City of Cornwall

Universal Water Metering and AMI Project

Findings and Recommendations Report

Submitted by:

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Acronyms and Terms

Acronym or Term	Expansion	Definition
AMR	Automated Meter Reading	Typically refers to a drive-by meter reading system to automate “on foot” meter reading.
AMI	Advanced Metering Infrastructure	A network of fixed based equipment that captures detailed consumption information from the metering population that is retrieved by data collection software on at least a daily basis.
BCV	Building Control Valve	A water shut-off valve installed before the meter so the water entering the building can be shut-off.
CIS	Customer Information System	Refers to the City of Cornwall’s water billing software provided by CentralSquare.
C/I	Cut-In	Where a meter has never been installed and the plumbing requires modification to allow for the installation of a water meter.
C/O	Change-out	Used in connection with either a large or small meter change-out/replacement.
CPI	Consumer Price Index	Measures the overall change in prices which is used to measure inflation. Assumed to be 3% annually in this document.
DWQMS	Drinking Water Quality Management Standard	A quality management standard specifically designed for drinking water systems as mandated through the Safe Drinking Water Act (SDWA), of Ontario, Canada.
FAN	Fixed Area Network	See AMI definition
GIS	Geographical Information System	A Geographic Information System (GIS) is a computer system that analyzes and displays geographically referenced information. It uses data that is attached to a unique location.
IC&I	Industrial, Commercial, and Institutional	A class of water customers that generally require Intermediate to Large Meters.
IM	Intermediate Meters	Meters that are 38mm (1.5”) or 50mm (2”).
LM	Large Meter(s)	Meters that are 75mm (3”) or larger.

MDM	Meter Data Management	Software application that helps manage and ensure the accuracy and completeness of the volumes of data provided by a fixed network for billing, analysis, reporting and presentment.
MIS	Meter Installation Software	Software that captures the details of the installation including meter serial #, transmitter identification #, account information of where the equipment was installed.
RF	Radio Frequency	Refers to radio communications being broadcast from a radio transmitter connected to a water meter.
S&I	Supply and Installation	Includes capital cost of item as well as its installation
SCADA	Supervisory Control and Data Acquisition	Computer-based system for gathering and analyzing real-time data to monitor and control equipment. Monitoring functions allow real-time insights across filtration plants, pump stations, and entire distribution networks. https://www.dpstele.com/scada/how-systems-work.php.
SM	Small Meters	Meters that are either 15mm (5/8”) or 20mm (3/4") or 25mm (1”)
Transmitter	n/a	A radio device connected to the water meter to provide meter readings for either a mobile or fixed network meter reading system.
UME	Unitized Measuring Element	Unitized Measuring Element is the field replaceable measuring chamber used in conjunction with the City’s OMNI meters.
VEE	Validation, Estimation and Editing	Functionality provided by some providers of an MDM to ensure the accuracy of the data being delivered by an AMI.
WAN	Wide Area Network	In an AMI deployment, the backhaul from the data collectors to the data collection software.

Table 1 - Summary of Acronyms and Terms

Acknowledgements

The success of this analysis is greatly attributed to the support and collaborative efforts by the City of Cornwall stakeholders and their vested interest in investigating technology options to satisfy the goals of this project and to benefit the City of Cornwall's customers.

Project Team

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Stephen Romano	Manager – Environment Division
Owen O'Keefe	Supervisor – Water Purification Plant
Mike Carriere	Supervisor – Property Tax and Assessment
Erika Leroux	Billing and Collection Clerk
Louis Savard	Manager – Technology, and Innovation
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Michael Fawthrop	General Manger – Infrastructure and Municipal Works

Steering Committee

Natasha Pozega	Water Conservation Coordinator
Stephen Romano	Manager – Environment Division
Tracey Bailey	General Manager – Financial Services and Treasurer
Michael Fawthrop	General Manager – Infrastructure and Municipal Works
Shawn O'Brien	Manager – Municipal Works
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1. Executive Summary

1.1. Background

To promote water conservation and resolve inequities in the existing water billing structure, the City of Cornwall ("the City" or "Cornwall") retained Diameter Services ("Diameter") as part of Request for Proposal #22-P12 - Universal Water Metering, AMI Consulting & Project Management.

At the start of the project, Diameter requested an extensive list of documents and data to get a full picture of the City's existing situation. Analysis of this information allowed Diameter to effectively prepare for workshops, meetings, and budget preparation.

Diameter's analysis included investigation into the City's current water meter assets and existing AMR radio transmitters. At the onset of this study, Diameter requested that the City of Cornwall provide a database with specific information pertaining to all the active water accounts. Since water meters are not installed in most of the City's water accounts, Diameter conducted an analysis of the information that was provided to determine meter quantities and meter sizes that would be required for this universal metering project. Diameter's investigation also included a business process review, an evaluation of existing systems such as the City's CIS provided by CentralSquare, and discussions with the cities of Peterborough and North Bay who were the two most recent utilities similar in size to Cornwall to undergo universal water metering.

Diameter's subject matter experts worked closely through the project with a cross functional team of stakeholders from Cornwall. The City's Project Team included 8 people from different departments including Conservation, Customer Service and Billing, Environmental, Water Purification, Infrastructure and Municipal Works, Water Distribution and Wastewater Collection, and Technology and Innovation. The City's stakeholders were highly competent in their areas of expertise and passionate about achieving conservation, equitability among customers, improving the customer experience and operations, and reducing unnecessary costs.

Stakeholder engagement included approximately 48 hours of workshops and three Steering Committee meetings to ensure there was a solid understanding of necessary subjects. Workshop topics included organizational goals and needs assessment, technology options and comparisons, AMI business drivers, review of existing systems, field inspections findings, detailed project scoping, project support,

business process review, capital life cycle cost estimates, implementation schedules, risk management, procurement strategies and public outreach.

Diameter's deliverable is the attached report broken out into chapters that focus on different elements of the engagement. The report is structured as follows:

- Chapter 01 – Executive Summary
- Chapter 02 – Organizational Goals and Needs
- Chapter 03 – AMI Business Drivers
- Chapter 04 – Database Assessment
- Chapter 05 – AMI and Water Meter Technologies
- Chapter 06 – Project Scope
- Chapter 07 – System Assessment
- Chapter 08 – Business Process Review and Changes
- Chapter 09 – Public Outreach Strategy
- Chapter 10 – Procurement Strategy
- Chapter 11 – Implementation Strategy
- Chapter 12 – Project Support
- Chapter 13 – Recommendations
- Financial Report (provided separately)

1.2. Project Objectives

The City expressed that one of the primary goals of the project was to promote water conservation. As stated in Request for Proposal #22-P12 - Universal Water Metering, AMI Consulting & Project Management "This decision was made following the receipt of a third-party Water Conservation Master Plan which outlines a pathway to promote a 37% reduction in water consumption across the community."

Section 2.4 of this report provides evidence that water meters significantly help reduce water consumption. The opportunity to support broader, previously established City goals and objectives was also explored as part of the City's engagement with Diameter. In brief, the Universal Water Metering and AMI Project supports certain aspects of the City's Strategic Priorities (2019 – 2022), The City's Official Plan, the Water Conservation and Servicing Master Plan (2021) and the City's Conservation and Demand Management Plan.

Through workshops, Diameter and Cornwall's Project Team determined objectives and technology requirements for the project. This process involved evaluating 38 business drivers, 20 of which were deemed Important (score of 2) or Essential (score of 3) to the City of Cornwall.

Table 3, below, shows that 19 of the Important or Essential business drivers are all supported by AMI, 17 of which are fully supported by AMI. The only one not supported by AMI was the identification of lead services which can be accomplished as part of the installation, however AMI technology itself won't help in this regard. This is compared to AMR technology that fully satisfies none of the business drivers and partially satisfies 15 of them. As such, the City is not considering AMR as a suitable option.

It should be noted that AMI/AMR technologies function differently, have different operational impacts on the utility, and provide different benefits partially due to the differences in data each provides. For example, one of the key differences in AMR mobile technology and AMI technology is AMI radio transmitters provide hourly meter reads (720 reads / month) compared to just one meter read per month with mobile AMR technology.

Table 3 shows whether each individual business driver is satisfied by either AMR or AMI technology and, if so, to what extent using the following Scoring:

Score	Ability to Support the Business Driver	Description
	Does not support a Driver	The business driver as described cannot be implemented using this technology.
	Partially supports a Driver	The business driver as described can be partially implemented using the technology.
	Fully supports a Driver	The business driver as described can be fully implemented using the technology.

Table 2 - Scoring: Ability to Support the Business Driver

ID	Revenue Protections (RP)	Score	AMI	AMR
RP 1	Unauthorized Use of Water	2		
RP 4	High Bill Complaints	3		
RP 4a	Run Your Water Accounts	2		
RP 4b	Suspension of Service for non-payment	3		
RP 4c	Support for Leak Forgiveness Program	2		
	Operational Efficiency (OE)			
OE 1	Collecting Meter Readings	3		
OE 3	Meter Reader Safety	3		
OE 4	Meter Reading Reliability / Elimination of Estimates	3		
OE 5	Detect Register and Cut Wire Problems	2		
	Improved System Distribution Management (DS)			
DS 2	Water Audit Support	3		
DS 4	Detect Backflow Events	2		
DS 8	Hydraulic Modelling	2		
	Customer Service Enhancements (CS)			
CS 3	Customer Engagement - Passive	3		
CS 4	Customer Engagement - Interactive	3		
CS 5	Customer Engagement - Progressive	2		
CS 6	Leak Detection - Small	3		
CS 7	Leak Detection - Broken Pipe	2		
	Societal Benefits (SB)			
SB 1	Water Conservation Program Support	3		
SB 2	Energy Cost Reduction	2		
SB 3	Lead Service Identification	2		

Table 3 – Business Drivers that are Important or Essential

The business drivers show that there are multiple opportunities for AMI to help with revenue protection and to improve water operations and customer service. Examples of improvement opportunities include increasing meter reading reliability, performing same day final reads, customer leak detection, having the data to support leak forgiveness claims, better information for hydraulic modelling, backflow

detection, and conservation program support. These examples are all readily achievable with AMI as is the ability to have detailed, timely data to enhance the customer experience and provide new ways for the City to engage its customers and help conserve water.

Recommendation 1: Proceed with the installation of universal waters with AMI.

1.3. Assessing the City's Metering Needs

The City of Cornwall has a combination of flat rate water customers and others (some Industrial, Commercial, or Institutional customers) who are billed based on actual water consumption. Some flat-rate customers have meters installed, but they are not used for billing.

Flat rate billing for water consumption makes it more difficult to promote water conservation and is generally not considered as equitable as billing based on actual consumption. Customers are billed based on the number of water consumption fixtures in their premises regardless of the number of people living in the dwelling or their consumption patterns. Conservation is not encouraged through a flat rate system and would fall to those who would follow good conservation practices as a matter of course and not because of the financial incentive.

When moving to metered consumption, Diameter recommends that one meter is installed in a premises fed by a single service and where plumbing is not already (properly) "split" between the individual units. Allowing landlords to split the plumbing within the premises so individual units can be metered is fraught with delays, inspections, and disputes; it is not recommended by Diameter or by one utility, recently surveyed, who went from billing on flat rate to metered consumption. Under this recommendation, the City of Cornwall will continue to bill property owners for water supplied to their properties.

Recommendation 2: The City should install one meter per service.

Determining the City's water meter needs, in terms of the quantities and the sizes required, entailed assessing the current meter population and whether the assets are usable for Advanced Metering Infrastructure or whether they need to be replaced. The second challenge was deciding the meter quantities and meter sizes required at flat rate accounts given the complexities of multi-unit or mixed-use

properties, and the fact that consumption and water service sizing at each location were both unknown.

Diameter's analysis determined the City's existing metering assets were not suitable for AMI for the following reasons:

- None of the existing meters appear to provide the reading resolution required to take advantage of an AMI investment. (See section 4.3 for more detail).
- The radio transmitters attached to the meters have a lifespan of up to 20 years but do not contain the latest AMI technology currently being proposed by Neptune.
- The radio transmitters are not compatible with meter manufacturers other than Neptune.
- The cost and customer disruption of appointment setting and re-visiting customers with existing meters (even if the technology was compatible) is generally considered not cost-effective and is more than the remaining asset value in the meter.

Determining metering quantities and sizes required at flat rate accounts was based on a detailed analysis of the data provided that considered the following:

- "Sub-units" in multi-residential dwellings that contain one water service will not require individual meters and will be billed collectively. Only water services will be metered.
- Some "hyphenated addresses" in the City's current CIS will require multiple meters and will need to be separate accounts in the CIS.
- Addresses were classified according to MPAC property codes; that information was used to estimate meter requirements and sizes required at individual locations.

After the analysis was conducted, the Work Types that were determined are shown in the table below.

Meter Size	New Meter Cut-In	Replace Meter	Install Radio Transmitter
15mm (5/8")	13,842	1,890	15,732
20mm (3/4")	1,235	206	1,441
25mm (1")	48	148	196
38mm (1.5")	2	109	111

Meter Size	New Meter Cut-In	Replace Meter	Install Radio Transmitter
50mm (2”)	15	131	146
75mm (3”)	7	35	42
100mm (4”)	5	14	19
150mm (6”)	2	2	4
Total	**15,156**	**2,535**	**17,691**

Table 4 – Summary of Work Types (including 5% buffer)

In consideration of the estimations that were used in determining Work Types and the multiple sources of data used in the analysis for meters installed at the City, Diameter has used a 5% contingency for New Meter Cut-Ins and Meter Replacements.

1.4. Meter and Meter Reading Technology

As part of the development of the Recommendations Report, Diameter performed a comprehensive review of water meter and AMI technologies.

1.4.1. Meters

Metrology within the water industry has been around for more than 100 years, and some of the original types of measurement technology continue to be used today. Chapter 5 of this Findings and Recommendations Report explains how each type of measurement works, the history of measurement products, product availability, and key advantages and disadvantages associated with each type of measurement.

There are two categories with respect to the types of water meter technology: 1) mechanical measurement, and 2) non-mechanical measurement.

1.4.2. Mechanical Meters

Positive displacement type water meters measure the actual volume of water that flows through the measuring chamber. There are two types common in the North American industry: nutating disc and oscillating piston. These meters are typically installed in a horizontal orientation, although manufacturers of piston type meters often also market a warranty for vertical installations. Nutating disc meters have been known to extend their warranty for vertical installation in special situations where this is a mandatory requirement.

Positive displacement type mechanical water meters are the most popular type of water meter in North America; most large water utilities rely on these meters for many of their residential applications. They do not require a battery, and it is quite rare for a positive displacement meter to over-register consumption. This provides confidence to the utility that if a meter is inaccurate, it is to the benefit of the customer.

These meters have good accuracy at low flows, with AWWA standards requiring these meters to achieve between 98.5% to 101.5% accuracy when measuring normal operational flow ranges (0.5 to 25 gpm). Many water meters manufacturers exceed this standard, either by exceeding the accuracy thresholds, or meeting the accuracy standard over a larger flow range.

These products continue to be very reliable and cost competitive technology. The City should continue to utilize these where horizontal installations are possible.

1.4.3. Non-Mechanical Meters

Non-mechanical meters include electromagnetic and ultrasonic technologies. One of the key features of non-mechanical meters over positive displacement meters are improved accuracy at very low flows, making non-mechanical technology the preferred option for large meter sizes (75mm (3”) or greater). They will also experience very limited deterioration of accuracy over time.

They also offer additional features and functionality, depending on make and model, including:

- Temperature reading
- Alarm conditions such as: empty pipe, reverse flow, tamper, low battery, leak detection, etc.
- Pressure reading

Although these may not apply to all manufacturer products, the additional functionality described above of these meters has expanded beyond just meter readings.

The accuracy of the meter over time will not show any degradation, and these meters are expected to be as accurate at year 19 as on the day of shipment. Thus, there are no lost revenues over time, and the expected replacement date is defined which aids in capital planning.

A key consideration is that this technology requires battery power to measure water flow. Typically, manufacturers offer a 20-year warranty. It is important to understand that these meters will have a known and firm product end date. This changes the water utility practice of performing meter accuracy sampling to determine the optimal replacement age. Meters in this class must be replaced prior to the end of their pre-determined (based on battery) meter age.

Non-mechanical water meters have the benefits of being able to be installed in any position (horizontal, vertical, angled) without impacting water meter accuracy. This meter setting flexibility may eliminate the need for a meter horn or additional plumbing.

Depending on budget, consideration for 100% non-mechanical meters should be considered during the procurement specification development stage.

Recommendation 3: Positive displacement meters should be installed up to 75 mm (3”) and non-mechanical meters should be installed where meters greater than 75mm (3”) are required to provide improved accuracy.

Recommendation 4: Small and intermediate mechanical meters should be installed horizontally using a plumbing loop where necessary.

1.5. Meter Reading Technology Options

The preparation of this Report included a comprehensive look into Advanced Metering Infrastructure (AMI). Automated Meter Reading (AMR) was confirmed to lack the functionality and data timeliness that the City requires - which is not surprising given the technology was first introduced to the water industry circa 1996. The ability to satisfy the business drivers mentioned earlier underscores the functional differences in the two technologies. AMR does not fully satisfy any of the business drivers whereas AMI fully satisfies 17.

Advanced Meter Infrastructure (AMI) relies on fixed-in-place network data collectors to listen for the RF radio transmitter device all the time. Options include leveraging public carrier cellular data collectors or installation of several data collectors from the chosen AMI vendor across the City’s service territory. Data collectors communicate readings back to software applications (headend software and meter data management software) daily.

The data granularity (hourly meter readings from AMI vs. monthly, bi-monthly, or bi-annually from AMR) provides numerous benefits for enhanced customer service, operational efficiencies and conservation programs including measuring their effectiveness.

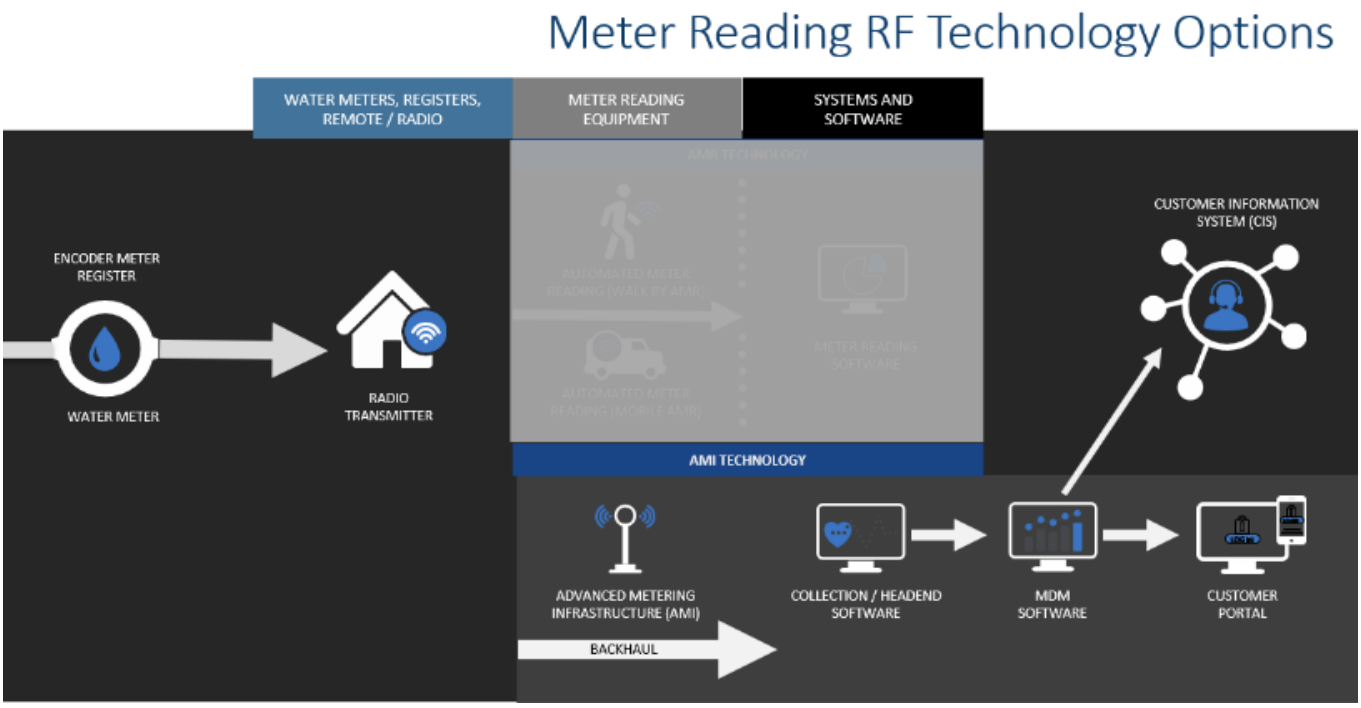


Figure 1 - AMI Technology Overview

1.6. Implementation

1.6.1. Project Scope

The following elements are recommended as part of the project scope:

Component	Items Included
1) AMI Technology	• Radio Transmitters installed on the outside of the premises. • AMI Network Infrastructure (if necessary). A standalone AMI would require the installation of fixed in place data collection equipment whereas a cellular would leverage an existing cellular network. • AMI software for meter data collection and meter data management (MDM), • Training, Implementation, and Integration Services.

Component	Items Included

2) Customer Portal	• Fully functional customer portal including:
	  ○ Billing and Payment View
	  ○ Online Payment Ability
	  ○ Consumption Information
	  ○ Outbound Communications (Global and Individually)
	  ○ Program enrollment (i.e., Conservation program)

3) Meter Supply	• Mechanical meters for Small and Intermediate; non-mechanical for Large Meters
4) Installation	• Project management • External installation services • Data management, • Curb stop support and repair

5) Internal Project Support	• Most of the Project Support will be provided with previously budgeted resources. (Project Manager, Facilities Coordinator, Meter Supervisor, Public Outreach, CIS and Interface Subject Matter Expert and Billing Lead).
	• Newly budgeted City positions to support project during Implementation: Curb stop support and repair, Billing Clerk, AMI Analyst.
	• On-going Project Support includes:
	  ○ A Billing Clerk (1 FTE),
	  ○ Meter Maintenance Person (1 FTE)
	  ○ AMI data analyst (0.25 FTE)
	  ○ Data Support (for turning the data provided by the AMI into usable information)
	  ○ Outsourced bill printing, stuffing and mailing
	• All other project roles will be provided with previously budgeted resources

Component	Items Included

6) External Project Support	• Consulting Support to provide the following Project assistance:
	  ○ Project Coordination
	  ○ Subject Matter Expertise
	  ○ Quality Assurance Program
	  ○ Field Inspections
	  ○ Integration Coordination/Support
	  ○ Public Outreach/ Communications
	• CIS Integration (Diamond)

The City is not expected to have available resources to handle the Field Inspection tasks. One resource has been previously budgeted under Consulting Support, but an additional FTE would be required. The following tasks would be performed by Field Inspectors:

- Pre-approval of additional work required on site such as carpentry work or additional plumbing work.
- QA inspection of installation company's work at customer sites, ensuring the installation is done properly, the proper data is captured (meter number, radio transmitter number), and the radio transmitter is programmed properly (if applicable).

The following tasks were not anticipated in the consulting engagement, and we anticipate will require additional resources:

- Task resolution (typically internal): inspection and resolution of poor plumbing, inaccessible plumbing, refusal by difficult homeowners.
- Sub-unit account deletion verifications (typically internal)

Recommendation 5: Project scope should include AMI, customer portal, meter supply, installation, internal project support, and external project support.

1.7. Capital and Operational Cost Implications

1.7.1. Capital Costs

The inputs that determine the total cost of an AMI project include AMI technology supply, water meter supply, installation services, and both external (consulting) and internal project support.

An AMI implementation project is complex. The combination of products being supplied (often from different vendors), along with installation services, engineering work (installing data collectors), software applications and software integration to the City of Cornwall's existing and new applications presents challenges not usually experienced in water projects. Complicating this further is the product and software applications' compatibility with one another. Each component must provide the right data, in the right way, to the right system, at the right time in the business process. Finally, this all needs to be done while engaging with 100% of the City's water customers.

The project team evaluated two scenarios. Scenario 1 - Standalone AMI which assumed the City would implement fixed data collection devices and own its own AMI network. Scenario 2 - Cellular AMI assumed Cornwall would install radio transmitter devices that utilize existing cell infrastructure. The total capital costs by components are detailed below.

Assumption	Scenario 1 - Standalone	Scenario 2 - Cellular
Meter Supply	$2,687,405	$2,687,405
AMI Supply	$2,722,823	$3,168,946
Installation	$6,394,029	$6,394,029
CIS Support	$137,500	$137,500
Consulting Support	$1,577,920	$1,577,920
Project Support	$466,800	$466,800
Contingency	$2,430,668	$2,497,586
CPI	$572,341	$596,485
Total	**$16,989,486**	**$17,526,671**

Table 5 - Capital Cost Summary by Scenario

Internal Project Support includes additional internal City resources (not currently in the budget) that are required to support the project. Contingency has been included in the Installation portion of the project (25%) as well as on the Meter Supply and AMI Supply (15% each).

Recommendation 6: Maintain the existing budget of $17.3 million.

1.7.2. Operational Impacts

The City of Cornwall maintains 275 meters today and will move to maintaining meters and AMI radio transmitters at all ~17,691 of its locations. Couple that with the fact only 275 customers are billed based on consumption today whereas all customers will be billed on consumption going forward, and the City will experience increased operational costs in the following areas:

- Additional Meter Maintenance will be required to maintain meters and AMI radio transmitters and ensure they are working correctly.
- Customer Service will experience an increase in call volume as customers are moved from a constant, predictable flat rate bill to consumptive billing which will vary based on consumption.
- Moving from bi-annual billing to bi-monthly billing increases the staff effort associated with bill preparation and the cost of stationery and postage. Staff will also have more bill exception handling than it does currently where bills are flagged for high or low usage that might require investigation.
- Unauthorized water consumption is likely to become more of an issue than it is in a flat rate environment.
- IT costs will increase for software associated with data collection from all the City's meters and leveraging that data for reports and actionable items. A customer portal will be required to engage customers to the extent desired and allow for detailed consumption views, alarm notification, bill presentment and payment.

Although operational costs will increase, it has been shown above in the Project Objectives and in Chapter 2 Organizational Goals and Needs that installing water meters is an absolute necessity – and especially as they relate to supporting the City's conservation goals. Currently, the City has an inability to measure consumption, distribution system losses or leaks in customer premises. It has little data to plan its distribution system, to right size infrastructure or to plan significant

capital investments in treatment facilities without understanding water consumption and its trends. Moving to water meters will accomplish these goals.

The following table summarizes the annual departmental financial impact. The details and assumptions behind this summary can be found in the Financial Report. Each scenario outlines the operational cost change to what is deployed today and is the value put into the net present value calculation.

Further details on the operational impacts can be found in the Financial Report.

Operational Cost Category	Scenario 0 - Manual Meter Reading	Scenario 1 - Standalone AMI	Scenario 2 - Cellular AMI
Operational - Customer Services	No Impact	($165,867)	($165,867)
Operational - Meter Maintenance	No Impact	($118,893)	($118,893)
Operational - System Management Improvements	No Impact	($88,243)	($88,243)
Operational - IT Costs	No Impact	($266,625)	($296,711)
Total Financial Impact	**No impact**	**($622,128)**	**(652,214)**

Table 6 – Operational Financial Impact Summary
A negative number indicates an increase in cost in the Operational Cost Category.

1.8. Implementation Schedule

An AMI Project has five key phases. The City of Cornwall is currently in the Design Phase (Phase 1) which will be followed by a 10-month Procurement (Phase 2).

The City of Cornwall is a medium sized Ontario utility and will command competitive pricing given the nature of this project. Water utilities who complete an AMI installation in 2.5 years gain the benefit of economies of scale. With a slower approach, products and equipment become more expensive due to the lower volumes and the vendor pricing in risk/inflation.

The 29-month implementation and mock billing schedule/plan proposed at the City of Cornwall ensures all City customers will share equitable access to service levels as quickly as possible. In comparison, a prolonged approach provides one subset of

customers with the benefits of consumption management tools (leak detection, etc.), while others are left waiting years for those same benefits.

The implementation duration by phase of a 29-month schedule is shown in the table below.

29-Month Implementation	
Phase	**Duration (months)**
Phase 3: Startup Phase	6 months
Phase 4a: Proof of Concept	4 months
Phase 4b: Installation and Deployment	18 months
Phase 5: Close-out	1 month
Total	29 months

Table 7 – Duration of Project Phases (29-Month Implementation)

Recommendation 7: Follow a 29-month implementation schedule including start-up, proof of concept, installation, and project close-out.

1.9. System Assessment and Interface Requirements

Through workshop activities, Diameter performed a system review with the City's project team. The purpose of this assessment was to identify the systems currently in use and those systems that may be impacted with the implementation of AMI technology.

Cornwall's systems, interfaces and business processes are well established, with Diamond's CIS (a CentralSquare product) being the key system of record to support the water billing process.

The blue systems and interfaces shown in Figure 2, below, represent existing applications. The solid lines represent automated interfaces, the dashed lines represent a manual process that relies on manual intervention.

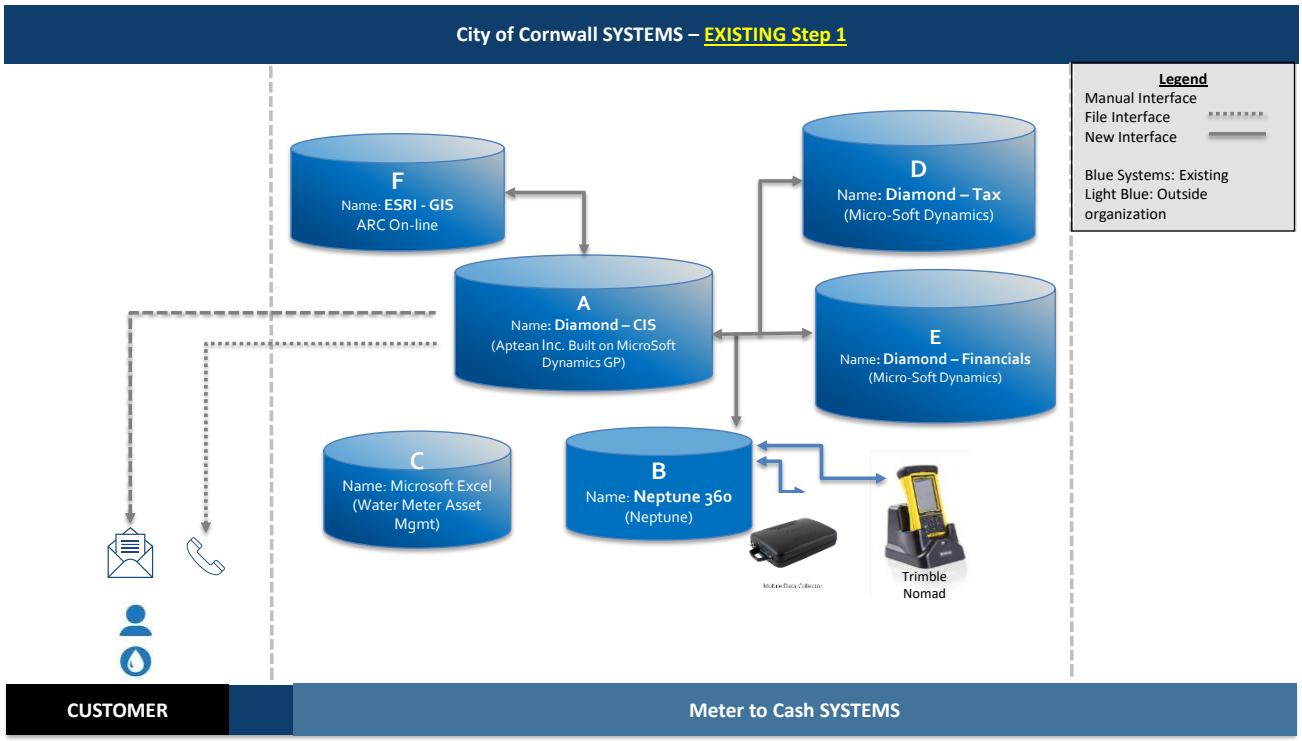


Figure 2 – Existing System Architecture

The diagram below provides an overview of the future system architecture once AMI is implemented.

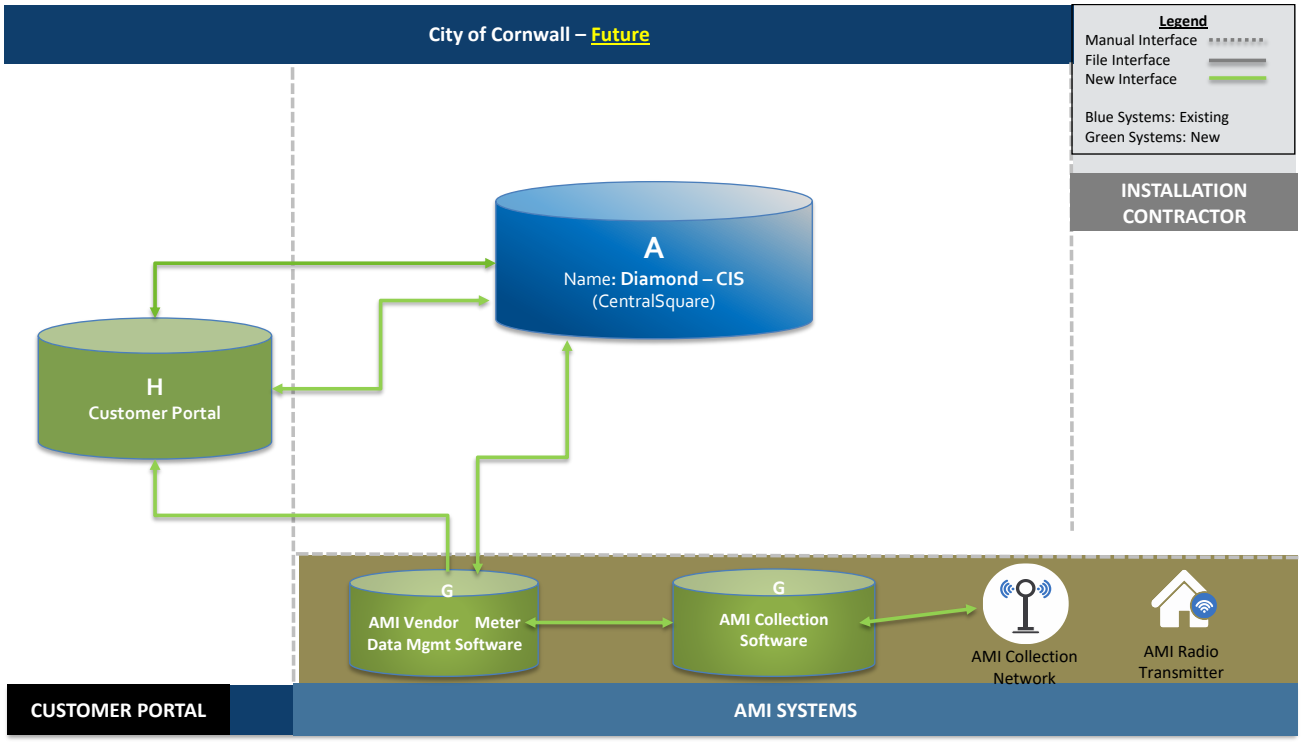


Figure 3 - Future System Architecture

The blue system will remain whereas green represents new systems, system enhancements or interfaces contemplated. Points of note include the Customer Portal which is expected to be a fully functional portal that leverages AMI data and provides the customer experience desired by the City of Cornwall. Other new systems include the AMI vendor's data collection software for collecting meter readings, issuing commands (i.e., on-demand reads), and network management. This system can be coupled with the MDM (meter data management), or the MDM can be a standalone application, which provides reporting and analytics on the data and is key to a utility's ability to extract valuable, actionable information from its AMI investment. The MDM will be provided by the AMI provider.

Integrations will need to be developed between the MDM and Diamond so Diamond can request meter readings at the time of billing. Integration between the MDM and the City's Customer Portal will be necessary so customers can see their detailed consumption data. Integration will also be required between the Customer Portal and Diamond so billing information and payment capability is available to customers and Diamond can be updated as appropriate.

These diagrams are not intended to depict the final solution as different vendors may propose different types of AMI system architecture. It is intended to give the City a representative idea of the scale of the impact this project may have on their systems and the integration requirements the City should anticipate.

1.9.1. Changes Required in Diamond

Although Diamond is shown as a constant in the diagrams above, CentralSquare will need to be engaged to develop integrations required in the system. Diamond will also be required to track water meter information, radio transmitters and to bill based on metered consumption. Examples of changes required in Diamond include:

- Water accounts will include metered water services and any current flat account that won't receive a meter will be eliminated.
- Uploading all existing meter asset information into Diamond.
- Leveraging Diamond's digital work order system in lieu of the City's current paper process.
- Making Diamond's e-billing capability available to all customers to reduce billing costs.

1.10. Public Outreach – the "TIE" Philosophy

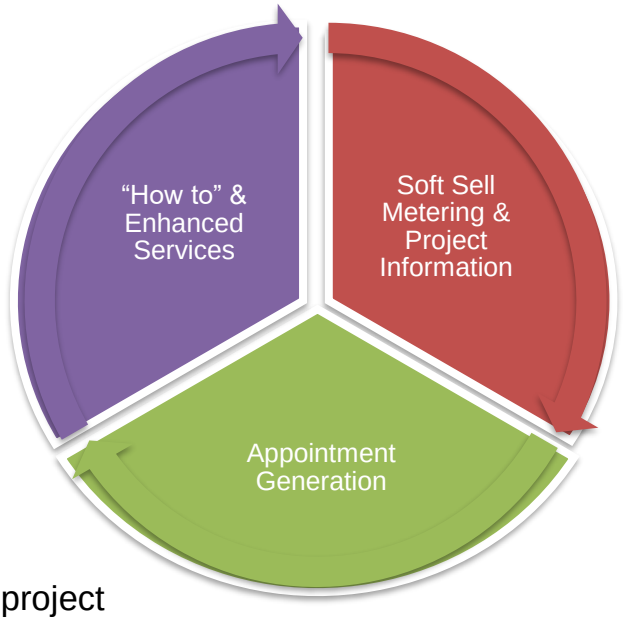
Public outreach for a universal metering project is critical to the overall success of the program. When approaching an outreach strategy, it is important to understand that the water meter is simply a measurement tool and to effectively achieve the desired goals of the Water Conservation and Servicing Master Plan, one should consider the **"TIE"** philosophy.

T represents the **Tool** (the water meter that measures the water based on actual use)
I represents the **Incentive** (a rate structure that allows for a user pay system)
E represents the **Ethic** (users desire to efficiently manage their water use)

An effective demand side management program considers all three elements. A well-planned public outreach program uses the TIE philosophy as a framework to complement an integrated messaging strategy catered to internal and external stakeholders.

1.10.1. Integrated Messaging Strategy

A carefully crafted messaging strategy is necessary to ensure that the water meter installation project progresses smoothly and is completed in a timely manner. It is important that the outreach program generates trust and goodwill with the City's Customers, supports acceptance of the new technology and successfully generates appointments. Key themes the City should consider as part of program messaging include:



- Soft sell the concept of metering and provide project information.
- Appointment generation.
- "How to" effectively manage water use and "how to" access enhanced services.

When developing the public outreach strategy, the plan should address both internal and external stakeholders. Internal stakeholders include the City's communication team, City departments, the Project Team, Steering Committee and City Council.

External stakeholders include residential and IC&I customers as well as the Installation Contractor.

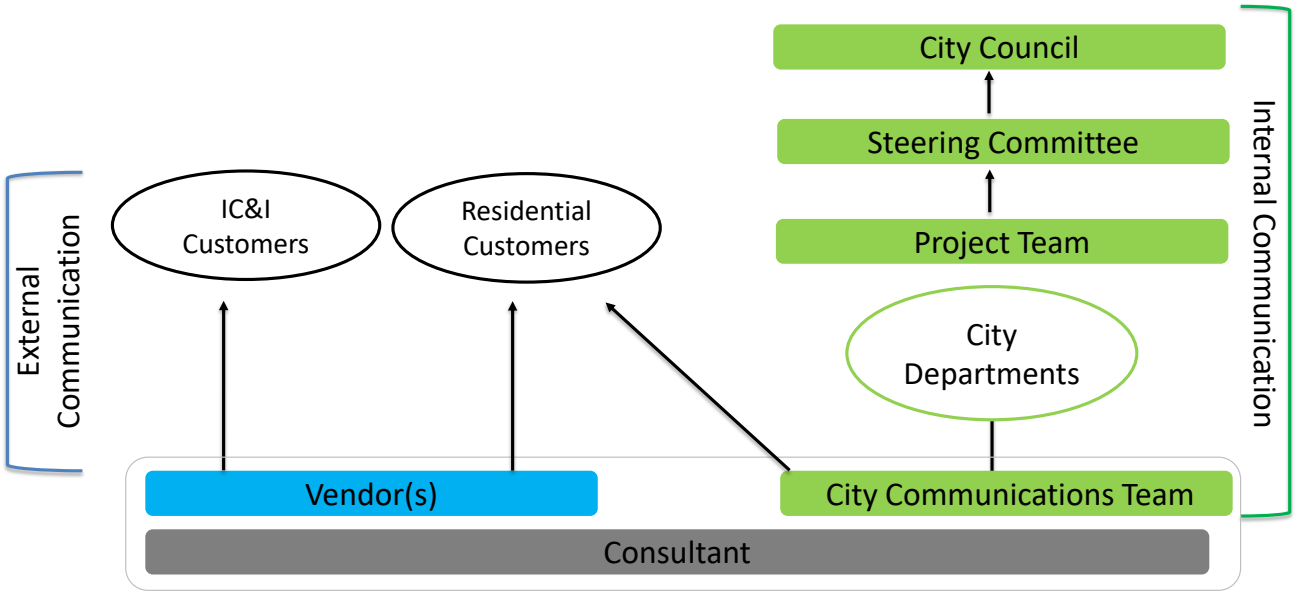


Figure 4 – Public Outreach Stakeholders

1.10.2. Internal Stakeholders

Internal stakeholders can easily be overlooked when developing the strategy, however they play an important role as project ambassadors, embracing change management, and providing customer support. The strategy should include internal communication across departments using emails, kick-off meetings, intranet and training to provide project information and benefits. Helping internal stakeholders understand the value of the project as it relates to their role and the customer will be critical. Internal communication can begin in advance of project start up and Council debriefs are recommended.

1.10.3. External Stakeholders

External stakeholders include residential and IC&I customers. It is recommended that prior to the project start-up, the City consider soft launching project information in local newspapers, website and on social media. This allows for residents to understand that this project is approaching and the benefits as part of the overall Water Conservation and Servicing Master Plan. As previously mentioned, outreach to external stakeholders is recommended in both official languages using the following contact methodology:

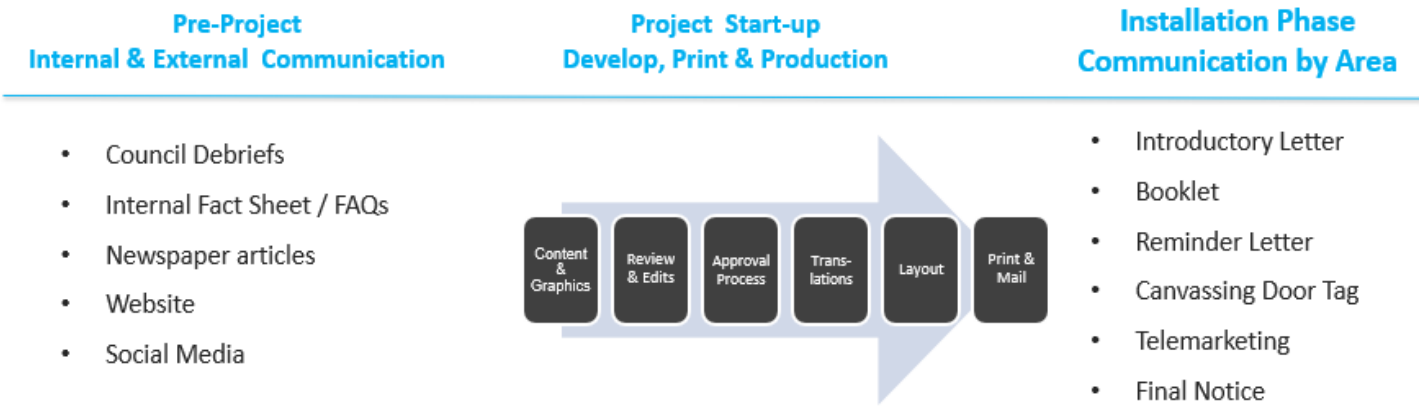
- Introductory letter

- Appointment and Informational Booklet (Contact 1)
- Reminder Letter (Contact 2)
- Door to Door Canvassing and Door Tag (Contact 3)
- Outbound Phone Attempts (Contact 4)
- Final Notice Letter (Contact 5)

Notably, all five (5) contacts are typically performed between 6 and 8 weeks, evenly spacing out the contacts where possible. All materials are developed in collaboration between the City, the Consultant and the Contractor. Final approval resides with the City.

1.10.4. Timelines and Resource Planning

The heaviest lift in terms of development happens during the project start-up phase. Establishing a governance structure and understanding the approval process is essential to establishing the critical path. Content development, translation to French, design, approval, printing and mailing all need to be carefully planned to ensure alignment with the first day of installations as appointment generation is key for technicians to perform the work.



1.11. Procurement Strategy

Chapter 10 of the Report discusses in detail the procurement options available to the City. For example, it outlines how meters can be separately procured from the AMI technology and the option of separately procuring installation services or coupling it with another element.

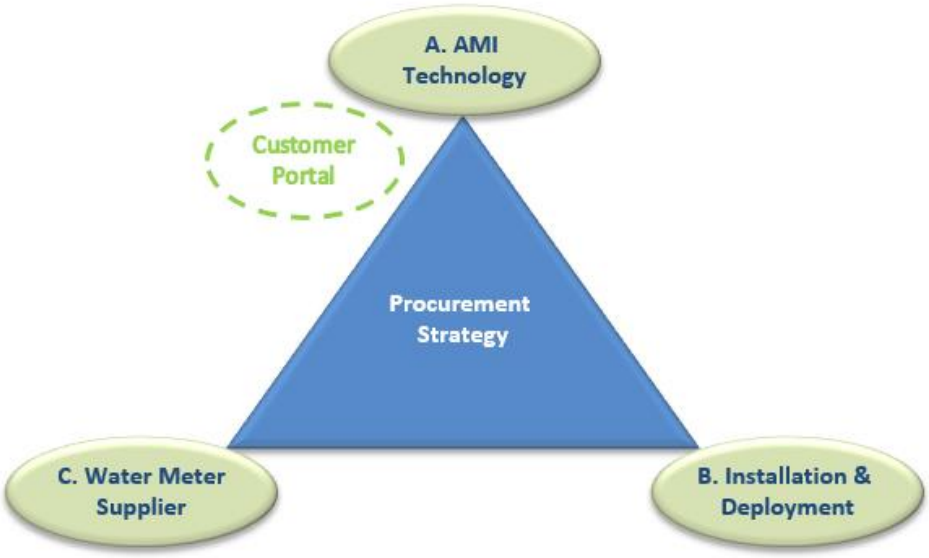


Figure 5 - Components of an AMI Procurement

Option 1 Single Procurement Turnkey (A+B+C)	Option 2 Two Procurements AMI + Installation (A+B) Meter Supply Separate (C)	Option 3 Two Procurements AMI Separate (A) Installation + Meter Supply (B+C)
Advantages (Benefits) • Responsibility for all components in a single vendor. • Product warranty can include in/out costs for the first year. • Product payment is tied to installation.	Advantages (Benefits) • Responsibility for AMI performance is in a single contract. • Installation remains with AMI vendor who then has complete responsibility for successful communication to collection equipment. Since Installation issues create the greatest risk of poor AMI performance coupling Installation with AMI is	Advantages (Benefits) • Some AMI vendors do not provide installation services or a water meter. As a result, this option provides best selection of AMI systems since AMI vendors will not require a partner to submit a proposal.

Option 1 Single Procurement Turnkey (A+B+C)	Option 2 Two Procurements AMI + Installation (A+B) Meter Supply Separate (C)	Option 3 Two Procurements AMI Separate (A) Installation + Meter Supply (B+C)
	advantageous for the City. • Allows for multiple meter manufacturers and components.	
Disadvantages (Risks) • May be higher costs due to some vendors having to put margin on margin for products. • Prime contract performance bond requirements may limit vendors (smaller companies may not be able to bid). • The number of installation companies in the market may limit AMI technology options.	Disadvantages (Risks) • Issues with faulty meters will be a City responsibility. • Bad wiring to encoder could be blamed on meter (City responsibility).	Disadvantages (Risks) • City will bear liability: - Supplying meters - Install and AMI system working together has the most liability. • Non-mechanicals meters - AMI and meter supply need to be procured together to ensure you get all the functionality

Table 8 - Procurement Options

Diameter has recommended a turnkey procurement that includes all the AMI components, the meter requirements and the installation services in a single RFP to be provided by one vendor. A second procurement should be expected for a fully functional customer portal since most AMI vendors are in the infancy stage of customer portal development. A third procurement will be required for curb stop operation and repair. The City of Cornwall will be operating all customers' building control valves, most of which likely haven't been operated in years. As a result, some will not function properly and will require curb stops to be operated and repaired where necessary.

Recommendation 8: Plan for three procurements that include:

1) Meters, AMI and Installation Services (including on-going maintenance of AMI infrastructure)
2) Customer Portal
3) Curb Stop Operation and Repair

1.12. Changes to Business Processes

1.12.1. Water Billing

Today, the City of Cornwall bills its water customers every six months, for the following six months. Since customers are billed a flat rate, there are no "surprises" to a customer's water bill, and customers can budget accordingly.

Because AMI delivers meter reading information from every customer daily (or multiple times per day), the City can choose the billing frequency that makes most sense.

The move to billing based on consumption eliminates the opportunity to bill customers in advance since customers will be billed for the water they consume. Continuing to bill customers every six months, or even quarterly, likely will not contribute to the goals of the universal water metering project. One of the goals of metered billing is to encourage conservation. Providing customer bills every month, or every other month, enables more constant feedback and more of an opportunity to promote conservation. It also provides customers more of an opportunity to control water bill costs. Billing less frequently will also increase accounts receivable and negatively affect cashflow.

Although monthly billing and bi-monthly billing were both considered, the move from bi-annual billing to monthly billing was seen to be too costly both in terms of staff time and billing costs (printing, stuffing, mailing) without a significant benefit over bi-monthly. Bi-monthly was viewed as contributing to the goals of the project while minimizing unnecessary costs.

We recommend moving both moving to bi-monthly and to billing at the end of the period to be implemented six (6) months before the start of mock billing.

Recommendation 9: Leverage AMI as a tool to support the transition from bi-annual to bi-monthly billing for all customers.

1.12.2. Water Rates

Watson and Associates developed the City of Cornwall's Water Conservation and Servicing Master Plan. In the Plan, future metered rates were proposed based on the information available to enable the City "full cost recovery" for its annual operating and annual capital investment requirements.

Following the City's business case development for the universal water metering and AMI program, updated costs for the project have been provided for the capital cost requirements of the project as well as annual operating costs for additional staffing requirements, bi-monthly billing, and other recurring costs associated with software for example.

Based on the current information available, it is recommended Watson update its rate study prior to public outreach and mock billing so customers have the most up-to-date costing information available, and expectations are set appropriately.

Recommendation 10: Request an updated Rate Study by Watson & Associates to be completed by April 2024.

1.12.3. Mock Billing

Once water rates are finalized, Mock Billing enables customers to compare their current flat rate charge against water charges based on volume. This enables customers to make behavioral changes to consume less water and lower their bill prior to being billed on a metered rate.

Initiating this process across all customers together, and for a set period, will be most equitable to all customers and not over-complicate the process. Mock billing would be initiated following the move to bi-monthly billing so customers receive a few bills prior to the move to metered billing and can understand the impact of their changes on consumption and subsequently their bill.

Recommendation 11: Implement a 6-month mock billing period in advanced of moving to metered billing.

1.12.4. Leak Forgiveness

The change from flat rate billing to metered billing will force customers to be more cognizant of their consumption including leaks and "wasted" water. This behavioral change will take time and will differ based on the individual, but conservation will result.

However, from time-to-time some customers may receive high water bills unexpectedly for a variety of reasons. Perhaps there was a broken pipe, a toilet flap was stuck open forcing the toilet to run continuously, or a hose was mistakenly left in the on position. While one of the goals of the project is conservation, penalizing customers for a one-time mistake is not the objective.

Some utilities offer leak forgiveness programs, and some do not. The recommendation is for the City of Cornwall to offer customers one-time leak forgiveness in special circumstances for mistakes impacting their bill as part of good customer relations. The City can consider requiring that customers be registered to the customer portal to qualify for leak forgiveness. This would require the user to provide an email address, phone number, or another contact method to be notified where unusual consumption is suspected. This will allow the issue to be rectified early, minimizing water loss.

Recommendation 12: Consider implementing a Leak Forgiveness Program.

1.12.5. Non-Compliant Customers

As part of the universal metering project and requiring access to all customers' premises, the City of Cornwall will experience some customers who refuse to allow a meter to be installed. Customers who refuse access are usually significant water consumers who are generally concerned about the impact of metered billing. In these circumstances the City will need a method to encourage participation in the metering program. Many utilities will not allow the water to be turned off for non-compliant customers even if receiving a meter is a "condition of service." More common is charging customers triple their current flat rate; the customer's financial

incentive (of paying a flat rate as opposed to a metered rate) is thereby removed,

Recommendation 13: Implement a triple flat rate for non-compliant customers.

making metering more palatable. Generally, this method incentivizes customers to allow access and a meter to be installed.

1.13. Resources

The City of Cornwall can expect a significant jump in call volumes from water customers which is to be expected when moving from flat rate billing to metered billing. High bill complaints, leak forgiveness calls, balance requests, meter accuracy questions are just a few examples of the types of calls that the City will field from water customers.

Anecdotal evidence suggests that the City might expect one call per customer per year initially which can be reduced over time depending on participation in the customer portal, proactive communication from the City (i.e., water conservation measures, leak notifications), and initial successful public outreach communications. Coupled with the increased call volume, the move to bi-monthly billing will place more burden on staff for bill preparation, exception handling, and follow-up. For these reasons, it is recommended the City add one FTE to Customer Service and Billing and determine additional needs based on the call volumes the City is experiencing.

As mentioned earlier, the City of Cornwall will have more meter related tasks after installing meters throughout the City and new tasks associated with AMI radio transmitters that it does not have today. Examples include radio transmitters replacements due to failures or vandalism, customer follow-up as requested by customer service, meter register failures, investigations for high consumption or zero consumption, and suspected meter or radio transmitter tampers.

It is estimated that one FTE will be required going forward to handle issues such as those stated. Initially, it is expected issues such as radio transmitter failures or meter issues will be minimized since the assets will be new. Regardless, the City should anticipate the need for an additional FTE to maintain meter and endpoint AMI assets and ensure they are working correctly.

Recommendation 14: Plan for the addition of one FTE in Customer Service and Billing, and one for Meter Maintenance. The City should have a contingency plan to allow for one additional Customer Service representative to cover if call volumes increase during specific points during the project.

2. Organizational Goals & Needs

2.1. Introduction

The City of Cornwall has direction from its Municipal Council to implement universal water meters to enable water billing based on consumption versus the current flat rate methodology. As part of this process, the City engaged Diameter Services ("Diameter") to provide Universal Metering and AMI consulting services.

The City's RFP for consulting services stated that the goals of the Project are to:

- standardize and update City-wide water meter infrastructure
- streamline billing and payment collection
- improve customer communication regarding water consumption
- promote water efficiency
- rapidly detect damaged/ leaking infrastructure
- reduce operational costs
- strengthen asset management

While all these goals can be accomplished as part of the Project, the opportunity to support broader, previously established City goals and objectives was also considered. Diameter evaluated the following City documents and held a workshop with the City's Project Team to assess whether the Universal Metering Project supported certain aspects of the City's plans and priorities.

The relevant Documents that were reviewed include:

- City's Strategic Priorities (2019 – 2022)
- City of Cornwall's Official Plan (2018)
- Water Conservation and Servicing Master Plan (2021)
- Energy Conservation and Demand Management Plan

The information provided below discusses how universal water metering will support the City of Cornwall's goals and priorities set out in the following documents.

2.1.1. Mission, Vision and Strategic Priorities (2019 – 2022)

The City of Cornwall has a Strategic Priorities Document that is built on key pillars and includes the City's Mission and Vision Statements. The City's Project Team, along with Diameter, evaluated if, and how, the Universal Metering Project supported the City's Strategic Priorities.

2.1.2. City of Cornwall's Mission

As described in the City's Strategic Priorities, the City of Cornwall's Mission Statement is to "provide services that enable a financially and environmentally sustainable community which will care and provide for the needs and values of its residents." Key to the Universal Metering Project is water conservation and ensuring our most valuable resource is sustainable through conservation and reducing waste, while at the same ensuring equitable funding of the water utility through a user pay approach.

2.1.3. City of Cornwall's Vision

Similarly, Cornwall's Vision Statement in part emphasizes the City's desire to provide effective services and infrastructure. This portion of the Vision Statement is supported by AMI's ability to provide the City individual and totalized water consumption patterns (i.e., hourly consumption information) enabling effective distribution system planning without oversizing its infrastructure.

2.1.4. Strategic Priorities

This Universal Metering Project aligns with certain aspects of Cornwall's existing 2019-2022 Corporate Strategic Priorities. There are five Strategic Priorities and various goals associated with each priority. Diameter and City's Project Team ranked whether this Universal Metering Project supported each priority using the categorizations outlined in the table below:

Adherence to Goal	Definition
Not applicable	This goal does not apply
Low	There are few elements of this goal that align to this project AND/OR the technology considered may not fully support this goal.
Medium	There are some elements of this goal that may align to this project AND/OR the technology considered may support this goal.
High	Yes, this goal aligns well with this project AND/OR the technology strongly supports this goal.

Table 9 - Definition of Adherence to Goal Rankings

Strategic Priority	Strategic Goals	Adherence to Goal	Comments
Developing waterfront through ownership, partnerships for business, recreational opportunities	N/A	N/A	The Universal Metering Project is not related to this Strategic Priority.
Attracting, enhancing workforce that meets demands of local employers	N/A	N/A	The Universal Metering Project is not related to this Strategic Priority.
Growing quality of housing stock, including affordable housing.	N/A	N/A	The Universal Metering Project is not related to this Strategic Priority.
Economic development and pursuing diverse population growth of 50,000.	1. Better branding for areas of the City	N/A	The Universal Metering Project is not related to this goal.
	2. Attract remote workers via incentives	N/A	The Universal Metering Project is not related to this goal which is to attract “work from home” employees to reside in Cornwall.

Strategic Priority	Strategic Goals	Adherence to Goal	Comments
	3. Focus on reducing number of vacant commercial spaces	Low	The City will be receiving daily water consumption information from all accounts. Being “flagged” on zero consumption accounts will enable the City to retrieve information more quickly on vacant properties and take action.
	4. Continue to invest in infrastructure	High	This project is a significant infrastructure investment that will enable more accurate distribution system planning and help avoid unnecessary upgrades to both treatment facilities through its conservation goals.
	5. Encourage infill project (e.g., Brookdale)	N/A	The Universal Metering Project is not related to this Strategic Priority.
Being leaders in sustainability and climate change impact.	1. Create Environmental & Climate Change Committee	High	The Universal Metering Project will contribute to reducing water consumption and water losses reducing water treatment and pumping. Reducing these two elements contributes to energy savings which helps to “reduce and offset greenhouse gas emissions produced within our community”.

Strategic Priority	Strategic Goals	Adherence to Goal	Comments
	2. Composting	N/A	The Universal Metering Project is not related to this goal.
	3. Water meters	High	The project will require installation of water meters at all water accounts.
	4. Education on recycling & waste reduction	N/A	The Universal Metering Project is not related to this goal.
	5. Plastic bag ban	N/A	The Universal Metering Project is not related to this goal.
	6. Identify what the City could take the lead on	High	The City plans to take the lead on providing customers a portal to view their consumption information, receive notification of potential leaks, view and pay water bills.

There were eleven goals associated with the two strategic priorities that the Universal Metering Project supports. The Project Team determined that the Project supported seven of them:

- 4 of the goals were highly supported by the Project
- 3 of the goals were ranked as supported by the Project but considered “low”
- 4 of the goals were not applicable to the Project

2.2. City of Cornwall Official Plan

In evaluating the City's Official Plan, there were major goals outlined in the Plan with respect to Services and Utilities that were ranked using the criteria outlined above. These are outlined below with comments provided where relevant.

Plan Goal	Adherence to Goal	Comments
1. Guide urban development in terms of the capacity of municipal services and treatment facilities and the principle of promoting an orderly, compact and staged development pattern	High	Universal Metering Project will provide system wide consumption data (daily, monthly, yearly) to project system capabilities and capacity needs/enhancements to promote an orderly development plan.
2. Protect all properties from flood waters through appropriate zoning and development controls.	N/A	Goal does not apply.
3. Provide and maintain facilities for the safe disposal of solid wastes in the municipality and encourage rehabilitation and reuse of landfill sites no longer required.	N/A	Goal does not apply.
4. Provide water purification, supply and distribution facilities to serve existing and	High	Universal Metering Project will provide system wide consumption data (daily, monthly, yearly) to determine supply and distribution

Plan Goal	Adherence to Goal	Comments
proposed developments on a practical, economical and reliable basis.		facility needs to serve existing and proposed developments.
5. Provide and maintain sanitary sewers in the developed areas, within the financial capacity of the Municipality.	High	Water conservation/reduced consumption will create less burden on sanitary sewers and help avoid massive capital investments in wastewater treatment facilities.
6. Ensure that treatment plants have the necessary capacity to accommodate future growth and development, including treatment capacity for hauled sewage from private communal sewage services and individual on-site sewage services.	High	The Universal Metering Project will provide system wide consumption data (daily, monthly, yearly) to project capacity needs to accommodate future growth. Accurate consumption statistics help predict burden on treatment facilities while water conservation and reducing consumption will create less burden on water treatment and sanitary sewers and help avoid massive capital investments in treatment facilities
7. Ensure that all areas of the City are provided with acceptable fire protection coverage	High	The data provided by Advanced Metering will provide information for infrastructure planning to help ensure acceptable fire protection coverage.
8. Protect, maintain, and enhance water and related resources,	High	Reducing overall water consumption lowers the possibility of over-burdening the wastewater treatment

Plan Goal	Adherence to Goal	Comments
aquatic ecosystems, drainage patterns and flood risk through stormwater management		facility during heavy storm events and lessens the risk of raw effluent being directly discharged into the St. Lawrence River.

2.3. Water Conservation and Servicing Master Plan

The City of Cornwall's Water Conservation and Servicing Master Plan contained the Province of Ontario's 9 principles of financially sustainable water and wastewater services. A condensed version of these principles is outlined in the table below including whether the Project supports these principles, and to what extent, using the previously established criteria. These rankings were based on a workshop conducted between Diameter Services and the City's Project Team.

Province's 9 Principles	Adherence to Goal	Comments
1. Transparent public engagement	High	The City of Cornwall has been completely transparent with the public regarding the reasons for the Universal Metering initiative and the costs associated with the Project. Moving forward, having data to support future investments will build confidence in the City's financial plans as they relate to water utility investments.
2. Integrated planning of water, wastewater and storm water systems	High	The Universal Metering Project will provide the City of Cornwall the ability to plan for peak flows (i.e., m^3 volume at specific time of day) based on the data provided by AMI and better

Province's 9 Principles	Adherence to Goal	Comments
		understand capacity needs of its water and wastewater systems.
3. Revenues collected for the provision of water and wastewater services should ultimately be used to meet the needs of those services.	High	Understanding consumption, both at a per account level and system wide, enables the City of Cornwall to set rates appropriately for full-cost recovery. It also helps distribute costs based on the "need" for the service where those who consume more pay more.
4. Lifecycle Planning with mid-course corrections is preferable to planning over the short term, or not planning at all.	High	The Universal Metering Project will provide consumption data that will be used for real and apparent losses and a calibrated hydraulic model so watermains can be "right sized" to relieve stress on the distribution system or to ensure watermains are not oversized unnecessarily.
5. Asset Management Plan is key input to the Financial Plan	High	AMI will provide individual and system wide consumption statistics to assist with the City's Asset Management Plan.
6. Generation of sustainable revenues for the reliable services and future rehabilitation and replacement of infrastructure	High	As stated above.

Province's 9 Principles	Adherence to Goal	Comments
7. Equitable outcomes and promotion of water conservation through users paying for the services they receive.	High	The City's Water Conservation Master Plan developed by a Third Party outlines a pathway to promote a 37% reduction in water consumption across the community. Further, a user pay system is far more equitable for all and ensures water "abusers" aren't subsidized by others.
8. Ability to compare the accuracy of financial projections with actual results can lead to improved future planning	Low	Although flat rates do afford the City the ability to accurately predict revenues, it is not able to control its costs with any degree of certainty. Nothing prevents a flat rate user from consuming water well beyond what is expected. In the future, the City will be able to predict costs more accurately by being able to better predict consumption and reducing the inherent waste in a flat rate system.
9. Financial Plans benefit from the close collaboration of various groups	High	With AMI data, the City of Cornwall will be better informed on the performance of its water utility and enable better planning among City engineers, utility staff and Council as it relates to investments or operational changes that may be required.

In addition to the 9 Principles outlined above, the Master Plan outlines a Ministry of Environment, Conservation and Parks (MECP) Recommendation to the City of Cornwall that "measures should be considered to promote water conservation. This could include studies of current practices to determine how much water would be saved by implementing conservation measures."

Further, the City's Master Plan states that "a new update of Ontario's Drinking Water Quality Management Standard (DWQMS) puts greater emphasis on the external and internal audit process for water conservation programs. To audit the effectiveness of a water conservation program, the City needs to be able to measure the volume of water utilized by residents and businesses within the City."

This Universal Metering Program supports both the recommendation for the City to promote water conservation and the ability to audit the effectiveness of the programs it chooses to implement.

2.4. Energy and Conservation Demand Management Plan

The goal of the City of Cornwall's Energy and Conservation Demand Management Plan is to "continuously reduce the energy requirement of our facilities through implementation of smart technologies, engineering standards, control (By-Law) and through the purchase of the highest efficiency equipment available through the municipal procurement process."

In many ways, this statement defines the benefits of the Universal Metering Project. As mentioned above, one of the Project's goals is to promote water efficiency and water conservation and by their very nature, water meters will accomplish this goal. Generally, it is regarded that by installing water meters, overall water consumption will be reduced by 25% or greater within a utility.

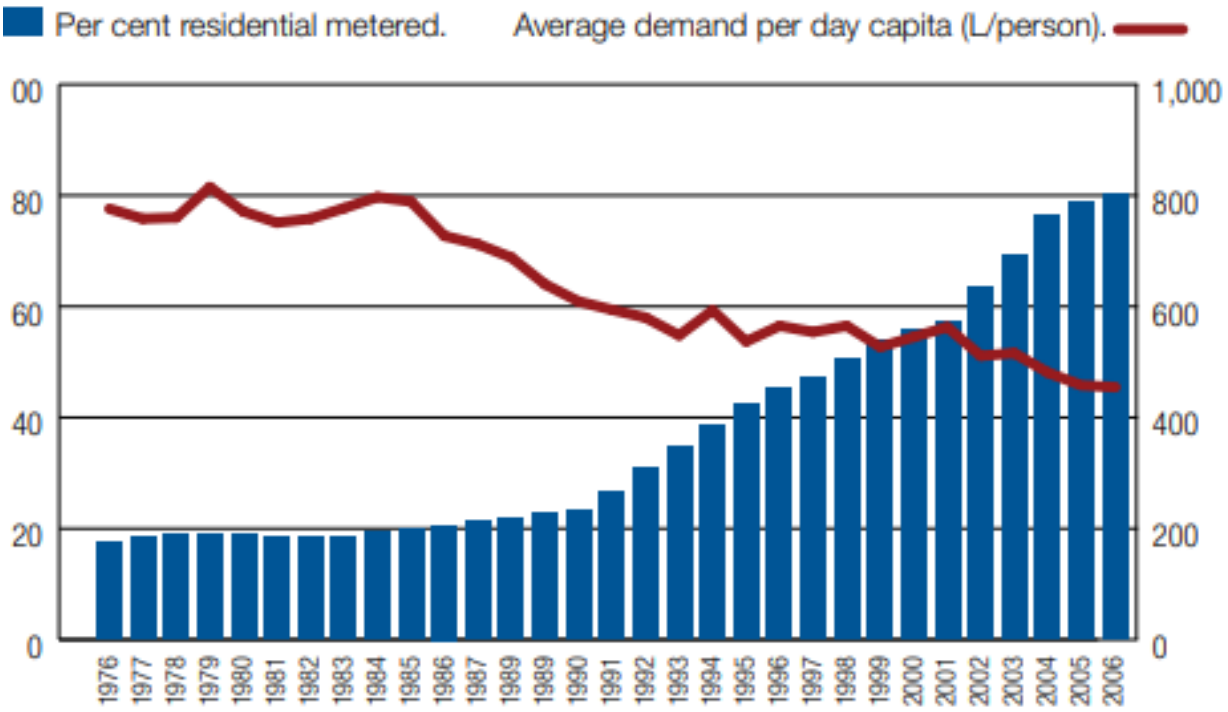
According to Measurement Canada, "water meters will play a significant role in achieving the Government's environment and climate change objectives. They help households monitor their water usage. According to a 2009 survey, Canadian households with meters on volume-based water pricing schemes used 73% less water than unmetered households on flat-rate water pricing schemes." (https://www.ic.gc.ca/eic/site/mc-mc.nsf/eng/lm04972.html)

In the City of Calgary, which implemented mandatory water metering in 2002, the water withdrawn from the Bow and Elbow Rivers measured 18% less in 2016 than it did in 2003, despite a population growth of 30%.

According to the City of Calgary's Water Efficiency Plan from 2006, "Metering has played a particularly significant role in reducing residential water use in Calgary. From their Plan, Figure 4.2 (below) shows, growth in metered residential accounts in our city has paralleled a significant reduction in per capita demand."

Figure 4.2

Growth and impact of residential water metering in Calgary.



AMI expands on the potential of water meters to promote conservation. For example, AMI in conjunction with a customer portal, can provide customers leak notification alarms to help reduce leaks, save customers money, and reduce the amount of water that needs to be treated. Similarly, reducing Distribution System leaks more quickly reduces the amount of water that needs to be produced to serve the City's customers.

While conserving our most valuable resource is an honourable goal in and of itself, the benefits extend to the City's efforts to reduce its energy requirements. Reducing the amount of water that needs to be treated - whether by reducing consumption or through the elimination of (distribution system and customer) - contributes to reducing the energy used to pump and treat water and wastewater. Depending on the energy source (i.e., Natural gas) the reduction in energy has the added benefit of reducing Greenhouse Gas (GHG) emissions and supporting the City of Cornwall's Climate Action Plan.

3. AMI Business Drivers

3.1. Connecting Project Goals with AMI/AMR Business Drivers

In collaboration with the City of Cornwall, the Diameter Services team reviewed, assessed and ranked 41 different AMI/AMR business drivers. To frame the overall analysis, Diameter Services has identified six categories where AMI/AMR technology offer benefits:

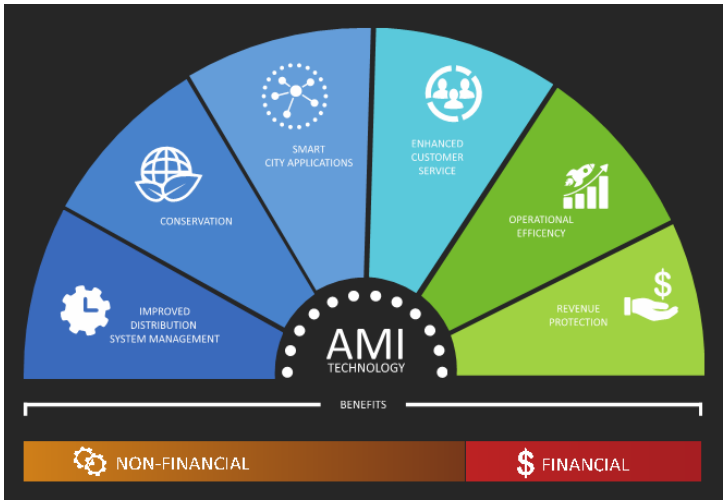


Figure 6 - Business Driver Categories

1. **Revenue Protection (RP)**
   Ability to identify areas of revenue improvement, reduce theft and tampering, respond quicker to stopped meters, and an improved ability to apply the right meter technology to customer applications.

2. **Operational Efficiency (OE)**
   Improvements in response time to maintenance issues; reduced meter reading costs and hazards; reduced exceptions, effort to bill and additional trips into the field to collect data.

3. **Improved Distribution System Management (DS)**
   Improvements in the utility's ability to manage its distribution system through district leak detection, dynamic water balance, system wide leak detection, discrete water quality monitoring and more efficient code enforcement.

4. **Enhanced Customer Service (CS)**
   Improvements in customer service through the ability to provide customers' consumption information, online access to consumption, alerts to avoid high water bills or damage, and customer leak detection.

5. **Societal Benefits (SB)**
   Improvements in water conservation and carbon emissions.

6. **Smart Utility/Smart City (SC)**
   Improvements to areas beyond water consumption by leveraging the network for other organizational needs.

The purpose of this exercise is that a business case of this nature is most successful when:

1. **The goals identified in the business case align with the City of Cornwall's broader goals:** The City of Cornwall as a whole and the Water Department itself has stated goals that can specifically align with the results of this project. The Business Drivers outlined herein, and their respective rankings, will reflect Cornwall's desired outcomes as outlined above. The role of AMI technology in addressing those Business Drivers is discussed.

2. **Functionality of the system meets the needs of the Water Department and the communities and citizens it serves:** Just because a technology allows for certain functionality does not necessarily mean it addresses a requirement or the needs of a utility and the communities it serves. The AMI business driver assessment (ranking) allows Cornwall to focus on technology features that address specific utility needs. Although AMI technology is the focus of the City of Cornwall, AMR information has been included for reference only. Both AMR and AMI are assessed to show how well each technology meets the functional need.

3. **Capital cost estimate should match the real costs:** The capital costs used in the business case should include the full scope to successfully implement the recommended approach. This cost should be revisited as the City progresses through the technology upgrade process (i.e., after procurement and at key milestones during installation phase). Assumptions were required as part of the initial capital costs to determine meter requirements (i.e., Quantities of each meter size) using the information available. Utilities implementing universal metering projects typically cannot furnish all the information needed to determine exact metering needs especially due to multi-family dwellings that may, or may not, have separate water services.

4. **Benefits should extend outside just the meter to cash process:** The business drivers need to look beyond the meter to cash process. This may include benefits to the City and to the customer that may be more difficult to calculate but offer improved efficiencies, service levels or societal benefits such as a reduction in CO2 emissions.

Understanding existing challenges and establishing priorities is fundamental to benchmarking the success of any water meter replacement and meter reading

technology review. It is important that the business case clearly show the expected impact to the customer as well as to the City of Cornwall.

3.2. Evaluating Business Drivers

AMI and AMR technology have different features and functionality. The movement to a specific technology should be driven by looking at the importance of various business drivers and selecting the technology that best addresses those drivers. When features or functionality within the AMI/AMR technology address a challenge or improve delivery of water service, it is considered a **business driver.**

The Diameter Services team reviewed 41 different business drivers with the City of Cornwall's staff to determine the organization's needs and identify the best technology fit. The development and assessment of the business drivers provides a definition of the actions Cornwall should expect to implement, first by identifying what is important to the Utility followed by matching the technology that supports these actions.

A business driver may have a financial or non-financial impact (benefit or cost). For the purposes of this report, they have been separated. If a business driver has both a financial and non-financial impact, it will show up accordingly. Only those financial business drivers that were defined by the City of Cornwall as important or essential have been quantified in terms of financial benefit or cost. See Table 11 for definitions of important or essential.

AMI/AMR technology will improve a water utility's operations in several areas; some can be easily calculated, while others will show a qualitative improvement in a respective area. AMI/AMR technology should be considered a tool that the utility uses to improve how the utility operates. The areas of improvement often do not have a direct financial improvement but are still critical to the utility achieving the broader goals of the organization.

To evaluate business drivers, Diameter developed a scoring system that allowed Cornwall to establish the importance of each business driver and by extension the goals of the project.

Importance to the water utility is defined and scored using the table below.

Score	Importance	Description
0	Not Important	The City will not implement the business driver in the future
1	Future	The City may implement the business driver
2	Important	The City will implement the business driver immediately
3	Essential	The City will implement the business driver immediately and it is critical to the project

Table 10 - Business Drivers Score and Importance to the City

AMI/AMR technologies function differently, have different operational impacts on the utility and provide different benefits partially due to the differences in data each provides. Depending on the technology allows the City of Cornwall will be able to either fully achieve, partially achieve, or in some cases not achieve specific business drivers. This system of scoring is designed to accomplish two things. First it prioritizes those business drivers that are most important to the City of Cornwall and secondly, it helps to define the technology alternatives that provide required functionality, which is key to developing cost/benefit results. The following criteria is used in this determination:

Score	Ability to Support the Business Driver	Description
	Does not support a Driver	The business driver as described cannot be implemented using this technology.
	Partially supports a Driver	The business driver as described can be partially implemented using the technology.
	Fully supports a Driver	The business driver as described can be fully implemented using the technology.

Table 11 - Scoring: Ability to Support the Business Driver

3.3. Business Driver Assessment Summary

A complete list of the business drivers and recommendation rationale are detailed later in this section which will describe the business drivers along with each technology's ability to achieve the goals of the driver.

As a preface to that in-depth discussion, and to provide a high-level overview of the workshop findings, an overview is provided below, which is designed to provide a quick snapshot of the business drivers and related priorities for the AMI/AMR project.

ID	Revenue Protections (RP)	Score
RP 1	Unauthorized Use of Water	2
RP 1a	Unauthorized Use of Hydrants	1
RP 2	Zero Consumption - Stopped Meter	2
RP 4	High Bill Complaints	3
RP 4a	Run Your Water Accounts	2
RP 4b	Suspension of Service for non-payment	3
RP 4c	Support for Leak Forgiveness Program	2
	Operational Efficiency (OE)	
OE 1	Collect Meter Readings	3
OE 3	Meter Reader Safety	3
OE 4	Meter Reading Reliability – Elimination of Estimates	3
OE 5	Detect Register and Cut Wire Problems	2
OE 6	Remote Turn-off / Turn-on	0
	Improved System Distribution Management (DS)	
DS 1	District Metering	0
DS 2	Water Audit Support	3
DS 3	Acoustics Leak Detection (ALD)	0
DS 4	Detect Backflow Events	2
DS 5	Watering By law/By law Enforcement	0
DS 6	Pressure Monitoring	0
DS 7	Temperature Monitoring - Frozen Services	0

DS 8	Hydraulic Modelling	2
DS 9	SCADA	0
DS 10	Wastewater Monitoring	1
DS 11	Water Quality Monitoring	0
	Customer Service Enhancements (CS)	
CS 3	Customer Engagement - Passive	3
CS 4	Customer Engagement - Interactive	3
CS 5	Customer Engagement - Progressive	2
CS 6	Leak Detection - Small	3
CS 7	Leak Detection - Broken Pipe	2
CS 8	Vacation Monitoring	0
CS 9	ICI Data Sharing	1
	Societal Benefits (SB)	
SB 1	Water Conservation Program Support	3
SB 2	Energy Cost Reduction	2
SB 3	Lead Service Identification	2
	Smart Cities (SC)	
SC 1	Smart Utilities / Smart Data Sharing	1
SC 2	Smart Street Lighting	1
SC 3	Garbage Can Monitoring (i.e., In Public Areas)	0
SC 4	Public Safety	0

Table 12 - Summary of Important and Essential Business Drivers (higher score is more important)

The following provides a summary of the business driver assessment summarizing only those ranked as Important (Score of 2) or Essential (Score of 3).

ID	Revenue Protections (RP)	Score	AMI	AMR

RP 1	Unauthorized Use of Water	2		
RP 4	High Bill Complaints	3		
RP 4a	Run Your Water Accounts	2		
RP 4b	Suspension of Service for non-payment	3		
RP 4c	Support for Leak Forgiveness Program	2		
	Operational Efficiency (OE)			
OE 1	Collect Meter Readings	3		
OE 3	Meter Reader Safety	3		
OE 4	Meter Reading Reliability – Elimination of Estimates	3		
OE 5	Detect Register and Cut Wire Problems	2		
	Improved System Distribution Management (DS)			
DS 2	Water Audit Support	3		
DS 4	Detect Backflow Events	2		
DS 8	Hydraulic Modelling	2		
	Customer Service Enhancements (CS)			
CS 3	Customer Engagement - Passive	3		
CS 4	Customer Engagement - Interactive	3		
CS 5	Customer Engagement - Progressive	2		
CS 6	Leak Detection - Small	3		
CS 7	Leak Detection - Broken Pipe	2		
	Societal Benefits (SB)			
SB 1	Water Conservation Program Support	3		
SB 2	Energy Cost Reduction	2		
SB 3	Lead Service Identification	2		

Table 13 - Summary of Important and Essential Business Drivers

3.4. Detailed Business Driver Assessment

A complete list of the business drivers and recommendations are provided below in the detailed business driver assessment which describes each business driver along with the technology's ability to support the goals of the driver. The detailed assessment includes:

- a reference number for each business driver.
- a description/definition of the business driver.

- how the business driver applies to the City based on workshop discussions.
- technology implications.
- the benefits to the City of Cornwall.
- rank of importance.

Table 14: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
Revenue Protection (RP)					
RP1	(2) Important	Unauthorized Use of Water	Tamper Detection - Residential customers: removal of register head or meter (zero consumption for full days in the middle of a billing period). Tamper Detection - Commercial customers: turning on bypasses (zero or reduced consumption compared to other similar industries). AMI technology allows a utility to detect potential tampering in a number of ways: • Abnormal consumption: by way of detecting consumption (or a reduction in consumption) in accounts where Cornwall would be expecting the opposite behavior. Examples include: - A commercial property (for example a laundromat) that requires water to operate suddenly has zero consumption during peak times. - A property is vacant and should be zero consumption, but suddenly shows consumption. - At a commercial property, the bypass is opened thereby reducing consumption through the meter. - If applicable, detector check meters show consumption (where none was expected). • Meter removed tamper (manufacturer specific) – whereby a customer removes the register or the meter, and the register detects the physical movement. This would have to be reset by the customer. • Empty pipe alarm (specific to Ultrasonic and Mag meters) – there is no water in the meter and an alarm is sent.	**Discussion Points:** • Would there be any financial benefits or efficiencies with consumption-based algorithms? • Alerts to property owner (high) or low consumption alert to utility? **Discussion Outcomes:** • Everyone needs to pay for the water they use. This is something the City will want to ensure is captured following metering.	**AMR (**PART) - There are zero consumption flags, and they can be collected on a monthly basis but cannot analyze unusual consumption behavior. • Zero consumption are a Yes / No flag • Limitation due to resolution • Cannot determine patterns **AMI** (FULL) – The utility can analyze consumption behavior (through hourly readings for example). When trends are detected special stopped meter or tamper reports can created to initiate action. • Can build algorithms to find certain types of consumption patterns (or zero consumption notification through the MDM for example). • Can establish “watch” list customer that creates alerts.

Table 14: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
RP1 a	(1) Nice to Have	Unauthorized Use of Hydrants	• Water being pulled from Hydrants illegally.	**Discussion Points:** • Is this a Potential Problem? • If so, do we have an idea of the number of private Hydrants and a list of hydrants? • Could we estimate a % of commercial consumption that is being diverted to hydrant water theft. • Calculation would be based on billed rate for water. **Discussion Outcomes:** • Cornwall does have some Private Hydrants. Water Dispensing Stations/City sales of water have been impacted by unauthorized use through Hydrants when filling trucks take advantage of hydrants. There is a potential risk to water quality issues when hydrants are tampered with.	**AMR (**ZERO) – AMR does not provide a solution for this business driver. **AMI** (PART) – The utility can expand the scope of the project to include acoustic leak detection devices on hydrants. This would also require separate software apart from the AMI head-end data collection software.
RP2	(2) Important	Stopped Meter	• Positive displacement meter is jammed and requires replacement. Applicable to residential or small side of compound meters which tend to “burn out” and stop registering.	**Discussion Points:** • Is this happening now with limited meter population? Is it important to be notified of these events when fully metered? **Discussion Outcomes:** • 10 -15 occurrences of this now on only 273 Meters (~4.5%) • Opportunity to deal with this as it happens can limit estimates and customer services issues. • Financial benefit of being able to identify and address stopped meters sooner.	**AMR** (ZERO) - Resolves after the billing cycle. Lost revenue could be between 30 and X days. **AMI** (FULL) – Can setup a flag (e.g., 5-day). To reduce the number of days these meters do not record revenues**.**
RP4	(3) Critical	High Bill Complaints	Being able to resolve high bill complaints more efficiently	**Discussion Points:** • How many high bill complaints are received per year? • Are there write-offs for high bills?	**AMR** (ZERO) – Missed reading can occur depending on route travelled. **AMI** (FULL) – With hourly consumption data the high bill complaint customers can be proactively notified of a potential high bill prior to receiving it through alarms and alerts.

Table 14: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
				Discussion Outcomes: • High Bill Complaint Phone Calls (2021) was ~50 first week following billing, ~25 each week after. • Expected to be a significant source of calls when moving to metered billing	Hourly consumption information provides effective backup for customer service to explain consumption profile or provided through the customer portal for customer "self-service". Obtaining actual meter reading to verify usage has returned to normal is accomplished through the network without a truck roll.
RP4 a	(2) Important	"Run Your Water" Accounts	Customers who need to run water during winter months due to risk of freezing Effectively tracking this consumption can reduce apparent losses based on the number of customers and the amount of consumption they use in this period	**Discussion Points:** • Does this happen at the City of Cornwall? • Are there ICI customers who have this issue? **Discussion Outcomes:** • Depends on the particular year – i.e., the severity of the winter. • Can be 50 or more frozen services	**AMR** (PART) – Limited ability to capture hourly data to capture amount of constant flow. **AMI** (FULL) – With hourly consumption data the City can monitor the flow rate of running water at a particular account, track the amount of water not being consumed for apparent loss calculation and provide the appropriate "forgiveness" to customers.
RP4 b	(3) Critical	Suspension of Service for non-payment	• Monitor those customers that were turned off for non-payment - Some customers will illegally turn water back on • Ability to put them into a "virtual" shut off groups – usually for move/in move/out monitoring	**Discussion Points:** • What effort is associated with monitoring turned off customers? • Do customers turn the water back on? **Discussion Outcomes:** • 1,400 Arrears Notices Issued in 2021; Amount of arrears is added to property taxes and becomes legal lien. • A lot of people do not pay	**AMR** (PART) – Meters can be monitored but reaction would be every 30 days (depending on read frequency) after the bill is produced. **AMI** (FULL) **–** Hourly consumption tracked and meters report daily or multiple times per day. Can setup Virtual Shut-off Group so City is notified of unauthorized consumption. Customers using fire service for domestic purposes could be identified prior to bills are produced.
RP4 c	(2) Important	Support for Leak Forgiveness Program	• Where a major leak occurs (customer side leak) and there is a Leak Forgiveness Program in place. • Pin-point major leak to a specific event or date. • May lead to fewer people qualifying.	**Discussion Points:** • Reduce the total pay-out dollars due to Alerts catching these issues sooner. • Reduce the Staff time associated with justifying approvals / denials of Leak Forgiveness claims **Discussion Outcomes:** • City will need to discuss a Leak Forgiveness Program • Although one is not currently in place, the ability to track consumption associated with	**AMR** (ZERO) – Not applicable. **AMI** (PART) **–** Would help calculate how long and how much water leaked on a customer service.

Table 14: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
				potential claims was classified as “Important” as defined in Table 11 when moving to metered consumption.	
Operational Efficiency (OE)					
OE1	(3) Critical	Collecting Meter Readings	• Without meter reading technology, every meter needs to be visited for a read • Virtually eliminates the need to manually collect meter reads • Reduces the operating cost of collecting meter readings.	**Discussion Points:** • All meter reads collected through the network daily and remotely • Generally, avoids the necessity of Regular Reads, Final Reads and Re-Reads • No need to roll trucks **Discussion Outcomes:** • Ability to effectively collect meter readings is ‘the whole point of the initiative.’ • City currently bills every 6 months but if the intent is water conservation, customers need to see their consumption more often to take action and change behaviours.	**AMR (PART)** – AMR mobile allows meter readings to be collected by driving in close proximity to the property. Typically, meter readings are collected for billing purposes, although some manufacturer AMR mobile can allow daily and hourly readings to be collected at the cost of some system performance (driving speeds). Mobile data collection will also collect leak detection, tamper, and backflow flags. This provides a Yes / No response that can be incorporated into reports and CIS. **AMI (FULL)** – Allows for all meter readings to be collected from fixed network devices via the head-end software. Eliminates 98% of meter reading performed in the field.
OE3	(3) Critical	Meter Reader Safety	• Reduce lost time Injuries related to meter reading. • AMI technology will eliminate liability associated with employees in the field. • It is important to highlight that improving meter reading safety may not drive functionality, but it is still an important business driver that avoid tasks that may lead to high rate of Lost time injuries.	**Discussion Points**: Reduce lost time injuries related to meter reading, which could include: • Vehicle accidents • Dog or slips and falls • High crime areas • Environmental: Air quality during environmental events. **Discussion Outcomes:** • Eliminating meter readers in the field avoids risky situations at certain locations. While this is not a great concern currently with flat rate billing, moving to meters would introduce the need for meter readers without AMI technology. • Eliminating meter readers can also avoid accidental damages to customer property and negative impacts to the City’s reputation.	**AMR** (PART) – AMR reduces the number of meter readers in the field and decreases some safety aspects of manual meter reading (slips and falls, dog bites). However, it increases vehicle safety risks to meter readers and citizens. **AMI** (FULL) – AMI virtually eliminates all meter readers in the field aside from exceptions such as a non-communicating meter where a meter reading may be manually read.

Table 14: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
OE4	(3) Critical	Meter Reading Reliability / Elimination of Estimates	• Reduce the time to re-read missed readings. • Use an estimated read due to inability to get a meter reading within the billing window.	**Discussion Points:** • What % of meter reader resources perform these re-reads? How much time does estimate bills take a Customer Acct Specialist? What % of their time do they spend on this? • Are there any customer complaints the City receives due to meters not being read? **Discussion Outcomes:** • Cornwall "estimates" 19,000 bills twice a year as the City is on flat rate. • Meter reading technology helps minimize estimates since its more reliable than obtaining meter reads manually and eliminates human error. AMI further reduces estimates as compared to AMR because meter readings are received daily, or multiple times per day, reducing missed meter readings. • Correcting missed reads and estimates including staff time answering customer questions on estimates can be considerable.	**AMR** (PART) – Missed reading can occur depending on route travelled. **AMI** (FULL) – Missed readings are less likely once the network is deployed. Usually reading exceed 98.5% RSR.
OE5	(2) Important	Detect Register and Cut Wire Problems	• Detect issues with the meter, meter register, wiring, radio transmitters	**Discussion Points:** • Not currently a problem since there are no meters but this would be a benefit of technology once meters are deployed. **Discussion Outcomes:** • Considered Important by the City.	**AMR** (PART) – Some system can receive a "tamper" flag to indicate a cut wire. However, the information is limited and can only be retrieved at the time of meter reading. **AMI** (FULL) – AMI in conjunction with its associated software will provide information to capture issues with the meter, meter register, wiring or radio transmitter and do so in a timely manner.

Table 14: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
OE6	(0) Not Important	Remote Turn-off / Turn-on	• A two-way AMI technology can allow a water utility to remotely shut off valves or valve enabled water meters. This would eliminate the need to send a technician out to shut off the water. • Available on meters up to 1”	**Discussion Points:** • Who performs this work? How many people are dedicated to this? Are the shut offs that are occurring in a certain area or associated with certain customers? Would charging customers the cost of a meter technician to turn the water back on be a reasonable policy? **Discussion Outcomes:** • There were 110 Total Requests • City charges $59.50 to turn the water off	**AMR** (ZERO) – No benefits. **AMI** (FULL) – Possible with the following conditions: • Two-way with reasonable latency (sub-hour). • Most are incorporating valve into a non-mechanical meter. • Others use a secondary device that would require large meter set. • RF encryption should be employed to prevent unauthorized use.

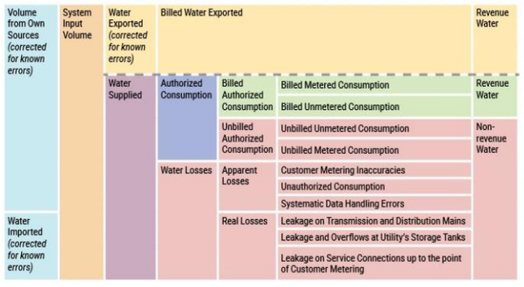
Table 15: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
Improved System Distribution (DS)					
DS1	(0) Not Important	District Metered Areas	• Identify and monitor real losses on the distribution system. • Perform non-revenue water calculation on a subset (or district) of customers within a given geographic area. • Requires all distribution mains to be metered to measure water in and out of a districted metered area (DMA). • An AMI system takes all the identified customers within the DMA and subtracts consumption from the master / district meters.	**Discussion Points**: • Does Cornwall see implementing DMAs in the short to medium term? **Discussion Outcomes:** • Something to be considered in the longer term but not a driving force for the Project.	**AMR** (ZERO) – Not able to perform with AMR data. Does not allow this type of program to be implemented. **AMI** (FULL) – Requires: • Master meters on distribution network. • Hourly readings from all meters. • MDM has the ability to group and calculate water loss. Meter consumption can be grouped and compared to master meters within most high-quality MDM software if the master meters are in place.
DS2	(3) Critical	Water Audit Support	• Water utilities perform a water balance (AWWA Water Audit Software) to calculate non-revenue water across their system. Example of the AWWA C35 Water Balance  	**Discussion Points:** • With hourly AMI consumption data for all customers, a water balance could be performed more accurately and on a more frequent basis, allowing the City to identify and react to significant changes in non-revenue water percentage. • Dynamic water balance could be implemented either on the entire system or just smaller more problematic parts of the system. **Discussion Outcomes:** • The City uses its Water Loss estimate to help determine its wholesale rate. Accurate information will aid in properly establishing the wholesale rate.	**AMR** (ZERO) – Not able to perform this calculation. Would not allow this type of program to be implemented. **AMI** (FULL) – Requires: • Meters on all water sources and to be setup as a revenue meter. • MDM has the ability to group and calculate water loss. Consumption information can be summed and monitored on a frequency of the utility's choosing (monthly, weekly, daily) and can be compared to SCADA. MDM may be able to interface with SCADA to perform water loss calculation in a report or user interface, but this functionality is still in development within the system available.
DS3	(0) Not Important	Acoustic Leak Detection (ALD)	• Detect changes in noise that a leak will cause. • Typically expect 1 ALD for each 10 meters. • Very dependent on distribution system. • Materials - Drop and place does this temporarily.	**Discussion Points:** • Helps reduce all real loss categories. **Discussion Outcomes**: • Not seen as Important for the City to implement as part of the Project.	**AMR** (ZERO) – Not applicable. Does not allow this type of program to be implemented. **AMI** (PART) **–** Can help facilitate these programs. Requires: • Acoustic ALD • Additional software to map it

Table 15: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
					The utility could install radio transmitters and acoustic monitoring devices on the water systems which would be collected by the fixed network along with the readings.
DS4	(2) Important	Detect Backflow Events	• ICI customers often require backflow detection devices (single check, double check, reduced pressure detector, etc.) installed on certain types of water services and customers. Once installed, the devices need to be tested annually to ensure they continue to operate correctly. Depending on who is responsible for testing, the validation process may be more difficult. An AMI system can monitor certain accounts to ensure reverse flow does not exceed forward flow, indicating a backflow device is not operating correctly. These alerts/alarms then allow a water utility to monitor and respond quickly to backflow events. • Monitor those properties that have backflow. Often 5% to 10% of backflow devices can fail per year. Helps validate property owner testing programs and reduces cross contamination risks.	**Discussion Points:** • Certain meters can monitor any backflow (i.e., backflow detection) but most require more backward flow than forward flow to register the event. - What is the City's policy on backflow preventers? - Who is responsible for testing and reporting? - Frequency – assume annual testing. **Discussion Outcomes:** • This will help in identifying backflow devices that are not operating correctly and not waiting for a customer provided backflow test.	**AMR** (PART) – Reverse flow could be monitored using the flags produced by the AMR register/ transmitter. The drawback is that it will not tell you when it occurred and how much water came back, and you cannot set thresholds that would eliminate very small events. **AMI** (FULL) **–** The utility could set up reports based on hourly consumption information to monitor the backflow. If an event occurred, they would be able to tell when and how much water came back into the system.
DS5	(0) Not Important	Watering By-Laws	• Support By-Law compliance on water restrictions: - Water bans - Odd / even lawn watering provisions - Support seasonal water pricing • Often By-Law enforcement is dependent on customer complaints or utility personnel driving through neighborhoods to identify customers who are in violation of a water enforcement ban. • AMI technology can allow for monitor customer consumption and highlight those who may be violating the ban. Depending on the fines issued, this may increase utility revenues. Repeat	**Discussion Points**: • Does the City have regular water restrictions? • Does the City enforce the By-Laws? • Types of restrictions Cornwall would consider. **Discussion Outcomes:** • There is no lawn watering By-Law. No mandatory programs to restrict use or time of use (i.e., odd / even day lawn watering). • Voluntary programs – low flow toilets, subsidized rain barrels, free residential water-use audit	**AMR** (ZERO) – Not applicable. Does not allow this type of program to be implemented. **AMI** (FULL) **–** MDM requires reports / alerts that can identify and compare odd / even days and compare. The utility could set up reports that would monitor customers during water restriction events.

Table 15: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
			offenders could also be flagged on a separate report to monitor them more closely.		
DS6	(0) Not Important	Pressure Monitoring	• Monitor Pressure across the distribution system. Changes in pressure may: - Indicate potential leaks. - Reduce pressure - lower real water loss - Respond to customer complaints. • Pressure readings can be taken across a water system on a daily (or more frequent) basis. The pressure readings will either come from a pressure gauge or a non-mechanical water meter that is compatible with the selected AMI technology. • Pressure readings can be used for a few purposes: - Better respond to customer pressure complaints. - Monitor pressure for fire protection.	**Discussion Points:** • Changes in pressure may: - Indicate potential leaks. - Reduce pressure to lower real water loss. - Respond to customer complaints. • Does the City receive pressure complaints? • Would additional pressure information help distribution management? **Discussion Outcomes:** • City did not see the need for Pressure Monitoring especially when considering the cost and technology implications. (See Technology Assessment)	**AMR** (ZERO) – Not applicable. Does not allow this type of program to be implemented. **AMI** (PART) **–** Would require: • Water meter that transmits pressure or 3rd party pressure monitor that is compatible with the RF network • Meter and AMI manufacture to be the same AMI technology would need to either have a radio transmitter that can communicate and pull pressure readings from a pressure device or the AMI technology in combination with a water meter capable of monitoring pressure (manufacture specific).
DS7	(0) Not Important	Temperature Monitoring	• Monitor temperature on shallow services. • Be able to better proactively respond to freezing temperatures.	**Discussion Points:** • To what extent is freezing an issue? **Discussion Outcomes**: • City can have about 50 frozen services per year depending on the severity of the winter.	**AMR** (ZERO) – Not applicable **AMI** (PART) **–** Would require: • Water meter that monitors and transmit temperature (C715) • Meter and AMI manufacture to be the same Alerts to be emailed within a reasonable timeframe
DS8	(2) Important	Hydraulic Modelling	• Using more detailed consumption information (specific time of day or seasonal) to allow the model to better model the system.	**Discussion Points:** • Does Cornwall use the Hydraulic Model? • Would there be value in having more granular consumption inputs? **Discussion Outcomes:** • Hydraulic Model was theoretical but can now use AMI data to understand usage patterns and provide effective Hydraulic Modelling.	**AMR** (PART) – Improve monthly consumption forecasts. **AMI** (FULL) **–** Using data to predict different types of behaviour. • Current relies on API's – ad hoc reports, not a direct connection.

Table 15: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
DS9	(0) Not Important	SCADA	• Incorporating SCADA data to better understand where the water is going.	**Discussion Points:** • Would combining SCADA with AMI consumption data allow for improved models / DMA? **Discussion Outcomes:** • City does anticipate integration between the SCADA and AMI	**AMR** (ZERO) – Not applicable **AMI** (PART) **–** It is only theorical. No MDM has incorporated / interfaced SCADA to AMI.
DS10	(1) Nice to Have	Wastewater Monitoring	• Using the network to monitor wastewater flows. • Using the network to monitor tank and reservoir levels. • AMI Vendors have endpoints devices that can be connected to other control devices (different product that connects to water), Allows a 4-20MA connection	**Discussion Points:** • How is this performed currently? Would there be any benefit to have an AMI network support this function? **Discussion Outcomes:** • Wastewater treatment upgrade in 2015 to increase capacity • Have put in flow level detectors in a few sanitary manholes. • May want to incorporate down the road.	**AMR** (ZERO) – Not applicable **AMI** (PART) **–** Endpoints that connect. to 4-20MA. • Still in development. • There are marketing materials, but how proven they are is uncertain.
DS11	(0) Not Important	Water Quality Monitoring	• Using the network to monitor water quality (pH, chlorine, etc.) • Still very much a field in development for many vendors.	**Discussion Points:** • Would more frequent readings be of value to the City? • There were water quality complaints? • What type (colored, pressure, taste). **Discussion Outcomes:** • Real time monitoring need is there. Not suitable for AMI at this point. • Trying to accomplish water quality monitoring over AMI network is too risky	**AMR** (ZERO) – Not applicable **AMI** (PART) **–** Endpoints that connect. to 4-20MA. • Still in development for many vendors. • There are marketing materials, but how proven they are is uncertain.

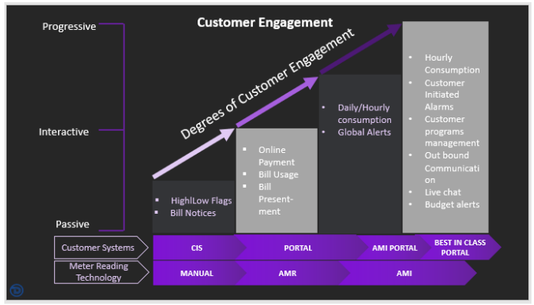
Table 15: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
Enhanced Customer Service (CS)					
CS3	(3) Critical	Customer Engagement Passive	 • Utilities often start with lower levels of customer engagement usually defined as reactive responses to customer complaints or passive notices included on water bills. • As a utility starts to allow for online web access to water bills (for viewing and payment), this provides a more services/engagement to the customer; however, the utility is reliant on the customer to initiate the engagement.	**Discussion Points**: • Cornwall is already at this level of customer engagement. **Discussion Outcomes:** • Critical to maintain what is happening now.	**AMR** (FULL): AMR readings will support a passive engagement where the customer can decide to view their billable consumption. This level of engagement is usually driven more by the Customer Information System than the meter reading technology. **AMI** (FULL): Would achieve the goal on a passive customer engagement. But not really required.
CS4	(3) Critical	Customer Engagement Interactive	• As a utility applies AMI technology that includes a customer portal, the engagement becomes more interactive. • Customers can access better consumption graduality (hourly buckets as compared to monthly) and potentially be sent consumption flags (continuous leak, intermittent leak) allowing them to better understand their consumption behavior. • The utility can also start to establish global leak flags that allow notifications to be proactively sent to all customer meeting certain consumption conditions (i.e., 500% of daily average consumption over a 5-day period) via the customer portal credentials (Email, text).	**Discussion Points:** • Cornwall does not appear to have interactive features at this point (bill presentment, online payments) **Discussion Outcomes:** • Building and By-Law launching a customer portal called CityView. CityView is to be assessed to determine if this system has the ability to provide alert information (i.e., Leaks) to customers, water bill presentment, allow payments, interface with the billing system, etc.	**AMR** (PART): AMR readings will support a passive engagement where the customer can decide to view their billable consumption. Displaying consumption flags could enhance the level of engagement especially when a continuous leak flag could be displayed for a customer complaining of a high bill. Some interactive engagement but likely would fall short in several areas. Requires a portal. **AMI** (FULL): AMI technology would allow customers to view hourly consumption to better understand their consumption behavior. This would depend on the AMI vendor's ability to provide a consumption customer portal that would receive customers credentials from the existing customer portal or payment provider. Typically, the AMI consumption portal will include some global consumption alerts but may not distinguish between

Table 15: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
					customer type or meter size (where consumption patterns may be significantly different). • Alerts and consumption views would allow for a more interactive customer engagement enabling customers to be proactively notified if criteria are met for leaks, vacation monitoring, or high usage for a specific period of time as a few examples. • More advanced Portal is likely required
CS5	(2) Critical	Customer Engagement Important	• As a utility moves towards “best in class” customer engagement, it allows: - customers to personalize their own leak or bill notifications, - provide workflows that help customers proactively investigate consumption, - consumption algorithms that can identify different types of consumption behavior (continuous overnight consumption, leaking toilet or irrigation system, odd-even water ban violators) with a high degree of accuracy and provide workflows that help adjust this behavior.	**Discussion Points:** • Best in class (full function) customer portals. • AMI functionality related to consumption, leaks. • Conservation program management. • Communications **Discussion Outcomes:** • Important to have this functionality to accomplish the goals of the Project and succeed with conservation initiatives.	**AMR (ZERO):** AMR readings system would have limited capabilities. Would not achieve a progressive engagement even with a customer portal. **AMI (FULL):** AMI technology and a best-in-class customer engagement platform would provide the “personalized” service through customize alerts, and resolution workflows. The customer engagement portal would be connected to the City’s Identity Provider (i.e., Active Directory) enabling the passing of customer credentials, completely invisible to the customer. • Improve engagement from utility. • Improve engagement from the customer.
CS6	(3) Critical	Leak Detection – Small	• Two types of customer side leak detection: - Continuous / intermediate consumption - High consumption for a short period of time (300% over a 3-day period) - Utility set threshold - Customer set thresholds - Water budgets • Provides the utility with an improved ability to respond to customer’s high-water bill complaints. • AMR equipment includes algorithms that determine a continuous or intermittent leak. Different types of yes/no flags can provide a billing agent with indication that a leak has occurred at a property.	**Discussion Points:** • This type of customer side leak detection would allow customer to avoid large bills. • Water budget could help keep lower income customers with water bill affordability. **Discussion Outcomes:** • Critical	**AMR** (PART) – Would only do continuous leak detection. Need bill print adjustment or a portal to display. **AMI** (FULL) **–** A combination of AMI and customer portal will achieve this. Will provide hourly consumption data to use for consumption alerts that includes: • Continuous leaks over a utility defined period of time. • Intermittent leaks over a utility defined period of time. • High consumption (X% over daily average consumption) over a utility defined number of days. Utility defined threshold that eliminates customers with very small leaks from being notified.

Table 15: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
			• This reactive approach helps a utility better service its customers.		
CS7	(2) Important	Leak Detection - Broken Pipe	• Provides a utility with the ability to set global alerts to initiate customer service or field personnel to contact a customer because it appears a pipe has broken based on the volume of water going through the meter. • Would provide a “real time” alert if the consumption match ~80% of the service capacity for a 1-to-4-hour period.	**Discussion Points:** • Small leak detection might be setup to trigger over a few days vs. a broken pipe which could trigger a more immediate alarm because of extraordinary large flows. • Would this be of value? • How many broken pipe complaints would Cornwall receive in a year? **Discussion Outcomes** • Great opportunity to offer more customer service. • City receives about 30 broken pipe alarms in a year.	**AMR** (ZERO) – Not applicable. **AMI** (FULL) **–** Set global leak thresholds and great alerts for when consumption meets 75% or greater hourly flow based on the service size. • Available on most • Bubble up/Wake up functionality would be important.
CS8	(0) Not Important	Vacation Monitoring	• Allow for a customer to set a vacation alert that will tell them if water is being used when it should not be. This would be setup through a customer portal which allows for an alert to be sent. • Customer established zero consumption alarm. • Where consumption exceeds a customer define amount, they receive an alarm.	**Discussion Points:** • Would this be of value to your customers? **Discussion Outcomes:** • Not Important	**AMR** (ZERO) – Technology does not provide enough data to achieve this functionality. **AMI** (FULL) – Customer driven zero consumption monitoring. Customers can set thresholds for alerts to be send to them. Alerts include: • Vacation/vacant notice • Customer driven zero consumption monitoring • AMI and Customer Portal would be critical
CS9	(1) Nice to Have	ICI Data Sharing	• ICI customers (Energy Managers) may value hourly consumption data to aid with their energy management programs / conservation initiatives.	**Discussion Points:** • Is the City approached now by Commercial / Industrial customers for this information? **Discussion Outcomes:** • Nice to Have. Not something where the City receives a great deal of requests for this information from ICI customers.	**AMR** (PART) – Limited ability to capture hourly data **AMI** (FULL) – Will receive hourly consumption data (or up to 15-minute interval information) that can be provided to commercial / industrial accounts.
Societal Benefits (SB)					

Table 15: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
SB1	(3) Critical	Water Conservation Program Support	• User consumption data to support: - Reduction of peak water demand - Measure impact of conservation initiatives (Low flow device programs, top dressing, outreach programs, etc.) • There are a number of different types of water conservation programs that focus on changing customers' water consumption behavior. The types of programs that are implemented within a utility really depend on the challenges faced, customers groups (residential, commercial, and industrial) and the type of usage the utility is targeting (indoor usage, outdoor usage). AMI technology can promote water conservation by providing information to customers which enables them to change their behavior. • The greatest benefit - the ability to target customers meeting a specific consumption profile and to measure the affects water conservation programs have on reducing water consumption. As a result, program dollars can be better targeted and utilized towards programs that are proven to be the most effective.	**Discussion Points:** • AMI by itself doesn't initiate conservation but does help support conservation programs and understand program effectiveness. • Water Conservation Programs help avoid system expansion – both water treatment and wastewater treatment **Discussion Outcomes:** • Water Supply is not a huge driving force • The City anticipates looking at customer usage and targeting areas for specific campaigns based on the information provided by the data. • Water Audits where customers can be shown their consumption while showing the impact of their fixtures would be effective.	**AMR** (ZERO) – Not applicable. Technology does not provide enough data to achieve this functionality. **AMI** (FULL) – Hourly and daily consumption data can be used to support conservation initiatives. Hourly consumption data in combination with grouping and report functionality from an MDM can have an impact on water reduction.
SB2	(3) Critical	Energy Cost Reduction	• Real water loss represents lost energy to pump water that never reaches the consumer. - Reduce Non-Revenue Water à reduce energy • Reduction in overall water usage results in reduced energy usage / costs for water and wastewater treatment. By extension this has a positive impact on CO2 emissions / nuclear waste depending on the energy source.	**Discussion Points:** • E.g., $5M for Production and Delivery of Water. With a 20% water loss, wasted energy cost would be $1M. By cutting water losses by 2%, energy cost can be reduced by $20K / year all things being equal. **Discussion Outcomes:** • The City's Energy Conservation and Demand Management Plan identifies projects that can be completed that would both reduce energy usage and GHG emissions. Reducing water loss and	**AMR** (ZERO) – Not applicable. **AMI** (PART) – Eliminate the vehicles for meter reading purposes. AMI's effectiveness in helping tackle Water Loss Management, customer leaks and Apparent Losses results directly in energy savings. Further, the ability to understand customer demand patterns as well as system demands might change water pumping strategies and contribute to energy savings if water can be pumped during "off peak" times.

Table 15: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
				water consumption will reduce energy usage and GHG emissions.	
SB3	(2) Important	Lead Service Identification	• Cornwall has changed City-owned pipes to lead free. • However, the status and prevalence of lead pipes on the customer-side is unknown.	**Discussion Points:** • Mostly applicable to residential and light commercial. • AMI crews will be entering each building and can identify lead service lines. **Discussion Outcomes:** • It is Important to identify Lead Service lines as part of the Project.	**AMR** (ZERO) – Not applicable. **AMI** (ZERO) – Not applicable. This Business Driver would be satisfied as part of the Installation. The technology being implemented does not impact this Business Driver.
Smart Cities (SC)					
SC1	(1) Nice to Have	Smart Utilities / Smart Data Sharing	• Smart Utilities leverage AMI networks beyond their traditional use and employ connected devices to optimize operations in addition to water metering. • Smart Utilities" often means bringing data into a single source and then using the application to look for trends • Smart Utilities applications start to move a water utility beyond the meter to cash process and potentially well outside the water utility functional area.	**Discussion Points:** • Does the City have Smart Utility/ Smart City Initiatives? • Is there an Official Smart City Plan? **Discussion Outcomes:** • No official plan at this point	**AMR** (ZERO) – Not applicable. **AMI** (PART) – Requires: • Additional LED lights • Light control devices • Software Smart City's is manufacturer specific; the functionality is dependent on the manufacturers system.
SC2	(1) Nice to Have	Smart Lighting	• Smart street lighting: - LED installs reduce energy needs - Smart controls allow: • Controlled Dimming • Emergency lighting • Outage notification • Flat rate to metered consumption (pending measurement Canada approval	**Discussion Points:** • Has the City explored "Smart City" type initiatives with other departments? • How many streetlights does the City have? **Discussion Outcomes:** • ~ 5,447 streetlights owned by the City. • City has contracted Dundas Power Line Ltd. To maintain streetlights	**AMR** (ZERO) – Not applicable. **AMI** (FULL) – Requires: • Additional LED lights • Light control devices • Software • Vendor Specific. Not all vendors provide this functionality. Potentially a "partner" solution for those who do which poses some risk. Smart City's is manufacturer specific; the functionality is dependent on the manufacturers system.
SC3	(0)	Smart Cities	• Placing sensors on garbage cans (i.e., In Parks) can provide alerts when they need	**Discussion Points:**	**AMR** (ZERO) – Not applicable.

Table 15: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
	Not Important	Garbage Can Monitoring	to be emptied. Avoid unnecessary trucks; Maintain cleanliness of public areas.	• Have there been any discussion with these other departments? **Discussion Outcomes:** • Not Important	**AMI** (PART) – Requires: • Additional listening equipment
SC3	(0) Not Important	Smart Cities Public Safety	• Using a single network to help with gunshot or earthquake notification or other matters impacting public safety.	**Discussion Points:** • Have there been any discussion with these other departments? **Discussion Outcomes:** • The City did submit an idea for the “Smart Cities Challenge” in 2018 relative to Home Monitoring that was not approved. • No Bus. Driver to attach other Public Safety initiatives as part of this AMI project.	**AMR** (ZERO) – Not applicable. **AMI** (PART) – Requires: • Additional listening equipment

4. Database Assessment

4.1. Introduction

At the onset of this study, Diameter requested that the City of Cornwall provide a database with specific information pertaining to all the active water accounts. Since water meters are not installed at most accounts, Diameter conducted an analysis of the information that was provided to determine meter quantities by size that would be required for this universal metering project.

4.2. Process to Determine Water Meter Requirements

4.2.1. Information Provided by the City of Cornwall

The City of Cornwall provided three different Microsoft Excel databases to help determine the metering requirements for its customers.

1. The first database was of accounts that are currently metered and are billed on metered consumption. This database contained meter asset information that was used in Work Type determination. There were 306 accounts in this database.
2. The second database contained flat rate accounts. There were 17,616 flat rate accounts, all listed as residential accounts. There was no meter information in this database.
3. The third file provided was a database of flat rate accounts *that had meters installed*. For background, it should be noted that the City of Cornwall has accounts where meters were installed but the customer continues to be charged a flat rate for water. The account / address information in this database was expected to also be contained in the database mentioned in 2, above, but provided additional details to help determine existing meter asset information at the City. There were 2,523 meters in this database.

4.2.2. Initial Results

Database Provided by the City	Total Number of Accounts
Metered Accounts/Metered Billing	306
Flat Rate Account	17,616
Total Accounts	17,922
Metered Flat Rate Customer	2,523

As one can see in the table above, the initial count was 17,922 accounts. But determining the exact quantity of each meter size needed, and which of those accounts require a meter, required further analysis and comparison of multiple databases to extract the information.

4.2.3. Challenges

The City of Cornwall has a large multi-residential population, and each individual unit is setup as a flat rate account in the Diamond CIS and billed based on the number of fixtures. The decision has been made to only install meters on the water service line feeding the property – i.e., A property fed with one service line will have one meter regardless of the number of individual tenants. The implication is that flat rate accounts setup in the CIS - that are sub-units within a multi-tenanted building - will not require a meter and will need to be removed from the billing system.

There are 185 hyphenated addresses in the Flat Rate databases that may require multiple meters. I.e., 2850-2880 Marleau Road shown below.

Figure 7 - Street View of 2850-2880 Marleau Road

The data is held in different databases and information may not be consistent across all databases. For example, the "Metered Flat Rate Accounts" database had 2,523 meters but with some addresses duplicated (since there were multiple meters at the location) whereas the address would only appear once in the Flat Rate Accounts database. For example, 26 Montreal Road has four meters but is listed in the flat rate database once.

Figure 8 - Street View of 26 Montreal Road

The City does not have private service line size information available that could be used to determine meter sizes.

4.2.4. Methodology

The methodology followed to arrive at a single database used to determine the number and size of each meter required by the City of Cornwall and that would allow a Financial Model to be created and provide quantities to an RFP was as follows:

- Combine Flat Rate Accounts and Metered Accounts into one “All Accounts” database.
- Import all metering information from Metered Flat Rate Accounts into All Accounts database to determine whether the location has a meter and whether a meter change-out or a new meter will be required.
- Classify whether each existing account in All Accounts is Primary. (Primary accounts will require a meter). These were denoted as “Y” or “N” in the

database to remove accounts not needing a meter (i.e., Sub-units in a multi-residential dwelling).

- Import MPAC information for each property into the All Accounts database. This information helped provide insight into the particular property and was used to determine meter size where no other information could be provided. For example, a property denoted with MPAC code 333 (residential property with three self-contained units) was given a ¾" meter. See Table below for additional assumptions.
- Determine the number of meters required for hyphenated addresses in the Flat Rate database.
- Classify ICI Accounts according to MPAC information. This process updated 99 accounts originally classified as "residential" but were classified by MPAC as a "warehouse," "other industrial," etc. Twenty of these properties had no meter sizes and meter sizes were estimated based on the type of property or estimated through a manual search process.
- Eliminated residential Flat Rate accounts denoted with A or B (i.e., 142A First Street West was not given a meter). These were not considered as Primary locations. The Primary location (i.e., 142 First Street West) was given a meter. Research indicated that these units would likely have one service and therefore were given one meter.
- MPAC 100 and 105 (vacant land) were not classified as Primary and filtered out.
- Assumptions on how meter sizing was arrived at is included in the following table.

MPAC Code	MPAC Definition	Meter Size Used	Notes (if applicable)
311	Semi-detached residential – two residential homes sharing a common center wall with separate ownership.	15mm (5/8")	Separately owned dwellings; assumed to have separate service lines.
322	Semi-detached residence with both units under one ownership – two residential	15mm (5/8") or 20mm (3/4")	Were assumed to have one service and given a 3/4" meter unless the City had a

MPAC Code	MPAC Definition	Meter Size Used	Notes (if applicable)
	homes sharing a common center wall.		different size already installed at that location
333	Residential property with three self-contained units	20mm (3/4”)	
334	Residential property with four self-contained units	20mm (3/4”)	
335	Residential property with five self-contained units	20mm (3/4”)	
340	Multi-residential, with 7 or more self-contained units (excludes row-housing)	Various	Manually investigated to determine meter size
352	Row housing with 7 or more units under single ownership" all given 5/8" meters.	15mm (5/8”)	
365	Group Home as defined in Claus 240(1) of the Municipal Act, 2001 – a residence licensed or funded under a federal or provincial statute for the accommodation of three to ten persons, exclusive of staff, living under supervision in a single housekeeping unit	20mm (3/4”) or 25mm (1”)	Manually determined based on the size of the unit
370	Residential Condominium Unit	Various	Evaluated individually. Some appeared to be individually metered and some were large condo buildings expected to have one large meter.
374	Cooperative housing - non-equity – Non-equity Co-op corporations are not owned by individual shareholders.	15mm (5/8”)	

MPAC Code	MPAC Definition	Meter Size Used	Notes (if applicable)
	The shares are often owned by groups such as unions or non-profit organizations which provide housing to the people they serve. The members who occupy the co-operative building do not hold equity in the corporation. Members are charged housing costs as a result of occupying a unit.		
382	Mobile home park – more than one mobile home on a parcel of land, which is a mobile park operation.	25mm (1”)	
402	Large office building (generally multi - tenanted, over 7,500 sq. ft)	Various	30 accounts classified as 402 had meters ranging in size from 5/8” to 4” as provided by the City. The remaining 15 where no meter size was provided were estimated to be 1” meters.
405	Office use converted from house	15mm (5/8”) to 20mm (1”)	Denoted sub-units were not considered Primary and therefore did not get a meter.
410	Retail – one storey, generally under 10,000 sq. ft	15mm (5/8”)	All given 5/8” meter except where the City provided specific data on meters previously installed.
421	Specialty automotive shop/auto repair/ collision service/car or truck wash	20mm (3/4”) or 50mm (2”)	There were 7 of this class. 4 were given 3/4" meters and 3 were assumed to be car / truck washes and given 2" meters.

MPAC Code	MPAC Definition	Meter Size Used	Notes (if applicable)
430	Neighbourhood shopping centre - with more than 2 stores attached, under one ownership, without anchor - generally less than 150,000 sq. ft	20mm (3/4”)	
471	Retail or office with residential unit(s) above or behind - less than 10,000 sq. ft gross building area (GBA), street or onsite parking, with 6 or less apartments, older downtown core	15mm (5/8”)	
477	Retail with office(s) - less than 10,000 sq. ft GBA with offices above	20mm (3/4”)	
486	Campground	50mm (2”)	
520	Standard industrial properties not specifically identified by other industrial Property Codes	25mm (1”)	
530	Warehousing	20mm (3/4”)	
625	Nursing Home	100mm (4”)	Manually Investigated to estimate meter size.
626	Old Age/Retirement Home	100mm (4”)	Manually Investigated to estimate meter size.

Table 16 - Meter Sizing Assumptions

4.2.5. Meters by Size

The above-described process determined accounts that required meters and the size of meter at each account as well as the current flat rate accounts where no meters are required (i.e., sub-units in a residential building). The meter sizes and quantities are shown in the table below.

Meter Size	Quantity
15mm (5/8”)	14,983
20mm (3/4”)	1,372
25mm (1")	187
38mm (1.5”)	106
50mm (2”)	139
75mm (3”)	40
100mm (4”)	18
150mm (6”)	4
Grand Total	**16,849**

Table 17 - Meters by Size and Consumption

To allow for assumption errors, five percent was added to the quantity of each meter size required bringing the total of required meters to 17,691 meters.

4.3. Water Meter – Work Types

4.3.1. Water Meter Replacement Recommendation

The Work Types associated with water meters for utilities considering an AMI program is impacted by several factors including meter age, meter reading resolution (i.e., is the data coming from existing meters granular enough to provide meaningful hourly data), budget, and expected revenue gains by changing out meters.

The City of Cornwall has 2,827 existing Neptune meters and R900 radio transmitters. According to information provided by Neptune Technology Group, 2,656 are over 10 years old and none appear to provide the reading resolution required to take full advantage of an AMI investment. An example of the resolution expected from water meter delivering data to an AMI is provided below.

Meter Size	Expected Minimum Resolution	Example – Cubic Meter Registers
5/8" – 1.5"	.001 M3 (litre)	x x x x x x x x ■ — 10K 1K 100s 10s 1 .1 .01 .001 .0001
2" – 4"	.01 M3 (tens of litres)	x x x x x x x x ■ — 100K 10K 1K 100s 10s 1 .1 .01 .001
6" – 12"	.1 M3	x x x x x x x x ■ — 1M 100K 10K 1K 100s 10s 1 .1 .01
16"- 20"	1M3	x x x x x x x x ■ — 10M 1M 100K 10K 1K 100s 10s 1 .1

Least significant encoded digit measures litres

Figure 9 – Example of Register Resolution

In addition, the current version of R900's deployed at Cornwall (v4) do not contain the latest technology likely to be bid by Neptune. Given the age of Cornwall's water meters, accuracy decline in meters over time, the fact they are not expected to provide the necessary reading resolution shown above, and the fact the R900s lack Neptune's most recent AMI technology, it is recommended that these meters are replaced as part of the current water meter and AMI initiative.

4.3.2. Meter Technology Recommendation

Diameter recommends that the City of Cornwall install mechanical meters for Small and Intermediate meters since they are historically proven, do not require a specific replacement timeframe because there is no battery and can be significantly less expensive among these sizes as compared to their non-mechanical counterparts. Since the cost difference between mechanical and non-mechanical meters among these meters is the primary reason for this recommendation, Diameter would recommend allowing for vendors to bid non-

mechanical in the event some choose to price the two technologies the same or comparatively. However, the City has no incentive, as determined by its business drivers, to choose non-mechanical meters for Small and Intermediate meters if the pricing is not comparable.

For Large Meter (75mm (3") and larger) replacements and installations, Diameter recommends non-mechanical meters. Over the long term, non-mechanical meters are reported to provide greater accuracy and revenue since there are no moving parts to wear and therefore maintain their accuracy throughout the life of the meter. This is an important factor for the City's Large Meter population, since these meters (although relatively few) will account for a significant portion of the City's consumption. In Cornwall's case, 75mm (3") and larger meters are expected to comprise ~.36% of the City's meter population but will likely account for 20% or more of the City's consumption based on evidence from other Ontario municipalities.

Many non-mechanical meters also provide standard value-added information not available in mechanical meters including temperature and pressure data that can be transmitted across the AMI network – assuming the meter manufacturer and the AMI solution provider are the same company. In addition, Large non-mechanical meters are generally priced very similar to mechanical meters making them a cost-effective choice all things considered.

4.3.3. Work Types

In the tables below, two Work Types have been provided. Replace Meter involves removing the existing meter in favor of a new one of the same size whereas a New Meter Cut-In is required where no meter exists today. All installations will require an AMI transmitter.

The Work Types numbers were impacted by the following information:

- 1,944 meter sizes provided by the City were able to be imported into the All Accounts database.
- Hyphenated addresses were often individually metered and required an additional 60 meters (53 of which were 15mm, 2 were 20mm, 3 were 25mm and two were 38mm).
- 472 meters were added to account for situations where there were multiple meters at the same address in the Metered Flat Rate Database whereas only one address was included in the Flat Rate database.

Meter Size	New Meter Cut-In	Replace Meter	Install Radio Transmitter
15mm (5/8”)	13,183	1,800	14,983
20mm (3/4”)	1,176	196	1,372
25mm (1”)	46	141	187
Total	**14,405**	**2,137**	**16,542**

Table 18 - Small Meter Work Types

Intermediate Meters (1.5” and 2”) are expected to account for 243 meters of the City’s meter population.

Meter Size	New Meter Cut-In	Replace Meter	Install Radio Transmitter
38mm (1.5”)	2	104	106
50mm (2”)	14	125	139
Total	**16**	**229**	**245**

Table 19 - Intermediate Meter Work Types

Work on the City’s Large Meters consists of mostly change-out as most of these accounts were previously metered.

Large Meter Work Types are outlined in the following table.

Meter Size	New Meter Cut-In	Replace Meter	Install Radio Transmitter
75mm (3”)	7	33	40
100mm (4”)	5	13	18
150mm (6”)	2	2	4
Total	**14**	**48**	**62**

Table 20 – Large Meter Work Types

4.3.4. Quantities Used in the Financial Model

As mentioned previously, the numbers derived for the Work Types outlined above used multiple databases, assumptions and estimations based on property type. To account for actual discrepancies that will be found in the field, Diameter has recommended adding 5% to the Work Types outlined above and the following numbers will be used in the Financial Model.

Meter Size	New Meter Cut-In	Replace Meter	Install Radio Transmitter
15mm (5/8”)	13,842	1,890	15,732
20mm (3/4”)	1,235	206	1,441
25mm (1”)	48	148	196
38mm (1.5”)	2	109	111
50mm (2”)	15	131	146
75mm (3”)	7	35	42
100mm (4”)	5	14	19
150mm (6”)	2	2	4
Total	**15,157**	**2,535**	**17,691**

Table 21 - Meter Quantities by Work Type and Size (includes 5% quantity contingency)

The City should expect that these numbers are estimates based on research and the information provided.

Summary of Diameter Services Guidance in Chapter 4:

- Replace the existing Neptune meters with R900 radio transmitters.
- Install mechanical meters for Small and Intermediate meters; however, it is valuable to allow vendors to bid non-mechanical meters for comparison purposes.
- Choose non-mechanical meters for Large Meter replacements.
- Use a contingency factor on the work types and meter quantities for financial modeling.

5. AMI and Water Meter Technologies

5.1. Introduction

This meter reading technology overview will provide a detailed review of the functionality, benefits and City's implications relating to Advanced Metering Infrastructure (AMI) technology. Although touch pad meter reading and Automated Meter Reading (AMR) are available technologies, they would not provide the advantages the City hopes to achieve, so they have been omitted from this write up.

AMI Technology Alternatives: Meter reading technology is discussed in more detail below and includes the following:

- Fixed Base AMI Technology
- Cellular AMI Technology
- Smart City Technology (e.g., LoRaWAN)

5.2. Radio Transmitters Features and Benefits Overview

Radio Transmitter Alerts and Flags

Algorithms that can detect certain consumption patterns can be performed in either the meter register, the radio transmitter or the Meter Data Management (MDM) software application (when AMI is deployed). For most walk-by, mobile, and some fixed base radio transmitters, these calculations can identify leaks, backflow, or zero consumption conditions. It is important to note that although some manufacturers provide this functionality within the register head, most have moved towards providing this same functionality within the radio transmitter or within the MDM software application (when AMI is deployed).

Leak Detection Flag

When this functionality is within the encoder register or radio transmitter, a continuous leak detection flag checks for changes to readings on an hourly or 15-minute interval (depending on the product) and stores a 1 (if the read changed) or a 0 (if the read did not change). At the end of the day, if all periods hold a "1" then it assumes there was continuous consumption for that day. The algorithm will send a flag to the data collection unit once 30 to 45 days are registered with continuous consumption, indicating that there may be a leak occurring at that property. This will allow the utility to either warn the customer via the water bill, a

phone call from customer service, or web portal to indicate that a leak may be present at their property and that a higher water bill may be the result.

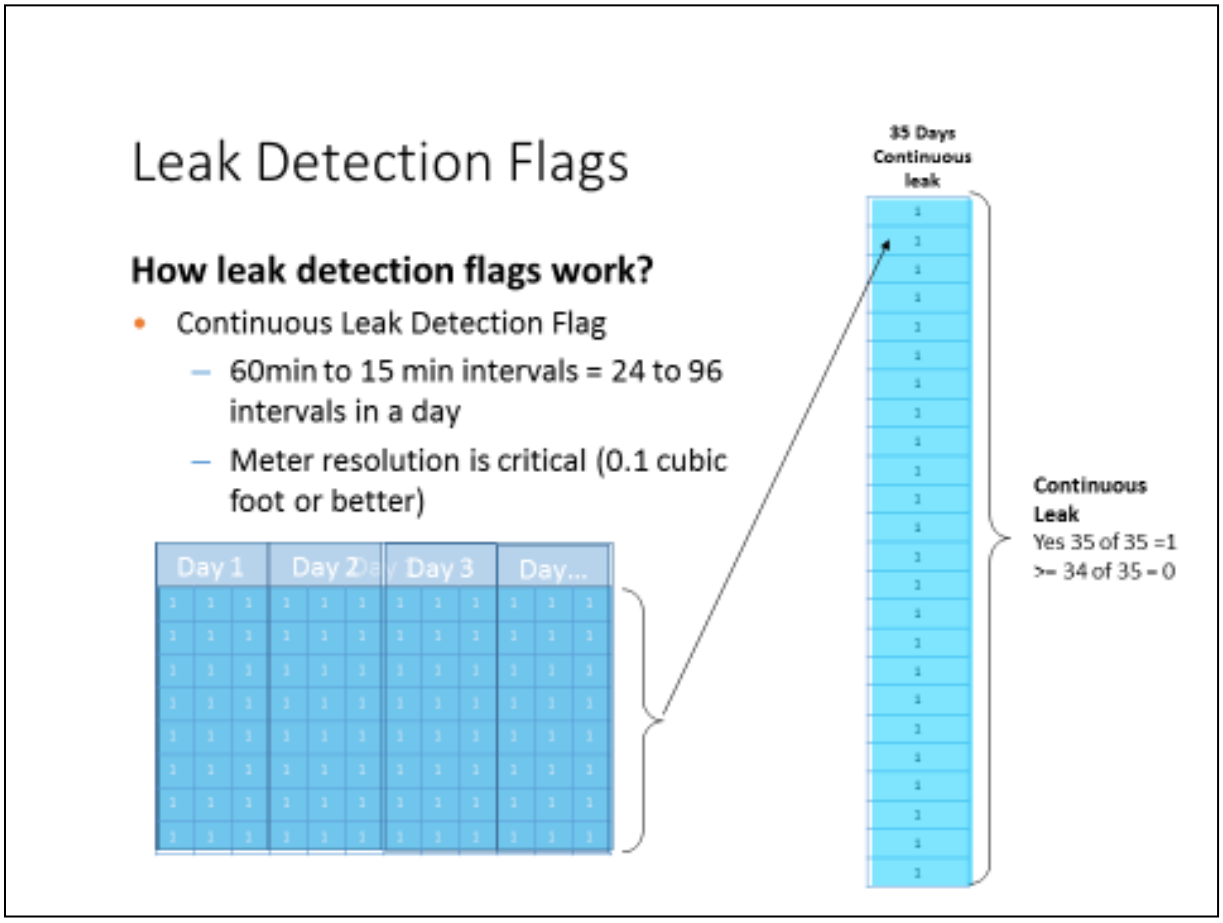


Figure 10 - Leak Detection Flags

For AMI systems, many vendors have moved this continuous consumption algorithm to the MDM software application. It works similarly but has the benefit of being able to reduce the duration of the continuous leak notification to a user defined number of days. Some MDM applications also allow the volume threshold to be increased (e.g., from .001m3 to .01m3) that will allow the Utility to only notify the customers with the bigger private side leaks.

These algorithms are highly dependent on the resolution of the water meter. If only a billable unit (for example m3) is being encoded, then only the largest of leaks or backflows would be detected on large meters and likely not at all on small meters (i.e., the “leak” would have to be at least 17 liters/minute). On the other hand, if the resolution is very low (liter or .001m3) then many customers may experience this flag.

Reverse Consumption Detection Flag

Like leak detection technology, radio transmitters and certain register heads can detect if reverse consumption has occurred or is occurring at a property. This information is sent through the meter reading equipment in the form of a flag. The water utility can then take corrective action to eliminate this risk to the water system. To be detected by the meter, the backflow event must cause the meter to read negative volume. If the register is read every fifteen minutes, then the volume of reverse flow during this time must exceed the volume of water being consumed in a positive direction. Short, small volume backflow events will not normally be detected by these register heads. This feature is best utilized on those high risk, large sized water meter customers who have backflow prevention devices installed on their property that may or may not be operational.

This algorithm can be performed at the radio transmitter or in the MDM application.

Zero Consumption Flag

There are radio transmitter and specific register heads that can determine if zero consumption has taken place for an extended period. With an AMI technology, this zero-consumption duration can be revised in the MDM application, allow the utility to determine when the zero consumption may have started.

Zero consumption may be a symptom of water theft or vacant properties or periods of time where the property is not using water. With this information, the water utility can send staff to investigate the situation.

Low Radio Transmitter Battery Flag

Most manufacturers' radio transmitters monitor the voltage level of their own battery and send an alarm a short period of time before it's expected to no longer function (3 to 12 months). This may provide some notice to the utility to initiate a work order to replace the radio transmitter/battery unit before the battery failure, so that fewer readings are missed.

This flag can either be a time-based flag or an actual voltage reading, that may allow the utility to predict when a radio transmitter is about to fail.

Tamper Flag

Radio transmitters can determine if there is a communication error between the radio transmitter and the encoder register. Some systems can decipher between a cut wire, an incorrectly wired register, and a programming error/issue with the register. In some cases, this flag may alert the utility to a legitimate customer tampering with their meter, but there will be other cases that are unintentional maintenance issues. These flags would initiate a response in the field to investigate and resolve the issue.

Data Logging

Certain manufacturers' radio transmitters store daily and hourly readings for 30 to 40 days. This additional information can be used to resolve customer complaints. This data logging feature can provide the same type of hourly reading information a fixed base system produces for individual customers who may request this information.

This data logging functionality would only be important for a utility implementing AMR mobile technology. AMI technology would transmit all interval consumption data to the MDM, which prevents the Utility from having to attend the property to collect this information. Systems that have this data logging capability often use this data stored as a means to provide redundancy – so if a certain reading is missed due to a RF interference, a future transmission can backfill this interval data.

5.3. AMI Technology – Proprietary RF Overview

The diagram below shows the critical pieces of a Proprietary Radio Frequency (RF) AMI system.

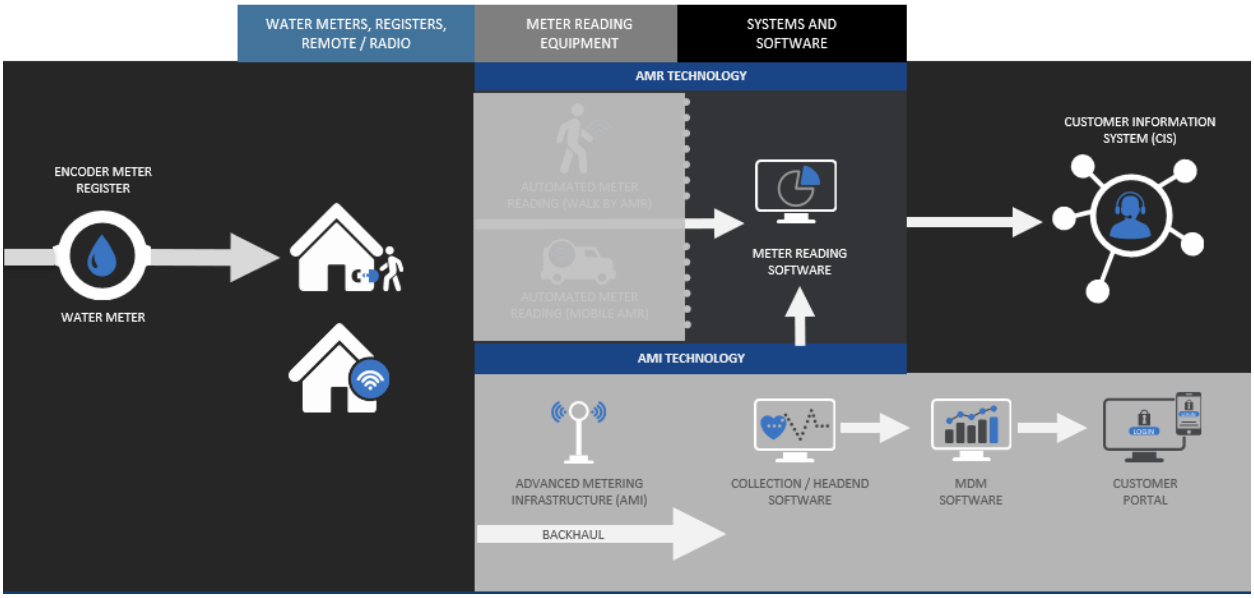


Figure 11 - Fixed Base AMI System Diagram

In a fixed area network (FAN) configuration, radio transmitters are attached to each water meter and are read by permanently installed radio collectors (receivers) or “data collectors (DCUs)”. These RF radio transmitters are based on similar proprietary technology that is prevalent in AMR mobile radio transmitters. All currently marketed AMR technologies have a path to AMI.

The data collectors are strategically deployed in the geographic area by mounting them on poles, towers, or utility owned buildings. The data collectors are connected to the collection software using a wide area network (WAN). The type of WAN varies depending on what the data collector location has available: directly to the City network, fiber or cellular would-be typical examples. The collectors are constantly receiving data from the radio transmitters in the population and providing the information to the head-end collection software.

One of the key differences in AMR mobile technology and AMI technology is AMI radio transmitters provide hourly meter reads (720 rads / month) compared to just one meter read with AMR mobile technology.

5.3.1. Functionality

An AMI system that produces that much data requires additional software applications to collect, process and transform the hourly meter readings into usable information. There are two software applications associated with an AMI solution, Collection software (also known as headend software) and Meter Data Management (MDM) software. Depending on the AMI manufacturer, these

applications may be combined into a single application or sold and implemented separately.

The functionality is discussed in more detail below.

Collection Software

A fixed base network requires collection or headend software that receives all the reading information from the collection network. This software monitors the network devices (collectors and radio transmitters) and can display and report on the different components in the field and their status. It is also passing the daily billable and hourly interval readings required to the MDM application, usually daily. The headend is also typically used to send commands or time synchronization messages to the various components of the network.

Some AMI software vendors limit the number of years hourly consumption data can be stored in this system due to its impact on performance as the database gets larger over time.

Meter Data Management (MDM) Software – Core Functionality

Meter Data Management software is required in a fixed base AMI system due to the large amount of readings and consumption data that needs to be stored, accessed, and reported on. This software can be procured from the AMI vendor as part of the AMI system, as part of a CIS application or separately as a standalone application. The MDM has several functions:

1. Data Repository – The software is optimized to store years' worth of data that an AMI system produces. For an AMI system that provides hourly readings, the MDM will need to store 8,760 readings and any alerts produced by the radio each year for every customer. Analyzing consumption patterns over a period of months or years necessitates the management of a large amount of data that needs to be accessed and reported on quickly. Most utilities store between three and five years of consumption data.
2. Validations, Editing and Estimation (VEE) – Depending on what the data is being used for, a utility may want the software to identify data gaps or problem data and display estimates for that period of missing or suspect data. An MDM with VEE functionality can often define the types of data validations that can be performed, whereby a utility is able to create

routines on how to handle the different situations. For example, if only 50% of the readings were received for a certain period, the validation will identify what is missing and then create estimates for the missing data. This will ensure when a customer graphs the data, it does not appear like there were large periods of no consumption. This functionality is often employed for electric smart meters. For a water utility, this may only be beneficial when displaying data through a customer web portal.

3. Reporting – Another function of an MDM is the ability to produce different types of reports in an efficient manner in comparison to custom SQL queries. Given the amount of data that is accessible, report generation can be problematic and can take up significant IT resources. MDMs provide a standard set of reports, in addition to a custom report builder which allows users to add fields of data or additional criteria and groupings.

The more advanced MDM have built dashboards within their applications to display the data for the user, minimizing or eliminating reports being generated. More and more water-based MDMs are better understanding how to make the data usable and actionable without giving the utility data overload. Water based MDMs continue to see significant development in functionality, which is why most manufacturers are leaning toward Software as a Service (SaaS), to allow for an agile approach to software development.

1. Utility Management – MDMs used for water utilities usually have modules that perform water utility functions such as: district metering, leak detection, misapplied meters, and water consumption program monitoring. Ideally, the MDM will have a Reports and User Interface application that will allow the user to easily use and modify this functionality.
2. Water Customer Web Portal – To improve customer service, utilities are now providing online access to the consumption data of their rate payers. This can be achieved in many ways, either by passing the consumption data to the CIS or third-party customer engagement web portal, or in some cases, the MDM can allow customers to login directly and view their consumption. The issue with providing customers with this type of access, is that there is a limit to what a customer can view, and a large number of Customer Accounts are required. Utilities are moving towards more advanced customer engagement software that allow water customers to enroll in programs, and view water bills, payment history, service requests

on their account, as well as consumption history. A standalone MDM usually does not have all these capabilities.

MDM and collection software can also be interfaced with other utility systems such as geographic information system (GIS), supervisory control and data acquisition (SCADA), 311/CIS and works management software. These interfaced connections to other systems need to be well planned to ensure the costs and effort to develop the interface is matched or exceeded by the benefits provided. For example, it may be very critical to be able to open a work order for field personnel to investigate a high-water consumption event that the MDM has identified. In this case, an interface from the work management software to the MDM may avoid manual entries and multiple staff engagement steps to resolve the problem in the field.

Meter Data Management (MDM) Software – Enhanced Functionality

Larger utilities often have options beyond an AMI vendor supplied MDM. For example, many Customer Information Systems (CIS) have an integrated MDM to make data management and implementation easier.

Some larger utilities have also decided to procure a best-in-class MDM, which required them to have a separate procurement for MDM. This allows the utility to choose the MDM that best meets the desired functionality.

The enhanced MDM functionality can include the following elements:

1. Meter and Radio transmitter asset management – the MDM can store all water meter and radio transmitter assets. This links the account and premises numbers associated with the CIS used for water billing. Some asset management applications can store maintenance history, RMA, warranty and testing information.
2. Service orders based on the asset – once an asset has been identified as having a potential issue, the MDM would allow the utility to issue a service order to investigate and repair the asset. Depending on the MDM, this functionality may only issue the work order and may rely on a separate existing utility work order system in the field. It varies vendor by vendor.
3. Customer relationship management: the MDM would hold key customer information that is associated with the account and premises. This would allow communication to be sent to specific or a subset group of customers (boil water alert, water outage, water conservation messages)

4. Water billing and collection: where the MDM is an integrated application with the CIS, some water utilities implement MDM prior to CIS, then build on the functionality at a later date.

Data Collection Network

Establishing the data collection network of a fixed base system can be one of the more challenging parts of a deployment effort. This is not because data collector installations are difficult, but finding and getting the appropriate approval for locations that meet all the right conditions to allow the AMI network to collect readings for the metered population is often much more difficult than utilities anticipate.

Propagation and Redundancy –

Planning the right amount and location of equipment is determined through a propagation study performed by the manufacturer of a proposed solution. This “prop” study provides a theoretical performance of the system based on many factors including: the topography of the geographic area being covered, the strength and frequency of transmissions, location of the radio transmitter (inside or outside) and the number and location of data collectors. Once a radio transmitter is installed, there are many factors that can block or redirect transmissions and prevent a data collector from hearing the signal. An AMI system requires redundancy to ensure that if one data collector misses a radio transmission, another is in a position where it can receive it. This is achieved by having overlapping coverage areas where every single radio transmitter can be heard by at least two different data collectors where possible or practical.

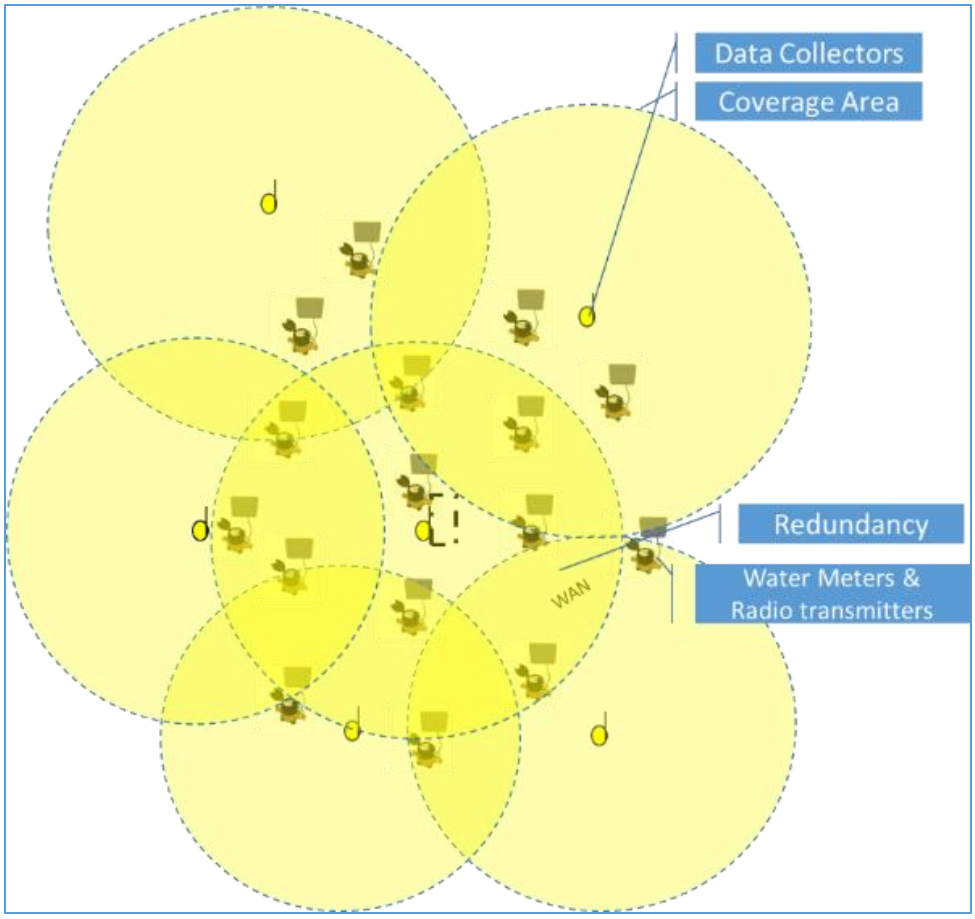


Figure 12 - Overlapping Data Collection Coverage Areas

Data Collector Location and Approval – Most utilities prefer to mount the system's data collectors on buildings, pump houses and water towers that the utility or City owns. Installing data collectors on the roof of these locations (buildings, pump houses, water towers, schools, fire and police halls, etc.) often avoids rental fees when installing the device.

Alternating current (AC) power is also (usually) readily available and relatively easy to wire to the device. Another advantage to these locations is that the utility's intranet may be available for backhaul, eliminating additional data costs. To achieve the level of redundancy required, it is very likely that these locations will not allow for the propagation study to cover the entire area and more locations will need to be considered.

After considering its own buildings, most utilities review the installation of data collectors on existing power or light poles that the utility owns and controls. Depending on where the poles are located, this infrastructure may be the next

cheapest way of installing a collector. Installation on these types of poles may require additional costs for connection (including electric meter) to the electric grid. Some systems allow for optional solar panels to power the collector to avoid the need for a direct link to AC power.

After all building and pole locations have been exhausted the next option would be for the utility to install new 30' to 90' poles (usually the higher the better) in the areas that have no available locations to install a data collector. This option may be frowned upon because it is usually not popular with the public or politicians to install new poles. Irrelevant of how unappealing this option is, a certain portion of the network will likely require newly installed poles to get full redundant coverage. The utility should position this option as a reality when selling the concept of a fixed based system.

Engineering Drawings and Approvals – Understanding the complete approval process that must be taken to install data collection equipment is important. Often very specific engineering drawings are required for approval and some municipalities may not have a defined process for approving network locations and installations. Some approval processes require extensive review or public notices and input.

Ensuring the process for approval is clear and well documented, regardless of the type of data collector, is vital for a smooth deployment.

Wide Area Network/Backhaul – When planning for a fixed area network, backhaul consideration is required to allow the collectors to pass data back to the collection software. Usually, the most cost-efficient WAN process would be to connect the data collection unit (DCU) to the utility's intranet using a secured modem. This option would eliminate any additional data charges; however, it could also introduce some network security risks. A utility may also have an existing fiber optic network that can allow access to their intranet. If this is the case, then the access points would need to be identified, so preferred locations could be planned around them. Cellular is often the most popular way to backhaul a data collector, especially if the data collector is installed on poles or privately-owned properties or if the headend software is implemented as a Software as a Service model.

5.3.2. Features and Benefits

There are many manufacturers of fixed base AMI systems with some providing a unique set of features and functionalities. RFP specifications may reduce the number of systems that could compete during the procurement process. A list of necessary or preferred features would need to be discussed prior to procurement when specification documents are being developed.

Radio Transmitter Alerts and Flags

Fixed base radio transmitters may have algorithms within the radio transmitters that allow for various flags. Some fixed base systems have not added this feature to their radio transmitters as the same functionality can be achieved at the collection/headend or MDM software by analyzing the hourly consumption data. The benefit of performing these functions through the software (collection or MDM) is that the utility can more easily change leak detection thresholds. As an example, if identifying continuous consumption of a litre per hour creates too many events, the utility could easily alter how leaks are determined – i.e., more consumption per hour over a longer time frame. The second advantage of performing customer side leak detection with an AMI system is you do not need to wait for the water bill to identify a leak has occurred, the MDM can be configured to trigger an alarm over a much shorter time frame (say 3 days), so the alert being sent to the customer can better avoid high water bills and wasted water.

Data Logging

With a fixed network system, hourly read information is delivered to the collection software, so there is limited value to having the radio transmitter store reading information. Some systems have designed their radio transmitters to store readings, which can act as another means of data redundancy within the overall system. These radio transmitters will transmit past readings as well as new ones, so if a transmission was not heard by a data collector, the headend software can backfill these readings during a future transmission.

Software as a Service (SaaS) versus On-Premises Software

Most providers of Data Collection, MDM and Customer Portal software applications only offer solutions through either a Software as a Service (SaaS) or a hosted software, both of which allow software to be accessed through the cloud

while the application itself is hosted in a professionally managed data centre. The benefits to this industry change are:

- Easier for the Vendor and the Utility to maintain the software.
- Moves the responsibility of patches and testing away from the Utility.
- A combination of SaaS system and agile software development allows the Vendor to push out additional functionality gradually without the Utility needing to configure the next version of software.
- No hardware or servers are required to maintain.
- Limited initial licensing fees.

These benefits do come with some drawbacks:

- SaaS fees are often calculated based on the number of radio transmitters, and over time it is a more costly licensing model.
- Software customization has been almost eliminated; Utilities who have a unique functionality would need to rely on an API to access the data. User interfaces can usually be configured, but customization of software screens is no longer allowed.

The benefits of SaaS far outweigh the drawbacks and this change of approach by the industry has been a good thing.

Time Synchronized Readings and Two-way Communication

All currently marketed AMI systems are considered two-way communication systems. The functionality of two-way AMI systems is:

Time Synchronized Top of the Hour Readings – "clocks" in radio transmitters tend to drift and become inaccurate. Synchronization ensures that the timestamping of consumption is accurate, but it requires a two-way radio transmitter to receive the time stamp from the network. Meter readings can be time synchronized to allow all readings in the utility's network to be read at the same time. An AMI system schedules these readings at the top of the hour, which allows hourly consumption periods to be easily compared.

On-demand Read – Many AMI systems allow a utility to request an on-demand reading from the water meter anytime it is requested. This feature could be beneficial to a utility if their billing agent is talking to a customer and requires a reading at that very moment. Most utilities are looking to obtain readings for final

bills and a daily read pulled from the data collector would suffice. Final bill reading can be accomplished by both a one-way and two-way system.

Remote Shut-off Valves

A two-way AMI system can allow a utility to install remote shut-off valves for certain customers who have a history of non-payment or other By-Law violations. These valves would be able to reduce flow to a site or turn off completely without the need for someone to attend the property.

Installation of these devices may be more challenging, as they will likely require changes to the meter setting or installing a specific manufacturer's water meter that includes a remote shut-off device within the meter itself. Also, once a utility moves to device management, it is usually necessary to add a higher level of encryption to the system's radio transmissions which adds complexity and cost to the solution. It is unlikely a water utility would want to install these devices on 100% of the population due to the costs involved.

Some water meters are coming out with remote shut off capability within the standard water meter lay length, which would address some of the increased cost of installing this feature.

Some good applications for these products would include:

- Tenant properties with high tenant turn over. Some university or college areas may have many new water customers every year and it could be challenging and costly to utilize collection agencies and moving charges to Tax Roll.
- Master and child meters, some utilities have properties with a single curb stop but multiple customers, so if a single customer does not pay their bill there is no means for the utility to shut them off.
- Seasonal services – where the water is shut off and turned on twice or more each year, having a remote shut off meter may help reduce truck rolls.

Acoustic Leak Detection

An optional addition to a fixed base AMI system is the installation of acoustic leak detection (ALD) devices across part or all the utility's water system. These devices could be permanent or temporary installations where the devices are picked up and relocated on a regular basis. These devices measure the noise of

the water flowing in the system and sends these acoustic readings through several radio transmitters in the network. It will then make its way back to a leak detection software that will place each device on a GIS map. Leaks in the system are detected by the pitch and change in acoustic readings from each reporting device. Typically, depending on the density of the devices and the type of material used for the water mains, an ALD device would be installed for every 10 water meters in the system.

Temperature and Pressure Gauge

Water utilities have expressed interest in receiving temperature and pressure readings from more locations within their service area and pressure zones. This additional information can help better manage their system in several different ways.

Temperature: A water utility whose temperature can drop below freezing may benefit from having temperature readings from meters situated in meter pits by way of alerts of potential freezing events. Temperature may also help a water utility in hotter climate better understand their chemical levels in various parts of the system.

Pressure: Water utilities with numerous pressure zones or limited SCADA points find it expensive to collect pressure readings. Pressure readings collected in more locations of a water system provide several benefits:

- Better response to customer's water pressure complaints.
- Drop in pressure as an indicator of main or water service breaks.
- Pressure readings within the water utilities hydraulic model to better understand the distribution system.
- Reduce pressure within specific pressure zone to reduce the leakage within the system while still maintaining minimum fire pressure levels.

Although this is still in the development phase with some vendors, the functionality will be more widely available in the future. Pressure and temperature readings are achieved through a separate device that would need to be installed on the water systems. Some devices lay length would allow them to be installed with a shortened 15mm (5/8") or 20mm (3/4") water meter. This allows these devices to be installed in the existing lay length.

Other manufacturers are developing their non-mechanical water meter (C715-18 Cold-Water Meters – Electromagnetic and Ultrasonic Type, for Revenue Applications) that include a temperature and pressure sensor within the product itself.

It should be noted that some manufacturers have limited the meter's ability to pass this data to competitive AMI radio transmitters, so if this functionality is part of the business drivers it should be included in the quantities required within the AMI procurement.

5.3.3. City of Cornwall Implications

It is recommended that the City implement AMI technology to fully achieve the 17 of 20 business drivers ranked as important or critical. This solution should include AMI vendor provided radio transmitters, AMI network (City owned or third party) and vendor provided City owned Meter Data Management (MDM) software. However, none of district metering, pressure or temperature monitoring were ranked as important or critical during business driver discussions and the City's ability to control pressure in individual areas is limited given there is only one pressure zone within the City of Cornwall.

5.4. AMI Technology – Third Party AMI Network Overview

A third-party AMI network would be owned and operated by someone other than the City, but the City would leverage the network for its AMI deployment. The typical third-party AMI network options include:

- *Cellular AMI network:* where the cellular radio transmitter communicates directly to the cellular provider that has adequate coverage across the service territory.
- *Overlapping Utility AMI network:* where the local electric or gas utility has already implemented an AMI network and the water utility chooses the same AMI technology with the same RF frequency.
- *Vendor AMI network:* where the AMI vendor proposes to own and operate the AMI network long term.

In most cases, a third-party AMI network eliminates the need for new data collectors to be installed. The radio transmitters transmit directly to the existing network. If the property has coverage, the radio transmitter can be heard and transfer the readings to the AMI Vendor's hosted headend software. This hosted

headend software would have the same functionality as the data collection software discussed earlier. Although, when the water utility does not own the data collection software, often Third-Party network providers may restrict access to the software application.

5.4.1. Functionality

Cellular AMI Network

Not all AMI vendors have a cellular AMI system available for the water market. Most vendors are working on having cellular radio transmitters to augment coverage (i.e., gap fill) for their dedicated fixed network. There are some benefits to using a cellular network, including not having to worry about maintaining a separate fixed network and no additional backhaul costs.

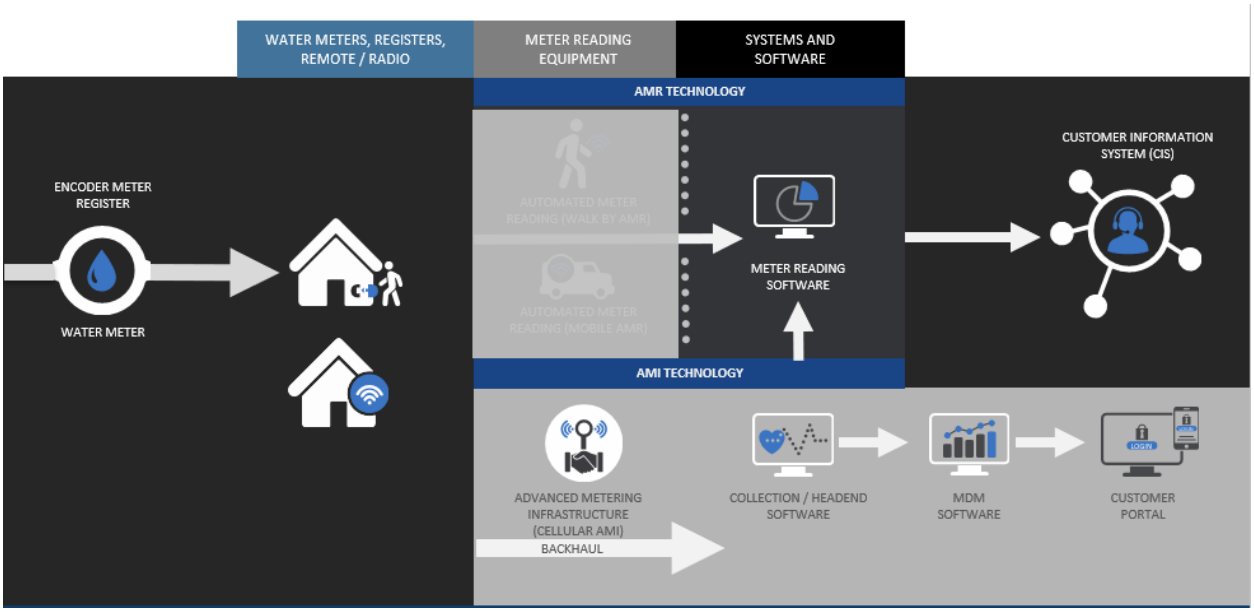


Figure 13 - Cellular System Diagram

A number of AMI vendors do market cellular radio transmitters using the CAT-M chip, but some limit the product warranty and may not support a 20-year product life. Where the cellular product is supported by a 20-year warranty (10 full replacement value + 10 prorated replacement value) and the price of the radio transmitter is market competitive, this technology may compete with other proprietary RF systems or be provided in a hybrid model where a percentage of the cellular radio transmitters are installed in low density areas.

The cost of a cellular system needs to be evaluated over the full 20-year life, due to the fact the annual cost to operate this system can be higher than that of a

standalone RF system. In recent procurements, the cost of both the cellular product and the on-going operational costs have continued to decline, making them more competitive with RF systems. Usually, cellular AMI systems are more cost effective for small water utilities (less than 25,000 services).

Another option for deploying cellular radio transmitters can be to parts of the distribution system where the meters are dispersed or there is no cost-effective data collector location. Included in a hybrid type application, this technology can have benefit to keep the overall system cost lower.

The last limitation that should be highlighted is regarding latency. A cellular radio transmitter is not always awake, so the latency of a command (remote shut off) could be delayed between 4 and 24 hours depending on the vendor.

Overlapping Utility AMI Network

As water utilities start to contemplate whether to implement AMI, they often look for efficiency in partnering with the local gas or water utility. If the water utility is a stand-alone utility and is not a multi-commodity utility, the reality of cost savings is often smaller than expected. The entire cost of an AMI system consists of radio transmitters (85% of the total cost), AMI network (10% of the total costs), AMI software and implementation (5% of the total cost). If the water utility chooses this technology outside a procurement process, there would be limited pressure of the radio transmitter price due to a less competitive situation, which could quickly raise the cost of the overall system.

We would recommend a water utility selecting a third-party system within a procurement process and have the AMI provider partner with the AMI vendor (manufacturer) and propose a third-party as an overall solution. This allows a water utility to compare third-party solutions with other AMI solutions.

Vendor(s) with an Existing AMI Network

AMI vendors will provide the option to own and operate the AMI network on behalf of the City. Although this option typically comes at a higher cost, it could be incorporated in procurement documents and compared against City owned AMI networks.

These Third-Party AMI systems are dependent on an agreement with a Third-Party AMI provider and specific vendors. The interface between the cellular provider and the Vendor will limit a utility’s ability to purchase endpoints from

various vendors. In essence, these systems operate similar to proprietary RF vendor products with limited access to their RF protocols. Both situations force a water utility to select products from a single vendor with limited ability to apply competitive pressure.

There is a specific risk associated with cellular products that the agreement with the cellular provider is limited and may not be disclosed by the AMI vendor. Unless the product has the ability to have more than one cellular chip, there is a small risk of the products being stranded prior to the end of its useful life due to the cellular vendor no longer supporting the products. To address this risk, water utilities need to require the AMI vendors to extend their warranty to include cellular network availability for the full products life.

The other functionality discussed in AMI Technology Propriety RF relating to headend software and MDM still apply to a cellular system.

5.4.2. Features and Benefits

The features and benefits should be the same as a Proprietary RF AMI system, as detailed in Section 5.3.2, although some variance may exist based on the third-party cellular AMI vendor.

5.4.3. City of Cornwall Implications

There are no known existing AMI networks or electric utility AMI systems deployed in the City of Cornwall. Cellular AMI may be a proposed solution that the City can consider either as a full network solution or a hybrid solution, installed in combination with a standalone AMI network.

5.5. AMI Technology – Smart City (LoRaWAN) Overview

The diagram below shows the critical pieces of a Smart City (LoRaWAN) AMI system.

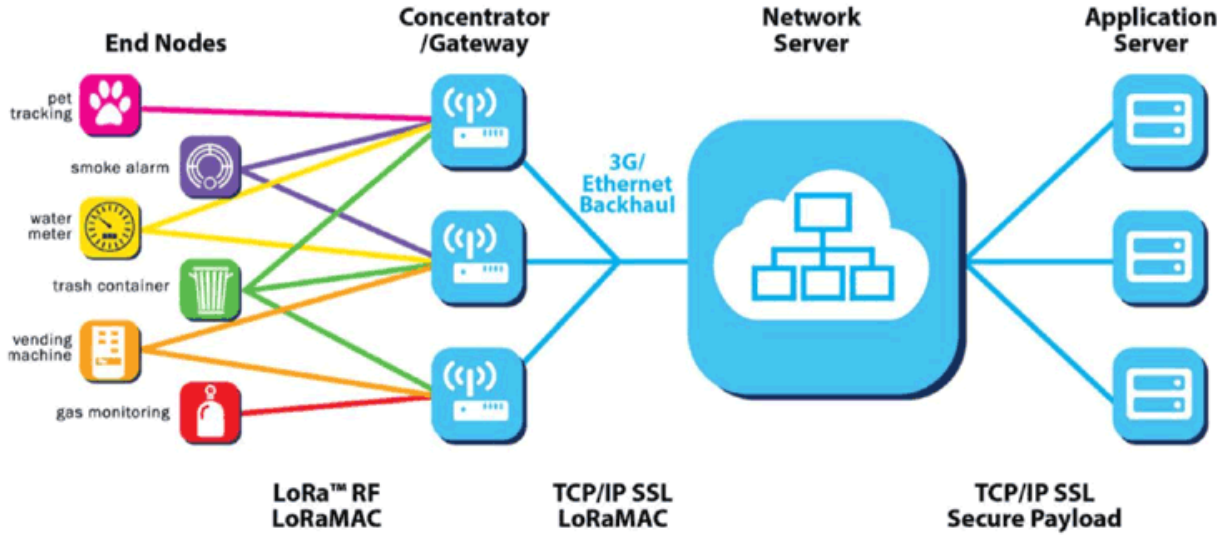


Figure 14 - Smart City System Diagram

5.5.1. Functionality

LoRaWAN™ is a Low Power Wide Area Network (LPWAN) specification intended for wireless battery-operated things to communicate within a regional, national, or global network.

The LoRa Alliance is an open, non-profit association that is looking to create a global standard for Low Power Wide Area Networks. These networks are being deployed around the world to allow internet of things, machine to machine communication and smart cities models to be widely adopted. The alliance which is made up of industry leaders and organizations of all types have adopted the LoRa protocol, LoRaWAN.

The LoRa alliance has a primary goal “to standardize LPWAN and through standardization enable large scale volume IoT deployments. The LoRaWAN® ecosystem will enable product availability, the LoRaWAN® Certification Program will ensure interoperability and both are due to members collaborating together on the LoRaWAN® standard.”

This is not to say that all LoRa devices will automatically communicate across all LoRaWAN networks. As the diagram indicates, different deployments of LoRaWAN networks will deploy different network servers and by extension different network management software (NMS). Examples of NMS include OrbiWise, Senet and The Things Network. These network management systems

perform tasks such as device authentication, network monitoring, maintenance and security, and firmware upgrades as a few examples. The “application server” software would provide data collection and user applications from the end nodes. However, the vendors for each end node device must work with the network management software providers to have their devices certified and ensure it can effectively operate across the network deployment.

5.5.2. Features and Benefits

The features and benefits should be the same Proprietary RF AMI system as detailed in Section 5.3.2, although some variance may exist based on the third-party cellular AMI vendor.

5.5.3. City of Cornwall Implications

There is no known existing LoRa network that covers Cornwall’s service territory. AMI vendors proposing a LoRa technology would be proposing either a Vendor owned, or City owned LoRa network. A City owned LoRa network would be similar to a Proprietary RF network; if they proposed an AMI Vendor owned LoRa network, it would be similar to the third-party network.

5.6. Water Meters

5.6.1. Technology Introduction

Metrology within the water industry has been around for more than 100 years, and some of the original types of measurement technology continue to be used today. This section will explain how each type of measurement works, the history of measurement products, product availability, and key advantages and disadvantages associated with each type of measurement. Lastly, key specifications related to each type of technology will be compared.

5.6.2. AWWA Specifications

American Water Works Association (AWWA) is an industry organization that provides manufacturer guidelines for many of the water meters used today. Some newer technologies have just recently been approved. These specifications provide water utilities with a common set of key characteristics (lay length, types of threads, type of material, etc.) and performance standards (accuracy at certain flow rates) that can be applied for comparison purposes during competitive procurement.

It is important to note that AWWA does not make recommendations nor state preferences with respect to the type of meter technology, nor does AWWA validate that meter manufacturers adequately comply with the AWWA specifications. The water meter technology selection and validation functions, therefore, remain the responsibility of the water utility.

There are two categories with respect to the types of water meter technology: 1) mechanical measurement, and 2) non-mechanical measurement. The AWWA specifications for each category are described below.

- AWWA Standards for Mechanical Measurement
  - C700-15 Cold-Water Meters – Displacement Type, Metal Alloy Main Case
  - C708-15 Cold-Water Meters – Multi-jet Type
  - C710-15 Cold-Water Meters – Displacement Type, Plastic Main Case
  - C712-15 Cold-Water Meters – Single-jet Type
- AWWA Standards for Non-mechanical Measurement
  - C713-15 Cold-Water Meters – Fluidic Oscillator Type
  - C715-18 Cold-Water Meters – Electromagnetic and Ultrasonic Type, for Revenue Applications

Water utilities usually opt to use these standards during water meter procurement. Although these standards represent different types of measurement technology, many have similar applications. Some water utilities consider meters from different AWWA standards as comparable, thus different types of technologies (and AWWA standards) would be price comparable. Other water utilities restrict their procurement to a single AWWA standard for a single type of application. Because there are many manufacturers that produce meters that comply with each standard, this has a limited impact on the competitiveness of the procurement.

Although multiple standards may be allowed, the meter performance and pricing may vary depending on the meter standard being used. Notably, the most common standard used in North America is the C700-15 positive displacement meter. Often water utilities restrict their residential water meter procurement to only allow meters that meet this standard. It is up to the water utility to decide which water meter standards will be allowed based on their experience and the

manufacturer's stated product benefits.

5.7. C700-15 Cold Water Meters – Displacement Type, Metal Alloy Main Case

5.7.1. Description of Measurement

Positive displacement type water meters measure the actual volume of water that flows through the measuring chamber. There are two types common in the North American industry: nutating disc and oscillating piston. Both the nutating disc and the oscillating piston measure volumes of water; the method in which they do so, however, differ slightly. Figures 12 and 13 below display how each type works.

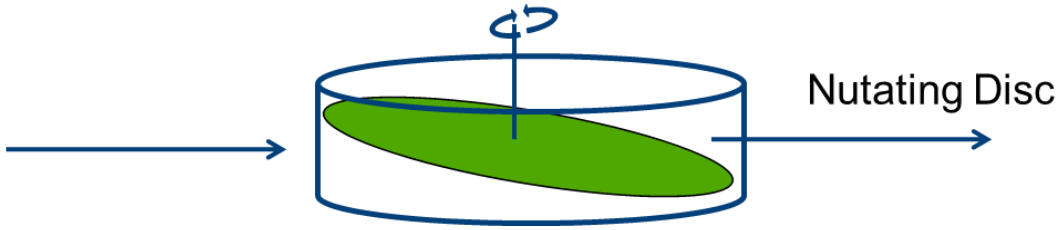


Figure 15 - Nutating Disc Position

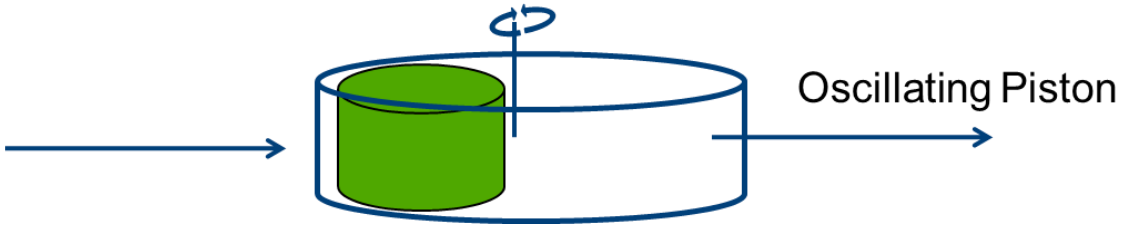


Figure 16 - Oscillating Piston Position

As the disc or piston rotates around the axis, it turns a magnet. This movement is detected by a corresponding magnet located in the register head. For each manufacturer, a known number of rotations equal a unit of measure.

These meters are typically installed in a horizontal orientation, although manufacturers of piston type meters often also market a warranty for vertical installations. Nutating disc meters have been known to extend their warranty for vertical installation in special situations where this is a mandatory requirement.

5.7.2. History

Positive displacement type of measurement is the oldest (over 100 years in use) and most popular type of water meter used in North America. The patent for the

nutating disc meter was filed by James A. Tilden in 1887 and 1888. The oscillating piston meter by Lewis N. Nash in 1884 – this was adapted from older designs. It has proven to be a resilient and long-lasting water meter, with an expected life of between 15 and 25 years depending on the quality of the water it is measuring.

5.7.3. Market

There are five major domestic manufacturers of the positive displacement type water meters (with brass bodies). These manufacturers include Badger Metering, Master Meter, Mueller, Neptune Technology Group, and Sensus Water Meters.

5.7.4. Advantages

Positive displacement type water meters are the most popular type of water meter in North America; most large water utilities rely on these meters for many of their residential applications.

These meters have good accuracy at low flows, with AWWA standards requiring these meters to achieve between 98.5% to 101.5% accuracy when measuring normal operational flow ranges (0.5 to 25 gpm). Many water meters manufacturers exceed this standard, either by exceeding the accuracy thresholds, or meeting the accuracy standard over a larger flow range. Different manufacturers publish slightly different performance specifications; however, at minimum, all major meter manufacturers meet the published AWWA specification requirements.

The positive displacement water meters do not require a power source to measure flow. The registers for some positive displacement water meters are powered by batteries; however, the measurement of flow is not dependent on this battery power source.

It is very rare for a positive displacement meter to over-register consumption. This provides some confidence to the utility that if a meter is inaccurate, it is to the benefit of the customer. If over registration occurs, it is usually due to an incorrect water meter register being installed on a small sized water meter.

5.7.5. Disadvantages

Positive displacement water meter chambers and discs/pistons wear over time. As these meters wear, they become less accurate. Depending on the quality of the water it measures, the life of a meter is usually between 15 and 25 years. At

this point, replacing older meters with new ones is likely to have a reasonable payback of around five years.

Because mechanical water meters have moving parts, they can sometimes make noise as water moves through the meter. Residents may complain of a ticking sound that can vibrate throughout the plumbing of the property.

The tolerance between the disc/piston and the measuring chamber is quite tight; if debris is in the water, it can jam the water meter, stop the disc/piston from turning and the restrict the available flow. When this occurs, the meter stops registering consumption and requires a repair/replacement.

5.7.6. City of Cornwall Implications

The City currently has a number of positive displacement water meters installed, ranging from 15mm to 50mm in size.

These products continue to be very reliable and cost competitive technology. The City should continue to utilize these where horizontal installations are possible.

5.8. C710-15 Cold Water Meters – Displacement Type, Plastic Main Case

5.8.1. Description of Measurement

Refer to Section 5.7.1 for the description of cold-water meter operation.

5.8.2. History

The market was influenced by factors including NSF/ANSI 61 Annex G and Annex F certification, and the Safe Drinking Water Act (NSF 372) that became effective January 4, 2014. Meter manufacturers needed to comply with providing lead free alloy. As the price of metals continued to rise, some meter manufacturers tried to lower meter cost by replacing a brass body with plastic or composite material.

5.8.3. Market

There are three major domestic manufacturers of positive displacement type meters constructed with plastic or composite material bodies. These manufacturers include Badger Metering, Mueller, and Sensus Water Meters.

5.8.4. Advantages

Replacing the brass body meter (C700-15) with a plastic/polymer/composite body can reduce the cost of the water meter between 5% and 10%.

All other advantages are the same as outlined in Section 5.7.4.

Some manufacturers' composite/polymer meters have a break pressure rating that is higher than the rating for a similar brass meter. Main case strength may have limited benefit to the utility because both meters' break pressure far exceeds normal utility operating pressure.

5.8.5. Disadvantages

One of the main issues related to plastic main cases is cross threading. Installation issues are encountered when the plastic meter is threaded with brass meter tailpieces. If the meter is not aligned perfectly, the threads can be cross threaded, which make the meter unusable until either the threads are repaired, or the meter is replaced. Cross-threading is not typically covered by warranty.

A second disadvantage reported by utilities is the inability for plastic/composite/polymer meters to withstand over torquing. Often a brass meter can withstand some torque due to the somewhat malleable nature of brass, whereas plastic/composite/polymer meters may break when subjected to the same conditions.

These meters also have the same disadvantages as described in Section 5.7.5.

5.8.6. City of Cornwall Implications

Given the City has a large number of properties that require plumbing modifications to the piping using solder and a torch, there is a chance of meter damage during the initial installation. For these reasons, despite being more cost effective, we would only recommend considering a metallic meter as the primary bid.

5.9. C715-18 Cold-Water Meters – Electromagnetic and Ultrasonic Type

5.9.1. Description of Measurement

The AWWA standard applies to both Ultrasonic and Electromagnetic meters.

Electromagnetic meters measure the change in voltage due to ion movement through a magnetic field. Additional features can be incorporated such as temperature, pressure, alarm conditions and remote shut-off within the existing meter lay length. A battery is required to power the sensors that detect water flow. The battery has a 20-year warranty, typically represented by a “10/10 warranty,” which covers 100% of the replacement value for the first 10 years, and a prorated replacement value for years 11 through 20. This battery is typically “potted” and not replaceable.

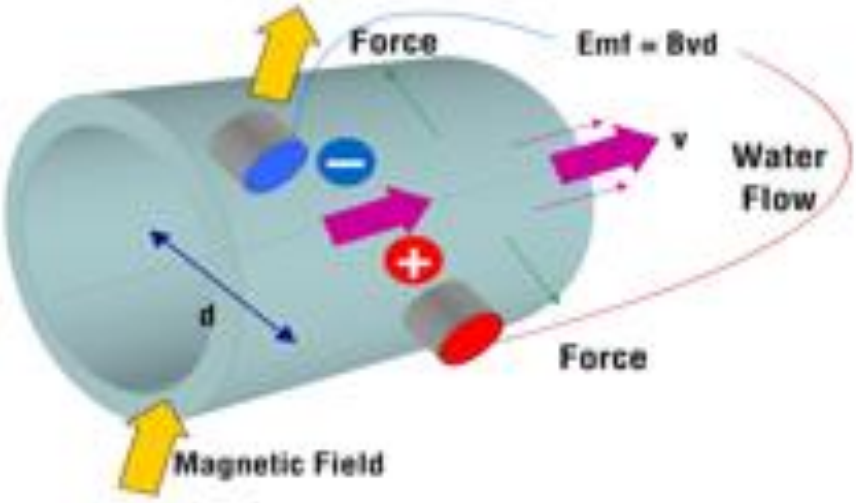


Figure 17 - C715-18 Cold-Water Meters Electromagnetic and Ultrasonic Type, For Revenue Applications (Courtesy of Sensus)

Ultrasonic meters measure the time it takes for a sonic pulse to travel between two transducers. Pulses reflect off particulates in the water. Additional features can be incorporated such as temperature, pressure, alarm conditions and remote shut-off within the existing meter lay length. A battery is required to power the sensors that detect water flow. The battery is typically covered by a 20-year (10/10) warranty, structured where the warranty provides 100% of the replacement value during the first 10 years, and prorated replacement value for years 11 through 20. This battery is typically “potted” and not replaceable.

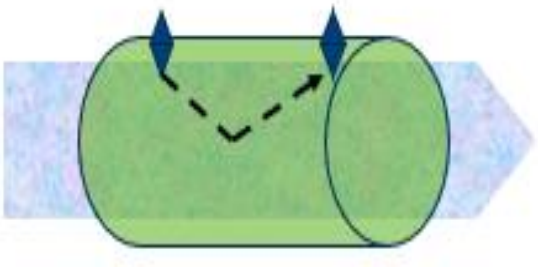


Figure 18 - Ultrasonic Meter

5.9.2. History

Electromagnetic consumption meters have been available in the market for about twenty years. Ultrasonic consumption meters have been readily available in the North American market for approximately five years, in sizes up to 2-inch. AWWA standards have just been approved, and C715 was approved at the AWWA Annual Conference and Exhibition in 2018.

5.9.3. Market

Electromagnetic meters: The only major manufacturer of residential electronic magnetic meter is Sensus Water Meters.

Ultrasonic meters: The major manufacturers of ultrasonic meters include Badger Metering, Diehl, Itron, Kamstrup, Master Meter, and Neptune Technology Group.

5.9.4. Advantages

One of the key features of non-mechanical meters over positive displacement meters are improved accuracy at very low flows, and very limited deterioration of accuracy over time.

They also offer some additional features and functionality, depending on make and model, including:

- Temperature reading
- Alarm conditions such as: Empty pipe, reverse flow, tamper, low battery, leak detection, etc.
- Pressure reading

Although these may not apply to all manufacturer products, the additional functionality described above of these meters has expanded beyond just meter readings.

The accuracy of the meter over time will not show any degradation. In theory, the meter should be as accurate at year 19 as it was on the day of shipment. So, there are no lost revenues over time, and the expected replacement date is defined which aids in capital planning.

5.9.5. Disadvantages

A key consideration is that this technology requires battery power to measure water flow. Typically, manufacturers offer a 20-year warranty. It is important to understand that these meters will have a known and firm product end date. This changes the water utility practice of performing meter accuracy sampling to determine the optimal replacement age. Meters in this class must be replaced prior to the end of their pre-determined (based on battery) meter age.

Although this meter type is not new to the water industry, this is a new application of this meter type, and hence there is less history of performance and problems. It is not known/field proven if these meters will prove reliable long term.

The market has shown that electronic and ultrasonic meters are typically more expensive due to lower manufacturing volumes as well as selling to water utilities based on some of the enhanced functionality. It is expected that these meters will eventually be competitively priced with positive displacement meters, but without a larger purchase volume, presently it is difficult to get the product cost to levels of a positive displacement meter.

5.9.6. City of Cornwall Implications

Non-mechanical water meters are still considered a premium offering and will likely come at a higher cost. These meters will come with better accuracy over the finite 20-year product life and may come with additional functionality not available in a mechanical water meter.

Non-mechanical water meters have the benefits of being able to be installed in any position (horizontal, vertical, angled) without impacting water meter accuracy. This meter setting flexibility could potentially eliminate the need for a meter horn or additional plumbing.

Depending on budget, consideration for 100% non-mechanical meters should be considered during the procurement specification development stage.

5.10. Water Meter Specification Comparison

The table below shows a comparison of key performance specifications and characteristics of each type of meter technology.

Consideration	Positive Displacement	Electro Magnetic	Ultrasonic
Age in market (yrs.)	>100	~20	~ 2 - 5
Estimated meter life	20 to 30 soft EOL	20 Hard EOL	20 Hard EOL
Flow Range	.5 to 25 GPM (at +/-1.5%)	.11 to 25 GPM (at +/-1.5%)	.1 to 25 GPM (at +/-1.5%)
Extended low flow	.125 GPM (at +/-5%)	.03 GPM (at +/-5%)	.05 GPM (at +/-3%)
Installation flexibility	Horizontal*	Any	Horizontal or Vertical
Power Source	None	Battery	Battery
Number of Suppliers	6	1	6

Table 22 – Comparisons of each type of meter technology

5.11. Meter Register Technology

The foundation of an AMI system is the water meter and register technology. The register head tracks and displays the total volume of water that has passed through the water meter. Many registers allow remote meter reading. Advances in register technology have enabled the introduction of many other features and benefits since the inception of AMI. Different meter manufacturers present different options. Diameter reviewed the key features of the different technologies and discusses the benefits.

5.12. Direct Read Registers

5.12.1. Direct Read Registers Description

A direct-read register head is not capable of accommodating the technology necessary to allow the water meter to be read remotely. Direct read registers are an older technology that requires a person physically view and record the odometer reading. Meter manufacturers and water utilities are moving away from direct read registers due to their associated (and high) meter reading labor costs and lack of flexibility. Most of the industry has transitioned towards newer technologies that allow a utility to capture reading information with greater consistency and at a reduced reading cost.

5.12.2. City of Cornwall Implications

City does not have direct reading water meters and direct meters are not recommended as they do not allow either AMR or AMI technology to be used for meter reading.

5.13. Pulse Registers

5.13.1. Pulse Registers Description

A pulse type register is a much older type of register that allows pulses to be generated at the register head as a certain amount of water passes through the meter. These pulses would be sent to a remote odometer or an AMR radio transmitter. The biggest issue with this type of technology is if the remote or radio transmitter is removed, the pulse data would be lost and not available for billing.

This results in the reading on the meter not matching with the remote or radio transmitter. Often when a meter is replaced, a catch-up bill is needed to bill for any differences between the two. This technology is no longer supported by most AMI vendors.

5.13.2. City of Cornwall Implications

City does not have pulse odometer style water meters registers and these meters are not recommended since they are not widely manufactured and are not widely supported by either AMR or AMI vendors.

5.14. Encoder Registers

5.14.1. Encoder Registers Description

Encoder technology is the most common water meter register used as the foundation of an AMI system. The AWWA standard that governs encoder registers is C707-10(16). This technology allows the meter to be read directly from an AMI radio transmitter opposed to a pulse-type AMI-compatible register, an encoder register ensures that consumption is being recorded and read from a single source – the register.

Encoder registers do come with proprietary restrictions. There are predominantly two main encoder protocols which most water meter manufacturers adhere to: Sensus protocol (all meters except Neptune) and Neptune protocol. Fortunately, the technology has been around long enough that agreements among most manufacturers have been worked out to allow reading devices (i.e., AMI radio transmitters) to read both protocols. When procuring any encoder technology, water utilities must fully understand the limitations of what and who is able to read a meter register.

5.14.2. City of Cornwall Implications

The City has a limited number of water meters with older low resolution encoded registers on them. Although these 5- or 6-digit meter registers are compatible with both AMR and AMI, they would require high resolution 8-digit reading to get the functionality that supports the business drivers. Given the age of the water meters and the low-resolution reading, it is recommended the full water meters are replaced instead of upgrading the existing water meters by replacing the encoded register.

5.15. Other Register Features and Functionality

Some encoder registers provide water utilities with advanced features that provide a utility with additional functionality. They are also easier to read and provide the utility with more data in addition to the reading.

5.15.1. Digital Display

Some encoder registers are available with a digital display instead of a mechanical odometer display. These new registers may also allow for a toggle of the display, so the property owner or service personnel can see the flow rate, in various units, of water passing through the meter while it is being inspected together with any active alarm flags. This is a helpful feature that is often used

during meter testing or when property owners want to understand a leak that may be at their building/residence.

One drawback of some digital displays is that they can be difficult to manually read or require a light source (flashlight) to view the display; this problem can be more pronounced in low light areas (meter pits, crawl spaces, etc.) or where dirt and water can impair visibility of the register (meter pits).

5.15.2. Powered Registers

With the advent of digital display registers, the issue of powering the display has been addressed in a number of ways. Some registers use a non-replaceable "potted" battery that comes with a 20-year warranty that matches the expected life of the water meter and the warranty for the transmitter. This trend of batteries being required for various metering products has reinforced the development of coordinating full meter and radio transmitter replacement every 20 years. In other words, the industry has shifted customer expectations to accept a fairly firm end date for the product life cycle, regardless of Positive-Displacement or Ultrasonic meter type, driven largely by the battery life that supports the register.

This risk should be evaluated at the time of procurement by establishing an evaluation criterion that allows the Utility to apply a technical weight to those products to effectively address these concerns. One important feature may be the register's ability to transmit a low battery flag to the radio transmitter.

5.15.3. Detection Flags

Some advanced encoder meter registers and most AMI radio transmitters have detection flags (i.e., alarms conditions) embedded in the product. They have algorithms that detect certain simply defined conditions; once those conditions are met, a "Yes" flag is transmitted to the radio transmitter and data collector.

Common flags include a continuous consumption flag, a backflow detection flag, and a zero-consumption flag. The majority of meter and AMI manufacturers have designed the radio transmitter to perform the algorithms necessary to produce these flags, however a couple manufacturers perform these functions in the meter register. When flags are produced using the register head, often only that manufacturer's AMI radio transmitter can access them. As a result, if an encoder register is responsible for performing these algorithms, then the utility may tie itself to a specific radio transmitter and water meter manufacturer if it chooses this kind of solution. On the other hand, when the radio transmitter performs

these functions, the utility can continue to competitively procure a wider variety of water meters in the future.

Diameter recommends that the utility seek a solution with radio transmitters that are responsible for delivering this feature.

5.15.4. City of Cornwall Implications

It is recommended that these other product features or functionalities be evaluated during the RFP evaluation process.

5.16. High Resolution Registers

5.16.1. High Resolution Registers Description

A high-resolution water meter register head allows for higher precision increments to be recorded; smaller units of measure (i.e., litres) can be communicated to the AMI radio transmitter. Although having high resolution registers is not a mandatory requirement, it is highly recommended to ensure resolution does not negatively impact the Utility's ability to perform many of the business drivers the Utility identified as essential (i.e., small meter leak detection). It is also important for water meters of the same size and application to have the same resolution, therefore even for new water meters Diameter recommends replacing the low-resolution registers (6 digits) with high resolution ones (8 digits). All water meter manufacturers produce a high-resolution meter; meaning this specification will not limit procurement to a single manufacturer.

Table 9 in Section 4.3.1, above, shows the resolution expected at various sized meters to provide effective AMI data.

As an example, to demonstrate the difference between high and low-resolution registers, a residential sized (i.e., 15mm to 25mm) low-resolution meter would pick up a "leak" of 1000 litres of water per hour, whereas a high-resolution meter would pick up a leak as little as 1 litre of water per hour.

5.16.2. City of Cornwall Implications

It is recommended all new water meters have a high resolution 8-digit reading on the register.

5.17. Integrated Radio with Register

5.17.1. Integrated Radio with Register Description

Some meter manufacturers who also have AMI products have produced an integrated encoder register with an AMI radio transmitter incorporated into the register itself (often referred to as “radio under the glass”). The single product comes shipped attached to a water meter and requires no installation of the radio transmitter itself. Some manufacturers require the installer to activate the radio transmitters by sweeping a magnet across a location on the register, while others detect water moving through the meter which activates the radio transmitter.

The main benefit of this type of product is ease of installation. The installer does not have to run a wire, connect the wire to the meter encoder, and at times program the radio transmitter. An integrated encoder and AMI register does not require these additional installation steps and there is no future maintenance required for the wiring.

There are a couple disadvantages to an AMI solution that is built on an integrated radio transmitter and encoder register. First, this type of product eliminates competitive water meter purchases for the entire life of the system (15 to 20 years). An AMI system already has restrictive RF protocols that prevent a utility from using radio transmitters from a different supplier. Combining a radio transmitter with the integrated water meter register puts the same procurement restriction on the water meter purchase. In the future if issues develop relating to product quality or pricing the utility will have limited options for alternatives.

The second issue with an integrated radio transmitter for AMI technology is that the radio transmitter’s location cannot be relocated to maximize propagation (i.e., raised to the floor joists). Where meters are installed inside properties, which is the City’s predominant installation type, the RF propagation (radio transmitter performance) may be impacted. The resolution may require additional data collector equipment, additional repeaters, or require the utility to collect these types of problem reads via manual means.

Manufacturers who market an integrated radio transmitter with the register are:

- Neptune R900i product
- Sensus Ally electro-magnetic meter
- Kamstrup MULTICAL 21/flowIQ 21xx water meter
- Diehl

- Master Meter

For these reasons, Diameter recommends being cautious with a solution that requires an integrated radio transmitter with a water meter register. The short-term benefits (ease of installation) may expose a utility to long term risk. Some Ultra-sonic meters have an integrated radio transmitter with the meter register, allowing a single battery to perform the reading and transmission functions. These should be evaluated with the additional risk discussed above.

5.17.2. City of Cornwall Implications

The City currently has no integrated radio transmitters. With AMI technology this meter, register and radio transmitter configuration is not recommended. It is better to locate the radio transmitters on the exterior of the property to maximize the RF performance.

5.18. Registers that Adapt / Program to Different Meter Manufacturers

5.18.1. Introduction

Encoder registers are available that can be installed on various manufacturer water meter bodies.

These registers usually have different mounting rings for the different meter manufacturer register bayonet mounts. The programming depends on the installer selecting the correct meter manufacturer, meter model, and size. Any issues with this programming can lead to high or low registration. Some manufacturers also include the AMI radio transmitter integrated into this register.

The benefit of a single register is that it can be installed on any manufacturer's water meter, which is relevant to the Utility given the lack of upgrade pathway for its existing Elster meters by the manufacturer. This alternative may eliminate the need to replace meters less than 15 years old due to AMI incompatibility.

There are two main disadvantages for this type of product:

- Billing errors in installing these registers: Programming can be problematic, and any type of installation error could lead to significant billing issues. If the public loses confidence in the water meter used by the

utility, it could force a 100% inspection to ensure that programming is correct on all meters.

- Void of warranty: Neither the meter manufacturer nor the retrofit register manufacturer will warranty the combined product as installed, meaning that any issue with meter accuracy or readings are owned by the Utility.

Examples of these types of products include:

- Master Meter 3G Interpreter
- Elinx Interpreter

Due to the high liability of installation programming errors, this product is not recommended for the large-scale AMI solution required by the Utility. For residential meters, it is more cost effective to replace the entire water meter.

5.18.2. City of Cornwall Implications

The City does not have any mismatched register and water meter manufacturers and recommends not allowing these products on a future project.

5.19. Other Field Sensor Technology

5.19.1. Introduction

In addition to traditional consumption meter reading functionality, some AMI systems are starting to support the other types of field devices. The most common devices that AMI systems are starting to support include pressure and temperature monitoring devices, remote shut-off valves, acoustic detection sensors, and water quality (WQ) sensors.

5.19.2. Pressure Transmitters

5.19.3. Pressure Transmitters Description

Availability alternatives: Most AMI vendors do have radio transmitter that can be connected to pressure monitoring devices. Although separate devices are available, it is expected the pressure monitoring devices will be included in the non-mechanical water meters (i.e., ultra-sonic meters). Including pressure monitoring within the meter itself avoids additional devices and radio transmitters having to be installed and maintained.

Viability: Yes, most AMI and meter manufacturers have developed or are developing both radio transmitters that can communicate to pressure monitoring

devices or meters that include pressure readings with the normal volumetric meter reading.

Vendors: Sensus, Neptune, Kamstrup, Itron

Advantages:

- Provides ultimate flexibility for setting pressure transmitters within the Utility's service area with minimal infrastructure compared with traditional SCADA installations.

Disadvantages:

- Hourly pressure data may not provide enough granularity for real-time Operational decisions.

5.19.4. City of Cornwall Implications

Pressure monitoring was not considered an important or critical business driver, so it is not recommended this functionality be procured. If this functionality is offered for very low or no additional cost, the City may consider collecting this data.

5.19.5. Remote Shut-off Valves

5.19.6. Remote Shut-off Valves Description

Available alternatives: Most AMI systems have developed remote shut off devices for residential applications. Like pressure monitoring devices, the remote shut off valve is either a separate device or has been incorporated into the water meter, often with the same AWWA C700 lay lengths. The remote shut off valve often has three settings, open, closed and partially closed. This allows a utility to either partially or fully shut off the water to a residential property without the need to send a person to the property. This device requires two-way communication between the radio transmitter and Head End system.

Viability: Yes, most AMI systems have proven the technology works on a small scale. There are still no known large-scale North American deployments.

Vendors with separate devices: Neptune

Vendors with devices included in the water meter: Sensus, Mueller, Kamstrup, Badger

Advantages:

- Claimed maintenance free operation for the life of the valve. Most products include a regular (typically monthly) valve actuation during periods of zero consumption.
- Battery operated, requiring no utility power infrastructure, for the life of the valve.
- Potential to be cost effective for locations with specific sets of conditions (i.e., accounts with high delinquent payment history, etc.).

Disadvantages:

- High cost.
- Bulky construction may not be compatible with all residential existing meter box sizes.

5.19.7. City of Cornwall Implications

Remote shut off was not considered an important or critical business driver so it is not recommended to be included in the RFP.

Summary of Diameter Services Guidance in Chapter 5:

- Implement an AMI solution to achieve 17 of 20 business drivers ranked important or critical.
- Use a procurement process to ensure comparing all possible solutions against one another.
- Consider a metallic meter as the primary bid.
- Direct read registers are not recommended as they do not allow AMR or AMI technology.
- Pulse odometer style meter registers are not recommended.
- Replace full water meters rather than upgrading existing meters by replacing the encoded register.
- Seek a solution with radio transmitters that provide detection flags.
- Choose high-resolution (8-digit) registers.

- Exercise caution with a solution that requires an integrated radio transmitter and water meter register. For AMI technology it is better to locate the radio transmitter on the exterior of the property.
- Registers that can be used with multiple meter manufacturers are not recommended.
- Pressure monitoring was not an important or critical business driver; pressure transmitters are not recommended to be part of the solution.
- Remote shut off was not considered an important or critical business driver so it is not recommended to be included in the RFP.

6. Project Scope

The purpose of this chapter is to explain the scope of work involved in undertaking a universal water metering program. Universal metering programs present a unique and challenging opportunity for utilities undertaking a project of this size and complexity. A project that requires access to every home and business in the City of Cornwall. Metering is one of the best practices a utility can undertake to ensure equity while promoting water efficiency and environmental stewardship. Universal metering involves migrating a current flat rate customer to a meter so that every user pays for what they use. This Project Scope will outline the key elements of the universal metering program.

6.1. Work Types Defined

One of the first elements of a universal metering program to work out are the different work types that might be in scope for your project. The work type establishes what work the Installation Contractor will be undertaking at each location. While the main work type will be an “install”, knowing the City of Cornwall has varying types of infrastructure in place, it is known there will be other work types the Installation Contractor will encounter.

Work Type:

- Cut-In (Install)
    - An install or cut-in work type is used for any account that is currently flat rate and does not have an existing water meter or idler in place. Cut-in installations require a basic level of plumbing knowledge to install a meter. The work will include at a minimum 2 tailpieces, 2 rubber gaskets and wire run to the outside to connect to an exterior radio device.
- Replacement
    - Replacement installations include the replacement of an existing water meter or idler. It is important to note that installations with an idler should be considered as a replacement as they mimic that of an existing water meter even though there is no old meter information to collect. This ensures the City is not paying for the added cost of a cut-in when the work is essentially the same. The work will include 2 rubber gaskets and wire to connect to a radio device.
- Upgrade

    - An upgrade is similar in nature to a replacement in that you need to collect the same data. However, there is no plumbing involved as only the register head needs replacing and a radio transmitter added. Not all meters can be upgraded. Only those that have replaceable register heads will fall into this category. The work involves the removal of the existing register head and replacement with a new one. The work will include a seal pin and wire to connect to a radio device.
- Retrofit
    - A retrofit requires no plumbing to complete this work type. The work simply involves the addition of a new radio transmitter to an existing meter in situ. It is important to confirm key data (serial number, meter manufacture, etc.) the existing water meter in place is the same as what is recorded in the current City database. The work will only include wire to connect to a radio device.

While all the work types are different in the physical work that is done on them, there is one constant between them all and that is to ensure the data collected is extremely accurate. Completing the work at an incorrect address will result in an incorrect bill getting generated for that account. A proper data governance plan and quality assurance program will ensure these risks are minimized throughout the life of the program.

Once work types are assigned in the database, this becomes the driver for the work to be completed by the Contractor. After the different work types are established, the accounts are further classified by size. Small, intermediate, and large classifications allow the City greater control over the type of work that can be completed at each account. As the size increases, so does the complexity and cost of the work. The size classification will also drive additional approval matrices to ensure the Installation Contractor is selecting appropriate line items for the work that is planned/performed. For extensive large or intermediate work, it is recommended that a pre-approval process is used. When the work is passed through the integration file to the Installation Contractor, they will receive the expected work type along with its size classification which will determine the work the installer is able to do based on contract line items.

Work that does not go through the approval process will still be managed through a quality assurance program that benchmarks the quantity of work completed at each line item and compares the trend across the installers to ensure they are

not “plumbing for code” and charging for lines they should not be.

6.2. Approach to Extra Work – Post Approval

Work types establish the baseline work to be completed at each account in the database. However, not every installation is the same and extra work may be required at an account. Our experience has shown that our estimates are extremely accurate and where a line item may exceed the plan, another one will more than likely offset it with a decrease while still bringing the project in on budget.

Our estimates are planned to be 5%-10% higher on all line items in order to build contingency within the line. The result ensures the project remains on budget. Again, having a proper quality assurance program in place further supports accurate billing on each line to keep the project on budget and the Contractor billing accurately. Having a good program in place from the onset allows Diameter to catch anomalies that can be addressed immediately.

For small meter and most intermediate meter size classifications, the work can be easily managed and controlled through Diameter’s QA program. Again, looking at percentages across all completed work while visibly inspecting additional line items, Diameter is confident the project will remain on budget.

6.2.1. Quality Assurance

Diameter’s best practices help ensure quality related issues are prevented and the volume of issues is minimized. Quality Assurance initiatives include:

Project Planning & Governance

The most important part of any AMI project is the planning phase and associated deliverables. All parties involved in the implementation of the project must understand what is expected, what will be monitored from a Quality Control perspective, and how issues will be addressed. Having this in place is critical to ensure all stakeholders are aware of the scope, deliverables, and KPI’s associated with the project.

Risk Register & Risk Management

This includes a detailed analysis of the types of risks that could be encountered, the likelihood they'll be encountered, the impact they could have on the project, and how they'll be mitigated to help ensure success.

Traceability Matrix

To ensure that each requirement adds business value to the project, the Requirement Traceability Matrix (RTM) is a grid that links the requirement from their origin in the RFP to the project objectives and business drivers.

The Requirement Traceability Matrix is a live document that will continue to be tracked and updated throughout the project. It is communicated with the project team at the introduction of each progress meeting to provide additional insight on the project progress, risks, and challenges.

Contractor Evaluation Form

The Contractor Evaluation Form helps ensure that the contractors involved perform at an acceptable level, are held accountable, and deliver per the terms and conditions of the Contract.

Diameter has developed a Contractor Performance Evaluation form that is reviewed and agreed upon during the initiation phase of the project. This form is broken down into key activities to be executed by the Contractor, including:

- Project Management Performance
- Adherence to the Contract, Specifications and Provisions
- Stakeholder Engagement Performance
- Other KPI's and Key Deliverables

The Evaluation Form template can be modified as required based on the unique objectives of each project but must be agreed upon by all parties prior to use.

Integration Testing & Proof of Concept (POC)

Data quality and the process put in place to ensure all systems are synchronized is paramount to project success. If this is not built and tested thoroughly during the start-up phase of the project, it will inevitably cause issues and take substantial effort to rectify once the project has started. Diameter has developed an integration requirement gathering and testing approach as part of its Quality

Assurance efforts to help ensure risks and issues associated with data quality, integrations, and system performance do not impact the project during the execution phase.

In short, the goal is to test integrations in a staged approach, and finally test the entire system and end-to-end processes (POC) prior to meters and radios being installed in a production environment.

Change Management

A critical element of Quality Assurance involves the effective management of change requests, and subsequent scope, budget or schedule changes. It is important to have a process defined to manage these events and ensure that approval is acquired before an official change is made to the project baseline.

6.3. Approach to Extra Work – Pre-Approval

As previously mentioned, some intermediate and all large meter size classifications should be flagged for pre-approval. Having the work inspected and pre-approved avoids all unnecessary disruptions to the property owners by clearly identifying the work to be completed up front before water is turned off and the work starts.

All large meter accounts should be inspected prior to any work being completed. There are several benefits in doing this including:

- A clear up-front understanding of all the work that is required for the large meter accounts.
- The ability for the Installation Contractor to order all the necessary parts ahead of the work being scheduled to avoid repeat site visits and disruptions to property owners.
- Confirmation the water can be turned off and if necessary, pre-planning of water shut offs or repairs by City staff for main line valve operations. Again, assuring that all the planned work can be scheduled for one interruption.

The following line items are recommended for pre-approval:

- All hourly work types for plumbing and carpentry.
- Sites where a meter should be placed in a pit at the property line.

- Any major plumbing lines for intermediate and large meter size classifications.

Having the work properly detailed in the specification avoids any back and forth between the installation Contractor and the City and allows for clear communications up front with property owners.

6.4. Installation and Extra Work Responsibility

Extra work is inevitable on any project, and it is important to set the boundaries and understanding up front in the contract. While it is typical for cities to not be responsible for private plumbing, in projects of this nature, it is recommended that these policies be relaxed to allow for a positive customer experience through minimizing the number of repeat visits to a property. Relaxing these policies allows for a smooth rollout of the program.

Unlike new construction projects where the responsibility can be passed back to the general contractor of the development, universal metering projects rely on each individual property to be in a state that will allow for a meter to be installed. Giving some leeway to the contractor to perform some basic plumbing and carpentry modifications while on site goes a long way for property owners to accept the work and keeps the project moving without unnecessary interruption. The added benefit being a high completion rate with minimal accounts falling back on the City to complete.

6.5. Water Meter Sets

The meter set represents the labour, material and parts required to install a meter. The meter set is the part of the installation that is owned and operated by the City and is either inside or outside of the home as close to the main shut off valve as possible to avoid water loss from theft. It is important for the meter setting to be in a place that is easily accessible for reading, servicing, and testing (if applicable).

6.5.1. Inside set:

6.5.2. Vertical vs horizontal

There are benefits and drawbacks to both horizontal and vertical meter installations. Most service lines come into a property from the ground and run in a straight vertical direction upwards to the header. The AWWA M6 guideline

along with most meter manufacturers of positive displacement meters will recommend meters be installed in a horizontal plane.

- Benefits of horizontal installations:
  - Easier to service and replace.
  - Easier to read.
  - Meter wears evenly over time as the meters are typically manufactured for horizontal installation and does not require a signed affidavit to warranty a vertical installation.
- Drawbacks of horizontal installations:
  - More costly to plumb a meter horizontally either with a horn, meter setter or loop.

6.5.3. Horns vs. Plumbing a Loop:

Just as there are benefits and drawbacks to installing horizontally vs. vertically, there are also benefits and drawbacks to installing a meter horn versus plumbing a loop.

Benefits of installing a horn:

- Less plumbing joints to avoid risk of leaks.
- Maintains electrical continuity during future meter maintenance.
- Better support of the water meter for servicing.

Drawbacks of installing a horn:

- Very costly
- Does not allow the meter to be set easily into the wall and could increase the amount of carpentry boxes required to cover them.

It is therefore our recommendation that vertical service lines have meters installed by plumbing a loop.

6.5.4. Outside – Meter pits

In the very unlikely event a meter cannot be installed inside, it is recommended that a meter pit be used immediately downstream of the main service line valve (curb stop). While there are many benefits to installing a meter in a pit such as easy access, capturing all leakage on the supply side, the major drawback is the high cost of installation. Some of the unlikely events that would be cause for a meter pit to be used are:

- The inability to find where the main service line comes into the property.
- The service line is split underground and comes in at several points in the property not allowing one meter to capture all the consumption.

It is therefore recommended to minimize the number of pit installations and only use them if necessary.

6.6. Types of Extra Work

Extra work completed on the project will vary depending on the work type as it relates to cut-in versus changeout. It is anticipated that due to property owners not having to concern themselves with access to a meter setting that in all cases, the percentage volume of additional work is higher on cut-in line items than changeout line items.

6.6.1. Plumbing

6.6.2. Minor plumbing:

Minor plumbing includes the installation of one to three fittings, not including the two tailpieces from the cut-in line item, to upgrade the meter setting to a point where it can accept a meter.

The anticipated volume of this line item varies from 15% on change out line items to 25-35% on cut-in line items.

6.6.3. Normal Plumbing

Normal plumbing includes the installation of four to seven fittings, not including the two tailpieces from the cut-in line item, to upgrade the meter setting to a point where it can accept a meter. The percentages on the normal line item are higher as this is the line item that would be used to plumb a loop for the meter to sit horizontally.

The anticipated volume of this line item varies from 7.5% on change out line items to 65% on cut-in line items.

6.6.4. Major Plumbing

Major plumbing is priced at an hourly rate that requires pre-approval before the installation can complete the work. Typically, these installations are complex in nature and involve eight or more fittings.

The anticipated volume of this line item varies from 3% on change out line items to 5 % (assuming a 3-hour visit) on cut-in line items.

6.6.5. Carpentry

6.6.6. Minor Carpentry

Minor carpentry includes the equipment and labour to cut open a wall or to remove a stud to accommodate a meter installation.

The anticipated volume of this line item varies from 7% on change out line items to 20% on cut-in line items.

6.6.7. Normal Carpentry

Normal carpentry includes the equipment and labour to cut open a wall or to remove a stud to accommodate a meter installation and finish it with the installation of a prefabricated cover box.

The anticipated volume of this line item varies from 4% on change out line items to 10% on cut-in line items.

6.6.8. Major Carpentry

Major carpentry is priced at an hourly rate that requires pre-approval before the installation can complete the work. Typically, these installations are complex in nature and require detailed instruction on the additional work that is required to complete them. In some cases, the work required to access the plumbing may be too large to be completed by the City, in these rare situations, the homeowner may be asked to access plumbing at their own costs prior to the Contractor performing the meter installation.

The anticipated volume of this line item assumes 1% of the small meter cut-in and change out work types require this work.

6.6.9. Valve Replacement

6.6.10. Building control valve

A building control valve (BCV) is a valve that separates the service pipe from the distribution pipe typically where the service enters the property. It is the valve that can stop the water from the incoming service.

Where the valve is inoperable, leaking exteriorly, not stopping the water, or not located close to the point of entry on small and intermediate size (15mm to

50mm) classifications, it is Diameter's recommendation to replace these valves as part of the project.

For large meter size classifications, it is Diameter's recommendation to only allow for replacement where the valve becomes inoperable while completing the installation. If the valve is identified as inoperable during the site inspection, the valve replacement should be passed back to the property owner to upgrade in a reasonable timeframe ahead of the meter replacement being scheduled.

It is anticipated that 5-7.5% of the change out lines and 15-25% of cut-in lines will require a new BCV depending on the size classification.

6.6.11. Isolation valve

An isolation valve is a secondary valve that is installed downstream of the water meter to allow for ease of service and emergency repair. Isolation valves can be a costly additional item and are only recommended to install if budget allows.

To that end, it is not recommended that the City install isolation valves.

6.6.12. Curb Stop Operation

A curb stop is a valve owned and operated (typically) by the utility that is usually installed right at the property line that can completely isolate the water service to the premises. In many cases, utilities have strict rules over who can physically operate a curb stop. For water meter projects of this size and scale, it is recommended that curb stop operation be permitted by the Installation Contractor.

In order to grant authorization of the curb stop operation to the Installation Contractor for small and intermediate size meter, it is recommended that the City provide the Installation Contractor with training that ensures the valves are being operated correctly. The City can monitor performance of the Installation Contractor and revoke this privilege if they are negligent.

For large meter installations that require shutdowns at the main, it is recommended that City staff perform these operations.

6.6.13. Curb Stop Difficult to Locate, Operate or Repair

When the Installation Contractor is unable to locate and/or operate a curb stop, additional resources will be required to assist. Given the size and magnitude of this project, there will be a significant number of accounts that will flow back to

the City that will require support. It is Diameter's recommendation that an outside contractor support this additional work. This work is outside the skill set of the meter Installation Contractor, and therefore would be outside the scope of the Installation Contractor.

It is anticipated that 25% of the small meter accounts will require a building control valve. Of that number, 50% of those accounts will require some form of additional support, whether it is a simple locate (15%), box and rod replacement (25%) or curb stop replacement (10%). With that anticipated volume, it will be difficult for the City to keep up with demand from the Installation Contractor to ensure the project does not fall behind schedule. Bringing in an outside contractor allows the City to continue to focus on their day-to-day tasks including any emergency repairs that may arise as a result of the program.

6.6.14. Freezing the pipe

Pipe freezing involves the creation of a frozen plug in a pipe or fitting with the use of a cryogenic freezing agent (electric or gas). Once the plug is established, an installation can be carried out. This technique is primarily used on copper pipe where the curb stop is inoperable and there is enough room below the building control valve to establish a freeze. Due to the high cost to repair a curb stop, this is one method that can be used to reduce the overall cost of the project.

It is anticipated that up to 4% of the population could have this line item applied.

6.6.15. Constrained (crawl space) and Confined Space

We define a constrained space (or crawl space) as an area that limits entry or exit and is not a space where continuous occupancy will occur. These spaces can be found underneath homes or a low ceiling area within a home. They could be areas where work occurs to install or replace a water meter. They require a second technician on site to ensure a safe working environment and to alert others in the event of an accident within the space.

The key difference between a constrained space and a confined space is the existence of a potential physical hazard, hazardous atmosphere or a space that can trap a technician. For confined space entry, proper permits and safety procedures must be followed as required by law.

It is anticipated that 4% of the accounts will require a crawl space line item and that fewer than 2.5% may require confined space entry.

6.7. Radio Transmitter Locations

Ideally all radio transmitters shall be located on the outside of the property for ease of downstream maintenance and increased read success rate performance.

6.7.1. Inside Location

While an inside location may prove to be an easier option for the Installation Contractor to complete, it does not serve the City well long term when it comes to overall system performance and ease of maintaining radio transmitters. An inside installation should only be considered when all options for an outside installation have been exhausted.

If all options have been exhausted and an inside installation is required, the radio transmitter should be installed as high as possible, ideally in the header of the basement for the best read success rate possible.

6.7.2. Outside Location

Outside radio transmitter installations are the ideal scenario to provide the best possible system performance.

The ideal location for an outside radio transmitter installation is 1-1.5 metres above grade. To assist with the ease of maintaining the network long term, it is recommended that radio transmitters be installed on the home in an area that is easily accessible by City personnel i.e., not behind a fence.

6.8. Risk Management

Diameter would like to acknowledge the valuable work completed in the “Water Conservation and Servicing Master Plan”. As the City proceeds forward, Diameter is positioned to deliver subject matter expertise specific to this AMI technology and universal metering project. It is at this point in the engagement where water AMI/AMR and metering specialists help to mitigate risk and set the stage for a successful procurement and project delivery.

6.8.1. Risk Register

Diameter has developed an approach of identifying and ranking project risks associated specifically with universal metering and AMI deployments. This process provides a framework for prioritizing what risks may have the highest impact on the overall success of the project (likelihood of occurrence and severity of occurrence). The risks identified as High and Medium will have "risk owners" assigned and a mitigation strategy will be developed to be proactively prepared in the case that the risk turns into a real issue during the project. Based on our experience, we believe that this process promotes accountability and forward thinking to ensure negative events are not handled in a reactionary fashion; well-planned steps are defined to mitigate the damage of the event. The intent of the Risk Register is to track the identified risks and monitor changes and mitigation strategies throughout the duration of the project. A snapshot of the Risk Register prepared with the City Of Cornwall is shown in Figure 19, below.

Current Status	Severity of Impact	Probability	Risk Matrix	Risk Description	Phase	Risk Category
Open	Medium	Low	Green	**Project Buy In** Lack of internal stakeholder buy-in. Senior Management and Finance are not engaged in the entire project.	Phase 1 - Project Planning	Public Outreach
Open	High	Medium	Red	**Funding - Council Approval** Project funding is dependent on debt financing / approval of Council	Phase 1 - Project Planning	Financial
Open	Medium	High	Red	**Customer Service Enhancement (Landlords)** Public understanding the what the project is / Why it's being done	Phase 1 - Project Planning	
Open	Low	Low	Green	**Negotiated Legal Agreement**: The timeline could extend the project timeline (currently expected at 60 days); varies by vendor	Phase 2 - Procurement	Project Support
Open	Low	High	Yellow	**Customer Engagement Against the AMI Technology.** less than 1% which will be vocally against the project.	Phase 2 - Procurement	Public Outreach
Open	High	High	Red	**Customer Engagement Against Moving to a Metered Rate** Customers who are vocally against the project.	Phase 2 - Procurement	Public Outreach
Open	Medium	High	Red	**Delays in Internal Staff document review** Staff requirements in numerous other projects (Asset Mgmt, Cityview (portal)), changes to billing system, staffing up, etc.	Phase 2 - Procurement	Public Outreach
Open	Low	Low	Green	**Go Slow Approach:** Complicates procurement, integration and installation validation process.	Phase 1 - Project Planning	
Open	Medium	Medium	Yellow	**Integration Effort and timeline:** Cost and Time overruns due to Diamond Integration support requirements (Will budget for this effort); Implication on internal resources	Phase 3 - Start Up	Project Support
Open	Low	Low	Green	**Data Collector Locations** Being able to locate and secure sites for data collectors.	Phase 3 - Start Up	Technology

Figure 19 – Risk Register

6.8.2. Risk Management Monitoring

This process began during the Design Phase where Diameter developed a risk management framework and a risk management register the City will use throughout the project. Once the project moves into Implementation, the risks identified as High and Medium will have "risk owners". "Risk Owners" are responsible for the risks assigned and monitoring any changes throughout the duration of the project with the guidance of the Diameter Project Manager. Risk

owners are also to ensure a mitigation strategy has been developed in case the risk turns into a real issue during the project. The Risk Register will continuously be reviewed to track the identified risks, include new risks as they are anticipated, and monitor any changes in risk status as they occur so strategies can be implemented or adjusted as needed. This monitoring process is a critical component of the overall success of the project.

It will be important to continue communication with the Steering Committee to communicate project progress, discuss project challenges, and evaluate risk mitigation strategies. As this project will affect many of the City's departments and potentially outside organizations, it is important that the City's project team has the support and communication path to the City's executive team.

Summary of Diameter Services Guidance in Chapter 6:

- Use a pre-approval process for extensive Large or Intermediate meter work.
- Use a pre-approval process for: hourly plumbing and carpentry, pit meter installations, major plumbing lines for Large or Intermediate meter work.
- Relax policies around City responsibility for private plumbing to facilitate project tasks.
- Consider revising By-Laws ahead of project start to include reasonable adjustment to private plumbing and the ability to access the meter setting.
- Meters be installed in a horizontal plane.
- Existing vertical service lines have meters installed by plumbing a loop.
- Minimize pit installations; when necessary, place them immediately downstream of the curb stop.
- Replace building control valves on Small and Intermediate services when inoperable as a part of the installation.
- For Large meters, evaluate operability of the building control valve during the site inspection; require property owner to replace if inoperable.
- Installation of isolation valves is not recommended.
- Allow operation of curb stops by the Installation Contractor on Small and Intermediate meters; require City staff operate curb stops when necessary with Large meters.

- Consider a 3rd party contractor to support curb stop locates, box and rod replacement, and curb stop replacement.
- Consider allowing pipe freezing by the Installation Contractor instead of incurring costs for curb stop repair.
- Install radio transmitters 1-1.5 meters above grade on the exterior of the premises in an area easily accessible by City personnel.

7. System Assessment

7.1. System Assessment – Existing

Through workshop activities, Diameter performed a system review with the City's project team. The purpose of this assessment was to identify the systems currently in use and those systems that may be impacted with the implementation of AMI technology. In addition, risks and challenges were identified as well as opportunities to improve the customer experience. This current system diagram is augmented with Transition and Future system design diagrams. These diagrams are not intended to depict the final solution as different vendors may propose different types of AMI system architecture. It is intended to give the City a good idea of the scale of the impact this project may have on their systems. This document is an initial step in understanding the level of integration the City should anticipate supporting this organizational change.

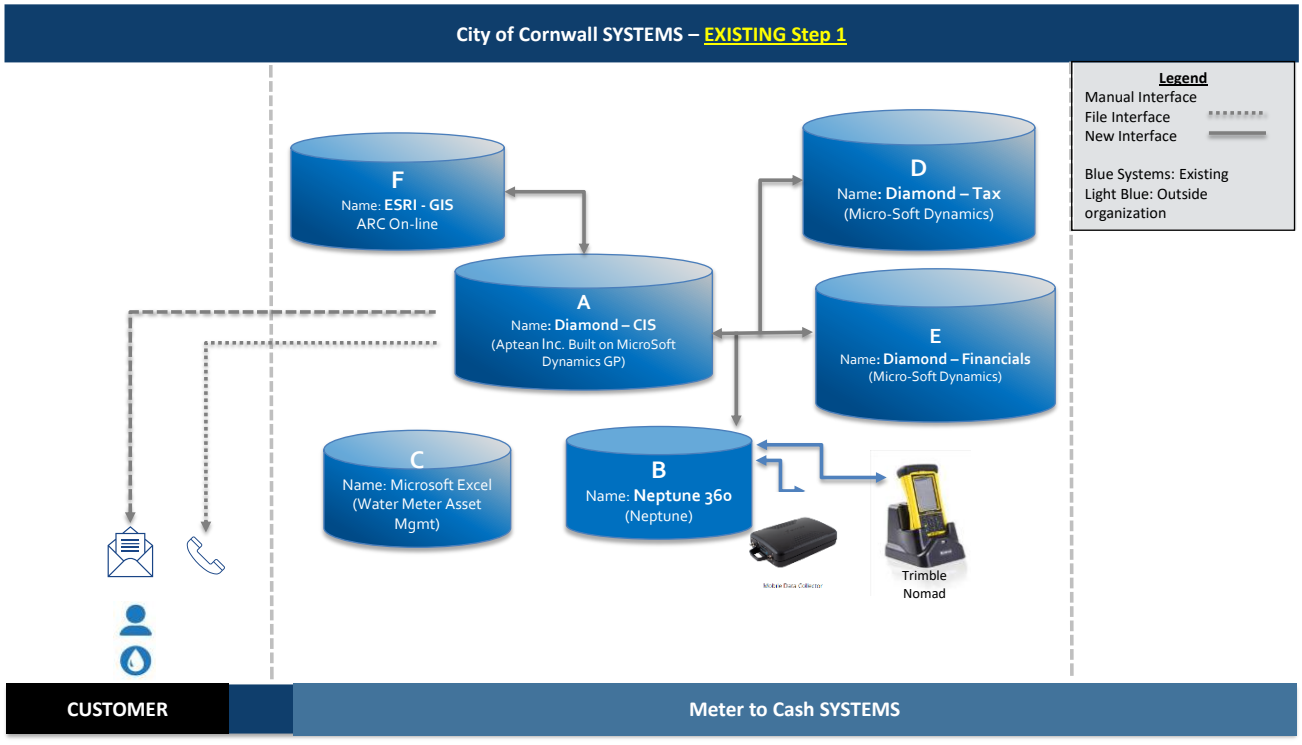


Figure 20 - Existing System Diagram

The blue systems and interfaces represent existing architecture. The solid lines represent automated interfaces that require no or very limited people interaction, the dashed lines represent a manual process that relies on manual intervention.

7.1.1. System A. Diamond – Water Billing System

The main purpose of CentralSquare's Diamond software is to support the City's financials, tax and water billing and collections. The City tracks some customer calls by making notes on the water account, but this application does not have customer relationship management functionality (CRM).

This system supports both flat rate water and wastewater billing and allows for the small number of metered customers to be billed on consumption basis. There are no bad debts or write off because any unpaid amounts are passed to Diamond's tax system.

The City does not use Diamond for work order creation, this process is manual and tracked using a paper process.

7.1.2. Challenges and Recommendations

The City has moved to Diamond in the last few years, away from a different CIS system. In addition to being for water billing, this system is also used by the City's Tax Department for tax billing. Water bills are split into two groups and each group of meters are billed twice per year. Diamond can bill for water on a metered basis and has been modified to allow for flat rates to be setup to bill based on the type and number of fixtures that are at each property.

The Diamond system is maintained by CentralSquare. The City relies heavily on CentralSquare for system configuration support and report development. For this project we have already started discussing the need for CentralSquare resources to support the configuration and interface development.

Challenges identified:

1. **Missing flat rate meter data in Diamond:** The City installed approximately 2,800 water meters about 10 years ago. Until a couple years ago these water meters were read outside the Diamond system, even though they were still on a flat rate of billing. None of the meter data was updated in the Diamond system, it is currently stored in an excel spreadsheet that is not maintained or updated. As we move into this project, it is important for the City to maintain a single source of truth on which locations have a water meter (even if they are still being billed a flat rate) in Diamond. As installations are completed, the Diamond system is going to need to receive new meter and radio transmitter data. In order to

have a single source of truth and to test how Diamond will treat meter and radio data it is recommended to upload the flat rate meter data into Diamond prior. Although it would be most valuable to upload this information in the production environment, it is recommended to do this on a Diamond test system prior to the startup phase of the project. Moving this data into the production environment should be re-evaluated during the startup phase.

2. **Tenanted property accounts**: As highlighted in Section 4 – Database Assessment, although there are currently approximately 17,900 current accounts in Diamond, a number of these accounts are associated with a separate living unit, not necessarily a separate serviced property. With a recommended policy of one water service one water meter, it is expected the number of current accounts to be reduced by between 700 and 1,500.

3. **Manual paperwork order process:** As the City moves toward AMI, data integrity and consistency become critically important. Replacing new water meters, registers or radio transmitters using a manual process can be problematic. With hourly consumption data and a new customer portal, updating changes to equipment in the field is very time sensitive. It is recommended to implement an automated interface between Diamond and the future Installation Contractor.

4. **Diamond is not configured to issue work orders**: the City does not currently use Diamond to create a digital work order within Diamond. A manual paperwork order process is used if an existing water meter requires maintenance. A best practice for a project of this nature would be to use digital work orders within Diamond to issue and then track information that is sent to the Installation Contractor. As the City engages with CentralSquare, it is recommended to explore how Diamond could support this type of functionality, worse case the interface with the Installation Contractor will be based on account numbers.
   The City should also consider evaluating a digital work order in the field to support the City's maintenance of the meter system long term. This could be accomplished either through Diamond or through the new asset management application the City is implementing. This recommendation is not considered urgent and should be evaluated near the end of the

installation project.

5. **Lack of Access to Diamond**: The Tax department has exclusive access to Diamond, the City's water distribution and project team who maintains the water meters does not. This can lead to some confusion as the water distribution and Project Team only has access to a separate excel sheet (System C) with meter data that is out of date and may not be reflective of what is in Diamond. It is recommended the City's Project Manager and eventually the water distribution personnel be given access to Diamond in a read only fashion, so as the project progresses that role does not have to rely on someone in Tax to obtain meter information.

7.1.3. System B: Meter Reading Software

The City currently uses Neptune 360 to read the existing water meters. This application is interfaced with Diamond to support the bi-annual meter reading process that takes place. Only the ~240 metered properties are read using this system. All meter equipment has a water meter and a R900 radio transmitter connected to the meter's encoder register, allowing these meters to be read wirelessly (by drive by) without having to physically view or touch pad the water meter remote to obtain the reading.

7.1.4. Challenges and Recommendations

1. **Aging equipment**: As discussed in the Database Assessment, the current meter equipment is more than 10 years old. Since these radio transmitters only have a 20-year life and because they are incompatible with today current AMI systems being deployed, it is recommended to replace all water meter and radio transmitter equipment, so the entire system is new at the start of the project.
2. **Lack of access to this system**: Similar to Diamond, Neptune 360 is maintained and operated by the water distribution department, and the Tax department does not have access to it. As this project progresses, it is recommended the Tax department be given access and trained to access this current meter reading software as well as the future AMI application.

7.1.5. System F: GIS

The City uses ESRI ArcGIS online for mapping and spatial analysis needs. This application does receive data from Diamond on an ad hoc basis. This application would be considered non-essential system for this project.

The Installation Contractor can obtain new GPS coordinates as part of the installation process for no additional cost. The City can then view and upload this data into ESRI to ensure all water meters have an accurate geolocation. This data can also be used to troubleshoot any issues if there were some uncertainties as to where the water meter was installed.

7.1.6. System D, E: Diamond Tax & Financials

The City uses Diamond for both Tax and the City's financial systems. These are interfaced to the water billing model but are not essential systems relating to this project. Being able to view the tax account may be useful when determining which account should have the water meter (for multi account premises). Giving the Project Manager access to this portion of the Diamond system is recommended but not essential.

7.1.7. Customer Portal

The City does not currently have a customer portal. Customer access to water billing information is accomplished through the water bill or through the customer calling the tax department. This project will create significantly more interest in their water meter data and allow customers to view their billing and consumption information. Implementing a customer portal as part of this project should help give customers a location to obtain more information about the project, as well as water conservation tips and programs which will reduce the customers reliance on phone calls and water bills to obtain this information.

7.2. System Assessment – Project Transition

The diagram below provides an overview of the systems and interfaces that will be impacted by movement to an advanced metering system.

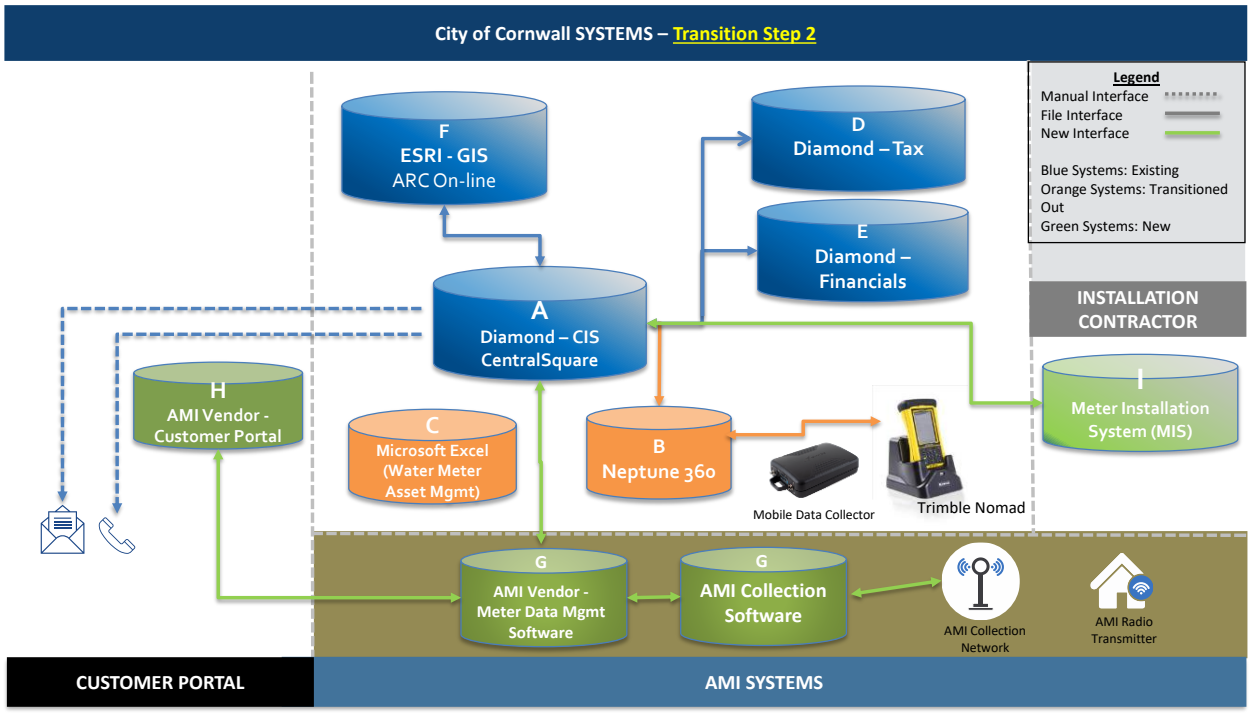


Figure 21 - Transitional System Diagram

The blue systems and interfaces represent existing applications, orange will represent transitionary systems or interfaces that will be impacted (changed or removed) after the project is completed, and green represents new systems or interfaces contemplated. The solid lines represent automated interfaces, the dashed lines represent a manual process that relies on manual intervention.

7.2.1. System C & B: Water Meter Assets & Neptune 360

Once the project starts, it is the intent to upload the excel file (C) of flat rate metered data into Diamond. This will eliminate the need to keep or maintain this excel data source. It is recommended this be done during the procurement phase of the project.

Neptune 360 is currently being used to read the existing 275 water meters that are used for billing purposes. This application also supports AMI and provides MDM functionality but would only be used if Neptune is selected as the AMI vendor since each AMI provides their own software as part of their AMI solution. If Neptune was not selected as the AMI vendor, the chosen AMI vendor's AMI software would need to be implemented (Application G) and we would recommend retiring Neptune 360 during the initial phase of the project.

7.2.2. System H: Customer Portal

Part of achieving the business drivers relating to enhanced customer service and water conservation benefits will require a new channel of communication with the City's customers. A best-in-class customer portal that provides customers with functionality related to viewing water bill and payment histories, provides detailed consumption so customers better understand their consumption behaviour, give customer tools like high and continuous consumption alerts, and better access to conservation information and programs the City is promoting.

There are three approaches to obtaining a Customer Portal that should be considered in improving the customer experience.

- Option 1: Extension of a CIS (e.g., through the City's CentralSquare vendor)
- Option 2: Extension of AMI vendor
  - Most AMI vendors have a customer portal either optional or included.
- Option 3: Best in Class (independent application)
  - WaterSmart, SEW, Harris Silverblaze, AquaHawk, Accelerated Innovations

The table below provides some high-level functionality comparison of the three options. These are general in nature, both CIS and AMI vendor continue to improve their product offering so some of the high-level functionality assessment may not match exactly what vendor may propose.

High Level Functionality	Option 1 CIS	Option 2 AMI	Option 3 Standalone
Customer Authentication (SSO)	Yes	Not usually	Yes
Billing and payment view	Yes	Not usually	Yes
Consumption	Usually	Yes	Yes
Online Payment	Usually	No	Yes
Conservation Message	No	Usually	Yes

High Level Functionality	Option 1 CIS	Option 2 AMI	Option 3 Standalone
Outbound Global Communication	Usually	No	Yes
Outbound individual communication	Usually	Not usually	Yes
Program enrollment	Not usually	No	Usually
CRM Management	Yes (relying on CIS)	No	Usually

Table 23 – Customer Portal Options

Generally, a CIS vendor's customer portal is good with providing functionality relating to dollars and cents; AMI vendors customer portal is good with providing functionality relating consumption; best in class CIS providers generally do a good job with displaying both types of functionalities.

The project team did meet with CentralSquare and discussed their Citizen Engagement Portal, which was also evaluated during the water billing implementation. The portal was not bilingual, which really eliminates it from consideration. A deep dive of its functionality relating to billing and consumption was not performed.

Recommendation: The City should consider Options 2 and 3. The AMI RFP specifications relating to the customer portal functionality should detail what the City wants to achieve and rely on the AMI vendors to bring an appropriate solution forward.

7.2.3. System I: Meter Installation System (MIS)

The Installation Contractor who is selected to install the water meters in the field will provide a meter installation system (MIS). The purpose of this application is to manage the installations in the field, eliminating any paper processes. The main functionality of this type of system includes work order management, mobile data capture, customer appointments, task tracking, reporting and extensive data validations. The City and the project team will have cloud access to this software that is owned and operated by the Installation Contractor. Once the project is complete, the MIS will not be required.

The MIS is the conduit between the devices installed in the field ensuring the new meter data is setup correctly in Diamond. This is accomplished through a detailed list of interfaces, the ones between Diamond and MIS will be maintained during the life of the project, other interfaces between Diamond and the AMI system or the customer portal will be maintained long term. This anticipated list of interfaces is detailed in the diagram below.

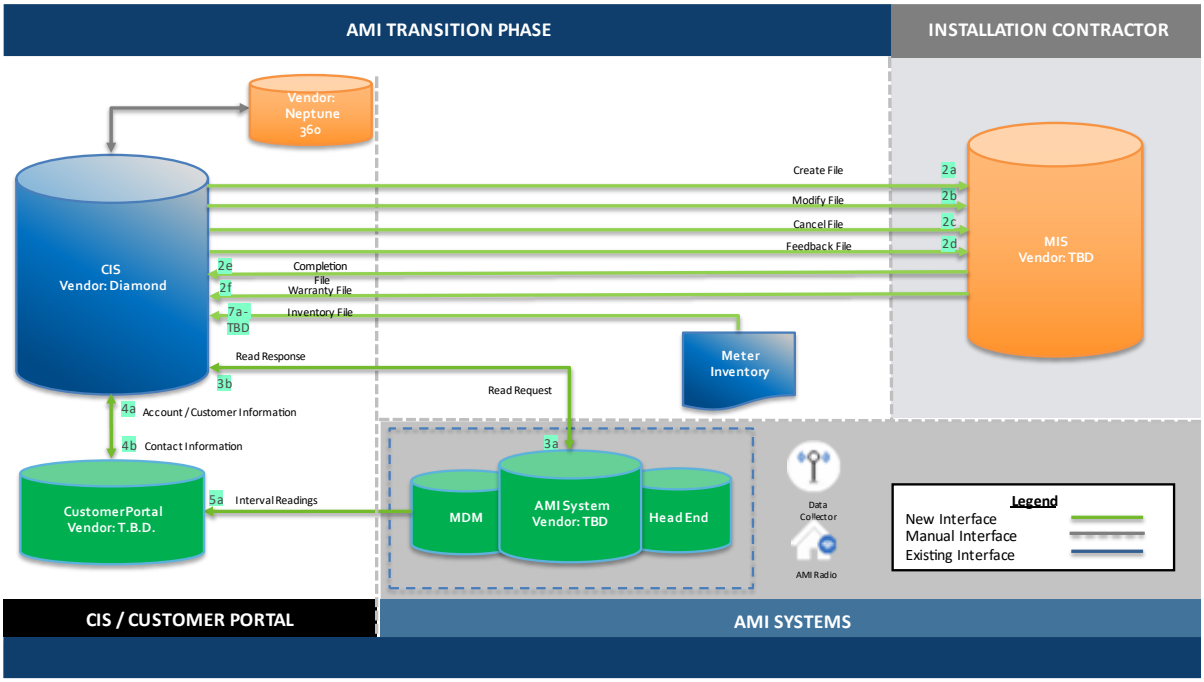


Figure 22 - AMI Transition Phase

All interfaces and systems will be configured and tested during the start up and proof of concept phases of the project. Depending on the vendors selected for both the MIS, AMI and customer portal the exact interfaces may be different than shown. This diagram is meant to provide an understanding of the scope of the interfacing Diameter would anticipate with this project.

7.2.4. System Assessment – Future

The diagram below provides an overview of the City's future system architecture. This should act as a guide or reference point as the City moves forward with some of the recommendations made in this report.

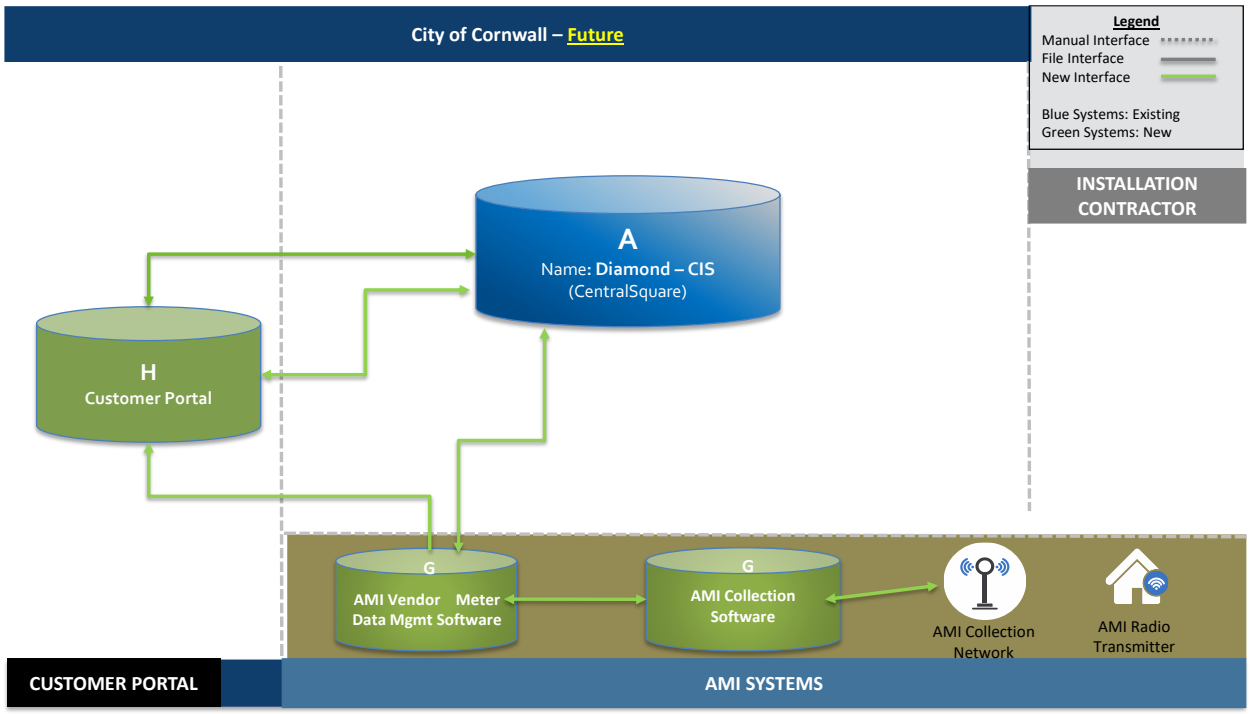


Figure 23 - Future Systems Diagram

Summary of Diameter Services Guidance in Chapter 7:

- Maintain a single source of truth for flat rate meter data.
- Install one water meter per service.
- Implement an automated interface between Diamond and the Installation Contractor.
- Consider implementation of a digital work order system for future field work.
- Allow read-only access to Diamond for City Project Manager and distribution personnel.
- Replace all water meter and radio transmitter equipment.
- Allow access to the Neptune 360 system to the Tax Department.
- If Neptune is not selected as the AMI vendor, retire Neptune 360 during the initial phase of the project.
- Consider either AMI vendor-supplied Customer portal or standalone customer portal to achieve the best portal solution.

8. Business Process Review

The Purpose of this Business Process Review is to ensure Diameter Services ("Diameter") understands the City's existing processes associated with the meter to cash process. The intent of this review is to identify any areas of potential change before, during or after the project that require planning as the City moves the majority of customers from flat rate to metered billing.

8.1. Meter Maintenance and Water Billing Process

8.1.1. Meter Maintenance

The City of Cornwall will have more meter related tasks after installing meters throughout the City as well as new tasks associated with AMI radio transmitters. Examples include radio transmitter replacements due to failures or vandalism, programming radio transmitters for new builds or where programming changes may be required, meter register failures, investigations for high consumption or zero consumption, and suspected tampering of meter or radio transmitter.

Today 0.25% of an FTE in the water purification department deals with meter reading and all meter-related issues. It is estimated one FTE will be required going forward to handle issues such as those stated, and the City should determine at the start of the project whether water meter and AMI maintenance will continue in water purification or another department such as water distribution.

8.1.2. Current Water Billing Process

The City of Cornwall currently bills approximately 17,894 accounts. 275 institutional, industrial and commercial properties (accounts starting with a "Z") have an existing water meter and are billed at a metered rate. These customers are billed for water at the end of the billing period once a meter reading is obtained.

The remaining 17,619 customer accounts (accounts starting with "A" to "Y") are billed on a flat rate basis which is calculated based on the number of living units and associated fixtures at the property. The rate is calculated using Schedule A – Water Rates of the annually updated *By-Law to provide for the supply and distribution of water and the collection of rates for use of water and water related services* (2021 By-Law 2020-156 was used as a reference). Flat rate customers are billed at the beginning of the billing period.

Customers are billed for water on a semi-annual basis according to the following schedule:

Row Labels	Qty	First Bill (coverage)	First Bill (coverage)
A to K Flat Rate Accounts	9652	January (January 1 to June 30) Billed Beginning of period	July (July 1 to December 31) Billed Beginning of period
L to Y Flat Rate Accounts	7967	April (April 1 to September 30) Billed Beginning of period	October (October 1 to March 31) Billed Beginning of period
Z Metered Rate Accounts	275	February (August 1 to Jan 31) Billed End of period	August (February 1 to July 31) Billed End of period
Grand Total	**17,894**		

Table 24 - Current Billing Schedule

All bills are processed and mailed out by the City's Property Tax and Assessment department over a one or two-day period. The timing of the water bills avoids some tax billing administration effort. The City does see an increase in customer calls right after these water bills go out, with questions about bills and payments.

8.1.3. Challenges with Existing Process

The City's transition from flat rate to metered billing is a significant change in how the City bills for water. Customers will require support as they adjust to the new process and get accustomed to how it will impact them. There are a few challenges with existing business processes that will make this change more difficult for customers and City staff.

A. **Semi-Annual Billing Frequency:** Semi-annual billing frequency will cause a number of issues as the project moves forward. First, when customers are charged a metered rate, a leak on their private plumbing (toilet, irrigation, etc.) could lead to a very large bill because it could have been a problem for up to 6 months. A more frequent water bill will ensure any high bills are identified much sooner limiting the cost of that leak. Second, as customers move from paying at the beginning of the period (flat rate billing) to a metered rate, which will be done at the end of the period, there will be a cashflow impact in the first year of implementing metered billing. Third, if water conservation is the reason the City is moving all customers

to a metered rate of billing, semi-annual bills do not support smaller water bills and notification of high consumption in a reasonable period. More frequent billing enables customers to see the impact of their consumption behaviour changes and avoid getting an unexpectedly high water bill.

B. **Additional customer service support:** Customers will be concerned and somewhat fearful of this type of change to water billing. Those who may be on a lower or fixed income will be concerned about affordability. We expect this anxiety to lead to additional calls to the City to field questions about this change, likely during the project, but increasingly during mock billing and the first six months of metered billing.
C. **Additional effort to process metered water bills:** Once the meters are set up in Diamond, the effort required to apply meter readings, review any exceptions, and investigate billing exceptions will require additional administrative time. The current resources supporting the water billing process will likely be inadequate to support the billing and customer service support both during the project and after the metered rate goes into effect.
D. **Diamond Customer Conversion requires planning:** moving from a flat rate to a meter rate is not only a change to systems but customers are going to need to be informed. Currently the steps to do this conversion is unclear; customers will need to be informed through a robust planning and public outreach program.
E. **When metered rate should take effect:** There are two ways of implementing a metered rate: either change all customers at the same time once the project is substantially complete or convert them as the meter is installed. Although some customers may want to move to a metered rate right away, it is more challenging to do this conversion throughout the project. It can also create a disincentive to comply with the requests for the customer to book an appointment. Delaying booking an appointment will delay a customer who is reluctant or concerned with receiving a meter to remain on a flat rate of billing.
F. **Billing cycles are not evenly loaded throughout the period:** Typically, a utility will evenly load all billing accounts across their billing cycle so a relatively even number of accounts are billed each day of the cycle. This would lead to even work loads for both billing and customer service staff. The City currently bills 50% of the customers on two days each year, and the other 50% on two other days in the following month. This may lead to

heavy workload peaks four times per year. The City should consider performing water billing more frequently during the billing schedule to reduce peak workloads for administrative and call center resources.

G. **Preauthorized Payments may be Impacted:** The City has a good percentage of pre-authorized payments and will need to consider the impact the changes to the billing process will have on the preauthorized payment process. Given the preauthorized amount will vary with a metered rate, the City will need to communicate the change to billing amounts to customers.

8.1.4. Recommend Changes to Water Billing Process

The following changes are recommended to the water billing process:

Recommendation 1: The City should convert to metered billing once the project has achieved substantial completion. Customers cannot request moving to a metered rate prior to this date.

Recommendation 2: Move all customers from semi-annual to bi-monthly water billing at least six months before the start of mock billing. This should be completed while these customers are on a flat rate, as water meters are being installed. This more frequent communication (in the form of a water bill) will provide some additional opportunity to communicate project progress through a bill insert (if they choose to use them).

Recommendation 3: The City currently bills water in advance for the following six months. However, billing on metered consumption will be done every two months for the previous two months from when the bill is sent to the customer (post-billing). The City should consider the move to post-billing in conjunction with the move to bi-monthly flat billing. In this way, customers will have a metered “mock bill” that lines up with the same flat period which will eliminate some customer confusion. This will also maintain the billing cadence when making the move from flat rate to metered consumption and help eliminate some customer anxiety.

Recommendation 4: City should perform mock billing at least six months prior to moving all customers to a metered rate. The City should expect additional phone, bill and field customer service support during the mock billing period and for six months after the metered rate goes into effect. A detailed plan should be

developed that will include how the City will support this through the new AMI meters, a Diamond test environment, and a public communications strategy.

Recommendation 5: The City should review and decide how often during a bi-monthly billing cycle they should consider running the billing process. We would recommend considering either a once per week process or a daily process, 3 or 4 times per week during the billing cycle. This should be reviewed with the development of a bi-monthly implementation plan.

Recommendation 6: The City should plan for a full-time permanent resource to be added to the finance department that will support the additional workload anticipated to support metered billing and customer service. The City should also have a contingency plan to bring a second full time temporary resource into this department during key points of the project (mock billing and six months of metered billing). If completion of these tasks can be completed between January and August, interns and summer students may suitable resources.

8.2. Meter Readings

The City currently reads the customers who are on a metered rate using a handheld, collecting the reading via radio frequency. Depending on the manufacturer of the AMI technology, this meter reading equipment may not be compatible. We would recommend replacing, upgrading or retrofitting (in accordance with the work types) these ~300 water meters in the first six months of the project. This will allow the City to collect these readings through the AMI network eliminating the manual read process.

All other water meters will be read through the AMI network as they are being installed, but this data will not be used for billing purposes until the City converts all customers to the metered rate. It is recommended for the City to review and analyze this consumption information prior to moving to a metered rate so they can tweak the water conservation program and analyze the impact moving to a metered rate may have on the City's overall water and wastewater revenues.

8.3. Move-ins and Move-outs

Once all customers have converted to a metered rate, the City will need to review and potentially revise the process for customers starting, stopping, or changing

owners. The AMI system will support obtaining the meter reading on the day the change of ownership occurs.

Some options for customers to make this request would be through a phone call, email request, or potentially through the new customer portal.

8.4. Meter Related Maintenance

8.4.1. Departmental Responsibility for Water Meters

Currently, due to the City's low number of water meters, water meter maintenance requests are handled as a one-off work order. This work is handled by the Water Purification Plant.

When all customers have water meters, the City should expect a higher number of water meter maintenance calls. Currently, the City does not have resources dedicated to meter maintenance or quality control. In addition, it will be important for the technician to be familiar with the work as the data they are collecting will be critically important to avoid billing errors. Most water utilities either have a specific water meter group or the water meter maintenance work falls under the water distribution department. The number of maintenance requests and investigations is likely less than 1% per year, but these do need to be handled by a competent, customer-focused, trained water meter installation personnel.

8.4.2. New Development Meters

Currently the City does not require the builder/developer to install a water meter or water meter idler in private plumbing during new property construction. The City will want to adjust the By-Law to require developers to purchase a water meter and radio transmitter from the City, to be installed prior to the property being approved for occupancy. The City should initiate this requirement once the metered rate comes into affect. During the project, the Installation Contractor can perform water meter installation on new buildings and developments.

Summary of Diameter Services Guidance in Chapter 8:

- Move to metered billing once the project has achieved substantial completion.

- Move customers to bi-monthly billing 6 months before the start of mock billing.
- Shift the billing period to after the consumption data is collected rather than pre-billing as a part of the move to bi-monthly billing.
- Perform mock billing at least 6 months prior to moving customers to a metered rate.
- Review and set a schedule for how often the bi-monthly billing process will take place (once per week, daily, or 3-4 times per week?).
- Plan for an FTE to be added to finance to support the additional workload.
- Replace or upgrade the 300 meters currently read via handheld during the first 6 months of the project.
- Review and analyze early consumption data prior to moving customers to a metered rate to tweak the water conservation program and prepare for changes to revenue.
- Update the Water Works By-Law # 2016-019 to require developers to purchase a water meter and radio transmitter from the City, to be installed prior to the property being approved for occupancy.

9. Public Outreach Strategy

9.1. The "TIE" Philosophy

Public outreach for a universal metering project is critical to the overall success of the program. When approaching an outreach strategy, it is important to understand that the water meter is simply a measurement tool and to effectively achieve the desired goals of the Water Conservation and Servicing Master Plan, one should consider the **"TIE"** philosophy.

T represents the **Tool** (the water meter that measures the water based on actual use)

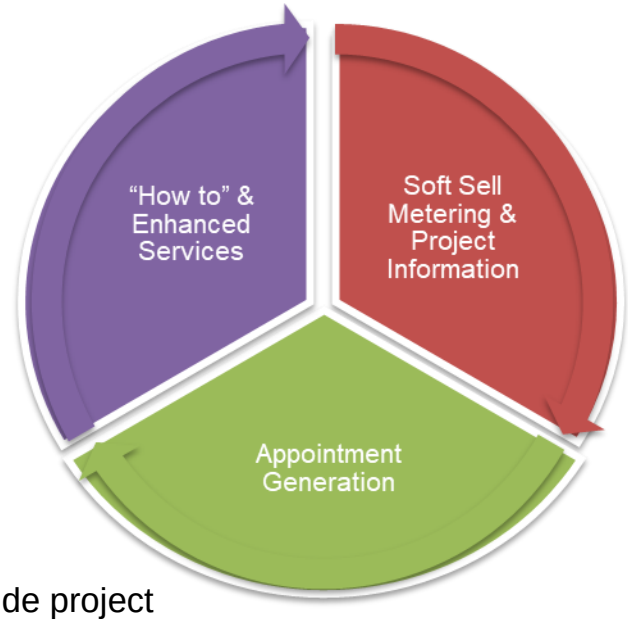
I represents the **Incentive** (a rate structure that allows for a user pay system)

E represents the **Ethic** (users desire to efficiently manage their water use)

An effective demand side management program considers all three elements. A well-planned public outreach program uses the TIE philosophy as a framework to complement an integrated messaging strategy catered to internal and external stakeholders.

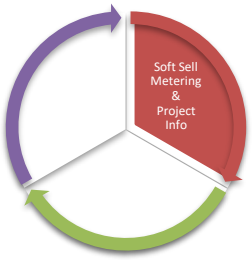
9.2. Integrated Messaging Strategy

A carefully crafted messaging strategy is necessary to ensure that the water meter installation project progresses smoothly and is completed in a timely manner. It is important that the outreach program generates trust and goodwill with the City's Customers, supports acceptance of the new technology and successfully generates appointments. Key themes the City should consider as part of program messaging include:



- Soft sell the concept of metering and provide project information.
- Appointment generation.
- "How to" effectively manage water use and "how to" access enhanced services.

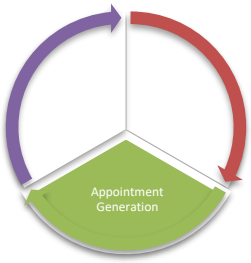
9.2.1. Soft Sell Metering and Provide Project Information



Soft Selling Metering – Universal metering involves moving from a flat rate to a system of user pay whereby users pay for what they use. This model provides equitability but also requires change which can make some users uneasy, especially during the transition. It is important that communication include the benefits of moving to a metered system and outline the phased approach to transitioning.

Project Information – It is important to include in the outreach materials basic information about the program including what the project involves, when it is taking place, who is performing the work and when work will be conducted in specific areas. It will be important to communicate how plumbing or carpentry work will be performed and what homeowners can expect when the technician is on site. Information should be concise and consistent and available through a number of outreach platforms (informational booklet, letters, website, social media, call centre representatives).

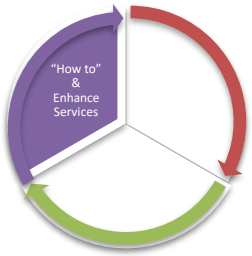
9.2.2. Appointment Generation



Appointment Generation – Unique to this project, technicians will require access to every account within the City. Therefore appointment generation is critical to the overall success. Best practice for deployment is based on installations being carried out on an area-by-area basis. A new area is not released to the technician(s) until a 90%+ completion rate is achieved. This approach of sweeping the City allows for operational efficiencies and avoids all of the difficult installations being left scattered across the City at the end of the project. It is expected that the Installation Contractor will have sample materials to generate appointments, and we recommend that the City and the City's Consultant work closely to determine the final content and branding. A typical program includes the following outreach materials: a mailed informational booklet that soft sells metering, provides information about the project and prompts the homeowner to book an appointment by calling the Installation Contractor's call centre or booking through the Installation Contractor's real time booking website. Where needed, for those accounts that do not book an appointment, follow up contacts will include a reminder notice, phone call and/or door-to-door canvassing (with door tag). These contacts are typically made in a staggered approach over a 6-week period. As a final measure, a final notice will be issued. It is important that the

outreach program state that the program is mandatory and backed by a By-Law. Any remaining hold out accounts will become the responsibility of the City and addressed through a compliance program involving By-Law.

9.2.3. "How to" and Enhanced Services



"How to" – As previously mentioned, moving from a flat rate to a metered rate involves changing customers' behaviours and to soft sell the concept of metering; it is important that the outreach program provide educational information on "how to" monitor and manage water use. This can include information within the mailed informational booklet, website and social media. Many municipalities include indoor and outdoor water use information, offer home water audits, and/or offer water efficiency devices (toilet rebate or flapper programs, low flow showerheads).

Enhanced Services - It is also important to educate users on how to monitor their water use. The use of a customer portal will provide a unique set of tools for monitoring and alerts providing proactive visibility to users which helps to mitigate high water bills and billing disputes. Promotion of enhanced services can be staged in terms of roll out commencing with a high-level overview with the booking information with further information post-installation.

Mock Billing – The use of mock billing is a highly effective strategy to easing in a metered rate. Once all the meters are installed across the City, "mock bills" are issued to customers to demonstrate what their bill would look like on a metered rate. This visibility allows for customers to become aware of their usage, modify habits or check for leaks. Customers would pay the flat rate for a 6-month period before the metered rate would take effect. This transitional approach in combination with the City's move to bi-monthly billing provides a very customer friendly approach.

9.3. Internal and External Stakeholders

When developing the public outreach strategy, the plan should address both internal and external stakeholders. Internal stakeholders include the City's communication team, City departments, the Project Team, Steering Committee and City Council. External stakeholders include both residential and IC&I customers as well as the Installation Contractor.

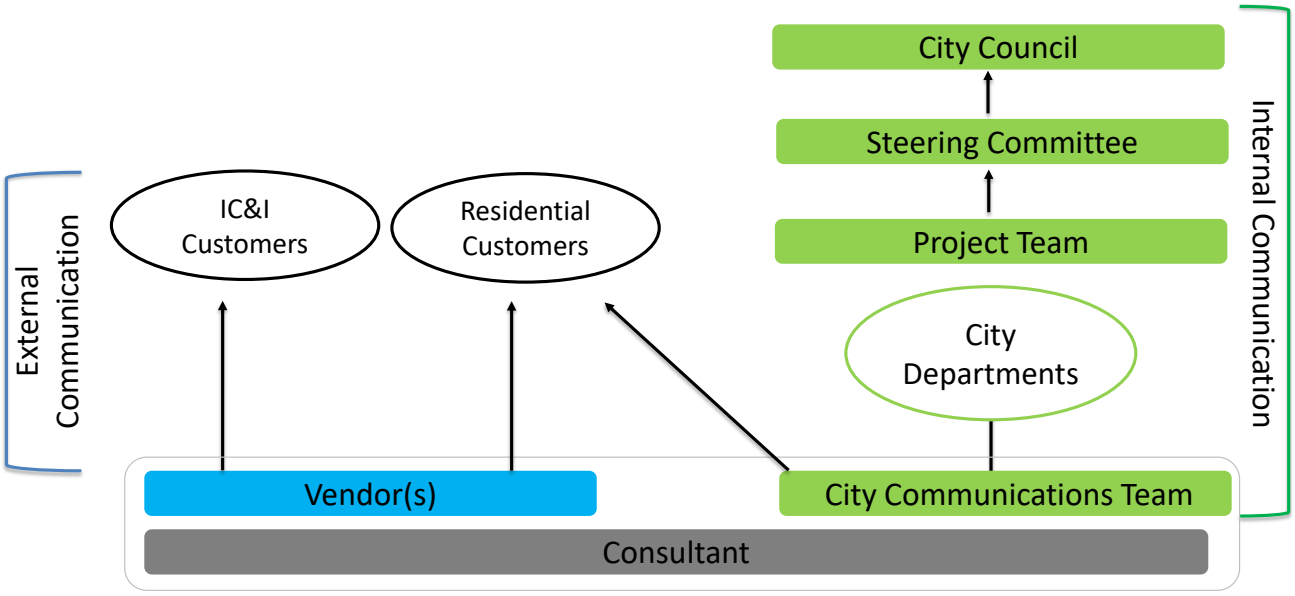


Figure 24 – Public Outreach Stakeholders

9.3.1. Internal Stakeholders

Internal stakeholders can easily be overlooked when developing the strategy, however they play an important role as project ambassadors, embracing change management, and providing customer support. The strategy should include internal communication across departments using emails, kick-off meetings, intranet and training to provide project information and benefits. Helping internal stakeholders understand the value of the project as it relates to their role and the customer will be critical. Internal communication can begin in advance of project start up and Council debriefs are recommended. During project start-up, it is recommended that an Internal Fact Sheet and a Frequently Asked Questions memo be developed in conjunction with the City's communication team, Project Team, Consultant and vendor. As external facing materials are developed, it is important to have a centralized management process of project facts and messaging. With a project of this nature, customers will have access to a variety of communication materials and have the ability to communicate with the vendor's call centre representatives, City personnel and potentially Councillors. It is essential that information be concise, accurate and consistent across all communication channels. This will provide customers with confidence in the program and provide the best overall customer experience.

9.3.2. External Stakeholders

External stakeholders include residential and IC&I customers. It is recommended that prior to the project start-up, the City consider soft launching project information in local newspapers, website, and social media. This allows for customers to understand that this project is approaching and the benefits as part of the overall Water Conservation and Servicing Master Plan. As previously mentioned, outreach to external stakeholders is recommended in both official languages using the following contact methodology:

- Introductory Letter: The letter produced by the City introduces the Installation Contractor, the project, the benefits of the project, and generally describes the appointment-making process. Introductory letters are typically sent on an area-by-area basis once the Contractor has approval to perform work in the area.

- Appointment and Informational Booklet (Contact 1): The Contractor develops a full colour appointment and informational booklet that initiates Customers to call/or and book an appointment online. The Contractor is responsible for printing and delivering Contact 1. The booklet will follow City branding guidelines, include the City logo, the Contractor's logo, provide information about the project, appointment information options and security information about the installer attending the property.

- Reminder Letter (Contact 2): The Contractor develops a reminder letter and will be responsible for all costs associated with printing, envelopes, and delivery by mail to the service address. There is typically a minimum of two (2) weeks between the mailings of Contact 1 and Contact 2.

- Door to Door Canvassing and Door Tag (Contact 3): The Contractor develops, prints, and delivers by hand door tags to be left at the property during canvassing when there is no answer at a residence or when a Customer does not show up for a scheduled appointment. Typically, the Contractor will canvass each address a minimum of once with at least one attempt being performed after 5:00PM during the week or on a Saturday.

- Outbound Phone Attempts (Contact 4): The Contractor will also attempt to contact the Customer by phone, performed after 5:00PM during the week or on a Saturday. Where no phone is provided or is incorrect, the Contractor shall obtain the phone number by using 411, reverse phone

number look up, and Google searching the address based on customer and property owner information provided by the City. Where a phone number cannot be found, the Contractor shall perform contact attempts through canvassing and door tags.

- Final Notice Letter (Contact 5): The Contractor will send out a Final Notice letter to give the Customer one last opportunity to call and book an appointment. Once the Contractor has performed all five (5) required attempts to contact the Customer, it shall be deemed as a Soft Refusal and these accounts will become the responsibility of the City.

Notably, all five (5) contacts are typically performed between 6 and 8 weeks, evenly spacing out the contacts where possible. All materials are developed in collaboration between the City, the Consultant, and the Contractor. Final approval resides with the City. The Contractor is responsible for costs associated with development, printing and mailing with the exception of the Introductory Letter. It is important to clearly outline from the onset of the communication that the program is mandatory and backed by the City's By-Law.

External stakeholder communication can also include the following:

- Public Information Sessions: It is recommended that, at minimum, one public information session be hosted at the beginning of the project. The public information sessions should allow for affected Customers to ask questions of the representatives from the City and the Contractor. The City will be responsible for selecting the location for the information session. The Contractor shall host an information session that is at least two (2) hours in duration. The City typically determines what advertising will be done for the purposes of the public information session and shall organize and bear all costs of this advertising. Examples include: an introductory letter, City website, or social media. The Contractor typically provides a display booth as well as a sample installation showcasing various product samples. The City, the Consultant, and the Contractor provide staff for the public information session.

- City Website and Social Media: It is recommended that the City's website and social media channels be part of the public outreach program. To ensure content is consistent with other program materials, the City, with

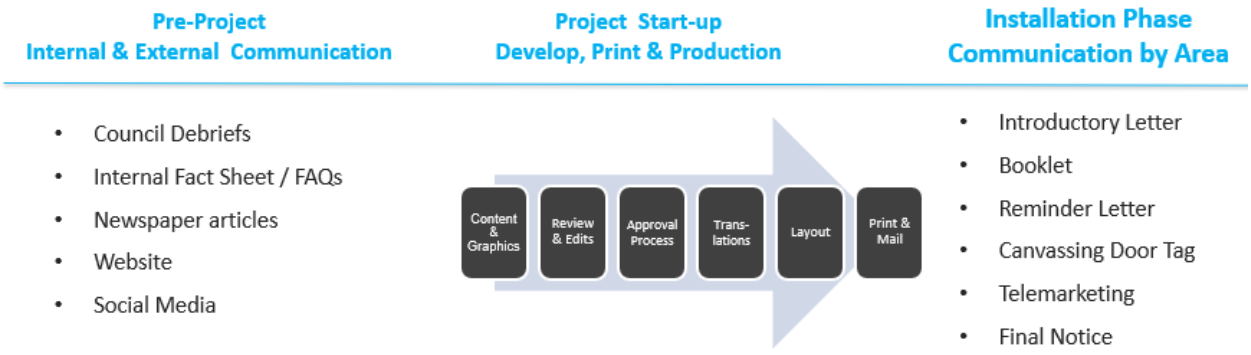
support, will develop the content taking into consideration the other materials developed as part of contact management.

Videos and/or Media Interviews: During project start-up, the City may want to consider media editorial interviews, or creating a project video which explains the benefits of the project and what to expect during the installation process. The City may also want to build on the great work related to the existing YouTube videos and the Water Conservation and Servicing Master Plan. These strategies in combination with others helps to support customers are they move from to a user-based system of billing for water.

The implementation of water meters will provide several benefits to the community:

9.4. Timelines and Resource Planning

The heaviest lift in terms of development happens during the project start-up phase. Establishing a governance structure and understanding the approval process is essential to establishing the critical path. Content development, translation to French, design, approval, printing and mailing all need to be carefully planned to ensure alignment with the first day of installations as appointment generation is key for technicians to perform the work.



Summary of Diameter Services Guidance in Chapter 9:

- City and Consultant should work closely to determine final content and branding for customer communications materials.
- Begin internal communications in advance of the start of field work including Council debriefs, Internal Fact Sheet, and Frequently Asked Questions memo.
- Prior to project start-up, consider a soft launch of project info in local newspapers, website, and social media.
- Ensure all materials are available in both official languages.
- Hold at least one public information session.
- Keep City website and social media channels consistent with other program materials. Consider media editorial interviews, project video, etc.

10. Procurement Strategy

10.1. Scope and Groupings

Setting the framework for the City's procurement strategy is driven by two primary decisions; what to include in the procurement scope and how to group the different procurement elements. This process begins by defining the products and services required for procurement and determining who should perform the work (City resources or outsourced resources). In the case of the City, the following elements and support structures for the AMI system, water meters and installation were discussed in a procurement workshop with Diameter to provide a broader understanding of all of the procurement elements and how they pertain to the City.

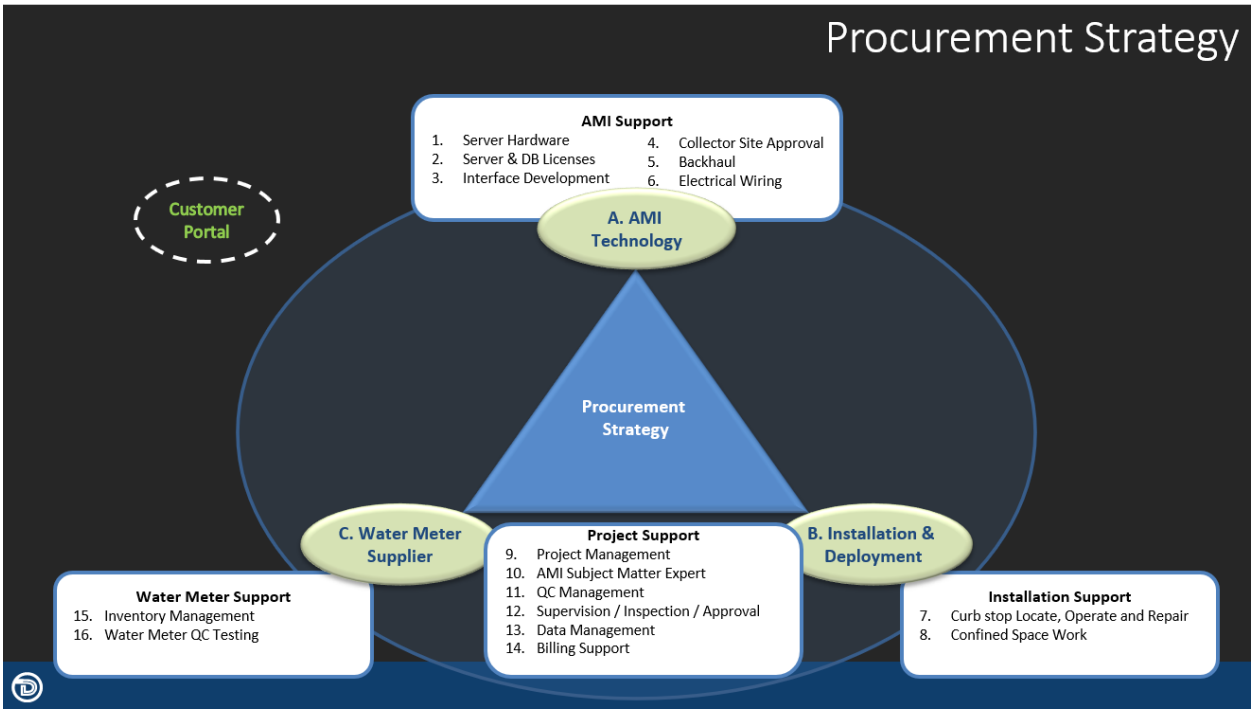


Figure 25 - Project Scope

With an understanding of what products and services are required as part of the procurement strategy, the City's decision-making process shifted to determine what elements should be grouped together during procurement and in which order should the various components be procured.

The primary procurement groupings include:

A. AMI technology (which may include the MDM software),
B. Installation and deployment, and

C. Water meter supply.

The customer portal may also be procured as a component of the AMI technology if the AMI vendor's features and functionality meet the City's needs; alternatively, a fully functional customer portal can be procured separately.

Based on the primary procurement groupings depicted above, there are four procurement options for the City's consideration:

Options	Description
Option 1	**Turnkey** Single Procurement (A+B+C).
Option 2	Combine A (AMI Technology) + B (Installation & Deployment), and **C (Meter Supply) as a separate procurement.**
Option 3	A (AMI Technology) as a separate procurement and Combine B (Installation & Deployment) + C (Meter Supply)
Option 4	**All Separate** Procurements: A (AMI Technology), B (Installation & Deployment), and C (Meter Supply).

Table 25 – Procurement Options

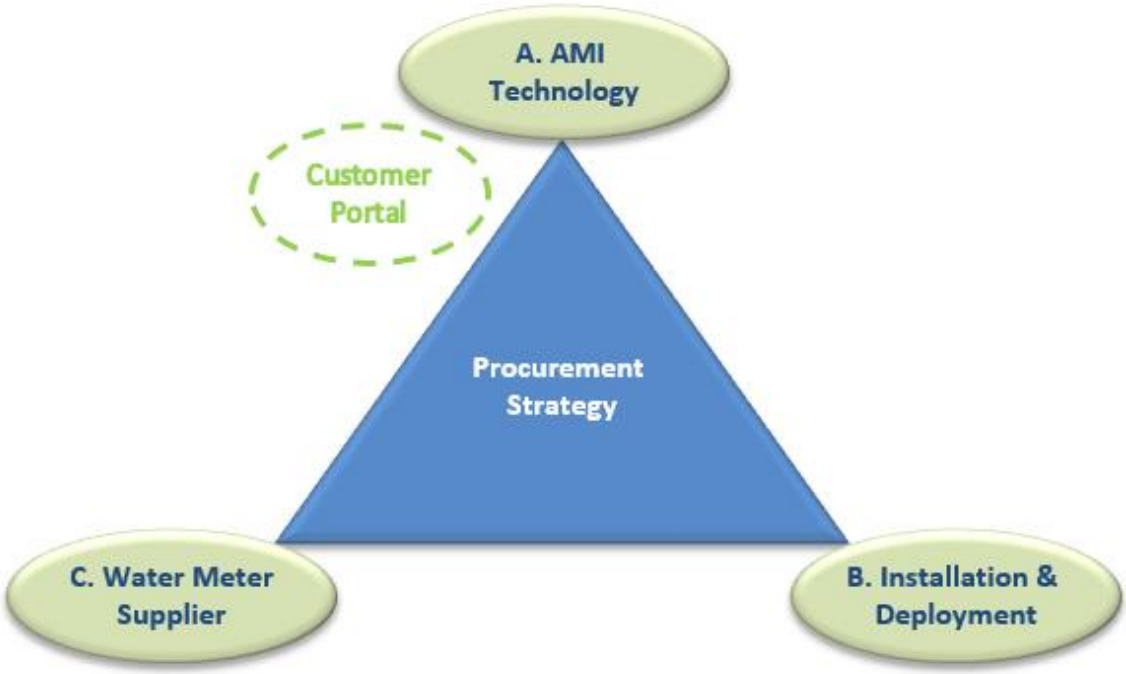
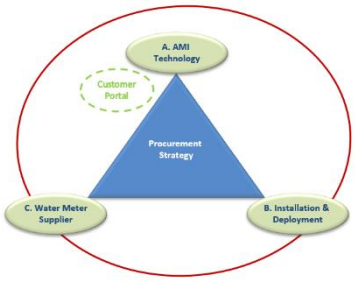
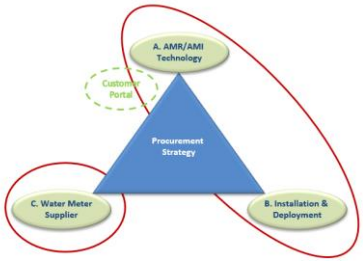


Figure 26 - Procurement Strategy

Option 1 Single Procurement Turnkey (A+B+C)	Option 2 Two Procurements AMI + Installation (A+B) Meter Supply Separate (C)	Option 3 Two Procurements AMI Separate (A) Installation + Meter Supply (B+C)
		

Option 1 Single Procurement Turnkey (A+B+C)	Option 2 Two Procurements AMI + Installation (A+B) Meter Supply Separate (C)	Option 3 Two Procurements AMI Separate (A) Installation + Meter Supply (B+C)
Advantages (Benefits) • Responsibility for all components in a single vendor. • Product warranty can include in/out costs for the first year. • Product payment is tied to installation.	**Advantages (Benefits)** • Responsibility for AMI performance is in a single contract. • Installation remains with AMI vendor who then has complete responsibility for successful communication to collection equipment. Since Installation issues create the most risk of poor AMI performance coupling Installation with AMI is advantageous for the City. • Allows for multiple meter manufacturers and components.	**Advantages (Benefits)** • Medium cost scenario. • Provides best selection of AMI systems.
Disadvantages (Risks) • May be higher costs due to some vendors having to put margin on margin for products. • Prime contract performance bond requirements may limit vendors (smaller companies may not be able to bid). • The number of installation companies in the market may limit AMI technology options.	**Disadvantages (Risks)** • Issues with faulty meters will be a City responsibility. • Bad wiring to encoder could be blamed on meter (City responsibility).	**Disadvantages (Risks)** • City will bear liability: - Supplying meters - Install and AMI system working together has the most liability. • Non-mechanical meters - AMI and meter supply need to be procured together to ensure you get all the functionality

Table 26 - Procurement Advantages and Disadvantages

There are advantages and disadvantages to each option and some options are more prevalent than others in the marketplace. It is important to know that the groupings can also influence the competitiveness of the marketplace and impact overall project costs and resource demands for the City. The competitive landscape is expected as follows:

Prime	AMI Provider	Meter Provider	Installation Provider
Aclara	Aclara	Badger Diehl Other	Metercor
KTI	Sensus	Sensus	KTI
MasterMeter	MasterMeter	MasterMeter	
Metercor	Itron	Kamstrup Badger Mueller MasterMeter	Metercor
Mueller	Mueller	Mueller	Metercor
Neptune	Neptune	Neptune	Neptune
Wolseley	Badger Itron	Badger Mueller Other	Wolseley MeterCor

Table 27 – Procurement Competitive Landscape

With a turnkey procurement strategy (option 1), it is expected that the City would receive at least 4 submissions including the major market players.

If the City opted for AMI separately (option 3), the AMI procurement should be conducted first, then followed by the installation and meters as a secondary procurement. With this strategy it is important to note that non-mechanical meter functionality could be impacted depending on the AMI vendor selected. Therefore, for non-mechanical meters, it is recommended that the AMI and meter be procured together to ensure the City receives all functionality.

Recommendations: Given the complexities of a universal metering project, Diameter recommends **Option 1** for a turnkey solution which best supports responsibility for all components in a single vendor. It is also recommended that the procurement for the customer portal be included as part of the turnkey single RFP.

10.2. Procurement Type

Diameter presented the City with several competitive procurement methods for consideration. It is important to mention that typically AMI projects do not fall neatly into normal procurement rules. Through workshop discussions, Diameter reviewed the advantages and disadvantages of pursuing an RFP versus a tender process; notably the tender process primarily focuses on price solicitation for specific goods and services (generally commodity items), is highly structured, and leaves little room for deviation from what has been requested, while the RFP process allows for alternatives and variability in the offerings.

Diameter does not recommend a tender process for the AMI or the installation procurement as the market offers too much variability in experience and product functionality for a tender process. An RFP for the water meter supply also allows the City to score product support and customer service levels offered post project. It could also allow the City to place value on a market presence and future support. This approach also allows for the City to evaluate product options as some manufacturers have unique features related to AMI that should be given qualitative points should they align with the City's business drivers.

RFP Process	Tender Process
Advantages • Allows for apples to oranges comparison • Allows for alternatives • Procurement includes strong specification but allows for variation in the offering • Software can be difficult to compare • Most common type of AMI/AMR procurement	**Advantages** • Likely lowest price • Save time on evaluation • Could work for just water meters

Disadvantages • The awarded solution may not be the lowest cost solution	**Disadvantages** • No consideration for innovative solution • Easy to have bidders disqualified due to a small non-compliance • Price is not the only factor with these types of projects • Quality of team and proven products need to be evaluated

Table 28 – RFP vs. Tender, Summary of Key Advantages and Disadvantages

The City of Cornwall Project Team expressed a preference for an RFP process, and the evaluation would ensure that the City would be moving forward with vendor(s) that are proven in the market.

Summary of Diameter Services Guidance in Chapter 10

- Procure AMI and meter technology together.
- Require a turnkey solution with responsibility for all components through a single vendor.
- A tender process is not recommended.

11. Implementation Strategy

11.1. Introduction

An AMI system implementation project is not your typical engineering project. The combination of products being supplied (often from different vendors), installation service providers, software applications and software integrations to existing and new applications presents unique challenges. Complicating this further, the products and software applications all need to be compatible with one another and provide the right data, in the right way, to the right systems, and at the right time in the business process. In fact, often AMI projects more closely mirror technology projects rather than installation projects. Finally, the work needs to be done while ensuring the City's water customers are informed and engaged in this very important project.

These challenges require a single, dedicated, and focused implementation approach. To create this focus, Diameter recommends establishing distinct project phases that, once complete, represent progress of key elements of the overall project.

The implementation plan for a universal metering project is unique as it compels new processes for handling infrastructure that does not exist today while managing the change of existing processes to accommodate the added features of the AMI system.

11.2. Project Phases

Below is a description of the Project's unique phases and some key activities the City should expect within each phase. Often resource requirements may change depending on the nature of the project phase, some requiring a heavier legal, procurement or IT element.

11.2.1. Phase 1 – Design

Diameter's current assignment would represent Phase 1 of the Project. This phase provides the framework and foundation that will guide future phases. The completed deliverables of this investigation are the key activities required.

11.2.2. Phase 2 – Procurement

The procurement phase is more complicated than most. As detailed in Chapter 9, Procurement Strategy, it is expected that three procurements will be required to support the various elements of this project. These procurements are:

- The turnkey AMI RFP, which will include the following elements:
  - AMI technology including the radio transmitters, data collectors and all the associated software components (head-end meter data collection software, meter data management software, and customer portal as provided by the AMI vendor).
  - Installation Services for meter cut-ins, meter changeouts (as required), radio transmitter installation, fixed network infrastructure installation (if necessary), and meter box lid replacement (if necessary).
  - Network Maintenance: it is generally recommended to turn over the network maintenance to the AMI vendor to ensure network uptime as outlined in the RFP and agreed to by the vendor under contract is achieved. Although the City will be responsible for the meter and radio transmitter performance, the AMI vendor will be responsible for annual inspection and maintenance of data collection equipment and ensuring network uptime in the event of a failure as defined in the service level agreement.
- Procurement for a fully functional customer portal. This procurement will be optional and only proceed as necessary following evaluation of Procurement #1. As part of Procurement #1, AMI vendors will be asked to provide a customer portal meeting the City's specifications. Most AMI vendors are in the infancy stage of customer portal development and will likely need to partner with a third-party vendor to meet these specifications. Depending on whether the City's needs are met through this RFP, and the cost of doing so, it will be determined whether a second procurement for a fully functional customer portal is necessary.
- Procurement for curb stop operation and repair. As part of this Universal Water Metering project, the City of Cornwall or the selected Installation Contractor will be operating all customers' building control valves, most of which likely have not been operated in years. As a result, some will not function properly and will require the use of curb stops. While the City will

allow the Installation Contractor to use freeze kits, this option is not always possible; the least risky choice is to use the curb stop.

- The City of Cornwall does not have the resources to undertake curb stop operation and repair, and this service will need to be contracted out as part of the project.

11.2.3. Phase 3 – Start Up

This phase includes engaging Diameter and the City's internal resources as the AMI and installation vendors set up the facilities, software, integration services, and user acceptance testing. The detailed activities include:

- Contractor setup of the local project office and warehouse to support project Phase 4.
- Development and approval of the public outreach program and materials.
- Integration development between the various new and existing systems.
- The Contractor's development and internal testing of the Meter Installation System (MIS) to manage the installation work orders.
- Configuration and training on all proposed software applications.
- Inspection, planning, deployment, and configuration (as required) of the AMI collector network.
- Development of installer training policies, procedures, and training.
- Setup and training of the Contractor's call centre personnel in project specific protocols.
- Material planning, approval and forecasting of all water meter, encoder register, radio transmitter and other required installation materials.
- Perform Initial User Acceptance Testing (IUAT) to ensure all systems are ready for installation and continued water billing. Approval of the Final User Acceptance Testing (FUAT) is the milestone to ensure the new systems support the billing process and will allow the Contractor to move into Phase 4a – Proof of Concept.

11.2.4. Phase 4a – Installation and Deployment, Proof of Concept (POC)

The project will go through a limited proof of concept where the software applications are fully integrated, and the Contractor installs a limited number of water meters and AMI equipment. This is an important project phase to ensure the Contractor is ready to ramp up production in a controlled manner.

- Complete the deployment and configuration (as required) of the AMI collector network for the entire service territory.
- Perform water meter installs, replacement, retrofit and upgrade activities within the pre-defined POC area.
- The Contractor will perform quality assurance on installations performed.
- Diameter, as the Consultant and owner's representative, will perform quality inspections on the Contractor's installation work.
- Implementation of the public outreach program.
- Operate a project call center to receive customer inquiries, appointment requests, and receive and manage any customer complaints.
- Planning and implementation of the FUAT to ensure all identified AMI business drivers as well as Contractor committed functionality are achieved. Approval of the FUAT is the milestone to allow the Contractor to move into Phase 4b – Installation and Deployment.

11.2.5. Phase 4b – Installation and Deployment

Once the Contractor has passed the Final User Acceptance test, the City and Diameter will validate that the system and Contractor are meeting the specifications of the procurement. Like the activities of the proof of concept, this phase includes the following:

- Perform water meter installs, replacement, retrofit and upgrade activities on an area-by-area basis.
- The Contractor will perform quality assurance on installations.
- Diameter field inspectors will use their QA app to perform quality inspections on the Contractor's installation work.
- Implementation of the public outreach program.
- Operate a project call center to receive customer inquiries, appointment requests, and receive and manage any customer complaints.
- Achieve completion of the Project Milestones within the agreed upon timeline.

11.3. Schedule by Project Phase

11.3.1. Program Master Schedule

The Program Master Schedule is grouped into the key project phases as discussed above.

A summary of the project phases duration is detailed in the table below.

Task Name	Duration	Months
Project Approval	52 days	1.7 M
Design Stage / Phase 1	159 days	5.3 M
Procurement Stage / Phase 2	218 days	7.2 M
Manage Stage / Phase 3, 4, 5	650 days	30 M
Phase 3 - Startup	153 days	5.1 M
Phase 4 - Proof of Concept, Installation and Deployment	470 days	15.4 M
Phase 5 - Close Out	35 days	1.2 M
Mock Billing	131 days	4.4 M
Total Duration	**3.6 Years**	

Table 29 - Overall Project Schedule

11.3.2. Phase 1 – Design

Phase 1 of the project is the design or Professional Consulting Services for a Universal Water Metering AMI Consultant (RFP 22-P12), which produced this report.

Task Name	Duration	Total Duration
DESIGN Part A1 - Preliminary Design	159 days	159 Days
Project Pre-Kickoff Meeting	0.5 days	
Project & Stage Kickoff Meeting	0.5 days	
Project Management	100 days	
Information Request	20 days	
Database Assessment	16.5 days	
Workshop 1	15.5 days	
Design Report - Part 1	20.5 days	
Workshop 2	21 days	

Task Name	Duration	Total Duration
Workshop 3	60 days	
Design Report - Part 2	59.5 days	
Final Design Report	26.5 days	
Preparation for Systems Integrations with Diamond	20 days	
Step 1 - SOW	20 days	
Council Approval	52 days	
Request to be on Council Meeting Agenda	0 days	
Submit Report to Council	0 days	
Council Meeting and Endorsement	0 days	
Total Days		**159 Days**
Total Months		**5.3 M**

Table 30 - Phase 1 Project Schedule

11.3.3. Phase 2 – Procurement

Phase 2 of the project is estimated to have a duration of just over 7 months, as shown below.

Task Name	Duration	Total Duration
PROCURE Part A2 - Detailed Design and Tendering Services	218 days	218 days
Pre-Kickoff Meeting	5 days	
Prepare for Kickoff Meeting	5 days	
Procurement Stage Kickoff Meeting	1 day	
Information Request	5 days	
Project Management	175 days	
Progress Meetings (1 hour remote meeting every 2 weeks)	175 days	
Risk Management Monitoring	175 days	
RFP Development – AMI, Meter, Install, Customer Portal	69 days	
RFP Structure Meeting	6 days	

Task Name	Duration	Total Duration
Specification Development	54 days	
Strategic Delivery & Legal	25 days	
Evaluation Criteria	25 days	
RFP Final - 100%	15 days	
Procurement	35 days	
Proposal Evaluation	38 days	
Contract Negotiations	30 days	
Recommendation and Approval	21 days	
Prepare Recommendation Report	3 days	
Council Approval (Onsite)	0 days	
Contract Execution	1 day	
Total Days		**218 Days**
Total Months		**7.2 M**

Table 31 - Phase 2 Project Schedule

11.3.4. Phase 3 - Start Up

This phase of the project will include the City, CentralSquare, the Consultant team and the AMI and Installation vendors. The purpose of this phase is to pre-plan the project, develop the customer outreach program, develop and test interfaces, and configure the new and existing software applications.

Task Name	Duration	Total Duration
Startup	153 days	153 Days
Onboarding of PMO Team	10 days	
Introductions and Preparation for Kickoff Meeting	22 days	
Introductory Call with Diameter Team	1 day	
Kickoff Meeting with Cornwall and Vendor	1 day	
Progress Meetings	121 days	
WORKSTREAMS	126 days	
Project Governance	126 days	

Task Name	Duration	Total Duration
Integration Development	99 days	
Network Deployment and Installation	126 days	
Public Outreach Development	92 days	
Installation Preparedness	104 days	
Software Deployment	15 days	
Training	62 days	
Quality Assurance	42 days	
Change Management	41 days	
Testing	13 days	
Initial User Acceptance Testing (I-UAT)	10 days	
Call Centre Operations	1 day	
Online Booking Systems	1 day	
After Hours and Emergency Response	1 day	
Preparing for the First Installation	20 days	
Pre-Construction Meeting	1 day	
Mail out of City Initial Introduction Letters - Contact 0	1 day	
Open House	1 day	
Mailout of initial Territories for POC - Contact 1	1 day	
Total Days		**153 Days**
Total Months		**5.1 M**

Table 32 - Phase 3 Project Schedule

11.3.5. Phase 4a Proof of Concept

This phase of the project will include the City, CentralSquare, the Consultant team and the AMI and Installation vendors. Having passed the Initial User Acceptance Test, the AMI and Installation Contractor will proceed to install approximately 1,000 water meters. The purpose of this phase is twofold: first, it validates the installation Contractors people, processes, and systems ability to handle the production volumes that will be necessary in the next phase; secondly, it will provide real consumption data using water meters installed in a

production environment, this data will be used in the Final User Acceptance Testing (FUAT) to complete a full end to end test of the system.

Task Name	Duration	Total Duration
Proof of Concept	80 days	80 Days
First Installation	0 days	
Installations (POC)	16 wks	
Program Management	80 days	
Communication and Project Coordination	16 wks	
Document Control	16 wks	
Diameters Project Playbook	16 wks	
Progress Meetings / Dashboarding	71 days	
Steering Committee Support	16 wks	
Contract Management	16 wks	
Project Scope Management	16 wks	
Project Budget Management	16 wks	
Contract Schedule Management	16 wks	
Risk Management Monitoring	16 wks	
Quality Assurance Program (KPI's)	80 days	
QA Performance Dashboard	16 wks	
QA Installation Data Management Review	16 wks	
QA Post Installation Approvals	16 wks	
QA Field Inspections	16 wks	
Progress Claim Approvals	16 wks	
Task Management Approvals	16 wks	
Customer Service Support	16 wks	
Training	7 days	
Final User Acceptance Test (F-UAT)	20 days	
Total Days		**80 Days**
Total Months		**2.7 M**

Table 33 - Proof of Concept Project Schedule

11.3.6. Phase 4b Installation Phase

The Installation Phase of the project will take 12.7 months, as show below.

Task Name	Duration	Total Duration
Installation and Deployment	390 days	
Installations	78 wks	
Public Outreach / Communication / Open houses	78 wks	
Program Management	390 days	
Communications and Project Coordination	78 wks	
Document Control	78 wks	
Diameter's Project Playbook	78 wks	
Progress Meetings	78 wks	
Steering Committee Meeting (Quarterly)	300 days	
Steering Committee Meeting support	60 wks	
Scope Management	78 wks	
Budget Management	78 wks	
Schedule Management	78 wks	
Risk Management Monitoring	78 wks	
Project Performance Dashboard	78 wks	
Quality Assurance Program (KPI's)	390 days	
QA Performance Dashboard	78 wks	
QA Installation Data Management Review	78 wks	
QA Post Installation Approvals	78 wks	
QA Field Inspections	78 wks	
Approvals and Oversight	390 days	
Progress Claim Approvals	78 wks	
Task Management	78 wks	
Compliance Management	78 wks	
Material Handling	78 wks	
Customer Service Support	78 wks	
Substantial Completion	Milestone	
Total Days		**390 Days**

Task Name	Duration	Total Duration
Total Months		**12.7 M**

Table 34 - Installation Phase Project Schedule

11.3.7. Phase 5 Close Out

The Project Close Out will take 1 month, as show below.

Task Name	Duration	Total Duration
Close Out	35 days	35 Days
Clean up Installations	2 wks	
System Acceptance	10 days	
Project Close Out and Reporting	5 days	
Lessons Learned	5 days	
Transition Program to Operations	5 days	
Total Days		**35 Days**
Total Months		**1.2 M**

Table 35 - Close Out Project Schedule

11.3.8. Production Schedule

The production schedule of a project of this size requires a strategic ramp up. Structuring the project in key phases requires the Installation and AMI Contractor(s) to prove their system and business processes are producing the desired performance prior to ramping up production. The Proof-of-Concept phase (Phase 4a) has two purposes, 1) to ensure the AMI technology works and can support the water billing process; 2) to ensure the Installation Contractor meter installation system (MIS) is able to handle the production volumes this project requires.

Given the Program Master Schedule, it is expected the ramp up will have the following number of installs completed in each year.

Year	Installs
2023	-
2024	930
2025	12,296
2026	4,745
Grand Total	**17,961**

Table 36 - Installs by Year

This shows a peak production in 2025 with installation being completed in 2026. The production schedule would assume POC would be carried out at the end of 2024, carrying slightly into 2025 to allow for full production throughout 2026.

11.3.9. Mock Billing

As a part of the universal metering program, Diameter has added a mock billing workstream that will provide the City with added confidence in the conversion from the current billing process to their new process with an AMI system. The table below describes the expected duration of the overall project phases including the mock billing workstream and considers the City's internal review and approval processes.

During the workshop activities, the City and Diameter identified mock billing as a key component to allow customers an easier transition to a metered rate. Diameter has included an additional workstream in the plan to accommodate the elements of a mock billing cycle. Mock billing will allow customers to identify any issues with their private side supply such as leaks and conservation practices before heading into their first actual bill. Having three mock bill periods should provide property owners enough time to adjust their habits prior to receiving their first actual bill.

As part of the mock billing process, Diameter has included the following steps in the project plan that dive into the necessary components of billing at the right time in the process, when the CIS vendor, CentralSquare, is at the table.

Task Name	Duration	Start	Finish
Mock Billing		Wed 3/27/24	Fri 1/29/27
Mock Billing kickoff meeting	1 day	Wed 3/27/24	Wed 3/27/24

Account Management workshop (Cycle and Route Management)	1 day	Wed 3/27/24	Wed 3/27/24
Bi-Monthly Billing workshop	1 day	Thu 3/28/24	Thu 3/28/24
Mock billing communication workshop	1 day	Fri 3/29/24	Fri 3/29/24
Draft mock billing plan	5 days	Mon 4/1/24	Fri 4/5/24
Review mock billing plan	5 days	Mon 4/8/24	Fri 4/12/24
Approve mock billing plan (First draft of actual billing plan)	5 days	Mon 4/15/24	Fri 4/19/24
Prepare for mock billing test run	1 day	Thu 6/11/26	Thu 6/11/26
Mock billing test run	10 days	Fri 6/12/26	Thu 6/25/26
Approval to start mock billing cycle	5 days	Fri 6/26/26	Thu 7/2/26
Mock billing starts (3 bi-monthly bills)	131 days	Fri 7/31/26	Fri 1/29/27
Billing period 1	40 days	Fri 7/31/26	Thu 9/24/26
Review and adjust billing plan based on findings	4 days	Fri 9/25/26	Wed 9/30/26
Billing period 2	40 days	Thu 10/1/26	Wed 11/25/26
Review and adjust billing plan based on findings	3 days	Thu 11/26/26	Mon 11/30/26
Billing period 3	40 days	Tue 12/1/26	Mon 1/25/27
Review and adjust billing plan based on findings	4 days	Tue 1/26/27	Fri 1/29/27
Transition to actual billing	0 days	Fri 1/29/27	Fri 1/29/27

Table 37 - Mock Billing Project Schedule

Summary of Diameter Services Guidance in Chapter 11

- Establish distinct project phases for the deployment, that once complete, represent progress of key elements of the overall project.
- Turn network maintenance over to the AMI vendor.

12. Proposed Internal Project Support Organization

A project of this nature needs to be supported through a combination of internal (in blue) and external resources (in white). There will be two main categories of oversight, support and participation in this project. The Steering Committee will be made up of City of Cornwall key leaders guiding the overall direction and the Project Team will be made up of roles from Customer Service, Operations, Finance, Water Purification, Infrastructure and Environmental.

The information below outlines the key member of the Project Team for the Procurement Phase of the project as well as the Installation Deployment and outlines the effort, by role, which should be anticipated.

12.1. Procurement – AMI, Meter Supply, and Installation (Phase 4,5)

A turnkey RFP for the AMI system including AMI infrastructure, all the software components, meter supply and installation services will require staff time to support the RFP development, evaluation of proposals and demonstrations.

The following diagram suggests a Project Team that will support the Procurement of the AMI system and its various components. The RFP document itself will be largely developed by Diameter Services containing the specifications developed with the City through the Design phase of the Project but with document input and approval from the City through the process. The Project Team should anticipate the time required to review proposals (or their assigned sections of the proposals) and participate in evaluation meetings led by Diameter to determine final scores. While the diagram depicts the Project Team, it is understood that team members will want to leverage specific subject matter expertise within their department or within the City for certain aspects of the Procurement process including meter specifications, IT security assessment, integration requirements, or installation requirements as a few examples.

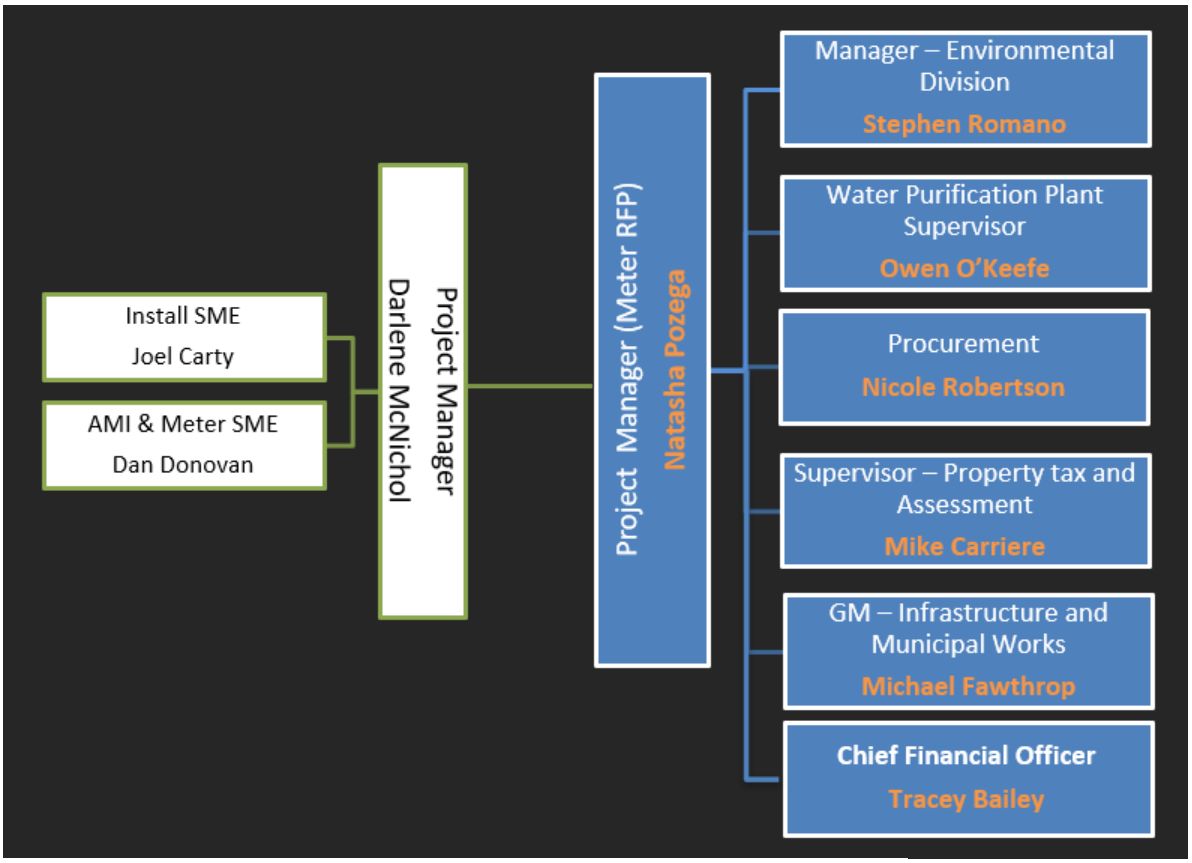


Figure 27 – AMI Project Team (Procurement)

12.2. Project Team: Phase 3, Phase 4a, 4b, and Phase 5

Phase 3 consists of a 6-month Startup, Phase 4a is the 4-month Proof-Of-Concept and Phase 4b is the 18-month Installation and Deployment. Phase 5 is the one-month Close-out.

The Project Team for the various Phases is outlined below and the oval shown beside each role indicates the Phase at which the role would start on the Project. As with Phase 3, the diagram below represents the Project Team for Phases 3 – 5 with internal team members being in blue and external support shown in white. This is not intended to be a complete list of contributors to the project since each team member may want to leverage additional resources throughout the course of the project. An estimate of the time requirement from those resources and the specific tasks they will accomplish are outlined in the tables below.

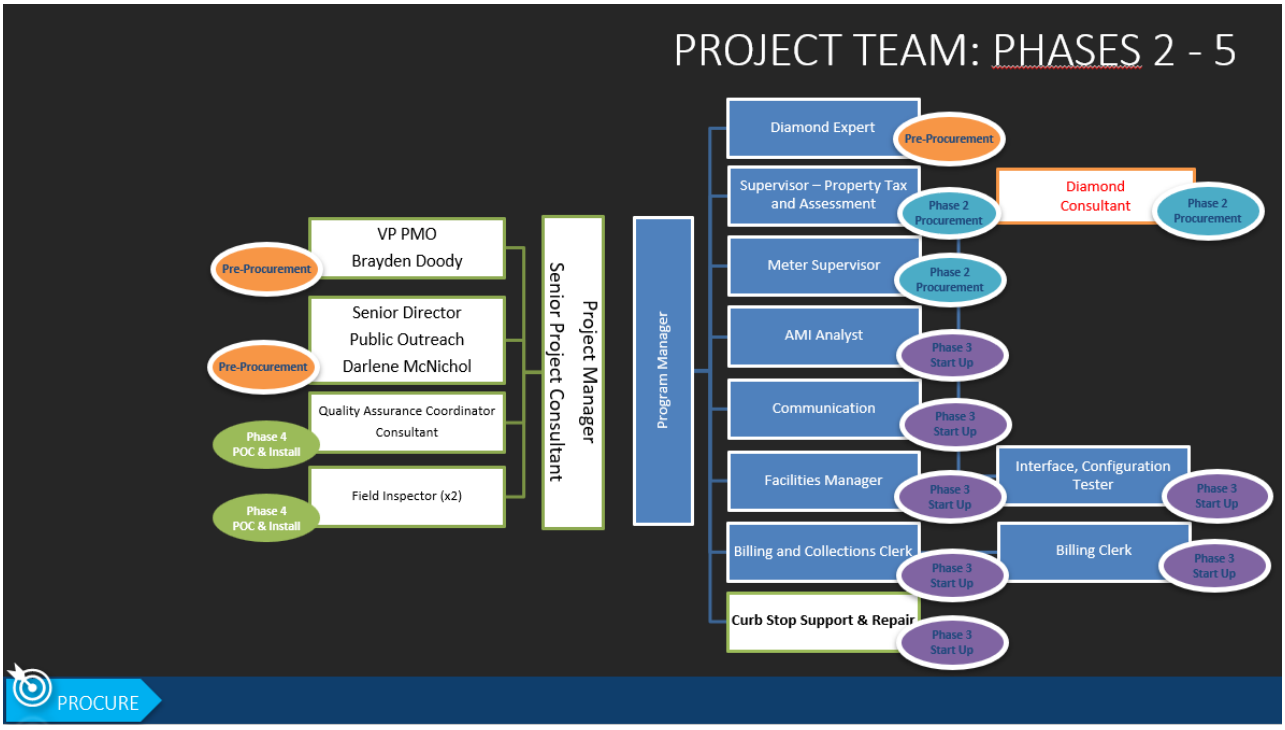


Figure 28 – AMI Project Team (Startup, POC, Installation and Deployment)

The table below provides the role, specialty, department, and a description of the expected tasks.

Role	Specialty	Department	Task
Steering Committee	Leadership and Vision		Attend Steering Committee meetings to guide the vision of the project.
Core Team		Usually made up of 5 to 8 people across the major stakeholder departments. Customer Services, Engineering, Technology.	Key personnel that contribute to the design and procure phases.
A. Project Manager	Project Management	Engineering, Operations or Conservation	Progress meetings, contract management
B. Field Supervisor	Field Supervision	Customer Service, Meter Shop	Task Resolution, field support (5% of all accounts) / Progress meetings
C. Field Inspector	Water Meter inspections - Small Meters (SM)	Customer Service, Meter Shop or Outsourced depending on resource availability	Quality inspections, support supervisor on task Resolution for small meters and retrofits
C. Field Inspector	Water Meter inspections - Large Meters (LM)	Customer Service, Meter Shop or Outsourced depending on resource availability	Quality inspections, support supervisor on task Resolution, FTE estimate depends on the number of LM replacements.
D. Data Collector Coordination	Project Management	Facilities	Gain access, coordination surveys and installations with the Contractor, approved work performed at each site. Time estimate is dependent on type of technology.

Role	Specialty	Department	Task
E. AMI Analyst	Business Analysis	Customer Service	Review and define business requirements, perform system testing, become the trainer, run reports, monitor system.
G. IT Security, Network, Security	Single sign on	IT	Support and testing of single sign on authentication. Threat Assessment, penetration test if required.
H. CIS Admin Supervisor	Application specialist	Customer Service, Business Solutions	Oversee the development of Diamond changes, development of interfaces, testing, business requirements meetings.
I. CIS Billing Supervisor	Application Specialist - MIS	Customer Service, Business Solutions	Business requirement development support for the new systems and interfaces. Development of integration testing, User acceptance Testing, Focus on the Contractor Meter Installation System (MIS)
J. CAS Lead Billing	Water Billing	Customer Services, Operations	Monitoring the water billing process and the installation data quality.
K. Communication Coordinator	Communications / public outreach	Communications	Outreach materials - Development/review/approval

Table 38 – Detailed Project Roles

The following table shows the position, the project phases, and the number of expected hours per quarter that each role should expect. It should be noted that 480 hours in a quarter is considered Full Time (FT) or 100% of a Full Time Equivalent (FTE).

	Role	Phase 4,5 - Procure - May/2023 - March 2024	Phase 6 - Start Up - March 2024 - Sept 2024	Phase 7a - POC - Sept 2024 - Jan 2025	Phase 7b - Full Deployment								
					Q1 2025	Q2 2025	Q3 2025	Q4 2025	Q1 2026	Q2 2026	Q3 2026	Q4 2026	Q1 2027
	Available Hours	**1600**	**960**	**640**	**480**	**480**	**480**	**480**	**480**	**480**	**480**	**480**	**480**
	Steering Committee	8	4	4	4	4	4	4	4	4	4	4	4
	Core Team												
A.	Project Manager	1280	768	512	384	384	384	384	384	384	384	384	384
B.	Field Supervisor	80	48	96	72	72	72	72	72	72	72	72	72
C.	Field Inspector	0	0	0	0	0	0	0	0	0	0	0	0
D.	Data Collector Coordination	0	240	160	0	0	0	0	0	0	0	0	0
E.	AMI Analyst	0	240	160	120	120	120	120	120	120	120	120	120
G	IT Security, Network, Software	80	96	0	0	0	0	0	0	0	0	0	0
H	CIS Admin Supervisor	240	480	96	72	72	72	72	72	72	72	72	72
I	CIS Billing Clerk Senior	240	480	160	120	120	120	120	120	120	120	120	120
J	CIS Billing Clerk Junior	0	0	224	240	240	240	240	240	240	240	240	240
K	Communications	80	48	0	0	0	0	0	0	0	0	0	0

Figure 29 - Estimated Effort by Role (Estimated Hours)

	Role	Phase 4,5 - Procure - May/2023 - March 2024	Phase 6 - Start Up - March 2024 - Sept 2024	Phase 7a - POC - Sept 2024 - Jan 2025	Phase 7b - Full Deployment								
					Q1 2025	Q2 2025	Q3 2025	Q4 2025	Q1 2026	Q2 2026	Q3 2026	Q4 2026	Q1 2027
	Steering Committee	8	4	4	4	4	4	4	4	4	4	4	4
	Core Team	0%											
A.	Project Manager	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
B.	Field Supervisor	5%	5%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
C.	Field Inspector	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
D.	Data Collector Coordination	0%	25%	25%	0%	0%	0%	0%	0%	0%	0%	0%	0%
E.	AMI Analyst	0%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
G	IT Security, Network, Software	5%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
H	CIS Admin Supervisor	15%	50%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
I	CIS Billing Clerk Senior	15%	50%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
J	CIS Billing Clerk Junior	0%	0%	35%	50%	50%	50%	50%	50%	50%	50%	50%	50%
K	Communications	5%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Figure 30 - Estimated Effort by Role (Percentage of FTE)

13. Recommendations

The recommendations within this chapter are derived from the workshops conducted with the City of Cornwall, and the analysis and feedback on potential direction and alternatives discussed throughout the course of our engagement. The recommendations should guide the City's decisions relating to the universal water metering and AMI project.

Recommendation R1: Proceed with the installation of universal waters with AMI.

The City has expressed that one of the primary goals of the project is to promote conservation. As stated in Request for Proposal #22-P12 - Universal Water Metering, AMI Consulting & Project Management, "This decision was made following the receipt of a third-party Water Conservation Master Plan which outlines a pathway to promote a 37% reduction in water consumption across the community."

Section 2.4 of this report provides some reference material that water meters can significantly help reduce water consumption. The opportunity to support broader, previously established City goals and objectives was also considered. Section 2 outlines the findings in detail and a brief overview of how the project supported the City's priorities is provided below.

- The project supports two of the City's Strategic Priorities (2019 – 2022) and 6 of 8 Plan Goals associated with Services and Utilities that formed part of the City's Official Plan (2018)
- The Water Conservation and Servicing Master Plan (2021) contains the Province's nine (9) principles of financially sustainable water and wastewater services, all of which are supported by the project.
- Similar to the goal of the City's Climate Action Plan, the goal of the Conservation and Demand Management Plan is to "continuously reduce the energy requirement of our facilities through implementation of smart technologies…" Inherently, the project promotes water conservation which by extension leads to energy conservation. Additional project benefits such as helping to curb distribution system leaks and leaks within customer premises eliminates wasted water where possible and the unnecessary treatment and pumping of water provides energy conservation.

As part of the Workshops conducted by Diameter and the City's project team, 38 business drivers were reviewed. Twenty (20) of the business drivers were deemed Important or Essential to the City, and 19 of them were supported by AMI. In addition, the enhanced Customer-related functionality provided by this project will enable new ways for the City to engage customers, promote conservation programs, and help preserve water.

Recommendation R2: Install one meter per service.

The City of Cornwall has over 1,600 residential properties with self-contained units typically used as rental units in those residences. Today, the City of Cornwall typically bills the property owner for their water based on the number of fixtures within the dwelling, including any fixtures within sub-units.

When moving to metered consumption, Diameter recommends that one meter is installed in a premises fed by a single service and where plumbing isn't already (properly) "split" between the individual units. Allowing landlords to split the plumbing within the premises so individual units can be metered is fraught with delays, inspections, and disputes strongly discouraged by Diameter or by one utility, recently surveyed, who went from billing on flat rate to metered consumption. The utility is in the process of stopping this practice due to issues that were encountered.

This recommendation would require the landlord to pay for the water consumed in all their apartment dwellings and seek repayment through appropriate means, and the City needs to remove "sub-units" from its billing system.

Recommendation R3: Install positive displacement water meters up to 75mm (3") and non-mechanical meters for meters 75mm (3") and larger to provide improved accuracy.

Non-mechanical meters in smaller sizes carry a significant premium of approximately 25% to 50% over mechanical meters. The additional functionality available in non-mechanical meters, such as pressure monitoring, temperature monitoring or remote shut offs can push this premium to 100%.

Cornwall's business drivers established that it has no requirement for the additional functionality available in non-mechanical meters. The City's water hardness is below the provincial average and therefore no unanticipated meter

accuracy loss is expected when using mechanical meters. Since there is no compelling rationale for the City to install non-mechanical meters in the smaller sizes, Diameter recommends mechanical meters up to 75mm (3”).

Larger non-mechanical meters can generally be justified over their mechanical counterparts for a variety of reasons. Non-mechanical meters offer greater accuracy over a broader flow range (resulting in more revenue for the utility) and this accuracy is maintained for the life of the meter. They do not require strainers, are generally priced in line with mechanical meters at the larger sizes and may come with value-added features such as temperature and pressure monitoring – sometimes at no additional cost.

Non-mechanical meters in the larger sizes have been installed at utilities for the past 15 years or more and generally function as expected.

Recommendation R4: Install Small and Intermediate mechanical meters horizontally using a plumbing loop where necessary.

All mechanical water meters operate properly and without warranty caveats when installed horizontally. This allows the City to choose whatever manufacturer it prefers, now and in the future. Also, horizontally installed meters generally result in fewer noise complaints. Diameter is therefore recommending that meters are installed horizontally using a plumbing loop in lieu of Kornerhorns. Plumbing loops require more soldered connections and do pose a slightly higher (leak) risk, but Kornerhorns are expected to be slightly more than 50% more expensive adding unnecessary cost to the project.

Depending on the vendor chosen and the products being proposed, the City may consider revisiting this recommendation as part of procurement. For example, non-mechanical meters can be installed in any orientation and since there are no moving parts do not create noise issues like mechanical meters might when installed vertically. Also, the additional cost of plumbing a meter to a horizontal position may help pay for the anticipated higher product cost. The RFP can allow for this alternative approach.

Recommendation R5: Project scope should include AMI, customer portal, meter supply, installation, internal project support, and external project support

Component	Items Included
1) AMI Technology	• Radio Transmitters installed on the outside of the premises. • AMI Network Infrastructure (if necessary). A standalone AMI would require the installation of fixed in place data collection equipment whereas a cellular would leverage an existing cellular network. • AMI software for meter data collection and meter data management (MDM), • Training, Implementation, and Integration Services.

2) Customer Portal	• Fully functional customer portal including:
	  ○ Billing and Payment View
	  ○ Online Payment Ability
	  ○ Consumption Information
	  ○ Outbound Communications (Global and Individually)
	  ○ Program enrollment (i.e., Conservation program)

3) Meter Supply	• Mechanical meters for Small and Intermediate; non-mechanical for Large Meters
4) Installation	• Project management • External installation services • Data management, • Curb stop support and repair

Component	Items Included

5) Internal Project Support	• Most of the Project Support will be provided with previously budgeted resources. (Project Manager, Facilities Coordinator, Meter Supervisor, Public Outreach, CIS and Interface Subject Matter Expert and Billing Lead).
	• Newly budgeted City positions to support project during Implementation: Curb stop support and repair, Billing Clerk, AMI Analyst.
	• On-going Project Support includes:
	  ○ A Billing Clerk (1 FTE),
	  ○ Meter Maintenance Person (1 FTE)
	  ○ AMI data analyst (0.25 FTE)
	  ○ Data Support (for turning the data provided by the AMI into usable information)
	  ○ Outsourced bill printing, stuffing and mailing
	• All other project roles will be provided with previously budgeted resources

6) External Project Support	• Consulting Support to provide the following Project assistance:
	  ○ Project Coordination
	  ○ Subject Matter Expertise
	  ○ Quality Assurance Program
	  ○ Field Inspection
	  ○ Integration Coordination/Support
	  ○ Public Outreach/ Communications
	• CIS Integration (Diamond)

Table 39 – Recommended Project Scope

The City is not expected to have available resources to handle any of the Field Inspection tasks. One resource has been previously budgeted under Consulting Support, but an additional resources may be required. The following tasks would be performed by Field Inspectors:

- Pre-approval of additional work required on site such as carpentry work or additional plumbing work.
- QA inspection of installation companies work at customer's sites and ensuring the installation is done properly, the proper data is captured (meter number, radio transmitter number) and the radio transmitter is programmed properly (if applicable).

The following tasks were not anticipated in the consulting engagement, and we anticipate will require additional resources:

- Task resolution (typically internal): inspection and resolution of poor plumbing, inaccessible plumbing, refusal by difficult homeowners.
- Sub-unit account deletion verifications (typically internal)

Recommendation R6: Maintain the existing budget of $17.3M given the project's uncertainties and have reasonable contingencies given inflationary pressures and installation uncertainties.

The various project components and total estimated spend for each component are listed below for both a standalone AMI fixed network and a cellular AMI solution. The standalone AMI network would include City owned data collection equipment installed by the AMI vendor whereas a cellular scenario would leverage an existing cellular network and not require the same infrastructure investment. The main reason for the cost difference shown below is the higher cost of the cellular transmitters (offset somewhat by the infrastructure requirements of Scenario 1) as the costs associated with the two scenarios are virtually identical otherwise.

Assumption	Scenario 1 - Standalone	Scenario 2 - Cellular
Meter Supply	$2,687,405	$2,687,405
AMI Supply	$2,722,823	$3,168,946
Installation	$6,394,029	$6,394,029
CIS Support	$137,500	$137,500
Consulting Support	$1,577,920	$1,577,920
Project Support	$466,800	$466,800

Contingency	$2,430,668	$2,497,586
CPI	$572,341	$596,485
Total	**$16,989,486**	**$17,526,671**

Table 40 - Total Estimated Spend for AMI Project Options

Points of note in this budget recommendation include:

- A 25% Contingency was included on the installation component and 15% contingency on the AMI and meter components.
- Exact meter sizes and exact meter quantities were estimated as outlined in the Meter Assessment in Chapter 4, but actual requirements may differ impacting project costs.
- Consulting Support includes an additional Field Inspection requirement not previously included in the contract.
- Project Support costs reflect the need for additional resources throughout the startup and installation portion of the project including a billing clerk, an AMI analyst, effort associated with coordination of curb stop work, and mock billing communication costs.

The budget stated above would result in cashflows by fiscal year as indicated below. A 3% annual inflation rate has been assumed, and the cashflows have been broken out to reflect how the project will be implemented. For instance, in the first fiscal year costs associated with the project will be mainly consulting, integration development and a limited ~1000-meter deployment for the Proof-of-Concept, whereas 2025 and 2026 see the remaining roll-out of the meters and radio transmitters.

	Calendar Year Cash Outflows			
Scenarios	**2024**	**2025**	**2026**	**Total**
Scenario 1- Standalone	$1,754,359	$8,905,684	$6,329,443	**$16,989,486**
Scenario 2 – Cellular	$1,672,933	$9,240,524	$6,613,214	**$17,526,671**

Table 41 – Expected Annual Cashflow

Recommendation R7: Following Procurement, follow a 29-month implementation schedule, including startup, proof of concept, installation and project close-out)

Including a 10-month Procurement, a proper, reasonably aggressive, implementation timeframe would be 39 months. This duration allows for software integrations to be completed and tested properly during the six (6) month Startup, a reasonable Proof of Concept of ~1,000 meters, and an installation timeframe that is reasonably accomplished over 19 months. Completing installations reasonably quickly minimizes overhead and inflation while enabling the City to realize the benefits of its AMI investment in a shorter period.

The recommended Project Plan is as follows:

Task Name	Duration	Start	Finish
City of Cornwall AMI Project Plan	1011 days	Thu 10/13/22	Thu 8/27/26
DESIGN Part A1 - Preliminary Design	159 days	Thu 10/13/22	Tue 5/23/23
PROCURE Part A2 - Detailed Design and Tendering Services	218 days	Wed 5/24/23	Fri 3/22/24
MANAGE Part B - Contract Administration and Inspection	650 days	Fri 3/1/24	Thu 8/27/26
Startup	153 days	Fri 3/1/24	Tue 10/1/24
Proof of Concept (POC), Installation and Deployment	470 days	Thu 9/19/24	Thu 7/9/26
Proof of Concept	80 days	Thu 9/19/24	Thu 1/9/25
Installation and Deployment	390 days	Fri 1/10/25	Thu 7/9/26
Close Out	35 days	Fri 7/10/26	Thu 8/27/26

Figure 31 – Recommended Project Schedule

Recommendation R8: The City of Cornwall should plan on 3 Project Procurements.

1. The first and most complicated will be a turnkey AMI RFP which will include the following elements:

    i. AMI technology including the radio transmitters, data collectors and all the associated software components (head-end meter data collection software, meter data management software, and customer portal as provided by the AMI vendor).

    ii. Positive Displacement Meters for Small and Intermediate Meters and non-mechanical meters for those that are 75mm (3”) and larger.

iii. Installation Services for meter cut-ins or meter changeouts as required, radio transmitter installation, fixed network infrastructure installation (if necessary), plumbing and construction work as necessary.

iv. Network Maintenance. It is generally recommended to turn over the network maintenance to the AMI vendor to ensure network uptime as outlined in the RFP and agreed to by the vendor under contract. Although the City would be responsible for the meter and radio transmitter performance, the AMI vendor would be responsible for annual inspection and maintenance of data collection equipment and ensuring network uptime in the event of a failure as agreed to in the service level agreement.

2. The second Procurement for a fully functional customer portal will be optional and only proceed as necessary following evaluation of procurement #1. As part of procurement #1, AMI vendors will be asked to provide a customer portal that meets the City's specifications outlined in the turnkey AMI RFP. Most AMI vendors are in the infancy stage of customer portal development and will likely need to partner with a third-party vendor to meet the City's specifications. Depending on whether the City's needs are met through the initial RFP, and the cost of doing so, it will be determined whether the second procurement for a fully functional customer portal is necessary.

3. The third procurement will be for curb stop operation and repair. As part of this Universal Water Metering project, The City of Cornwall will be operating all customers' building control valves, most of which likely haven't been operated in years. As a result, some will not function properly and will require curb stops to be operated and repaired where necessary. While the City will allow the Installation Contractor to use freeze kits (to freeze), this option is not always possible, and the least risky choice is to first use the curb stop.

The City of Cornwall does not have the resources to undertake curb stop operation and repair and this service will need to be contracted out as part of the project.

Recommendation R9: Leverage AMI as a tool to help the transition to bi-monthly billing for all customers currently being billed bi-annually.

Today, the City of Cornwall bills its water customers every six months, for the following six months. Since customers are billed a flat rate, there are no "surprises" to a customer's water bill, and customers can budget accordingly.

Because AMI delivers meter reading information from every customer daily (or multiple times per day), the City can choose the billing frequency that makes most sense.

The move to billing based on consumption eliminates the opportunity to bill customers in advance since customers will be billed for the water they consume. Continuing to bill customers every six months, or even quarterly, likely will not contribute to the goals of the universal water metering project. One of the goals of metered billing is to encourage conservation. Providing customer bills every month, or every other month, enables more feedback and more of an opportunity to promote conservation. It also provides customers more of an opportunity to control water bill costs. Billing less frequently will also increase accounts receivable and negatively affect cashflow.

The 2022 Municipal Study produced by BMA Management Consulting Inc. surveyed 115 Ontario Municipalities. Of those surveyed, the City of Cornwall was the sole municipality to bill for water and wastewater service twice per year.

	Residential	ICI
Monthly	46	68
Bi-Monthly	32	26
Quarterly	33	19
Every 4 months	3	1
Twice Yearly	1	1
Total	115	115

Figure 32: Frequency of Municipal water and wastewater billing. ***Source****: 2022 Municipal Study. 2022. BMA Management Consulting Inc. (p.397)*

Although monthly billing and bi-monthly billing were both considered, the move from bi-annual billing to monthly billing was seen to be too costly both in terms of staff time and billing costs (printing, stuffing, and mailing) without a significant benefit over bi-monthly. Bi-monthly was viewed as contributing to the goals of the project while minimizing unnecessary costs.

We recommend moving to bi-monthly and to billing at the end of the period to be implemented six (6) months before the start of mock billing.

Recommendation R10: Request an updated Rate Study by Watson & Associates to be completed by April 2024.

Watson and Associates developed the City of Cornwall's Water Conservation and Servicing Master Plan. In the plan, rates were proposed based on the information available to enable the City "full cost recovery" for its annual operating and annual capital investment requirements.

Following the City's business case development for the universal water metering and AMI program, updated costs for the project have been provided for the capital cost requirements of the project as well as annual operating costs for additional staffing requirements, bi-monthly billing, and other recurring costs associated with software for example.

Based on the current information available, it is recommended Watson update its rate study prior to public outreach and mock billing so customers have the most up-to-date costing information available, and expectations are appropriately set.

Recommendation R11: Implement a six (6) month mock billing period in advance of moving to metered billing and after meters are substantially installed.

Once water rates are finalized, Mock Billing enables customers to compare their current flat rate charge against water charges based on volume. This enables customers to make behavioral changes to consume less water and lower their bill prior to being billed on a metered rate.

Initiating this process across all customers together, and for a set period, will be most equitable to all customers and not over-complicate the process. Mock Billing would be initiated following the move to bi-monthly billing so customers receive a few bills prior to the move to metered billing and can understand the impact of their changes on consumption and subsequently their bill.

Recommendation R12: Consider the implementation of a Leak Forgiveness Program.

The change from flat rate billing to metered billing will force customers to be more cognizant of their consumption including leaks and "wasted" water. This behavioral change will take time and will differ based on the individual, but conservation will result.

However, from time-to-time some customers may receive high water bills unsuspectingly for a variety of reasons. Perhaps there was a burst pipe, a toilet flap was stuck open forcing the toilet to run continuously, or a hose was mistakenly left in the on position. While one of the goals of the project is conservation, severely penalizing customers for a one-time mistake is not the objective.

Some utilities offer leak forgiveness programs, and some do not. The recommendation is for the City of Cornwall to offer customers one-time leak forgiveness in special circumstances for mistakes impacting their bill as part of good customer relations. The City can consider forcing customers to qualify to be eligible for leak forgiveness by signing up to its customer portal, providing an email address, or some means to be contacted where unusual consumption is suspected so the issue can be rectified early.

Recommendation R13: Implement a triple flat rate for non-compliant customers.

As part of the universal metering project and requiring access to all customers' premises, the City of Cornwall will experience some customers who refuse to allow a meter to be installed. In these circumstances the City will need a method to encourage participation in the metering program. Many utilities will not allow the water to be turned off for non-compliant customers even if receiving a meter is a "condition of service." More common is charging customers triple their current flat rate; the customer's financial incentive (of paying a flat rate as opposed to a metered rate) is thereby removed, making metering more palatable. Generally, this method incentivizes customers to allow access and a meter to be installed.

Recommendation R14: Plan for the addition of one FTE in Customer Service and Billing, one for Meter Maintenance, and 0.25 FTE for an AMI analyst. The

City should have a contingency plan to allow for one additional Customer Service representative to cover if call volumes increase during specific points during the project.

The City of Cornwall can expect a significant jump in call volumes from water customers which is to be expected when moving from flat rate billing to consumptive billing. High bill complaints, leak forgiveness calls, balance requests, meter accuracy questions are just a few examples of the types of calls that the City will field from water customers.

Anecdotal evidence suggests that the City might expect one call per customer per year initially which can be reduced over time depending on participation in the customer portal, proactive communication from the City (i.e., water conservation measures, leak notifications), and initial successful public outreach communications. Coupled with the increased call volume, the move to bi-monthly billing will place more burden on staff for bill preparation, exception handling, and follow-up. For these reasons, it is recommended the City add one FTE to Customer Service and Billing and determine additional needs based on the call volumes the City is experiencing.

The 0.25 FTE AMI Analyst will ensure the City has adequate resourcing to monitor the AMI system, run reports and perform periodic testing.

As mentioned earlier, the City of Cornwall will have more meter related tasks after installing meters throughout the City and new tasks associated with AMI radio transmitters that it doesn't have today. Examples include radio transmitters replacements due to failures or vandalism, customer follow-up as requested by customer service, meter register failures, investigations for high consumption or zero consumption, and suspected meter or radio transmitter tampers.

It is estimated that one FTE will be required going forward to handle issues such as those stated. Initially, it is expected issues such as radio transmitter failures or meter issues will be minimized since the assets will be new. Regardless, the City should anticipate the need for an additional FTE to maintain meter and endpoint AMI assets and ensure they are working correctly.