IBM's Smarter Cities Challenge

Tucson

Report

Contents

1. Executive summary

In 2013 IBM selected Tucson in Arizona, USA, to receive a Smarter Cities Challenge® grant as part of its citizenship efforts to build a Smarter Planet®.

The City of Tucson wishes to deliver a world-class, reliable and efficient water service. Mayor Jonathan Rothschild and City Manager Richard Miranda invited the Smarter Cities Challenge team to make recommendations based on the following challenge:

How can the City of Tucson leverage data-driven management to improve customer service; upgrade systems to capture failures, leaks and water usage; and reduce the cost of energy?

The challenge

Given that it is surrounded by desert, water is one of Tucson's highest priorities. A reliable water service, adequate water supply and affordable energy to deliver it will be essential to Tucson's survival as its population grows.

The team identified the following problems with the current system, which define the scope of the effort:

- Customers have said that processes to address water bill issues need improvement
- The current infrastructure, including the physical distribution network, metering, process control systems and IT systems, is aging.
- There is no integration within and across processes, systems and data, creating a barrier to data-driven management.

A team of five IBM experts spent three weeks in the city, working with stakeholders to deliver recommendations around key issues for Tucson Water.

Findings and recommendations

The Tucson Water system has 4,521 miles of pipes, 57 water storage facilities, 214 production wells and 117 booster pumping facilities. Add to this 225,000 water meters, tens of databases, applications from several vendors, servers, storage, networking and trucks, and we begin to see the complexity of the modern-day system.Most of these systems are manually controlled, although some have begun to embrace automation. Many applications do not share data and some even duplicate data.

In order to meet the Mayor's vision of data-driven management to empower customers and Tucson Water staff, this complex web of mechanical, electrical, electronic and software systems needs to become interconnected and integrated.

As both water and energy prices increase, the City could use IT to drive efficiencies in water service delivery. It could apply technology to integrate data, and optimization techniques (data-driven management) to reduce the cost of energy and sustain a reliable supply of water.

Following an issues tour of Tucson Water, multiple meetings and interviews with almost 100 stakeholders, the team developed four recommendations:

1. **Provide real-time data to Customer Service Representatives (CSRs) and customers:** Empower customers and provide CSRs with a single view of customer information.
2. **Implement an Automated Metering Infrastructure (AMI) pilot and accelerate AMI system deployment:** Enable more efficient, real-time water meter readings.
3. **Lower energy costs and reduce water loss through water control optimization best practices:** Refresh the Supervisory Control and Data Acquisition (SCADA) system with additional metering, optimization analytics, water balancing strategies and data integration with other IT systems.
4. **Develop an IT master plan to enable data-driven management:** Support the previous three recommendations and ensure the systems work together.

Conclusion

Developing an IT plan that integrates data and applications to break down silos is fundamental to delivering the City's vision of a data-driven water system.

The team's four recommendations address the challenge to improve customer service; upgrade systems to capture failures, water usage and leaks in real time; conserve water; and reduce the cost and energy needed to deliver water.

Highlights

By acting on the recommendations, Tucson Water will:

- Reduce percentage of non-revenue water
- Enable earlier warnings for potentially high bills
- Decrease volume of customer queries to call centers
- Increase customer satisfaction with Tucson Water
- Lower energy expenditure
- Empower employees

2. Introduction

A. The Smarter Cities Challenge

By 2050, cities will be home to more than two thirds of the world's population. They already wield more economic power and have access to more advanced technologies and capabilities than ever before. Simultaneously, cities are struggling with a wide range of challenges and threats to sustainability in their core support and governance systems, including transport, water, energy, communications, healthcare and social services.

Meanwhile, trillions of digital devices, connected through the Internet, are producing a vast ocean of data. All of this information, from the flow of markets to the pulse of societies, can be turned into knowledge because we now have the computational power and advanced analytics to make sense of it. With this knowledge, cities could reduce costs, cut waste, and improve efficiency, productivity and quality of life for their citizens. In the face of the mammoth challenges of economic crisis and increased demand for services, ample opportunities still exist for the development of innovative solutions.

In November 2008, IBM initiated a discussion on how the planet is becoming "smarter".

By this it meant that intelligence is becoming infused into the systems and processes that make the world work — into things no one would recognize as computers: cars, appliances, roadways, power grids, clothes, even natural systems such as agriculture and waterways.

By creating more instrumented, interconnected and intelligent systems, citizens and policymakers can harvest new trends and insights from data, providing the basis for more informed decisions.

A Smarter City uses technology to transform its core systems and optimize finite resources. Because cities grapple on a daily basis with the interaction of water, transportation, energy, public safety and many other systems, IBM is committed to a vision of Smarter Cities® as a vital component of building a Smarter Planet. At the highest levels of maturity, a Smarter City is a knowledge-based system that provides real-time insights to stakeholders and enables decision makers to manage the city's subsystems proactively. Effective information management is at the heart of this capability, and integration and analytics are the key enablers.

As IBM aligns its citizenship efforts with the goal of building a Smarter Planet, we realize that city leaders around the world face increasing economic and societal pressures. Given the increased demand for services, they have to deliver new solutions ever more rapidly.

With this in mind, IBM Corporate Citizenship has launched the Smarter Cities Challenge to help 100 cities around the world over a three-year period become smarter through grants of IBM talent. Tucson, Arizona, USA was selected through a competitive process as one of 100 cities awarded a Smarter Cities Challenge grant in 2013.

During a three-week period from February 25 through March 15, a team of five IBM experts (referred to in this report as "the Smarter Cities Challenge team") worked in Tucson to deliver recommendations around key issues for Mayor Jonathan Rothschild and City Manager Richard Miranda.

B. The challenge

The City of Tucson wishes to transform the way it manages water: to deliver a world-class, reliable and efficient water service.

Thus, the Mayor and City Manager invited the Smarter Cities Challenge team to make recommendations based on the following challenge:

How can the City of Tucson leverage data-driven management to improve customer service; upgrade systems to capture failures, leaks and water usage; and reduce the cost of energy?

The Mayor and City Manager intend to replicate the model used to address this challenge for Tucson Water as they continue to improve all City departments.

The team interviewed just under 100 stakeholders representing the City, Tucson Water (Customer Service, Metering, Maintenance, Operations, Engineering and Quality), Tucson Water customers, academia, nonprofit community organizations (including Community Action Water Coalition and Pima County Community Action Agency) and consultants. The team also talked to the Citizens' Water Advisory Committee, which acts as the official advisory body on Water Capital Improvement planning and rate structure formulation to the City.

The team took part in an issues tour of Tucson Water's facilities (including Metering, Maintenance, Operations, SCADA Control and Water Quality). This, alongside the interviews and customer focus groups, helped the team to identify the following problems, which define the scope of the effort:

- Customers have said that processes to address water bill issues need to be improved
- The current infrastructure, including the physical distribution network, metering, process control systems and IT systems, is aging.
- There is no integration within and across processes, systems and data, creating a barrier to data-driven management.

Based upon the observations and findings described in section 3 of this report, the team developed the recommendations detailed in section 4.

3. Context for recommendations

A. Findings

Given that Tucson is surrounded by desert, water is one of the city's highest priorities. A reliable water service, adequate water supply and affordable energy to deliver it are essential to Tucson's survival.

As both water and energy prices increase, the City could use IT to drive efficiencies in water service delivery. It could apply technology to integrate data and optimization techniques (data-driven management) to reduce the cost of energy and sustain a reliable supply of water.

The Tucson Water system has 4,521 miles of pipes, 57 water storage facilities, 214 production wells and 117 booster pumping facilities. These are controlled by a network of Supervisory Control and Data Acquisition (SCADA) systems. Add to this 225,000 active water meters, tens of databases, applications from several vendors, servers, storage, networking and trucks, and we begin to see the complexity of the modern-day system.

Unfortunately many of these systems exist in silos. Some because of security concerns; others because they were acquired from many different vendors or use custom-developed software; some simply due to a lack of communication between owners of systems that were not designed to work together. Tucson is not unique in this; many cities and commercial organizations face the same problem.

Most of these systems are manually controlled, although some have begun to embrace automation.

Many applications do not share data and some even duplicate data, intentionally or by accident, leading to inconsistencies. Customer Service Representatives (CSRs) do not have access to real-time customer information; it is spread across multiple systems and takes longer to process. This has a direct impact on customers, who must spend longer on the phone resolving issues.

Tucson Water is sitting on a treasure trove of data that could be used to operate its systems in a unified and optimized manner. The key to unlocking it is to better integrate data and applications and make them available to all the interconnected software, hardware, networks and employees that operate the water system.

Tucson Water needs to better integrate its metering, asset management and customer relationship management (CRM) systems.

While some applications currently have Web interfaces and Windows user interfaces, some still use green screens. Information needs to be accessible through a series of dashboards to stakeholders, including customers, CSRs, City managers and other Tucson Water staff.

In order to meet the Mayor's vision of data-driven management to empower customers and Tucson Water staff, this complex web of mechanical, electrical, electronic and software systems needs to become interconnected and integrated. It also needs to become more intelligent, deriving insights by analyzing the data available. These insights can be used to reduce non-revenue water (NRW) loss and energy use, and alert customers, CSRs and managers in a timely manner.

In short, integrated software applications, databases and management systems will not only optimize water delivery for Tucson but will also delight customers – who, ultimately, pay the bills.

Following an issues tour of Tucson Water, multiple meetings and interviews with almost 100 stakeholders, the team segmented its findings into four areas:
- Customer service
- Metering management
- Operations management
- Information technology (IT)

The team then streamlined its findings, focusing on opportunities for Tucson Water to improve customer service and reduce the cost of energy and non-revenue water. The team's key observations are described below.

Customer service

Tucson Water provides good quality water and has established a long history of best practices in many areas. Through excellent demand planning it has secured a reliable water supply for customers and achieved a goal of delivering one million gallons of recharged water.

Conservation programs and customer education on the importance of conserving water – including Beat the Peak, workshops and focus groups – have been very effective. Many customers now have a great conservation ethic, leading to a decrease in per capita demand for water to levels consumed in 1995.

Tucson has a significant (15-25%) transient population, which includes school students and *"snowbirds"*: people moving from cold climates to enjoy the warmth. The City must maintain continuous and expanded outreach to ensure customers can take advantage of conservation initiatives and rebates.

After reflecting on issues and figures quoted in interviews with CSRs, the team identified some significant opportunities for improvement.

Around two years ago customer call volumes increased from a 50,000 to 80,000 per month, with a hold time of 45 minutes, because of a number of changes to the billing process. For example, Tucson Water was asked to include a charge for the County Sewer Department on water bills shortly before sewer rates rose significantly. Seeing this, customers would call Tucson Water to complain. After recruiting more staff and upgrading the Interactive Voice Response (IVR) system, the hold time has been reduced to less than two minutes, but the volume of calls remains high.

Around 30% of calls are made because customers and CSRs lack information. The data silos described above often prevent CSRs from handling customer queries and requests accurately and promptly.

For example, CSRs often have to locate paper documents, such as Landlord-Tenant Agreements (LTAs), while keeping the customer on hold, which makes the customer unhappy. There is no integrated CRM system in place to make this information available quickly.

Around 20-30% of calls coming to the call center are not "coded" – categorized against an established list of reason codes – resulting in incomplete information analysis.

Metering management

Tucson Water already has an active program to replace aging mechanical meters with new digital drive-by or walk-by Automated Meter Reading (AMR) meters. It has budgeted $5 million per year for next 10 years for this.

Like mechanical meters, AMR meters are read once a month; but the reading is captured much faster. This is good news for those employed to read the meters, who work in extreme heat in the summer months.

While AMR meters help, they do not address core customer satisfaction issues around unexpected high bills.

These high bills are often prompted by water leakage or stuck meters: customers receive low or no bills for a short time, followed by a sudden high bill when the meter is fixed or a leak is taken into account. Even with AMR meters in place customers are unaware of these situations until they receive their water bill at the end of the month. Some customers have seen bills greater than $1,000 when their normal expected usage is dramatically less.

Tucson Water currently spends close to $1.3 million per year on adjustments where customers have questioned high bills, which they are entitled to do once every three years.

Customers and CSRs do not currently have access to daily or hourly water consumption or leak data, although new AMI technology is available to enable access.

An AMI with a communication module could be added to each existing AMR at a cost of $70 per meter, along with a fixed network of communications infrastructure to enable hourly data collection.

Operations management

Tucson Water could streamline its operations to reduce waste and save energy.

Tucson Water has an excellent track record for supply planning where water supply exceeds demand by more than 40,000-60,000 acre-feet per year, which it stores in underground reservoirs.

However, non-revenue water (NRW) – water lost, mainly through leaks in reservoirs and water mains in the distribution network – has been calculated to account for as much as 10-12% of Tucson's overall output in recent years. If it does not reduce this, Tucson Water may have to pay penalties from the State of Arizona for exceeding American Water Works Association (AWWA) standards. While some cities in the US have a higher percentage, others have achieved NRW as low as five percent, so clearly there is room for improvement.

Tucson Water's annual energy cost is around $15 million, which is almost 10% of its operations and maintenance budget and almost 30% of its variable cost of operations.

The water supply and distribution system has been growing more complex in recent years. As already explained, data across Tucson Water systems is not integrated and is not shared with enterprise systems.

Eighty percent of the water supply comes through the Central Arizona Project (CAP) – 144,170 acre-feet per year – from the Colorado River. This supply is recharged in an aquifer and supplemented from other sources, including ground water, Tucson Airport Remediation Project (TARP) water and reclaimed waste water.

Some figures about the 2012 potable Tucson water supply include:

- Population served: 709,000 people
- Number of active customer accounts and meters: 225,000
- Total production for the potable water system: 104,000 acre-feet
- Energy required for water supply: 120,000,000 kWh
- Total length of water pipes: 4,521 miles
- Number of active production wells: 214
- Number of water storage facilities: 57
- Number of boosters: 117
- Number of fire hydrants: 20,601
- Number of valves: 80,000

Information technology (IT)

Tucson Water has recently put new IT management in place and hired a new CIO at the end of 2012. An infrastructure refresh is also underway, implementing a new enterprise resource planning system for HR, payroll, budget, finance and general ledger.

But many IT systems operate in silos and have not been integrated with other Tucson Water systems. Staff still perform some processes manually. NaviLine (billing) and Synergen (work and asset management) are not integrated; staff must make extra effort to cut and paste to transfer data from one to the other.

The IT infrastructure has not been refreshed over the years, primarily because of staffing and budget issues, resulting in systems that are out of date and difficult to maintain and modify. Applications are:

- Outdated and unsupported by vendor (Synergen)
- Lacking function (Telvent 522)
- Unstable (NaviLine)

There is no adequate documentation system and no consistent way to share data between applications. There is, however, a potential to use key performance indicators (KPIs) to drive better IT performance.

Based on these key observations, the team made tactical and strategic recommendations for each of the four domains to address Tucson's challenges.

B. Context

The Smarter Cities Challenge team recommends that the City implement a holistic IT program to improve its water management systems.

The team believes that by capturing detailed data, applying the data through continuous processes of analysis and optimization, and enabling the maximum degree of integration between systems, the City and Tucson Water could improve customer service and reduce the amount of money it spends on energy and NRW loss.

To better understand how a holistic approach would benefit the City's effort to upgrade its aging water infrastructure, we can look to the automobile industry.

For the first several decades of its existence the automobile industry focused on speed, horsepower, mechanical engineering and some electrical engineering. Electronics and software began to appear in automobiles – the 1977 Oldsmobile Toronado from General Motors contained a single computer unit for spark plug timing.

Fast-forward to 2013, and it is now very common to see a network of more than 30 computer units and tens of millions of lines of code in automobiles like the Toyota Prius and the Chevy Volt. The 2010 BMW has more than 100 million lines of software code. What does all this software do? It optimizes fuel efficiency, lowers emissions, improves braking in hazardous weather, protects passengers with airbags and uses technologies like GPS and OnStar to provide emergency location information about the vehicle to first responders.

Integrated software, data and mechanical and electrical systems are the lifeblood of a modern automobile. This is before we even get close to talking about the software and hardware needed in cars such as the Google self-driving car. This is simply the intelligent and interconnected automobile.

What does all this have to do with Tucson's water challenges?

It shows how powerful the evolution from a decades-old infrastructure of pipes, pumps and reservoirs to devices that have instrumentation, connectivity and, increasingly, intelligence could be.

After two weeks of intense interviews, analysis and modeling, the Smarter Cities Challenge team developed four specific recommendations that address the problems in customer service, metering management, operations management and IT.

These recommendations and the challenges addressed, illustrated in Figure 1, are:

1. **Provide real-time data to CSRs and customers.** This will empower customers and provide CSRs with a single view of customer information.
2. **Implement an AMI pilot and accelerate AMI system deployment.** Including a data collection and customer portal will enable more efficient readings than AMR meters alone.
3. **Lower energy costs and reduce water loss through water control optimization best practices.** Refresh the SCADA system with additional metering, optimization analytics, continuous water balancing strategies and data integration with other IT systems.
4. **Develop an IT master plan to enable data-driven management.** This will support the previous three recommendations and ensure the systems work together. The plan can then be extended to the rest of the city.

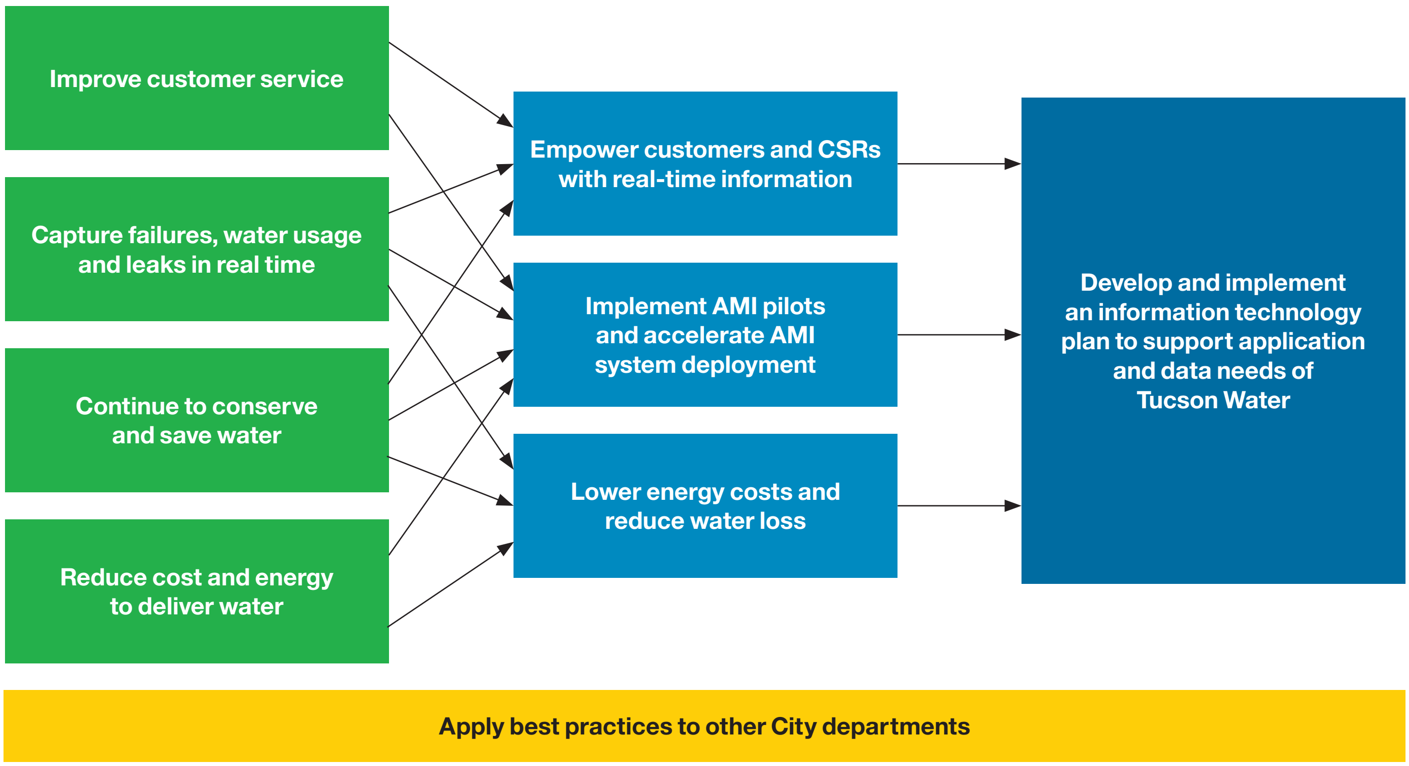

Figure 1:
Recommendations for Tucson

C. Roadmap of recommendations

Figure 2 shows a summary roadmap and timeline for implementing the recommendations. This brings together individual recommendation roadmaps. The team recommends that Tucson Water take the initial roadmap recommendations and create its own detailed project plan.

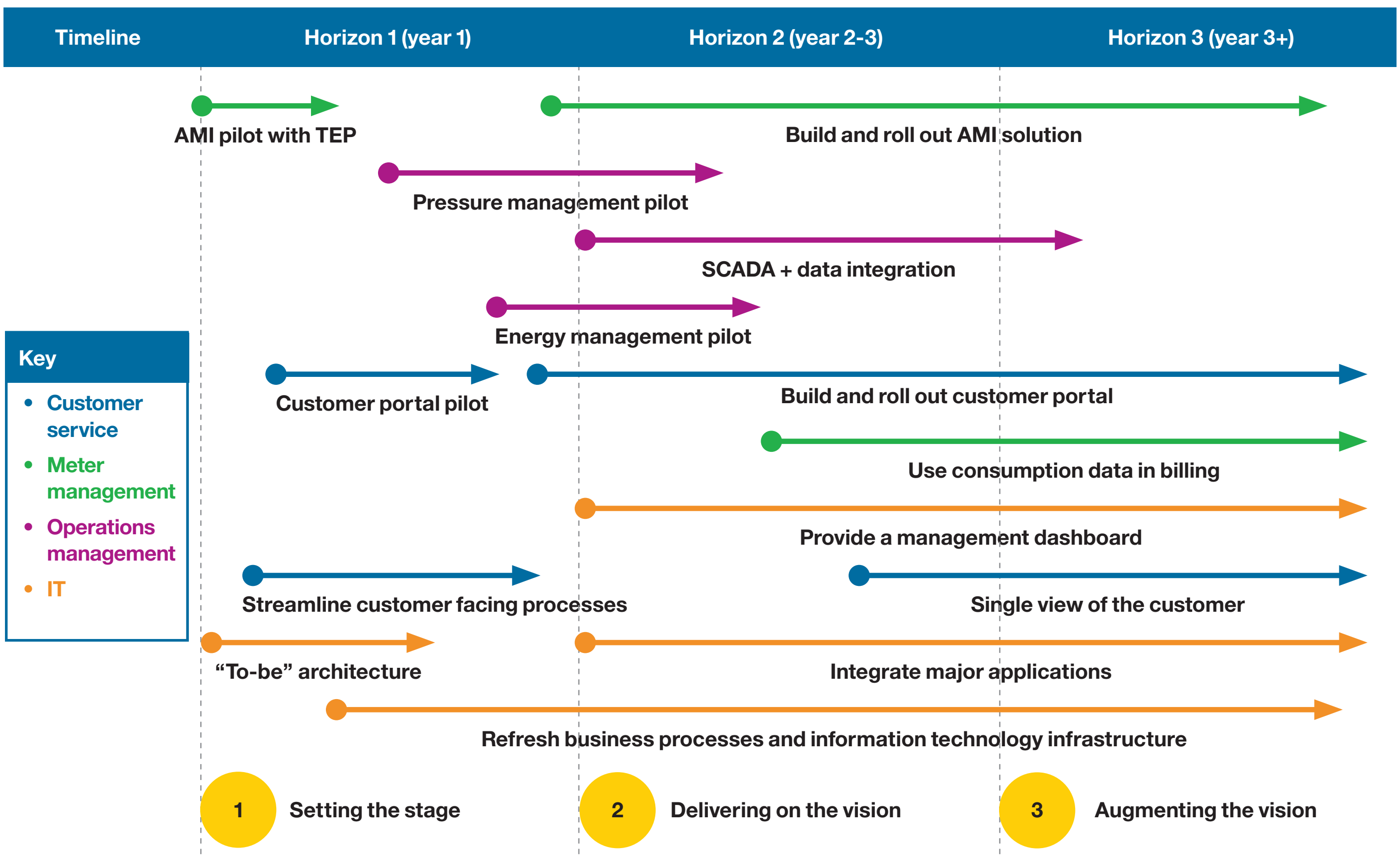

Figure 2:
Summary roadmap and timeline

Below is a list of some of the key tasks identified in the roadmap summary. The team has identified dependencies between these projects in the detailed recommendation descriptions highlighted in section 4.

1. Quick wins that require little or no additional cost

- AMI pilot with Tucson Electric Power (TEP)
- Streamline customer-facing processes, such as move requests and digitize LTA documents
- Document existing processes, systems and data models and begin to define the enterprise architecture

2. Incremental investments that deliver significant value

- Fund and begin a customer portal pilot in conjunction with the AMI pilot
- Launch pressure management pilot
- Launch energy management pilot
- Build and roll out AMI – $50 million already budgeted over 10 years, adjust plan to support AMI
- Provide a management dashboard
- Start integrating key applications and prepare for a shared data infrastructure that will enable insights to be developed from customer data
- Use consumption data in billing

3. Long-term investment on capital intensive projects and infrastructure refresh

- Roll out SCADA with data integration to key enterprise systems
- Refresh business processes and IT infrastructure
- Start developing single view of the customer

The team anticipates that lessons learned and best practices in improving water systems, such as enterprise architecture and data-driven management, will then be applied to other City departments and agencies.

4. Recommendations

Recommendation 1: Provide real-time data to CSRs and customers

Some Tucson Water customers have received bills greater than $1,000, when their normal expected usage is a lot less. This prompts a huge volume of calls to the call center, to CSRs who are not fully equipped to deal with the inquiries.

A great deal of CSR time is currently spent handing this small number of calls, which take much longer to handle than more straightforward bill inquiries.

In order to improve customer service and reduce call center resource, the City should provide real-time data to both customer service representatives (CSRs) and customers.

Tucson Water should also investigate the impact of real-time alerts using email, web or mobile phones. Or, for those customers not yet comfortable with digital channels, have a message service call the home phone with a prerecorded warning message. Either method will alert customers about potential high bills earlier so that they can take remedial action sooner.

Implementing more efficient and accessible AMI meters and making consistent data available will enable customers to handle many issues themselves. This does require the City to invest in a well-designed and easy to use customer portal.

The Smarter Cities Challenge team has developed early prototypes of analytical models that can be used to (a) model and plan AMI implementation and (b) model water usage/ leakage scenarios. This tool will be made available to Tucson Water staff to help implement the recommendations.

The City could improve customer service with these specific recommendations and a modification to the current rollout plan for AMR meters to include AMI capability.

As the number of calls to the call center decreases, the City will have an opportunity to redeploy staff and assets (such as vehicles) to other areas in need of help.

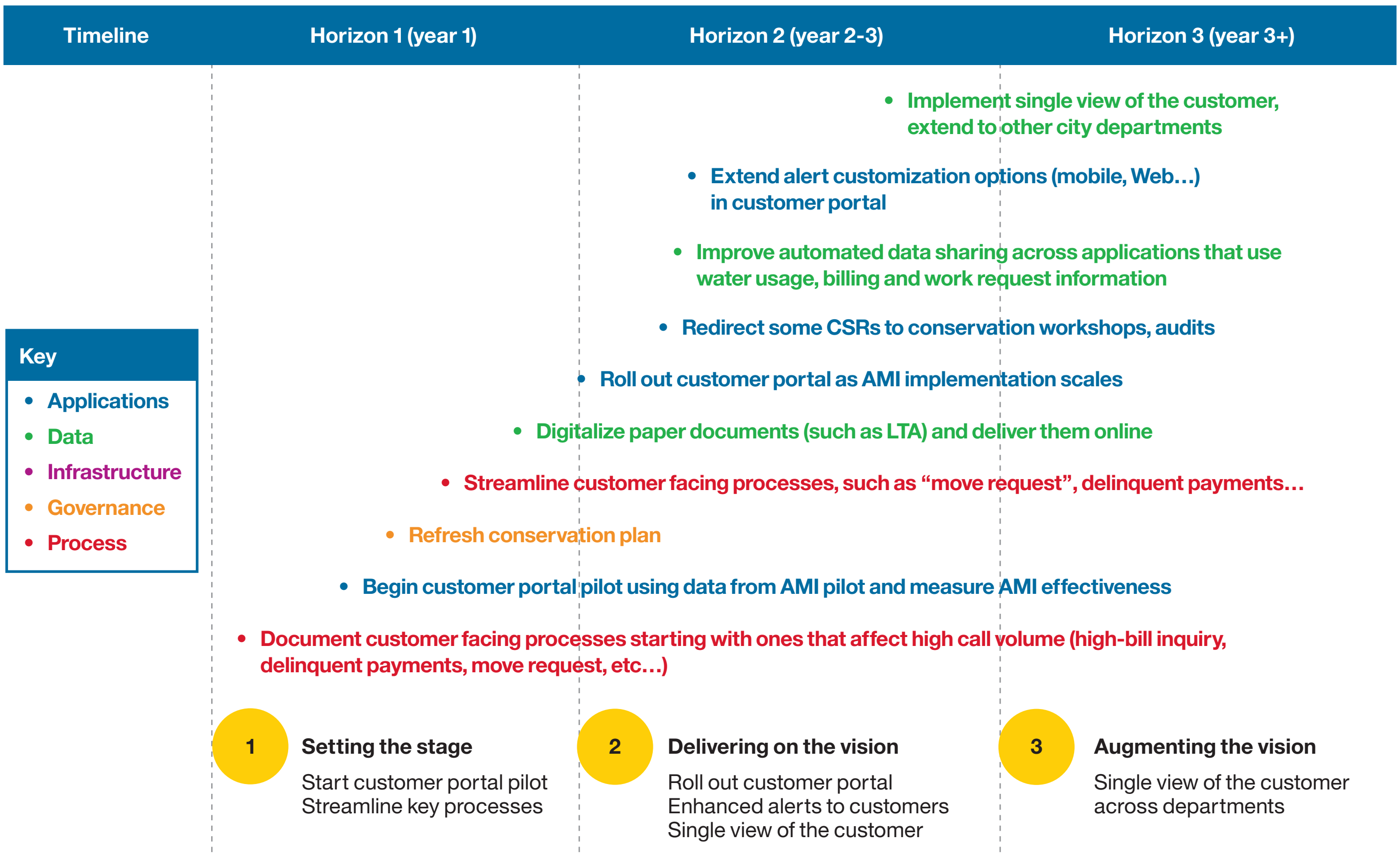

Figure 3:
Roadmap for Recommendation 1

Recommendation 1: Provide real-time data to CSRs and customers

Begin a customer portal pilot to explore leveraging real-time usage data and leak reports from the existing AMI pilot; redesign and consolidate customer-facing processes and digitize paper documents to make them available online to CSRs.

Scope and expected outcomes

Scope

Data collection pilot and customer portal pilot (immediately or at beginning of fiscal year 2014)

- Start a pilot with at least 200 users to collect and display hourly customer data. Collection can begin immediately, using the fixed network communication infrastructure already used by TEP.
- While the data collection pilot is underway, start a customer portal pilot that will access the hourly data collected and display the hourly/daily/weekly water usage using a Web browser or mobile phone.
- Monitor the pilot to ensure improvements in customer satisfaction and use of the portal warrant broader rollout of AMI meters. Such portals are already used by TEP and water utilities in other parts of the country.
- Evaluate alternatives – for example, TEP communications infrastructure, a separate communications network, or a hosted AMI solution – and the financial, operational and technical feasibility of an accelerated rollout of AMI meters. Tucson Water has enlisted a consultant (Arcadis) for AMR implementation. For more detail on AMI implementation, see Recommendation 2.
- Make sure the customer portal information is available to customers, as well as CSRs.

Business process improvements

- Improve the "move request" process, used when customers move from one home to another, to ensure bills are not sent charging a customer for the new address without a closing bill for the old address. This is an example of a process improvement that can be made with minimal investment. Tucson Water should continually look for others.
- Digitize LTAs and other customer documents to reduce call center wait times. Tucson Water already has many maps available online, indicating that this would not be a difficult task.

Customer outreach initiatives

Use multiple communication channels to raise awareness and get customers (especially transient customers and their landlords) more actively involved in conservation. Many customers are not aware of all the rebates and education opportunities available to them.

Expected outcomes

- Customers receive more consistent, accurate bills
- High-bill inquiries to the call center decrease
- Customers are able to handle many issues themselves
- The City redeploys staff and assets to other areas in need of help

Savings and investment

- Improved customer satisfaction and lower cost of running call centers
- Earlier detection of leaks and implementation of alerts will improve water balance and decrease the cost of loss of NRW

<table>
<tr><th colspan="2">Recommendation 1: Provide real-time data to CSRs and customers (continued)</th></tr>
<tr><th>Proposed owner and stakeholders</th><th>Suggested resources needed</th></tr>
<tr><td>Owner:
• Tucson Water
• Deputy Director responsible for Customer Services

Stakeholders:
• Tucson Water customers
• CSRs</td><td>• Project Manager
• CSRs

Cost estimate: low to medium</td></tr>
<tr><th>Dependencies</th><th>Key milestones, activities and timeframe (see p16)</th></tr>
<tr><td>• The start of a customer portal pilot is dependent upon the implementation of the AMI pilot
• The redesign/consolidation of customer facing processes and digitization of paper processes are dependent upon available resources</td><td>1. Document customer facing processes
2. Interlock with AMI pilot team on requirements
3. Begin customer portal pilot/measure
4. Streamline customer facing processes
5. Digitize paper documents
6. Roll out customer portal as AMI implementation scales
7. Redirect some CSRs to conservation workshops, audits
8. Improve automated data sharing across apps that use water usage, billing and work request
9. Educate CSRs on changes
10. Communicate changes to customers
11. Extend alert customization options
12. Implement single view of the customer, extend to other city departments</td></tr>
<tr><th colspan="2">Priority</th></tr>
<tr><td colspan="2">High</td></tr>
</table>

Recommendation 2: Implement AMI pilot and accelerate AMI system deployment

The City should implement an AMI data collection pilot (already budgeted) and customer portal pilot (needs an incremental small investment) to make water usage information available in real time to customers and CSRs.

This would eliminate most of the high-bill inquiries that result from leaks and stuck meters. More importantly, customers could look up water usage information using a Web browser – or in the future opt-in to get mobile phone alerts – at their convenience.

For those customers without access to a Web browser, CSRs could call with a warning when usage suddenly exceeds a threshold to address the problem more quickly.

As an added benefit, empowered customers tend to have a greater awareness of water conservation, leading to savings both from reduced leaks and increased conservation.

A few customers in focus group sessions requested a mobile phone alert when excess water usage kicks in a higher rate tier. AMI systems make these kinds of alerts easy to implement – another way for Tucson Water to delight its customers.

Please note that just implementing AMR meters without AMI capabilities will continue to result in surprise customer bills at the end of the month. Implementing AMIs without an integrated meter data-management solution that shares data with the billing system and enterprise systems like CRM will not address core customer-satisfaction issues.

As customers begin to use self-service portals, staff could be redirected to priority efforts in areas such as conservation and infrastructure refresh. Additional savings may also result from fewer trucks being used for drive-by or manual meter reading. Some may still be needed in areas with a rugged terrain or where radio signals cannot easily be used.

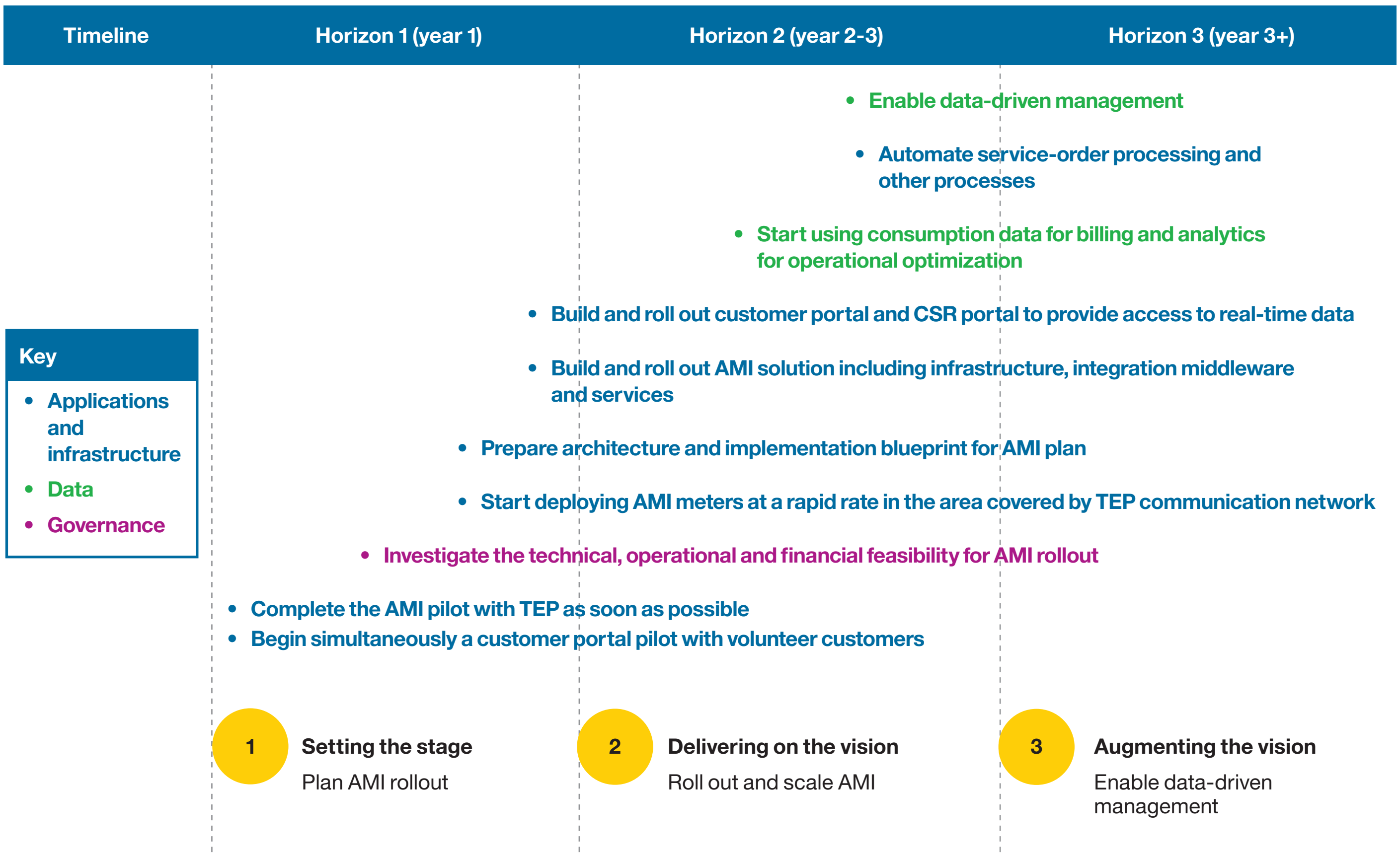

Figure 4:
Roadmap for Recommendation 2

Recommendation 2: Implement AMI pilot and accelerate AMI system deployment

Begin an AMI pilot, trialing a data collection and customer portal, and accelerate AMI meter deployment with real-time usage data from the AMI pilot.

Scope and expected outcomes

Scope

- Begin an expedited AMI pilot (no later than fiscal 2014) using TEP's AMI infrastructure to evaluate the feasibility of AMI meter reading with a selected number of customers.
- Assuming the pilot is successful Tucson Water has at least three implementation options to consider – pick the one that delivers the most value based on a feasibility study:
  - Partner with TEP and rapidly implement the data collection pilot. Replace the aging mechanical meters with AMI meters or add AMI modules to current AMR meters
  - Install a fixed network
  - Use a software/systems package as a hosted solution
- As the AMI system gives many more readings than monthly manual readings, plan for a massive influx of data
- Utilize data not only for customer service but also to improve demand forecasting and additional data driven process optimization

In parallel, start a customer portal pilot to measure customer satisfaction.

Expected outcomes

- Real-time usage information is more accessible
- Fewer leaks and stuck meters
- Fewer high-bill inquiries
- Resources redirected into conservation and infrastructure refresh

Savings and investment impact

Tucson Water has already budgeted $50 million over 10 years to replace the aging mechanical meters with the digital meters. Already, 30,000 AMI-compatible meters have been installed – the rest need to be upgraded at a cost of around $112 per meter. Mechanical meters need to be replaced with AMI meters (around $182 per meter).

Consider funding the AMI meter and infrastructure rollout using savings from reduced manual meter readings, driving and high-bill adjustment costs, and potentially bank 10% less water from CAP for a short time to free up more budget.

Recommendation 2: Implement AMI pilot and accelerate AMI system deployment (continued)	
Proposed owner and stakeholders	**Suggested resources needed**
Owner: • Tucson Water • Deputy Director responsible for Customer Services **Stakeholders:** • Tucson Water customers • Meter Readers	• Project Manager • Meter Readers **Cost estimate:** Medium
Dependencies	**Key milestones, activities and timeframe (see p20)**
Negotiation with TEP if Tucson Water decides to pilot with it. A proposal for a pilot has been submitted	1. Begin a customer portal pilot with volunteer customers 2. Investigate technical, operational and financial feasibility for AMI rollout 3. Start deploying AMI meters quickly in the area covered by TEP communication network 4. Prepare architecture and implementation blueprint for AMI plan 5. Build and roll out AMI solution including infrastructure, integration middleware and services 6. Build and roll out customer portal and CSR portal to provide access to real-time data 7. Start using consumption data for billing and analytics for operational optimization 8. Automate service-order processing and other processes 9. Enable data-driven management
Priority	
High	

Recommendation 3: Lower energy costs and reduce water loss through best-practice water control techniques

Tucson Water must reduce NRW loss to below 10%. This is not just a compliance issue; it is a long-standing effectiveness objective. Since NRW is made up of apparent and real losses, the City must implement programs to address each. Recommendation 2 addresses apparent water loss due to inaccurate meters.

The team recommends piloting a data-driven approach to anticipate and reduce real water loss in the distribution system.

One of the most useful tools available to a water engineer is the hydraulic model. A computer program that utilizes advanced mathematical optimization techniques could check many different options, find the most suitable one and predict the flow and pressure at specific points in the network using a hydraulic simulator. If no leaks exist, it would then compare predicted values to actual measurements obtained from sensors, such as pressure gauge and infrastructure meter data. If leaks exist, there would be measurable differences between actual and predicted readings. This process can be repeated with every new meter reading. Where the system finds anomalies, Tucson Water could apply non-invasive leakage detection/location techniques.

The more meters and pressure gauges in the system, the more specific the location of each leak alert. The more frequent the data, the faster the detection of the leak.

Additional data and analysis can be applied to improve detection performance. "Point" technologies such as microphones, light detection and radar (LIDAR), ground-penetrating radar, infra-red cameras, conductivity sensors, pipe inspection cameras and other technologies can help to better locate the sources of leaks.

As Tucson Water's electricity bill currently makes up approximately 30% of its entire variable expenses for operations, reducing electricity use is a priority. Tucson Water could use a SCADA system to optimize energy consumption, processing information about water pressure and energy uses and sources; and automate pump flows, energy use and reservoir operations.

Tucson Water should pilot a dynamic pump optimization process to reduce energy costs and improve water system quality. This would reduce energy by moving water more efficiently to meet real-time demands.

By adopting these techniques to ensure continuous water balance and leveraging real-time usage information, Tucson Water could make 5-10% energy savings.

The team recommends integrating the SCADA system with other IT systems, such as Work and Asset Management, to ensure repairs are made promptly. It should use machine learning techniques to detect anomalies, analyze trends, understand behavioral models and make usage predictions.

All of this will help Tucson Water get the best from its systems and IT investments and achieve operational KPIs. The use of real-time data to automatically control and optimize operations will minimize energy costs and optimize operations.

Timeline	Horizon 1 (year 1)	Horizon 2 (year 2-3)	Horizon 3 (year 3+)

- Enable data-driven management automation and optimization
- Automate pumping operations with optimization strategies
- Start using the AMI consumption data and analytics for operational optimization
- Build and roll out integration of AMI demand data with SCADA including infrastructure instrumentation and analytics
- Complete existing SCADA operations and automation planning and execution
- Develop algorithms for hydraulics and for AMI pilot demand data and SCADA decision support enhancements pilot
- Investigate the technical, operational and financial priorities and feasibility for enhanced metering of water supply and distribution network
- Develop control system optimization strategies including utility rate schedules, alternative energy sources, pressure monitoring, AMI data to mitigate NRW

Key

- Applications
- Data
- Infrastructure
- Governance
- Process

1 Setting the stage
Plan optimized control goals

2 Delivering on the vision
Roll out and scale optimized control systems

3 Augmenting the vision
Enable data-driven management and optimization

Figure 5:
Roadmap for Recommendation 3

Recommendation 3: Lower energy costs and reduce water loss through best-practice water control techniques

Refresh the SCADA system with additional metering, optimization analytics, continuous water balancing strategies and data integration with other IT systems.

Scope and expected outcomes

Scope
- Pilot best practices in water operations such as advanced optimization techniques to:
  - Dynamically adjust pump systems in order to reduce the energy costs of moving water in the distribution system
  - Analyze water pressure in the distribution system in order to detect and potentially prevent pipe breaks and leaks
- Improve distribution network sensors and metering using optimization techniques to solve complex and high-impact problems
- Integrate data from across water operations with other IT systems

Expected outcomes
- Predicted and reduced NRW loss
- Reduced electricity use
- Reduced system leaks
- Maximized water operations

Savings and investment
- Pressure management leads to feasible reductions in costs associated with NRW and extends the life of the system.
- Pump optimization leads to 5-10% energy savings. This can also reduce water latency and costs associated with water quality.

Proposed owner and stakeholders	Suggested resources needed
Owner: Tucson Water Deputy Director responsible for System Operations **Stakeholders:** Tucson Water	• Project Manager • Data from SCADA systems • Hydraulic models • Systems planning • Pump operations **Cost estimate:** Low to medium

Dependencies	Key milestones, activities and timeframe (see p24)
• Availability of staff and data • Availability of analytic skills • Meter readings for AMI • TEP support	1. Develop control system optimization strategies including utility rate schedules, alternative energy sources, pressure monitoring, AMI data to mitigate NRW 2. Investigate the technical, operational and financial priorities and feasibility for enhanced metering of water supply and distribution network 3. Develop algorithms for hydraulics, AMI pilot demand data and SCADA decision support enhancements pilot 4. Complete existing SCADA operations and automation planning and execution 5. Build and roll out integration of AMI demand data with SCADA including infrastructure, instrumentation and analytics 6. Start using AMI consumption and data and analytics for 7. Automate pumping operation with optimization strategies 8. Enable data-driven management, automation and optimization

Priority

High

Recommendation 4: Develop an IT master plan to enable data-driven management

The City should develop and implement an IT master plan with documentation of current business processes, applications, data models and data interchange across key systems.

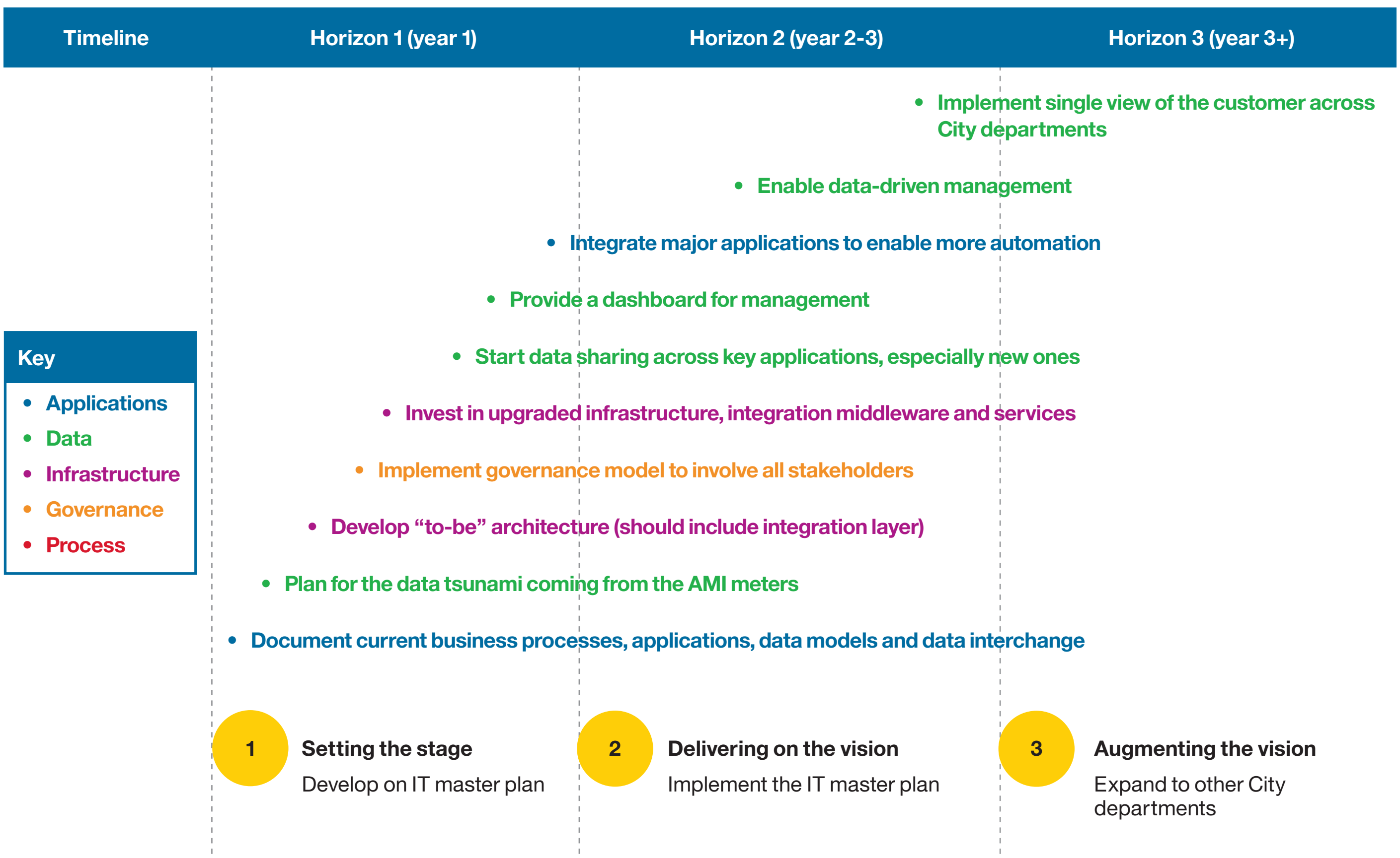

Figure 6:
Roadmap for Recommendation 4

Recommendation 4: Develop an IT master plan to enable data-driven management

Implement an IT plan to support the previous three recommendations and ensure the systems work together.

Scope and expected outcomes

Scope

Include in the master plan:

- An enterprise architecture that covers business processes, applications, data models and data interchange. This is a blueprint for Tucson Water IT systems.
- A governance model that involves stakeholders and oversees IT system implementation. Standards and interfaces need to be enforced.
- Investment in refreshed infrastructure, integration middleware and services (applications, data, servers, cloud). Maintenance or breaks eventually need to be paid for.
- Integration and consolidation of major applications to enable more automation and interchange of data between systems (business, metering data management, SCADA and water quality systems). This leverages investment in new systems.
- Dashboards with KPIs for management, customer service personnel and key functional areas.

Expected outcomes

- Integration layer connects existing and new systems
- Better access to information means CSRs improve performance and therefore customer satisfaction
- Integration and automation reduce manual operations and improve productivity
- Aggregating and analyzing data from various systems enables data-driven management and single view of the customer

Savings and investment

- Valuable investment in skills of project managers, architects, business analysts, integration specialists and others. New skills will be needed as IT becomes a partnership.
- IT does not all have to be done in-house. Savings could be made through a variety of sourcing methods for different areas such as cloud services or external hosting.

Proposed owner and stakeholders	Suggested resources needed
Owner: Director of IT **Stakeholders:** • Tucson Water • Customer Service • Billing • Operations • Other City departments	• Project managers • Architects • Business analysts • Integration specialists **Cost estimate:** Medium

Recommendation 4: Develop an IT master plan to enable data-driven management (continued)	
Dependencies	**Key milestones, activities and timeframe (see p26)**
Budget, collaboration with Tucson Water departments and leadership	1. Document current business processes, application, data models and data interchange 2. Plan for the data tsunami coming from the AMI meters 3. Develop "to-be" architecture including integration layer 4. Implement governance model to involve all stakeholders 5. Invest in upgraded infrastructure, integration middleware and services 6. Start sharing data across key applications, especially the new ones 7. Provide a dashboard for management 8. Integrate major applications to enable more automation 9. Enable data-driven management 10. Implement single view of the customer across City departments
Priority	
High	

5. Conclusion

The Smarter Cities Challenge team has enjoyed tackling the challenge that the Mayor and City Manager set out:

How can the City of Tucson leverage data-driven management to improve customer service; upgrade systems to capture failures, leaks and water usage; and reduce the cost of energy?

Developing an IT plan that integrates data and applications to remove silos is fundamental to delivering on the City's vision of a data-driven water system.

The team's four recommendations break down, and address, the challenge as below:

1. Improve customer service
2. Upgrade systems to capture failures, water usage and leaks in real time
3. Conserve and save water
4. Reduce the cost and energy needed to deliver water

They do this by:

- Empowering customers and CSRs with real-time information
- Launching AMI pilots and accelerating AMI system deployment
- Lowering energy costs and reducing water loss using an integrated SCADA system
- Implementing an IT plan to support Tucson Water's application and data needs

6. Appendix

A. Stakeholders

Name	Title	Organisation
Cheryl Avila	Superintendent	Advanced Metering Infrastructure (AMI) – City of Tucson/Tucson Water
Clint Beattie	Water Services Supervisor	Advanced Metering Infrastructure (AMI) – City of Tucson/Tucson Water
Stephen Dean	Administrator	Advanced Metering Infrastructure (AMI) – City of Tucson/Tucson Water
Adrian Gonzalez	Water Services Supervisor	Advanced Metering Infrastructure (AMI) – City of Tucson/Tucson Water
Stephen Davis	Vice President	Arcardis
Mark Day	Member	Citizens' Water Advisory Committee (CWAC)
Chuck Freitas	Member	Citizens' Water Advisory Committee (CWAC)
Mark Taylor	Chair	Citizens' Water Advisory Committee (CWAC)
Alan Tonelson	Member	Citizens' Water Advisory Committee (CWAC)
Charisse Craig	Senior Accounting Clerk	City of Show Low/Water Department
Albert Elias	Assistant City Manager	City of Tucson/City Manager's Office
Kelly Gottschalk	Chief Financial Officer (CFO) and Assistant City Manager	City of Tucson/City Manager's Office
Richard Miranda	City Manager	City of Tucson/City Manager's Office
Andrew Greenhill	Assistant to City Manager/SCC Program Manager	City of Tucson/City Manager's Office
Jonthan Rothschild	Mayor	City of Tucson/Mayor's Office
Carlos Wilderman	GIS Project Manager	City of Tucson/Parks and Recreation
Jeff Biggs	Administrator	City of Tucson/Tucson Water
Peter Chipello	Hydrologist	City of Tucson/Tucson Water
Sandy Elder	Deputy Director	City of Tucson/Tucson Water
Alan Forrest	Director	City of Tucson/Tucson Water
Nancy Gradillas	Staff Assistant	City of Tucson/Tucson Water
Belinda Oden	Administrator	City of Tucson/Tucson Water
Leonard Quihuis	Lead Utility Service Worker	City of Tucson/Tucson Water
Leah Rhodes	Executive Assistant	City of Tucson/Tucson Water
Mike Ring	Water Operations Superintendent	City of Tucson/Tucson Water
Ivey Schmitz	Deputy Director	City of Tucson/Tucson Water
Melinda Stevenson	Staff Assistant	City of Tucson/Tucson Water
Dean Trammel	Civil Engineer	City of Tucson/Tucson Water
Tom Victory	Engineering Manager	City of Tucson/Tucson Water
Ray Wilson	Administrator	City of Tucson/Tucson Water
Wally Wilson	Chief Hydrologist	City of Tucson/Tucson Water
Ron Proctor	Member	Community Water Coalition
Karilyn Roach	Program Coordinator	Community Water Coalition
Fernando Molina	Public Information Officer (PIO)	Conservation – City of Tucson/Tucson Water
Sarah Durand	Service Supervisor	Customer Service – City of Tucson/Tucson Water

Name	Title	Organisation
Monica Gallegos	Service Supervisor	Customer Service – City of Tucson/Tucson Water
Jessica Rodriguez	Service Supervisor	Customer Service – City of Tucson/Tucson Water
Reyna Woods	Service Supervisor	Customer Service – City of Tucson/Tucson Water
Bob Cjaza	Interim IT Administrator	IT Department – City of Tucson
DJ Parslow	Deputy Director	IT Department – City of Tucson
Dave Scheuch	Director	IT Department – City of Tucson
Frank Soto	IT Technology Specialist	IT Department – City of Tucson
Rick Kaneen	Owner	Kaneen Advertising
Rosemary CoraCruz	Community Services Manager	Pima County Community Action Agency
Evelyn Gonzalez	Customer Service Supervisor	Pima County Community Action Agency
Eric Bender	Water Control Systems Manager	Supervisory Control and Data Acquisition (SCADA) – City of Tucson
Jim Carr	Water Control Systems Engineer	Supervisory Control and Data Acquisition (SCADA) – City of Tucson
Mike Carr	Water Control Systems Engineer	Supervisory Control and Data Acquisition (SCADA) – City of Tucson
Michael Baruch	Program Manager	Tucson Electric Power (TEP)
John Bord	Program Manager	Tucson Electric Power (TEP)
Larry Lucero	Senior Director of Customer Programs and Services	Tucson Electric Power (TEP)
Brian Moore	IT Application	Tucson Electric Power (TEP)
Scott Plum	Metering Services	Tucson Electric Power (TEP)
Jim Taylor	Director, Transmission and Distribution (T&D) Engineering	Tucson Electric Power (TEP)
Marilyn Arechavaia	Customer	Tucson Water
Gloria Bloomer	Customer	Tucson Water
Clay Campbell	Customer	Tucson Water
Erica Chavarria	Customer	Tucson Water
Gloria Espinoza	Customer	Tucson Water
Diane Ford	Customer	Tucson Water
Sabrina Garcia	Customer	Tucson Water
Robert (Sapo) Guarjardo	Customer	Tucson Water
George Jackson	Customer	Tucson Water
Joyce Kelly	Customer	Tucson Water
Katharine Kent	Customer	Tucson Water
Brett Lange	Customer	Tucson Water
Shirley Muney	Customer	Tucson Water
Laura Penny	Customer	Tucson Water
James Provincio	Customer	Tucson Water
Carmen Sinotes	Customer	Tucson Water
Frank Szalay	Customer	Tucson Water

Name	Title	Organisation
Bryon Taylor	Customer	Tucson Water
Maria Teresa	Customer	Tucson Water
Keith Ladd	Coordinator, College of Architecture, Planning, Landscape Architecture	University of Arizona (UofA)
Kevin Lansey	Professor and Department Head Dept of Civil Engineering	University of Arizona (UofA)
Regina Romero	Council Member	Ward 1
Paul Cunningham	Council Member	Ward 2
Katie Bolger	Council Aide	Ward 2
Karin Uhlich	Council Member	Ward 3
Shirley Scott	Council Member	Ward 4
Jerri Ward	Council Aide	Ward 4
Richard Fimbres	Council Member	Ward 5
Steve Kozachik	Council Member	Ward 6
Brandon Erndt	Managing Principal Engineer	Westin
Douglas Harp	CEO/President	Westin

B. Team biographies

Barbara Guzak
Senior IT Architect, Global Solution Center (GSC)

The GSC is a technical core competency center focused on working with IBM customers worldwide to architect, integrate and test scalable, leading-edge solutions. Guzak's responsibilities include building industry solution prototypes, which highlight software integration and data analysis in order to demonstrate IBM's capabilities.

Guzak has more than 36 years of experience in the computer industry, including such inspiring projects as the Space Shuttle Launch Processing and the Winter Olympic Games in Nagano, Japan. In the past 12 years she has focused on the public sector, working with various clients in government, education and healthcare.

Chet Karwatowski
Senior Technical Staff Member, Global Supply Technology and Transformation, CIO

Karwatowski has 25 years of diverse experience ranging from supply chain management, high-tech manufacturing, business-to-business ecosystem development, semiconductors and technology architecture. Karwatowski's current assignment puts him at the forefront of IBM's latest technologies, including cloud, social business and data analytics.

Karwatowski is a long-time resident and volunteer in the Ashokan Watershed, a key part of the water supply for nine million residents of New York City. His role as a watershed planning advisor is focused on creating partnerships to ensure watershed protection.

Sridhar Iyengar
IBM Distinguished Engineer, TJ Watson Research Center

Iyengar leads the technical strategy for software tools, methods and application innovation. His recent focus has been on simplifying the process for developing Internet-scale application solutions by taking advantage of cloud computing and the value of big data and analytics.

His work, through the use of models, metadata, scalable services and architectural frameworks, aims to create simplified integrated application platforms, making it easier for customers to develop, optimize and deliver Internet-scale applications.

Satish Kalyani
Executive IT Architect, Global Business Services

Kalyani has more than 24 years of diverse IT experience, including developing and implementing end-to-end architectural solutions across a diverse set of industries.

Kalyani's most recent focus has been around architecture planning and blueprinting, design and implementation of Advanced Metering Infrastructure (AMI) projects, involving the integration of millions of automated smart meters as part of the Smart Grid initiatives in the US utility industry. His expertise in the domain of smart metering proved critical for an internal IBM venture to build and roll out a Software as a Services (SaaS) offering on the IBM Smart Cloud®, which provided a suite of pay-as-you-go data services to small-to-midsize water and electric utilities.

Carol Savage
Director, Global Business Offering Development

Savage is responsible for the development of standardized global offerings for IBM products, services and solutions. She is also involved with the integration of newly acquired offerings into the IBM portfolio. Savage is responsible for the management and leadership of a worldwide team of managers and SMEs.

Savage has led numerous IBM employee teams through an expansive list of diverse job assignments that include contracts, negotiations, supply chain, sales and distribution, defense industry, procurement integrity, project management, education and quality.

Personally she is involved with her community in support of health, human services, community service and sports associations.

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D. Analytical model for Automated Metering Infrastructure

The Smarter Cities Challenge team developed an analytical model to simulate ways to accelerate Automated Metering Infrastructure (AMI) meter deployment and calculate potential savings assuming the following factors:

- The current budget for rolling out 20,000 meters per year
- Savings from lowering Central Arizona Project (CAP) water allocation use by 10%
- Energy savings from dynamic pump management
- Additional revenue from increased accuracy of newly deployed AMI meters

The team developed the prototype model in the closing days of the project and will provide it in an excel spreadsheet to Tucson Water staff on an as-is basis. This will help them to do "what if" analysis when evaluating the cost and benefit of different options for implementing and funding the recommendations.

The following worksheets make up the initial model:

1. **Factoids:** List of more than 70 facts and statistics the team gathered over the course of the project. Not all facts are used in the model, but additional facts can be used. The list is on p39-40.
2. **AMI model initial:** Simulation using the budgeted model.
3. **AMI deployment rollout:** Graph (p38) that shows "high water bill adjustment" and meter reading costs decreasing as AMI meter rollout increases.
4. **Funding model to speed up AMI rollout:** Graph showing increased AMI rollout using revenue diverted from CAP water allocation and energy savings. This model is still a work in progress. Note that this is a preliminary model and may have inaccuracies, but it serves as a tool that can be corrected and extended.

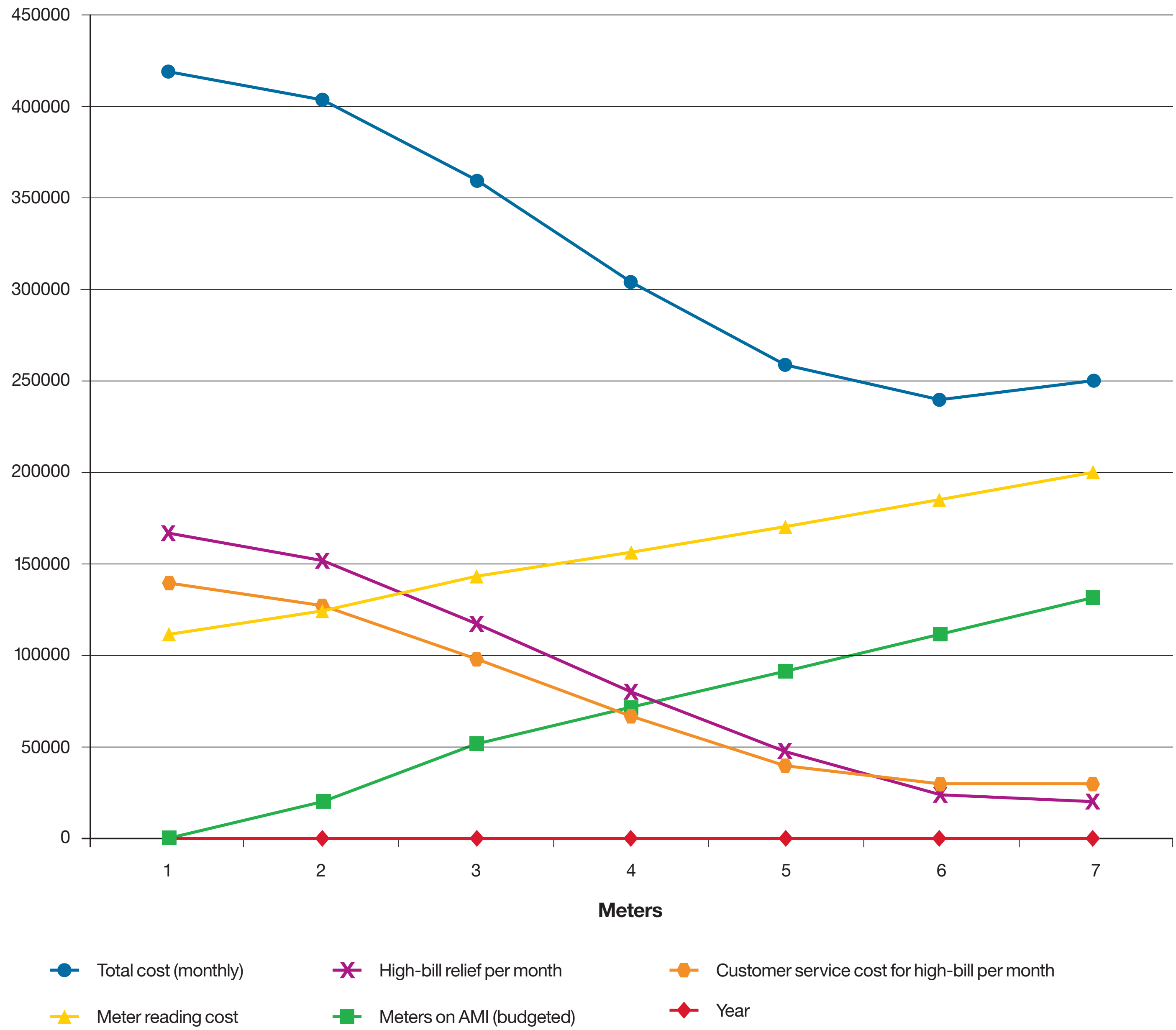
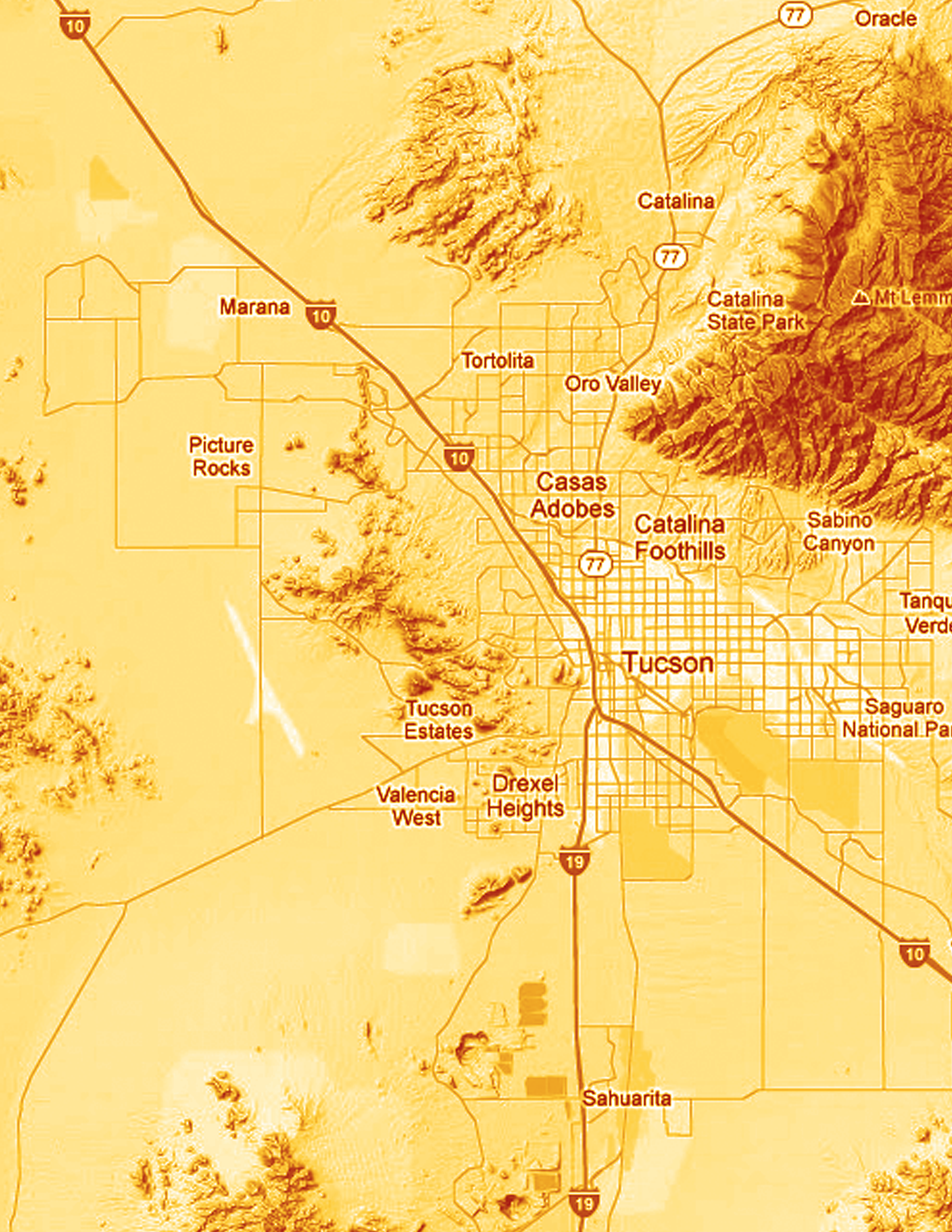


Figure 7:
AMI deployment rollout

Tucson Water factoids	Value	Unit/notes
Miles of pipe	4,521	Miles
Production wells	214	
Monitoring wells	270	
Pressure zones	14	
Storage facilities	57	
Customers	709,000	
Service points	280,000	
Valves	80,000	Most not metered
Fire hydrants	20,601	
Valves In ground	90,000	
Sprinkler systems	40,000	
Billable accounts/ customer meters	225,000	
Cost of AMR meter	$150	
Cost of AMI meter	$200	
AMR meters installed	30,000	
Adjustment relief	$2,000,000	$
Adjustment relief (2018)	$500,000	
Meter replacement rate	20,000	Per year
Cost of power (2013)	$15,000,000	$
Tucson area	227	Square miles
Cost of CAP water	$100	$ per acre foot
Customer service calls	90,000	Per January 2013
Delinquency	45,000	
Not categorized	27,000	
High bills	4,500	
Bill inquiry	19,800	
On/off	9,000	

Tucson Water factoids	Value	Unit/notes
SCADA implementation	$21,600,000	Six years, 21 tasks
AMR implementation	$50,000,000	10 years, 5 million per year
AMI consulting	$90,000	
Fixed network implementation	TBD	Based on Show Low number
Number of towers		
Number of turn on/offs per day	$150	95 locks per day
FTEs maintenance distribution system	162	
FTEs call center	31	
Cost per call	$15	$
Salary call center	$30,000	Fully burdened cost including benefits
TW staff budget	$35,000,000	
Gallons consumed	34,000,000,000	34 billion
Supply side meters	203	3.4% are metered in supply
Meter reader salary	$30,000	
Number of meter readers	28	
Hours meter read per day	6	
Meter reading cycle	21	
Meter reader cost	$840,000	Monthly
Fixed network cost	$5,000,000	Per TEP pilot proposal includes training
Average cost to read meter	$2.50	$ per industry average per month
TEP cost to read meter	$1.00	Once per hour, 360x manual once per month
Tucson Water cost to read meter	$0.31	Once per month
Non-revenue water loss 2013	11%	Percent

Tucson Water factoids	Value	Unit/notes
Non-revenue water loss 2018 (p)	7%	
Meter readers draw down as AMI rollout	5%	5% reduction per year
Projected inflation rate	3%	3% per year wage increase for readers/ call center
Projected TEP rate increase	2%	TEP charges 2% more per year
Number of trucks	28	
Miles driven per truck per month	3,000	
2012/2013 cost of CAP Water	$474	$ per acre foot
2013/2015	$530	
2015/2016	$596	
2016/2017	$666	
Meters read per reader per month	8,036	
CAP water commodity and capital 2013	$19,933,220	
Power electricity/gas	$15,681,460	
Requested operations and management budget	$149,485,480	
Less debt service	$433,383,800	
Less salaries/wages	$35,709,570	
Remaining O&M	$70,392,110	
CAP water acre foot per year	150,000	
Water used by customers (acre feet)	96,000	
Water banked (acre feet)	54,000	



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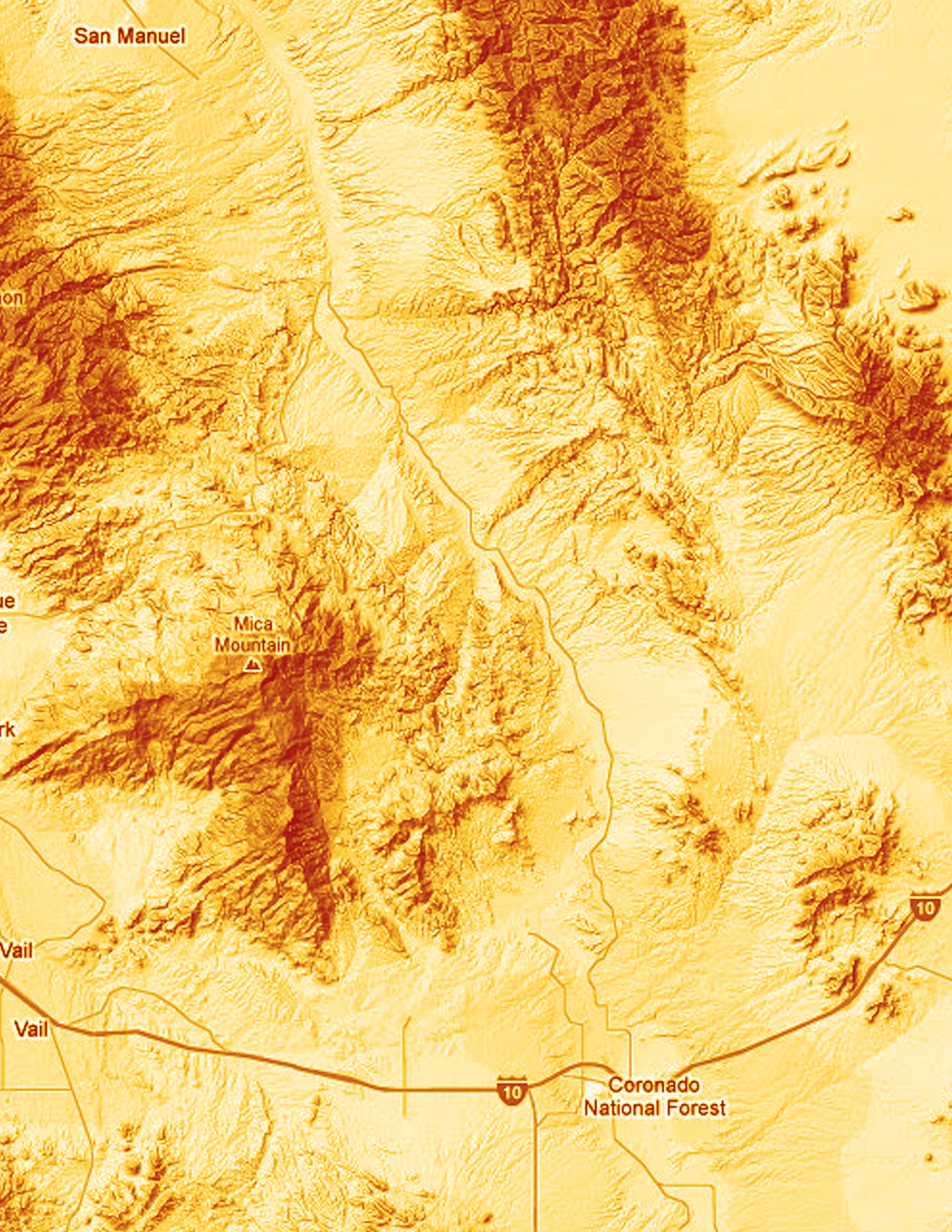
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Mica Mountain
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Coronado National Forest

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