meter as discussed in the Section C.2.6. Readings on a per-time block basis (every 15 minutes, every hour, every day, etc.) can be taken and recorded for later analysis. The RTU can likewise automatically actuate an existing VFD system to slow down the pump motor or otherwise turn off the pump motor should the overhead tanks become full and/or the required system pressure is achieved or exceeded or a combination of the said events. Only with the use of intelligent RTUs running the said pre-programmed automation sequences can energy efficiency be achieved in the operation of water wells with or without VFDs.

C.3. Elevated Storage Tank Automation

There are four (4) existing Elevated Storage Tanks capable of storing approximately 30,000 gallons of water each. At minimum, the water level and gauge pressures at each of the said elevated tank should be monitored for greater system efficiency.

C.3.1. Water Level Monitoring

Level monitoring shall be accomplished using digital water level meters. At a predetermined level, a digital water sensor will actuate (turn-on) when the water level reaches the said water sensor. The assigned level of each water sensor can be adjusted at each pre-defined levels (every 10cms, 20cms, 30cms, etc). The Rod where the digital water sensors are attached will be constructed using stainless steel pipe that will be bolted to the rim of the tank.

C.3.2. Pressure Monitoring

System Pressure monitoring at the elevated tank locations shall be accomplished by utilizing a 4-20mA pressure transducer. Currently the system is fitted only with a mechanical pressure gauge. The pressure transducer will be connected into the analog input module of the OPTO22 PAC Controller and frequency at which the pressure data will be read based on the data refresh time that will be set at the control station.

C.3.3. Motorized Valves

Optionally, the overhead tanks can also be fitted with motorized valves that the RTU can actuate to close the water inlet filling the tanks should the required level is reached. This way, the system pressure used to fill the tanks can be redistributed to the rest of the system automatically once the tanks are full. The valves can also be automatically actuated in the event of pump-motor failure or during pre-defined schedule to release the water from the tanks.

The RTU will likewise take note of the time it took for the tank to fill after a scheduled discharge. This data will contribute to the overall efficiency of the distribution system.

C.4. Central Monitoring and Control Interface

At the central monitoring station, the pumping station can be monitored and controlled using the customized graphical interface or Human Machine Interface (HMI). A sample of the graphical interface is shown below.

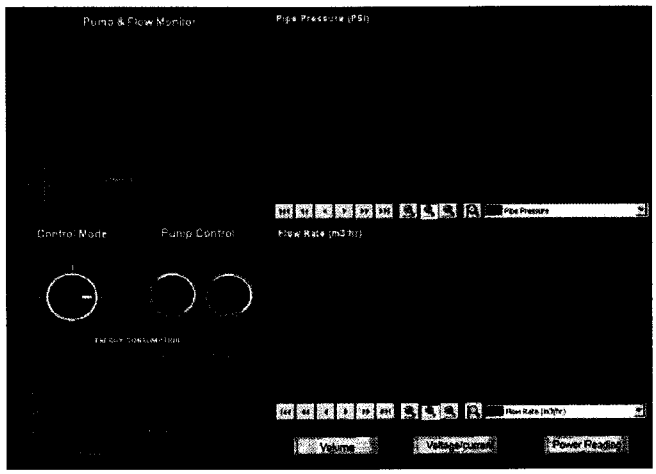


Figure 2: Sample Graphical Interface for monitoring & control of pumping stations

Active buttons for motor controls, dynamic display of collected data, real time graphing interface are just some of the features of the graphical interface. Moreover, the local engineers can design their own graphical interfaces to suite their everyday needs.

C.5. DATA ACQUISITION & PUBLISHING

The Datalink architecture will enable data taken by the sensor head (flow meters, level meters, and energy meters) to be written directly into open standards databases. The typical database link architecture is shown below.

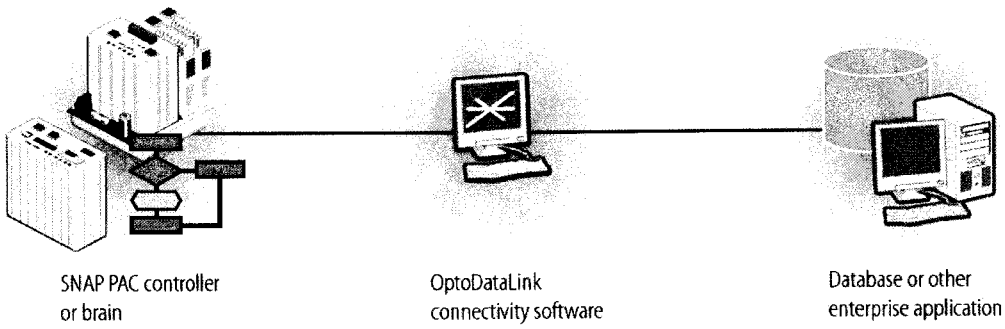


Figure 3: Data acquisition architecture

Other enterprise application can readily share the data from an existing database or the system can be programmed to write to multiple destination databases at the same time.

C.6. SCADA COMMUNICATIONS TOPOLOGY

Today, more than ever, efficient, well-designed control systems depend on communications to integrate the sharing of information between the various hardware components that make up a complete system. Data from the RTUs will be backhauled to the central station using wireless communications. The proposed signal path of the wireless backhaul network from the resettlement area to the Mabalacat Water District Office is shown in Figure 4 below.

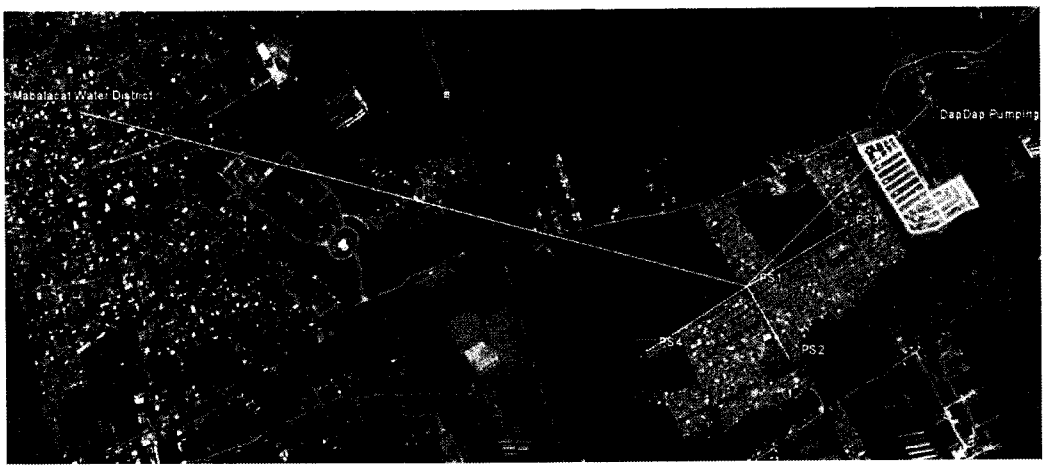


Figure 4: Wireless IP Network Signal Path Diagram

Please refer to Section F.2.4 for the general RTU/System communication topology single line diagram. Essentially all components of the system (RTUs /Servers /Storage /Databases) will be linked using a TCP/IP network.

Overhead tank designated as PS3 will be used as the collection station for the rest of the communication devices at the resettlement area. From this communication link, the main wireless backhaul will be mounted and aligned with the receiving antenna at the main office.

The communication system will incorporate a mixed of 5.4GHz and 2.4GHz wireless data communication devices to backhaul the SCADA data form the individual telemetry units to the central office.

C.7. SCADA SYSTEM COST

Total system investment is as follows:

Item	Description	Unit Price	Qty	Unit	Total
1	Dapdap Metro Clark Pumping Station Components		1.00	Lot	
2	Elevated Tank Automation Components		1.00	Lot	
3	Wireless Networking Components		1.00	Lot	
4	Central Office Monitoring Components		1.00	Lot	
5	Human Machine Interface Customization Services		1.00	Lot	
6	Control Programming Customization Services		1.00	Lot	
7	Database Integration Services		1.00	Lot	
8	Web Interface Development Services		1.00	Lot	
9	Training & Skills Transfer		1.00	Lot	
		Total System Cost			

Please refer to section F.1.1 to Section F.1.4 for the complete Bill of Materials.

D. REGULATORY CONSIDERATIONS ON IMPLEMENTING A SCADA SYSTEM

Regulatory requirements for the design and implementation of a SCADA system for use by a water utility in the Philippines virtually do not exist. The only regulation existing is outlined in the National Telecommunications Commission Memorandum Circular 09-11-2005 allocating the 481.250-481.475 MHz and 486.250-486.475 MHz for use by telemetry and related data system. This regulation however does not apply to this particular study specifically because we will be employing Wireless I.P. radios instead of the conventional analog radios.

We will however comply with National Telecommunications Commission Memorandum Circular 09-09-2003 outlining and regulating the use of wireless data networks and devices utilizing 2400MHz to 2483 MHz, 5150MHz to5350MHz and 5470MHz to 5850MHz bands. All license requirements shall be complied with in this implementation.

E. PROJECT IMPACT ASSESSMENT & CONCLUSION

Operational efficiencies can be achieved faster with the use of efficient data collection systems. Improvements are enabled by continuously adjusting the system using the data collected over time. Overall, the use of an open system based SCADA/RTUs will result in energy efficiency, flow efficiency, lower cost of production and ultimately better water quality for the residents of Metro Clark and the Mauaque Resettlement Area.

Furthermore, aside from the operational efficiencies that the SCADA system will provide to the water utility, the potential decrease in energy consumption will contribute to environment, the more efficient use of Chlorine will contribute to the improved health and well being of the residents of Mauaque Resettlement and Metro Clark homes while improving the financial viability of the water utility operations due to the resulting decrease in utility and operational costs.

Skills improvement opportunities are also made available to the employees of the Water District. The use of the state of the art SCADA system will open doors for improve technical know-how in the field of system management, system programming, system operation, troubleshooting and maintenance all in line with the enabling the independent operation of the SCADA system by the Water District. In the long run, the operation and maintenance of the SCADA system will require minimal help from outside consultants.

F.1 BILL OF MATERIALS

F.1.1. Dapdap Metro Clark Pumping Station Components

Item	Description	Qty	Unit
Pressure Transducer	0-6 Bar Pressure Transducer with 4-20mA Output	1.00	Unit
SNAP-AIARMS/AIPM	SNAP 2-Ch 0-10 amp RMS Analog Input Module	1.00	Unit
SNAP-AIMA	SNAP 2-Ch -20mA to +20mA Analog Current Input Module	1.00	Unit
SNAP-SCM-485	RS 485 Communication Module	1.00	Unit
SNAP-IDC5D	SNAP 4-Ch 2.5-28 VDC Digital Input Module	1.00	Unit
SNAP-OAC5	SNAP 4-Ch 12-250 VAC Digital Output Module	1.00	Unit
SNAP-PAC-RCK8	SNAP Multifunction 8 Module Rack	1.00	Unit
SNAP-PAC-R2	SNAP PAC R-series Programmable Automation Controller On-The-Rack	1.00	Unit
SNAP-ITEM-PM	SNAP Package System Enclosure, Power Supply, Battery, Relays	1.00	Unit
Services	Cabling Services	1.00	Lot

F.1.2. Elevated Tank Automation Components

Item	Description	Qty	
Pressure Transducer	0-6 Bar Pressure Transducer with 4-20mA Output	1.00	Unit
SNAP-AIMA	SNAP 2-Ch -20mA to +20mA Analog Current Input Module	1.00	Unit
Water Level Sensor	8 Position digital water level switch	1.00	Unit
SNAP-IDC5D	SNAP 4-Ch 2.5-28 VDC Digital Input Module	2.00	Units
Motorized Valve	Motorized Valve Assembly 24VDC/VAC Control Voltage	1.00	Unit
SNAP-OAC5	SNAP 4-Ch 12-250 VAC Digital Output Module	1.00	Unit
SNAP-PAC-RCK8	SNAP Multifunction 8 Module Rack	1.00	Unit
SNAP-PAC-R2	SNAP PAC R-series Programmable Automation Controller On-The-Rack	1.00	Unit
SNAP-ITEM-PM	SNAP Package System Enclosure, Power Supply, Battery, Relays	1.00	Unit
Services	Cabling Services	1.00	Lot

F.1.3. Wireless Networking Components

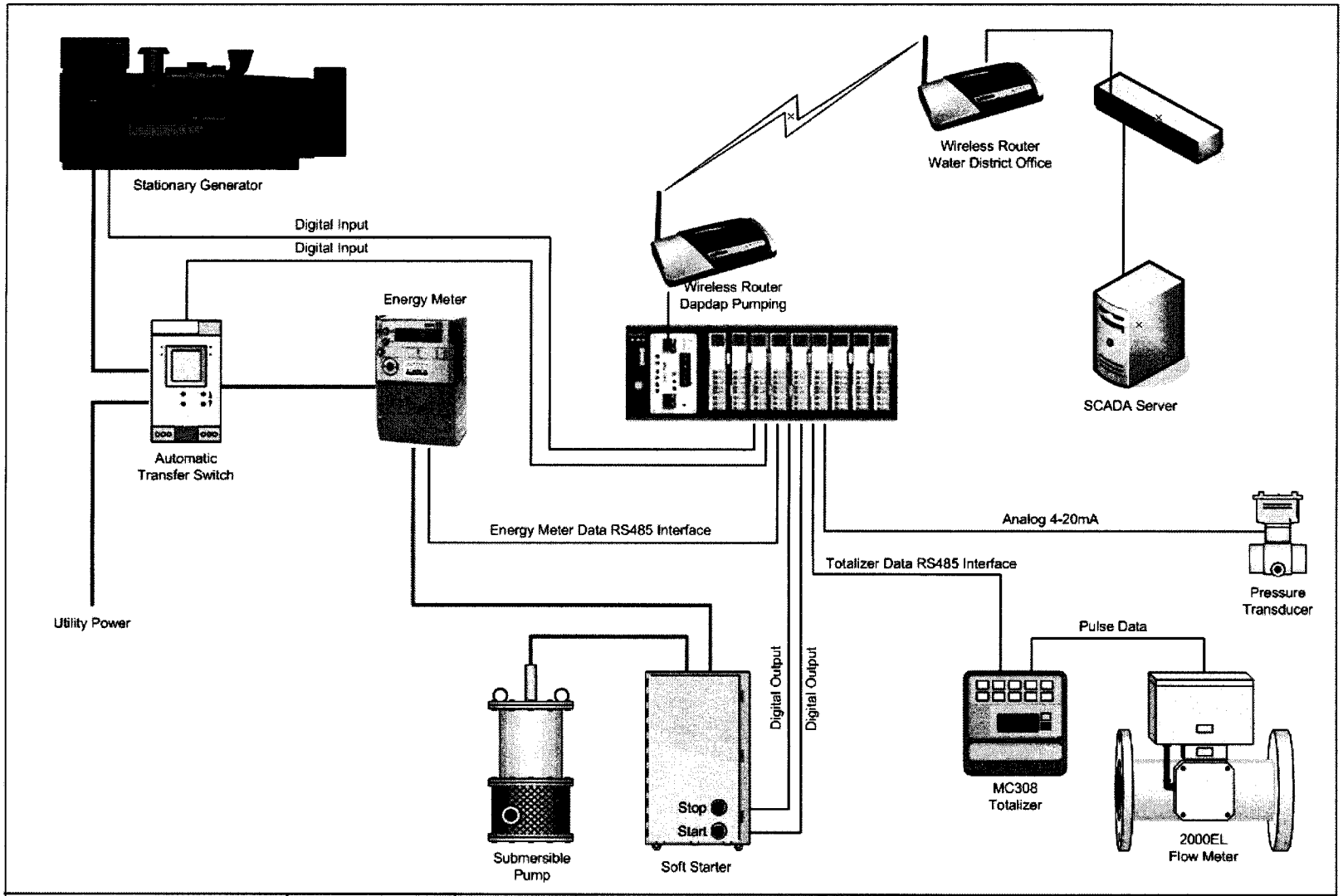
Item	Description	Qty	
Wireless Router	2.4GHz 19dB Directional Antenna	6.00	Units
Wireless Router	2.4GHz 8dB Omni-Directional Antenna	1.00	Unit
Wireless Router	Wireless 802.11b/g Router	7.00	Units
Wireless Router	12M Outdoor Cables	7.00	Units
Others	Mounting Brackets	1.00	Lot
Services	Installation, Configuration and Commissioning Services	1.00	Lot
Others	Government Licenses & Permits	1.00	Lot

F.1.4. Central Office Monitoring Components

Item	Description	Qty	
SCADA Server	Intel Xeon, 1GB RAM, 1TB Hard Disk, Windows 2000, Installation,	1.00	Set
PAC Project Pro	Software Development Tools License	1.00	Lic
Network Switch	8 Port 10/100 Network Switch	1.00	Unit
Services	HMI Development & Customization	1.00	Lot
Services	Control Program Development & Customization	1.00	Lot
Services	Database Integration & Web Interface Development	1.00	Lot

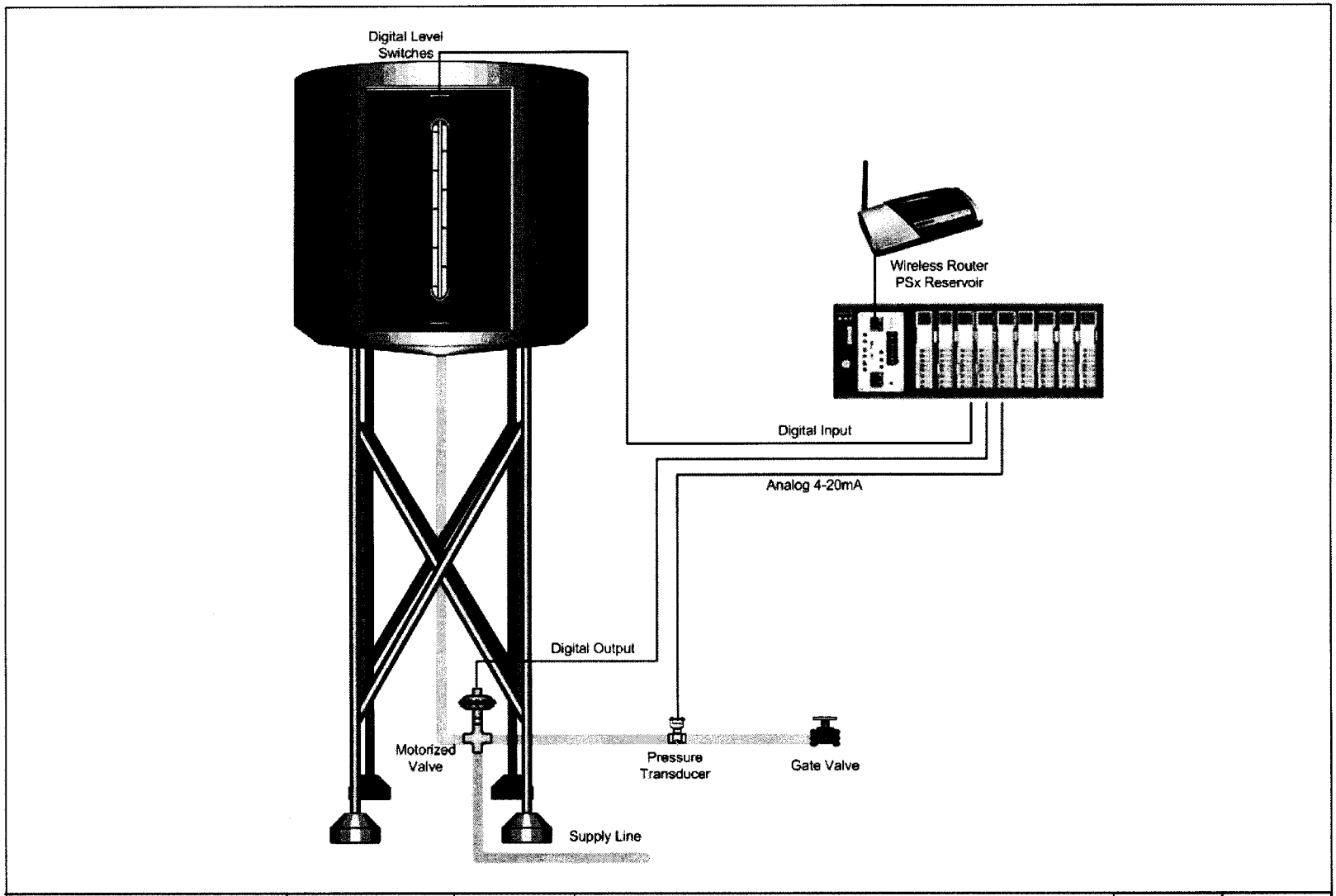
F.2. Single Line Diagrams

F.2.1. Dapdap Metro Clark Pumping Station Single Line Diagram



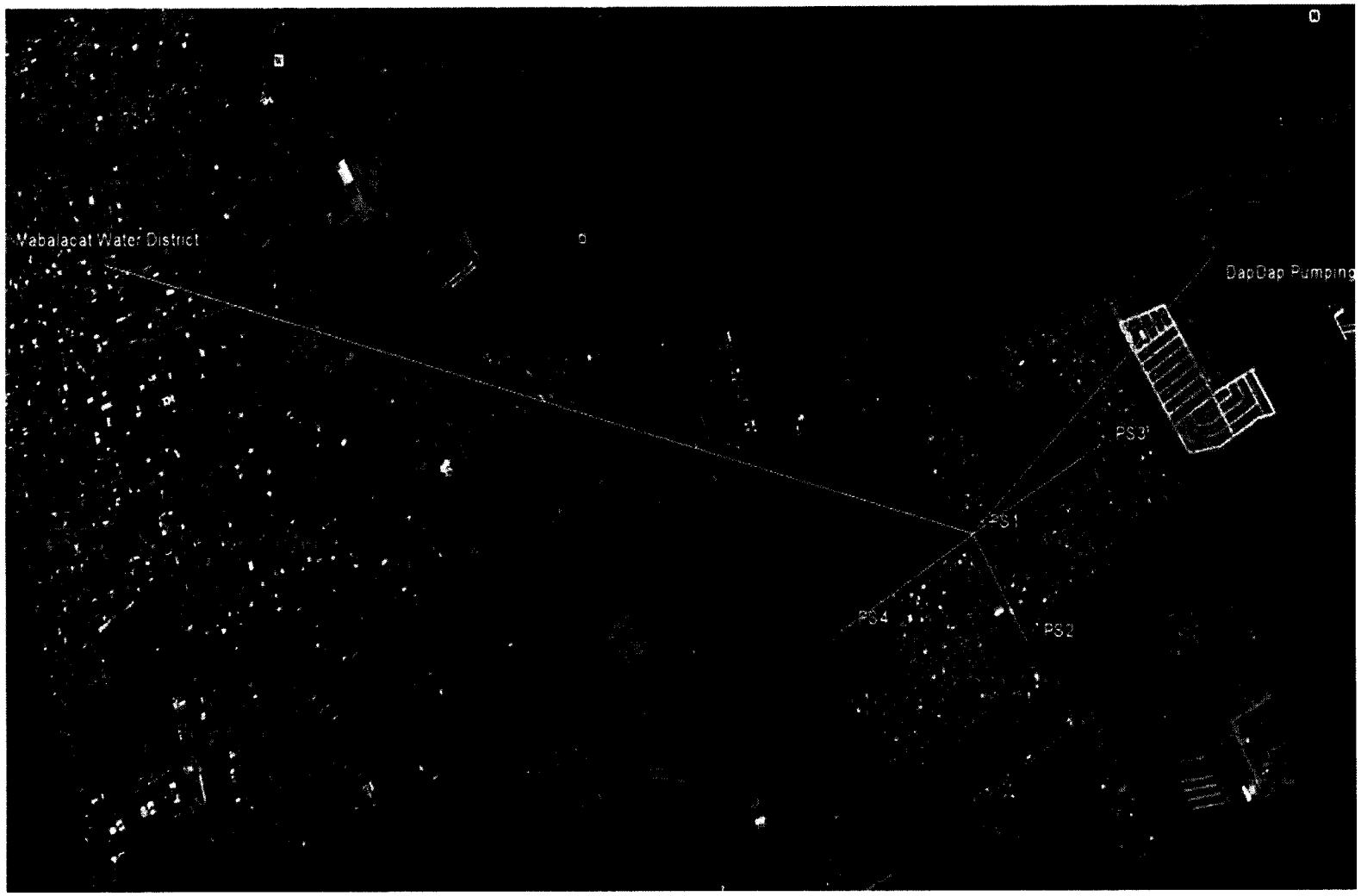
East Asia TECHNOLOGIES CORPORATION	DRAWN BY:	AZ ABRAZADO	PROJECT NAME	REVISION	SHEET
	DESIGNED BY:	PG TUGONON JR.	Dapdap Pumping Station Telemetry Single Line Diagram	1.10	1/6
	CHECKED BY:	PG TUGONON JR.			
	DATE:	29MARCH2009			
	FILENAME:	DAPDAP.vsd	LOCATION: Dapdap Metro Clark, Mabalacat, Pampanga		

F.2.2. Elevated Tank Automation Single Line Diagram



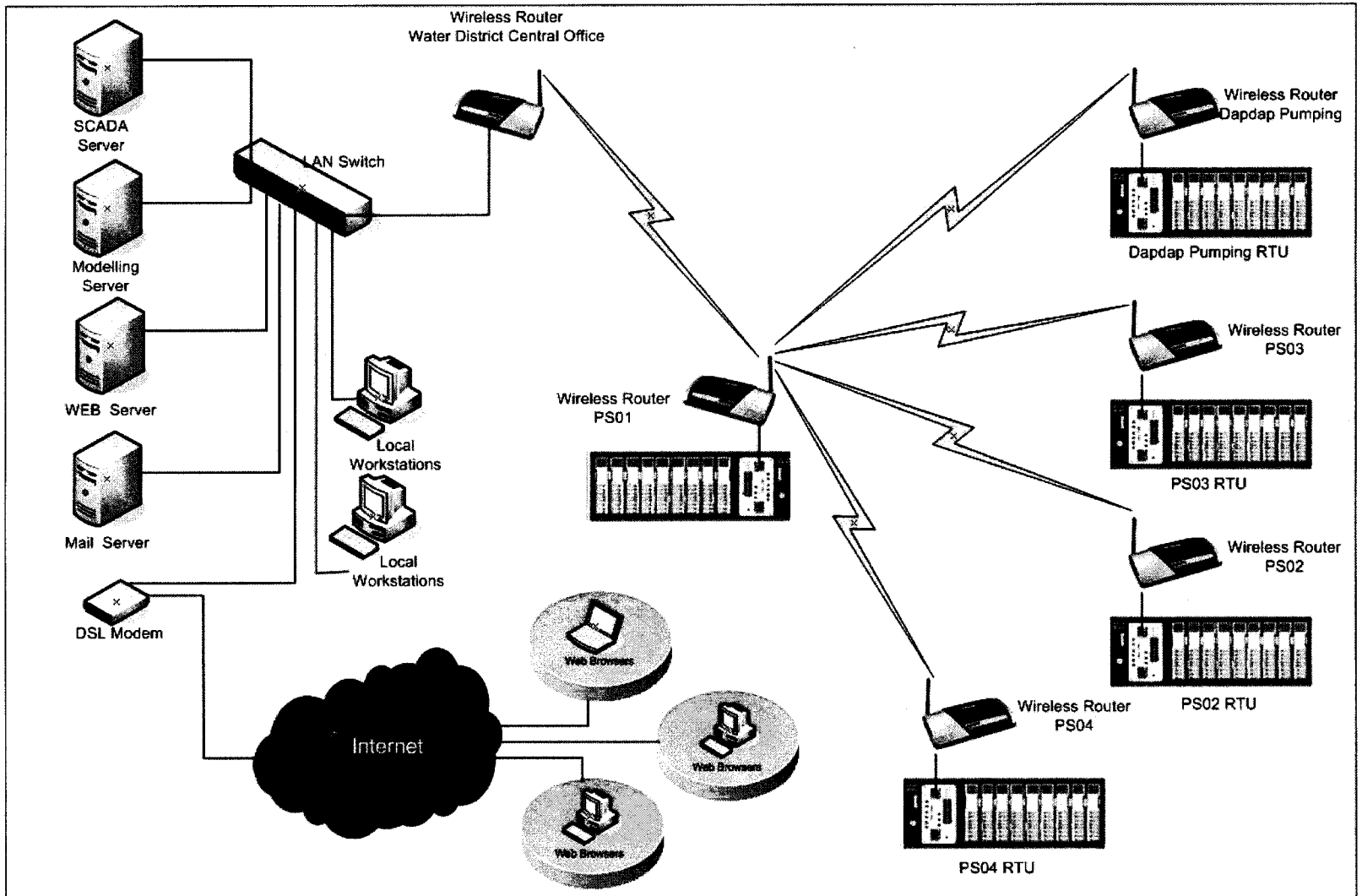
East Asia TECHNOLOGIES CORPORATION	DRAWN BY:	AZ ABRAZADO	PROJECT NAME	REVISION	SHEET
	DESIGNED BY:	PG TUGONON JR.	Elevated Storage (PS1, PS2, PS3, PS4) Tank Automation Single Line Diagram	1.10	2/6
	CHECKED BY:	PG TUGONON JR.			
	DATE:	29MARCH2009			
	FILENAME:	DAPDAP.vsd	LOCATION: Dapdap Metro Clark, Mabalacat, Pampanga		

F.2.3. Wireless Network Signal Propagation Path



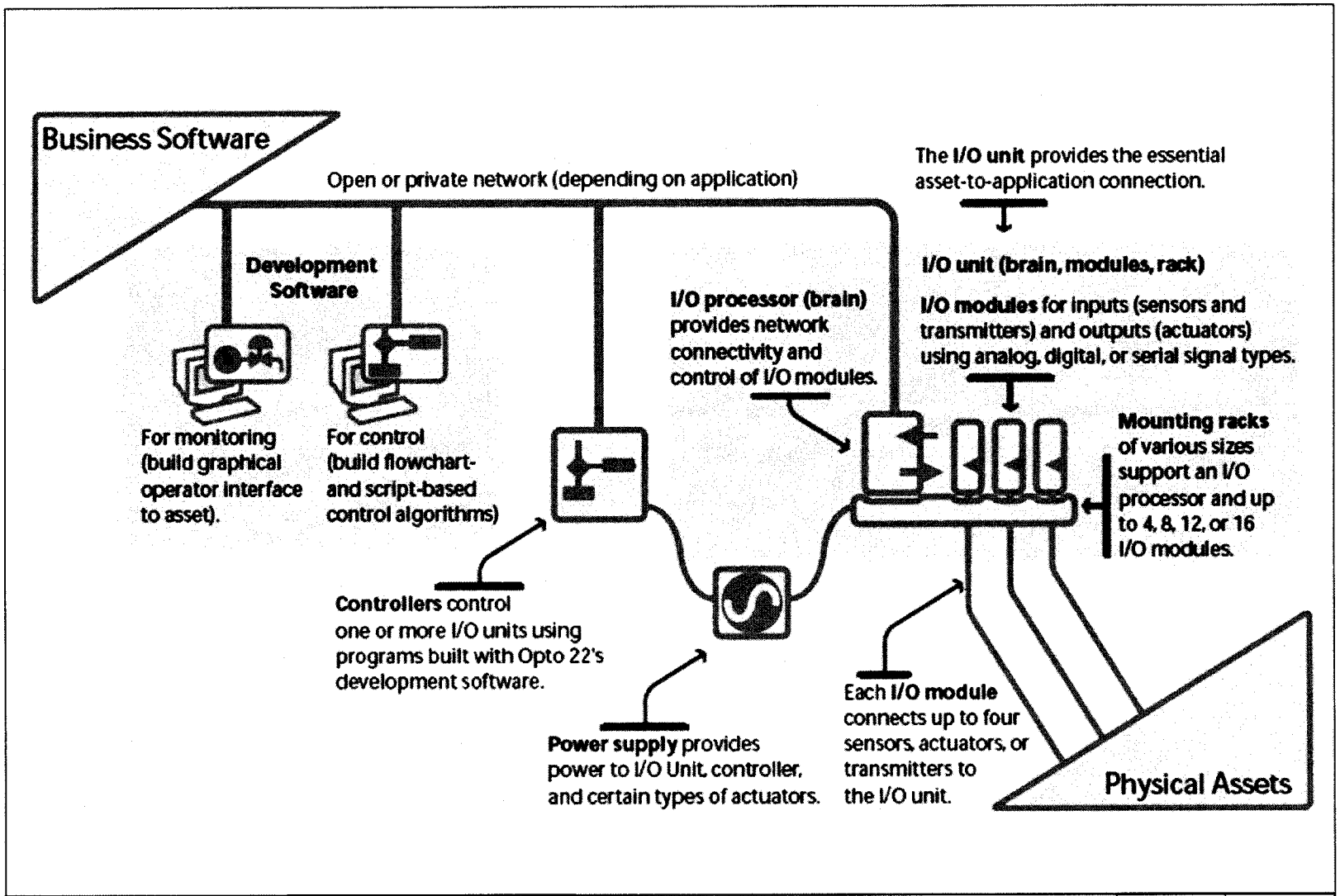
East Asia TECHNOLOGIES CORPORATION	DRAWN BY:	AZ ABRAZADO	PROJECT NAME	REVISION	SHEET
	DESIGNED BY:	PG TUGONON JR.	Wireless Network Signal Propagation Path Single Line Diagram	1.10	3/6
	CHECKED BY:	PG TUGONON JR.			
	DATE:	29MARCH2009			
	FILENAME:	DAPDAP.vsd	LOCATION: Dapdap Metro Clark, Mabalacat, Pampanga		

F.2.4. Network & Server Systems Single Line Diagram



East Asia TECHNOLOGIES CORPORATION	DRAWN BY:	AZ ABRAZADO	PROJECT NAME	REVISION	SHEET
	DESIGNED BY:	PG TUGONON JR.	Network & Server Systems Single Line Diagram	1.10	4/6
	CHECKED BY:	PG TUGONON JR.			
	DATE:	29MARCH2009			
	FILENAME:	DAPDAP.vsd	LOCATION: Dapdap Metro Clark, Mabalacat, Pampanga		

F.2.5. General RTU Architecture

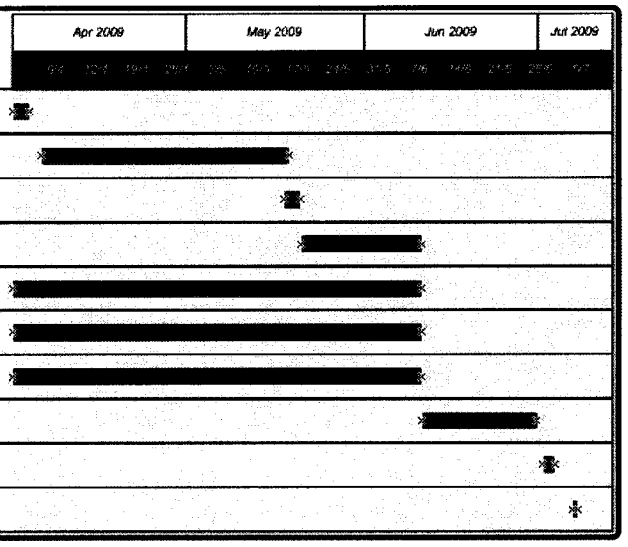


East Asia TECHNOLOGIES CORPORATION	DRAWN BY:	AZ ABRAZADO	PROJECT NAME	REVISION	SHEET
	DESIGNED BY:	PG TUGONON JR.	General RTU Architecture Single Line Diagram	1.10	5/6
	CHECKED BY:	PG TUGONON JR.			
	DATE:	29MARCH2009			
	FILENAME:	DAPDAP.vsd	LOCATION: Dapdap Metro Clark, Mabalacat, Pampanga		

Estimated Implementation Schedule

(Subject to change & customer approval)

ID	Task Name	Start	Finish	Duration
1	Mobilization/Inspections	4/1/2009	4/3/2009	3d
2	Procurement of Equipment	4/6/2009	5/18/2009	31d
3	Equipment Testing/Programming	5/18/2009	5/20/2009	3d
4	Equipment Installation	5/21/2009	6/10/2009	15d
5	HMI/Control Program Development	4/1/2009	6/10/2009	51d
6	Database Integration	4/1/2009	6/10/2009	51d
7	Web Interface Development	4/1/2009	6/10/2009	51d
8	System Testing	6/11/2009	6/30/2009	14d
9	User Training	7/2/2009	7/3/2009	2d
10	Project Turnover	7/7/2009	7/7/2009	1d



East Asia TECHNOLOGIES CORPORATION

DRAWN BY:	AZ ABRAZADO	PROJECT NAME	REVISION / SHEET
DESIGNED BY:	PG TUGONON JR.	Estimated Implementation Schedule	1.10 / 6/6
CHECKED BY:	PG TUGONON JR.		
DATE:	29MARCH2009		
FILENAME:	DAPDAP.vsd	LOCATION: Dapdap Metro Clark, Mabalacat, Pampanga	

Pumping Station Automation

Item	Description	Unit Cost	Qty	Unit	Total Cost
Pressure Transducer	0-6 Bar Pressure Transducer with 4-20mA Output	25,000.00	1.00	Unit	25,000.00
Pressure Transducer for level	0-6 Bar Pressure Transducer with 4-20mA Output IP68	75,000.00	1.00	Unit	75,000.00
Power Monitor	EDMI	120,000.00	1.00	Unit	120,000.00
Current Transducer	Dougnut Type, Ratio 500/5A, Volts 600V, Class 1.0	3,000.00	3.00	Unit	9,000.00
SNAP-AIARMS/AIPM	SNAP 2-Ch 0-10 amp RMS Analog Input Module	18,800.00	1.00	Unit	18,800.00
SNAP-AIMA	SNAP 2-Ch -20mA to +20mA Analog Current Input Module	21,400.00	1.00	Unit	21,400.00
SNAP-SCM-485	RS 485 Communication Module	46,000.00	1.00	Unit	46,000.00
SNAP-IDC5D	SNAP 4-Ch 2.5-28 VDC Digital Input Module	4,608.00	1.00	Unit	4,608.00
SNAP-OAC5	SNAP 4-Ch 12-250 VAC Digital Output Module	3,780.00	1.00	Unit	3,780.00
SNAP-PAC-RCK8	SNAP Multifunction 8 Module Rack	12,400.00	1.00	Unit	12,400.00
SNAP-PAC-R2	SNAP PAC R-series Programmable Automation Controller On-The-Rack	94,600.00	1.00	Unit	94,600.00
SNAP-ITEM-PM	SNAP Package System Enclusore, Power Supply, Battery, Relays	37,320.00	1.00	Unit	37,320.00
Services	Cabling Services	40,000.00	1.00	Lot	40,000.00
			Subtotal		507,908.00

Elevated Storage Tank Automation (4 Tanks)

Item	Description	Unit Cost	Qty		Total Cost
Pressure Transducer	0-6 Bar Pressure Transducer with 4-20mA Output	25,000.00	4.00	Unit	100,000.00
SNAP-AIMA	SNAP 2-Ch -20mA to +20mA Analog Current Input Module	21,400.00	4.00	Unit	85,600.00
Water Level Sensor	8 Position digital water level switch	24,000.00	4.00	Unit	96,000.00
SNAP-IDC5D	SNAP 4-Ch 2.5-28 VDC Digital Input Module	4,608.00	8.00	Unit	36,864.00
Motorized Valve	Motorized Valve Assembly 24VDC/VAC Control Voltage		4.00	Unit	0.00
SNAP-OAC5	SNAP 4-Ch 12-250 VAC Digital Output Module	3,780.00	4.00	Unit	15,120.00
SNAP-PAC-RCK8	SNAP Multifunction 8 Module Rack	12,400.00	4.00	Unit	49,600.00
SNAP-PAC-R2	SNAP PAC R-series Programmable Automation Controller On-The-Rack	94,600.00	4.00	Unit	378,400.00
SNAP-ITEM-PM	SNAP Package System Enclusore, Power Supply, Battery, Relays	37,320.00	4.00	Unit	149,280.00
Services	Cabling Services	40,000.00	4.00	Lot	160,000.00
			Subtotal		1,070,864.00

Wireless Communication Devices

Item	Description	Unit Cost	Qty		Total Cost
Wireless Router	2.4GHz 19dB Directional Antenna	20,000.00	2.00	Units	40,000.00

Wireless Router	2.4GHz 8dB Omni-Directional Antenna	15,000.00	7.00	Unit	105,000.00
Wireless Router	Wireless 802.11b/g Router	40,000.00	7.00	Units	280,000.00
Wireless Router	12M Outdoor Cables	17,000.00	7.00	Units	119,000.00
Others	Mounting Brackets	5,000.00	1.00	Lot	5,000.00
Services	Installation, Configuration and Commissioning Services	90,000.00	1.00	Lot	90,000.00
Others	Government Licenses & Permits	50,000.00	1.00	Lot	50,000.00
			Subtotal		689,000.00

Central Monitoring System

Item	Description	Unit Cost	Qty		Total Cost
SCADA Server	Intel Xeon, 1GB RAM, 1TB Hard Disk, Windows 2000, Installation	100,000.00	1.00	Set	100,000.00
LCD Panel	20" LCD Panel for HMI Presentation	25,000.00	1.00	Set	25,000.00
PAC Project Professional	Software Development Tools License	60,000.00	1.00	Lic	60,000.00
Network Switch	8 Port 10/100 Network Switch	4,500.00	1.00	Unit	4,500.00
Services	HMI Development & Customization	125,000.00	1.00	Lot	125,000.00
Services	Control Program Development & Customization	100,000.00	1.00	Lot	100,000.00
Services	Web Interface Development	-	1.00	Lot	0.00
			Subtotal		414,500.00

Total System	2,682,272.00

Task 5 - Overview of US Manufacturers

5.1 Introduction

The roles of Geographic Information System (GIS), Hydraulic Modeling (HM), water metering, and Supervisory Control and Data Acquisition (SCADA) system in the modern water utility cannot be understated. Each represents a set of tools for the administrators of the water utility to use in order to provide effective and efficient service for the ratepayers. There is no single one of these tools that can provide the desired outcome – their true strength comes from a highly integrated system using the best aspects of each of them.

This section will identify the various sub-parts of each of these important tool sets and describe how they can be applied in the modern water utility.

5.2 Geographic Information Systems

5.2.1 Introduction

Geographic Information Systems (GIS) represent an extremely powerful tool in the management of a water utility. GIS is much more than simple mapping of a water system – it represents a database that gives the utility manager insight into all aspects of the water system. By adding data to the graphical elements on the map, a whole new realm of analysis tools are made available to the user.

GIS has two main components that together make the whole system work:

- Data Conversion and Editing Software
- GIS Database Software

5.2.2 Data Conversion and Editing Software

The first step in creating a GIS database is the process known as data conversion. Data conversion starts with a variety of data sources, from paper maps and photographs, to customer databases and other records. The GIS technician identifies which of these data sources contains the information that is needed for the GIS and uses certain software tools to create the data required by the GIS.

Each GIS Database software firm has its own line of data conversion tools included in the GIS software packages that will be described later. However, in large production environments, there are instances where greater efficiency can be had by using Computer Aided Drafting (CAD) software for the initial data conversion process. CAD packages have the advantage of efficiency in use as well as a larger pool of qualified technicians to use these systems. If an employer is going to have several staff people working on GIS data conversion, deploying a well known CAD package for data editing will result in a larger talent pool from which to select employees.

5.2.2.1 AutoCAD

AutoCAD is a full-featured design and drafting software package sold by AutoDesk, Inc. It is part of a complete line of engineering drafting software systems in AutoDesk's line of products. AutoDesk also sells a type of GIS software known as AutoCAD Map, which provides a certain level of GIS capabilities but not quite the sme level as the packages that will be described in the GIS section of this document.

One of the features of AutoCAD that makes it so useful for GIS data conversion is the fact that it is extensible, that is, third party vendors can write custom tools for use in AutoCAD to improve performance or productivity. Nobel Systems has developed a set of mapping tools that work within AutoCAD to provide a higher level of production and data compatibility with GIS software.

AutoCAD enjoys an approximate 85% market share of CAD users and in some arenas is considered the de-facto standard for CAD

AutoDesk us a US company with annual revenues of over $2B USD, headquartered in California but also with a presence in the Philippines as noted below.

Autodesk, Inc.
111 McInnis Parkway
San Rafael, CA 94903
Phone 1-800-964-6432
www.autodesk.com

Autodesk Asia Pte Ltd
(Philippines Rep Office)
28th Floor Tower 2
Enterprise Centre
6766 Ayala Avenue
Cor. Paseo de Roxas
Makati City
Manila Philippines
Phone +63-2-849-3933
Fax +63-2-885-8561
www.autodesk.com.ph

5.2.2.2 Microstation

Microstation is also a full-featured CAD package sold by Bentley Systems, Inc. as part of a large suite of software offered by the firm. Microstation is second to AutoCAD in market share in the US. As will be noted later, Bentley Systems also sells hydraulic modeling software that integrate with Microstation. Microstation also has conversion tools to adapt their data sets to other GIS packages, such as those offered by ESRI to be described later.

Microstation also integrates with Bentley's ProjectWise collaboration tool which helps organizations control multiple projects at once and prevent errors through a common project data set. This sort of production control can be helpful in large data conversion efforts.

Bentley Systems has an annual revenue of about $450M USD and is headquartered in Pennsylvania but also has offices in the Philippines.

685 Stockton Drive
Exton, PA 19341
1-800-BENTLEY (1-800-236-8539)
Outside the US +1 610-458-5000
www.bentley.com

Bentley Systems Philippines
Unit 1508,88 Corporate Centre
41 Valero Corner Sedeno Streets,
1227 Makati City
Philippines
Phone: +63 2 752 0391
Fax: +63 2 817 0393

5.2.3 GIS Database Software

Once the GIS data has been converted the tools that allow users to fully explore the data for productive use reside in the GIS database software. These software packages contain powerful tools for relating disparate information sources into cohesive, spatially aware data sets that can be customized to meet virtually any need.

There are a number of firms in the GIS software arena, including both of the CAD software firms noted above, but the market is dominated by ESRI with over 80% market share. There are also a number of firms whose GIS software is not tailored to the utility market, instead specializing in other areas such as real estate. These firms will not be included in this list which will have only the main US manufacturers whose products have significant ties to the utility industry.

5.2.3.1 ESRI

As noted above, ESRI commands the GIS software market and its data formats have become the de-facto standard in the industry. Virtually every CAD and GIS software company has conversion tools for interoperability with ESRI software systems. While other GIS software providers can meet and match different parts of ESRI's lineup of software packages, none can match the full scope of systems offered by ESRI.

ESRI is the GIS of choice for the vast majority of water utilities in the US and there are many utility specific tools available. Another consideration in favor of ESRI is the fact that most GIS technicians are trained in the use of ESRI products and thus the labor market for technicians is highly skewed in favor of ESRI products.

ESRI also has the largest group of third party firms that provide complimentary software packages built upon the industry standard ESRI platforms. An example is Nobel Systems' GeoViewer web based GIS that provides water industry specific tools built on top of ESRI's data products.

ESRI is a privately held firm with annual revenues of over $600M USD that is based in Redlands, CA.

380 New York Street
Redlands, CA 92373-8100
909-793-2853
www.esri.com

ESRI is represented in the Philippines by

Geodata Systems Technologies, Inc.
19th Floor Strata 100 Bldg.
Emerald Ave., Ortigas Center
Pasig, Metro Manila
Philippines
Ms. Francisca Dayrit
Mr. John Morales
Email: fndayrit@geodata.com.ph
Email: jmorales@geodata.com.ph
Phone: 63-2-637-4447
Phone: 63-2-633-7788
Fax: 63-2-633-6873
Web: http://geodata.com.ph

5.2.3.2 Intergraph

Intergraph is a privately held firm that specializes in geospatial software and services. Intergraph has a full line of Geospatial products that are tailored to nearly any industry group. The water and public works components are sold in a product known as GeoMedia Public Works Manager which features industry specific tools for data viewing and analysis.

Intergraph is headquartered in Alabama at:

170 Graphics Drive
Madison, AL 35758
1.800.345.4856
www.intergraph.com/

Intergraph is represented in the Philippines by:

Intergraph Process and Building Solutions Philippines, Inc
Suite 1402, BDO Plaza
8737 Paseo de Roxas, Salcedo Village
Makati City, Philippines
Tel: +63.2.8170706
Fax: +63.2.8170709
http://www.intergraph.com/global/sa/

5.2.3.3 AutoDesk

In addition to it's CAD software, AutoDesk also offers a full featured GIS package collectively known as AutoCAD Map. While a small player when compared to ESRI, AutoCAD Map has many similar features that are of benefit to the water utility.

AutoCAD Map also has the capability to tie directly into ESRI's software products as CAD is AutoDesk's primary software focus and the geospatial aspects are a secondary role.

Autodesk, Inc.
111 McInnis Parkway
San Rafael, CA 94903
Phone 1-800-964-6432
www.autodesk.com

Autodesk Asia Pte Ltd
(Philippines Rep Office)
28th Floor Tower 2
Enterprise Centre
6766 Ayala Avenue
Cor. Paseo de Roxas
Makati City
Manila Philippines
Phone +63-2-849-3933
Fax +63-2-885-8561
www.autodesk.com.ph

5.3 Hydraulic Modeling

5.3.1 Introduction

Hydraulic Modeling (HM) can play an essential role in the effective design and operation of the modern water utility. The fluid dynamics present in water distribution systems can be very complex and the age-old method of trial and error can be costly in terms of water loss and manpower. With ever increasing regulations on water quality, hydraulic modeling is an effective tool for understanding water quality in distribution systems.

When considering an HM software package, it is important to consider whether or not the software has robust GIS integration capabilities. HM's and GIS share a common set of data about the water distribution system and the highest level of efficiency and accuracy can only be obtained by using the same data set for both purposes.

5.3.1.1 MWH Soft

MWH Soft is a spin off firm that was originally the hydraulic modeling department of the large engineering firm Montgomery Watson. The firm offers a complete line of modeling tools that have been developed with the water utility end user in mind. Of particular note for this project is a specific piece of software called InfoWater LDM that is tailored to Leak Detection and Management.

MWH Soft's products are tailored to integrate directly with AutoCAD or ESRI packages or both if the data structures are consistent. A leader in the HM industry, MWH Soft has among the most advanced software and support services in the industry.

MWH Soft
380 Interlocken Crescent, Suite 200
Broomfield, CO 80021 USA
303-533-1934
www.mwhsoft.com

5.3.1.2 Haestead Methods

Haestead Methods became part of the Bentley Systems family of software when it was acquired by Bentley in 2004. Haestead's WaterGEMS modeling software is a full featured product that features total interoperability with AutoCAD, ESRI and Microstation data files. WaterGEMS has many robust features that allow the full range of modeling including leak detection systems.

The ability to work on all of the major CAD and GIS platforms as well as in a stand along mode makes WaterGEMS a great choice for firms that have multiple data standards or consulting firms that work with many different client data sets.

685 Stockton Drive
Exton, PA 19341
1-800-BENTLEY (1-800-236-8539)
Outside the US +1 610-458-5000
www.bentley.com

Bentley Systems Philippines
Unit 1508,88 Corporate Centre□
41 Valero Corner Sedeno Streets,
1227 Makati City
Philippines
Phone: +63 2 752 0391
Fax: +63 2 817 0393

5.5.1.3 KY Pipe

KY Pipe is a smaller firm that offers a low cost (in some cases free) HM software package that is based on software originally developed at the University of Kentucky. The software has the technical capacity to provide model runs but does not feature the same level of integration with other software packages as either Haestead or MWH Soft.

The Graphical User Interface (GUI) for KY Pipe is not as robust as the other offerings from HM vendors and some of the feature sets are not as robust.

KYPIPE
LLC Software Center
3229 Brightton Place
Lexington, KY 40509-2314
859.263.2234
www.kypipe.com

5.4 Residential Water Meters

5.4.1 Introduction

As the main component of water utility revenue, water meters are a critical part of the operation of any utility. Water meters represent the primary mechanism for monitoring both customer use as well as overall system performance. Since nearly all revenue comes from the information provided by meters, the accuracy and dependability of meters is absolutely critical to the effective operation of the utility.

Meter accuracy can be a complex issue that relates to the type of meter, the sizing of the meter, the nature of the water being metered, the age of the meter, and even the meter

reading methodology. Many utilities have found that by making adjustments to how they meter their water they can make huge differences in their water revenues.

There are a wide variety of water meters in the worldwide market and the accuracy and dependability of the meters vary considerably. In this section, the focus will be on US manufacturers whose products are considered to meet the highest standards of quality and reliability.

5.4.2 Types of Residential Water Meters

In general, there are two types of residential water meters available in the meter industry. The first, the positive displacement meter, was a staple of the small residential meter industry for decades. The second type, the turbine or multi jet meter, has overtaken the positive displacement meter over time.

Positive displacement meters usually rely on what is known as a nutating disk within the meter to measure the water as it passes through. This disk wobbles in the meter body and when functioning properly allows a precise volume of water to pass through the meter for each full "wobble" of the disk. The disk is precision machined to fit within the body of the meter as gaps between the disk and the body would allow water to pass through unmeasured.

Another type of positive displacement meter is the oscillating piston type. As water passes through the meter, a piston is moved back and forth by the water and its movement turns the gears that register the volume of water. As with the nutating disk meter, this principle is based on tight tolerances between machined parts and sand or grit in the water supply can degrade performance rapidly.

For applications that might have fine sands in the water, such as a groundwater system, these small particles can pass through the built in strainer at the front of the meter and wedge themselves in the gap between the disk and the bode, leading to wear that allows water to pass, and eventually complete stoppage of the meter. For this reason, nutating disk meters are generally not recommended for such systems and have fallen out of favor in general in the water industry.

The turbine, or multi jet meter relies on a measurement of the velocity of the water in the meter chamber to record the volume of water passing through. A small multi bladed rotor is inserted in the flow stream and its rate of revolution is directly proportional to the velocity of the water passing through. Since the meter manufacturer knows the area of the measuring chamber, the flow rate can be determined using standard fluid mechanics calculations. These calculations are built in to the gears that are attached either directly or magnetically to the rotor and drive the register on top of the meter.

Turbine meters have high rates of accuracy at most flow ranges depending on the manufacturer. Each meter manufacturer publishes accuracy curves for the meters that they sell so these are good references to review when making meter selections. In all cases, the proper selection of the meter size is an important factor in overall metering accuracy. In the pilot area selected as part of this project, over 99% of the meters are 13 mm in size. Most US manufacturers do not make a 13mm meter, stopping at 15 mm as the smallest size. Some have adapted 13 mm pipe threads to the 15 mm body for use in small meter applications.

A detailed datasheet for each of the meters described in this section is included in Appendix A.

5.4.3 Sensus Metering Systems

Sensus traces its metering roots back almost 125 years and has been building water meters for all of that time. With a wide range of water meters for virtually any application, Sensus has provided many millions of meters worldwide. Sensus also offers a complete line of Automate Meter Reading (AMR) systems to compliment their line of meters.

In the small residential metering area, Sensus offers both a positive displacement and a multi jet meter in their lineup. The SR and SRII line of meters are oscillating piston type positive displacement meters that have a minimum size of 15 mm. With an accuracy curve that is very flat except at the lowest flows, this is a very accurate meter. See Figure 1 below.

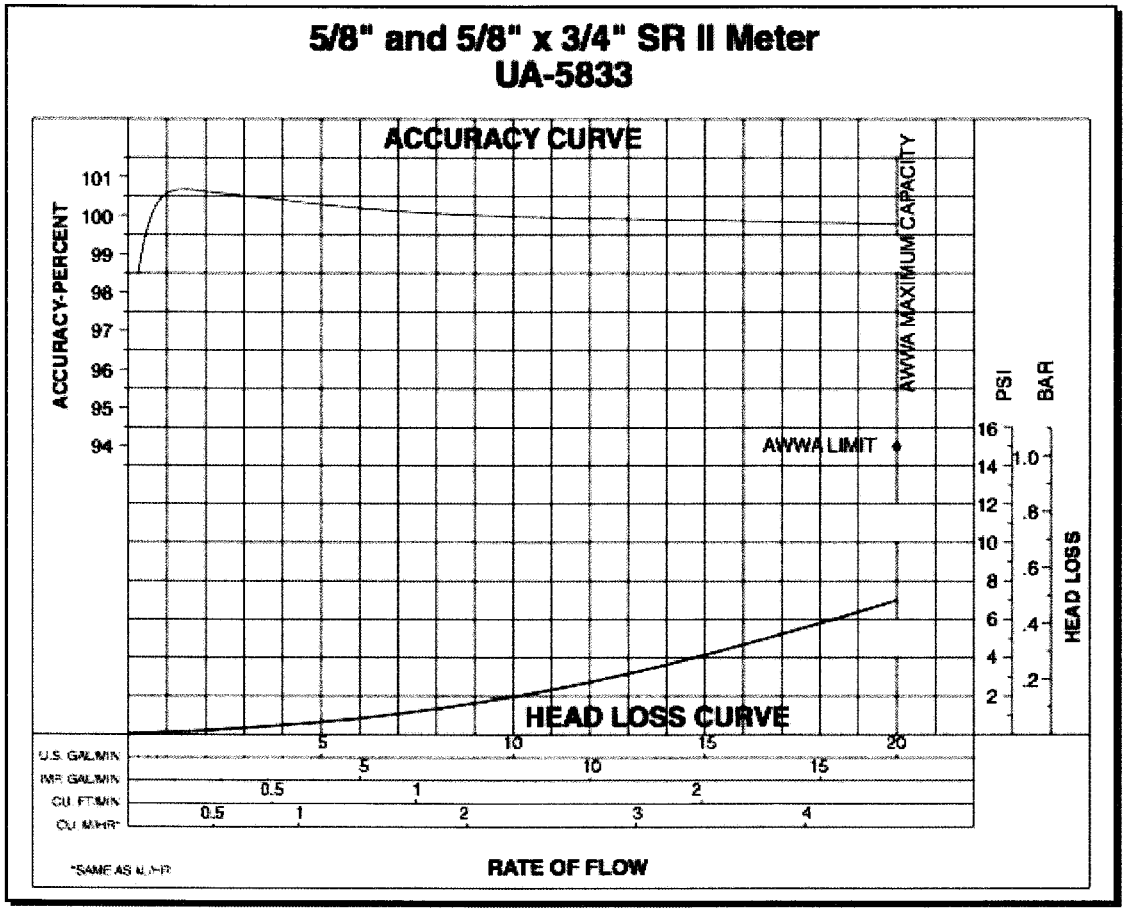


Figure 1: Sensus SR Accuracy Curves

Sensus also markets a multi jet meter in its PM line of meters. This meter features a sealed register and only one part exposed to the water making it very resistant to sand or grit in the water. It is available in sizes down to 15 mm and has features that prevent customers from tampering with the register to obtain water without registering on the meter.

Figure 2 below shows that the accuracy curve of the PM line of meters is very flat at all flow ranges making this an excellent meter for a low use system with a groundwater source that may have sand or grit in the water.

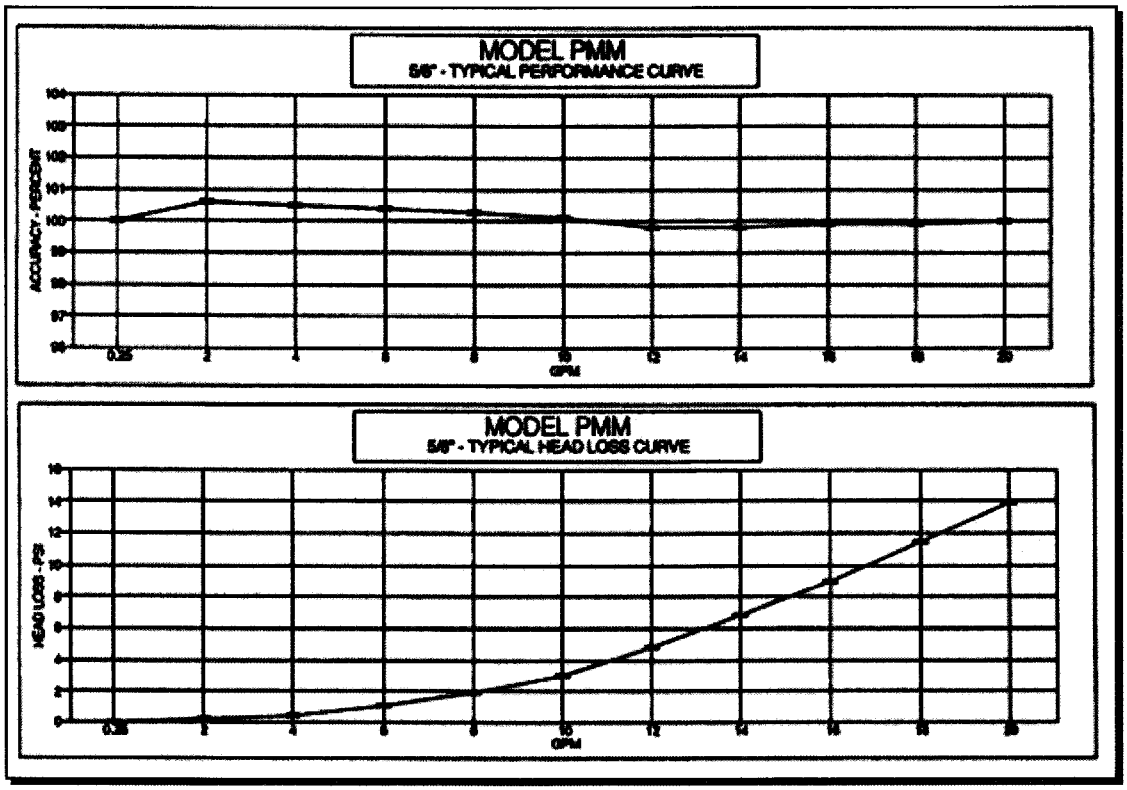


Figure 2: Sensus Model PM Accuracy Curve

Sensus Metering Systems has a global presence with offices and manufacturing facilities in 8 countries around the world.

Sensus Metering Systems
Water Customer Service
P.O. Box 487
Uniontown, PA 15401
Phone – 1.800.638.3748
Fax – 724.439.7729
www.na.sensus.com

5.4.4 Hersey Meters

As another manufacturer with a long history of metering in the US, Hersey is part of Mueller Water Products, Inc., a large supplier of a wide variety of water industry parts and equipment. Hersey's history dates back to 1859 and the firm has been innovating water industry products ever since.

Hersey has a complete line of water meters that are suitable for any use in the water utility, with sizes up to 25mm and a full line of AMR products. In the small residential metering application, Hersey offers only one meter.

The Hersey 400 IS Series positive displacement meter is a nutating disk type meter that has been time tested in water utilities. It is a preferred meter where meter volumes are low. However, its nutating disk design makes it more susceptible to sand and grit than other designs.

As the accuracy curves shown in Figure 3 show that this meter has a somewhat less desirable low end characteristic, with a sharp accuracy drop off below 2 US Gallons per minute (0.45 m^3/hr). These charts also show a lower relative head loss at high flow rates than other meters.

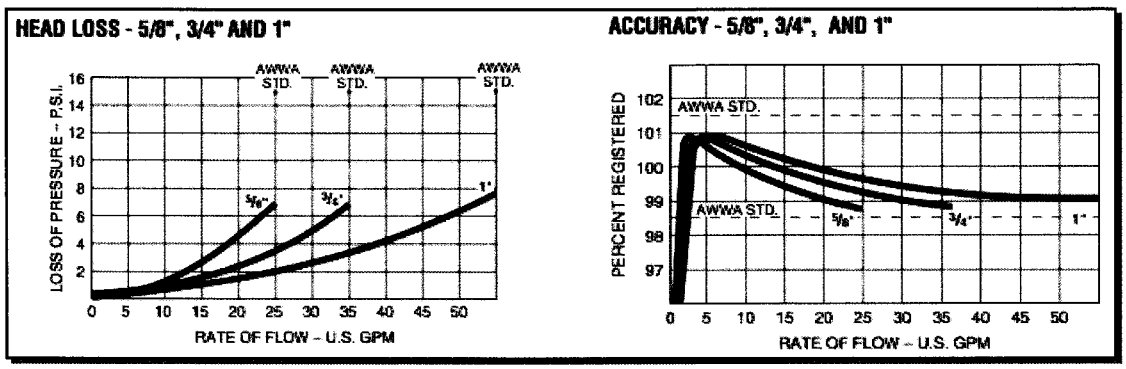


Figure 3: Hersey 400 IS Accuracy Curves

Hersey Meters
10210 Statesville Boulevard
Cleveland, NC 27013
Tel: 800.323.8584
704-278-2221 (in USA)
www.herseymeters.com

5.4.4 Neptune Technology Group

Neptune Technology Group has focused its efforts not only on making water meters, but also in the concept of utility management through automation in meter reading. Neptine led the industry with the first Automated Reading and Billing (ARB) system in 1964. Their AMR products are now used not only in the water industry but also in the electric utility industry.

Neptune has a full line of water meters of various sizes and configurations from 25mm down to small residential meters. In the small residential metering category, Neptune offers one model, the Neptune T-10 water meter.

The T-10 is a nutating disk meter with a minimum size of 15 mm. It features a tamperproof register and a bayonet style register that can be serviced with the meter in place. Figure 4 below outlines the performance curves of the T-10 meter. Note that this meter shows a high degree of low end accuracy, with accuracy falling below 98% only below about 0.07 m^3/hr.

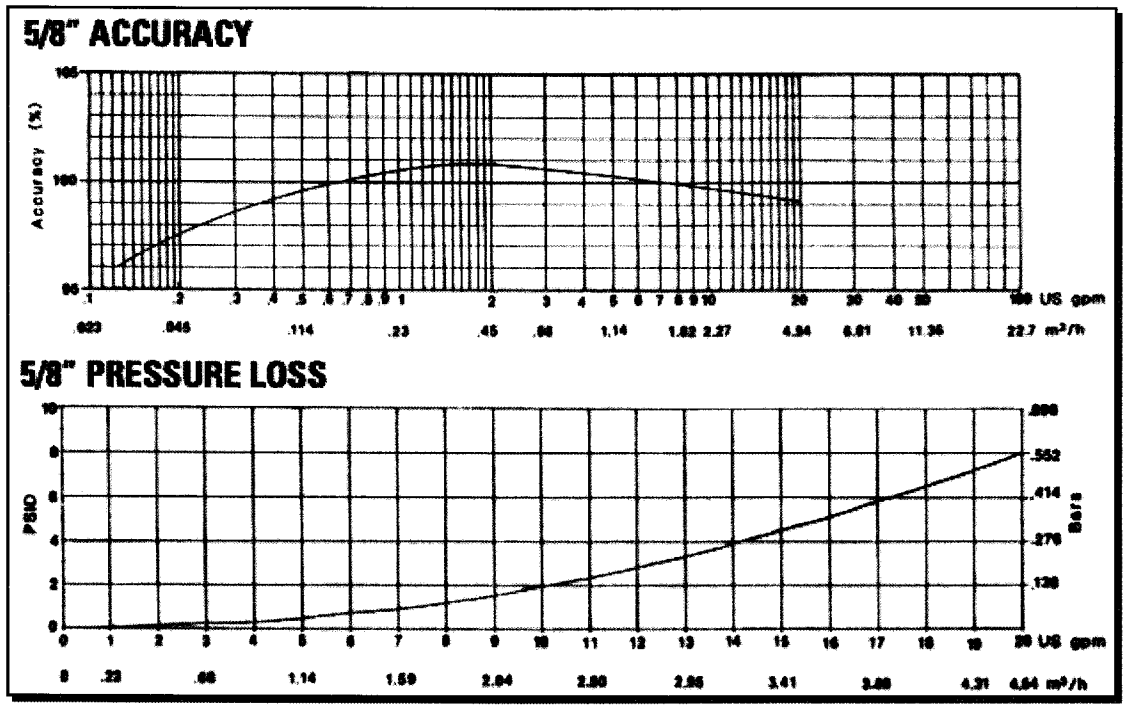


Figure 4: Neptune T-10 Accuracy Curves

Neptune Technology Group Inc.
1600 Alabama Highway 229
Tallassee, AL 36078
Tel: (800) 645-1892
Fax: (334) 283-7299
www.neptunetg.com

5.5 Supervisory Control and Data Acquisition (SCADA) Systems

5.5.1 Introduction

Within any water system there are a multitude of systems that control the flow of water from the source, through treatment, and on to the customer. As its name implies, SCADA systems are designed to supervise, or monitor, the status of various parts of the water system, allow operators to control these features, and finally collect data about the status of the system for later analysis.

Most water agencies have a way to monitor their system pressures, flows, and even control any pumps or reservoir levels. In the past, this was all done by a person who went from site to site and made adjustments as needed for the particular demand scenario of the day. For larger systems, this quickly becomes impractical as getting to all sites and making the correct decisions each day is difficult and inaccurate. Early telemetry systems connected remote sites to the main headquarters in a variety of ways. Some simply sent a signal back for a human to interpret and others fed pen based chart recorders with information that was collected on large circle charts or strip recorders.

Over the last 20 years, the computer revolution that has altered the technological landscape has provided the SCADA industry with a variety of new tools, both in hardware and in software, to make SCADA more effective and efficient. With modern Programmable Logic Controllers (PLC), each remote site can have independent decision making capability – as if an operator were standing there, all done autonomously according to a pre-determined program that established the decision making rules.

The complexity of modern SCADA systems is extremely variable. Small systems can install very simple systems, where larger systems with multiple pressure ones and pump stations will require systems of ever increasing complexity. The initial design and integration of a SCADA system is the first, and arguably the most important, step in deploying an effective SCADA system. The utility manager must communicate to the systems designer all of the details on how they want the system to be controlled and the designer and integrator then match the hardware and software needed to achieve the desired result.

In general, SCADA systems have four major components:

- Instrumentation equipment that collect data
- PLCs that assemble data at remote sites and perform local control

- Communication systems that relay information from the remote sites to the main SCADA
- SCADA software that tracks and collects data from many remote sites and allows users to control hardware at remote sites

5.5.2 Instrumentation Equipment

There are dozens of parameters that a water utility manager might want to monitor at a remote site. The decision as to what to monitor depends on what type of facility is being monitored and what information the utility manager feels is necessary to properly run their system. Of the parameters that are most often monitored in a SCADA system, a few stand out above the rest:

- Pressure
- Flow
- Level

There are dozens of other parameters such as a signal that indicates whether or not a pump is running that may be of interest. Many of these types of status signals will come from the equipment that is being monitored when the owner specifies that a status signal is desired. Another set of useful pieces of instrumentation include limit switches that can be installed so that they send a positive signal when a valve has stroked fully open.

A key factor when choosing the instrument for any given application is ongoing support. Most modern instruments are highly technical devices that require specialized knowledge to install and maintain. Even the best instrument will need periodic calibration and maintenance for without such attention the usefulness of the data provided will degrade over time. Careful consideration should be given to how a given company is prepared to provide local support before choosing an instrument. Many US firms maintain a technical presence in the Philippines for this very purpose.

5.5.2.1 Pressure Monitoring Equipment

Pressure monitoring equipment has evolved over the last 20 years to become more reliable and efficient in design and function. Microelectronics have allowed manufacturers to construct tiny devices that can be threaded into nearly any pipe and send out consistent signals on the pressure in that pipe. Most devices on the market today send out pressure information in what is known as a 4-20 mA signal, where the instrument will send out a current of 4 mA when the pressure is zero and 20 mA when the pressure is at 100% of the range of that particular instrument. The use of 4mA as the lower end allows

the user to differentiate between zero pressure and a broken cable or instrument. A reading of zero mA means that there is a fault somewhere in the system.

5.5.2.1.1 Rosemount Inc.

Rosemount Inc., part of the Emerson Process Management, is a leader in pressure monitoring equipment. With a wide range of instruments, Rosemount has the right equipment for nearly any application. A tested staple of the US pressure monitoring industry, Rosemount is one of the de-facto standards in pressure monitoring.

8200 Market Blvd.
Chanhassen, MN 55317 USA
Tel: 1-800-999-9307 or 1-952-906-8888
Fax: 952-949-7001
http://www.emersonprocess.com/Rosemount/

Rosemount also has South Asian representation in Malaysia

Emerson Process Management (Malaysia) Sdn Bhd
No.1, Block A
Jalan SS 13/5
Subang Jaya 47500
Selangor Darul Ehsan
Malaysia
Tel +60 3 5638-1010
Fax +60 3 5638-6060
www.AP.EmersonProcess.com/Malaysia

5.5.2.1.2 Omega Engineering, Inc.

Omega Engineering supplies a wide variety of instrumentation equipment, with hundreds of models and options to choose from. Their compact, solid-state pressure transmitters are simple to install and their high-end instruments offer all the calibration and output options desired.

OMEGA Engineering, INC.
One Omega Drive
Stamford, Connecticut 06907-0047
P.O. Box 4047
(800)-848-4286 or (203)-359-1660

Fax: (203)-359-7700
www.omega.com

5.5.2.1.3 Ashcroft Inc.

Ashcroft has been in the pressure measurement business for over 100 years and specializes on pressure and temperature monitoring. With a wide variety of pressure monitoring products, Ashcroft has rangeable pressure transmitters that allow users to precisely control the scale of the instrument.

Ashcroft, Inc.
250 East Main Street
Stratford, CT 06614-5145
Tel: (203) 378-8281
Fax: (203) 385-0408
www.ashcroft.com

5.5.2.1.4 Honey well

With a company history that dates back to 1885, Honeywell has been in the business of monitoring environmental conditions for a long time. Honeywell has pressure transmitters that are useable in the water industry, but this is not their particular specialty as HVAC applications in the mainstay of their business.

Honeywell
2080 Arlingate Ln
Columbus, OH 43228-4112
1-800-867-3888
http://sensing.honeywell.com/

5.5.2.2 Flow Measurement

There are a lot of ways to measure water flowing in pipes. From impeller based mechanical meters, to venturi differential pressure meters, to modern mag meters, the range of choices is nearly unlimited. The selection of which type of meter should be used in a particular instance relies greatly upon the site-specific constraints of the application. Variables such as desired overall accuracy, space limitations, power requirements, as well as local availability of support can drive the selection of flow meters.

5.5.2.2.1 McCrometer Inc.

For over 50 years, McCrometer has been manufacturing flow meters for a wide variety of applications. Most notable is their V-Cone flow meters, which are a differential pressure type flow meter, designed for rugged conditions. With no moving parts, this type of meter can provide years of service in adverse conditions. McCrometer also has a range of propeller and mag meters to compliment their line of products.

McCrometer Inc.
3255 West Stetson Ave
Hemet, CA 92545 USA
Tel: +1-800-220-2279
Fax: +1-951-652-3078
www.mccrometer.com

5.5.2.2.2 SeaMetrics, Inc

Located in the Pacific Northwest, SeaMetrics offers a complete line of flowmeters for use in industrial and municipal applications. They have a line of convenient paddlewheel insertion flowmeters that provide an easy way to get information on flows in small diameter pipe, albeit without the highest level of accuracy. Such meters can be useful for simply indicating that a pump is running and water is moving when the intent is to verify pump operation rather than measure flow.

SeaMetrics, Inc.
19026 72nd Ave South
Kent, WA 98032
Tel1: 253.872.0284
Tel2: 800.975.8153
Fax: 253.872.0285
www.seametrics.com

5.5.2.2.3 Badger Meter

Badger Meter is a large US manufacturer of residential water meters as noted earlier, but also has a full line of industrial and municipal meters. In the large diameter arena, their mag meters have a good reputation for quality and service. With a robust testing and engineering facility complete with a hydraulic flow lab, Badger has refined their designs to meet the needs of the customer.

Badger Meter
4545 West Brown Deer Road
Milwaukee, WI 53223
(414) 355-0400
www.badgermeter.com

Badger Meter is represented in the Asia/Pacific area by

Badger Meter, Inc
Singapore Representative Office
80 Marine Parade Rd.
21-04 Parkway Parade
Singapore 449269
Phone: +65-63464836
Fax: +65-63464837

5.5.2.3 Level Measurement

Water levels in tanks and other vessels are an important indicator of the status of a water distribution system. There are a number of ways to measure level in a vessel, but modern systems generally wither use a pressure transmitter at the bottom of the vessel or a non-contact ultrasonic system to measure the distance to the liquid level surface from inside the vessel.

Outputs of level sensors vary and generally must be field calibrated to provide useful results. In the case of pressure-based systems, a conversion from the output of the pressure transmitter to a calculated result of the corresponding liquid level is required.

5.5.2.3.1 Rosemount Inc.

Rosemount adds to its line of pressure monitoring equipment with a full line of pressure based, ultrasonic, and even radar based instruments. Rosemount's reputation for quality instruments make their products the instruments of choice among many US utilities.

8200 Market Blvd.
Chanhassen, MN 55317 USA
Tel: 1-800-999-9307 or 1-952-906-8888
Fax: 952-949-7001

http://www.emersonprocess.com/Rosemount/

Rosemount also has South Asian representation in Malaysia

Emerson Process Management (Malaysia) Sdn Bhd
No.1, Block A
Jalan SS 13/5
Subang Jaya 47500
Selangor Darul Ehsan
Malaysia
Tel +60 3 5638-1010
Fax +60 3 5638-6060
www.AP.EmersonProcess.com/Malaysia

5.5.2.3.2 Omega Engineering, Inc.

Omega Engineering compliments its pressure monitoring line of instruments with level sensing instruments. Omega's line includes very complex instruments as well as a line of simple, low cost ultrasonic devices.

OMEGA Engineering, INC.
One Omega Drive
Stamford, Connecticut 06907-0047
P.O. Box 4047
(800)-848-4286 or (203)-359-1660
Fax: (203)-359-7700
www,omega.com

5.5.2.3.3 Babbit International

Babbit is a smaller manufacturer of specialty level switches and monitoring equipment. While not as large as their competitors, Babbit does have a full line of products including an exterior mounted liquid level gauge that allows for a visual check of liquid levels as well as transmitter capabilities.

Babbit International, Inc.
1330 Sherwood Forest, Bldg. 205
Houston, Texas 77043
Toll-Free: (800) 835-8012

Fax: (713) 467-8736
www.babbitlevel.com

5.5.3 Programmable Logic Controllers

Programmable Logic Controllers (PLCs) are specialized devices that are used to monitor and control systems in industrial and municipal applications. PLCs differ from Remote Terminal Units (RTUs) in that PLCs can have on board logic to automate certain control functions whereas RTUs generally simply relay data to the main SCADA system.

PLCs consist of a processor with data storage capacity to hold the PLC programming and control logic, as well as a series of systems to handle incoming signals from devices and outgoing signals that send control instructions to selected devices. Most PLCs will have an option for a communication system that ties the PLC into the main SCADA system. In the past, a wide variety of communication protocols were used, many specific to the brand of PLC used. More modern PLCs are settling on Ethernet as the standard for communication between PLCs and the SCADA. This allows for more standardized network hardware to be used rather than proprietary devices.

When selecting a PLC vendor, it is important to consider the range of PLCs available, as some water sites will not need anywhere near the processing capacity of large facilities like water treatment plants. Another essential consideration is the presence of local support for the PLC programming, as the PLC cannot function until properly programmed. The process of developing the PLC programming, sometimes call ladder logic, is generally performed as a service by a firm specializing in SCADA Integration. While advances in remote monitoring and programming have been made, having a local presence is extremely important for a successful PLC deployment.

5.5.3.1 Rockwell Automation

Allen Bradley is the brand of PLCs and accessories manufactured by Rockwell Automation Inc. Allen Bradley has one of the most robust lines of PLCs on the market with a device for virtually any purpose. From the tiny Pico line of PLCs that can handle only a dozen or so inputs to the PLC-5 system that is large enough to take on any challenge, Allen Bradley sets the standard for water system automation.

Rockwell's RSLogix programming software is well tested in the water industry and features standard Ladder Logic programming with some enhanced feature sets. With a commanding lead in market share among US water utilities, Allen Bradley continues to deliver innovative products that meet the needs of end users.

Rockwell Automation
Allen-Bradley & Rockwell Software Brands
1201 South Second Street
Milwaukee, WI 53204-2496
Tel: 1.414.382.2000
Fax: 1.414.382.4444
www.rockwellautomation.com

Rockwell Automation has a Philippines office for local service and support

Rockwell Automation (Philippines) Inc
40th Floor, Rufino Pacific Tower
6784 Ayala Avenue, 1226 Makati City
Philippines
Tel: +63 2 323 0588
Fax: +63 2 323 0561
www.rockwellautomation.com.ph

5.5.3.2 General Electric Fanuc

GE Fanuc is the industrial controls division of General Electric and has been making control systems for over 20 years. GE Fanuc has a complete line of industrial automation products as well as a line that is tailored for use in the water and wastewater industries. With a product line that ranges from the small capacity VersaMax Nano PLC to its larger brother the VersaMax, GE Fanuc has a solution for nearly every application.

Combined with a wealth of other SCADA and industrial control products, the GE Fanuc line of PLCs provide the user with many options when selecting components.

GE Fanuc
2500 Austin Dr.
Charlottesville, VA 22911
Phone: 434-978-5000
Fax: 434-978-5205
www.gefanuc.com

GE Fanuc is represented in the Philippines by:

Barrier Software Services
Mr. Arvin P Barredo
37 Tindalo Street, Project 3, Quezon City, 1102, Philippines
Phone: +63 917 8591121, +63 2 4211668
FAX: +63 2 4366433

5.5.3.3 Opto 22

Opto 22 has been been supplying specialty control systems since 1974. Their line of PLCs has morphed into a new style of control system that they call a Programmable Automation Controller or PAC. These controllers combine the features of a traditional PLC with some other features that are generally only found in PCs. With a full line of PAC products that can be configured for virtually any application, Opto 22's PAC systems are a growing part of the PLC market.

The PAC systems also use a different type of programming language than other PLCs. Traditional PLCs use a type of programming called Ladder Logic in which the PLC uses the "rungs" of a logic chain to execute the desired result. Opto 22's programming suite called PAC Project uses a flowchart based programming system. For many users, this type of programming is simpler to understand but it also has the drawback of being one of the only vendors to use this type of language, thereby diminishing the pool of programmers available.

Opto 22
3044 Business Park Drive
Temecula, CA 92590-3614
Phone 800-321-6786
www.opto22.com

Opto 22 is represented in the Philippines by

M2M i3
Suite 412
Cityland Pasong Tamo Tower
Pasong Tamo, Makati City, Philippines
Fax: 63 2 8137598
www.m2m.com.ph

5.5.4 SCADA Communications Systems

With remote sites at wells, tanks, and pump stations, communications with the home office is the critical link for a SCADA system. Not only does the communications

system tie the whole SCADA together into a cohesive unit, it allows for rapid alerts for alarm conditions to be collected at the central location.

In the past, many remote communications, or telemetry, systems were based on dedicated phone lines and other physical connections from point to point. While this can be an excellent way to connect a PLC with the home SDCA system, in most cases such direct connections are either impossible or uneconomical. In these instances, radio communications are the industry standard.

As noted earlier, the migration of PLC communications away from proprietary standards and toward Ethernet based communications has allowed many firms to move into the market of wireless LAN radio systems. These radio systems are designed to simply extend the corporate network out into the field with secure radio links. If desired, all normal network functionality can be provided at even the most remote site using a properly configured wireless WAN radio system.

It is important to note that many radio systems use licensed radio frequencies, so permits are sometimes required. It is recommended that before any selections are made, a check with the Philippines National Telecommunications Commission be made to ensure that the selected products are compliant with local regulations.

5.5.4.1 Cisco Systems

As one of the global leaders in wired networking technologies, Cisco is also a leader in wireless network systems. Cisco has all of the routers switches and other equipment needed for any network of any size as well as a line of Aironet radios that extend this network anywhere the customer wants. Cisco can deliver a robust, secure network of any size in any place.

Cisco Systems, Inc.
170 West Tasman Dr.
San Jose, CA 95134□
(408) 526-4000
www.cisco.com

Cisco has multiple business partners in the Philippines who have extensive experience in wireless LAN products

5.5.4.2 Synetcom Digital Inc.

Synetcom is a manufacturer dedicated to wireless industrial data radios. In business for over 16 years, Synetcom has its sole focus in industrial radios. With multiple types of

radios and sizes for many applications, Synetcom radios can be tailored to meet nearly any need.

Synetcom Digital, Incorporated
23879 Madison Street, Torrance, CA 90505
Phone: (310) 379-2000
Fax: (310) 372-2331
www.synetcom.com

5.5.4.3 Teledesign Systems

Teledesign Systems has created a wide range of radios for many uses, with the most notable being one of their radios that was used to transfer data back to Earth from a payload package aboard the Space Shuttle. Part of their product line includes a series of matched radios and other hardware specifically for SCADA applications.

Teledesign Systems Inc.
1729 South Main Street
Milpitas, CA 95035
(408) 941-1808 Phone
(408) 941-1818 Fax
www.teledesignsystems.com

5.5.4.4 Nota Bene Technology (NBT)

NBT is a specialty manufacturer of telemetry equipment for use in SCADA systems. In business for over 20 years, NBT's line of products include a low cost line of RTU's that are tied together with NBT license free radio systems.

NBT Nota Bene Technology
19900 County Rd. 81
Maple Grove MN, 55311
763-428-8686
Fax 763-428-9009
www.nbtinc.com

5.5.4.5 CalAmp Inc

CalAmp is a firm that specializes in a large range of wireless products, from Automate Meter Reading systems to radios for data transfer. For SCADA uses, CalAmp's DataRadio line of wireless data products can provide robust data connections between remote sites.

CalAmp Inc
1401 N. Rice Avenue
Oxnard, CA 93030
Phone: (805) 987-9000
Fax: (805) 987-8359
www.calamp.com

5.5.5 SCADA Software

The heart of the SDADA system is the software the ties all of the other components into a cohesive, unified monitoring and control system. The SCADA software communicates with all of the remote systems, collects information, and analyzes the data to ensure that all systems are functioning within pre-established boundaries. Any anomalies will be highlighted for the operators so corrective action can be taken.

The SCADA software will also allow the operator to control systems at remote sites from a central location. For instance, an operator can turn pumps on and off, open and close valves, or perform any other function as long as the systems being controlled are properly configured. This allows for more precise operations of water distribution systems as well as quicker responses to problems since the operator can do it all from a central location, or even from a laptop located anywhere in the world.

There are many vendors of SCADA software and most PLC manufacturers have their own line of SCADA software. For the purposes of this project, the discussion will be limited to those firms that routinely provide SCADA software for the US water industry.

5.5.5.1 Wonderware

Wonderware is a software company that specializes in industrial automation and has been a leader in the industry since 1987. Wonderware does not make hardware and its software is not limited to certain hardware companies, giving it the flexibility that is needed in may mixed vendor environments. With a full line of software systems, Wonderware can provide a turnkey solution through a global network of software integrators.

Wonderware's InTouch and ActiveFactory platforms bring incredible power to the end user as well as robust data storage and historical trending capacity. This software allows end users to spot trends in data that allow for more effective decision-making on a day-to-day basis. Wonderware's powerful, yet simple software allows operators to make modifications that enhance their use of the system with minimal training.

Wonderware
26561 Rancho Parkway South
Lake Forest, CA 92630
Tel 949-727-3200
www.wonderware.com

Wonderware has 5 Asia/Pacific offices located in Australia, Singapore, Japan, Korea, and several in China

5.5.5.2 Open Automation Software

Open Automations OPC line of software packages are designed for advanced users who can develop their own custom SCADA packages using Microsoft's .net environment. A full line of modules is available for tailoring the SCADA to be as simple or complex as desired.

Open Automation Software
5077 Bear Mountain Drive
Evergreen, CO 80439
Phone: 1-(303) 679-0898
Toll free: 1-(877) 679-0898
Fax: 1-(303) 679-8698
www.opcsystems.com

5.5.5.3 GE Fanuc

GE Fanuc's Proficy iFIX line of SCADA software is designed to compliment their line of PLCs and other automation products. The software also features built in drivers for non-GE hardware and is scalable so that it can handle even the largest systems. The Water Solutions Pack is designed specifically for the water industry with pre-configured graphics and other modules to meet common needs in the water industry.

GE Fanuc
2500 Austin Dr.

Charlottesville, VA 22911
Phone: 434-978-5000
Fax: 434-978-5205
www.gefanuc.com

GE Fanuc is represented in the Philippines by:

Barrier Software Services
Mr. Arvin P Barredo
37 Tindalo Street, Project 3, Quezon City, 1102, Philippines
Phone: +63 917 8591121, +63 2 4211668
FAX: +63 2 4366433

5.5.5.4 Rockwell Automation

Rockwell compliments its line of Allen Bradley PLCs with several offerings of SCADA software. The RSView line of software has been in use for many years and has a large installed base. Industry specific modules ease setting up the software.

Rockwell Automation
Allen-Bradley & Rockwell Software Brands
1201 South Second Street
Milwaukee, WI 53204-2496
Tel: 1.414.382.2000
Fax: 1.414.382.4444
www.rockwellautomation.com

Rockwell Automation has a Philippines office for local service and support

Rockwell Automation (Philippines) Inc
40th Floor, Rufino Pacific Tower
6784 Ayala Avenue, 1226 Makati City
Philippines
Tel: +63 2 323 0588
Fax: +63 2 323 0561
www.rockwellautomation.com.ph

5.5.5.5 Opto 22

In order to compliment its suite of Programmable Automation Controllers noted above, Opto 22 offers its own SCADA package for a fully integrated system. Called PAC Project, the suite of software contains many components that allow users to build and deploy SCADA in a variety of ways. With Control Programming and Human Machine Interface packages, a fully customizable user interface can be created for any application.

The suite also includes software for archiving data in historical servers as well as special components for connecting the SCADA to other information systems. While these systems are designed to operate mainly with Opto 22 equipment, there is also support for integrating Allen Bradley PLCs and other types of equipment into the Opto 22 ecosystem.

Opto 22
3044 Business Park Drive
Temecula, CA 92590-3614
Phone 800-321-6786
www.opto22.com

Opto 22 is represented in the Philippines by

M2M i3
Suite 412
Cityland Pasong Tamo Tower
Pasong Tamo, Makati City, Philippines
Fax: 63 2 8137598
www.m2m.com.ph

5.6 List of Contractors & Sub-Contractors used in this study

Prime Contractor

Nobel Systems
436 E. Vanderbilt Way
San Bernardino, CA 92408
(909) 890 5611
Michael Samuel
President
msamuel@nobel-systems.com
www.nobel-systems.com

Sub Contractors

Hydraulic Modeling

ID Modeling
300 N. Lake Ave., Suite 230
Pasadena, CA 91101
(626) 765 0500
Paul Hauffen
President
paulhauffen@idmodeling.com
www.idmodeling.com

MWHSoft
618 Michillinda Ave., Suite 200
Arcadia, CA 91007
(626) 568 6855
Erick Heath
Vice President
Erick.Heath@mwhsoft.com
www.mwhsoft.com

NRW Consultants

Halcrow, Inc.
4343 Shallowford Road Suite C-1,
Marietta, Georgia 30062
(770) 552-8290
Elio Arniella
Vice President & Chief Engineer
ArniellaE@halcrow.com
www.halcrow.com

Kennedy Consulting Services
1163 Honeysuckle Way,
Escondido, CA 92026
(760) 445-0000
Tom Kennedy
Owner & CEO
tomzomail@gmail.com

Task 6: Project Implementation Plan

6.1 Introduction

The development and use of GIS, Hydraulic Modeling, and SCADA (GIS/HM/SCADA) technologies for the control of NRW is not a simple process. There is no "one size fits all" solution that can be copied from one project to the next in its entirety with any expectation of success. There are many variables that enter into the decision making process about the correct way to approach such a project. It is expected that while there may be certain common factors between agencies, there will be enough variation of factors present to warrant a phased implementation plan for each.

In a phased implementation plan, each agency will start with a process in which the results of this study and the various factual details it contains are compared against the conditions present in their unique situation. As will be described later, the goal of this process is to determine whether the conditions present for the study for the pilot area of this project are considered to be similar or dissimilar to the conditions present at the subject agency. From there, modifications to the approach of the analysis must be made in order to avoid unnecessary analysis or analysis that will not provide meaningful results.

In some cases, it may be found that the results of the pilot area study are so different than the conditions on the ground at any given agency, that there will be no basis for pursuing GIS/HM/SCADA for NRW control. In others, the process of evaluating the study may lead to conclusions that identify entirely different courses of action that could be undertaken, such as a focus on water meter accuracy. This can only be known for certain after this analysis has been done.

Once the local conditions are compared against the pilot area conditions and adjustments are made to the project plans, the procurement process can begin. This document will provide a general plan on how to proceed with the procurement of GIS/HM/SCADA once the appropriate project has been identified.

6.2 Phased Implementation Plan

As noted above, in order for each agency to achieve the highest return on investment, a phased implementation plan must be developed for each agency. There will be many differences between the fully developed implementation plans for each agency, though the process to develop the plan should be consistent across the board. This process is intended to adapt the results of the pilot study from this report to any number of agencies.

The Phased Implementation Plan will consist of the following:

- Review of Pilot Study Results
- Adaptation of Pilot Study Process to Local Conditions
- Validation of Results of Pilot Study to Local Conditions
- Development of Localized Implementation Plan
    - Development of Localized Procurement Documents
    - Identification of Capital Asset Replacements

6.3 Review of Pilot Study Results

The pilot study area in the Mabalacat Water District has many characteristics that affect the outcome of the study. Some of these characteristics are unique to the pilot area and some are likely found in many other agencies. If another agency has a system where the characteristics of the pilot area match their own area very closely, then the results of the

study could be assumed to apply to their area accurately. If there is much dissimilarity between the areas, the results of the pilot study may not be an accurate predictor of what would be found locally.

There are a number of key characteristics that need to be evaluated in order to determine if the pilot area study results can be applied "as-is" to any given area. Each of these should be evaluated carefully by the staff of each agency or by contracted experts in these areas in order to assess the applicability of each to the local conditions.

6.3.1 Distribution System Evaluation

The pilot area is unique in that it consists primarily of a resettlement area from the Mt. Pinatubo eruption of 1991. This fact meant that the pilot area has some unique characteristics, including the following:

- Nearly all main line pipe is the same material – PVC
  - Consistent main materials allows for easier water loss estimation and HM development
- Nearly all main lines are the same age
  - Large variations in pipe age complicate the analysis
- There were easily segregated District Metered Areas (DMAs)
  - This is critical to the study because accurate measurement of water in and out of the DMAs are the key to this study.
- There was a single source of water into the pilot area that facilitated water input measurement
  - Multiple sources make it difficult or impossible to cost effectively establish DMAs
- There is a single pressure zone
  - Multiple pressure zones or large variations in pressure can affect leakage rates

- There are few noted mainline failures or leaks
    - This was generally considered to be a "tight" system – areas with greater leakage histories may not benefit from GIS/HM/SCADA as main line leak control could be a better use of funds.

These factors allowed the study for this pilot area to ignore some of the effects of aging infrastructure or material dissimilarities that other agencies may find to be larger participants in the overall NRW mix. In these cases, some of the conclusions about the source of NRW for the pilot area in Mabalacat may not apply. If this is the case, the agency in question should evaluate other areas of study appropriate for whatever conditions are found.

6.3.2 Existing Data Sources

An analysis of the type undertaken for the pilot area requires good sources of data for the project. These sources of data are not just the billing records from the agency, which tend to be computerized and more or less accessible, but also include data on the distribution system and other conditions present at the agency. Each agency should evaluate how their data sources compare to the pilot area.

Customer and billing data must be complete and in a format that can be readily exported for use in external databases. Accurate information about the meters must be available, including meter make, model, size, and age for each customer. Customer usage and connection status history must also be available, as the pilot area study pointed toward unauthorized water use by disconnected customers are a significant contributor to NRW overall.

Data on the distribution system must also be available. If a fully developed GIS/HM is not yet completed for an agency, at a minimum there needs to be some data source for the

development of the GIS/HM. This would include paper based as built drawings or even atlas maps. At a minimum, the following data must be available:

- Pipe Size (for this list, the term "pipe" refers to all main lines and service laterals)
- Pipe Material
- Pipe Age
- Valve location, size, etc
- Meter locations
- Storage tank location and size/height data
- Pump station location and pump curve data
- Pressure zone information
- Elevation data

If a significant amount of this information is not available, the agency must undertake an analysis of what it would take to bring this information together for the project. In some cases, the cost to develop this data set can be prohibitive and may delay the project or cause for a re-evaluation of whether this is the correct approach for any given agency.

6.3.3 Staff Capacity

Implementing a project like the one undertaken in the pilot area requires a great deal of staff time from the host agency. Of particular importance is the ability of the staff to collect data in an accurate and timely manner. It is presumed here that there are experienced people in each agency who can perform the work accurately; the challenge is making sure that they are made available – sometimes for long periods – to the study team. There are many points where information is needed for this type of work and if this information cannot be reliably developed in a timely manner the project may not succeed.

In addition, each agency needs to consider that if it fully implements this project, upon completion there will be a need for additional staff time to operate and maintain these systems. Since GIS/HM/SCADA systems are highly technical, computer-based systems, there may nor may not be in house capacity to manage these systems. Agencies who implement must commit the funding for the requisite amount of people with appropriate skills to manage the systems going forward. If this critical component is not available, the development of a GIS/HM/SCADA system will have very short-term benefits.

6.3.4 NRW Characteristics Evaluation

Since this project was intended for the control of NRW through the use of GIS/HM/SCADA, before embarking on such an effort each agency should carefully evaluate the nature of their NRW issues. There will likely be wide variation between agencies with respect to how much GIS/HM/SCADA can help them with their particular NRW problems.

For instance, if an agency has an extensive history of pipeline failures or large leaks, it is likely that the development of a GIS that can be used to quantify relative areas of risk due to material type and age could be very beneficial. In this condition, the SCADA, while potentially useful as an operational tool, may not be something that is needed to deal with this sort of an NRW problem whose solutions are more likely based in pipeline rehabilitation or replacement programs.

Each agency must take a hard look at this issue using their own knowledge of the facts that pertain to their own agency. The assumptions present in the pilot area study must be compared to actual conditions on the ground.

6.4 Adaptation of Pilot Study Process to Local Conditions

In order to validate the results of the pilot study process for any given agency, the results of the evaluations completed in Section 6.3 must be used to adapt the processes used in the pilot study to match local conditions. The pilot study had several components that need to be evaluated. Agencies may determine that the processes used in the pilot study are appropriate for their use without modification or they may choose to modify them based on local conditions. In some cases, the agency may find that the processes used in the pilot study are wholly inappropriate for use at their agency and in this case that process will be dropped altogether.

The pilot study consisted of the following steps

GIS Development
HM Development
Residential Meter Testing Program
District Metered Area Flow Monitoring Program
Hydraulic Modeling of NRW

6.4.1 GIS Development

Agencies that already have GIS may be able to skip this step altogether. In this case, the agency must ensure that all required data are present in the GIS in order to satisfy the needs of the GIS and HM. If all data is present, the process can be dropped entirely. If only certain data is missing, the project plan should be modified to capture just this missing information.

If there is no GIS present currently, the agency must evaluate the available data sources to determine whether or not the requisite information is available for introduction to the GIS. If a review of agency records indicates that the needed information is available, the pilot study processes can be used as – is. If not, the agency must determine where the gaps are in the data and create additional processes to first develop this required data and then follow through with the GIS development.

The pilot project GIS was developed from paper based data sources. If an agency does not have any accurate maps or as builts of any kind for all or part of the distribution system, additional steps will be required. This is sometimes a very difficult and expensive process, sometimes requiring the mains to be excavated to determine size, material and approximate age. An estimation of the cost to develop this data should be created so that a decision as to the relative value of the data with respect to its cost can be undertaken.

6.4.2 Hydraulic Model Development

In the case of the pilot study, the hydraulic model was developed from the GIS data. This is the best possible way to build a hydraulic model, but by no means is it the only way to go. An agency may have already some sort of hydraulic model that is not GIS based and this model may serve the purpose of the project in an acceptable manner. An evaluation of any existing models and their capabilities and limitations must be undertaken.

If no model is present and the GIS development is not undertaken or is delayed for some reason, an agency may decide to make a more skeletal model of the system, concentrating on whole DMAs as demand sources rather than a lot of meters as sources of demand. While this can be less accurate than a more detailed model, depending on the agency such a model may serve the purpose of the study satisfactorily at a lower overall cost.

6.4.3 Residential Meter Testing Program

While note related to GIS/HM/SCADA directly, residential water meter accuracy can play a big part in NRW. In many cases, a meter replacement program can be the single most cost effective tool for managing NRW. All water meters wear with age and this wear leads to inaccuracies in reading. By monitoring average meter accuracy and replacing meters before they become grossly inaccurate, water utilities can effectively maintain low water loss rates through residential water meters.

For the purposes of this pilot study it was important to determine the impact of meter inaccuracy on the overall rate of NRW. Only when the impact of residential meter inaccuracies are known can the scope of the other sources of NRW be quantified. If the relative contribution of the meters to the overall NRW is large, then there may be no economic justification to proceed with the GIS/HM/SCADA part of the process.

Each agency should evaluate the nature of their installed meter base, including age, size, and type. In general, new multi-jet meters are more accurate than older positive displacement meters. If the installed base of meters is generally new multi-jet meters, then perhaps only a small sample need to be tested to validate overall accuracy. If the installed base is mainly older displacement meters, a comprehensive meter evaluation should be undertaken. Based on the results of the meter tests, there is a possibility that this could be identified as a main source of NRW. In such a case, the decision could be made to focus on meters rather than GIS/HM/SCADA.

6.4.4 District Metering Area Monitoring Program

In the pilot study area, there was a convenient way to break the overall distribution system into four sub-areas that could be easily metered individually. This made the

process of in-depth analysis of NRW within each DMA possible. That this was possible in this pilot area does not mean that it will be possible everywhere. In fact, as the report for Task 2 indicated, there were a number of agencies whose proposed pilot areas did not have a mechanism to conveniently break out DMAs.

Each agency should closely evaluate their systems for the potential to be broken into DMAs. Agencies who have multiple water sources and pressure zones are going to have a harder time developing DMAs. It may be an impractical task altogether in many cases. In others, there may need to be modifications made in order to allow for setting up DMAs. Still others may need to set up meters that can record flow in both directions and separately totalize flows. This is more complicated that simpler flow monitoring programs and costs more to install, but it may be the only way to measure what goes into, and out of any given DMA.

Agencies should take a look at their options with respect to DMAs. If there are areas where DMAs are not possible with the current system, the selective placement of new valves or inter-ties between areas can help the process along. These systems may take some extra planning to implement as well as more funds, so the determination as to whether to undertake such an investment should be made on how each agency feels that the relative contribution of the DMA metering process will make to the overall NRW reduction goal.

6.4.5 Hydraulic Modeling of NRW

In the pilot study performed as part of this project, the main function of the hydraulic model was to simulate demands within each DMA in order to approximate the actual

measured quantities of water that entered each DMA. The results of this analysis drew a particular conclusion related to the relative contribution of residential water theft as a primary component of NRW. This result, however, is unique to this pilot study area and may not be typical across the board at other agencies.

Prior to embarking on the deployment of the HM, each agency should evaluate the various aspects of the pilot area and the similarities or differences to their own areas. In the case of the pilot area there is a strong suggestion that socioeconomic conditions could be causally related to the rate of unauthorized use of water. If similar conditions exist in other areas, there may be similar activities going on – only the local agency will know.

Further, there are other ways to use HM to identify the locations of leaks, especially in those systems that have accurate metering systems and low water theft. In these cases, the use of the model will differ significantly from what it was used for in the case of the pilot study. Each agency, or its contracted experts, should make a determination as to what type of HM evaluation makes the most sense for their particular area.

6.5 Validation of Results of Pilot Study to Local Conditions

The investment each agency would make in the full scale deployment of GIS/HM/SCADA is significant and should not be undertaken without a full understanding as to the expected benefits that will result. Section 6.4 described how each agency should review the results of the pilot study and compare these results to their own systems and experiences. This evaluation will result in some sort of modified pilot study approach.

It may be tempting to simply extrapolate the results of the actual pilot study to a particular agency with modifications of the data being made as appropriate based on differing conditions. This methodology could certainly provide some sort of result that could be used to specify the actual implementation of GIS/HM/SCADA. The problem here is that there are many variables that cannot be fully accounted for based on a simple review of the data and modifications made as a result. The expected accuracy of any such process would be low.

For this reason, each agency should validate its modified pilot study at the local level in order to confirm any assumptions made along the way. This validation should consist of an additional pilot study being performed in an area of the agency's service area that is typical of local conditions. Each component of the original study that was deemed necessary for this agency should be performed as applicable.

The result of this process will allow the agency or its contracted experts to draw some conclusions about the impact that GIS/HM/SCADA deployment will be able to make on the NRW problem. It may turn out that assumptions made either in the original pilot study or in the modified local pilot study were incorrect. In this case, the results of the localized pilot study will may be inconclusive. It is possible that the resulting data will point toward additional modifications to the localized pilot study that will need to be made so that the effort can produce useful information.

In any event, each agency should strive to develop a localized pilot program and implement it in such a way that meaningful data is achieved. In order to be meaningful, the data should identify the relative impact on the deployment of the various technologies on the NRW problem. It is only after this information is completed and deemed accurate that the agency should move forward.

If localized pilot work cannot produce meaningful data, each agency will have to decide just how much effort to put into the pilot process. It is conceivable that the particular characteristics of one or more agencies may not be amenable to such piloting efforts. If

this is the case, the agency will have to use other means to make the decision as to whether to proceed with the NRW program.

6.6 Development of Localized Implementation Plan

Once the process of validating the pilot study is complete, each local agency should have a very good idea as to the nature and scope of the actual project at hand. This scope would include part or all of the aspects of a GIS/HM/SCADA project, depending on local conditions and the outcome of the previous reviews and local piloting.

Assuming that a decision is made to move forward with this project as defined locally, each agency should plan out the implementation carefully. The implementation plan should identify the main parts of the project as well as any subtasks associated with each. Each task should also have some sort of identified deliverable and a way to measure the relative success of achieving this goal. This will be used in conjunction with the procurement documents to ensure that the agency gets what it expects from any contracts that are let as part of the project.

Each individual agency will also need to decide how best to implement this project with respect to its particular needs and capabilities. If the needs are great and the funding and staff availability is present, these projects could be done nearly simultaneously. If there are conditions that require a more measured approach, the project can be spaced out over several years. A review of the level of effort that is required, along with the fiscal implications of the project must be undertaken to determine the appropriate course of action for each agency.

6.6.1 Develop Localized Procurement Documents

This type of project is very specialized and the commonalities between agencies may be small when compared to the differences. For this reason, it is impossible to create a single set of procurement documents that all agencies could use. What will be provided here are sample RFPs for the three main aspects of the project, GIS, HM, and SCADA. It is expected that each agency will need to adapt these documents to meet their local conditions. These adaptations could be in scope, schedule, or deliverables, depending on what the required outcome of the project is for each agency.

6.6.1.1 GIS Procurement Documents

Appendix A includes a sample GIS Request for Proposal document that can be used by any agency for procurement purposes. This document must be modified by each agency in order to "fill in the blanks" that are on each document. Also, any local circumstances that are not accurately reflected on this document must be corrected or inserted prior to publication for procurement.

The following items must be changed on the document:

- Insert appropriate agency name wherever the term AGENCY NAME or AGENCY appears. A 'Find and Replace" function on standard word processors makes this a simple task. A final check for grammatical consistency should be made after this is done.
- Complete the information needed for the local agency contact and bid location as well as bid date on page 1.
- Complete missing Project Background information on Page 1
- Complete Potable Water System description table 1 on Page 2

- Set pre-proposal workshop date on Page 3
- Identify source of parcel data on Page 4
- Provide the appropriate number of project phases at the bottom of Page 6. Note that for this project, 6 phases were used for the project schedule in Table 2.

This document includes large-scale plots of the data model. It is preferred to provide these at full scale to the Contractors, as they are difficult to read at smaller scales. Outside assistance may be needed for printing these documents.

6.6.1.2 Monetary Savings for Water and Wastewater Agencies Using GIS

Geographic Information Systems are designed to put a disparate set of data, such as maps, pictures, and raw data, into a cohesive package that allows the user to view the data in different ways. This ability to combine, adjust, and display data in an immeasurable variety of combinations gives the users unprecedented power to use this information to improve their productivity. There is no practical limit to what a GIS can do – all you need is a full-featured GIS and the data to go in it.

In order to maximize the improvements in productivity that a GIS can bring, it is essential to put the information into the hands of the people who can actually use it. Some agencies have a GIS "department" churn out maps for people who need them without allowing the end users of the information to actually manipulate the information themselves. This problem is mainly a function of the high learning curve that most GIS applications have that makes the manipulation of the data sets available only to a specially trained few. This is unfortunate, because in most cases people who train on GIS and information systems to the degree necessary to learn these systems are by default not generally in tune with what the actual needs of a water or sewer utility are with regard to what a GIS can do.

If the goal is to maximize the return on the investment into a GIS, it is important to select a Online (Web-Based) GIS viewing application that is full featured AND easy to learn. Once the application is selected, it must be deployed to as many people as possible in the organization. In order to get the most return on the investment, access to the data must be immediate – real time – for field personnel. When data is needed for an urgent shutdown, the end user can't wait days or a week to get a map made – they need it in 20 minutes or less! The only way to do this is to have the GIS installed right at their desktop, or even in their truck.

The Online (Web-Based) service is an excellent way to deploy a full-featured GIS to a virtually unlimited number of users at an extremely low cost. Using advanced thin client technology and ultra secure Internet connections, the same Online application that can be installed on a GIS workstation can be accessed by any authorized user, from any Internet enabled computer, from anywhere. In the office, at home, or even in a truck – there is nowhere that the benefits of a full featured GIS can't be enjoyed.

The wide variety of cost savings impacts of a full featured GIS such as Online (Web-Based) service that are described below represent only a fraction of the ways that agencies save money every day using GIS. The actual cost savings will vary from agency to agency, but can potentially save a moderate sized utility hundreds of thousands of dollars each year!

6.6.1.2.1 Rapid Access to Plans Using Scanned As-Builts

Field crews frequently are faced with the challenge of quickly locating pipelines for both routine repairs and emergencies., While the methods for storage and retrieval of as built drawings are well known to engineering staff members, in many organizations the field crew leaders and foremen have limited access to these plans. This limited access is due to unfamiliarity with filing systems as well as having to go "into the office" to get at the plans. Field crew members, who could most benefit from the plans, tend to do without rather than deal with the effort needed to come in and navigate the plan racks.

The end result is that pipe and appurtenance locations are made quite frequently by using atlas map layouts, which are nowhere near as accurate as as-built drawings. Crew members use a variety of methods, including line of sight, recollections from many years ago, and even divining rods (yes, they are still in common use) to locate pipelines. While some of these efforts yield acceptable results, the actual location of pipelines is commonly several feet off from the estimated location resulting in substantially larger excavations. While the true number is likely to be much higher, a conservative estimate is that one in 10 jobs located in this manner experiences much more excavation than is actually necessary. Thus, providing easy access to as built plans for field crews could save 5% to 10% of the time spent excavating pipelines along with the associated extra time for traffic control, extra backfill costs, extra paving costs, as well as possible damage to other utilities (digging close to the pipeline reduces the probability of hitting a parallel facility).

When all of the costs associated with excavation, traffic control, backfill and paving are considered, total savings from elimination of unnecessary excavation could exceed 10% of the total cost of excavation per year. For a moderate sized utility, this would total in the tens of thousands of dollars per year.

6.6.1.2.2 Up To Date Maps for Project Planning

Traditional atlas map books in use by most water agencies are updated by hand on an infrequent basis. Books are generally distributed throughout the organization and are in trucks, under desks, on bookshelves, and there's usually a good copy at the counter. When a map update is made to the master Mylar, copies are generally prepared to be distributed to the holders of atlas map books. In some cases, especially in the case of the counter book, these updates are done properly as the maps become available. In most cases, however, especially in the case of copies used by field personnel, some map updates are missed for months, years, or the book is never updated.

The result is that new facilities, such as valves or main extensions are not shown on the maps of many field workers (and even some in the engineering department). As projects are planned, such as main repairs, shutdowns, new services, etc, the planner may not be aware of other connections to the subject pipeline. When this happens, crews assembled to do a job prepare the job site and close the valves as instructed only to find that the pipeline does not de-energize as expected, or find that an entire neighborhood is out of water without notification. In either case, progress on the work must halt until the situation can be resolved.

In the absence of up to date maps, such an occurrence could happen several times per year in an area of moderate growth – more if growth is more pronounced. If project planners, including field personnel, have access to a continuously updated GIS, the maps that they use will represent not only all the facilities that are currently installed, but frequently include projects that are still under construction as well (when the first draft mapping is done from improvement plans and then revised when as builts are completed). In many GIS applications, the used can simply click on the valves that are going to be closed and the system will highlight all affected pipelines and properties automatically. Shutdown lists can be prepared in minutes instead of hours and will be much more accurate.

For agencies that do not have accurate and continuously updated mapping systems, the scenarios described above may happen several times per year. If only one of these events is avoided, the agency stands to save several thousand dollars in wasted staff time as well as avoid the unnecessary disruption of water service to customers.

6.6.1.2.3 Map Making for Presentations

Water agencies frequently enlist consultants to prepare visual aids for presentations to Boards of Directors or public groups. These include poster maps as well as diagrams, maps for PowerPoint style presentation, flyers for public outreach, and any number of other possibilities. When a full-featured GIS is deployed at an agency, in house staff can accomplish such map preparation. When a Online (Web-Based) GIS viewing application

is used, the map creation process is greatly simplified so that even staff members whose primary job something other than GIS can make presentation quality maps in minutes that would have cost hundreds or thousands of dollars and many weeks to get from an outside firm

The addition of aerial imagery makes maps a visual tool that everyone, from Board Members to the general public, can understand. Overlaying pipelines, easements and other features can quickly and accurately convey whatever message is intended. With Online (Web-Based) Map Composer, maps such as this can be created in a few simple clicks and plotted at any scale or saved as a PDF file for distribution.

6.6.1.2.4 Development of Accurate Valve, Hydrant, and Appurtenance Databases

For many agencies, record keeping on main line valves, hydrants, and other appurtenances such as air release valves consists of a series of card files or books in which information on these items are stored. These records contain information on the type and size of the item as well as service dates and maintenance information. While you may be able to find out information about an individual valve fairly readily by searching through the volumes of books or cards, there is no good way to obtain a good overall sense of the condition of these features because the information is scattered among the paper records.

When a GIS is developed, a database of all of these items is generated as part of the data conversion process. Once established, this database can now accept all the information that formerly was hand written on cards, never to be seen again, and place that data in a form that can be searched, queried, and processed to the utility manager can spot trends or patterns in the system that were previously invisible.

This also allows the manger to deploy field based data collection systems in order to improve the efficiency of maintenance. Handheld computers can display the GIS data and maps so field personnel can enter maintenance information ion hydrants or air vacs as it occurs in the filed. Modern valve turning machines can record the number of turns

and torque required to operate a valve. This data can be easily uploaded into the GIS for processing by the operations management staff. As this data is amassed, maintenance efforts can be streamlined to match the frequency of maintenance to the level of priority given to the item.

For instance, rather than turning all valves every year or every other year, valves that operate within a lower torque range can be moved into a lower frequency of turning so that more effort could be placed on valves that need more frequent turning. It is estimated that a typical distribution system, over 75% of the valves operate easily below 100 ft-lbs. Such valves could go into a lower frequency of turning, say once every three years, and the remaining 25% could be operated every year. This would save 50% of the labor cost of an annual valve turning program.

6.6.1.2.5 Capital Asset Replacement Planning

All agencies should fully account for the capital facilities that are present in the field and consider the lifespan of these assets while planning future revenue reserves. Agencies that do not have a full-featured GIS will have to hire extra staff or an outside consultant to pore over paper based mapping systems and develop a database of the facilities present in order to establish the life spans of different facilities. This process is quite costly. If an agency deploys a full-featured Online (Web-Based) GIS service, all of the pertinent data is already in the system. A map and dataset showing all pipe of a particular material over a particular size and age could be generated in seconds. Statistics on how much pipe, how many appurtenances, and where they are can be easily derived. Engineering staff need only apply a unit cost of replacement to the various types of facilities and an estimate of total replacement costs could be forecast as far into the future as needed – all with in house staff! Such a process would likely save many tens of thousands of dollars over having an outside consultant develop a similar report.

6.6.1.2.6 Visualization of Issues in the System Using Work Order and Customer Data

One of the challenges facing all water system managers is spotting trends in the distribution system over the long term. This is a difficult task, because information about water quality, pressure, and other customer issues is usually stored in a paper-based system or in an electronic system that can only print out massive volumes of paper consisting of endless tables of information. Making sense of these data sets is nearly impossible.

With a full featured Online (Web-Based) GIS service, this jumbled mass of data can be superimposed against a distribution system map so that clusters of issues, that would never have been spotted in the reams of lists and tables, can now be spotted quickly and easily. As long as the system that documents service calls or complaints includes a geographic reference, such as address or APN, the data can be matched to the map with great accuracy.

This allows the water manager not only to spot troublesome trends early and move to correct them, but it also allows predictive work to be done to minimize impacts on customers. If there is going to be an ongoing impact, the GIS makes it possible to accurately define the impact area and quickly develop mailing or door hanger lists for notification. The cost savings in this process mainly consists of preventing small problems from becoming big problems and fixing them before the cost to do so spirals out of control.

6.6.1.2.7 Training Tool with GIS And Aerial Photos

Accurate mapping systems are always a great way to get new employees familiar with the system. Online (Web-Based) GIS viewing software, make it easy for employees to "tour" the system right from the office. Turning on and off different layers allows the user to "construct" the system piece by piece and can give them a new understanding of how the system works.

When aerial photos are included, the role of the GIS as a training tool expands. Since most of the water distribution system is hidden from view underground, it is extremely valuable to have the pipeline superimposed over actual above ground landmarks. While most aerial photos contain a certain degree of optical distortion in the image that makes these superimposed pipelines unsuitable for actual line locating work, the process of showing someone where to look for a valve vault, or an easement, or any other feature that may not be right on the sidewalk, is made much easier with these maps. Most water managers have wasted countless hours driving out to show someone where to find a hard to spot object.

With a GIS, a quick map can be prepared showing less experienced employees exactly where to go even if they have never been to the site. This process can also allow newer employees to hit the road on their own faster – the need to have an old timer show them around for months (or years) is greatly reduced. Simple tasks in even remote sites can be assigned to even new employees to handle alone. The savings in wasted staff time from sending two people out to do a one-person job because one didn't know how to find something will exceed the actual cost of a full time employee in many cases.

6.6.1.2.8 Line Location

One of the most important, and most time consuming, things that a water utility does is line location. Accurate line location is essential to avoiding the cost to repair broken lines from other utility work. In many utilities, the line locator uses either paper maps at the office, or a microfiche system in the truck. The sight of a line locator squinting into the sun with a small piece of film in front of his/her face is not uncommon. Clearly, this is not a good way to ensure accurate line locations. Failure to accurately locate facilities can lead to catastrophic losses and liabilities in the millions.

With a Online (Web-Based) GIS viewing application that includes scanned as built drawings, the line locator can have access to thousands of sheets of drawings – right there in the field! This can either be accomplished by loading the entire GIS onto a high

capacity laptop or by accessing Online service using a cellular modem. The optimal solution depends on the nature of wireless services available, but where moderately fast (56K or higher) is available, the Online (Web-Based) solution provides the most up to date information on a day to day basis, since the GIS data on the laptop would have to be updated frequently.

As builts accessed on Online (Web-Based) service can be viewed at any zoom level, measurements can be made to scale at any zoom level, and a print of a selected section of a drawing could be generated in a small inkjet printer right there in the truck. Online (Web-Based) services are now in use in this exact capacity at other agencies with great success. Line locators can even take dig alert emails right in the truck and mark out the facilities without ever coming back to the office to look up plans. Efficiency of line location can be improved by at least 25% with a field based Online (Web-Based) GIS.

6.6.1.2.9 Easement Identification and Encroachment Control

Most water and sewer agencies have pipelines buried in easements that cross over private property. A typical utility will have hundreds or even thousands of individual easements. Maintaining access over these easements and preventing unwanted obstructions that are frequently constructed by property owners is a time consuming problem for most utilities. Whenever walls, fences, trees, and other encroachments hamper access to a repair or leak site, utilities suffer costly delays and extended service outages. Every utility has experienced the situation where a property owner plants a row of trees right on top of a pipeline that runs in an easement along the back of their property. These trees often cause expensive damage from root invasion into sewers and breaks in water lines form root growth.

Additionally, property owners who unknowingly build on easements only to have their expensive improvements removed during an emergency repair can become quite a problem. It is important for any encroachment to be either promptly removed or permitted under an encroachment permitting system.

One of the primary reasons that easement and encroachment control is so difficult is that the exact boundaries of easements are not well known among the field personnel who are best suited to monitor these important features. In many cases, easement documents are locked away in a file cabinet or vault and finding the appropriate plat maps is beyond the capability of filed personnel. Additionally, easements are frequently omitted from most hand drawn field maps because they are too complicated to show at larger scales or clutter up the hand drawn map.

With a properly constructed GIS, easements can be placed on a separate layer with the shape of the actual easement shown relative to the various property lines. The resulting polygons can be shaded in any way it is desired, resulting in a map that clearly displays the easement in question. Permitted encroachments can have a separate fill pattern applied so that field personnel can quickly determine if an obstruction on an easement is permitted.

Most importantly, advanced Online (Web-Based) GIS viewing applications, can link scanned copies of the actual easement documents right to the GIS, allowing one click access to the actual plat maps of the easement as well as the associated legal documents. Encroachment permit documents can be similarly scanned so that every member of the utility can quickly determine exactly what was permitted to be constructed on the easement. If a field worker notices a new wall on an easement, they can quickly determine if that object was permitted, and if not, take proper action for permitting or removal before it becomes a problem. Property owners are much more willing to work together if they are notified early than if years pass between construction and notification.

This benefit of GIS can save a typical utility thousands of dollars for each time an encroachment is eliminated and access to easements is maintained. If the system prevents a single line break from a tree root issue, the savings can multiply tremendously.

6.6.1.3 Hydraulic Model Procurement Documents

Appendix B includes a sample Hydraulic Model Request for Proposal document that can be used by any agency for procurement purposes. This document must be modified by each agency in order to "fill in the blanks" that are on each document. Also, any local circumstances that are not accurately reflected on this document must be corrected or inserted prior to publication for procurement.

The following items must be changed on the document:

- Insert appropriate agency name wherever the term AGENCY NAME or AGENCY appears. A 'Find and Replace" function on standard word processors makes this a simple task. A final check for grammatical consistency should be made after this is done.
- Complete the information needed for the local agency contact and bid location as well as bid date on page 1.

This proposal includes requirements for model calibration. It is strongly recommended that agencies pursue the calibration of the model once it is completed as un-calibrated models have a higher level of inaccuracy. If the model is not ever going to be used for extended period simulations, the calibration process is not as critical.

6.6.1.4 SCADA Procurement Documents

Appendix C includes a sample SCADA Request for Proposal document that can be used by any agency for procurement purposes. This document must be modified by each agency in order to "fill in the blanks" that are on each document. Also, any local

circumstances that are not accurately reflected on this document must be corrected or inserted prior to publication for procurement.

The following items must be changed on the document:

- Insert appropriate agency name wherever the term AGENCY NAME or AGENCY appears. A 'Find and Replace" function on standard word processors makes this a simple task. A final check for grammatical consistency should be made after this is done.
- Complete the information needed for the local agency contact and bid location as well as bid date on page 1.
- Set pre-proposal workshop date on Page 1
- Complete missing Project Background information on Page 1
- Complete Required SCADA Components (Table 1) on Page 2

This document includes both the design and installation of the system on the same document. This is in anticipation that the systems that will be installed will be not be overly complex. If during the preparation of this document the agency determines that contractors may not be able to properly bid the project as it is written here, the document should be split into two procurement packages, one for the design and one for the installation.

If this occurs, simply omit Tasks 3 through 7 from the design RFP and omit Tasks 1 through 3 from the installation RFP.

6.6.2 Identification of Capital Asset Replacements

Whenever an agency undertakes a significant capital project, it is appropriate to investigated what sort of commitment the agency is making to replace these assets once they have reached the end of their useful lives. Such information is very useful in long term capital budgeting.

In the case of GIS and HM, the assets acquired are somewhat unique in that they are not made of steel or concrete, but consist purely of information. This sort of data, once created, does not depreciate like other sorts of physical assets. If there were no changes to the physical distribution system after the GIS and HM were constructed, the data would remain relevant indefinitely.

Of course, there are always changes in water systems, so it is important to make incremental changes to the GIS, and thereby the HM, as these system changes are made. There will be no need to replace the GIS or HM completely as long as these small changes are made from time to time. This falls entirely under an operational maintenance program, not a capital replacement program.

The SCADA is a different story. While SCADA does have a significant software component, there are a significant number of hardware components to the system. These systems do have defined useful life spans and will require replacement as time goes on.

It is impossible to predict at this stage what these replacements will be since the projects are not fully defined and the specific hardware components have not been selected. For this reason, Section 2.3 of the SCADA RFP requires the selected contractor to develop a schedule of Capital Asset Replacements as part of the project. This schedule will allow the local agency to have a customized capital asset plan for their project.

6.7 Estimated Implementation Costs

The following are costs that the Water Districts could expect if it were to choose to deploy these technologies in an effort to control NRW. The GIS and HM costs were developed by Nobel Systems staff and are considered to be accurate. The SCADA costs were an extrapolation of the cost estimates at Mabalacat and would be considered to be rough budgetary estimates only. Nobel Systems has estimated the costs based on an exchange rate of 1USDollar = 47 Philippine Pesos.

	Angeles City Water District		**Batangas Water District**		**Butuan Water District**	
	PHP	USD	PHP	USD	PHP	USD
GIS Costs	7,890,000	$167,872	7,365,315	$156,709	7,967,216	$169,515
Hydraulic Model Costs	980,000	$20,851	800,310	$17,028	987,934	$21,020
SCADA Costs	32,000,000	$680,851	18,150,000	$386,170	27,791,280	$591,304
TOTAL	40,870,000	$869,574	$26,315,625	$559,907	$36,746,430	$781,839
	Calbayog Water District		**Mabalacat Water District**		**San Fernando Water District**	
	PHP	USD	PHP	USD	PHP	USD
GIS Costs	4,764,042	$101,363	6,711,840	$142,805	6,443,334	$137,092
Hydraulic Model Costs	590,741	$12,569	720,000	$15,319	800,310	$17,028
SCADA Costs	10,324,000	$219,660	20,632,860	$438,997	16,144,788	$343,506
TOTAL	15,678,783	$333,591	28,064,700	$597,121	23,388,432	$497,626
	San Pablo Water District					
	PHP	USD				
GIS Costs	7,790,121	$165,747				
Hydraulic Model Costs	965,975	$20,553				
SCADA Costs	23,232,000	$494,298				
TOTAL	31,988,096	$680,598				

Appendix A

GIS Procurement Document

Request for Proposals

For

GIS Data Conversion

AGENCY NAME

DATE

Table Of Contents

1.0 INTRODUCTION 1

1.1 SUMMARY 1

1.2 PROJECT BACKGROUND 2

1.3 CONSULTANT SELECTION PROCESS 3

1.4 PRE-PROPOSAL WORKSHOP 4

2.0 SCOPE OF WORK 5

2.1 PROJECT SUMMARY 5

2.2 SUMMARY OF DATA SOURCES. 6

Atlas Maps 6

As-built Drawings 6

Parcel and Street Centerline Data 6

Customer Service Database 7

2.3 DELIVERABLES 7

Data Model 7

Pilot Area Geodatabase 7

Final ArcGIS Geodatabase 8

2.4 FORMAT OF DATA TRANSFER 8

2.5 COORDINATES AND DATUM 8

2.6 DATA CONVERSION DOCUMENTATION 9

2.7 DATA VERIFICATION PLOTS AND REPORTS 10

3.0 MANAGEMENT PROCEDURES 10

3.1 PROJECT SCHEDULE 10

3.2 PROJECT MANAGEMENT STRUCTURE 11

3.3 PROJECT TRACKING AND REPORTING 12

3.4 QUESTIONS AND RESOLUTION TRACKING 12

3.5 DOCUMENT CONTROL 13

3.6 ACCEPTANCE PROCEDURES 13

3.7 MANAGEMENT MEETINGS 14

3.8 PROGRESS PAYMENTS 15

4.0 QUALITY ASSURANCE PROCEDURES 15

4.1 PRE-DATA CONVERSION QUALITY CONTROL 16

Review of source materials 16

Software 16

4.2 POST – DATA CONVERSION CARTOGRAPHIC FEATURE PROCESSING QUALITY CONTROL 17

Feature Accuracy 17

5.0 PROPOSAL CONTENT 19

5.1 OVERVIEW 19
5.2 COVER LETTER 20
5.3 EXECUTIVE SUMMARY 20
5.4 PROJECT APPROACH 21
5.5 PROJECT SCHEDULE 21
5.6 RESOURCE DESCRIPTIONS 21
5.7 PROJECT TEAM AND RELEVANT EXPERIENCE 22
5.8 EXCEPTIONS TO THE RFP 22
5.9 COST PROPOSAL 23

Exhibit A – Production Database Design

1.0 INTRODUCTION

1.1 Summary

The AGENCY NAME (AGENCY NAME) is soliciting proposals from firms qualified and experienced in building GIS databases of water facilities. The water distribution system data will be converted from atlas sheets (sectionals) and as-built drawings.

The RFP does not commit the AGENCY NAME to retain any consultants, to pay cost incurred in the preparation of proposals, or to proceed with the project. The AGENCY NAME reserves the right to reject any or all proposals, or to negotiate with any qualified respondent.

Proposals will be accepted at the AGENCY NAME offices located at,

AGENCY NAME
Address

no later than _____.

Four copies of the proposal are requested. One of these copies should be unbound for duplication purposes. An electronic copy of the proposal in PDF form must be included on a CD with the hard copy proposals.

1.2 Project Background

The AGENCY NAME's water service area encompasses _____ square miles. As of 2009 the population of the service area was ____. The water supplies for the AGENCY NAME include local groundwater, and surface water. The AGENCY NAME operates production and distribution facilities that include ____ wells, ____ pump stations, and ___ reservoirs with a combined capacity of ____. The AGENCY NAME also operates two water treatment plants.

The AGENCY NAME's potable water distribution system consists of approximately _____ service connections and roughly ____ miles of mains that operate in ____ pressure zones. Approximately _____ gate valves and _____ fire hydrants are part of the potable system. For a complete listing of the potable and recycled water system components, see Table 1.

The AGENCY NAME maintains a library of atlas sheets or sectionals that cover approximately _____% of the potable and recycled water distribution systems. In addition, as-built drawings are available for the remaining area. The primary objective of this project is to convert all available potable and recycled water facility information from the atlas maps and as-built drawings into the AGENCY NAME's GIS database. See Exhibit A for a detailed ESRI GIS data model.

Table 1: Potable Water System Description

Mains	____KM
Chlorination Facilities	
Valves	
Fire Hydrants	
Water Meters	

1.3 Consultant Selection Process

A committee composed of AGENCY NAME staff members will evaluate all proposals. Proposals will be evaluated using the following criteria:

1. Understanding of Scope
   a. Address all tasks
   b. Identify additional issues
   c. Appropriateness of manpower allocation, and technical staff proposed for the project.
   d. Adherence to the requested proposal formats.

2. Project Approach
   a. Discussion and understanding of technical issues
   b. Identify additional issues or alternative methods for conversion process.
   c. Quality assurance procedures.
   d. Project Schedule, ability to complete project in a timely basis.
   e. Adequacy of resources.

3. GIS Data Conversion Experience
   a. Relevant experience of project team.
   b. Relevant experience of Company
   c. Comments from client references.
   d. Similar project experience.
   e. ArcGIS Experience

4. Overall level of effort.
   a. Organization and clarity of proposal.

5. Cost

The AGENCY NAME reserves the right to request additional information from Respondents or to request a visit to the respondent's site prior to final selection, and to consider information about a firm other than that submitted in the proposal. The AGENCY NAME may select for contract negotiations the firm that, in the AGENCY NAME's judgement, will best meet its needs, irrespective of the comparison of fees and costs estimated by the respondent.

Proposals (including accompanying materials) will become the property of the AGENCY NAME. Proposals will be held in confidence to the extent permitted by law. After award of a contract or after the rejection of all proposals, the proposals will be public record subject to disclosure under the rules outlined in Article IX of Republic Act 9184.

Specific proposal requirements are listed in the RFP and it should be noted that proposals must conform to these requirements and must follow the proposed format. Deviations from these terms may be grounds for disqualification.

1.4 Pre-Proposal Workshop

A pre-proposal workshop will be held on ____(date)____ at ____(time)____ at ____(location)____ . The purpose of the workshop will be to provide a brief background of the project and answer or investigate any questions regarding the process and other requirements for submittal of proposals hereunder.

2.0 SCOPE OF WORK

2.1 Project Summary

The focus of the AGENCY NAME GIS Data Conversion Project consists of the following:

a. Data Model Development – the Contractor shall meet with AGENCY NAME staff to customize the ESRI standard Data Model provided in Exhibit A to meet local requirements. In addition to any extra fields that AGENCY NAME may require, the Consultant shall develop a complete set of Domain ranges to match the nomenclature and numerical values used by AGENCY NAME.

b. Pilot Area Conversion – the Contractor shall perform a full data conversion on a pilot area selected by AGENCY NAME. This pilot area will represent approximately 10% of the overall service area. The pilot area conversion will be evaluated by AGENCY NAME staff for completeness and data quality before approval is granted to the Contractor to move into full production on the rest of the data conversion process.

c. Convert all atlas maps/as-built drawing data pertaining to potable water distribution systems into the AGENCY NAME's GIS database. The conversion process will include rectification of all features and interpretation of attributes depicted on existing atlas maps, as-built drawings, and other source documents.

2.2 Summary of Data Sources.

The following data sources will be used during the conversion process:

- Atlas Maps
- As-built drawings
- Parcel and street centerline database
- Customer Service Database.
- Pilot Project maps and database

All the information required to create the water GIS geodatabase as specified in this RFP can be obtained from the above data sources. Prior to commencing work, the Contractor shall verify that all necessary data is present in these sources. The following is a brief description of the data sources as they relate to each of the major geodatabase to be created.

Atlas Maps

AGENCY NAME maintains a library of water system atlas maps. These maps will be the primary data source for the project.

As-built Drawings

AGENCY NAME maintains a library of as-built drawings. These drawings will be a secondary data source for the project used where Atlas Maps are not available.

Parcel and Street Centerline Data

_____ maintains an accurate parcel and street centerline geodatabase. This data will be available to the contractor during the course of the project.

Customer Service Database

The Customer Service Database contains detailed information pertaining to water meters. This data will be useful when creating the water meter geodatabase. All meters are tied to a specific Parcel Number. This data will be made available to the contractor.

2.3 Deliverables

Data Model

The Contractor shall deliver the customized data model including the new domain ranges in both the UML and PDF formats. Full size plots of the model be provided at a scale that will allow convenient reading of the documents.

Pilot Area Geodatabase

The Contractor will be required to deliver an ArcGIS geodatabase containing all the water facilities and related data in the form described below. This data will be evaluated by AGENCY NAME for completeness and accuracy prior to granting the Contractor permission to complete the rest of the project. Changes to the model and/or the data conversion standards may be made at this point and the Contractor shall implement these changes for both the pilot area and the remaining data conversion process.

Final ArcGIS Geodatabase

The Contractor will be required to deliver an ArcGIS geodatabase containing all the water facilities and related data in the form described below. This geodatabase is fully described in Exhibit A, Data Model.

2.4 Format of Data Transfer

Data should be delivered on a CD-ROM. Data that needs immediate attention can be transferred by electronic mail. Any electronic submission should contain a document identifying the files. The naming convention for the files will be established jointly by the contractor and the AGENCY NAME.

Data transferred to the AGENCY NAME must be in ArcGIS Geodatabase format. Document accompanying the CD-ROM must include the date, filenames, description, and notes pertaining to data.

2.5 Coordinates and Datum

The coordinate system used shall be as follows:

Projected Coordinate System: PRS_1992_UTM_Zone_51
Projection: Transverse_Mercator
False_Easting: 500000.00000000
False_Northing: 0.00000000
Central_Meridian: 123.00000000
Scale_Factor: 0.99960000
Latitude_Of_Origin: 0.00000000
Linear Unit: Meter

Geographic Coordinate System: GCS_PRS_1992

Datum: D_Philippine_Reference_System_1992

Prime Meridian: Greenwich

Angular Unit: Degree

2.6 Data Conversion Documentation

When data is delivered in a digital format, it is required that complete documentation of the Data Conversion procedures, standards, and quality control measures be provided. A draft Data Conversion procedure document shall be submitted by the contractor and approved by the AGENCY NAME prior to the start of any Data Conversion activities. This document should then be maintained by the contractor during the course if the project. At the end of the Data Conversion, a final version shall be submitted by the contractor and approved by the AGENCY NAME. At a minimum, Data Conversion documentation should address the following:

a. Geodatabase name

b. Data Conversion Dates: Include period of time over which Data Conversion occurred

c. Data Conversion Procedures: A detailed account of the Data Conversion procedures used, including a description of the hardware and software used for Data Conversion and the quality control procedures used in creation of digital data files.

d. Cartographic Specifics – A description of how each cartographic feature was interpreted from the source documents.

e. Data Model – A data dictionary should be maintained with content and format similar to Exhibit A, Data Model. If variations on the data dictionary provided in Exhibit A were used during the conversion process, these should be documented.

2.7 Data Verification Plots and Reports

The contractor must provide a detailed description of the proposed approach for the quality control procedures to be used on this project. The contractor will be required, at the time of file delivery, to submit data verification plots and reports used in this process. This information will be used by the AGENCY NAME to support deliverable review and acceptance.

Verification plots must be submitted based on an atlas page.

3.0 MANAGEMENT PROCEDURES

This section describes the overall project management structure along with the status reporting, feature counting, and error reporting procedures.

3.1 Project Schedule

Respondents shall submit a detailed project schedule in their proposals. The AGENCY NAME will break the project into 6 strategic project areas or phases. Table 1 below is to be used as a guideline for the development of project schedule. All periods are taken from Notice to Proceed (NTP) date.

Table 2: Project Schedule

Data Model Development	+2 weeks
90% Submittal - Pilot Area	+4 weeks
Final Submittal - Pilot Area	+6 weeks
90% Submittal - Phase 1	+8 weeks
Final Submittal – Phase 1	+12 weeks
90% Submittal - Phase 2	+14 weeks
Final Submittal – Phase 2	+18 weeks
90% Submittal - Phase 3	+20 weeks
Final Submittal – Phase 3	+24 weeks
90% Submittal - Phase 4	+26 weeks
Final Submittal – Phase 4	+30 weeks
90% Submittal - Phase 5	+32 weeks
Final Submittal – Phase 5	+36 weeks
90% Submittal - Phase 6	+38 weeks
Final Submittal – Phase 6	+42 weeks

The final project schedule will be negotiated between the contractor and the AGENCY NAME. The contractor shall provide an overall estimate based on ability to apply staff and resources to this project.

3.2 Project Management Structure

The contractor shall provide a diagram and description and of the proposed project management structure for this project in the proposal.

3.3 Project Tracking and Reporting

The contractor must maintain procedures throughout the project for tracking and reporting progress in the conversion of the database. Tracking and reporting must be performed by tile page for each layer on a bi-weekly basis. As part of the bid response, Respondents must submit a written description of the project tracking procedures and systems that will be used.

The contractor will provide the AGENCY NAME with periodic project tracking reports that document the activities performed during the previous month. At a minimum, the report should address the following:

a. The task status for each layer by atlas grid.
b. Anticipated work to be completed in the ensuing month.
c. Problems encountered in performing the work.
d. Steps taken to resolve those problems.
e. Collect and summarize geodatabase feature counts for each type of feature and linear miles of mains automated.
f. Flow and schedule charts that can be updated to demonstrate various critical path scenarios, maintaining the relationships between Data Conversion resources, budgets, delivery milestones and the project's critical path timeline.
g. If there is a schedule slippage, the report should contain plans for rectification

3.4 Questions and Resolution Tracking

Like any data Data Conversion effort, it is critical that communication between the AGENCY NAME and the contractor follow a standard flow. The contractor will assume the primary role of controlling communication between team members and the AGENCY NAME.

During the course of the project, issues may arise that require direct communication between team members outside of the normal flow of communications. The contractor will attempt to arrange and monitor these communications in order to ensure that the decisions made during the communications are appropriate and that all resolutions are documented. In the event that communications occurred which were not arranged, the contractor shall have established procedures for proper documentation of any questions and resolutions.

The contractor shall provide a description of the proposed question and resolution tracking procedures to be used for this project in the proposal.

3.5 Document Control

Delivery of sectionals, as-built drawings, and related source documents will be according to a plan oriented to strategic project areas or phases. This plan will be developed jointly between the AGENCY NAME and the contractor. The document exchange process shall include documentation of transmittal and receipt by both the AGENCY NAME and the contractor. The contractor shall maintain a database that records dates of transactions and materials included in these transactions.

All GIS data pertaining to the project (parcel, centerline, etc) will be provided to the contractor at the start of the project.

3.6 Acceptance Procedures

The AGENCY NAME will be conducting in-house reviews of all products received. These include both preliminary and final products, and hard copies as well as digital products. These reviews will be performed in a timely and orderly manner. The contractor shall be responsible for correcting errors or other inconsistencies that represent noncompliance with the specifications agreed to by the contractor and the AGENCY NAME. In no case will the completion date jointly agreed upon by the contractor and the AGENCY NAME be extended without the prior written approval of the AGENCY NAME.

After initial checking, work increments will be categorized by the AGENCY NAME as follows:

ACCEPTED: Products that meet specifications and contain no more than 2% errors will be formally indicated as ACCEPTED. Payment for work completed will not be made until the AGENCY NAME accepts the products, regardless of the number of edits required.

REJECTED WITH EDITS: The product has a number of errors that do not permit acceptance. For the product to be accepted all errors noted by the AGENCY NAME must be corrected by the contractor. The AGENCY NAME will verify through an edit plot and error report that the contractor has made all corrections called for in an earlier edit plot and error report upon re-submission of previous edit plots.

REJECTED: The number and character of errors detected by the AGENCY NAME are such that the product is returned to the contractor without complete editing. The Project Manager will formally notify the contractor of the REJECTED status of the product. The contractor must edit and correct the product for re-submittal. It will be the sole responsibility of the contractor to find and correct the errors. If, at the sole discretion of the AGENCY NAME, there are an undue number of rejected products, the AGENCY NAME may require the contractor to suspend production until the problems contributing to the rejections are identified and corrected.

3.7 Management Meetings

It is expected that several visits by the contractor project management staff to various AGENCY NAME offices will be required during the course of the project. Contractor should indicate, based on their experience, the number of visits that may be necessary, and their anticipated duration. Any such visits should be reflected in the cost section of the contractor's proposal. AGENCY NAME staff may visit the contractor work site to view the work in progress.

3.8 Progress Payments

All progress payments will be subject to a 10% retention payable upon completion of the project.

4.0 QUALITY ASSURANCE PROCEDURES

Quality assurance (QA) is an important part of any digital database Data Conversion project. Not only is QA critical to producing products within specified limits of accuracy, it also exerts great influence on the flow of materials through the production process. Poorly implemented quality control (QC) procedures can greatly increase the cost of database development by forcing duplication of effort and disrupting smooth production flows.

There are three primary criteria for characterizing digital cartographic data quality within a production environment. These are:

Consistency of Cartographic Features - In the ArcGIS production environment, consistency of cartographic features is addressed through data structuring. The ArcGIS topological data structure is capable of automatically identifying errors of closure in polygon geodatabase and other disruptions in a unified structure as part of the users routine processing activities. Using tools within ArcGIS allows the Data Conversion technician to identify cartographic problems.

Positional Accuracy – The second criterion for characterizing cartographic data quality is positional accuracy. Positional accuracy refers to two data quality characteristics: 1) consistency of line work between adjacent processing modules, and 2) overall positional accuracy. The first characteristic is addressed through examinations of edges of adjacent sheets. The second is determined through comparisons to source materials and/or independently derived data. Digitizing and editing practices and quality of source materials are the most important factors controlling this criterion.

Attribute Accuracy – The third criterion associated with data quality in a production environment is attribute accuracy. Measures of overall attribute accuracy are best determined

through random sampling. When performing attribute QC checks, personnel should make use of any available collateral data that may assist in the process. Checking codes along adjacent processing modules is an effective way of identifying many common attribute errors. Duplicate coding strategies will also greatly assist in ensuring attribute accuracy.

In many instances, individual production tasks are dependent upon effective implementation of preceding production steps. In most data Data Conversion projects errors in individual production steps can be extremely difficult to correct once that particular step has been completed and another begun. As a result, QC checks are most effectively implemented as "loops," whereas checks are performed in conjunction with specific processing steps in an iterative fashion. In this manner, quality is assured for crucial processing tasks prior to continuing the production flow. The number of QC loops depends on the nature of the geographic data involved and the level of accuracy desired.

4.1 Pre-Data Conversion Quality Control

Pre-Data Conversion QC is the review of the source materials for problems and checking that the hardware and software to be used in the Data Conversion are working properly.

Review of source materials

Source materials should be reviewed for poor matching between sheets, lines, or attributes, and unclear or ambiguous features. Optimally, all such problems should be resolved prior to automating the data.

Software

The contractor is required to provide all data to the AGENCY NAME in **ArcGIS 9.3** format.

4.2 Post – Data Conversion Cartographic Feature Processing Quality Control

Quality control activities following Data Conversion are probably the most crucial to the data Data Conversion project. Within this step, all three primary quality control criteria are addressed. Unlike other QC activities, post-Data Conversion checks are deeply imbedded in the production flow and are difficult to separate. In essence, post-Data Conversion cartographic feature processing QC is the iterative process of making edits and plotting out data to check for errors.

Feature Accuracy

Feature accuracy is evaluated by comparing plots of the data layers to the source documents.

Arc Criteria

a. Connectivity

All lines (linear features and polygon boundaries) must be digitized as solid line arcs that support building of topology among the lines. End points (nodes) must be specifically defined at each end. Intersections of lines must be represented as distinct end points (nodes) of the arcs.

b. Segmentation Accuracy

The digital representation of linear elements must reflect the visual network structure of the data type. If a water main branches at a fork, one element must enter the fork and two must leave the fork. At an intersection of two mains, four separate elements must meet at the junction. The requirements for connectivity and smoothness must also be observed. There should not be undue segmentation. An element should not be broken or segmented

unless that segmentation reflects a visual or attribute code characteristic, or unless the break is forced by a database limitation.

c. Edgematching

All digitized map sheets must be both visual and coordinate edgematched with all adjoining sheets. Features at the sheet edge must match corresponding features on the adjoining sheets. Attributes for adjoining features must be identical.

Point Criteria

Point geodatabase will include all features on the map that are not necessary for hydraulic continuity. All point features within those geodatabase, shall be digitized as single x,y coordinate pair at the visual center of the graphic feature as delineated on the source map.

Polygon Criteria

Polygons must close perfectly using the same node for beginning and end points. Each polygon must also have a unique centroid to which attributes can be associated.

Attribute Accuracy

A series of quality control checks should be applied in order to ensure that the correct attribute information is linked to the correct feature.

Verification Plots

Plots based on the sectional number will be used to verify completeness of delivered files.

Annotation Placement

Criteria for annotation placement are:

a. Annotation should not over plot any existing annotation.
b. Annotation themes should be the correct size to provide for easy recognition of features displayed.

Completeness of Data Files

The verification plots will be used to verify completeness of the delivered files and compliance with the requirements described herein. The contractor will identify the following errors for correction:

a. Missing arcs or points
b. Extra arcs
c. Intersections without nodes
d. Multiple arcs or points where a single feature is required
e. Undue segmentation. Arcs should not be divided into multiple segments unless they have different attributes.
f. Smoothness of curves with appropriate amount of vertices.

5.0 PROPOSAL CONTENT

5.1 Overview

All proposals shall include the following information as a minimum (proposals should be limited to no more than 30 pages not including resumes and appendices):

- Cover Letter
- Executive Summary
- Scope of work
- Project Approach

- Project Schedule
- Computer Hardware and Software Description
- Relevant Experience
- Exceptions to the RFP
- Additional Pertinent Information
- Cost Proposal

The actual format of the proposal is left to the discretion of the respondent, however, the above mentioned sections should be clear and distinct. As previously mentioned, any proposal missing any of these sections may be disqualified from consideration. A description of what is expected in each of these sections is presented in the following sections.

5.2 Cover Letter

The cover letter shall identify the person(s) in your organization who will respond to questions or additional requests the AGENCY NAME may have regarding your proposal. Please include title, telephone number, and address where this person may be contacted.

5.3 Executive Summary

The Executive Summary should highlight the major feature of your company and proposal. This section should be written for staff who need to review the proposal but may not be technically oriented.

The executive summary should include information about your firm and any proposed subcontractors. A summary of your approach should be presented in this section.

5.4 Project Approach

This section is intended to be the heart of the proposal and should clearly show the Respondent's knowledge of the data conversion process. This section must clearly show the Respondent's understanding of the scope of work and present a detailed explanation of the conversion methodology to be used on this project.

The scope of work will be used as a basis for later contract negotiations. The scope of work should be based on, but not limited to, the information presented in Section 2.0 of this RFP.

The methodology must comprehensively define each task in the conversion process. Respondents are encouraged to use methods not discussed in this RFP that will increase the efficiency or accuracy of the data conversion.

Include any flow charts, diagrams, and other graphics that clarify the approach proposed for this project.

5.5 Project Schedule

Indicate the schedule for completing each of the deliverables identified in Section 2.5 of this RFP. Include start and end dates and intermediate delivery dates, including time for review of each submittal.

5.6 Resource Descriptions

This section should include a brief description of the available resources for completing this project. This section should include the following resource descriptions:

- Manpower Resources – Indicate, by category, the number of people in your firm, at your facility, and that you plan to assign to this project.

- Hardware – Describe the types of computer hardware you foresee using on this project.

- Software – List the type of software you foresee using on this project by name and version.

5.7 Project Team and Relevant Experience

This section should list the relevant experience of the project team proposed for project. Include a schedule showing the percentage of time each member will contribute. This section should also list company experience. Of particular interest to the AGENCY NAME is experience that includes conversions similar in technical scope and magnitude to the requirements presented in this RFP. Summarize specific projects describing the rate of production, geographic area, number of map sheets, and average number of features. Describe data models used in previous projects and data conversion methods used in those projects.

The same information and relevant experience should be included for subcontractors of the respondent. Description and information as to the subcontractor must be clear and complete.

5.8 Exceptions to the RFP

List any exceptions that you have to the RFP. Elaborate on the reasons for the exceptions and proposed alternatives.

5.9 Cost Proposal

This section shall include an analysis of the estimated hours and costs that each member of the project team will contribute for the individual task depicted in the scope of work. The identity of and estimated costs for all subcontractors. Reproduction, travel and other direct cost should be included in the estimate. As a minimum, the contractor shall break down the man-hour and cost estimates into the six phases as proposed in this RFP.

Appendix B

Hydraulic Model Procurement Document

REQUEST FOR PROPOSAL (RFP)

FOR

AGENCY NAME WATER DISTRIBUTION HYDRAULIC MODEL

AGENCY NAME

DATE

Table of Contents

REQUEST FOR PROPOSAL **1**

SCOPE OF WORK **2**

A. DATA GATHERING AND REVIEW 2

B. MODEL DEVELOPMENT AND FIELD TESTING 3

1. MAPPING 4

2. FIELD TESTING 4

3. SOURCES OF SUPPLY AND OPERATIONAL CONTROL 5

4. DEMAND ALLOCATION AND DEVELOPMENT OF DEMAND PATTERNS 6

C. MODEL CALIBRATION AND DELIVERABLES 7

Proposal Requirements 7

Selection Process 8

REQUEST FOR PROPOSAL

AGENCY NAME is seeking a qualified professional consultant to develop a hydraulic computer model. This model is intended to be developed in conjunction with AGENCY NAME's GIS and there must be a 1:1 relationship between GIS features and Model elements.

Any change to the provisions or specifications of the RFP shall be made by written addendum issued no later than four (4) working days prior to the RFP acceptance date. Prospective vendors shall have complete responsibility for being aware of any and all addenda.

There will be no pre-proposal meeting. However, review of the available documents may be arranged by appointment.

All proposals must be received by 4:00 PM prevailing time on _____. **Proposals received after that date and time shall not be considered.** Interested parties must submit six (6) copies of the proposal, on double-sided pages on maximum post-consumer recycled content paper, to: _____, and be clearly labeled as **'Request for Proposal (RFP) For AGENCY NAME's Water Distribution Hydraulic Model'.**

Copies of proposal documents may be obtained free of charge from the AGENCY NAME offices located at _____

Correspondence regarding this proposal may be directed to

_____

SCOPE OF WORK

The following scope of work shall be provided.

A. DATA GATHERING AND REVIEW

The consultant will facilitate a kickoff meeting with AGENCY personnel to discuss project goals and to exchange and review existing information. Prior to this meeting, the consultant shall submit a formal request to the AGENCY in memo format outlining the geographical, facilities, operational and demand data that will be required to perform the scope of work. Examples of information available from the AGENCY are shown below. Additional data may be available upon request.

- Geographical data
- Electronic water model files and mapping of the distribution system depicting pump stations, water sources, storage facilities, control valves, pressure zones, and most pipes greater than 6-inch in diameter.
- Paper mapping of the distribution system, including recent and proposed improvements.
- GIS layers from the AGENCY's database.
- Facilities data
- Description of storage facilities, including capacity, location, dimensions, base and top elevations, and system connections.
- The design and operating features of service and booster pump stations, including capacity, system head, elevation and pump curves.
- Elevation and operability status on control and regulating valves.
- Service area and pressure zone boundaries.

- Operating data
- Diurnal and seasonal treated water production records.
- Well supply drawdown records and corresponding well production.
- Service and booster pump flows and pressures.
- Recorded flows from various distribution system meters.
- Clearwell and distribution storage level variations for various demand conditions
- System operation criteria and set points for pump stations, valves, storage, and service pumps.
- System operating pressures.
- Observed low-pressure areas indicating system deficiencies.
- Observed fire-flow capabilities and other flow test results.
- Demand Data
- Total yearly water sales (billing records).
- Service population
- Number, type and size of service connections.
- Consumption and location of major users that comprise the top 10% of the total water demand.

The data provided to the consultant shall be reviewed for completeness and accuracy. The consultant shall notify the AGENCY of any preliminary findings where the data appear deficient or where improvements in recordkeeping should be considered to assist the AGENCY in maintaining future accuracy of the model.

B. MODEL DEVELOPMENT AND FIELD TESTING

The consultant shall utilize the AGENCY 's existing distribution system hydraulic model as a basis for further model development. In addition to the existing model, the data collected during the Data Gathering and Review Phase shall be used to develop a physically complete model. Also, temporal changes in the status of the distribution

system such as tank levels, diurnal demands, and pumping rates shall be entered into the model to provide for modeling of Extended Period Simulations (EPS).

1. MAPPING

The consultant shall create model using available maps and GIS Data to build a complete hydraulic model of the distribution system. The GIS is to be the primary data source for pipeline information. Any relevant information from as-built drawings of recent improvements not incorporated into the maps shall also be added to the model. The selected consultant shall also review the AGENCY 's paper distribution plans with AGENCY staff to verify the physical layout and confirm accurate model connectivity (i.e. pipes that cross but do not connect to one another). Elevational data associated with model features such as junction nodes, tanks, pressure regulators, pumping stations and supplies shall also be verified.

2. FIELD TESTING

The consultant shall assist the AGENCY in conducting a fire flow and C-value testing program to supplement and verify historical fire flow testing results. The selected firm must recognize the importance of careful planning with regard to field testing and shall focus on minimizing the effect on system operations and disturbance caused to AGENCY NAME customers. The AGENCY NAME has extensive documentation on historical fire flow testing conducted throughout the AGENCY. However, this data has been collected over many years making correlation with boundary conditions such as well operation and tank levels difficult.

The Consultant will review previous fire-flow test results and develop a field testing program to verify historical results and to fill in gaps in existing data. The consultant

shall also take into account operators' institutional knowledge of areas in the system with observed low pressures or low available fire flows. Field testing shall consist of a minimum of:

- Sixteen (16) fire flow tests.
- Four (4) C-value tests
- Distribution system pressure-monitoring for a period of one week using a minimum of four data loggers to develop hydraulic grade lines and observe the effect of fire flow tests on more distant areas of the system. Data Loggers to be provided by the consultant.
- Field crews conducting testing shall consist of two Consultant employees. AGENCY NAME will provide a minimum of two employees to assist with the testing. Consultant staff will not be required to operate any valves or hydrants in the AGENCY NAME distribution system. Professional traffic control, if needed during these tests, will be paid for by the AGENCY.
- The Consultant shall
    - Provide the test equipment
    - Take readings
    - Tabulate data
    - Calculate results
    - Incorporate the data into the computer model
- The AGENCY will make the following operations data recorded during the period of field testing available to the consultant:
    - Discharge flows and pressures for all pumps and regulating valves.
    - Well drawdown levels and production.
    - Distribution system storage tank water level variations.
    - Operational status of critical water system components.

3. SOURCES OF SUPPLY AND OPERATIONAL CONTROL

The consultant shall verify that the various boundary conditions and operational parameters such as production rates, typical well drawdown, pump curves, on-off set points and control valve settings are accurately represented in the model. Verification shall be based on available records including daily logs, pump test data, equipment nameplate information and the operations staff's institutional knowledge.

4. DEMAND ALLOCATION AND DEVELOPMENT OF DEMAND PATTERNS

Average day demands shall be assigned individually to the nearest model junction node for those large water users comprising the 10% percent of total system demand based on billing records. The remainder of the demand will be distributed evenly among the remainder of the nodes with the largest demand being proportionally allocated to areas with high node density corresponding to higher population densities.

The consultant shall develop a diurnal demand curve for the system to facilitate the preparation of the Extended Period Simulation (EPS). The diurnal curve shall be developed based on hourly well production records and distribution storage tank fluctuation. The consultant shall input this curve into the model and shall use it to provide information on demand peaks, determine peaking factors, and establish the distribution of demand over time. The methodology utilized by the consultant to develop the diurnal curve shall be presented to the AGENCY in tabular format along with a summary narrative.

The consultant shall also develop a Maximum Day Demand model scenario based on historical production records and the ratio of maximum day to average day demands.

C. MODEL CALIBRATION AND DELIVERABLES

The consultant shall calibrate the model using tank level data, pressure data recorded by data loggers, and results of fire-flow tests. Verification of the model shall be achieved by comparing computer model generated information with actual recorded conditions for the period being modeled. Calibration shall be verified for both steady state conditions (using fire flow data) and for extended period simulations (using tank level and water production records).

The consultant shall develop a project technical memo outlining how the model was developed, calibrated and verified for accuracy and shall include model input and output for the various scenarios evaluated as part of the calibration activities. The memo shall describe the procedure for utilizing the computer model to evaluate the potential impact of proposed development activities on the existing system.

The consultant shall meet with the AGENCY to present the final deliverables and to discuss the findings and methodologies used in completion of the scope of services.

It is expected that the Consultant will have as many meetings with AGENCY personnel as necessary to complete each task, but a minimum of five meetings total is expected, including one final meeting to present the project and discuss the findings.

Proposal Requirements

Each proposal shall include the following:

Six (6) copies of the proposal submitted on double-sided pages.

Evidence of understanding of the project.

Demonstrated experience and qualifications of the actual personnel who will undertake the work.

A detailed description of the analysis and plan concepts including presentation format, displays, models, etc., and the personnel who will be performing various tasks, with the number of hours estimated for each, and the location of the office from which personnel are based.

Description of what steps will be taken, who will work on various tasks, location of office from which personnel are based.

Evidence of experience with other projects successfully competed on time and within budget.

A schedule that demonstrates that the project can be completed in one hundred twenty (120) calendar days.

Selection Process

A review committee, comprised of AGENCY staff, will review all proposals and, from these, will select a number for formal presentation and interview. The selection will be based upon a combination of factors including, but not necessarily limited to:

- Understanding of project
- Quality of proposal
- Experience and training of personnel assigned to, and actually working on, the project
- Completion by the proposing firm of at least two (2) projects of similar size and

scope within the past three (3) years.

- Schedule/time
- Project approach
- Experience with similar projects successfully completed on time and within budget
- Current work load/ personnel availability and number of hours committed to the project by personnel in various roles.

Proposals, when received, shall be irrevocable for a period of sixty (60) calendar days following proposal opening date. Selection shall be final. The AGENCY, through its AGENCY Manager, reserves the right to reject any or all proposals as he/she may determine and to waive defects in form or minor irregularities where the best interest of the AGENCY would be served.

Appendix C

SCADA Procurement Document

REQUEST FOR PROPOSALS (RFP)

FOR THE DESIGN AND INSTALLATION

OF A

SUPERVISORY, CONTROL, AND DATA ACQUISITION (SCADA) SYSTEM

AGENCY NAME

DATE

TABLE OF CONTENTS

Summary **1**

Project Background **1**

Pre-Proposal Workshop **1**

SCOPE OF WORK **2**

Task 1 - Review Project Goals 2

Task 2 - Prepare Detailed Design 3

Subtask 2.1 - Conduct Site Visits and Meet with AGENCY NAME Staff 3

Subtask 2.2 - Prepare Detailed Design Plans 3

Subtask 2.3 – Prepare Capital Asset Replacement Schedule 4

Task 3 - System Installation 4

Task 4 - System Programming/Integration 5

Task 4.1 – Programming and Control Workshop(s) 5

Task 4.3 – Programming 6

Task 5 - System Startup and Testing 6

Task 5.1 – Prepare Testing Plan 6

Task 5.2 – Factory Testing 6

Task 6 - System Documentation 6

Task 7 – Final Inspection/System Warranty 7

Summary

The AGENCY NAME is soliciting proposals from firms qualified and experienced in building SCADA Systems for water facilities. The SCADA system will be used to monitor and control the water system operated by AGENCY NAME.

The RFP does not commit the AGENCY NAME to retain any consultants, to pay cost incurred in the preparation of proposals, or to proceed with the project. The AGENCY NAME reserves the right to reject any or all proposals, or to negotiate with any qualified respondent.

Proposals will be accepted at the AGENCY NAME offices located at,

AGENCY NAME
Address

no later than _____.

Four copies of the proposal are requested. One of these copies should be unbound for duplication purposes. An electronic copy of the proposal in PDF form must be included on a CD with the hard copy proposals.

Project Background

The AGENCY NAME's water service area encompasses _____ square miles. As of 2009 the population of the service area was ____. The water supplies for the AGENCY NAME include local groundwater, and surface water. The AGENCY NAME operates production and distribution facilities that include ____ wells, ____ pump stations, and ___ reservoirs with a combined capacity of ____.

The AGENCY NAME's potable water distribution system consists of approximately _____ service connections and roughly ____ miles of mains that operate in ____ pressure zones. Approximately _____ pump stations and _____ water tanks are part of the potable system. For a listing of the potable water system components, see Table 1.

Pre-Proposal Workshop

A pre-proposal workshop will be held on ____(date)____ at ____(time)____ at ____(location)____. The purpose of the workshop will be to provide a brief background of the project and answer or investigate any questions regarding the process and other requirements for submittal of proposals hereunder.

SCOPE OF WORK

The Scope of Work outlined below presents the basic project requirements including the major tasks for this Project. If proposed revisions will improve project execution and/or functionality, Contractors may comment on, reorganize or expand upon the proposed Scope of Work; however such revisions may or may not be accepted.

The selected Contractor shall perform the following Scope of Work.

Task 1 - Review Project Goals

The Contractor shall meet with AGENCY NAME to review the goals of the project and obtain insight into the issues that AGENCY NAME is working to solve with the implementation of the SCADA system. This project is generally designed to monitor the pressures and flows in the distribution system as well as provide for pump controls and water tank level monitoring.

The following components are part of this project

Table 1: Required SCADA Components

Item	Quantity	SCADA Needs
Pump Stations		Pump Control, metering, flow monitoring, local HMI
Flow Meters at DMAs		Flow monitoring and data logging
Pressure monitors		Pressure monitoring and data logging
Water tanks		Level monitoring and valve control
HQ SCADA	1	Full SCADA workstation, historical data servers, trending software

Task 2 - Prepare Detailed Design

Subtask 2.1 - Conduct Site Visits and Meet with AGENCY NAME Staff

It is critical that the Contractor meet with AGENCY NAME staff and visit each site to confirm the requirements at each site. This is particularly true relative to site layout and space considerations. Contractor shall visit all sites during the detailed design phase and shall conduct workshops (minimum of two) with AGENCY NAME staff to confirm the requirements for each site. Contractor shall prepare workshop agendas and meeting minutes.

Subtask 2.2 - Prepare Detailed Design Plans

The Contractor shall prepare and submit for review design drawings and specifications for the SCADA system improvement. Submittals shall be made at the 50 and 100 percent design completion levels. These submittals are not expected to include final design detail as would be typical for a design package intended for construction bidding. They are intended to provide the AGENCY NAME with sufficient detail to understand and confirm the proposed architecture and functionality of the SCADA system and to review the proposed physical layout of each SCADA site. A detailed construction cost estimate shall accompany each design submittal. The purpose of each estimate will be to compare it to the Guaranteed Maximum Price (GMP) and to help ensure that the project can be constructed within the AGENCY NAME's budgetary constraints.

The detailed design plans shall be developed in accordance with the provisions outlined in the Predesign. The AGENCY NAME will review the 50 percent design plans, develop comments as required, and provide these comments to the selected Contractor. The 100 percent revised submittal shall be prepared and submitted to the AGENCY NAME, incorporating AGENCY NAME comments. Upon approval by the AGENCY NAME, the 100 percent design drawings shall become the basis for installation of the SCADA improvements.

Plans shall be developed in AutoCAD format and submitted to the AGENCY NAME in PDF format for review. Plans shall include, at a minimum, the following for each site:

- Scaled site maps (plan view) including location of all new panels and equipment, conduits runs, trenches, lighting, instrumentation, etc. Show panels and equipment

at actual size. Include space for additional wiring in new conduits for future expansion.
- Block diagram(s) to illustrate the proposed SCADA architecture
- List of I/O points and ranges for variable parameters, including provisions for future I/O expansion
- Process and Instrumentation/Control drawings

Also include the following with this submittal:

- Details (information, cut sheets, etc) for new instrumentation and control equipment.
- Master HMI screens (may be deferred to later submittal, but shall be approved by AGENCY NAME prior to acceptance)
- Proposed tags for all equipment and instrumentation and recommended initial settings
- Description of the control logic for each site
- Standard construction details, including trenching, paving, conduit depth and material, etc, AGENCY NAME design standard details shall be used as applicable.

Subtask 2.3 – Prepare Capital Asset Replacement Schedule

In order to assist AGENCY NAME in long term budgeting for replacement of assets, the Contractor shall compile Capital Asset Replacement Schedule for all hardware that is specified under this design. This table shall include, at a minimum:

- Asset Name
- Asset Description
- Estimated Value as installed at the time of installation
- Estimated useful life before requiring replacement

Task 3 - System Installation

The Contractor shall procure and install all equipment and accessories as required to create a fully functional SCADA system for the AGENCY NAME's water supply and distribution system. The Contractor shall be responsible for all aspects of the system's installation and construction, including keeping facilities in operation, maintaining access for AGENCY NAME O&M staff, and permitting (but excluding environmental permitting).

Note the following specific system supply and installation requirements:

- All PLCs shall be provided by the same manufacturer and shall be Opto22. No other manufacturers shall be allowed

- HMI software shall be Wonderware In Touch (current release) The Contractor shall obtain all software licenses necessary for software use; these shall be in the AGENCY NAME's name. Software support shall be provided through the expiration of the one-year warranty period.

- All water system sites are active and access to each site by AGENCY NAME personnel must be maintained at all times. The AGENCY NAME will provide specific protocols for site access and maintenance, and for system outages, as required. All sites shall be returned to their original condition at the conclusion work. Site restoration shall include backfill and paving of all trenches; repair of any facilities or utilities damaged during construction; replacement, in kind, of any facility or utility permanently or temporarily relocated during construction; complete abandonment, in a safe and secure manner, or removal of any existing equipment or utilities made obsolete by new construction (including conduits, wiring, cabinets and miscellaneous SCADA and controls equipment); and similar work.

- All work is subject to review and inspection by the AGENCY NAME, and all work shall
- be constructed in compliance with applicable codes and regulations.

Task 4 - System Programming/Integration

Programming shall be completed to include all control logic to remotely and locally operate the water system, monitor system performance and status, and receive and respond to alarms. Operator interfaces shall be established based on AGENCY NAME input.

Task 4.1 – Programming and Control Workshop(s)

A minimum of two workshops shall be held with AGENCY NAME staff to discuss site operation and control strategies prior to the start of programming. Contractor shall prepare workshop agendas and meeting minutes. Workshop(s) shall be conducted by the Contractor with the objective of obtaining direction from the AGENCY NAME on control logic, equipment operation, system reporting and alarms, etc, as required to produce a fully functional and comprehensive SCADA system at all sites.

Task 4.3 – Programming

Contractor shall complete system programming to implement the control logic and operating characteristics agreed to and approved by the AGENCY NAME during project workshops.

Programming shall be fully documented in writing; see Task 6.

Task 5 - System Startup and Testing

Task 5.1 – Prepare Testing Plan

A complete testing plan shall be submitted for review and approval by the AGENCY NAME. The testing plan shall be comprehensive, allowing all local and remote functionality to be tested.

Task 5.2 – Factory Testing

Factory testing of all equipment and panels shall be completed prior to field installation. Certification of successful factory testing shall be submitted to the AGENCY NAME and approved by the AGENCY NAME prior to installation.

Task 5.3 – Field Testing (Site Acceptance Test)

Field testing (Site Acceptance Test) shall confirm all signals and proper programming of all operational and alarm conditions. Testing shall be documented. The system shall operate for a period of not less than 7 days without hardware or software failure/fault prior to acceptance by the AGENCY NAME. Should any component of the new SCADA system fail, the 7-day period shall reset. Documentation of field testing, including certification by the Contractor that the field test has been successfully passed, shall be submitted to the AGENCY NAME for review and approval.

Task 6 - System Documentation

At the conclusion of the installation period, the SCADA system shall be fully documented. This shall include for each site, at a minimum:

- Complete drawings of the SCADA system, including:

    - Site plans and elevations with as-built panel and equipment/instrumentation locations, conduit sizes and alignments and installation/construction details
    - Panel layouts/schematics
    - Complete process, instrumentation and control diagrams.
    - Complete wiring diagrams
    - Drawings, as required, to illustrate complete SCADA architecture
- All equipment/instrumentation shall be identified by tags approved by the AGENCY NAME
- Nameplate data and cut-sheets for all instrumentation and equipment
- Complete I/O lists for each site
- Operations and maintenance manuals for all equipment/instrumentation
- Warranty data for all equipment/instrumentation

5 sets of draft documentation, in appropriately sized 3-ring binders, shall be submitted along with a CD/DVD containing .PDF formats of all pages. AGENCY NAME will review and return comments on the documentation. Contractor shall incorporate comments into a final set of documentation binders and a CD/DVD for final AGENCY NAME review and approval if all comments have been adequately responded to.

Task 7 – Final Inspection/System Warranty

Upon construction completion the AGENCY NAME and Contractor will conduct a final walkthrough of the project in order to develop a final punchlist. The Contractor shall complete all punchlist work prior to final acceptance. The Contractor shall warrant the system against failure due to design, programming or faulty workmanship for a period of 12 months following the completion of design. This warranty is separate from equipment warranties.