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4 VOLUME 4: IDENTIFICATION AND EVALUATION OF ALTERNATIVE WATER SYSTEM SOLUTIONS

As part of the CGS Water and Wastewater Master Plan, WSP has developed and evaluated a number of alternative solutions for each water system, in response to the existing deficiencies determined through a gap analysis, outlined in Volume 2. As outlined in Volume 1, alternatives developed as part of the Master Plan are weighed against determined evaluation criteria, prior to selecting a preferred solution.

Upon completion of the alternatives evaluation, preferred water system servicing solutions were selected and are presented in Volume 6. Following the alternative solutions evaluation and preferred solution selection, a Capital Plan of the preferred alternative was developed and is presented in Volume 8.

The following sections will provide a thorough understanding of the alternatives specific to each water system that were developed in order to address capacity concerns to the 2041 growth scenario, and will outline the evaluation carried out in order to assess the alternative servicing solutions for each system.

4.1 ALTERNATIVE WATER SUPPLY ALTERNATIVES

A number of water supply capacity concerns were identified through gap analysis, presented in Volume 2. Supply gaps were identified in the Sudbury and Valley Water Systems before the 2041 growth scenario, for which alternative solutions were then developed and evaluated. An evaluation was also carried out of alternative solutions for the Vermilion Water System, considering the third party ownership that currently exits. It should be noted that no alternatives were considered for water systems that were recognized to have sufficient supply capacity to the year 2041. In other words, information will not be included in the following subsections regarding water supply analysis for the Dowling, Falconbridge, and Onaping-Levack Water Systems.

The following subsections will outline the alternative solutions developed to address the identified deficiencies, and the evaluation undertaken to arrive at a preferred solution.

4.1.1 VERMILION WATER SUPPLY

Although the Vermilion Water System proves to have sufficient supply capacity to service population growth to the 2041 scenario, alternative solutions were considered due to the current supply being owned by a third party, Vale. This shared system provides the opportunity for the City to optimize their system by implementing their own water supply in this case.

The following subsections summarize the alternative solutions associated with each system component, the evaluation of the alternative solutions, and finally the preferred water servicing solution.

WATER SUPPLY INFRASTRUCTURE GAP

While the existing water supply is secure and reliable, consideration was made to the potential connection of the Vermilion Water System to the existing Sudbury drinking water system, which is City owned and operated, in order to ascertain the financial viability of doing so. The City requested the evaluation of this option, due to the fact that they are responsible for cost sharing future upgrades with Vale.

WATER SUPPLY SERVICING ALTERNATIVES

Two (2) water supply alternative solutions were considered for the Vermilion Water System, and they are as follows:

1 **Alternative 1: Do Nothing (Continue with Existing System As Is)**
2 **Alternative 2: Disconnect Vermilion Water Supply from Vermilion WTP and Connect System to Sudbury WTP**

The following would be required for the implementation of each alternative:

Alternative 1: Do Nothing (Continue with Existing System As Is)

— Vermilion would continue to be serviced using existing infrastructure, with water being supplied from the Vermilion WTP owned by Vale.

Alternative 2: Disconnect Vermilion Water Supply for Vermilion WTP and Connect System to Sudbury WTP

— Construction of a booster station for Lively Zone
— Construction of a booster station for Inco Zone (North of PRV3)
— Construction of a new watermain from Sudbury water supply system to the Vermilion Water Distribution System (Copper Cliff) and selection of the preferred route
— Construction of a new Water Storage Reservoir
— Construction of a new watermain connecting Walden to Copper Cliff
— Disconnection of other City / Vale interconnections and construction of new linear infrastructure

This alternative would provide the City autonomy in operations as well as improve operating flexibility, and allow the City to utilize available capacity at the Sudbury WTP.

Depending on the works required, the following EAs would be required:

— Schedule B to build a new booster pumping station (Lively Zone)
— Schedule B to build a new booster pumping station (Inco Zone)
— Schedule B to construct a new forcemain either within or outside of a road allowance or easement.
— Schedule B to construct a new water storage reservoir
— The City could complete all these studies inside one (1) Schedule B Class EA project.

EVALUATION OF WATER SUPPLY SERVICING ALTERNATIVES

Upon developing alternative solutions to address future water supply in the Vermilion Water System, as described above, an evaluation was carried out to select a preferred solution. Due to cost implications being the main contributing factor in the evaluation, a detailed cost evaluation in the form of a Net Present Value (NPV) Analysis was first undertaken.

NET PRESENT VALUE ANALYSIS

An NPV analysis was completed to compare the long term capital, replacement and maintenance costs associated with each alternative. The NPV analysis was undertaken given the complexity of the potential expenditures related to maintaining multiple facilities. That is, a simple comparison of just the capital costs for the various alternatives was not sufficient given the complexity of the alternatives. Table 4-1 summarizes the capital costs associated with each alternative, as well as the NPV cost of each alternative for a duration of 26 years (to 2041). It should be noted that the NPV analysis assumes a 5% interest rate, and a 2% inflation rate.

Table 4-1 NPV Comparison of Vermilion Water Supply Alternatives

COSTS	ALTERNATIVE 1	ALTERNATIVE 2
Capital Cost[1]	-	$ 85,054,000
Replacement Cost[1]	$ 2,332,000	-

COSTS	ALTERNATIVE 1	ALTERNATIVE 2
Total Operations and Maintenance Costs (2016 to 2041) [1]	$ 15,696,000	$ 5,411,000
NPV Total[2]	$ 18,028,000	$ 90,465,000

[1] Total costs in 2016 dollars for the next 26 years

[2] Net Present Value upon deducting inflation and interest for each year.

The following assumptions were made when determining the NPV for Alternative 1:

Alternative 1: Do Nothing (Continue with Existing System As Is)

- No major capital costs were assumed for the upgrades to the Vermilion WTP. Per the Agreement, up to 2019 there are no additional costs for major upgrades to the plant which is solely for the purposes of treatment water to be supplied to the City.
- The City has agreed to pay 30% of the annual ongoing repairs and maintenance costs of the WTP.
- Vale Canada Limited agrees to supply water to the City beyond their existing agreement maximum 13,824 m^3/d.
- Copper Cliff storage is available, therefore no additional storage was assumed.
- The 2015 Annual Cost was used as the basis. Per the Agreement, in 2015 the City was charged an approximate value of $648,000 for water supply and fluoridation plus an additional replacement cost of $145,500.

The following assumptions were made when determining the NPV for Alternative 2:

Alternative 2: Disconnect Vermilion Water Supply from Vermilion WTP and Connect System to Sudbury WTP

- Construction of a new storage reservoir with a total capacity of 5,302 m^3 (2041 storage requirement)
- Construction of a new watermain from Sudbury water system to Vermilion water system
- Construction of two (2) new booster stations
- A portion of the total capital cost of necessary water treatment plants expansions within the existing Sudbury water system
- Disconnection of the water distribution network

ALTERNATIVE SOLUTIONS EVALUATION

As described in Volume 1 of this report, each alternative solution was evaluated against a set of criteria developed as part of the Master Plan. Table 4-2 summarizes the Vermilion Water System supply alternative solutions.

Table 4-2 Evaluation of the Vermilion Water Supply Alternatives

EVALUATION CRITERIA	ALTERNATIVE 1	ALTERNATIVE 2
Healthy Watersheds	No concerns with existing system, but does not improve on status quo.	No concerns.
Natural Heritage	No construction would be needed; therefore, no impact on natural heritage.	Construction impacts on water course crossing, and other natural areas. Would have one-time construction impacts.
Community Well Being	No construction impacts. Current agreement would need to be renegotiated in 2019	Would have one-time construction impacts.

EVALUATION CRITERIA	ALTERNATIVE 1	ALTERNATIVE 2
Safe and Clean Drinking Water	No concerns with the existing drinking water quality. System is being operated by Licensed Professionals and has a Drinking Water Works Permit from the Ministry of the Environment and Climate Change. The water quality meets the required drinking water quality requirements.	Water supply is secured at all times through one (1) central WTP that the City owns and operates. The water quality at Sudbury WTP meets the required drinking water quality requirements.
Cost Effectiveness	Probable capital cost since any increase in rated capacity of the WTP or improvement of water quality requested by the City shall be paid by the City. City is paying 30% of the costs for the ongoing repairs and maintenance and conduct of capital projects. No control over charges from third party. Will be charged for reinvestment in current plant infrastructure. NPV (26 years) = $23 M	High capital cost due to construction of a new watermain, a new storage tank and two (2) booster stations plus the disconnection of watermains in the system. Also a portion of the costs to upgrade the Sudbury water supply system would be required The City has control over its water supply system and can perform infrastructure planning without dependency on third party approval. NPV (26 years) = $83 M
Constructability and Ease of Integration	No construction or integration required.	Requires construction planning phasing to prevent water outages during transitioning period between Vermilion WTP to Sudbury WTP supply network.
Operability	The City is not responsible for the WTP's operation.	Easy to operate. Integrated with the Sudbury System.
Sustainability	The City has no control over energy utilization and the leakage, pipe depth and etc. for the infrastructure owned by Vale.	City can control the annual energy utilization and improve infrastructure sustainability.
Preferred Solution	**Most Preferred**	**Less Preferred**

RECOMMENDED WATER SUPPLY SERVICING SOLUTION

The recommended water supply solution for the Vermilion water system is **Alternative 1: Do Nothing (Continue with Existing System As Is)**. The long and successful history of working with Vale to supply water to this area, and the fact that both parties have a need for safe potable water are two major contributors to the selection of the preferred solution. The overall lower financial impact associated with the Do Nothing alternative is another major factor. The water supply recommendation for the Vermilion Water System can be found in Volume 6 of this report.

4.1.2 VALLEY WATER SUPPLY

Alternative solutions were considered to address the identified water supply deficiencies in the Valley and Sudbury water systems simultaneously, given that there is an opportunity to interconnect the systems. Additionally, it is important to note that although there is no supply deficiency identified in the Falconbridge water supply, there is an opportunity to interconnect the Falconbridge, Sudbury, and Valley Water Systems to optimize water servicing, therefore it has been included in the evaluation as part of the Valley and Sudbury Systems' water supply analysis.

The following subsections summarize the deficiencies identified in the system, the alternative solutions associated with each system component, the evaluation of the alternative solutions, and finally the preferred water servicing solution.

WATER SUPPLY INFRASTRUCTURE GAP

The Valley Water System comprises thirteen (13) wells with total rated capacity of 34,796 m^3/d; however, the current maximum production is 24,579 m^3/d. The wells are rehabilitated every three (3) years, but City staff has noted decreasing well capacity over time, even after frequent rehabilitation. Through the gap analysis it was determined that an additional 432 m^3/d of supply capacity would be required to service growth to 2041.

The Sudbury Water System is supplied by the David St. WTP, the Wanapitei WTP, and three (3) wells located in Garson. The total rated capacity for the system is 101,827 m^3/d; however, it is not possible to operate at its rated capacity due to constraints at the WTPs, therefore the estimated production capacity for the system is 81,813 m^3/d. Through the gap analysis it was determined that an additional 8,013 m^3/d of supply capacity would be required to service growth to 2041. It is important to note, that part of the production deficiency is caused by pressure limitations in the transmission line from the Wanapitei WTP to the Sudbury network. Additionally, due to source water concerns and detectable tetrachloroethylene (PCE) levels noted at the Garson Wells, source protection and monitoring recommendations have been made, and are detailed in Volume 6.

A broader summary of the Valley and Sudbury Water System supply gaps are included in Volume 2 of this report, and a detailed description of the gap analysis is comprised in the Valley and Sudbury Gap Analysis and Status Quo Reports, found in Appendix 2-A.

WATER SUPPLY SERVICING ALTERNATIVES

Three (3) water supply alternative solutions were considered to address the Valley and Sudbury Water System deficiencies as described above, and they are as follows:

1. **Alternative 1: Do Nothing (Continue with Existing System As Is)**
2. **Alternative 2: Optimize Valley Wells**
3. **Alternative 3: Construct New WTP at Wanapitei Lake**

The following would be required for the implementation of each alternative:

Alternative 1: Do Nothing (Continue with Existing System As Is)

The Do Nothing alternative does not include implementation of additional infrastructure, and assumes the continued use of all existing infrastructure. As an overall preliminary conclusion, this alternative would not satisfy the requirement to meet growth projections to 2041 within the CGS. The key servicing pitfalls of the Do Nothing alternative, with respect to addressing the identified gaps, are as follows:

— Not able to meet maximum day demand requirements in Valley starting in 2031;
— Sudbury Water System requires a new water supply by 2031;

Alternative 2: Optimize Valley Wells

Alternative 2 comprises modifying the existing water supply infrastructure to optimize operation of the respective systems. The key upgrades for this alternative are the following:

- Retain and use the existing Wanapitei WTP and implement new infrastructure to overcome the pressure limitation and to reach the WTP's rated capacity again. The required infrastructure includes:
  - New Wanapitei feedermain (parallel trunk to the existing feedermain) (750 mm Ø, 7.5 km)
- Retain and use existing David St. WTP:
  - Life cycle upgrades required due to source water quality deterioration
- Retain and use the Valley, Capreol, Falconbridge and Garson Wells:
  - Rehabilitate the Valley system to ensure rated capacity is maintained
  - Rehabilitation of Valley Well UV systems
  - Additional treatment for Valley Wells.
  - Upgrade the Falconbridge fluoridation facility
  - Add stand-by power

Through the implementation of Alternative 2, the Valley and Sudbury water systems would have sufficient water supply capacity to service 2041 water demand. Nevertheless, the ability to restore the 13 wells' capacity to their rated capacity is presently uncertain, since the wells have shown signs of not being able to produce their rated capacities periodically. Therefore it is a potential risk that their production may decline.

Through the implementation of this alternative, source water protection and monitoring would be maintained for the wells.

Alternative 3: Construct New WTP at Wanapitei Lake

Alternative 3 involves the construction of a new, centralized surface water treatment plant with an intake from Wanapitei Lake. The plant would be located near the Sudbury Airport. The plant would supply the existing Sudbury, Falconbridge, and Valley Drinking Water Systems, and allow decommissioning of some of the existing supply infrastructure and securing all water sources. The key proposed upgrades for this alternative are the following:

- Construction of a new WTP with intake from Wanapitei Lake, and WTP located near airport which includes the following components:
  - New raw water pumping station on Wanapitei Lake (1,200 HP)
  - New raw water watermain (750 mm Ø, 7.5 km)
  - New water treatment plant with storage (60 MLD, 15 ML)
- Interconnect Sudbury with the Valley, and Falconbridge systems:
  - New WTP-Sudbury (Maley Drive) feedermain (750 mm Ø, 20.5 km),
  - New WTP-Valley (Notre Dame Avenue) feedermain (600 mm Ø, 13 km),
  - New WTP-Falconbridge watermain (300 mm Ø, 0.5 km).
- Retain and use the existing Wanapitei WTP and implement new infrastructure to overcome the pressure limitation and to reach the WTP's rated capacity again. The required infrastructure includes:
  - New Wanapitei feedermain (parallel trunk) (600 mm Ø, 7.5 km),
- Discontinue use of David St. WTP:
  - Retain for emergency supply only.
- Discontinue use of Valley, Capreol, Falconbridge and Garson Wells:
  - Decommission all the wells.

Sudbury, Falconbridge, and Valley, now part of the same water system through the implementation of this alternative, would have sufficient water supply capacity to service 2041 water demand.

EVALUATION OF WATER SUPPLY SERVICING ALTERNATIVES

Upon developing alternative solutions to address water supply deficiencies in the Valley and Sudbury Water Systems, as described above, an evaluation was carried out to select a preferred solution. Due to cost implications being the main contributing factor in the evaluation, a detailed cost evaluation in the form of a Net Present Value (NPV) Analysis was first undertaken.

NET PRESENT VALUE ANALYSIS

As mentioned, an NPV analysis was completed to compare the long term capital, replacement and maintenance costs associated with each alternative. The NPV analysis was undertaken given the complexity of the potential costs expenditures related to maintaining multiple facilities. A simple comparison of just the capital costs for the various alternatives was not sufficient given the complexity of the alternatives. Table 4-3 summarizes the capital costs associated with each viable alternative, as well as the NPV cost of each alternative for a duration of 26 years (to 2041). Similar to the NPV analysis for the water supply options for the Vermilion system, the NPV analysis for the water supply alternative for Sudbury, Valley and Falconbridge assume a 5% interest rate, a 2% inflation rate.

Table 4-3 NPV Comparison of Valley and Sudbury Water Supply Alternatives

COSTS	ALTERNATIVE 2	ALTERNATIVE 3
Capital Costs[1]	$ 47,311,000	$ 256,793,000
Replacement Costs[1]	$ 17,619,000	$ 11,710,000
Total Operations and Maintenance Costs (2016 to 2041) [1]	$ 80,789,000	$ 73,590,000
NPV Total[2]	$ 145,719,000	$ 342,093,000

[1] Total costs in 2016 dollars for the next 26 years

[2] Net Present Value upon deducting inflation and interest for each year.

ALTERNATIVE SOLUTIONS EVALUATION

As described in Volume 1 of this report, each alternative solution was evaluated against a set of criteria developed as part of the Master Plan. Table 4-4 summarizes the Valley and Sudbury Water System supply alternative solutions.

Table 4-4 Evaluation of the Valley and Sudbury Water Supply Alternatives

EVALUATION CRITERIA	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
Healthy Watersheds	No concerns with existing system, but does not improve on status quo.	Increase of pumping rates for Valley.	Reduction of pumping rates for Valley.
Natural Heritage	No construction would be needed; therefore, no impact on natural heritage.	Some construction would be needed; therefore, a few impact on natural heritage are expected.	Infrastructure would be located in a rural and urban area; a few impacts on natural heritage are expected. Would have one-time construction impacts.

EVALUATION CRITERIA	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
Community Well Being	No construction impacts. Unknown facilities' condition and remaining life. Will not meet growth projections within the CGS.	Some construction would be needed; therefore, a few impacts on community well-being are expected. Unknown facilities' condition and remaining life.	Infrastructure would be located in a rural and urban area; impacts on community well-being are expected. Would have one-time construction impacts.
Safe and Clean Drinking Water	No security of water supply Some water sources are susceptible to contamination. Not able to supply required water demand.	Unknown long-term sustainability of the Valley water supply system.	No concerns with the drinking water quality.
Cost Effectiveness	No capital cost, medium operating costs and high maintenance costs.	Low capital cost, medium operating costs and high maintenance costs. NPV (26 years) = $146M	High capital cost, medium operating costs and low maintenance costs. NPV (26 years) = $342M
Constructability and Ease of Integration	No construction or integration required.	Requires construction phasing to prevent outages during transition; easily integrated with existing system.	Requires construction phasing to prevent outages during transition; easily integrated with existing system.
Operability	High operational requirements.	High operational requirements. Environmental protection measures required.	Easy to operate. Fewer facilities given the integration of Sudbury, Falconbridge and Valley Systems.
Sustainability	Unknown long-term sustainability since condition of wells and plants is not known. High potential risk.	Poor sustainability. Unknown long-term sustainability of Valley system.	Most sustainable since new surface water treatment plant with available expansion capacity.
Preferred Solution	**Least Preferred**	**Most Preferred**	**Less Preferred**

RECOMMENDED WATER SUPPLY SERVICING SOLUTION

Alternative 2: Optimize Valley Wells is the preferred solution based on the evaluation; however, there remain concerns about the long term viability of the Valley Wells as a drinking water source, since in recent years the production capacity of the wells has not always met the rated capacity for the water production system.

The challenges and risks identified in implementing this alternative, based on the above evaluation, are summarized below.

- Retaining Valley Wells
  - Recent well performance data indicates production capacity is deteriorating.
  - Aquifer is not able to sustain long-term pumping rates.
  - High risk of not obtaining additional supply from these wells on a continuous basis, particularly under drought/stress conditions.
  - The lifespan of existing wells unknown and it is uncertain whether it can be relied upon for the community's long-term water needs.
  - Capreol Wells are classified as potential GUDI water source.
  - Aesthetics declining, high iron & manganese.
  - Additional studies are required to assess the current performance of individual wells.
  - Water source protection plan and monitoring are required.
  - The wells are susceptible to weather and climate change.
  - Water source protection plan and monitoring are required.
- Retaining Garson Wells
  - Elevated levels of PCE.
  - Water source protection plan and monitoring are required.
  - Water source protection plan and monitoring are required.
- Retaining Wanapitei WTP
  - Water levels of the Wanapitei River are governed by Ontario Power Generation (OPG).
  - The plant is susceptible to weather and climate change.
  - The plant is in need of upgrades
  - Water source protection plan and monitoring are required.
- Retaining Davis St. WTP
  - Ramsey Lake is susceptible to source contamination (it is located in an urbanized area; close to major routes, storm sewer system, fuel spills; and is used for multiple recreational uses).
  - Sodium levels at Ramsey Lake are increasing.
  - Ramsey Lake is likely to present cyanobacteria blooms (Microscystin LR).
  - Ramsey Lake has a limited yield (it is part of a small watershed).
  - Water source protection plan and monitoring are required.
  - The plant is susceptible to weather and climate change.

Alternative 3 has a significantly higher cost compared to Alternative 2, and is therefore not the preferred recommendation; however, a better understanding of the capabilities of the Valley Wells is required to ensure that Alternative 2 is a viable option. In the case that the existing Valley system is no longer sustainable or that climate change affects the available source waters significantly, a new water source will inevitably be required in the future. **In other words, failing that these conditions are met, Alternative 3 will have to be implemented, though the preference is to optimize the existing infrastructure before giving further consideration to the implementation of a new water supply facility. It is important that the viability of maintaining the use of the wells be verified by 2020 through a wells source water protection plan and monitoring efforts, as described in Volume 6 of this report**. The planning and implementation process of Alternative 3 would need to begin by then, assuming growth in the community meets the current projections. Additionally, it would be beneficial for future Master Plan updates to consider this verification and timeline, and to comment on the progress of the matter.

4.2 ALTERNATIVE WATER DISTRIBUTION ALTERNATIVES

Another component included in system analysis were the distribution elements. These included booster pumping stations, storage facilities, and watermains. A number of water distribution capacity concerns were identified through gap analysis, presented in Volume 2.

The following sections will outline the alternative solutions developed to address the identified deficiencies and the evaluation undertaken to arrive at a preferred solution.

4.2.1 DOWLING WATER SYSTEM

The following subsections will summarize the Dowling Water System distribution deficiencies in terms of pumping, storage, and watermains, the alternative solutions developed to address the infrastructure gaps, the evaluations undertaken, and statements of the preferred solutions.

PUMPING AND STORAGE FACILITIES

It was determined through analysis that booster pumping capacity in the Dowling Water System will be sufficient to accommodate water distribution servicing to the 2041 growth scenario. Therefore, the following gaps, alternatives, evaluation, and preferred solution will be relevant to the storage facility analysis, in this case; analysis of the Dowling Elevated Tank.

WATER DISTRIBUTION INFRASTRUCTURE GAP

Although it was identified that the Dowling Elevated Tank alone cannot support water storage requirements to the 2041 growth scenario, fire flow requirements and peak hour demands can be met from a combination of the available storage volume and direct pumping from the Dowling Wells. This was concluded based on the system being able to supply more than the maximum day demand, as described in Volume 1. The following alternatives were developed for storage in the Dowling Water System to ensure all potential options were being considered, in order to select the most beneficial and feasible solution.

WATER DISTRIBUTION SERVICING ALTERNATIVES

Two (2) water storage alternative solutions were considered to address existing and future storage requirements in the Dowling Water System, and they are as follows:

1. **Alternative 1: Do Nothing (Continue with Existing System As Is)**
2. **Alternative 2: New Storage Facility and Decommissioning of Existing Facility**

The following would be required for the implementation of each alternative:

Alternative 1: Do Nothing (Continue with Existing System As Is)

— The Dowling Elevated Tank would continue to operate as it currently does, with 907 m^3 of usable volume. The additional storage requirement will be off-set by the installed well pump capacity.

Alternative 2: New Storage Facility and Decommissioning of Existing Facility

— Construction of new water storage infrastructure to accommodate the projected demands.

— Decommissioning of the existing Dowling Elevated Tank.

EVALUATION OF WATER DISTRIBUTION SERVICING ALTERNATIVES

As described in Volume 1 of this report, each alternative solution was evaluated against a set of criteria developed as part of the Master Plan. Table 4-5 summarizes the Dowling Water System storage alternative solutions.

Table 4-5 Evaluation of the Dowling Water Storage Alternatives

EVALUATION CRITERIA	ALTERNATIVE 1	ALTERNATIVE 2
Healthy Watersheds	N/A	N/A
Natural Heritage	No construction would be required on site. There would be no impact on natural heritage.	Infrastructure would be introduced in already disturbed areas on the existing site; therefore, no impacts to natural heritage are expected.
Community Well Being	No construction impacts.	Would introduce construction impacts for construction of new facility and decommission of existing facility. Would provide additional storage to resolve existing deficit.
Cost Effectiveness	Existing maintenance and operational spending will remain.	Large capital cost and long term operational and maintenance costs.
Constructability and Ease of Integration	No construction or integration would be required.	Would require complex construction and difficult integration into the existing system.
Operability	Existing operational requirements will remain.	New operational requirements will be introduced for new facility. Structural issues would be resolved and additional storage would be provided.
Sustainability	Unknown long-term sustainability. The existing facility requires repairs and upgrades to meet storage and structural requirements.	Would provide long-term sustainability by resolving all structural and storage issues.
Preferred Selection	**Most Preferred**	**Least Preferred**

RECOMMENDED WATER DISTRIBUTION SERVICING ALTERNATIVES

Alternative 1: Do Nothing (Continue with Existing System As Is) is the recommended alternative solution for addressing the water storage deficiencies in the Dowling Water System.

WATERMAINS

Watermains in the Dowling Water System were analysed to determine whether fire flow and demand requirements could be met to the 2041 growth scenario. The following subsections will summarize the watermain gaps identified within the system, the alternative solutions considered to address the deficiencies, and the evaluation of alternatives in order to arrive at a recommended solution.

WATER DISTRIBUTION INFRASTRUCTURE GAP

It was identified through hydraulic modelling that certain pipes within the Dowling Water System would not be adequate to provide sufficient fire flows, per current standards, to service population growth to 2041. In the Dowling Water System Gap Analysis and Status Quo Report, included in Appendix 2-A, specific areas in the system that require additional pipes, pipe upgrades, or replacements were identified. The following alternatives were developed in order to address identified watermain deficiencies.

WATER DISTRIBUTION SERVICING ALTERNATIVES

1 **Alternative 1: Do Nothing (Continue with Existing System As Is)**

The Do Nothing alternative would not support the Master Plan objective of servicing population growth to 2041 and rectifying deficiencies in the Dowling Water System.

2 **Alternative 2: Extend/Replace Existing System**

The Extend/Replace Existing System alternative for watermains encompasses replacing existing infrastructure to increase capacity, or the addition of new infrastructure or the creation of loops to address capacity deficiencies.

EVALUATION OF WATER DISTRIBUTION SERVICING ALTERNATIVES

A screening process was undertaken as the evaluation of watermain alternative solutions. Since the Do Nothing alternative would simply not satisfy the requirement to accommodate growth to the 2041 growth scenario, **Alternative 2: Extend/Replace Existing System** is the remaining viable option.

RECOMMENDED WATER DISTRIBUTION SERVICING ALTERNATIVES

Alternative 2: Extend/Replace Existing System is the recommended alternative solution for addressing the water distribution deficiencies in terms of watermains in the Dowling Water System. The watermain projects recommended as part of the Master Plan can be found in Volume 6 of this report.

4.2.2 FALCONBRIDGE WATER SYSTEM

The following subsections summarize the Falconbridge Water System distribution deficiencies in terms of pumping, storage, and watermains, the alternative solutions developed to address the infrastructure gaps, the evaluations undertaken, and statements of the preferred solutions.

PUMPING AND STORAGE FACILITIES

It was determined through analysis that the booster pumping capacity in the Falconbridge Water System will be sufficient to accommodate water distribution servicing to the 2041 growth scenario. Therefore, the following gaps, alternatives, evaluation, and preferred solution will be relevant to the storage facility analysis, in this case; analysis of the Falconbridge Storage Tank.

WATER DISTRIBUTION INFRASTRUCTURE GAP

Upon completing a capacity analysis of the Falconbridge Storage Tank it was concluded that, in addition to the tank aging and requiring repairs, it will require an additional 605 m^3 of water storage capacity in order to accommodate servicing requirements for population growth to 2041. The alternatives developed to address this capacity deficiency are described in the following subsection.

WATER DISTRIBUTION SERVICING ALTERNATIVES

Three (3) water storage alternative solutions were considered for the Falconbridge Water System, and they are as follows:

1. **Alternative 1: Do Nothing (Continue with Existing System As Is)**
2. **Alternative 2: New Storage Facility and Decommissioning of Existing Facility**
3. **Alternative 3: New Supplemental Storage Facility**

The following would be required for the implementation of each alternative:

Alternative 1: Do Nothing (Continue with Existing System As Is)

— The Falconbridge Storage Tank would continue to operate as it currently does, with a usable volume of 1,136 m^3.

Alternative 2: New Storage Facility and Decommissioning of Existing Facility

— Construction of new water storage infrastructure to accommodate the projected demands.

— Decommissioning of the existing Falconbridge Storage Tank.

Alternative 3: New Supplemental Storage Facility

— Retention of existing Falconbridge Storage Tank.

— Construction of new water storage infrastructure to accommodate the existing and future storage capacity deficiency.

EVALUATION OF WATER DISTRIBUTION SERVICING ALTERNATIVES

As described in Volume 1 of this report, each alternative solution was evaluated against a set of criteria developed as part of the Master Plan. Table 4-6 summarizes the Falconbridge Water System storage alternative solutions.

Table 4-6 Evaluation of the Falconbridge Water Storage Alternatives

EVALUATION CRITERIA	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
Healthy Watersheds	N/A	N/A	N/A
Natural Heritage	No construction would be required on any sites. There would be no impact on natural heritage.	Infrastructure would be introduced in already disturbed areas on the existing site. Potential for disturbance of natural heritage based on location of the new facility.	Potential for disturbance of natural heritage based on location of the new facility.
Community Well Being	Would have no construction impacts. The existing facility is in poor condition and therefore can be considered less reliable.	Would introduce construction impacts for construction of new facility and decommissioning of existing facility.	Would include one-time construction impacts for construction of new facility.

EVALUATION CRITERIA	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
Cost Effectiveness	No new capital spending. Long-term costs to maintain the existing facility in poor condition would be substantial.	New capital cost to implement the new water storage infrastructure. Overall maintenance costs to maintain the new infrastructure would be less than the costs to maintain the existing water storage tank.	New capital cost to implement the new water storage infrastructure. Overall maintenance costs would be high, given the need to maintain the existing water storage infrastructure in poor condition and the additional water storage infrastructure.
Constructability and Ease of Integration	No construction or integration would be required.	Would require complex construction; however, integration into the system would not be as difficult as for Alternative 3.	Would require complex construction and difficult integration into the existing system.
Operability	Existing operational requirements will remain.	New operational requirements will be introduced for new facility.	New operational requirements will be introduced to control the two water storage tanks in conjunction.
Sustainability	Not sustainable in the long term. The existing facility requires repairs and upgrades to meet storage and structural requirements.	Would provide long-term sustainability by resolving all structural and storage issues.	Would provide increased sustainability, in comparison to Alternative 1, by resolving all structural and storage issues.
Preferred Selection	**Least Preferred**	**Most Preferred**	**Less Preferred**

RECOMMENDED WATER DISTRIBUTION SERVICING ALTERNATIVES

Alternative 3: New Supplemental Storage Facility is the recommended alternative solution for addressing the water storage deficiencies in the Falconbridge Water System. Additional details can be found in Volume 6 of this report.

WATERMAINS

Watermains encompassed in the Falconbridge Water System were analysed to determine whether fire flow and demand requirements could be met to the 2041 growth scenario. The following subsections will summarize the watermain gaps identified within the system, the alternative solutions considered to address the deficiencies, and the evaluation of alternatives in order to arrive at a recommended solution.

WATER DISTRIBUTION INFRASTRUCTURE GAP

It was identified through hydraulic modelling that certain pipes within the Falconbridge Water System are 150 mm diameter or smaller, and therefore may not have capacity to deliver fire flows that meet current standards. Similarly, areas with dead end watermains were determined to deliver flows that do not meet current fire flow standards. In the Falconbridge Water System Gap Analysis and Status Quo Report, included in Appendix 2-A, specific areas in the system that require additional pipes, pipe upgrades, or replacements were identified. The following alternatives were developed in order to address identified watermain deficiencies.

WATER DISTRIBUTION SERVICING ALTERNATIVES

1 **Alternative 1: Do Nothing (Continue with Existing System As Is)**

The Do Nothing alternative would not support the Master Plan objective of servicing population growth to 2041 and rectifying deficiencies in the Falconbridge Water System.

2 **Alternative 2: Extend/Replace Existing System**

The Extend/Replace Existing System alternative for watermains encompasses replacing existing infrastructure to increase capacity, or the addition of new infrastructure or the creation of loops to address capacity deficiencies.

EVALUATION OF WATER DISTRIBUTION SERVICING ALTERNATIVES

A screening process was undertaken as the evaluation of watermain alternative solutions. Since the Do Nothing alternative would simply not satisfy the requirement to accommodate growth to the 2041 growth scenario, **Alternative 2: Extend/Replace Existing System** is the remaining viable option.

RECOMMENDED WATER DISTRIBUTION SERVICING ALTERNATIVES

Alternative 2: Extend/Replace Existing System is the recommended alternative solution for addressing the water distribution deficiencies in terms of watermains in the Falconbridge Water System. The watermain projects recommended as part of the Master Plan can be found in Volume 6 of this report.

4.2.3 ONAPING-LEVACK WATER SYSTEM

The following subsections will summarize the Onaping-Levack Water System distribution deficiencies in terms of pumping, storage, and watermains, the alternative solutions developed to address the infrastructure gaps, the evaluations undertaken, and statements of the preferred solutions.

PUMPING AND STORAGE

It was determined through analysis that the booster pumping capacity in the Onaping-Levack Water System will be sufficient to accommodate water distribution servicing to the 2041 growth scenario. Water storage is also sufficient to meet the 2041 growth scenario.

WATERMAINS

Watermains encompassed in the Onaping-Levack Water System were analysed to determine whether fire flow and demand requirements could be met to the 2041 growth scenario. The following subsections will summarize the watermain gaps identified within the system, the alternative solutions considered to address the deficiencies, and the evaluation of alternatives in order to arrive at a recommended solution.

WATER DISTRIBUTION INFRASTRUCTURE GAP

It was identified through hydraulic modelling that certain pipes within the Onaping-Levack Water System do not meet fire flows, specifically at the majority of the dead ends in the system. The Onaping-Levack Water System Gap Analysis and Status Quo Report, included in Appendix 2-A, identifies the specific areas in the system that require additional pipes, pipe upgrades, or replacements.

WATER DISTRIBUTION SERVICING ALTERNATIVES

1 **Alternative 1: Do Nothing (Continue with Existing System As Is)**

The Do Nothing alternative would not support the Master Plan objective of servicing population growth to 2041 and rectifying deficiencies in the Onaping-Levack Water System.

2 **Alternative 2: Extend/Replace Existing System**

The Extend/Replace Existing System alternative for watermains encompasses replacing existing infrastructure to increase capacity, or the addition of new infrastructure or the creation of loops to address capacity deficiencies.

EVALUATION OF WATER DISTRIBUTION SERVICING ALTERNATIVES

A screening process was undertaken as the evaluation of watermain alternative solutions. Since the Do Nothing alternative would simply not satisfy the requirement to accommodate growth to the 2041 growth scenario, **Alternative 2: Extend/Replace Existing System** is the remaining viable option.

RECOMMENDED WATER DISTRIBUTION SERVICING ALTERNATIVES

Alternative 2: Extend/Replace Existing System is the recommended alternative solution for addressing the water distribution deficiencies in terms of watermains in the Onaping-Levack Water System. The watermain projects recommended as part of the Master Plan can be found in Volume 6 of this report.

4.2.4 SUDBURY WATER SYSTEM

The following subsections summarize the Sudbury Water System distribution deficiencies in terms of pumping, storage, and watermains, the alternative solutions developed to address the infrastructure gaps, the evaluations undertaken, and statements of the preferred solutions.

PUMPING AND STORAGE FACILITIES

It was determined through analysis that booster pumping capacity in the Sudbury Water System will be sufficient to accommodate water distribution servicing to the 2041 growth scenario. Therefore, the following gaps, alternatives, evaluation, and preferred solution will be relevant to the storage facility analysis.

WATER DISTRIBUTION INFRASTRUCTURE GAP

It was determined through analysis of the Ellis Reservoir that, unless improvements are made to allow use of the full volume, there would not be sufficient capacity to provide water storage to the 2041 growth scenario. Without system improvements, the potential storage deficiency is 2,721 m^3 by the 2041 growth scenario. The following alternatives were developed as potential solutions to address this identified gap.

The City isn't currently filling the Ellis Reservoir to the top level due to increased frequency of watermain breaks when its full storage capacity is utilized (36,400 m^3). The current effective storage in the reservoir 26,700 m^3.

WATER DISTRIBUTION SERVICING ALTERNATIVES

Three (3) water storage alternative solutions were considered for the Sudbury Water System, and they are as follows:

1 **Alternative 1: Do Nothing (Continue with Existing System As Is)**
2 **Alternative 2: Optimize Existing Storage through New System Configuration**
3 **Alternative 3: New Supplemental Storage Facility**

The following would be required for the implementation of each alternative:

Alternative 1: Do Nothing (Continue with Existing System As Is)

— The Ellis Reservoir would continue to operate as it currently does, with a usable volume of approximately 26,700 m^3 (which is not its full capacity).

Alternative 2: Optimize Existing Storage through New System Configuration

— The installation of a number of PRVs in the distribution system (Zone 1) to reduce excessive pressures and allow Ellis Reservoir to be used to its full capacity.

Alternative 3: New Supplemental Storage Facility

— The installation of a new storage tank in Sudbury

EVALUATION OF WATER DISTRIBUTION SERVICING ALTERNATIVES

As described in Volume 1 of this report, each alternative solution was evaluated against a set of criteria developed as part of the Master Plan. Table 4-7 summarizes the Sudbury Water System storage alternative solutions.

Table 4-7 Evaluation of the Sudbury Water Storage Alternatives

EVALUATION CRITERIA	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
Healthy Watersheds	N/A	N/A	N/A
Natural Heritage	No construction would be required on any sites. There would be no impact on natural heritage.	Limited construction would be required on site. There would be no impact on natural heritage.	Would impact the existing site and surrounding area.
Community Well Being	No construction impacts. Concerns regarding adequate storage would remain.	Limited construction would be required. Entire tank volume will be utilized.	Would include one-time construction impacts. Would provide additional storage to resolve existing deficit.
Cost Effectiveness	Existing maintenance and operational spending will remain.	Minimal capital cost to implement booster pumps and PRVs in the system. Low operating and maintenance costs would continue.	Large capital cost and long term operational and maintenance costs.
Constructability and Ease of Integration	No construction or integration would be required.	Would require minimal construction on the existing sites with easy integration into the existing system.	Would require complex construction and difficult integration into the existing system.
Operability	Existing operational requirements will remain.	Minimal additional operational requirements for pump stations.	New operational requirements will be introduced for new facility. Additional storage would be provided.
Sustainability	Unknown long-term sustainability due to tank volume not entirely being utilized.	Would provide long-term sustainability by making use of all available storage.	Would provide long-term sustainability by resolving all storage issues.
Preferred Selection	**Less Preferred**	**Most Preferred**	**Least Preferred**

RECOMMENDED WATER DISTRIBUTION SERVICING ALTERNATIVES

Alternative 2: Optimize Existing Storage through New System Configuration is the recommended alternative solution for addressing the water storage deficiencies in the Sudbury Water System. The water infrastructure recommendations can be found in Volume 6 of this report.

WATERMAINS

Watermains encompassed in the Sudbury Water System were analysed to determine whether fire flow and demand requirements could be met to the 2041 growth scenario. The following subsections will summarize the watermain gaps identified within the system, the alternative solutions considered to address the deficiencies, and the evaluation of alternatives in order to arrive at a recommended solution.

WATER DISTRIBUTION INFRASTRUCTURE GAP

It was identified through hydraulic modelling that certain pipes within the Sudbury Water System are 150 mm diameter or smaller, and therefore may not have capacity to deliver fire flows that meet current standards. Similarly, areas with dead end watermains were determined to deliver flows that do not meet current fire flow standards. In the Sudbury Water System Gap Analysis and Status Quo Report, included in Appendix 2-A, specific areas in the system that require additional pipes, pipe upgrades, or replacements were identified. The following alternatives were developed in order to address identified watermain deficiencies.

WATER DISTRIBUTION SERVICING ALTERNATIVES

Alternative 1: Do Nothing (Continue with Existing System As Is)

The Do Nothing alternative would not support the Master Plan objective of servicing population growth to 2041 and rectifying deficiencies in the Sudbury Water System.

Alternative 2: Extend/Replace Existing System and Optimize Zone Boundaries

The Extend/Replace Existing System alternative for watermains encompasses replacing existing infrastructure to increase capacity, or the addition of new infrastructure or the creation of loops to address capacity deficiencies.

EVALUATION OF WATER DISTRIBUTION SERVICING ALTERNATIVES

A screening process was undertaken as the evaluation of watermain alternative solutions. Since the Do Nothing alternative would simply not satisfy the requirement to accommodate growth to the 2041 growth scenario, **Alternative 2: Extend/Replace Existing System** is the remaining viable option.

RECOMMENDED WATER DISTRIBUTION SERVICING ALTERNATIVES

Alternative 2: Extend/Replace Existing System is the recommended alternative solution for addressing the water distribution deficiencies in terms of watermains in the Sudbury Water System. The watermain projects recommended as part of the Master Plan can be found in Volume 6 of this report.

4.2.5 VALLEY WATER SYSTEM

The following subsections will summarize the Valley Water System distribution deficiencies in terms of pumping, storage, and watermains, the alternative solutions developed to address the infrastructure gaps, the evaluations undertaken, and statements of the preferred solutions.

PUMPING AND STORAGE FACILITIES

It was determined through analysis that the booster pumping capacity in the Valley Water System will be sufficient to accommodate water distribution servicing to the 2041 growth scenario. Therefore, the following gaps, alternatives, evaluation, and preferred solution will be relevant to the storage facility analysis, in this case; analysis of the Azilda Standpipe, the Chelmsford Elevated Tank, and the Val Caron Storage Tank.

WATER DISTRIBUTION INFRASTRUCTURE GAP

The key storage infrastructure concern in the Valley Water System is the occurrence of stagnant water and freezing in the Azilda Standpipe. Although the Valley Water System's existing storage provides sufficient capacity to service population growth to the 2041 growth scenario per gap analysis, both the low and high water levels in the Azilda Standpipe are lower than in the other two (2) tanks. Since the three (3) storage facilities are located within the same pressure zone, this causes water to be distributed from the tanks with higher water levels, and not the Azilda Standpipe. Alternative solutions were developed to determine whether storage in the system could be optimized through reconfiguration or through additional infrastructure. The alternatives are described in the following subsection.

WATER DISTRIBUTION SERVICING ALTERNATIVES

Three (3) water storage alternative solutions were considered for the Valley Water System, and they are as follows:

1. **Alternative 1: Do Nothing (Continue with Existing System As Is)**
2. **Alternative 2: Optimize Existing Storage through New System Configuration**

The following would be required for the implementation of each alternative:

Alternative 1: Do Nothing (Continue with Existing System As Is)

- The existing storage facilities would continue to operate as they currently do:
  - Azilda Standpipe with a usable volume of 4,524 m^3, and stagnant water and freezing remaining a concern.
  - Chelmsford Elevated Tank with a usable volume of 1,353 m^3.
  - Val Caron Tank with a usable volume of 5,274 m^3.

Alternative 2: Optimize Existing Storage through New System Configuration

- This includes the installation of a new booster pump, electric actuator on isolation valves and reprogramming of the SCADA system to ensure turnover of water in the Azilda Standpipe.

EVALUATION OF WATER DISTRIBUTION SERVICING ALTERNATIVES

As described in Section # of Volume 1 of this report, each alternative solution was evaluated against a set of criteria developed as part of the Master Plan. Table 4-8 summarizes the Valley Water System storage alternative solutions.

Table 4-8 Evaluation of the Valley Water Storage Alternatives

EVALUATION CRITERIA	ALTERNATIVE 1	ALTERNATIVE 2
Healthy Watersheds	N/A	N/A
Natural Heritage	No construction would be required on any sites. There would be no impact on natural heritage.	Limited construction would be required on site. There would be no impact on natural heritage.
Community Well Being	No construction impacts. Concerns regarding adequate storage would remain.	Limited construction would be required. All valley storage facilities will utilize entire tank volume.
Cost Effectiveness	Existing maintenance and operational spending will remain.	Minimal capital cost to implement booster pumps in the system. Low operating and maintenance costs would continue.

EVALUATION CRITERIA	ALTERNATIVE 1	ALTERNATIVE 2
Constructability and Ease of Integration	No construction or integration would be required.	Would require minimal construction on the existing sites with integration into the existing system.
Operability	Existing operational requirements will remain. The system not currently cycling smoothly.	Minimal additional operational requirements for pump station.
Sustainability	Potential for poor long-term sustainability since the full volume of the tank is not being utilized.	Would provide long-term sustainability by making use of all available storage.
Preferred Selection	**Less Preferred**	**Most Preferred**

RECOMMENDED WATER DISTRIBUTION SERVICING ALTERNATIVES

Alternative 2: Optimize Existing Storage through New System Configuration is the recommended alternative solution for water storage in the Valley Water System. The water infrastructure recommendations can be found in Volume 6 of this report.

WATERMAINS

Watermains encompassed in the Valley Water System were analysed to determine whether fire flow and demand requirements could be met to the 2041 growth scenario. The following subsections will summarize the watermain gaps identified within the system, the alternative solutions considered to address the deficiencies, and the evaluation of alternatives in order to arrive at a recommended solution.

WATER DISTRIBUTION INFRASTRUCTURE GAP

It was identified through hydraulic modelling that certain pipes within the Valley Water System are 150 mm diameter or smaller, and therefore may not have capacity to deliver fire flows that meet current standards. The Valley Water System Gap Analysis and Status Quo Report, included in Appendix 2-A, identifies the specific areas in the system that require additional pipes, pipe upgrades, or replacements.

WATER DISTRIBUTION SERVICING ALTERNATIVES

1 **Alternative 1: Do Nothing (Continue with Existing System As Is)**

The Do Nothing alternative would not support the Master Plan objective of servicing population growth to 2041 and rectifying deficiencies in the Valley Water System.

2 **Alternative 2: Extend/Replace Existing System**

The Extend/Replace Existing System alternative for watermains encompasses replacing existing infrastructure to increase capacity, or the addition of new infrastructure or the creation of loops to address capacity deficiencies.

EVALUATION OF WATER DISTRIBUTION SERVICING ALTERNATIVES

A screening process was undertaken as the evaluation of watermain alternative solutions. Since the Do Nothing alternative would simply not satisfy the requirement to accommodate growth to the 2041 growth scenario, **Alternative 2: Extend/Replace Existing System** is the remaining viable option.

RECOMMENDED WATER DISTRIBUTION SERVICING ALTERNATIVES

Alternative 2: Extend/Replace Existing System is the recommended alternative solution for addressing the water distribution deficiencies in terms of watermains in the Valley Water System. The water infrastructure recommendations as part of the Master Plan can be found in Volume 6 of this report.

4.2.6 VERMILION WATER SYSTEM

The following subsections will summarize the Vermilion Water System distribution deficiencies in terms of pumping, storage, and watermains, the alternative solutions developed to address the infrastructure gaps, the evaluations undertaken, and statements of the preferred solutions.

PUMPING AND STORAGE FACILITIES

It was determined through analysis that the booster pumping capacity in the Vermilion Water System will be sufficient to accommodate water distribution servicing to the 2041 growth scenario. Therefore, the following gaps, alternatives, evaluation, and preferred solution will be relevant to the storage facility analysis, in this case; analysis of the Walden Standpipe.

WATER DISTRIBUTION INFRASTRUCTURE GAP

Through capacity analysis of the City's usable volume in the Walden Standpipe (2,662 m^3), it was determined that an additional 2,640 m^3 of storage volume would be necessary to achieve requirements to the 2041 growth scenario. The following subsection outlines the alternatives that were developed in order to address this deficiency.

WATER DISTRIBUTION SERVICING ALTERNATIVES

Three (3) water storage alternative solutions were considered for the Vermilion Water System, and they are as follows:

1. **Alternative 1: Do Nothing – Continue to Utilize Vale's Storage**
2. **Alternative 2: New Storage Facility**

The following would be required for the implementation of each alternative:

Alternative 1: Do Nothing – Continue to Utilize Vale's Storage

— The Walden Standpipe would continue to operate as it currently does, with a usable volume of 2,662 m^3. The City would continue to have access and utilize water storage in Vale's Water System (60,543 m^3).

Alternative 2: New Storage Facility

— Construction of a new storage facility in the system

EVALUATION OF WATER DISTRIBUTION SERVICING ALTERNATIVES

As described in Section # of Volume 1 of this report, each alternative solution was evaluated against a set of criteria developed as part of the Master Plan. Table 4-9 summarizes the Vermilion Water System storage alternative solutions.

Table 4-9 Evaluation of the Vermilion Water Storage Alternatives

EVALUATION CRITERIA	ALTERNATIVE 1	ALTERNATIVE 3
Healthy Watersheds	N/A	N/A
Natural Heritage	No construction would be required on site. There would be no impact on natural heritage.	New infrastructure would be constructed potentially disturbing natural heritage areas.

EVALUATION CRITERIA	ALTERNATIVE 1	ALTERNATIVE 3
Community Well Being	No construction impacts. Concerns regarding adequate storage would remain.	Would include one-time construction impacts. Would provide additional storage to resolve existing deficit.
Cost Effectiveness	Existing maintenance and operational spending will remain.	Large capital cost and long term operational and maintenance costs.
Constructability and Ease of Integration	No construction or integration would be required.	Would require complex construction and difficult integration into the existing system.
Operability	Existing operational requirements will remain.	New operational requirements will be introduced for new facility.
Sustainability	Unknown long-term sustainability. The existing facility requires repairs and upgrades to meet storage and structural requirements.	Would provide long-term sustainability by resolving all storage issues.
Preferred Selection	**Most Preferred**	**Least Preferred**

RECOMMENDED WATER DISTRIBUTION SERVICING ALTERNATIVES

Alternative 1: Do Nothing – Continue to Utilize Vale's Storage is the recommended alternative solution for addressing the water storage deficiencies in the Vermilion Water System. Water System recommendations can be found in Volume 6 of this report.

WATERMAINS

Watermains in the Vermilion Water System were analysed to determine whether fire flow and demand requirements could be met to the 2041 growth scenario. The following subsections summarize the watermain gaps identified within the system, the alternative solutions considered to address the deficiencies, and the evaluation of alternatives in order to arrive at a recommended solution.

WATER DISTRIBUTION INFRASTRUCTURE GAP

It was identified through hydraulic modelling that certain pipes within the Vermilion Water System are 150 mm diameter or smaller, and therefore may not have capacity to deliver fire flows that meet current standards. Similarly, areas with dead end watermains were determined to deliver flows that do not meet current fire flow standards. The Vermilion Water System Gap Analysis and Status Quo Report, included in Appendix 2-A, identifies the specific areas in the system that require additional pipes, pipe upgrades, or replacements.

WATER DISTRIBUTION SERVICING ALTERNATIVES

1 Alternative 1: Do Nothing (Continue with Existing System As Is)

The Do Nothing alternative would not support the Master Plan objective of servicing population growth to 2041 and rectifying deficiencies in the Vermilion Water System.

2 Alternative 2: Extend/Replace Existing System

The Extend/Replace Existing System alternative for watermains encompasses replacing existing infrastructure to increase capacity, or the addition of new infrastructure or the creation of loops to address capacity deficiencies.

EVALUATION OF WATER DISTRIBUTION SERVICING ALTERNATIVES

A screening process was undertaken as the evaluation of watermain alternative solutions. Since the Do Nothing alternative would simply not satisfy the requirement to accommodate growth to the 2041 growth scenario, **Alternative 2: Extend/Replace Existing System** is the remaining viable option.

RECOMMENDED WATER DISTRIBUTION SERVICING ALTERNATIVES

Alternative 2: Extend/Replace Existing System is the recommended alternative solution for addressing the water distribution deficiencies in terms of watermains in the Vermilion Water System. The water infrastructure recommendations as part of the Master Plan can be found in Volume 6 of this report.

4.3 WATER LEAKAGE

As part of the City of Greater Sudbury Water and Wastewater Master Plan, WSP has reviewed the water leakage in the City's water supply systems. The following subsections document the analysis of the leakage in the City's water supply systems and the recommendations regarding the preliminary actions that should be undertaken by the City to reduce leakage within their water systems. It should be noted the analysis performed is based on the hydraulic modeling results.

4.3.1 AN EXPLANATION OF AUTHORIZED WATER CONSUMPTION AND WATER LOSSES IN A WATER SYSTEM

Many water supply systems suffer a variety of water losses. Most operators recognize piping distribution system leakage as a primary type of loss; however, poor accounting, meter inaccuracy, and unauthorized consumptions are other possible sources of water losses in the water supply network. Piping distribution system leakage is usually categorized as **real losses**, whereas the other water loss sources are collectively labeled as **apparent losses**. The initial, essential step in calculating the water losses is to identify the nature and volume of losses in the existing water supply system.

Nonrevenue water is the difference between the volume of water produced by a treatment plant and the volume of authorized water used. In other words, it is the amount of water that has been "lost" before it reaches the user, and therefore not billed to customer. Revenue water is the metered water that is billed to the customer.

The American Water Works Association (AWWA) and International Water Association (IWA) have developed a Water Audit Method which allows water utilities to assess their water loss standing, benchmark themselves with other water utilities and set performance targets based on predefined performance indicators (Infrastructure Leakage Index (ILI)). The first step in the method is to develop a water balance in the water system. Table 4-10 and Table 4-11 define the format of IWA/AWWA method water balance and the terminology used in this method.

Table 4-10 IWA/AWWA Water Balance

<table>
<tr><td rowspan="10">System Input Volume (Corrected for Known Errors)</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption (Including Water Exported)</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="8">Nonrevenue Water (NRW)</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="6">Water Losses</td><td rowspan="3">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Customer Metering Inaccuracies</td></tr>
<tr><td>Systematic Data Handling Errors</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission and Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to Point of Customer Metering</td></tr>
</table>

Table 4-11 Components and Definitions of the IWA/AWWA Water Balance

WATER BALANCE COMPONENT	DEFINITION
System Input Volume	The annual volume input to the water supply system
Authorized Consumption	The annual volume of metered and/or unmetered water taken by registered customers, the water supplier and others who are authorized to do so
Water Losses	The difference between System Input Volume and Authorized Consumption, consisting of Apparent Losses plus Real Losses
Apparent Losses	Unauthorized Consumption, all types of metering inaccuracies and systematic data handling errors
Real Losses	The annual volumes lost through all types of leaks, breaks, and overflows on mains, service reservoirs and service connections, up to the point of customer metering
Revenue Water	Those components of System Input Volume which are billed and produce revenue
Non-Revenue Water	The difference between System Input Volume and Billed Authorized Consumption

4.3.2 EXISTING LEAKAGE IN THE CITY'S WATER SYSTEMS

The City's water supply systems' water production and billed water volumes, including the calculated leakage volume for 2012, are presented in Table 4-12. The volume of leakage in each system was calculated using a water balance between the water production, delivery of water to each consumer, and leakage rate obtained from the hydraulic model. The leakage rates for each system are also illustrated in Figure 4-1.

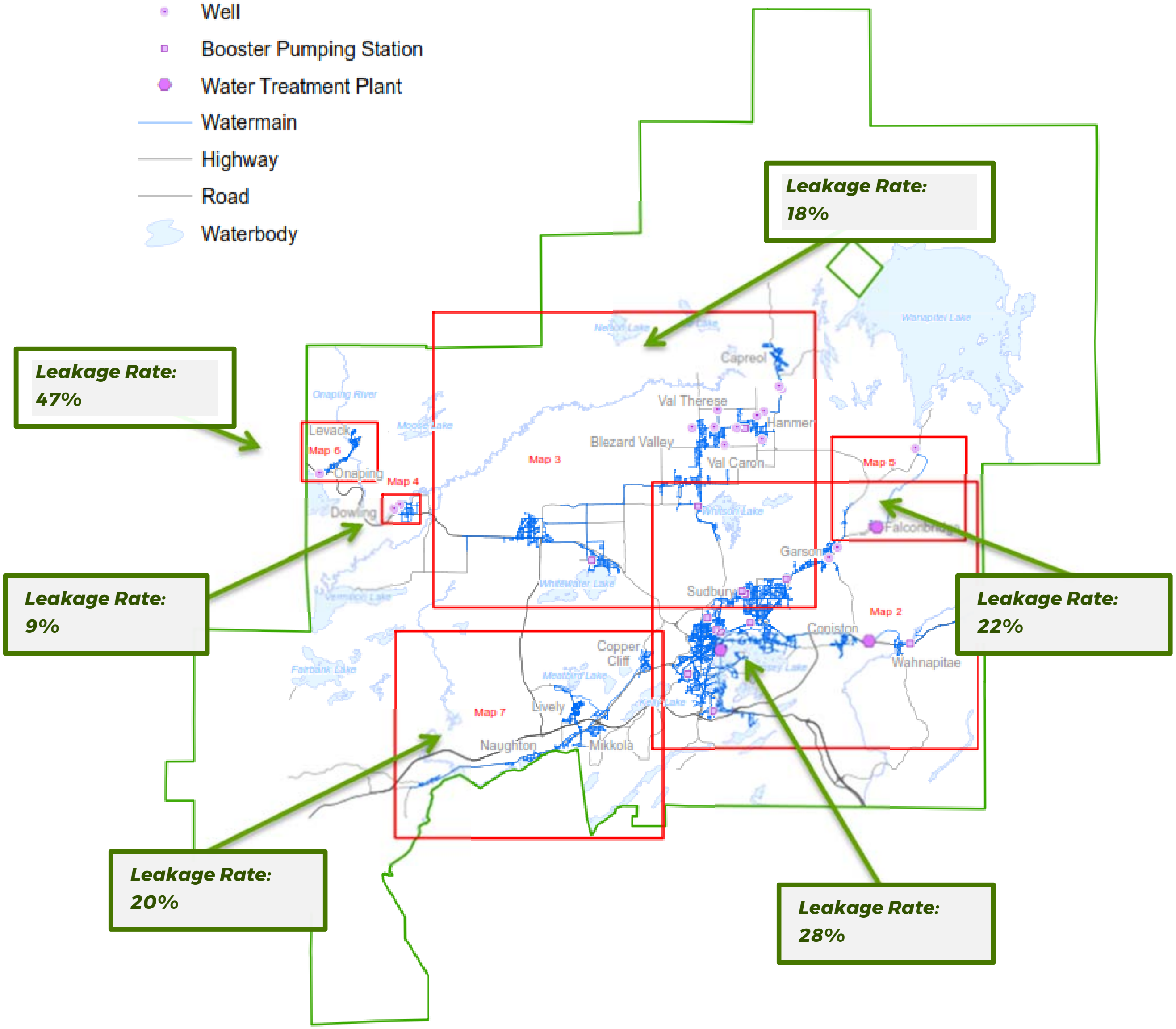

Figure 4-1 The CGS Existing Water Supply System Leakage Rates

Table 4-12 Water Production, Billed Water Volumes, and Calculated Leakage Volumes by Water System

LOCATION	TOTAL PRODUCTION (M^3)	TOTAL BILLED (M^3)	TOTAL NONREVENUE VOLUME 2012 (M^3)	NONREVENUE WATER PERCENTAGE	LEAKAGE RATE	TOTAL LEAKAGE VOLUME IN 2012
Dowling	139,788	120,214	19,574	14%	9%	12,221
Falconbridge	373,861	270,775	103,086	28%	22%	84,043
Onaping-Levack	617,403	292,680	324,723	53%	47%[1]	290,387
Sudbury (inc. Sudbury, Coniston, and Wahnapitae)	15,441,241	10,201,831	5,239,410	34%	28%	4,352,254
Valley (inc. Valley East, Capreol, Azilda, and Chelmsford)	3,689,314	2,807,736	881,578	24%	18%	676,715
Vermilion (Inc. Copper Cliff, Lively, Walden, Naughton, Whitefish)[2]	1,585,000	1,177,213	407,787	26%	20%	322,870
Total	**21,846,607**	**14,870,449**	**6,976,158**	-	-	**5,738,490**

[1] It should be noted that on October 26th, 2015, one (1) of the water services in Onaping-Levack, located in the Hardy Industrial Park that ran to an abandoned mine, was repaired. It is expected that this will positively reduce the leakage in the system.

[2] Due to the lack of existing data for Vermilion system, a leakage rate of 20% has been assumed. Currently there is a metering program in place for Vermilion; once this program has been completed, the actual leakage rate shall be recalculated.

Based on 2012 data presented in Table 4-12, Onaping-Levack and Sudbury have had the highest rate of leakage with 47% and 28% respectively; however, as mentioned, the leakage in Onaping-Levack is thought to have lessened and therefore was not included in the following leakage assessment. The recommendation is for the City to recalculate the leakage rates as part of the future Water and Wastewater Master Plan Update.

METHODOLOGY FOR QUANTIFYING LEAKAGE IN A WATER SYSTEM

The AWWA has recommended the ILI as one (1) of the water audit methods for managing nonrevenue water. All calculations in the leakage analysis are based on this method to determine the level of leakage within the City's water distribution systems. The ILI is defined as the Current Annual Real Losses (CARL) divided by the Unavoidable Annual Real Losses (UARL). The UARL represents the lowest technically achievable annual real loss for a well maintained system. The water balance in the supply system allows reaching a meaningful assessment of volumes of annual real losses (CARL). Once the ILI is calculated, the ILI target matrix, documented in Table 4-13 is used to determine the technical performance category. Benchmarking is based on international studies.

Table 4-13 ILI Technical Performance Category[1]

TECHNICAL PERFORMANCE CATEGORY	ILI	LITERS/CONNECTION/DAY (WHEN THE SYSTEM IS PRESSURIZED) AT AN AVERAGE PRESSURE OF):				
		14 PSI	28 PSI	42 PSI	57 PSI	71 PSI
Developed Communities	A	1-2	-	<50	<75	<100
	B	2-4	-	50-100	75-100	100-200
	C	4-8	-	100-200	150-300	200-400
	D	>8	-	>200	>300	>400

[1] *Reproduced from McKenzie, RS and Liemberger, R. (2005) International Benchmarking of Leakage from Water Reticulation Systems.*

Table 4-14 defines each category of the Technical Performance of the water supply system.

Table 4-14 Definition of Each ILI Category[1]

ILI	CATEGORY	TECHNICAL PERFORMANCE CATEGORY
1-2	A	Further loss reduction may be uneconomic unless there are shortages; careful analysis needed to identify cost effective improvement
2-4	B	Potential for marked improvements; consider pressure management; better active leakage control practices, and better network maintenance
4-8	C	Poor leakage record; tolerable only if water is plentiful and cheap; even then, analyze level and nature of leakage and intensify leakage reduction efforts
>8	D	Horrendously inefficient use of resources; leakage reduction programs imperative and high priority

[1] *Reproduced from McKenzie, RS and Liemberger, R. (2005) International Benchmarking of Leakage from Water Reticulation Systems.*

ILI CALCULATION

Table 4-15 provides a summary of pipe lengths, service pressures, number of service connections and hydrants for each water supply system/community.

Table 4-15 The CGS Water Supply Summary

COMMUNITY	PIPE LENGTH (M)	AVERAGE PRESSURE UNDER EXISTING CONDITION (PSI)	AVERAGE PRESSURE UNDER EXISTING CONDITION (KPA)	AVERAGE PRESSURE UNDER EXISTING CONDITION (M)	NUMBER OF SERVICE CONNECTIONS (NC)	NUMBER OF HYDRANTS
Dowling	16,177	61	417	43	667	121
Falconbridge	20,130	65	445	45	307	41
Onaping-Levack	25,126	69	478	49	935	124
Sudbury (Includes: Sudbury, Coniston, Garson, and Wahnapitae)	523,635	78	535	55	31,584	3,079
Valley (Includes: Valley East, Capreol, Azilda, and Chelmsford)	118,475	67	464	47	13,919	1,658
Vermilion (Includes: Copper Cliff, Lively, Walden, Naughton, Whitefish)	118,545	78	536	55	3,965	574

Based on the above table, the total length of all water mains (Lm) has been calculated for each community. The average length of hydrant leads was assumed to be two (2) meters and has been included in the calculation of Lm (Lm = lengths of mains + lengths of hydrants). It should be noted that the average length of service connections (Lp) was assumed to be six (6) meters and Nc represents the number of service connections to the system. Based on these assumptions, Table 4-16 is a summary of ILI calculation for each community. ILI is calculated based on the following formula:

$$\text{ILI} = \frac{\text{CARL}}{\text{UARL}}$$

Where UARL is:

$$UARL(m3/year) = ([18 \times Lm + 0.8 \times Nc + 25 \times Lc] \times P) * 365/1000$$

Table 4-16 ILI Calculation for Each Community (2012)

COMMUNITY	AVERAGE PRESSURE (M)	2012 LEAKAGE VOLUME (CARL) (M^3/YR)	LM (KM)	LC (KM)	UARL (M^3/YR)	ILI	RECOMMENDATION
Dowling	43	12,221	16	4	14,434	1	A
Falconbridge	45	84,043	20	2	10,870	8	C
Onaping-Levack	49	290,387	25	6	23,925	12	D
Sudbury (Includes: Sudbury, Coniston, Garson, and Wahnapitae)	55	4,352,254	530	190	788,241	6	C
Valley (Includes: Valley East, Capreol, Azilda, and Chelmsford)	47	676,715	282	84	316,445	2	B
Vermilion (Includes: Copper Cliff, Lively, Walden, Naughton, Whitefish)	55	322,870	120	24	119,168	3	B

Based on the range presented in Table 4-13, the Performance Category of each community was determined. The analysis showed that the communities of Falconbridge (Category C), Onaping-Levack (Category D) and Sudbury (Category C) had a poor leakage record in 2012. As result, the recommendations in the Master Plan will focus on the leakage reduction strategies in Falconbridge and Sudbury given that, as stated previously, work has been undertaken by the City to reduce the leakage in Onaping-Levack. It is recommended that the ILI for Onaping-Levack be recalculated based on more recent years' data in advance of additional leak detection work.

4.3.3 QUANTIFYING LEAKAGE REDUCTION IN THE SUDBURY WATER SYSTEMS

To better understand how leakage reduction might impact the water supply system demand for 2041, an analysis was conducted on the basis that leakage in each system can be reduced down to a rate of 15%. The analysis for the potential water reduction is summarized in Table 4-17. Whereas the calculations to determine ILI in the preceding section made use of the UARL, which represents the lowest technically achievable annual real loss for a well maintained system, the analysis for the potential water savings in the system was based on a more conservative leakage target of 15%. The calculated UARL rates for each water system correspond to target leakage rates between 2% and 9% which are considered to be quite aggressive. The analysis indicates that a significant rate of water demands savings (a total of 6,768 m^3/d within all systems, and 5,655 m^3/d in just the Sudbury and Falconbridge systems) can be achieved through means of leakage reduction in the systems, even when considering the more conservative leakage target of 15%.

Table 4-17 Possible Water Production Savings Achievable By Means of Leakage Reduction

WATER SYSTEM	2041 AVERAGE DAY DEMAND (M^3/D)	EXISTING LEAKAGE RATE[1] (M^3/D)	TARGET LEAKAGE OF 15% (M^3/D)	TARGET LEAKAGE REDUCTION RATE (M^3/D)	REDUCED 2041 AVERAGE DAY DEMAND (M^3/D)
Dowling	468	33	33[2]	0	468
Falconbridge	1,206	230	154	77	1,129
Onaping-Levack	1,887	796	254	542	1,345
Sudbury (inc. Sudbury, Coniston, and Wahnapitae)	64,546	11,924	6,346	5,578	58,968
Valley (inc. Valley East, Capreol, Azilda, and Chelmsford)	17,131	1,854	1,516	338	16,793
Vermilion (Inc. Copper Cliff, Lively, Walden, Naughton, Whitefish)	6,657	885	651	233	6,424
Total (All Systems)	**91,895**	**15,722**	**8,954**	**6,768**	**85,127**
Sudbury and Falconbridge Systems Only[3]	**65,752**	**12,154**	**6,500**	**5,655**	**60,097**

[1] *'Existing Leakage' was analyzed based on 2012 water consumption data.*

[2] *A 15% leakage target would be 57 m^3/d which is greater than the existing leakage in the system of 33 m^3/d. The existing leakage rate of 33 m^3/d (9%) leakage was therefore considered for the analysis.*

[3] *Totals for Sudbury and Falconbridge water systems are listed given that the recommendation in the Master Plan is to focus on these systems in terms of leakage reduction, given their calculated ILI ratings.*

It should be noted that for this analysis it has been assumed that all the water supply networks remain the same without any modification except reduction in leakage. Albeit there are average day water savings that will result by reducing leakage in the system, it is not possible at this stage to determine what impact leakage reduction would have on the system's maximum day demands, which ultimately determine the sizing for future water production and distribution infrastructure. Analysis of future years' water production consumption will have to be undertaken as part of the next Water and Wastewater Master Plan to determine the impact on lowering both the average day and maximum day water demands. That being said, reducing leakage is critical to the overall management of any water system and therefore efforts to reduce water leakage should be prioritized.

4.3.4 RECOMMENDED LEAKAGE MANAGEMENT PROGRAM

It is recommended that the City commences a proactive leakage management program. Once the leaks have been detected in 2020, a detailed costs analysis shall be performed for further infrastructure reinvestment. The following measures can be taken to reduce the cost associated with water losses in the water supply network. The first step in leakage management is to detect the sources of leakage. Currently, there are a variety of techniques that are being used within the industry. Performing a leak survey, using leak detection systems such as acoustic devices and the application of new technologies such as helium and sounding pods are all examples of current industry methodologies. District Meter Area (DMA) is another technique used for sub dividing the system to monitor leakage and other types of actual water losses. It is typically established for areas servicing 2000 to 3000 customer accounts. Where beneficial for managing pressure and reducing real water loss due to high pressure, the DMA district can be used for pressure management.

Water utilities should employ proactive leakage management activities with appropriate combinations of leak survey, flow monitoring, pressure management, and system renewal. The following table represents some of the measures that can be taken to reduce the leakage in these communities. The costs associated with the programs presented in Table 4-18 are approximate since they are based on previous experiences and have only been presented for comparison purposes.

Table 4-18 General Leakage Reduction Measures

ITEM	2016	2017	2018	2019	2020
Acoustic leak detection survey program on non-plastic pipes	$50,000	$50,000	$50,000	$50,000	$50,000
Detailed DMA study, pressure management study, break history review, internal leak/break record system audit and metering program review	$75,000	$75,000	-	-	-
Implementation of DMA (Capital delivery of the project)	-	$55,000	$120,000	$300,000	$300,000
Implementation of Pressure Management Measures (in-house costs)	$25,000	-	-	-	-
Implementation of internal leak/break record system improvements	$5,000	$5,000	-	-	-
Implementation of metering program* (meter testing and replacement program – this is low based on the current number of meters)	-	-	$100,000	$100,000	$100,000
Sub-Total	**$155,000**	**$185,000**	**$270,000**	**$450,000**	**$450,000**
Grand Total	**$1,510,000**				

The above table indicates that if the City invests approximately $1.5M to 2020, they would be able to locate the potential sources of leakage and reduce the volume of leakage. These programs are necessary in order to be able to plan for future required infrastructure replacement projects.

Figure 4-2 indicates the locations/zones in Sudbury area where Acoustic leak detection survey program on non-plastic pipes, DMA and pressure management studies can be performed and implemented to reduce the leakage rate through the pipes. These locations were chosen based on two (2) criteria: pipe age and high pressure zones. Sudbury consists of pipes installed between 1930 and 2011. Areas with aged pipes (more than 30 years old) are more susceptible to leakage at higher water pressures (more than 80 psi).

Figure 4-2 Locations within the CGS to Implement Leakage Reduction Measures

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4.4 WATER CONSERVATION

4.4.1 THE CITY'S EXISTING WATER CONSERVATION INITIATIVES

The City of Greater Sudbury has proactively implemented a water conservation program to reduce water consumption and sewage treatment costs. The water conservation initiatives and programs currently in place are planned and funded through a collaboration between EarthCare Sudbury and the City's Water and Wastewater Engineering departments. The City currently imposes lawn watering restrictions to reduce water use during the summer. Even numbered addresses may only water on even numbered calendar days. Odd numbered addresses may only water on odd numbered calendar days. Further temporary water use restrictions can be enforced during times of peak water demand including complete banning of outdoor water use. The City has also supported educational programming regarding water use and conservation. Since 2005, the City of Greater Sudbury has supported and participated in the Sudbury Children's Water Festival and became the lead host organization in 2016 (Public Health Sudbury & Districts was the host of the Children's Water Festival until 2016 when EarthCare Sudbury became the organizer). The event brings together educators, water specialists and representatives of industry and government to educate grade 3 students about the importance of water in their day to day lives. The event typically features a variety of activity stations regarding topics such as conservation, protection, and science and technology. Furthermore, the City and the Province of Ontario have been working on developing water conservation measures including programs to incentivize low flush toilets and low flow showerheads.

Recognizing that the City has already implemented many water conservation initiatives, the Master Plan includes an evaluation of what further water demand reductions are possible within the water systems, above and beyond the reductions made through current conservation efforts. The following section summarizes this analysis.

4.4.2 QUANTIFYING WATER DEMAND REDUCTIONS POSSIBLE BY MEANS OF WATER CONSERVATION

Table 4-19 presents the per capita residential water demands and the existing projected average day water demands for 2041. The values in this table are referenced in the analysis of the potential average day water demand reductions achievable by means of water conservation presented in Table 4-20.

Table 4-19 Per Capita Residential Water Demand & Projected 2041 Average Day Demands

WATER SYSTEM	EXISTING POP PER CAPITA RES DEMAND (L/CAP/D)[1]	FUTURE GROWTH DESIGN PER CAPITA RES DEMAND (L/CAP/D)[2]	2041 AVERAGE DAY DEMAND (M^3/D)[3]
Valley	241	250	17,131
Sudbury	337	350	64,546
Falconbridge	295	300	1,206
Vermillion	249	250	6,657
Dowling	179	200	468
Onaping-Levack	348	350	1,887
Total	-	-	**91,894**

[1] The average per capita demand rate for the existing population in the community (the 'existing' year in the Master Plan being 2011). The rate was calculated based on historical water production data from 2009 to 2013. Details regarding how this rate was calculated are included in the Population Projections and Development of Unit Rates Technical Memorandum.

[2] The per capita demand rate for all future growth in the community. Details regarding how this rate was determined are included in the Population Projections and Development of Unit Rates Technical Memorandum.
[3] The 2041 projected average day demand calculated as part of the Water and Wastewater Master Plan. These demands were used to assess the water production gaps in each water system. The calculation sheets for these demands are included in the Population Projections and Development of Unit Rates Technical Memorandum.

Table 4-20 summarizes the calculations for the potential average day water demand reductions possible by means of implementing further water conservation efforts (above and beyond the City's current efforts) in select water systems within the CGS. It is important to note that the water demands presented in the table include indoor water use, outdoor water use as well as water leakage in each system.

The first step in the analysis was to determine in which systems it would be feasible to further reduce water demands. Water consumption demands in Canada are typically quite high in comparison to many other countries; therefore, consideration of the typical water usage rates in Ontario was considered for the analysis. A review of the MOECC guidelines indicated that values of 270 to 450 L/cap/d were typical within the province. The per capita demand values estimated in Table 4-19 are either within or below this range. The per capita residential demand was compared to the lower end of the MOECC guideline values (300 L/cap/d) except in the circumstance that the per capita demands are lower than the current MOECC guidelines (i.e. as is the case for the Falconbridge, Valley, Vermilion and Dowling water systems). The demand rate of 300 L/cap/d was determine to be a realistic target for water conservation alone. The use of this rate translates into per capita water reduction rates between 37 L/cap/d and 50 L/cap/d which equate to a percentage reduction in residential rates between 12% and 17% (as summarized in Table 4-20). These values are reasonable water conservation targets given the City has already implemented water conservation practices. Once the target reduction rates were established, the potential water reduction demands thought to be achieved by means of water conservation practices were calculated – the calculations are summarized in Table 4-20.

Table 4-20 Estimated Average Day Demand Reductions (By Means of Water Conservation)

WATER SYSTEM	2041 AVERAGE DAY DEMAND (M^3/D)[3]	EXISTING POP (2011)	FUTURE GROWTH POP (2011 - 2041)	REDUCED RATE (L/CAP/D)[4]	REDUCED WATER DEMAND FOR EXISTING POP (L/CAP/D)[5]	REDUCED WATER DEMAND FOR FUTURE POP (L/CAP/D)[6]	2041 REDUCED AVERAGE DAY DEMAND (M^3/D)[7]	NEW REDUCED 2041 AVERAGE DAY DEMAND (M^3/D)[8]	2041 AVERAGE DAY DEMAND PERCENT REDUCTION[9]
Valley	17,131	36,382	3,382	-	-	-	0	17,131	0%
Sudbury	64,546	94,868	4,582	300	37[10]	50[10]	3,739	60,807	4%
Falconbridge	1,206	707	69	-	-	-	0	1,206	0%
Vermillion	6,657	10,359	1,726	-	-	-	0	6,657	0%
Dowling	468	1,773	243	-	-	-	0	468	0%
Onaping-Levack	1,887	2,112	47	300	48[11]	50[11]	104	1,783	3%
Total	**91,894**	**146,201**	**10,049**	**-**	**-**	**-**	**3,843**	**88,051**	**-**

4 The reduced per capita demand used to assess the potential water demand reductions possible by means of water conservation.
5 The per capita water savings calculated for existing populations, based on the proposed reduced per capita water demand rate.
6 The per capita water savings calculated for future populations, based on the proposed reduced per capita water demand rate.
7 The amount by which the 2041 average day water demand can be reduced by means of water conservation.
8 The revised 2041 average day water demand, based on reducing water demands through water conservation.
9 Percentage of water demand savings achieved through increased water conservation efforts.
10 Expresses as a percentage, the reduction rates are equivalent to 12% and 17% residential demand reduction.
11 Expresses as a percentage, the reduction rates are equivalent to 16% and 17% residential demand reduction.

4.4.3 RECOMMENDATIONS REGARDING WATER CONSERVATION INITIATIVES

The water conservation analysis presented in Table 4-20 indicates that there are average day water savings to be made by means of implementing further water conservation efforts. That said, the discussion in Section 4.3 indicates that a considerably higher volume of the water produced is unaccounted for, meaning that there is a considerable amount of water to be gained by reducing the amount of leakage in the systems. The amount of water to be gained by rectifying water leakage in the systems is noticeably higher than the gains that can be made through implementing additional water conservation practices (6,768 m^3/d compared to 3,843 m^3/d). Therefore, for the purpose of this Master Plan, no additional water conservation measures are being recommended to reduce per capita consumption as it the immediate focus (over the next 5 years) is being placed on reducing water leakage. The implementation of additional water conservation programs should be revisited in the next iteration of the Master Plan once further work has been undertaken to identify the underlying causes of leakage in the system.

The City understands that lower water consumption values may be achieved based on a review of other jurisdictions. The York Region Long Term Water Conservation Strategy states that in North America it is generally accepted that 150 L/cap/d is an achievable **indoor** water consumption rate for new houses equipped with water efficient fixtures and appliances. Please note the values in Table 4-20 include both indoor and outdoor water usage.

The City also recognizes that other municipalities are making great gains in terms of water conservation. For instance, the Town of East Gwillimbury, a municipality within York Region, requires new development to limit per capita consumption of potable water to 150 L/cap/d for residential units and as low as 25 L per person per day for commercial water consumption. The 150 L/cap/d has been verified through flow monitoring to be achievable; however, it is imperative to note that this is for new development and therefore necessitates the use of low water fixtures. That said, it is not that the City of Sudbury cannot work towards achieving lower water consumption rates, but rather that it would take longer to achieve those rates. It is still recommended that the City continue its current water conservation programs; however, it has been noted that concentrating on water leakage in the short term can yield higher water savings. A review of best practices for water conservation measures and a benchmarking of achievable reduced water demand rates (based on analyzing the gains made in other municipal water systems) should be undertaken in the next iteration of the City's Master Plan.

4.5 FROZEN WATERMAINS

As part of CGS Master Plan, a review was conducted of the frozen watermains and service connections in the City’s water supply systems. The following section serves as a summary of the existing frozen pipe issues in the City’s water supply system, and a discussion of the available preventive measures that could be undertaken by the City and the residents to reduce the risk of frozen water pipes. It should be noted the analysis performed is based on 2014 data provided by the CGS.

4.5.1 BACKGROUND

Every winter, severe and uninterrupted cold can freeze the City’s infrastructure as well as residents’ private connections. When the frost penetrates the ground during long periods of extremely cold temperatures, water starts to freeze in pipes, preventing it from reaching the homes of residents. This applies to both watermains and service lines. Based on the data presented on the CGS website, there were a total of 370 frozen pipe incidents in 2014, affecting both residences and businesses, whereas in 2015 this number increased to 635. The increase in the number of recorded frozen pipes between 2014 and 2015 has been attributed to the fact that the 2015 winter season was one of the coldest winters recorded since 1994-1995. The following are some of the factors that increase the chance of frozen pipes in the environment:

- Snow cover on the ground
- Sudden low temperatures
- Saturated ground conditions

Some of the watermains and service lines in the CGS are located at shallow depths due to geological conditions. During the winter season, the frost depth can be as deep as 2 to 2.5 meters below the grade, where the water pipes are located. Usually, it takes several months for the frost depth to reach these depths, and often occurs in late February or early March.

FROZEN SERVICE CONNECTIONS IN THE CGS

The following figures outline the locations of the reported frozen pipes for all the areas in CGS during the winter of 2014.

Figure 4-3 Dowling Water System Frozen Water Services

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Figure 4-4 Falconbridge Water System Frozen Water Services

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Figure 4-5 Onaping-Levack Water System Frozen Water Services

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Figure 4-6 Sudbury Water System Frozen Water Services

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Figure 4-7 Valley Water System Frozen Water Services

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Figure 4-8 Vermilion Water System Frozen Water Services

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4.5.2 WATER PIPE RESPONSIBILITIES

Figure 4-9 shows the ownership boundary for water pipes in CGS. The watermain, owned by the City, is the primary water pipe that delivers potable water from the water treatment plant to the users. The water service line runs underground and connects the home/business to the City's watermain. Therefore, every property that receives water from the City has a water service connection. Home owners and businesses own the water pipe from the property to the shut-off valve (usually at the property line). Any leaks or frozen pipe on private property is the responsibility of the owner. The City is responsible for the service line between the property line and the municipal watermain.

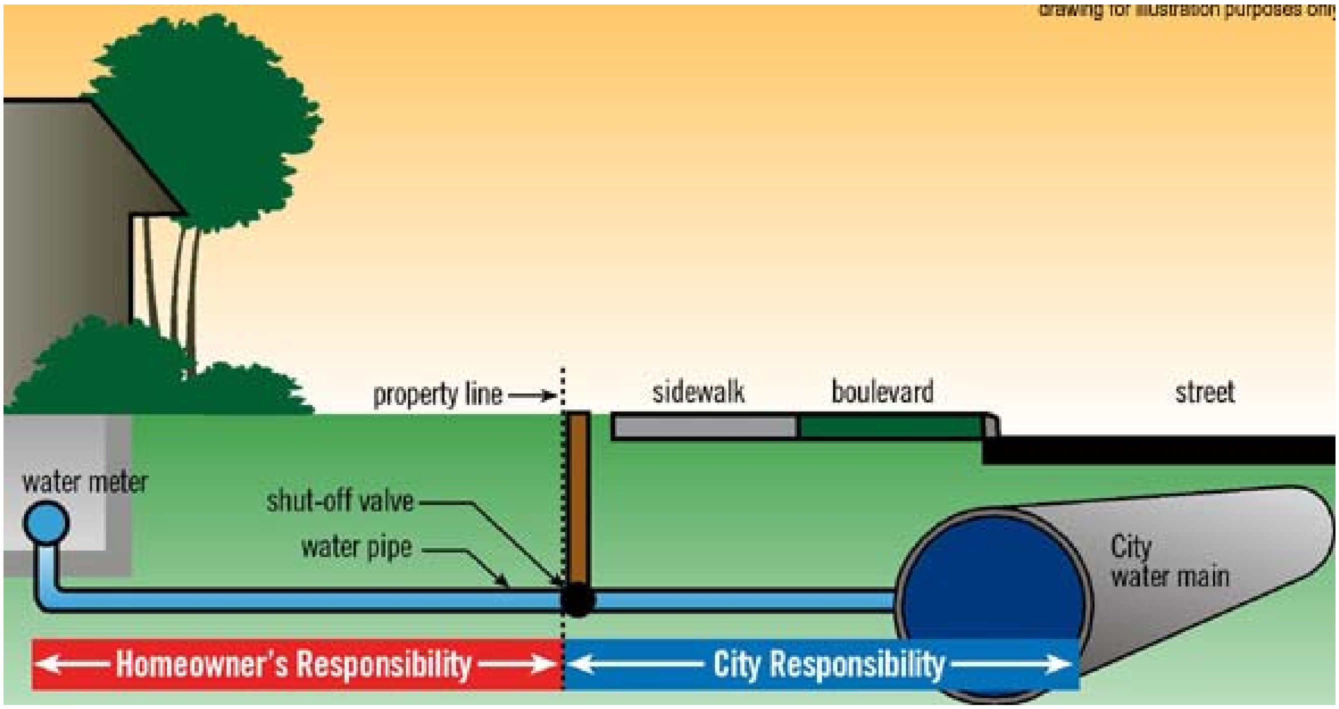

Figure 4-9 Ownership Boundary for Water Pipes

4.5.3 THE CGS'S CURRENT APPROACH REGARDING MITIGATION AND REHABILITATION OF FROZEN WATERMAINS

The City has provided general guidelines to its customers to reduce the risk of frozen water pipe, such as:

— Running a cold water tap at a steady stream of six millimeters to allow continuous water flow inside the pipe
— Leaving cupboards door of the kitchen and bathroom sink open in case the water pipes are near the exterior walls
— Shutting off the valves on the pipes that lead to an outdoor faucet and drain the pipe
— Insulating the pipes susceptible to freezing
— Ensuring the temperature of the house does not go below 13°C at night or during vacancy

If the City receives a call regarding a frozen water pipe, the affected residence or businesses will be inspected by a water/wastewater service operator to determine the location of the frozen portion of the pipe. If the frozen pipe is somewhere inside the private property line, it is the responsibility of the owner to repair the pipe. The owner is advised to thaw the service line either themselves or with the help of a licensed plumber. Conversely, if the frozen portion is located on the municipal property, the City will thaw the affected area at no charge and will advise the owner to run their tap water at a steady stream to prevent refreezing. The water bills for the properties that have officially received a letter from the City with specific instruction to run their tap water will be adjusted based on daily average consumption during the same period in the previous year. Otherwise, the property owner is responsible for the full cost of extra water consumption due to running their tap water.

4.5.4 MEASURES FOR DEALING WITH FROZEN WATER PIPES IN OTHER MUNICIPALITIES

Table 4-21 summarizes the long term measures some of the municipalities have undertaken to manage frozen pipe issues:

Table 4-21 Long Term Solutions for Frozen Pipes in Other Municipalities

MUNICIPALITY	LONG TERM SOLUTION
Halton Region	The water service lines with a history of freezing on the municipal side or unclear location of freezing is to be insulated or buried deeper by 2018. Advising the home owners to insulate or lower their private water service line at their own expense.
City of Timmins	The first call to the City for a frozen line on the municipality side is free of charge and the owner will be advised to run their tap water for one quarter of an inch. However, if a second call was made to the City for a house that has already been reported, the Owner will be charged a) the cost to thaw a frozen waterline, at $675, which includes the basic cost of $588 plus a 15% administrative fee, and b) the cost to bring in an excavation backhoe to dig down and steam heat the frozen line, at roughly $4,500)
City of Winnipeg	After the City's Winter 2013-2014 frozen pipe crisis (a total of 2192 repairs – City's responsibility), the City of Winnipeg started to increase their number of staff, obtained newer machinery and technologies and improved their planning to allow faster response times. In Winter 2015, the number of frozen pipe repairs dropped to 233 and the City no longer asks affected property owners to keep a trickle of water flowing from one tap. It would cost approximately $150 million to bury all service lines that have a history or risk of their water pipes freezing. City's crews have buried pipes at deeper depths at 33 different locations in 2015. Moreover, public works staff have started adding extra insulation on some roads that are particularly low and insulating at-risk sites when work is being undertaken on watermains.
City of Guelph	As of November 2015, the City of Guelph has started to implement their Freeze Prevention Program which is triggered by the cumulative mean daily temperature (-400 C following the first confirmed fall frost event) – All customers, particularly the ones with a history of water supply interruption due to frozen pipe will be informed to run their tap water as instructed by Water Services. They also have temporary water service, access and special assistance program.

4.5.5 RECOMMENDATIONS FOR DEALING WITH FROZEN WATER PIPES IN THE CGS

Since it isn't feasible to prevent watermain freezing without a large infrastructure investment, it is recommended that the CGS inform its previous affected customers to ensure they run their tap water through winter season. It is also recommended the CGS allow for provisions to place the service connections deeper (or insulate them) during any required ongoing replacement / maintenance work, if possible.

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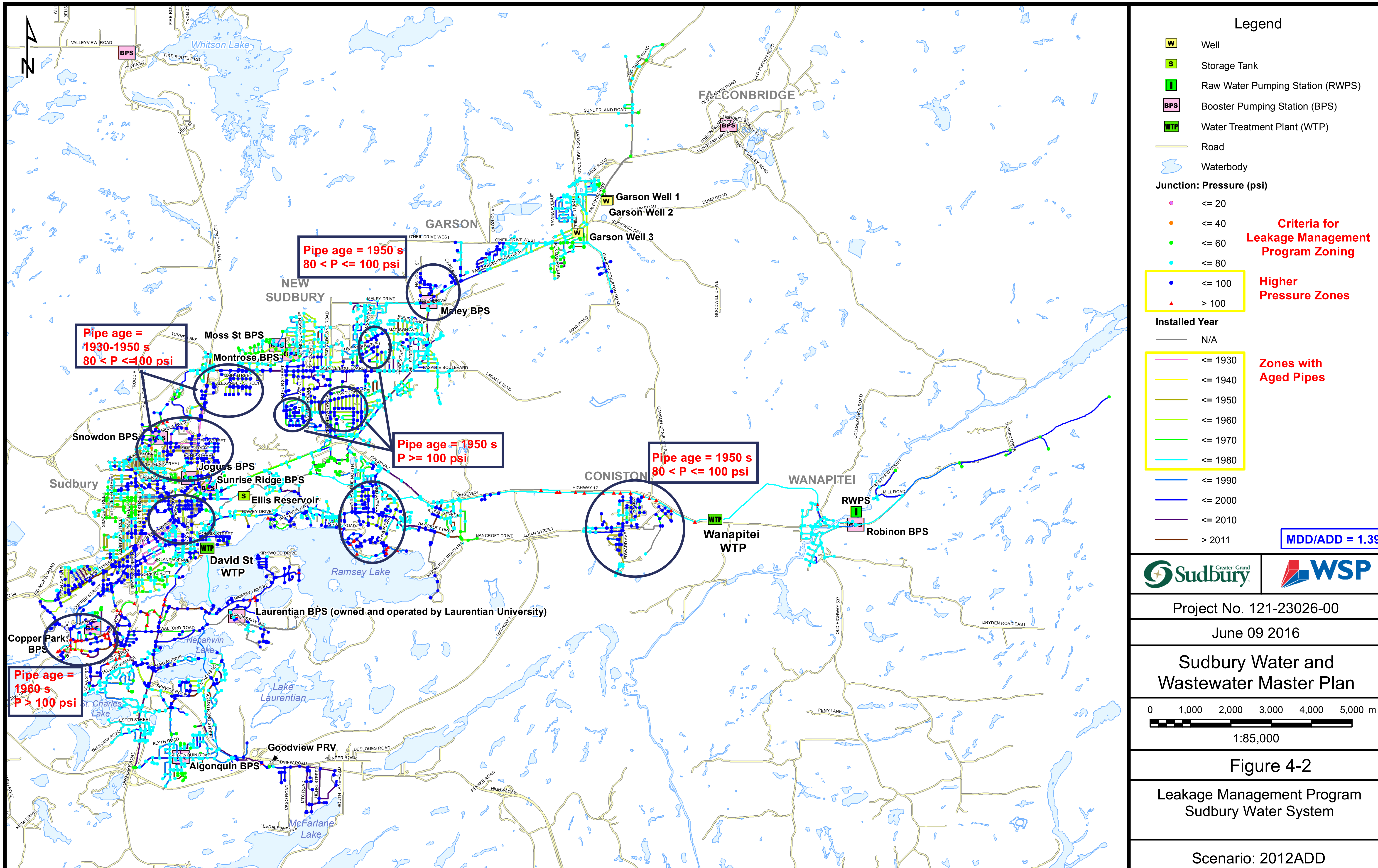
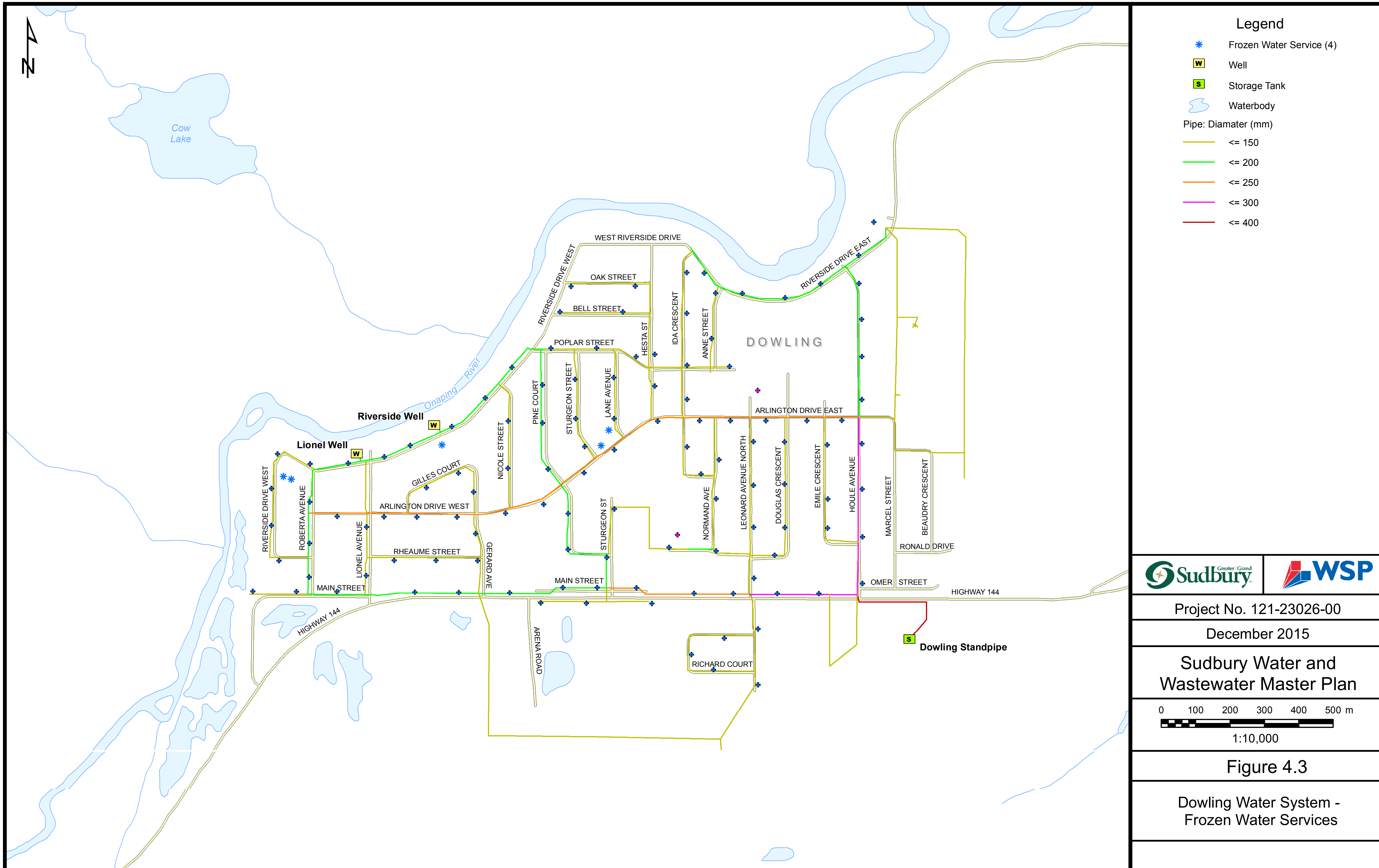

Legend
Well
Storage Tank
Raw Water Pumping Station (RWPS)
Booster Pumping Station (BPS)
Water Treatment Plant (WTP)
Road
Waterbody
Junction: Pressure (psi)
<= 20
<= 40
<= 60
<= 80
<= 100
> 100
Criteria for Leakage Management Program Zoning
Higher Pressure Zones
Installed Year
N/A
<= 1930
<= 1940
<= 1950
<= 1960
<= 1970
<= 1980
<= 1990
<= 2000
<= 2010
> 2011
Zones with Aged Pipes
MDD/ADD = 1.39
Greater Grand Sudbury
WSP
Project No. 121-23026-00
June 09 2016
Sudbury Water and Wastewater Master Plan
0 1,000 2,000 3,000 4,000 5,000 m
1:85,000
Figure 4-2
Leakage Management Program
Sudbury Water System
Scenario: 2012ADD
Pipe age = 1950 s
80 < P <= 100 psi
Pipe age = 1930-1950 s
80 < P <=100 psi
Pipe age = 1950 s
P >= 100 psi
Pipe age = 1950 s
80 < P <= 100 psi
Pipe age = 1960 s
P > 100 psi
FALCONBRIDGE
GARSON
NEW SUDBURY
CONISTON
WANAPITEI
Sudbury
Garson Well 1
Garson Well 2
Garson Well 3
Maley BPS
Moss St BPS
Montrose BPS
Snowdon BPS
Jogues BPS
Sunrise Ridge BPS
Ellis Reservoir
David St WTP
Laurentian BPS (owned and operated by Laurentian University)
Copper Park BPS
Goodview PRV
Algonquin BPS
Wanapitei WTP
RWPS
Robinon BPS
Whitson Lake
Ramsey Lake
Nepahwin Lake
Lake Laurentian
St. Charles Lake
McFarlane Lake



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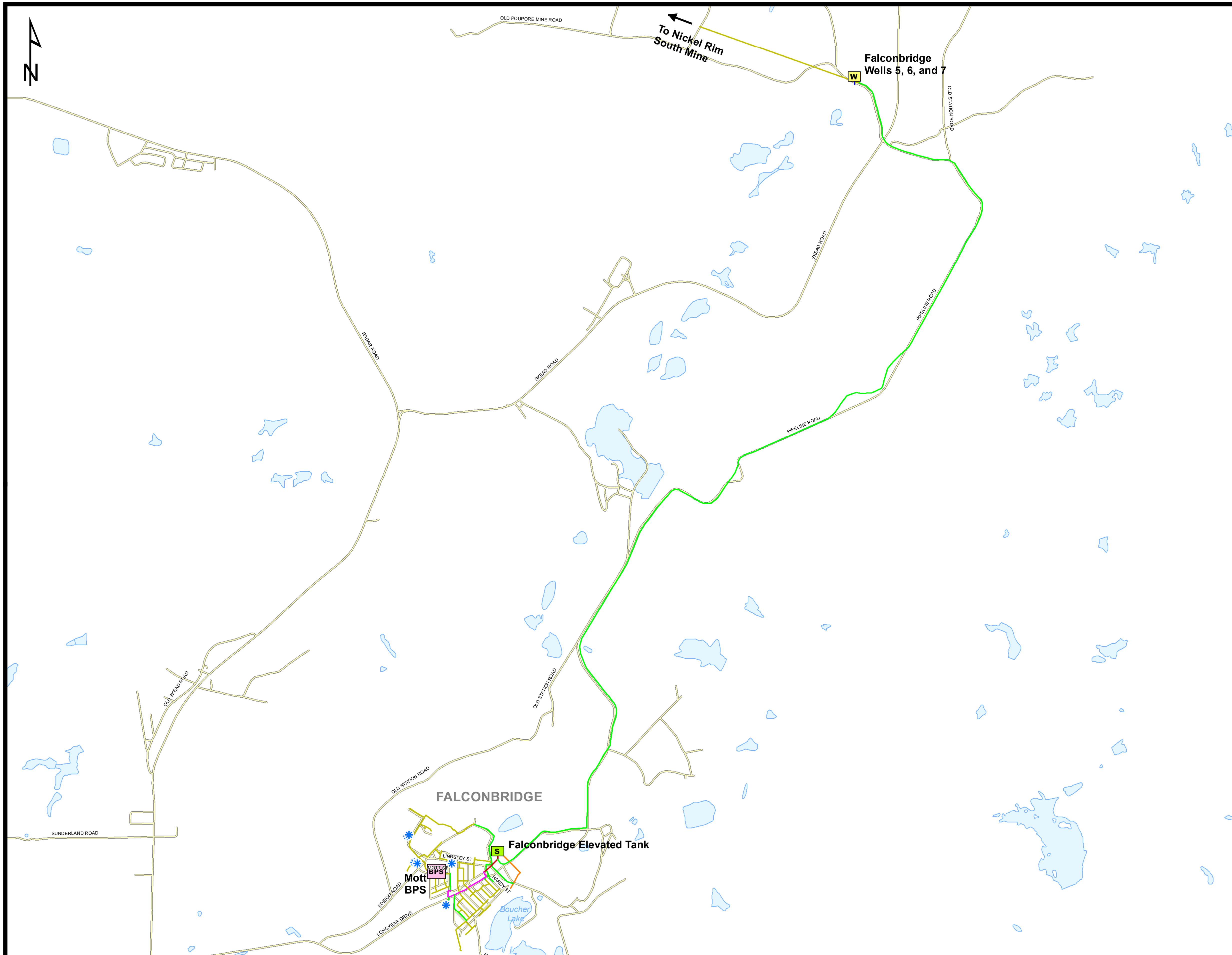
Sudbury Water and Wastewater Master Plan

Figure 4.3

Dowling Water System - Frozen Water Services



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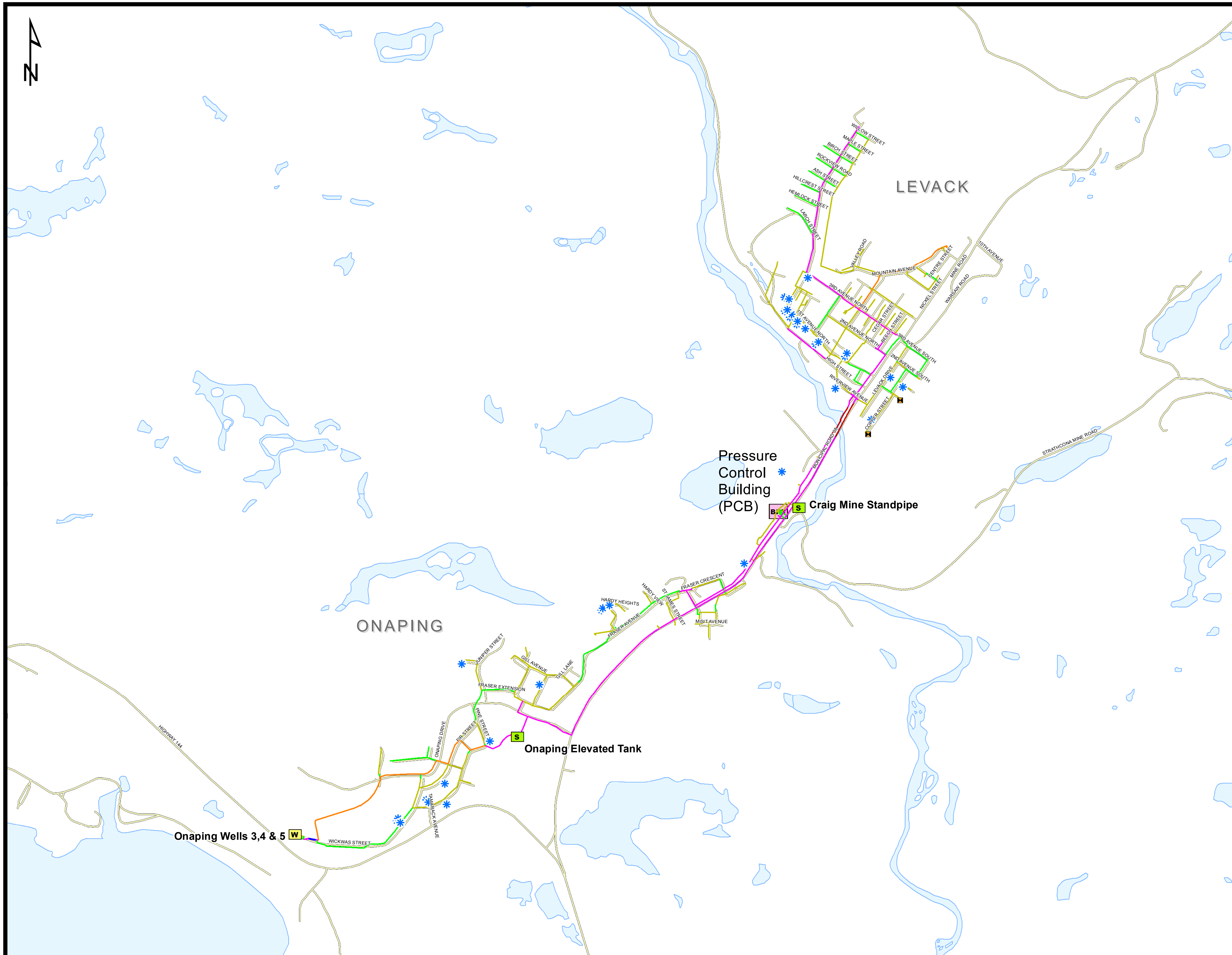
0 0.5 1 1.5 2 km

1:32,000

Figure 4.4

Falconbridge Water System - Frozen Water Services



Legend

- Frozen Water Service (22)
- Well
- Storage Tank
- Booster Pumping Station (BPS)
- Water Treatment Plant (WTP)
- Road
- Waterbody

Pipe: Diamater (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 400
- <= 600
- > 600

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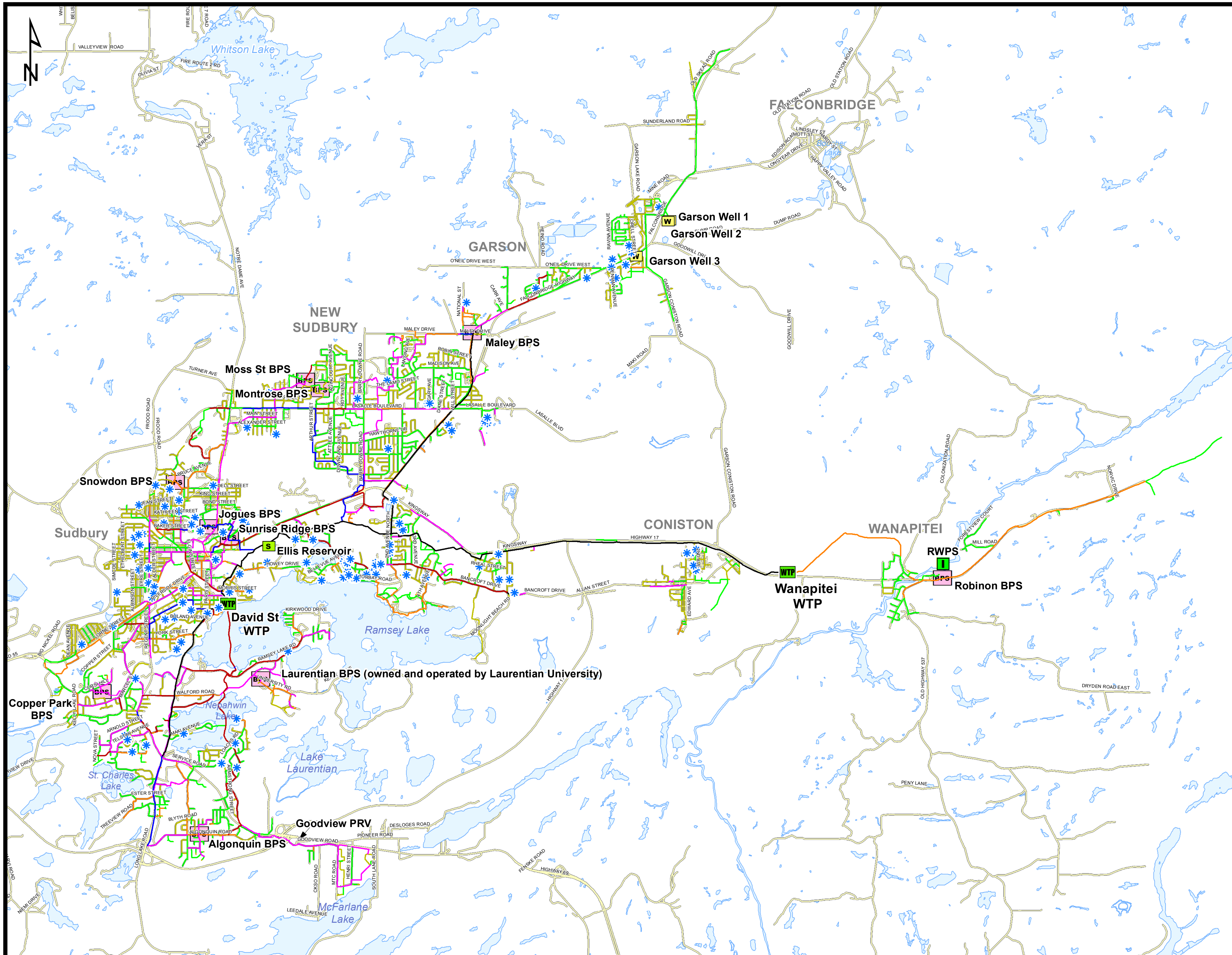
0 200 400 600 800 1,000 m

1:20,000

Figure 4.5

Onaping & Levack Water System - Frozen Water Services



Legend

- Frozen Water Service (125)
- W Well
- S Storage Tank
- I Raw Water Pumping Station (RWPS)
- BPS Booster Pumping Station (BPS)
- WTP Water Treatment Plant (WTP)
- Road
- Waterbody

Pipe: Diamater (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 400
- <= 600
- > 600

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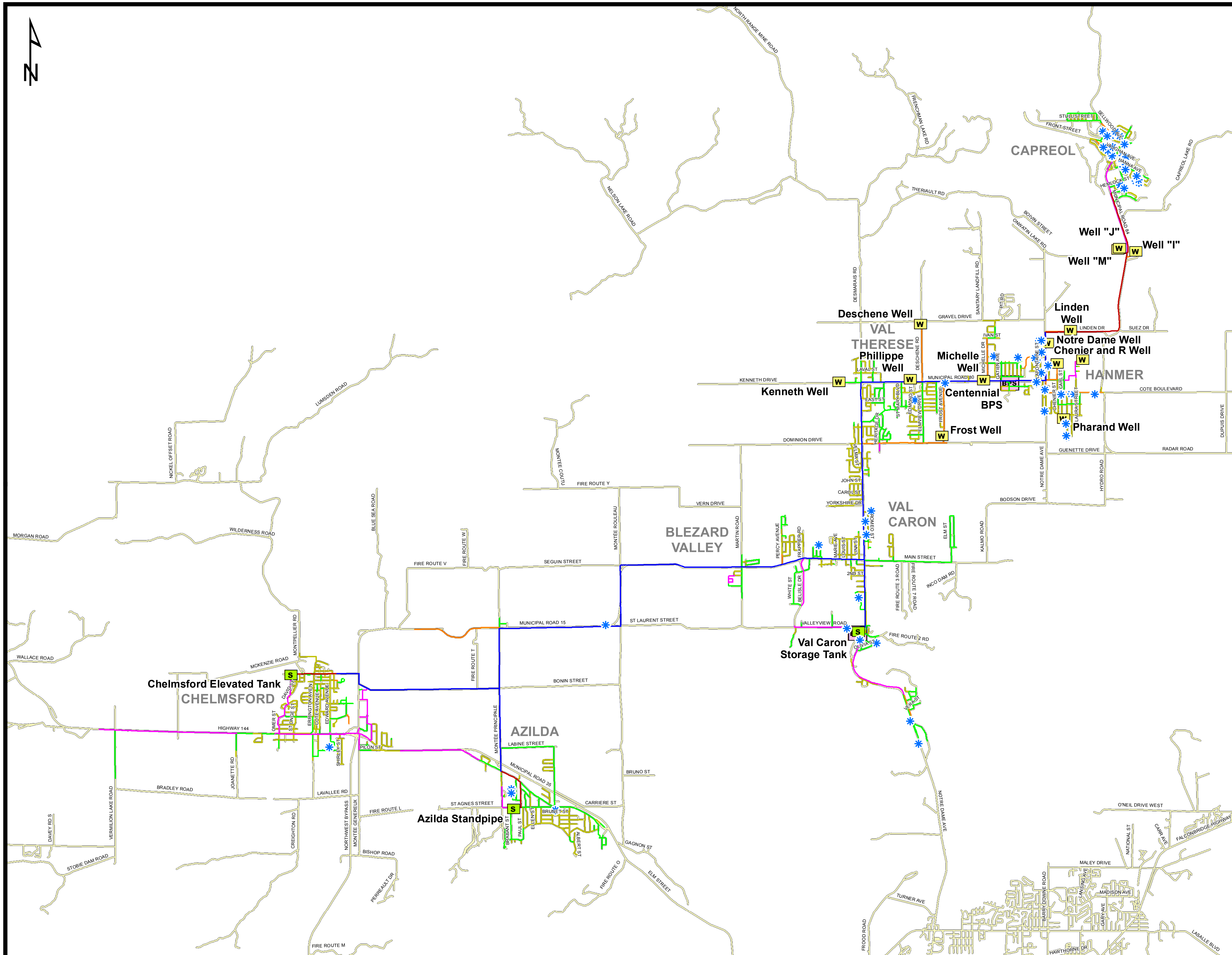
Sudbury Water and Wastewater Master Plan

0 1,000 2,000 3,000 4,000 5,000 m

1:85,000

Figure 4.6

Sudbury Water System - Frozen Water Services



Legend

- Frozen Water Service (68)
- W Well
- S Storage Tank
- BPS Booster Pumping Station
- Road

Pipe: Diamater (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 400
- <= 600
- > 600

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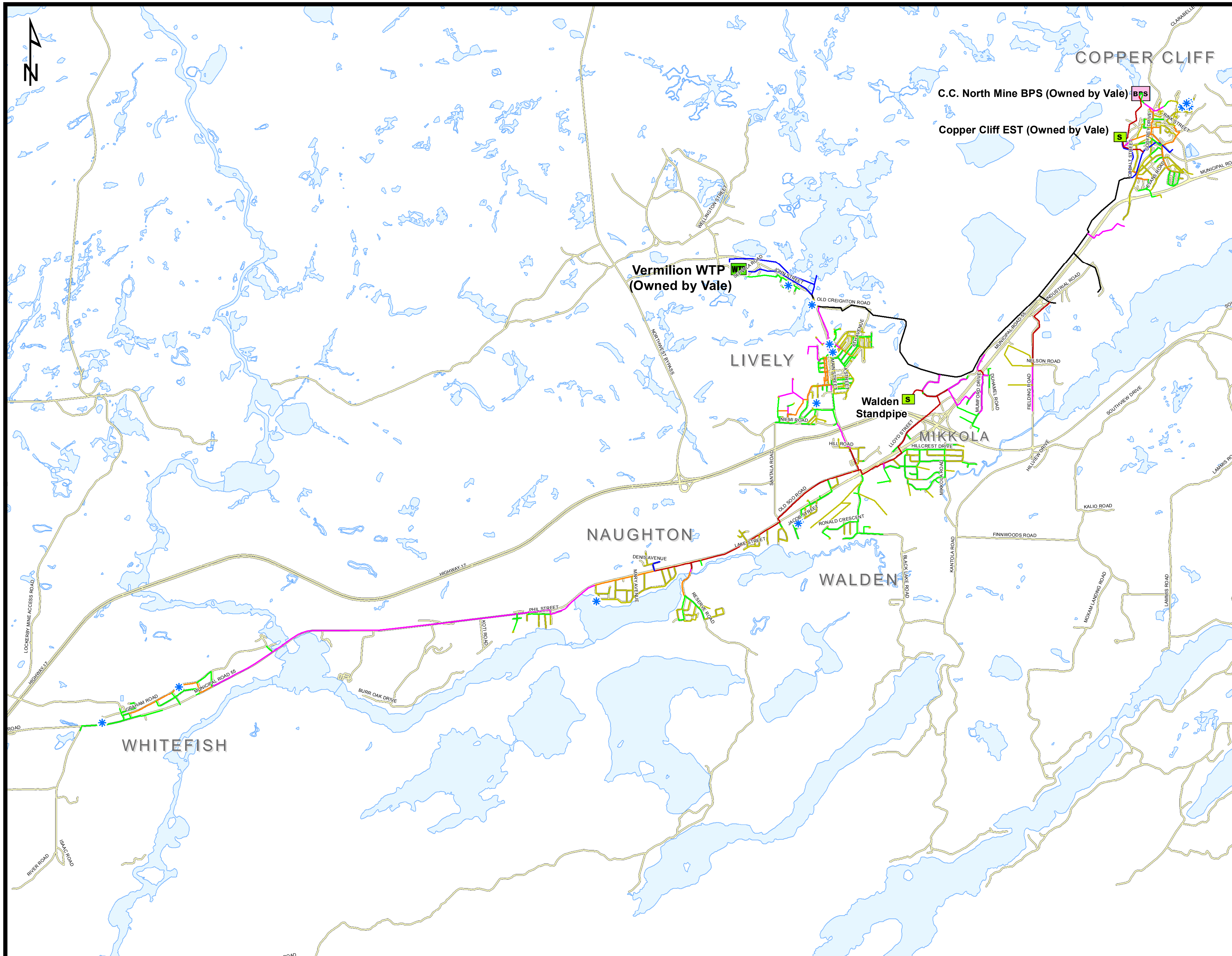
0 1 2 3 4 5 km

1:100,000

Figure 4.7

Valley Water System - Frozen Water Services



Legend

- Frozen Water Service (15)
- Well
- Storage Tank
- Booster Pumping Station (BPS)
- Water Treatment Plant (WTP)
- Road
- Waterbody

Pipe: Diamater (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 400
- <= 600
- > 600

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0 1,000 2,000 3,000 4,000 m

1:70,000

Figure 4.8

Vermilion Water System - Frozen Water Services