Asset Management: A Guide For Water and Wastewater Systems

2006 Edition

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Acknowledgements

The information presented in this document has been compiled from various sources. The overall basis for asset management presented in this document is the approach of Australia and New Zealand as presented in the International Infrastructure Management Manual – Version 2.0, 2002. This information was supplemented with information included in EPA's Advanced Asset Management Training program which is conducted by EPA and GHD Inc. This training program is based on the Australia/New Zealand methodology that has been tailored for the United States.

Additional information for this manual was gained through site visits and interviews that the EFC Director held with many individuals involved with asset management in Australia and New Zealand. These interviews were held with asset management personnel connected with utilities, governmental entities, consulting firms, associations, users groups, and elected officials. The specific focus of the interviews was how to tailor the asset management principles from larger systems to smaller systems. Information gathered from these interviews and discussions has been incorporated into this document.

Lastly, the NM EFC has been providing asset management training to water and wastewater utilities across the state and in several other states and has been working directly with three small water systems in New Mexico to develop asset management plans. The experiences gained from working directly with systems and from discussions at the training sessions has also been incorporated into this document.

Purpose and Need for Guide

New Mexico's drinking water and wastewater systems will need to implement new administrative systems and management tools to allow them to adapt to the increased regulatory requirements and environmental complexities they face. These new tools will allow the systems to operate on a "business model" for long term sustainability to help address the issues of: new and stricter regulatory requirements, growing populations, increased service demands, limited water supplies, a highly variable climate, aging infrastructure, and limited state and federal funding.

Cost estimates for water and wastewater system needs in New Mexico are several billion dollars, while the existing state and federal funding sources can only meet a fraction of this need. These sources of funding are not expected to increase, and in many cases, are declining. Therefore, approaches to reducing the gap between what is needed and what funds are available will need to be adopted. In addition, funders want assurance that the investments they make in water and wastewater infrastructure will be adequately managed and maintained to ensure long term sustainability and security. This assurance will require water and wastewater systems to present convincing evidence that they possess adequate financial, technical, and managerial capacity to provide the service that their customers expect, to maintain the infrastructure necessary to provide that service, and to manage the organization technically and financially throughout the life expectancy of the improvements being financed.

To address these significant challenges, the 2005 New Mexico Legislature passed HJM86, which called for the State Engineer, in collaboration with the New Mexico Environment Department and other agencies, to "develop criteria for water system planning, performance and conservation as a condition of funding." The results of the HJM86 efforts indicated that requiring specific standards related to water and wastewater system operation, management, and planning is the best way to ensure that the millions of dollars in annual state and federal funding is invested in the most appropriate and cost-effective projects and is provided to systems that have adequate capacity to protect that investment. The report developed in response to HJM86 recommended that systems adopt a "business model" for managing the delivery of services that includes:

- a five-year financial plan with a fully allocated rate structure;
- an asset management plan;
- a water accounting system with full metering;
- full compliance with the Safe Drinking Water Act (SDWA), the Clean Water Act (CWA), and all of the regulations of the Office of the State Engineer and the New Mexico Environment Department;
- a governance structure adequate for proper management and oversight; and
- participation in regional efforts to collaborate on long term solutions.

In 2006, three Technical Assistance Providers[1] and the State of New Mexico teamed-up to develop guidebooks to help water and wastewater systems better manage their water resources and plan for their future. The guidebooks are titled:

---Water Use Auditing: A Guide to Accurately Measure Water Use and Water Loss
---Financial Planning: A Guide for Water and Wastewater Systems; and
---Asset Management: A Guide for Water and Wastewater Systems.

These guidebooks address core issues regarding water system sustainability: auditing water use to reduce water losses and increase system efficiency, financial planning and management to ensure sufficient revenues to sustain operations, and asset management to allow the system to provide a sustained level of service at the lowest life cycle cost. Water and wastewater system owners, operators, managers, and board members will find that these guidebooks are useful tools for assessing the current status of their operations and for developing strategic plans for sustainable water and wastewater service.

These guidebooks are intended to be used together as integrated tools for efficient management to enable the system to meet future service demands and regulatory requirements and to provide for long-term sustainability. For example, asset management is a fundamental step in determining financial resources needed to operate the system and pay for system improvements, expansions, or replacements. The water auditing program can tie to asset management by providing information about the condition of some of the buried assets. The water auditing process also ties to water conservation and rate setting. Because of these ties, water and wastewater system personnel are encouraged to examine all three manuals before beginning their system evaluation. However, the guides can be used independently, allowing a water or wastewater system to implement the "business model" incrementally, starting with the system's most pressing needs or starting with the easiest success. No matter how the system implements the practices, the ultimate goal should be incorporating all three of these tools into the system's standard management practices.

Once initial assessments are complete, findings can and should be used by key decision makers to guide the future of the water or wastewater system. These are not "one time" activities; it will be important to reevaluate and update this information annually or whenever the system's needs change. Over time, the use of the tools can be increased and enhanced to support more complex and sophisticated operations.

Providing safe and dependable supplies of drinking water and protecting water quality through adequate wastewater treatment is critical to maintaining New Mexico's economic vitality and quality of life. These guidebooks should provide the tools needed by water and wastewater systems to actively and consistently analyze current operations and future needs in order to develop robust management systems and well-designed infrastructure to meet these growing challenges.

[1] Three technical assistance providers contributed to this project. They are the Environmental Finance Center, New Mexico Rural Water Association, and Rural Community Assistance Corporation.

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Section 1
Introduction

1.1 What is Asset Management

All water and wastewater systems are made up of assets, so me that are buried assets and some that are visible. These are the physical components of the system and can include: pipe, valves, tanks, pumps, wells, hydrants, treatment facilities, and any other components that make up the system. The assets that mak e up a water or wastewater system generally lose value over time as the system ages and deteriorates. Along with this deterioration, it may be more difficult to deliver the type of service that the utility's customers want. Costs of operation and mainten ance will increase as the assets age. Then, the utility may be faced with excessive costs that it can no longer afford.

There is an approach to managing the assets of the system that can assist the utility with making better decisions on managing these aging assets. This approach is called asset management. The techniques involved in asset management have been refined by the international community, particularly in Australia and New Zealand.

The International Infrastructure Management Manual defines t he goal of asset management as meeting a required level of service in the most cost -effective way through the creation, acquisition, operation, maintenance, rehabilitation, and disposal of assets to provide for present and future customers. A community, water or wastewater utility should care about managing its assets in a cost effective manner for several reasons 1) these types of assets represent a major public or private investment; 2) well - run infrastructure is important in economic development; 3) pr oper operation and maintenance of a utility is essential for public health and safety; 4) utility assets provide an essential customer service; and 5) asset management promotes efficiency and innovation in the operation of the system.

The intent of asset management is to ensure the long -term sustainability of the water or wastewater utility. By helping a utility manager make better decisions on when it is most appropriate to repair, replace, or rehabilitate particular assets and by developing a long-term funding strategy, the utility can ensure its ability to deliver the required level of service perpetually.

1.2 Benefits of Asset Management

There are many positive benefits of asset management. Systems that fully embrace asset management principals ma y achieve many or all of these benefits. However, systems may receive some of these benefits just by starting asset management. The benefits of asset management include, but are not limited to, the following:

- *Better operational decisions*
- *Improved emerge ncy response*
- *Greater ability to plan and pay for future repairs and replacements*

- *Increased knowledge of the location of the assets*
- *Increased knowledge of what assets are critical to the utility and which ones aren't*
- *More efficient operation*
- *Better communication with customers*
- *Rates based on sound operational information*
- *Increased acceptance of rates*
- *Capital improvement projects that meet the true needs of the system*

Systems should strive to achieve as many benefits as they can with their asset management program.

1.3 Intended Audience

This guide to asset management is intended for any water and wastewater system, but it is intended to be a starting point for systems. For systems that wish to have a more robust asset management program, there are many guides and resources that can help achieve a higher-level program. In addition, systems with greater economic resources may wish to seek out consultants specializing in asset management to aid them in developing a more detailed asset management program.

This manual contains all the basic elements of asset management, but does not go into extreme depth on any of the topic areas. The manual is structured for systems that will not be able to handle extremely sophisticated asset management techniques at this time. Over time, however, systems will be able to improve their asset management programs and will be able to increase the sophistication of the programs. Some systems may form cooperative arrangements with other systems that would allow them to eventually achieve an even higher level of sophistication.

1.4 Core Components of Asset Management

There are five core components of asset management. This manual will discuss each of these components in greater depth. A general discussion of the component can be found in Sections 3 through 7. There is also an appendix for each of these components that provides resource information and specific details regarding options for conducting each component.

- Asset Inventory
- Level of Service
- Critical Assets
- Life Cycle Costing
- Long-term Funding Strategy

1.5 Updating this Manual Over Time

Asset management is a core business principle that will underlie everything a water or wastewater system does. As such, it is not a “side activity” that can be completed. It becomes the way a system does business and therefore is always ongoing to some extent. Therefore, systems will be continuously updating and improving their asset management programs. Thus, this asset management manual needs to be updated to keep pace with the systems using it. As utilities move forward with asset management, it may become apparent that portions of the document need to be revised or new sections need to be added. This document will be revised over time to include new information, new techniques, or greater clarification.

Section 2
Asset Management: The Way To Do Business

One of the most important aspects of asset management is that it cannot be something the utility does on the side as one of its many activities, rather it must be the w ay the utility does business. Asset management thinking must underlie every activity, every action, and every decision that the utility undertakes.

Having asset management underlie all of the utilities activities means that there must be "buy in" of the asset management concepts at all levels of the utility from the least senior employee all the way through the highest elected official or manager. Every level of employee must be convinced that asset management is important to the overall function of the utility. If there is insufficient acceptance of asset management, the plan will be much less successful and may not succeed at all.

One way to obtain acceptance of asset management is to explain to each employee or volunteer working with the system t he overall goal of the system's asset management strategy and how that particular employee will input into the process. When asset management is adopted as the way of doing business, each employee's input, knowledge and expertise is important to the proce ss and all are critical to the successful implementation.

Each activity that is undertaken must have asset management thinking at its core. For example, when working on the water system to fix a break, the operator should have a map of the system and indicate on it the exact location of the break. The operator should note all pertinent information to the asset management program, such as: location of break, type of break, type of pipe, type of repair, length of time from report of leak to response to scene, length of time to repair the pipe, materials used, and difficulties encountered. This information can then be used in many ways. Did the same pipe break multiple times? Has the system experienced more breaks on one type of pipe than another? Did the operator respond in a timely manner? Did the repair get fixed in a timely manner? By tracking this type of data a utility manager can begin to develop a picture of the overall system and its operation.

Another example is a customer complaint. When the utility receives a customer complaint, it should track various items such as: What routine maintenance or operational activities were taking place in the time frame before the complaint? Is there any unusual condition that would cause this type of pro blem? Has this complaint been made before? Is there a pattern of complaints of this type (same area, same source, etc.)? Has an operator been dispatched to check out this type of complaint? How long did it take to respond?

Throughout the entire utility – whether it has 3 employees or 300 – everyone should be considering how their activities impact the overall operation of the utility and how their activities fit within the broader structure of the asset management plan.

One of the best approaches to receiving buy-in or acceptability of the asset management program at all levels of the water or wastewater system, is to demonstrate successes using the asset management techniques. There are many small successes that the program may demonstrate over time that can be used to convince even reluctant employees or volunteers that the efforts will benefit the utility. As an example, producing a map showing the system's assets in a visual format can be of great benefit to the system, especially if there has never been a good map showing these assets.

Section 3
Asset Inventory

3.1 Introduction

The first core component of asset management is the asset inventory. This component is probably the most straightforward of all. It is also, arguably, the most important as it underlies all other aspects of asset management. Some asset managers of systems in Australia and New Zealand believe that this step is absolutely critical for a water or wastewater utility and feel that completing this component alone can greatly improve a system's management.

The types of questions that the utility will ask themselves in this component are: What do I own? Where is it? What condition is it in? What is its remaining useful life? What is its value? Each of these facets is discussed in more detail below.

3.2 What do I own?

The most fundamental question a utility owner, manager, or operator can ask, is what assets do I have? It is absolutely critical for a utility to understand what it owns. It is pretty hard to manage something effectively if you don't know what that "something" consists of.

Although "what do I own" is a seemingly straightforward question, it is not always easy to answer. The difficulties arise from several factors: some of the assets are underground and can't be seen; assets generally are put in at different times over a long period of time; records regarding what assets have been installed may be old, incomplete, inaccurate, or missing; and staff turnover in operations and management may limit the historical knowledge of system assets. Given these difficulties it will probably not be possible to form a complete asset inventory the first time the system attempts to do so. It is important to recognize that the system is only trying to form the best inventory it can and develop an approach to adding to or improve the database over time.

To develop the initial inventory, several approaches can be used and these are listed below. However, the utility should be as creative as possible with other approaches to obtaining this information.

- Determine who was operating, managing and/or owning the system at the time of the major construction periods (when a large number of assets were put in.) Interview these individuals and gather as much information as possible regarding their recollections of what assets were installed and where they were installed. If there are maps of the system, these can be used during the discussions.
- Examining any as-built or other engineering drawings of the system

- Visual observations of above-ground or visible assets (e.g., hydrants, pumps, manholes, treatment works)
- Interviewing community residents who may have lived in the area during construction and who are familiar with the construction activities (especially helpful in very small towns in which the residents were actively involved in developing the utility)
- Estimates on buried assets using above ground assets as a guide (e.g., using manholes to estimate locations, size, and type of pipe between the manholes; using isolation valve locations to estimate buried water pipe locations)

Several approaches may be necessary to get a good start on the asset inventory. A utility should use as many approaches as it deems necessary to get the best initial inventory of assets.

3.3 Where are my assets?

The next question in inventorying the assets is where are they? Once you know what you have, it is important to know where they are. This component involves two steps: 1) mapping the assets and 2) putting a location in the inventory. In terms of mapping, the most important factor is to have a visual picture of the asset locations, especially the buried assets. The map can be as simple (hand drawn) or as complex (Geographic Information System) as the system is capable of. The most important factor is that it is useable to track any changes to the asset inventory and can be used to track asset failures. Several different approaches to mapping are discussed in Appendix 1.

The second aspect involves putting a location in the asset inventory indicating where the asset is located. Generally, this would be a street name, street address, or building location such as pump house or treatment building. The addresses should be as specific as possible. That way, assets can be grouped together based on their location. It is important to be able to group assets by their category (i.e., all valves, all hydrants) and by their location (all assets on main street.) In this manner, the system can answer various questions about their system, such as, "If I replace the pipe on main street, what other assets are associated with that pipe that will also have to be replaced?" "If I replace a component in the treatment building, what other assets might be impacted?"

The location of the asset should be included along with the other inventory data to allow the types of querying discussed above. Methods of including data in an inventory are discussed further in Section 3.7 below.

3.4 What is the condition of my assets?

After the assets are determined and located on a map, it is important to know the condition of the assets. A condition assessment can be completed in many different ways, depending on the capability and resources of the system. In terms of the simplest approach, the system can gather people who have current or historical knowledge of the system in a room. The group can then select a condition ranking approach (0 through 5, A through F, Excellent through unacceptable, etc.) and ask the group to look at the list of assets and rate each asset using the selected methodology. This approach uses the best information available but does not require systems to gather additional data in order to rate the assets.

As a higher level approach or as a next step after the initial ratings of the assets, systems can gather data on asset condition through more sophisticated means and re-rate the assets. As an example, a sewer can be televised to determine the interior pipe condition. Water pipes can be evaluated using leak detection technology. A ranking system as described above may still be used with this higher-level data, or a more sophisticated numbering system can be used. Examples of these types of ranking systems are included in Appendix 1.

3.5 What is the remaining life of my assets?

All assets will eventually reach the end of their useful life. Some assets will reach this point sooner than other assets. In addition, depending on the type of asset, it will either reach that point through amount of use or length of service. For example, a pump will wear out sooner if it is used more and will last longer if it is used less. The actual age of the pump is not as important as the amount of work the pump has done. On the other hand, pipe assets wear out based more on the length of time in the ground. If a pipe is in the ground for decades it has had considerable time to contact the soil around it and the water within it and may start to corrode.

There are many additional factors that will affect how much life a given asset has. Factors such as poor installation, defective materials, poor maintenance, and corrosive environment will shorten an asset's life, while factors such as good installation practices, high quality materials, proper routine and preventative maintenance, and non-corrosive environment will tend to lengthen an asset's life. Because of these site-specific characteristics, asset life must be viewed within the local context and the particular conditions of that utility. Cast Iron pipe may last 100 years at one facility and 30 years at another. It is best to make judgments on asset life based on past experience, system knowledge, existing and future conditions, prior and future operation and maintenance, and similar factors in determining useful life. In the absence of any better information, a system can use standard default values as a starting point. However, over time, the system should use its own experiences to refine the useful lives.

As an example, if a given water utility routinely replaced its chlorinator every 5 years because that was as long as that asset lasted, then 5 years should be used as chlorinator life, not a standard default value. However, if the system only had its pipe in the ground for 20 years and had no knowledge of how long it could be expected to last, it could use a standard default value of between 50 to 75 years. However, as time goes on, if the system did not notice any reduction in the integrity of the pipe after 40 years, the useful life could be increased from 50 years to say 75 to 100 years. If the system started seeing a reduction in the pipe integrity (lots of breaks due to corrosion) at 40 years, it would keep the useful life closer to 50.

Additional information regarding useful lives is contained in Appendix 1.

3.6 What is the Value of the Assets?

Generally, when utilities consider the value of assets, they think about the cost of initially installing the assets. This cost has no other importance than historical information or it can be used by a system that depreciates the costs of assets over time. However, the installation cost does not have a direct bearing on what it will cost to replace that asset when it has reached the end of its useful life. The asset may not be replaced by the same type of asset (e.g., cast iron pipe may be replaced by PVC pipe) or it may be replaced by a different technology entirely (e.g., a chlorination system replaced by an ultraviolet disinfection facility). Furthermore, costs of various assets may change drastically over time, such that the cost of installing pipe in 1956 in no way reflects the costs of installing pipe 50 years later in 2006. Some prices may increase, such as materials, while technological advances may decrease other costs.

The real value of the assets is the cost it would be to replace the assets using the technology the system would employ to replace them. If the system has asbestos cement pipe now, but would replace the system with PVC pipe, the real value of the assets is the cost of replacement using PVC and the installation cost associated with PVC.

Although the idea behind an asset value is relatively simple, obtaining costs for the asset replacement is not as easy. Small utilities may not have the expertise to estimate replacement costs. In these cases, the utility should either estimate in the best manner possible or leave this portion of the inventory blank for the initial stages of the asset management strategy. This information can be added later as the system gathers additional information or expertise.

If estimation is done, the possible approaches include:

- If the system has had recent improvements, such as pipe replacement, information regarding the cost per linear foot can be used.
- If a neighboring system that is similar has had work done, costs obtained in their project may be used.
- Organizations that complete a large number of construction projects per year may be able to provide estimates, such as New Mexico Environment Department's Construction Programs Bureau, Rural Development or New Mexico Finance Authority.
- Some organizations, such as the City of Albuquerque, periodically publish unit costs for construction. These costs can be used as a starting point and revised as necessary to cover costs in other areas. If costs are

typically higher in a particular area than Albuquerque, they can be raised, if costs are typically lower, the prices can be decreased.

Over time, as more systems begin completing asset management strategies, a users group can be formed that will allow water or wastewater utilities to share information, such as unit costs/replacement costs with each other.

3.7 Organizing the Asset Inventory

There are many options regarding how to manage the asset inventory data. Specific options include:

- Commercially available software for asset inventory
- Generic database software
- Spreadsheet software
- Hand written inventory

These options are discussed in greater detail in Appendix 1. The best option is a specifically designed asset management software program. This type of program provides the greatest level of flexibility in terms of use and is already programmed to contain asset inventory data. However, this type of program is expensive and may require a robust computer system to make it accessible to all operational and management personnel.

The next option, generic database software, is much less expensive but will require a time commitment on the part of someone within the utility to set up the database and input the data. This option will, however, allow the system to sort the information and will allow the information to be useable. This option is the recommended option for smaller systems that cannot afford commercial software. If the system cannot initially develop a database for their asset inventory, they should develop a plan for how they will get a database in the future. For example, if they need to purchase a computer or software, they should begin setting aside funds for that purpose.

The other options available, spreadsheets and handwritten inventories, should only be considered temporary solutions until the system can obtain a database of some type (the first two options.) Neither of these approaches allows the system to easily categorize information and both are very cumbersome to use. Neither approach allows the type of querying that an asset management database needs. For example, a database can answer the question, "Provide me a list of all pipes installed in 1950 that are cast iron that have had at least 1 break in the last 10 years." This list can be obtained in a matter of moments with a database. However, with a handwritten list or a spreadsheet, answering a question like this would be an extremely tedious and time-consuming activity.

The key with the inventory is to structure it to provide the information the system needs in an easy to retrieve fashion. If the data is not easily obtainable, the system will not use it and the inventory ceases to have value or as much value as it can.

3.8 Summary

It is critical for systems to understand that they do not need to worry about the data quality initially. The most important step is to develop at least a rudimentary asset inventory with all of the characteristics discussed above. The data quality can be increased over time as the system gathers more information and becomes more comfortable with the concept of asset management.

Systems should also be careful to not let themselves get "bogged down" in this step. This step is important but it should not be all consuming. The system should complete this step to the extent possible and then move on to the other steps.

In taking a long-term view of asset management, systems should consider ways in which they can make the inventory more sophisticated. As an example, a system may want to develop a GIS map and database within 10 years. The system could begin saving money for this approach now so that in 10 years sufficient funds are available. Systems can also work with neighboring systems to share GIS equipment or GIS specialists to reduce the costs for all participants. A group of systems could contract with a local university or community college or consulting firm that has a GIS employee, student or professor to get them to manage the GIS software for all participants. This person could provide updates or print outs of information to the system.

Section 4
Level of Service

4.1 Introduction

A Level of Service Agreement (LOS) defines the way in which the utility owners, managers, and operators want the system to perform over the long term. The LOS can include any technical, managerial, or financial components the system wishes, as long as all regulatory requirements are met. The LOS will become a fundamental part of how the system is operated.

4.2 Why a Level of Service Agreement?

There are two key facets to asset management – defining the level of service the system will strive to provide its customers over the long term and determining the most efficient and economical way to deliver that service (the least cost approach). Therefore, determining and detailing the level of service that the system is going to provide is a key step in the overall process.

The Level of Service Agreement – the document that will spell out the service the system wishes to provide – is a multi-faceted tool that can fulfill a wide array of purposes as described below. Further explanation regarding each of these items folllows.

- Communicate the system's operation to the customers (residential, industrial, or commercial)
- Determine critical assets
- Provide a means of assessing overall system performance
- Provide a direct link between costs and service
- Serve as an internal guide for system management and operations staff
- Provide information for system annual report or annual meeting presentation
- Reduce system costs through customer involvement

Customer Communication
It is important for a water or wastewater utility to communicate with its customers to avoid confusion, bad feelings, accusations of improper operation, and to make clear what the customer's expectations should be. This need for communication is particularly important for smaller, rural systems, but it is important for all.

As an example, consider a system that has periodic water outages. The system is fed by wells or springs that periodically stop producing water or produce less water. However, not all sources are depleted at once, so the system can serve some customers but not others. The system may have a plan to deal with this situation by moving water around the system so that different areas are without water on any given day or portion of a day. However, it is critical that this plan be communicated with the customers so that they will understand the approach the system is taking to address the situation. One way the system can achieve this communication is to have their approach be part of the LOS. The LOS could say, “In the event of an outage, the system will move water around so that no area is without water for more than 1 day. The rotation of water movement will be posted in a public area so that customers know when they will be with and without water.”

Determine Critical Assets
The LOS can be one factor in determining critical assets. Further considerations in criticality are discussed in the next section. An example of how the LOS can impact criticality is where a system’s LOS includes the factor “water will be delivered to customers 99% of the time.” If the system has only one water source, the source will be a critical asset for the system. It must keep the source operational at all times in order to meet this criteria.

Provide a Means for Assessing Overall System Performance
If at least some of the LOS factors include measurable items, the system can keep information regarding how well they are meeting these criteria and use that as one measure in assessing the overall operation. For example, consider a system that includes the following measures in its LOS:

- Breaks will be repaired within 6 hours of initiation of repair 95% of the time.
- Customer complaints will be responded to within 24 hours, Monday through Friday.
- Losses will be kept to less than 15% as measured by gallons pumped each month – gallons sold each month.
- System will meet all state and federal regulations.

All of these items are measurable if the system collects the appropriate data. Assume the system has the following data from its past year of operation.

- 250 breaks occurred, 230 were fixed in less than 6 hours
- 30 complaints were received, all 30 responded to within 24 hours
- Losses over the year as follows: January 12%, February 10%, March 19%, April 14%, May 9%, June 13%, July 9%, August 10%, September 12%, October 9%, November 10%, December 12%
- System met all regulations; no violations

Based on this data, the system met some, but not all of its LOS factors. The following items were met: The customer complaints were responded to on time and the system met all the state and federal regulations. The following items were not met: breaks were not repaired within 6 hours and the losses were not kept to less than 15% in all months. The system can look at these results and determine the items that it needs to work harder on in order to meet the level of service requirements.

Provide a Direct Link Between Costs and Service

There is a direct link between the Level of Service provided and the cost to the customer. When a higher LOS is provided, the costs to the customers will likely increase. This relationship provides an opportunity for the water system to have an open dialogue with its customers regarding the LOS desired and the amount the customers are willing to pay for this level of service or increased services. For example, customers may complain about aesthetic contaminants in the water – those contaminants that cause taste, odor, or color issues in the water, but not health concerns – and wish to have these contaminants removed. The water system can install treatment to remove these contaminants but it will cost each customer more for their water each month. The water system can have a dialogue with the customers to explain what the treatment would entail, what the finished water quality would be, and how much it would cost the customers. Following the discussions, the customers could decide whether or not they were willing to pay for the additional treatment. In this way, the LOS sets desired services and provides information to the customers regarding what the costs of their LOS will be.

Serve as an Internal Guide to System Operation and Management

It is much easier to operate or manage a system when the operations and maintenance staff as well as the management staff understand the goals of the operation. Defining the LOS sets these goals for the system. These goals allow the operations staff to have a better understanding of what is desired from them and the management has a better understanding of how to use staff and other resources more efficiently and effectively. Checking how well the system is meeting LOS also allows the management to shift resources if need be from one task to another to meet all the goals more effectively.

Provide Information for Annual Report or Meeting

If the system tracks information regarding how well it is meeting the LOS criteria on a weekly or monthly basis, it can use this information to prepare an annual report regarding how well the system met these criteria over the course of a year. This information can be presented to the customers at an annual meeting so that customers are aware of how well the system met the overall goals for the operations of the system. This meeting would also be an opportunity to discuss any changes needed in the LOS, based on the operations data. Perhaps some of the LOS conditions are not possible to be met given the current staff or resources. If that is the case, the system will either have to reduce the LOS provided or increase staff or other resources in order to meet the current LOS. The decision to increase staff or other resources or decrease LOS will directly impact customers, so it is important to use the opportunity of the annual meeting to discuss the potential options with them.

Alternatively, the system may decide that some criteria are very easily met and may not be stringent enough. The system may find that it can increase the LOS for particular criteria without impacting costs and may wish to discuss the changes with the customers at the annual meeting.

Savings Due to Customer Involvement
Many water systems believe they have a good understanding of what their customers want, although they may never have directly asked their custome rs. One system believed their customers wanted breaks fixed within 4 hours of initiation of repair. However, it was expensive to operate in this mode, and the system wished to determine if they could cut costs by increasing the amount of time required to make a repair. The question was whether or not the customers would be amenable to a change in the amount of time to make a repair. They decided to hold a series of meetings with customers to ask them if they were okay with the change to a longer time to repair breaks. The customers indicated that the amount of time was not their biggest concern; the biggest issue was receiving advanced notification that the water would be shut off for a period of time. They wished to receive a minimum of 15 minutes not ice that the water would be shut off, but once this notice was received, they were not concerned if the repair took longer than 4 hours to complete. In this manner, the system was able to save money and actually provide more of the type of service the cus tomers wanted.

4.3 What is the Minimum Starting Point for the LOS?

All systems must operate within the state and federal regulations and requirements. These regulations are generally specified in the Safe Drinking Water Act for water systems and the Clean Water Act for wastewater systems, but there are additional rules and regulations at the state and federal level. All systems should already be aware of these rules and should already be following them. Because there are many elements to the regulations, it is not necessary to spell out conformance with each and every regulation in the LOS. Instead, the LOS could contain a basic statement indicating that "the system will conform to all applicable state and federal regulations." Alternatively, the LOS may include statements that describe categories of compliance such as, "will conform to all water quality requirements," "will conform to all operator certification requirements," or "will meet all requirements of the open meetings act." In this case, the LOS may also need a summary statement to the effect that "the system will conform to all other applicable federal and state regulations" to ensure that nothing has been left out.

Although the state and federal regulations set bare minimum standards o f operation in the LOS, these standards do not adequately address all areas of operation and should not be the sole components of the LOS. Without adding additional elements, the LOS will not fulfill the range of purposes described in the preceding sectio n. Systems should include many other components to spell out important areas of the system's operation.

4.4 What else should be included in the LOS?

The maximum level of the LOS is defined by the maximum capabilities of the assets. A system cannot include something within a LOS that the system is not capable of doing. As an example, if the system wishes to include the provision of fire flow in its LOS, but it only has 2 and 4 inch lines with no fire hydrants, there is no way the system can provide fire flow. The system may wish to include the provision of fire flow in its long -range

Capital Improvement Plan and seek funding for a system upgrade to provide this, but until the assets for fire flow are in place, fire flow provision should not be included in the LOS.

Within the range of the minimum (regulations) and maximum (capabilities of assets) there are numerous items a system could include within its LOS. Items may be included so the system can: communicate its intentions with its customers, measure its performance, and determine critical assets.

Examples of items that can be included in the Level of Service include, but are not limited to the following:

- Number of breaks per mile that are acceptable
- Length of time from report of a leak or break until repair
- Amount of notification (and method) prior to a scheduled shut down
- Amount of notification (and method) prior to a non-scheduled but non-emergency shutdown
- Quantity of unplanned interruptions in service verses planned interruptions
- Number of hours to fix the pipe break once on site
- System losses maintained at less than X% overall
- Maximum system flow will be X gpd
- No detection of TC or EC at the source
- Water pressure will be maintained throughout the system at X psi
- Rates will be raised annually to avoid rate shock in the system
- Rates will be reviewed annually
- Storage capacity will be maintained at X gallons total
- No water outage will be longer than X hours total
- Customers will be notified of planned system outages at least X hours or X days before the interruption
- Customers will be notified at least X minutes prior to shut down for an emergency condition, unless life threatening conditions cause a need for immediate shut down
- Water conservation will be instituted to reduce average daily use by X percent in Y years

The LOS does not have to be lengthy; it can concentrate on a few key items the system really wishes to focus on. It can also start out with a few items and grow from there to include additional items as the system gains more experience with asset management. Examples of a few LOS Agreements are presented in Appendix B.

4.3 How can the public be involved in the LOS?

Ideally, the public or customers of the utility would be actively involved in the development of the LOS. This involvement could be done through focus group meetings, surveys, public meetings, or other means. In a practical sense, it is difficult to get the customers to attend meetings or complete surveys and it can be difficult for them to understand certain components of the LOS. For example, customers may not understand how many breaks per mile may be acceptable prior to pipe replacement.

Rather, the best-case scenario may be to ask for specific input on items that directly affect the customers and for which they would have a reasonable understanding of the social and economic costs associated with the item. An example may be the length of notice prior to a schedule or non-emergency, unscheduled shut down. In this case, it is important to understand how much notice the customers would want and in which way it would be best to notify them. The customers are in the best position to indicate how and when to be notified. They may indicate they want door hangers, or mailings or postings in public places. The utility can indicate to the customers the impact financially of each of these options to inform the decision-making process.

4.4 Can the LOS be Changed Over Time?

Similar to the overall Asset Management Program that will change and adjust over time, the LOS may need to be adjusted from time to time. This adjustment may be required because the system may discover that it is too costly to operate the system at the levels previously defined. Or the adjustment may be necessary due to new rules or regulations that require a change. Additionally, the customers may feel that they desire a different level of service. For example, the system may not be providing fire flow to all customers. The customers may decide that they are willing to pay for the upgrades to the system to provide fire protection. In this case, the LOS may need to be revised to reflect the fact that "all customers are to receive fire protection." Another example may be a system that includes a statement in the LOS that "repairs will be completed within 4 hours from the start of the repair 90% of the time. " If the system monitors its performance over time, it may find out that it cannot achieve this time frame without additional staff or additional equipment. The choice then becomes whether the system wishes to add the staff or purchase the equipment and keep the LOS the same or whether it wishes to reduce the LOS to a more realistic time frame for the current staff and resources. The LOS may change to completing repairs in 6 or 8 hours instead of 4.

Section 5
Critical Assets

5.1 Introduction

Not all assets are equally important to the system's operation; some assets are highly critical to operations and others are not critical at all. Furthermore, critical assets are completely system specific. Certain assets or types of assets may be critical in one location but not critical in another. For example, one system may believe their chlorinator is a critical asset because they lack redundancy and have been known to have total coliform in their source. Another system may feel their chlorinator is not a critical asset because they have a redundant system and adequate spare parts to fix the broken chlorinator quickly. A system must examine its own assets very carefully to determine which assets are critical and why.

5.2 Determining criticality

In determining criticality, two questions are important. The first is how likely the asset is to fail and the second is the consequence if the asset does fail. Criticality has several important functions, such as allowing a system to manage its risk and aiding in determining where to spend operation and maintenance dollars and capital expenditures.

As a first step in determining criticality, a system needs to look at what it knows about the likelihood that a given asset is going to fail. The data available to assist in this determination is: asset age, condition assessment, failure history, historical knowledge, experiences with that type of asset in general, and knowledge regarding how that type of asset is likely to fail. An asset may be highly likely to fail if it is old, has a long history of failure, has a known failure record in other locations, and has a poor condition rating. An asset may be much less likely to fail if it is newer, is highly reliable, has little to no history of failure and has a good to excellent condition rating.

The following paragraphs describe each of the components that can go into a determination of likelihood of failure. Any additional information or resources that a system has to supplement these components should be considered also.

- ***Asset Age:*** The asset's age can be a factor in determining likelihood of failure, but should not be a sole factor. Over time, assets deteriorate, either from use or from physical conditions such as interaction with water or soil, and are more likely to fail. There is no "magic age" at which an asset can be expected to fail. An asset's useful life is highly related to the conditions of use, the amount of maintenance, the original construction techniques, and the type of material it is constructed out of. A piece of ductile iron or cast iron pipe may last 75 to 100 years in one application, 150 years in another, and 50 years in yet another. Rather than being a sole predictor of likelihood of failure, age should be supplemental to other information. For example, given the same set of factors: poor condition rating, 3 failures in the past 5 years, poor construction techniques for two different ages 5 years and 50 years old, the asset that is 50 years old would probably be given a higher likelihood of failure than the one that is 5 years old.

If there are no other issues with an asset than its age, the likelihood of failure can still be relatively low even if the asset is quite old. For example, if the system has a cast iron pipe in the ground that was installed well, using good materials and it has never had a history of failure, even though it is 75 years old, it does not need to have a high likelihood of failure.

- ***Asset Condition:*** One of the most important factors in determining an asset's likelihood of failure is the condition of the asset. As the asset's condition deteriorates, it will become much more likely to fail. It is important, therefore, to make the best attempt possible to give the assets a reasonable condition assessment. The condition assessment should also be updated over time, so that criticality can likewise be updated.

  Assets given a poor or fair condition rating are more likely to fail than those given an excellent or good rating. When the asset condition is combined with other factors, the utility can begin to make predictions regarding the likelihood of a given asset failing.

- ***Failure History:*** It is important to monitor when assets fail and record the type of failure that occurred. This information should be as specific as possible to assist the system in understanding its failure modes. Systems should track when the asset failed (or at least when the failure was discovered), how the failure was determined (customer report, operator observation, lack of service in that part of the system, etc.), type of failure (rupture, mechanical failure, small leak), specific location of failure, and any field observations that may help explain the failure (lack of bedding sand, subsidence of soil, overheating, etc.) Systems should track failure history on all of the asset categories.

  Past failure is not a complete predictor of future failure, but it can provide some indication of the likelihood of future failure, especially if detailed information on the failures is collected and reviewed. If the asset failed because its construction was poor or the pipe was severely corroded, it is likely to fail again unless some action was taken to correct the problem. If the asset failed because a construction crew ruptured the pipe, it is not likely to fail again if this is the only failure the pipe had once construction in the area is completed. If a pipe has failed several times in the past few years, it would be more likely to fail. If the pipe had never failed, it would be less likely to fail.

- ***Historical Knowledge:*** If the system has any additional knowledge regarding the asset, it should be considered in the analysis of likelihood of failure. The type of information may include, knowledge of construction practices used in the system at the time the system was constructed or knowledge of materials used in the system.

- ***General Experiences with the Asset:*** Although likelihood of failure is site specific, some guidance regarding likelihood of failure can be gained by examining experience with that type of asset in general. For example, if there is a history of a certain type of pump failing frequently after 2 years of use, and a system has that type of pump and it is currently 18 months of age, the asset may be given a higher likelihood of failure than it would be if there was no general experience of this type.

- ***Knowledge of How the Asset is Likely to Fail:*** John Moubray defines failure as follows: "Failure is defined as the inability of an asset to do what its users want it to do." In that regard, asset failure can be any time the asset is not able to meet the level of service the system wants. For example, a meter may be reading, but reading 25% less than what it should be reading. If the LOS states, "all meters will read within a 10% accuracy range" then this meter reading 25% less has failed, even though it is still operational. This is not a failure in the classical sense – i.e., a meter leak or a plugged meter – but it is failure in the sense that it is not meeting the operational expectations.

  Failure in the more classical sense depends on the type of asset. Passive assets (such as pipes) decay over time and active assets (pumps, motors) decay with use. Passive and active assets do not fail in the same manner so they must be considered differently.

  In the case of passive assets, the types of considerations in failure mechanism include: soil characteristics, groundwater level and characteristics, physical loads, bedding conditions, pipe attributes, internal corrosion, and temperature conditions. A system must examine its individual circumstances to see which of these mechanisms may be likely to be at work in its particular case. If the system is subjected to severe weather extremes, pipes may break due to freezing. If the system was installed with poor construction techniques, the pipe may fail due to poor soil support beneath the pipe or due to inadequate bedding allowing rock to contact the pipe. If the soils are highly corrosive for the pipe, the failures may be due to corrosion of the pipe wall creating holes in the pipe. Once a system understands how its assets fail when they do fail, it can determine how likely others may be to fail.

In the case of active assets, failure mechanisms can be related to hours of use, amount or lack of preventative maintenance, climatic conditions, replacement of wear parts, improper alignment, and the amount of lubrication or cooling of parts. Active assets, such as pumps, may fail because they are not given proper maintenance or lubrication.

The factors discussed above can be taken together to predict how likely an asset is to fail. The rating can be a simple rating on a scale from 1 to 5 or 1 to 10 or may be more sophisticated. The ability to produce a more sophisticated failure rating is dependent on the amount and quality of data available. It may be necessary to start with a more basic analysis and then increase the sophistication over time as the system managers and operators gain more knowledge and experience regarding what information should be gathered and evaluated.

In terms of the consequence of failure, it is important to consider all of the possible costs of failure. The costs include: cost of repair, social cost associated with the loss of the asset, repair/replacement costs related to collateral damage caused by the failure, legal costs related to additional damage caused by the failure, environmental costs created by the failure, and any other associated costs or asset losses. The consequence of failure can be high if any of these costs are significant or if there are several of these costs that will occur with a failure. Further discussion of each of these factors is presented below.

- ***Cost of Repair:*** When an asset fails, it will be necessary to fix the asset in some way. Depending on the type of the asset and the extent of the failure, repair may be simple or extensive. A small leak in a pipe can be repaired with a clamp. A chlorine pump can be replaced with a spare pump or perhaps the diaphragm can be replaced inside the pump. A failure of a well may be much more involved and may require much more extensive repair efforts. The cost of the repair of the failed asset should be considered in the analysis of the consequence of failure. If the asset can be repaired easily and without a tremendous cost, then there is a lower consequence. If the cost of repair is higher, then the consequence of the failure is also greater.

- ***Social Costs Related to the Loss of the Asset:*** When an asset fails, there may be an inconvenience to the customer. In some cases, this inconvenience may be minor, while in other cases, the social costs may be much higher. If a pipe must be repaired in a residential area, there may be a few customers who are out of water for a short period of time. This outage would constitute an inconvenience, but would not be a severe situation. On the other hand, if the system has very few isolation valves so that any repair on the system requires the whole system to be shut down, the inconvenience to the customers is much greater. In the first example (simple repair in residential area that shuts off a few customers), the cost of the consequence of failure related to the social cost is low. In the second case where the whole system must be shut down to make any repair, the cost of consequences related to social costs is much higher.

- ***Repair/Replacement Costs Related to Collateral Damage Caused by the Failure:*** When an asset fails, in some cases damage may be caused to other assets unrelated to the water or wastewater system. Examples of this type of damage include the following: a water line fails causing a sinkhole which then causes damage to the foundation of a building or a house or causes major sections of a road to collapse. In addition, cars may be damaged in the sinkhole. The damage from the pipe failure without the sinkhole would be fairly minimal. With the sinkhole, there is collateral damage including the road, the building or house, or cars. Another example would be a sewer pipe leak that leaks sewage into a home or yard or onto a schoolyard or playground. In this type of case, a significant amount of cleaning will be required to restore the building, house or property. The utility will be held responsible for this collateral damage, so the costs related to this type of failure need to be considered in the assessment of costs of the consequence of failure.

- ***Legal Costs Related to Additional Damage Caused by Failure:*** In some cases, individuals or businesses may sue the utility for damages or injuries caused by an asset failure. These costs would be in addition to the costs of repairing and replacing damaged property or other assets. For example, if a driver is driving down the road and a water line fails causing a sinkhole that the driver then falls into causing an injury, the driver may sue the utility to cover the costs associated with the injury and loss of work time.

- ***Environmental Costs Related to the Failure:*** Some types of asset failures can cause environmental impacts. The costs related to these impacts may not always be easy to assess in monetary terms. However, some attempt should be made to establish some type of monetary value to the environmental consequences. An example of an environmental cost related to a failure would be a sewer pipe that leaked sewage into a waterway or onto land. A value, either monetarily or qualitatively, would need to be placed on this type of consequence. A failure that could result in raw sewage being discharged into a major waterway could be given a higher consequence than a failure that would have the potential to cause a more limited environmental impact.

- ***Reduction in Level of Service*** The assets must be in working order to deliver the level of service desired by the water system and its customers. If the assets fail, the ability to deliver the desired level of service may be compromised. An asset that has a major impact on the ability to meet the

LOS would be considered more critical to the system than an asset whose failure would not have a significant impact on the LOS.

- ***Other Costs Associated with Failure or Loss of Asset:*** The costs in this category are any other costs that can be associated with an asset failure that are not adequately defined within the categories above. Some examples of a cost that may be included in this type of category are a cost associated with loss of confidence in the water or wastewater system or loss of the system's image. Certain types of failures may negatively impact the public's confidence in the water or wastewater system and this may have a cost to the system. Other examples include: loss of income related to the inability to provide service for a period of time, loss of the service itself, or health impacts to workers or customers.

In assessing the consequence or cost associated with the asset failure, the system should consider all the costs associated with all of the categories above. The assessment can be a simplistic ranking of the consequences from 1 to 5 or 1 to 10. In this type of structure, the assets would be ranked against each other, but a specific monetary amount would not be calculated for the failure of each asset. For example, a major distribution line that has the potential to cause major failures and social, collateral damage, and legal consequences could be ranked "5" while a small valve serving a residential area that has low costs of repair, essentially little to no social or environmental consequence would be given a ranking of "1." In this way, there is a qualitative assessment of which assets have a greater consequence than others, but no specific quantitative assessment is performed.

A more robust analysis can be performed that would assign costs of consequences in each category to each asset (or to at least the major assets) and then compare the assets with actual costs of consequences. Some of the costs would be known, such as the cost of a repair, while others would need to be estimated using the best information available, such as the cost of legal action. Past experience or experience from other utilities could be used to help estimate costs.

A system can start out with the simpler estimate of consequence of failure and move to a more robust analysis over time.

5.3 Assessing Criticality

Assessing criticality requires an examination of the likelihood of failure and the consequence of failure as discussed above. The assets that have the greatest likelihood of failure and the greatest consequences associated with the failure will be the assets that are the most critical. The next most critical assets will fall into three main categories:

- Assets that have a very high likelihood of failure with low consequence
- Assets that have a very high consequence with a low likelihood

- Assets that have a medium likelihood and medium consequence

The remaining assets that have low consequence and low likelihood will be the least critical assets.

A technique such as a ranking table as presented below can be a good place to start in assessing criticality. Appendix C contains copies of this table for use in the criticality analysis.

Multiplied		**Consequence (Cost) of Failure**				
		1	**2**	**3**	**4**	**5**
Probability of Failure	**1**	*1*	*2*	*3*	*4*	*5*
	2	*2*	*4*	*6*	*8*	*10*
	3	*3*	*6*	*9*	*12*	*15*
	4	*4*	*8*	*12*	*16*	*20*
	5	*5*	*10*	*15*	*20*	*25*

1	Very Low	4	High
2	Low	5	Very High
3	Moderate		

To use this table, estimate the probability of failure from 1 to 5 with 5 being very high probability of failure and 1 being a very low probability of failure. Then assess the consequence of failure from 1 to 5 in the same manner. Using the number for probability of failure, move across the row until the column associated with the number for consequence of failure is reached. Alternatively, move down the column for the consequence of failure until the row for probability of failure is reached. Locate the number that is in the box where the row and column intersect. That is the number for criticality for that asset.

As an example, look at the following scenario.

Asset: 10 inch Cast Iron pipe; constructed in 1950, so 56 years old
Service History: Numerous breaks in the past 5 years
Service Area: Serves 3 major subdivisions, but there are loop lines available and only residential customers

Likelihood of failure: 4 – pipe has broken many times, but when repaired it was still in reasonable condition

Consequence of failure: 2 – There are loop lines so not all customers will be out of water. Repair costs are moderate. Line isn't in a critical roadway so repair is relatively easy.

Using the chart, move across the row for 4, until the column for 2 is reached. The number in the box is 8. Therefore, 8 is the criticality factor for this asset. (See the table below.)

Multiplied		**Consequence (Cost) of Failure**				
		1	**2**	**3**	**4**	**5**
Probability of Failure	**1**	*1*	*2*	*3*	*4*	*5*
	2	*2*	*4*	*6*	*8*	*10*
	3	*3*	*6*	*9*	*12*	*15*
	4	*4*	***8***	*12*	*16*	*20*
	5	*5*	*10*	*15*	*20*	*25*

As another example, look at the following scenario.

Asset: Chlorine pump
System uses hypochlorite so chlorine pump pumps liquid chlorine solution into the system for disinfection
System has both spare parts and a spare pump
Chlorine pump has failed due to many factors several times in the past 10 years
Chlorine is checked once per week

Likelihood of failure: 4 – pump has failed many times

Consequence of failure: 4 – A failure in a chlorine pump has the potential to be a major consequence. However, the consequence is mitigated by the presence of a spare pump and spare parts. Because the pump may fail for a significant period of time before the failure is known (up to 1 week because the levels are only checked once per week), the consequence is not substantially reduced by the spare parts and pump.

Using the chart, move across the row for 4, until the column for 4 is reached. The number in the box is 16. Therefore, 16 is the criticality factor for this asset. (See the table below.)

Multiplied		Consequence (Cost) of Failure				
		1	**2**	**3**	**4**	**5**
Probability of Failure	**1**	*1*	*2*	*3*	*4*	*5*
	2	*2*	*4*	*6*	*8*	*10*
	3	*3*	*6*	*9*	*12*	*15*
	4	*4*	*8*	*12*	***16***	*20*
	5	*5*	*10*	*15*	*20*	*25*

In looking at the two assets, the chlorinator is much more critical than the piece of pipe. If all assets are viewed in this way, an analysis can be done to determine the criticality number for each one and then the results can be compared to see which assets are more critical than others.

Once an analysis of this type is done, the results can be reviewed to determine if they make sense to the utility. If the utility does not believe the results for a particular asset make sense (i.e., the asset seems to have the wrong relative ranking), a re-evaluation can be completed to achieve reasonable results.

5.3 Criticality Analysis Over Time

The condition of the asset will change over time as will the consequences related to failure. Costs of repair may go up, the community may grow, new roads may be built or similar factors may occur that cause the consequence of failure to change. Therefore, it is necessary to periodically review the criticality analysis and make adjustments to account for changes in the likelihood of failure and the consequence of failure.

The criticality analysis must be kept up to date to ensure that the utility is spending its time and resources on the appropriate assets as discussed in the next section. Also, the analysis must incorporate replacement of assets. If an asset that was critical primarily due to its likelihood of failure fails and is replaced with a new asset, the criticality number will go down since the likelihood of failure is much less.

Section 6
Life Cycle Costing

6.1 Introduction

This component is one of the most complex of all of the components of asset management. It is difficult for a small system to gather all of the data necessary for a sophisticated analysis of life cycle costing. There are several components of developing a lifecycle strategy for asset management plans. Most small communities can easily begin with one or two of these components.

Lifecycle Asset Management focuses on management options and strategies considering all relevant economic and physical consequences, from initial planning through to disposal. The Lifecycle components include:

- Asset Planning
- Asset Creation/Acquisition/Design
- Financial Management
- Asset Operation and Maintenance
- Asset Condition and Performance Monitoring
- Asset Rehabilitation/Renewal
- Asset Disposal
- Asset Audit and Review

As communities begin to develop their Asset Management plans, these components can seem overwhelming. It does not make sense to try to begin with all eight components at once. Therefore, this manual will guide communities through the basics of the components that can easily be started.

6.2 Options for Dealing with Assets Over Time

There are four basic options for dealing with the actual assets over time:

- Operate and maintain the existing assets
- Repair the assets as they fail
- Rehabilitate the assets
- Replace the assets

These options are intimately connected to each other. Choosing to do more or less of one impacts how much of the others is done, whether or not the other is done at all, or the time frame in which one of the others is done. For example, choosing to spend more on operating and maintaining assets will decrease the need to repair the asset and will increase the amount of time until the asset is replaced. Choosing to rehabilitate an asset will eliminate the need to replace the asset in the short term and will increase the amount of time until the asset ultimately needs to be replaced. The rehabilitation will also reduce the amount of operation and maintenance that needs to be done and reduce the need for repairs.

Each of these options has its own costs and considerations. The expenditure of funds becomes a balance between monies spent in each of these four categories. The purpose of asset management is to try to determine the optimal way to spread the money between each of these categories, while maintaining the LOS desired.

Generally, the most expensive option is replacement of the assets. Therefore, keeping the assets in service longer, while still meeting LOS conditions, will usually be the most economical for the utility over the long term. The three other options: maintenance of the asset, repair of the asset, and rehabilitation are options that can be used to keep the asset in service longer. Each of the options is discussed further in the sections below.

6.3 Asset Operation and Maintenance

Operation and maintenance (O&M) functions relate to the day-to-day running and upkeep of assets and are particularly relevant to short-lived dynamic assets (such as pumps) where deterioration through lack of regular maintenance may result in rapid failure.

Properly operating and maintaining assets is critical to the success of the overall program. Operation and maintenance is directly linked to Level of Service and Critical Components. In the July 2006 AWWA Journal Current Issues article by Eugene Nelms, the importance and process of establishing O&M procedures is discussed in detail. Following are some key points from the article. Establishing standardized O&M procedures achieves maximum asset life and reduces O&M costs. Standardizing O&M procedures helps utility personnel to operate all assets within acceptable operational levels and ensures that each person is following the same routines. By standardizing the operations of all assets, maximum asset life can be obtained (assuming that periodic maintenance is performed as required).

O&M procedures can be categorized as operational, maintenance and (where applicable) laboratory.

Operational procedures can be classified as:

- Standard Operating Procedure: most common, typically used during normal operations, day-to-day
- Alternate Operating Procedure: Used when operational conditions require that an asset or process be modified or taken off-line, scheduled, periodic
- Emergency Operating Procedure: used in emergency conditions, incorporated into overall emergency plan developed for facility

Maintenance procedures can be classified as:

- Corrective Maintenance Procedures: used by field technicians for the breakdown and repair of assets that are malfunctioning (e.g., replace broken bearing)

- Preventative Maintenance Procedures: developed to prevent breakdown and prolong asset life (lubrication or overhaul)
- Reliability-centered Maintenance Procedures: developed to assist maintenance managers in predicting asset failures and lessening effects on facilities (asset condition monitoring or failure modes and effects analyses)

Laboratory procedures can be classified as:

- Equipment-related Procedures: developed on the basis of how to operate the equipment and what maintenance and/or calibration the equipment requires
- Sampling-related Procedures: developed around sampling routines and specify to the laboratory technician when, where, and how samples should be taken

Several choices exist for who develops O&M procedures.

- New facilities or assets: engineering firm or designer, supply vendors, contract professional technical writer
- Existing facilities or assets: existing staff, technical writer

In order to develop O&M procedures the reference materials must be located. Reference materials include O&M Manuals, process and instrumentation drawings, vendor submittals, specifications, pictures, design data, design drawings, as-built drawings, and interviews with experienced staff.

Developing operational procedures includes:

- Titling the procedure appropriately, so it is easily identified. (e.g., “Shutdown of Alum Feeder Number 4”)
- Introduction: lists associated information such as the reason for the procedure, responsible parties, desired outcomes, safety procedures, special equipment requirements and notification requirements
- Steps and/or Activities: Step 1, Shut power off at the breaker located on the south wall labeled Alum Pump
- Note any cautions or hazardous conditions with each step or activity before the activity is performed

Maintenance procedures are generally developed using vendor-supplied information. Using a template with fields for the vendor to complete, such as the Work Maintenance Management System (WMMS), has proven successful for many utilities.

Two factors can adversely affect the development of procedures.

- Costs. The costs of developing procedures in a new facility are typically covered in the capital improvement plan (CIP) budget. If this budget is limited, facility managers must determine which procedures are critical and work with their staff and an outside source, if needed, to develop the critical procedures first. Remaining procedures can then be spread out over time to minimize budgetary effects.
- Time. The other key factor is time. For an existing facility where staff may already be stretched thin, it becomes impractical to include the development of

O&M procedures into daily routines. The use of a third-party O&M group, or even a dedicated staff member can reduce the time requirements on the O&M staff while developing procedures.

The benefits of developing and implementing effective and useful O&M procedures far outweigh the effects on the facility and staff. If standard procedures are not implemented system wide, O&M procedures will be created on an ad-hoc basis, which can lead to fluctuations in process efficiencies, discord between operations and maintenance, increased asset downtime, wasting of chemicals and energy, and other similar problems.

The greatest reward for developing O&M procedures is that all operations activities, maintenance activities, and laboratory activities are backed by management and standardized across all shifts by all personnel. This ensures management consistency of personnel activities, product quality, and O&M costs. The application of standardized maintenance procedures can reduce asset downtime and ensure lifetime productivity. The application of standardized laboratory procedures is essential for a good quality-assurance/quality-control program.

6.3.1 Operation and Maintenance and Critical Assets

One of the purposes for identifying critical assets is to allow the utility to make more informed decisions regarding the use of its operation and maintenance dollars. As discussed previously, the most critical assets are those assets that are likely to fail and have a significant consequence if they do fail. Therefore, it is most advantageous to the utility to spend the greatest portion of its operation and maintenance budget on assets that are critical to the overall operation of the utility. These assets have the greatest chance of costing the utility money if they fail.

Figure 6-1 below shows the relationship between likelihood of failure and consequence of failure for assets. The letters A through D represent different categories of assets. Assets in category A have a low likelihood of failure and a low consequence of failure, while those in category D would have a high likelihood of failure and a high consequence if they do fail. The expenditures on operation and maintenance, or O&M, would vary for these various categories of assets. Those in category A should have lower expenditures on O&M and less investment into condition assessment, while those in category D should have much more expenditure on O&M and more investment into condition assessment. Table 6-1 contains a summary of this information.

Figure 6-1: Relationship Between Likelihood of Failure and Consequence of Failure

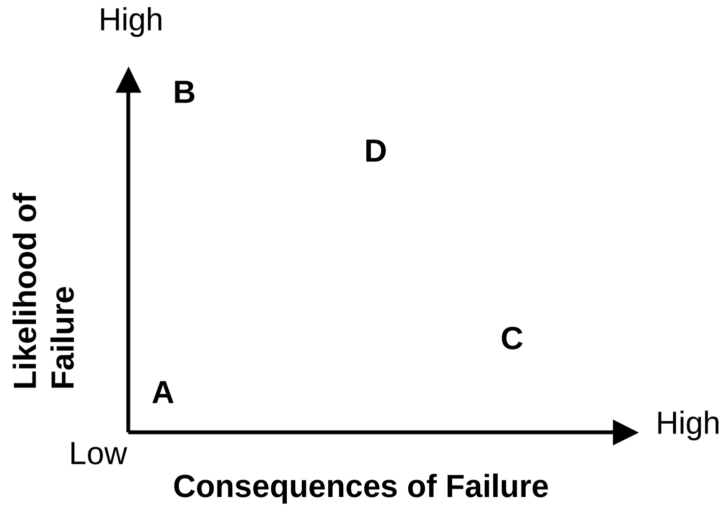


Table 6-1: Summary of O&M Expenditures and Criticality

Letter from Graph 6-1	Likelihood of Failure	Consequence of Failure	Relative Amount Spent on O&M	Relative Amount Spent on Condition Assessment	Example of an Asset that Could be in this Category
A	Low	Low	Low	Low	4 year old PVC pipe in a residential area
B	High	Low	Moderate	Moderate	60 year old steel pipe in a residential area
C	Low	High	Moderate	Moderate	Encased pipe under a railroad track
D	High	High	High	High	60 year old steel pipe under a major arterial road

In deciding how to spend O&M and condition monitoring dollars, the system should perform an assessment similar to the one above, putting specific types of assets or asset categories in the boxes instead of A through D. Then the O&M program and condition monitoring program can be structured so that expenditures are made on the most appropriate assets. An example of a table such as 6-1 for a water distribution system is contained in Appendix D.

Thought of another way, if the system had $100 dollars to spend on Operation and maintenance and the only assets were A, B, C, and D as shown on Figure 6-1, the money should be spent in a manner similar to Table 6-2 below.

Table 6-2: Operation and Maintenance Expenditure by Criticality

Asset	O&M Dollars Out of a $100 dollar Expenditure	Percentage of the Total Expenditure
A	$5	5%
B	$15	15%
C	$30	30%
D	$50	50%

The table shows how the money is spent between the different categories of assets. The most money is spent on the assets with the greatest failure potential and greatest consequence.

6.4 Repair of Assets

In addition to operating and maintaining the assets, systems will need to plan for the repair of assets as they fail. Systems need to consider how long they will keep an asset in service prior to replacement of the asset. To some extent, these two items – repair and replacement - are off-setting. If more resources (personnel and money) are spent on repair, there will be a decreased need for replacement. On the other hand, if greater resources are applied to replacing the assets, fewer resources will be applied to repair. There is a balance between how much to spend in each category: maintenance, repair, and replacement to achieve the most efficient system.

As an example, consider a car. If a new car is purchased every year, the car's owner will probably spend little to nothing on repair but will have an extremely high cost of purchase. If another owner decides to keep his car and repair everything that breaks on the car in order to keep it running, this owner will have a very low bill for replacement cost but will have a very high repair bill. Most likely, the repair bill will significantly increase over time as the car ages. Neither of these extremes would be the most cost effective approach to owning and operating a car. In the first case, the replacement cost is too high and in the second case, the repair costs are too high. The most efficient approach would lie in between these extremes, with repair taking place until costs are prohibitive at which point the asset – the car – would be replaced.

In developing a water or wastewater system repair schedule, the utility must determine its own approach to repairing verses replacing assets. The utility will need to decide when it is spending more money (including personnel hours) to repair the asset than it would cost to replace the asset.

In comparing U.S. utilities to utilities in Australia and New Zealand, it has been observed that U.S. utilities generally replace assets much sooner than utilities in Australia and New Zealand who have fully implemented asset management. The asset management analysis these utilities have done, has shown them that it is generally more efficient to repair assets longer than to replace them.

6.5 Rehabilitation of Assets

When an asset fails, or approaches failure, the typical thought process is that of replacing the asset with a new asset. There is another option for some water or wastewater system assets; assets may be rehabilitated rather than an outright replacement. Rehabilitation brings the assets back to a useable condition without actually replacing them. In many cases, it may be cheaper to rehabilitate the asset rather than replacing it, it may extend the life span of the asset considerably and may reduce other impacts related to asset replacement. An example of a rehabilitation approach is slip lining a wastewater pipe that is nearing the end of its useful life. The pipe can be lined without having to dig the original pipe out of the ground, thus possibly reducing the costs of installation and the inconvenience of the construction.

6.6 Replacement of Assets

Eventually, all assets will need to be replaced. There will reach a point where the asset can no longer be kept in service through maintenance or repair or where the asset is no longer capable of meeting the LOS, either economically or at all. At that point, the asset will need to be replaced. Replaced assets can either be part of a replacement schedule or a capital improvement plan.

In both cases, the assets are replaced. The main difference is that the replacement schedule includes those items that are routinely replaced, smaller dollar replacements, and items replaced using the water or wastewater system revenues or reserve funds. The capital improvement plan indicates items that are major expenditures that do not routinely occur and that generally require outside funding for at least a portion of the project. Further information regarding each of these types of replacements is presented below.

6.6.1 Replacement Schedule

A replacement schedule should be developed that indicates those assets that will be replaced within the next 20 years that will be funded out of system revenues. The schedule will contain assets that are smaller dollar amount or routinely recurring and should include assets that will be paid for out of system revenues. A couple of examples of these types of assets are: water meters and chlorine pumps. Additional assets, such as small diameter water distribution piping, valve s, and hydrants can also be included.

This schedule can also be expanded to include programmed maintenance or repair, making it a Repair and Replacement Schedule. The types of activities that can be included here are major, programmed repair elements, su ch as a storage tank inspection annually and a tank overhaul (repaint, structural testing, cleaning) or leak detection every 3 years. This Schedule does not replace the operation and maintenance schedules discussed above. It merely reflects those element s that are major budget items and that will occur routinely, but much less often than daily, weekly, or monthly. These are generally items that are annually or greater in schedule and that constitute a major budget expenditure.

The schedule should includ e all of the recurring and non-recurring items for a 20 year period. The Repair and Replacement Schedule should be updated annually so that it is always 20 years long.

The type of information to include on a Repair and Replacement Schedule includes:

- Year
- Item
- Description
- Estimated Cost
- Method of Estimation
- One time or Recurring
- Time Period of Reoccurrence

Appendix D contains an example table for a Repair and Replacement Schedule.

It is absolutely critical that the items in the Repair and Replacement Schedule be entered into the rate setting process. These items must be funded out of system revenues, so they must be accounted for in the annual budget and in the rates. The Schedule will probably not be uniform from year to year in terms of amount of expenditure. To address this issue, the system may wish to set an annual annuity payment to cover the Repair and Replacement Schedule expenses over the long term. Some years, the payment would be greater than that year's expenses, so money would go into a Repair and Replacement Reserve. Other times, the amount collected would be less than required so the additional funds would come from the reserve account. The annual annuity set would have to be sufficient to cover all of the expenses over the

20 year period. It may need to be increased over time if expenses increase and it can be decreased if it turns out too much money was dedicated to this purpose.

6.6.2 Capital Improvement Planning

A long-term capital improvement plan should look at the utility's needs for the future. Ideally, the planning period would be at least 20 years, with a minimum of 5 years. It is understood that the specific expenditures and needs of the utility in the latter years, say 15 to 20 years, are more speculative than the needs for the first 5 to 10 years, particularly the first 5 years. However, the inclusion of the needs for this longer time period will provide a better opportunity for the water system to plan for its capital needs.

There are several categories of capital improvements that must be considered. The categories are listed below.

- **Capital Needs Related to Future/Upcoming Regulations:** The state and federal regulatory agencies periodically issue new rules and regulations that may require water or wastewater systems to invest in new technologies to meet the requirements. For example, when the arsenic standard was reduced from 50 parts per billion to 10 parts per billion, many water systems in New Mexico were required to consider capital needs to meet this standard. The capital needs may be related to treatment facilities, distribution system changes, connections with other sources, development of new sources, or any other type of capital project to meet the standard. Systems ought to be aware of upcoming regulations and consider the costs that may be associated with compliance so that money can be set aside to help pay the costs.

- **Capital Needs Related to Major Asset Replacement:** Some assets can be repaired within the repair and replacement schedule, while others will be major expenditures that will have to be replaced under the capital improvements program. Assets such as storage tanks, treatment facilities, and major portions of the distribution or collection system could fall into this category.

- **Capital Needs Related to System Expansion:** Over time, the system may expand due to growth in the area or through serving customers who were previously on private wells or septic tanks. This type of expansion may involve new distribution or collection pipes, additional storage, additional water source, or additional treatment.

- **Capital Needs Related to System Consolidation or Regionalization:** Some systems may find it advantageous to consolidate or regionalize with other nearby systems. In some cases, this type of regionalization may involve additional assets, such as sources, pipes, storage or treatment facilities.

- **Capital Needs Related to Improved Technology:** Systems may wish to replace assets because the technology of the assets originally installed is out of date and needs to be modernized or because technology improvements will allow improved customer service or enhanced efficiencies. An example of this type of capital needs is a SCADA system that electronically controls the system's operations.

System managers need to consider all of these types of needs when developing a long term Capital Improvement Plan or CIP. Each item needed by the system for each of the applicable categories for a 20 year time horizon needs to be identified. At a minimum, the following information should be identified for each item.

- Description of the project
- Brief statement regarding the need for the project
- Year project needed
- Is the year needed flexible or absolute
- Estimate of project cost
- How costs were estimated
- Funding source(s) considered/available for this type of project
- Changes in overall operations that may occur as a result of the project (include operator requirements, additional O&M costs, regulatory changes, any efficiencies that may be gained, etc.)
- Impact of the project on LOS

As stated previously, the CIP should cover a 20 year period. It should be updated each year so that it always shows 20 years of needs. If there are no needs in a particular year, the CIP can reflect this. Appendix D contains an example table t hat can be used to develop the CIP.

Some of the expenses related to capital improvements may be funded out of the system's revenues rather than solely outside sources. If system revenues are to be used either to offset costs or as a debt repayment stream , the budgets and rates must reflect the costs.

6.7 Annual Review of Asset Replacement Projects

Asset replacement projects will be included in the Repair and Replacement Schedule and the Capital Improvement Plan. It is a good idea to review both of thes e documents on an annual basis to determine if all of the listed projects are indeed necessary. Sometimes another look at the project list may reveal that some projects can safely be pushed back for several years or may not be needed due to changing condi tions. The projects were projected out several years in advance, so conditions may have changed eliminating or reducing the need for the project. Alternatively, the projects may also have changed in terms of specifically what technology or approach is be st. As an example, the system may have anticipated growth in a certain area and budgeted for line extensions into that area 10 years into the future. However, over time, it may turn out that development did not occur or the patterns were different than e xpected. The extension project can then be eliminated from the budget.

The types of questions to examine in the completion of this type of review include the following:

- Is the reason/need for the project still valid?
- Have the costs changed since origi nally projected?
- Is there a better approach or a better technology that can be used to address the need?
- Can the project be safely delayed?
- Does the project need to be completed sooner?
- Is there a method of rehabilitation that could be used rather than rep lacement to save costs?
- Would it be more reasonable to reduce the LOS than increase the asset's capability?
- Will funding be available for the project?

Each year the overall Repair and Replacement Schedule and Capital Improvement Plan must be revised to re flect completion of the current years projects or the new schedule for those projects if they were not completed, any changes to the projects on the list, and to add the additional year at the end of the project period to keep the list at 20 years.

Section 7
Long-Term Funding Strategy

7.1 Introduction

The first four components of the asset management strategy lead a system to discover what actions are most appropriate to take to manage the system at the desired level of service at the lowest life cycle cost. The final factor in the asset management strategy is determining the best manner in which to fund the operation and maintenance, repair, rehabilitation, and replacement of assets. There are several sources of funding available to a system, so it is important to evaluate the item needing funding and the various options.

7.2 Funding Sources Available

The sources of funding for the overall operation and maintenance of a water or wastewater system, including asset repair, replacement, and rehabilitation include the following:

- System revenues from:
  - User fees
  - Hook up fees
  - Stand-by fees
  - Late fees
  - Penalties
  - Reconnect charges
  - Developer impact fees
- System reserve funds
  - Emergency reserves
  - Capital improvement reserves
  - Debt reserves
- System generated replacement funds:
  - Bonds
  - Taxes
- Non-System revenues:
  - State grants
  - State loans
  - Federal grants
  - Federal loans
  - State or federal loan/grant combinations

Appendix E contains a further discussion of funding sources and a link to the uniform funding application.

7.3 Rates and Asset Management

System revenues are a major component of an asset management plan. The system revenues will fund the operation and maintenance of the system; there generally are no outside funding sources for routine operation and maintenance of a water or wastewater utility. In addition, the rates will need to fund reserve accounts for emergencies, repairs, and debt coverage (for any loans.)

A well developed rate structure will take into account needs for the water system for the current year as well as needs for the water system in future years, through reserve accounts. For example, if the water system is anticipating a new regulation that will require additional treatment, the system should be collecting money through the rates to help pay for the needed equipment.

The rate structure should also anticipate routine replacements of parts, particularly those parts that wear out regularly. For example, if the system replaces its chlorinator every 5 years, the rates should cover this expense, rather than seeking state or federal funding to cover these types of needs.

If a system engages in asset management as it sets rates, the rates may increase as the system moves from traditionally being underfunded (i.e., collecting insufficient revenues to cover all expenses) to being properly funded. However, rates that are set based on sound asset management principles are very defensible to the public. Asset management brings transparency to the process so that it is clear what the rate is based on. The more clearly the rate can be defended, the more likely it is to be accepted by the public.

There are many sources of rate setting assistance, including trainings and free rate setting programs. Any approach that includes all costs of operation, considers the long-term view, includes reserve accounts, and considers conservation or other utility goals is acceptable.

7.4 Long-Term Funding Plan

The Rural Community Assistance Corporation developed a manual regarding 5 year funding strategies. This document should be consulted as a resource in the development of the long-term funding strategy needed for the asset management plan.

Section 8
Implementation

8.1 The "Just Do It" Philosophy

The asset management program described in this document is based on the "just do it philosophy." A system should be able to jump right into asset management and start doing it without a tremendous amount of preparation or resources. Over time, a system will increasingly improve its asset management program and will increase its knowledge base and the quality of its data. A system may wish to increase its level of sophistication and may input a greater degree of resources – personnel or money – as it improves over time. However, the most important thing is for a system to get started on a more systematic manner of operating its utility.

Asset management is firmly rooted in common sense and good business practices. As such, any activities the system undertakes in the area of asset management will improve the system's overall operation. The more sophisticated and cohesive the program, the more improvement, but improvement will occur even at a lower level of asset management activity.

Utilities do not need to worry about making mistakes with asset management. Asset management is meant to be on-going and improved over time. If the program is not working properly or needs to be changed, the system can change it.

8.2 The Sustainable Process

As stated in the Section 2 of this manual, asset management needs to become *the way you do business.* As such, as long as the system is operational, the system should be engaged in asset management. The system must view this process as never ending. The asset management program should improve and change over time, as the system's needs change but it will never be something that is "complete" and should not be thought of in that way.

8.3 The Asset Management Plan

The system may wish to compile its approaches to asset management into a single document discussing each element and how that is handled. The document, however, must be flexible and should contain an explanation of how the system is doing each component, not the actual data obtained from each component. The actual data should be in a format that is continually changeable (e.g., computer data base, map that can be drawn on, etc.)

The Asset Management Plan should be thought of as a "road map" to explain how the system is going to do each component and how the system will continue with asset management over the long-term, but should not be thought of as "the answer."

The Asset Management Plan should also be written in such a way that all levels of the organization can make use of it. It should be readily available to all members of the organization and distributed freely. It can also be made available on the web to customers of the organization. It should not be thought of as a secretive document that only employees or volunteers should have. The document provides information to the customers on exactly how the system is being run and creates more confidence in the proper operation of the system and the applicability of the rates that are charged.

The data that is part of the Asset Management Plan should be updated continually as the system performs its operational duties (e.g., as breaks are repaired information is gathered.) This type of updating should not require the overall plan to be revised. The Asset Management Plan should be periodically reviewed (annually or biannually or perhaps every 3 years) to determine if the overall methodology used for each component has changed in any way. If so, the document should be revised and redistributed. If not, the document can be left in its current status until the next review.

The Asset Management Plan document does not need to be lengthy. The goal is to make it easy to understand and useable by the employees or volunteer workers for the utility.

8.4 Asset Management Plan Review

If Asset Management becomes a requirement of funding or an activity that can provide additional points towards the application or a higher ranking for a particular project, funding agencies may wish to review the asset management plans to determine if it contains all the required elements. A checklist that can be used for this purpose is provided in Appendix F. Appendix F also contains an example of a checklist filled out on a fictitious water system.

Section 9
Asset Management Resources/References

9.1 Introduction

As asset management programs have been implemented around the world, seve ral resources and reference articles have been published, ranging from simple, brief overviews, to complex, thorough documents. Listed below are some of the additional resources available with brief descriptions.

A manual written specifically for asset management, outlining all steps and experience levels. Most widely recognized manual

International Infrastructure Management Manual . (2006).

Asset management guide provides a brief overview of asset management for small water and wastewater systems and a list of recommended resources for implementing an asset management program:

Ward, Melissa. (2005). *A Guide to Asset Management for Small Water Systems.* National Environmental Services Center

Four page article with practical applications and examples of the benefits of asset management, along with references to other sources of information:

Falvey, Cathleen. (2006). Asset Management: A New Frontier for Utilities. *On tap.* **6**(2), 26-29.

Website with many short, informative articles about asset management a nd links to good references

Brown and Caldwell Asset Management Website. URL: http://www.bcwaternews.com/assetmgt/

A free asset management software for small communities developed for Microsoft Office Suite 97 or later.

Total Electronic Asset Management System . URL: www.mcet.org or http://www.mcet.org/am/index.html

Train-the-Trainer Toolkit: Asset Management Guide f or Wastewater Utilities . URL: www.mcet.org or http://www.mcet.org/am/am/Presentations/toolkit2.html

Handbook designed to help owners and operators of small water systems .

Asset Management: A Handbook for Small Water Systems . (2003). United States Environmental Protection Agency

Asset Management: A Handbook for Small Water Systems. URL: http://www.epa.gov/safewater/smallsys/pdfs/guide_smallsystems_asset_mgmnt.pdf

Handbook developed by the EPA Office of Water for very small systems such as manufactured home communities and homeowners' associations.

Taking Stock of Your Water System. (2004). United States Environmental Protection Agency

Taking Stock of Your Water System. URL: http://www.epa.gov/safewater/smallsys/pdfs/final_asset_inventory_for_small_systems.pdf

The American Public Works Association (APWA) has several resources available for purchase through their bookstore, including *The Managing Infrastructure Assets – Knowledge Product* and *Getting The Most Out of Your Infrastructure Assets.*

Bridging the Gap is a ground-breaking on-line video designed to help elected officials and water and wastewater managers make smart choices as they address water and wastewater infrastructure issues.

Bridging the Gap. URL: https://courses.worldcampus.psu.edu/public/buried_assets/

Section 10
Document References

International Infrastructure Management Manual . (2006).

Moubray, John. "Reliability-centered Maintenance." Industrial Press, Inc. 1997

Nelms, Eugene E. (2006). Establishing O&M Procedures for a Water Treatment Plant. *AWWA Journal*. **98**(7), 38-40.

US EPA Advanced Asset Management Workshop materials, prepared by Steve Allbe e, US EPA, Duncan Rose and Roger Byrne, GHD.

Information in this manual has also been obtained through personal communication with asset managers in Australia and New Zealand.

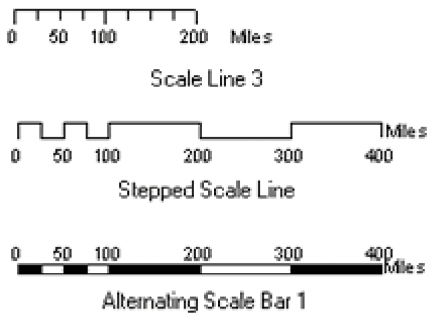
Appendix A
Asset Inventory

A.1 Asset Mapping Resources

As mentioned in section 3, an asset inventory helps water systems identify what they own, where assets are located, and consider what the condition of the system is. Therefore, creating or obtaining a map of your water system is an important step in preparing an asset inventory. An asset inventory map can help operators and managers conceptualize the water system as whole. The map should show everything that the water system owns, and identify where the assets are located. It is best to start with any maps you may have readily available, and work with your operator to determine what you know about the system. A good starting point is to take a look at the maps the water system currently owns, such as engineering "as built", community planning maps, etc. If your water system has ever contracted with an engineering firm to conduct an assessment or design improvements, chances are you may already have a map of your water system. For most projects engineering firms will include engineering drawings of the water system that includes a description of the pipes and where they are located. Others may just include a map known as an "as built" that will depict the part of the system where work has been done. If you have several "as-builts," as a result of several projects over a period of time, you may want to consider obtaining copies and creating your own mosaic map by fitting and taping the "as-builts" together to create a large map of the water system.

If the water system does not have a regular map or "as-built" map available, an alternative would be to contact your local County Government Office, Regional Council of Governments, or local public library. If you have a computer and Internet connection you may try creating a map yourself using mapping Web Sites. The following are some pointers and some examples of Web Sites to use to get started.

There are a few basic concepts to keep in mind when dealing with sizing a map. Understanding what map scale is appropriate for the project is crucial because, (1) you want the map to display as much of the detailed information as possible, and (2) you want to make sure that your assets, such as pipe lengths, are accurately displayed on the map. In dealing with scale there are two things to keep in mind. One, the term small scale refers to maps with a scale that is 1:100,000, which means that every length unit on the map represents 100,000 of the same unit on the ground. Typically, the most common length unit used is inches so there is some converting involved, 100,000 inches equals approximately 1.58 miles. Secondly, the large scale refers to maps with a scale of 1:24,000 or less. Large scale maps typically, cover less area then a small scale map but the land features are displayed in greater detail. A map with a scale of 1:24,000 easily converts to 1 inch on the map equals 2,000 feet on the ground. The 7.5 minute USGS topographic maps have a scale of 1:24,000. This is useful because starting with a map scale of 1:24,000 one can enlarge the map into smaller units. For example, knowing that 1:24,000 is equivalent to 1 inch equals 2,000 feet, if you double or enlarge the size of the map by 200 percent your map scale will change to 1 inch equals 1,000 feet. Conversely, if you enlarge or quadruple your map by 400 percent your map scale will be 1 inch equals 500 feet. In addition, most maps should have a scale bar at the bottom of the map, which is useful because it subdivides the length unit into smaller units for easier estimates of shorter distances. The following is a typical example of a scale bar; (image)



Source: ArcGIS, a geographic information system software package.

There are several map resources available on the Internet for both public and commercial use. Identifying which map type and size type that is right for your water system can seem overwhelming. One thing to keep in mind when starting an asset inventory project is that your map does not have to be fancy. Most importantly, you just need a map to start with.

Depending on how big your water system is will depend on the type, size and scale of your map. There are three, easy-to-use, mapping Web Sites on the Internet and they are Yahoo Maps, Google Maps, and MapQuest. It is easier to use these Web Site to accommodate a smaller water system, systems that cover an area less than 1 square mile, than larger systems. However, the mapping sites are so easy to use that a person can print out large-scale sections of their water system and create a mosaic map. A person can create a mosaic map by printing out and taping together enlarged sections of the water system. Mapping Web Sites, such as Google Maps, has a feature that allows the user to view aerial photographs in addition to street maps called "hybrid." The quality and extent of aerial photographs available does vary, and for some parts of rural New Mexico recent aerial photography may not be available from the mapping sites. Depending on the size of the water system, creating a mosaic can be a timely process. Unfortunately, Google Map does not allow the user to print aerial photographs using the print feature. Instead, it is recommended to access TerraServer-USA, mentioned later in this section, for free aerial photographs, also known as digital orthophotography, that are easy to print from your home computer. The following are web address to the three Web Sites that are useful viewing and printing small area street maps:

(1) Google	(2) MapQuest	(3) Yahoo
http://maps.google.com/	http://www.mapquest.com/	http://maps.yahoo.com/

The United States Geological Survey (USGS) is a reliable and inexpensive source for finding maps. The USGS does not sell maps directly to the public; instead, the USGS has established business partners in various cities to sell map products to the general public. Typically, these business partners are sporting goods, surveying and travel stores. The New Mexico Bureau of Geology and Mineral Resources at New Mexico Tech in Socorro is another source to obtain and purchase USGS topographic maps. The best type of US GS topographic map to use for an asset inventory is the 7.5-minute topographic map. The 7.5-minute topographic map is smallest (large scale) map available. Each 7.5-minute topographic map is given a quadrangle name (also referred to as a quad name), and is required in order to track down a map of your specific area. There are index maps available through the USGS and its business partners to help determine which maps are needed to cover your area. There are also resources on the Internet that will help you locate the maps you need by using latitude and longitude coordinates, or place name. The only drawback in using USGS topographic maps is that rural areas are not updated as regularly as growing urban areas. However, the maps are a useful starting point in creating an asset inventory because they contain useful information such as the scale bar, contour lines, and latitude and longitude coordinates. Also, depending on how old your water system is, the USGS may have already mapped the water tank or water well, since the USGS would typically document manmade features on their maps as markers in the field. You can also order aerial photographs from USGS by contacting one of the business partners that were mentioned before. There are also data information research companies who specialize in researching aerials photographs, which will charge a research fee and the cost of the photographs. You could also do the research and ordering yourself by using the following Web Sites.

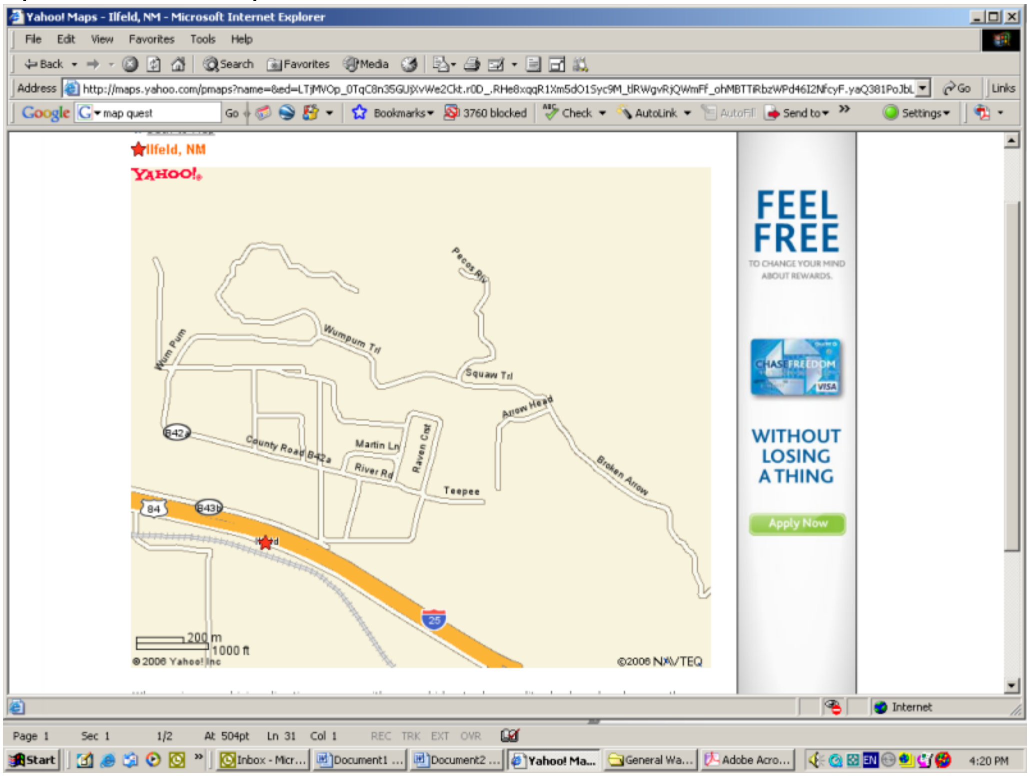
(1) TerraServer-USA	http://terraserver.microsoft.com/
(2) NM Bureau of Geology and Mineral Resources	http://geoinfo.nmt.edu/publications/maps/topographic/home.html
(3) TerraServer®.com	http://www.terraserver.com/
(4) TopoZone.com	http://www.topozone.com
(5) USGS Earth Resources Observation and Science (EROS)	http://edc.usgs.gov/

If you have experience using a geographical information systems software package, such as ArcGIS, then you may already be familiar with gathering map data from online sources data such as;

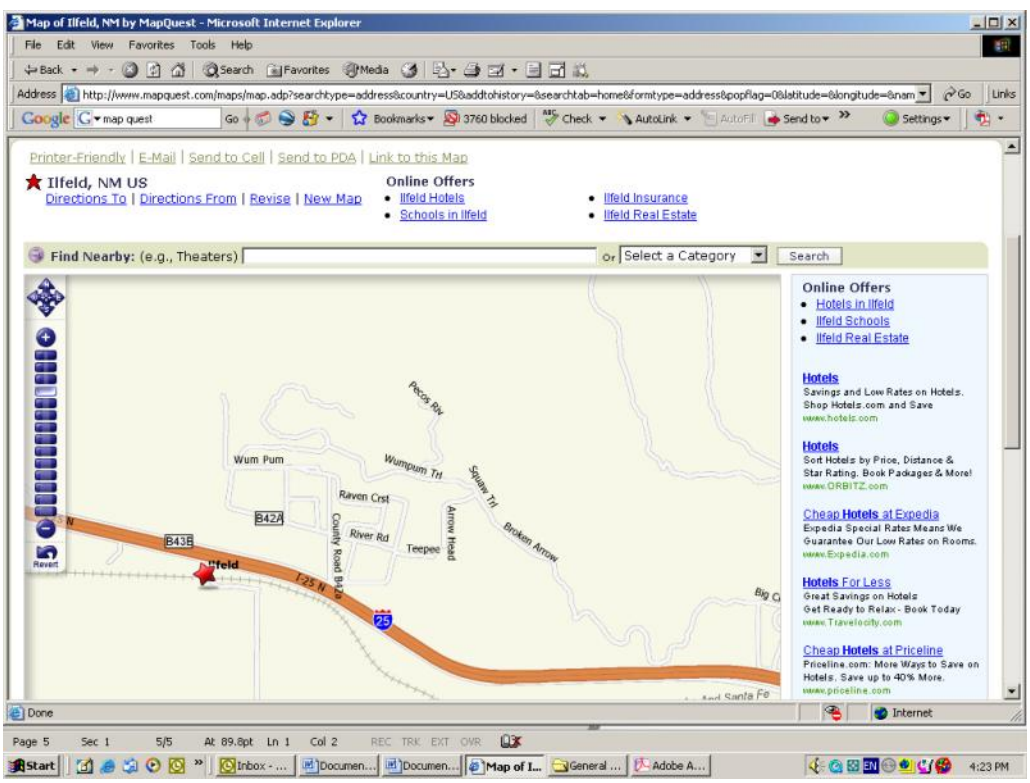
(1) http://www.webgis.com/ (2) http://www.esri.com/ (3) http://rgis.unm.edu/

One of the drawbacks in downloading digital maps from the Internet is the data file size. Most high quality digital maps available online are several megabits in file size and require a high speed Internet connection to download successfully.

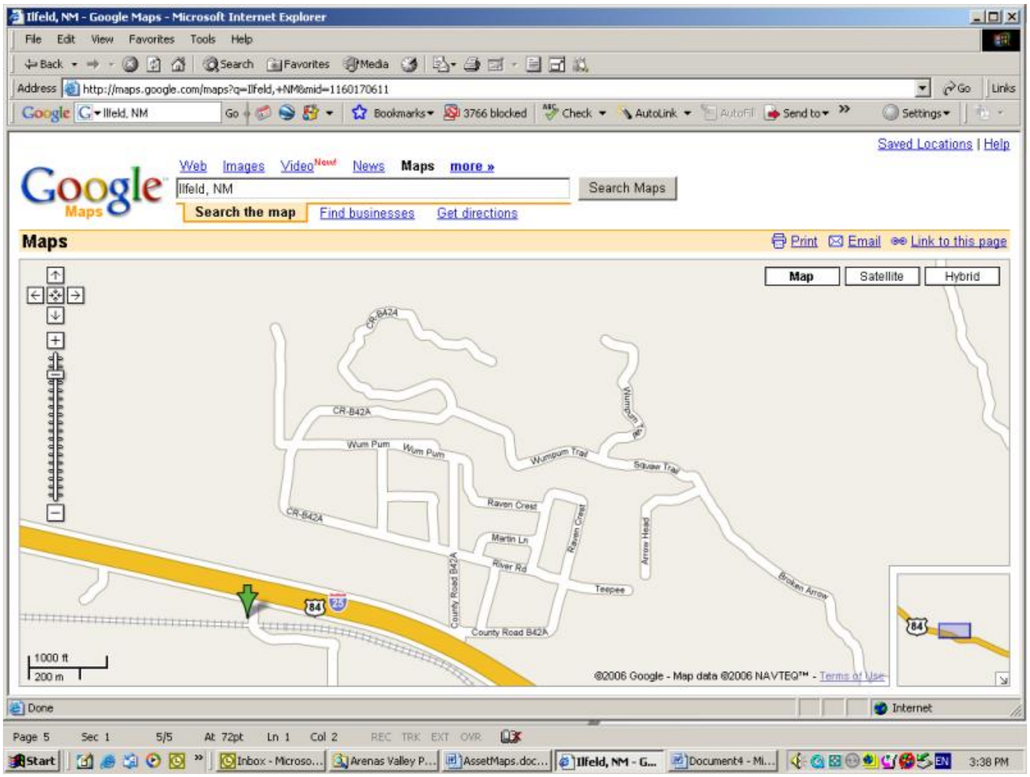
Example of Yahoo Maps:



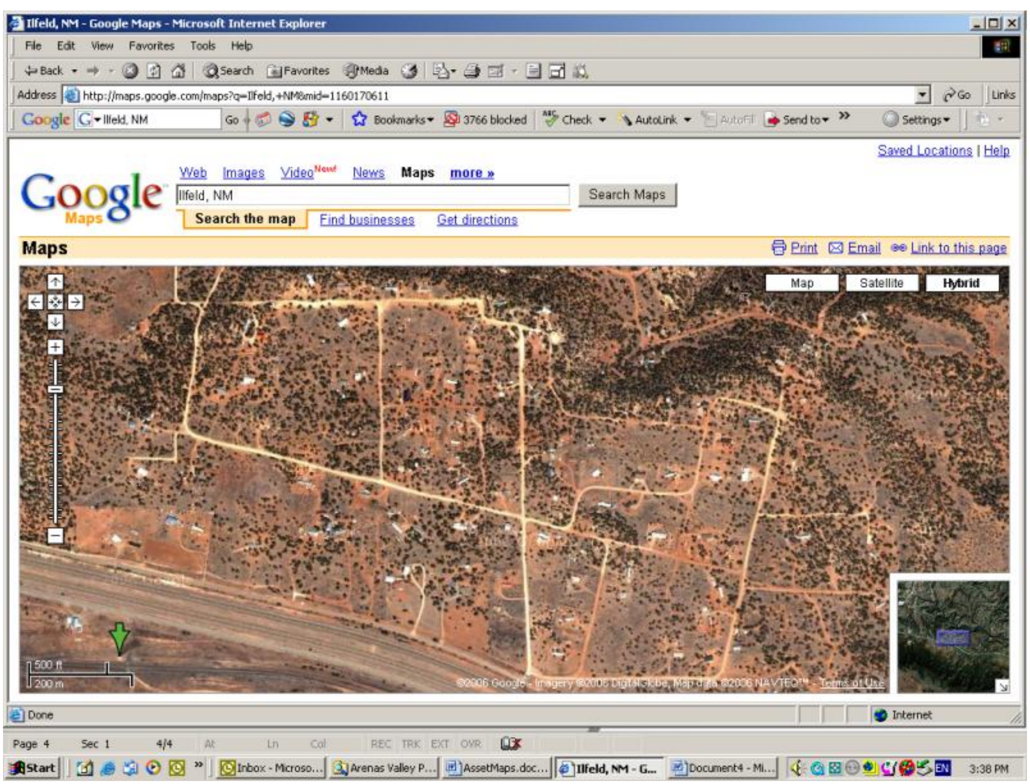
Example of a map from MapQuest:



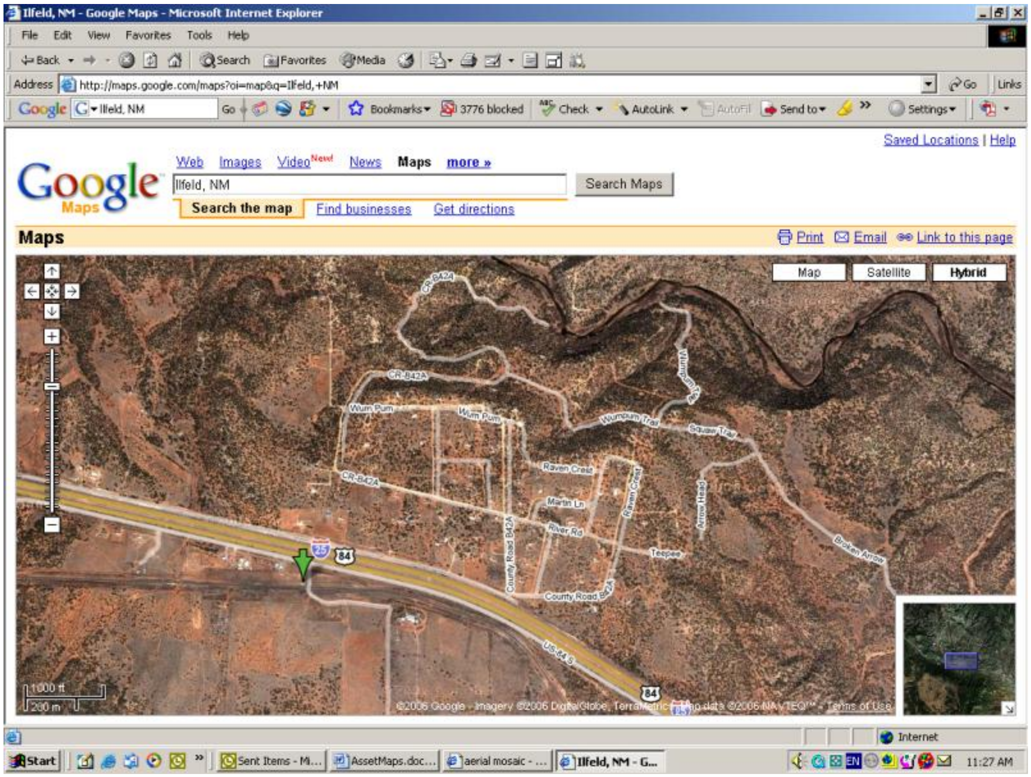
Example of Google Maps



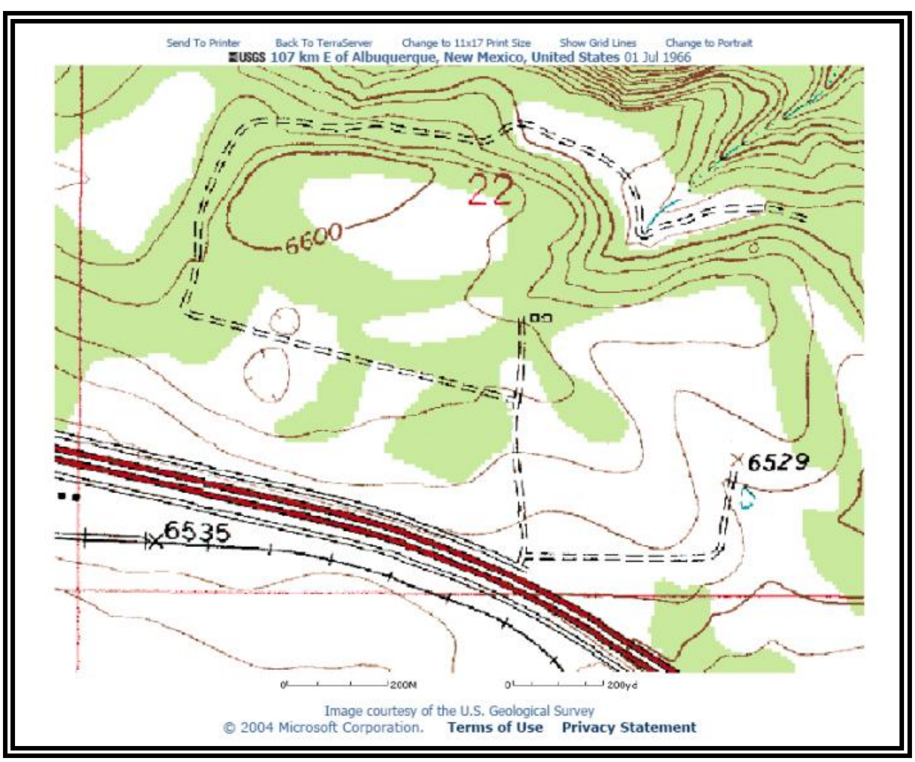
Example of an aerial map from Google Maps.



Hybrid map using Google Map's road and aerial photograph featu re.

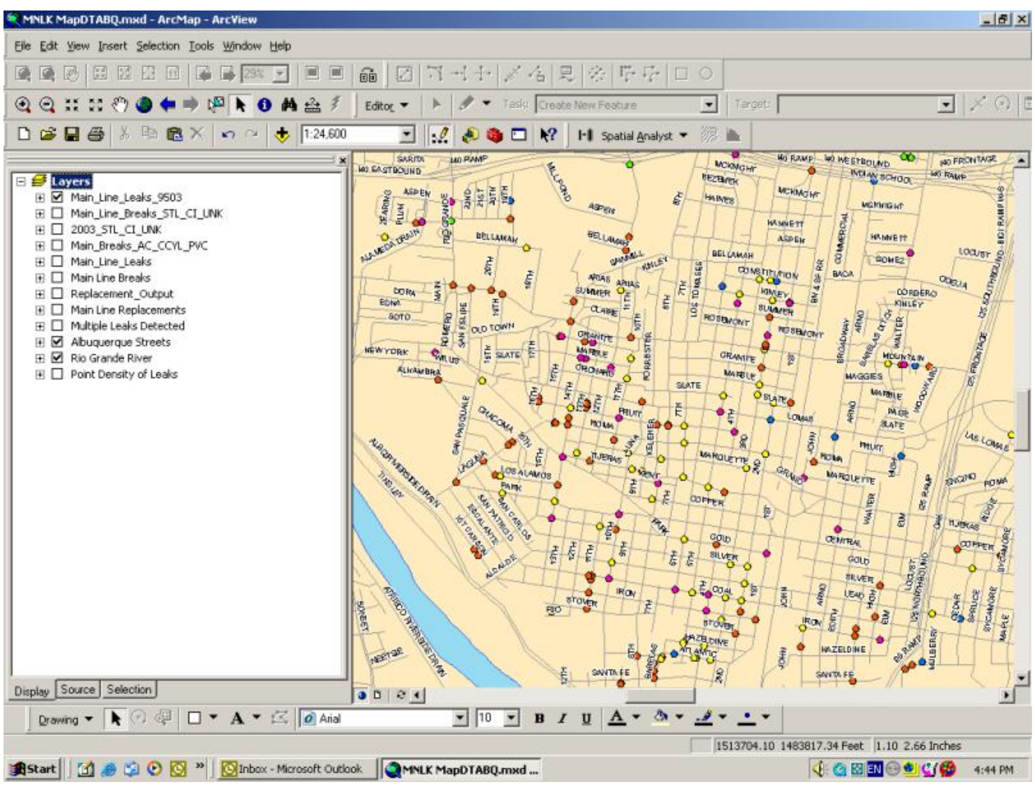


Example of a topographic map from TerraServer -USA



Example of an aerial photograph from TerraServer -USA

Example of GIS map using ArcGIS software



A.2 Asset Condition

It is critical that utilities have a clear knowledge of the condition of their assets and how they are performing. All management decisions regarding maintenance, rehabilitation, and renewal revolve around these two aspects. Not knowing the current condition or performance level of an asset may lead to the premature failure of the asset, which leaves the utility with only one option: to replace the asset (generally the most expensive option).

There are many ways to assess the condition of the assets. For example, some assets can be visually assessed, water lines can be pr essure tested, or leak tested, buildings can be monitored for energy efficiency, etc. Sometimes the only suitable way to assess an asset is to compare its performance (repair history) to its expected life. Below is a table that shows ways to monitor asse ts and which assets those monitoring systems apply to.

Suitability of some Condition Monitoring Systems for a Range of Asset Types

Asset Groups / Condition Monitoring Systems	Vibration	Temperature	Oil Usage/Level/Contaminants	Efficiency Change (Head Loss)	Infra Red Thermography, Ground Penetrating	Hours Run	Power Usage Monitoring	Concrete Decomposition Testing and Core	X-ray	Remote Control Television Inspection	Pressure Testing	Smoke Testing	Capacity Modeling (for failure)	Leak Testing	Intelligent Pigs	Protection (Paint) Thickness	Manual Inspection (Operators)	Alarms/Auto Shutdown/Shutdown Telemetry	Life Expectancy Review	Visual Assessments	Laser Profiling/Roughness Meters	Pavement Strength Testers	Skid Resistance Testers
Dynamic																							
Mechanical Plant	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✗	✓	✓	✗	✗	✓	✓	✓	✓	✗	✗	✗
Instruments	✗	✓	✗	✗	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✗	✗	✗	✗
Control Systems	✗	✓	✗	✗	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✗	✗	✗	✗
Passive																							
Roads	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✓	✗	✓	✓	✓	✓	✓
Structures																							
Concrete	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✓	✓	✗	✗	✗
Earthen	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗
Buildings	✗	✗	✗	✗	✗	✗	✓	✓	✓	✗	✗	✗	✓	✗	✗	✓	✓	✗	✓	✓	✓	✗	✗
Pipelines																							
Gravity	✗	✗	✗	✓	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✓	✗	✓	✗	✓	✓	✗	✗	✗
Pressure	✗	✗	✗	✓	✓	✓	✗	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗
Electrical																							
Poles	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✓	✓	✗	✗	✗
Wires	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✓	✓	✓	✓	✗	✗	✗

Once the assets have been monitored, a condition grading should be implemented and each asset should be rated based on this grading. The utility should determine what type of grading system works best for the s pecific utility. Below are some examples of grading systems that can be implemented.

Condition Rating Model

Rank	Description of Condition
1	**Very Good Condition** Only normal maintenance required
2	**Minor Defects Only** Minor maintenance required (5%)
3	**Maintenance Required to Return to Accepted Level of Service** Significant maintenance required (10 -20%)
4	**Requires Renewal** Significant renewal/upgrade required (20 -40%)
5	**Asset Unserviceable** Over 50% of asset requires replacement

Intermediate Condition Rating Model

Rank	Description of Condition	
3.0	Level of Service Maintenance	Minor
3.4		Average
3.8		Significant
4.0	Requires Major Upgrade	Minor
4.2		Average
4.4		Medium
4.6		Substantial
4.8		Significant
5.0	Asset Basically Unserviceable	Minor
5.2		Average
5.4		Medium
5.6		Substantial
5.8		Significant

Sophisticated Condition Assessment Model

Base Ranking	Roads (0-100)	Drains – Sewers (0-200)	Water Mains (0-500)	Buildings (0-10)	Parks (0-125)	Plant (0-100)
1	0-200	0-40	0-100	0-2	0-25	0-20
2	200-400	40-80	100-150	2-4	25-50	20-40
3	400-600	80-120	150-200	4-6	50-75	40-60
4	600-800	120-160	200-300	6-8	75-100	60-80
5	800-1000	160-200	300-500	8-10	100-125	80-100

Letter Based Ranking System

Rank	Condition Description
A	Very Good
B	Good
C	Fair
D	Poor
E	Very Poor
F	Failing, needs replacement

Life Remaining Ranking System

Rank	Life Remaining
5	New or nearly new
4	10-20 years
3	5-10 years
2	2-5 years
1	1-2 years
0	0 years

A.3 Resources for Assessing Useful Life

There are publications that discuss the projected useful life for many types of assets. The utility operator should know the system better than any projection. For example, a water distribution system operator may know that the ductile iron pipe in the system was buried too shallow and has a risk of freezing every winter. The useful life of the ductile iron pipe for this community would be significantly lower than the published projections. However, published projections are useful to have as a starting place. The following table is one such example.

Typical Useful Life for Selected Infrastructure Assets

Sample Useful Live (years)		Sample Useful Live (years)	
Roads:		**Wastewater:**	
Pavement Substructure	50-100	Gravity Sewer Lines	80-100
Wearing Surfaces	10-20	Manholes	20-50
Curb and Gutter	50-80	Pumping Station Structures	50
Footpaths	15-50	Pumping Station Electrical	15
Bridges	30-80	Risers	25
Culverts	50-80	Treatment Plant Structures	50
Roadside furniture or signage	10	Treatment Plant Electrical	15-25
Bus shelters	20	**Parks:**	
Bike paths	50	Parks & Gardens	*
Street lighting	20	Fields	*
Traffic Signals	10	Swimming Pools	50
Unsealed roads	-	Plant Nurseries	20
Drainage:		Fountains	50
Drains (underground)	50-80	Cemeteries	*
Culverts	50-80	Public Barbecues	10
Manholes	20-50	Fences	25
Detention Basins	50-100	Play Equipment	25
Pumping Station Structures	50	**Buildings:**	
Pumping Station Electrical	25	Chambers/offices/halls	50-100
Water Supply		Toilet blocks	50-100
Storage tanks	50-80	Houses	50-100
Treatment Plant Structures	60-70	Sports Clubs	50
Treatment Plant Electrical	15-25	**Waste Facilities**	
Water lines	65-95	Landfills	Depends on fill rate
Pumping Station Structures	60-70	Transfer Stations	20
Pumping Station Electrical	25	Garbage collection vehicles	6
		Corporate:	
		Work depots	50
		Vehicles	5
		Office Equipment	5-10
		*Consider each component separately	

A.4 Asset Inventory and Recordkeeping

Once you have determined what you own, and where it is, its time to catalog that data in some format. There are many ways in which this can be done.

Commercially Available Asset Management Database

For larger systems with a planning budget and dedicated personnel, a software package written specifically for the purpose of Asset Management can be used. There are many types of Asset Management software available. A simple internet search with a search engine such as Google for "Utility Asset Management Database" will point you in the right direction.

Since this software is written specifically for Asset Management, it is designed to allow the input data to be searched and printed, has pre-designed reports, can track budgets, and do many other things. This type of software is manufactured by a company that understands the many needs of utilities and provides customer support.

Database Software

Ideally, all systems would have a database to manage their asset inventory. If the software created specifically for Asset Management is not realistic, a general database software is the next best option. Many manufacturers produce database software, some are available for purchase at office goods and computer stores, some are available for purchase and download, some are available for free.

Creating a database is not typically self-explanatory. However, there are courses available for learning about databases at most colleges and some high schools, that are relatively short and inexpensive. Also, many communities may have a student or someone with database knowledge that would be willing to assist with this project. Once the database is created and tested, maintaining and updating the data can be accomplished by any member of the utility.

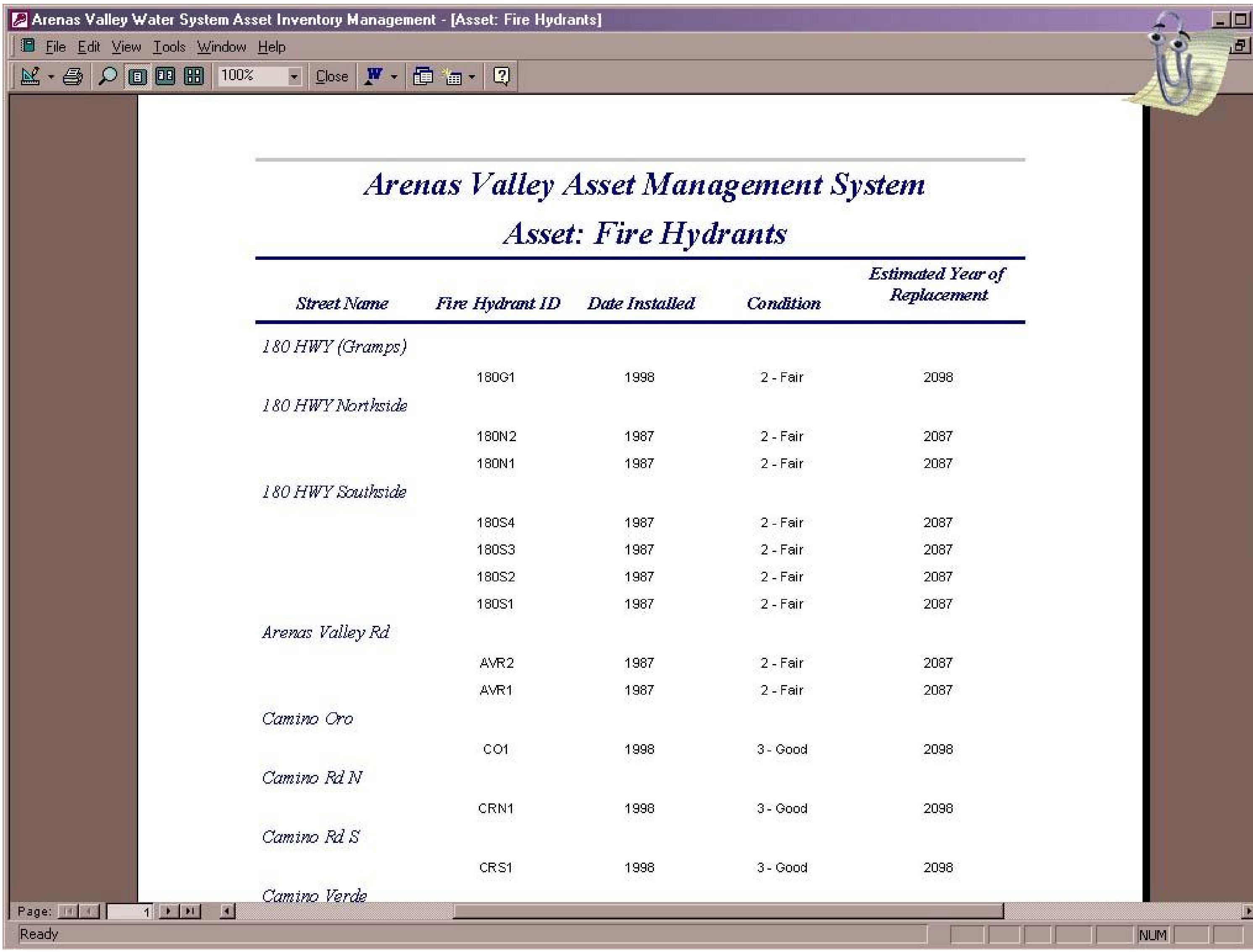
Some examples of database software that are readily available include, MySQL, Microsoft Access, Oracle, FoxPro, and Open OfficeBase.

Spreadsheet Software

Another method of creating an inventory, is to create a spreadsheet that lists every asset in the utility's inventory. Spreadsheet software is standard on most computers. However, there are many disadvantages to using a spreadsheet. Spreadsheets have very limited searching capabilities. Creating a spreadsheet inventory will essentially create a list of assets that can be printed. It is not as dynamic as a database and is not recommended.

Handwritten
If software and computers are not readily available, the utility should have a written inventory of all the assets they own. This handwritten list should be edited as the system grows and changes. A handwritten inventory is even less desirable than a spreadsheet inventory, but is better than no inventory at all.

Below is an example of a report generated from an Asset Inventory created using Microsoft Access.



Arenas Valley Asset Management System

Asset: Fire Hydrants

Street Name	Fire Hydrant ID	Date Installed	Condition	Estimated Year of Replacement
180 HWY (Gramps)				
	180G1	1998	2 - Fair	2098
180 HWY Northside				
	180N2	1987	2 - Fair	2087
	180N1	1987	2 - Fair	2087
180 HWY Southside				
	180S4	1987	2 - Fair	2087
	180S3	1987	2 - Fair	2087
	180S2	1987	2 - Fair	2087
	180S1	1987	2 - Fair	2087
Arenas Valley Rd				
	AVR2	1987	2 - Fair	2087
	AVR1	1987	2 - Fair	2087
Camino Oro				
	CO1	1998	3 - Good	2098
Camino Rd N				
	CRN1	1998	3 - Good	2098
Camino Rd S				
	CRS1	1998	3 - Good	2098
Camino Verde				

Appendix B
Level of Service

B.1 Level Of Service Examples

A system is bounded in its Level of Service by two criteria: the system can not go below the requirements of state and federal regulations (the minimum level of service a system can provide) and the system can not go above the maximum capabilities of the assets (the maximum a system can provide.) Between these two boundaries, the system can set any Level of Service it deems appropriate, acceptable to the public, management, and elected officials and that is affordable to the system.

There are no standards regarding the number of items to include in a level of service. The system can decide for itself what to include in the LOS. Some examples of LOS Agreements are presented in this Appendix. These examples are based on actual systems, but have been adapted and adjusted for use here.

Level of Service Agreement
Example 1

Water System

All federal and state water quality regulations will be met

Water Losses should be less than 10%

The system will maintain a minimum pressure of 40 psi.

There will be fire flow available for 100% of the customers within the system.

No adverse event, not related to electrical failure or severe weather condition, will cause the customer to be without water for more than 8 hours at a time.

EPA's secondary standards related to aesthetics shall be met b y the system.

Rates will be reviewed on an annual basis and raised as needed to ensure full cost recovery.

The source shall be monitored on a bi -monthly basis, by the water system and there shall be no E. coli detected in the source waters.

All customer complaints will be investigated within 2 business days of reporting the complaint.

Level of Service Agreement
Example 2

Water System

System will meet all state and federal regulatory standards.

Two days of storage will be maintained at all times in the system.

Source water pumps will be functional 99% of the time. Spare parts will be maintained to the extent possible to repair source water pumps quickly.

All customer complaints regarding water quality will be responded to within 90 minutes of the complaint 95% of the time.

Water losses will be maintained below 12%.

Unscheduled water supply interruptions will be reduced 5% per year until a 25% reduction has been achieved.

Breaks will be repaired within 6 hours from the initiation of repair 95% of the time.

Level of Service Agreement
Example 3

Water System

System will meet all state and federal regulatory standards.

System will strive to reduce complaints to fewer than 5 complaints per month.

Complaints will be addressed within 24 hours of receipt 95% of the time.

Under normal conditions, pressures will be maintained between 30 and 70 psi.

Drought restrictions will be enacted whenever the source cannot meet daily demands. If drought restrictions must be enacted more than 20% of the year, the system will investigate additional or alternative sources.

Customers will receive written notice 24 hours in advance of any planned interruption in service.

Planned interruptions will occur during the hours of 9 am and 4 pm Monday through Friday 90% of the time.

For unplanned interruptions, 15 minutes of notice prior to shut down will be provided, unless there is a critical emergency situation.

Service will be restored within 6 hours of shut down 90% of the time.

Customers will be notified of how well the system meets the LOS criteria on an annual basis.

Appendix C
Critical Assets

C.1 Critical Assets

A detailed discussion of assessing critical assets is presented in Section 5. In summary, the assessment should examine the probability of a failure occurring and the consequences of the failure if it were to occur.

In the determination of the criticality of the assets, the water system should ask itself questions similar to the following:

- What happens if the asset fails?
- What are the chances of the asset failing?
- If this asset fails, how much of the community is affected?
- If this asset fails, how much would it cost to repair it?
- If this asset fails, how many other assets could potentially be damaged?
- If this asset fails, how is the community's opinion of the water system affected?
- If this asset fails, are there public health consequences?

The worksheet on the following page can be used to determine the criticality of each of the assets. The value of probability of failure can be entered on the rows and the value of consequence can be entered on the columns. Where the rows and columns intersect, is the value for criticality of that asset.

This criticality assessment is a simplistic approach that constitutes a reasonable start for a water or wastewater system. Over time, the criticality analysis can be more robust. Or if a system has sufficient data and resources to assess criticality in a more sophisticated way initially, it can start at a higher level than this approach.

Asset:_______________
Date:________________

Circle the row and column that matches the ranking for both probability and consequence.
Where the two intersect becomes your risk.

Multiplied		**Consequence (Cost) of Failure**				
		1	**2**	**3**	**4**	**5**
Probability of Failure	**1**	*1*	*2*	*3*	*4*	*5*
	2	*2*	*4*	*6*	*8*	*10*
	3	*3*	*6*	*9*	*12*	*15*
	4	*4*	*8*	*12*	*16*	*20*
	5	*5*	*10*	*15*	*20*	*25*

1	Very Low
2	Low
3	Moderate
4	High
5	Very High

Risk = Consequence x Probability = ___

Appendix D
Life Cycle Costing Resources

D.1 Example of O&M Expenditures for A Water Distribut ion System

Table D-1 below presents an example of how the expenditures on O&M and condition assessment can be addressed for a water distribution system. Similar tables can be completed for other categories of assets, such as treatment facilities, sources, and storage facilities. This table presents general activities that could be completed on the assets, and provides an example of costs that would be spent on an annual basis on each of these assets. The costs are meant for illustrative purposes only to show the relative difference between expenditures on various levels of critical assets. These costs are not meant to be "real" costs for any specific utility. The O&M activities are also just examples; individual utilities should develop their own O&M s chedule of activities for each asset.

Table D-1: Summary of O&M Expenditures and Criticality

Asset Category	Likelihood of Failure	Consequence of Failure	O&M Activities	Condition Assessment Activities
0-30 year old PVC distribution pipe and associated appurtenances in Residential area	Low	Low	Flush lines 1/year Exercise valves 1/year $500/yr	Track break locations and break information (type, repair, size, etc) based on field activity and work orders $500/yr
30-50 year old PVC distribution pipe and associated appurtenances in residential area	Medium	Low	Flush lines 1/year Exercise valves 1/year $500/yr	Track break locations and break information (type, repair, size, etc) based on field activity and work orders $500/yr
Greater than 50 year old PVC distribution pipe and associated appurtenances in residential area	High	Low	Flush lines 1/year Exercise valves 1/year Replace pipes that have multiple failures. Program in pipes for replacement in the repair and replacement program $50,000	Track break locations and break information based on field activity. $1,500/yr

Asset Category	Likelihood of Failure	Consequence of Failure	O&M Activities	Condition Assessment Activities
0-30 year old PVC pipe in major arterials	Low	Medium - High	Flush lines 1/year Exercise valves 1/year $500/yr	Track break locations and break information based on field activity. Perform some proactive condition assessments on the pipe, such as leak detection $2,000/yr
30-50 year old PVC pipe in major arterials	Medium	Medium - High	Flush lines 1/year Exercise valves 1/year Pipes that have poor condition based on condition assessment should be replaced $150,000/yr	Track break locations and break information based on field activity. Perform proactive condition assessments on the pipe, such as leak detection $5,000/yr
Greater than 50 year old PVC pipe in major arterials	High	High	Flush lines 1/year Exercise valves 1/year Pipes that have poor condition based on condition assessment should be replaced $250,000/yr	Track break locations and break information based on field activity. Perform significant proactive condition assessments on the pipe, such as leak detection and other methods $10,000/yr

Table D-2: Repair and Replacement Schedule

Year	Item	Brief Description	Estimated Cost	Method of Estimation	One Time or Recurring	Time Period of Reoccurrence

Table D-3: Repair and Replacement Schedule Example

Year	Item	Brief Description	Estimated Cost	Method of Estimation	One Time or Recurring	Time Period of Reoccurrence
2007	Meters	Replace 1/5 of meters	$10,000	Knowledge of meter costs from previous purchases	Recurring	Every 5 Years
2008						
2009	Chlorine Pump	Replace chlorine pump	$2,000	Based on previous purchase	Recurring	Every 8 years based on past experience
2010	Tank 1 Maintenance	Tank Cleaning, Repair, Painting, Inspection	$50,000	Cost for neighboring system with similar tank	Recurring	Every 10 years
2011						
2012	Meters	Replace 1/5 of meters	$10,000	Knowledge of meter costs from previous purchases	Recurring	Every 5 Years
2013						
2014						
2015						
2016						
2017	Meters	Replace 1/5 of meters	$10,000	Knowledge of meter costs from previous purchases	Recurring	Every 5 Years
	Chlorine Pump	Replace chlorine pump	$2,000	Based on previous purchase	Recurring	Every 8 years based on past experience

Year	Item	Brief Description	Estimated Cost	Method of Estimation	One Time or Recurring	Time Period of Reoccurrence
2018						
2019						
2020	Tank 1 Maintenance	Tank Cleaning, Repair, Painting, Inspection	$50,000	Cost for neighboring system with similar tank	Recurring	Every 10 years
2021						
2022	Meters	Replace 1/5 of meters	$10,000	Knowledge of meter costs from previous purchases	Recurring	Every 5 Years
2023						
2024						
2025	Chlorine Pump	Replace chlorine pump	$2,000	Based on previous purchase	Recurring	Every 8 years based on past experience
2026						

The table above indicates the routine replacements that this system will undertake for the next 20 years. Some years have multiple items, while some years have no projects.

Table D-4: Capital Improvement Plan

Year	Project Name	Project Description	Project Need	Year Project Needed	Date Flexible (Y or N)	Estimate of Project Cost	Method of Estimation	Potential Funding Source	Changes in Operations	Impact of Project on LOS

Table D-4: Capital Improvement Plan Example

Year Desired	Project Name	Project Description	Project Need	Date Flexible (Y or N)	Estimate of Project Cost	Method of Estimation	Potential Funding Source	Changes in Operations	Impact of Project on LOS
2007	Main Street Line Extension	Extend Main Street 6" PVC pipe to serve 20 customers currently on individual wells	The 20 customers are facing significant challenges with their individual wells and must be added to water system	Yes, could potentially be delayed up to 2 years	$150,000	Based on previous line extension cost; increased 5% to cover inflation	25% connection fees; 25% CDBG; 25% RIP Loan	None	Will be able to provide additional customers with water
2008	None Needed								
2009	Arsenic Removal Facility	Add Arsenic Adsorption System with building and all needed equipment	Source water can not meet new regulatory requirement of 10 ppb	N, must meet date for regulatory requirements	$300,000	Engineer's Estimate	Requesting Legislative Grant; SRF loan	Requires higher level operator, requires replacement and disposal of media, O&M costs significantly higher	Will allow system to meet LOS requirement to be in compliance with regulatory standards
	2nd Street Line Replacement	Replacement of 2nd Street Line with new pipe	Line failures are so numerous, LOS can not be met	Y, but needs replaced within 1 to 2 years	$250,000	Based on previous costs	30% from reserves; RD loan/grant	None	Will allow the system to meet LOS requirements
2010	None								

Year Desired	Project Name	Project Description	Project Need	Date Flexible (Y or N)	Estimate of Project Cost	Method of Estimation	Potential Funding Source	Changes in Operations	Impact of Project on LOS
2011	Replace 4 miles of 6" PVC Distribution Pipe	It is anticipated that 4 miles of pipe will need to be replaced due to current condition assessment and estimated useful life	Needed to keep the system in good operating order	Y	$1.5 million	Engineer's Estimate	SRF loan or RD loan/grant	None	Reduce number of unplanned outages
2012									
2013									
2014	Replace Storage Tank 3	Replace Storage Tank #3 with a new, larger tank	Storage tank has been well maintained but is reaching the end of its useful life, further rehab difficult; also, size of tank needs to be increased	Y	$500,000	Cost several neighboring systems paid for a similar tank	Need 50% grant, 50% from revenues or loan sources	Increase system pressures and water availability; may require some changes in the amount of time wells are pumped.	Would improve systems overall quantity of storage, would increase fire flow potential, would improve system pressure
2015									
2016									
2017									
2018									

Year Desired	Project Name	Project Description	Project Need	Date Flexible (Y or N)	Estimate of Project Cost	Method of Estimation	Potential Funding Source	Changes in Operations	Impact of Project on LOS
2019									
2020	Replace Well #7	Drill a new well to take the place of Well #7	Well #7 has been declining in quantity for many years. It is anticipated that it will need replaced by 2020.	N	$15,000	Driller's Estimate	50% existing revenues and reserve funds; 50% loan funds	May require changes in the current pumping system	Will improve overall water availability to the community and the systems ability to provide water continuously
2021									
2022									
2023									
2024									
2025									
2026									

As the table shows, multiple projects can be done in the same year by adding another row to the table. Some y ears can remain blank with no projects if there is no anticipated need for a project in that year.

Appendix E
Long-Term Funding Strategy

E.1 Long-term Funding Strategy

The objective in preparing long-term financial forecasts is to outline the organization's future financial requirements based on all information relating to asset creation, maintenance, renewal/rehabilitation and disposals.

Three questions must be answered when preparing the strategy:

- What funds are needed to acquire, operate, maintain and renew the asset?
- When will the funds be required?
- How do these types of funds affect the utilities rates?

There are five types of expenditures that a utility needs to plan for. Each type of expenditure has a typical funding source associated with it as well.

Expenditures and Funding

Expenditure Type	Description	Funding Source
Operational	Activities which have no effect on asset condition but are necessary to keep the asset utilized appropriately (i.e. power costs, overhead costs, etc.).	Annual Budget, Rates, Revenue
Maintenance	The ongoing day-to-day work required to keep assets operating at required service levels (i.e. repairs, minor replacements).	Annual Budget, Rates, Revenue
Renewal	Significant work that restores or replaces an existing asset towards its original size, condition or capacity.	Annual Budget, Rates, Revenue, Grants, Loans
New Work, Development, Capital Projects	Works to create a new asset, or to upgrade or improve an existing asset beyond its original capacity or performance, in response to changes in usage, customer expectations, or anticipated future need.	Annual Budget, Rates, Revenue, Grants, Loans
Disposal	Any costs associated with the disposal of a decommissioned asset.	Annual Budget, Rates, Revenue

It is worth noting that many funding agencies have a Uniform Funding Application. In an effort to reduce the time spent and expense that local governments incur when applying to multiple agencies for financial assistance, the New Mexico Environment Department/Construction Programs Bureau (CPB) along with the New Mexico Finance Authority, Department of Finance/Local Government Division and USDA Rural Development signed a memorandum of understanding in December of 2003 whereby each of the agencies agreed upon the use of a Uniform Funding Application. Once completed, the application can be copied and submitted to any of the funding programs described. Each agency may have additional requirements, unique to a particular program.

You may download the application in PDF format or a Word Document from: http://www.nmenv.state.nm.us/cpb/cpbtop.html#UNIFORMFUNDINGAPP

Appendix F
Checklist for Asset Management Reviews

Asset Management Components Checklist

System Name: ____

Water or Wastewater System (circle one)

Component of Asset Management	Specific Item	Completed Y or N	Method of Completion	Comments
Asset Inventory	List of Assets			
	Map of Assets			
	Asset Condition Assessment			
	Remaining Useful Life of the Assets			
	Asset Value (Optional)			
Level of Service	Level of Service Agreement			
Critical Assets	Criticality Analysis			
Life Cycle Costing	Operation and Maintenance Program			
	Repair Replacement Schedule			
	Capital Improvement Plan (CIP)			
Long-Term Funding Strategy	5 Year Financial Plan			
	Funding Strategy for Repair and Replacement Schedule			
	Funding Strategy for CIP			

Overall Assessment:

EXAMPLE

Asset Management Components
Checklist

System Name: ____H2O Water System ______________________________________

Water **or Wastewater System** (circle one)

Component of Asset Management	Specific Item	Completed Y or N	Method of Completion	Comments
Asset Inventory	List of Assets	Y	Handwritten	
	Map of Assets	Y	Google Map with Hand-drawn assets	
	Asset Condition Assessment	Y	Ranked from 0 to 5	Many assets ranked as 1, may underestimate condition
	Remaining Useful Life of the Assets	Y	Provided years of life left	
	Asset Value (Optional)	N		
Level of Service	Level of Service Agreement	Y	Agreement provided to customers	Includes 8 elements
Critical Assets	Criticality Analysis	N		
Life Cycle Costing	Operation and Maintenance Program	Y	Notebook of each piece of equipment and maintenance required	Very thorough program
	Repair Replacement Schedule	N		
	Capital Improvement Plan (CIP)	Y	5 Year CIP	

Component of Asset Management	Specific Item	Completed Y or N	Method of Completion	Comments
Long-Term Funding Strategy	5 Year Financial Plan	Y	Followed RCAC Guide	
	Rate Structure	Y	Used Computer program to set rates	Rates cover expenses
	Funding Strategy for Repair and Replacement Schedule	N		Didn't have repair replacement schedule
	Funding Strategy for CIP	Y	Table indicating potential funding sources for each CIP element	

Overall Assessment: This is a small water system. Their asset management strategy contains most of the required elements. For the size system, they did a good job gathering information and completing the required items.