5.4 Stormwater Systems

5.4.1 System Overview

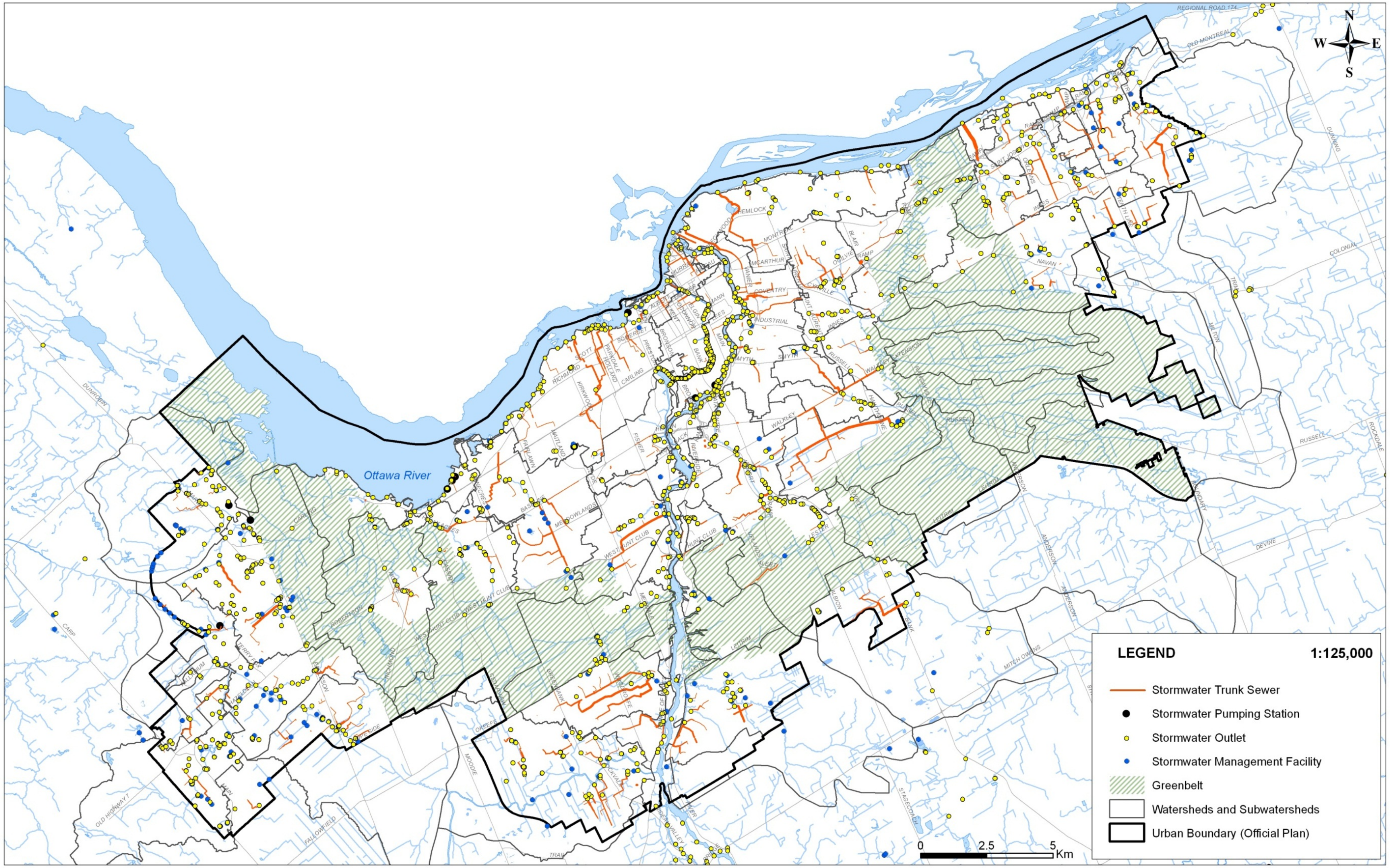
Unlike the central water and wastewater systems, the City owns and operates a multitude of decentralized SWM and drainage systems comprised of collection systems, outlet structures, storage and treatment facilities, and a limited number of small stormwater PSs. Finally, the stormwater systems also include the local receiving watercourses into which all runoff is eventually discharged. *Figure 5.9* provides an overview of existing stormwater systems within the urban area (locations of larger trunk sewers, SWM facilities, stormwater PSs, storm outfalls and receivers).

5.4.1.1 Collection Systems

The collection systems capture and convey stormwater runoff. These systems include over 2,600 km of storm sewers and more than 2,500 km of ditches (within the urban and rural areas), as well as approximately 100,500 catchbasins and 51,000 storm sewer maintenance holes.

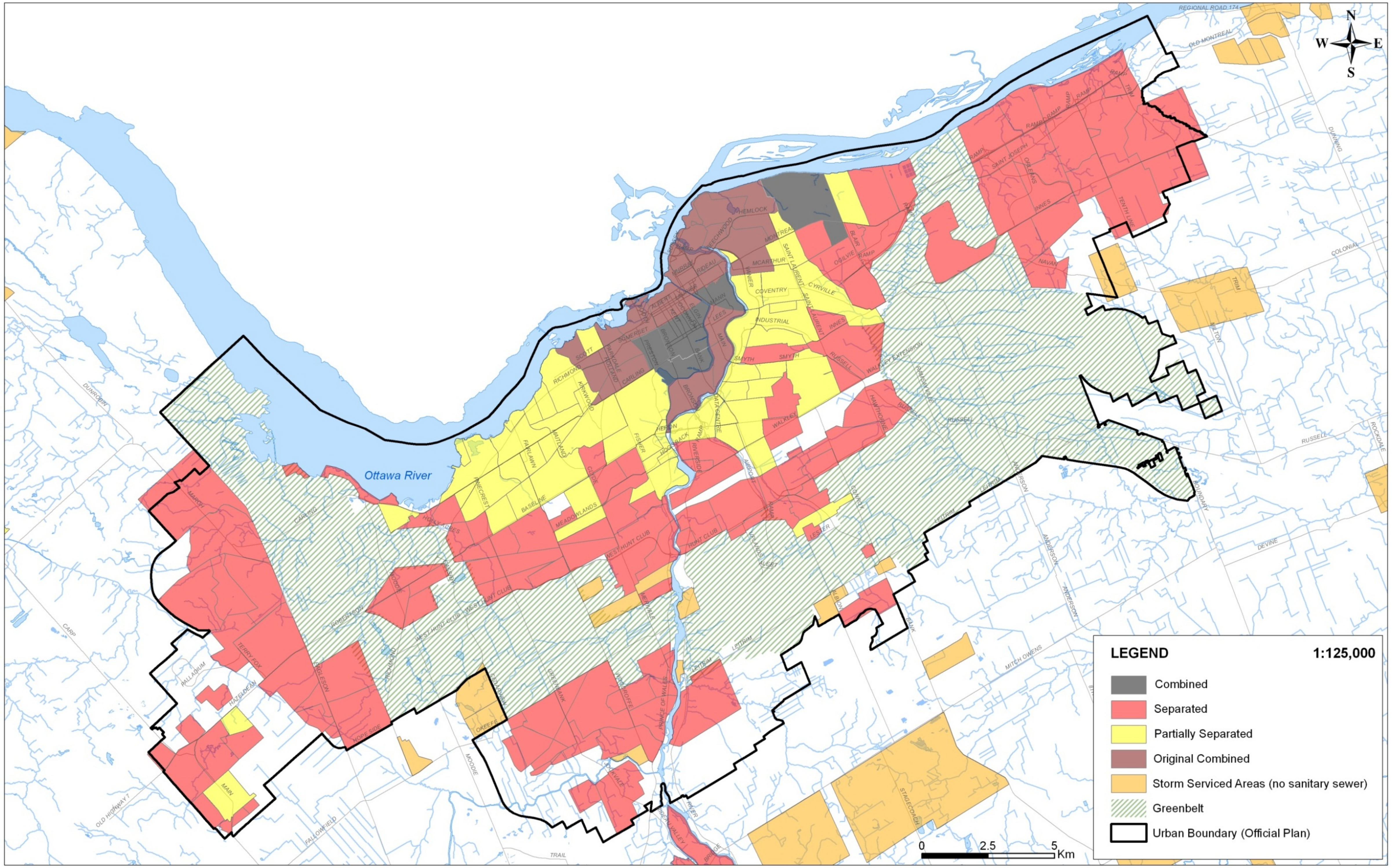
Collection systems conveying stormwater are classified as combined, partially separated, or fully separated. The combined system is concentrated in the core of the city and consists of a single sewer system that conveys both stormwater and sanitary flow. Partially separated sewer systems consist of a shallow storm sewer that conveys stormwater, and a deeper sewer that conveys sanitary flows and foundation drainage. Partially separated sewer systems are generally found in older neighbourhoods located inside the Greenbelt. Fully separated sewers have been a requirement for new development since 1961. Separated systems also have two sewers, but the storm sewers are deep enough to allow the foundation drains to be connected providing complete separation of storm and sanitary flow. The extent of the different types of collection systems is provided on *Figure 5.10*.

The LOS for the collection systems also varies across the city, depending primarily on age. In general, for those areas built before the 1980s without dual drainage designed for a 1 in 100 year return period, i.e. 1% chance of being exceeded in any one year., the LOS is typically a minor system with a two or five year return period capacity and no designed major system. In the case of combined sewers, the capacity may be less than the one in two year return period, i.e. 50% chance of being exceeded in any one year, and protection from flooding is provided by inlet control restrictions, deep storage, and CSOs.



Source: City of Ottawa GIS infrastructure database

Figure 5.9: Existing Stormwater Management and Drainage Systems



Source: City of Ottawa GIS infrastructure database

Figure 5.10: Storm Collection System Type

5.4.1.2 Stormwater Management Facilities

The City owns and operates a total of 254 SWM facilities that provide one or a number of functions to mitigate the impacts of increased imperviousness on receiving watercourses, including water quality treatment, flood control, runoff volume reduction and erosion control. These facilities include:

- 108 wet ponds
- 73 dry ponds
- 18 infiltration facilities
- 55 interceptors (oil/grit separators).

SWM facility locations across the city are provided on *Figure 5.9*. *Figure 5.14* identifies the extent of the urban area that currently has (or will have when development proceeds) water quality treatment.

5.4.1.3 Pumping Stations

The City operates a total of 10 stormwater PSs that aid in the drainage of local collection systems when the Ottawa and Rideau Rivers are at flood stage, pump out low areas such as railway underpasses, or pump from one collection system to another. Two of these PSs, Brewer Park and Windsor Park, are owned by the Rideau Valley Conservation Authority (RVCA) but operated by the City under agreement with the RVCA. All PS locations are shown on *Figure 5.9*.

5.4.1.4 River and Stream Corridors

River and stream corridors form an essential part of the City's drainage systems, eventually receiving and conveying all runoff. Various types of infrastructure are also located within river and stream corridors such as utility crossings, pathways, bridges, sewers, storm outfalls and retaining walls. The stability of river and stream corridors has a direct bearing on the continued operation of the City's drainage systems as well as the condition of infrastructure located within those corridors. *Figure 5.9* provides the locations of river and stream corridors within the urban area.

The impacts of development on stream stability are well known. The increased imperviousness that comes with urbanization results in higher volumes of runoff and more frequent and higher peak flows to receiving streams, leading to increased erosion as the stream adjusts to the change in hydrologic regime over time.

While more recently developed areas of the city, typically outside the Greenbelt, have SWM controls that mitigate some of these impacts, older areas of the city developed without such controls. The repercussions of this legacy is becoming apparent as the streams adjust, in some cases affecting slope stability and threatening property and infrastructure. Site-specific remedial measures have been undertaken in the past to address imminent threats but experience has shown that isolated, reactive approaches often provide only temporary solutions as the underlying problems are shifted elsewhere, creating further problems upstream or downstream.

The importance of stream corridors to the City's drainage systems requires a more formal asset management approach, similar to that applied to built infrastructure. While the management of natural systems is necessarily more complex and must address ecological functions, the objective is similar: to determine the optimum combination of monitoring, maintenance and rehabilitation investment over the long term.

As with other municipal infrastructure, a sufficient level of spending to maintain stream corridor assets over the long term is required. Determining what that level of spending should be will require an improved understanding of the asset including:

- an inventory and assessment of infrastructure located within stream corridors such as storm outfalls, erosion and flood control protection works, various types of crossings and pipe and utility under-crossings;
- an assessment and prioritization of current and future anticipated threats and the required remedial measures to address those threats; and
- a program of on-going monitoring to better understand how urban streams are adjusting.

Through the development of SWM retrofit plans on a subwatershed basis, the City is now completing the initial steps of applying an asset management approach to the City's urban stream corridors (refer to *Section 5.4.3.2* for further details).

5.4.1.5 **Municipal Drains**

There are approximately 1200 km of municipal drains within the city, representing about 25% of the total length of watercourses in the municipality. Municipal drains have been constructed to provide both a legal and sufficient outlet for agricultural drainage systems and rural roads and subdivisions.

Municipal drains are created under the authority of the provincial *Drainage Act*, a legislative tool for landowners to resolve drainage problems. A *Drainage Act* project is initiated by landowners but is administered by the local municipality. The Act provides for the adoption of a formal process through which engineered drainage systems are planned, designed, financed, constructed, and maintained or improved through the financial contribution of the benefiting landowners. The process culminates in the adoption of an Engineer's Report that forms the basis of a municipal by-law. Upon adoption of the by-law, the municipal drain is constructed and becomes part of the municipality's infrastructure. While most municipal drains within the City of Ottawa were created as artificial drainage systems, some were natural watercourses that have been modified through the *Drainage Act*. Other types of open drains include private drains, mutual agreement drains and award drains, all of which have different legal status from that of municipal drains.

Municipal drains are an important part of rural, and sometimes, urban drainage infrastructure and often provide fish habitat. Just as land use change impacts the function of natural watercourses, it can also impact the function of municipal drains. Therefore, in addition to meeting specific requirements of the *Drainage Act*, new (non-agricultural) development adjacent to municipal drains is also required to incorporate stormwater management measures that mitigate such impacts on the receiving drain.

Municipal drains are subject to periodic maintenance so ready access for maintenance purposes is important. But beyond their primary role of drainage, municipal drains can also have a significant impact on overall watershed health, so it is important to strive to balance the drainage and ecological functions of municipal drains. With new development, this can be achieved through requiring appropriate development setbacks as defined in the OP and maintaining or improving a riparian buffer that continues to allow for sufficient maintenance access.

5.4.1.6 **Monitoring**

The City undertakes various types of monitoring to inform SWM and drainage system design and to track watercourse health. The data collected is also valuable to others, including local Conservation Authorities (CAs) who use it for subwatershed reporting and to assist with stewardship targeting.

<u>Rainfall:</u> The City operates a permanent network of 21 active tipping bucket rain gauges from March to November that provides detailed and continuous accounts of rainfall events. A total of 24 rain gauges will be active by the end of 2014. This data

complements the available rainfall data from local Environment Canada stations and provides useful information about significant storm events. The City also makes use of available rainfall radar data to estimate rainfall depths in the areas between the existing network of rain gauges.

Water quality: The City has a comprehensive surface water monitoring program comprised of over 130 monitoring sites located across six rivers, four lakes and 40 creeks. Water quality samples are collected on a monthly basis, conditions permitting, and analyzed for 43 parameters including *E.coli*, nutrients, and standard metals. These water quality data provide reference information used to support various planning and design purposes and are used to track water quality changes over time

Streamflow: The City's streamflow monitoring program provides continuous flow data that supports a variety of purposes and programs including subwatershed planning, SWM and drainage design, and the Baseline Water Quality Monitoring Program.

Stream and Fisheries Assessments: Biological assessments are carried out at more than 35 locations annually. The biological monitoring consists of channel morphology and fish community assessments that are carried out in accordance the Ministry of Natural Resources (MNR) Ontario Stream Assessment Protocol and benthic macroinvertebrate community sampling carried out in accordance with the Ontario Benthos Biomonitoring Network Protocol.

5.4.2 Stormwater Management Master Plan Development Approach

With respect to growth in greenfields, SWM and drainage infrastructure is designed and implemented on an area-specific basis, typically through separate developer-driven studies completed as part of the development review and approval process for servicing requirements. As a consequence, instead of growth related projects, the SWM Master Plan focuses on the identification of gaps and emerging issues that affect how the City manages stormwater. This includes:

- A capacity review of large, existing SWM facilities
- Moving forward with low impact development (LID) approaches
- SWM retrofit
- Development of a stormwater collection systems Master Plan as a subset of the Wet Weather IMP

- Best Practices review of adaptive approaches to climate change for SWM and drainage.

5.4.2.1 Greenfield Growth and Urban Expansion Areas

SWM and drainage infrastructure required to service growth in greenfield areas is planned and implemented through Master Servicing Plans, plans of subdivision and funded through Development Charges if included in the Development Charges by-law or directly by the development proponents if not included in the Development Charges by-law.

Based upon the recommendations within servicing studies completed to date, the need for a total of 31 new SWM facilities has been identified. These new facilities are listed in *Table 5.10* and identified on *Figure 5.11*. This does not include the new SWM facilities that will be required for expansion areas (studies pending) nor the potential for new SWM retrofit facilities to be identified through the completion of future SWM retrofit studies. Updated cost estimates for SWM growth projects are currently under review and will be provided as part of the 2014 update to the Development Charge By-law.

Table 5.10: Future Planned Stormwater Management Ponds

Development	Facility Name	Treatment (Water Quality/Quantity)	Drainage Area [ha]
Avalon	Neighbourhood 5	Quality and Quantity	194
Barrhaven South	Clarke Pond	Quality	87
	Cedarview Pond	Quality	42
	Greenbank Pond	Quality	39
EUC	Pond 2	Quality and Quantity	134
Fernbank	Pond 1	Quality and Quantity	82
	Pond 2	Quality and Quantity	24
	Pond 3	Quality and Quantity	94
	Pond 4	Quality and Quantity	62
	Pond 5	Quality and Quantity	146
	Pond 7	Quality and Quantity	46
	Pond 8	Quality and Quantity	67
SUC Nepean	Foster Drain Pond	Quality	373
	Kennedy Burnett Pond	Quality	305
Kanata West	Pond 1	Quality	77
	Pond 2	Quality	24
	Pond 3	Quality	29
	Pond 4	Quality	239
	Pond 5	Quality	93
	Pond 6	Quality	89
	Pond 7	Quality	34
Leitrim	Pond 2	Quality and Quantity	140
O'Keefe	Pond 1	Quality and Quantity	68

Development	Facility Name	Treatment (Water Quality/Quantity)	Drainage Area [ha]
	Pond 2	Quality and Quantity	35
	Pond 3	Quality and Quantity	36
Richmond Village	Pond 1	Quality and Quantity	67
Riverside South	Pond 2	Quality and Quantity	44
	Pond 3	Quality and Quantity	345
	Pond 4	Quality and Quantity	191
	Pond 5	Quality	398
	Pond 6	Quality and Quantity	64

Source: City of Ottawa, Planning and Growth Management, Infrastructure Policy Unit: Stormwater Management Pond Review, 2013.

- Urban expansion areas without supporting studies not accounted for.
- Future retrofit ponds not included.
- Updated cost estimates for SWM growth projects to be provided in the 2014 update to the Development Charge By-law

5.4.2.2 Capacity Review of Large Existing Stormwater Management Ponds

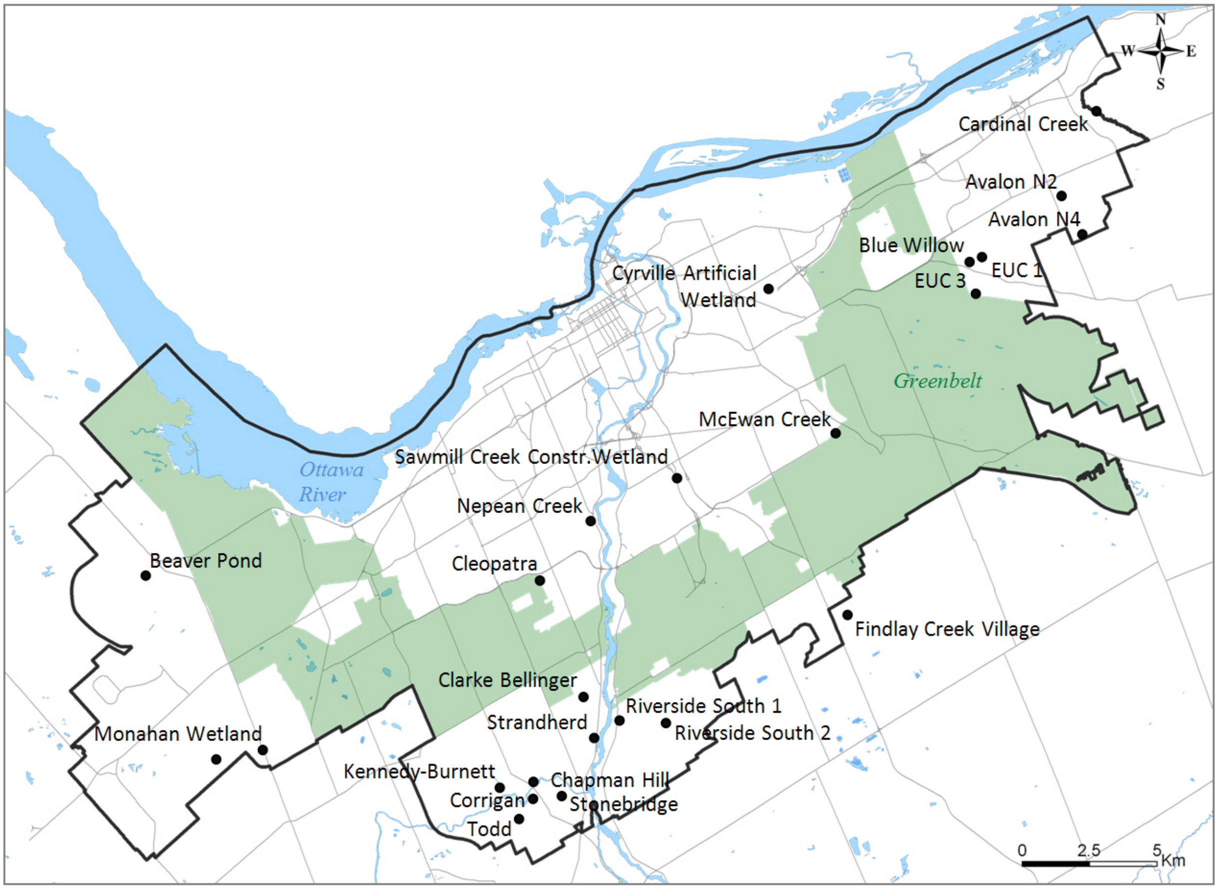
Development within greenfield areas may be constrained by the capacity of existing SWM facilities from both a water quality and water quantity control perspective. The City has completed a screening level assessment of the capacity of the larger facilities with catchment areas that are not fully built out. The purpose of the assessment was to determine whether there is potential for the original design capacity of these existing SWM facilities to be exceeded as the catchment areas build out.

A screening criterion of 100 ha (catchment area) was chosen to select only the larger ponds on the assumption that smaller catchment areas would build out relatively quickly. For the selected ponds, a review of the drainage area was performed according to the latest Master Servicing Study or Detailed Design Report. The amount of remaining build-out for each pond was then assessed. This exercise confirmed that for ponds inside the Greenbelt the remaining build-out is minor. For a number of the selected ponds outside the Greenbelt, the remaining build-out is significant. For these ponds, further review was completed based upon the following factors:

- the type of control provided by the facility (water quality/quantity treatment);
- the imperviousness assigned for the design of the facility;
- the actual imperviousness of the constructed areas; and
- total design rainfall volume used for the design of the facility.

According to the latest inventory (March 2013), the City maintains and operates over 130 SWM ponds within the urban boundary. As shown in *Figure 5.12* the majority of these ponds have a drainage area less than 100 ha. The smaller ponds providing only major system storage were screened out for the analysis.

For the purposes of this analysis, five and 19 ponds were reviewed, respectively, for areas inside and outside the Greenbelt (refer to *Figure 5.13*).

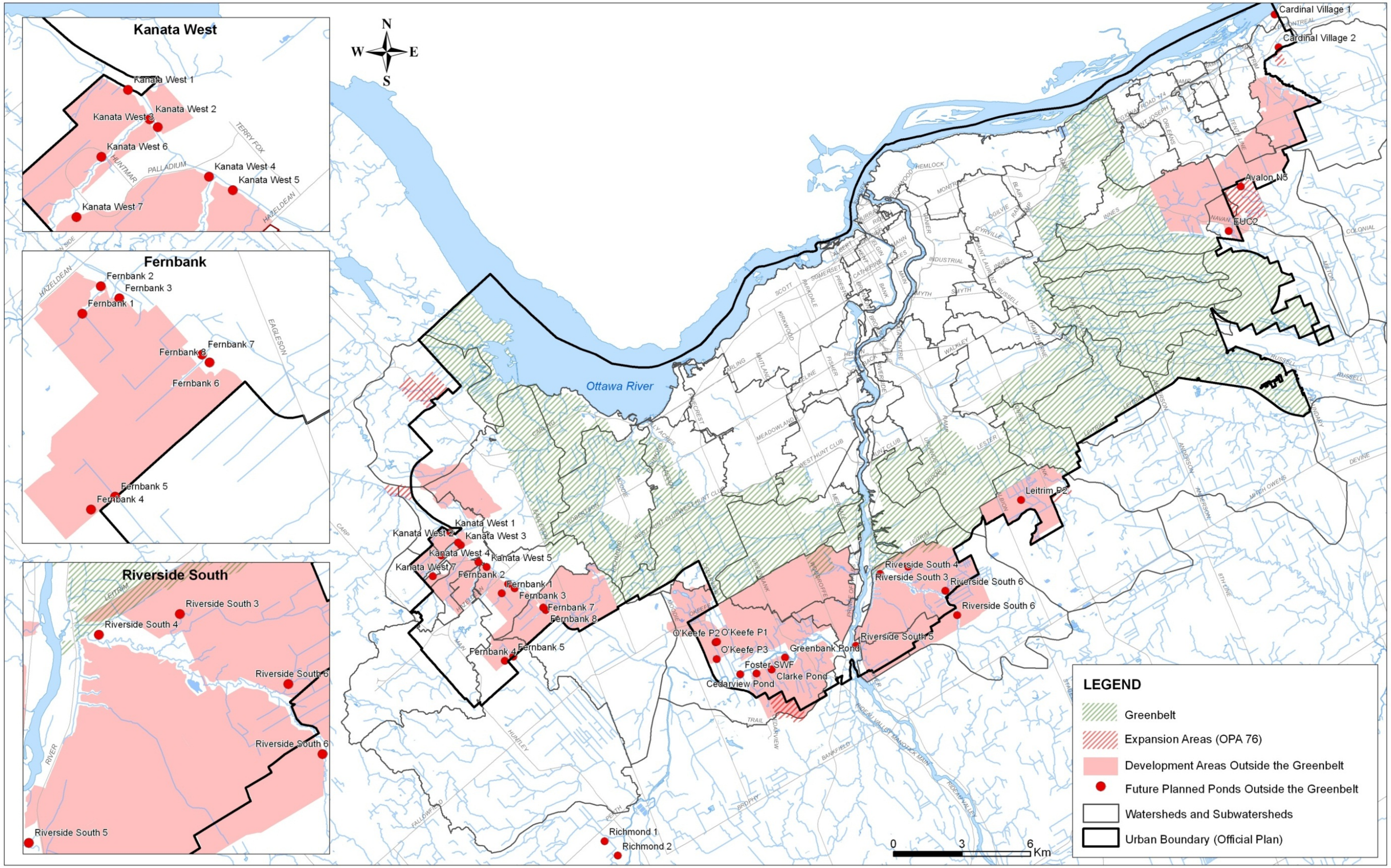


Source: City of Ottawa GIS infrastructure database

Figure 5.11: Location Plan of Selected Ponds

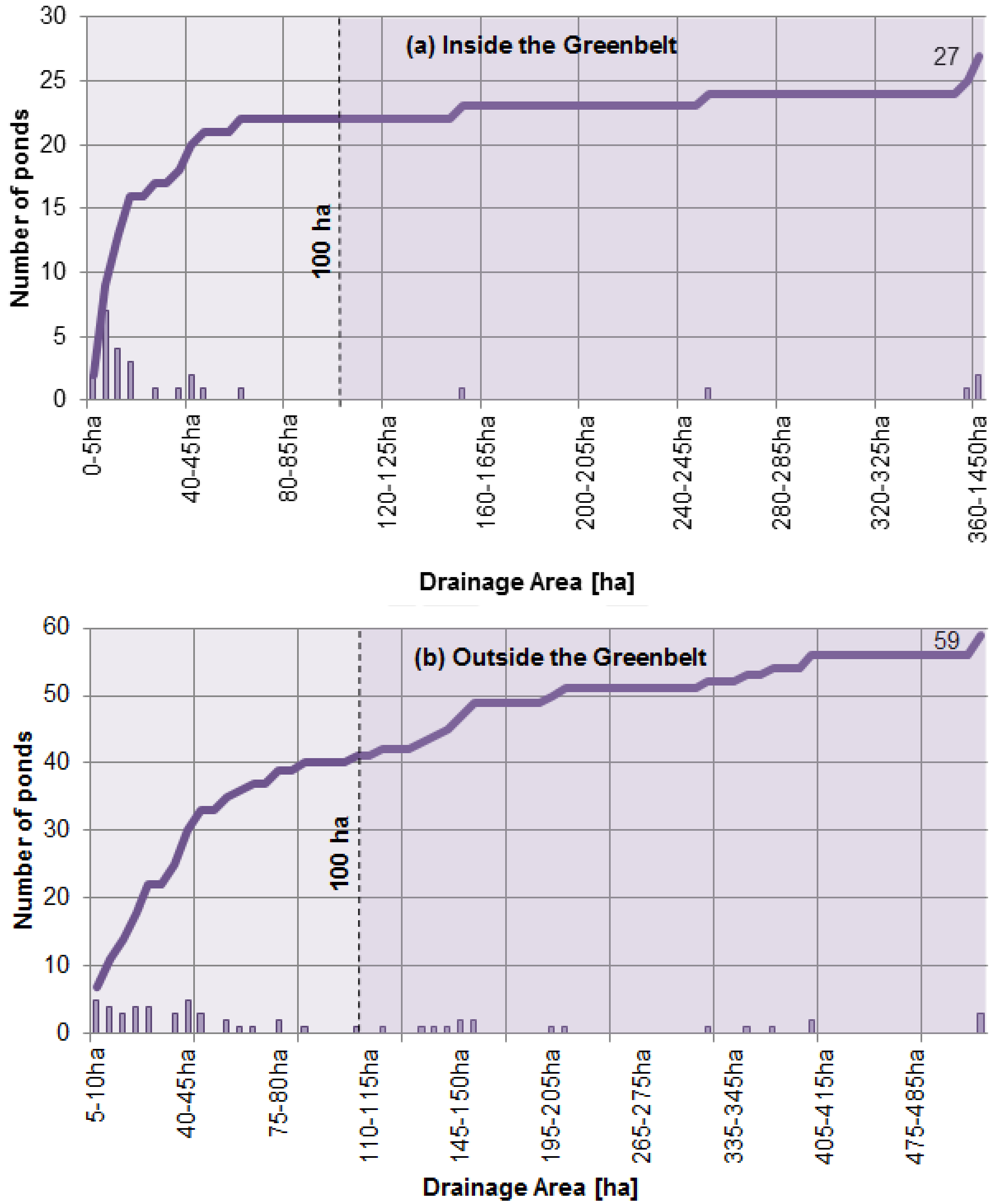
Inside the Greenbelt: As previously noted, the potential for future intensification or changing design criteria to affect pond capacities prior to full build-out inside the Greenbelt is very limited.

Outside the Greenbelt: The review identified several existing ponds located outside the Greenbelt with emerging issues where continued build-out and/or intensification may generate capacity problems including elevated HGLs and/or reduced water quality treatment. A summary of emerging issues is presented in *Table 5.11*.



Source: City of Ottawa GIS infrastructure database

Figure 5.12: Future Planned Stormwater Management Ponds



Source: City of Ottawa, Planning and Growth Management, Infrastructure Policy Unit: Stormwater Management Pond Review, 2013.

Figure 5.13: Distribution of Stormwater Management ponds within the urban boundary: (a) inside the Greenbelt and (b) outside the Greenbelt

Table 5.11: Summary of emerging issues for existing Stormwater Management ponds located outside the Greenbelt

Development	Pond Name	Treatment	Vacant lands[1] [%]	Design TIMP[2]	Actual TIMP[3]	Design Ptot[4]
Avalon	Neighbourhood 4	Qual./Quant.	48%	57%	47%	< 106 mm
Barrhaven South	Corrigan Pond	Quality	83%	51%	59%	Ok
EUC	EUC Pond 3	Qual./Quant.	55%	45%	52%	< 106 mm
Leitrim	Findlay Creek Village	Qual./Quant.	72%	45%	46%	< 106 mm
Riverside South	Pond 1	Qual./Quant.	45%	35%	49%	Ok

Source: City of Ottawa, Planning and Growth Management, Infrastructure Policy Unit: Stormwater Management Pond Review, 2013.

1. Remaining build-out within pond catchment based on 2010 land use layer
2. Percent of total imperviousness (TIMP) based on the actual imperviousness of the constructed areas, measured from 2011 air photos. The actual TIMP is compared with the design TIMP, i.e., the value used for the design of the facility as per the Detailed Design Report
3. Total amount of precipitation (Ptot) used for the design of the facility as per the Detailed Design Report, compared with current City guideline specification (106 mm)
4. Ptot used for the design of the facility as per the Detailed Design Report

As summarized in *Table 5.11*, the actual imperviousness of existing development in Barrhaven South, EUC and Riverside South is higher than the value used for the detailed design of the facilities. In addition, the rainfall volume used for the design of Neighbourhood 4, EUC 3 and Findlay Creek Village SWM ponds is lower than the 106 mm volume specified in the Sewer Design Guideline (City of Ottawa, 2004). These factors may result in capacity constraints and a lower LOS as the catchments for these ponds build out.

Further details regarding the pond capacity review are provided in *Annex B.7*.

The foregoing assessment was completed at a screening level to flag potential capacity constraints related to water quality treatment and water quantity control for large existing SWM facilities.

Action:

- The City will further review the remaining build-out areas for large SWM facilities flagged for potential capacity constraints. Based upon the anticipated level of ultimate imperviousness, the need for additional measures that may be required to maintain water quality and/or quantity targets will be determined.

5.4.2.3 Moving Forward with Low Impact Development Approaches

Low impact development (LID) is a generic term which describes the management of stormwater at the source, either on individual properties (‘lot-level controls’) or included in the conveyance systems. LID is distinguished from ‘end-of-pipe’ SWM facilities in that LID provides for reduced runoff volume, as well as water quality treatment and (some) reduction in peak flows for smaller events. LID measures include ‘lot-level controls’ in the form of green roofs, rain gardens, and pervious pavers on individual properties, as well as bioretention facilities within right-of-way boulevards. LID approaches can complement or reduce (but may not eliminate) the need for ‘end-of-pipe’ solutions. This is a significant trend in SWM in North America, stemming from the recognition that mitigating the flooding, erosion and water quality impacts of urbanization on receiving watercourses cannot be achieved by end-of-pipe approaches alone.

The Province of Ontario has recognized the need to move forward with greater implementation of LID approaches and is currently funding a number of LID efforts via the “Showcasing Water Innovation” program including pilot installations on residential, industrial and commercial lands, and public lands and rights-of-way. These efforts include the preparation of design and construction guidelines intended to assist municipalities in moving forward with LID projects. Additional detailed information about these on-going initiatives funded by the Province is provided here: http://www.creditvalleyca.ca/low-impact-development/showcasing-water-innovation-2/

These initial efforts are essential given that LID represents a considerable shift in municipal engineering practice. There are also a number of barriers to moving forward including lack of local knowledge about LID technologies, their applicability to the local climate, and the long-term effectiveness of lot level measures implemented on private property. Notwithstanding what the City can learn from the experience of other municipalities and jurisdictions, local efforts are required if LID approaches are to be effectively integrated into existing SWM design guidelines and standards.

Action:

- The City will carry out low impact development demonstration projects, low impact development training, and adopt low impact development design guidelines and standards.

5.4.3 Intensification and Redevelopment

Planned growth in the form of intensification within the Greenbelt presents a challenge for the existing storm collection systems with respect to ensuring that existing and future development is provided with an adequate level of flood protection. Development of a Stormwater Collection Systems Master Plan to address this challenge is described in the following section.

5.4.3.1 Wet Weather Infrastructure Management Plan: Stormwater Collection Systems Master Plan

Owing to the younger age of the separated sewer system assets, there has been less attention paid to the performance and investment needs for separated storm sewers than there has been on the older combined sewer system. Recent attention has been focused on developing a comprehensive model of the sanitary trunk sewer system, and on optimizing the performance of the combined sewer system to minimize overflows while preventing flooding.

Various neighbourhood and community scale hydrologic and hydraulic models of the storm sewer and surface drainage systems have been developed by the City over the last five years. These have been focused on priority areas where flooding has occurred, or areas where there is a risk of basement flooding. Areas that developed prior to the adoption of the 100 year protection standard are the subject of recent studies of the storm drainage system to improve conveyance capacity and create a major system to prevent flooding. This has resulted in improvements to surface storage and conveyance, as well as the application of inlet controls in catchbasins to prevent the surcharge of storm sewers.

Data management is ongoing to identify problem areas and required improvements to the City's infrastructure databases. The inventory of surface and storm sewer elements is continuously being improved.

Given the improvements in existing system data, the recent work to address flooding issues, and the need to understand the impacts of ongoing intensification, the development of a comprehensive system-wide Stormwater Collections System Master

Plan is now justified. The plan would focus on major/minor system conveyance capacity and flood protection requirements. This would involve a series of neighbourhood level plans under a single, managed program. This Stormwater Collections System Master Plan should be developed and implemented as a component of the WW-IMP.

Action:

- The City will prepare a Stormwater Collections System Master Plan as part of the Wet Weather IMP.

5.4.3.2 Stormwater Management Retrofit

SWM retrofit refers to the insertion of various measures into established, older communities that were originally built without the infrastructure needed to mitigate the impacts of uncontrolled runoff. These impacts include degraded water quality, increased flooding and erosion, and the impairment or destruction of fish habitat. Unlike greenfield development, where SWM measures are incorporated as a matter of course, the challenge of SWM retrofit is to identify effective measures that can be implemented after the fact – when there is limited land available to implement conventional SWM facilities. *Figure 5.14* illustrates the extent of the existing urban area that developed prior to the current requirements for SWM being in place.

ORAP recognized the importance of addressing the impacts of both CSOs and uncontrolled stormwater runoff. This need for SWM retrofit was reflected in two ORAP projects: the preparation of SWM retrofit plans for the Pinecrest Creek/Westboro study area and the Eastern Subwatersheds study area (subwatersheds of Taylor, Bilberry, Voyageur and Green's Creeks). These study areas are shown on *Figure 5.15*. The Pinecrest/Westboro SWM Retrofit Plan has been completed and is now being implemented. The Eastern Subwatersheds SWM Retrofit Plan is scheduled to be complete by the end of 2013.

Beyond the two study areas identified as part of ORAP, there remains a significant portion of the existing urban area that also developed with little or no SWM (refer to *Figure 5.15*). Completing SWM retrofit plans for these remaining areas on a subwatershed or catchment basis will provide a comprehensive city-wide SWM retrofit plan. Implementation of city-wide SWM retrofitting will require a long-term effort in the order of several decades that will allow for retrofits within the rights-of-way and on City-owned properties to be completed 'opportunistically' when roadways, City buildings and parking lots come to the end of their life cycle. In this way, the cost of retrofitting public properties for SWM will represent only a portion of or 'premium' on the total cost of replacing existing infrastructure. For example, for City properties, green roofs can be considered when roof areas need to be replaced; permeable materials can be considered when parking lots are re-surfaced and; roof drainage disconnected where feasible. The same approach can be applied to road rehabilitation projects: as lengths of road come up for rehabilitation, consideration can be given to implementing conveyance retrofits where feasible and appropriate.

Action:

- The City will identify and incorporate Stormwater Management retrofit measures into City renewal projects where appropriate.

Reducing runoff from private property – at the source or 'on the lot' - is also a key objective of SWM retrofit and efforts will also be required to encourage participation from private property owners.

Actions:

- The City will educate property owners on retrofit opportunities at the lot level; and
- The City will inform the community of the connection between the Ottawa River and public use of sanitary and stormwater systems, and how individuals can help protect the River and its many tributaries.

An additional component of SWM retrofit studies is completing the work to better understand the many smaller tributaries that receive uncontrolled urban runoff. As noted in *Section 5.4.1.4*, receiving watercourses are important assets in the city's drainage system, requiring management and intervention. While retrofitting these highly urbanized subwatersheds will offer many benefits, it is unlikely that post-development hydrology can be sufficiently modified to avoid further stream adjustments and instability. It is anticipated that in-stream intervention will be required to effectively manage these tributaries and minimize future remedial costs that may be required for both infrastructure and property.

Action:

- The City will continue monitoring and assessing receiving watercourses to determine how they are adjusting and to support future decision-making.

Beyond identifying retrofit measures to be implemented within the subwatersheds, retrofit studies therefore also incorporate the completion of tasks related to improving the management of the watercourses themselves. These tasks include the inventory and assessment of infrastructure located within stream corridors, the prioritization of current and future anticipated threats and the identification of remedial measures to address those threats.

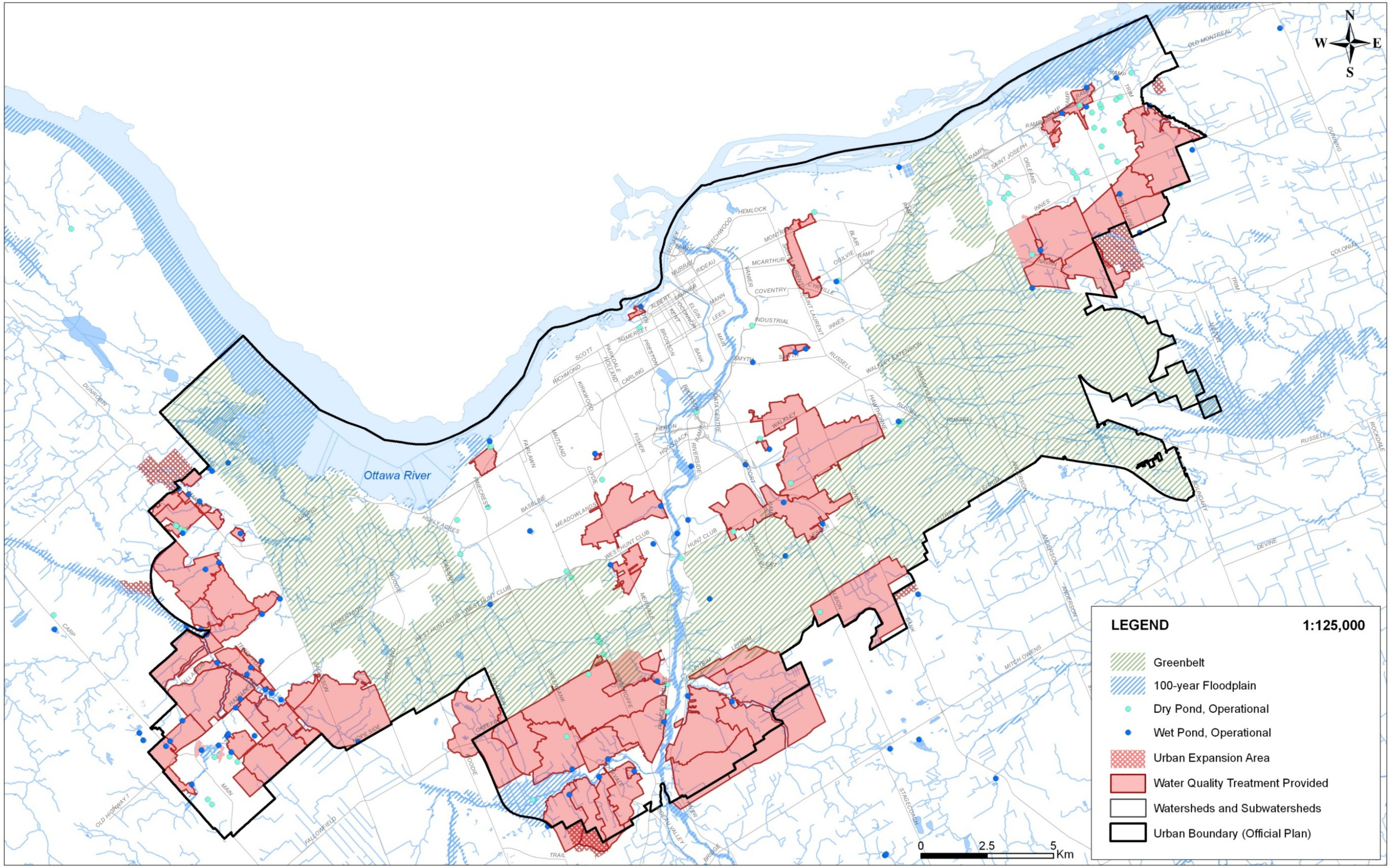
Action:

- The City will work with local Conservation Authorities to prioritize stream restoration projects.

Finally, while a key objective of SWM retrofit is to address existing development, many retrofit study areas have been and will continue to be subject to intensification and redevelopment. While new development must incorporate SWM measures in their plans, implementing SWM retrofit measures over time will also assist in addressing the cumulative impacts of intensification and redevelopment.

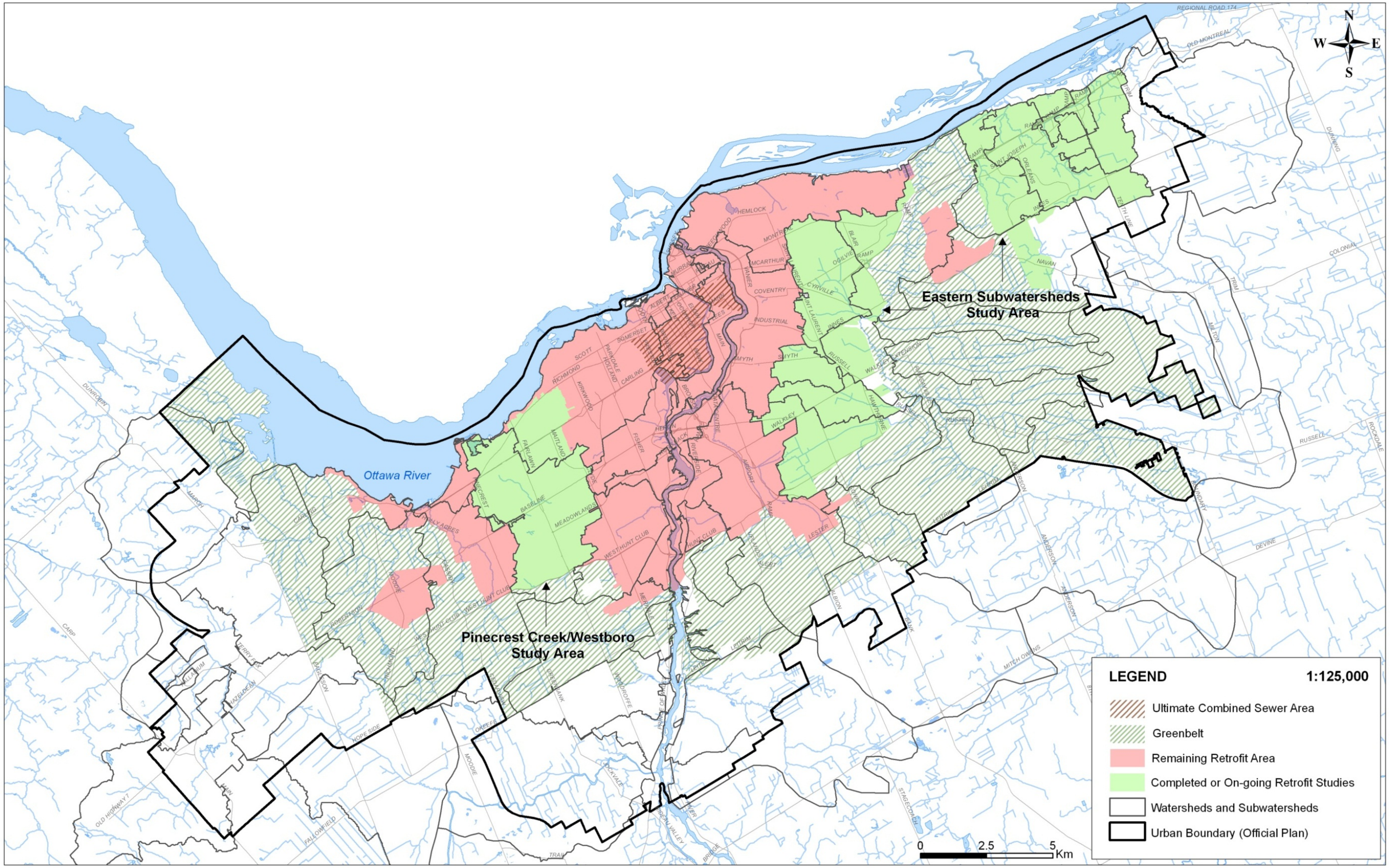
Action:

- The City will complete a city-wide Stormwater Management Retrofit Master Plan.



Source: City of Ottawa GIS infrastructure database

Figure 5.14: Extent of Water Quality Treatment



Source: City of Ottawa GIS infrastructure database

Figure 5.15: Status of Stormwater Management Retrofit Planning

5.4.4 Climate Change Implications: Best Practices Review

The OP directs the City to take measures to adapt to the effects of climate change by:

a) Completing a climate change adaptation strategy; and

b) Considering the potential impact of climate change and adaptation strategies when completing environmental management and subwatershed plans.

The City has recognized the need to account for climate change impacts to storm drainage and SWM systems as reflected in the city's 2004 Sewer Design Guideline. For new development, storm drainage designs are required to incorporate a number of robust and cost-effective redundant features such as inlet control devices, overland flow routes with outlets to SWM facilities or watercourses, backwater valves on service laterals, and SWM pond outlet structures with high capacity overflows. Designs must be tested to assess performance for extreme historical rainfalls. Further, for older neighbourhoods that have experienced flooding and during renewal projects, drainage systems are retrofitted to include these features to the extent possible to improve the level of service.

Notwithstanding the current efforts being made, the City has completed a best practices review of adaptive approaches to respond to the anticipated impacts of climate change on local rainfall patterns as a further step in considering additional climate change adaptation measures for SWM and drainage infrastructure. A summary of the report as well as a link to the complete report are provided in *Annex B.8*. The key findings of the review are provided as follows:

- While there is uncertainty regarding the scope and impacts of climate change for which to plan, municipalities are acting with confidence on available information;
- While there is a lack of senior government policy and legislative frameworks for adaptation, municipalities are increasingly being recognized as leaders in acting on climate change;
- While there are a limited number of examples of successful municipal adaptation policy and planning processes, cities in Ontario including Toronto, London, Windsor and Kitchener are frequently referenced as state of practice leaders;
- Research indicated that examples of planning processes for stormwater adaptation in Canada, the United States, Europe, Australia and elsewhere concluded, essentially, on the same objectives, implementing measures and constraints;

- While a limited number of examples of implemented SWM adaptation measures are in place and remain to be fully evaluated for cost effectiveness through long term operational success, many of the measures being implemented are considered to be ‘no regret’ measures, worth undertaking regardless of the extent of future climate change; and
- While there are considerable concerns at the municipal level regarding the cost of adaptation, many municipalities are recognizing that the financial risks of not addressing climate change may be greater; some municipalities are recognizing that well planned adaptation will, in particular for their own SWM challenges, decrease municipal costs.

The recommendations of the best practices review include the following:

- Develop a common understanding of SWM adaptation;
- Develop an enhanced SWM adaptation plan, plan for adaptation as a process and develop a framework of themes;
- Promote the use of green infrastructure including for CSO control and green street pilot projects;
- Review the City of Welland infrastructure vulnerability assessment – a recent and relevant example;
- Incorporate enhanced adaptation measures as part of planned infrastructure rehabilitation;
- Ensure an interdisciplinary approach to incorporating adaptation into municipal practice;
- Review the City’s standby power capacity in consideration of climate risks;
- Develop standardized City SWM modelling tools to incorporate options for considering adaptation;
- Review the many approaches to updating IDF curves; and
- Review and understand the many approaches available that have been used by others to assess the cost of climate adaptation.

Action:

- The City will form a Stormwater Management interdepartmental working group to develop and recommend enhanced actions for dealing with climate change and adaption.

5.5 Responding to Intensification

The urban growth projections that were prepared to support the OP Review and the IMP Update translated into the expected development intensification across the city, in particular inside the Greenbelt. The determination of development intensification included due consideration to the emerging TOD plans and CDPs that are centered around the proposed OLRT system as well as intensification planned for mixed use centres and mainstreets. As described in *Section 2*, the projections for TODs extend well beyond the 2031 planning horizon.

The backbone water and trunk wastewater infrastructure upgrades that are proposed in this IMP respond to the projected intensification to 2031, with consideration of opportunities for the longer-term planning horizon to 2060. The upgrades also reflect the servicing studies that have been completed to date for the TOD and urban CDP areas keeping in mind the 2031 horizon. However, more detailed local servicing studies need to be undertaken in response to development proposals to identify local pipe upgrades that may be needed to support the increased levels of intensification.

An interdepartmental working group is needed to identify and undertake the local servicing study priorities and opportunities to coordinate upgrades with the City's infrastructure renewal program. An integrated renewal/growth/extraneous flow removal program requires sufficient time and resources to understand local capacity constraints, where development is likely to occur and the condition and location of the older infrastructure.

Undertaking local servicing studies to identify priorities and opportunities to coordinate upgrades with the City's infrastructure renewal program is key to ensuring intensification development can be directed to areas where there is residual capacity, thus taking advantage of the opportunity within the existing system and minimizing the cost of having to add infrastructure. As part of reviewing and assessing priorities, resourcing requirements will be identified. Under some circumstances, local pipe upgrades will need to be evaluated by development proponents in consultation with the City's engineering review staff.

5.5.1 Water Supply

The core area of the city is very well served with a robust network of transmission mains, feedermains, and local watermains. Any backbone system upgrades that would be needed to support intensification are identified in this IMP, within *Annex A.1*.

(Additional upgrades may be identified by TOD studies completed subsequent to this IMP.)

Local watermain upgrades may be required, as determined by local servicing studies. These upgrades will be driven by fire demand. Thus the character and spacing of the buildings themselves will determine the local watermain sizing. Intensification would tend to increase fire demand, but in many cases, fire demand may actually fall due to the provision of internal sprinkling systems and improved construction standards.

Actions:

- The City will assess requirements for and will develop detailed water, wastewater, and stormwater models to deal with the issues of intensification. Included in the assessment will be the resources required to ultimately develop and maintain the models.
- The City will continue to develop and maintain models of the CWDS and CWWCS to support performance analysis and infrastructure planning and to prioritize remedial actions.
- The City will consult with its stakeholders when assessing and implementing IMP Projects.

5.6 Servicing in the Rural Area and Urban Area Enclaves

5.6.1 Existing Servicing

Servicing in the rural area, i.e. outside of the urban boundary, is predominantly by private wells and sewage systems (traditionally called ‘septic systems’). Over the years, municipal services have been provided in certain villages for a variety of reasons, but predominantly to resolve issues with private services. *Table 5.12* lists all of the villages with municipal services and the type and extent of those services.

Table 5.12: Villages with Partial or Full Municipal Services

Village	Type of Service	Extent of PSA
Carp	Water and Wastewater	Entire Village
Munster	Water and Wastewater	Entire Village
Richmond	Wastewater	Entire Village
Kings Park (Richmond)	Water and Wastewater	Kings Park Subdivision
Manotick	Water and Wastewater	Entire Village (except SDA)
Shadow Ridge (Greely)	Water and Wastewater	Shadow Ridge Subdivision
Notre-Dame-Des-Champs	Water	Entire Village
Vars	Water	Entire Village
Carlsbad Springs	Water	Entire Village and Area

Source: City of Ottawa GIS infrastructure database
PSA = Public Service Area
SDA = Special Design Area (in the most westerly portion of Manotick)

There are a number of defined privately serviced enclaves within the urban boundary. These areas consist of older developments, typically located where municipal servicing is not readily available. Some of these areas will connect to municipal services in time, through resident-funded Local Improvements, but some may remain on private services. Figure 7 in Annex *A.3 Infrastructure Schedules* shows the location of the major privately serviced enclaves.

5.6.1.1 Private Individual Services

Most of rural Ottawa is serviced by private individual services, where homeowners are responsible for their own services. The City plays a role where a municipal approval is required, such as when a Building Permit is sought, or when the creation of lots is proposed, typically through the subdivision or severance process under the *Planning Act*.

Where a Building Permit is sought the proponent must obtain a permit under the *Ontario Building Code* from the *Ottawa Septic System Office* for the sewage system. There is no permit process for the construction of wells, but the well must be drilled by a driller licensed by the Province of Ontario.

In a case where lot creation is proposed, the City or its agents review the viability of the private services. The City's general requirements for approval of developments on private systems are detailed in the OP. Hydrogeological and Terrain Analysis studies must have sufficient detail to demonstrate that the private services will be sustainable over the long-term, and include an assessment of hydrogeological sensitivity and calculations supporting the proposed density of development. The City, or its agent, reviews these studies against Provincial legislation and guidelines and City of Ottawa guidelines. The minimum lot size that will be considered for private servicing is 0.4 ha.

Not all areas in Ottawa are conducive for development on private services. Some areas exhibit poor water quality and/or are sensitive sites where insufficient groundwater protection is available for private on-site services.

5.6.1.2 Village Servicing

The majority of the City's 26 villages are serviced by private individual wells and sewage systems. This method of servicing reflects the history of the City's villages, which for the most part have been in existence for a long time, serving as hubs within the general rural area. There are however seven villages that have either full or partial municipal services. These are listed in *Table 5.12*.

The City owns and operates five municipal wells. *Table 5.13* provides some information on each of these Drinking Water Systems.

Table 5.13: Municipal Wells

Well System	PTTW[1] m^3/d	ECA[2] m^3/d	Ave. Day (2012) m^3/d	Max. Day (2012) m^3/d
Carp	2,782	2,732	536	1,217
Kings Park (Richmond)	2,620	2,620	166	283
Munster	2,362	2,160	357	1,154
Shadow Ridge (Greely)	1,683	550	114	579
Vars	2,300	2,290	238	559

Source: City of Ottawa, Environmental Services Department, Drinking Water Services Branch: Drinking Water Summary Reports, 2012.
PTTW = Permit To Take Water
ECA = Environmental Compliance Approval
1. MOE PTTW capacity
2. MOE ECA capacity

The Village of Carlsbad Springs and the surrounding area are serviced with municipal water, provided through a relatively unique low pressure system, referred to as the Carlsbad Springs Trickle Feed System. The PSA created at the time of the implementation of the system (1997) was to service existing dwellings, as well as a few developments that already were being considered at the time. The system was implemented in order to resolve an existing issue with groundwater and was not intended to service future development. There is no fire protection on this system. *Annex B.3* provides information on the Servicing Case Studies for Rural Villages.

5.6.2 Rural Growth Strategy

The OP's rural growth strategy aims to support a denser model for development with less scattered housing by:

- focusing development in villages;
- discontinuing the creation of new country lot subdivisions; and
- relaxing, moderately, the limit to the number of severances permitted.

Where village expansion is required, the first choice will be in those villages which have the most community facilities and municipal services.

5.6.3 Village Growth and Rural Servicing Strategy

Over the next 10 years, there is an excess in the supply of village building lots and as such the OP does not include an expansion of villages. The strategy for the growth in villages over the next five years is focused on the following:

- recognition that most development will occur in the large and medium sized villages;
- allowing for natural build out of current vacant land in the small villages; and
- monitoring the 10-year supply of village land and assessing future land needs by village category.

Figure 5.16 describes villages by population and their characterization as large, mid-size or small.

The cost of providing municipal servicing to villages where no services currently exist is significant. Currently there is a sufficient supply of undeveloped land within the larger villages where growth is predominantly occurring. The remaining villages are growing at slower rates and their growth can be accommodated through private servicing. Owing to the cost of providing infrastructure and the fact that there is no current proposal by the City to expand village boundaries, it was concluded that development will continue for the most part on private servicing unless environmental risks are presented or there are changes to provincial legislation.

In view of the proposed road widening on Carp Road south of Highway 417 and the associated issues with existing private sewage systems, and in consideration of the water servicing that already exists on this road, this IMP adds Carp Road corridor from Rothbourne Road to Highway 417 as a Public Service Area for sanitary servicing (see Figure 7 in Annex *A.3 Infrastructure Schedules*).

Action:

- The City will assess the expansion of Public Service Areas on a case by case basis subject to capacity limitations and restrictions, and may not include both water and wastewater services.

5.6.4 Village Water Servicing

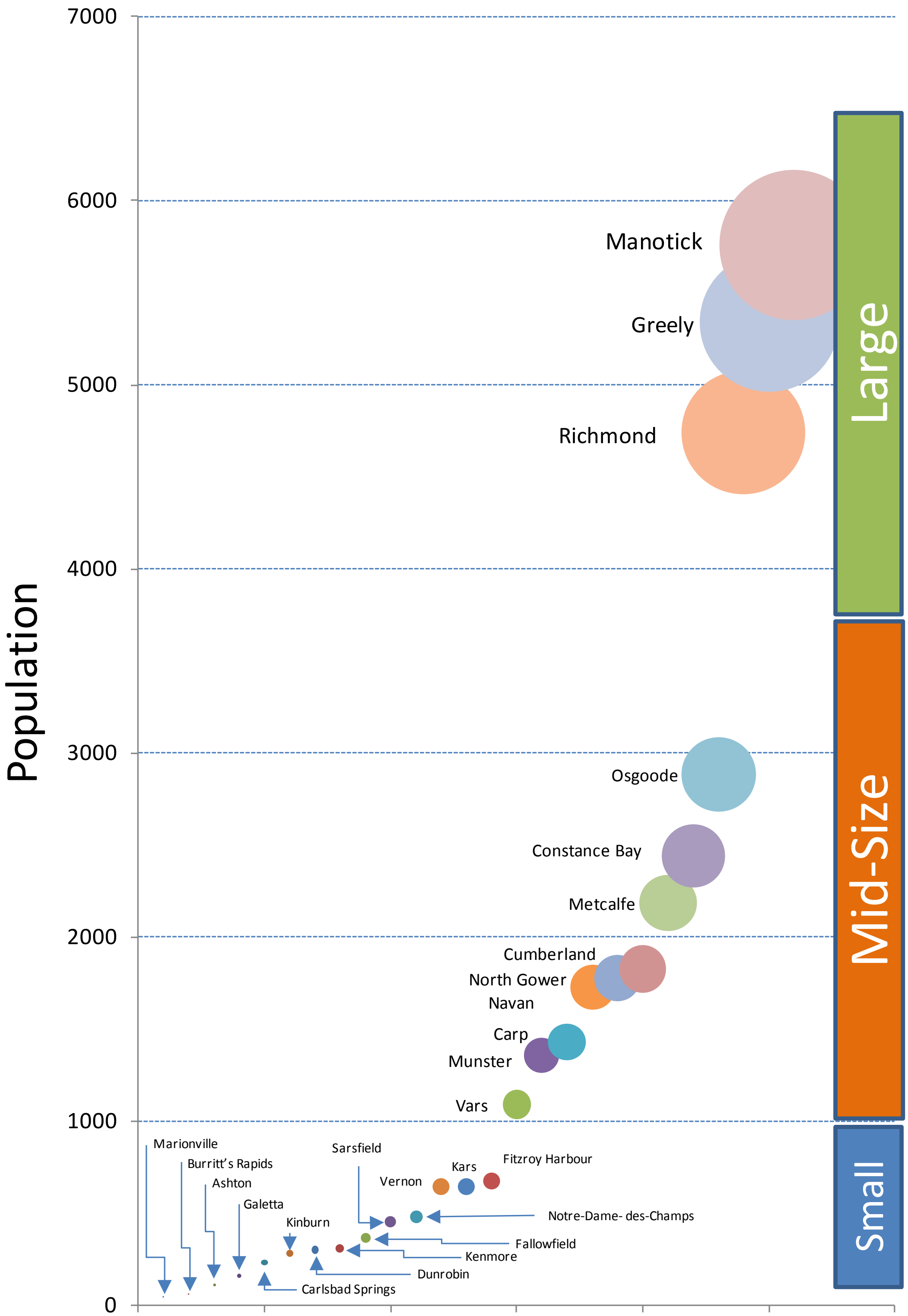
5.6.4.1 Carp

The Village of Carp is serviced by two municipal wells completed in overburden. The water system also includes an in-ground two-cell reservoir, a chlorination system, an array of high-lift pumps and a piped distribution system throughout the Village. In addition to the Village, a future residential development at the Carp Airport will also have to be accommodated by the well water supply.

Based on the Class EA for Carp, completed in 2009, the existing well system will have the capacity to supply the existing development and expected growth in Carp and the Airport until approximately 2020. From the assessment of various water supply alternatives, an expansion of the well supply system (rather than an extension of the City's central water system) is the preferred alternative for providing water for the Village of Carp.

The in-ground storage in Carp will be adequate to provide balancing, fire protection and emergency storage for the existing and expected growth in Carp and the Airport until approximately 2019. The available volume will have to be increased at that time, and a third storage cell will be required.

At some point into the future, dependent on the rate of growth, the high lift pumps will have to be replaced and pressure reducing valves will have to be installed at 49 individual homes. The timing for these projected modifications is based on design flows, and it is possible that continued monitoring of the system will demonstrate that upgrades to the system can be somewhat deferred.



Source: City of Ottawa, Planning and Growth Management, Research and Forecasting Unit: Rural Residential Land Survey.

Figure 5.16: 2011 Village Population

In addition to growth-based modifications, the following process improvements and system reliability ameliorations are proposed:

- Filters to address taste and odour.
- Enhancement of the on-site SCADA network.
- Miscellaneous field instruments replacements.
- Electrical system modifications including the addition of a fully redundant backup power system.
- Upgrade to pumps to better facilitate operation during low flows and restore small pump redundancy.

5.6.4.2 Richmond

There is an existing municipal well system servicing the Kings Park subdivision, with a population of approximately 450 persons. This system consists of two production wells completed in the Nepean Formation (sandstone) aquifer, with open holes in the Oxford and March Formations. The water treatment system includes chlorine disinfection and hydrogen sulphide treatment by oxidation. Kings Park subdivision is fully built and no expansion to the system is contemplated. However, process improvements are proposed:

- Miscellaneous field instrument replacements.
- Installation of natural gas service.
- Additional disinfection contact chambers to meet anticipated regulatory changes to the minimum disinfection levels.

Two large subdivisions in the Richmond Western Development Lands are being proposed on municipal well water. There are approximately 2,000 homes planned within these two subdivisions. Wells have been drilled and are undergoing testing.

The rest of the Village of Richmond, other that Kings Park and the Western Development Lands, is currently serviced by private wells but has the potential to be serviced with municipal water from the Nepean Formation aquifer, although any project funding would need to be obtained as a Local Improvement. The entire village is designated PSA for water in the Village of Richmond CDP.

5.6.4.3 Munster

The Village of Munster is serviced by municipal water from two wells, constructed in a similar fashion as those for Richmond. Chlorine disinfection is provided, as well as storage and a high-lift pumping system.

The village of Munster is fully developed and no expansion to the system is proposed. However, process improvements, system reliability and life cycle replacement items as well as eventual replacement of the existing facility are proposed:

- Renewal and eventual replacement of the existing facility including property acquisition and new production wells.
- Construction of groundwater wells for aquifer water quality monitoring.

5.6.4.4 Vars

The Vars water system draws groundwater from two municipal wells completed in an esker formation. The source water is high in organic carbon, colour, iron and manganese. While these naturally occurring substances can lead to aesthetic issues, such as taste and odour and staining of household fixtures, they do not pose a health risk to the safety of the drinking water supply.

A series of treatment steps successively remove undesirable substances such as iron, manganese, organic carbon, colour, bacteria and viruses from the water. The purification process in Vars consists of oxidation using potassium permanganate, greensand filtration, carbon adsorption, chlorine disinfection, storage and high-lift pumping.

The system should be able to accommodate the full build-out of the village, save perhaps the greensand filters, which is the limiting component in the treatment process. However, process improvements and system reliability items are proposed:

- Electrical system modifications including the addition of a redundant backup power system.
- Renewal and upgrades of various system components such as process piping, production well pumps and drives, process waste disposal, structural / concrete repairs and purification system upgrades.
- Expanded on-site SCADA network.
- Miscellaneous field instrument replacements.

- Construction of groundwater wells for aquifer water quality monitoring.

5.6.4.5 Shadow Ridge (Greely)

The Shadow Ridge Subdivision in Greely is serviced by two municipal wells completed in overburden. The water system includes a chlorination system, pressure tanks, log giardia removal through filtration and a piped distribution system throughout the subdivision.

The water system in Shadow Ridge is operated but not yet owned by the City. This is an on-going development and the developer is proceeding to Phase 2, and will be upgrading the system for the additional units being proposed. Eventually, process improvements and system reliability items will be required:

- Upgrades of various system components such as, permanent well level monitoring, chemical feed pumps and controls, process piping and valves and redundant backup power system
- Miscellaneous field instrument replacements.
- Construction of additional groundwater wells for aquifer water quality monitoring.

5.6.5 Village Wastewater Servicing

5.6.5.1 Carp

The existing wastewater collection system in Carp consists of PVC pipe ranging from 200 mm to 450 mm in diameter. The pumping system includes one local PS and one main PS delivering sewage to the central system and associated forcemains. The collection system directs sewage to the two PSs. The existing system is sufficient to handle a portion of the projected increased flows. The preferred solution in the Class EA includes emergency overflows at both sewage PSs, twinning the existing forcemains, upgrading existing pumps and some sewers (e.g. Hines Road). The Class EA is predicting that the Donald B. Munro PS will have to be upgraded in 2023 and the Carp PS in 2019.

5.6.5.2 Richmond

The main PS in Richmond collects sewage from Richmond by gravity and from Munster through a sanitary forcemain. The proposed growth in Richmond will require an expansion of the existing PS, the installation of a second forcemain and the upgrading of some sections of gravity sewers. The required work is expected to proceed in stages.

5.6.5.3 Munster

The Village of Munster is fully development and no expansion to the system is proposed. The existing system consists of one local PS in the northeast section of the Village, and a gravity collection system to a main PS delivering sewage to Richmond.

5.6.5.4 Manotick

The wastewater system in Manotick consists of gravity sewers, one local PS servicing Mahogany Harbour, one main PS and 3.4 km of forcemain delivering sewage to the West Rideau Collector, through a sewer on Stonebridge. Most of the existing residents are still on septic systems, but have the opportunity for obtaining sanitary sewers through a local improvement by-law. New development is on the basis of full servicing. At some point, depending on the rate of growth, the pumps in the main station will have to be upgraded.