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TEWIN LANDS CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT

April 2024

Prepared For:

David Schaeffer Engineering Ltd
120 Iber Road (UNIT 103)
Stittsville, ON
K2S 1E9

Prepared By:

J.F. Sabourin and Associates Inc.
52 Springbrook Drive
Stittsville, ON
K2S 1B9

1.1 Introduction

This Tewin Lands: Cumulative Hydrologic Impact Assessment is part of a set of technical reports which have been prepared as part of Phase 1 of the Tewin study process. The Tewin Study Area ("Study Area") lands were identified as a future urban development area in the new City of Ottawa Official Plan (2023). The Study Area is located in southeast Ottawa, generally bordered by Leitrim Road to the north, Farmers Way to the east, Thunder Road to the south, and Anderson Road and Ramsayville Road to the west. The Study Area is outlined in **Figure 1** below. These technical reports are intended to establish an understanding of the existing physical, social and ecological conditions that characterize the Study Area. Where appropriate, these reports also identify preliminary opportunities to help guide the next phase of the master planning process.

This information will be used to identify opportunities and strategic considerations that will inform the Tewin community design process going forward, as well as frame the preparation of additional site-specific technical studies and recommendation reports. Development at Tewin will explore new approaches to planning, design and development, including alternative strategies and solutions that can successfully implement the key community objectives.

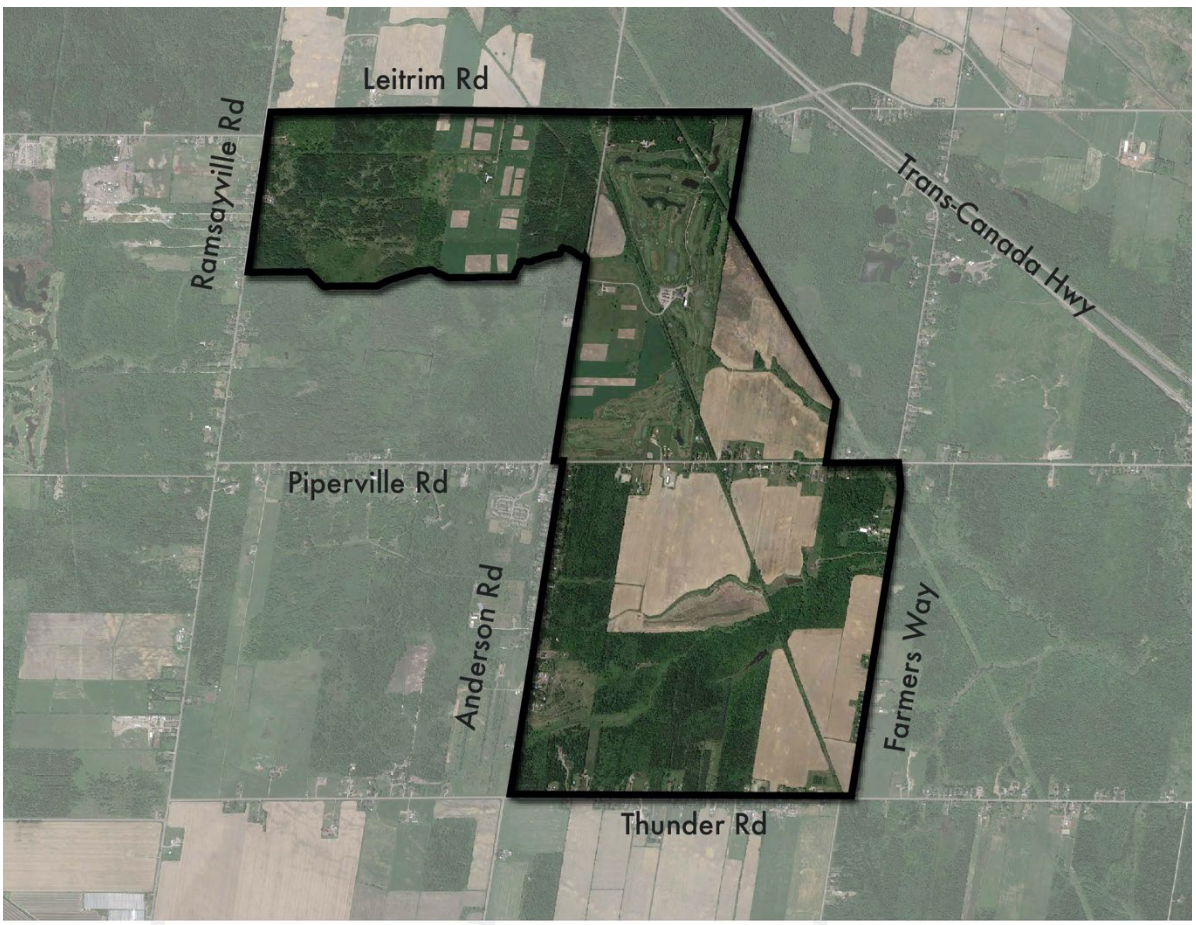


Figure 1: The Tewin Study Area is identified in black outline

1.2 Integrated Master Plan & Municipal Class EA Process

The ambition and scale of Tewin requires ongoing internal and external consultation. The purpose of the integrated Master Plan and Municipal Class EA process is to consolidate the various technical and community planning elements of the project to promote coordinated community engagement through streamlined and aligned decision making. This format will ensure critical partners, consultants and stakeholders are brought together at major milestones to identify and track challenges and opportunities through the development process.

The integrated Master Plan and Municipal Class EA process will include a public consultation strategy and technical study review timeline that achieves the requirements of the Master Plan and Municipal Class EA concurrently. The statutory Municipal Class EA meetings will be timed to align with the development of the community objectives, urban framework, preferred plans, and the draft secondary plan. Additional public and targeted consultations will be planned to complement the statutory consultation requirements. The development of the One Planet Action Plan (OPAP) will occur in parallel, with the final OPAP available at the time of final secondary plan Council approval. One Planet Living endorsement will follow Council approval of the secondary plan.

1.3 Tewin Overview and Community Vision

Tewin is planned to be a community of approximately 45,000 people and thousands of jobs. It will be more compact and dense than existing suburbs in Ottawa, with new urban areas integrated alongside valuable natural areas. Tewin will be an inclusive community, anchored in Algonquin wisdom and placekeeping principles, and welcoming to all. The community will have a meaningful mix of land uses and support active mobility, to achieve a complete, future ready community. The Tewin Project Team and City of Ottawa have committed to exploring appropriate options, alternatives and standards to enable Tewin to become a model of best practices in sustainable and inclusive community design in the North American context.

The integrated Master Plan and Municipal Class EA process will bring together various technical and community planning considerations.

The key objectives for Tewin are to create a community that is:

- Anchored in Algonquin wisdom, principles and placekeeping;
- A benchmark for community design, demonstrating achievement of the 5 Big Moves identified in the Ottawa Official Plan;
- Mobility-oriented and supportive, promoting a broad range of active forms of movement, where personal vehicles are optional;
- Characterized by a meaningful mix of housing, community amenities, jobs and services in order to achieve a complete, future-ready community;
- Designed to protect and integrate alongside valuable natural areas and agricultural lands; and
- Affordable, inclusive, healthy, welcoming and accessible to all.

1.4 Tewin Intent: A Forward-Thinking Framework

Development at Tewin will explore new approaches to planning, design and development, finding successful options and alternatives to implement the key community objectives, in some cases likely going beyond what current development standards would allow for. The Tewin Project Team and the City of Ottawa have articulated these in the “Tewin Intent” which sets out the following:

1. Bold and Innovative Thinking:
Tewin is about creating a new kind of community, a future-focused model for smart, healthy and sustainable development. It will be a people-centred place that seeks to create the conditions for well-being. The Tewin Project Team will be open to bold ideas, innovative approaches, creative solutions, efficient use of land and resources, emerging

technologies, smart city infrastructure that advances the City's goals and objectives, and other future-forward ideas and opportunities that will enable Tewin to reach its full potential.

2. Integrating Algonquin Values and Principles:
Algonquin principles, values and teachings will guide the planning, consultation, design and development process for Tewin. The integration of Algonquin principles and design intentions will ensure the community is nature-based and sensitive to Mother Earth while creating capacity-building and economic development opportunities for the Algonquin people.

3. Sustainability and Resilience:
Tewin will be a model community that will position Ottawa as a leader in integrated sustainable design with the goal of being a resilient and holistic community. Tewin will be guided by the One Planet Living framework and Algonquin values of respect for the earth. The Community Design Plan will respond to the City's High Performance Development Standard and Climate Change Master Plan, and will result in a Community Energy Plan. A Community Energy Plan and performance-based sustainability metrics that address climate mitigation and adaptation, and the other categories of the High Performance Development Standards will be established from the start and monitored over time.

4. Systems-Based Environmental Planning
Tewin's organization and functions will be designed to respect nature and integrate natural features and landscapes into its form, character, and spirit. To that end, the Tewin Project Team is committed to pursuing a systems-based approach to natural heritage protection, environmental management, and water management in a way that is inclusive and integrated and encourages stewardship and a positive relationship with the natural world. Natural features are regarded as opportunities rather than constraints, will be woven into the fabric of the community, and will be central to its design and character.

5. Alternative Design Solutions:
Designing a community of the future requires progressive and forward-thinking infrastructure solutions. The Tewin Project Team is committed to being solutions-oriented and will consider alternative design and engineering standards that prioritize natural systems, pedestrians, cyclists and transit users, and which efficiently use available land and resources.

Surface water management strategies that achieve quality, conveyance and storage objectives will be based on the fundamentals of natural cycles, green/soft infrastructure, and multi-use opportunities that complement the human realm. Infrastructure design will consider the needs of those involved in the construction, operation and maintenance of municipal services to find opportunities to efficiently service the community and showcase sustainable practices while meeting the community's needs.

A framework for assessing alternative design standards will be established to consider and review alternatives against existing standards within the context of goals and objectives for the City and Tewin.

6. Cost-Effectiveness and Efficiency:
Tewin will demonstrate best practices in efficient and compact development. As a dense, mixed-use community of scale, Tewin will achieve a critical mass of people and jobs to support new infrastructure investments. The Tewin Project Team is committed to exploring opportunities to optimize the community's efficiency through a range of strategies, including prioritizing space-efficient modes of transportation, use of technology, green infrastructure, innovative construction practices, shared-use agreements, and mixed-use forms of development that will promote the efficient use and optimization of land; housing affordability; and supporting the long-term financial viability of the community and city resources.

7. Integrated Planning Process:
We are committed to advancing Tewin through a comprehensive and integrated planning and environmental assessment process where possible or applicable. The process will bring together various planning, environmental, transportation,

urban design, infrastructure, economic, financial, social and technical considerations. The process will be underpinned by engagement with the Algonquin people, other stakeholders, and the public.

8. Collaboration and Problem Solving:
The Tewin Project Team and City of Ottawa Project Team are committed to working collaboratively together to move Tewin forward in an expedited way. We will plan with a spirit of collaboration and joint problem-solving to ensure that the development of Tewin meets the best interests of the City of Ottawa and the Algonquins of Ontario.

9. Communication and Transparency
The Tewin Project Team and the City of Ottawa Project Team commit to open and transparent communication throughout the project. This will require proactively sharing information between the groups as decisions are made and to ensure relevant communication materials are distributed in a timely manner.

The Tewin Project Team and the City of Ottawa Project Team will ensure that all parties, including City Council, residents, and other stakeholders, are provided with pertinent details. Effective information sharing will ensure the project achieves outcomes that are, to the greatest extent possible, known by all involved.

1.5 Existing Conditions Technical Reports

A range of specialized consultants have been studying the physical environment of the Study Area to support community design, servicing strategies and the future development of Tewin. This data has been collected and reported on in a set of Existing Conditions and Opportunities Reports, of which this document is one. The full suite of reports includes the following:

- **Tewin Existing Conditions and Preliminary Opportunities Report** dated April 2024 and prepared by Urban Strategies
- **Fluvial Geomorphology Study - Tewin Lands: Existing Conditions Summary Report - Bear Brook and Ramsay Creek Watersheds** dated April 2024 and prepared by GEO Morphix Ltd.
- **Tewin Lands: Existing Conditions Hydrogeological Study** dated April 2024 and prepared by Dillon Consulting
- **Existing Conditions - Geotechnical: Tewin Lands** dated April 2024 and prepared by Paterson Group
- **Tewin Lands: Natural Heritage Preliminary Existing Conditions Report** dated April 2024 and prepared by Kilgour and Associates
- **Tewin Lands: Cumulative Hydrologic Impact Assessment** dated April 2024 and prepared by J.F. Sabourin and Associates
- **Tewin Lands: 2021-22 Field Monitoring Report** dated April 2024 and prepared by J.F. Sabourin and Associates
- **Tewin Lands - Existing Conditions Water Budget** May 2024 and prepared by J.F. Sabourin and Associates
- **Tewin Mobility Existing Conditions** dated 2024 and prepared by CGH Transportation
- **Tewin Public and Stakeholder Engagement Plan** dated April 2024 and prepared by Urban Strategies

1.6 Framework for Identifying Preliminary Opportunities

Given the unique scale, vision and project goals for Tewin, as well as the shared commitment to exploring new ways of advancing the community design process as expressed in the Tewin Intent, the Phase 1 reports for Tewin include a discussion of potential opportunities to be explored in subsequent stages of the integrated Master Plan and Municipal Class EA process. The identification of preliminary constraints and opportunities, as well as a preliminary community structure, is required in Phase 1 of the integrated Master Plan and Municipal Class EA process as per specific Terms of Reference that were established for each of the Tewin planning, environmental and transportation studies.

The opportunities introduced within these reports are based on a series of key policy directions and strategic considerations, including:

- **Ottawa's new Official Plan**, which promotes the creation of complete, transit-supportive communities;
- **Algonquin values and principles**, underscored by respect for nature, integration of water, and planning the natural environment to achieve long-term vitality over many generations;
- **The Tewin Intent**, which promotes innovative thinking and alternative, performance-based solutions;
- **One Planet Living**, a holistic framework for achieving environmental resiliency, sustainable development, and reduced carbon emissions;
- **Provincial policy** direction focused on supporting housing development and facilitating growth, in order to address the province's housing supply challenges; and,
- **An integrated, systems-based approach** to planning at Tewin that brings together diverse planning, environmental, technical and economic considerations.

April 30, 2024 Project Number: P971

David Schaeffer Engineering Limited
120 Iber Rd
Stittsville, Ontario
K2S 1E9

Attention: Steve Pichette, P.Eng.

Subject: Tewin Lands: Cumulative Hydrologic Impact Assessment

INTRODUCTION

JFSA Canada Inc. (JFSA) has been retained by David Schaeffer Engineering Limited (DSEL) to conduct a cumulative hydrologic impact assessment of the Bear Brook and Tributaries watershed in consideration of the future Tewin Lands located in the City of Ottawa, Ontario. The Bear Brook watercourse headwaters are located in the east of the City of Ottawa and outlets to the South Nation River near Lemieux.

This report is an update to a previous report dated May 31st, 2023, following review comments received from the City of Ottawa and South Nation Conservation Authority on October 23rd 2023. The first among the two main updates consists of changes in the modified HEC-HMS summer models in which the City of Ottawa design storms for the conceptual design of Stormwater Management Facilities (SWMFs) were replaced with design storm rainfall data from Environment Canada and Climate Change (ECCC) IDF curves for the Ottawa McDonald Cartier Airport (release version 3.0 dated 2019-02-27). The second update is about the consideration of spring conditions (through snowmelt plus rainfall event HEC-HMS modelling) in this Tewin cumulative hydrologic impact assessment study.

The study area for this analysis is consistent with that assessed in the *Bear Brook and Tributaries Flood Hazard Mapping Report* by South Nation Conservation (SNC) dated March 2022 *[1]*. **Figure 1** outlines the subject area assessed in the cumulative impact study. It is noted that some drainage area boundaries in other documents may differ from those found in the SNC flood mapping study which are maintained in the current analysis.

The general purpose of this cumulative hydrologic impact assessment study is to assess the impact of development on the proposed Tewin Lands, as shown in **Figure 2**, on the Bear Brook and Tributaries watershed. Two objectives have been identified.

1. Determine whether the Stormwater Management (SWM) control measures proposed for the development of the Tewin Lands have adverse downstream impacts on the Bear Brook and Tributaries watershed in terms of peak flow increases along its watercourses when compared to the existing conditions.

2. Determine whether the same Stormwater Management (SWM) control measures proposed for development of the Tewin Lands can be used for the other urban development lands (**Figure 2**) without increasing peak flows along the Bear Brook River and its tributaries within the study area when compared to the existing conditions.

EXISTING CONDITIONS HYDROLOGY (2022) – ORIGINAL (SUMMER/SPRING)

The existing conditions hydrologic models that were prepared by SNC in the scope of the *Bear Brook and Tributaries Flood Hazard Mapping Report* were acquired by JFSA and have been used as the basis for the Tewin Lands: Cumulative Hydrologic Impact Assessment study. These models have been referred to as "original" in the scope of this study. Note that the subject hydrologic models, which include summer and spring (snowmelt + rainfall) models – "May2021 – Calib" and "Snow" basin models, respectively – have been prepared using the HEC-HMS software that has been developed by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers (USACE).

EXISTING CONDITIONS HYDROLOGY (2022) – MODIFIED (SUMMER/SPRING)

Several updates have been made to the original HEC-HMS summer and spring models received from SNC to ensure that the models fulfill the purpose of this cumulative impact study. Note that these models have been referred to as "modified" in the scope of this report. The following section outlines these changes.

1.1.1 Subcatchment Delineation

As shown in **Figure 2**, the subcatchment boundaries in the original HEC-HMS models match neither those of the proposed Tewin Lands nor the development limits of the East Urban Community (Phases 1, 2 and 3), South Orleans Urban Expansion and Leitrim - East of Bank Street (S-5) Urban Expansion. Therefore, the watershed delineation in the original HEC-HMS models was updated as follows:

- Original HEC-HMS summer/spring model subcatchments partially located within a development area or intersecting a development area limit were split at the development area limit.
- Any portions of development areas falling outside the Bear Brook and Tributaries watershed as represented in the original HEC-HMS summer/spring models were not accounted for in this cumulative impact assessment study.

Figure 3 illustrates the subcatchments resulting from the revised subcatchment delineation in the HEC-HMS models.

Once the model subcatchments were adjusted to reflect the proposed development area limits more accurately, the associated model parameters were updated accordingly.

Note that the drainage areas and associated imperviousness in the spring model were globally revisited to best represent spring conditions. It was considered, according to results obtained from a snowmelt plus rainfall data analysis completed by JFSA at the Ottawa Macdonald Cartier Int'l Airport between 1940 and 2011, that half of the volume in the snowmelt plus rainfall event may be attributed to snowmelt, and half to rainfall.

As it is expected that most of the snow on impervious areas like roads, driveways and roofs would have melted prior to such an event, half of the impervious area was removed from each subcatchment in the HEC-HMS spring model, such that only the runoff resulting from rainfall, not snowmelt, is simulated for impervious areas. Besides the aforementioned changes that are only relevant to the spring model, the general structure/setup of the original HEC-HMS models was maintained in the modified models and modelling parameters were only adjusted where deemed necessary.

For instance, the same loss, transformation and routing methods were used (i.e., SCS Curve Number, Clark Unit Hydrograph, and Muskingum-Cunge methods, respectively). The original SCS loss method parameters were applied to the modified subcatchments; whenever an original subcatchment was split into several modified subcatchments, the Initial Abstraction (Ia), Curve Number (CN) and imperviousness of the original subcatchment were applied to all modified subcatchments.

Furthermore, the original drainage scheme remained unchanged; reaches and junctions were not modified while subcatchments outlets were maintained. Therefore, whenever an original subcatchment was split into several modified subcatchments, all these modified subcatchments were assigned the same outlet as the original subcatchment.

In terms of the transformation method, the Clark Unit Hydrograph parameters (Time of Concentration and Storage Coefficient) for each modified subcatchment were updated to reflect the physical parameters of these newly generated subcatchments.

The following section outlines the approach applied when updating the Tc and R values for the modified subcatchments.

1.1.2 Time of Concentration (Tc)

In the original summer model, the Uplands method was selected among the various methods tested to determine the time of concentration. As such the modified subcatchments Tc values were derived using the Uplands method as well. Based on the flow type (comparable to the land use type), this method is used for shallow concentrated flows and correlates the slope and the velocity.

Subsequently, the time of concentration is obtained by dividing the channel length by the velocity. Note that both slope and channel length parameters were obtained based on topographic data drawn from both the HEC-HMS and HEC-RAS models of the *Bear Brook and Tributaries Flood Hazard Mapping* study, along with GIS tools. It is worth mentioning that the 85/10 method was used to determine the slope of the modified subcatchments while the flow type was chosen based on the original model and aerial photos.

In the original spring model, it was observed that Tc was taken as 2/3 of the Tc in the original summer model. Hence, the same approach was used in the modified spring model where each subcatchment has a Tc equating to 2/3 of its Tc in the modified summer model.

1.1.3 Storage Coefficient (R)

Like the time of concentration (Tc), there are several possible approaches/equations to calculate the storage coefficient, R. Due to a lack of explicit information regarding the determination of R in the *Bear Brook and Tributaries Flood Hazard Mapping* study by SNC, a relationship between R and Tc commonly found in the literature, as per the formula below, was applied. Note that the indicator Kc is a constant affecting the hydrograph peaking characteristics, as suggested by Wang and Dawdy *[2]*.

$$Kc = \frac{R}{Tc + R}$$

In the original HEC-HMS summer model, it was determined that the indicator Kc for all subcatchments consistently yielded a value of 0.65. Hence, based on this Kc of 0.65 and the Tc values obtained using the Uplands method, R values were determined for each modified subcatchment.

In the original HEC-HMS spring model, Kc differed from one subcatchment to another within a range of **0.25** to **0.87**. Hence, for each modified subcatchment in the modified HEC-HMS spring model, the same Kc as calculated in the original HEC-HMS spring model was used along with its spring Tc value as described in the previous *“Time of Concentration (Tc)”* section to derive the R value.

TEWIN LANDS CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT PROCEDURE

The following section outlines the updates made to the existing conditions HEC-HMS model that had to be completed to reflect the proposed development conditions.

1.1.4 Target Release Rates and Storage Requirements

Unitary target release rates were set for the proposed development of the Tewin Lands using the original spring (snowmelt + rainfall) HEC-HMS model, which was also used to delineate the 100-Year flood risk lines within the Bear Brook and Tributaries watershed in the *Bear Brook and Tributaries Flood Hazard Mapping Report*. To establish these unitary target release rates, the 2-, 5-, 10-, 50- and 100-Year peak flows at Node J32 located downstream of the Tewin Lands and South of Highway 417 (refer to **Figure 4**) were obtained from the original HEC-HMS spring model then divided by the total drainage area of **4,898 ha**.

A SWMHYMO model was then built to estimate the resulting storage requirements under post-development conditions. For these proposed development lands, STANDHYD commands were applied and a total imperviousness of **70%** was assumed with **60%** assumed to be directly connected impervious area (conservative assumptions). Horton’s infiltration parameters were applied per the City of Ottawa Design Guidelines (Fo = 76.2 mm/hr, Fc = 13.2 mm/hr, DCAY = 4.14 /hr, F = 0.00 mm).

Finally, 2-, 5-, 10-, 50- and 100-Year 3-Hour Chicago and 24-Hour SCS Type II City of Ottawa design storms were applied in the SWMHYMO model, with the 24-Hour SCS Type II storms being the most critical. **Table 1** represents a summary of the unitary target release rates set for the Tewin Lands along with the storage requirements estimated using SWMHYMO. It is worth mentioning that the storage requirements specified in **Table 1** include quality control (**40 m^3/ha** volume released over **48 hours**).

Note that in HEC-HMS, the control measures provided in **Table 1** are implemented using the reservoir routing command. For each controlled subcatchment, a reservoir node was created. Runoff generated from the subcatchment is directed to the reservoir which drains to an HEC-HMS node/junction. A storage-discharge curve is associated with the reservoir using **Table 1**; each return period represents a storage-discharge curve point that has the target release rate and storage requirement. Note that these values were obtained by multiplying the values in **Table 1** with the associated drainage area (ha) of the controlled proposed development lands.

Table 1: Unitary Target Release Rates and Storage Requirements for the Tewin Lands

Return Period	Target Release Rate (L/s/ha)	Storage Requirement (m^3/ha)
2-Year	1.37	265.18
5-Year	2.02	362.09
10-Year	2.57	426.51
50-Year	4.10	560.91
100-Year	5.21	617.83

1.1.5 Development Areas Hydrologic Parameters

To reflect post development conditions in the modified HEC-HMS models as modelled in SWMHYMO, several subcatchment hydrologic parameters needed to be updated. The imperviousness of the relevant future development subcatchments (outlined in **Figure 3**) was essentially adjusted to **60%** in HEC-HMS. This aligns with the **60%** of directly connected impervious areas modelled in SWMHYMO since the SCS loss method in HEC-HMS does not account for indirectly connected areas.

Furthermore, in the modified summer model, Ia and CN values in HEC-HMS for the subject subcatchments were adjusted to **6.25 mm** and **57.6**, respectively, to mimic runoff generated in SWMHYMO.

Note that Ia and CN values of **4.7 mm** and **95**, respectively, were assigned to all subcatchments in the modified spring model, which is consistent with the original HEC-HMS spring model.

The imperviousness of the relevant future development subcatchments (outlined in **Figure 3**) was essentially adjusted to **43%** in the HEC-HMS spring model, which is equivalent to the **60%** imperviousness considered in the summer model given that only half of the impervious areas in the HEC-HMS subcatchments is accounted for under spring conditions. **Figure 5** illustrates all the HEC-HMS subcatchments that were ultimately updated with the hydrologic parameters indicated above.

Additionally, the Clark Unit Hydrograph parameters for these subcatchments were also adjusted to reflect developed conditions. In the modified summer model, using the Uplands method and considering flow type 'G' – Small upland gullies & paved areas (sheet flow) – Tc was recalculated then R derived using the same Kc value of **0.65** as in the original HEC-HMS summer model. In the modified spring model, Tc was taken as 2/3 of the corresponding Tc in the modified summer model under post development conditions and R was recalculated based on the same subcatchment Kc as in the original spring model.

Tewin Lands Cumulative Hydrologic Impact Assessment Scenarios

For the Tewin Cumulative Hydrologic Impact Assessment study, five (5) scenarios were assessed in each of the summer and spring models. Note that all the models were run using the same design storms as in the original HEC-HMS models.

1.1.6 Scenario 0 – Existing Conditions (JFSA Delineation Updates + Spring Modelling Considerations)

This scenario is reflective of the existing conditions HEC-HMS model as provided by SNC with adjustments made to the subcatchment delineations to reflect the proposed development boundaries. As such, adjustments have also been made to the Tc and R values for the affected subcatchments.

Additionally, drainage area and imperviousness revisions have been implemented in the spring model to only account for runoff resulting from rainfall, not snowmelt, on impervious areas. Refer to the **"***Existing Conditions Hydrology (2022) – Modified (Summer/Spring)"* section of this memo for further details on the modifications made.

Note that the modified summer and spring models that are representative of this scenario 0 are considered the "base" existing conditions models in this Tewin Cumulative Impact Assessment study.

1.1.7 Scenario 1 – Proposed Conditions (Tewin Lands Uncontrolled)

This scenario builds on the base existing conditions models (scenario 0) but updates the Tewin Lands subcatchments to reflect post-development conditions without any SWM controls (refer to **Figure 3**), while all other subcatchments remain as per existing conditions.

Refer to the ***"****Tewin Cumulative Hydrologic Impact Assessment Procedure - Development Areas Hydrologic Parameters"* section of this memo for further details.

1.1.8 Scenario 2 – Proposed Conditions (Tewin Lands Controlled)

This scenario builds on the proposed conditions models (scenario 1) but considers SWM controls for the Tewin Lands. The SWM controls (release rates and required storage volumes) applied in the models are specified in **Table 1** above.

Refer to the **"***Tewin Cumulative Hydrologic Impact Assessment Procedure - Target Release Rates and Storage Requirements"* section of this memo for further details.

1.1.9 Scenario 3 – Proposed Conditions (Tewin Lands Controlled + Future Development Uncontrolled)

This scenario is reflective of the proposed conditions and builds on scenario 2. Under this scenario, the future Tewin Lands are fully developed with onsite SWM controls, while the additional future development areas (refer to East Urban Community, South Orleans Urban Expansion and Leitrim - East of Bank Street (S-5) Urban Expansion in **Figure 3**) are also developed but with no SWM controls implemented.

Refer to the **"***Tewin Cumulative Hydrologic Impact Assessment Procedure - Development Areas Hydrologic Parameters"* section of this memo for further details.

1.1.10 Scenario 4 – Proposed Conditions (Tewin Lands Controlled + Future Development Controlled)

This scenario is reflective of the proposed conditions and builds on scenario 3, where both the future Tewin Lands and Future development lands (East Urban Community, South Orleans Urban Expansion and Leitrim - East of Bank Street (S-5) Urban Expansion) are developed with onsite SWM controls implemented, as specified in **Table 1**.

Refer to the **"***Tewin Cumulative Hydrologic Impact Assessment Procedure - Target Release Rates and Storage Requirements"* section of this memo for further details.

TEWIN LANDS CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT RESULTS

Six HEC-HMS nodes/junctions were selected to best represent peak flows along the Bear Brook River and its Tributaries in the scope of this Tewin Cumulative Hydrologic Impact Assessment study (refer to **Figure 4**). **Table 2** summarizes these peak flow locations along with a description.

Table 2: HEC-HMS Key Nodes/Junctions Locations

HEC-HMS Node/Junction	Description
J32	• Drainage Area (ha): 4,898 • South of Highway 417 • Downstream of the Leitrim - East of Bank Street (S-5) Urban Expansion • Downstream of the Tewin Lands • On the Bear Brook River mainstream
MK_DN5	• Drainage Area (ha): 3,361 • North of Highway 417 • Downstream of the East Urban Community (Phases 1, 2 and 3) • Downstream of the majority of the South Orleans Urban Expansion • Off the Bear Brook River mainstream
J23	• Drainage Area (ha): 17,588 • Downstream of J32 and MK_DN5 • On the Bear Brook River mainstream
J13	• Drainage Area (ha): 23,274 • Downstream of J23 • On the Bear Brook River mainstream
J6	• Drainage Area (ha): 37,239 • Downstream of J13 • On the Bear Brook River mainstream
Sink-1	• Drainage Area (ha): 44,720 • Downstream End of HEC-HMS model / Bear Brook Near Bourget gauge (02LB008)

Under summer conditions, **Table 3**, **Table 5**, **Table 7**, **Table 9, and Table 11** summarize peak flows at the locations specified in **Table 3** for scenarios 0 through 4, respectively.

Under spring conditions, **Table 4**, **Table 6**, **Table 8**, **Table 10, and Table 12** summarize peak flows at the locations specified in **Table 3** for scenarios 0 through 4, respectively.

Table 3: Scenario 0 – Existing Conditions (JFSA Delineation Updates) Results - Summer

		Modified Model		Modified Model		Modified Model		Modified Model		Modified Model		Modified Model		Modified Model
J32		3.9		5.9		7.4		9.3		10.8		11.4		12.3
MK_DN5		18.8		26.3		30.2		36.0		40.8		48.4		45.9
J23		29.6		42.3		51.6		64.3		74.1		84.9		84.2
J13		44.3		64.1		78.2		97.1		111.7		127.6		126.5
J6		55.1		80.8		99.2		123.3		142.3		156.0		161.3
Sink-1		64.1		94.1		115.4		143.0		164.9		178.8		186.6

As seen in **Table 3**, the original and modified existing conditions summer models under Scenario 0 yield different peak flow results due to the changes in Clark Unit Hydrograph parameters (Time of Concentration and Storage Coefficient) for the subcatchments affected by the subcatchment delineation updates, which were made to accommodate the development areas limits. The biggest differences, in terms of percentage, are spotted at J32 and MK_DN5, which are downstream of the Leitrim - East of Bank Street (S-5) Urban Expansion and the Tewin Lands, and East Urban Community and the majority of the South Orleans Urban Expansion, respectively. At J32, peak flows for the different return periods increased on average by 48% while an 11% average decrease in peak flows is observed at MK_DN5. Note that between J23 and the downstream end of the models, Sink-1, peak flows generated in the modified model are within -6% to +3% of the original model peak flows.

Table 4: Scenario 0 -Existing Conditions (JFSA Delineation Updates + Spring Modelling Considerations) Results - Spring

HEC-HMS Node	SPRING Peak Flows (m^3/s)							
	100-Year 1-Day Snow + Rain		100-Year 3-Day Snow + Rain		100-Year 5-Day Snow + Rain		100-Year 10-Day Snow + Rain	
	Original* Model	Modified Model	Original* Model	Modified Model	Original* Model	Modified Model	Original* Model	Modified Model
J32	13.1	18.8	21.2	26.4	23.0	29.4	24.5	30.7
MK_DN5	31.4	31.3	36.1	36.0	37.1	37.0	37.6	37.5
J23	73.1	75.7	105.1	109.4	116.7	120.8	122.3	125.7
J13	118.7	120.2	163.9	167.5	178.5	181.9	185.4	188.0
J6	166.2	168.0	235.7	239.6	259.5	263.4	270.0	273.0
Sink-1	180.7	182.6	261.1	264.8	289.7	293.4	302.7	305.5

* Original SNC spring model with spring modelling considerations consisting of adjustments to drainage areas and imperviousness (to only account for the effective distribution of snowmelt and rainfall volumes over impervious areas)

Table 4 represents a summary of spring peak flow results at key locations along the Bear Brook River between the original and modified models under Scenario 0. It should be noted that, for a fair comparison, the original model was subject to changes consisting in a reduction of the impervious areas by 50% as was the case in the modified model. As can be seen in **Table 4**, J32 is the location where the biggest peak flow differences are observed between the original and modified spring models, with an average increase of 30% noted across the different snowmelt plus rainfall event durations considered in this analysis. Besides, peak flow results are very similar at MK_DN5 between the two models while increases in peak flow ranging from 1% to 4% are observed at the downstream locations.

Table 5: Scenario 1 (Tewin Lands Uncontrolled) Results - Summer

	SUMMER Peak Flows (m^3/s)								
HEC-HMS Node	**2-Year 24-Hour SCS TII**	**5-Year 24-Hour SCS TII**	**10-Year 24-Hour SCS TII**	**25-Year 24-Hour SCS TII**	**50-Year 24-Hour SCS TII**	**100-Year 12-Hour SCS TII**	**100-Year 24-Hour SCS TII**	**100-Year 12-Hour SCS TII % Diff (Scenario 1 .vs. Scenario 0)**	**100-Year 24-Hour SCS TII % Diff (Scenario 1 .vs. Scenario 0)**
J32	7.4	10.5	12.6	15.4	17.5	21.2	19.7	+86%	+60%
MK_DN5	18.8	26.3	30.2	36.0	40.8	48.4	45.9	0	0
J23	33.8	47.6	57.4	70.9	81.6	95.1	92.5	+12%	+10%
J13	47.7	68.8	83.5	103.4	118.7	136.8	134.4	+7%	+6%
J6	57.7	83.9	102.6	127.0	146.3	162.9	165.7	+4%	+3%
Sink-1	66.6	97.1	118.7	146.7	168.8	184.8	190.9	+3%	+2%

Table 5 above outlines the summer results from Scenario 1 (Tewin Lands Uncontrolled). From Scenario 1 it is shown that developing the Tewin Lands without any SWM controls generally leads to increased peak flows along the Bear Brook River with a 100-Year peak flow increase of 86% at J32 for the 12-Hour SCS Type II storm. These peak flow increases are found to diminish further downstream along the main branch of the Bear Brook River. Note the peak flows at MK_DN5 are generally unaffected by the proposed development of the Tewin Lands since this node is not located on the Bear Brook River mainstream.

Table 6: Scenario 1 (Tewin Lands Uncontrolled) Results - Spring

	SPRING Peak Flows (m^3/s)				
HEC-HMS Node	**100-Year 1-Day Snow + Rain**	**100-Year 3-Day Snow + Rain**	**100-Year 5-Day Snow + Rain**	**100-Year 10-Day Snow + Rain**	**100-Year 10-Day Snow + Rain % Diff (Scenario 1 .vs. Scenario 0)**
J32	16.4	23.0	25.6	26.8	-13%
MK_DN5	31.3	36.0	37.0	37.5	0
J23	79.9	112.2	123.3	128.0	+2%
J13	124.0	170.3	184.5	190.5	+1%
J6	170.9	241.6	265.2	274.7	+1%
Sink-1	185.0	266.5	294.9	307.0	+0%

Under spring conditions, as can be seen in **Table 6**, developing the Tewin Lands without any SWM controls (Scenario 1) initially leads to decreased peak flows along the Bear Brook River downstream of the Tewin Lands with a peak flow reduction of 13% at J32 for the 100-Year 10-Day snowmelt plus rainfall event. Peak flow increases of no more than 2% are then observed further downstream along the main branch of the Bear Brook River.

Table 7: Scenario 2 (Tewin Lands Controlled) Results – Summer

	SUMMER Peak Flows (m^3/s)								
HEC-HMS Node	**2-Year 24-Hour SCS TII**	**5-Year 24-Hour SCS TII**	**10-Year 24-Hour SCS TII**	**25-Year 24-Hour SCS TII**	**50-Year 24-Hour SCS TII**	**100-Year 12-Hour SCS TII**	**100-Year 24-Hour SCS TII**	**100-Year 12-Hour SCS TII % Diff (Scenario 2 .vs. Scenario 0)**	**100-Year 24-Hour SCS TII % Diff (Scenario 2 .vs. Scenario 0)**
J32	3.7	5.6	7.0	8.8	10.3	10.9	11.7	-4%	-5%
MK_DN5	18.8	26.3	30.2	36.0	40.8	48.4	45.9	0	0
J23	29.4	42.3	50.7	61.5	70.7	81.7	80.4	-4%	-5%
J13	43.7	62.9	76.6	94.7	108.9	125.2	123.3	-2%	-3%
J6	54.2	79.2	97.0	120.5	139.2	153.1	158.1	-2%	-2%
Sink-1	63.3	92.7	113.4	140.5	162.0	176.1	183.5	-2%	-2%

Table 7 above outlines the results from Scenario 2 *(*Tewin Lands Controlled) under summer conditions. The implementation of the proposed SWM control measures within the Tewin Lands resulted in lower peak flows along the Bear Brook River when compared to the existing baseline conditions, with a peak flow decrease of at least 4% at J32 (downstream of the Tewin Lands) for the 100-Year events. A reduction in peak flow, ranging between 2% and 5%, is also observed at the downstream locations selected in this study.

Table 8: Scenario 2 (Tewin Lands Controlled) Results - Spring

	SPRING Peak Flows (m^3/s)				
HEC-HMS Node	**100-Year 1-Day Snow + Rain**	**100-Year 3-Day Snow + Rain**	**100-Year 5-Day Snow + Rain**	**100-Year 10-Day Snow + Rain**	**100-Year 10-Day Snow + Rain % Diff (Scenario 2 .vs. Scenario 0)**
J32	17.4	24.6	27.7	29.2	-5%
MK_DN5	31.3	36.0	37.0	37.5	0
J23	72.3	104.2	115.8	120.9	-4%
J13	117.7	163.3	177.8	184.2	-2%
J6	165.3	235.4	259.2	269.2	-1%
Sink-1	179.9	260.9	289.6	302.1	-1%

Table 8 above, which is representative of Scenario 2 *(*Tewin Lands Controlled) under spring conditions, shows evidence that developing the Tewin Lands while incorporating the proposed SWM control measures results in lower peak flows along the Bear Brook River when compared to the existing baseline conditions, with peak flow decreases of 5% and 1% during the 100-Year 10-Day snowmelt plus rainfall event at J32 (downstream of the Tewin Lands) and Sink-1 (downstream end of the Bear Brook River within the study area) respectively. Nevertheless, the implementation of the proposed SWM control measures within the Tewin Lands leads to higher peak flows compared to Scenario 1 which did not include any SWM control measures.

Table 9: Scenario 3 (Tewin Lands Controlled + Future Development Uncontrolled) Results – Summer

	SUMMER Peak Flows (m^3/s)								
HEC-HMS Node	**2-Year 24-Hour SCS TII**	**5-Year 24-Hour SCS TII**	**10-Year 24-Hour SCS TII**	**25-Year 24-Hour SCS TII**	**50-Year 24-Hour SCS TII**	**100-Year 12-Hour SCS TII**	**100-Year 24-Hour SCS TII**	**100-Year 12-Hour SCS TII % Diff (Scenario 3 .vs. Scenario 0)**	**100-Year 24-Hour SCS TII % Diff (Scenario 3 .vs. Scenario 0)**
J32	3.6	5.5	6.8	8.6	10.1	10.7	11.5	-6%	-7%
MK_DN5	20.0	27.1	31.5	38.1	43.1	51.8	48.9	+7%	+7%
J23	30.4	43.0	52.4	65.1	74.8	86.3	85.1	+2%	+1%
J13	44.8	64.6	78.9	97.8	112.4	128.7	127.4	+1%	+1%
J6	55.4	81.0	99.4	123.4	142.5	157.0	161.9	+1%	+0%
Sink-1	64.5	94.4	115.7	143.2	165.1	179.7	187.1	+1%	+0%

Table 9 above outlines the summer results from Scenario 3 *(*Tewin Lands Controlled + Future Development Uncontrolled). From this scenario, it is seen that higher peak flows are observed at MK_DN5, which is downstream of the East Urban Community and the majority of the South Orleans Urban Expansion. Although propagating downstream of MK_DN5 along the Bear Brook mainstream, peak flow increases are found minor at those locations. Note the reduction in 100-Year peak flow at J32 by 6% and 7% for the 12-Hour and 24-Hour SCS Type II storms respectively; this is deemed to result from an impactful change in the timing of peak flow occurrences, considering that the Leitrim - East of Bank Street (S-5) Urban Expansion development is located upstream of J32.

Table 10: Scenario 3 (Tewin Lands Controlled + Future Development Uncontrolled) Results - Spring

	SPRING Peak Flows (m^3/s)				
HEC-HMS Node	**100-Year 1-Day Snow + Rain**	**100-Year 3-Day Snow + Rain**	**100-Year 5-Day Snow + Rain**	**100-Year 10-Day Snow + Rain**	**100-Year 10-Day Snow + Rain % Diff (Scenario 3 .vs. Scenario 0)**
J32	16.9	24.0	27.1	28.6	-7%
MK_DN5	32.5	37.4	38.4	38.8	+3%
J23	74.2	106.0	117.5	122.6	-2%
J13	119.3	164.7	179.1	185.5	-1%
J6	166.9	236.7	260.4	270.3	-1%
Sink-1	181.4	262.1	290.6	303.0	-1%

Scenario 3 modelling results under spring conditions (**Table 10**) indicate the absence of SWM control measures in the Future Development areas under fully developed conditions (on top of the Tewin Lands being fully developed and controlled) results in a 3% peak flow increase at MK_DN5 followed by a decrease in peak flow (between 1% and 2%) at the downstream locations for the 100-Year 10-Day snowmelt plus rainfall event in comparison with existing spring conditions.

Table 11: Scenario 4 (Tewin Lands Controlled + Future Development Controlled) Results – Summer

	SUMMER Peak Flows (m^3/s)								
HEC-HMS Node	**2-Year 24-Hour SCS TII**	**5-Year 24-Hour SCS TII**	**10-Year 24-Hour SCS TII**	**25-Year 24-Hour SCS TII**	**50-Year 24-Hour SCS TII**	**100-Year 12-Hour SCS TII**	**100-Year 24-Hour SCS TII**	**100-Year 12-Hour SCS TII % Diff (Scenario 4 .vs. Scenario 0)**	**100-Year 24-Hour SCS TII % Diff (Scenario 4 .vs. Scenario 0)**
J32	3.7	5.6	6.9	8.8	10.3	10.8	11.6	-5%	-6%
MK_DN5	18.1	25.8	29.7	35.3	39.9	46.6	44.4	-4%	-3%
J23	28.6	41.4	49.9	60.5	68.7	80.0	77.9	-6%	-7%
J13	42.9	61.9	75.1	92.6	106.4	122.8	120.7	-4%	-5%
J6	53.3	77.9	95.2	118.6	137.2	150.7	156.0	-3%	-3%
Sink-1	62.4	91.4	111.7	138.6	160.0	173.8	181.4	-3%	-3%

Finally, the incorporation of the proposed SWM control measures in the future developed subcatchments within the East Urban Community, South Orleans Urban Expansion and Leitrim - East of Bank Street (S-5) Urban Expansion development limits, as specified in **Table 1**, resulted in lower summer peak flows at all six key locations with respect to the baseline conditions. Hence, for the 100-Year SCS Type II storms, a 3% to 7% decrease in peak flows is noted (refer to **Table 11**). This is the final scenario (Scenario 4) in which all the development areas in the scope of this Tewin Lands Cumulative Hydrologic Impact Assessment study are accounted for as fully developed and controlled to the specified release rates provided in **Table 1**.

Table 12: Scenario 4 (Tewin Lands Controlled + Future Development Controlled) Results - Spring

	SPRING Peak Flows (m^3/s)				
HEC-HMS Node	**100-Year 1-Day Snow + Rain**	**100-Year 3-Day Snow + Rain**	**100-Year 5-Day Snow + Rain**	**100-Year 10-Day Snow + Rain**	**100-Year 10-Day Snow + Rain % Diff (Scenario 4 .vs. Scenario 0)**
J32	17.0	24.2	27.3	28.8	-6%
MK_DN5	30.8	35.0	36.1	36.6	-2%
J23	70.2	101.8	113.4	118.7	-6%
J13	116.2	161.2	175.8	182.3	-3%
J6	163.8	233.3	257.2	267.3	-2%
Sink-1	178.5	259.0	287.7	300.4	-2%

In the final Scenario 4 which consists of fully developed and controlled Tewin Lands and Future Development areas, **Table 12** demonstrates that under spring conditions, peak flow decreases ranging between 2% and 6% can be expected at all six key locations with respect to the baseline spring conditions during the 100-Year 10-Day snowmelt plus rainfall event.

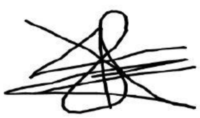
CONCLUSIONS

From the analysis above, it was observed that the development of the Tewin Lands with the proposed Stormwater Management (SWM) control measures did not result in increased peak flows along the watercourses within the Bear Brook watershed in the scope of this Tewin Lands Cumulative Hydrologic Impact Assessment.

Furthermore, the same Stormwater Management (SWM) control measures proposed for the future Tewin Lands were implemented in the East Urban Community, South Orleans Urban Expansion and Leitrim - East of Bank Street (S-5) Urban Expansion developments, which resulted in no peak flow increases along the Bear Brook River and its tributaries within the study area with respect to the existing conditions.

Yours truly,
J.F Sabourin and Associates Inc.

Prepared by:



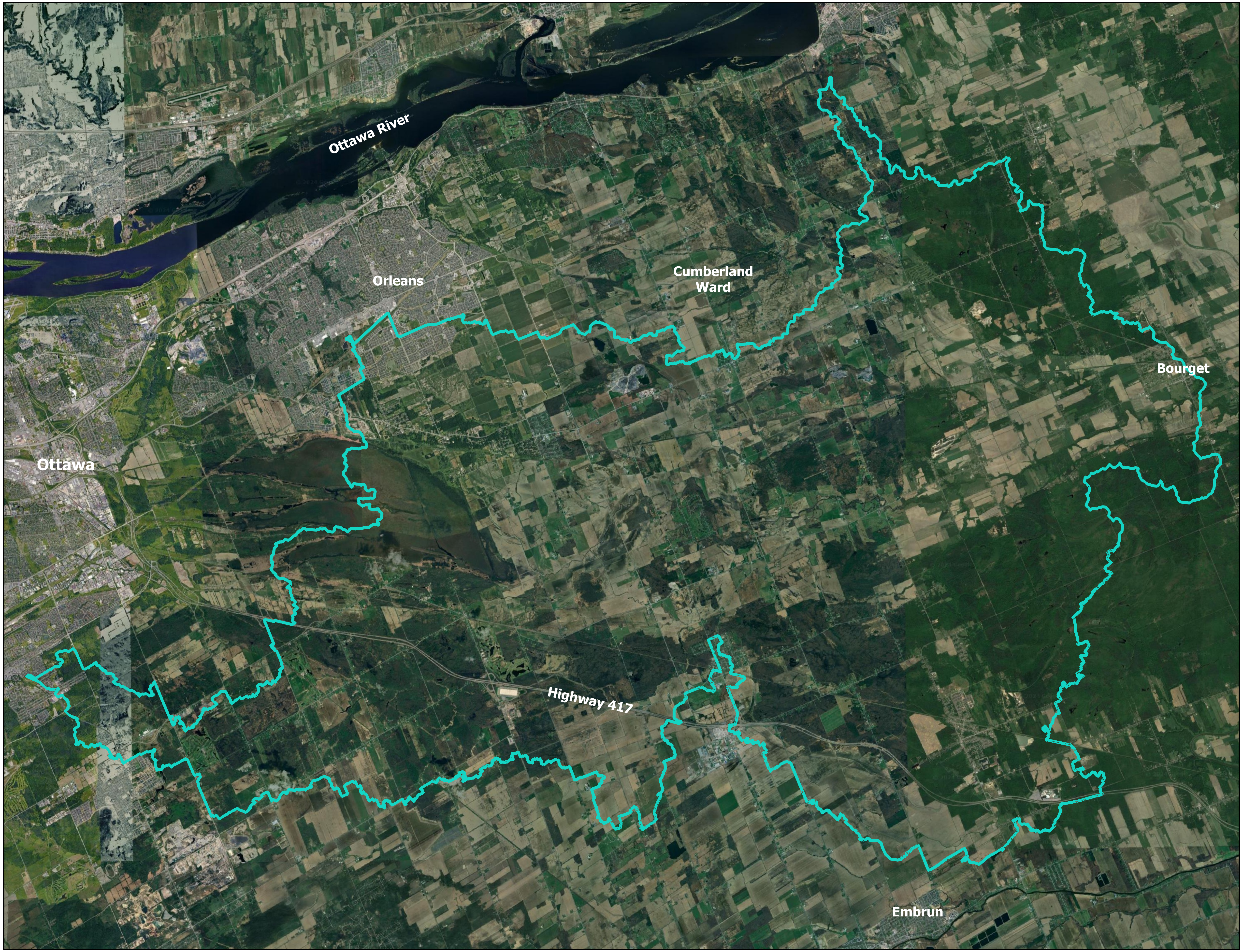
Oumar Daly Ndiaye, M.Eng., EIT.

Reviewed by:

J.F. Sabourin, M.Eng., P.Eng.
Director of Water Resources Projects

Reference *[1]*: South Nation Conservation (SNC), "Bear Brook and Tributaries Flood Hazard Mapping Report," March 2022 [Updated version received April 2023].

Reference *[2]*: W. C. Wang and D. R. Dawdy, "Estimating Basin Storage Coefficient of the Clark Unit Hydrograph," in American Geophysical Union (AGU) Fall Meeting, San Francisco, 2012.



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Legend

Assessment Area

SCALE: 1:120000

0 2.5 5 km

Tewin Cumulative Hydrologic Impact Assessment

Figure 1: Assessment Area

PROJECT	0971
DRAWN	BT
DATE	APRIL 2024

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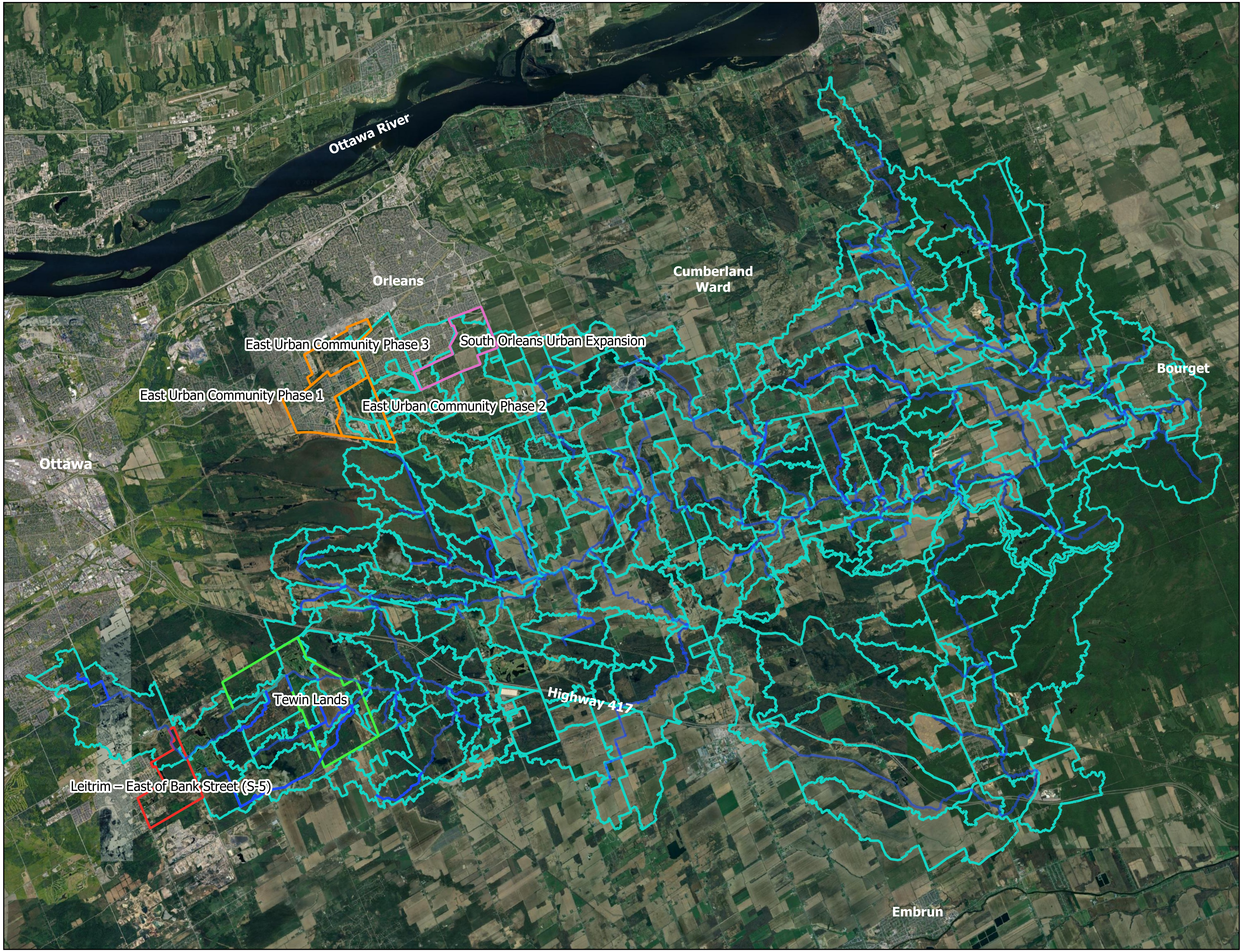

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Legend

- HEC-HMS Reaches
- HEC-HMS Subcatchments
- East Urban Community
- South Orleans Urban Expansion
- Tewin Lands
- Leitrim – East of Bank Street (S-5) Urban Expansion

SCALE: 1:120000

0 2.5 5 km

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Tewin Cumulative Hydrologic Impact Assessment

Figure 2: Development Areas

PROJECT	0971
DRAWN	BT
DATE	APRIL 2024

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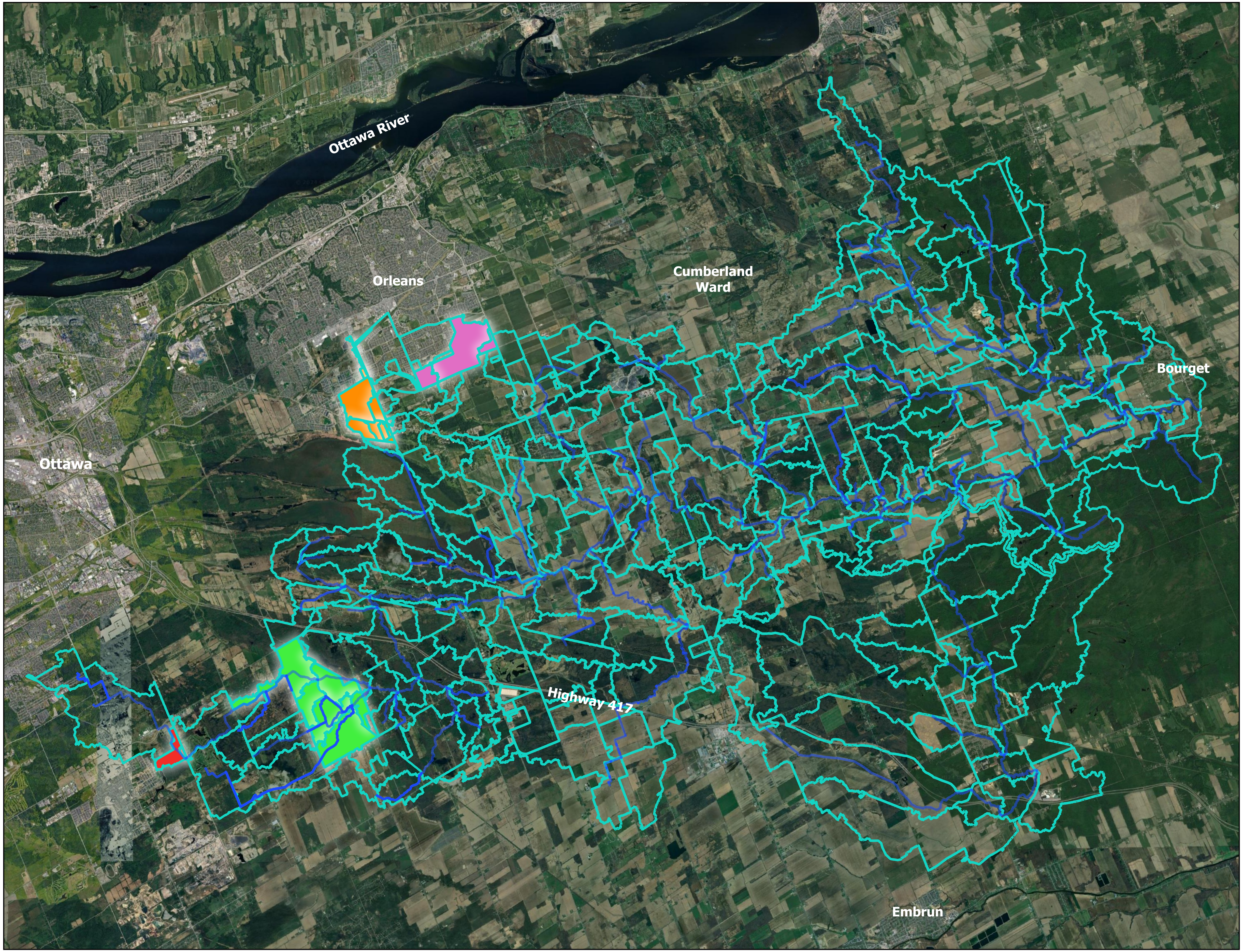

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Legend

- HEC-HMS Reaches
- HEC-HMS Subcatchments

Ottawa Expansion Areas

- East Urban Community
- South Orleans Urban Expansion
- Tewin Lands
- Leitrim – East of Bank Street (S-5) Urban Expansion

SCALE: 1:120000

0 2.5 5 km

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Figure 3: Modified Subcatchments Within Development Areas

PROJECT	0971
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DATE	APRIL 2024

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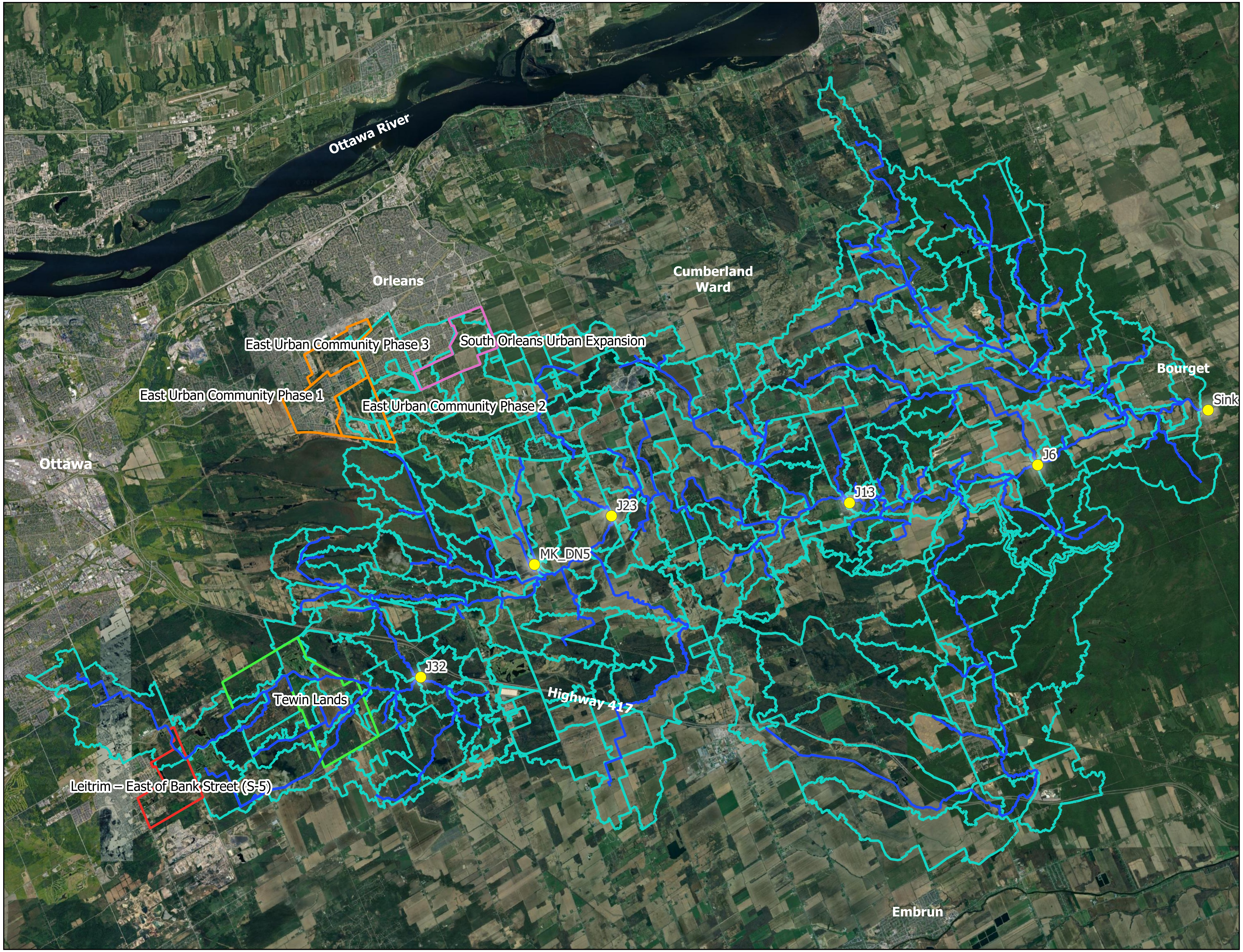

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Legend

- Key Nodes
- HEC-HMS Reaches
- HEC-HMS Subcatchments
- East Urban Community
- South Orleans Urban Expansion
- Tewin Lands
- Leitrim – East of Bank Street (S-5) Urban Expansion

SCALE: 1:120000

0 2.5 5 km

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Tewin Cumulative Hydrologic Impact Assessment

Figure 4: Key Node Locations

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DATE	APRIL 2024

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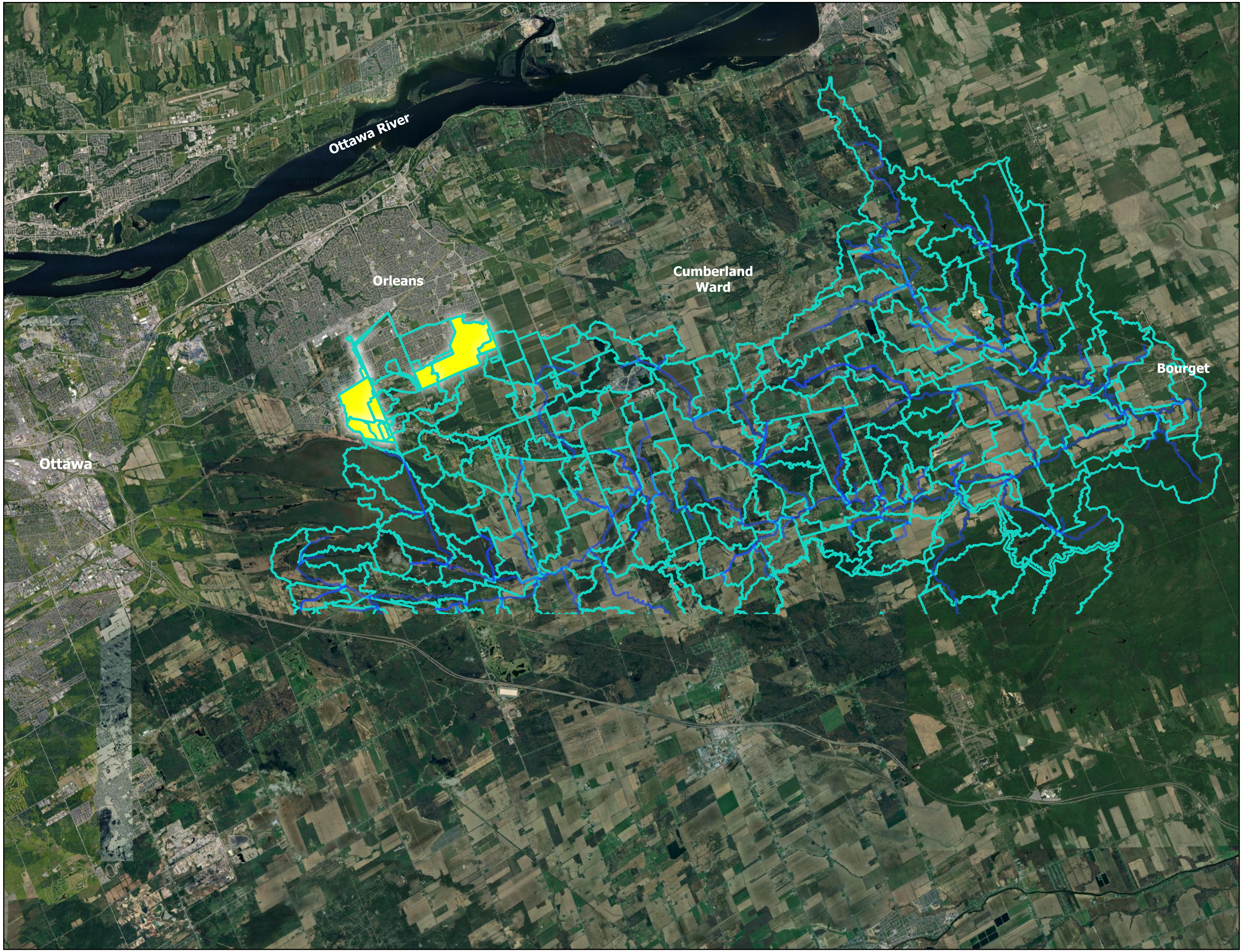

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Legend

HEC-HMS Reaches
HEC-HMS Subcatchments
Developed Subcatchments
Summer
Ia = 6.25 mm
CN = 57.6
% XIMP (directly connected imperviousness) = 60
Spring
Ia = 4.7 mm
CN = 95
% XIMP (directly connected imperviousness) = 43

SCALE: 1:120000

0 2.5 5 km

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Tewin Cumulative Hydrologic Impact Assessment

Figure 5: Developed Subcatchments

PROJECT	0971
DRAWN	BT
DATE	APRIL 2024

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