Water Flow Meter Replacement

San Juan, Puerto Rico

Puerto Rican Aqueduct and Sewer Authority

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Abstract

The Puerto Rican Water and Sewer Authority (PRASA) is losing money because of failing water meters and under-billing. The goal of our project was to help PRASA by recommending an efficient replacement plan. To do this we performed a customer survey to determine their satisfaction with the authority. We also interviewed the directors of Customer Service to gain knowledge of the replacement effort and its problems. Replacement plans from around the world were compared to Puerto Rico's to determine where Puerto Rico ranks. Finally, we performed a cost benefit analysis on metering systems using new reading technology. We made recommendations on new meter technology, as well as ways to improve the efficiency of the meter replacement plan, enabling the replacement of 200,000 meters a year.

Authorship

Initially, Tom Ryan drafted Chapter 1, the Appendices and the Abstract, David Marsh drafted Chapters 2, 4 and 5 and Dan Wesolowski drafted Chapter 3 and the executive summary. However, during the course of the project, all sections underwent revision by all group members. Additionally, all group members contributed equally achieving all parts of the methodology. Therefore, the authorship of this project is equally distributed among all three members.

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Executive Summary

Failing water meters have been a problem for PRASA (Puerto Rican Aqueduct and Sewer Authority) since they took charge of the Puerto Rican water system in 2004. During the preceding ten years, Puerto Rico contracted the management of the water system to a succession of two different private companies. These companies allowed miles of pipe to fall into disrepair causing customers to be without water for extended periods of time. Meter failures cause incorrect customer billing, undetected leaks, and other system errors that result in increased maintenance expenses. These failing meters and infrastructure problems, along with a desire to improve efficiency are what prompted PRASA to request assistance.

In 2005, PRASA replaced 130,000 meters, and they hope to replace 200,000 in 2006. Their current replacement efforts are effective, but could be improved. Studying similar projects completed in other cities is helpful in effective planning. Many cities across the United States and the world are currently involved in, or have recently finished a replacement similar to PRASA's such as Toronto, Seattle, and Atlantic City. Although no one plan will work for every situation due to variations in such things as geographic population distribution and terrain, the methods used in these cities can offer helpful insights and may be adapted for use in Puerto Rico.

This project provided suggestions that satisfied the water meter management needs of Puerto Rico, specifically, for improving PRASA's current replacement efforts, implementing new meter technology and addressing some customer concerns.

The project was divided into two main sections, meter management evaluation and the information system evaluation. To satisfy the meter management section, we performed comparisons on meter replacement efforts in Puerto Rico and in the United States. PRASA

customers were surveyed concerning their opinions of their services and information was gathered from Customer Service directors about the state of their region and any concerns they had about the current replacement effort. Finally, we performed a cost-benefit analysis comparing present meters to new technology alternatives.

We evaluated PRASA's current information system by inspecting it and speaking with its administrators to gain an understanding of how it works and if the current technology was adequate.

The results of the cost-benefit analysis prompted the recommendation that PRASA keep their current meters and install the ITRON AMR technology at an initial investment of $187.6 Million. This provides PRASA with AMR technology they trust while keeping their current meter technology. AMR will allow PRASA to read a larger quantity of meters in a shorter period of time while saving money on reading costs. The other systems analyzed were either too expensive or required a larger investment of time and money.

Currently, the meters installed by PRASA are capable of supporting AMR technology, but are not installed with the necessary hardware: a radio transmitter. As PRASA continues to replace meters, the number of meters without AMR technology will grow. In light of this, we recommend that PRASA finalize their decision on AMR and begin installing the transmitters with every new meter in order to reduce the cost of retrofitting currently installed meters.

PRASA's goal of replacing 200,000 meters this year would allow them to complete all 1.3 million meter replacements in 7 years. We recommend that they continue with the replacement and evaluate the relative success at the end of the year.

AMR technology will enable fewer employees to take more readings than the current system allows. Those employees not participating in the meter reading can be used for a meter testing program. Testing allows meter life to be calculated instead of estimated, meaning that meters can be replaced more economically. While not every meter can be tested, representative samples could be tested every few years. Through random sampling or other such methods, each region would select enough meters to represent the health of the system. Once enough data are gathered, regions could accurately predict whether the current replacement timeline needs adjustment.

The opinions of the customers are very important to PRASA. We administered a customer survey and found that 61% of people said they were not informed in a timely manner of work that would leave them without water, and 64% indicated their preferred method of notification was postal mail. Once a replacement interval is established, the database can be queried to identify meters due for replacement. The affected customer can then be notified of an impending meter change and interruption of service via an insert in the monthly bill.

An evaluation of PRASA's current information system was originally planned. This would have involved an inspection and administrator interviews to gain an understanding of the process and possible improvements. However, the PRASA data center had already collected bids for a new system and is currently in the process of analyzing them. They plan to finish the upgrade process in 3 years. It was our opinion that they had the situation under control, and it was unnecessary for us to proceed with the investigation. Any problems we would report are already known and any recommendations we could give would not be as informed as the recommendations they will make.

These recommendations will help PRASA to improve their replacement effort and meter management while also reducing the Authority's costs.

Chapter 1: Introduction

Fresh, potable water provided directly to our homes and work places is an expensive commodity. There are many processes and expenses that go into the treatment and transportation of potable water, all of which require a steady flow of income to finance. A water system, run appropriately, will provide enough revenue to the water department so that all operating and improvement expenses can be fully covered. If an authority is unable to properly bill customers for the water they use, it will be unable to adequately finance continuing service and improvements to infrastructure.

The Puerto Rican Aqueduct and Sewer Authority (PRASA) maintains the over 1.3 million water meters under its jurisdiction. Currently, a large portion of those meters are reaching or have reached the end of their useful life. As the meters age, they begin to underestimate water usage. This has lead to billing customers for less water than they have actually used. The incorrect billing of water usage has produced a reduced amount of revenue, which, in turn, diminishes the authority's ability to finance operations and improvements. Despite several upgrades, the current technology is obsolete. This, combined with an inefficient and inaccurate meter reading system, contribute to PRASA's difficulties in maintaining a sufficient revenue level.

Many water departments have implemented replacement plans to address the issues they have encountered with failing meters. Atlantic City has embarked on a ten year replacement effort in order to accommodate anticipated residential and commercial growth in their city. Seattle, Washington, has detailed a plan that encompasses every aspect of their water system in order to address maintenance and replacement concerns. These plans have increased the constant revenue each department receives and financed various improvements to both their infrastructure and organization.

PRASA's revenue generation abilities are hindered by several factors including their replacement plan, information system, and meter-reading technology. Of these issues, the archaic meter-reading system is the most problematic for the authority. This system involves a pair of technicians who travel from meter-to-meter reading the actual numbers off of the meter-register and entering them into a handheld computer. A reading system of this type is not only inefficient, but also inaccurate. Human errors, along with the occasional inability to actually locate the meter, often lead to incorrect readings and therefore incorrect billing. Water authorities around the world are switching to newer, more efficient Automated-Meter-Reading Technologies (AMR), and are able to read meters and bill customers with much improved accuracy and spend fewer man hours reading meters.

PRASA understands the importance of AMR technology to the future of the organization. In late 2005, the company released a Request for Proposals from AMR companies in the hopes of initiating a move to a new reading system. Since December 2005, PRASA has received several estimates from related companies, and is currently involved in small pilot programs on several parts of the island. The pilot programs have been running for several months, but no conclusions have been made. Currently, PRASA recognizes that AMR is the next step, but is wary of proceeding with a full change-over due in part to the costs associated with such an endeavor. In order to continue with the modifications to the system, the company will need to determine whether the benefits of the system outweigh the initial costs.

PRASA also realizes the importance of having correctly functioning meters. In 2005, the authority replaced over 130,000 water meters. The current replacement effort is moving forward; however, the plan in use may not be the most effective. Of the meters installed before 2005, a large number of them have been buried, relocated, or overtaken by plant growth. This poses significant problems when the meter is due for reading or replacement. For the success of the current venture, along with any future replacement, PRASA should locate all missing or buried meters.

This project explored each of these issues and produced a set of recommendations which will aid PRASA in the minimization of costs and failing water meters, as well as increase revenue and ensure customer satisfaction. These recommendations will enable the company to conserve money that would normally be spent on inefficient meter reading and replacement procedures. This will increase the annual revenue allowing the company to focus more resources on serving the customer.

Chapter 2: Background

Creating a water meter replacement plan is not a task to be taken lightly. Many aspects must be considered in order to create a successful plan. Water meters are a large part of a water meter replacement plan. A flow meter provides reliable water usage measurement. This enables the water authority to accurately bill customers so that the funds necessary to maintain the system are collected. Replacement strategies are also an important part of a meter replacement plan. General replacement strategies as well as specific examples of other replacement plans will be discussed to demonstrate what other water authorities are doing to keep their water meters functioning. Finally, Puerto Rico is in a unique situation concerning the water authority. Understanding how this fits in with their current water system and the water concerns of an island will be necessary to make proper recommendations for Puerto Rico. This chapter will present this information as it relates to Puerto Rico.

2.1 Flow Meters

While it is the function of a flow meter to only record the volume of water that passes through it, the meter is needed for much more than that. Understanding the importance of a flow meter, as well as the technological issues that must be dealt with is necessary in choosing the right water meter. This section will discuss why a flow meter is an important piece of a water distribution system and mention some technological and managerial flow meter considerations.

2.1.1 Flow Meter Importance

Correctly billing the customer is the primary use for a flow meter (Allender, 1996, Detection). It allows the water utility to properly measure how much water a specific house or business has used and charge them appropriately. For some utilities, like PRASA (Puerto Rican Aqueduct and Sewer Authority) these bills are their only source of income. Block rate billing, which charges for the specific amount of water used, as opposed to flat fee billing has been said to encourage water conservation. In order for this kind of billing to be possible, functioning flow meters are necessary.

The economic effects of incorrect billing can be significant (Allender, 1996, Optimum). In some areas, inaccurate flow meters have resulted in a loss of up to $200,000 a year in water bills. This is an especially important issue for towns that purchase their water from neighboring towns. If a town pays for a certain amount of water from another town and then does not make all of that money back, revenue is lost, causing problems if the water department does not generate enough money to sustain the facilities needed to keep water flowing to its customers.

Water meters may also be used to find leaks in a system (Shea, Horsman & Hanson, 2002, p.60). If the water meter is accurate, then discrepancies between how much water went out and how much water was paid for can indicate leaks or problems in the delivery system. Moreover, it is possible for a leak in a pipe to erode the surroundings of the pipe. When these surroundings are in a sewer below busy roads, the result can be a cave in.

If the amount of water being sent out is equal to the amount of water being billed for, then flow meters can indicate something more (Satterfield, Bhardwaj, 2004, p.1). They can report the water usage for a community. Armed with this knowledge, the authorities can monitor water consumption and better judge current and future water needs.

2.1.2 Meter Reading Techniques and Considerations

Choosing how to read the meters is almost as important as choosing the meter itself. The meter reading technique can affect accuracy, maintenance and even whether the meter is read or estimated.

The first kind of reading is manual reading (Satterfield, Bhardwaj, 2004, p.3). This is done by a reader looking at the meter itself and recording the number it displays. The display can read like an odometer, markings on a spinning disk or just a readout on a small screen. If there are 1.3 million meters in an area, as there are in Puerto Rico, then 1.3 million separate readings must occur every billing period and is a very time consuming process.

The reader is an issue as well (Jim Deming, personal communication, 2/9/2006). If the people reading the meter does not understand what they are reading or the reading is ambiguous, then an incorrect number will be recorded and the billing will be wrong. The physical location of the meter can also be an issue. If the meter is located in the basement of an uncooperative customer, or a yard surrounded by a locked fence, then meter reading is difficult.

A solution to a few of these issues is an electric wand (Satterfield, Bhardwaj, 2004, p.3). This still involves going to the location of the meter but now the readings are interpreted by a computer instead of a person. This removes the uncertainty of the reading and the measurement is recorded in a computerized system. Nevertheless, this method shares many disadvantages with manual reading. Each meter still needs to be read by hand and the wand must physically touch the meter's surface.

A popular solution today is remotely read meters (Satterfield, Bhardwaj, 2004, p.3). Using radio frequencies or similar technology, the water company can read meters much faster than the other two methods allow. Using radio transmitters, all the meters on a street can be read by traveling up and down the street with sensing technology. This method does not require contact with the homeowner and any dangers of physically reading the device are avoided (Jim Deming, Personal Communication, 2/9/2006). The transmitter itself is attached to the body of the meter by a wire. This means that if either the meter or the transmitter fails, the other one does not have to be replaced. Unfortunately, the radio transmitter is usually much more expensive than the meter.

Right now, radio transmitter technology is very proprietary, meaning that readers and transmitters cannot be freely intermixed, but this is improving (Jim Deming, personal communication, 2/9/2006). All aspects of the transmitter are reliant on battery life, especially the range. As the battery wears down, the range decreases until it ceases to broadcast. In the past, people have expressed concerns about potential risks. They feel that a radio broadcaster in their house could put their health at risk, or reveal personal information. Finally, radio broadcasting requires a license, which is another added cost to consider.

Currently, PRASA uses manual reading on their 1.3 million meters. There is, however, an effort to change over to automatic meter reading, specifically using radio transmitters. This effort is being made easier by the fact that all of the meters are on public property. This means that customer availability or customer concerns about the technology used do not factor in as greatly and they are free to pursue the technology that will work the best for them.

2.2 Meter Replacement Considerations

Replacing water meters is not an easy task. There are many issues that need to be addressed before meters are bought and replacements are done. Reviewing solutions from other locations is a good way to understand the ideas behind a good replacement plan. Also, management issues such as the economic life of a meter must be understood for any plan to be successful. This section will discuss general meter replacement concerns, review past meter replacement efforts and discuss a few management issues.

2.2.1 General Replacement Considerations

There is no meter replacement plan that will work for every situation. What worked well for one city could fail for another. Puerto Rico's water system is very complex compared to other water systems, encompassing much more land and containing thousands more miles of pipes than most systems. Nevertheless, a few guidelines have been compiled that experts in the field and research on this project suggest. Are the main points of a water replacement plan, regardless of the size of the system or replacement effort.

Choosing the technology to use is the most important part of planning a water meter replacement (Jim Deming, personal communication, 2/9/2006). This is something unique to every town or city. The water department must look at all of the available options before coming to a decision. Once this decision has been made, the average cost for a meter can be determined, and in turn, so can the average total cost for replacement. The annual budget can be used to tabulate how many meters the city can afford to replace in a year.

Jim Deming is the Head of the Town of Acton Massachusetts Water Department, a small town in northern Massachusetts (Personal Communication, 2/9/2006). For him, choosing which meters to replace is a simple matter. The broken meters should be replaced first until there are no more. When this has been completed, a section of town should be chosen at random and all of the meters in that section should be replaced. This should continue until all meters in all sections have been replaced.

The final consideration to make is whether to do the replacement with local resources or hire an external company (Deming, personal communication, 2/9/2006). Hiring an external company could produce faster results but at a higher price. Another problem with an external company is that they might complete the work much faster than if the town or city did it themselves. This is an issue because all of the meters will be roughly the same age (1-2 years to each other) which means that they will all fail roughly at the same time. Extending the contract to step out meter replacements would likely drive the overall cost higher by forcing the town to make payments over a longer period of time.

Doing the replacement with town resources can be cheaper but may take as much as 5 to 10 years longer depending on the size of the town and resources available (Deming, personal communication, 2/9/2006). This is an advantage because their meters are stepped out in terms of age. Fewer meters will fail at the same time, so less money is spent each year and there are no financial problems.

The last thing is to go back and look at the meters that were replaced at the beginning of the process (Deming, personal communication, 2/9/2006). An analysis of their remaining life should be done. This will be an indication of when another meter replacement cycle should begin.

This is the strategy used by a small town. Practices and methods used here may not directly fit the needs of a larger region like Puerto Rico, but could be adapted to work. Randomly selecting the meters to be replaced, for example, would not work with so many water meters. A careful and systematic approach should be used to ensure all meters are taken care of and resources are allocated efficiently. Testing the meters a while after replacement, however, can be adapted to work in Puerto Rico. All replacement plans and strategies should be looked at to determine whether a specific strategy could be used or adapted to work for Puerto Rico.

2.2.2 Other Meter Replacements

Looking at what other locations have done and are doing about their water meter problems will help to shape the efforts of cities and towns trying to solve their own problems. Atlantic City was facing a water meter problem around 15 years ago (McLees, 1993, Anatomy). The meters that served the 40,000 people living there were becoming 10 to 20 years older than they should have been and beginning to show signs of wear and tear. This, coupled with their growing gaming industry forced Atlantic City to draw up a plan to replace their water meters. They decided to replace every meter in the city over a span of 5 years with a meter that was factory sealed and prepared for installation. Additionally, electronic meter readers were acquired to eliminate the need for manual entry. Meter readings would be downloaded into hand-held devices and uploaded to a central computer for processing.

The time that the already installed meters saved in meter reading time helped to expedite the replacement process (McLees, 1993, Anatomy). In the end, average billable water readings jumped from 3.05 billion to 3.65 billion gallons, a significant amount of water and revenue. Like Atlantic City, Puerto Rico is growing with an established tourism industry, and water is an important resource for sustaining this kind growth. Meters in Puerto Rico are read by hand, so a boost in available personnel, similar to the one experienced by Atlantic City, is possible if Puerto Rico changes to automatic meter reading.

Pontiac, Michigan, was in a similar situation (Jackson, 1996, Meter Replacement). Their aging meters served about 20,000 different clients. Meter replacements were rare, only for new houses or completely broken meters. At the same time, they were purchasing water from another city. The failing meters led to inaccurate measurements. The city was unable to collect enough revenue from the customers to cover the costs of the purchased water.

There was also a problem with fenced in meters, meters in yards with vicious dogs and other dangers (Jackson, 1996, Aging Meters). Estimating meter readings can result in an overcharge with supporting data, causing customer complaints. To alleviate this problem, they decided to use radio frequency meters. Their primary concerns were the financial and technological aspects of the new meters (Jackson, 1996, Research). The meters needed to be technologically sound and equipped with radio frequency equipment but not so expensive that one meter would be too costly to replace if it were vandalized or another one needed to be added.

The company they hired to do this combined their work force with that of the town to increase progress (Jackson, 1996, Research). Although estimated that the project would be completed within 2 years, the project was 90% complete within 10 months.

The new system resulted in fewer customer complaints due to accurate meter readings (Jackson, 1996, Benefits). They could read more data faster due to the radio signals, and the safety of the people reading the meters was ensured. The electrically based system reduced the need for repairs on the mechanical parts.

The financial and technological concerns this town had about their meters are the same that Puerto Rico has. With so many meters on the island, the purchase of $200 meters would pose a financial burden on the authority. The meters would have to be durable enough to withstand any weather situation in Puerto Rico, as they are exposed to more weather than meters located indoors.

Toronto, Canada and the surrounding area had a number of water meter problems in 2002 (City of Toronto, 2002, Background). Their meter reading methods were antiquated, even relying on manual labor. Eighteen percent of their accounts did not have meters and were paying a flat rate for water. Finally, many of the meters they used were over 30 years old and beginning to break down. In order to address these and other issues, several agencies within Toronto collaborated to solve these problems.

Toronto has three main account types: high volume accounts, low volume metered accounts, and low volume non metered accounts (City of Toronto, 2002, Background). These three accounts provide a total of $408,600,000 to the water department. Accounts are billed through a combination of manual reading, customer reading, remote reading and no reading. A significant percentage of accounts are read through manual reading. This was determined to be an inefficient use of the employee's time.

A study of the high volume meters in the Toronto area revealed that only 35% of these meters were operating within acceptable parameters (City of Toronto, 2002, Meter Testing Results). The rest of the meters were causing an estimated $15 million in losses for the company each year. The low volume meters had similar problems, with 27% of them being over 30 years old and beginning to misread water flow.

In the end, it was determined that there were several things Toronto could do to improve its water meter infrastructure (City of Toronto, 2002, Conclusion). The first was to upgrade all accounts, including non metered accounts, to radio meters. This allowed employees to collect more data faster and streamline the billing process. It was also recommended that all 8,500 non-metered accounts be upgraded to metered accounts over the next four years. The proposal gives a tentative plan for an eight year replacement program. In the Toronto area, the high volume meters are to be replaced over the course of two years, doing 5,000 the first year and 10,000 the second. The low flow meters are to be replaced in groups of 20,000 over the next four years. Starting in year 2 and going to year 8, the surrounding areas are to have anywhere from 25,000 to 63,000 meters replaced in a year.

These fixes are expected to bring average savings of $255 million over the next 15 years (City of Toronto, 2002, Purpose). Additionally, estimated meter readings will disappear due to the new meter technology. This will result in a more satisfied customer base.

Currently, there is an issue with estimated billing in Puerto Rico. There are too many meters for each one to be read every billing period. Due to this, some readings are estimated. Like Toronto, Puerto Rico hopes to eliminate the need for estimated billing by installing better meter reading technology.

Replacements in Tampa, Florida follow a strict schedule of testing and replacement (Robert Lauria, Personal Communication, 3/1/2006). Meters that are 5/8", 3/4" and 1" are all replaced every 10 years. Beyond 1”, the larger diameter a meter has, the more frequently it is tested. If a meter begins to show usage patterns of a meter the next size up, then its testing schedule is changed to that of the next size.

Tampa’s meter replacement began in 1992 as a test to see if meters were appropriately sized for the environments they were in (Robert Lauria, Personal Communication, 3/1/2006). After many meters were replaced due to size reasons, they continued to check for meters that needed to be replaced for other reasons. They wound up doing 10,000 – 15,000 meters a year until they finished. The specifics of the plan were chosen rather arbitrarily. The start of the meter replacement was the southern part of Tampa because it was the oldest. They started replacing larger meters first because those garnered the most revenue and moved down in size as they progressed. In the end, they saw a 14% increase in billed water.

This plan exemplifies several items that are either not suitable for Puerto Rico or not currently used. Arbitrary choices, for example, are not something an island with so many water meters can consider. Similarly, the amount of testing done in Tampa is not something done in Puerto Rico, nor can it be due to the number of meters. If PRASA were to implement meter testing, a modified schedule that either spreads out testing or takes a representative sample of meters would need to be considered.

Tucson, Arizona does things a little differently (Cheryl Avila, Personal Communication, 3/23/2006). They determine all of the 5/8", 1", 1.5" and 2" meters that are 20 years or older and mark them for replacement. They try to balance difficult meter replacements (old pipes and valves, access problems, hard to find meters) with easier replacements to make the replacement quota more reasonable.

They use a private contractor to carry out the actual meter replacement, but they themselves keep track of everything that has been done and needs to be done (Cheryl Avila, Personal Communication, 3/23/2006). There were several problems they encountered when dealing with a private contractor. First and foremost was that the Tucson Water Department could not simply give the contractor a list of meters to replace and tell them to report back once it was completed, because they indicated that they would have needed another full time employee to deal with the amount of paperwork that is associated with the meter replacements. Secondly, the contractor was having trouble keeping enough people in the Tucson area to effectively do the work.

If PRASA were to switch to a private company, a few issues would need to be dealt with before the switch could be made. First, the Tucson Water Department had to do a great deal of communication and paperwork when dealing with the company they used. It is likely that PRASA would experience a similar inundation of extra work to be done if they switched to a private company. Secondly, the costs involved in dealing with a private company are likely to be higher than if PRASA were to use their own technicians. This is due to the fact that all companies have overhead to take care of. The cost of meter would represent not only parts and labor, but other company expenses as well.

In Seattle Washington, Their small meters are allowed to run to failure and are replaced when they are discovered by the billing system. For their large meters, three replacement plans were reviewed before a decision was made on which one to use (Henry Chen, Personal Communication, 3/26/2006). The large meters are replaced when they become stuck or unreadable, are the wrong size or their accuracy cannot be assured. Currently, there is a backlog of 710 large meters to be replaced that have been identified as having a problem.

The first option, test until failure, was to keep testing and replacing meters until the decline in meter accuracy was noticeable from month to month (Henry Chen, Personal Communication, 3/26/2006). It was estimated that it would take 20 years to finish the backlog of meters. During this time, inconsistencies in prices would confuse the customers.

Option two, short-term priority replacement, was to keep testing meters that were not deemed a problem and replace them as necessary (Henry Chen, Personal Communication, 3/26/2006). Those that were deemed a problem were to be replaced on a priority basis, with the meters that would garner the most profit being the highest priority. The whole process was to take six years. However, the resources needed to do this were beyond the resources of the office. The third plan, long-term priority replacement, was to take the methods from the second option but stretch the timeline out to longer than six years, putting the lower priority ones at the end.

Testing until failure reduces the risk of replacing a meter with life left on it, something that could happen with short term and long term priority replacement (Henry Chen, Personal Communication, 3/26/2006). However, Seattle felt the likelihood that a meter so degraded that its decline is clearly visible in the billing system was too great to consider this option.

Short term priority replacement solves the issue of price inequality but was deemed to require too much money and resources (Henry Chen, Personal Communication, 3/26/2006). Long term priority replacement provides most of the benefits of the short term priority replacement with no need for an increase in resources and a slightly longer time table. Long term priority replacement was their final choice.

The process Seattle went through is a good example of weighing available resources against desired outcomes and making a compromise. The second option is the most desirable method, solving their problem as quickly as possible. However, it was not possible due to the money and resources necessary, so a compromise was made in order to meet the resource requirements and still solve the problem in an adequate amount of time. This is something that Puerto Rico may have to consider the needs of the customer and the water authority.

Countless other states and counties are beginning to replace antiquated water meters in the same fashion, turning more and more on electronic or wireless meter reading protocols to expedite the reading process.

2.2.3 Water Meter Management

Knowledge of how to maintain so many meters is crucial to keeping the system working (Schlenger, 2000, Encompassing All Aspects). An important thing to keep in mind is that each meter is part of a larger network; they cannot be considered individual pieces. If one meter is having a problem, that same problem might be happening somewhere else.

Meter maintenance is another thing to consider. It is a possibility for towns that use mechanical meters, but not cost effective for electrical meters (Jackson, 1996, p.1). Some meters are too expensive to be repaired and must be replaced instead, or the meter is so cheap that replacing it is more cost-efficient.

A city needs to maintain a delicate balance between replacement and economics (Allender, 1996, Optimum). Replacing a meter too early will result in a loss of time when that meter would still be good. Replacing a meter too late will result in a loss of billed water. In general, the loss of revenue due to meter replacement will be a constant. The loss of money due to unbilled water increases each year the aging meter is not dealt with. In the case of Anne Arundel County, Maryland, old meters were costing up to $13.25 per meter per year. Each city needs to look at its own situation and determine which method will save it more money in the long run.

2.3 Puerto Rico's Water System

Puerto Rico has a unique water system. Despite being a small island, they have a very complex water distribution system. In addition to this, being an island presents water concerns of its own. Finally, the Puerto Rican Aqueduct and Sewer Authority has an important history that must be examined to understand the current state of the water system. This section will talk about Puerto Rico's water system, their island concerns and the history of PRASA.

2.3.1 Water Resources

Puerto Rico uses around 430.9 million gallons of water per day (Ortiz-Zayas, 2004, p.393). The two highest uses of water are domestic and unaccounted for (leaky pipes and illegal connections) at 171.2 and 183.3 MGD respectively. Commercial, industrial and tourist facilities make up the bulk of the remaining percent with thermoelectric coming in at the lowest percent.

Puerto Rico has many renewable natural water resources along with aqueducts, dams and desalination plants to supplement and maintain the water supplies (Pigram, 2000, p.3). Despite this, Puerto Rico is often plagued with water shortages and droughts. Hurricanes can devastate infrastructure, while the natural terrain on the island can block some storms from reaching parts of the island and replenishing natural aquifers. High tides can also cause salt water to contaminate the underground water supplies of coastal areas.

2.3.2 Island Considerations

Puerto Rico is different from other places that do meter replacements in the sense that Puerto Rico is an island with many more customers and meters to deal with than smaller towns (Pigram, 2000, p.3). Even for the cities that have a similar population, their people are concentrated in one area. The population of Puerto Rico is scattered around the island, making the logistics of a meter replacement harder than the logistics for a city with a concentrated population. Most islands, Puerto Rico included, should and do monitor their water supply. It is easier for a city in the United States to buy water from other towns and cities than it is for an island to import water. Golf courses and other large tourist attractions are also an issue because of the large amounts of water they use for chores like laundry and keeping the grounds green.

Currently, water meter import costs are not a concern because PRASA has their meters manufactured on the island for a cost of $22.75 per meter (Andres Garcia, personal communication, 2/3/2006). This does not mean there are not better solutions that could save them money in the long run, but right now the meters they get are relatively inexpensive.

2.3.3 PRASA

PRASA is the company that handles the water needs of nearly the entire island. Currently, PRASA checks the entire island by reading each meter by hand. Their replacement plan is to replace meters on a set schedule or locate failed or failing meters during billing rounds and replace them accordingly. Their information system stores meter information as well as billing history and customer information.

One major advantage that Puerto Rico has over other cities and towns is that most of their water meters are located on public, government controlled land (Andres Garcia, personal communication, 2/3/2006). This means that PRASA does not have to contact the customers to replace or read their water meters.

Ownership of the PRASA has changed hands several times in past years. (McPhaul, 2005) By 2004, the government had privatized the Puerto Rican water system to two different companies, Ondeo and Vivendi. The first company, Vivendi, did an unsatisfactory job running the water system, allowing facilities to remain in disrepair and asking for more and more money to do their work.

Vivendi started to show signs of weakness quickly (Pucas, 2002, p.11). Complaints built up until 2001 when there were a documented 3,181 individual counts of faults and deficiencies in maintenance and administration. Customers consistently complained of paying for water they did not use as well as interruptions in their water service for days or weeks at a time. During these times of drought, health problems arose from the lack of fresh water and the physical labor involved in carrying back large quantities of water from a river or other source. Families that did not carry water had to stretch their budgets by buying bottled water.

Aside from service problems, the company was having financial problems as well (Pucas, 2002, 11). In 1999 the company deficit was around $241 million, which rose to $695 million in 2001. On top of this, the EPA fined them $6.2 million for violating EPA standards and they had not collected $165 million in bills.

When Vivendi's contract was up for renewal in 2002, Puerto Rico decided to contract with a different provider, Ondeo (Blasor, 2004, p.1). Ondeo was not much better than Vivendi, achieving a deficit of $1.2 billion as of June, 2003. Relations between the government and Ondeo were not on stable ground towards the end. When the government decided to cut their 10 year agreement short in 2004, they cited the fact that an extra $93 million was requested by Ondeo for the continuation of their services. Ondeo said they had been misinformed as to the status of the system and the $93 million was necessary to maintain functionality. At this point, the government stepped in and reclaimed control of PRASA.

According to the new president of PRASA the company was “a total mess” when they took over from Ondeo (McPhaul, 2005, p.1). This is a big factor in the water meter problems Puerto Rico is currently having. It is also reflected in the EPA’s quote, “Preventive maintenance at PRASA doesn’t exist at all.”

PRASA now has a replacement plan. Currently, all residential meters are replaced every ten years and their larger meters every five years. Regardless of this, any meter found to be ineffective is replaced immediately. The only other stipulation is that all meters replaced must be ready to accept Automatic Meter Reading technology. Finally, information is gathered on meters that may fail in the future, but it is not obvious as to whether this information is used.

Flow meters are essential to any water distribution system. They help with customer billing as well as system maintenance and monitoring. The meters must be managed and replaced correctly or else they will not be used to their full potential. Almost all areas that have water meters have a replacement plan to ensure that their meters are functioning correctly. In the case of Puerto Rico, their plan is not as robust as it should be. It is this as well as the increasing numbers of failing water meters that sparked PRASA into requesting assistance with these issues.

Chapter 3: Methodology

The goal for this project was to provide recommendations to PRASA (Puerto Rican Water and Sewer Authority) on how to improve their water meter management. To do this, we evaluated their current replacement effort in order to understand the state of the system. At the same time, the evaluation was designed to show us how their plan fared against other replacement plans. Additionally, we looked at their information system to see if there were any changes or upgrades that could be made to improve the system. Lastly, all of the information was compiled together to produce a series of recommendations for PRASA to follow. This chapter outlines the methodology we used to reach our conclusions.

3.1 Evaluation of Meter Replacement Plan

In 2005, PRASA replaced 100,000 water meters out of its approximately 1.3 million meters. In 2006, the organization planed to replace 200,000. Meter replacement is important to PRASA, prompted this evaluation of their meter replacement plan. This section will describe the methods used to evaluate Puerto Rico's current efforts for meter replacement and allowed us to make recommendations on how the effort can be improved.

3.1.1 Customer Survey

Our first method for evaluating the replacement plan was to survey a sample of PRASA's customer base. We chose a survey because it enabled us to ask more questions to a larger audience within a shorter time frame than interviews would allow. Considering the number and types of questions we wanted answered, we chose to use Likert Scales on our questionnaire. "A scale is a device for assigning units of analysis to categories of a variable" (Bernard, 2006, 318). In other words, the scale allowed for easy analysis of the responses received. The questionnaire measured the satisfaction of the customers and their awareness of a problem with meters on the island. Appendix C contains the questionnaire we administered to PRASA's customers.

The questionnaire was reviewed and revised by PRASA officials until it was ready to be administered. Convenience sampling was selected as the best sampling choice given the time frame and that a mall would be the best place to carry out our survey. Large numbers of people visit malls daily. This meant that we had access to more people than if we were to go door to door or mail out surveys. Plaza Las Americas and Plaza Del Caribe were the two malls at which we administered our survey. These malls are on different sides of the island, shopped at by people representing their communities. By combining the results of the two malls, a better representation of Puerto Rico was obtained. Our goal was to have 150 questionnaires completed by the end of the survey. However, due to time restraints and number of people willing to respond, we only received 84.

Convenience sampling does not guarantee that the data collected were representative of the entire population of Puerto Rico. Therefore, an attempt to increase the diversity of the responses was necessary. The sampling of different regions increased the quantity of responses and variety of the populace we questioned.

The survey results were analyzed by first gathering and quantifying the customers' opinions of PRASA. Subsequently, we used the same process for questions regarding their water consumption, water price and service reliability. The data received were categorized by question and graphed to determine if any correlations existed. See Appendix A for a sample questionnaire

3.1.2 Interview Directors of PRASA Replacement Plan

Our second method for evaluating the current plan was to survey/interview the customer service directors in all five regions of Puerto Rico. This method provided us with multiple perspectives on the replacement effort by gathering opinions and concerns from each director about the replacement. By determining what the directors were having a problem with, we were able to concentrate our focus on those sections and leave the functioning sections alone.

To create the survey questionnaire, we reviewed the responsibilities of the customer service department in PRASA. These responsibilities include meter replacement scheduling, the actual meter replacement and fielding customer requests. From this, we devised a small draft containing questions trying to elicit their thoughts on the efficiency of their current efforts. Budget, staffing, costs, and operating efficiency were all issues we felt were important to query on. We created specific questions that investigated these issues further to understand how each played a role in the department. We traveled to director meetings in each region to deliver our questionnaires. In addition to the ones on the questionnaire, we asked, in person, specific questions about problems they were having with their replacement effort and their opinions on other matters. See Appendix B for a sample questionnaire.

3.1.3 Compare the Current Plan to Plans from Other Locations

Researching past efforts was an important step in determining how to proceed. In light of this, we evaluated plans obtained from other agencies throughout the United States as discussed in Chapter 2. This involved reviewing their processes and determining if each was feasible for Puerto Rico. This determination was influenced by the results of the director and customer surveys as well as conversations with our liaisons. Additionally, the agencies overseeing these other replacement efforts were asked what problems they encountered and if there was anything they would change about their plans.

Information concerning progress of the current meter replacement was obtained and used to determine the state of the effort. The plan specifics of other water authorities were analyzed and the major replacement specifics were extracted. After this, each major plan specific was looked at and determined whether it could be directly implemented or adapted for use in Puerto Rico.

Comparing plans established a better sense of PRASA's relative level of efficiency and enabled us to further concentrate our focus for plan revisions. The plans were gathered prior to arriving but the comparison took place in Puerto Rico.

3.1.4 Cost-Benefit Analysis of New Meter Technology

In addition to an improved meter replacement plan, PRASA was interested in obtaining new meter technology. They expressed interest in a type of meter that allowed an employee to collect meter readings wirelessly. A cost-benefit analysis was performed on the current situation to determine whether purchasing a new meter reading system was more cost-effective than keeping the current one.

Costs on the current expenses, such as salaries of all personnel involved in the replacement, vehicle costs, meter costs and any other pertinent figures were gathered. Information concerning pricing, discounts on bulk purchases, accessory costs and similar information was gathered about several different metering systems. Any costs not available because they are not yet an issue for PRASA, such as AMR reading and revenue increases due to better accuracy, were inferred by using related figures within PRASA. Using these figures, an established cost-benefit analysis methodology was used to reach our conclusion. The results of this CBA were used to indicate which meter technology would be most appropriate and cost effective for PRASA. Our research and research done by PRASA was used to determine what metering systems were analyzed.

3.2 Evaluation of Current Information System

A good information system is central to having good data with which to make decisions. The information system in place at PRASA was thought to be outdated, preventing PRASA from working efficiently. Additionally, the data within the system itself could not be guaranteed to be 100 percent accurate.

3.2.1 Interview with System Administrators

We spoke with the administrators of the PRASA data center to determine what problems existed and how they might be solved. During the interview, we determined the age and shape of the system. We asked what kinds of reading systems worked with the current system and how readings taken in the field were inserted into the database. Finally, we determined what steps the administrators were taking to improve the system.

Additionally, we sent out employee questionnaires along with the director questionnaires. These surveys were to be filled out by employees that use the information system. Questions regarding ease of use, the accuracy of the data and what data should be accessible were used to obtain employee reactions to the system.

3.3 Creation of a New Replacement Plan

Meter replacement plans currently in place are not as effective as they could be. The plan must be enhanced with new procedures that are more efficient. The following sections detail the methods used to create the new plan.

3.3.1 Combine Ideal Strategies from Other Plans

After the evaluation of current plans from other locations, applicable strategies were derived and combined with the suggestions from the staff and customers to create a final set of recommendations. This method involved taking aspects from other plans and tailoring them to work for Puerto Rico.

Plan specifics from each plan were investigated and their suitability for Puerto Rico was judged. Judgment was based on the size of the area the plan came from, how inclusive the plan was for that area and how successful the plan was in meeting their needs. Additional information such as complexity and cost was gathered and used in the judgment as well. PRASA has more meters to deal with than most American water authorities. If a replacement strategy calls for the testing of every meter, but came from a town with 20,000 meters, this size discrepancy must be taken into account when adapting the plan for use in Puerto Rico. The same idea is applicable to any meter replacement strategy: anything used from these plans must be applicable in a situation 10 times larger than the one it came from.

Director and customer surveys were all considered when choosing a plan to implement. This allowed our time to be spent more efficiently, modifying proven replacement strategies rather than creating new ones. This method answers the question: what does an efficient plan look like? The final product was a series of recommendations given to improve their meter replacement strategies.

3.3.2 Iterative Drafting of Plan

The drafting process was the final stage of the plan development. Information we gathered was shared with our liaison in order to receive his feedback. This was continued throughout the initial drafting of the plan and the successive reviews and updates by our sponsor and advisors. Drafting the plan allowed us to determine what should be altered or improved. This method was chosen because it allowed the sponsors to give feedback on recommendations and enabled creation of the best plan possible for the authority.

This methodology was successful in accomplishing our goal of providing recommendations on how to make PRASAs meter management better. Customer and director surveys helped to establish the current state of the system as well as what could be changed about it. Evaluating replacement plans indicated how PRASA ranks in relation to other water utilities and helped identify new replacement techniques. The cost-benefit analysis showed us whether it was better for PRASA to keep their current system or replace it with a new one. Interviews with the data center administrators determined what was needed to improve the information system. The final recommendations were made based on the results of our combined research.

Chapter 4: Results and Data Analysis

The goal of our project was to provide PRASA (Puerto Rican Aqueduct and Sewer Authority) with recommendations and suggestions on how to improve their meter management system. In this chapter, we describe the results of our customer and director surveys. The main points of the plan comparisons will be detailed and the results of the cost benefit analysis will be presented. Finally, our observations on the information system will be explained. This chapter will focus on the analysis and presentation of our findings.

4.1 Evaluation of Meter Replacement

The purpose of this evaluation was to gain an understanding of the current system as well as its major problems. This section will present our findings on the customer survey, director survey, replacement plan evaluation and the cost-benefit analysis.

4.1.1 Customer Survey

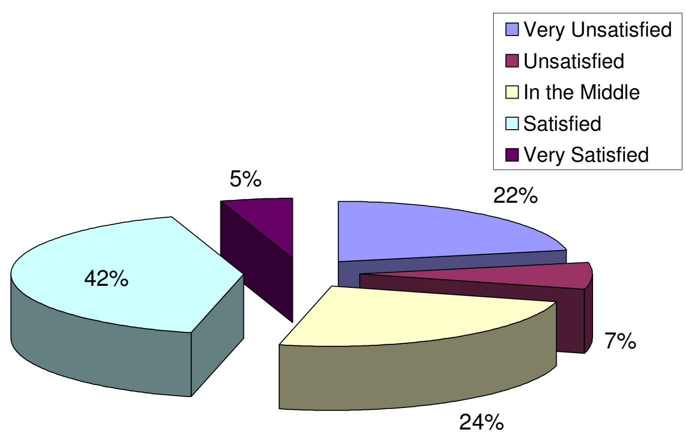


Figure 1 – Overall Satisfaction with PRASA

In total, we collected 84 questionnaires from Plaza Las Americas and Plaza Del Caribe in San Juan and Ponce. The information collected from the questionnaires was separated into four different categories: Overall Rating of PRASA, Pricing, Water Consumption Knowledge and lastly, Service Reliability and Interruptions. In general, people were willing to give us their opinions of PRASA, but many people did not have the time to fill out a questionnaire.

Overall opinions of PRASA were varied. A majority, seventy-one percent, of people said they were either satisfied or had no problem. A smaller percentage of customers, 22%, said they were very unsatisfied with PRASA's service. These results did not match our original predictions. Our preliminary predictions had people rating PRASA very negatively with only a few positive results. We drew these conclusions from the news articles and other research we conducted. Most of the articles studied about PRASA concerned the previous privatization, a sensitive issue. These articles were critical of the privatization, painting a negative picture of what people thought of PRASA.

It is important to note that the results of this survey likely do not represent the poorer communities in Puerto Rico, where water problems are the worst. The people living in these areas do not frequent large malls such as Plaza las Americas and Plaza Del Caribe, preventing their opinions from being determined.

Water consumption knowledge was the next concept analyzed. Around 47% of people know how much water they are using. However, only 34% reported that PRASA was informing them of their water usage. Expectedly, a large number of people reported they were not being under billed. Given our identity as PRASA representatives, people could have been hesitant about reporting any under billing, so this may not be an accurate representation of the actual number.

Service and reliability were the final concepts analyzed. Sixty-one percent of respondents said they were not given any warning before work was done that would leave them without water. Whether interruptions, planned or otherwise, were fixed promptly was a point of disagreement. Only 13% of people had nothing to say on the matter. The rest were split down the middle, half saying the downtime was acceptable while the rest said this was unacceptable. In total, the average downtime was reported in hours or days. Only a few respondents reported having outages lasting longer than this. However, the bias of our survey does not allow us to know how long outages last in poorer communities.

An interesting correlation between overall satisfaction and the service reliability rating was found. A scatter plot revealed that the lower the overall satisfaction, the lower the service reliability rating. The following graph illustrates this point:

Figure 2 - Overall Satisfaction vs. Reliability Rating

An interesting observation about this graph is that some people rated their service reliability higher than their overall satisfaction. From this, we can conclude that most people rated their satisfaction low because their service was not reliable. However, given that some people did not conform to this trend, there are possibly other reasons why people are not satisfied with their water service.

Price was something customers were also concerned about. Approximately 57% of people surveyed said that they paid too much for their water. A scatter plot of Pricing vs. Overall Satisfaction reveals a trend similar to the one above.

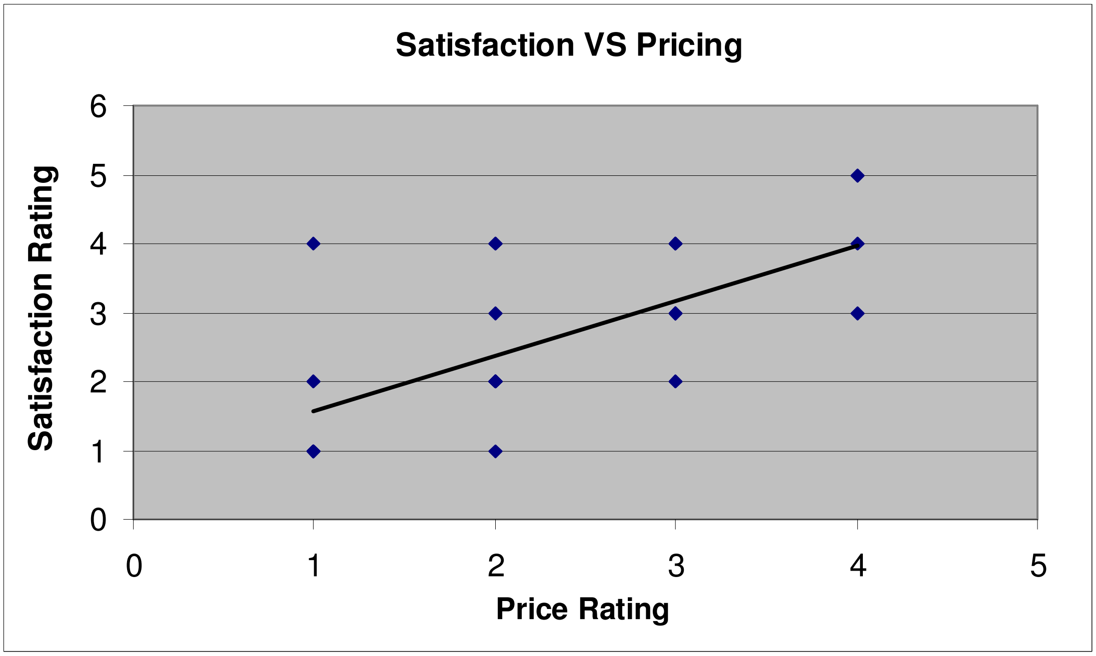


Figure 3 - Overall Satisfaction vs. Price Rating

The same trend, that is, people rating their overall satisfaction low when they rate their water prices fair, emerges in this graph as well. When the numbers are compared side by side, respondents can be grouped into four categories, as seen in the following graph:

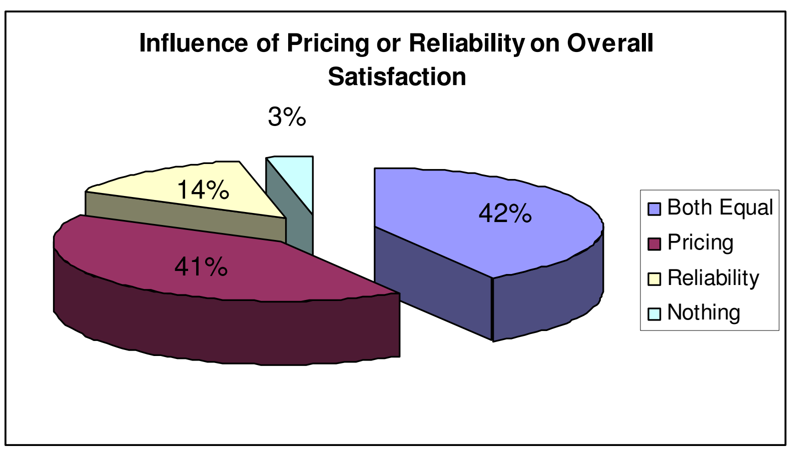


Figure 4 - Influence of Pricing or Reliability on Overall Satisfaction

About 42% of people rated their reliability and pricing equally with their overall satisfaction, meaning neither category influenced their overall satisfaction more than the other. A similar number of people, 41%, indicated that price was a larger factor than reliability in their overall reliability rating. Only 14% said that reliability was the larger contributor and the remaining 3% were dissatisfied with both pricing and service reliability. This is not to say the customers were totally satisfied with either factor, only that it was not the biggest influence. Some customers who followed the trend that pricing was a larger influence still rated reliability negatively. For these customers, pricing was closer to their overall satisfaction rating and vice versa. See Appendices C and D for survey data.

4.1.2 Director Interviews

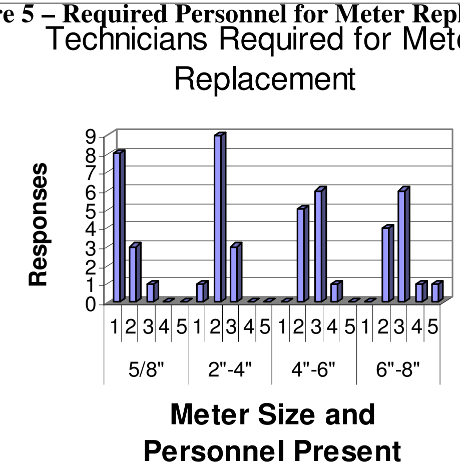
PRASA divides Puerto Rico into 5 regions: North, South, East, West and Metro. Of those regions, we have the results of four: Metro, East, West and South.

Our interviews and questionnaires revealed that there is one major problem common among the regions: buried or inaccessible meters. This problem ranges from meters covered in trash to having the cover completely cemented over. Each region experiences this problem differently, with the west region experiencing it the most.

There were some common themes among the regions. Firstly, all directors reported that, as the diameter of the meter goes up, so does the number of employees required to change it. Secondly, all regions agree that, if given the chance, they would hire more employees to help with their work.

In the East region, over 2000 meters were installed but not recorded into the information system. The West region has a large number of buried meters or meters that can not be accounted for. However, West Region officials are executing a 55 week plan to locate them all. Despite having problems, the West region seems to

Figure 5 – Required Personnel for Meter Replacement



be leading the replacement effort. Their meter replacement plan is said to be the best and is being considered as a standard for the island.

The primary difference between each region is how many meters they are having trouble locating. Their responses to all other questions were very similar, indicating the differences between the regions are minimal. While each region has its own issues to deal with, no regional plans are necessary. These problems can be solved by adapting the island's plan. PRASA wants island wide recommendations made, and an island plan would ensure that all regions are operating under the same replacement methods. From there, any special consideration for each region can be dealt with separately. See Appendices E, F, G, and H for survey data.

4.1.3 Plan Comparisons

For the plan comparison, plans were collected from locations such as Seattle, WA, Tucson, AZ, Toronto, Canada, and Tampa, FL. Besides comparing the plans, we extracted the replacement techniques and evaluated their usefulness for Puerto Rico.

On the whole, Puerto Rico's plan is equivalent in caliber to the other replacement plans that we have researched. Their replacement schedule is similar to that of Tucson, that is, set replacement schedules, where a certain number of meters are replaced every year. While Seattle has a more sophisticated large meter replacement plan, their residential meter replacement plan is to work the meters until failure. Even places like Toronto, which spent a great deal of time and money on their meter replacement, does not have much more than simple goals for how many meters a particular area should replace in a certain amount of time.

There were several main replacement strategies that were encountered while going through replacement plans: meter testing, private companies, future predictions and how to choose which meters to replace.

The city of Tampa uses strict testing procedures for their meter replacement. All meters are tested at some point during their life to determine which meters need to be replaced. This method, while a good way to ensure that the maximum life of a meter is reached, is not suitable for the island of Puerto Rico. Tampa only has around 120,000 meters while Puerto Rico has 1.3 million, making testing every meter on the island impractical.

There are only two ways available for PRASA to test the meters: test beds and individual testing. The beds can test 40 meters at a time and ensure that the meters are tested in the same manner. Currently, PRASA only has one bed for large meters and one bed for small meters. Additionally, the beds are very expensive.

The second method is individual testing of the selected meters. PRASA has a system to test a meter in half an hour. Currently, it is used only when customers request that testing be done on their meter. This method of testing could be done quicker and by more people than using the test beds, but the accuracy of testing could vary among test administrators and testing equipment.

Tucson uses a private company to do the meter replacement. The utility itself keeps track of which meters need to be replaced, but an external company goes into the field and changes the meter. Our contact at the Tucson Water Department said that using a private company was too much paperwork for a city of 486,699 people. Scaling this up to the island of Puerto Rico with 1.3 million water meters would be a significant amount of paperwork and communication to consider. Additionally, the results of the director survey indicate that there are sufficient employees and technicians at PRASA to do the replacement themselves.

Prediction of meters that are going to fail is something that a few utilities (including PRASA) perform, but do not always use. Tucson and PRASA both query their database for meters on the verge of failure. The results are stored and analyzed to locate any problem areas.

The way meters are chosen to be replaced is the final strategy considered. Most towns and cities do not have a replacement order, or the order is chosen by which meters will bring in the most money. This works for most areas, but Puerto Rico has a meter count of almost 10 times that of even the largest city that we investigated. Inefficient meter replacement selection strategies could lead to a backlog of meters needing replacement.

Most of the meter replacement strategies discussed in this chapter are not directly usable in Puerto Rico, but they can be adapted to work. Some techniques, such as contracting with a private company, could be adapted but would not be cost effective.

4.1.4 Cost-Benefit Analysis

The cost-benefit analysis performed allowed us to determine which metering and reading systems were the most cost-effective for PRASA. Five different systems were analyzed, including the current system, to determine the overall costs of each. This section will review the results of the analysis of each of the five systems.

The first system was the system that is currently in use by the authority. This system involves AMCO V100 water meters, which are read visually and the data recorded by hand. From internal PRASA cost documents, we were able to determine the costs of the system. This system, over the course of 10 years, will cost

AMR System/Meters	**Payback Period**	**ROI**	**IRR**	**Investment Total**
Datamatic/AMCO	1 yr 5 mo	1303%	214.3%	$142.3 Million
Badger(ORION)/AMCO	~11 years	-0.1%	0%	$438.3 Million
Badger(ORION)/Badger	3 yr 3 mo	623.%	65.4%	$197.5 Million
ITRON/AMCO	2 yr 5 mo	915.1%	100%	$187.6 Million

Table 1 - Comparison of AMR Systems

Please refer to Appendix I for cost data

PRASA around $88.3 Million. This figure includes the cost of replacing all 1.35 million water meters as well as the costs for reading the system yearly, or around $11.1 Million.

The next system studied would continue to use AMCO V100 meters and pair them with an AMR system from Datamatic Metering Systems Inc. This system would yield a large reduction in yearly costs, while increasing accuracy and efficiency. The initial investment in the system would cost around $141.4 Million for replacing all of the 1.35 Million meters, ten Mobile AMR systems, On-Site training, and system optimization. For the same system, but with 20 Mobile AMR systems, it would cost around $141.6 Million. One of the most significant benefits of an AMR system is the extreme reduction in reading costs. This system, as well as every other AMR system analyzed, will yield a yearly reading cost of $221,760, significantly lower than the current reading cost.

This system is the lowest in cost and contains a few features, including its compatibility with a number of other meters, which make it a good candidate for PRASA. If they were to switch to another meter, there is a good chance the transmitters would still work. Additionally, they are a very high-tech company, having a lot of experience outfitting a water authority with advanced equipment. There is, however, a major drawback. This system would have the meters being read by an employee in a vehicle. To use a fixed-network system, where stationary receivers are placed throughout the area with readings transmitted over phone or internet lines, different transmitters would be needed. PRASA is planning on upgrading to a fixed network system in the near future. This system would entail a great deal more work in the future and ultimately cost them more money.

Thirdly, we reviewed a system using the AMCO V100 with the ORION system from Badger Water Meters. The initial cost of the investment would total around $438.3 Million for a 10-system kit, including the AMCO Meters, Badger AMR hardware and software, and personnel training. A 20-system kit would cost around $438.5 Million and would enable the authority to read the entire island's meters in a fraction of the time it takes with manual reading.

This system is very costly in comparison to the other systems. This is primarily due to the conversion from the signals that the AMCO meters emit to the ones required by the Badger transmitters. Besides this issue, Badger is a reliable company that PRASA has had experience with in the past. If this system did not represent such a large investment, it would be a reliable choice.

The next system was the same Badger AMR system from above, but matched with the Badger Recordall Disc meter. This system, while more costly than the previously mentioned one, will interface better due to the fact that the AMR system was engineered to match the meters. The system, with 10 mobile AMR systems, would cost about $197.5 Million, while the system with 20 mobile AMR systems would cost around $197.7 Million. Again, the extra 10 systems would allow the authority to read the entire island's meter supply, accurately, in half the time it would take a 10 mobile reader system. However, if this system is chosen, any meters installed after January 1st, 2005 would be lost and in need of replacement. This means that, if the new system is installed starting on January 1st, 2007, 330,000 AMCO meters would be rendered useless and, at the least, $7,500,000 worth of meters would have been wasted. This amount would have to be added to the cost of the final system, raising the total cost for this system by 7.5 Million dollars.

This system is very similar to the other Badger system, using the same transmitters. Additionally, the introduction of badger meters removes the need for the very expensive conversion piece. However, the issue concerning the older meters is an important one. Replacing the meters is not just a matter of money, but time as well. The time and effort necessary to go back and replace the older meters while continually replacing newer meters are issues that cannot be overlooked.

The final system analyzed was a system from ITRON Automated Systems which would use the AMCO V100 meter. This system wound up being the second cheapest option with a final cost of around $182.1 Million for a system with 10 mobile AMR devices, or around $183 Million for a system with 20 mobile AMR devices. Additionally, this system is the preferred system of the Customer Service department and the system they were looking into the most.

This system, while not being the cheapest, boasts a very important feature. The transmitters can interface with either a vehicle mounted reading system or a fixed-network reading system. This means additional transmitters would not be necessary for the upgrade to fixed-network. This flexibility coupled with the inexpensive price tag makes this an ideal candidate.

4.2 Evaluation of Information System

The information system used at PRASA contains meter age and usage information as well as billing and similar information. Our first impressions of the system were that it appeared to be outdated and difficult to use. Our conversations with the system administrators were helpful in learning about the system to determine possible improvements.

4.2.1 Interview with Administrators

Information we discovered upon meeting with the information system administrators contradicted initial impressions of the system. First and foremost, while the billing software is roughly 10 years old, the hardware is only three. This is a significant improvement in technology and puts the system in a much better position than we previously had thought.

The data center has a very modern and professional look. During our interview, the data center administrators demonstrated their knowledge and grasp of the situation by answering all our questions quickly and completely. The administrators indicated that the current hardware setup was more than capable of meeting the needs of PRASA. The main problem they are having is maintenance. A complete system shutdown and restart takes between 6 and 7 hours. Additionally, a ten year old software program, while still doing its job, is not as efficient and user friendly as a newer program.

Currently, the data center has been analyzing the bids it received for a new information system. They will be moving away from mainframes, powerful but older computers used for intensive calculations, to a more traditional server model, newer computers based on a different architecture that makes them easier to use and maintain. Their goal is to have the upgrade process finished within three years.

The data and analysis presented in this section were used to reach conclusions and form recommendations that would benefit PRASA in both the near and distant future.

Chapter 5: Conclusions and Recommendations

The goal of this project was to provide recommendations and suggestions to PRASA (Puerto Rican Aqueduct and Sewer Authority) regarding their water meter replacement strategies and management techniques. To this end, we performed an evaluation of their current practices, an investigation of other water authorities, and a feasibility study of newer metering technologies. Based on this, we formed conclusions and recommendations to help PRASA improve their meter management practices and information system.

5.1 Meter Replacement Strategies

The majority of this project dealt with meter replacement strategies, specifically, how the meters are replaced and what they should be replaced with. Additionally, processes relating to customer service were investigated. This section details our conclusions and recommendations on these issues.

5.1.1 Metering Technology

The results of the cost-benefit analysis were used to determine which system PRASA should implement in order to reduce overall costs and improve the efficiency and accuracy of the meter readings. This section will detail our conclusions about each system, and then will present our recommendations for the best AMR system to use.

The current system, while using quality meters, no longer uses efficient reading practices. Automatic meter reading systems have been readily available, and widely used, for around 10 years. These systems have rendered manual reading practices virtually obsolete. The current reading practices cost PRASA around 11 million per year which is significantly more than the costs to use the newer AMR systems. Simply by switching to *any* AMR system, PRASA will reap the benefits of a significant decrease in expenses per year. Additionally, the increased accuracy and efficiency will lead to significantly higher revenue generation as well. Thus we recommend that PRASA move to a newer AMR system as soon as possible in order to save money and increase its revenue generation potential.

The system that uses Badger meters and AMR devices, while providing one of the better integrated solutions, represents a large investment of time and money to replace the currently installed meters. To use this system, any AMCO meters in the field would need to be replaced by Badger hardware. This represents at the very least a $7,500,000 loss in meters and an additional two years of replacement. Adding this to the already expensive $197.8 Million system renders a cost of nearly $205 Million. This cost is a large one, and certainly more difficult to recover from.

Similarly, the system using Badger AMR and AMCO meters is far too expensive to consider. The astronomical cost does not allow this system to pay itself off in an acceptable amount of time, 11 years as opposed to 2 or 3 for the other systems. This would leave PRASA attempting to recover from its losses for a long period of time.

Although the Datamatic system is the least expensive, it has a significant drawback that does not allow us to recommend it. While being the cheapest system, the transmitters for vehicle reading are not compatible with a fixed-network system. This is something PRASA needs to have the flexibility to do without more cost and replacement issues.

The only system without a major drawback is the ITRON AMR and AMCO meters system. Its low cost makes it comparable to Datamatic but the flexibility it offers when it comes to vehicle and fixed-network reading makes it the only real choice.

Based on these evaluations, using the ITRON AMR system with the currently installed AMCO V100 water meters is the most cost-effective solution as it will save PRASA the same amount each year and provide them with quality and flexible AMR technology from a company they have been doing business with for many years.

5.1.2 Automatic Meter Reading (AMR) Technology

PRASA has been investigating the use of Automatic Meter Reading technology. The decision regarding whether to keep the current meters and the accompanying AMR technology, or to use or a completely new metering technology needs to be made promptly. PRASA is currently in the process of replacing a large number of meters. Each meter replaced is not being replaced with the proper AMR transmitter. If the decision to install AMR technology is delayed, the number of meters that must be revisited will increase each year. The worst case scenario is that every meter on the island must be revisited and fitted with AMR technology. Making the switch earlier will allow the meters currently being replaced to be fitted with AMR technology.

5.1.3 Meter Replacement Timeline

PRASA would like to be able to replace every meter on the island within a timeframe of 6 to 7 years. In order to do this, an average of 200,000 meters should be replaced each year, starting in 2006. According to data received during the plan comparison, PRASA's monthly replacement goal for 2006 is 17,000 meters a month. In January they replaced 15,225 meters and in February they replaced 21,269. In March, they replaced roughly 18,000 meters. These numbers average 18,164 meters per month. Continuing their current trend, they could replace 217,967 meters by the end of this year. Given this information, we feel PRASA should continue to replace meters as it has been. At the end of the year, the goal and the actual number should be compared. If PRASA is within 20,000 to 30,000 meters of their goal, they should continue. If not, a more realistic quota should be created and evaluated the following year.

In order to facilitate this replacement, meters should be replaced in groups. Meters in close proximity should be replaced by the same technician(s) on the same trip. Meters close to needing replacement should be considered for replacement. Replacing a still functioning meter may save money by doing so along with meters that do need replacing. This way, a separate trip to the meter will not be necessary in the future. Densely populated regions lend themselves to this strategy because their meters are close together, so grouping is easy. Sparsely populated regions would benefit from this by reducing the travel time needed to go from meter to meter.

5.1.4 Meter Testing

With the introduction of AMR, fewer PRASA technicians will be needed to do meter readings. The increase in available personnel could be utilized for a meter-testing plan. Other water authorities have implemented similar techniques with positive results. The number of meters PRASA manages is too large to test every one in a timely manner. Therefore, a representative sample of meters could be used to determine the health of the system. Samples taken over time could provide a more accurate measurement of meter life and usage. From this, a refined meter replacement timeline could be made.

This testing should be done with the equipment used to test a meter at a customer's request. This would allow testing to be done on site and the results recorded immediately. The use of a test bed would allow many meters to be tested at once, however, the time needed to collect and replace the selected meters and bring them back for testing is more work than doing the testing on site. Additionally, PRASA only has one small meter test bed. For test beds to be used, each region would need at least one test bed of its own.

Selecting which meters to test is important. Testing every meter is only possible if meters are grouped and tests are done over a long period of time. At half an hour a test, not counting travel time or other breaks, it would take 140 employees 11 weeks to test 130,000 meters. This could be done over the course of ten years until all meters had been serviced.

A method that would produce quicker results would be random testing. Each region would randomly select 10-20% of the meters on each reading route to test. Selecting meters from each route as opposed to from the entire region would ensure that each round of testing took meters from all over the region. Randomly selecting from the regional pool of meters could result in grouping and depict an inaccurate portrayal of the region.

If, through testing, it is determined that a particular region's meters last longer than the others, that region should replace their meters less often. Adjusting its replacement timeline to make better use of the meter would save time and money. A slower paced replacement timeline would allow more meters to be tested by the workers not needed for meter replacement.

If it is determined that a region's meters do not last as long as other regions, the replacement should be stepped up, replacing the meters sooner. This will ensure that a meter is replaced once it begins to underestimate water usage. It is possible that the entire island would show a significant increase or decrease in average meter life after these tests. If this is so, the replacement timeline for the entire island would be changed to match the new data.

A faster paced replacement timeline would require more work from the technicians. If the increase in work is minimal, replacement schedules can be adjusted so workers from adjacent regions could assist in the replacement. This way, for example, workers from the metro and north regions could concentrate on the metro region one week and the northern region the next, removing the need to hire more workers. If the work is too much, additional workers could be hired or replacement schedules could be offset in order for resource pooling to be more effective.

5.1.5 Informing Customers of Work to be Done

One of the major results of the survey was that 61% of customers felt they were not given sufficient time before work was done that would leave them without water. The current meter replacement plan states that meters needing replacement in the near future are searched for in the database. These two pieces of information can be combined and the customer could be informed approximately when services like meter replacement would happen. The preferred method of notification as indicated by 64% of the customers was postal mail. To save postage, the notification could be sent with the water bill in the form of an insert to catch the customers' attention. Customers would be given a window of time, during which their meter would be replaced. Any possible concerns or conflicts could be dealt with prior to the work.

5.2 Information System Recommendations

While PRASA is using relatively old software and slightly newer hardware that should be replaced, the PRASA data center is in the process of collecting and analyzing bids for a new system. They hope to have the upgrade process completed within three years. Based on the amount of progress the data center has already made and the level of competence we saw in the data center administrators, PRASA should continue on its present course in the information system area without any changes.

These recommendations, coupled with the experience and talent employees at PRASA, will help improve meter management and customer satisfaction by better utilizing resources and information.

References

1. Allender, Hans D. (1996). Determining the economical optimum life of residential water meters. *Water Engineering & Management 143*(9), 20-24.

   Talks about water meter replacement and how often to replace them to minimize costs.

2. Bernard, H. Russell. (2006). Research Methods in Anthropology 3rd edition. New York: AltaMira Press.
   Considerations and research methods, used primarily for the construction of surveys

3. Blasor, Lorraine. (2004). Ondeo terminated in Puerto Rico. Retrieved Feb 20th from http://www.waterindustry.org/New%20Projects/prasa-1.htm
   Contains information concerning Ondeo and their relationship with the government.

4. Canfield, R. V. (1986). Cost optimization of periodic preventive maintenance. *IEEE Transactions on Reliability*, *35*(1), 78-81.
   Article talks about preventative maintenance and how to make sure you are getting the most out of it. Preventative maintenance plays a role in the replacement of flow meters before they actually fail.

5. City of Toronto, CFO. (2002). Water Metering and Meter Reading Technology Options for the City of Toronto. Retrieved Feb 26th from http://www.toronto.ca/legdocs/2002/agendas/committees/wks/wks021009/it002.pdf
   An in depth analysis on Toronto, Canada's water system. Provides recommendations and time tables on what to do and when to do it.

6. Flanagan, Larry. (2005). What is this thing called calorimetric?. Retrieved on Jan 30th, 2006 from The Flow meter directory http://www.flowmeterdirectory.com/flowmeter_artc/flowmeter_artc_05082801.html
   This website is a source of suppliers and prices of water meters. A good general background for flow meters. Retrieved on Jan 30th, 2006

7. Food and Agriculture Organization of the United Nations – Land and Water Development Division. (2005). Retrieved From Aquastat online database http://www.fao.org/ag/agl/aglw/aquastat/dbase/index.stm
   Provides water usage statistics for many areas around the world (including Puerto Rico) as well as other related statistics. Retrieved on Jan 30th, 2006

8. Gomez, Morera. (2006). Document – Badger Meter Price Sheet. Unpublished internal document, BadgerMeters Inc., Milwaukee, WI**.**
   This document contained confidential pricing information concerning Badger metering systems

9. Henry, Mark. (2006). Document – ITRON Meter Price Sheet. Unpublished internal document, ITRON, Spokane, WA.
This document contained confidential pricing information concerning ITRON metering systems

10. The Industrial Manufacturers Directory. (2006). - Flow Meters (http://www.iqsdirectory.com/info/flow-meters/index.htm)
Basic information on water meters as well as links to many other places on the internet dealing with water meters. Retrieved on Jan 30th, 2006

11. Jackson, M. (1996). AMR installation: Make your own decision. *Water Engineering & Management, 143*(8), 21-22. Retrieved Jan 30th from the ArticleFirst database
This is an article about a water meter replacement program done in Pontiac, Michigan. Will help us gain perspective on previous water replacement programs.

12. Luciano, Miguel. (2006). Document – AAA Revenue and Consumption Figures. Unpublished internal document, PRASA, San Juan, PR.
This report contained data on internal PRASA costs and consumption figures.

13. Luciano, Miguel. (2006). Document – Datamatic Price Sheet. Unpublished internal document, PRASA, San Juan, PR.
This report detailed meter system prices given to Miguel by Datamatic.

14. McLees, William P. (1993). Anatomy of a water meter replacement program. *Water Engineering & Management, 140*(1), 22-23. Retrieved Jan 30 from the ArticleFirst database
This is an article about a water meter replacement program done in Atlantic City, NJ. Will help us get an idea of what people have done in the past

15. McPhaul, John. (2005). Government took reins of water authority, faced strike. Retrieved February 10th from http://www.waterindustry.org/Water-Facts/puerto%20rico-4.htm
This is article details PRASA's previous experience with privatization

16. Ortiz-Zayas, J.R (2004). Integrated Water Resources Management in the Luquillo Mountains, Puerto Rico: An Evolving Process. *International Journal of Water Resources Development, 20* (3), 387-398.
Water management issues for an area of Puerto Rico. It is important to know all of the water issues concerning all areas of Puerto Rico to better understand how the meters would be placed.

17. Perez, Alphonso. (2006). Document – AMCO Meter Price Sheet. Unpublished internal document, AMCO, Isabella, PR.
This document contained confidential pricing information concerning AMCO metering systems

18. Pigram, John J. (2000). Water Resources Management in Island Environments: The Challenge of Tourism Development. Retrieved Jan. 30, 2006 from http://www.une.edu.au/cwpr/Papers/update.pdf

The article talks about tourism and how water management plays an important role when that tourism is on an island. The article gives pertinent information on water island concerns.

19. PRASA – Nueva Estructura Tarifaria, (2006). Conozca su nueva tarifa Retrieved March 23rd from (http://www.acueductospr.com/nueva_estructura_tarifaria.htm)
    Provided current and future PRASA water rates for the island of Puerto Rico

20. Pridco – Operation Advantages Infrastructure, (2006). Water (http://www.pridco.com/english/operational_advantages/4.3opr_adv_infrastructure.html)
    Gives more statistics on the water infrastructure of the PRASA (Puerto Rico Aqueduct and Sewer Authority). Retrieved on Jan 30th, 2006.

21. Puscas, Darren. (2002). Vivendi Universal – Corporate Profile.
Retrieved Feb 20th, 2006 from
http://www.polarisinstitute.org/corp_profiles/public_service_gats_pdfs/VivendiProfile.pdf
    A look at various Vivendi projects and their outcomes. Discusses their venture into Puerto Rico

22. Satterfield, Zane., & Bhardwaj, Vipin. (2004). Water Meters. Retrieved Jan 30th, 2006 from http://www.nesc.wvu.edu/ndwc/articles/OT/SU04/TechBrief_WaterMeters.pdf
    Article provides reasons for having flow meters other than customer payment as well as meter information. It helps to justify why the meters need to be fixed.

23. Schlenger, Donald L. (2000). Best Meter Management Practices for Water Utilities. Water engineering & management, 147(8), 14-15. Retrieved Jan 30th from the ArticleFirst database
    Gives water meter purchasing and management advice. Will give another perspective on how other people think water meters should be handled.

24. Shea, Kendra., Horsman, Dale, & Hanson Eric, (2002). IQP – Water Conservation Options for Fajardo, Puerto Rico. Unpublished IQP report, WPI, Worcester, MA.
    Names big water consuming companies as well as general water use patterns for Puerto Rico.

25. Smith, Anthony M. (2005). Four task categories to understand in undertaking preventive maintenance. *Plant Engineering, 59*(12), 37.
    Article talks about preventative maintenance and different styles of doing so. Preventative maintenance plays a key role in keeping a large system of breakable units running smoothly.

26. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. (2004, June). *Water Management Plan for Fort Buchanan, Puerto Rico*. Retrieved Jan 30th, 2006, from http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14533.pdf
    Water management plan for a fort in North Western Puerto Rico, specifically the section on metering. Provides a glimpse at the water concerns for this fort and metering concerns and distribution for this fort.

27. Wilson, Tom. (1985). Evaluation Strategies for Library/Information Systems. Unpublished paper, University of Sheffield.

Metrics and suggestions for evaluating information systems.

28. WPI Global Perspectives Program. (2004). The IQP and the WPI Plan http://www.wpi.edu/Academics/Depts/IGSD/IQPHbook/ch1.html

Contains the definition of an IQP.

Appendices

Appendix A: Customer Questionnaire

Estudio Sobre el Servicio de Agua En Puerto Rico

Aclaración: Este documento es un estudio sobre las opiniones del servicio de la Autoridad de Acueductos y Alcantarillados. Será administrado por estudiantes de Worcester Polytechnic Institute, una universidad de los Estados Unidos, como parte de un proyecto educativo. La información obtenida de este estudio sólo será usada para los propósitos del proyecto, y por la Autoridad en un intento de mejorar servicio a sus clientes. También, toda de esta información será privada y anónima.

Edad: _________ Sexo: Masculino ó Femenino

Ciudad: ______________________ Ocupación: _________________________

Tipo de Residencia: Casa Apartamento Condominio Otro

____

<u>Por favor circule el artículo que se siente retrata lo mejor sus opiniones.</u>

1. En general, estoy satisfecho con el servicio que ofrece la Autoridad de Acueductos y Alcantarillados (AAA).

Muy en desacuerdo En desacuerdo Ni de acuerdo ni en desacuerdo De acuerdo Muy de acuerdo

2. Se me factura por la cantidad de agua que uso.

Muy en desacuerdo En desacuerdo Ni de acuerdo ni en desacuerdo De acuerdo Muy de acuerdo

3. Usualmente, se me factura por menos agua de la que uso.

Muy en desacuerdo En desacuerdo Ni de acuerdo ni en desacuerdo De acuerdo Muy de acuerdo

4. No sé exactamente la cantidad de agua que uso.

Muy en desacuerdo En desacuerdo Ni de acuerdo ni en desacuerdo De acuerdo Muy de acuerdo

5. Comparado a lo que pago por otras utilidades, como electricidad, el precio de agua es apropiado.

Muy en desacuerdo En desacuerdo Ni de acuerdo ni en desacuerdo De acuerdo Muy de acuerdo

6. Se me notifica, con tiempo suficiente, sobre algún trabajo que la AAA va a realizar y me va a dejar sin agua.

Muy en desacuerdo **En desacuerdo** **Ni de acuerdo ni en desacuerdo** **De acuerdo** **Muy de acuerdo**

7. ¿Cuánto tiempo antes del servicio Vd. debe estar notificado?

1-3 días **3-5 días** **5-7 días** **2 semanas** **Un Mes** **Más de un Mes**

8. Debo estar notificado por:

Correo **Teléfono** **En Persona** **Correo Electrónico** **Toda de Estas Maneras**

9. El servicio de agua en mi comunidad es interrumpido frecuentemente.

Muy en desacuerdo **En desacuerdo** **Ni de acuerdo ni en desacuerdo** **De acuerdo** **Muy de acuerdo**

10. Algunas interrupciones de servicio, cuando ocurrieron, fueron corregidas pronto.

Muy en desacuerdo **En desacuerdo** **Ni de acuerdo ni en desacuerdo** **De acuerdo** **Muy de acuerdo**

11. Las interrupciones de servicio en mi casa o comunidad pueden durar por días o semanas.

Muy en desacuerdo **En desacuerdo** **Ni de acuerdo ni en desacuerdo** **De acuerdo** **Muy de acuerdo**

12. Durante el día, el tiempo más conveniente de trabajar en mi sistema de agua es:

La Mañana **Medio Día** **La Tarde**

13. ¿Ha tenido unos problemas sobre que debemos saber? **Sí** **No**

Por Favor, descríbalos:

____

____

____

____

Appendix B: Customer Service Questionnaire

INSPECCIÓN DEPARTMENTAL – SERVICIO DEL CLIENTES

Las respuestas de este estudio estarán usadas en un Interactive Qualifying Project (IQP) por un grupo de estudiantes de Worcester Polytechnic Institute. Para asegurar la representación correcta de su departamento, por favor conteste las preguntas lo más completa y honradamente que pueda.

1) Por favor, dénos sus opiniones en las preguntas siguientes:

	Discrepo				Convengo
Los contadores usados ahora son los mejores para la Isla	**1**	**2**	**3**	**4**	**5**
La tecnología para leer los contadores de agua usada ahora es la mejor.	**1**	**2**	**3**	**4**	**5**
AMR es el paso próximo por la tecnología de leer.	**1**	**2**	**3**	**4**	**5**
AMR debe ser instalado tan pronto que sea posible.	**1**	**2**	**3**	**4**	**5**
Los contadores usados ahora están los mejores por usar con AMR.	**1**	**2**	**3**	**4**	**5**

1) ¿En promedio, cuántos técnicos están en un reemplazo de contador?

Técnicos

Reemplazo de Contador Residencial	**1**	**2**	**3**	**4**	**5**	**6+**
2” – 4” Reemplazo de Contador	**1**	**2**	**3**	**4**	**5**	**6+**
4” – 6” Reemplazo de Contador	**1**	**2**	**3**	**4**	**5**	**6+**
6” – 8” Reemplazo de Contador	**1**	**2**	**3**	**4**	**5**	**6+**

Empleados
(Lo incluya supervisores, no-técnicos, y técnicos)

Reemplazo de Contador Residencial	**1**	**2**	**3**	**4**	**5**	**6+**
2” – 4” Reemplazo de Contador	**1**	**2**	**3**	**4**	**5**	**6+**
4” – 6” Reemplazo de Contador	**1**	**2**	**3**	**4**	**5**	**6+**
6” – 8” Reemplazo de Contador	**1**	**2**	**3**	**4**	**5**	**6+**

a) ¿Cuántas personas están necesario por un reemplazo de contador?

Técnicos

Reemplazo de Contador Residencial	**1**	**2**	**3**	**4**	**5**	**6+**
2” – 4” Reemplazo de Contador	**1**	**2**	**3**	**4**	**5**	**6+**
4” – 6” Reemplazo de Contador	**1**	**2**	**3**	**4**	**5**	**6+**
6” – 8” Reemplazo de Contador	**1**	**2**	**3**	**4**	**5**	**6+**

Empleados
(Lo incluya supervisores, no-técnicos, y técnicos)

Reemplazo de Contador Residencial	**1**	**2**	**3**	**4**	**5**	**6+**
2" – 4" Reemplazo de Contador	**1**	**2**	**3**	**4**	**5**	**6+**
4" – 6" Reemplazo de Contador	**1**	**2**	**3**	**4**	**5**	**6+**
6" – 8" Reemplazo de Contador	**1**	**2**	**3**	**4**	**5**	**6+**

b) ¿Afecta las decisiones de su organización el Sindicato? **Sí** **No**

	Poquito				Mucho
Si es la verdad, ¿cuánto?	**1**	**2**	**3**	**4**	**5**

¿Cómo? ____

____

2) ¿Hay problemas de acceso a los contadores? **Sí** **No**

a) Si es la verdad, ¿qué tipos de problemas pueden ocurrir durante de un reemplazo?

(a) Tubos Viejos **(b) Control de Acceso**

(c) Seguridad **(d) Vegetación o Hierba Excesiva**

(e) Otro ______________________________

3) ¿Qué se puede hacer para hacer este proceso más eficiente?

	Discrepo				Convengo
Debe haber más técnicos.	**1**	**2**	**3**	**4**	**5**
Debe haber menos técnicos.	**1**	**2**	**3**	**4**	**5**
Debe estar instrucción mejor para los técnicos.	**1**	**2**	**3**	**4**	**5**
Los técnicos deben tener instrumentos mejores.	**1**	**2**	**3**	**4**	**5**
Tubo y contador deben ser conectados antes de cada instalación: (Reemplazando los términos de los tubos cada vez)	**1**	**2**	**3**	**4**	**5**
Especialización de los Técnicos: (Sólo trabajan en un tipo de contador específico: 5/8" o 2"+)	**1**	**2**	**3**	**4**	**5**

4) ¿Cuántos empleados están en el departamento de Servicio de los Clientes en su región?

____

a) ¿Debe haber más? **Sí** **No**

b) ¿Debe haber menos? **Sí** **No**

¿Cuántos empleados crearían una situación ideal por su departamento? ______________

Appendix C: Customer Survey Results – Plaza Las Americas

QUESTION ANSWERS:

1	2	3	4	5	6	7	8	9	10	11
3	3	4	2	4	2	4	2	4	3	2
4	3	4	2	3	3	4	3	2	2	2
3	3	3	1	4	1	1	3	4	2	2
4	2	2	1	1	1	2	4	2	4	3
4	2	3	2	3	1	5	3	2	4	1
4	2	2	2	2	1	5	2	3	4	2
1	1	1	1	1	1	1	1	1	1	1
4	2	3	3	3	2	2	2	2	4	2
3	2	2	1	1	2	4	1	5	2	4
1	5	1	1	1	1	1	1	5	1	1
3	3	4	1	2	3	4	4	1	4	1
3	3	4	1	4	1	5	2	2	3	2
5	5	4	3	4	4	3	5	2	5	2
4	3	3	2	3	1	5	4	4	2	4
1	4	1	1	1	1	4				
1	4	1	4	1	1	4	1	4	4	2
1	5	5	1	2	1	3	2	2	5	2
4	2	5	1	4	4	1	4	1	5	1
3	2	5	1	2	2	2	2	3	4	2
1	5	4	3	3	1	3	1	5	2	4
4	2	4	2	3	1	1	3	2	2	3
2	4	1	1	2	1	5	3	2	2	4
4	3	4	1	1	1	5	2	5	2	2
5	2	3	1	5	3	3	4	2	4	1
4	2	4	2	2	4	2	4	1	5	1
3	3	3	2	2	4	3	3	2	3	2
4	4	2	2	4	2	2	4	2	2	2
4	2	1	4	5	5	5	3	2	1	5
2	4	1	1	2	1	1	1	4	1	2
1	5	1	2	2	3	2	1	3	1	1
3	3	3	3	3	5	1	1	1	5	3
4	2	4	1	2	2	3	4	3	3	1
1	4	3	0	4	4	4	3	4	0	2
1	5	3	3	3	2	4	2	4	4	3
4	4	4	4	3	4	4	4	3	4	4
3	3	2	3	2	4	3				
3	3	3	3	3	3	3	3	3	3	3
4	3	3	3	3	3	3	4	3	2	3
4	1	4	2	2	1	4	2	2	4	2
4	2	2	3	3	4	2	4	2	2	2
2	2	4	1	4	2	2	2	4	2	2
Average:										
3	3	2.9	1.9	2.7	2	3	2.7	2.8	2.9	2.26

Table 2 - Customer Survey Results - Plaza Las Americas

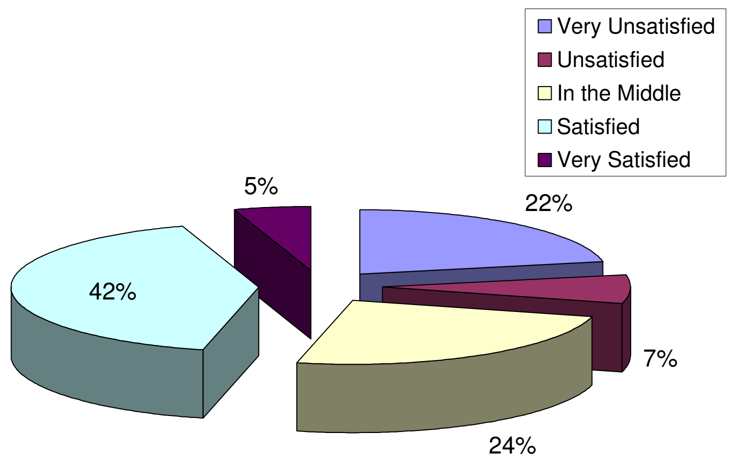


Figure 5 - Overall Satisfaction of Customers with PRASA - Plasa Las Americas

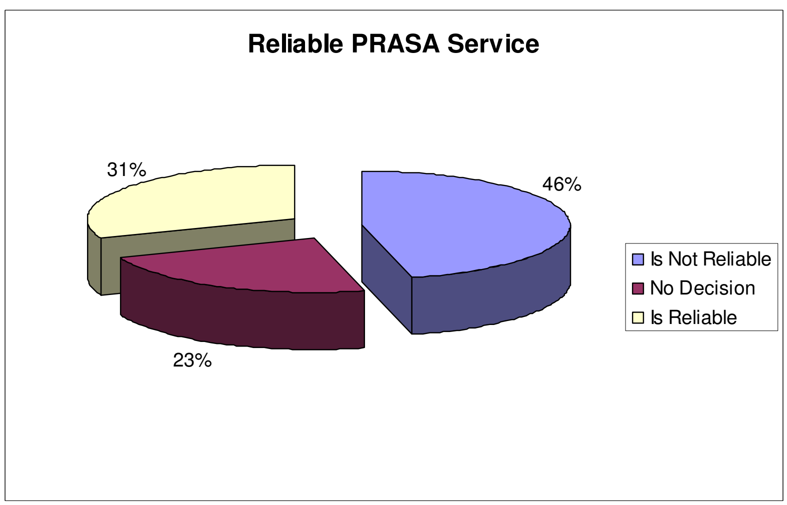


Figure 6 - Opinions on Reliability of PRASA Service - Plaza Las Americas

Appendix D: Customer Survey Results – Plaza Del Caribe

Age	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
24	1	1	1	5	2	5	6	5	1	5	1	2
59	1	2	1	2	1	1	1	5	3	2	2	3
64	4	1	5	4	5	4	2	3	3	4	3	1
59	2	2	2	4	2	1	2	2	2	2	2	3
38	3	4	2	2	4	2	1	1	2	3	4	1
63	2	2	2	2	2	4	1	5	4	4	4	3
22	1	2	1	4	1	1	3	12	1	3	1	1
52	1	1	1	4	1	1	3	5	5	1	1	2
31	3	4	2	4	4	2	3	13	4	2	4	1
58	1	2	1	2	2	1	1	5	5	1	4	1
50	1	1	2	3	1	2	3	1	5	2	4	1
54	2	1	1	4	2	1	2	5	5	2	1	3
60	2	4	2	4	4	1	1	123	4	1	4	3
38	2	2	2	2	2	1	4	1	2	4	2	3
57	3	4	2	2	4	2	1	3	2	3	2	3
68	1	1	1	1	1	1	1	3	3	4	1	1
30	3	3	3	3	2	4	4	23	4	4	4	2
60	1	2	4	2	1	1	5	5	2	4	1	
54	2	2	1	1	2	1	3	5	4	1	4	3
75	2	4	1	1	4	1	2	2	2	2	2	3
67	1	4	2	2	4	1	3	1	2	4	2	1
48	3	2	2	4	3	1	1	1	4	2	4	1
73	2	2	2	4	2	1	2	2	4	2	4	2
37	4	4	2	3	3	1	2	1	2	4	2	1
23	4	4	1	4	4	1	2	2	4	3	3	1
52	2	2	2	2	1	1	2	5	4	2	4	1
51	3	3	2	2	3	2	2	5	2	2	2	3
31	3	3	1	3	2	1	3	5	3	3	4	1
33	3	2	2	3	3	2	1	otro	2	3	4	1
53	2	3	2	2	3	2	4	1	4	1	4	3

Table 3 - Customer Survey Results - Ponce

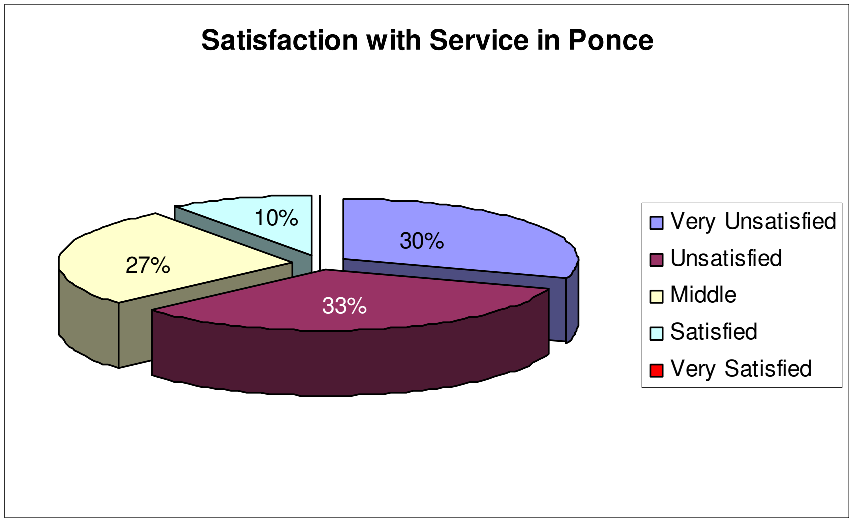


Figure 7 - Satisfaction with Service in Ponce

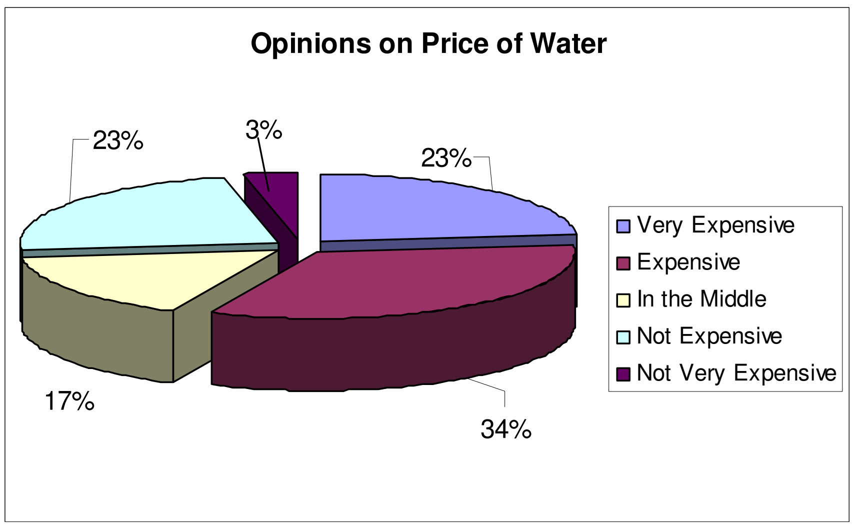


Figure 8 – Opinions of the Price of Water - Ponce

Appendix E: Director Survey Results – Metro Region

Question	#1	#2	#3	#4	#5	#6	#7	#8
Are the current meters the best?	2	3	3	3	3	3	2	5
Is the technology used to read the meters is the best?	2	1	1	3	1	1	1	1
AMR is the next step	4	3	3	NA	3	3	3	3
AMR needs to be installed ASAP	4	3	3	NA	3	3	3	3
these meters are the best to use with AMR	3	3	3	NA	3	3	3	3
How many technicians go to a replacement?								
Residential 5/8	1	1	1	1	1	1	1	NA
2 inches -4 inches	2	3	2	1	2	2	2	NA
4 inches to 6 inches	3	4	3	1	3	3	3	NA
6 inches to 8 inches	4	5	4	1	4	4	4	NA
How many employees go to a replacement?								
Residential 5/8	1	1	1	1	1	1	1	2
2 inches -4 inches	2	2	2	2	2	2	2	2
4 inches to 6 inches	3	3	3	4	3	3	3	2
6 inches to 8 inches	4	4	4	4	4	4	4	2
How many technicians are necessary?								
Residential 5/8	1	1	1	1	1	1	1	NA
2 inches -4 inches	2	2	2	1	2	2	2	NA
4 inches to 6 inches	3	3	3	1	3	3	3	NA
6 inches to 8 inches	4	4	4	1	4	4	4	NA
How many employees are necessary?								
Residential 5/8	1	1	1	1	1	1	1	NA
2 inches -4 inches	2	2	2	2	2	2	2	NA
4 inches to 6 inches	3	3	3	4	3	3	3	NA
6 inches to 8 inches	3	4	4	4	4	4	4	NA
Does the union affect your decision	no	yes	yes	no	yes	yes	yes	no
Problems with acessing the meters	yes	yes	yes	yes	yes	yes	yes	yes
what types	a,b,c,d	obs	b/obs	a,b	a,b,d	ALL	a,b	a,b,c
what can you do to make it more efficient								
more technicians	5	1	1	1	1	1	4	1
less technicians	1	2	2	5	2	2	3	5
teach technicians better	4	2	1	5	2	3	1	NA
technicians should have better instruments	4	4	2	5	4	3	2	NA
the pipe and meter should be connected after each installation	3	1	1	5	1	1	1	NA
have specialized technicians	2	2	2	1	2	1	1	NA
how many people are in the customer service	52	42	39	70	39	64	35	NA
how many should there be?	66	50	47	NA	41	10+	47	NA

Table 4 - Results from Director Interview - Metro Region

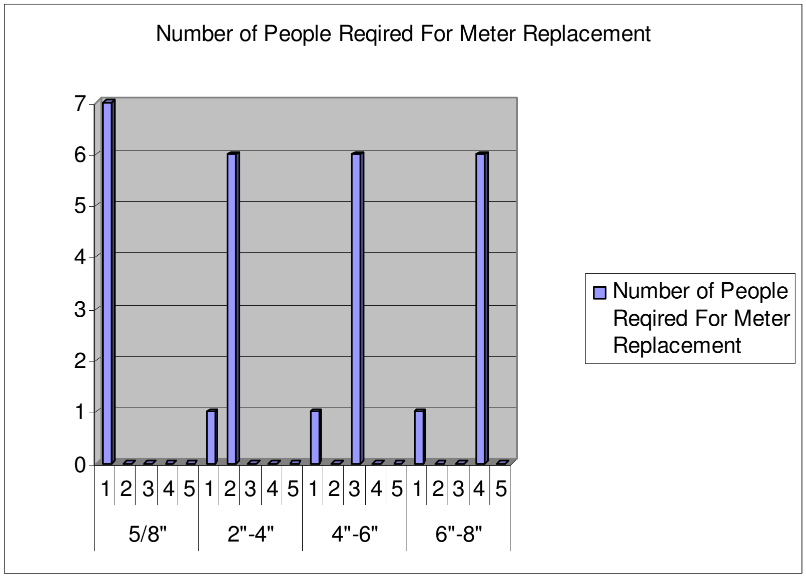


Figure 9 - Technicians Required for Meter Replacement – Metro Region

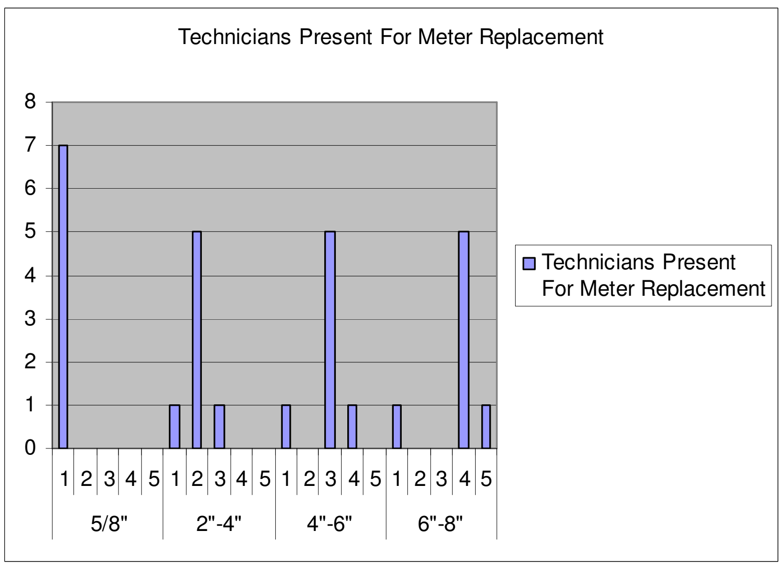


Figure 10 - Technicians Present for Meter Replacement – Metro Region

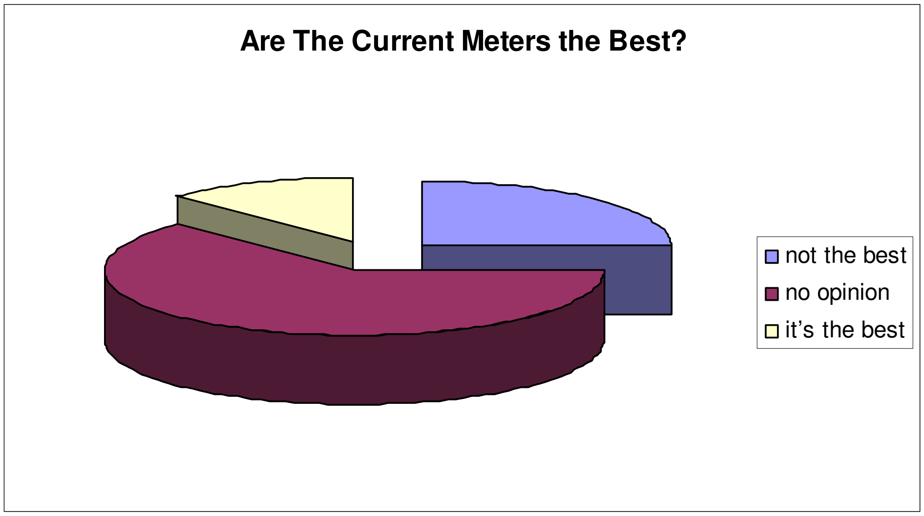


Figure 11 – Opinions on Current Meter Technology – East Region

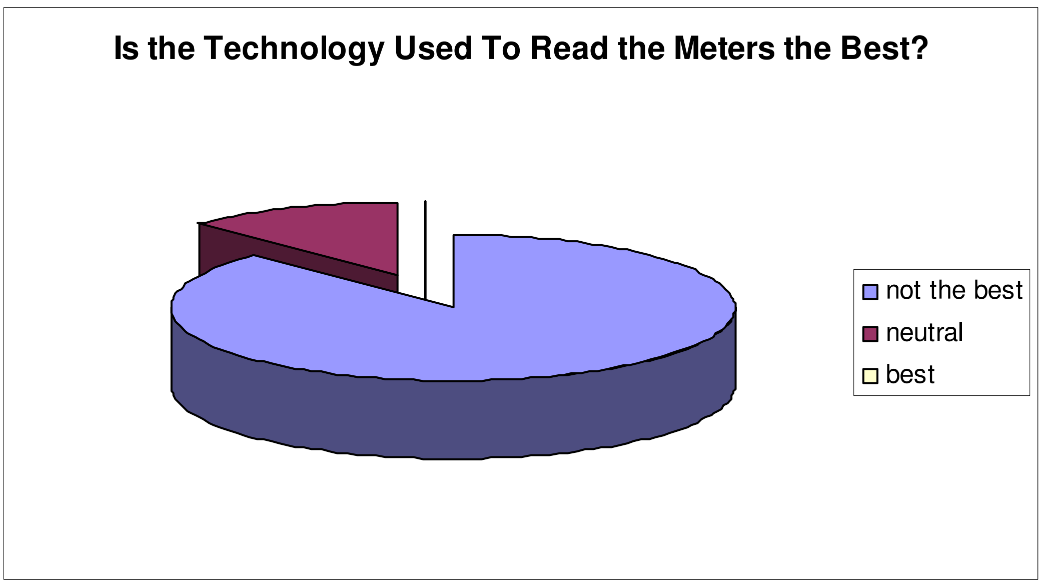


Figure 12 - Opinions on Current Reading Technology – East Region

Appendix F: Director Survey Results – East Region

Question	#1	#2	#3	#4	#5	#6	#7
Are the current meters the best?	3	1	5	NA	3	3	5
Is the technology used to read the meters is the best?	1	2	3	NA	3	1	3
AMR is the next step	3	5	5	NA	3	5	5
AMR needs to be installed ASAP	3	5	5	NA	3	5	5
these meters are the best to use with AMR	3	1	3	NA	3	4	1
How many technicians go to a replacement							
residential 5/8	1	1	1	1	1	1	1
2 inches -4 inches	2	2	3	2	2	2	2
4 inches to 6 inches	3	3	3	2	3	2	3
6 inches to 8 inches	3	3	3	2	3	3	3
How many employees go							
residential 5/8	1	1	1	1	1	1	1
2 inches -4 inches	2	2	4	2	2	2	2
4 inches to 6 inches	3	3	4	2	2	2	3
6 inches to 8 inches	3	4	4	2	2	3	3
How many technicians are necessary							
residential 5/8	1	1	1	1	1	1	1
2 inches -4 inches	2	2	2	2	2	2	2
4 inches to 6 inches	2	2	2	2	3	2	2
6 inches to 8 inches	2	2	3	2	3	3	2
How many employees are necessary							
residential 5/8	1	1	6+	6+	1	5	5
2 inches -4 inches	2	3	6+	6++	3	6+	6+
4 inches to 6 inches	2	3	6+	6+	3	6+	6+
6 inches to 8 inches	2	4	6+	6+	3	6+	6+
Does the union affect your decision	yes	NA	yes	yes	yes	yes	yes
Problems with acessing the meters	yes	yes	yes	yes	yes	yes	yes
what types	a,d	e	a,b,d	d	a	b,d	ALL
what can you do to make it more efficient							
more technicians	1	1	1	1	1	2	1
less technicians	5	5	5	5	1	4	5
teach technicians better	2	4	5	2	1	3	1
technicians should have better instruments	5	5	5	5	5	5	5
the pipe and meter should be connected after each installation	3	5	5	5	5	4	1
have specialized technicians	3	4	5	3	5	1	2
how many people are in the customer service	225	NA	62	250	20	300	250
how many should there be?	275	10	70	70	20	310	300

Table 5 - Results from Director Interview - Metro Region

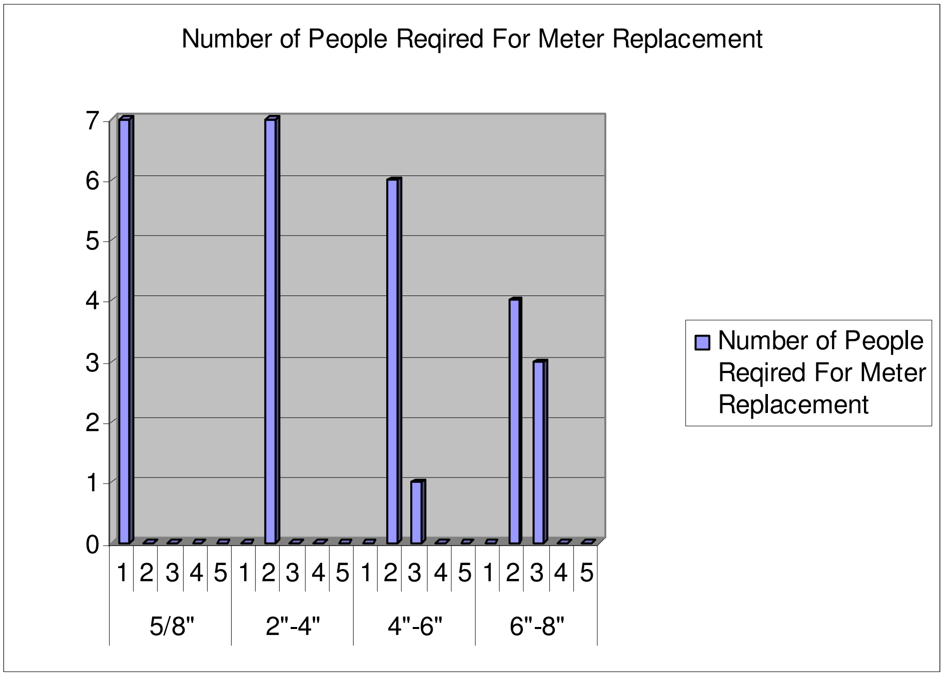


Figure 13 - Technicians Required for Meter Replacement – East Region

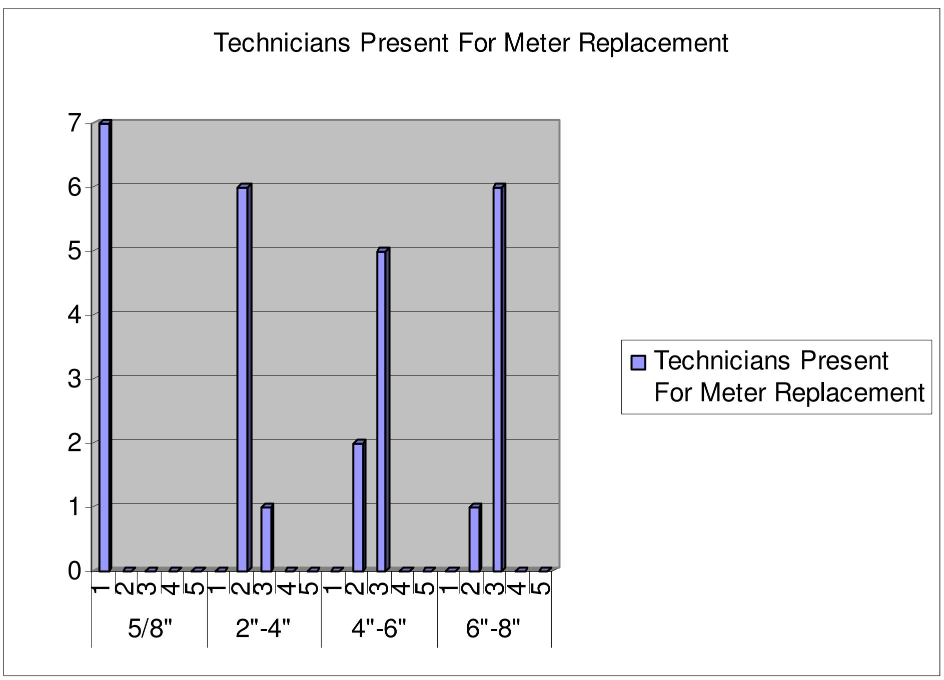


Figure 14 - Technicians Present at a Meter Replacement – East Region

Appendix G: Director Survey Results – South Region

Question	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13
Are these meters are the best	na	1	2	4	3	3	5	3	4	1	2	2	2
the technology used to read the meters is the best	na	5	2	3	3	3	na	3	4	1	4	3	3
AMR is the next step	na	5	5	3	3	3	na	3	na	1	3	5	5
AMR needs to be installed ASAP	na	5	5	4	3	3	na	3	na	1	3	5	5
these meters are the best to use with AMR	na	na	5	2	3	3	na	3	na	1	4	2	3
how many technicians go to													
residential 5/8	na	2	2	1	1	2	1	1	1	1	1	1	1
2 inches -4 inches	na	2	3	4	2	2	na	2	1	2	3	2	3
4 inches to 6 inches	na	3	3	4	2	2	na	3	2	3	3	4	3
6 inches to 8 inches	na	4	3	4	2	2	na	3	3	3	3	5	4
how many employees go													
residential 5/8	1	1	2	1	1	1	1	1	1	1	1	1	1
2 inches -4 inches	2	2	3	1	3	1	na	2	1	2	3	2	2
4 inches to 6 inches	3	2	3	2	3	1	na	3	2	3	3	3	2
6 inches to 8 inches	3	2	3	2	3	1	na	3	3	3	3	5	2
How many technicians is necessary													
residential 5/8	1	2	2	1	1	2	1	1	1	1	3	1	1
2 inches -4 inches	2	2	3	2	2	2	na	2	1	2	3	2	2
4 inches to 6 inches	3	3	3	2	2	2	na	3	2	3	3	4	2
6 inches to 8 inches	3	4	3	2	2	2	na	3	3	3	3	5	2
Does the union affect your decision	yes	yes	yes	no	no	no	yes	yes	na	y	y	n	n
Problems with acessing the meters	yes	yes	yes	yes	yes	no	yes	yes	y	y	n	n	n
what types	all	abd	a,b,d	all	all	na	ALL	b	bcd	abd			
what can you do to make it more efficient													
more technicians	1	4	5	1	3	4	3	3	3	5	4	2	2
less technicians	5	1	1	1	3	4	3	2	3	1	4	na	4
teach technicians better	1	0	5	2	3	4	2	2	3	5	3	2	2
technicians should have better instruments	1	5	5	2	3	4	3	3	3	5	4	4	4
the pipe and meter should be connected after each installation	1	5	5	1	3	4	3	1	3	3	3	3	4
have specialized technicians	1	5	5	1	3	4	1	1	na	5	4	2	2
how many people are in the customer service	250	43	50	14	183	14	38	39	38	43	55	42	42
how many should there be?	na	50	50	20	na	na	na	40	48	51	na	49	49

Table 6 - Results from Director Survey - South Region

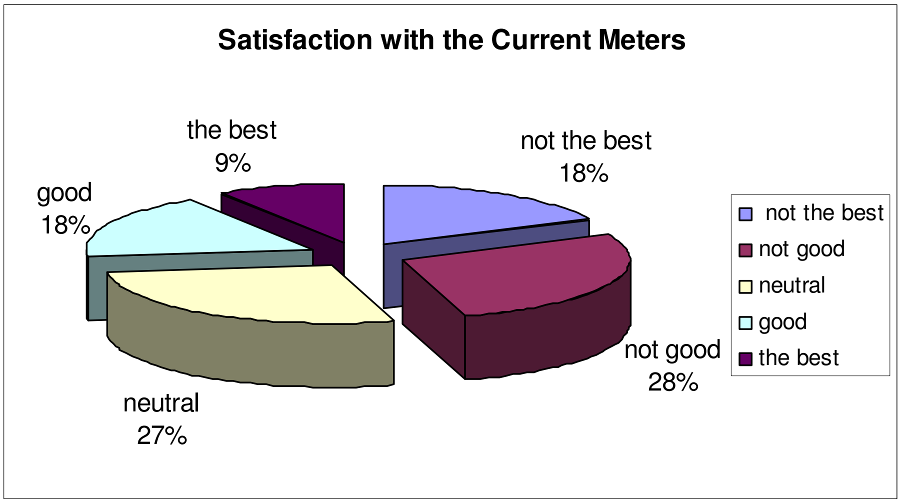


Figure 15 - Satisfaction with the Current Meters - South Region

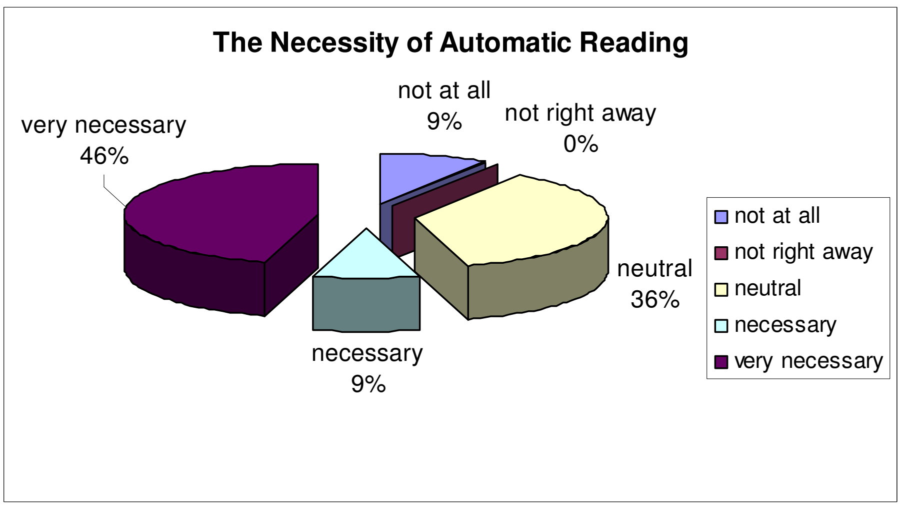


Figure 16 - Necessity of Automatic Reading – South Region

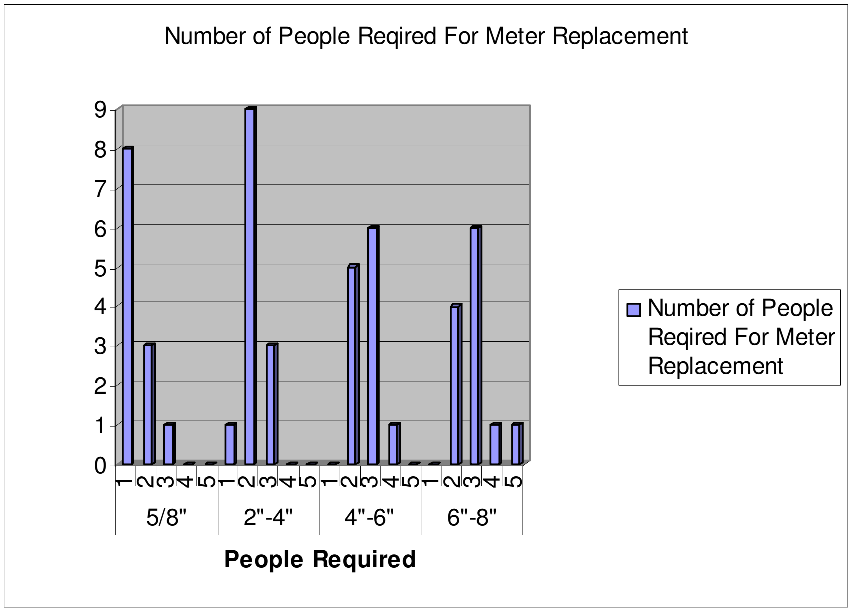


Figure 17 - Number of People Required for Meter Replacement – South Region

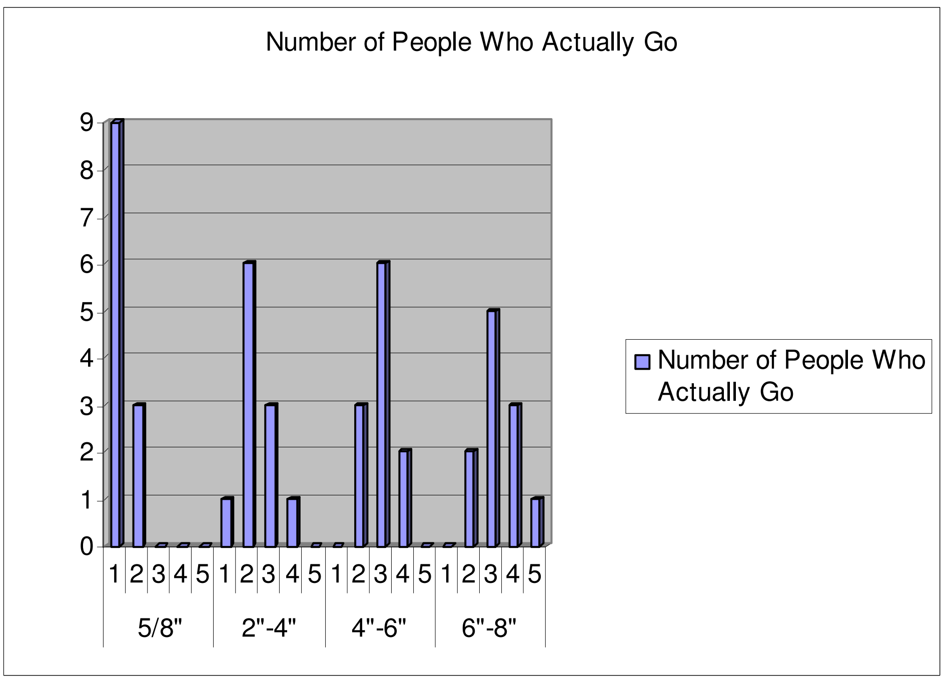


Figure 18 - Number of People Present at Meter Replacement - South Region

Appendix H: Director Survey Results – West Region

Question	#1	#2	#3	#4	#5
these meters are the best	5	5	3	5	4
the technology used to read the meters is the best	5	5	1	2	5
AMR is the next step	5	5	3	5	4
AMR needs to be installed ASAP	5	5	3	5	4
these meters are the best to use with AMR	5	5	3	5	4
how many technicians go to					
residential 5/8	1	1	1	1	1
2 inches -4 inches	2	2	0	2	2
4 inches to 6 inches	3	3	0	3	3
6 inches to 8 inches	3	3	0	3	4
how many employees go					
residential 5/8	2	2	0	1	1
2 inches -4 inches	2	2	0	3	2
4 inches to 6 inches	3	3	0	3	4
6 inches to 8 inches	3	3	0	3	4
How many technicians is necessary					
residential 5/8	1	1	0	1	1
2 inches -4 inches	2	2	0	2	2
4 inches to 6 inches	3	3	0	3	2
6 inches to 8 inches	3	3	0	3	3
Does the union affect your decision	y	y	y	y	NA
Problems with acessing the meters	y	y	y	y	y
what types	bd	bd	all	abd	bd
what can you do to make it more efficient					
more technicians	1	1	5	2	4
less technicians	1	1	1	5	2
teach technicians better	1	1	0	5	5
technicians should have better instruments	2	1	4	2	5
the pipe and meter should be connected after each installation	3	1	2	1	3
have specialized technicians	1	1	2	1	2
how many people are in the customer service	200	200	41	169	36
how many should there be?	220	220	48	less	41

Table 7 - Director Survey Results – West Region

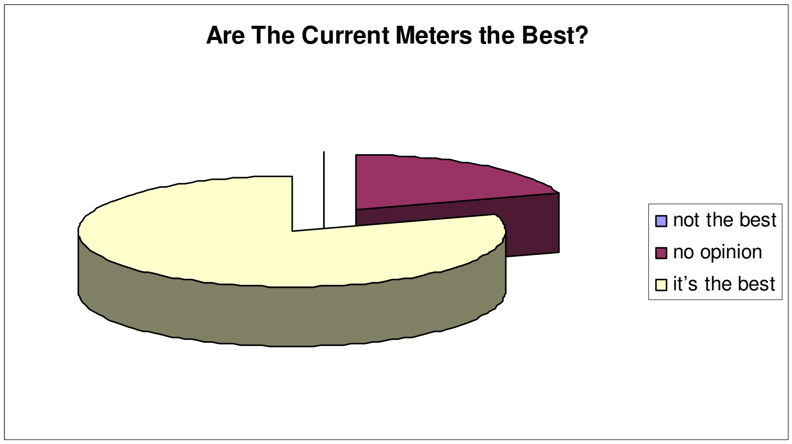


Figure 19 - Opinions on Current Meter Technology - West Region

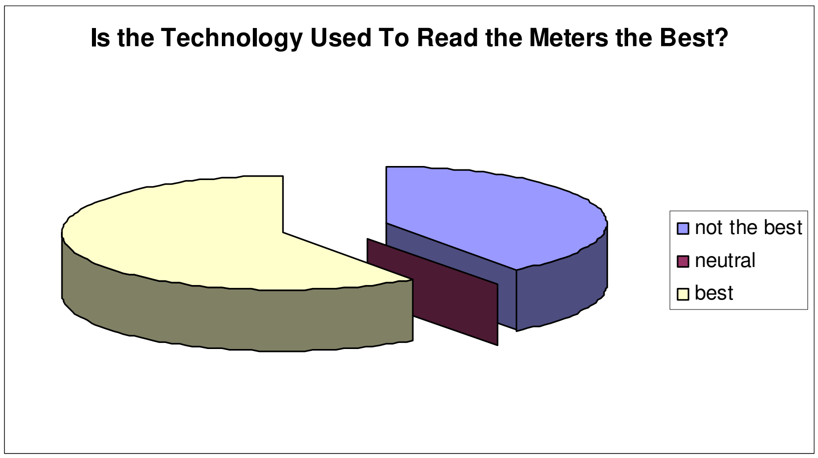


Figure 20 - Opinions on Current Reading Technology - West Region

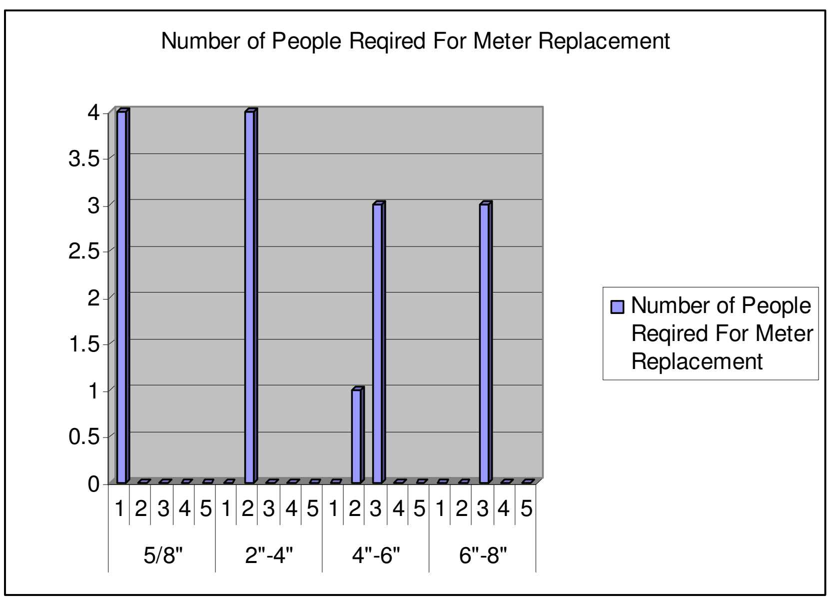


Figure 21 - Technicians Required for Meter Replacement - West Region

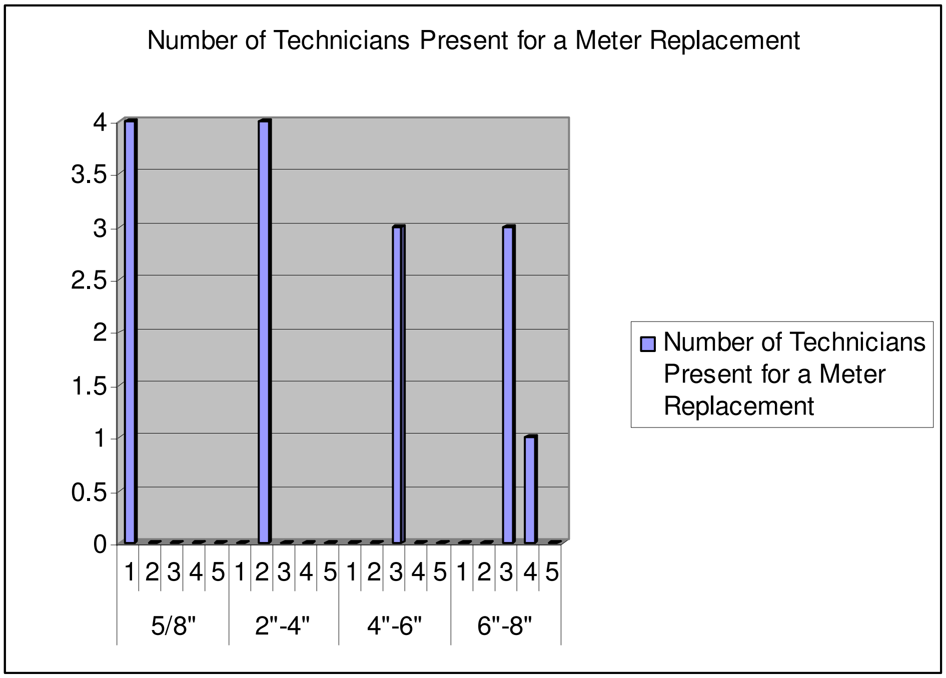


Figure 22 - Technicians Present at a Meter Replacement - West Region

Appendix I: Cost Benefit Analysis Data

Specific meter costs obtained from various meter manufacturers could not be made public and included in this report due to reasons of commercial confidentiality

Water Rates

Table 8 - Water Rates - Current and Future

(PRASA, 2006, Conozca su Nueva Tarifa)

RESIDENTIAL			
		Fase 1	Fase 2
Bloq 1	11 - 15	0.88	1.1
Bloq 2	16 - 35	1.13	1.6
Bloq 3	> 35	1.41	2.16
Commercial/Government			
Bloq 1	11 - 15	1.09	1.53
Bloq 2	16 - 35	1.13	1.6
Bloq 3	> 35	1.28	1.9
Industrial			
Bloq 1	> 10	1.16	1.67

RESIDENTIAL	Fase 1	Fase 2
1/2" y 5/8"	7.67	10.6
3/4"	11.71	16.18
1"	19.23	26.58
1 1/2"	36.33	50.22
2"	61.84	85.49
3"	94.85	131.13
4"	213.37	294.97
6"	569.03	786.63
8"	910.44	1,258.61
10"	1,456.70	2,013.79
12"	0	0

Commercial/Government/Industrial	Fase 1	Fase 2
1/2" y 5/8"	15.51	21.43
3/4"	22.95	31.73
1"	38.86	53.72
1 1/2"	77.87	107.64
2"	123.77	171.11
3"	277.84	384.09
4"	461.56	638.07
6"	1,162.93	1,607.67
8"	1,869.65	2,584.65
10"	2,991.45	4,135.45
12"	0	0

Consumption Figures

Table 9 - Consumption Figures – A, B, C, F, G

(Luciano, AAA Revenue, 2006)

1 m^3 =	264.11458	gal				Comercial	Comercial
		Estimada	**Real**	**Estimada**	**Real**	**Estimada**	**Real**
NEW_Meter	**Data**	**A**	**A**	**B**	**B**	**C**	**C**
5/8, 1/2	# Cuentas	177.00	125	9.00	9	58,873.00	49908
	Consumo Prom.	46.87	39.04	32.70	37.77	42.49	56.31
	Precio					$1.28	$1.90
	Costo	**0.00**	**0.00**	**0.00**	**0.00**	**3,201,922.15**	**5,339,450.39**
1 1/2"	# Cuentas	4				799	655
	Consumo Prom.	65.90				429.61	558.34
	Precio					$1.28	$1.90
	Costo	**0.00**	**0.00**	**0.00**	**0.00**	**439,367.36**	**694,851.36**
1"	# Cuentas	58	32			3098	2521
	Consumo Prom.	249.16	95.38			209.11	246.47
	Precio					$1.28	$1.90
	Costo	**0.00**	**0.00**	**0.00**	**0.00**	**829,218.07**	**1,180,562.71**
2"	# Cuentas	45	20	3	2	1908	1783
	Consumo Prom.	2,466.74	5,053.14	1.85	1.95	999.65	1,119.39
	Precio					$1.28	$1.90
	Costo	**0.00**	**0.00**	**0.00**	**0.00**	**2,441,394.97**	**3,792,148.70**
3"	# Cuentas	1	2			48	42
	Consumo Prom.	13,494.45	4,636.96			3,081.82	3,843.58
	Precio					$1.28	$1.90
	Costo	**0.00**	**0.00**	**0.00**	**0.00**	**189,347.17**	**306,717.71**
3/4"	# Cuentas	18	10			1939	1430
	Consumo Prom.	274.11	1,219.42			120.79	137.20
	Precio					$1.28	$1.90
	Costo	**0.00**	**0.00**	**0.00**	**0.00**	**299,793.03**	**372,784.61**

4"	# Cuentas	6	4			123	119
	Consumo Prom.	11,410.89	5,565.45			6,827.98	7,543.63
	Precio					$1.28	$1.90
	Costo	**0.00**	**0.00**	**0.00**	**0.00**	**1,074,996.49**	**1,705,615.43**
6"	# Cuentas	3	2			15	13
	Consumo Prom.	5,653.17	7,775.88			30,891.23	30,830.18
	Precio					$1.28	$1.90
	Costo	**0.00**	**0.00**	**0.00**	**0.00**	**593,111.63**	**761,505.55**
8"	# Cuentas					6	5
	Consumo Prom.					29,099.02	25,824.67
	Precio					$1.28	$1.90
	Costo	**0.00**	**0.00**	**0.00**	**0.00**	**223,480.45**	**245,334.37**
Total # Cuentas						**66,809.00**	**56,476.00**
Promedio Global						**106.49**	**132.36**
Total Costo						**$9,292,631.32**	**$14,398,970.84**

		Gobierno	Gobierno		
Estimada	Real	Estimada	Real	Estimada	Real
F	F	G	G	Total	Total
1.00	1	5,833.00	4004	64,706.00	53,912.00
9.95	8.87	86.18	112.94	64.33	84.62
		$1.90	$1.90	[redacted]	[redacted]
0.00	**0.00**	**955,091.45**	**859,184.95**	**$4,157,013.60**	**$6,198,635.34**
		550	328	1,349.00	983.00
		461.06	621.80	445.34	590.07
		$1.90	$1.90	[redacted]	[redacted]
0.00	**0.00**	**481,811.17**	**387,504.60**	**$921,178.52**	**$1,082,355.95**
		1629	1001	4,727.00	3,522.00
		264.71	265.99	236.91	256.23
		$1.90	$1.90	[redacted]	[redacted]
0.00	**0.00**	**819,295.18**	**505,889.23**	**$1,648,513.25**	**$1,686,451.94**
		1735	1136	3,643.00	2,919.00
		1,062.87	1,769.14	1,031.26	1,444.26
		$1.90	$1.90	[redacted]	[redacted]
0.00	**0.00**	**3,503,745.58**	**3,818,501.08**	**$5,945,140.55**	**$7,610,649.77**
		57	38	105.00	80.00
		1,062.49	1,492.87	2,072.15	2,668.22
		$1.90	$1.90	[redacted]	[redacted]
0.00	**0.00**	**115,067.14**	**107,784.95**	**$304,414.31**	**$414,502.67**
		507	265	2,446.00	1,695.00
		149.95	194.83	135.37	166.02
		$1.90	$1.90	[redacted]	[redacted]
0.00	**0.00**	**144,443.91**	**98,094.70**	**$444,236.94**	**$470,879.32**
		177	128	300.00	247.00
		4,136.74	4,710.35	5,482.36	6,126.99
		$1.90	$1.90	[redacted]	[redacted]
0.00	**0.00**	**1,391,184.43**	**1,145,558.26**	**$2,466,180.92**	**$2,851,173.68**
		41	26	56.00	39.00
		16,086.15	13,350.68	23,488.69	22,090.43
		$1.90	$1.90	[redacted]	[redacted]
0.00	**0.00**	**1,253,111.14**	**659,523.44**	**$1,846,222.76**	**$1,421,029.00**

		5	4	11.00	9.00
		192,148.24	92,713.30	110,623.63	59,268.98
		$1.90	$1.90	[redacted]	
0.00	**0.00**	**1,825,408.29**	**704,621.08**	**$2,048,888.73**	**$949,955.44**
		10,534.00	**6,930.00**	**77,343.00**	**63,406.00**
		451.11	**589.22**	**171.44**	**208.02**
		$10,489,158.28	**$8,286,662.28**	**$19,781,789.60**	**$22,685,633.12**

P= Residencial Públic

G= Gobierno

A = Cuentas de la AAA

R = Residencial Privado (cuentas regulares)

C= Comercial

Tipo de Cliente = Basicamente te resume los Service Class ejemplo

Los service class R (residencial), C (comercial), I (Industrial) = son Regular

El G = Gobierno

La A = Cuentas AAA

La P = Residencial Público

Table 10 - Consumption Figures - I, P, R, and Totals

(Luciano, AAA Revenue, 2006)

		Industry	Industry	Residencial Público		Residencial Privado	
		Estimada	Real	Estimada	Real	Estimada	Real
NEW_Meter	Data	I	I	P	P	R	R
5/8, 1/2	# Cuentas	230.00	161	50,600.00	39673	1,085,955.00	967258
	Consumo Prom.	84.43	110.69	30.90	32.07	30.87	34.36
	Precio	1.67	1.67	2.16	2.16	2.16	2.16
	Costo	**32,430.80**	**29,759.95**	**3,377,469.01**	**2,747,800.84**	**72,413,551.45**	**71,783,798.80**
1 1/2"	# Cuentas	110	74			146	129
	Consumo Prom.	698.83	1,108.92			390.11	564.75
	Precio	1.67	1.67	No Consumption	No Consumption	2.16	2.16
	Costo	**128,374.65**	**137,039.76**	**0.00**	**0.00**	**123,025.54**	**157,361.81**
1"	# Cuentas	160	110	10	6	1249	1082
	Consumo Prom.	260.48	339.20	18.10	10.85	97.86	118.87
	Precio	1.67	1.67	2.16	2.16	2.16	2.16
	Costo	**69,600.66**	**62,311.28**	**390.86**	**140.66**	**264,015.54**	**277,802.12**
2"	# Cuentas	795	770	1	1	269	240
	Consumo Prom.	902.66	1,123.54	5.28	3.53	515.50	711.35
	Precio	1.67	1.67	85.49	85.49	2.16	2.16
	Costo	**1,198,414.58**	**1,444,759.34**	**451.02**	**301.69**	**299,525.97**	**368,763.46**
3"	# Cuentas	18	18			12	10
	Consumo Prom.	7,570.54	7,475.34			566.94	763.39
	Precio	1.67	1.67	No Consumption	No Consumption	2.16	2.16
	Costo	**227,570.52**	**224,708.67**	**0.00**	**0.00**	**14,695.01**	**16,489.22**
3/4"	# Cuentas	55	37	27	17	4661	4079

	Consumo Prom.	138.71	209.30	34.47	23.87	55.61	60.08
	Precio	1.67	1.67	2.16	2.16	2.16	2.16
	Costo	**12,740.38**	**12,932.85**	**2,010.27**	**876.61**	**559,896.66**	**529,333.26**
4"	# Cuentas	105	101			20	19
	Consumo Prom.	10,733.16	9,526.88			2,184.11	2,292.53
	Precio	1.67	1.67	No Consumption	No Consumption	2.16	2.16
	Costo	**1,882,059.85**	**1,606,898.71**	**0.00**	**0.00**	**94,353.45**	**94,085.57**
6"	# Cuentas	30	30			4	4
	Consumo Prom.	31,770.50	32,858.75			1,785.33	1,825.29
	Precio	1.67	1.67	No Consumption	No Consumption	2.16	2.16
	Costo	**1,591,702.25**	**1,646,223.48**	**0.00**	**0.00**	**15,425.27**	**15,770.53**
8"	# Cuentas	12	12				
	Consumo Prom.	28,808.03	27,133.44				
	Precio	1.67	1.67	No Consumption	No Consumption	No Consumption	No Consumption
	Costo	**577,312.98**	**543,754.20**	**0.00**	**0.00**	**0.00**	**0.00**
Total # Cuentas		**1,515.00**	**1,313.00**	**50,638.00**	**39,697.00**	**1,092,316.00**	**972,821.00**
Promedio Global		**2,051.75**	**2,376.04**	**30.90**	**32.06**	**31.27**	**34.86**
Total Costo		**5,720,206.66**	**5,708,388.24**	**3,380,321.15**	**2,749,119.79**	**73,784,488.88**	**73,243,404.77**

Estimada	Real	Estimada	Real	Total	AMR
Total	**Total**	**Grand Total**	**Grand Total**	**6 Months**	**Incremental Benefits**
1,136,785.00	1,007,092.00	1,201,491.00	1,061,004.00	2,262,495.00	1,201,491.00
48.74	59.04	56.53	71.83	64.18	4.00
[redacted]					
75,823,451.26	**74,561,359.59**	**79,980,464.86**	**80,759,994.94**	**160,740,459.79**	**10,167,132.16**
256.00	203.00	1,605.00	1,186.00	2,791.00	1,605.00
362.98	557.89	404.16	573.98	489.07	4
[redacted]					
251,400.18	**294,401.57**	**1,172,578.71**	**1,376,757.53**	**2,549,336.24**	**10,267.12**
1,419.00	1,198.00	6,146.00	4,720.00	10,866.00	6,146.00
125.48	156.31	181.19	206.27	193.73	4
[redacted]					
334,007.06	**340,254.06**	**1,982,520.31**	**2,026,706.00**	**4,009,226.31**	**40,188.72**
1,065.00	1,011.00	4,708.00	3,930.00	8,638.00	4,708.00
474.48	612.81	752.87	1,028.53	890.70	4
[redacted]					
1,498,391.56	**1,813,824.48**	**7,443,532.11**	**9,424,474.26**	**16,868,006.37**	**30,931.68**
30.00	28.00	135.00	108.00	243.00	135.00
2,712.49	2,746.24	2,392.32	2,707.23	2,549.78	4
[redacted]					
242,265.53	**241,197.88**	**546,679.84**	**655,700.55**	**1,202,380.39**	**902.88**
4,743.00	4,133.00	7,189.00	5,828.00	13,017.00	7,189.00
76.26	97.75	105.82	131.88	118.85	4
[redacted]					
574,647.30	**543,142.72**	**1,018,884.25**	**1,014,022.04**	**2,032,906.29**	**54,652.60**
125.00	120.00	425.00	367.00	792.00	425.00
4,305.76	3,939.80	4,894.06	5,033.40	4,963.73	4
[redacted]					
1,976,413.29	**1,700,984.27**	**4,442,594.21**	**4,552,157.96**	**8,994,752.17**	**2,849.16**
34.00	34.00	90.00	73.00	163.00	90.00
11,185.28	11,561.35	17,336.98	16,825.89	17,081.44	4
[redacted]					

1,607,127.52	**1,661,994.01**	**3,453,350.28**	**3,083,023.01**	**6,536,373.29**	**623.36**
12.00	12.00	23.00	21.00	44.00	23.00
9,602.68	9,044.48	60,113.15	34,156.73	47,134.94	4
577,312.98	**543,754.20**	**2,626,201.72**	**1,493,709.65**	**4,119,911.37**	**148.88**
1,144,469.00	**1,013,831.00**	**1,221,812.00**	**1,077,237.00**	**2,299,049.00**	**1,221,812.00**
50.28	**60.89**	**63.85**	**79.91**	**71.90**	**4**
82,885,016.69	**81,700,912.80**	**102,666,806.29**	**104,386,545.92**	**207,053,352.21**	**10,307,696.56**
					4.98%

Net Cash Flow – Proposed Systems

Table 11 - Net Cash Flow - Proposed System

Calculated using information received from all meter companies and internal PRASA cost data.
(Gomez and Morera, 2006) and (Perez, 2006) and (Luciano, AAA Revenue, 2006) and (Luciano, Datamatic, 2006) and (Henry, 2006)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Cash Inflows / Benefits and Gains	1	2	3	4	5	6	7	8	9	10	
Datamatic	$631,953,559	$636,483,028	$641,012,497	$645,541,965	$650,071,434	$654,600,902	$659,130,371	$662,876,649	$662,876,649	$662,876,649	$6,507,423,703
Badger/AMCO	$631,953,559	$636,483,028	$641,012,497	$645,541,965	$650,071,434	$654,600,902	$659,130,371	$662,876,649	$662,876,649	$662,876,649	$6,507,423,703
Badger/Badger	$631,953,559	$636,483,028	$641,012,497	$645,541,965	$650,071,434	$654,600,902	$659,130,371	$662,876,649	$662,876,649	$662,876,649	$6,507,423,703
ITRON	$631,953,559	$636,483,028	$641,012,497	$645,541,965	$650,071,434	$654,600,902	$659,130,371	$662,876,649	$662,876,649	$662,876,649	$6,507,423,703

Cash Outflows / Costs & Expenses											Sub Total
Datamatic	(31,431,832.99)	(21,742,513.79)	(21,450,513.79)	(21,158,513.79)	(20,866,513.79)	(20,574,513.79)	(20,282,513.79)	(276,756.48)	(276,756.48)	(276,756.48)	(158,337,185.17)
Badger/AMCO	(67,619,023.95)	(64,144,513.79)	(63,852,513.79)	(63,560,513.79)	(63,268,513.79)	(62,976,513.79)	(62,684,513.79)	(276,756.48)	(276,756.48)	(276,756.48)	(448,936,376.13)
Badger/Badger	(45,681,909.25)	(25,375,783.22)	(25,083,783.22)	(24,791,783.22)	(24,499,783.22)	(24,207,783.22)	(23,915,783.22)	(276,756.48)	(276,756.48)	(276,756.48)	(194,386,878.00)
ITRON	(37,882,642.99)	(23,077,950.00)	(22,785,950.00)	(22,493,950.00)	(22,201,950.00)	(21,909,950.00)	(21,617,950.00)	(276,756.48)	(276,756.48)	(276,756.48)	(172,800,612.43)

	Cash Flow Summary						
Datamatic	Total inflows	631,953,559.35	636,483,027.93	641,012,496.52	645,541,965.10	650,071,433.69	654,600,902.27
	Total outflows	(31,431,832.99)	(21,742,513.79)	(21,450,513.79)	(21,158,513.79)	(20,866,513.79)	(20,574,513.79)
	Net cash flow	**600,521,726.36**	**614,740,514.14**	**619,561,982.73**	**624,383,451.31**	**629,204,919.90**	**634,026,388.48**
Badger/AMCO	Total inflows	631,953,559.35	636,483,027.93	641,012,496.52	645,541,965.10	650,071,433.69	654,600,902.27
	Total outflows	(67,619,023.95)	(64,144,513.79)	(63,852,513.79)	(63,560,513.79)	(63,268,513.79)	(62,976,513.79)
	Net cash flow	**564,334,535.40**	**572,338,514.14**	**577,159,982.73**	**581,981,451.31**	**586,802,919.90**	**591,624,388.48**
Badger/Badger	Total inflows	631,953,559.35	636,483,027.93	641,012,496.52	645,541,965.10	650,071,433.69	654,600,902.27
	Total outflows	(45,681,909.25)	(25,375,783.22)	(25,083,783.22)	(24,791,783.22)	(24,499,783.22)	(24,207,783.22)
	Net cash flow	**586,271,650.10**	**611,107,244.71**	**615,928,713.30**	**620,750,181.88**	**625,571,650.47**	**630,393,119.05**
ITRON	Total inflows	631,953,559.35	636,483,027.93	641,012,496.52	645,541,965.10	650,071,433.69	654,600,902.27
	Total outflows	(37,882,642.99)	(23,077,950.00)	(22,785,950.00)	(22,493,950.00)	(22,201,950.00)	(21,909,950.00)
	Net cash flow	**594,070,916.36**	**613,405,077.93**	**618,226,546.52**	**623,048,015.10**	**627,869,483.69**	**632,690,952.27**

659,130,370.86	662,876,649.03	662,876,649.03	662,876,649.03	6,507,423,702.81
(20,282,513.79)	(276,756.48)	(276,756.48)	(276,756.48)	(158,337,185.17)
638,847,857.07	**662,599,892.55**	**662,599,892.55**	**662,599,892.55**	**6,349,086,517.64**
659,130,370.86	662,876,649.03	662,876,649.03	662,876,649.03	6,507,423,702.81
(62,684,513.79)	(276,756.48)	(276,756.48)	(276,756.48)	(448,936,376.13)
596,445,857.07	**662,599,892.55**	**662,599,892.55**	**662,599,892.55**	**6,058,487,326.68**
659,130,370.86	662,876,649.03	662,876,649.03	662,876,649.03	6,507,423,702.81
(23,915,783.22)	(276,756.48)	(276,756.48)	(276,756.48)	(194,386,878.00)
635,214,587.64	**662,599,892.55**	**662,599,892.55**	**662,599,892.55**	**6,313,036,824.81**
659,130,370.86	662,876,649.03	662,876,649.03	662,876,649.03	6,507,423,702.81
(21,617,950.00)	(276,756.48)	(276,756.48)	(276,756.48)	(172,800,612.43)
37,512,420.86	**662,599,892.55**	**662,599,892.55**	**662,599,892.55**	**6,334,623,090.38**

Current System Costs

Table 12 - Net Cash Flow - Current System

Calculated using information received from internal PRASA cost data. (Luciano, AAA Revenue, 2006)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Cash Inflows / Benefits and Gains		`				
Revenue	621,160,056.63	621,160,056.63	621,160,056.63	621,160,056.63	621,160,056.63	621,160,056.63
Total cash inflows	**621,160,056.63**	**621,160,056.63**	**621,160,056.63**	**621,160,056.63**	**621,160,056.63**	**621,160,056.63**
Cash Outflows / Costs & Expenses						
Reading Costs	(11,070,259.20)	(11,070,259.20)	(11,070,259.20)	(11,070,259.20)	(11,070,259.20)	(11,070,259.20)
Meters	(4,369,473.79)	(4,369,473.79)	(4,369,473.79)	(4,369,473.79)	(4,369,473.79)	(4,369,473.79)
Total cash outflows	**(15,439,732.99)**	**(15,439,732.99)**	**(15,439,732.99)**	**(15,439,732.99)**	**(15,439,732.99)**	**(15,439,732.99)**
Cash Flow Summary						
Total inflows	621,160,056.63	621,160,056.63	621,160,056.63	621,160,056.63	621,160,056.63	621,160,056.63
Total outflows	(15,439,732.99)	(15,439,732.99)	(15,439,732.99)	(15,439,732.99)	(15,439,732.99)	(15,439,732.99)
Net cash flow	**605,720,323.64**	**605,720,323.64**	**605,720,323.64**	**605,720,323.64**	**605,720,323.64**	**605,720,323.64**

	Year 7	Year 8	Year 9	Year 10	Total
Revenue	621,160,056.63	621,160,056.63	621,160,056.63	621,160,056.63	6,211,600,566.29
Total cash inflows	**621,160,056.63**	**621,160,056.63**	**621,160,056.63**	**621,160,056.63**	**6,211,600,566.29**
Reading Costs	(11,070,259.20)	(11,070,259.20)	(11,070,259.20)	(11,070,259.20)	(110,702,592.00)
Meters	0.00	0.00	0.00	0.00	(26,216,842.74)
Total cash outflows	**(11,070,259.20)**	**(11,070,259.20)**	**(11,070,259.20)**	**(11,070,259.20)**	**(136,919,434.74)**
Total inflows	621,160,056.63	621,160,056.63	621,160,056.63	621,160,056.63	6,211,600,566.29
Total outflows	(11,070,259.20)	(11,070,259.20)	(11,070,259.20)	(11,070,259.20)	(136,919,434.74)
Net cash flow	**610,089,797.43**	**610,089,797.43**	**610,089,797.43**	**610,089,797.43**	**6,074,681,131.55**

Incremental Cash Flow – Current System

Table 13 - Incremental Cash Flow - Current System

Calculated using information received from internal PRASA cost data. (Gomez and Morera, 2006) (Perez, 2006) (Luciano, AAA Revenue, 2006) (Luciano, Datamatic, 2006) (Henry, 2006)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Datamatic	10,793,502.72	15,322,971.30	19,852,439.89	24,381,908.47	28,911,377.06	33,440,845.64
Badger/AMCO	10,793,502.72	15,322,971.30	19,852,439.89	24,381,908.47	28,911,377.06	33,440,845.64
Badger/Badger	10,793,502.72	15,322,971.30	19,852,439.89	24,381,908.47	28,911,377.06	33,440,845.64
ITRON	10,793,502.72	15,322,971.30	19,852,439.89	24,381,908.47	28,911,377.06	33,440,845.64

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Datamatic	(15,992,100.00)	(6,302,780.80)	(6,010,780.80)	(5,718,780.80)	(5,426,780.80)	(5,134,780.80)
Badger/AMCO	(52,179,290.96)	(48,704,780.80)	(48,412,780.80)	(48,120,780.80)	(47,828,780.80)	(47,536,780.80)
Badger/Badger	(30,242,176.26)	(9,936,050.23)	(9,644,050.23)	(9,352,050.23)	(9,060,050.23)	(8,768,050.23)
ITRON	(22,442,910.00)	(7,638,217.01)	(7,346,217.01)	(7,054,217.01)	(6,762,217.01)	(6,470,217.01)

Year 7	Year 8	Year 9	Year 10	Total
37,970,314.23	41,716,592.40	41,716,592.40	41,716,592.40	295,823,136.52
37,970,314.23	41,716,592.40	41,716,592.40	41,716,592.40	295,823,136.52
37,970,314.23	41,716,592.40	41,716,592.40	41,716,592.40	295,823,136.52
37,970,314.23	41,716,592.40	41,716,592.40	41,716,592.40	295,823,136.52

Year 7	Year 8	Year 9	Year 10	Total
(9,212,254.59)	10,793,502.72	10,793,502.72	10,793,502.72	(21,417,750.43)
(51,614,254.59)	10,793,502.72	10,793,502.72	10,793,502.72	(312,016,941.39)
(12,845,524.02)	10,793,502.72	10,793,502.72	10,793,502.72	(57,467,443.26)
(10,547,690.80)	10,793,502.72	10,793,502.72	10,793,502.72	(35,881,177.69)

Incremental Cash Flow Summary

Table 14 - Incremental Cash Flow Summary - Possible Systems

Calculated using information received from all meter companies and internal PRASA cost data. (Gomez and Morera, 2006) (Perez, 2006) (Luciano, AAA Revenue, 2006) (Luciano, Datamatic, 2006) (Henry, 2006)

D	Incremental Cash Flow Summary											
	Total incremental inflows	10,793,502.72	15,322,971.30	19,852,439.89	24,381,908.47	28,911,377.06	33,440,845.64	37,970,314.23	41,716,592.40	41,716,592.40	41,716,592.40	295,823,136.52
	Total incremental outflows	(15,992,100.00)	(6,302,780.80)	(6,010,780.80)	(5,718,780.80)	(5,426,780.80)	(5,134,780.80)	(9,212,254.59)	10,793,502.72	10,793,502.72	10,793,502.72	(21,417,750.43)
	Net incremental cash flow	**(5,198,597.28)**	**9,020,190.50**	**13,841,659.09**	**18,663,127.67**	**23,484,596.26**	**28,306,064.84**	**28,758,059.64**	**52,510,095.12**	**52,510,095.12**	**52,510,095.12**	**274,405,386.09**
B/A	Total incremental inflows	10,793,502.72	15,322,971.30	19,852,439.89	24,381,908.47	28,911,377.06	33,440,845.64	37,970,314.23	41,716,592.40	41,716,592.40	41,716,592.40	295,823,136.52
	Total incremental outflows	(52,179,290.96)	(48,704,780.80)	(48,412,780.80)	(48,120,780.80)	(47,828,780.80)	(47,536,780.80)	(51,614,254.59)	10,793,502.72	10,793,502.72	10,793,502.72	(312,016,941.39)
	Net incremental cash flow	**(41,385,788.24)**	**(33,381,809.50)**	**(28,560,340.91)**	**(23,738,872.33)**	**(18,917,403.74)**	**(14,095,935.16)**	**(13,643,940.36)**	**52,510,095.12**	**52,510,095.12**	**52,510,095.12**	**(16,193,804.87)**
B/B	Total incremental inflows	10,793,502.72	15,322,971.30	19,852,439.89	24,381,908.47	28,911,377.06	33,440,845.64	37,970,314.23	41,716,592.40	41,716,592.40	41,716,592.40	295,823,136.52
	Total incremental outflows	(30,242,176.26)	(9,936,050.23)	(9,644,050.23)	(9,352,050.23)	(9,060,050.23)	(8,768,050.23)	(12,845,524.02)	10,793,502.72	10,793,502.72	10,793,502.72	(57,467,443.26)
	Net incremental cash flow	**(19,448,673.54)**	**5,386,921.08**	**10,208,389.66**	**15,029,858.25**	**19,851,326.83**	**24,672,795.41**	**25,124,790.21**	**52,510,095.12**	**52,510,095.12**	**52,510,095.12**	**238,355,693.26**
I/A	Total incremental inflows	10,793,502.72	15,322,971.30	19,852,439.89	24,381,908.47	28,911,377.06	33,440,845.64	37,970,314.23	41,716,592.40	41,716,592.40	41,716,592.40	295,823,136.52
	Total incremental outflows	(22,442,910.00)	(7,638,217.01)	(7,346,217.01)	(7,054,217.01)	(6,762,217.01)	(6,470,217.01)	(10,547,690.80)	10,793,502.72	10,793,502.72	10,793,502.72	(35,881,177.69)
	Net incremental cash flow	**(11,649,407.28)**	**7,684,754.29**	**12,506,222.88**	**17,327,691.46**	**22,149,160.05**	**26,970,628.63**	**27,422,623.43**	**52,510,095.12**	**52,510,095.12**	**52,510,095.12**	**259,941,958.83**

Cumulative Cash Flow

Table 15 - Cumulative Cash Flow

Calculated using information received from all meter companies and internal PRASA cost data. (Gomez and Morera, 2006) (Perez, 2006) (Luciano, AAA Revenue, 2006) (Luciano, Datamatic, 2006) (Henry, 2006)

#N/A

Datamatic	Year 1	Year 2	Year 3	Year 4	Year 5
Total incremental inflows	$10,793,502.72	$15,322,971.30	$19,852,439.89	$24,381,908.47	$28,911,377.06
Total incremental outflows	($15,992,100.00)	($6,302,780.80)	($6,010,780.80)	($5,718,780.80)	($5,426,780.80)
Net incremental cash flow	($5,198,597.28)	$9,020,190.50	$13,841,659.09	$18,663,127.67	$23,484,596.26
Cumulative Incremental CF	($5,198,597.28)	$3,821,593.22	$17,663,252.31	$36,326,379.99	$59,810,976.25

Badger/AMCO	Year 1	Year 2	Year 3	Year 4	Year 5
Total incremental inflows	$10,793,502.72	$15,322,971.30	$19,852,439.89	$24,381,908.47	$28,911,377.06
Total incremental outflows	($52,179,290.96)	($48,704,780.80)	($48,412,780.80)	($48,120,780.80)	($47,828,780.80)
Net incremental cash flow	($41,385,788.24)	($33,381,809.50)	($28,560,340.91)	($23,738,872.33)	($18,917,403.74)
Cumulative Incremental CF	($41,385,788.24)	($74,757,597.74)	(103,327,938.65)	(127,066,810.97)	(145,984,214.71)

Badger/Badger	Year 1	Year 2	Year 3	Year 4	Year 5
Total incremental inflows	$10,793,502.72	$15,322,971.30	$19,852,439.89	$24,381,908.47	$28,911,377.06
Total incremental outflows	($30,242,176.26)	($9,936,050.23)	($9,644,050.23)	($9,352,050.23)	($9,060,050.23)
Net incremental cash flow	($19,448,673.54)	$5,386,921.08	$10,208,389.66	$15,029,858.25	$19,851,326.83
Cumulative Incremental CF	($19,448,673.54)	($14,061,752.46)	($3,853,362.80)	$11,176,495.45	$31,027,822.28

ITRON	Year 1	Year 2	Year 3	Year 4	Year 5
Total incremental inflows	$10,793,502.72	$15,322,971.30	$19,852,439.89	$24,381,908.47	$28,911,377.06
Total incremental outflows	($22,442,910.00)	($7,638,217.01)	($7,346,217.01)	($7,054,217.01)	($6,762,217.01)
Net incremental cash flow	($11,649,407.28)	$7,684,754.29	$12,506,222.88	$17,327,691.46	$22,149,160.05
Cumulative Incremental CF	($11,649,407.28)	($3,964,652.99)	$8,541,569.89	$25,869,261.36	$48,018,421.41

Year 6	Year 7	Year 8	Year 9	Year 10	Total
$33,440,845.64	$37,970,314.23	$41,716,592.40	$41,716,592.40	$41,716,592.40	$295,823,136.52
($5,134,780.80)	($9,212,254.59)	$10,793,502.72	$10,793,502.72	$10,793,502.72	($21,417,750.43)
$28,306,064.84	$28,758,059.64	$52,510,095.12	$52,510,095.12	$52,510,095.12	$274,405,386.09

$88,117,041.09	$116,875,100.73	$169,385,195.85	$221,895,290.97	$274,405,386.09

Year 6	Year 7	Year 8	Year 9	Year 10	Total
$33,440,845.64	$37,970,314.23	$41,716,592.40	$41,716,592.40	$41,716,592.40	$295,823,136.52
($47,536,780.80)	($51,614,254.59)	$10,793,502.72	$10,793,502.72	$10,793,502.72	$312,016,941.39
($14,095,935.16)	($13,643,940.36)	$52,510,095.12	$52,510,095.12	$52,510,095.12	($16,193,804.87)

$160,080149.87	$173,724,090.23	$121,213,998.11	($68,703,899.99)	($16,193,804.87)

Year 6	Year 7	Year 8	Year 9	Year 10	Total
$33,440,845.64	$37,970,314.23	$41,716,592.40	$41,716,592.40	$41,716,592.40	$295,823,136.52
($8,768,050.23)	($12,845,524.02)	$10,793,502.72	$10,793,502.72	$10,793,502.72	($57,467,443.26)
$24,672,795.41	$25,124,790.21	$52,510,095.12	$52,510,095.12	$52,510,095.12	$238,355,693.26

$55,700,617.69	$80,825,407.90	$133,335,503.02	$185,845,598.14	$238,355,693.26

Year 6	Year 7	Year 8	Year 9	Year 10	Total
$33,440,845.64	$37,970,314.23	$41,716,592.40	$41,716,592.40	$41,716,592.40	$295,823,136.52
($6,470,217.01)	($10,547,690.80)	$10,793,502.72	$10,793,502.72	$10,793,502.72	($35,881,177.69)
$26,970,628.63	$27,422,623.43	$52,510,095.12	$52,510,095.12	$52,510,095.12	$259,941,958.83

$74,989,050.04	$102,411,673.47	$154,921,768.59	$207,431,863.71	$259,941,958.83

Payback Period

Table 16 - Payback Period

Calculated using information received from all meter companies and internal PRASA cost data. (Gomez and Morera, 2006) (Perez, 2006) (Luciano, AAA Revenue, 2006) (Luciano, Datamatic, 2006) (Henry, 2006)

#N/A

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Total incremental inflows	$10,793,503	$15,322,971	$19,852,440	$24,381,908	$28,911,377	$33,440,846
Total incremental outflows	($15,992,100)	($6,302,781)	($6,010,781)	($5,718,781)	($5,426,781)	($5,134,781)
Net incremental cash flow	($5,198,597)	$9,020,191	$13,841,659	$18,663,128	$23,484,596	$28,306,065
Cumulative Incremental Cash Flow	($5,198,597)	$3,821,593	$17,663,252	$36,326,380	$59,810,976	$88,117,041
Payback Period:	1.53199599	Years	1.53199599	6.950470057		

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Total incremental inflows	$10,793,503	$15,322,971	$19,852,440	$24,381,908	$28,911,377	$33,440,846
Total incremental outflows	($52,179,291)	($48,704,781)	($48,412,781)	($48,120,781)	($47,828,781)	($47,536,781)
Net incremental cash flow	($41,385,788)	($33,381,809)	($28,560,341)	($23,738,872)	($18,917,404)	($14,095,935)
Cumulative Incremental Cash Flow	($41,385,788)	($74,767,598)	($103,327,939)	($127,066,811)	($145,984,215)	($160,080,150)
Payback Period:	N/A	Years	FALSE	FALSE		

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Total incremental inflows	$10,793,503	$15,322,971	$19,852,440	$24,381,908	$28,911,377	$33,440,846
Total incremental outflows	($30,242,176)	($9,936,050)	($9,644,050)	($9,352,050)	($9,060,050)	($8,768,050)
Net incremental cash flow	($19,448,674)	$5,386,921	$10,208,390	$15,029,858	$19,851,327	$24,672,795
		Cell is named: "Yr1CumCF"				
Cumulative Incremental Cash Flow	($19,448,674)	($14,061,752)	($3,853,363)	$11,176,495	$31,027,822	$55,700,618
Payback Period:	3.236658937	Years	3.236658937	6.160835902		

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Total incremental inflows	$10,793,503	$15,322,971	$19,852,440	$24,381,908	$28,911,377	$33,440,846
Total incremental outflows	($22,442,910)	($7,638,217)	($7,346,217)	($7,054,217)	($6,762,217)	($6,470,217)
Net incremental cash flow	($11,649,407)	$7,684,754	$12,506,223	$17,327,691	$22,149,160	$26,970,629

Cell is named: "Yr1CumCF"

Cumulative Incremental Cash Flow	($11,649,407)	($3,964,653)	$8,541,570	$25,869,261	$48,018,421	$74,989,050

Payback Period: 2.292628695 Years 2.292628695 6.643443217

Year 7	Year 8	Year 9	Year 10	Total
$37,970,314	$41,716,592	$41,716,592	$41,716,592	$295,823,137
($9,212,255)	$10,793,503	$10,793,503	$10,793,503	($21,417,750)
$28,758,060	$52,510,095	$52,510,095	$52,510,095	$274,405,386

$116,875,101	$169,385,196	$221,895,291	$274,405,386

Year 7	Year 8	Year 9	Year 10	Total
$37,970,314	$41,716,592	$41,716,592	$41,716,592	$295,823,137
($51,614,255)	$10,793,503	$10,793,503	$10,793,503	($312,016,941)
($13,643,940)	$52,510,095	$52,510,095	$52,510,095	($16,193,805)

($173,724,090)	($121,213,995)	($68,703,900)	($16,193,805)

Year 7	Year 8	Year 9	Year 10	Total
$37,970,314	$41,716,592	$41,716,592	$41,716,592	$295,823,137
($12,845,524)	$10,793,503	$10,793,503	$10,793,503	($57,467,443)

$25,124,790	$52,510,095	$52,510,095	$52,510,095	$238,355,693

$80,825,408	$133,335,503	$185,845,598	$238,355,693

Year 7	Year 8	Year 9	Year 10	Total
$37,970,314	$41,716,592	$41,716,592	$41,716,592	$295,823,137
($10,547,691)	$10,793,503	$10,793,503	$10,793,503	($35,881,178)
$27,422,623	$52,510,095	$52,510,095	$52,510,095	$259,941,959

$102,411,673	$154,921,769	$207,431,864	$259,941,959

Return on Investment (ROI)

Datamatic

Table 17 - Return on Investment - Datamatic

Calculated using information received from Miguel Luciano and internal PRASA cost data. (Luciano, AAA Revenue, 2006) (Luciano, Datamatic, 2006)

Datamatic	Year 1	Year 2	Year 3	Year 4	Year 5
Total incremental inflows	$10,793,503	$15,322,971	$19,852,440	$24,381,908	$28,911,377
Total incremental outflows	($15,992,100)	($6,302,781)	($6,010,781)	($5,718,781)	($5,426,781)

Simple ROI, 3 years: 62.4%

=IF(SUM(H13:J13)<>0,(SUM(H12:J12)+SUM(H13:J13))/(-1*(SUM(H13:J13))),"N/A")

Simple ROI, 5 years: 151.6% Formula for ROI cell G18:

=IF(SUM(H13:L13)<>0,(SUM(H12:L12)+SUM(H13:L13))/(-1*(SUM(H13:L13))),"N/A")

Simple ROI, 7 years: 217.2% Formula for ROI cell G21:

=IF(SUM(H13:N13)<>0,(SUM(H12:N12)+SUM(H13:N13))/(-1*(SUM(H13:N13))),"N/A")

Year 6	Year 7	Year 8	Year 9	Year 10	Total
$33,440,846	$37,970,314	$41,716,592	$41,716,592	$41,716,592	$295,823,137
($5,134,781)	($9,212,255)	$10,793,503	$10,793,503	$10,793,503	($21,417,750)

Simple ROI, 10 years: 1281.2% Formula for ROI cell G21:

=IF(SUM(H13:L13)<>0,(SUM(H12:L12)+SUM(H13:L13))/(-1*(SUM(H13:L13))),"N/A")

Badger/AMCO

Table 18 - Return on Investment - Badger/AMCO

Calculated using information received from BadgerMeters Inc., AMCO and internal PRASA cost data. (Gomez and Morera, 2006) (Perez, 2006) (Luciano, AAA Revenue, 2006)

Badger/AMCO	Year 1	Year 2	Year 3	Year 4	Year 5
Total incremental inflows	$10,793,503	$15,322,971	$19,852,440	$24,381,908	$28,911,377
Total incremental outflows	($52,179,291)	($48,704,781)	($48,412,781)	($48,120,781)	($47,828,781)

Simple ROI, 3 years: -69.2%

=IF(SUM(H26:J26)<>0,(SUM(H25:J25)+SUM(H26:J26))/(-1*(SUM(H26:J26))),"N/A")

Simple ROI, 5 years: -59.5% Formula for ROI cell G18:

=IF(SUM(H26:L26)<>0,(SUM(H25:L25)+SUM(H26:L26))/(-1*(SUM(H26:L26))),"N/A")

Simple ROI, 7 years: -50.4% Formula for ROI cell G21:

=IF(SUM(H26:N26)<>0,(SUM(H25:N25)+SUM(H26:N26))/(-1*(SUM(H26:N26))),"N/A")

Year 6	Year 7	Year 8	Year 9	Year 10	Total
$33,440,846	$37,970,314	$41,716,592	$41,716,592	$41,716,592	$295,823,137
($47,536,781)	($51,614,255)	$10,793,503	$10,793,503	$10,793,503	($312,016,941)

Simple ROI, 10 years: -5.2% Formula for ROI cell G21:

=IF(SUM(H26:Q26)<>0,(SUM(H25:Q25)+SUM(H26:Q26))/(-1*(SUM(H26:Q26))),"N/A")

Badger/Badger

Table 19 - Return on Investment - Badger/Badger

Calculated using information received from BadgerMeter Inc. and internal PRASA cost data (Luciano, AAA Revenue, 2006) (Gomez and Morera, 2006)

Badger/Badger	Year 1	Year 2	Year 3	Year 4	Year 5
Total incremental inflows	$10,793,503	$15,322,971	$19,852,440	$24,381,908	$28,911,377
Total incremental outflows	($30,242,176)	($9,936,050)	($9,644,050)	($9,352,050)	($9,060,050)

Simple ROI, 3 years: 105.9%

=IF(SUM(I39:K39)<>0,(SUM(I38:K38)+SUM(I39:K39))/(-1*(SUM(I39:K39))),"N/A")

Simple ROI, 5 years: 160.7% Formula for ROI cell G18:

=IF(SUM(I39:M39)<>0,(SUM(I38:M38)+SUM(I39:M39))/(-1*(SUM(I39:M39))),"N/A")

Simple ROI, 7 years: 313.0% Formula for ROI cell G21:

=IF(SUM(I39:O39)<>0,(SUM(I38:O38)+SUM(I39:O39))/(-1*(SUM(I39:O39))),"N/A")

Year 6	Year 7	Year 8	Year 9	Year 10	Total
$33,440,846	$37,970,314	$41,716,592	$41,716,592	$41,716,592	$295,823,137
($8,768,050)	($12,845,524)	$10,793,503	$10,793,503	$10,793,503	($57,467,443)

Simple ROI, 10 years: 585.8% Formula for ROI cell G21:

=IF(SUM(I39:R39)<>0,(SUM(I38:R38)+SUM(I39:R39))/(-1*(SUM(I39:R39))),"N/A")

ITRON/AMCO

Table 20 - Return on Investment - ITRON/AMCO

Calculated using information received from ITRON, AMCO and internal PRASA cost data. (Luciano, AAA Revenue, 2006) (Perez, 2006) (Henry, 2006)

ITRON	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Total incremental inflows	$10,793,503	$15,322,971	$19,852,440	$24,381,908	$28,911,377	$33,440,846	$37,970,314	$41,716,592	$41,716,592	$41,716,592	$295,823,137
Total incremental outflows	($22,442,910)	($7,638,217)	($7,346,217)	($7,054,217)	($6,762,217)	($6,470,217)	($10,547,691)	$10,793,503	$10,793,503	$10,793,503	($35,881,178)

Simple ROI, 3 years: 170.2%

=IF(SUM(I52:K52)<>0,(SUM(I51:K51)+SUM(I52:K52))/(-1*(SUM(I52:K52))),"N/A")

Simple ROI, 5 years: 245.6% Formula for ROI cell G18:

=IF(SUM(I52:M52)<>0,(SUM(I51:M51)+SUM(I52:M52))/(-1*(SUM(I52:M52))),"N/A")

Simple ROI, 7 years: 475.6% Formula for ROI cell G21:

=IF(SUM(I52:O52)<>0,(SUM(I51:O51)+SUM(I52:O52))/(-1*(SUM(I52:O52))),"N/A")

Simple ROI, 10 years: 1077.7% Formula for ROI cell G21:

=IF(SUM(I52:R52)<>0,(SUM(I51:R51)+SUM(I52:R52))/(-1*(SUM(I52:R52))),"N/A")

Internal Rate of Return (IRR)

Table 21 - Internal Rate of Return

Calculated using information received from all meter companies and internal PRASA cost data. (Gomez and Morera, 2006) (Perez, 2006) (Luciano, AAA Revenue, 2006) (Luciano, Datamatic, 2006) (Henry, 2006)

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
(5,198,597)	9,020,191	13,841,659	18,663,128	23,484,596	28,306,065

Internal Rate of Return (IRR)	216.4%

#N/A

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
(41,385,788)	(33,381,809)	(28,560,341)	(23,738,872)	(18,917,404)	(14,095,935)

Internal Rate of Return (IRR)	-1.7%

#N/A

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
(19,448,674)	5,386,921	10,208,390	15,029,858	19,851,327	24,672,795

Internal Rate of Return (IRR)	64.9%

#N/A

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
(11,649,407)	7,684,754	12,506,223	17,327,691	22,149,160	26,970,629

Internal Rate of Return (IRR)	105.3%

Year 7	Year 8	Year 9	Year 10	Total
28,758,060	52,510,095	52,510,095	52,510,095	274,405,386

Year 7	Year 8	Year 9	Year 10	Total
13,643,940	52,510,095	52,510,095	52,510,095	(16,193,805)

Year 7	Year 8	Year 9	Year 10	Total
25,124,790	52,510,095	52,510,095	52,510,095	238,355,693

Year 7	Year 8	Year 9	Year 10	Total
27,422,623	52,510,095	52,510,095	52,510,095	259,941,959

Net Present Value (NPV)

Table 22 - Net Present Value

Calculated using information received from all meter companies and internal PRASA cost data. (Gomez and Morera, 2006) (Perez, 2006) (Luciano, AAA Revenue, 2006) (Luciano, Datamatic, 2006) (Henry, 2006)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	(5,198,597)	9,020,191	13,841,659	18,663,128	23,484,596	28,306,065
Discounted Cash Flow Stream	(4,725,998)	7,454,703	10,399,443	12,747,167	14,582,087	17,575,839
Discounted Cash Flow Stream	(4,956,668)	7,818,558	10,907,028	13,369,342	15,293,821	18,433,696

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	(41,385,788)	(33,381,809)	(28,560,341)	(23,738,872)	(18,917,404)	(14,095,935)
Discounted Cash Flow Stream	(37,623,444)	(27,588,272)	(21,457,807)	(16,213,969)	(11,746,219)	(8,752,467)
Discounted Cash Flow Stream	(39,459,801)	(28,934,824)	(22,505,138)	(17,005,354)	(12,319,539)	(9,179,665)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	(19,448,674)	5,386,921	10,208,390	15,029,858	19,851,327	24,672,795
Discounted Cash Flow Stream	(17,680,612)	4,452,001	7,669,714	10,265,595	12,326,112	15,319,865
Discounted Cash Flow Stream	(18,543,583)	4,669,298	8,044,064	10,766,647	12,927,735	16,067,610

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	(11,649,407)	7,684,754	12,506,223	17,327,691	22,149,160	26,970,629
Discounted Cash Flow Stream	(10,590,370)	6,351,037	9,396,110	11,835,046	13,752,886	16,746,638
Discounted Cash Flow Stream	(11,107,274)	6,661,023	9,854,724	12,412,701	14,424,148	17,564,023

Year 7	Year 8	Year 9	Year 10	Total
28,758,060	52,510,095	52,510,095	52,510,095	274,405,386
				NPV
17,856,492	32,604,638	32,604,638	32,604,638	173,703,647
				NPV
18,728,047	34,196,033	34,196,033	34,196,033	182,181,922
Year 7	Year 8	Year 9	Year 10	Total
13,643,940	52,510,095	52,510,095	52,510,095	(16,193,805)
				NPV
(8,471,814)	32,604,638	32,604,638	32,604,638	(34,040,079)
				NPV
(8,885,313)	34,196,033	34,196,033	34,196,033	(35,701,536)
Year 7	Year 8	Year 9	Year 10	Total
25,124,790	52,510,095	52,510,095	52,510,095	238,355,693
				NPV
15,600,518	32,604,638	32,604,638	32,604,638	145,767,106
				NPV
16,361,961	34,196,033	34,196,033	34,196,033	152,881,831
Year 7	Year 8	Year 9	Year 10	Total
27,422,623	52,510,095	52,510,095	52,510,095	259,941,959
				NPV
17,027,292	32,604,638	32,604,638	32,604,638	162,332,552
				NPV
17,858,374	34,196,033	34,196,033	34,196,033	170,255,817

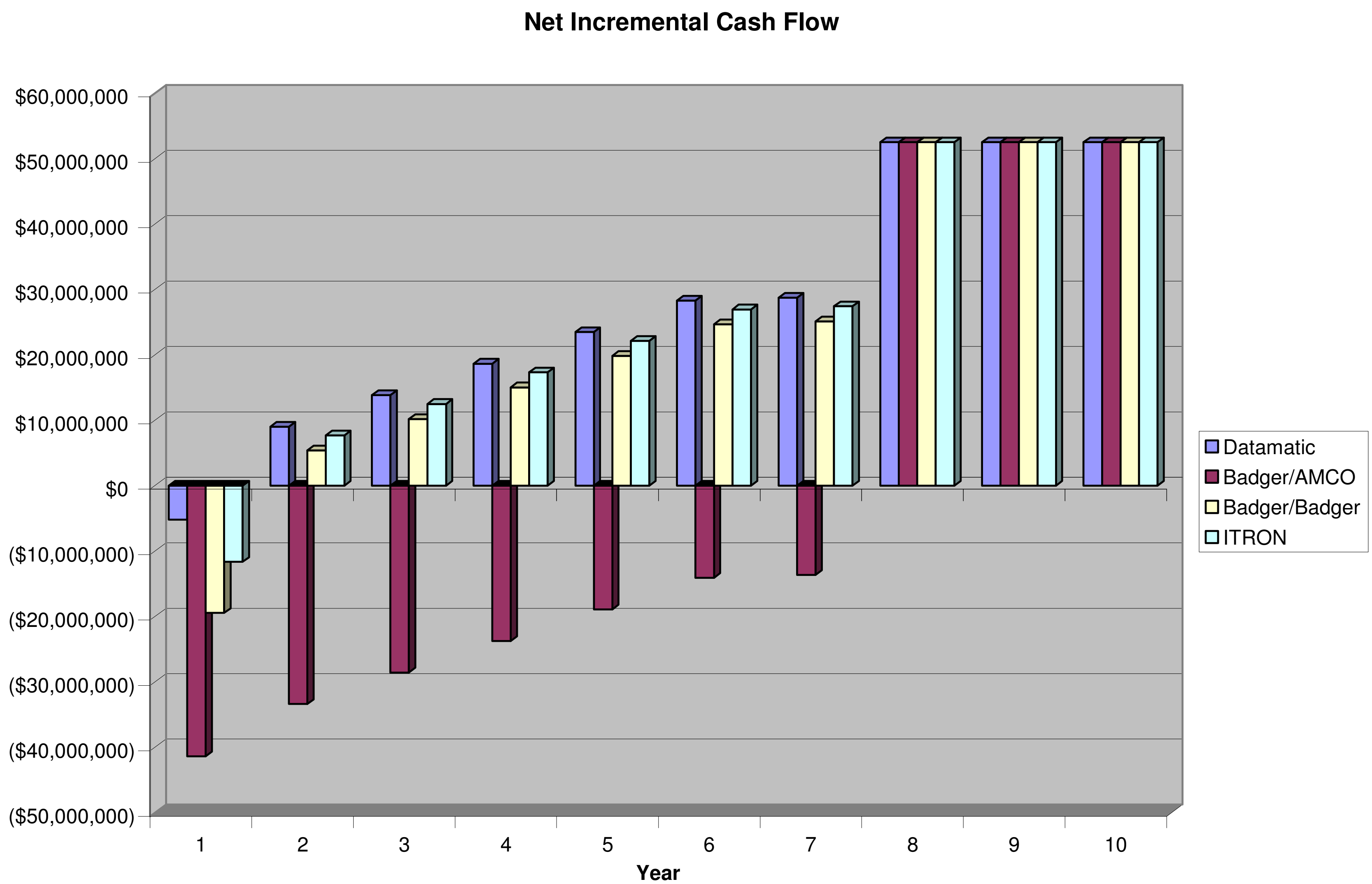


Figure 23 - Net Incremental Cash Flow

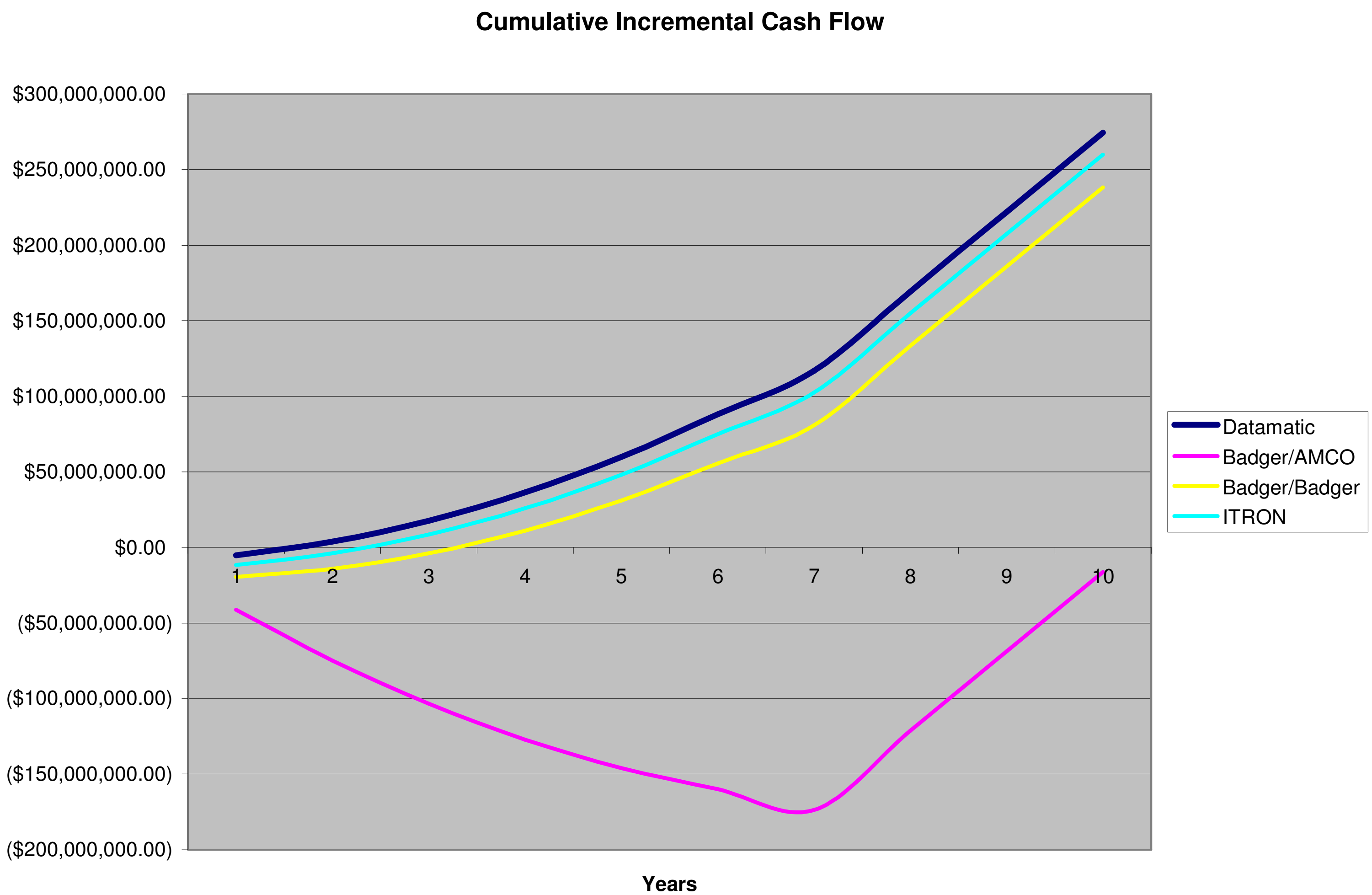


Figure 24 - Cumulative Incremental Cash Flow

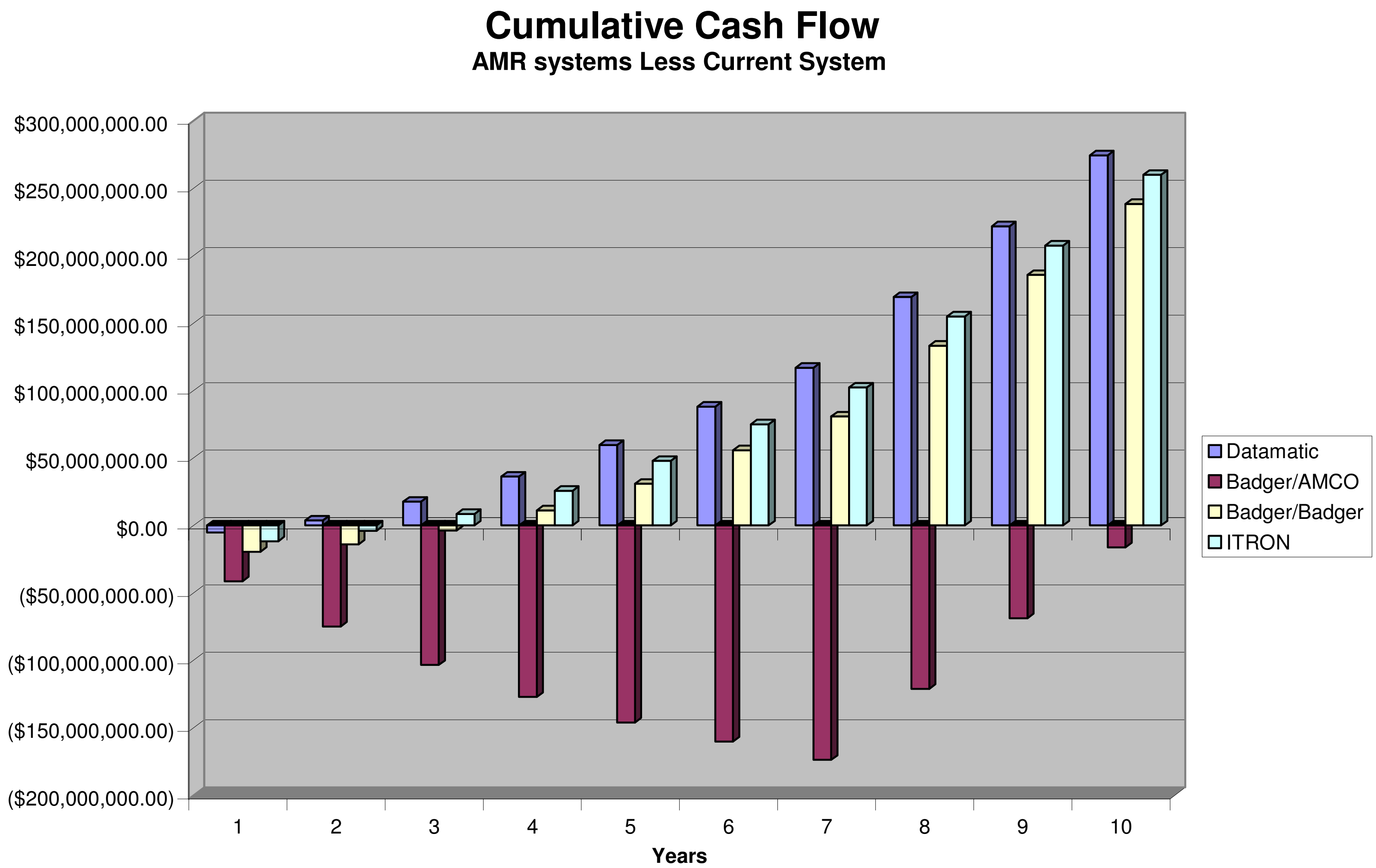


Figure 25 - Cumulative Cash Flow

Appendix J: Sponsor Description

The Puerto Rican Water and Sewer Authority (PRASA), currently a government run entity, is in charge of the water supply on the island of Puerto Rico (McPhaul, 2005). Since its inception in the 1940s until the mid 1990's it was a government run company. From the mid 90's to 2004, the government contracted two private companies, at different times, to run the organization. The companies did little for the authority, causing it to acquire massive amounts of debt towards the end of their contracts. In 2004 the government ended the privatization of the company which was referred to as "a mess" by the new president.

After this re-acquisition, PRASA launched several programs to improve their current situation. In 2005, a year after the change over, they began an effort to replace all meters on the island within 7 years. At the same time, they started researching AMR (Automatic Meter Reading) technology. This technology will allow them to read meters from a distance and in greater numbers. Finally, they began looking into improving their billing and data storage system in order to maintain better records of meter information and customer records.

The Authority is now a public corporation that is 100% governmentally controlled, receiving all of its funding from water service revenue (Andres Garcia, personal communication, 2/10/2006). The authority has a president/CEO that is selected by a board of directors. The company has a series of directors that are in charge of their respective divisions that report directly to the president. The four main divisions within PRASA are: Customer Service, Infrastructure, Finance and Operations. PRASA currently employs 4,500 employees who are spread across the company's 5 regions: North, East, South, West, and Metro.

The Puerto Rican Water and Sewer Authority has an annual budget of US $700,000,000. (Andres Garcia, personal communication, 2/3/2006) There are no other departments, government or independent, that work on the water system on the island of Puerto Rico (Pridco, 2006, Water). PRASA has numerous facilities throughout Puerto Rico that consist of: 134 filtration plants, 60 waste water treatment plants, 1,600 Pumping Stations, 1,200 km of water lines, 6,000 km of sewer lines, 1.3 million clients and 1.3 million water meters. (Andres Garcia, personal communication, 2/10/2006) In October 2005, the water rates increased by 68%, and in July of 2006, there is to be an expected increase of 38% over the new October rates.