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Flewellyn Cumulative Effects Study
City of Ottawa

Final Report

June 2016
SLR Project No.:209.40105.00000

FLEWELLYN CUMULATIVE EFFECTS STUDY

CITY OF OTTAWA

SLR Project No.: 209.40105.00000

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ACRONYMS

MNR	Ontario Ministry of Natural Resources
RVCA	Rideau Valley Conservation Authority
MVCA	Mississippi Valley Conservation Authority
NESS	Natural Environment Systems Strategy
OGS	Ontario Geologic Survey
OMAFR	Ontario Ministry of Agriculture, Food and Rural Affairs a.k.a. OMAF
MNR	Ministry of Natural Resources and Forestry (formerly Ministry of Natural Resources)
PPA	Provincial Policy Statement
TEEB	The Economics of Ecosystems and Biodiversity

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EXECUTIVE SUMMARY

There has been considerable discussion since 2005 about the origin, extent and importance of the wetlands that occur in the City of Ottawa west of Stittsville. The City retained SLR Consulting and Cole Engineering to develop a defensible understanding of existing conditions in the Flewellyn Road area in contrast to historical conditions and determine what data would be required to explain changes in wetland cover. Phase II of the study is intended to determine whether changes are permanent or transitory and to provide an assessment of the potential for change in the future.

This report documents the investigations undertaken in the first phase: review of the existing information with respect to vegetation change within the study area, and identification of a focussed workplan that will resolve questions about the origin and extent of the wetlands. Phase I terminates with recommendations for the Terms of Reference for Phase II. A workplan will be identified based on these Terms of Reference and conclude with recommendations for a wetland layer to be incorporated into the City of Ottawa Official Plan. It is expected that Phase II will follow once the Phase I is complete and the Terms of Reference have been presented to the stakeholders.

This study was triggered in part by controversy regarding the identification of additional units to the Goulbourn Provincially Significant Wetland Complex located in the headwaters of the Jock River, connecting north through to the Huntley subwatershed and northeast to the Poole subwatershed (OMNRF 2005). Based on a review of the existing documentation, including the extent of the recent revisions to the Goulbourn Wetland Complex, the principal study area is roughly bounded by Munster Road, Mansfield Road, Huntley Road and the Hazeldean/Hwy 417 extension across the north, encompassing the headwaters of the Flowing Creek and Hobbs Drain.

The study required review of an extensive bibliography of documents, City of Ottawa reports, resident presentations and submissions, email exchanges, aerial photography review and consultation with local residents, quarry engineers and the local councillor. Data were overlaid in a GIS environment in order to identify relationships among historical vegetation and soil mapping, historical and current drainage patterns and episodes of diversion and maintenance, and, quarry and residential development and associated changes to discharge.

The study concluded:

1. The study area is defined as the portion of the subwatersheds of Flowing Creek and Hobbs Drain north of Mansfield Drive based on the availability of historical aerial photography and wetland occurrence. This is the area within which the additional wetlands designated as Provincially Significant are located. There is no evidence that drainage from Poole Creek has been diverted to Flowing Creek, however the two subwatersheds do share headwater wetlands so minor changes in water supply may affect both drainages.
2. There has been quantifiable change in wetland cover within this study area between 1946 and 2011 with a net removal of 23% of wetland, reducing the percent wetland cover in the watersheds from 22% to 17%, a loss of 195 ha.
3. The source of this change is not limited to wetland shrinkage as a result of removals due to development (residential and quarries) and drainage for agricultural purposes. New wetlands have been created since 1946 which may be due to drainage diversion, lack of maintenance of drains and culverts and active obstruction by American Beavers.

4. The largest wetland removal has occurred in the lower Flowing Creek while the largest gains have occurred in the lower Hobbs Drain upstream into upper Flowing Creek.
5. The quarry operations do not appear to be responsible for large scale changes in wetland cover. Values reported in quarry reports should be calibrated in Phase II against the streamflow measured during this study to determine how these values influence water accumulation.
6. Based on the occurrence of organic soils (peat), which accumulates over a long time frame, many of the wetlands across this landscape are long term standing wetlands.
7. Evidence for cool/cold water attributes (watercress, sculpin) within the study area are indicative of permanent features supported by groundwater discharge.
8. Regardless of origin of the wetlands, if they are demonstrated habitat for a species afforded General Habitat protection under the Endangered Species Act, 2007, they are Provincially Significant by definition.

A Terms of Reference was then identified that would build on these conclusions. The goal is the determination of a "reference condition" for wetland coverage, defensible and functional limits of wetland on this landscape that integrates the hydrogeological, hydrological and ecological services that wetlands provide on this landscape to control flooding and other ecosystem services related to wetland functions. The outcome will have consequences for the maintenance of drainage, control of peak flows and protection of private property to avoid damage claims.

1.0 INTRODUCTION

The landscape surrounding Ottawa has been constantly renewed over the millennia. The last glaciations that retreated 10,000 years ago left unique landforms, exposed bedrock and soils that have weathered over time. First Nations activity followed by European occupation further altered the patterns of vegetation, drainage and topography. Most recently these lands have been subjected to increasing impermeability due to paving and rooftops associated with residential and commercial development, and quarry operations. As land cover, drainage catchments and maintenance of drainage by both human and beaver populations changed, so did the pattern of occupation, agriculture and flooding. Where water accumulated, saturating the soils beyond a threshold for upland plant survival, wetlands developed.

In concert with these changes is a growing recognition that natural features play important roles in regulating water quality and quantity, removal of air-borne pollutants and greenhouse gases, temperature regulation, nutrient cycling, erosion control and generally providing a range of benefits that otherwise would require expensive engineering solutions. Other benefits seldom evaluated include aesthetics, psychological benefits including crime reduction, and recreational activities such as canoeing/kayaking, hiking, photography and nature appreciation. These benefits are described as Ecosystem Services (TEEB 2009, 2010) and have been recognized increasingly as important factors to be considered in the land use planning process.

The Government of Ontario has identified matters of provincial interest under the Planning Act in the Provincial Policy Statements, 2014. They include direction to prevent “development and site alteration in *significant wetlands* in Ecoregions 5E, 6E and 7E” (PPS 2014). Ottawa and the study area lie within Ecoregion 6E.

The process used by the Province to identify significant wetlands is insensitive to the anthropogenic changes in water supply that may create wetlands, or convert wetlands to uplands. Wetlands by their very nature are subject to substantial fluctuation due to variation in climate (precipitation, temperature and wind). They often occur at the interface between aquatic environments (lakes, rivers and ponds) and upland environments (dry forests, thickets and meadows), or in depressions where water collects. They are often surrounded by substantial zones within which the actual boundary fluctuates over time. Within the Flewellyn Special Study Area this ambiguity may have been affected by human intervention in the form of agriculture and associated drain construction and maintenance, drainage alterations due to beaver activity, residential and commercial development, road construction and maintenance, and potential hydrologic changes due to quarry development and associated discharge.

This report documents the investigations undertaken in the first phase: review of the existing information with respect to vegetation change within the study area, and identification of a focussed workplan that will resolve questions about the origin and extent of the wetlands. Phase I terminates with the Terms of Reference for Phase II. A workplan will be identified based on these Terms of Reference and conclude with recommendations for a wetland layer to be incorporated into the City of Ottawa Official Plan. It is expected that Phase II will follow once the Phase I is complete and the Terms of Reference have been presented to the stakeholders.

The function of the hydrologic regime and wetlands that occur because of it are the key issues in this work. The wetlands are the expression of many contributing factors. In particular, the relatively flat surficial geology, characterized by fine grained soils over relatively low permeability bedrock limits drainage to depth resulting in changes to wetland boundaries with relatively small changes in water volume. Historical groundwater contributions are not anticipated due to the limited recharge however the Phase I review will examine whether this assumption is correct. Potential sources of change include:

- Local aggregate operations who discharge groundwater to surface water, which may exacerbate surface water issues, both in terms of water quantity (creating more wetlands) and/or water quality (lower nutrient regimes and lower temperatures are characteristic of groundwater in contrast to surface water);

- Historical farming practices that created artificial drainage to enable expansion of farming operations. In times of climatic drought (*e.g.*, the "dirty thirties"), wetlands receded providing for expansion of forests and farming. In times of increased precipitation, this trend reverses;

- Artificial drains that require maintenance to prevent slumping and accumulating vegetation. Some of them may have failed with time and dis-use, possibly contributing to flooding and wetland development over time;

- Global change that has triggered unprecedented changes to meteorology with more intense and variable events in recent years, both wet and dry. Vegetation responds to these changing conditions;

- Beaver activities that may have a substantive effect on drainage through damming and cutting of woody vegetation, which in turn affects water levels and vegetation; and,

- Anthropogenic effects that may include land development and road expansion, agricultural practices, and private drainage works altering the potential of the landscape to store and shed water.

All of these factors are linked and affect the natural features and function of the landscape, particularly as they subtly change with time. It is our goal to understand how these factors have evolved with time in order to provide guidance on future conditions.

There are a variety of policies and regulations that go beyond Ontario wetland policy that also apply that will affect the potential to provide a policy framework around the Ottawa wetlands in terms of implementation. Table 1 lists those that could affect the constraints and opportunities going forward. For example, if it is determined that a wetland was artificially created, a proposal to reverse the process could require approval under other instruments such as the Ontario Regulation 174/06, the Endangered Species Act, 2007 and/or the Fisheries Act. It is important to acknowledge that these instruments exist and that they often act in concert.

Table 1: Policies and Regulations that may Affect Future Management

Instrument	Relevance
Planning Act (1990) and Provincial Policy Statements (2014) (PPS) (Ministry of Municipal Affairs and Housing)	Determines wetlands of provincial interest based on a defined protocol and restricts development in and adjacent to wetlands of provincial significance. The PPS also identifies the need to protect significant wildlife habitat, fisheries, woodlands and landscape connectivity to which wetlands frequently contribute critical functions.
Rideau Valley Conservation Authority, *Ontario Regulation 174/06 — Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation*	Regulates land use changes within or adjacent to wetlands. RVCA has written draft policies specific to wetlands.
Fish and Wildlife Conservation Act (Ministry of Natural Resources)	Regulates fishing, hunting and trapping and provides protection to listed species.
Endangered Species Act, 2007 (MNRF)	Regulates habitat and provides protection for listed species. Authorization is required to develop in the habitat of an endangered or threatened species.
Federal Fisheries Act (Department of Fisheries and Oceans)	Manages and protects fish habitat and either a letter of advice or an authorization may be required to permit potential development
The Drainage Act, 2010 (Ontario Ministry of Agriculture and Food)	Regulates the construction and maintenance of certain types of drains (Municipal Drains, Mutual Agreement Drains, Petition Drains, and Requisition Drains)
Ditches and Watercourses Act. (repealed June 1, 1963)	The maintenance of an Award Drain is the responsibility of the landowners; however there are no longer any statutory provisions to enforce maintenance of an existing Award Drains.

For example the objective of the Fisheries Act is ‘no serious harm to fish’, and the goal of the Endangered Species Act, 2007 is a net benefit to endangered and threatened species. If these organisms occur within the study area, goals for management may conflict between these Acts, and also potentially with the Provincial Policy Statement with respect to outcomes for wetland management. This potential conflict and/or synergy among legislative instruments should be recognized and integrated into future planning initiatives.

1.1 Goals and Objectives

It is the goal of this study to develop a defensible understanding of existing conditions in the Flewellyn Road area, examine past conditions and provide the basis for future planning targets in order to provide guidance on input to the Ottawa Official Plan with respect to wetland protection in the study area. To do so this report relies on understanding the nature of change within the Study Area in the recent past, whether changes are permanent or transitory and to provide an assessment of the potential for change in the future.

The objectives include:

1. Identify the limits of the study area and availability of suitable data sets for Phase 2 through a review the existing information with respect to vegetation change within the study area:

2. Develop an ecologically integrated understanding of the existing conditions for the study area;

3. Provide a discussion of the current and historical relationships among hydrologic, hydrogeologic natural heritage functions, human intervention and wetland creation through time; and,

4. Identify a Terms of Reference that will resolve questions about the origin and extent of the wetlands, and lead to the recommendation of the extent of wetlands to be protected by policies in the Ottawa Official Plan.

2.0 STUDY AREA

The study area falls within the Jock River Subwatershed of the Rideau River Watershed. The Jock flows from headwaters in Montague and Beckwith Townships, through the former municipalities of Goulbourn and Nepean, and draining Barrhaven (City of Ottawa) where it outlets to the Rideau just north of Manotick. The Jock subwatershed is very large and is subdivided into of many smaller subwatersheds that include the Hobbs Drain and Flowing Creek (Figure 1).

This study was triggered in part by controversy regarding the identification of additional units to the Goulbourn Provincially Significant Wetland Complex located in the headwaters of the Jock River, connecting north through to the Huntley subwatershed and northeast to the Poole subwatershed (OMNRF 2005). Based on a review of the existing documentation, including the extent of the recent revisions to the Goulbourn Wetland Complex, the principal study area is roughly bounded by Munster Road, Mansfield Road, Huntley Road and the Hazeldean/Hwy 417 extension across the north, encompassing the headwaters of the Flowing Creek and Hobbs Drain (see section 2.1 for the rationale). A portion of the Poole Creek watershed falls within these boundaries but drains to the northeast and therefore does not affect the wetlands of the Goulbourn complex.

2.1 Criteria for Designation Based on Watersheds

A map of the existing watersheds in the area and the associated drainage was created using watershed maps from the Rideau Valley Conservation Authority (RVCA) and the Mississippi Valley Conservation Authority (MVCA): Figure 1 – Sub-watershed Boundaries. RVCA is currently using recent LiDAR to further refine the boundaries. Most of the study area falls within the Jock River Watershed, under the jurisdiction of the RVCA, however the northeast corner of the study area falls within the Poole Creek Watershed, under the jurisdiction of the MVCA. The area draining to Poole Creek is not discussed in detail in this report as it does not appear to be part of the drainage system for the wetlands in this study. However, this area should remain part of this study into Phase II as Poole Creek has been drastically altered by local development and may have contributed to the overall drainage system in earlier years. The study area may be modified as drainage boundaries are verified using LiDAR (Laser Radar).

The cumulative effects study is limited to the Jock River subwatersheds of Hobbs Drain and Flowing Creek north of Mansfield Road.

3.0 BACKGROUND REVIEW

Phase I focused on identifying, verifying and assembling reliable information and datasets, and developing an ecologically integrated understanding of the existing conditions for the study area. Hydrologic modelling is best conducted after Phase I is completed, when the extent of available information is realized.

The City of Ottawa and RVCA provided an extensive library of digital or hard copy reports, letters, memoranda as well as aerial photographs and digital mapping. Please refer to Appendix A for a full list of documents, maps and digital files used in the background review.

3.1 Discussion of Material Provided

As part of Phase I, information was gathered on the Municipal Drains and other watercourses within the project area. These include the Mansfield Municipal Drain and the Hobbs Municipal Drain, Flowing Creek, Poole Creek, and a number of unnamed watercourses. Records on maintenance work for the drains were also reviewed. No records pre-dating the construction of the Hobbs and Mansfield Municipal Drains were located, although the engineers' reports for the Hobbs and Mansfield Municipal drains state that they are constructed in part from existing Award Drains (built by engineers at the request of land owners to provide drainage for farm fields, discussed in Section 5.7).

The City provided Geographical Information System (GIS) files for the roads and culverts in the study area. These files include the construction dates for the roads and installation dates for culverts. These files combined with the Township of North Gower Municipal Drain Classification Map, (Mar. 2011 – Mar. 2012), were used to map the changes to the Municipal Drains and other watercourses in the study area.

Watershed maps from the Rideau Valley Conservation Authority (RVCA) and the Mississippi Valley Conservation Authority (MVCA) were also referenced as part of the background review.

The various letters, environmental reporting (Environmental Impact Studies [EIS]), memoranda, email and studies were reviewed. A chronological account of events surrounding the wetlands and watershed was prepared in order to assist in a cause and effect analysis. This chronology is provided in Appendix B.

4.0 METHODS

4.1 Terrain, Including Review of Quarry Developments and Discharge

The Flewellyn wetlands lie in an area of thin soils over flat lying limestone bedrock. Poor drainage to depth and low grades contribute to the very slow movement of water and thus high seasonal water table conditions. In recognition of these conditions the background review has closely examined the effects of terrain on water movement. Provincial geologic mapping was used to document the distribution of soils and shallow bedrock features. Digitized aerial photography from 1976, 1991, 1999, 2002, 2005, 2008 and 2011 was obtained through the City (for areas of various extents) to track the expansion of development and to look for significant changes in wetland extent (Figure 2). Stereoscopic aerial photography from 1946, 1959, and 1963 was also obtained through the City to enable stereoscopic interpretation of terrain and wetlands providing a historic perspective with time. The stereo pairs for 1946 (26 July 1946 at a scale of 1:20,000) in particular were stereoscopically interpreted by an experienced air photo interpreter and reviewed by a senior biologist to determine the extent of wetlands at that time. Wetland areas and watercourses were interpreted based on appearance of saturated substrates, vegetation patterns and depressions.

The shallow limestone bedrock has historically been quarried for aggregate in the Stittsville area. Through the City, RVCA and the Ministry of the Environment, publically available reports for the various quarries in the area were obtained and reviewed. These reports included monitoring reports, as well as those in support of quarry applications and PTTW applications. Information was available for the following quarries and proposed quarries, which are shown on Figure 3:

- Cumberland Ready-Mix PTTW Application, September 2010
- Cavanagh Henderson Quarry, Concession XI, west of Jinkinson Road
- Tomlinson Stittsville Quarry, Quarry Expansion, 2000, Concession XI, east of Jinkinson Road
- Dibblee/Lafarge Bell Quarry, Concession XI, north of former railway
- Cavanagh Beagle Club Quarry, Concession X, at Fernbank and Jinkinson
- Proposed Taggart Fernbank Quarry, Concession X, east of Beagle Club
- Goulbourn Quarry, Concession VIII, south of Flewellyn Road

With permission of the quarry owners, informal discussions with consultants for the owners (AECOM and Golder Associates), was also conducted to answer site specific questions on water taking, quarry staging, and monitoring programs.

4.1.1 Installation of Mini-piezometers

Four test mini-piezometers (MPs) were installed within the special study area (see Figure 3). Each was installed in a different creek. MPs are simple, but effective tools used to determine whether stream or wetlands are gaining water from the ground or losing water to the ground. MP construction details are attached in Appendix C.

4.2 Hydrology and Drains

A chronology of the hydrology and drainage in the study area was assembled using information contained in the engineers reports for the Hobbs and Mansfield Municipal Drains, Drainage investigation of the Hobbs Drain Extension, Conley Branch, drain maintenance records, comments from residents in the area, road and culvert mapping data and a map of the existing municipal drains, a full list of the documents used is located in Appendix A. The chronology includes:

- Dates that Municipal drains were constructed
- Dates that culverts were added or replaced as part of the drainage works

- Dates that changes were made which affect the drainage boundary of the Hobbs Municipal Drain
- Dates of other drainage works, such as ditch construction, done in the area
- Dates of recent work on the existing drains

This information was then summarised in a table to help identify significant dates where changes were made that would affect drainage in the study area (Appendix D). The drainage areas used to design the municipal drains were mapped, along with the watershed boundaries from the RVCA and MVCA, to illustrate the changes in the tributary areas for each drain. Although in some areas the topography has changed and/or runoff has been diverted by the construction of ditches, there are also some differences which were identified as being due to a different interpretation of the topography. Figure 4: Drain Construction Timeline, illustrates the local drains and shows when different sections of drain were built. Figures 5 and 6 give a more detailed look at the changes made to the Hobbs and Mansfield Municipal Drain. Figure 7 illustrates the geographical references for information provided by residents and RVCA. Using these maps and the chronology table important dates were identified to guide the study in the next phase of this project.

4.3 Aquatic Habitat

Due to the potential for changes in drainage to affect fish habitat that may fall under the jurisdiction of several agencies, an SLR fisheries biologist reviewed relevant accounts of aquatic habitat. Specifically, the kinds of fish communities present in the drainage features, evidence of seeps or groundwater upwelling, and species that may indicate cool or cold water conditions were investigated. The fisheries biologist reconnoitred the study area together with the terrestrial biologist and hydrogeologist to provide a balanced overview for the existing conditions report.

4.4 Vegetation Communities including Wetlands

As noted above, a wetland biologist, fisheries ecologist and hydrogeologist from SLR completed a preliminary field investigation on 8 June 2012 to confirm drainage, vegetation and aquatic habitat conditions in the field. The general vegetation characteristics as assembled by background documentation were confirmed through roadside observation and occasional vegetation sampling following the protocols of Ecological Land Classification for Southern Ontario (Lee *et al* 1998). Anthropogenic indicators with respect to recent flooding and other evidence of landscape alteration (such as drowned tree types) were considered to be of prime importance. Indicators of reliance of vegetation on groundwater *vs* recent origin from upland habitat were relied upon for evidence of permanent existence in the study area. Occurrence of non-native invasive species is often a clue to recent disturbance that may be related to stochastic flooding and drainage events however the level of detail of field investigations did not permit assessment of this characteristic within the study area. Sampling of soils to detect degree of oxidation (red/orange/bright colouration) *vs* gleying (gray/drab colouration) as indicators of current and past saturation or drainage may be important data to assist in the analysis if access is made available in Phase II.

The City of Ottawa has reviewed and revised the original non-evaluated wetlands mapping for the study area provided by Land Information Ontario, using 2011 color aerial photography, with a resolution of 20 cm, in Spring ‘leaf off’ conditions. The revisions were made by a qualified wetland evaluator, very familiar with the area, through ‘heads up’ digitization in ArcGIS at scales of 1:1000 and 1:2000. Wetlands were delineated on the basis of apparent wetland vegetation cover and 25 cm contour mapping derived from a high resolution, LiDAR Digital Elevation Model. Occasional reference was made to 2008 and 2005 aerial photography. The revisions fall into five basic categories:

1. No change: the LIO polygon appeared accurate.
2. Minor editing of a LIO polygon: the LIO polygon appeared generally correct, but required some additions or deletions.
3. Major editing of a polygon: the LIO polygon appeared generally incorrect, but included some wetland areas. These were deleted and a new polygon was created.
4. Deletion of a polygon: the LIO polygon did not include any wetland area.
5. Creation of a new polygon: the LIO wetland layer failed to include a wetland. A new polygon was created.

No changes were made to Evaluated Wetland Boundaries (whether provincially significant or not). However, in many cases, additional wetland areas contiguous with evaluated wetlands were identified and mapped as non-evaluated wetland.

In addition to interpretation of historical and recent aerial photography, background documents were reviewed for vegetation classification from a variety of contexts. The historical mapping was reviewed to identify characteristics that may indicate that the wetlands have persisted at this site for many years. These documents include:

- The Wetland Evaluation Data and Scoring Record (WEDSR) for the Goulbourn Provincially Significant Wetland Complex;
- Ontario Geological Survey 2010;
- Ministry of Natural Resources, Land Information Ontario, accessed 2013;
- Ontario Ministry of Agriculture and Rural Affairs mapping, 2011;
- Field Observations (Muncaster, B. 2010);
- Field Visits and reporting on wetland complexing potential (Huizer 2005 and 2006);
- Environmental Impact Statement (Muncaster 2003);
- Category 2 Class A License Application – Stittsville Quarry (Golder 2000);
- Natural Environment System Strategy (1997) vegetation data;
- Characterization of Ottawa's Watersheds: An Asset Management Approach to Natural Systems, City of Ottawa, March 2011;
- Regional Municipality of Ottawa-Carleton, 1976, Ottawa and Rideau River corridors: existing conditions. Background report; and,
- City of Ottawa Unevaluated Wetland Layer, interpreted from 2011 aerial photography and LiDAR in ArcGIS, 2015.

Southern Ontario Land Resource Information System (SOLRIS) mapping was examined but found to contain inaccuracies that could not be reconciled with the rest of the data set.

The wetland mapping from several sources was compared to identify areas reporting peatlands. The occurrence of peat (saturated, organic soil) is an indicator of permanence since it takes many hundreds, if not thousands of years for the organic layer to accumulate in the wetland. On this landscape, it was not expected that peat would occur extensively due to the relatively shallow soils. However the review identified peatlands well distributed across the study area, likely as a result of infiltration of precipitation into sandy end moraines and subsequent discharge of cool groundwater to topographic lows. These indications for the occurrence of peat, which also included the reports of plant species that occur on peat soils, were mapped in a layer that identifies wetlands with this characteristic. The layer was then compared to the 1946 and 2011 wetland layers. These data sets were useful in establishing historical wetland occurrence.

The 1946 interpreted wetland layer was overlaid on the 2011 wetland layer on the GIS platform. Net losses, gains, and areas identified as wetlands in both time periods were identified. Measurements of wetland extent in the watersheds upstream of Mansfield Rd. for Flowing Creek and Hobbs Drain was calculated in total, in addition to areas subdivided at Flewellyn Rd. Flewellyn is the approximate bisector of the study area. This comparison allows for examination of the potential differences in gains or losses in headwater areas as compared to downstream locations.

5.0 HISTORY OF DRAINAGE PATTERNS

The Ministry of Agriculture, Food and Rural Affairs and its forerunners have provided mechanisms for financing, engineering and appropriately outleting water in order to drain land to enhance agricultural resources. Several instruments governed drainage including the Ditches and Watercourses Act, repealed in 1963 and the Drainage Act, 2010. Currently, except for municipal drains under the Drainage Act, owners of drains are responsible for maintenance, but in reality "there are no statutory provisions to enforce compliance" (http://www.omafra.gov.on.ca/english/engineer/facts/89-166.htm accessed 2013).

Figures 4, 5, 6, and 7 provide a current understanding of the history of the construction of municipal drains in the study area.

5.1 Chronology of Alterations

Award Drains were built under the authority of the Ditches and Watercourse Act which passed in 1874 and repealed in 1963. No Award Drains were constructed after 1963, when construction of drains was then incorporated into Sections 2 and 3 of the Drainage Act. Award Drains were built by engineers at the request of land owners to provide drainage for farm fields. The maintenance of Award Drains is the responsibility of the land owners, so maintenance records would not have been kept by the municipality. Given that these drains no longer exist as built, having been reconstructed or removed in the interim and that they would have been built at least 50 years ago, it is possible that the records and design drawings from their construction have been lost.

5.1.1 Lackey Award Drain

There are no records of the construction of the Lackey Award Drain; however no Award Drains were constructed in Ontario after 1963 when the Drainage Act was amended. In 1970, when the Hobbs Drain Project was initiated, the Lackey Award Drain was described as having irregular grades and following a meandering course through Concessions 5, 6 and 7 of the Township of Goulbourn (Graham, A.J. 1972) (Figure 4). It was also noted that the two farm crossings on the main drain appeared to be in a poor state of repair. The Lackey Drain was incorporated into the Hobbs Drain after 1972.

5.1.2 Hobbs Municipal Drain

The Hobbs Municipal Drain (Hobbs Drain) was constructed in 1972 – 1973 in Lots 11, 12, 13, 14, 15, Concession 5, 6, and 7 to improve drainage to the lands being served by the former Lackey Award Drain (Graham, A.J., 1972) (Figure 4 and 5). The original Hobbs Drain had 17 branches built at the request of land owners and designed to convey water from the surrounding farms to the Main Drain. It was noted in the engineer's report that the proposed drainage system would not improve all the wet areas unless lateral drains were constructed by individual property owners. The existing drain was lowered in some areas to allow various branches to outlet to the drain and to provide better conveyance of runoff along the main drain.

As part of the construction of the Hobbs Drain the existing road culverts were analysed and replaced as needed. The changes made to road culverts in 1972 are as follows (refer to Appendix D for more detailed notes):

1. The existing culvert through Township Road in Lot 13 between Concessions 6 and 7 (Figure 5, Culvert A) was sufficient in size, however a second culvert was added, 20 feet to the east to provide a channel at a lower elevation (Figure 5, Culvert B).
2. A 10 foot channel was constructed through the existing culvert through Township Road in Lot 12 between Concessions 5 and 6 in order to provide a lower elevation than the existing structure (Figure 5, Culvert C).
3. The existing culvert through Township Road in Lot 14 between Concessions 5 and 6 (Branch #7) was replaced as it was insufficient in size and elevation for its location on the drain (Figure 5, Culvert D).
4. Approximately 6 inches of silt was excavated from the existing concrete culvert through Township Road in Lot 12 between Concessions 6 and 7 (at the outlet of Branch # 13) (Figure 5, Culvert E).
5. The existing culvert through Township Road in Lot 12 between Concessions 6 and 7 (Branch #14) was replaced as it was found to be insufficient in both size and elevation (Figure 5, Culvert F).
6. Existing culvert through Township Road at Branch #18 was lowered approximately 3 feet and 10 feet of pipe was added to the culvert in anticipation of road reconstruction in the area (Figure 5, Culvert G).

In addition to the road culverts thirteen (13) farm crossings and three (3) access culverts were added to the drain during construction.

5.1.3 Mansfield Municipal Drain

The Mansfield Municipal Drain (Mansfield Drain) was constructed in 1974 at the request of property owners to replace a series of existing drains, likely old Award Drains which were not maintained (Graham 1974) (Figure 6, Appendix D). The report for the Mansfield Municipal drain describes the existing drain as having neither the depth nor capacity to provide an adequate agricultural drainage outlet for the area. Existing tile drain outlets had little to no freeboard where they entered the drain, in some areas the outlets for tile drains were below the invert of the drain. There was considerable bank erosion along the drain, specifically at turns and where the branches joined the main drain.

The Mansfield Drain was designed with increased capacity and lowered to provide improved gravity outlets for the existing tile drainage systems. It was noted in the engineer's report that the proposed drainage system would not improve all the wet areas unless lateral drains were constructed by individual property owners. Culverts were provided where there was evidence that property owner crossed that existing drain. As part of the construction of the Mansfield Drain the existing road culverts were analysed and replaced as needed. The changes made to road culverts in 1974 are as follows:

A. The existing wooden plank structure on the Unopened Road between Lots 20 and 21, Concession 6 was replaced by a culvert as it was causing a restriction to the efficiency of the drain.
B. The existing culvert through Township Road at the east half of Lot 19, between Concessions 6 and 7 was lowered to the design grade for the Mansfield Drain.
C. The existing culvert through Township Road between Concessions 6 and 7, Lot 20 was replaced as it was found to be insufficient in both size and elevation. The new culvert was aligned at an angle in order to provide more efficient drainage under the road.
D. The existing entrance culvert at Township Road between Concessions 6 and 7 and the centre of Lot 19 (Graham McCoy Branch) was lowered as it has been installed at an elevation which prohibits proper drainage of the road ditch.
E. The existing culvert through the Township Road between Concessions 6 and 7 at Lot 19 was replaced as it was found to be insufficient in both size and elevation for its location on the Drain.
F. The existing culvert at Station 23+96 of the Main Drain was replaced as it was found to be insufficient in both size and elevation for its location on the Drain.

In addition to the six (6) road culverts which were replaced eleven (11) farm crossings were added along the drain at locations where there was evidence that land owners were crossing the drain.

5.1.4 Hobbs Municipal Drain Extension

The construction of the Hobbs Municipal Drain Extension (Hobbs Extension) was initiated by a petition signed by Mr. M. Westley and several other property owners (TSH, 1988). At the time when the Hobbs Drain Extension was being designed, the existing Award Drain was described as extensively obstructed by vegetation, including large trees, beaver dams and various constructed obstructions. It appeared that no work had been done in the previous few years to remove obstructions and generally improve the flow of water. A roadway ditch was excavated around 1979, along the west side of Conley from Flewellyn Road to the upstream end of the Conley Road Branch of the Hobbs Drain. This ditch, built to alleviate flooding along the road during spring, has a greater capacity and lower invert than its outlet which leads to significant seasonal flooding along the road and in Lots 15 and 16 (TSH 1988).

The area requiring drainage was described as “that portion of the sub-drainage area of the Conley Road Branch in the southeast quarter of Lot 15 and the southwest quarter of Lot 16 in the 9th Concession and in Lots 15 and 16 in the 8th Concession. It also includes lands in the drainage area generally through the middle half of Lot 14 of the 8th Concession.” The improvements were also meant to provide additional drainage for Lot 14, Concession 8 and provide a deeper outlet to accommodate future improvements to the Flewellyn Branch.

The Hobbs Extension was sized for a 2 year storm; the drain was a 2 m flat bottom ditch with 2:1 side slopes. For the most part the Hobbs Extension followed the path of the existing drain and no new road culverts were incorporated into the design. Two of the three farm crossings were replaced with larger culverts. The third crossing was a bridge which was replaced by the owner**.**

The Report for the Hobbs Extension included comments from residents at the second onsite meeting and in subsequent correspondence advising the engineer of specific concerns relating to the design of the Hobbs Extension. The residents pointed out areas where the original subwatershed boundary did not agree with the topography and/or their knowledge of the drainage in this area. These concerns were as follows:

I. The original drainage boundary was not in agreement with the topographic mapping of the area. The area used in the original (1972) design of the Hobbs Drain only extended to Fernbank Road, however topographic mapping shows that the tributary area starts well into the 9th concession, north of the C.P. Rail tracks. The drainage area was adjusted using the topographic mapping in 1988 (Figure 5).

II. A ditch built in 1987/88 by Cavanaugh Construction Ltd. as part of a quarry drainage system was capturing flow from Lot 11, Concession 8, a portion of Lots 12 and 13 in Concession 8 and a portion of the lands in Lots 11 and 12 of Concession 9. This area, which had been tributary to the Hobbs Extension, was now being conveyed to the Hobbs Drain on the South side of Fallowfield Road, downstream of the Hobbs Extension. The Drainage boundary for the Hobbs Extension was updated to exclude the area being diverted downstream in 1988.

III. A drain was constructed in 1979 across the height of the land in Lot 16, Concession 9, and southerly along an unopened road allowance between Lots 15 and 16, the Goulbourn Ditch (Figure 7). This drain, assumed to be an Award Drain, was built to convey water from a watercourse in mid-lot 16 in the 9th and 10th concession to the Hobbs Extension. The engineer concluded that the drain had been built to provide drainage to part of Lots 15 through 17 in Concession 9, Lots 14 through 17 in Concession 10 and Lots 14 through 16 in Concession 11. These lands had been draining to Flowing Creek but the Creek was now severely obstructed by vegetation, siltation and beaver dams. The Town stated that the cost of carrying out improvements in Flowing Creek was too high given the limited benefits to any owners. It is suggested that the drain was an Award Drain built because of the difficulty in improving the natural outlet to the east. This drainage ditch is visible on air photos going back to 1946, so it was not a recent development even at the time the original Hobbs drain was constructed. Around 2010, drainage diverted to Hobbs was restored to the original drainage to Flowing Creek when landowners undertook maintenance of the drainage to the east.

IV. A property owner in Lot 17, Concession 4, stated that the outleting of the Hobbs Drain onto her property (1987), without further downstream improvements, has injuriously affected her lands. The property owner stated that she would object to any further runoff being conveyed to the Hobbs Drain through improvements upstream of Fallowfield Road. Based on a qualitative assessment the engineer concluded that the net effect of the Drain Extension on the existing Hobbs Drain outlet would be negligible.

Figure 5 shows the drainage boundaries from the Engineer's Report for the original Hobbs Drain (1972) and the updated boundary from the Hobbs Drain Extension Report (1988) and the timeline for the construction of the Hobbs Drain and Hobbs Extension. The subwatershed boundaries will be slightly different when RVCA completes their analysis being completed as part of their six year cycle of catchment area reports. The redirection of the upper Flowing Creek toward Hobbs Drain is illustrated in blue hatching; a result of the 1963 diversion. The further upgrade of the Goulbourn Ditch in 1979 had the effect of shifting more of the drainage downstream, whose path was cleared following the old Award Drain pattern to reconnect to the Hobbs Drain in 1988 with the attendant culvert improvements.

There are no records of other drains being constructed in the study area since the Hobbs Drain Extension was built. In recent years (2009-2010) land owners have been performing drain maintenance works on these drains and Flowing Creek in order to improve drainage from their properties. Records of approved maintenance were provided by the Rideau Valley Conservation Authority, a list of the approved works is available in the chronology table, specific approval documents are listed in Appendix A.

5.2 Changes in Wetland Extent

5.2.1 1946 Wetland Distribution

As identified in Section 4.1, the 1946 aerial photography was stereoscopically interpreted to identify wetland cover at that time. The wetland areas have been transcribed onto Figure 8. Wetland area was calculated by watershed, and also as parsed by Flewellyn Drive into upper and lower reaches. The calculations are provided in Table 2.

Hobbs Drain has a total watershed area of 1,355 ha above Mansfield Road while Flowing Creek totals 2,483 ha, almost twice as big. Of this, the 1946 wetland extent comprised 861 ha, or 22% of the two watersheds. Hobbs Drain was comprised of less wetland (228 ha, 17%) and Flowing Creek substantially more (633, 25%) with Flowing Creek having almost three times as much wetland.

Table 2: Proportion of Wetlands in 1946

Subwatershed	Area	1946 Wetlands	% of Watershed
Upper Flowing Creek	1311	420	32%
Lower Flowing Creek	1171	213	18%
TOTAL FLOWING CREEK	2483	633	25%
Upper Hobbs Drain	625	122	19%
Lower Hobbs Drain	730	107	15%
TOTAL HOBBS DRAIN	1355	228	17%
TOTAL WATERSHED	3838	861	22%

The upper reaches, that is, those above Flewellyn Road, have considerably more wetland (122 and 420 ha = 28%) than the lower reaches (107 and 213 ha = 17%). The headwater of Flowing Creek was 32% wetland, the most concentrated portion of the study area.

5.2.2 2011 Wetland Distribution

The City of Ottawa prepared a map of wetlands as described in Section 4.4 that includes the portions of the evaluated Goulbourn Provincially Significant Wetland Complex within the study area (Figure 9, in green), plus additional units not evaluated (Figure 9 in purple). Table 3 has been prepared to show the relative distribution of the wetlands in 2011, based on reach and watershed.

Table 3: Proportion of Wetlands in 2011

Subwatershed	Area	2011 Wetlands[1]	% of Watershed
Upper Flowing Creek	1311	366	28%
Lower Flowing Creek	1171	117	10%
TOTAL FLOWING CREEK	2483	484	19%
Upper Hobbs Drain	625	100	16%
Lower Hobbs Drain	730	82	11%
TOTAL HOBBS DRAIN	1355	182	13%
TOTAL WATERSHED	3838	666	17%

In 2011 the total wetland cover across both watersheds has decreased to 17% (666 ha). There has been a net loss of wetland of 195 ha. Hobbs Drain still provides less wetland cover (13%) as compared to Flowing Creek (19%) although on a percentage basis, there is still three times as much wetland in Flowing as in Hobbs. The same pattern regarding upper and lower reaches remains: the upper reaches still have considerably more wetland (366 and 100 ha = 24%) than the lower reaches (117 and 82 ha = 11%). By watershed, Flowing Creek includes more wetland of the two watersheds at 28%.

The relative distribution of wetlands across these landscapes remains similar in both years although many wetland units are smaller in area. The largest removals are associated with the tributary of Flowing Creek in the east close to Huntley Road, wetlands in the upper Flowing between Fernbank and just north of Hwy 417. But the actual wetlands have not so much been removed as generally shrunken in size. Of interest is the large area of wetland that was farmland in 1946, but by 2011 has become wetland starting in Hobbs Drain north of Fallowfield Rd., and extending across the watershed divide into Flowing Creek between Flewellyn and Fernbank. As the following section describes, there is both loss and gain in wetland in the two watersheds with a net decrease from 22% to 17% of the total wetland cover, but in some areas, a notable gain.

5.2.3 Change in Wetland Distribution from 1946 to 2011

The interpreted extent of the 1946 wetlands was overlaid on the 2011 City of Ottawa wetland layer (Figure 10). The areas that are wetland in both the 1946 and 2011 air photos are illustrated in yellow as being “no change”. That refers to the footprint of the wetland only, as there may be considerable changes to the quality of the wetland and biodiversity that is beyond

[1] Rounded to nearest integer

this study to ascertain (Figure 10). Wetland cover that has been removed since 1946 is illustrated in orange, while wetlands that have developed by 2011 wetlands are illustrated in in green. The relative changes in wetland coverage are documented in Table 4.

Table 4: Relative Changes in Wetland Cover Between 1946 and 2011

Subwatershed	Area	1946 Wetlands (ha.)	% of Watershed	2011 Wetlands (ha.)	% of Watershed	Wetland Change (ha.)	% Change in Wetlands
Upper Flowing Creek	1311	420	32%	366	28%	-54	-13%
Lower Flowing Creek	1171	213	18%	117	10%	-95	-45%
TOTAL FLOWING CREEK	2483	633	25%	484	19%	-149	-24%
Upper Hobbs Drain	625	122	19%	100	16%	-22	-18%
Lower Hobbs Drain	730	107	15%	82	11%	-24	-23%
TOTAL HOBBS DRAIN	1355	228	17%	182	13%	-46	-20%
TOTAL WATERSHED	3838	861	22%	666	17%	-195	-23%

From 1946 to 2011 the net wetland cover declined across both subwatersheds by 23% (195 ha). The highest percentage loss occurred in the lower Flowing Creek (45%). This appears to be due to a combination of residential development, agricultural drainage and quarry construction. Three times as much wetland was removed in Flowing Creek as in Hobbs Drain. The gains mapped in Figure 10 do not compensate for the losses, where Lower Hobbs experienced a net loss of 11% and upper Flowing a net loss of 32%.

5.3 Quarry History

The Flewellyn Study Area is characterized by shallow soils over bedrock. The bedrock is composed primarily of limestone which exhibits very good characteristics for aggregate production. There are five quarries in the study area, with an application for a new quarry pending. Figure 3 shows the quarry locations. Table 5 summarizes the dates that the quarries became operational.

Table 5: Summary of Quarry Operations

Quarry	Date Operational	Receiving subwatershed
Goulbourn	Between 1959 and 1976	Hobbs
Beagle Club	Prior to1999	Hobbs
Dibblee (Bell)	Prior to 1999	Flowing
Stittsville	~2002	Flowing
Henderson	~2002	Does not drain into study area

The following information was determined for each quarry site.

5.3.1 Goulbourn Quarry

The exact start-up of the Goulbourn Quarry, located at the southeast corner of Munster and Flewellyn Roads, is not known at this point. It appears in the 1976 aerial imagery, but not the 1959 images. It is presently owned by Cavanaugh but is not particularly active as this group operates other quarries in the area. Drainage is easterly, reaching the roadside watercourse north of Fallowfield Road and eventually reaches the Hobbs Drain (Figure 3). Pumping records are unavailable, but it is assumed that no discharge is presently occurring due to the shutdown condition of the site.

5.3.2 Beagle Club Quarry

The Beagle Club Quarry, located at the northeast corner of Jinkinson and Fernbank Roads, was licensed before 1999. It is presently owned by Cavanaugh but is not particularly active. Drainage is easterly to a tributary of Hobbs Drain passing south under Fernbank Road (Figure 3). Ottawa Surface Water Station SW5 is directly downstream at Fernbank Road. Pumping records are available from 2008 to 2010. The quarry has not been operated recently and no pumping occurred in 2009-2010. In 2008 it was pumped sporadically in June at an average of 22.0 L/s. It operates under PTTW 4876-7NFPCU.

5.3.3 Dibblee Quarry

The Dibblee Quarry, known also as the Bell Quarry, is located at the northeast corner of Jinkinson and the former rail line, and was licensed before 1999. It is presently owned by Lafarge but is not particularly active. Drainage is currently easterly off property to a wetland due north of the property on the adjacent Stittsville Quarry Property, and eventually reaches Flowing Creek (Figure 3). Ottawa Surface Water Station SW1 is directly downstream at Fernbank Road. Before 2003, discharge was by a pipe to the rail line. Pumping records are available from 2003 to 2010. The quarry has not been operated recently and no pumping occurred throughout this period with the exception of 6 days in September 2005, and sporadically in May and November 2003. This sporadic pumping was reportedly to facilitate the removal of stockpiled aggregate. It operates under PTTW 5331-76443 for a permitted peak discharge of up to 72.4 L/s.

5.3.4 Stittsville Quarry

The Stittsville Quarry is located south of Highway 417 and east of Jinkinson Road, and was licensed in about 2002. It is presently owned by Tomlinson. Drainage is currently easterly through a wetland on the property and reaches an upper tributary of Flowing Creek (Figure 3). Ottawa Surface Water Station SW1 is directly downstream at Fernbank Road. Pumping records are available from 2007, and 2009 to 2010. The Stittsville Quarry operates under PTTW 5214-6WNJGY for a permitted peak discharge of up to 90 L/s. The quarry is active, but due to the apparently low permeability of the bedrock, continuous pumping is not necessary. For example in 2007, an average of 32 L/s was withdrawn for a few weeks in April. Similarly in 2009, 67 L/s was taken over April. It was roughly 63 L/s in 2010, but beginning in March. This pattern reflects the quarry’s need to dewater after winter closure. Occasionally there is a need to remove stormwater, but these are short duration, typically day long events.

5.3.5 Henderson Quarry

The Henderson Quarry is located west of Jinkinson Road and south of Highway 417 and was licensed in about 2002. It is presently owned by Cavanagh. Drainage is westerly to the Huntley

Wetland (Figure 3). The northern part of the quarry is drained to the wetland at the north end and subsequently flows to the north and is not in the Flewellyn study area watersheds. The southern part of the quarry is drained to the wetland at the south end and subsequently flows to the southwest (Jinkinson Drain and then into the Jock River). It too is not within the study area watersheds. Pumping records are available from 2008 to 2010. The Henderson Quarry operates under PTTW 2542-7QVK9D for a permitted peak discharge of up to 75 L/s. Similar to the other active quarries, continuous pumping is not necessary due to the apparently low permeability of the bedrock. For example in 2008, an average of 17.5 L/s was withdrawn in March and April. In 2009, an average of 36 L/s was taken sporadically in April, July and October. The taking was roughly 15.6 L/s in 2010, but only in December. This pattern reflects the quarry's need to dewater only when warranted.

5.3.6 Comparison of Quarry Discharge to Local Streamflow

It is important to understand that the quarry discharge information dates over several years, ending in 2011, whereas the streamflow measured by the City was done in 2012. Whereas this prevents direct comparison, the relative magnitudes are of some use. (It is recommended that more recent quarry records be obtained in Phase II to better compare.) The upper reaches of the Flowing Creek and Hobbs Drain watersheds were monitored in 2012 by City of Ottawa staff. The upper stations closest to the quarries carry streamflows throughout the year in the order of 0 to 300 L/s. Station 5 at the Fernbank Road is downstream of the Beagle Quarry and has been observed to carry up to 100 L/s, and then up to 287 L/s downstream at Station SW6 on Flewellyn Road. By way of comparison the typical quarry discharge is about 22 L/s discharge observed from that quarry. Station 1 is downstream of the Dibblee and Stittsville Quarries and has been observed to carry up to 300 L/s. This can be compared to the total permitted discharge of 162.4 L/s for those two quarries.

When compared to both the peak allowable discharge and the average discharge[2] for those quarries in that watershed it is clear that the watercourses have significant capacity to receive the quarry discharge, even cumulatively. Since the water that is discharged directly reaches the watercourses, it is conveyed downstream without retention in the wetlands. Those adjacent wetlands that also feed the watercourses are topographically higher and therefore are not susceptible to receiving quarry discharge water under normal conditions. During spring flood conditions, the quarry discharges are significantly smaller than peak flows. The quarry discharges are sporadic, although it is reasonable to assume that they may potentially occur at similar times (contrary to the observed results in 2007 to 2010). Based on these data, wetland formation cannot be accounted for by discharge from the quarries.

5.3.7 Summary

Of the five quarries, Henderson does not discharge into the study area. The diversion that originally diverted flow from Flowing Creek to Hobbs Drain occurred prior to 1963. Only Goulbourn was operational at that time, discharging to Hobbs and therefore an existing contributor. Dibblee/Bell and Stitsville discharge to Flowing Creek, and therefore are not responsible for wetland change in Hobbs Drain. Only Beagle Club could have aggravated flow

[2] It should be understood that typical quarry discharges available up to and including 2011 are being compared to specific 2012 ranges in flow. 2012 was a relatively dry year and thus this is deemed to be conservative in that the peak streamflows will normally be even greater than that quoted.

conditions in the Hobbs Drain, sometime before 1999 which should be confirmed through additional aerial photography review.

The quarry operations have been intermittent over the years, and dewater and discharge on a seasonal basis, usually at the beginning of the spring season. Discharge occurs for a short period into streams that are flowing under natural conditions. Based on the discussion in Section 5.3.7 above, the channels appear to be able to handle this additional flow. The wetlands flank the watercourses and do not derive their water from the watercourses, and thus are only prone to flooding when inundated from uphill. There are no quarry discharges in the summer except after large rainfalls. Based on this evidence, aside from removals of wetland for quarry construction, the operation of quarries do not appear to be contributing to large scale changes in wetland cover.

6.0 EXISTING CONDITIONS

6.1 Physiography and Water Movement

The Flewellyn study area is characterised by a flat lying limestone plain with thin drift (soil overburden). It lies in the Smith Falls Limestone Plain physiographic region as defined by Chapman and Putnam (1984). Topographically the land slopes gently to the southeast. As described above, 17% of the area is covered with wetlands. The regional drop in elevation is from 150 masl at the top end of Jinkinson Road to 100 masl at Mansfield Road near Huntley Road. This regional drop of 50 m is expressed laterally over 8,000 m, which yields a regional dip in the landscape of 0.6% to the south-southeast. Locally slopes as high as 5.5% to the local watercourses exist but are more in the 1 to 2% range. Both the Flowing Creek and Hobbs Drain watersheds (Figure 1) are subwatersheds of the Jock River.

The thin surficial drift is comprised of fine to medium sands associated with old beach and lake deposits. The soils are the thinnest and commonly absent in the upper part of the Hobbs and Flowing watersheds, but are thicker to the southeast. Depressional areas are filled with organic peat and host a high water table due to the low permeability bedrock below restricting downward drainage. Section 7 provides a description of the wetlands that are found in these features.

The bedrock in the area is from the Middle Ordovician Ottawa Group Limestone formations. Specifically, the Bobcaygeon Formation limestone is found at surface, overlying the upper and lower Gull River Formation limestones which have beds of shale, dolostone and sandstone in them (Wilson 2015). The limestone is the targets of the quarrying activities in the area. The basal formation is the Rockcliffe Formation sandstone, which is not mined for aggregate. The bedrock lies in nearly horizontal bedding formations which dip to the north.

From a groundwater flow perspective other authors (Golder, AECOM) note that the water table will emulate the topographic surface, with groundwater flowing from higher areas to lower areas. This is a reasonable assumption and this is demonstrated through their monitoring efforts at several sites. The presence of the wetlands in low pockets of the terrain is consistent with this interpretation and the low permeability bedrock underlying the shallow soils. Monitoring of minipiezometers installed in the watercourses show (Section 6.1, below) only very slightly upward gradients, but coupled with the low permeability actual discharge will be low. This shows that there is little upward groundwater discharge feeding the creeks, and since the wetlands are uphill of the creeks, there is likely no significant groundwater discharge to the wetlands. It is expected that most wetlands are surface water fed from the retention of run-off from the uphill catchment area. There could be some limited groundwater discharge from the shallow soils where topographic and shallow bedrock dictate water running laterally over the bedrock surface. This water would simply be the discharge of interflow and be comprised of recent runoff following a short groundwater pathway in the soils.

Various authors (Golder, AECOM) have conducted water budget analyses for the region in their documentation of the various quarries. AECOM most recently determined that based on 60 years of data at the Ottawa airport meteorological station, that the average annual precipitation for the region is 910 mm per year. Their calculations show an average annual actual evapotranspiration (water lost to the air by evaporation and plant uptake) is 463 mm/year, leaving a surplus of 447 mm/year. This surplus is available for runoff and infiltration. It will be recommended that these values be calibrated in Phase II against the streamflow measured during this study to determine how these values influence water accumulation.

6.2 Drainage

The existing drains, culverts and watersheds are shown on Figure 1. Based on the information gathered there has been little approved change to the local drainage patterns since 1988. The topography in the area is very flat with low lying areas where water ponds. Given the number of unnamed drains (both natural watercourses and constructed drains) in addition to the Municipal Drains it can be concluded that poor drainage in this area has been a historical problem. Drainage may have been made worse by the diversion of runoff through the construction of Award Drains and other Drainage Ditches as landowners shifted flooding problems downstream. Comments from landowners indicate that the Hobbs Municipal Drain does not provide a sufficient outlet for its current drainage area. This statement has not been verified.

Figure 7 shows the locations where owners have reported problems with drainage on their lands and areas where owners have been given permission to perform maintenance on local drains. These locations are as follows:

1. The owner at the intersection of Flewellyn Road and Conley Road has been experiencing flooding problems. The owner reported prior to 1987 the culvert under Conley Sideroad to allow water to flow from east to west to the Hobbs Drain is now reversed due to flooding. The same owner reported that his property is wetter due to poorly maintained drainage and that the culvert Conley Road and Flewellyn Road culvert is undersized and the backed up water is drowning trees.

2. 7660 Fernbank Road, the owner states that in 1983 the drainage ditch built across the back of his property to drain the adjacent subdivision became blocked by beavers and flooded his property, resulting in the dieback of 30 acres of cedar forest. In 1999 Cavanagh Construction cleared out the entire length of the ditch (from Fernbank to Flewellyn) and by 2006 the 30 acres was dry enough to cultivate.

3. The owner(s) of Lots 14 and 15, Concession 5 sought approval to perform maintenance work on Branches 7 and 11 of the Hobbs Municipal Drain in 2009.

4. The owner(s) of Lot 19, Concession 9 sought approval to perform maintenance on the watercourse on their property in 2010.

7. The owner(s) of Lot 23 and 24, Concession 5 sought approval to perform maintenance on the Mansfield Municipal Drain in 2011.

8. The owner(s) of 24, Concession 5 sought approval to perform maintenance on Flowing Creek Municipal Drain in 2011.

9. The owner(s) of 25, Concession 5 sought retroactive approval to perform maintenance on Flowing Creek Municipal Drain in 2012.

10. The owner of Lot 17, Concession 4 complained of flooding in 1987 just prior to the construction of the Hobbs Extension to relieve flooding in the vicinity of Conley and Flewellyn Roads.

It is important to note that the constructed drainage features on this landscape have been built over a long period of time with differing goals and to ever changing design standards. The majority of these watercourses are not designed to convey runoff from large storm events or spring thaws. They are designed to convey runoff from small storm events and reduce the time of ponding on fields. These drains were also built as the collectors for a drainage system; landowners were and are responsible for installing and maintaining either surface drainage channels or tile drains on their properties, which would outlet to the constructed drain, without these private drainage features the Municipal\Award drains may not reduce wet areas on adjacent properties.

6.2.1 Groundwater Interaction with Drains

Four locations were instrumented with drive point piezometers to determine if there was groundwater upwelling or loss of baseflow (Figure 3). This was done by measuring the vertical gradients in the piezometers. Table 6 summarizes the monitoring results from 2012 and 2013.

Table 6: Groundwater Levels and Vertical Gradients

Location	MP3			MP3-1			MP6			MP2		
Measure Point	121.197			123.675			122.6775			127.727		
Date	Grad	GW (in)	SW (out)	Grad	GW (in)	SW (out)	Grad	GW (in)	SW (out)	Grad	GW (in)	SW (out)
9-Jul-12		1.145	1.16		Dry	Dry		2.23	1.17		2.46	Dry
11-Jul-12		1.128			1.534	Dry		2.164			1.793	Dry
26-Jun-13	0.15	0.65	0.74	0.05	0.787	0.84	0.10	0.882	1.013	0.02	1.085	1.105
4-Jul-13	0.02	0.735	0.745	0.04	0.825	0.87	0.10	0.881	1.014	-0.17	1.089	0.93
24-Jul-13	0.03	0.735	0.755	0	0.75	0.75	0.16	0.847	1.046	0.04	1.1	1.14
24-Aug-13	0.03	0.745	0.762	-0.05	0.8	0.74	0.13	0.855	1.015	0.01	1.09	1.1

Note: Positive vertical gradients are upwards, negative vertical gradients are downwards

Upwards Gradient (blue shading)
Neutral Gradient (no shading)
Downward Gradient (orange shading)
Monitor recovering, Not representative (yellow shading)

MP3 is located on the east branch of Flowing Creek at Flewellyn Road and shows an upward gradient that becomes weaker as the summer period progresses. MP3-1 is 700 m to the west on the west branch of Flowing Creek and has a weaker upward gradient that reverses by late summer. Given the low permeability of the bedrock below this upward groundwater discharge is thought to be limited in volume and probably only locally derived by groundwater flowing laterally towards the creek in the overburden.

MP2 is located upstream on the west branch of Flowing Creek at Fernbank Road and shows a very weak upward gradient. On one occasion (July 4, 2013) the creek level was almost 20 cm higher, without a corresponding increase in the groundwater level, which reversed the gradient to a strong downwards condition. The gradient reversed itself to the pre-existing weak upward gradient which was recorded 20 days later. MP6 is located on the Hobbs Drain at Flewellyn Road (upstream of the diversion) and shows a stronger upward gradient that is consistent over the summer period. Watercress was observed at this location, which indicates continuous ground water discharge.

6.3 Vegetation & Wetlands

The vegetation within the study area reflects the limestone bedrock close to surface (generally within 50 cm), with occasional deeper sandy ridges that are possibly remnant glacial beaches. The slopes are relatively flat, with small changes in bedrock topography giving rise to basins in which wetlands have formed. The soils are derived from the underlying limestone therefore calcareous in nature.

Ottawa falls within the St. Lawrence-Lowlands physiographic region based on the underlying Paleozoic geology. Rowe (1972) includes the area in the Great Lakes – St. Lawrence Forest, characterized by Sugar Maple (*Acer saccharum*) and American beech (*Fagus grandifolia*), with red maple (*Acer rubrum*), yellow birch (*Betula alleghaniensis*), basswood (*Tilia americana*), white ash (*Fraxinus americana*), largetooth aspen (*Populus grandidentata*), red and burr oak (*Quercus rubra and Q. macrocarpa*), white and red pine (*Pinus strobus* and *P. resinosa*) and eastern hemlock (*Tsuga canadensis*). Drier sites are characterized by white cedar (*Thuja occidentalis*), white pine, white spruce (*Picea glauca*), white birch (*Betula papyrifera*) and trembling aspen (*Populus tremuloides*). Conifer forests and swamps in the two subwatersheds are typically dominated by white cedar with balsam fir and white spruce as common associates.(WESA/MMM 2007).

RVCA reports that overall the Flowing Creek subwatershed is 26% forested, with Hobbs Drain slightly greater at 32%. The current study area is confined to the headwaters of these subwatersheds. The forest cover is not homogeneous across the watershed, but rather concentrated in the headwaters where the shallow, stoney soils of the Farmington series are not well suited for agriculture. Wetlands (Flowing 7.2%, Hobbs almost 19%) follow a similar pattern except for the large natural area associated with Richmond Fen in the southern Hobbs (RVCA 2010).

Farmington soils are best suited to pasture because they are shallow, stoney and droughty. The water table can also be perched close to surface making them poorly drained. Under these conditions, landowners within the study area have installed tiles under their fields, and/or drains to increase the arable extent of fields but they remain subject to periodic flooding. As discussed above, the drains were not intended to convey large rainfall events or high spring flows, being sized to convey runoff from a 2-year storm event, but rather to drop the water table to permit cultivation. On such a flat landscape, it is not easy to drain away the water, and therefore these drains often remain full of water and attract American Beaver (*Castor canadensis*). The beaver build dams, aggravating the flooding and making maintenance of the drains much more difficult. Much of the study area has been cut over (by farmers and/or by beaver), and the early successional species (birch, poplar, aspen and willow thickets) dominate in many areas.

The wetlands occur on both mineral and organic soils. Common species observed included Freeman's or swamp maple (*Acer x freemanii*), white elm (*Ulmus americana*), white birch, eastern white cedar, red and black ash (*Fraxinus pennsylvanica* and *F. nigra*), balsam fir (*Abies balsamea*), with occasional Butternut (*Juglans cinerea*).

In southern Ontario, due to the long growing season and warm temperatures, the annual contribution of decaying material in wetlands (leaves and woody debris) is largely broken down into mineral components by soil organisms and summer heat. When a wetland occurs on mineral soils (clay, silt and/or sand), it is referred to as a mineral wetland in the ecological classification of land (Lee *et al* 1998). In some wetlands, decomposition of plant material lags behind the accumulation of leaves and woody debris, creating organic soils (also described as peatlands or muck). A soil profile is described as "organic" when this accumulation exceeds 40 cm, and therefore the plants that grow in this soil derive nutrients and water from this unique chemical environment. In order for this to occur, the wetland must be cooler than the adjacent mineral wetlands through a combination of site characteristics that include topography, exposure to the sun (i.e., cooler north-facing exposures promote accumulation of organic soil) and/or contribution of groundwater that maintains much cooler wetland temperatures during some or all of the growing season, as well as time (i.e., organic soils accumulate very slowly).

Mineral wetlands can expand and contract in much shorter timeframes with annual changes in precipitation that quickly affects surface water accumulation, drowning out vegetation characteristic of dry sites, and allowing plants adapted to survival under saturated conditions (i.e., wetland plants) to expand their footprint. Due to the much slower rates of infiltration and groundwater discharge, changes in peat accumulation are very much slower by orders of magnitude. For this reason, tracking the records of wetlands with organic soils assists in understanding the extent of historical wetlands as compared to mineral wetlands that may be the result of recent changes in water management.

Data from the following sources was reviewed to provide evidence of the accumulation of organic soils:

- Surficial Geology, Ontario Geological Survey, 2010 (Figure 11);
- The Goulbourn Wetland Complex Evaluation, 2005;
- City of Ottawa Wetlands (Figure 12);
- Map of soils for Carleton County (1944);
- Mapping provided in Environmental Impact Studies, (e.g., Muncaster 2010 Figure 13);
- Natural Environment Systems Strategy, City of Ottawa 1997 (Figure 14); and,
- OMAFRA Soils, 2011 (Figure 15);

Each wetland reported for the study area was given an identifier as indicated on Figure 11. The data sources were reviewed, and a table prepared to compare the classification across sources and through time. This tool provided a method to cross reference these resources; however it is unknown how heavily any one source relied on the others for their data. In other words, several sources may have been re-using information from another source. The data were also coarse, in that large areas were indicated as providing organic soils, whereas that characteristic may have been confined to only a portion of the feature. The field observations and consultation with stakeholders were useful to confirm that this approach had merit. The results of this inventory are provided in Appendix E.

The vegetation mapping from Environmental Impact Studies was used as a calibration tool to verify potential for organic soils (Figure 12). The Muncaster report is shown here as an example. The reports do not provide soils information, but Muncaster illustrates the wetland areas that correlate with wetland localities "S" and north "Q" on the north side of Fernbank Road east of Jinkinson Road (Appendix E) and suggests that fen-indicators are present. A fen is a peat accumulating wetland. For the sake of illustration, the units that are wetlands, or may be transitional wetlands are mapped in purple.

At flow monitoring station at Flewellyn Road west of Ironstone Court (SW3) and on Fernbank Road (SW2) (Figure 3), watercress (*Nasturtium officinale*) was observed. This plant is usually associated groundwater discharge. Mottled sculpin (*Cottus bairdii)* have been reported just to the south of this watershed northwest of the intersection of Garvin Road and Huntley Road in what appears to be Concession VI south of Mansfield Road (WESA/MMM 2007). It is groundwater discharge that provides the cold, wet conditions that allow organic soils to slowly accumulate over time. All three of these locations are on Flowing Creek.

The vegetation observed and reported in the wetlands (e.g., Black Ash, Swamp or Freeman's Maple) are communities that may occur on organic soils, or at least wetland mineral soils with an organic phase less than 40 cm. The Goulbourn Wetland Complex Evaluation states that over 50% of the wetland units have organic soil, and that was confirmed in the field for unit G north of Flewellyn Road (former Staltari Property, 6851 Flewellyn Road) and confirmed by Muncaster 2006.

Patterson and Associates (2003) did not sample soils in the wetlands, although since no map is provided it is not clear whether the property includes wetlands on Lots 19 and 20, Concession 10. Certainly the sand and gravels encountered would facilitate infiltration and discharge to topographic depressions. The static water levels were recorded on the same day as the drilling. If the wells had been permitted to recover, static groundwater may have been recorded closer to surface. A high water table and shallow soils were reporting and therefore fill was recommended for the septic bed construction.

These pieces of evidence provide corroboration that certain wetlands have existed on these lands for many years, and prior to the construction of drains and quarries. Based on these data, the wetlands for which organic indicators were reported are mapped on Figure 15. Note that the term "organic" is not well defined for many of the sources, and therefore this figure should be viewed as an inventory of potential occurrence rather than an accurate assessment of the location of organic soil profiles greater than 40 cm in depth.

6.3.1 Goulbourn Provincially Significant Wetland Complex

It is within the mandate of the Ontario Ministry of Natural Resources to evaluate wetlands in Ontario using the Ontario Wetland Evaluation System (OWES), which is updated periodically to reflect better understanding in wetlands science. This is a peer-reviewed approach to identifying those wetlands with important characteristics worthy of provincial interest (e.g., flood attenuation, erosion control, carbon sinks and wildlife habitat), and subject to protection under the Planning Act (1990) and the Provincial Policy Statement (2014). Under OWES, wetlands have been traditionally defined by the natural area within which at least 50% of the plant coverage is composed of "wetland species". These are species that can survive flooding, and therefore anoxic conditions for substantial portions of the growing season. More recent innovations to the application of OWES have included the use of wetland soils to assist in delineating areas where wetland plant coverage is problematic. These are soils that have characteristics that develop with saturation for most if not all the time.

The North Goulbourn Wetland Complex and Raceway Wetland were evaluated by MNR in 1990, but it became clear that extensive wetland areas had been overlooked. North Queensway, Rothbourne and Upper Poole wetland complexes are in the vicinity. Raceway wetland (Wetland B in this study), was evaluated in 1990, and complexed with Goulbourn. It has been suggested that all of these wetlands represent a single complex due to their proximity and shared functions (Huizer, 2005) however the mapping and reporting to support this was never completed. There have been local reports of Blanding's Turtle (*Emys blandingii*), a species listed as Threatened under the Endangered Species Act, 2007 from these wetlands (Smith 2013) A City of Ottawa retainer to identify additional wetlands that should be added to the Goulbourn complex was approved in 2004 and completed in 2005. General Habitat protection is provided to species such as the Blanding's Turtle under ESA, 2007, and the occurrence is also a trigger for listing of the wetland as provincially significant.

Subsequent to the presentation of the preliminary mapping, several of the wetland units were removed, represented in green on Figure 9. To be clear, the vegetation was mechanically removed and there have been attempts at drainage. In an area of high water table and near-level contours, the water does not drain well therefore the conditions that gave rise to the wetlands in the first place have not been substantially altered. Air photo interpretation of the wetland U in the Fernbank and Munster Road area shows water staining likely promoted by the removal of the wetland trees. Some of these drained areas were planted into crops and continual disturbance may permit some production. However the "former wetlands" that have not been cultivated have recovered wetland characteristics, and would likely now be evaluated as wetlands once again. On the basis of the presence of wetland soils, it is possible to delineate wetlands without cover of wetland plants. Within the current planning context, designation as a wetland does not remove the potential for agriculture to continue however constraints under the Planning Act may apply with respect to development potential.

For reasons that are not clear, the Fernbank Wetland was removed from those wetlands included as being "provincially significant" and are now represented as "non-significant". This removes them from the sphere of provincial interest, but due to the features and functions provided by this wetland, Ottawa may consider this wetland of regional significance and therefore still worthy of protection.

The 2011 City of Ottawa wetland layer (Figure 9) has included some of these wetlands.

6.4 Interactions: Groundwater, Drainage and Vegetation

Groundwater levels are typically high under the terrain conditions found in the study area due to the shallow soil and underlying limestone beds restricting drainage of groundwater to depth. The land is relatively flat and therefore there is little elevation difference to create a lateral driving head. Hence the water tends to pond at or near surface. Because the bedrock is both gently folded and relatively flat, there are plenty of low areas that capture surface water that cannot easily drain away. The presence of sand overburden is thin and unlikely to create a significant infiltration blanket. However, it retains and detains water, keeping the water table high. The low lying pockets therefore tend to host wetland features. Of those wetland features, most that exist in 2011 also have developed at least in part, an organic soil profile due to the combination of site, climate and lack of drainage. This may have resulted in wetlands with relatively stable hydroperiods, which would be consistent with the development of organic soils. As a consequence, in any particular year where there is above average precipitation, water accumulates and flooding occurs outside of the wetlands. This is consistent with stakeholder reports.

Before the municipal drain system was progressively built, much of this area would have been a prehistoric wetland. The advent of agricultural, local drainage and municipal drains led to the shrinkage of these wetlands. In the northern part of the two watersheds, soils are the thinnest and drains could not be deepened without blasting. In combination with wetland removal as development proceeded elsewhere in the watershed, the portions of the Flowing Creek and Hobbs Drain subwatersheds in the study area have declined in wetland area by 23%. It would appear that the organic wetlands have been the most stable over time.

Note that Environment Canada suggests that a healthy watershed typically is characterized by a minimum of 10% wetlands; subwatersheds a minimum of 6%. Flowing Creek has retained the minimum largely due to the substantial Goulbourn Wetland Complex. The wetlands in the upper subwatershed are the only reason that this threshold has been met. Hobbs Drain is in a deficit position at 4.5%, most of which occurs in the Richmond Fen (another organic wetland) but enhanced by the headwater wetlands within the study area.

6.5 Case Study: Lower Hobbs Drain and Upper Flowing Creek

As noted above, there has been an observable shift in wetland loss through shrinkage that has been offset in part by the formation of wetlands by 2011 that were cultivated in 1946 (Figure 10). As evidenced by the Award Drain locations (the straightened “intermittent watercourses” on Figure 8, and the occurrence of wetlands in 1946, the ability to cultivate the fields was controlled by a very small change in the elevation of the water table. With each successive change in drainage toward systems that were never meant to take storm flows, and on such a flat landscape, the potential for wetlands to form upstream of the engineering is likely, and appears to have happened.

Appendix D provides a chronology of the construction of drains in the study area. Drains built pre-1963, subject to Award Drainage Act in the upper Hobbs and upper Flowing, permitted agriculture on what otherwise would have been wetland. Sometime before 1963 when it appears on the aerial photography, a link was constructed crossing the subwatershed boundaries of Flowing Creek and Hobbs Drain (Figure 5). This had the effect of directing the extreme northern reaches of Flowing Creek into Hobbs.

Ten or so years later, in 1972-73 the Hobbs Municipal Drainage system was constructed in the lower Hobbs subwatershed, south of Fallowfield including new and modified culverts, possibly in response to increased flooding as a result of the diversion upstream. In 1979 the Goulbourn Township Ditch was constructed which resulted in local flooding in Lots 15 and 16, Concession 9. In 1983 drainage from the subdivision under construction directed flow easterly into the Hobbs Drain, across the south end of 7660 Fernbank Rd. which gradually became obstructed causing the dieback of 30 acres of cedar forest.

In 1988 the extension of Hobbs Drain was built to relieve flooding around the Goulbourn Ditch. Three culverts were made larger where there was historical farm drainage (e.g., double 1250’s to double 1400’s, single 900 to double 1200’s) (Appendix D, Section 5). This would increase water volume directed to the southeast but there appears to have been no increase in the capacity to absorb it downstream.

In the same year Cavanaugh built a ditch from the Goulbourn Quarry southwest, picking up drainage from the north and redirecting flow away from the Hobbs Extension and toward the ditch at Fallowfield and Hobbs Drain to the south creating another increase in flow. This may have been responsible for the reduced the size of wetlands interpreted in 1946 on this branch. The Goulbourn Quarry contributed little to the problem as it was not in operation after 1976.

As early as 1987 there was a complaint of flooding in the lower Hobbs to which the system drained. In 1999, Cavanaugh cleared the drainage across the back of 7660 Fernbank Rd. sufficiently to allow cultivation (Lot 11 and 12, Concession 9 and Lot 12, Concession 8.

In 2010 landowners cleaned out the existing Lot 16 and 17, Concession 9 drainage that had been bypassed before 1963, to restore contribution of the headwaters to Flowing Creek. The following year was a drought and the date of the aerial photography. It is too early to plot whether this correction has had an effect on wetland formation.

The net result of these changes appears to have created water accumulations that eventually converted the fields upstream of the Hobbs Extension into permanent wetland. Similarly, the 1974 drain improvements in the Mansfield Drain likely led to the net loss of wetland in the upper reaches.

7.0 DATA GAPS

A significant component of the Phase I study included data compilation and review, and the identification of missing information are recommendations to fill the gaps. In some cases, as with historical records of drainage ditches, it may not be practical to pursue the missing information. In other cases additional research and field investigation may be deemed necessary moving forward into Phase II of the project. Data gaps which have been identified are listed below. Recommendations for filling these gaps are detailed in Section 7.1.

Data that would assist in accounting for the changes in wetland cover over time include:

- Missing reports and drawings for the Award Drains;
- Missing plan and profile drawings for the original Hobbs and Mansfield Municipal Drains;
- Inconsistencies in drainage boundaries between the City and the conservation authorities;
- Missing detailed information on culverts;
- Missing information on the extent to which lands are or have been tile drained;
- Need for a survey vs. digital elevation model;
- Evaluation of effects of drain obstruction;
- Delineation of organic soils; and,
- Development of a time sequence.

7.1 Mitigation of Data Gaps

7.1.1 Missing reports and drawings for the Award Drains

Award Drains were built under the authority of the Ditches and Watercourse Act which was passed in 1874 and repealed in 1963. No Award Drains were constructed after 1963 when construction of drains was then incorporated into Sections 2 and 3 of the Drainage Act. Award Drains were built by engineers at the request of land owners to provide drainage for farm fields. The maintenance of Award Drains is the responsibility of the land owners, so maintenance records would not have been kept by the municipality. Given that these Drains no longer exist and that they would have been built at least 50 years ago, it is possible that the records and design drawings from their construction have been lost.

7.1.2 Missing plan and profile drawings for the Hobbs and Mansfield Municipal Drains

No Plan and profile drawings have been located for the Hobbs or Mansfield Municipal Drains. Drainage area plans were located, but these do not provide enough detail to calculate the conveyance capacity of the drains. Given the age of these drains it is possible that the Plan and profile drawings have been lost.

7.1.3 Inconsistencies in Drainage Boundaries between the City and the Conservation Authorities

Given the flat topography in the area and the large number of drainage features, it is difficult to determine the existing drainage boundaries for various watercourses. In order to accurately describe the existing conditions, drainage areas should be verified using detailed topographic mapping. LiDAR mapping is available for the site and RVCA is in the process of defining watershed boundaries as part of their review process. The same technology can be applied to finer scale drainage boundaries.

7.1.4 Missing Detailed Information on Culverts

A field investigation is needed to visually evaluate the drains, look for obvious blockages and signs of erosion and sediment build up that may restrict flow, areas with flow diversions, and culverts. Areas where blocked or damaged tile drains are visible along the drain should also be noted. The outcome of filling this gap would be a better functional analysis of drains and an ability to determine whether they functioning the way in which they were intended.

7.1.5 Locate Tile Drain Mapping

As the drains in some areas are designed as outlets for tile drains and not specifically for surface drainage some areas may be wet due to failed tile drainage systems. Areas that required tile drains in order to be farmed may have been wetlands and reverted to their natural state once the tile drains failed. Areas where wetland change has occurred based on historical aerial photography interpretation should be targeted.

7.1.6 Delineation of Organic Soils

The wetland boundaries were determined in many areas via air photo interpretation and aerial reconnaissance (Huizer 2003), although LiDAR was used to refine the City of Ottawa Wetland Layer (Figure 8). The soil data available is small scale and generalized. Field truthing of soil conditions to determine the extent of hydric (*i.e.*, wetland) soils and especially organic soils (which by definition are also hydric but indicators of permanence) would provide more clarity with respect to the extent of historical groundwater-connected wetland conditions as a baseline for the oldest wetlands within the study area. This baseline can then be used in conjunction with the hydrologic workplan to model wetland dynamics through time.

7.1.7 Need for a Survey vs. Digital Elevation Model

Due to the scale of this project a detailed topographic survey of the study area and the existing drains would be costly and time consuming. That level of detail is also not required given that this is a relatively high level analysis. It is our recommendation that site investigation in combination with the use of the DEM be used to refine the drainage boundaries and location of drains within the study area.

During Phase II of this study, areas where the DEM is deemed to have insufficient detail to resolve drainage boundaries, will be surveyed to fill the gap. Survey may also be required if sections of the drain need to be modeled in order to determine if they have the hydraulic capacity to convey stormwater.

A field survey should be conducted to visually asses the drain and culverts, specifically noting areas where the drain is obstructed or culverts have become raised or damaged. The engineer should also visit the site of the historical diversion of flows from Flowing Creek to the Hobbs Municipal Drain in order to determine the relative proportion of this runoff that is directed to Flowing Creek as a result of the 2010 maintenance.

7.1.8 Evaluation of Effects of Drain Obstruction

Anecdotal evidence has been provided that indicates that the relatively low flows on this landscape require regular drain maintenance to ensure that the drains function properly. They quickly become obstructed with vegetation growth, by woody vegetation on the banks falling into the drain, and by active dam building activities by the population of American Beaver. Site investigations, a more detailed understanding of the topography of the study area and the more detailed chronosequence of events would be useful to evaluate the significance of these effects and the capacity to enhance the wetland cover through time.

7.1.9 Development of a Time Sequence

In order to demonstrate that wetland change had occurred, stereo pairs of 1946 air photos were interpreted for the presence of wetlands because they predated the drainage works. There are key times in the chronosequence of events over time (e.g., drainage maintenance, diversion of drainage, development and road construction) that may have affected the flooding being reported by landowners. Air photo coverage is available and it is recommended that this be undertaken for these key years to better link cause and effect.

8.0 CONCLUSIONS

Based on the above results and discussion we provide the following conclusions.

1. The study area is defined as the portion of the subwatersheds of Flowing Creek and Hobbs Drain north of Mansfield Drive based on the availability of historical aerial photography and wetland occurrence. This is the area within which the additional wetlands designated as Provincially Significant are located. There is no evidence that drainage from Poole Creek has been diverted to Flowing Creek, however the two subwatersheds do share headwater wetlands so minor changes in water supply may affect both drainages.
2. There has been quantifiable change in wetland cover within this study area between 1946 and 2011 with a net removal of 23% of wetland, reducing the percent wetland cover in the watersheds from 22% to 17%, a loss of 195 ha.

3. The source of this change is not limited to wetland shrinkage as a result of removals due to development (residential and quarries) and drainage for agricultural purposes. That is, there is loss and gain of wetlands. New wetlands have been created since 1946 which may be due to drainage diversion, lack of maintenance of drains and culverts and active obstruction by American Beavers.
4. The largest wetland removal has occurred in the lower Flowing Creek. The largest gains have occurred in the lower Hobbs Drain, as well as the upper Flowing Creek.
5. The quarry operations do not appear to be responsible for large scale changes in wetland cover.
6. Based on the occurrence of organic soils (peat), which accumulates over a long time frame, many of the wetlands across this landscape are long term standing wetlands.
7. Evidence for cool/cold water attributes (watercress, sculpin) within the study area are indicative of permanent features supported by groundwater discharge.
8. Regardless of origin of the wetlands, if they are demonstrated habitat for a species afforded General Habitat protection under the Endangered Species Act, 2007, they are Provincially Significant by definition.
9. Key outcomes of Phase II should include:

9.1 Delineation of drainage catchments and topographic thresholds for flow that would influence wetland formation;

9.2 Water surplus (precipitation less evapotranspiraton) reported in quarry reports should be calibrated in Phase II against the streamflow measured during this study to determine how these values influence water accumulation

9.3 Clarification of existing flow patterns (including culvert condition and beaver management) based on site investigation for comparison to historical conditions and rates of wetland cover change;

9.4 Air photo interpretation of historical aerial photography to determine point in time responses of wetland cover to landscape changes;

9.5 Provide a recommendation for water storage in the wetlands to maintain ecological and hydrological function(s) and suggest an appropriate policy framework to maintain those functions.

9.0 TERMS OF REFERENCE PHASE II

The Province of Ontario has identified an approach to the identification and evaluation of wetlands (Ontario Wetland Evaluation System) that relies on the 50% wetland vegetation rule discussed above, which is now applied with an awareness of the underlying hydric soils. Regardless of the history of the identification of Provincially Significant Wetlands within the study area, it can be expected that the Ministry of Natural Resources and Forestry (OMNRF) will continue to use this metric as the tool for delineation, and subsequent evaluation. OWES evaluates wetlands as they occur on the landscape at the time of evaluation regardless of historical or recent events that may have created, enhanced or reduced them. Some discretion is available to the evaluator with respect to inclusions and exclusions, and in the way in which wetland complexes are compiled, but all decisions must be documented with a rationale and approved by OMNRF.

The evidence presented documents the change in wetland cover on this landscape. Wetlands clearly provide ecosystem services that are important on the landscape and should be represented in sufficient cover to ensure the healthy benefits are protected. This landscape can be modelled to determine changes in locations, magnitude and duration of wetland coverage. This information would clarify claims by landowners with respect to “unfair” flooding that has led to the creation of wetlands within recent times. It would provide evidence as to whether it is reasonable to propose a “baseline condition” that would provide reasonable ecosystem benefits while managing landowner expectations.

Recently the OMNRF has entered into consultation with respect to the potential to allow wetland compensation for wetlands proposed to be removed from the landscape. In view of this initiative, a case study that examines wetland change over time and the consequences to the subwatersheds may be timely.

The Terms of Reference are aimed at the determination of a “reference condition” for wetland coverage that integrates the hydrogeological, hydrological and ecological services that wetlands provide on this landscape to control flooding and other ecosystem services related to wetland functions. The outcome will have consequences for the maintenance of drainage, control of peak flows and protection of private property to avoid damage claims. The role of beaver in maintaining wetlands and/or impeding drainage should also be addressed.

The policy framework that may be designed in order to maintain these important functions can then be determined by the City of Ottawa.

The first phase of this study has identified some key findings and some information gaps. The goal of that phase was to scope this undertaking by understanding the features and functions of the landscape that govern wetland presence and quality. It was also important to identify those factors that did not have a great influence, and thus enable the second phase to focus on key conditions. The following Terms of Reference is intended to provide guidance on what needs to be completed, and what additional information and analyses are needed meet the goals and objectives of this work.

9.1 Goals and Objectives

The goal of Phase II is to identify defensible and functional limits of wetland on this landscape with the objective of informing a Schedule of Significant Wetlands to the City of Ottawa Official Plan Review in 2016.

Phase II will be prepared within the Study Area defined as the headwaters of the Hobbs Drain and Flowing Creek subwatersheds framed by Hwy 417/Hazeldean Road in the north, Mansfield Road in the south, Munster Road in the west and Huntley Road in the east.

1. Complete air photo interpretation of wetlands including drain locations, farms and residential development and quarries; for 1963, 1978, 1991 and 2011 to correlate with significant changes on the landscape.

2. Prepare a water balance in two steps. Average annual surplus for each year should be examined, and the implication for reference years (1946, 1963, 1978, 1991 and 2011) determined.

3. Use GIS Trend Analysis to identify landscape changes (wetlands, farms, drainage); determine % change in wetlands over time to include flow directions.

4. Confirmation of quarry discharge in the 2012 period when the City measured streamflows should be sought to confirm the conclusions of a lack of quarry impact.

5. For wetlands that have been affected by watercourse diversion with potential for growth or reduction (e.g., Fernbank and Munster), and a specific case upstream and downstream of areas where constructed drains have diverted water into a different watershed (e.g., Flowing to Hobbs watersheds and Conley and Flewellyn to the south and wetland Z to the north). Compare wetlands to determine whether changes are hydraulic (i.e., function of drains and culverts) vs. a hydrologic events (i.e., changes to the landscape feeding the drains and culverts), or both. Test whether the wetland footprint is a result of the failure of drain function. (based on indications that the quarry discharge has had no effect).

6. Prepare a Hydrologic Model to apply to test cases determined from air photo interpretation and trend analysis, where the relationship wetland development and drain capacity can be modelled.

7. Identify key ecosystem services and thresholds for performance to satisfy the legislative framework and requirements to maintain the water balance within the study area.

8. Provide a framework of policy recommendations to support the management of ecosystem services associated with wetlands for the City of Ottawa Official Plan.

10.0REFERENCES

Alex. J. Graham Engineering Consultants Ltd. 1972. Engineer's Report for the Hobbs Municipal Drain, Township of Goulbourn. June 28, 1972.

Alex J. Graham Engineering Consultants Ltd. 1974. Engineer's Report for the Construction of the Mansfield Municipal Drainage Works, Township of Goulbourn. Revised July 1974.

Alex .J. Graham Engineering. 1972. Engineer's Report for the Hobbs Municipal Drain, Township of Gouldbourn. Revised June 28, 1972 – to comply with Court of Revisions Decisions.

Chapman, L.J. and D.F. Putnam.1984.The Physiography of Southern Ontario, Third Edition

City of Ottawa. 2011. Characterization of Ottawa's Watersheds: An Asset Management Approach to Natural Systems. Document 1. Available on line: http://ottawa.ca/en/residents/water-and-environment/air-land-and-water/characterization-ottawas-watersheds.

City of Ottawa (LiDAR). 2011. Mapping Program for City of Ottawa. LiDAR mapping and Digital Elevation Model (DEM) Geographical Information System (GIS). Obtained 2011.

City of Ottawa, 2011. The Jock River Reach 2 Subwatershed Study Existing Conditions Summary

Endangered Species Act. 2007. Statutes of Ontario, 2997, Chapter 6. O Reg 242/08. Last amendment: O. Reg. 232/14. Accessed on line: http://www.ontario.ca/laws/statute/07e06

G.A Hills, N.R Richards and F.F Morwick. 1994. Soil Survey of Carleton County. Report No. 7 of the Ontario Soil Survey. Experimental Farms Service, Dominion Department of Agriculture and the Ontario Agricultural College. Available: http://sis.agr.gc.ca/cansis/publications/surveys/on/on7/index.html.

Golder Associates. 2000. Summary Statement Category 2 Class " A". License application for A Quarry Operation Proposed Stittsville Quarry. Parts of Lots 14 and 15, Concession XI, Township of Goulbourn Region of Ottawa-Carleton, Ontario. Prepared for R.W Tomlinson Limited, July 2000.

Golder Associates. 2010. Cumberland ready-Mix PTTW Application # 98-P4060, 891 Jinkinson Road.

Government of Canada. 1985. Fisheries Act (R.S.C., 1985, c. F-14) Accessed on line http://laws-lois.justice.gc.ca/eng/acts/F-14/. Last amended on 2015-02-26.

Government of Ontario 1990. The Planning Act. R.S.O. 1990, Chapter P.13. Accessed on line : http://www.elaws.gov.on.ca/DBLaws/Statutes/English/90p13_e.htm

Government of Ontario. 1997. Fish and Wildlife Conservation Act, 1997. S.O. 1997, Chapter 41. Including new Regulatory Amendments 2012. Accessed on line: http://www.ontario.ca/laws/statute/97f41

Huizer, Ron (Beacon Environmental). 2005. City's Consultant Field Visits – Identification of new Provincially Significant Wetlands within Goulbourn Ward. To Susan Murphy (City of Ottawa), September 28, 2005. 5 pages.

Huizer, Ron (Jacques Whitford). 2005. Pers. comm. Flewellyn Wetlands including: wetlands Maps, Report. Communication to Suzan Murphy (City of Ottawa) January 19, 2005.

Huizer, Ron (Ecosurveys Ltd). 2006. City's Consultant Field Visits – Identification of new Provincially Significant Wetlands within Goulbourn Ward. To Susan Murphy (City of Ottawa), March 15, 2006. 3 pages.

J.D Patterson and Associates Limited. 2003. Terrain Analysis and Hydrological Study - Proposed Residential Development West ½ of Lot 18, Concession 9, Township of Goulbourn City of Ottawa, Ontario. Prepared for Flewellyn Land Holdings Inc. Report no. G8868-1, June 18, 2003.

Lee, H.T., W.D. Bakowsky, J. Riley, J. Bowles, M. Puddister, P. Uhlig and S. McMurray. 1998. Ecological Land Classification for Southern Ontario: First Approximation and Its Application. Ontario Ministry of Natural Resources, Southcentral Science Section, Science Development and Transfer Branch. SCSS Field Guide FG-02. North Bay, Ontario. 225 pp.

Ontario Ministry of Agriculture and Food and Rural Affairs. 1977. The Soils of the Regional Municipality of Ottawa-Carleton.

Ministry of Agriculture, Food and Rural Affairs. 1874. Ditches and Watercourse Act. 1874. Repealed June 1, 1963. Accessed on line: http://www.omafra.gov.on.ca.

Ministry of Agriculture, Food and Rural Affairs. 2010. Drainage Act, R.S.O. 1990, c. D.17. Last amendment: 2010, c. 16, Sched. 1, s. 2. Accessed on line: http://www.ontario.ca/laws

Ministry of Agriculture, Food and Rural Affairs. 2011. Various Maps (Drainage, Soils, Land Use. Accessed 2011 on line - http://www.omafra.gov.on.ca.

Ministry of Agriculture, Food and Rural Affairs. 2013. Drainage Legislation Fact Sheet, Last revised 1997. R.W. Irwin - School of Engineering/University of Guelph, Accessed on line: http://www.omafra.gov.on.ca/english/engineer/facts/89-166.htm.

Ministry of Municipal Affairs and Housing (2014). Provincial Policy Statement. Queen's Printer for Ontario.

Ministry of Natural Resources- Kemptville District. 2005. Wetland Data Scoring Record for Goulbourn Wetland Complex (Amalgamation of wetland evaluations - originally evaluated from 1990 through 1995).

Ministry of Natural Resources - Land Information Ontario. 2013. Digital Data, open source including evaluated and non-evaluated wetlands. Accessed 2013.

Mississippi Valley Conservation Authority (MVCA). 2012. Watershed Maps. Accessed June 2012 on-line: http://mvc.on.ca/mvca-watershed-map/.

Muncaster Environmental Planning Inc. 2006. Environmental Impact Statement, Proposed residential Development Lot 18 (Southwest Part, Concession IX (former Township of Goldbourn) City of Ottawa. Prepared for Flewellyn Land Holdings Inc.

Muncaster Environmental Planning Inc. 2003. Environmental Impact Statement. Part Lot `7, Concession IX Goulbourn Ward, City of Ottawa. Prepared for Mario Staltari. March 2003.

Muncaster Environmental Planning Inc. 2010. Field Observations. Concession X. Lots 13 & 14, Goulbourn Ward, City of Ottawa Natural Heritage Update – Fernbank Road Site, Spring 2010 Natural Heritage Observations. 5 pages with Figures.

Ontario Geology Survey. 2010. Ontario Geological Survey 2010. Surficial geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 128 – Revised. Publications thru Ministry of Northern Development, Mines and Forestry

Rideau Valley Conservation Authority (RVCA). 2010. Jock River Subwateshed Report 2010 - Flowing Creek assessment data, including: maps, Surface Water Quality, Riparian Zone Condition, Land Cover, Groundwater Resources, Surface Water Resources. Accessed on line: http://www.rvca.ca/watershed/subwatershed_reporting/jock/sub-cachment_reports/flowing_creek/flowing_creek_index.html

Rideau Valley Conservation Authority (RVCA). 2010. Jock River Subwateshed Report 2010 – Hobbs Drain assessment data, including: maps, Surface Water Quality, Riparian Zone Condition, Land Cover, Groundwater Resources, Surface Water Resources. Accessed on line: http://www.rvca.ca/watershed/subwatershed_reporting/jock/sub-cachment_reports/flowing_creek/flowing_creek_index.html

Rideau Valley Conservation Authority (RVCA). 2012. Watershed maps. Accessed June 2012 on-line: http://www.rvca.ca/watershed/.

Rideau Valley Conservation Authority. 2006. Ontario Regulation 174/06 — Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation. Accessed on line: http://www.rvca.ca/plan-reg/regulations.html

Regional Municipality of Ottawa-Carleton. 1997. The Natural Environment System Strategy, (NESS) Digital Vegetation Data, Obtained 2011 - from Planning and Development Approvals Branch, Including Site Report 304 (Stittsville West Natural Summary Report) as referenced in Brunton, D.F. 1997. Summary: Natural Area Reports for Natural Areas West of Rideau River (500 series). Prepared for the Regional Municipality of Ottawa-Carleton, Planning and Development Approvals Department. 164 pp.

Regional Municipality of Ottawa-Carleton. 1976. Ottawa and Rideau River corridors: Volume 1 of Background report. 44 pages.

Rowe, J.S. 1972. Forest Regions of Canada. Canadian Forest Service Publication No. 1300. 172 pp.

Smith, Donald, 2013. Personal Communication. Resident of Huntley Road and Professor of Biology (retired), Carleton University.

South Nation River Conservation Authority, Rideau Valley Conservation Authority and Mississippi Valley Conservation Authority. 2011. Township of North Gower Municipal Drain Classification Map, Mapping of municipal drains in the South Nation River, Rideau River, and Mississippi River watersheds valid from March 2011 to March 2012.

Stow, Nicholas. Pers. comm. Planner III, Planning and Growth Management, Infrastructure Services and Community Sustainability, Ottawa.

TEEB- The Economics of Ecosystems and Biodiversity. 2009. The Economics of Ecosystems and Biodiversity for National and International Policy Makers – Summary: Responding to the Value of Nature 2009.

TEEB- The Economics of Ecosystems and Biodiversity. 2010. A Quick Guide to the Economics of Ecosystems and Biodiversity for Local and Regional Policy Makers (2010).

Totten Sims Hubucki Associates. 1988. Final Engineer's Report Hobbs Drain Extension, Township of Goulbourn, Revised September, 1988.

Water & Earth Sciences Associates (WESA) and Marshall Macklin Monaghan Limited (MMM). 2007. Jock River Reach 2 & Mud Creek Subwatershed Study Existing Conditions Report Volume 1: Report and 2: Figures. Prepared for the City of Ottawa.

Wilson, Stephen, 2015. Personal communication. Author of Golder Quarry reports.

11.0STATEMENT OF LIMITATIONS

This report has been prepared and the work referred to in this report has been undertaken by SLR for City of Ottawa. It is intended for the sole and exclusive use of City of Ottawa and its authorized agents for the purpose(s) set out in this report. Any use of, reliance on or decision made based on this report by any person other than City of Ottawa for any purpose, or by City of Ottawa for a purpose other than the purpose(s) set out in this report, is the sole responsibility of such other person or City of Ottawa City of Ottawa and SLR make no representation or warranty to any other person with regard to this report and the work referred to in this report and they accept no duty of care to any other person or any liability or responsibility whatsoever for any losses, expenses, damages, fines, penalties or other harm that may be suffered or incurred by any other person as a result of the use of, reliance on, any decision made or any action taken based on this report or the work referred to in this report.

The investigation undertaken by SLR with respect to this report and any conclusions or recommendations made in this report reflect SLR's judgment based on the site conditions observed at the time of the site inspection on the date(s) set out in this report (if any), on information available at the time of preparation of this report and on the interpretation of data collected from the field investigation (if undertaken). This report has been prepared for specific application to this site. Unless otherwise stated, the findings cannot be extended to previous or future site conditions.

Nothing in this report is intended to constitute or provide a legal opinion. SLR makes no representation as to the requirements of or compliance with environmental laws, rules, regulations or policies established by federal, provincial or local government bodies. References to the policy context for the peer review are for information purposes only, and must be validated by a certified Environmental Planner. Revisions to the regulatory standards referred to in this report may be expected over time. As a result, modifications to the findings, conclusions and recommendations in this report may be necessary.

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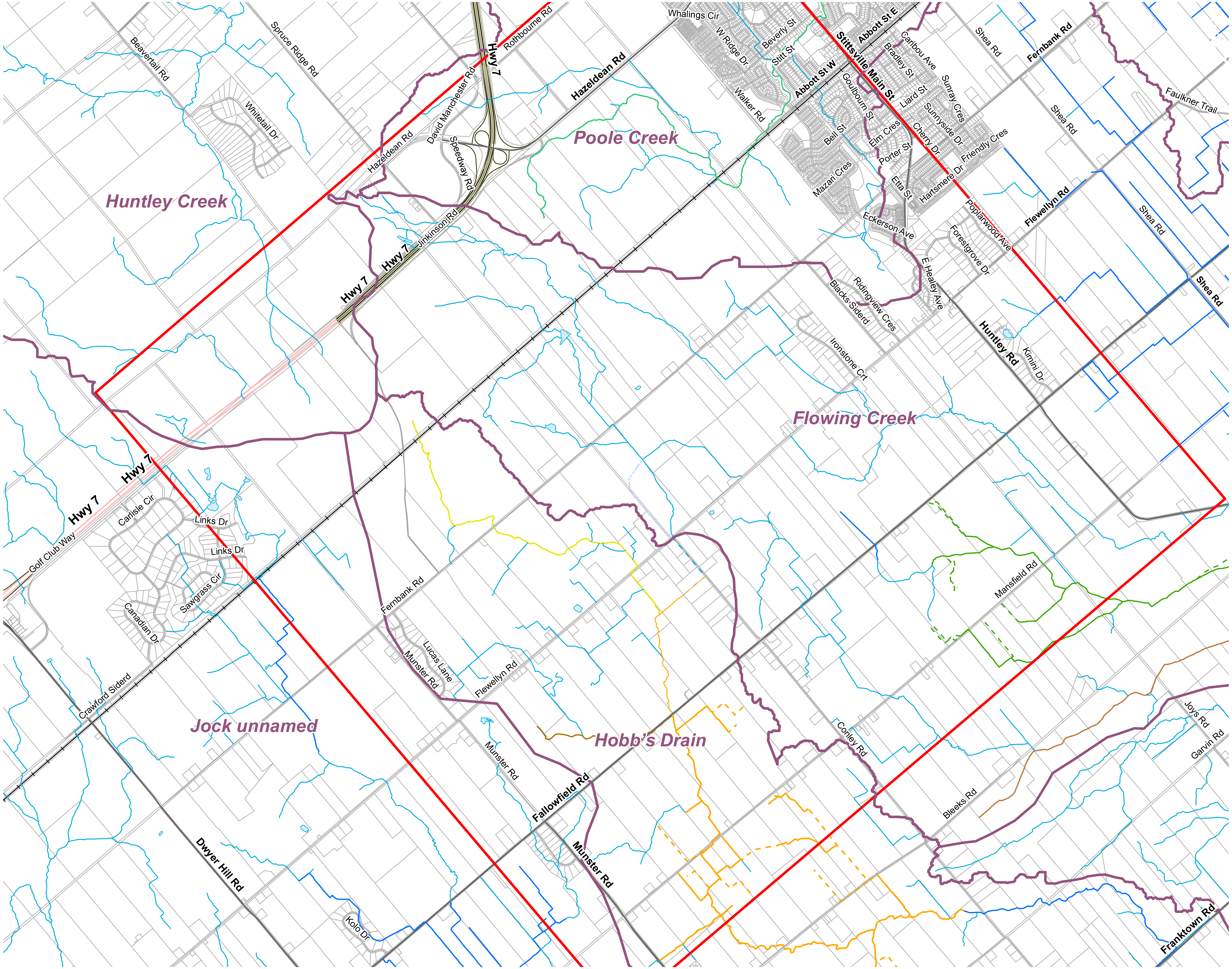
FIGURES

Flewellyn Cumulative Effects Study
City of Ottawa
SLR Project No.: 209.40105.00000



LEGEND

- StudyArea
- Subwatersheds (City of Ottawa)
- Waterbodies
- Award Drain (Pre 1963)
- Flowing Creek Award Drain (Pre 1963)
- Hobbs Municipal Drain (1972-73, approx. location)
- Hobbs Municipal Drain (1972-73)
- Hobbs Municipal Drain Extension (1988)
- Hobbs Municipal Drain Extension (1988, approx. location)
- Mansfield Municipal Drain (1974, approx. location)
- Mansfield Municipal Drain (1974)
- Municipal Drain
- Quarry Ditch (1987-88, approx. location)
- Quarry Ditch (1987-88)
- Township of Goulbour Ditch (1979)
- Poole Creek
- Jock River
- Unclassifed Constructed Watercourse (Pre 1963)
- Waterbody Segment

0 0.5 1 2 Kilometers

SCALE: 1:40,095
NAD 1983 UTM Zone 18N

NOTES

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CITY OF OTTAWA

FLEWELLYN CUMULATIVE EFFECTS STUDY

STUDY AREA AND EXISTING SUB-WATERSHED BOUNDARIES

December 1, 2015	Rev A	Figure No.
Project No. 209.40105.00000		1

SLR

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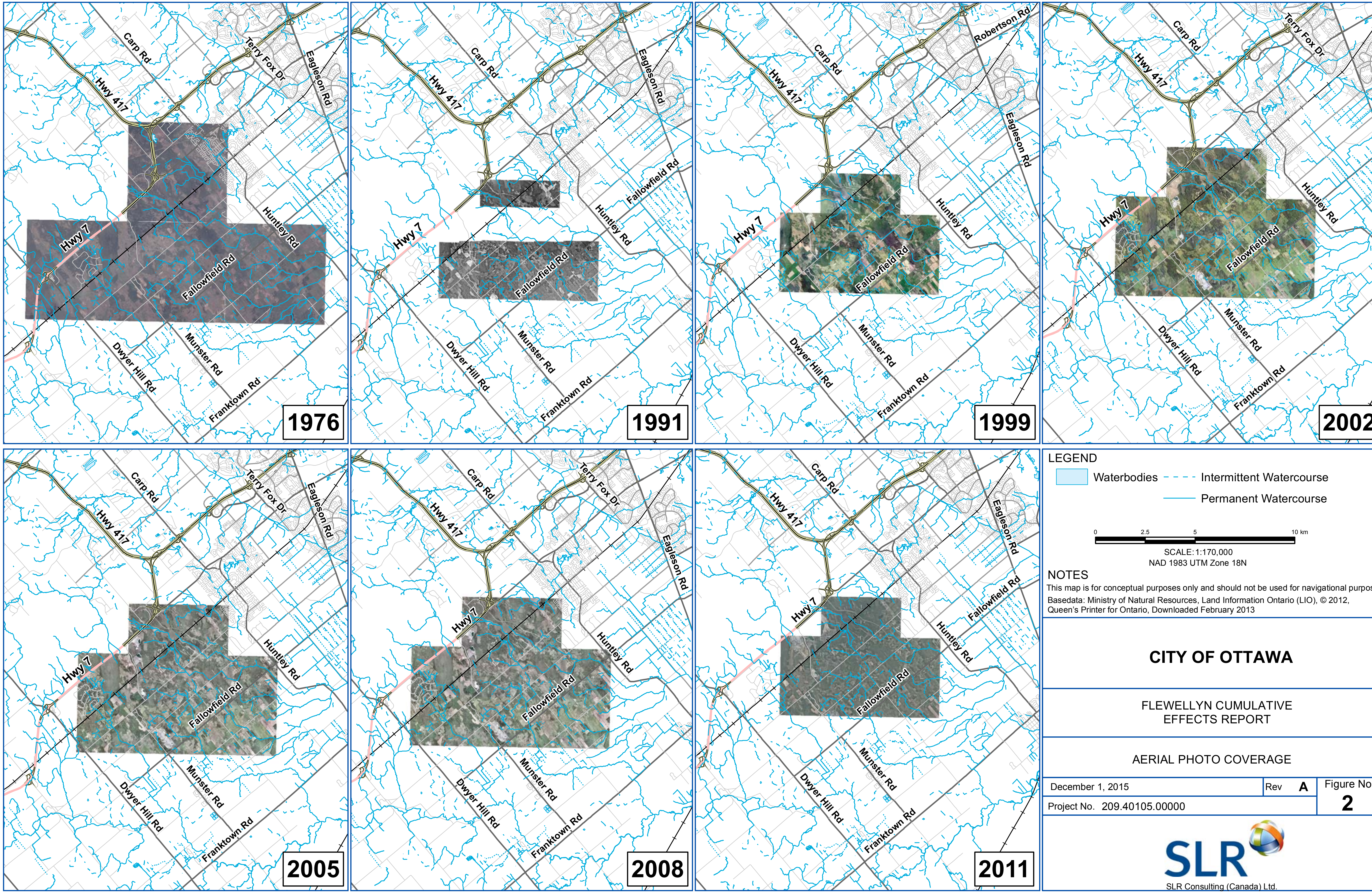

NOTES

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CITY OF OTTAWA

FLEWELLYN CUMULATIVE EFFECTS REPORT

AERIAL PHOTO COVERAGE

December 1, 2015	Rev **A**	Figure No. **2**
Project No. 209.40105.00000		

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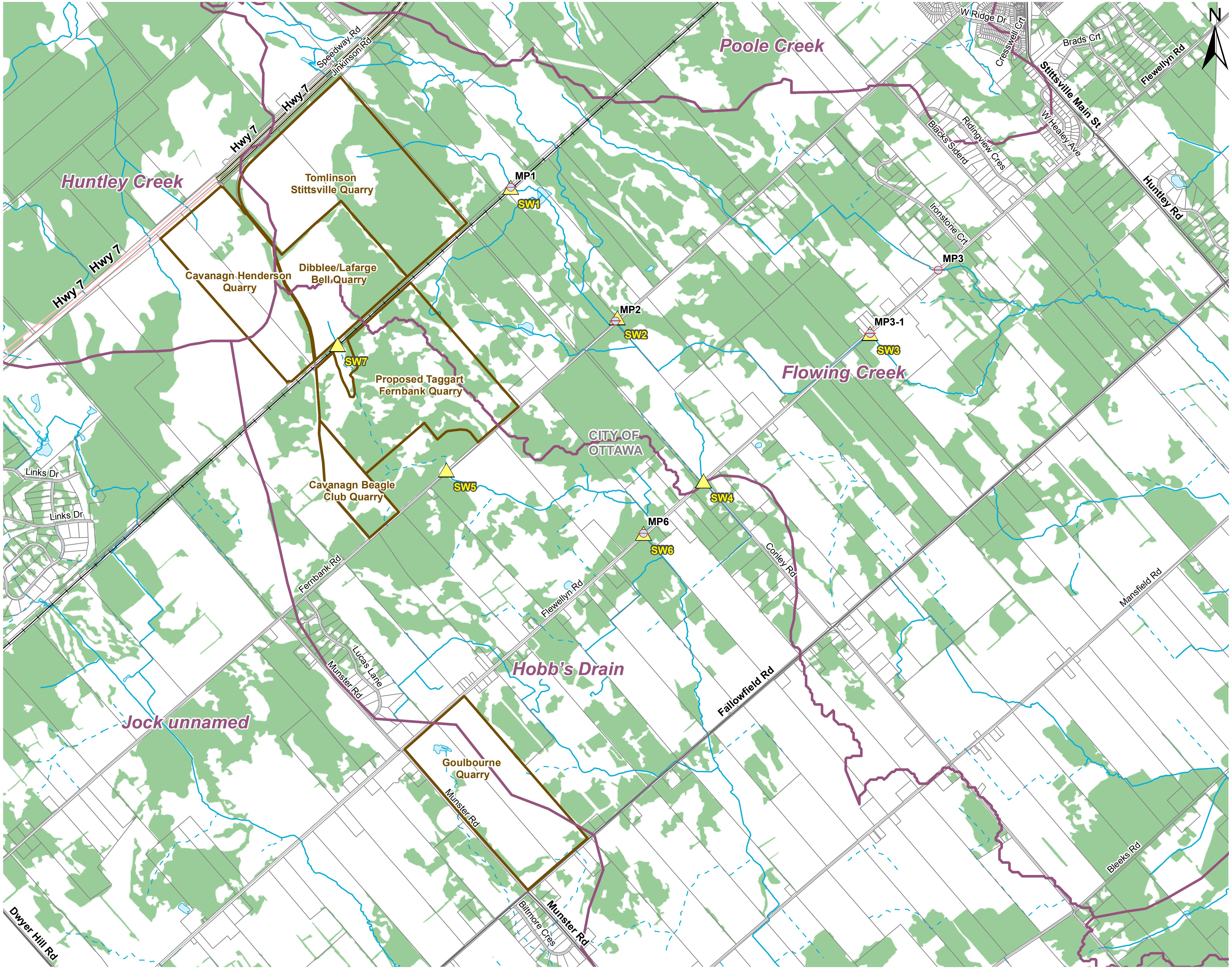

LEGEND

- Quarry Property Boundaries
- Subwatersheds (City of Ottawa)
- Mini-piezometer
- Stream Flow Station
- Parcel Fabric
- Municipal Boundary
- Wooded Area
- Waterbodies
- Intermittent Watercourse
- Permanent Watercourse
- Railway

0 250 500 1,000 Meters

SCALE: 1:28,000
WHEN PLOTTED CORRECTLY AT 11 x 17
WGS 1984 Transverse Mercator

NOTES

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CITY OF OTTAWA

FLEWELLYN CUMULATIVE EFFECTS STUDY

QUARRIES IN THE VICINITY AND WITHIN THE STUDY AREA

December 1, 2015	Rev	0.0	Figure No. 3
Project No.	209.40105.00000		

SLR
global environmental solutions

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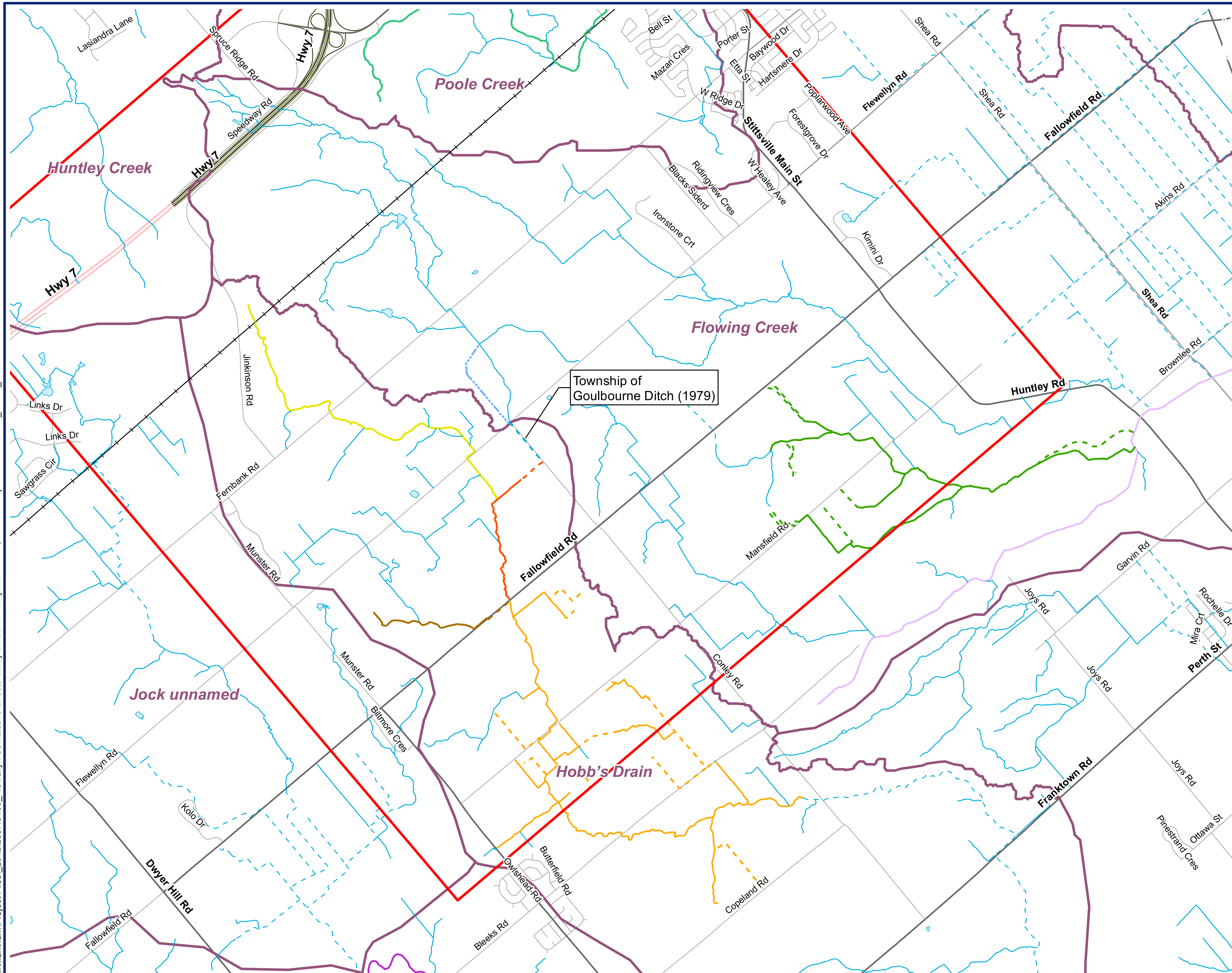

LEGEND

- StudyArea
- Waterbodies
- Award Drain (Pre 1963)
- Flowing Creek Award Drain (Pre 1963)
- Hobbs Municipal Drain (1972-73, approx. location)
- Hobbs Municipal Drain (1972-73)
- Hobbs Municipal Drain Extension (1988)
- Hobbs Municipal Drain Extension (1988, approx. location)
- Mansfield Municipal Drain (1974, approx. location)
- Mansfield Municipal Drain (1974)
- Quarry Ditch (1987-88, approx. location)
- Quarry Ditch (1987-88)
- Township of Goulbourne Ditch (1979)
- Poole Creek
- Jock River
- Unclassifed Constructed Watercourse (Pre 1963)
- Watercourse
- Municipal Drain

0 250 500 1,000 Meters

SCALE: 1:40,000
NAD 1983 UTM Zone 18N

NOTES

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CITY OF OTTAWA

FLEWELLYN CUMULATIVE EFFECTS STUDY

DRAIN CONSTRUCTION TIMELINE

December 1, 2015	Rev A	Figure No.
Project No. 209.40105.00000		4

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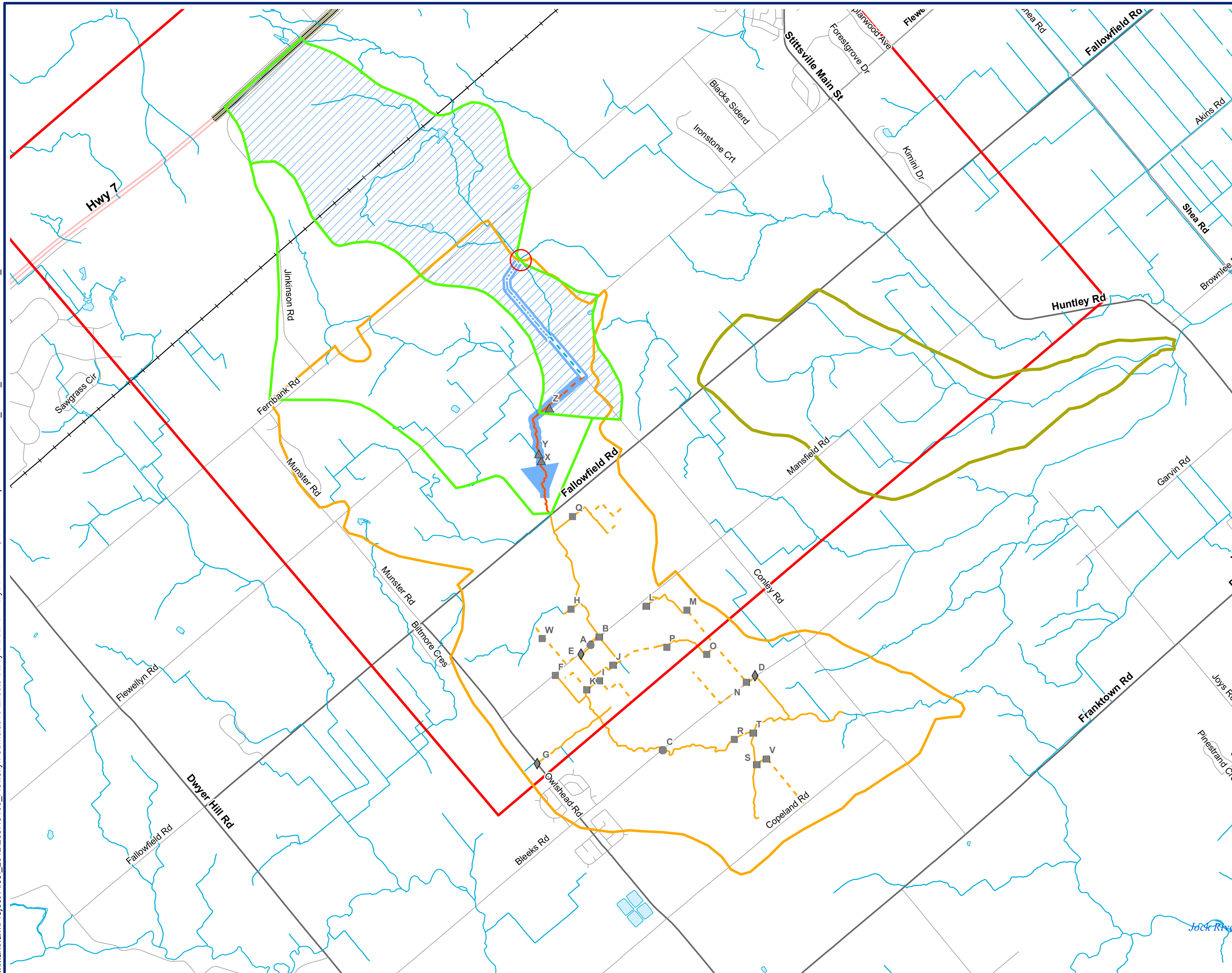

LEGEND

- Study Area
- Waterbodies
- Location of 1963 Diversion
- Unclassified Constructed Watercourse - 1963
- Upstream Catchment of 1963 Diversion
- Historical Municipal Drain Catchment - 1988
- Historical Municipal Drains Catchment - 1972
- Mansfield Drain Catchment - 1974
- Hobbs Municipal Drain (1972-73, approx. location)
- Hobbs Municipal Drain (1972-73)
- Hobbs Municipal Drain Extension (1988)
- Hobbs Municipal Drain Extension (1988, approx. location)
- Township of Goulbourn Ditch (1979)
- Unclassified Constructed Watercourse (Pre 1963)
- Watercourse
- Municipal Drain

Culverts

- Existing1972
- Installed 1972
- Modifed 1988
- Modified 1972

0 250 500 1,000 Meters

SCALE: 1:40,000
NAD 1983 UTM Zone 18N

NOTES

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CITY OF OTTAWA

FLEWELLYN CUMULATIVE EFFECTS STUDY

DRAIN CONSTRUCTION TIMELINE
HOBBS MUNICIPAL DRAIN

December 2, 2015	Rev A	Figure No. 5
Project No.	209.40105.00000	

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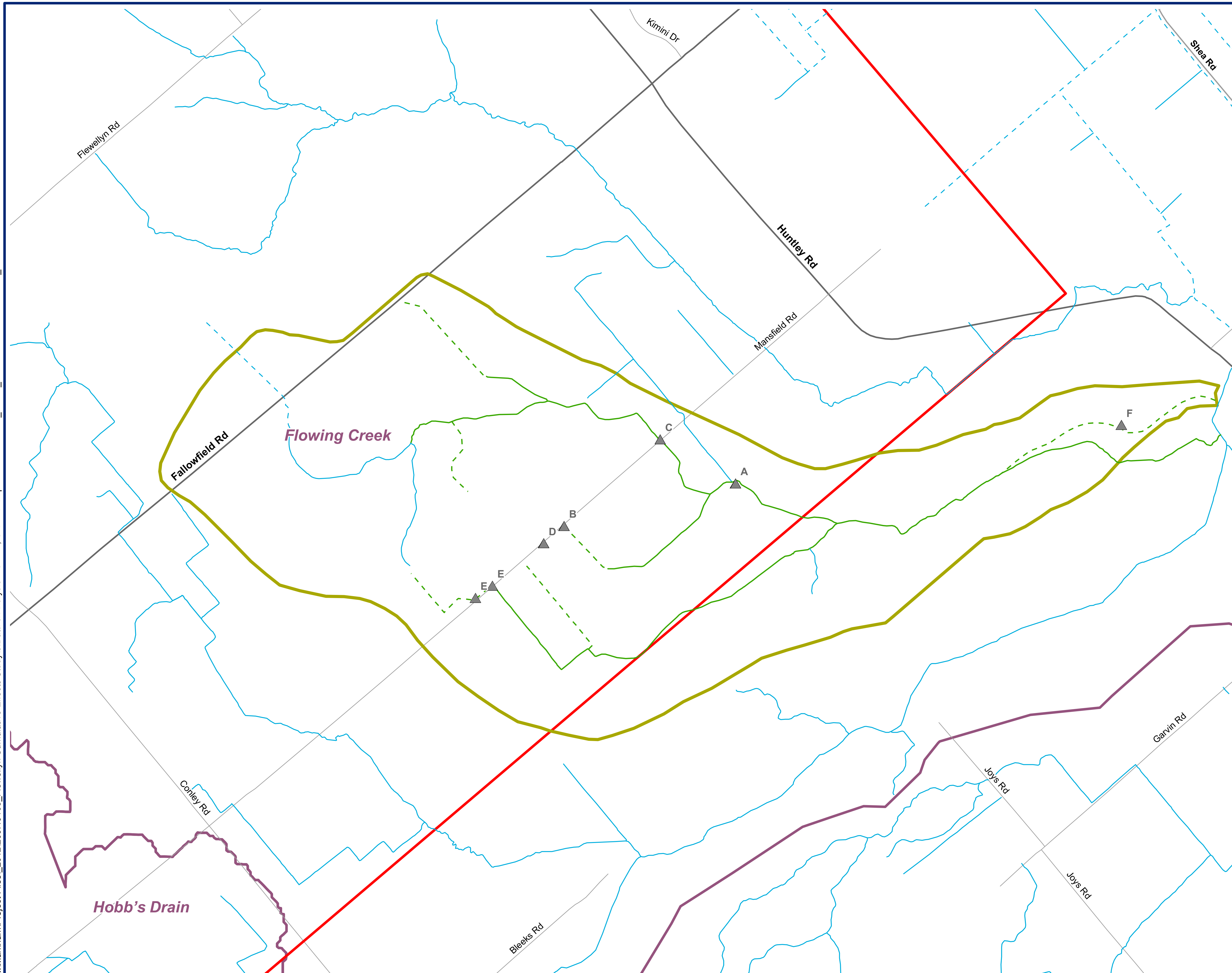

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LEGEND

- Study Area
- Waterbodies
- Mansfield Municipal Drain (1974, approx. location)
- Mansfield Municipal Drain (1974)
- Municipal Drain
- Watercourse
- Mansfield Drain Catchment - 1974

Culvert Improvements

- Modified 1974

0 250 500 1,000 Meters

SCALE: 1:18,000
NAD 1983 UTM Zone 18N

NOTES

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CITY OF OTTAWA

FLEWELLYN CUMULATIVE EFFECTS STUDY

DRAIN CONSTRUCTION TIMELINE
MANSFIELD MUNICIPAL DRAIN

December 1, 2015	Rev	A	Figure No.
Project No.	209.40105.00000		6

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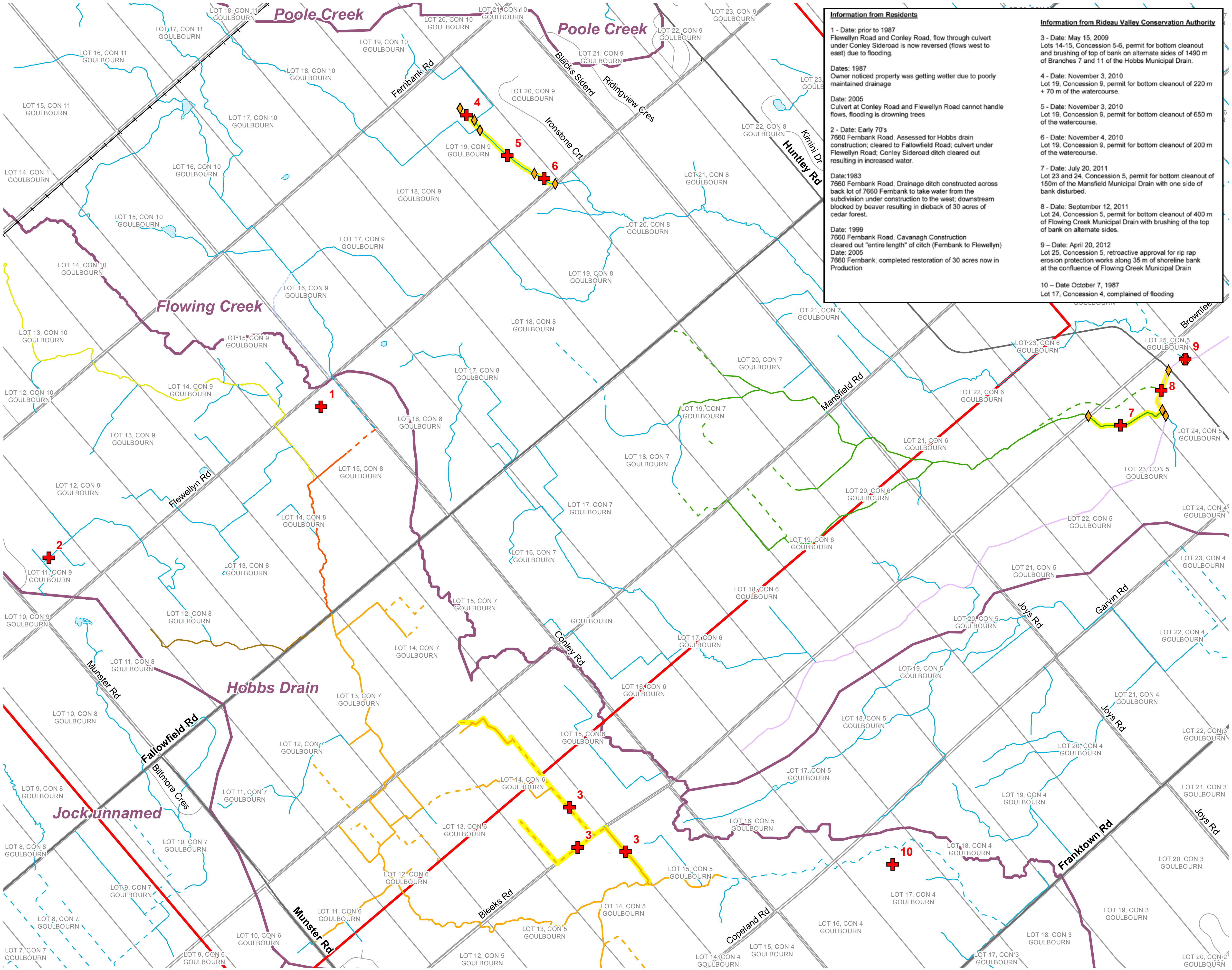

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Information from Residents

1 - Date: prior to 1987
Flewellyn Road and Conley Road, flow through culvert under Conley Sideroad is now reversed (flows west to east) due to flooding.

Dates: 1987
Owner noticed property was getting wetter due to poorly maintained drainage

Date: 2005
Culvert at Conley Road and Flewellyn Road cannot handle flows, flooding is drowning trees

2 - Date: Early 70's
7660 Fernbank Road, Assessed for Hobbs drain construction; cleared to Fallowfield Road; culvert under Flewellyn Road; Conley Sideroad ditch cleared out resulting in increased water.

Date:1983
7660 Fernbank Road, Drainage ditch constructed across back lot of 7660 Fernbank to take water from the subdivision under construction to the west; downstream blocked by beaver resulting in dieback of 30 acres of cedar forest.

Date: 1999
7660 Fernbank Road, Cavanagh Construction cleared out "entire length" of ditch (Fernbank to Flewellyn)
Date: 2005
7660 Fernbank; completed restoration of 30 acres now in Production

Information from Rideau Valley Conservation Authority

3 - Date: May 15, 2009
Lots 14-15, Concession 5-6, permit for bottom cleanout and brushing of top of bank on alternate sides of 1490 m of Branches 7 and 11 of the Hobbs Municipal Drain.

4 - Date: November 3, 2010
Lot 19, Concession 9, permit for bottom cleanout of 220 m + 70 m of the watercourse.

5 - Date: November 3, 2010
Lot 19, Concession 9, permit for bottom cleanout of 650 m of the watercourse.

6 - Date: November 4, 2010
Lot 19, Concession 9, permit for bottom cleanout of 200 m of the watercourse.

7 - Date: July 20, 2011
Lot 23 and 24, Concession 5, permit for bottom cleanout of 150m of the Mansfield Municipal Drain with one side of bank disturbed.

8 - Date: September 12, 2011
Lot 24, Concession 5, permit for bottom cleanout of 400 m of Flowing Creek Municipal Drain with brushing of the top of bank on alternate sides.

9 – Date: April 20, 2012
Lot 25, Concession 5, retroactive approval for rip rap erosion protection works along 35 m of shoreline bank at the confluence of Flowing Creek Municipal Drain

10 – Date October 7, 1987
Lot 17, Concession 4, complained of flooding

LEGEND

- Location of problems/maintenance work
- Reach Boundary
- StudyArea
- Drain Maintenance
- Waterbodies
- Lot and Concession
- Award Drain (Pre 1963)
- Flowing Creek Award Drain (Pre 1963)
- Hobbs Municipal Drain (1972-73, approx. location)
- Hobbs Municipal Drain (1972-73)
- Hobbs Municipal Drain Extension (1988)
- Hobbs Municipal Drain Extension (1988, approx. location)
- Mansfield Municipal Drain (1974, approx. location)
- Mansfield Municipal Drain (1974)
- Quarry Ditch (1987-88, approx. location)
- Quarry Ditch (1987-88)
- Township of Goulbour Ditch (1979)
- Poole Creek
- Jock River
- Unclassifed Constructed Watercourse (Pre 1963)
- Watercourse
- Municipal Drain

0 250 500 1,000 Meters

SCALE: 1:30,000
NAD 1983 UTM Zone 18N

NOTES

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CITY OF OTTAWA

FLEWELLYN CUMULATIVE EFFECTS STUDY

DRAIN CONSTRUCTION TIMELINE: COMMENTS FROM RESIDENTS

December 3, 2015	Rev	A	Figure No.
Project No.	209.40105.00000		7

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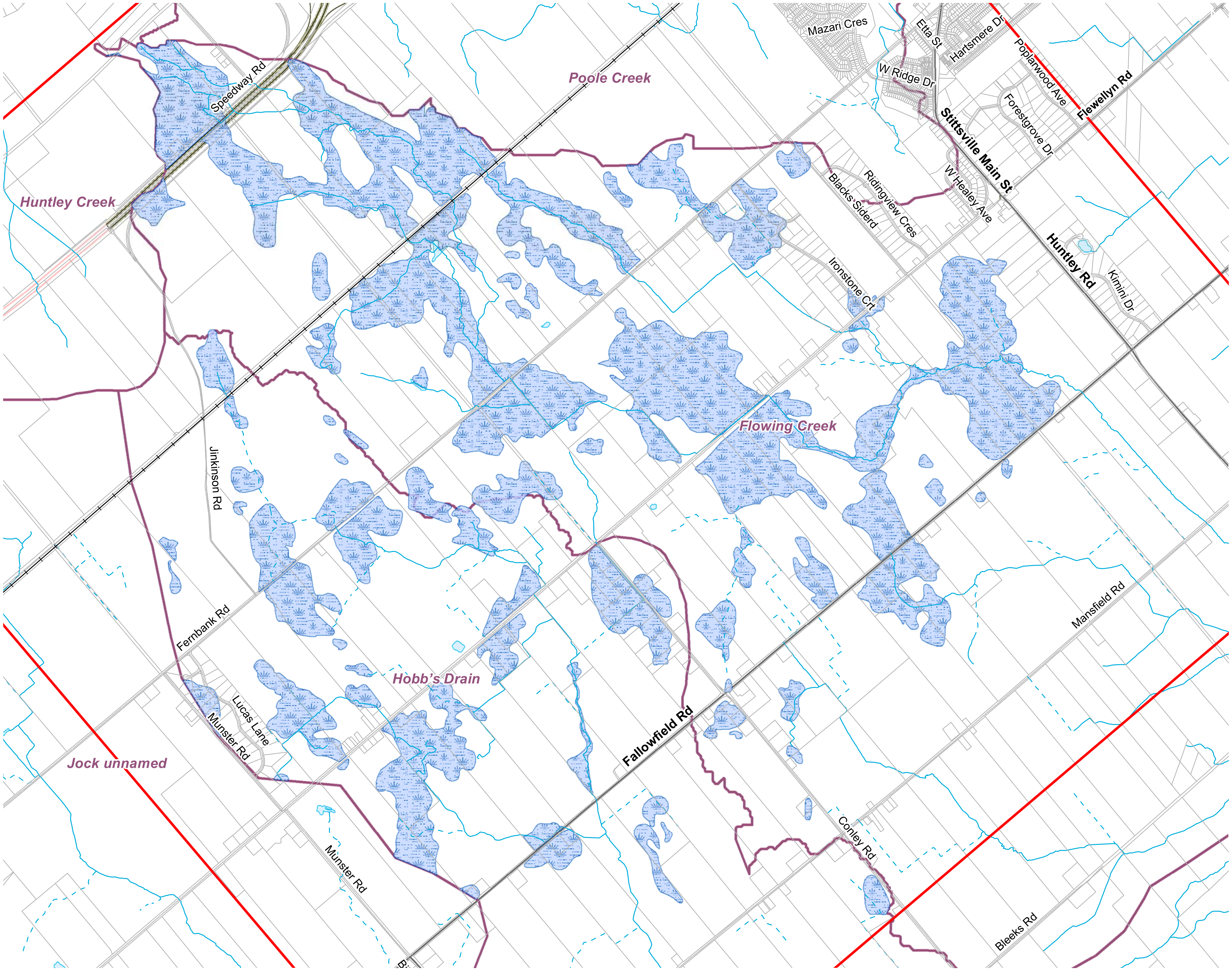

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CITY OF OTTAWA

FLEWELLYN CUMULATIVE EFFECT STUDY

INTERPRETATION OF EXTENT OF WETLANDS: 1946

December 1, 2015	Rev A	Figure No. 8
Project No.	209.40105.00000	

SLR Consulting (Canada) Ltd.

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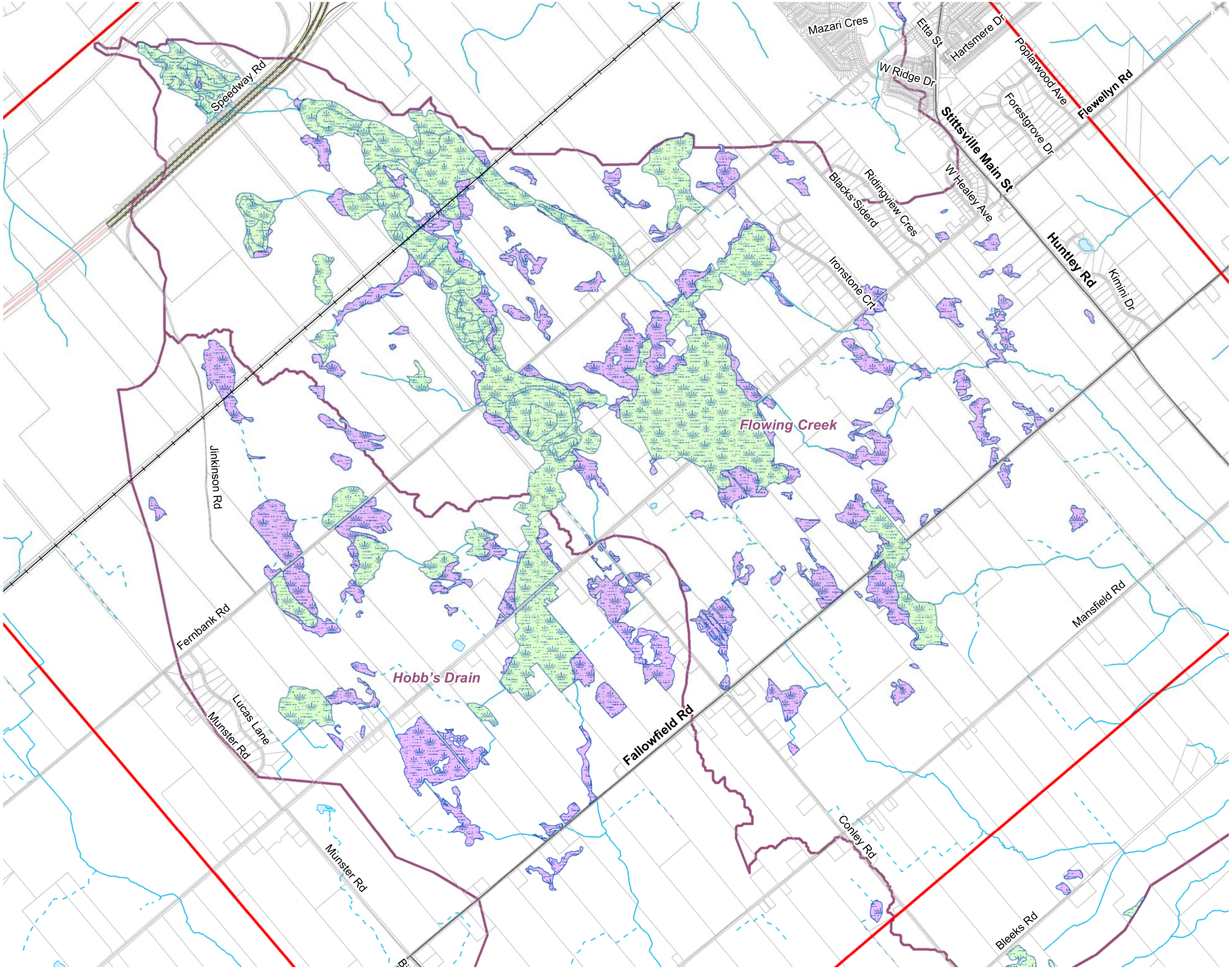

LEGEND

- Study Area
- Provincially Significant Weltand
- Wetlands (Interp. by City of Ottawa)
- Subwatersheds (City of Ottawa)
- Intermittent Watercourse
- Permanent Watercourse
- Municipal Drains
- Waterbodies

0 250 500 1,000 Meters

SCALE: 1:27,500
NAD 1983 UTM Zone 18N

NOTES

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CITY OF OTTAWA

FLEWELLYN CUMULATIVE EFFECT STUDY

CITY OF OTTAWA: INTERPRETED WETLANDS

December 1, 2015	Rev A	Figure No. 9
Project No.	209.40105.00000	

SLR Consulting (Canada) Ltd.

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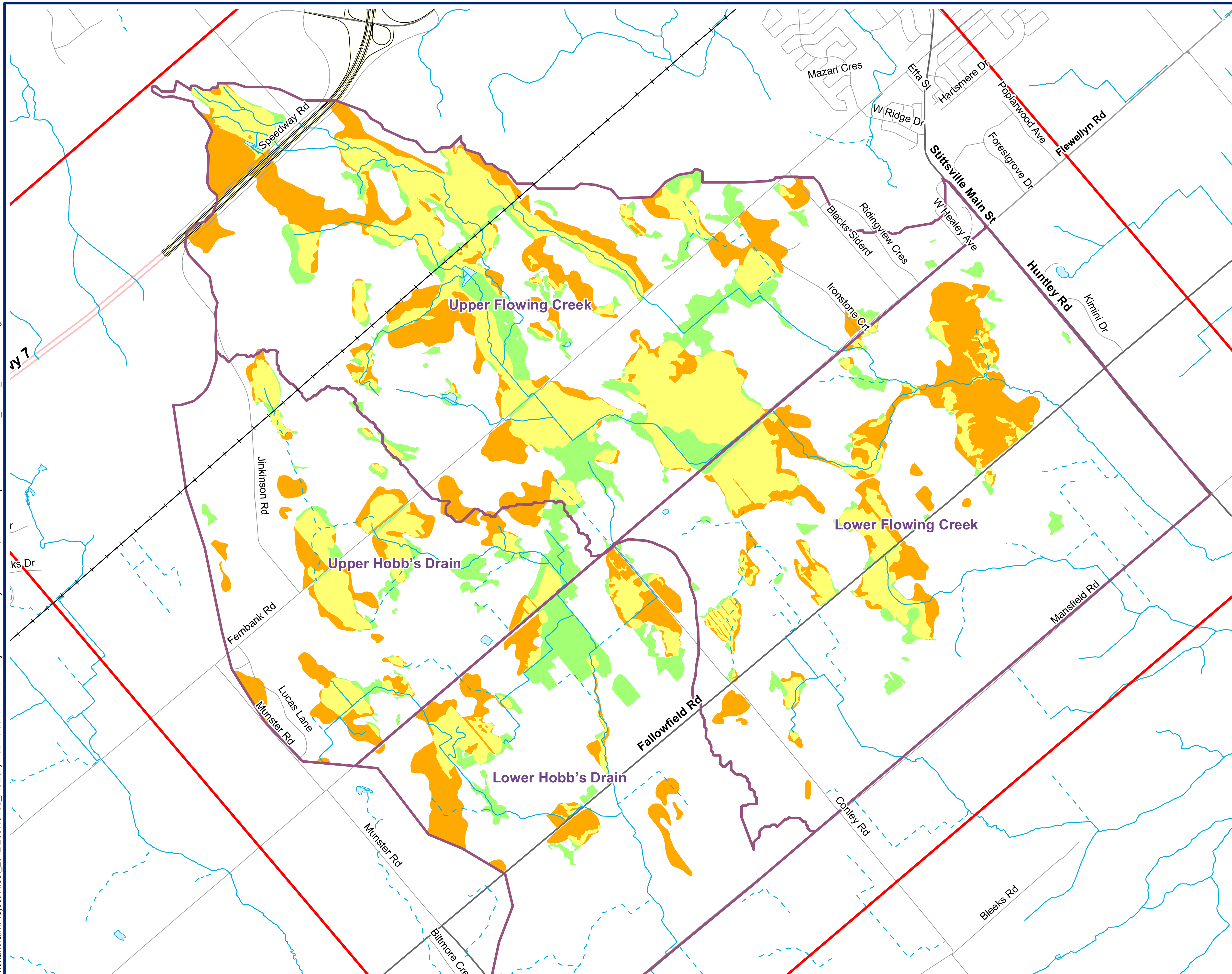

LEGEND

- Study Area
- Wetland Loss
- No Change
- Wetland Gain
- Subwatersheds (City of Ottawa)
- Intermittent Watercourse
- Permanent Watercourse
- Municipal Drains
- Waterbodies

0 250 500 1,000 Meters

SCALE: 1:30,000
NAD 1983 UTM Zone 18N

NOTES

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CITY OF OTTAWA

FLEWELLYN CUMULATIVE EFFECT STUDY

WETLAND CHANGE: COMPARISON OF 1946 AERIAL PHOTOGRAPHS AND OTTAWA WETLAND MAPPING

December 1, 2015	Rev A	Figure No. 10
Project No. 209.40105.00000		

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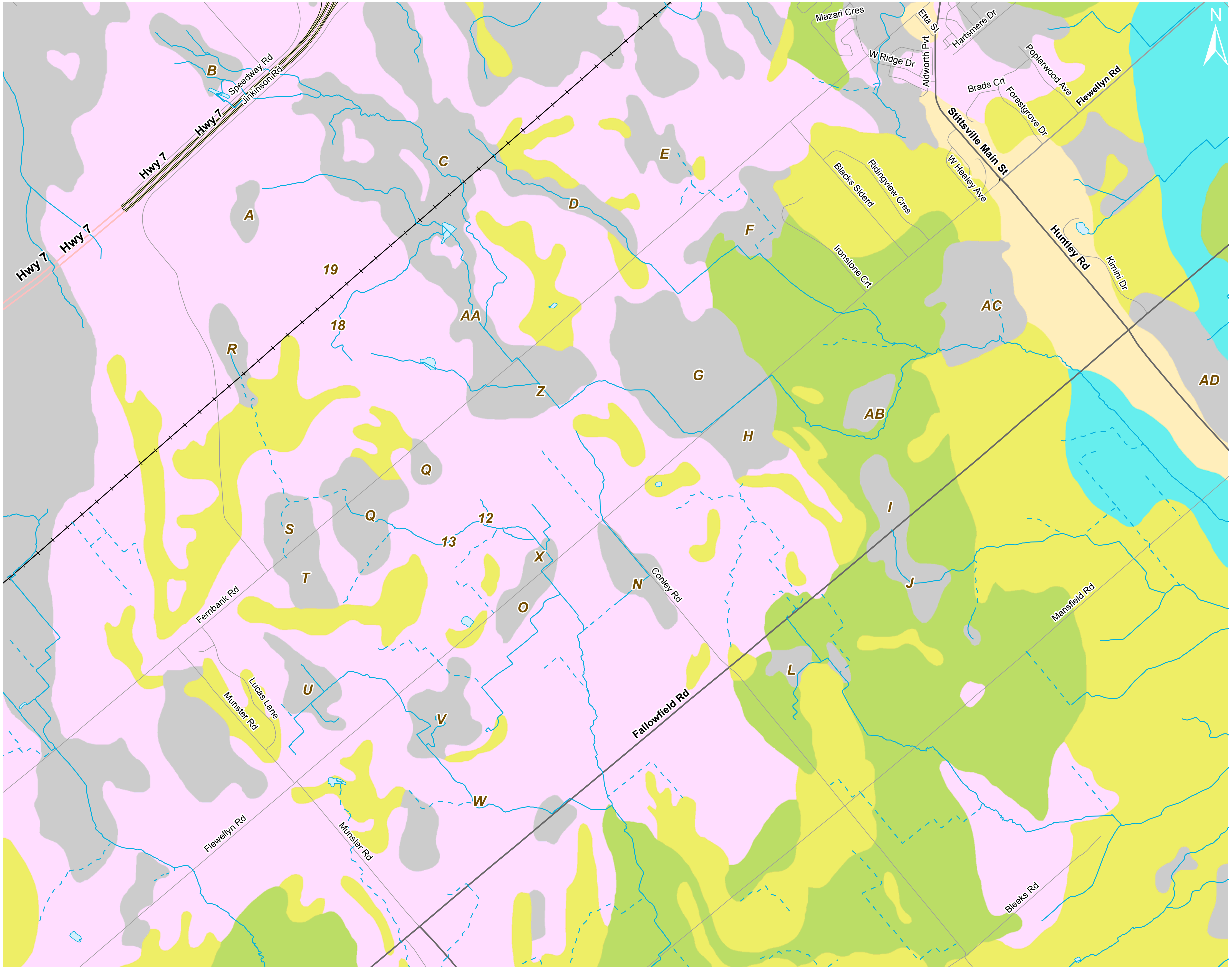

LEGEND

AA Wetland Reference Number

Surficial Geology

- 3: Paleozoic bedrock (thin drift)
- 5b: Stone-poor, carbonate-derived silty to sandy till
- 7: Glaciofluvial deposits of silt and clay
- 10a: Massive-well laminated silt and clay
- 11b: Littoral-foreshore deposits of sand
- 11c: Foreshore-basinal deposits of sand and silt
- 20: Organic deposits

0 250 500 1,000 Meters

SCALE: 1:28,000

NAD 1983 UTM Zone 18N

NOTES

This map is for conceptual purposes only and should not be used for navigational purposes.

Basedata: Ontario Geological Survey 2010. Surficial geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 128 – Revised.

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CITY OF OTTAWA

FLEWELLYN CUMULATIVE EFFECTS STUDY

SURFICIAL GEOLOGY, ONTARIO GEOLOGICAL SURVEY 2010 WITH WETLAND REFERENCE IDENTIFIERS

December 1, 2015	Rev A	Figure No.
Project No. 209.40105.00000		11

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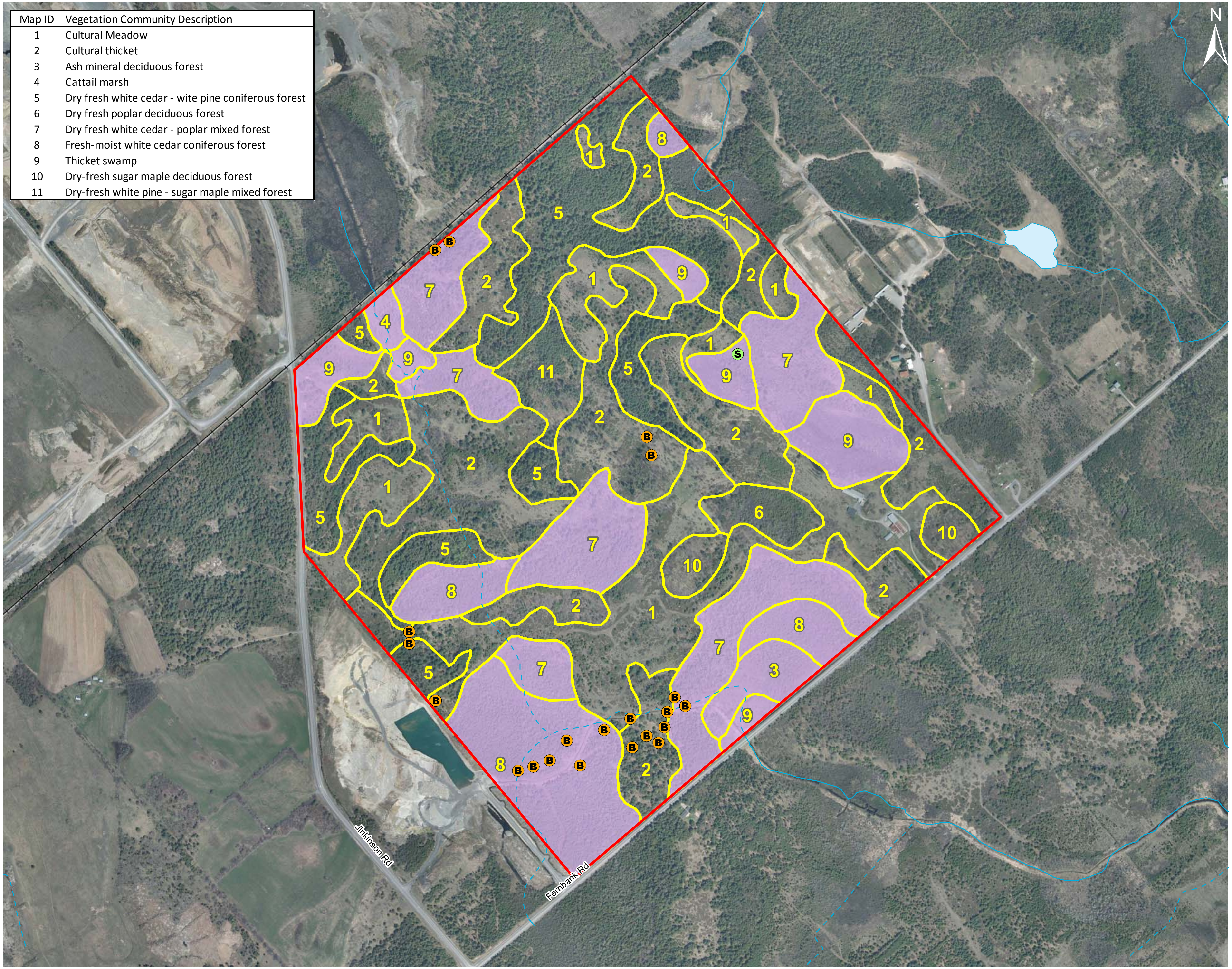

Map ID	Vegetation Community Description
1	Cultural Meadow
2	Cultural thicket
3	Ash mineral deciduous forest
4	Cattail marsh
5	Dry fresh white cedar - wite pine coniferous forest
6	Dry fresh poplar deciduous forest
7	Dry fresh white cedar - poplar mixed forest
8	Fresh-moist white cedar coniferous forest
9	Thicket swamp
10	Dry-fresh sugar maple deciduous forest
11	Dry-fresh white pine - sugar maple mixed forest

LEGEND

- Butternut tree(s) (Muncaster, 2010)
- Regionally rare sedge (Muncaster, 2010)
- Site Boundary
- Intermittent Watercourse
- Permanent Watercourse
- Vegetation Communities (Muncaster, 2010)
- Communities with Organic Soils

0 100 200 400 Meters

SCALE: 1:8,000
NAD 1983 UTM Zone 18N

NOTES

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Orthoimagery: 2011

CITY OF OTTAWA

FLEWELLYN CUMULATIVE EFFECTS STUDY

VEGETATION MAPPING EXCERPTED FROM MUNCASTER ENVIRONMENTAL PLANNING 2010, INTERPRETED WETLAND FEATURE

December 1, 2015	Rev A	Figure No.
Project No.	209.40105.00000	12

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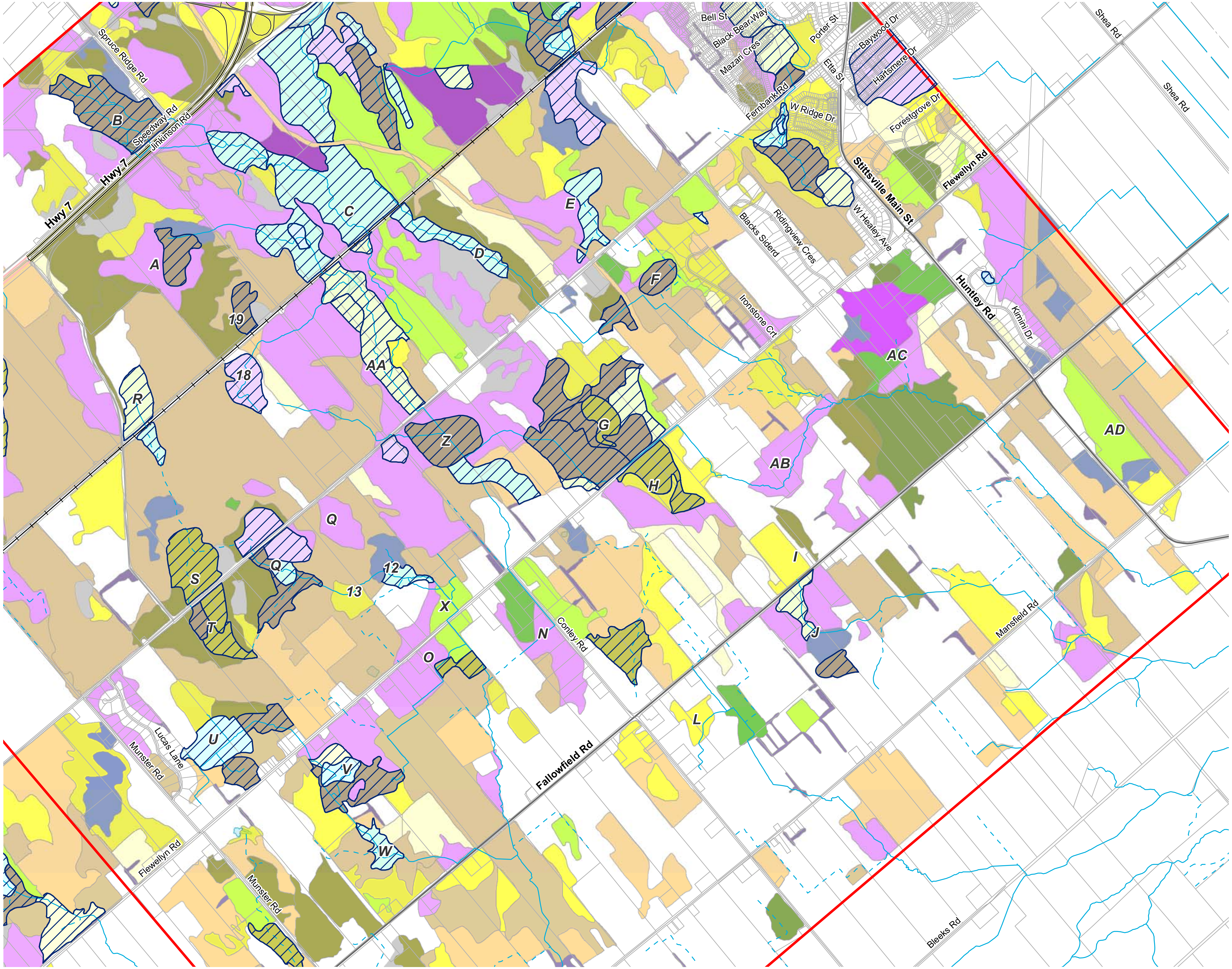


LEGEND

- StudyArea
- AA Wetland Reference Number
- Waterbodies
- NESS Wetland Communities

NESS Vegetation

Bog
- treed bog

Fen
- fen

Marsh
- marsh

Meadow
- meadow (old field)

Thicket
- scrub/thicket
- thicket swamp

Mixed
- mixed swamp forest
- early successional mixed forest
- mixed - successional stage unknown
- late successional mixed forest

Deciduous
- deciduous swamp forest
- early successional deciduous forest
- deciduous (planted)
- late successional deciduous forest
- deciduous - successional stage unknown

Coniferous
- coniferous (planted)
- coniferous - successional stage unknown
- coniferous - species unknown
- coniferous swamp forest
- early successional coniferous forest

Other
- hedgerow
- hardwood - species unknown
- rock/sand barren (outcrop)
- open water

0 250 500 1,000 Meters

SCALE: 1:28,000
NAD 1983 UTM Zone 18N

NOTES

This map is for conceptual purposes only and should not be used for navigational purposes.

Basedata: Ministry of Natural Resources, Land Information Ontario (LIO), © 2012, Queen's Printer for Ontario, Downloaded February 2013

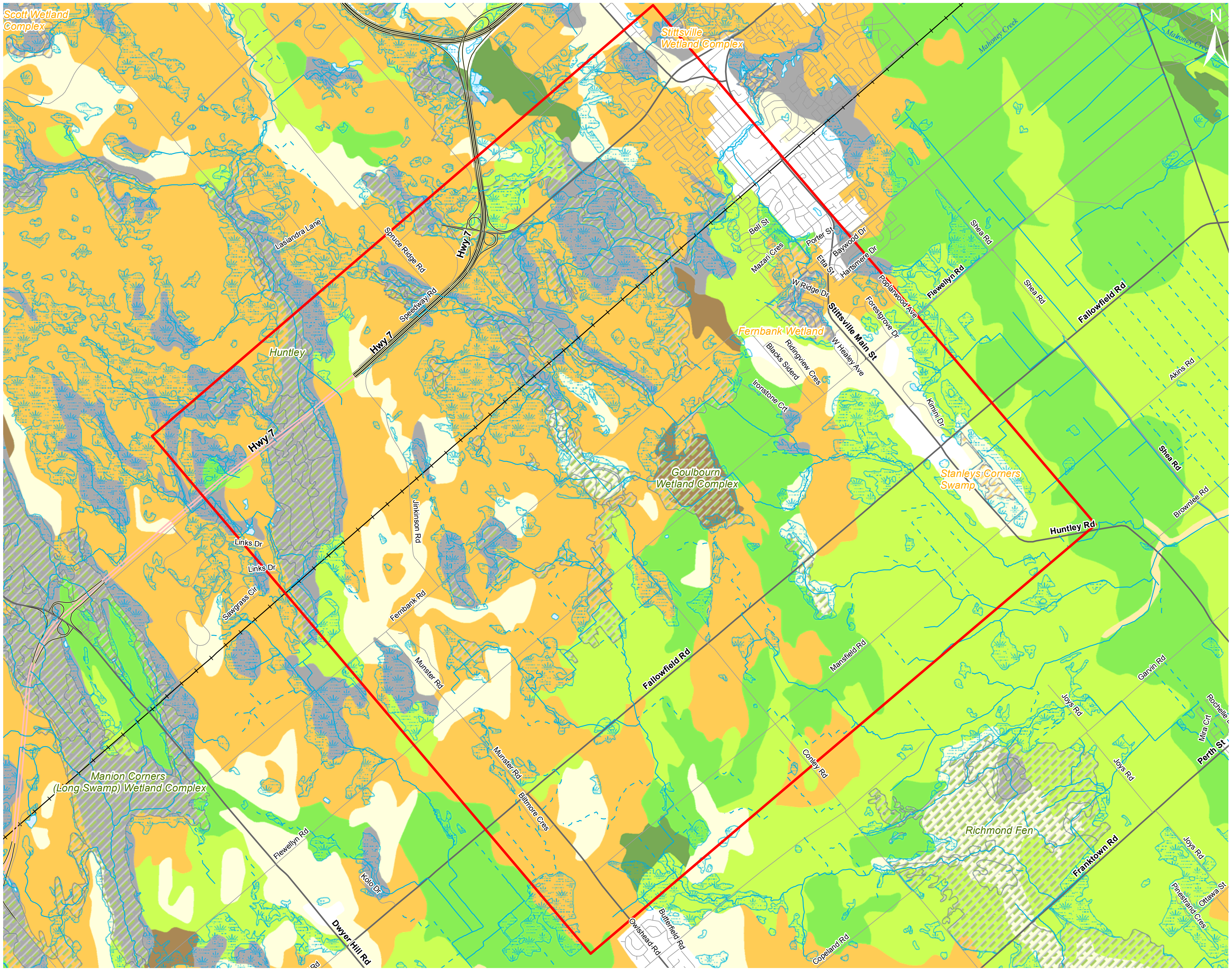
CITY OF OTTAWA

FLEWELLYN CUMULATIVE EFFECTS STUDY

NATURAL ENVIRONMENTAL SYSTEMS STUDY (NESS) VEGETATION MAPPING, 2011

December 1, 2015	Rev A	Figure No. 13
Project No.	209.40105.00000	

SLR Consulting (Canada) Ltd.



LEGEND

- StudyArea
- Waterbodies
- Intermittent Watercourse
- Permanent Watercourse
- Cartographic Wetland
- Non-significant Wetland
- Provincially Significant Wetland

Soil Complex (CLI, OMAFRA)

- N/A
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- Organics
- Water

0 250 500 1,000 Meters

SCALE: 1:48,000
NAD 1983 UTM Zone 18N

NOTES

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CITY OF OTTAWA

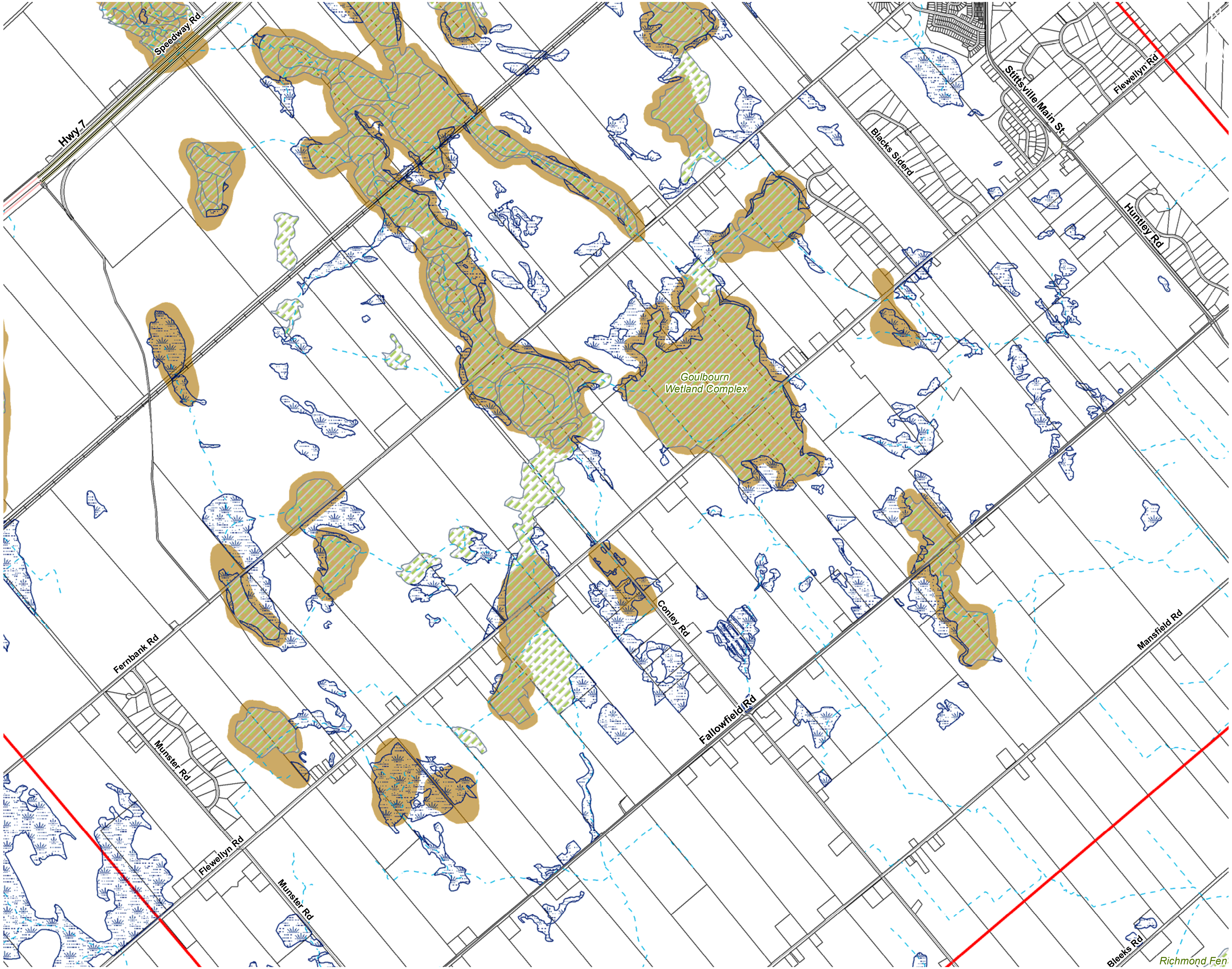
FLEWELLYN CUMULATIVE EFFECTS STUDY

SOILS MAPPING, 2011

December 1, 2015	Rev A	Figure No.
Project No.	209.40105.00000	14

SLR
SLR Consulting (Canada) Ltd.

N:\Markham\Project Files_2012\209.40105_Flewellyn Cumulative Effects Study\3.Data & Analysis\2.CADD, GIS\1.GIS\Spatial\1.MXDs\209_40105_SoilsMappingOMAFRA.mxd



LEGEND

- Study Area
- Reported Presence of Organic Soils
- Provincially Significant Wetland
- Other Wetland (City of Ottawa)
- Parcel Fabric
- Watercourse

0 250 500 1,000 Meters

SCALE: 1:24,000

NAD 1983 UTM Zone 18N

NOTES

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CITY OF OTTAWA

FLEWELLYN CUMMULATIVE EFFCTS STUDY

CITY OF OTTAWA: FLEWELLYN WETLAND EVALUATION RESULTS - POTENTIAL ORGANIC SOILS

December 1, 2015	Rev A	Figure No. 15
Project No. 209.40105.00000		

SLR

SLR Consulting (Canada) Ltd.

N:\Markham\Project Files_2012\209.40105_Flewellyn Cumulative Effects Study\3.Data & Analysis\2.CADD, GIS\1.GIS\Spatial\1.MXDs\209_40105_CityofOttawa_WetlandEvalResults_Organic.mxd

APPENDIX A
Reference Materials Provided as Background to the Study

Flewellyn Cumulative Effects Study
City of Ottawa
SLR Project No.: 209.40105.00000

Appendix A: Flewellyn Cumulative Study Effects – Document List			
Collection	**Documents**	**Author**	**Date**
City of Ottawa			
City	City of Ottawa Official Plan Excerpts on Provincially Significant Wetlands.	City of Ottawa	
City	Email Hendry to Dulmage3May2006.pdf	City of Ottawa	2006
City	Email Murphy to Jacobs6Oct2005.pdf	City of Ottawa	2005
City	Email Murphy to Marc 24Aug2004.pdf	City of Ottawa	2004
City	Information Meeting 2005.pdf	City of Ottawa	2005
City	Letter Coleman to Murphy 10Feb2005.pdf	Coleman	2005
City	Letter El-Chantiry.pdf	City of Ottawa	
City	Letter Ramsay from Chiarelli 31Jul2006.pdf	Ramsay	2006
City	Letter Ritchie to Jellett22June2006.pdf	Ritchie	2006
City	Letter to Laurie Miller(MMAH) from Anda Rungus(MNR) 25Aug2009.pdf	Rungus, Anda	2009
City	Letter to Residents with public meeting min 16May2005.pdf	City of Ottawa	2005
City	Meeting Minutes Stavinga June 2005.pdf	City of Ottawa	2005
City	Memorandum of Oral Decision - (July 21, 2011).PDF	Ontario Municipal Board	2011
City	Mtg Minutes 26April2006.pdf	City of Ottawa	2006
City	Mtg Minutes19May2006.pdf	City of Ottawa	2006
City	Potential to Complex Unevaluated Wetland Areas With the North Goulbourn Wetland Complex. Letter Report to Susan Murphy of Ottawa.	Jacques Whitford	2005
City	Property List 1Apr2005.pdf	City of Ottawa	2005
City	Property owners.pdf	City of Ottawa	2007
Consultation			
Consultation	CBC transcript 8Jun2005.pdf	CBC	2005
Consultation	Interim Report Stakeholders22June2006.pdf	Agricultural and Rural Affairs Committee	2006
Consultation	Juteau Johnson Comba Inc June 2006.pdf	Juteau, Ron	2006
Consultation	Letter from Landowners	Westley, Mike	1987, 2010
Consultation	Letter Ritchie to McRae10Nov2006.pdf	Ritchie	2006
Consultation	Letter to residents 24Feb2006.pdf	City of Ottawa	2006
Consultation	Letter to residents 31 Mar 2005.pdf	City of Ottawa	2005
Consultation	Letter to residents from Flavin 27Jan2003.pdf	Flavin	2003
Consultation	Letter to Residents from Lathrop 8Nov2005.pdf	Lathrop	2005
Consultation	Letter to Residents from Lathrop2Aug2005.pdf	Lathrop	2005
Consultation	Mtg Minutes 5April2006.pdf	City of Ottawa	2006
Consultation	Mtg Minutes5May2006 .pdf	City of Ottawa	2006
Consultation	Notes from Hale Wesley April 2006.pdf – timelines for drainage and increased water; drained wetland south of 7766	Hale, Wesley	2006
Consultation	Position Paper Goulbourn Landowners.pdf	Goulbourn Landowners	

Appendix A: Flewellyn Cumulative Study Effects – Document List			
Collection	**Documents**	**Author**	**Date**
Consultation	Presentation to ARAC 9Mar2006.pdf	ARAC	2006
Consultation	Status of Work Program 31May2006.pdf	unknown	2006
Consultation	Wetland Stakeholder Group TOR May 2006.pdf	City of Ottawa	2006
Consultation	Wetlands Technical Report Mar2006.pdf	City of Ottawa	2006
Development Applications			
Development Applications	EIS Muncaster 2003.pdf	Muncaster, B.	2003
Development Applications	EIS Muncaster July 2006.pdf	Muncaster, B.	2006
Development Applications	Environmental_Impact_Statement_D07-16-09-0026.pdf	Muncaster, B.	2009
Development Applications	Hydrogeological Assessment.pdf	RVCA, Glen McDonald	2006
Development Applications	Hydrogeological_and_Terrain_Analysis_D07-16-09-0026.pdf	Houle Chevrier Engineering	2009
Development Applications	Hydrogeological_and_Terrain_Analysis_D07-16-09-0027.pdf	Houle Chevrier Engineering	2009
Development Applications	John D Paterson Hydrogeology 2003.pdf	Paterson	2003
Development Applications	Jordan Estates Archaeological Assessment.pdf	Adams Heritage	2007
Development Applications	Mineral_Resoruce_Impact_Assessment_Gravel_Pit_License_D07-16-09-0026.pdf	Houle Chevrier Engineering	2009
Development Applications	Mineral_Resource_Impact_Assessment_D07-16-09-0026.pdf	Houle Chevrier Engineering	2009
Development Applications	Muncaster Letter(June 24 2010).PDF	Aird & Berlis (Zachem) (includes Muncaster report)	2011
Development Applications	Nov 2nd Meeting Min, Correspondence Sean Moore & Margaret Mc.pdf	City of Ottawa (Rob Phillips)	2007
Development Applications	Phase_I_Environmental_Site_Assessment_D07-16-09-0026.pdf	Houle Chevrier Engineering	2009
Development Applications	Phase_I_Environmental_Site_Assessment_D07-16-09-0027.pdf	Houle Chevrier Engineering	2009
Development Applications	Phase_II_Environmental_Site_Assessment_D07-16-09-0026.pdf	Houle Chevrier Engineering	2009
Development Applications	Phase_II_Environmental_Site_Assessment_D07-16-09-0027.pdf	Houle Chevrier Engineering	2009
Development Applications	Report on Factors Affecting Opportunity to Extract Minerals .pdf	Dave McManus Engineering	2003
Development Applications	Report on Factors Affecting Opportunity to Extract Minerals.pdf	John D. Paterson & Assts	2003
Development Applications	Stormwater Management Pl (2).pdf	Novatech	2007
Development Applications	Stormwater Management Pl.pdf	Novatech	2007
Development Applications	Stormwater_Site_Management_Plan_Phase_2_(report only)_D07-16-09-0026.pdf	Novatech	2009

Appendix A: Flewellyn Cumulative Study Effects – Document List			
Collection	**Documents**	**Author**	**Date**
Development Applications	Stormwater_Site_Management_Plan_Phase_2_(report only)_D07-16-09-0027.pdf	Novatech	2009
Development Applications	Stormwater_Site_Management_Plan_Phase_I_(report only)_D07-16-09-0026.pdf	Novatech	2009
Development Applications	Stormwater_Site_Management_Plan_Phase_I_(report only)_D07-16-09-0027.pdf	Novatech	2009
Development Applications	Submission 2 EIS D07-16-09-0026.pdf	Muncaster	2010
Development Applications	Submission 2 EIS D07-16-09-0027.pdf	Muncaster	2010
Development Applications	Terrain Analysis, Hydrogeological Study.pdf	John D. Paterson & Assts	2003
Municipal Drains			
Municipal Drains	2011-Feb Hazeldean App-A-Benefits and Assessments	Stantec	2011
Municipal Drains	2011-Feb Hazeldean App-B-Net Assessments.pdf	Stantec	2011
Municipal Drains	2011-Feb Hazeldean App-C-Plan LandOwnership Maps.pdf	Stantec	2011
Municipal Drains	2011-Feb Hazeldean App-D-Detailed Drawings.pdf	Stantec	2011
Municipal Drains	2011-Feb Hazeldean –Engineering Profile Elevations	Stantec	2011
Municipal Drains	2011-Feb-03 Hazeldean Municipal Drain Management Plan	Stantec	2011
Municipal Drains	Correspondence from RVCA to Land Owner - with regards to an application for permission to alter a waterway (tributary of Flowing Creek Municipal Drain). November 4th, 2010	RVCA	2010
Municipal Drains	Correspondence from RVCA to Land Owner - with regards to an application for permission to alter a waterway (tributary of Flowing Creek Municipal Drain). November 3rd, 2010	RVCA	2010
Municipal Drains	Correspondence from RVCA to Land Owner - with regards to an application for permission to alter a waterway (Jordan Estates Tributary). November 3rd, 2010	RVCA	2010
Municipal Drains	Correspondence from RVCA to Marc Gagne – with regards to Drain bank stabilization on Flowing Creek Municipal Drain, April 20th, 2012	RVCA	2010
Municipal Drains	Correspondence from RVCA to Marc Gagne – with regards to Drain Maintenance work on Hobbs Municipal Drain, May 15th, 2009	RVCA	2010
Municipal Drains	Correspondence from RVCA to Marc Gagne – with regards to Drain Maintenance work on Mansfield Municipal Drain, July 20th, 2011	RVCA	2010
Municipal Drains	Correspondence from RVCA to Rick O'Connor - with regards to application to alter a waterway	RVCA	2010

Appendix A: Flewellyn Cumulative Study Effects – Document List			
Collection	**Documents**	**Author**	**Date**
	(Flowing Creek Municipal Drain) March 29, 2010		
Municipal Drains	DFO_MDC_DrainageMaps_2011_North Gower.pdf	RVCA, MCA, SNCA, DFO	2011
Municipal Drains	Digital data from drainage catchment data sheets	RVCA	
Municipal Drains	Engineers Report, Hazeldean Road Municipal Drain and Watercourse Management Plan	Stantec	2011
Municipal Drains	Flowing_Creek_Catchment_Map.pdf	RVCA	2010
Municipal Drains	Hazeldean 2010-June Technical Background Report	Stantec	2010
Municipal Drains	Hazeldean 2010-Technical Background Appendix A	Stantec	2010
Municipal Drains	Hazeldean Municipal Drain (dwg)	Stantec	2011
Municipal Drains	Hobbs Eng Report March 1972 COR Revisions.pdf	A.J. Graham Engineering	1972
Municipal Drains	Hobbs Extension Eng Report Sept 1988.pdf	Totten Sims Hubicki	1988
Municipal Drains	Hobbs_Drain_Catchment_Map.pdf	RVCA	2010
Municipal Drains	Jenkinson_Drain_Catchment_Map.pdf	RVCA	2010
Municipal Drains	Jock_River_Report _2011.pdf	RVCA	2011
Municipal Drains	Letter Maciver to Ryan Aug 2006.pdf	Maciver, D.	2006
Municipal Drains	Mansfield Eng Report Revised July 1974.pdf	A.J. Graham Engineering	1974
Municipal Drains	Proposed Hazeldean Road Municipal Drainage Works	Stantec	2010
Municipal Drains	RE Files on Municipal Drain .rtf	City of Ottawa and others	2012
Municipal Drains	Robinson Drainage Report 2006.pdf	Robinson Consultants	2006
Municipal Drains	Senes Report January 2008.pdf	Senes	2008
Quarry Documents			
Quarry	Aggregates Technical Report March2006.pdf	City of Ottawa	2006
Quarry	Beagle Club Quarry Pump Monitoring Data	Golder	2008
Quarry	Bell Quarry Pump Monitoring Data,	Golder	2008, 2009
Quarry	Goulbourn Quarry Water Taking Records,	Golder	2009, 2010
Quarry	Henderson Pump Monitoring Data	Golder	2008
Quarry	Hydrogeological Level 1 and 2 Report – Proposed Fernbank Quarry	AECOM	2012

Appendix A: Flewellyn Cumulative Study Effects – Document List

Collection	Documents	Author	Date
Quarry	Letter Peter White to Susan Murphy 27Jul2005.pdf	White, P.	2005
Quarry	Mineral_Resource_Impact_Assessment_D07-16-09-0027.pdf	Houle Chevrier Engineering	2009
Quarry	Planning Rationale Fernbank Quarry: Summary Report	ZanderPlan	2012
Quarry	REPORT 10-1127-0002.pdf	Golder	2011
Quarry	Stittsville Quarry Pump Monitoring Data	Golder	2008, 2009, 2010
Quarry	Summary Statement Category 2 Class A License Application For.pdf	Golder	2000
Quarry	Tomlinson Quarry 2000.pdf	Golder	2000
Quarry	Tomlinson Stittsville Quarry Pumping Records, Water Quality and Shape Files	Golder	2007
Reference			
Reference	Bylaw 45-86 topsoil.pdf	City of Ottawa	
Reference	City of Ottawa Bylaw 2007-398.pdf	City of Ottawa	2007
Reference	Ontario Wetland Evaluation System March 1993.pdf	Ontario Ministry of Natural Resources	1993
Soils Mapping			
Soils	Agricultural Land Use Systems of the Regional Municipality of Ottawa-Carleton, West Carleton, March, Goulbourn Townships.	Land Resource Research Institute, Research Branch, Agriculture Canada	1980 (based on 1977 field surveys)
Soils	Soil Map of Carleton County	Ontario Agricultural College, Guelph and the Central Experimental Farms Service, Dominion Department of Agriculture, Ottawa	Undated
Soils	Soil Survey of Carleton County, Province of Ontario	Hills, G. A., N. R. Richards and F.F. Morwick	1944
Soils	Surficial geology of Southern Ontario; Miscellaneous Release--Data 128-REV ISBN 978-1-4435-2483-4 [DVD] ISBN 978-1-4435-2482-7	Ontario Geological Survey	2010
Watershed Reports, Regional Studies			
Watershed	An Evaluation Framework for Natural Areas in the Regional Municipality of Ottawa-Carleton	Regional Municipality of Ottawa Carleton	1995
Watershed	Conservation Branch. Rideau Valley conservation report; history, land use and forest, water, biology, recreation. Dept. of Energy and Resources Management	Conservation Authorities Branch of the Dept. of Energy and Resources Management.	1968
Watershed	Digital Jock River Subwatershed Report	RVCA	
Watershed	Jock River Reach 2 Mud Subw Study ECR Volume 1 Text Report Sept 2007.pdf	RVCA	2007
Watershed	Jock River Reach 2 Mud Subw Study ECR Volume 2 Figures Report.Sept 2007.pdf	RVCA	2007

Appendix A: Flewellyn Cumulative Study Effects – Document List

Collection	Documents	Author	Date
Watershed	Jock River Watershed Management Plan, Rideau Valley Conservation – November 2001	RVCA	2001
Watershed	Letter Huizer for Murphy 20Dec2004.pdf	Huizer, R.	2004
Watershed	Letter to Lyon from MNR 22Oct2003.pdf	MNR	2003
Watershed	Letter to Murphy from Crown TransCan May2005.pdf	Crown TransCan	May2005
Watershed	Level II Low Water Conditions Confirmed	RVCA	2012
Watershed	Mississippi Rideau GW Study Vol_1_Summary_Report.pdf	MVCA	
Watershed	Mississippi Rideau GW Study Vol_2_Technical_Appendices_update.pdf	MVCA	
Watershed	Natural Area Data and Evaluation Record – Stittsville West (Area 304) Natural Area Summary Report	Regional Municipality of Ottawa Carleton	1997
Watershed	Natural Environment Systems Strategy (NESS) 304.pdf	former Region of Ottawa-Carleton	
Watershed	Pages from EcoGifts File.pdf	City of Ottawa	2008
Watershed	Russell Mark Thesis 2010.pdf	Russell, Mark	2010
Watershed	Technical Memo_Quanify Wetlands in Flood Management.pdf	RVCA	2009
Wetland Documents			
Wetland	6851 Flewellyn Ecogifts.pfd		
Wetland	An Evaluation Framework for Natural Areas in the Regional Municipality of Ottawa-Carleton	Regional Municipality of Ottawa Carleton	1995
Wetland	City of Ottawa Official Plan Excerpts on Provincially Significant Wetlands.	City of Ottawa	
Wetland	Email Huizer to Murphy 19Jan2005.pdf	Huizer, R	2005
Wetland	Email Huizer to Thompson June 28 2005.pdf	Huizer, R	2005
Wetland	Email Ministry to Murphy Prop Owners 21Feb2005.pdf	MNR	2005
Wetland	Email Thompson to Huizer 13Aug2004.pdf	Thompson	2004
Wetland	Fax Ritchie to Lathrop 9Mar2006.pdf	Ritchie	2006
Wetland	Huizer 15Mar2006.pdf	Huizer, R.	2006
Wetland	Huizer 28Sept2005.pdf	Huizer, R.	2005
Wetland	Huizer Proposal 19Aug2005.pdf	Huizer, R.	2005
Wetland	Huizer13Jan2005 .pdf	Huizer, R.	2005
Wetland	Natural Area Data and Evaluation Record – Stittsville West (Area 304) Natural Area Summary Report	Regional Municipality of Ottawa Carleton	1997
Wetland	Potential to Complex Unevaluated Wetland Areas With the North Goulbourn Wetland Complex. Letter Report to Susan Murphy of Ottawa.	Jacques Whitford	2005
Wetland	Technical Memo: Quantify Wetlands in Flood Management.pdf	RVCA	2009

Aerial Photography

National Air Photos, Flewellyn Study Area – Stereo Pairs

Roll: A18001
Date: 1963-05-13
Scale: 40,000
Altitude: 20100
Photos: 47 – 58, 73 – 81

Roll: A10244
Date: 1946-07-26
Scale: 20,000
Altitude: 8600
Photos: 26 – 33, 105 – 111, 263 – 270, 334 – 340, 395 – 401

Roll: A16526
Date: 1959-05-31
Scale: 30,000
Altitude: 14500
Photos: 14 – 19

Roll: A16525
Date: 1959-05-29
Scale: 30,000
Altitude: 14300
Photos: 123 – 128

Digital Data

Dataset	Description	Source	Date	Format
Soils	Surficial geology of Southern Ontario; Miscellaneous Release--Data 128-REV ISBN 978-1-4435-2483-4 [DVD] ISBN 978-1-4435-2482-7	Ontario Geological Survey	2010	Vector
Wetlands	Wetland Units, Ontario Ministry of Natural Resources, Land Information Ontario (LIO) © Queen's Printer for Ontario, 2012,	Ontario Ministry of Natural Resources	Downloaded February 2013	Vector
Orthoimagery	Scanned and georeferenced Airphotos provided by the City of Ottawa	City of Ottawa	1976	Scanned Airphoto
Orthoimagery	Scanned and georeferenced Airphotos provided by the City of Ottawa	City of Ottawa	1991	Scanned Airphoto
Orthoimagery	Orthorectified imagery provided by the City of Ottawa	City of Ottawa	1999	Orthoimagery (raster)
Orthoimagery	Orthorectified imagery provided by the City of Ottawa	City of Ottawa	2002	Orthoimagery (raster)
Orthoimagery	Orthorectified imagery provided by the City of Ottawa	City of Ottawa	2005	Orthoimagery (raster)
Orthoimagery	Orthorectified imagery provided by the City of Ottawa	City of Ottawa	2008	Orthoimagery (raster)
Orthoimagery	Orthorectified imagery provided by the City of Ottawa	City of Ottawa	2011	Orthoimagery (raster)
StudyArea	Delineated by SLR in consultation with the City of Ottawa	City of Ottawa	2012	Vector
Road Network	Ontario Ministry of Natural Resources, Land Information Ontario (LIO) © Queen's Printer for Ontario, 2012,	Ontario Ministry of Natural Resources	Downloaded February 2013	Vector

Dataset	Description	Source	Date	Format
Surficial Geology - Lines	Ontario Geological Survey 2010. Surficial geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 128 – Revised.	Ontario Geological Survey	Downloaded February 2013	Vector
Surficial Geology - Polygons	Ontario Geological Survey 2010. Surficial geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 128 – Revised.	Ontario Geological Survey	Downloaded February 2013	Vector
Soils	Canada Land Inventory, National Soil DataBase, Agriculture and Agri-Food Canada. 1998.	Agriculture and Agri-food Canada	Downloaded February 2013	Vector
Streams	Ontario Ministry of Natural Resources, Land Information Ontario (LIO) © Queen’s Printer for Ontario, 2012,	Ontario Ministry of Natural Resources	Downloaded February 2013	Vector
Municipal Drains	Ontario Ministry of Natural Resources, Land Information Ontario (LIO) © Queen’s Printer for Ontario, 2012,	Ontario Ministry of Natural Resources	Downloaded February 2013	Vector
Waterbodies	Ontario Ministry of Natural Resources, Land Information Ontario (LIO) © Queen’s Printer for Ontario, 2012,	Ontario Ministry of Natural Resources	Downloaded February 2013	Vector
NESS_Vegetation	Natural Environment System Strategy (NESS)	Region of Ottawa-Carleton’s Natural Environment Systems Strategy	2011	Vector
Signficant Woodlands - 2011		Region of Ottawa-Carleton’s Natural Environment Systems Strategy	2011	Vector
Wooded Areas - 2010 Land Use		Region of Ottawa-Carleton’s Natural Environment Systems	2010	Vector

Dataset	Description	Source	Date	Format
		Strategy		
Parcel		City of Ottawa/Teranet	2012	Vector
Lot and Concession	Ontario Ministry of Natural Resources, Land Information Ontario (LIO) © Queen’s Printer for Ontario, 2012,	Ontario Ministry of Natural Resources	Downloaded February 2013	Vector

APPENDIX B
Recent Chronology of Construction, Consultation and Study

Flewellyn Cumulative Effects Study
City of Ottawa
SLR Project No.: 209.40105.00000

Appendix B: Chronology of Consultation

Source	Date	Event
Engineer's Report for the Hobbs Municipal Drain	Pre-1972	The Lackey Award drain was coustructed following a meandering path through Concessions 5,6 and 7.
Engineer's Report for the Hobbs Municipal Drain	1972-1973	The existing Lackey Award Drain was replaced by the Hobbs Municipal Drain.
Engineer's Report for the Mansfiled Municipal Drain	1974	Mansfiled Municipal Drain is build to replace "a drainage system, in all probability, comprised of a series of old Award Drains." It appears that little or no maintenance had been crarried out in the years prior to the Mansfield Drain Report"
Final Engineer's report Hobbs Drain Extension	1979	Township of Goulbourn excavated a roadway ditch along the west side of Coneley Road from Flewelyn Road to the upstream end of the Conley Road Branch. The roadside ditch was deep and had a greater capacity than the downstream drain. After the ditch was buit flooding was reported on lots 15 and 16 as weel as on the road.
Hale, Terry undated	1983	Drainage ditch constructed across back lot of 7660 Fernbank to take water from the subdivision under construction to the west; downstream blocked by beaver resulting in dieback of 30 acres of cedar forest
Final Engineer's report Hobbs Drain Extension	Prior to 1963	A drain (believed to be an Award Drain) was constructed in Lot 16 and on the unopened road allowance between Lots 15 and 16, Concession 9. This watercouse (if not blocked by a large beaver dam) outlets to the ditch on the west side of Conley Road, south of Flewellyn Road. It is believed that this drain was constructed because of the expected difficulty in improving Flowing Creek which has an outlet to the east.
Mr. G. Foad, Lot 15, Concession 9 (Final Engineer's report Hobbs Drain Extension)	1987	Advised that the original drainage boundary for the Hobbs Drain was not in agreement with topographic information, resulted in a significant increase to the draiange boundary used in the design
Final Engineer's report Hobbs Drain Extension	Winter of 1987-1988	Cavanaugh Construction Limited excavated a major ditch as part of a quarry drainage system. This ditch enters into Hobbs Drain on the south side of Fallowfield Road.
Mrs. M. Richardson, Lot 13, Concession 8, (Final Engineer's report Hobbs Drain Extension)	1988	Noted that the western drainage limit in Concessions 8 and 9 was incorect. The limit of the area was altered to remove all of lot 11, Concession 8 and a portion of Lots 11 and12 of Concession 9
Mr M. Westley in Lot 15, Concession 8 (Final Engineer's report Hobbs Drain Extension)	1988	Noted that a major area of land adjacent to the eastern boundary of the drainage area in concessions 9, 10, and 11, had been erroniouly omitted from the tributary drainage area. The drainage biundary increased when the drain was built in in Lots 16 and along the road allowance between Lots 15 and 16.
Audery Hickey Lot 17, concession 4 (Final Engineer's report Hobbs Drain Extension)	Octber 7th, 1987 (letter)	States the the outletting of the Hobbs Drain onto her property, without further downstream improvements, has injuriously affected her lands.
Hale, Terry undated	1999	Cavanagh Construction cleared out "entire length" of ditch [Fernbank to Flewellyn]
Hale, Terry undated	2000	7660 Fernbank; 30 acres dried; clearing 2000 - 2005
Hale, Terry undated	2002	OWES based on 2002 photos before restoration complete and included part of 7660 Fernbank in PSW
Hale, Terry undated	2006	7660 Fernbank; completed restoration of 30 acres now in production
Westly, Mike. 1987. Letter to Council	"some years ago"	culvert under Conley sideroad to allow water from east to flow west to Hobbs Drain; now reversed due to flooding.
Westly, Mike. 1987. Letter to Council	1987 Mar 25	notice that his property was betting wetter due to poorly maintained drainage
Notice of Information Mtg	2005 April 21	PSW expansion; notice of meeting,
Notice of Information Mtg	2005 April 21	Hobbs Municipal Drain Extension TSH 1980's and constructed
Notice of Information Mtg	2005 April 21	Conley Rd/Flewellyn culvert cannot handle flows drowning trees
Notice of Information Mtg	2005 April 21	Jaques Whitford report finished 13 January 2005 based on 2002 aerial photography combined with low altitude fly-over 2004
OWES record Goulbourn PSW	2005 January 13	> 50 % organic soil; need maps
Huizer 2005 January 13 letter	2005 January 13	justification for complexing
email Huizer to Murphy	2005 January 19	filed wetland evaluation with City
meeting minutes Stavinga June 2005	2005 June 30	city to appoint engineer to sort out drainage
Huizer 2005 September 28 letter	2005 September 28	confirmed wetland units as accurate with exception of 3, 4, 5
Huizer 2006 March 15 letter	2006 March 15	20 units identified suitable for complexing; landowners notified 2005 April 21; subsequent veg removal justified deletion from PSW in wetlands 3, 4, 5
Wetland Stakeholder Group TOR May 2006	2006 May 4	report to be submitted 2006 June 22
Rideau Valley Conservation Authority	2009 May 15	Approval of Drain Maintenance works on the Hobbs Municipal Drain (Branches 7 & 11) from Lots 14 and 15 on Concession 5. Works are limited to a bottom cleanout and brushing of top of bank on alternate sides.
Muncaster Letter Jun 24, 2010	2010 June 24	notes drier conditions in 2010 than 2009 in veg communities 4 & 9
Muncaster Letter Jun 24, 2010	2010 June 24	northwest corner wetland 9 "at least substantial cultural in origin"
Muncaster Letter Jun 24, 2010	2010 June 24	northwest wetland potential Blanding's Turtle
OMB Decision	2011 July 21	OMB Decision regarding designation of 14 PSWs; unique drainage conditions exist
Rideau Valley Conservation Authority	2010, March 29	Approval of Drain Maintenance (bottoom cleanout) of the watercourse starting at the Gibson/Quirion property line, to a point approximately 220 m upstream (to the northwest) including both sides of the farm road after the split in the watercourse, and terminating at a point approximately 70 meters to the north of the confluence ot he Jordan estates Tributary and the main watercourse.
Rideau Valley Conservation Authority	2010, November 3	Approval of Drain Maintenance works of 220 m + 70 m of the channel to the north-west (upstream) of the property line with the adjacent landowner (Doyle) located on Part of Lot 19, Concession 9. Works are limited to bottom cleanout of the watercourse.
Rideau Valley Conservation Authority	2010, November 3	Approval of Drain Maintenance works of 650m of the channel to the north-west (upstream) of the property line with the adjacent landowner (Doyle) located on Part of Lot 19, Concession 9. Works are limited to bottom cleanout of the watercourse.
Rideau Valley Conservation Authority	2010, November 3	Approval of Drain Maintenance works on Part of Lot 19, Concession 9, starting at the north end of the culvert at Flewellyn Road to a point approximately 200 m upstream (to the Northwest where the watercourse crosses the property line). Works are limited to bottom cleanout of the watercourse.
Westly, Mike. 1987. Letter to Council	Early '70s	Assessed for Hobbs drain construction; cleared to Fallowfield Road; culvert under Flewelyn Road; Conley rideroad ditch cleared out = increased water; blocked drain at arrow
Russell Thesis	2010 April	concludes that wetlands are the result of beaver and poor management by the City

APPENDIX C
MP Construction Details

Flewellyn Cumulative Effects Study
City of Ottawa
SLR Project No.: 209.40105.00000

Appendix C: Installation of Mini-piezometers

Four test mini-piezometers (MPs) were installed within the special study area (see Figure 3). Each was installed in a different creek. The MPs were specifically installed into a creek, to measure whether the creeks were gaining water from the ground or losing water to the ground.

The MPs were constructed out of ¾ inch black pipe of lengths 2 ft and/or 4 ft, depending on the total length required and a MP tip. The black pipe is threaded at both ends, and allows different combination to be screwed together. The pipe is not galvanized and should not be used to sample for water quality. The MP tip is approximately 0.45 m in length with a screen length of about 0.3 m. One end of the tip is a sharp point and the other is threaded.

The first black pipe lengths were screwed directly to the MP tip, then the following pipe lengths were attached using the couplers, and tightened together using pipe wrenches. To make installation easier, a minimum length of the MP tip and a 2 or 4 ft length, was stated with.

Once the minimum length was assembled, the MP was installed into the desired location using a fence post driver. To avoid destroying the threads at the top of the pipe a coupler was screwed onto the top of the MP. After the MP was banged into the ground far enough, another length was attached via a coupler. The process was repeated until the desired length was achieved. Lastly, a cap was loosely screwed onto the top of the MP to prevent rainfall from entering the MP.

APPENDIX D
Chronology of Drainage Construction and Maintenance: Hobbs and Mansfield Drain (Flowing Creek)

Flewellyn Cumulative Effects Study
City of Ottawa
SLR Project No.: 209.40105.00000

Appendix D: Mansfield Drain (Flowing Creek) Culvert Chronology

ID	Source	Date	Location	Existing prior to Drain design			Upgraded as part of Drain design			Notes
				Size of culvert		Type of culvert	**Size of culvert**		Type of culvert	6
				Dia.(in) x Length (ft)	Dia.(m) x Length (m)		Dia.(in) x Length (ft)	Dia.(m) x Length (m)		
A -	Engineer's Report for the Mansfield Municipal Drainage Work's (Road Culverts)	1974	Replace exisitng wooden plank structure through the Unopened Township Road, Concessions 6 between Lot 20 and Lot 21, (Station 0+13 Graham-Luebbert Branch)	-	-	Wooden plank structure	66'' Dia.	1.67 m Dia.	C.S.P.	Existing wooden plank structure was in poor condition and causing a restriction to the efficiency of the drain
B -	Engineer's Report for the Mansfield Municipal Drainage Work's (Road Culverts)	1974	Lower the existing culvert through Township Road between concession 6 and 7, east half of Lot 19 (Station 36+75 Graham-Luebbert Branch)	30'' x 44'	0.76m x 13.4m	N/A	30'' x 44'	0.76m x 13.4m	N/A	Existing culvert was adequate in size but required lowering to design grade
C -	Engineer's Report for the Mansfield Municipal Drainage Work's (Road Culverts)	1974	Replace and re-align the exisitng culvert through Township Road between Concessions 6 and 7, Lot 20 (Station 13+67 Tilgner-Cathcart Branch)	48'' Dia.	1.22 m Dia.	N/A	60'' Dia.	1.52 m Dia.	N/A	Existing culvert was deficient in size and elevation
D -	Engineer's Report for the Mansfield Municipal Drainage Work's (Road Culverts)	1974	Lowered the existing culvert at Township Road between Concessions 6 and 7 and the center of Lot 19 (Graham McCoy Branch)	60'' Dia.	1.52 m Dia.	N/A	60'' Dia.	1.52 m Dia.	N/A	Existing culvert was set at an elevation that was prohibiting proper drainage
E -	Engineer's Report for the Mansfield Municipal Drainage Work's (Road Culverts)	1974	Add a second culvert 39m west of the existing culvert at Township Road between Concessions 6 and 7 at Lot 19	24" Dia.	0.61 m Dia.		24" Dia.	0.61 m Dia.		Culvert was insufficient in size and elevation
							36" Dia.	0.91 m Dia.		
F -	Engineer's Report for the Mansfield Municipal Drainage Work's (Road Culverts)	1974	Replace the existing culvert at Station 23+96 of the Main Drain	48" x 20'			48" x 20'			Culvert was insufficient in size and elevation

	Chronology					
Source	**Date**	**Location**	**Size of culvert**		Type of culvert	Notes
			Dia.(in) x Length (ft)	Dia.(m) x Length (m)		
Engineer's Report for the Hobbs Municipal Drain (Road Culverts)	Pre-1972	Existing culvert through Township Road in Lot 13 between Concessions 6 and 7				Culvert sufficient in size for it's location on the drain
Engineer's Report for the Hobbs Municipal Drain (Road Culverts)	1972	New culvert through Township Road in Lot 13 between Concessions 6 and 7 - 20 feet east of existing structure	54'' x 48'	1.4m x 14.6m	CSP (12 gauge)	Culvert was added to provide a waterway at a lower elevation than the existing structure
Engineer's Report for the Hobbs Municipal Drain (Road Culverts)	Pre-1972	Existing culvert through Township Road in Lot 12 between Concessions 5 and 6				Culvert sufficient in size for however a 10ft (3.05 m) channel was constructed through the culvert at a depth of 1ft (0.30m) in order to provide a waterway at a lower elevation
Engineer's Report for the Hobbs Municipal Drain (Road Culverts)	1972	Replaced culvert through Township Road in Lot 14 between Concessions 5 and 6 (Branch #7)	54'' x 40'	1.4m x 12.2m	CSP (12 gauge)	Existing culvert was insufficient in size
Engineer's Report for the Hobbs Municipal Drain (Road Culverts)	Pre-1972	Existing concrete culvert through Township Road in Lot 12 between Concessions 6 and 7 (at the outlet of Branch # 13)				Culvert sufficient in size for it's location on the drain
Engineer's Report for the Hobbs Municipal Drain (Road Culverts)	1972	Replaced culvert through Township Road in Lot 12 between Concessions 6 and 7 (Branch #14)	42'' x 40'	1.1m x 12.2m	CSP (12 gauge)	Existing culvert was insufficient in size
Engineer's Report for the Hobbs Municipal Drain (Road Culverts)	1972	Existing culvert through Township Road at Station 0+15 of Branch #18	30'' x 10'	0.76m	CSP (14 gauge)	Culvert was lowered 3ft (0.9m) and an additional 10' of pipe was added to the culvert in anticipation of future road construction
Engineer's Report for the Hobbs Municipal Drain (Farm Crossings)	Pre-1972	There are 2 existing farm crossings on the exiting drain and both appear to be in a poor state of repair - size, type and location of these culverts is not specified in the report				
Engineer's Report for the Hobbs Municipal Drain (Farm Crossings)	1972	New culvert - Concession 7, west half of Lot 13, Branch #1	24'' x 26'		CSP (16 gauge)	Crossing for C. Massey
Engineer's Report for the Hobbs Municipal Drain (Farm Crossings)	1972	New culvert - Concession 6, east half of Lot 12, Branch #2	24'' x 26'		CSP (16 gauge)	Crossing for C. Hobbs
Engineer's Report for the Hobbs Municipal Drain (Farm Crossings)	1972	New culvert - Concession 6, west half of Lot 13, Branch #4	24'' x 26'		CSP (16 gauge)	Crossing for D. Casey
Engineer's Report for the Hobbs Municipal Drain (Farm Crossings)	1972	New culvert - Concession 6, east half of Lot 12, Branch #4	24'' x 26'		CSP (16 gauge)	Crossing for C. Hobbs
Engineer's Report for the Hobbs Municipal Drain (Farm Crossings)	1972	Concession 6, right west half of west quarter Lot 14, Branch #7	24'' x 28'		CSP (16 gauge)	Crossing for C. Hobbs
Engineer's Report for the Hobbs Municipal Drain (Farm Crossings)	1972	New culver - Concession 6, east half of Lot 14, Branch #7	36'' x 28'		CSP (14 gauge)	Crossing for P. Scott
Engineer's Report for the Hobbs Municipal Drain (Farm Crossings)	1972	New culver - Concession 6, east half of Lot 14, Branch #7	48'' x 28'		CSP (14 gauge)	Crossing for P. Scott
Engineer's Report for the Hobbs Municipal Drain (Farm Crossings)	1972	New culver - Concession 6, right west half of west quarter Lot 14, Branch #8	24'' x 30'		CSP (16 gauge)	Crossing for C. Hobbs
Engineer's Report for the Hobbs Municipal Drain (Farm Crossings)	1972	New culver - Concession 6, west half of Lot 14, Branch #8	24'' x 28'		CSP (16 gauge)	Crossing for P. Scott
Engineer's Report for the Hobbs Municipal Drain (Farm Crossings)	1972	New culver - Concession 7, right west quarter of Lot 14, Branch #9	36'' x 24'		CSP (14 gauge)	Crossing for P. J. Larkin
Engineer's Report for the Hobbs Municipal Drain (Farm Crossings)	1972	New culver - Concession 5, east half of Lot 13, Branch #16	30'' x 26'		CSP (14 gauge)	Crossing for Edsam Realties

Engineer's Report for the Hobbs Municipal Drain (Farm Crossings)	1972	New culver - Concession 5, east half of west half of Lot 14, Branch #16	36'' x 28'		CSP (14 gauge)	Crossing for D. Yuill
Engineer's Report for the Hobbs Municipal Drain (Farm Crossings)	1972	New culver - Concession 5, east half of west half of Lot 14, Main Drain	12'9'' x 8'8'' x 30'		CSPA (12 gauge)	Crossing for D. Yuill
Engineer's Report for the Hobbs Municipal Drain (Access Culverts)	1972	New culver - Concession 6, east half of Lot 12, Main Drain	2 - 8'7'' x 6'0'' x 38'		CSPA (12 gauge)	Crossing for C. Hobbs
Engineer's Report for the Hobbs Municipal Drain (Access Culverts)	1972	New culver - Concession 5, east half of west half of Lot 14, Branch #12	30'' x 28'		CSP (14 gauge)	Crossing for D. Yuill
Engineer's Report for the Hobbs Municipal Drain (Access Culverts)	1972	New culver - Concession 5, east half of Lot 12, Branch #13	30'' x 28'		CSP (14 gauge)	Crossing for C. Massey
Township of Goulbourn - Final Engineer's Report for the Hobbs Drain Extension (Farm Crossing)	1988	Replaced existing Twin 1250mm culverts - Concession 8, Lot 14, Main Drain Extension		2 x 1400mm	CSP	Crossing for W. Byrne
Township of Goulbourn - Final Engineer's Report for the Hobbs Drain Extension (Farm Crossing)	1988	Existing concrete bridge, precast deck slap and beams - removed temporarily for drain works				Crossing for F. Hoekstra
Township of Goulbourn - Final Engineer's Report for the Hobbs Drain Extension (Farm Crossing)	1988	Replaced existing 900mm culvert - Concession 8, Lot 15, Main Drain Extension		2 x 1200mm	CSP	Crossing for C. Massey

APPENDIX E
Inventory of Organic Characteristics of Wetlands (2011 layer)

Flewellyn Cumulative Effects Study
City of Ottawa
SLR Project No.: 209.40105.00000

Sub watershed	SLR Wetland ID	Monitor/ MP	Jock River Subwatershed Report 2010	MNR PSW Identifier	Soils			Vegetation		Notes
					OGS	OAC	RVCA	NESS	SLR Obs	
Flowing	A		PSW	PSW	6	O	O	SWT		
Flowing	B		PSW	PSW	O	O	O	SWT		
Flowing	C	SW1, MP1	PSW	PSW	O	O	O	MA		
Flowing	D		PSW	PSW	O		O	MA		
Flowing	E		PSW	PSW	6		O	MA		
Flowing	F		PSW	1	6		O	SWT/TH		
Flowing	G	SW3, MP3	PSW	1	5	O	O	SWT/SWC		Saltieri Property: thicket and forested swamp, organic soils, Sp, Water Hemlock, Blanding's Turtle; Mottled Sculpin in northern tributary of Flowing Creek; Reported forest 100-140 years old (ONS)
Flowing	H	SW3, MP3	PSW	1	5	O	O	SWC/FOC	watercress (indicator of groundwater upwelling)	
Flowing	I		PSW	2	4		O	FOC		
Flowing	J		PSW	2	4		O	SWT/FOD		
Flowing	K		PSW	3	5		sand	FOC		
Flowing	L		unevaluated wetland	waterbody	5		O	FOC		
Flowing	M		PSW	4	2		bedrock	SWC/FOC		
Hobbs	N	SW4, MP4	PSW	6	5		O	FOD?		At Conley and Flewellyn
Hobbs	O	SW6, MP6	PSW	8	5	O	O	FOD/SWC/FO/TH/FOC		
Hobbs	P		PSW	12	5		sand	MA/FOD		
Hobbs	Q	SW5	PSW	14,15	O	O	O	MA/SWM/SWT	Mf, Ab, Ew, Butternut; SWD/SWM	from Fernbank Quarry: SWT/SWC/SWD
Hobbs	R		PSW	20	O		O	SWD/MA	MAS2	
Hobbs	S	SW7	PSW	16	O	O	O	SWC/SWM	MAS2	Green Frog, Common Yellowthroat, Red-winged Blackbird, Swamp Sparrow, Painted Turtle and Whitetail Dragonfly
Hobbs	T		PSW	16	O	O	O	SWT/SWC	SWT	
Hobbs	U		PSW	11	5		O	MA/SWT		south of Fernbank; east of Munster Road/Lucas Lane - subject to draining
Hobbs	V		PSW	10	5		O	MA/SWT/SWD		
Hobbs	W		PSW	4	2		bedrock	MA		
Hobbs	13		PSW	13	5		bedrock	FOC		
Hobbs			?	9	3		bedrock	TH		
Hobbs			?	5	5		O	FOD		
Hobbs	X	SW6, MP6	PSW	7	5,3	O	O	SWC		
Flowing	Y		woodland	17	5		bedrock	MA?		
Flowing			PSW	18	5		bedrock	SWT		
Flowing			PSW	19	5		bedrock	SWC/SWT		
Flowing	Z	SW2, MP2	HDC	PSW 7	4	O	O	SWT/MA	Mf, Ab, Ew	
Flowing	AA	SW2, MP2	PSW	PSW 4	4	O	O	SWD/MA		
Hobbs	AB		HDC	4	4	O	O	FO ON DRAINAGE		
Flowing	AC		HDC	2,6	3,6	O	O	OD on drainage/waterbody		
Flowing	Fernbank Wetland		PSW		O	O	O			
	ONS = Ottawa Natural System									
	OGS = Ontario Geologic Survey									
	RVCA = Rideau Valley Conservation Authority									

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