

# CITY OF MARKHAM NATURAL ASSETS INVENTORY AND EVALUATION STUDY

## CONSOLIDATED REPORT

### Prepared by



May 2024

<p><b>Submitted by:</b> <b>Green Analytics</b> <a href="http://www.greenanalytics.ca">www.greenanalytics.ca</a></p>	<p><b>Guelph Office</b></p> <p>41 Verney Street Guelph, ON N1H 1N5 P. 226.820.0233 <a href="mailto:jeff.wilson@greenanalytics.ca">jeff.wilson@greenanalytics.ca</a></p>	<p><b>Head Office (Edmonton)</b></p> <p>Unit 413, 3428 99 Street Edmonton, AB T6J 4V9 P. 887.353.6835 <a href="mailto:contact@greenanalytics.ca">contact@greenanalytics.ca</a></p>
---	---	--

[WWW.GREENANALYTICS.CA](http://WWW.GREENANALYTICS.CA)



# Executive Summary

In late 2022, the City of Markham initiated their first comprehensive natural assets inventory and evaluation. This report provides a summary of the approach to and the outcomes of this project.

“Natural assets” can be defined as protected, restored or enhanced natural areas which are recognized and being maintained, managed and monitored for the services they provide. For this project, the focus was on terrestrial natural assets (i.e., woodlands, wetlands and meadows) on lands owned by the City. Nature-based solutions, including natural assets, are increasingly recognized for the core and non-core services they provide. City-wide, Markham’s natural assets were estimated at providing services valued between \$114 and \$120 million annually for contributing to: nature-based recreation, carbon sequestration, air pollution control, cooling, habitat preservation, crop productivity, stormwater regulation and Markham’s aesthetic value. Natural assets owned by the City were estimated to provide services valued between \$60 and \$62 million annually.

Integrating natural assets into broader municipal asset management planning and systems provides an established framework to support and track the acquisition, maintenance and – if needed – replacement of natural assets providing these valued services to the community. It also allows the City to consider its level of investment in natural assets in the same way it considers its level of investment in other assets (e.g., parks, stormwater management, sewers).

This project built on the data collected and management guidance provided in recently completed natural areas studies, and also considered the current natural heritage planning framework and guidance to fulfill the following two objectives:

1. To meet the requirements of Ontario Regulation (O. Reg.) 588/17, including identifying an appropriate asset structure and assigning condition ratings and determining levels of service (LOS) for City-owned natural assets.
2. To inform long-range planning initiatives related to growth management and natural features and areas, including management of natural assets in the City which supplement core municipal services while also building community resilience to climate change.

The City currently owns about 1,000 hectares (ha) of the about 7,000 ha of natural features and areas in the City’s Greenway System. While the scope of this project is focused primarily on City-owned natural assets, it was recognized that the City-owned natural assets are influenced by and therefore need to be considered in the context of the broader system, including lands owned by others (e.g., Parks Canada, private landowners).

Work completed as part of this project has:

1. Included an introductory guide titled “Markham’s Natural Assets and Climate Change Guide” intended for decision-makers (provided under separate cover).
2. Addressed the provincial requirements of Ontario Regulation (O. Reg.) 588/17 as they relate to natural assets, including:
  - a. Compiling a natural asset registry and inventory (Section 2).
  - b. Completing a condition assessment (Section 3) and risk assessment (Section 4).
  - c. Identifying and articulating corporate, customer and technical levels of service (LOS) (Section 5).

3. Developed estimates of current natural asset management costs along with preliminary estimates of the investment required to:
  - a. Enhance natural asset service provision in the face of climate change.
  - b. Meet established natural asset targets (Section 6).
4. Facilitated and guided multi-disciplinary collaboration and information sharing related to natural assets among City staff and some of their partners (as outlined in Section 1.3) while also building their expertise in the field of natural asset management.
5. Completed a valuation of some of the ecosystem services provided by Markham's natural assets to help engage staff, partners, decision-makers and the community on this topic (Section 7).

While an increasing number of municipalities in Ontario and elsewhere have started to integrate natural assets into their municipal planning frameworks, the City of Markham is one of the first to use the asset management framework to inform long range planning related to growth management, including improved financial planning to more fully recognize and leverage the services and co-benefits that are, and could be, provided by natural assets in Markham.

In addition to this report and the specific deliverables outlined above, this project includes delivery of a natural asset registry database and a GIS-based mapping and tracking tool, as well as recommendations to support the continued integration and advancement of natural assets in Markham's asset management planning and related financial strategy.

# Table of Contents

Executive Summary.....	2
1 Introduction .....	6
1.1 Project Objectives .....	8
1.2 Project Rationale and Scope .....	8
1.3 Targeted Project Engagement .....	10
2 Natural Asset Registry and Inventory .....	12
2.1 Scoping Markham’s Natural Asset Inventory.....	13
2.2 Markham’s Natural Asset Inventory Structure and Components .....	16
2.2.1 Natural Asset Replacement Costs .....	18
2.3 Natural Assets Inventory Outputs.....	20
3 Natural Asset Condition Assessment .....	27
3.1 Condition Assessment and the Natural Assets Hierarchy.....	28
3.2 Overview of the Condition Framework.....	28
3.3 Preliminary Condition Results.....	29
3.3.1 All Natural Assets in Markham.....	29
3.3.2 City-owned Natural Assets in Markham .....	31
4 Considering and Incorporating Risk .....	33
4.1 Hazards Risk Assessment .....	34
4.2 Preliminary Asset Risk Assessment.....	35
5 Levels of Service and Current Management.....	39
5.1 Corporate Levels of Service Objectives.....	41
5.2 Community Levels of Service Indicators .....	42
5.3 Technical Levels of Service Measures and Management Activities.....	43
6 Management Scenarios and Financial Analysis .....	50
6.1 Management Context .....	50
6.2 Approach to Management Scenario Development .....	51
6.2.1 Assumptions.....	52
6.3 Management Scenario Actions and Implications .....	52
6.3.1 Acquisition / Expansion.....	53
6.3.2 Maintain .....	54
6.3.3 Rehabilitate .....	58
6.4 Management Scenario Cost Estimates and Financial Analysis .....	60

6.4.1	Acquisition and Expansion .....	64
6.4.2	Maintenance .....	65
6.4.3	Rehabilitation and Renewal .....	65
6.4.4	Current Funding Sources in Planning and Parks .....	66
7	Ecosystem Service Valuation .....	67
7.1	The Business Case for Natural Assets .....	68
8	Summary of Recommendations.....	70
9	Concluding Remarks.....	72
10	References .....	73
11	Appendix A: Overview of Data Sources Reviewed.....	78
12	Appendix B: Natural Asset Inventory Attributes.....	82
13	Appendix C: Additional Examples of Inventory Mapping Outputs .....	89
14	Appendix D: Condition Assessment Approach Details and Results .....	91
14.1	Natural Areas Patch Size and Shape .....	91
14.2	Natural Asset Proximity to Watercourses.....	94
14.3	Relative Habitat Quality .....	97
14.4	Extent of Adjacent Complementary Land Uses .....	99
14.5	Intensity of Human-related Encroachment/Disturbances.....	101
15	Appendix E: Risk Assessment Approach .....	104
15.1	Risk and the Natural Assets Hierarchy .....	104
15.2	Overview of the Hazards Risk Assessment .....	104
15.3	Establishing Probability and Consequence of Failure .....	112
16	Appendix F: Levels of Service Business Drivers and Regulatory Context.....	115
17	Appendix G: Ecosystem Service Valuation Details.....	118
17.1	Provision of Recreational Activities .....	119
17.2	Value of Carbon Sequestration .....	121
17.3	The Value of Air Quality Regulation.....	125
17.4	The Value of Stormwater Regulation.....	127
17.5	Regulation of Extreme Heat Events .....	129
17.5	The Value of Habitat Preservation.....	134
17.6	The Value of Aesthetic Appreciation .....	135
17.7	The Value of Natural Assets Contribution to Crop Productivity .....	137

# 1 Introduction

Canadian communities generally rely on their local governments to provide services such as air pollution prevention/mitigation, noise abatement, waste management, potable water, wastewater and stormwater management. The [2019 Canadian Infrastructure Report Card](#) found that a considerable amount of the public grey infrastructure<sup>1</sup> currently providing these services is in poor condition and requires significant attention in the coming decades. Replacing or upgrading the grey infrastructure will require considerable investments. Consequently, governments have started to look for opportunities to limit and manage these costs while trying to maintain the levels of service which Canadians have come to expect. One opportunity being explored by an increasing number of public agencies is leveraging nature-based solutions (NbS), including natural assets<sup>2</sup> (see Figure 1-1), to help provide environmental services while also building resilience to climate change.

NbS cannot, by themselves, address the challenges of replacing and upgrading the extensive networks of ageing grey municipal infrastructure in a context of advancing climate change. However, **NbS (including natural assets) are increasingly recognized as cost-effective complements to grey infrastructure that can provide core services (such as helping to reduce flood risks and improve water quality), while also providing other co-benefits and services such as moderating urban heat and air pollution, and helping to sustain biodiversity (e.g., AE 2022, Bloomberg and Holloway 2018).**

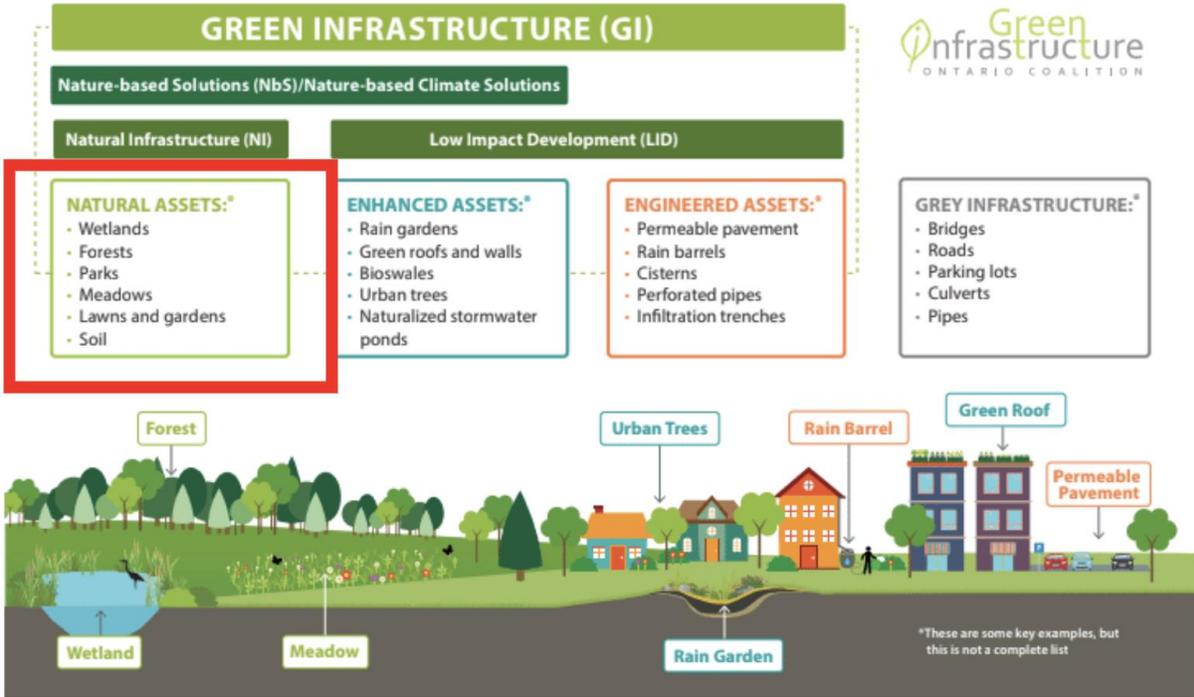


Figure 1-1. Infographic showing the difference between green and grey infrastructure, as well as the different types and sub-types of green infrastructure, including natural assets/natural infrastructure. Credit: Green Infrastructure Ontario (2020).

<sup>1</sup> Grey infrastructure refers to “engineered assets made exclusively of materials such as concrete and steel, including bridges, dams, water treatment plants, culverts, ditches and storm drains” (CCME 2021).  
<sup>2</sup> “Natural assets” refers to “the use of preserved, restored or enhanced elements or combinations of vegetation and associated biology, land, water and naturally occurring ecological processes to meet targeted infrastructure outcomes” (CCME 2021).

One of the key barriers to advancing the integration of NbS (including natural assets) in municipal asset planning and management has been the lack of regulatory drivers at the federal and provincial levels (Sarabi *et al.*, 2021, NAI 2023). This gap was, however, addressed in part in Ontario with the passing of Ontario Regulation 588/17 (Asset Management Planning for Municipal Infrastructure). O. Reg. 588/17 under the *Infrastructure for Jobs and Prosperity Act*, 2015, among other things, requires all municipalities to consider green infrastructure as part of their asset management planning including “natural heritage features and systems”.

The City of Markham’s approach to its natural features has evolved significantly over the past few decades and it has recently started to consider them from an asset management perspective. For example:

- The City undertook its first jurisdiction-wide study of natural features and areas in the 1990’s and recently completed a comprehensive update of its natural features mapping and high-level management guidance through its Natural Heritage Inventory and Assessment Study (NHAS) and Natural Heritage Management Study (NHMS) (NSEI and DAI 2021, CBCL 2022, CBCL 2024b).
- The City also has policies in its Official Plan for the protection of significant natural features and areas, and their functions, which date back to the 1980’s, which were last updated in 2014 and are due to be reviewed and updated again in the near future.
- Currently, the bulk of the significant natural features and areas in Markham are captured within the Greenway System (see Figure 1-2) and associated with its river and stream corridors, with the most substantial contiguous Greenway System lands concentrated in the eastern part of the City within the Provincial Greenbelt and the Federal Rouge National Urban Park (RNUP).

In late 2022, the City initiated their first comprehensive natural assets inventory and evaluation. This report provides a summary of the approach to and the outcomes of this project.

While an increasing number of municipalities in Ontario, and elsewhere have started to integrate natural assets into their municipal planning frameworks (e.g., MNAI 2021a-g), the City of Markham is one of the first to use the asset management framework to inform long range planning related to growth management, including improved financial planning to more fully recognize and leverage the services and co-benefits that are, and could be, provided by natural assets in Markham.

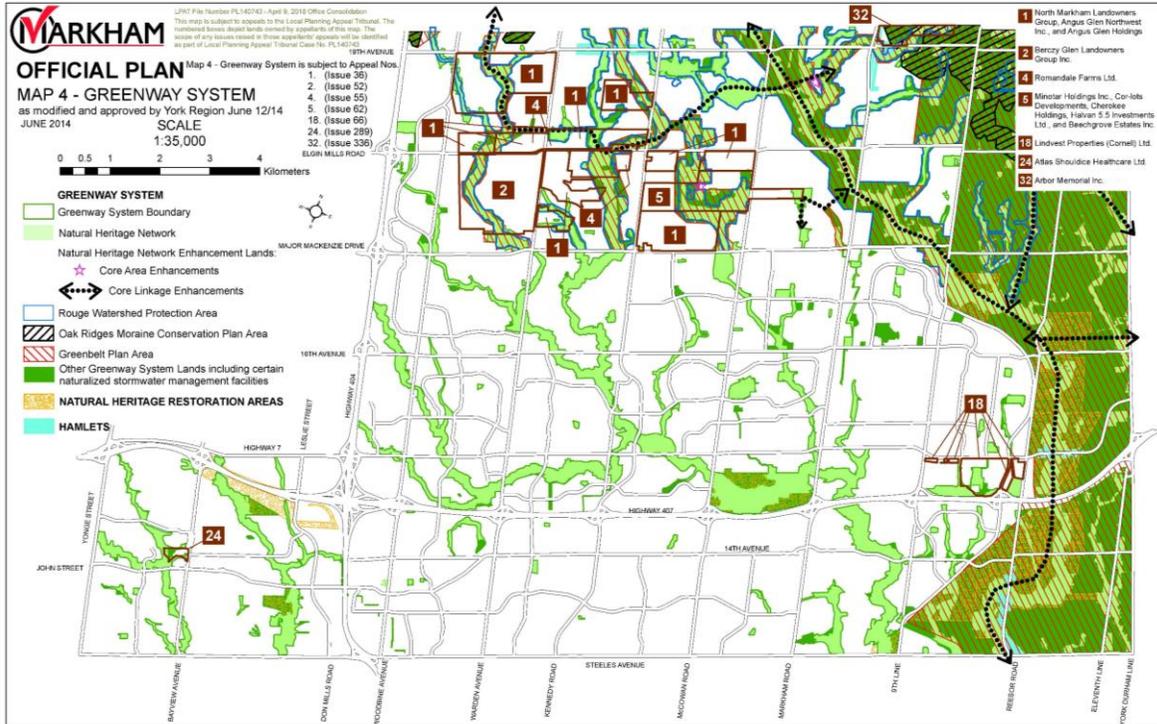


Figure 1-2. Map of Markham's current greenway system from its official plan.

## 1.1 Project Objectives

This project built on the data collected and management guidance provided in the recently completed NHIAS and NHMS, and also considered the current natural heritage planning framework and guidance to fulfill the following two objectives:

1. To meet the requirements of O. Reg. 588/17, including identifying an appropriate asset structure and assigning condition ratings and determining levels of service (LOS) for City-owned natural assets.
2. To inform long-range planning initiatives related to growth management and natural features and areas, including management of assets in the City, which supplement core municipal services while also building community resilience to climate change.

## 1.2 Project Rationale and Scope

What makes natural assets (such as forests, wetlands, meadows and watercourses) such a unique and value-added investment? They can provide a cost-effective alternative, or complement to, some types of built infrastructure while also providing co-benefits and services that can help communities adapt to climate change. For example, natural assets can:

- Contribute to core services such as stormwater management, erosion control and water quality improvements.
- Provide health benefits to residents by moderating the effects of heat waves, improving air quality, providing opportunities for passive recreation in nature, and more.

Investing in acquiring, protecting, maintaining and expanding natural assets can significantly offset the costs of having to upgrade, replace or expand built structures to provide the same services (e.g., stormwater), which come with few or no co-benefits.

The City currently owns about 1,000 hectares (ha) of the about 7,000 ha of natural features and areas within the Greenway System (14.3%). While the scope of this project is focused primarily on City-owned natural assets where the City has direct oversight, it was recognized at the outset of the project that these need to be considered in the context of the broader system, including lands owned by others (e.g., Parks Canada, private landowners) as all natural assets provide services including positive health outcomes. The scope of the project also considers enhanced green infrastructure assets<sup>3</sup> (see Figure 1-1) and agricultural lands in certain parts of the study as further described in Section 2.1.

Work completed as part of this project has:

1. Included an introductory guide titled “How Markham’s Natural Assets Can Help Build Local Resilience to Climate Change” intended for decision-makers (provided under separate cover);
2. Addressed the provincial requirements of Ontario Regulation (O. Reg.) 588/17 as they relate to natural assets, including:
  - a. Compiling a natural asset registry and inventory (Section 2).
  - b. Completing a condition assessment (Section 3) and risk assessment (Section 4).
  - c. Identifying and articulating corporate, community (also called customer) and technical levels of service (LOS) (Section 5).
3. Developed estimates of current natural asset management costs along with preliminary estimates of the investment required to:
  - a. Enhance natural asset service provision in the face of climate change.
  - b. Meet established natural asset targets (Section 6).
4. Facilitated and guided multi-disciplinary collaboration and information sharing related to natural assets among City staff and some of their partners (as outlined in Section 1.3) while also building their expertise in the field of natural asset management.
5. Completed a valuation of some of the ecosystem services provided by Markham’s natural assets to help engage staff, partners, decision-makers and the community on this topic (Section 7).
6. Resulted in the identification of a series of recommendations for building on the work completed and continuing to integrate natural assets into the City’s asset management system more fully (Section 8).

---

<sup>3</sup> Enhanced (green) assets incorporate “land, water and vegetation features alongside human-made elements to sustain ecosystem functions and services... the enhancement of conventional grey infrastructure (e.g., piped, ditch and culvert, dam and reservoir systems) with nature-based elements, [often] in order to achieve the active and everyday management of the full rainfall-runoff spectrum”. Examples include bioswales, green roofs, naturalized stormwater management ponds, and individual trees with engineered rooting environments to optimize water infiltration and retention capacity.

This comprehensive natural asset project is the first of its kind in Markham. It is expected to provide a foundation for ongoing natural asset planning and management, and to be refined and updated as needed to help inform long-term planning, particularly as it relates to natural heritage, as well as operational management of the natural assets owned by the City.

### 1.3 Targeted Project Engagement

This project was completed with guidance and input provided by a multi-disciplinary Technical Advisory Committee (TAC) including City staff from a wide range of departments. The TAC included:

- Key City staff from: Corporate Asset Management, Engineering, Information Technology, Operations, Parks (including Forestry), Planning and Urban Design (including Natural Heritage), Sustainability and Environmental Services (including Stormwater Services), and
- Senior Research Scientist(s) from Toronto and Region Conservation Authority (TRCA) with knowledge of Markham's natural heritage and expertise in natural assets.

The TAC was engaged for each component of this project through six workshops where members provided invaluable feedback on draft materials developed by the consulting team to ensure that the deliverables:

- a. Considered and incorporated all relevant sources of existing data and guidance.
- b. Aligned with the City's asset management framework and 2024 update to the Corporate Asset Management Plan (AMP).
- c. Reflected the local context, opportunities and challenges related to natural asset planning and management.

It is anticipated that this group, or one like it, will continue to provide a forum for the kinds of multi-disciplinary and inter-departmental information sharing, discussions and problem-solving required to continue to advance natural asset planning and management in Markham.

The City also reached out to selected external representatives from organizations with expertise and/or a specific interest in Markham's natural heritage/natural asset planning and management to inform them about this project and seek any insights they may be able to share related to their organizational experience.

Organizations invited to participate in this group included:

- Nature Conservancy of Canada (NCC)
- Oak Ridges Moraine Land Trust (ORMLT)
- Ontario Ministry of Natural Resources and Forestry (MNRF)
- Ontario Nature (ON)
- Parks Canada
- Toronto and Region Conservation Authority (TRCA)
- York Federation of Agriculture (YFA)
- York Region

Representatives from these organizations were engaged through two workshops over the course of the project to inform them about the work being done, answer any questions they may have, and hear their perspectives on natural assets in the city.

**Indigenous Engagement**

The City recognizes the importance of Indigenous engagement and the value of Indigenous knowledge – particularly as it relates to natural heritage. The City also recognizes that Indigenous community(ies) would be valuable partners in advancing natural asset management in Markham and is committed to exploring opportunities for engagement on this topic, and on other related environmental topics, in the future.

## 2 Natural Asset Registry and Inventory

An asset registry is the foundation upon which all other asset management tasks are built. The registry is the GIS-linked tabular database that contains all the data, metadata and attributes that comprise the natural asset inventory. Each individual asset is (a) assigned a unique identification code, and (b) represented as a row in the registry database. A series of related columns in the registry contain attributes assigned to each of the assets.

Natural assets are an asset category that have only recently begun to be considered in a municipal context (or otherwise), and so there are not many standards about how they should be integrated into the asset management framework. The first natural asset standards document to be released, Specifications for Natural Asset Inventories (CSA/W218-23), came out while this project was underway in 2023. These standards outline minimum requirements for data gathering and processing, inventory structure, documentation and registry maintenance/updates. These standards have been adhered to in the development of Markham's natural asset registry and inventory.

The availability of these standards does not, however, preclude municipalities from tailoring the structure and content of their inventory to the local biophysical, land use and planning context. In Markham, while the primary focus of this project is on City-owned natural assets, the development of this registry and inventory was also seen as an opportunity to take stock of all natural assets in the city (irrespective of ownership), City-owned enhanced (green) infrastructure assets<sup>4</sup> (see Figure 1) not already captured by other City asset registries, and the extant agricultural lands in the city. Given these inclusions, the main inventory was named the Green Space and Agricultural Lands asset inventory, with Natural Assets being one of the three sub-inventories (along with Manicured Open Spaces and Agricultural Lands).

Although this project, and the remaining sections of this report, build on the natural asset component of the inventory, the following sub-sections provide:

- The rationale for scoping and tailoring Markham's Green Space and Agricultural Assets inventory structure as described (Section 2.1).
- The components of Markham's Green Space and Agricultural Assets inventory, including locally appropriate natural asset replacement costs (Section 2.2).
- Examples of mapping outputs from the natural asset component of the inventory (Section 2.3).

A complete list and description of the data sources reviewed for Markham's first natural asset inventory are provided in Appendix A.

Appendix B includes descriptions of the various mapping attributes associated with Markham's Natural, Green Space and Agricultural Assets inventory.

Appendix C includes examples of mapping outputs from the Manicured Open Spaces and Agricultural Lands sub-components of the inventory.

---

<sup>4</sup> Enhanced (green) assets incorporate "land, water and vegetation features alongside human-made elements to sustain ecosystem functions and services... the enhancement of conventional grey infrastructure (e.g., piped, ditch and culvert, dam and reservoir systems) with nature-based elements, [often] in order to achieve the active and everyday management of the full rainfall-runoff spectrum". Examples include bioswales, green roofs, naturalized stormwater management ponds, and individual trees with engineered rooting environments to optimize water infiltration and retention capacity.

## 2.1 Scoping Markham's Natural Asset Inventory

The first step in establishing a natural asset inventory is deciding what components (i.e., asset types) to include or exclude in the registry and determine the structure and components of the inventory.

Working with the TAC, the project team considered a range of natural assets and enhanced assets, as well as Markham's fairly extensive agricultural land base, as described below.

### Natural Assets

Natural assets typically include features such as forests, wetlands and meadows, and can also include watercourses (and associated floodplains or riparian areas) and other water bodies (such as lakes and ponds). Groundwater may also be considered, as may cliffs, bluffs, shorelines, tidal zones, rocky outcrops and other habitat types.

Given the biophysical context and habitat types in Markham, it was agreed that natural asset types should include forests/woodlands, wetlands, meadows and other remnants of open habitats that occur in the city such as bluffs and beach bars. In addition, it was agreed that any of these feature types in riparian areas should be included as well as natural water bodies (such as lakes and ponds).

There are several sizeable watercourses, and their tributaries, that bisect Markham. These provide the "backbone" to Markham's Natural Heritage Network and many of the City's terrestrial natural assets are adjacent to these features. The City's watercourses have been mapped by TRCA and assessed as part of a city-wide Erosion Master Plan first completed in 2007 and last updated in 2018. Watercourses were however excluded from the current inventory on the basis that they are already managed by Environmental Services and included in the 2021 Asset Management Plan, although it was recognized that the presence of watercourses (and associated valley systems) effectively provides the backbone to Markham's Greenway System.

It was also agreed (in consultation with the TAC) that the bulk of the work for this project (e.g., the condition assessment, risk assessment, levels of service identification and management scenarios) would be focused on the natural assets on lands owned by the City and over which it has direct control. However, it was acknowledged that the natural assets on City lands do not exist or function in isolation from the natural assets on nearby lands owned by others. A notable example is the portion of the Rouge National Urban Park (RNUP) in eastern Markham outside the urban boundary that is owned by the Federal government and includes many hectares of natural assets as well as agricultural lands. Another example is that invasive plant infestations in a privately-owned natural area can easily spread into a City-owned natural area and therefore coordination planning and management would be required to address the challenge effectively. Therefore, it was decided by the TAC to include natural assets not owned by the city in the registry.

The entire Greenway System in Markham is about 6,885 ha, representing 32.4% of the City. Just over 1,000 ha (14.5%) of the Greenway System, including many natural and naturalized areas, is currently in City ownership. There is also land within the Greenway System in other types of public ownership including the RNUP. Approximately 33% of the Greenway System lands remain in private ownership. Although it is understood that the City will focus its natural assets management efforts on the lands under its ownership, to have a comprehensive natural asset inventory that allows for consideration of all natural assets across the City, and in relation to each other where appropriate, all natural features and areas in the Greenway System have been included in the inventory.

### **Enhanced Green Infrastructure Assets**

As illustrated in Figure 1-1, “enhanced” green infrastructure assets are generally assets that are not natural areas *per se* but are recognized as providing services that are complementary to or aligned with those provided by natural areas. Examples of these types of assets in Markham considered for the registry include: street and park trees, low-impact development (LID) assets (such as bioswales or infiltration trenches), naturalized stormwater management ponds, and manicured open spaces (such as golf courses).

Markham currently has some publicly-owned manicured greenspaces (such as golf courses), mainly within its urban boundary, and a significant number of trees outside its natural areas (e.g., park trees, street trees, trees in private yards). While not natural areas as such, these areas provide functions (and services) supportive to and/or aligned with those provided by natural areas (e.g., providing pervious surfaces that help manage stormwater quantity).

Markham’s natural areas also intersect with multiple naturalized stormwater management (SWM) ponds that have been constructed as part of the development process to help control flooding and water quality, while also contributing to local biodiversity.

It was agreed by the TAC that even though these assets would not be the focus of this project it made sense to include many of the enhanced green infrastructure assets on City lands. This was done to ensure their supportive and/or complementary functions would be recognized and considered as the City makes progress in its asset management efforts. However, these assets were not assessed in subsequent tasks (e.g., condition assessment, risk assessment, levels of service) as they are beyond the original scope of this project.

### **Agricultural Land Assets**

Markham currently has about 5,480 ha of lands in agricultural production. About half of these lands are within the Greenway System and provincial Greenbelt and as such are unlikely to be urbanized/developed. The other half, particularly those agricultural lands within the urban and urban expansion areas, are likely to be developed – in whole or in part – as growth in Markham progresses. The City recognizes that these lands are currently pervious lands with soil and vegetative cover<sup>5</sup> and are generally vegetated at least for parts of the year, that play an important role in local hydrologic dynamics (e.g., infiltration, evapotranspiration and water quality), and are not tracked as part of any other asset management framework.

It is recognized that, as with manicured green spaces, agricultural lands are not strictly speaking “natural assets.” However, through discussion with the TAC, it was decided that the natural asset inventory would be a good place to “house” this asset class so that changes to its extent over time could be tracked as needed. For example, land conversion and the loss of pervious surfaces could, in some instances, have direct effects on water quality, stormwater management and flood risk reduction. Some TAC members specifically noted that some of these lands, particularly in the Greenbelt Plan Area and/or RNUP, are good candidates for future naturalization and therefore having a “baseline” against which to track conversion from agriculture to natural or other assets will be useful.

For these reasons agricultural lands were included in the natural asset inventory. They were not, however, considered in all aspects of the natural asset evaluation (e.g., condition assessment, level of service assessment, risk assessment). Table 2-1 lists the natural and enhanced asset types that were considered along with the rationale for their inclusion or exclusion.

---

<sup>5</sup> Notably, soil is an asset that relates to almost all natural asset classes as well as agricultural lands. For the purposes of this inventory, while soil is not captured as a stand-alone asset, it is acknowledged as critical to the provision of services from natural and agricultural assets.

Table 2-1. Components of Markham’s green space and agricultural asset registry.

Natural or Enhanced Asset Type	Brief Description	Status & Rationale
Natural Assets	<ul style="list-style-type: none"> <li>▪ All the terrestrial natural areas (e.g., forests/woodlands, wetlands, meadows, etc.) located within the City of Markham.</li> <li>▪ Natural lakes, ponds and riparian areas</li> <li>▪ Watercourses</li> </ul>	<p>INCLUDED</p> <ul style="list-style-type: none"> <li>▪ All terrestrial natural assets (e.g., forests/woodlands, wetlands, meadows/prairies, open bluffs and beach bars) are the primary focus for this project.</li> <li>▪ Natural lakes, ponds and riparian areas.</li> <li>▪ These assets are a core component of City’s Greenway System and Natural Heritage Network. To be the focus of assessing condition, risk, levels of service, ecosystem service valuation, and management activities.</li> </ul> <p>EXCLUDED</p> <ul style="list-style-type: none"> <li>▪ Watercourses were excluded because they are already included in a previous asset management plan.</li> </ul>
Street and Park Tree Assets	All individual street trees that are owned and managed by the City (e.g., street trees, park trees). May also include individual street trees owned and managed by York Region.	<p>EXCLUDED</p> <ul style="list-style-type: none"> <li>▪ The City trees are already captured as a key component of Markham’s green infrastructure within the City’s asset management plan under Parks.</li> </ul>
Low-impact Development (LID) Assets	Assets such as constructed bioswales or infiltration trenches intended to support on site infiltration and quality control of surface water.	<p>EXCLUDED (GAP)</p> <ul style="list-style-type: none"> <li>▪ There are not many of these assets on City-owned lands at this time and they have not yet been inventoried.</li> <li>▪ This is an asset that should be captured within the City’s asset management plan under Stormwater Management in the future.</li> </ul>
Stormwater Management (SWM) Pond Assets	SWM ponds found across the City, including many naturalized ponds within and close to the Greenway System.	<p>EXCLUDED</p> <ul style="list-style-type: none"> <li>▪ These assets are already captured within the City’s asset management plan under Stormwater Management.</li> </ul> <p>INCLUDED</p> <ul style="list-style-type: none"> <li>▪ Notably, where natural assets overlap with a SWM pond (e.g., naturalized areas around pond), it is accounted for as part of the Natural Assets inventory.</li> </ul>
Manicured Open Space Assets	<ul style="list-style-type: none"> <li>▪ City-owned active use and sports field open spaces</li> <li>▪ City-owned passive use open spaces</li> <li>▪ City-owned golf courses</li> </ul>	<p>EXCLUDED</p> <ul style="list-style-type: none"> <li>▪ Active use and sports fields open spaces are already captured within the City’s asset management plan under Parks</li> </ul> <p>INCLUDED</p> <ul style="list-style-type: none"> <li>▪ Passive use open spaces (manicured) - not accounted for elsewhere, that contribute to community recreation, health and wellbeing, and stormwater management services.</li> <li>▪ City-owned golf courses – included as an enhanced asset; often located adjacent to natural assets.</li> </ul>
Agricultural Land Assets	Lands being cultivated or managed for agricultural uses within and outside Markham’s urban areas.	<p>INCLUDED</p> <ul style="list-style-type: none"> <li>▪ Recognized as not being natural or enhanced assets but not accounted for elsewhere so included in the registry to track and monitor the status of these lands over time.</li> </ul>

This work considered and built on the robust natural heritage data and assessments already completed by the City (e.g., Natural Heritage Inventory and Assessment Study (NHIAS), Stream Erosion Master Study Implementation Plan), supplemental natural heritage work underway (e.g., Natural Heritage Management Study) and the previously completed natural asset inventory work completed by Green Analytics and the Natural Assets Initiative (NAI), as well as other sources of information including natural heritage data from Toronto and Region Conservation Authority (TRCA), one of the City’s most long-standing partners in natural heritage assessment, planning and management.

## 2.2 Markham’s Natural Asset Inventory Structure and Components

Natural asset inventories tend to vary in terms of their data structure, attributes, and organization depending on the local biophysical and municipal context. The structure and hierarchy developed for Markham’s natural asset registry reflects the local context and areas of interest. As described in Section 2.1, it was decided by the project team, in consultation with the TAC, that for Markham it would be appropriate to include the following in its natural assets inventory:

1. All terrestrial natural assets (i.e., forests/woodlands, wetlands, meadows and open habitats such as bluffs) plus naturally occurring ponds/lakes, irrespective of ownership.
2. Manicured open spaces on City-owned lands excluding those identified for active park uses (considered enhanced green assets).
3. Agricultural lands, irrespective of ownership.

Given this context, it was decided it would make sense to call the broader framework the Green Space and Agricultural Lands asset inventory (i.e., the “main” inventory) comprised of the three following “sub-inventories” (as shown in Figure 2-1):

1. Natural Assets (privately and publicly-owned).
2. Manicured Open Spaces (City-owned only) (i.e., enhanced green assets).
3. Agricultural Land Assets (privately and publicly-owned).

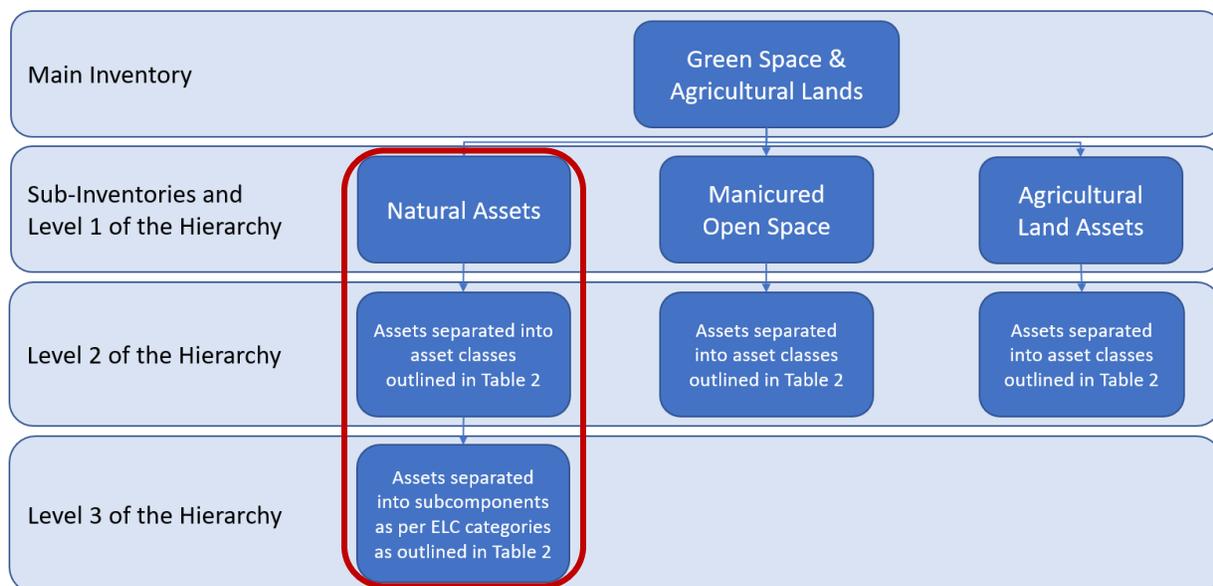


Figure 2-1. Hierarchical structure for Markham’s green space and agricultural land assets inventory.

Note: Although the inventory for this project has been broadened to incorporate selected enhanced assets and agricultural land assets, to enable and facilitate the tracking of these assets not captured in other City asset inventories, the remainder of the tasks for this project focus on the Natural Assets sub-inventory.

Figure 2-1 also shows the hierarchy levels within each sub-inventory. Table 2-2 provides a breakdown of the asset types within Level 2 and, where applicable, Level 3 asset classes for each sub-inventory.

Table 2-2. Detailed hierarchy and categorization of level 2 and level 3 asset classes for each sub-inventory.

Level 1 Assets	Level 2 Asset Class	Level 3 Asset Attribute
Natural Assets	Woodlands	Coniferous Forest
		Deciduous Forest
		Mixed Forest
		Cultural Woodland
		Plantation
		Cultural Savanah
		Cultural Thicket
		Treed Bluff
	Wetland	Coniferous Swamp
		Deciduous Swamp
		Mixed Swamp
		Thicket Swamp
		Meadow Marsh
		Shallow Marsh
		Treed Fen
		Floating-leaved Shallow Aquatic
		Submerged Shallow Aquatic
	Meadow	Cultural Meadow
		Open Tallgrass Prairie
	Waterbody	Open Water
	Hedgerow	Hedgerow
Beach / Bar / Open Bluff	Open Beach / Bar	
	Shrub Beach / Bar	
	Open Bluff	
Manicured Open Space	Passive use parklands (City-owned)	
	Golf Courses (City-owned)	
Agricultural Land Assets	In Rouge National Urban Park (RNUP)	
	In Greenway outside RNUP	
	In Countryside and Hamlets	
	In the Urban Area	

The primary source of data used to develop the natural asset registry is the Ecological Land Classification (ELC) system mapping for southern Ontario (in accordance with the standards established by Lee et al., 1998)

from the work started by North-South Environmental Inc. and Dougan and Associates Inc. (NSEI and DAI 2021) and completed by CBCL (CBCL 2021, 2022) as part of a city-wide Natural Heritage Inventory and Assessment Study (NHAS).

The ELC provides a good framework for classifying distinct ecological features into a hierarchy and has been used as the basis for dividing natural assets into distinct Level 2 and Level 3 asset types. This classification system is an established and widely accepted standard in southern Ontario that is useful for informing inventory structure as well as condition assessment and management of natural assets. As described in the [ELC Primer](#), the classification of the landscape into units based on physiography, climate and vegetation allows planners and ecologists to organize ecological information into logical integrated units that facilitate landscape planning and monitoring.

The assets contained in Markham's Green Space and Agricultural Lands Inventory have a number of mapping attributes (i.e., layers) associated with them in the registry. The following mapping attributes were identified as being the most relevant for this inventory. They are described briefly in Appendix B along with maps showing their current extent and boundaries in the City of Markham. These mapping attributes/layers can be updated as needed. Mapping attributes are comprised of the following:

1. Ownership (Private / public)
2. Stormwater management pond
3. Urban / Rural boundary
4. Greenway System
5. Greenbelt Plan Area
6. Rouge Nation Urban Park (RNUP)
7. Other Natural Heritage Areas

### 2.2.1 Natural Asset Replacement Costs

In addition to distinct natural asset types (i.e., as per natural asset levels 2 and 3 in Table 2-2) and mapping attributes, another important component of the natural asset sub-inventory provided as part of this project are natural asset replacement costs. In conventional asset management, replacement costs are typically used for capital planning and/or high-level financial planning to account for the anticipated costs when an asset reaches the end of its useful life and needs to be disposed of and replaced. However, while this model could be applied to some green infrastructure assets such as street trees, it generally does not apply to natural assets. This is because natural assets are generally self-sustaining and as such (a) tend to maintain or increase their value and their level of service provision over time, and (b) may never need to be replaced, particularly if they are adequately maintained/managed and protected.

Furthermore, **there are many types and many aspects of natural assets that if lost cannot simply be replaced or re-created**, particularly not within a relatively short time frame (e.g., 20 years). Ecosystems are complex, dynamic and not very well understood. Ecosystems can also take decades and even centuries to become well-established. Therefore, **the idea and costing of natural asset "replacement" should be understood as a simplified tool to facilitate the consideration of natural assets within an asset management framework, but should not be considered as costs that capture the full or real value of these assets.** This value is more fully (but still only partially) captured by the ecosystem services valuation provided in Section 7.

For this project, we have estimated the cost of replacing the existing natural assets by multiplying the area of each natural asset by its corresponding unit replacement cost assuming the land base has remained but the asset itself had been destroyed or removed (by natural events or human activities) and needs to be re-created/re-established in situ.

The unit replacement costs utilized in the analysis were provided by TRCA and based on their current (i.e., 2023) costs for creating and restoring various natural asset types. TRCA did not have habitat creation or restoration costs for all the natural asset types in Markham or for natural asset types at all levels. Therefore, replacement costs were assigned to the appropriate asset types to the greatest extent possible, although some gaps remain (e.g. treed bluffs, shallow aquatic, and open bluffs). The full list of the unit replacement costs applied to natural assets in Markham are summarized in Table 2-3.

In total, it was estimated that the basic replacement costs for all of the City-owned terrestrial natural assets is almost \$170 million, with woodlands accounting for \$97 million, wetlands accounting for \$45 million and meadows accounting for \$28 million of those costs. Watercourses and open water features were not costed as part of this exercise. All values were estimated in 2023 \$CDN.

Notably, the per hectare costs for natural asset creation/re-establishment from TRCA do not include any costs related to acquiring or securing the land, site assessment or preparation, developing restoration plans, obtaining permits, or undertaking post-establishment monitoring. The costs are exclusively related to the human resources and materials required to create or re-establish the given asset type, including basic maintenance (e.g., watering, mulching) during the establishment period.

Replacement costs have been included as an attribute in the natural asset component of the registry, except where data for the particular natural asset was not available from TRCA.

Table 2-3. Unit and total replacement costs for natural assets in Markham.

Asset Attribute	Total area in Markham (ha)	Area in the Greenway System (ha)	Area owned by Markham (ha)	Unit Replacement Costs (\$/ha)	Total Replacement Costs for City-owned Assets
<b>1. Woodlands</b>	<b>1,707.27</b>	<b>1,535.33</b>	<b>552.26</b>		
Coniferous Forest <sup>1</sup>	93.46	88.02	11.61	\$ 173,847	
Deciduous Forest <sup>2</sup>	669.1	621.58	277.07	\$ 173,847	
Mixed Forest <sup>3</sup>	254.15	208.47	74.01	\$ 173,847	
Cultural Woodland <sup>4</sup>	293.24	253.62	90.12	\$ 173,847	
Plantation <sup>5</sup>	160.2	150	24.94	\$173,847	
Cultural Savannah <sup>6</sup>	135.19	129.67	41.93	\$188,546	
Cultural Thicket <sup>7</sup>	101.6	83.63	32.24	\$188,546	
Treed Bluff	0.34	0.34	0.34	N/A	
<b>Total replacement costs for City-owned woodlands (i.e., 552.26 ha)</b>					<b>\$97,039,909</b>
<b>2. Meadow</b>	<b>1,498.93</b>	<b>712.09</b>	<b>226.29</b>		
Cultural Meadow <sup>8</sup>	1,498.60	711.77	226.13	\$198,144	
Open Tallgrass Prairie <sup>9</sup>	0.33	0.33	0.16	\$198,144	
<b>Total replacement costs for City-owned meadows (i.e., 226.29 ha)</b>					<b>\$ 44,838,837</b>
<b>3. Wetland</b>	<b>632.86</b>	<b>588.73</b>	<b>113.71</b>		

Asset Attribute	Total area in Markham (ha)	Area in the Greenway System (ha)	Area owned by Markham (ha)	Unit Replacement Costs (\$/ha)	Total Replacement Costs for City-owned Assets
Coniferous Swamp <sup>10</sup>	18.82	18.82	1.55	\$268,404	
Deciduous Swamp <sup>11</sup>	163.75	161.38	29.4	\$268,404	
Mixed Swamp <sup>12</sup>	57	55.62	9.2	\$268,404	
Thicket Swamp <sup>13</sup>	57.53	56.18	9.49	\$245,945	
Meadow Marsh <sup>14</sup>	260.29	233.19	42.46	\$224,816	
Shallow Marsh <sup>15</sup>	69.73	57.8	21.27	\$224,816	
Treed Fen <sup>16</sup>	0.19	0.19	0	\$268,404	
Floating-leaved Shallow Aquatic	0.7	0.7	0	N/A	
Submerged Shallow Aquatic	4.85	4.85	0.33	N/A	
<b>Total replacement costs for City-owned wetlands (i.e., 113.71 ha)</b>					<b>\$27,440,924</b>
<b>4. Waterbody: Open Water</b>	<b>196.34</b>	<b>165.96</b>	<b>92.82</b>	<b>N/A</b>	
<b>Total replacement costs for City-owned/managed waterbodies</b>					<b>N/A</b>
<b>5. Hedgerow<sup>17</sup></b>	<b>70.8</b>	<b>69.85</b>	<b>1</b>	<b>\$173,847</b>	
<b>Total replacement costs for City-owned hedgerows (i.e., 1 ha)</b>					<b>\$173,847</b>
<b>6. Beach / Bar / Open Bluff</b>	<b>2</b>	<b>1.74</b>	<b>0.6</b>	<b>N/A</b>	
Open Beach / Bar	1.24	1.24	0.6	N/A	
Shrub Beach / Bar	0.05	0.05	0	N/A	
Open Bluff	0.71	0.44	0	N/A	
<b>Total replacement costs for City-owned beach/ bar / open bluff</b>					<b>N/A</b>
<b>Estimated replacement costs for Markham owned natural assets</b>					<b>\$169,493,517</b>
Note: Asset types without replacement cost were ignored					

Table Notes: Replacement costs are obtained from Toronto and Region Conservation Authority (TRCA)

- Unit Restoration Cost for Enhanced Reforestation was used for asset attribute 1-5, and 17
- Unit Restoration Cost for Shrub Thicket Planting was used for asset attribute 6 -7
- Unit Restoration Cost for Native Meadow was used for asset attribute 8 - 9
- Unit Restoration Cost for Forested Wetland was used for asset attribute 10 – 12, 16
- Unit Restoration Cost for Wet Shrub Thicket was used for asset attribute 13

Unit Restoration Cost for Marsh Wetland was used for asset attribute 14 - 15

### 2.3 Natural Assets Inventory Outputs

This section provides sample outputs derived from Markham’s Natural Assets sub-inventory at Level 1, Level 2 and Level 3. The maps also distinguish City-owned assets where appropriate. Examples of outputs from the Manicured Green Spaces and Agricultural Land assets sub-inventories are provided in Appendix C.

There are 4,108 ha of natural assets within the City of Markham. The following figures demonstrate asset classes at different levels:

- Figure 2-2 shows them categorized into Level 1 asset classes.
- Figure 2-3 shows them categorized into Level 1 asset classes with a focus on the City-owned 986 ha.
- Figure 2-4 shows them categorized into Level 2 asset classes.
- Figure 2-5 shows them categorized into Level 2 asset classes with a focus on the City-owned 986 ha.

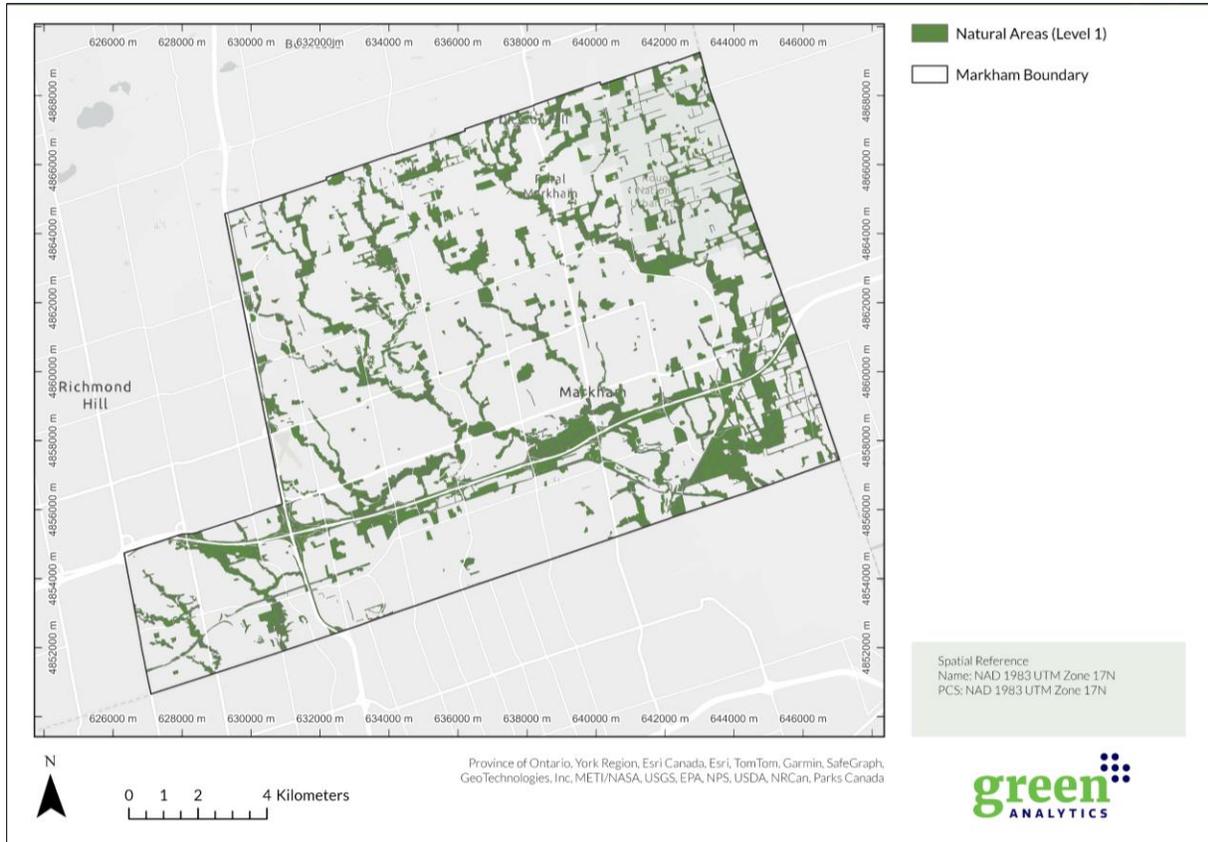


Figure 2-2. Natural assets sub-inventory at level 1.

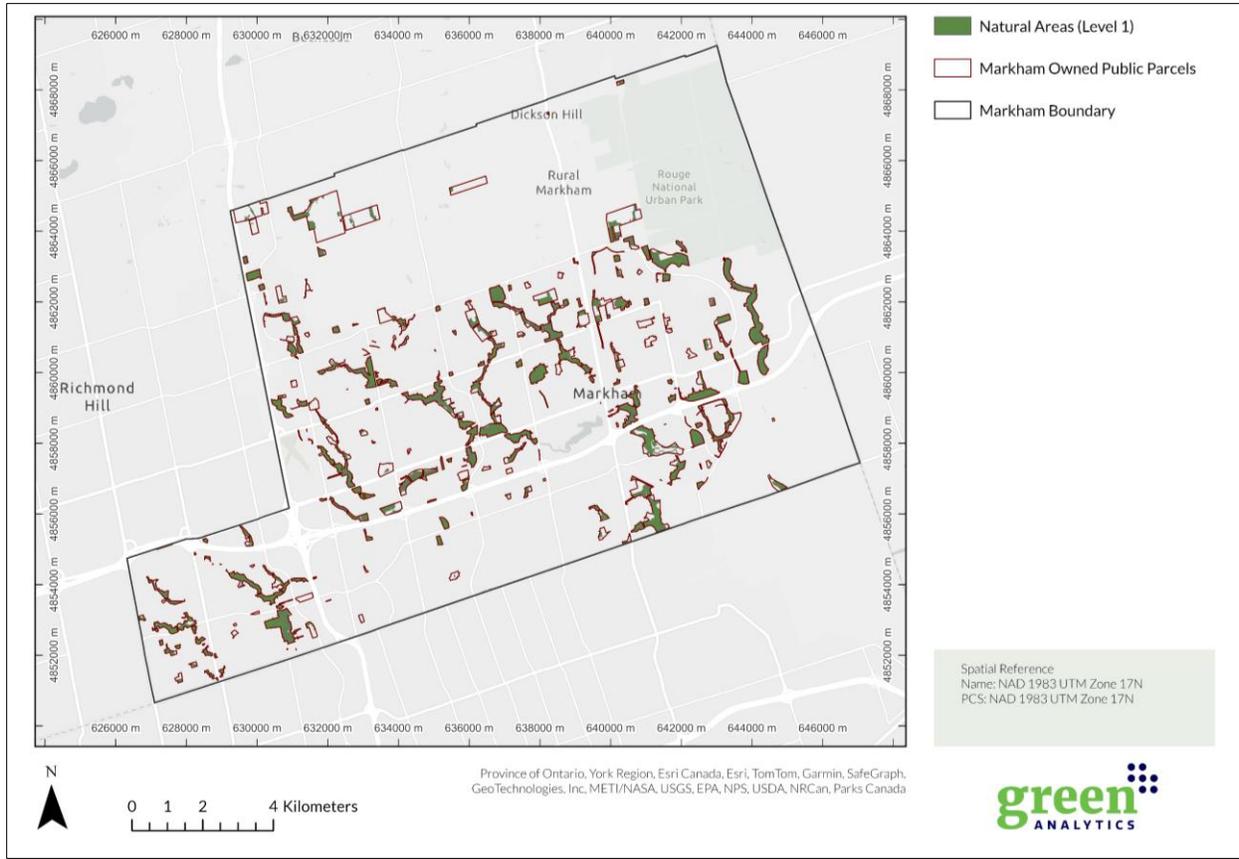


Figure 2-3. Natural asset sub-inventory at level 1 within areas owned by the city of Markham.

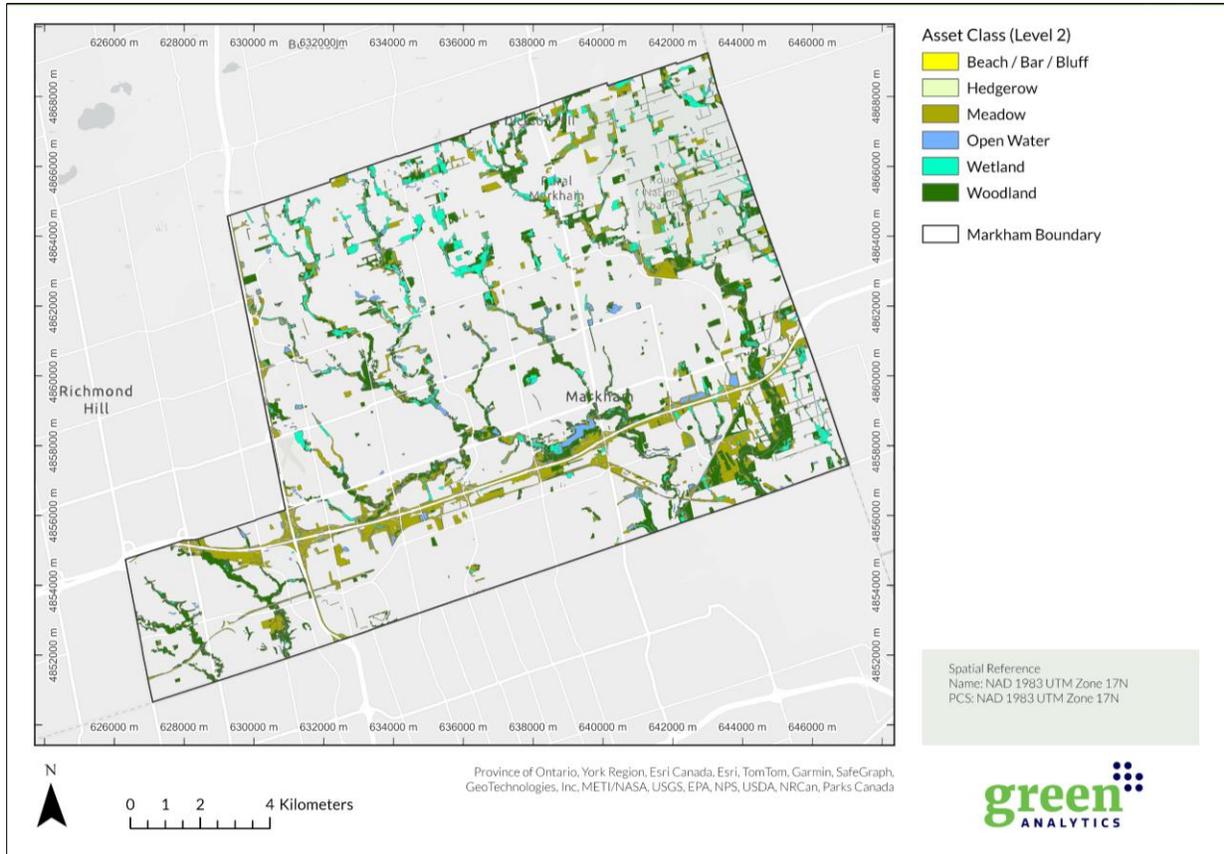


Figure 2-4. Natural assets sub-inventory at level 2.

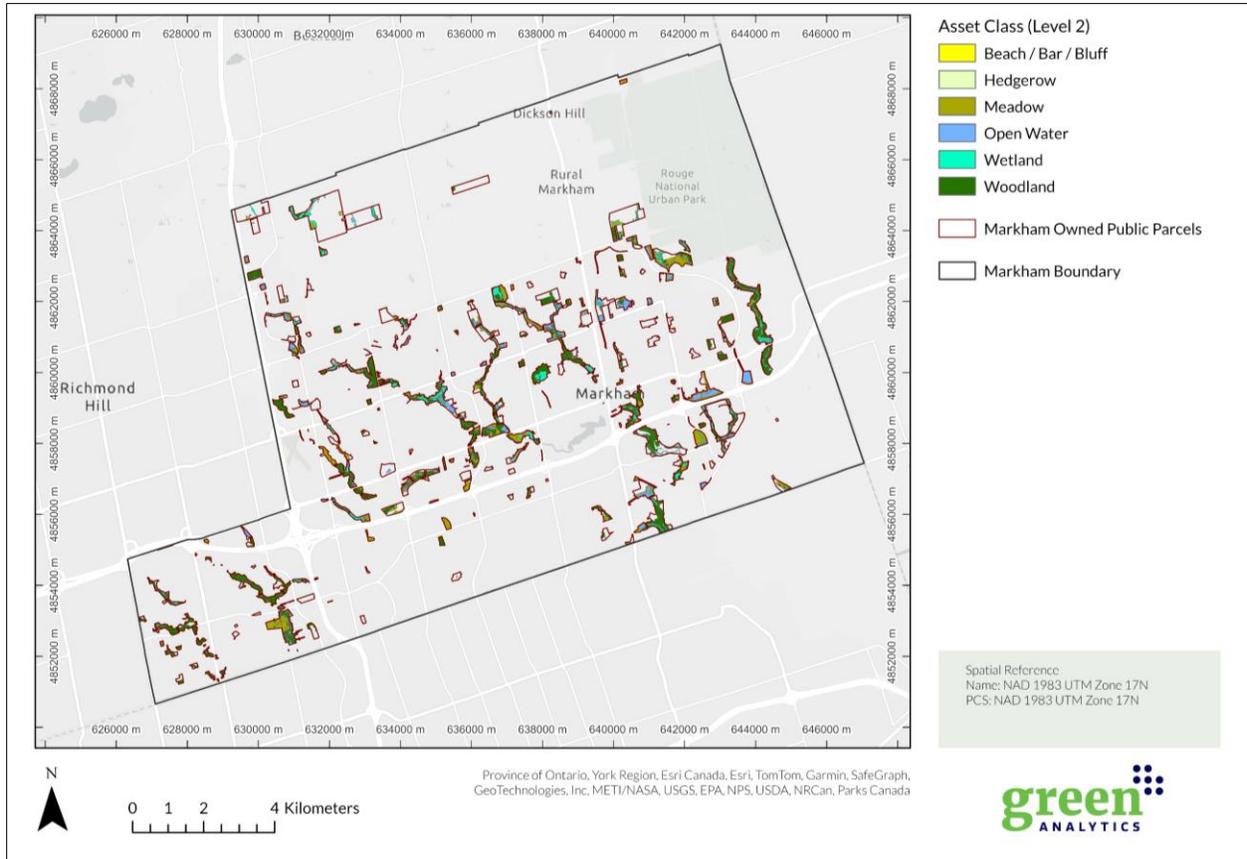


Figure 2-5. Natural assets sub-inventory at level 2 within areas owned by the city of Markham.

Table 2-4 provides area estimates for Markham’s natural assets. The majority of the assets are woodland, with a significant amount of meadow assets as well.

Table 2-4. Area of natural assets within Markham at level 2.

Natural Assets (Level 2)	Total Area (ha) in Markham	Area (ha) in the Greenway System	Area (ha) Owned by Markham
Woodland	1,707.27	1,535.33	552.26
Meadow	1,498.93	712.09	226.29
Wetland	632.86	588.73	113.71
Open Water	196.34	165.96	92.82
Hedgerow	70.80	69.85	1.00
Beach/Bar/Open Bluff	2.00	1.74	0.60
<b>Total</b>	<b>4,108.20</b>	<b>3,073.70</b>	<b>986.90</b>

In Figure 2-6, the distribution of Markham’s natural features and areas are shown categorized into Level 3 asset classes. Figure 2-7 also shows the distribution of Markham’s natural features and areas categorized into Level 3 asset classes with a focus on the City-owned natural assets.

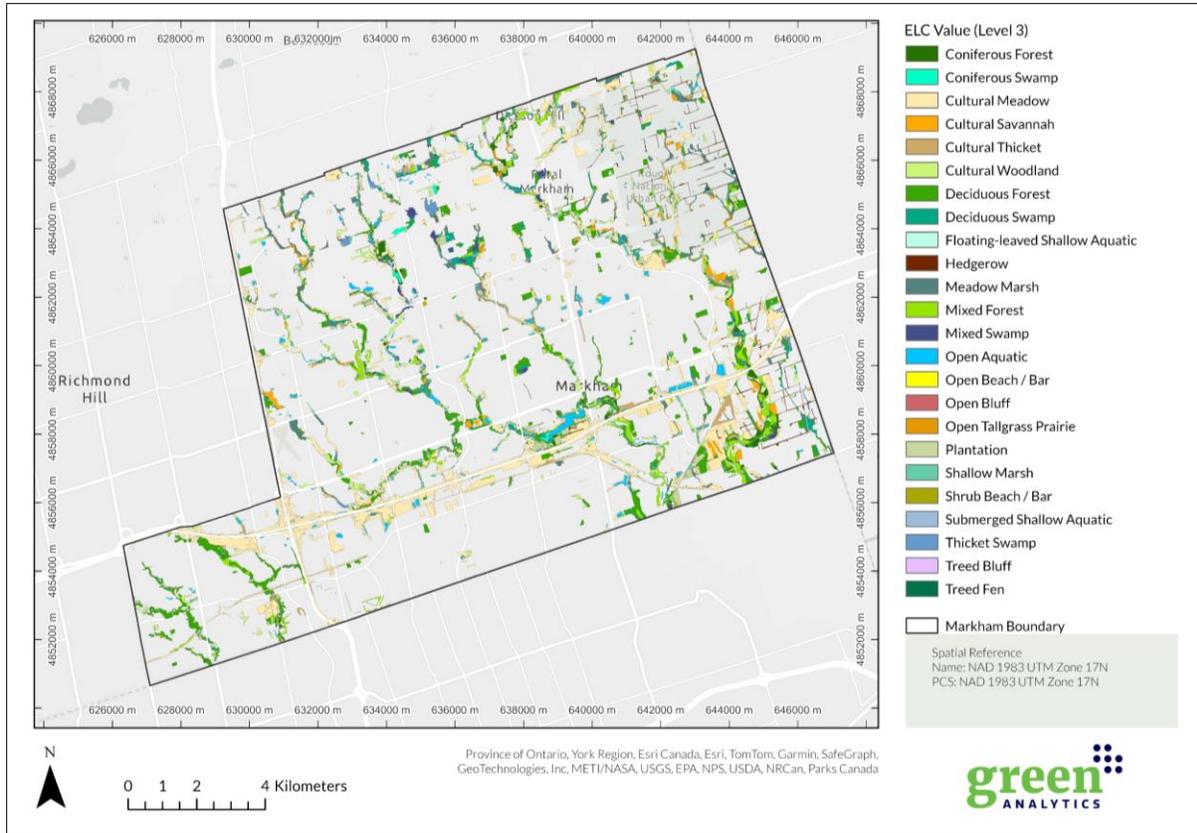


Figure 2-6. Natural assets sub-inventory at level 3.

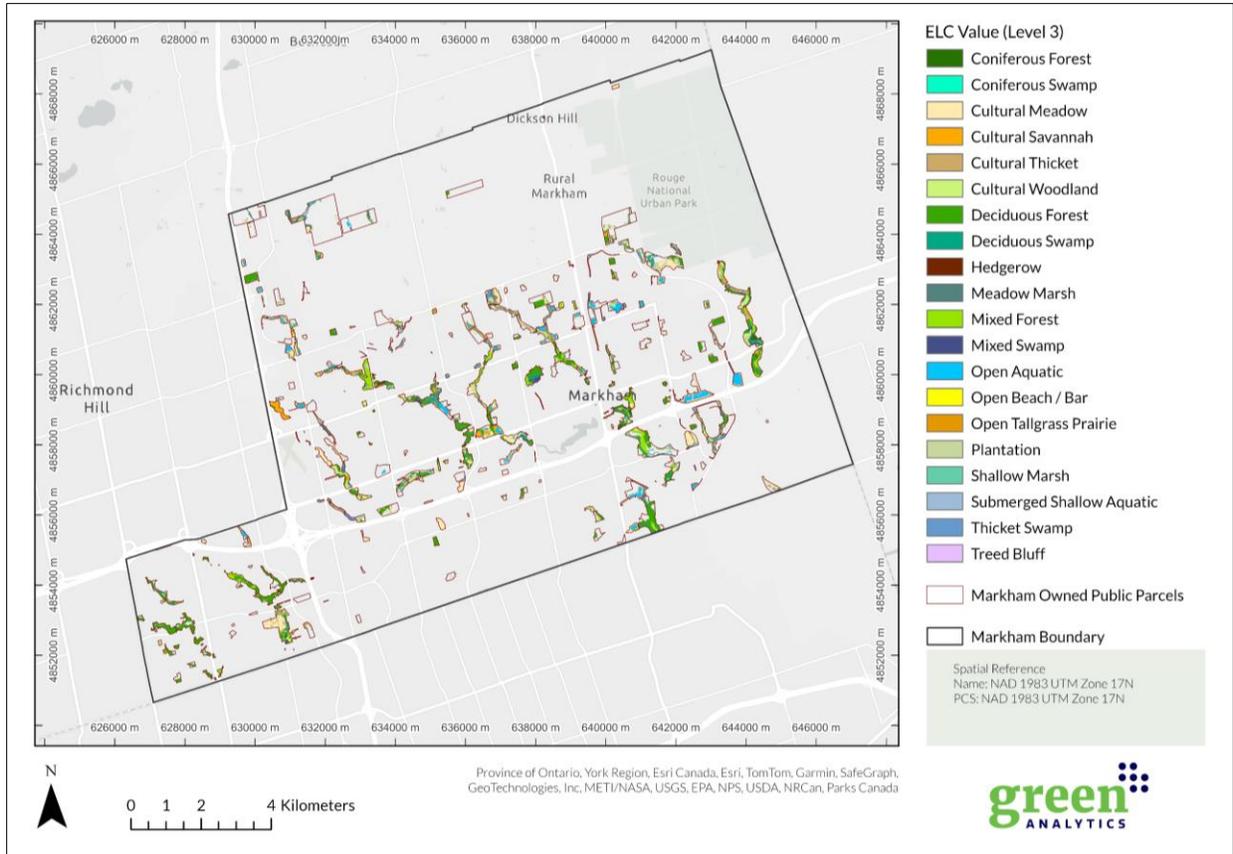


Figure 2-7. Natural assets sub-inventory at level 3 within areas owned by the city of Markham.

### 3 Natural Asset Condition Assessment

This section summarizes the approach and results of the condition assessment applied to Markham’s natural asset inventory.

The objective of this assessment is to estimate a natural asset’s ability to provide ecological services that are valued by the municipality (see Section 7). The underlying assumption of a natural assets condition assessment is that a natural asset assessed as being in a “good” condition from an ecological condition/function perspective, can provide a comparably “good” level of ecological services.

Ideally, assets (green or grey) are assessed for condition through *in situ* inspections using a standardized approach. In the case of natural assets, this would mean field assessments of targeted ecosystem components and/or their functions (e.g., level of native biodiversity).

For this project, we are relying on a desktop assessment (applied across the City) and the results of field work (primarily within City-owned natural assets) completed between 2020 and 2022 (NSEI and DAI 2021, CBCL 2021, CBCL 2022). As part of this field work, the City’s consolidated and comprehensive ELC mapping (as per Lee *et al.*, 1998) was supplemented with data related to invasive species and human-related disturbances. This data was used as the basis for applying a suite of condition indicators.

#### **Why is the condition assessment for Markham preliminary?**

Markham is somewhat unique/unusual in that it has a concentration of high quality natural areas in the Greenbelt and Rouge National Urban Park in its western side outside the urban area. However, most of the City-owned assets are within the urban area. As a result of this “imbalance” the approach to this preliminary condition assessment was tailored to be able to distinguish condition among City-owned natural assets. The results paint a better condition picture than is known to exist on the ground from an ecological perspective.

Further updates and refinements are required based on: (a) the findings and recommendations of the Invasive Plant Species Management Plan (CBCL 2024a) (e.g., 30% of City-owned natural assets are known to be dominated by invasive plants), and (b) the Urban Forest Management Plan (in progress), which will be looking at the condition of City-owned woodlands more closely, among other things.

A suite of five condition indicators was developed based on current landscape ecology principles and science as well as a good understanding of the nature and extent of the City’s natural assets.<sup>6</sup>

The primary focus of this condition assessment was on the natural assets under City ownership. However, it is understood that the condition of these assets is influenced and best understood in the context of the broader landscape and the larger natural heritage system in which they occur. This landscape includes:

- Other natural assets that are either privately owned or owned by another public body.

---

<sup>6</sup> Ecological assessments have been primarily based on the Ecological Land Classification (ELC) mapping from City’s 2021 Phase 1 NHIAS and the 2022 Phase 2 supplemental work (CBCL 2022). The 2022 work was undertaken by one of the members of the consulting team for this project (William van Hemessen of CBCL) who has been able to provide input to the appropriateness of the metrics selected and the results, particularly within Markham’s urban area.

- Other greenspaces that may be considered complementary to natural assets but are not considered “natural” per se (e.g., naturalized stormwater management ponds, manicured parks and open spaces, or agricultural lands).
- A range of built land covers and structures (e.g., roads, parking lots, sidewalks, buildings).

This context was also considered as part of the condition assessment.

### 3.1 Condition Assessment and the Natural Assets Hierarchy

The condition indicators described in the remaining sections of this report were applied at different levels of Markham’s natural asset inventory. The application of condition indicators to each level can be described as follows:

1. Level 1: All adjacent Level 2 natural assets were combined into continuous areas with natural land covers (regardless of the Level 2 asset type), and the condition indicator was applied to the contiguous areas.
2. Level 2: The condition indicator was applied to each asset where the asset was defined by the continuous area of the same land cover type (i.e., woodlands, wetlands, meadows, etc.).
3. Level 3: The condition indicator was applied to each asset where the asset was defined by the continuous area of the asset type (i.e. coniferous forest, deciduous forest, mixed forest etc.).

### 3.2 Overview of the Condition Framework

The framework and process used for the condition assessment aligns with the framework and process outlined in the recently released national standards and specifications for natural asset inventories (Figure 3-1) (CSA 2022).

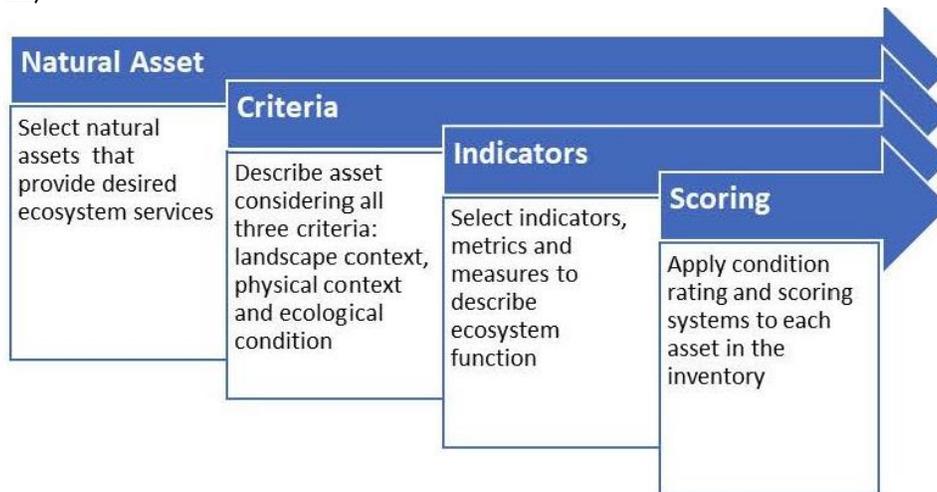


Figure 3-1. The natural asset condition assessment process (Source: CSA 2022).

Through a collaborative process with the City of Markham project team and TAC, several proposed indicators were identified and discussed. The final suite of five condition indicators are listed below and categorized into three criteria to align with the CSA standard for natural asset inventories.

CRITERIA FOR PHYSICAL CONTEXT:

1. Natural Area Patch Size and Shape
2. Natural Asset Proximity to Watercourses

CRITERION FOR ECOLOGICAL CONDITION:

3. Relative Habitat Quality

CRITERIA FOR LANDSCAPE CONTEXT:

4. Extent of Adjacent Complementary Land Uses
5. Intensity of Encroachments

The rationale for and the details of the approach used for assessing each indicator is provided in Appendix D. The results of the indicator-specific assessments were rolled up together, with each indicator result being evenly weighted, to provide an overall condition assessment for all natural assets in Markham, described in Section 3.3.

### 3.3 Preliminary Condition Results

An overall average condition score was identified based on combining each of the individual condition scores for each asset (see Appendix D for details) assuming equal weight to each condition indicator and rounding to the nearest whole number.

#### 3.3.1 All Natural Assets in Markham

The preliminary condition assessment found that 82% of natural assets in the City are in good or very good condition. However, note that these results are understood to paint a better picture than what is on the ground, in part due to data gaps related to plant invasive species and will be subject to updates and refinements going forward.

The results of the overall condition score are depicted in Figure 3-2. Table 3-1 provides the area of each Level 2 asset type by overall condition score. These results are illustrated in Figure 3-3.

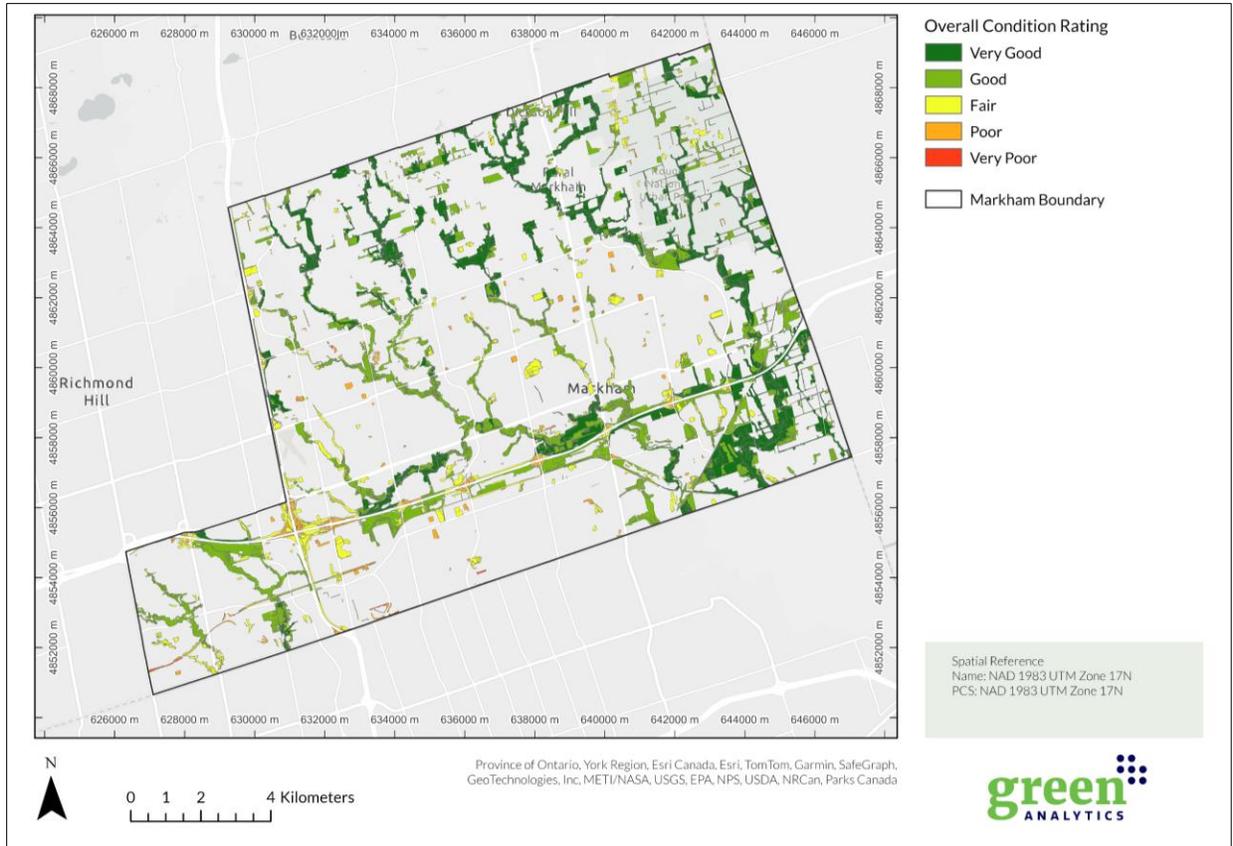


Figure 3-2. Overall condition rating for all natural assets within Markham.

Table 3-1. Condition breakdown by asset type for all natural assets within Markham.

Level 2 Asset Type	Very Good	Good	Fair	Poor	Very Poor
Woodland	648.43	818.07	190.70	47.69	2.38
Meadow	550.97	565.69	293.33	85.17	3.77
Wetland	358.69	220.66	50.74	2.77	0
Open Water	71.43	77.77	37.37	9.54	0.24
Hedgerow	24.45	38.56	5.49	2.30	0
Beach / Bar / Bluff	1.74	0.27	0	0	0
<b>Total Area (ha)</b>	<b>1,655.71</b>	<b>1,721.01</b>	<b>577.63</b>	<b>147.46</b>	<b>6.38</b>

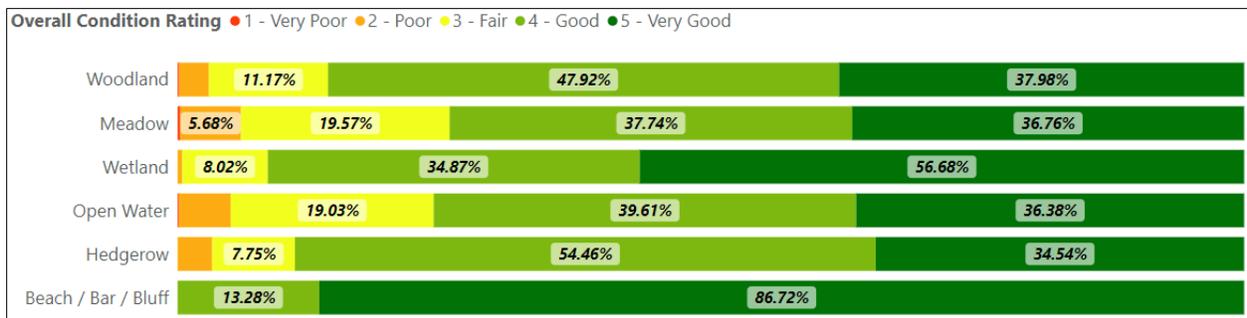


Figure 3-3. Condition breakdown by asset type for all natural assets within Markham.

### 3.3.2 City-owned Natural Assets in Markham

The preliminary condition assessment found that 77% of City-owned natural assets are in good or very good condition. However, note that these results are understood to paint a better picture than what is on the ground, in part due to data gaps related to plant invasive species and will be subject to updates and refinements going forward.

The following results provide the condition results focused on the City-owned natural assets, as outlined in Figure 3-4.

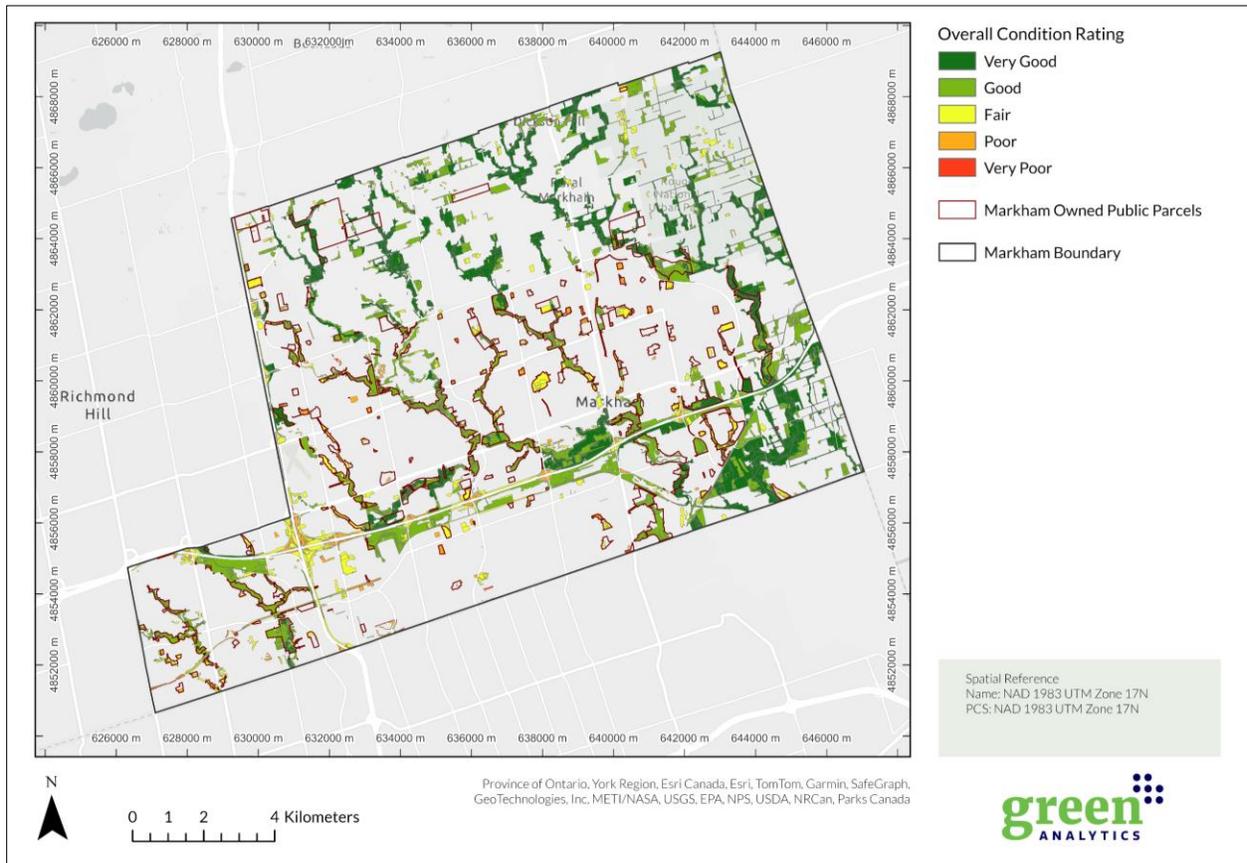


Figure 3-4. Overall condition rating for all natural assets within Markham set against Markham owned parcels.

Table 3-2 shows the breakdown of condition ratings by asset type for assets within the municipal boundary that are owned by the City of Markham. The majority of City-owned natural assets were rated as being in good condition with a significant proportion also rating “very good” and “fair”, with many of the assets in “fair” condition being in the urban boundary. None of the City-owned assets were rated in “very poor” condition. These results are also illustrated in Figure 3-5.

Table 3-2. Condition breakdown by asset type for all natural assets within parcels owned by Markham.

Level 2 Asset Type	Very Good	Good	Fair	Poor	Very Poor
Woodland	93.94	335.67	98.13	24.52	0
Meadow	52.23	116.44	49.64	7.98	0
Wetland	26.77	63.47	23.23	0.25	0
Open Water	21.76	45.65	19.28	6.13	0
Hedgerow	0.70	0.19	0.02	0.09	0
Beach / Bar / Bluff	0.60	0	0	0	0
<b>Total Area (ha)</b>	<b>196.00</b>	<b>561.41</b>	<b>190.30</b>	<b>38.98</b>	<b>0.00</b>

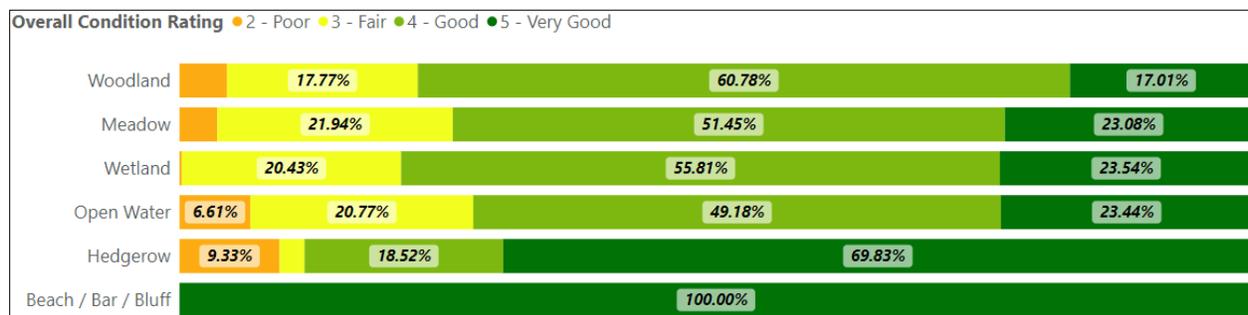


Figure 3-5. Condition breakdown by asset type for all natural assets within parcels owned by Markham.

In comparing the condition of the City-owned natural assets to the overall condition of natural assets in the City, the City-owned assets appear to be in slightly less good condition overall:

- 77% of City-owned assets are in good or very good condition as compared to 82% City-wide.
- 23% of City-owned natural assets are in fair or poor condition as compared to 18% City-wide.

As noted above, these results are preliminary and will be subject to refinements and updates.



Milne Dam Conservation Park in Markham

## 4 Considering and Incorporating Risk

Considering and managing risks to assets is a core component of the asset management process. By identifying and effectively managing asset risks, organizations can protect their assets, reduce the potential costs by responding proactively instead of reactively, and work to ensure that the assets are able to provide the services for which they have been secured/acquired for as long as possible. When specifically considering natural assets, as in this project, understanding risks related to losing, degrading, acquiring and protecting natural assets is also a core component of effectively integrating these assets into a municipality's overall asset management systems.

Natural assets can help communities mitigate and adapt to environmental stressors (e.g., air and water pollution control or moderation of extreme heat and drought). These services are of particular value in urban and urbanizing areas where populations are concentrated and where the effects of growth and climate change are felt most acutely. However, natural assets are also vulnerable to many of the same environmental stressors as communities (e.g., runoff contaminated with pollutants, slope erosion exacerbated by intense storm events, woodland trees negatively impacted by extreme wind and ice storms).

This section presents an overview of:

- The hazards risk assessment (Section 4.1)
- The preliminary asset risk assessment (Section 4.2)

The details of the approach developed are provided in Appendix E, including:

- The risk and the natural assets hierarchy
- An overview of the hazards risk assessment process
- An overview of the preliminary asset risk assessment

## Two types of risk considered for this project

**Hazards risk assessment** considers the risk of the hazard to the asset and indicates which assets are exposed to the most hazard risks.

**Asset risk assessment** considers the risk to the organization (in this case, the City of Markham) of the asset “failing” (i.e., no longer able to provide the services for which it is valued and on which the City and community rely).

## 4.1 Hazards Risk Assessment

The objective of a hazards risk assessment is to identify and rank the hazards that may negatively impact an organization’s natural assets. Consequently, having a good understanding of the types and level of risk presented to various natural assets in a given jurisdiction can help inform planning, management and tracking priorities.

Figure 4-1 shows the hazards risk rating for all natural assets in Markham, while Table 4-1 shows the relative proportion (and areas) of assets falling into each risk category, for all natural assets (irrespective of ownership) and specifically for City-owned assets.

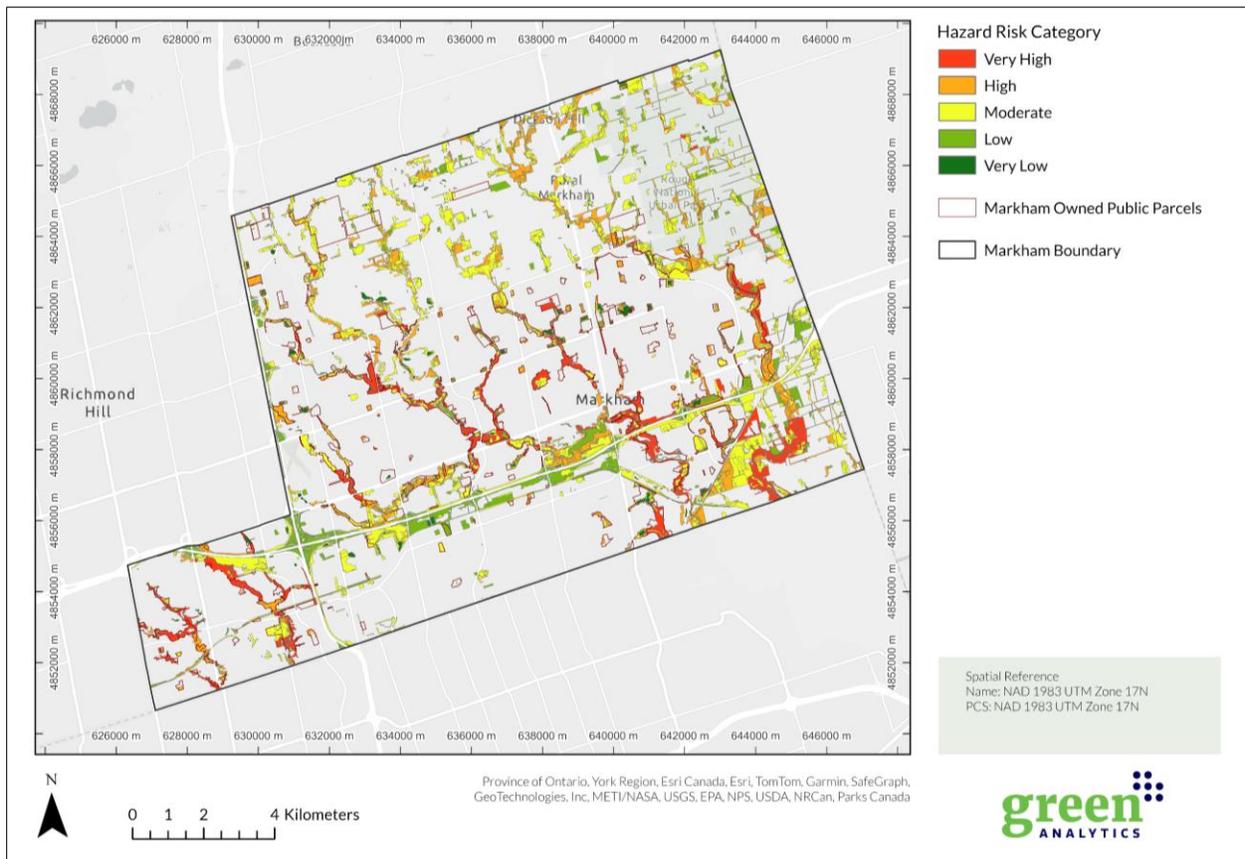


Figure 4-1. Spatial distribution of hazard risk scoring assigned to the various natural assets in the city, with city-owned assets outlined in red.

Table 4-1. Relative proportion of natural assets by hazard risk category.

Risk Category	Markham Natural Assets Ha and (%)	City-owned Natural Assets Ha and (%)
Very High	672.55 (16.4%)	343.89 (34.9%)
High	868.52 (21.1%)	204.95 (20.8%)
Moderate	1,919.48 (46.7%)	332.68 (33.7%)
Low	552.94 (13.5%)	58.39 (5.9%)
Very Low	94.27 (2.3%)	46.78 (4.7%)
<b>Total</b>	<b>4,108.2 (100%)</b>	<b>986.7 (100%)</b>

Notably, more than 50% of City-owned natural assets fall into the high or very high risk categories while the proportion is much lower (i.e., 37.5%) for natural assets City-wide. This difference can be attributed, in large part, to:

- The fact that most high-quality natural assets in Markham are concentrated in the Greenbelt and Rouge National Urban Park and are not owned by the City (as noted in Section 3).
- The City-owned natural assets are predominantly within the urban area and also tend to be:
  - Narrower and more fragmented than the natural assets in the rural parts of the City.
  - More vulnerable to more stressors as a result of both their condition and their location.

Understanding which assets are most vulnerable to hazards helps inform both the levels of service assessment and objectives, as well as the planning and management of these assets going forward.

## 4.2 Preliminary Asset Risk Assessment

In asset management, a further step that can be taken with respect to risk assessment is to estimate the risks to the organization (in this case the City) if the asset(s) were to “fail”. For natural assets, examples of “failure” could include:

- A fire removing an entire woodland (and thereby immediately eliminating the ability of its trees to filter air and water, provide cooling, sequester carbon, etc.).
- An intense flood event taking out a series of off-line wetlands in a creek floodplain (and thereby immediately eliminating their ability to attenuate and clean water and help manage erosion).

An asset risk score can be determined by combining the probability of failure (PoF) ranking and the anticipated consequence of failure (CoF) ranking.

To reflect the relatively more resilient nature of natural assets as compared to built assets, to assign an asset risk score, the following steps were taken:

- Considered both the relative condition (as shown in Section 3-3) and the relative hazard risk assigned to each natural asset (as shown in Section 4-1) to assign the PoF.
- Assigned a higher CoF rating to the “natural” than the “cultural” asset types based on the ELC classification system (on the assumption that they would be more expensive to replace and could result in a greater loss of services).
- Assumed natural assets within the Greenway System to be more valued, and thus have a higher CoF, than those outside the Greenway System.

**The assigned asset risk scores are recognized as an oversimplification but are being retained as these results provide a starting point for assigning more refined asset risk scores to natural assets going forward.**

Figure 4-2 shows the spatial distribution of natural assets by asset risk score, with City-owned natural assets outlined.

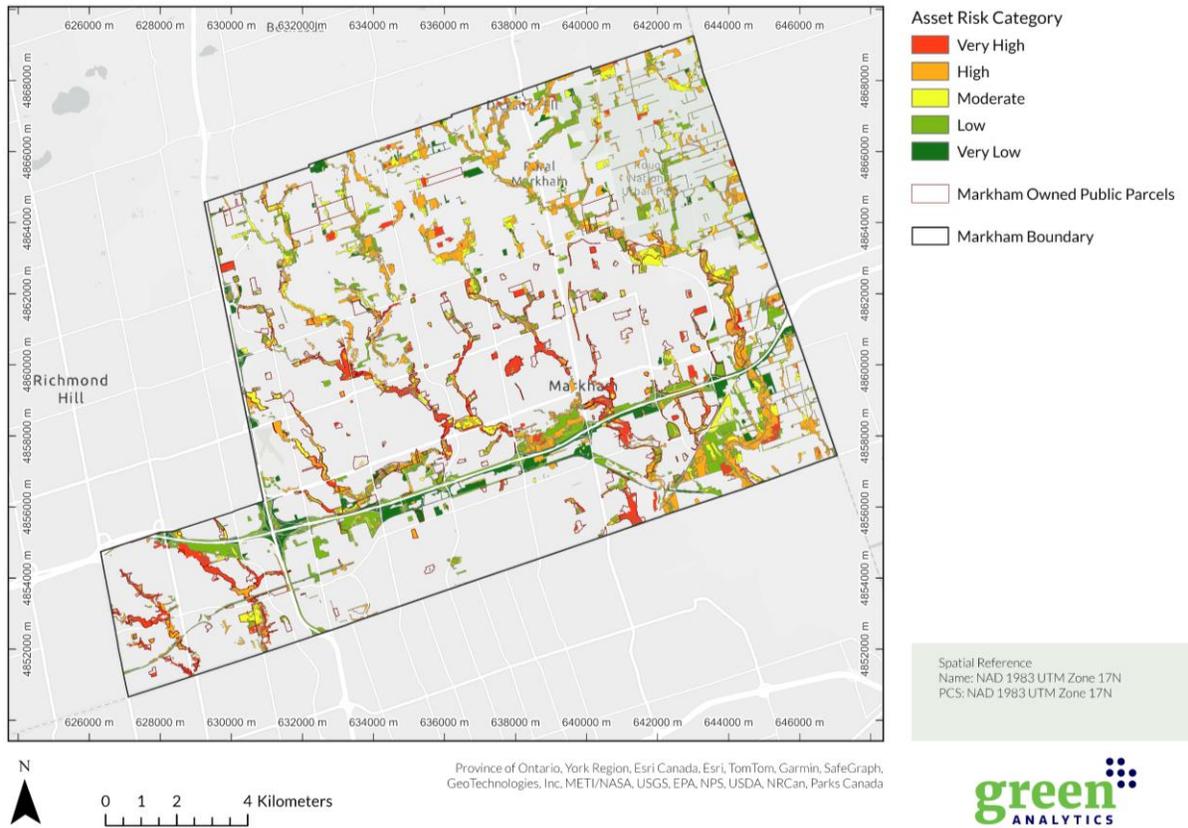


Figure 4-2. Spatial distribution of asset risk scores.

Table 4-2 shows the area and estimated costs in each category of asset risk for all natural assets within Markham. Table 4-3 shows the area and estimated costs in each category of asset risk for City-owned natural assets alone. Both tables show the basic replacement costs of the assets based on the approach outlined in Section 2.2.1.

**It is important to recognize that natural assets tend to be much more resilient than built assets because of their inherent capacity to re-establish/restore themselves over time (even following a catastrophic event), which actually reduces the asset risk. Developing a methodology for incorporating this unique aspect of natural assets into this assessment was outside the scope of this first natural assets project. Given this context, the asset risks assessment included in this report should be considered more illustrative of the value of the potential loss rather than used to directly inform financial planning.**

Table 4-2. Asset risk scores and replacement values for all natural assets in Markham.

Probability of Failure		Consequence of Failure				
		Very Low	Low	Moderate	High	Very High
		1	2	3	4	5
Very low	1	1	2	3	4	5
		7.8 ha \$1,553,528	37.1 ha \$7,349,589	20.3 ha \$0	136.5 ha \$838,804	0.7 ha \$185,218
Low	2	2	4	6	8	10
		364.7 ha \$72,251,035	446.8 ha \$87,921,440	33.9 ha \$4,994,309	220.2 ha \$40,603,864	181.7 ha \$48,030,483
Moderate	3	3	6	9	12	15
		422.6 ha \$83,589,003	475.0 ha \$90,552,278	370.9 ha \$65,548,775	671.6 ha \$122,811,254	109.6 ha \$28,897,905
High	4	4	8	12	16	20
		16.5 ha \$3,107,706	77.8 ha \$14,423,624	135.7 ha \$23,583,188	321.9 ha \$55,957,715	0 ha \$0
Very High	5	5	10	15	20	25
		0 ha \$0	9.8 ha \$1,804,297	11.3 ha \$1,966,719	36.0 ha \$6,263,491	0 ha \$0

Note: Replacement costs were based on the approach and values outlined in Section 2.2.1.

Table 4-3. Asset risk scores and replacement values for city of Markham owned natural assets

Probability of Failure		Consequence of Failure				
		Very Low	Low	Moderate	High	Very High
		1	2	3	4	5
Very low	1	1	2	3	4	5
		0 ha \$0	0.2 ha \$43,409	1.1 ha \$0	60.8 ha \$10,906	0 ha \$0
Low	2	2	4	6	8	10
		11.1 ha \$2,207,053	39.4 ha \$7,693,434	6.0 ha \$144,105	39.3 ha \$3,480,121	10.7 ha \$2,836,032
Moderate	3	3	6	9	12	15
		39.4 ha \$7,799,915	171.5 ha \$33,605,869	49.0 ha \$8,458,526	148.1 ha \$27,797,638	38.9 ha \$10,272,917
High	4	4	8	12	16	20
		4.6 ha \$862,825	34.1 ha \$6,360,818	65.5 ha \$11,380,564	222.7 ha \$38,706,130	0 ha \$0
Very High	5	5	10	15	20	25
		0 ha \$300,371	7.9 ha \$1,480,223	7.2 ha \$1,251,493	29.1 ha \$5,063,539	0 ha \$0

Note: Replacement costs were based on the approach and values outlined in Section 2.2.1.

Notably, similar to the hazard risk assessment outcomes, even though the City-owned natural assets represent 24% of the natural assets in the City based on area, these assets present a disproportionate amount of risk. For example, preliminary calculations indicate that natural assets across Markham with “very

high” asset risk scores have an estimated replacement cost of over \$98 million with City-owned natural assets accounting for more than half of those costs (i.e., \$55.3 million), even though the City only owns a quarter of the natural assets in Markham.

As with the hazard risks, this can be attributed, in large part, to the fact that the City-owned natural assets are predominantly within the urban area and tend to be both in poorer condition and more vulnerable to stressors as a result of both their condition and their location than natural assets in the rural parts of Markham. **This underscores the importance of maintaining and enhancing the City-owned assets to improve their condition and, where possible, making them less vulnerable to the environmental stressors of greatest concern.**

# 5 Levels of Service and Current Management

As noted in the Introduction, Ontario Asset Management Regulation O. Reg. 588/17 specifically lists green infrastructure, including “natural heritage features and systems” (referred to herein as natural assets), as an asset category to be included in municipal asset management plans. This demonstrates that the Province recognizes these assets as forming part of the municipal infrastructure system and contributing to the delivery of multiple municipal services. However, O. Reg. 588/17 does not prescribe specific levels of service (LOS) for green infrastructure because it is considered “non-core” infrastructure. The City of Markham therefore has discretion around how to define LOS for its natural assets, the subset of green infrastructure assets that are the focus of this project.

LOS are performance measures that define the expected performance of assets and related services. They represent the service delivery commitment of a local government and inform asset management and financial plans, including helping local governments determine and prioritize capital and operational spending. An example of a typical levels of service framework is shown in Figure 5-1.

It is the responsibility of the local governing body (e.g., typically a municipal council or its equivalent) to approve established LOS and monitor progress on meeting and maintaining established LOS, with support from municipal staff. Establishing clear LOS and measuring and reporting on the status of LOS supports transparency and accountability, while also allowing for continuous improvement in service delivery.

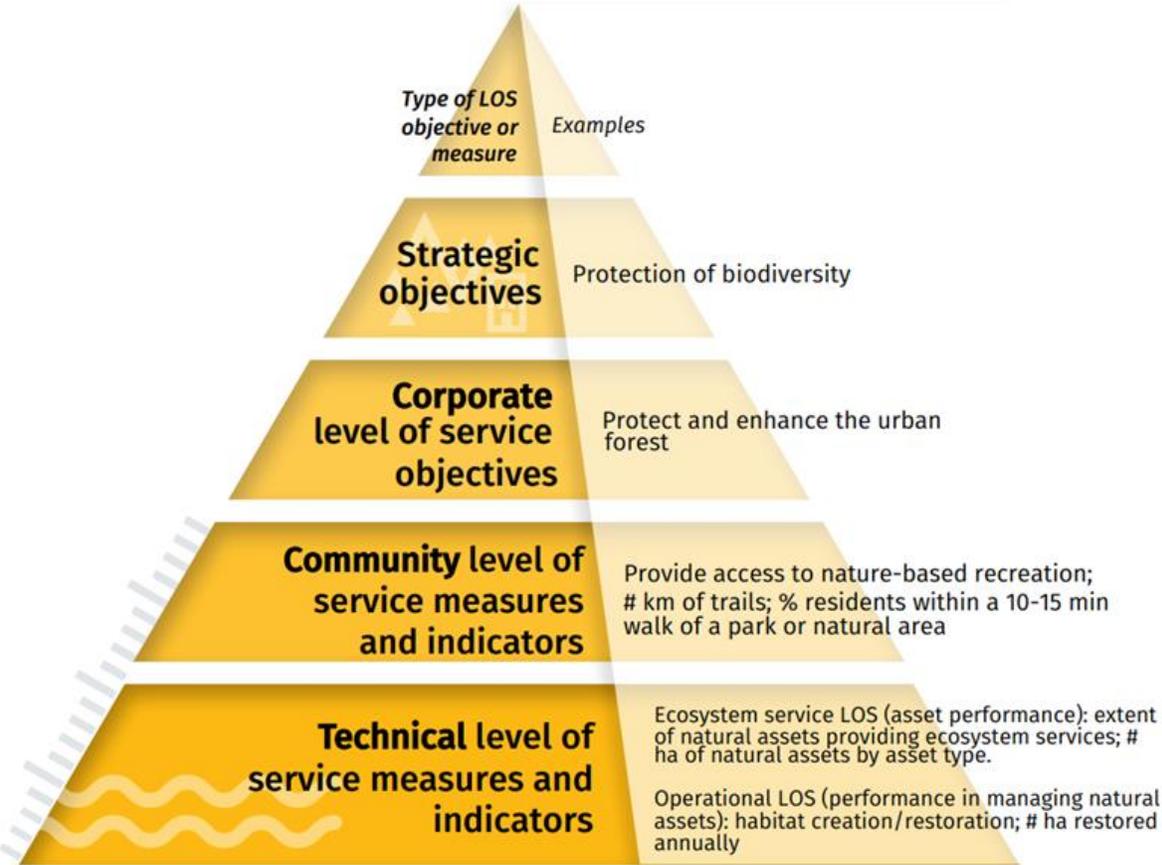


Figure 5-1. Typical levels of service (LOS) framework. (Source: MNAI 2022.)

There is currently no industry standard the City can follow to define LOS for natural assets, although a guidance document for local governments in Canada has been developed (MNAI 2022). Therefore, available natural heritage policies, plans and strategies applicable to the City of Markham from all levels of government were reviewed and, where deemed appropriate by the Project Team and TAC, were used to identify targets and thresholds for natural assets in Markham (see Appendix F for a complete list of the documents and considerations that informed Markham's LOS framework).

The LOS measures adopt a framework aligned with the City of Markham's organization-wide approach to asset management that is still being developed. For all service areas, the City plans to follow the Level of Service Framework developed by IPWEA (Institute of Public Works and Engineering Australia). This framework is based on three main types of LOS measures: corporate, community and technical.

**Corporate LOS Objectives describe:**

- What aspects of the service is important to the community.
- Whether they see value in what is currently provided.
- Likely trend over time based on the current budget provision.

Corporate LOS objectives can be understood to be the high-level service objectives the City is trying to achieve with natural assets. These measures consider the City's strategic objectives, business drivers and legislative requirements related to natural assets.

The more granular community and technical LOS measures, described below, should align with the corporate LOS objectives.

**Community LOS measures and indicators describe:**

- Quality: How good is the service ... what is the condition or quality of the service?
- Function: Is it suitable for its intended purpose .... Is it the right service?
- Capacity/Use: Is the service over or under used ... do we need more or less of these assets?

**Technical LOS measures and indicators describe:**

- Life cycle management activities and budgets (acquisition, operations and maintenance, and renewal) required to achieve the current or desired level of service.

The remainder of this section describes the LOS measures and indicators recommended for the City of Markham to track performance of natural asset management.

It is important to note that the types and number of LOS measures and indicators presented in this framework have been developed with consideration for the availability of data and staff capacity to track trends in ecological health and ecosystem services at this time. However, these measures are expected to be reviewed, refined and updated over time as the availability of data and staff capacity evolves.

As is shown in Figure 5-2, the articulation of corporate, community and technical LOS inform life cycle activities for managing natural assets taking into consideration risks. The City can then use this information to specify the capital and operating budget needed to support the activities.

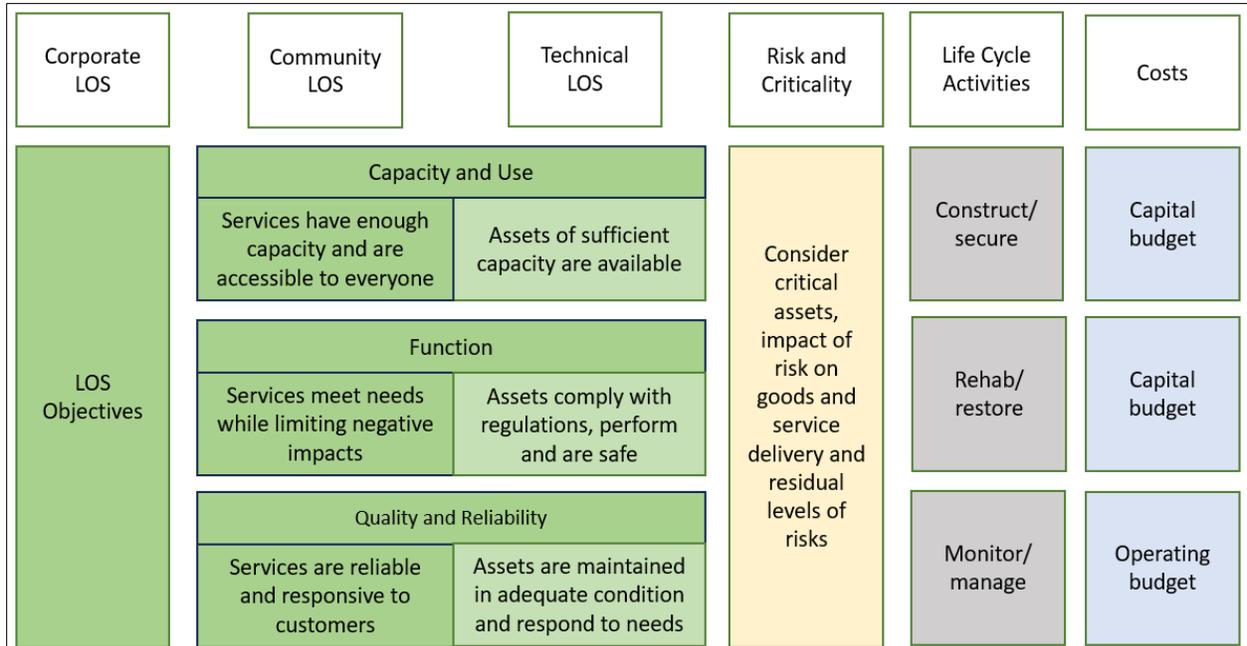


Figure 5-2. The LOS framework in the context of risks, lifecycle activities and costs.

## 5.1 Corporate Levels of Service Objectives

Three corporate LOS objectives have been identified to measure the City’s performance on natural asset management. These are:

- CO.1: The Greenway System includes Markham's Natural Heritage Network (NHN) that supports a diversity of natural habitats and ecosystems and is critical to maintaining biodiversity and a healthy environment for the benefit of all living things.
- CO.2: Natural areas help mitigate climate change and build resilience to climate change impacts, including extreme weather events.
- CO.3: Public natural areas and other greenspaces in the Greenway System provide access to nature for passive recreation and cultural activities.

These LOS objectives are the high-level service objectives the City is trying to achieve with natural assets. These measures consider the City’s strategic objectives, business drivers and legislative requirements related to natural assets.

Corporate LOS CO.1 relates to the ecological health and functioning of natural assets to support biodiversity and the delivery of ecosystem services. It is aligned with objectives set out in the City of Markham Greenprint Sustainability Plan (2011) and the City of Markham Official Plan (2014) and other local and regional strategic documents. This measure represents a high-level corporate service objective for natural assets and progress is best measured quantitatively through the related community LOS shown in Table 5-1.

Corporate LOS CO.2 relates to the corporate objective around leveraging natural assets to build resilience to climate impacts. As with CO.1, this measure represents a high-level corporate service objective and progress is best measured quantitatively through corresponding community LOS, which relates to the ability

of woodlands to sequester carbon, the value of carbon sequestered by woodlands and their role in supporting improved air quality.

In the future, the City of Markham may wish to refine or expand its customer satisfaction survey to gather input specifically related to green infrastructure – including stormwater management and City-owned natural areas management related to the City’s response time in addressing hazards from extreme weather events, such as flooding, fallen trees and erosion. In addition, progress on this measure could be assessed by analyzing the number of properties where naturalization has contributed to slope stabilization and/or where expanded woodland securement and restoration in headwaters has been prioritized to help manage stormwater and erosion downstream.

Corporate LOS CO.3 relates to objectives set in the City of Markham Greenprint Sustainability Plan (2011) and is aligned with the provincial regulatory framework, City of Markham Official Plan (2014) and other strategic plans, such as the Oak Ridge Moraine Conservation Plan (2017), the Greenbelt Plan (2017) and the Rouge National Urban Park Management Plan (2019). All of these documents include objectives related to providing public access to greenspace and natural heritage. Markham is currently measuring satisfaction on this community value through the City’s satisfaction survey, last conducted in 2022.<sup>6</sup> The question focuses on the community’s satisfaction with the extent of greenspaces, including parks, trails and open spaces. There are no community or technical LOS measures aligned with this customer value, as progress on publicly accessible greenspaces is best tracked by the Parks Department.

In the future, the City may wish to consider a more extensive survey or consultation that addresses the quality, safety, and accessibility of public greenspaces. For example, it could include questions related to the City’s management of its natural areas including: diligence in removing waste and/or encroachments and addressing hazard trees, follow-up maintenance and monitoring of restoration areas, etc. The City can also analyze quality, safety and accessibility through an analysis of customer service requests/complaints related to its greenspaces.

## 5.2 Community Levels of Service Indicators

Eight community LOS measures have been identified to enable the City to track the quality (ecological health/condition) and function (ecosystem service performance) of natural assets. They are designed to measure progress based on data availability. Table 5-1 summarizes the current performance and any anticipated management activities associated with these LOS.

Table 5-1. Community LOS along with performance measures, current performance and management activities.

Category	Level of Service	Performance Measure	Current LOS Performance	Associated Management Activities
Quality	<b>C.1</b> Ecological condition of the natural assets in the Greenway system	% of natural assets in very good or good condition, broken down by asset type at level 3 in the inventory	81% of natural assets are in good or very good condition. Detailed breakdown in asset registry.	Management actions are captured by technical LOS
Quality	<b>C.2</b> Biodiversity of native species in the Greenway System	#amphibians and reptiles, #birds, #mammals, #plants - native and non-native noted for each	SPECIES: 8 amphibians, 4 reptiles, 75 birds, 12 mammals, 530 plants (326 native and 204 non-native)	Management actions are captured by Technical LOS <b>T.2</b> .
Quality	<b>C.3</b> Biodiversity of native species: prevalence of invasive species in the Greenway system	% of City-owned lands where invasive species are dominant or abundant.	Invasive species dominant or abundant in ~ 66% of ELC polygons (% hectares City-owned land as in the asset registry)	Management actions are captured by Technical LOS <b>T.7a</b> . (Also T.2)
Function	<b>C.4</b> Extent of natural assets providing ecosystem services, City-wide.	% of City lands with natural ecosystems (including cultural ELC units - Woodlands, Wetlands, Open Country and Early Successional)	Total of 4108 ha, or 19.3% of lands.	The City restores open country habitats to woodland, but there should be no significant change to the overall extent of natural assets. Therefore, recommend no overall change to extent.  Management actions are captured by Technical LOS <b>T.6, T.8, T.11</b> .
Function	<b>C.5</b> Extent and types of woodland cover	ha of woodland cover, by type, in the City	Woodland Cover: 1707 ha	Management actions are captured by Technical LOS <b>T.2, T.6, T.11a</b>
Function	<b>C.6</b> Extent and types of wetland cover	# ha wetlands, by type, in the City	Wetlands: 632.9 ha	Management actions are captured by Technical LOS <b>T.11b</b> (Also T.2)
Function	<b>C.7</b> Extent of meadow and other open habitat cover, City-wide	# ha meadow and open habitat in NHH and % of City area	1498.9 ha (7%)	Management actions are captured by Technical LOS <b>T.7b</b> (Also T.2)
Function	<b>C.8</b> Ownership of Greenway System lands: proportion of Greenway that is in public ownership vs private ownership	% and Ha of the Greenway System that is in public ownership	4665.4 ha public out of total 6761.3 ha; 69.0%	Management actions are captured by Technical LOS <b>T.1</b>

### 5.3 Technical Levels of Service Measures and Management Activities

To achieve program objectives and maintain service levels, the City builds new infrastructure assets to meet capacity needs, upgrades assets to meet functional needs, and manages existing assets to meet reliability needs – all with limited funds and resources. This involves planning and strategizing, acquiring and maintaining assets, and assessing their full lifecycle needs and costs to inform short and long-term financial planning.

While natural asset management can be aligned with a “traditional” asset management in many respects, there are some important differences that require a tailored approach. Two key differences worth pointing out are as follows:

- A typical built asset (such as say a sewer pipe) has its greatest value when newly installed, decreases in value over time and even with regular maintenance eventually needs to be disposed of and replaced.
- A natural asset typically increases in value as it matures and – if adequately maintained/managed– can continue to provide benefits and services in perpetuity and may never need to be “disposed” of or fully replaced (as illustrated in Figure 5-2).

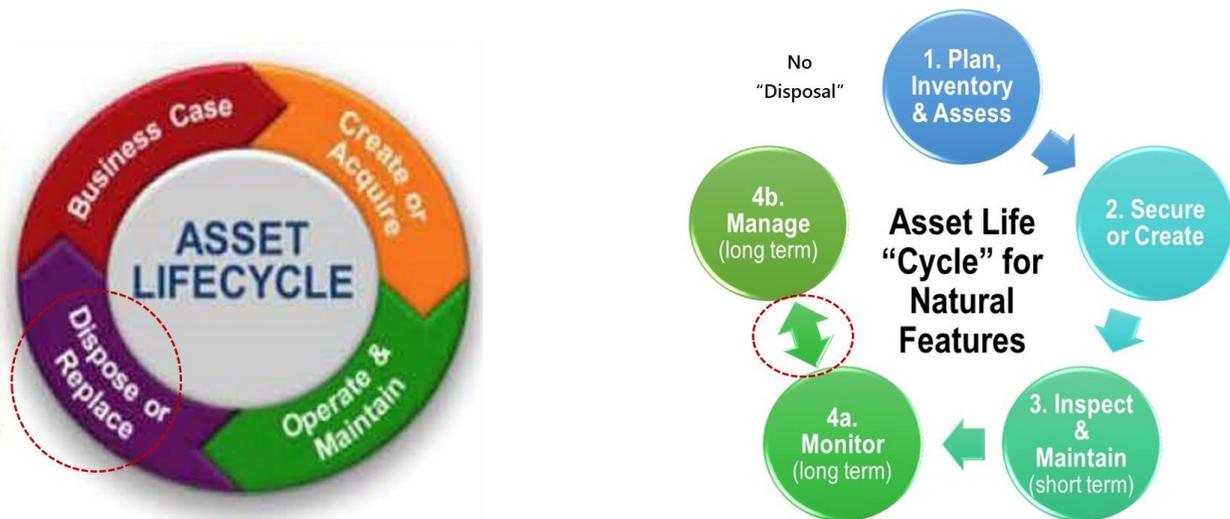


Figure 5.2. Comparison of typical life cycle for built assets (left) and natural assets (right) (Sources: Left graphic – City of Markham Asset Management Plan 2021; right graphic – Credit Valley Conservation 2020.)

In the context of natural assets the major life cycle activities can be clarified as falling into one of three typical life cycle categories (as shown in Table 5-2): (a) acquisition/securement of “new” natural assets to meet needs associated with growth and community expectations, (b) maintenance of existing natural assets, and (c) rehabilitation/restoration of existing natural assets that are not functioning well.

To inform asset management strategies, the technical LOS are organized around the categories listed in Table 5-2. The management actions associated with the Technical LOS describe what is needed to manage the risk discussed in Section 4.

Table 5-2. Life Cycle Management Category Definitions.

Life Cycle Management Category	Description	Examples of Associated Activities
Acquisition / Expansion	Activities to provide a new asset that did not exist previously or an expansion to an existing asset	New asset acquisition or expanded asset reforestation / creation.
Maintain	Activities to retain asset condition to enable it to provide service for its planned life	Minor repairs, tree pruning, invasive species removal
Rehabilitate	Activities that return the original service capability of an asset	Minor or major asset rehabilitations

Asset life cycle management strategies are planned activities that enable assets to provide service levels while managing risk at the lowest life cycle cost based on current data and knowledge. The Technical LOS are organized around specific life cycle management activities (i.e., acquisition, operations and maintenance, and renewal) required to achieve the current or desired level of service.

The following three tables summarize the current performance measures and management activities associated with each of the three main life cycle activities outlined in Table 5-2:

- Table 5-3: Technical LOS measures and management activities related to acquisition/securement of land for natural asset service provision.
- Table 5-4: Technical LOS measures and management activities related to maintaining City-owned natural assets.
- Table 5-5: Technical LOS measures and management activities related to rehabilitation of City-owned natural assets.

Table 5-3. Acquisition and land securement technical LOS along with performance measures, current performance and management activities.

Level of Service	Performance Measure	Current LOS Performance	Associated Management Activities	Estimated Staff Time
<b>T.1A</b> Securement of privately owned natural areas to incorporate into the publicly owned Greenway System	# ha secured/year by City	5 yr growth = 89.2 ha (Dec. 2018 - 937.4 ha to Dec. 2023 - 1026.6 ha)  Average of 17.8 ha/yr secured  Assume all growth has been through development applications.	Staff review Environmental Impact Studies (EIS) or equivalent to confirm limits of development and seek conveyance of Greenway System lands. Staff time covered by development application fees.	Planner II (1) - 25% Sr Planner (1) - 5%
<b>T.1B</b> Securement of privately owned natural areas to incorporate into publicly owned Greenway System (through City-initiated projects or processes)	Funds allocated to support land securement	\$250,000 allocated annually to Environmental Land Acquisition Fund	Opportunistic acquisition of Greenway System lands through the Environmental Land Acquisition Funds.  Incidental acquisition of Greenway lands from City land purchases for other purposes (e.g., trail, infrastructure and parkland projects).  Respond to requests from Council.	N/A

Table 5-4. Operations and maintenance technical LOS along with performance measures, current performance and management activities.

Level of Service	Performance Measure	Current LOS Performance	Associated Management Activities	Estimated Staff Time
<b>T.2</b> Monitor change in extent of NHN and Greenway System <sup>7</sup>	Change in extent and quality/condition of City-owned natural assets in the NHN and Greenway System	Update natural heritage inventory every 5 years as part of Official Plan Review. Create natural assets registry and update every 5 years.	Staff undertake natural heritage inventory every 5 years. Staff undertake natural assets registry. Cost: \$110,000 for inventory. \$140,000 for natural assets study. Forestry staff undertaking Strategic Urban Forest Management Plan with a City-owned woodland management plan deliverable (\$16,000).	Sr Planner (1) - 30% every 5th year; 5% all other years  Managers (3), Planning, Asset Management, Parks Operations - 5% every 5 years
T.2a Monitor change in extent of woodlands and associated service provision metrics	Change in extent of City-owned woodlands in the NHN and Greenway System	Captured by T.2	Captured by T.2	Captured by T.2
T.2b Monitor change in extent of wetlands and associated service provision metrics,	Change in extent of City-owned wetlands in the NHN and Greenway System	Captured by T.2	Captured by T.2	Captured by T.2

<sup>7</sup> Technical LOS T.2a, T.2b, T.2c, T.3, T.4, T.5 are not listed here as they are all management actions are all accounted for under T.2

Level of Service	Performance Measure	Current LOS Performance	Associated Management Activities	Estimated Staff Time
T.2c Monitor change in extent of meadows and open habitat and associated service provision metrics	Change in extent of City-owned meadows and other open habitats in the NHN and Greenway System	Captured by T.2	Captured by T.2	Captured by T.2
T.3 Monitor levels of native plant and wildlife biodiversity	Change in relative proportion and abundance of native plant and wildlife species (i.e., quality/condition) of City-owned natural assets in the NHN and Greenway System	Captured by T.2	Captured by T.2	Captured by T.2
T.4 Targeted invasive plant species monitoring in the Greenway	Change in relative proportion and abundance of invasive plant and wildlife species (i.e., quality/condition) of City-owned natural assets in the NHN and Greenway System	Captured by T.2, also related to T7a	Captured by T.2, also related to T7a	Captured by T.2, also related to T7a
<b>T.6</b> Natural areas stewardship program: include a description of partnerships, community-wide activities that enable stewardship of natural areas	Annual spending on stewardship program; where possible, # of volunteers engaged; # ha maintained / enhanced; # trees planted	Spending in 2023 (Trees for Tomorrow Program): \$125,300; Major Partners: 10,000 Trees; Friends of the Rouge Watershed; Trees Canada;	Capital budget allocation of \$125K for Trees for Tomorrow Stewardship program.  Money used to facilitate/provide matching funds for planting partners: ~7000 trees & shrubs/yr # volunteers: Not available at this time.  Note that the trees planted through this LOS are also repeated in LOS T.11a below.	<b>Staff Time</b> Parks Planner (1) - 20% OPS 150-day staff (1) - 35% Forestry 150-day staff (4) - 5% Forestry Supervisor (1) - 1% Urban Forestry Technologist (1) - 1%  Note that this staff time is also repeated in LOS T.11a below.
<b>T.7a</b> Targeted management of invasive plant species (Note: to be updated based on recommendations from the recently completed Invasive Plant Species Management Plan, CBCL 2024a)	# of sites/area managed; Annual spending on invasive plant species management	Management plan to be completed in May 2024.	<b>Giant Hogweed Control:</b> \$15,000/yr to remove giant hogweed from City properties. Recurring annual contract. (Operations)  <b>Other invasive plants:</b> \$10,000/yr to remove 0.4 ha of invasives per year - management occurs in support of planned reforestation projects (Planning)  <b>Noxious weeds:</b> Manual removal of wild/cow parsnip in select parks. Install signage. One-off removals, e.g., poison ivy spraying (Operations)	<b>Staff Time (recurring)</b> Parks Planner (1) - 15% OPS 150-day staff (1) - 10% Sr Planner (1) - 2% Forestry Working Supervisors (2) - 4%; annual ash tree inspections  <b>Staff Time (LDD moth program - 2021 and 2022)</b> Forestry 115-day staff (8) - 100%; Egg mass removal in 2021 and 2022 Forestry 150-day staff (4) - 5%; Tree injection marking and burlap kit distribution in 2022 only

Level of Service	Performance Measure	Current LOS Performance	Associated Management Activities	Estimated Staff Time
			<p><b>Customer Service:</b> Respond to resident complaints. (Operations)</p> <p><b>Invasive Pests (e.g., LDD moth):</b> Respond to invasive pests, as they arise. <u>LDD response - capital costs</u> \$21,000 in 2022 for tree Azin injections \$15,000 in 2022 for burlap kit giveaways (\$10K from Markham MESF; \$5K from Invasive species council) \$5,750 for backpack vacuums, batteries, chargers for egg masses</p>	Forestry Supervisor - 5% (2021/2022)
<b>T.7b</b> Targeted management of invasive plant species (meadow management)	# ha or # sites where meadows are actively managed (mowed to control woody/invasive vegetation)	2 meadows managed in German Mills Meadow and Pomona Mills Park	Mow sites, install signage, maintain pathway fencing once per three year outside of the breeding bird window (staff time).	OPS 150-day staff (1) - 5%
<b>T.8</b> City-managed maintenance of natural areas (includes, mulching, weeding/garbage removal, watering,	<p># ha and/or # sites where natural assets are actively managed</p> <p>Success of restoration projects (e.g., at least 75% survival and establishment with native species)</p> <p>Qualitative description of mulching, weeding, watering standards for new plantings.</p>	<p>Mulching on all reforestation projects.</p> <p>Weeding/garbage removal facilitated by staff and corporate/volunteer groups as available.</p> <p>Watering completed based on staff inspections. Usually covered, except during drought conditions in the summer.</p>	<p>Mulching on all reforestation projects by project proponents.</p> <p>Weeding/garbage removal facilitated by staff and corporate/volunteer groups as available.</p> <p>Watering completed based on staff inspections. Usually covered, except during drought conditions in the summer.</p> <p>Note: Trails and pathway assets are accounted for through Parks Facilities AMP. Trail maintenance through natural areas are included here for information.</p>	<p><b>Staff Time Maintenance (Trees for Tomorrow sites)</b> Parks Planner (1) - 35% OPS 150-day staff (1) - 45%</p> <p><b>Garbage Removal (all natural areas)</b> OPS 150-day staff (8) - 5%; cleaning litter in natural areas, storm ponds, trails</p> <p><b>Trail inspections in natural areas</b> OPS 150-day staff (4) - 4%; trail inspections and maintenance.</p>
<b>T.9</b> Removal of hazard trees or limbs adjacent to trails, sidewalks or other publicly used recreational areas of risk.	<p>% of City-owned assets inspected and managed for tree hazard risks.</p> <p>Number of active citizen requests (ACRs) responded to.</p>	<p>0% proactively inspected/managed.</p> <p># of ACRs per year for this request not currently specifically tracked.</p>	Respond to complaints.	<p><b>Staff Time</b> Arborists (3) - 12% - clean-up, pruning, removal, etc. of trees within natural areas. Working supervisor (1) - 8% - responding to</p>

Level of Service	Performance Measure	Current LOS Performance	Associated Management Activities	Estimated Staff Time
				ACRs and coordinating staff response
<b>T.10</b> Removal of hazard trees or limbs adjacent to privately-owned property, parcel lines or buildings	% of City-owned assets inspected and managed for tree hazard risks.  Number of active citizen requests (ACRs) responded to.	0% proactively inspected/managed.  # of ACRs per year for this request not currently specifically tracked.	Respond to complaints.	Included in T.9

Table 5-5. Rehabilitation and renewal technical LOS along with performance measures, current performance, and management activities.

Level of Service	Performance Measure	Current LOS Performance	Associated Management Activities	Estimated Staff Time
<b>T.11a</b> City managed ecological habitat creation and/or restoration (including within existing NHN areas, in the Greenway System or outside the Greenway System)	# ha of forest restored; annual spending for reforestation	8 ha of forest restored per year; annual spending for reforestation	Currently, reforestation occurs through two programs. Planning administers contracts with TRCA and other landscapers and this is funded through cash-in-lieu of tree/woodland removal. Operations administers Trees for Tomorrow Program that facilitates community tree planting events and reforestation projects by non-profits (e.g., Friends of the Rouge; 10000 Trees; Tree Canada).  <b>Forest Creation (contractors, e.g., TRCA)</b> - \$400,000/yr. Planting of 4 hectares of woodland/yr by contractors.  <b>Forest Creation/Trees for Tomorrow Stewardship Program - (see T.6)</b> \$125,000/yr. Planting of 4 ha of woodland/yr by volunteers and non-profit groups.	<b>Staff Time</b> <b>Forest Creation (contractors)</b> Sr Planner (1) - 10% Manager (1) - 2%  <b>Forest Creation (TFT Stewardship Program)</b> Parks Planner (1) - 20% OPS 150-day staff (1) - 35% Forestry 150-day staff (4) - 5% Forestry Supervisor (1) - 1% Urban Forestry Technologist (1) - 1%
<b>T.11b</b> City managed ecological habitat creation and/or restoration (including within existing NHN areas, in the Greenway System or outside the Greenway System)	# ha of wetlands restored; annual spending for wetland creation	0.2 ha of wetland restored per year; annual spending for reforestation	<b>Wetland Creation</b> - \$100,000 over the last 5 years. 1 ha created over the last 5 years. (\$20,000 and 0.2 ha per year). Wetland projects are completed by TRCA. Contracts administered by staff.	<b>Staff Time</b> Sr Planner (1) - 2%

# 6 Management Scenarios and Financial Analysis

The City of Markham is seeking to use the asset management framework to inform long range planning related to growth management, including improved financial planning. This planning is to consider the services and co-benefits that are currently provided by natural assets in Markham, and the levels of investment required to (a) maintain, (b) enhance and (c) expand these services. Three management scenarios have been developed to review different service levels and the associated life cycle costs to consider an appropriate balance between costs and service levels. The three management scenarios identified and costed are as follows: (a) a “current scenario”, (b) an “enhanced scenario” and (c) a “target scenario”, described in more detail below.

As noted in the Introduction, Markham’s population is expected to nearly double over the next 30 years. While this may result in more residents interested in engaging in stewardship of local natural areas, it will also put more pressure on these natural areas. Investing in protecting, maintaining and, where possible, expanding the City’s natural assets will be critical to helping Markham’s community adapt to climate change, while also providing the core services and co-benefits provided by natural assets.

This section summarizes the context for, approach to, and results of Markham’s natural asset management scenario development, including specific activities and costs closely aligned with the LOS (see Section 5). It includes:

- An overview of the local natural heritage context for management of City-owned natural assets (Section 6.1).
- A summary of the approach used for the three management scenarios (Section 6.2).
- A suite of tables outlining the management actions as well as the current and anticipated capital costs and staffing time (costs) associated with each of the 10 Technical LOS and each of the three management scenarios (Section 6.3).
- Summarized cost estimates associated with each of the 10 Technical LOS and each of the three management scenarios, as well as financial analyses comparing the Current Management Scenario to the Enhanced and Target Management Scenarios (Section 6.4).

These management scenarios are intended to inform the development of future/desired levels of service. The enhanced/target scenarios are not endorsed by staff or Council at this time and but have been developed to provide a starting point for future consideration. The City will be determining future/desired service levels in the future as part of 2025 Asset Management Plan and Financial Summary.

## 6.1 Management Context

The City of Markham first assessed the natural features and areas within its boundaries in the 1990’s and since then has undertaken a range of inventories and assessments related to its natural features and areas, including recent assessments by North-South Environmental Inc. and Dougan and Associates Inc., and ongoing assessments by CBCL (NSEI and DAI 2021; CBCL 2021; CBCL 2024b).

Management of natural areas by the City is primarily focussed on areas under City ownership and is, broadly speaking, focussed on maintenance of the overall feature and its ecological functions. Specific management activities the city undertakes in its natural areas on a somewhat regular basis include invasive species

management, public access management, and protection and / or restoration of sensitive areas and/or habitats.

Markham did not have a natural areas management study until very recently (CBCL 2024b) and therefore management efforts tended to be in response to issues identified by City staff or residents, or in response to opportunities to undertake works (e.g., through a capital project, through a volunteer project with support from partners, etc.).

Going forward, with adequate investment, this approach could gradually shift to be more strategic and proactive, in part with guidance from the completed Natural Heritage Management Study (2023), as well as within the context of the framework for natural asset planning and management developed as part of this project. Without this planning and investment, the City risks a reduction or loss of the valued ecosystem services these assets currently provide.

“Beyond enforcing and adhering to the requirements of municipal, provincial, and federal policies, the City’s approach to natural area management has generally been reactive, opportunistic, and driven by resource availability”. Source: Natural Area Management Guidebook (CBCL 2024b)

## 6.2 Approach to Management Scenario Development

To inform the assessment of management costs and the City’s financial strategy, three scenarios were developed in close consultation with the Project Team and TAC.

Each of the following scenarios:

- Were applied City-wide (with a primary focus on City-owned lands) but scoped to the priorities and targets identified through the LOS.
- Considered costs for (a) contracted work (capital costs) and (b) City staff time (operational costs).
- Used current activities and related costs as a realistic and defensible "baseline" (see Section 5).
- Used 2051 as an end date to compare performance levels and outcomes.
- Were developed as “building blocks” so that the “Enhanced Scenario” activities builds on the “Current Scenario” activities, and the “Target Scenario” activities builds on the “Enhanced Scenario” activities.

### 1. Current Management (Scenario 1):

- A baseline scenario based on current management activities (business as usual) to 2051.
- This scenario is a compilation of actual and ongoing management activities and current costs (both capital and staffing costs), and as such is considered a fairly accurate reflection of the current investment the City is making in maintaining and enhancing its natural assets.

### 2. Enhanced Management (Scenario 2):

- Management activities required to adapt to climate change risks.
- This scenario captures the current activities plus additional activities based on the guidance provided in the guide developed for this project titled “Markham’s Natural Assets and Climate Change Guide”.
- This scenario is a preliminary estimate of the activities, level of effort and investment required to improve the quality and quantity of natural assets in Markham.

- It includes actions expected to help build both natural area and community resilience to climate change as the City’s population grows.

### 3. Target Management (Scenario 3):

- Management activities required to meet Markham’s Target LOS by 2051.
- This scenario captures current and enhanced activities plus additional anticipated activities.
- This scenario is a preliminary estimate of the activities, level of effort and investment required to improve the quality and quantity of natural assets in Markham to the point where established natural heritage targets are met.
- This scenario is expected to help build both natural area and community resilience to climate change, while also helping to sustain a biodiverse and interconnected network of natural areas and features throughout the city to meet the needs of a growing population.

#### 6.2.1 Assumptions

The cost estimates related to annual salaries for different positions were provided by the City and are based on current (2023 \$CAD) salaries including overhead.

Costs for natural asset enhancement and restoration costs were derived from current available costs, excluding staff time (e.g., \$31,250/ha for non-profit/volunteer supported forest restoration, \$66,625/ha for contracted forest restoration, and \$100,000/ha for contracted wetland restoration).

### 6.3 Management Scenario Actions

As part of this project, a key deliverable was to outline and cost all current management activities related to City-owned natural assets in Markham (i.e., “Current Management Scenario”) and then to estimate costs for what would be required under the “Enhanced Management Scenario” and “Target Management Scenario” as outlined in Section 6.2.

This resulted in the identification of (a) capital costs and (b) staff time/costs for each of the 10 types of management activities (i.e., Technical LOS) which were organized into the three “standard” asset lifecycle categories (as per Table 5-2):

1. **ACQUIRE / EXPAND:** includes lands that are currently - or will be - natural areas being brought into City ownership. This primarily occurs through lands being dedicated through the planning process, but the City also has a small reserve fund to facilitate the purchase of lands when opportunities arise.
2. **MAINTAIN:** includes a range of tasks currently being done to (a) monitor the status of the City’s natural areas and (b) to try and maintain them in good condition including invasive species removal, restoration plantings, management of hazard trees and basic maintenance such as garbage clean up, mulching and watering.
3. **REHABILITATE:** is the lifecycle category which is the most resource intensive and involves the creation and/or restoration of woodland and/or wetland habitats in various locations.

Notably, each of the management scenarios were applied to each of the Technical LOS - not the Community LOS (as outlined in Section 5).<sup>8</sup> Key actions and management implications (i.e., capital costs and staff resources) are summarized for each scenario by life cycle management category, as follows:

Life Cycle Management Category: Acquisition / Expansion (Section 6.3.1)

- Table 6-1, T.1a: Land Securement
- Table 6-2, T.1b: Land Acquisition

Life Cycle Management Category: Maintain (Section 6.3.2)

- Table 6-3, T.2: Natural Areas Monitoring
- Table 6-4, T.6: Stewardship Activities
- Table 6-5, T.7a: Invasive Plant Management
- Table 6-6, T.7b: Meadow Management
- Table 6-7, T.8: Basic Natural Areas Management
- Table 6-8, T.9 & T.10: High Risk Tree Management

Life Cycle Management Category: Rehabilitate (Section 6.3.3)

- Table 6-9, T11a: Forest Restoration
- Table 6-10, T11b: Wetland/Riparian Restoration

Notably, Technical LOS T.2 (Natural Areas Monitoring) includes management implications for T.2a/b/c, T.3, T.4 and T.5 that speak to the specific monitoring actions and measures for each type of natural asset (i.e., forest/woodland, wetland and meadows).

### 6.3.1 Acquisition / Expansion

Table 6-1. Management scenarios related to land securement (technical level of service T.1a).

Summary of Scenarios	Annual Management Implications	
	Capital Costs	Staff Resources
<p>Current Management Scenario</p> <ul style="list-style-type: none"> <li>• Maintain an average of 18 ha of new assets secured per year through development applications</li> <li>• An estimated 402 ha new natural asset anticipated to be acquired by 2051</li> </ul>	None (i.e., lands dedicated through the planning process)	Planner II (1) - 25% Sr Planner (1) - 5%  Note: Staff time costs currently covered by development fees
<p>Enhanced Management Scenario</p> <ul style="list-style-type: none"> <li>• Not applicable, no additional acquisition anticipated or needed</li> </ul>	None (i.e., lands anticipated to continue to be dedicated through the planning process)	No additional staff resources beyond the Current Management Scenario
<p>Target Management Scenario</p> <ul style="list-style-type: none"> <li>• Not applicable, target LOS should be met with current management actions</li> </ul>	None (i.e., lands anticipated to continue to be dedicated through the planning process)	No additional staff resources beyond the Current Management Scenario

<sup>8</sup> The Technical LOS were the basis for the estimates as they have specific management implications that directly align life cycle management actions (acquisition, operation and maintenance, rehabilitation) which can be readily costed and scaled-up (or down) as appropriate.

Table 6-2. Management scenarios related to land acquisition (technical level of service T.1b).

Summary of Scenarios	Annual Management Implications	
	Capital Costs	Staff Resources
<b>Current Management Scenario</b> <ul style="list-style-type: none"> <li>“Environmental Land Acquisition Fund” available to support opportunistic acquisition of Greenway System lands**</li> <li>The use of the Environmental Land Acquisition Fund is expected to occur through Council direction on a case-by-case basis (less than 1 per year; large variation in the size of acquisition)</li> </ul>	Unknown, frequency and amount will vary depending on the specific opportunity	Led by Real Property Department. Cost is not quantified for these scenarios due to infrequent occurrences.
<b>Enhanced Management Scenario</b> <ul style="list-style-type: none"> <li>No additional acquisition expected to be needed beyond the current levels</li> </ul>	No additional capital costs beyond the current	No additional staff resources beyond the Current Management Scenario
<b>Target Management Scenario</b> <ul style="list-style-type: none"> <li>No additional acquisition expected to be needed beyond the current levels</li> </ul>	No additional capital costs beyond the current	No additional staff resources beyond the Current Management Scenario

\*\*A total of \$250,000 is allocated annually to the “Environmental Land Acquisition Fund” for acquisition of Greenway System lands. Actual spending on acquisition varies depending on acquisition opportunities and therefore has not been included in the annual capital costs.

### 6.3.2 Maintain

Table 6-3. Management scenarios related to natural areas monitoring (technical level of service T.2).

Summary of Scenarios	Annual Management Implications	
	Capital Costs	Staff Resources
<b>Current Management Scenario</b> <ul style="list-style-type: none"> <li>Update natural heritage inventory every 5 years</li> <li>Update the natural asset management plan every 5 years</li> </ul>	\$50,000 (\$250,000 every 5 years)	Sr Planner (1) - 30% every 5th year; 5% all other years  Managers (3), Planning, Asset Management, Parks Operations - 5% every 5th year
<b>Enhanced Management Scenario</b> <ul style="list-style-type: none"> <li>Target LOS expected to be met with the Current Management Scenario actions</li> </ul>	No additional capital costs beyond the current	No additional staff resources beyond the Current Management Scenario
<b>Target Management Scenario</b> <ul style="list-style-type: none"> <li>Target LOS expected to be met with the Current Management Scenario actions</li> </ul>	No additional capital costs beyond the current	No additional staff resources beyond the Current Management Scenario

Note: Technical LOS T.2 (Natural Areas Monitoring) includes management implications for T.2a/b, T.3, T.4 and T.5 which speak to the specific monitoring actions and measures for each type of natural asset (i.e., forest/woodland, wetland and meadows).

Table 6-4. Management scenarios related to natural areas stewardship (technical level of service T.6).

Summary of Scenarios	Annual Management Implications	
	Capital Costs	Staff Resources
<p>Current Management Scenario</p> <ul style="list-style-type: none"> <li>Maintain current existing stewardship programming and funding</li> <li>Demand for community planting and stewardship appear to be well met through this program</li> </ul>	<p>\$62,500</p> <p>(half of amount in Table 5-4 as shared with T.11a)</p>	<p>Parks Planner (1) - 10%</p> <p>OPS 150-day staff (1) – 17.5%</p> <p>Forestry 150-day staff (4) – 2.5%</p> <p>Forestry Supervisor (1) – 0.5%</p> <p>Urban Forestry Technologist (1) – 0.5%</p> <p>(half of amounts in Table 5-4 as shared with T.11a)</p>
<p>Enhanced Management Scenario</p> <ul style="list-style-type: none"> <li>Enhance current existing stewardship programming and funding</li> <li>Have dedicated staff person to work with partners and to apply for, coordinate and implement supplemental external funding secured</li> </ul>	<p>\$50,000</p>	<p>NEW Stewardship Coordinator -100% (to leverage / coordinate /oversee more external funding and resources)</p> <p>Operations (OPS) 150-day staff (1) – 100%</p>
<p>Target Management Scenario</p> <ul style="list-style-type: none"> <li>Target LOS expected to be met with the Enhanced Management Scenario actions</li> </ul>	<p>No additional capital costs beyond the enhanced</p>	<p>No additional staff resources beyond the Enhanced Management Scenario</p>

Table 6-5. Management scenarios related to invasive plant species management (technical level of service T.7a).

Summary of Scenarios	Annual Management Implications	
	Capital Costs	Staff Resources
<p>Current Management Scenario</p> <ul style="list-style-type: none"> <li>Continued removal of invasive species and noxious weeds based on existing activities</li> <li>Not enough data to confirm future trajectory of invasive species dominance, but most likely an increased proportion of city-owned lands to be dominated by invasive species</li> <li>Invasive pests (e.g., LDD or EAB) are not planned for on an annual basis, but rather as these issues arise. Each invasive pest will require their own response plan</li> </ul>	<p>Removal costs for invasive species: \$25,000</p>	<p>Parks Planner (1) - 15%</p> <p>Operations (OPS) 150-day staff (1) - 10%</p> <p>Sr Planner (1) - 2%</p> <p>Forestry Working Supervisors (2) - 4%</p>
<p>Enhanced Management Scenario</p> <ul style="list-style-type: none"> <li>Develop invasive species management plan. Plan to be endorsed in 2024 but assume it will need to be updated every 10 years</li> <li>Hiring an invasive species specialist to undertake targeted management.</li> <li>Educate community and municipal staff about invasive species identification (Note: Cost assumed to be undertaken by Invasive Species Specialist)</li> <li>Coordinate volunteer management support on public lands where safe and feasible. Assume this would be coordinated by Invasive Species Specialist with Stewardship Coordinator support</li> <li>Develop new municipal programs or strategies on invasive species.                             <ul style="list-style-type: none"> <li>Assume this would be coordinated by Invasive Species Specialist, as necessary</li> </ul> </li> </ul>	<p>\$5,000 (\$50,000 every 10 years for Invasive Species Management Plan)</p> <p>Removal costs for additional invasive species: \$50,000</p>	<p>NEW Invasive Species Specialist (1) – 100%</p> <p>Note: Stewardship Coordinator accounted for in T.6 would also provide support here</p>
<p>Target Management Scenario</p> <ul style="list-style-type: none"> <li>To be assessed once the Invasive Species Management Plan is approved and the invasive species specialist position is in place</li> </ul>	<p>GAP</p> <p>To be determined</p>	<p>GAP</p> <p>To be determined</p>

Table 6-6. Management scenarios related to invasive and woody plant species management in meadows (technical level of service T.7b).

Summary of Scenarios	Annual Management Implications	
	Capital Costs	Staff
<p>Current Management Scenario</p> <ul style="list-style-type: none"> <li>• 2 meadows managed in German Mills Meadow and Pomona Mills Park</li> <li>• Mow sites, install signage, maintain pathway fencing once per three year outside of the breeding bird window (staff time)</li> <li>• No scenario modelling is necessary. Meadow sites are not generally intended to be actively managed. The 2 existing sites have been selected as there is strong community support and community stewardship groups that contribute to management</li> </ul>	None	Operations (OPS) 150-day staff (1) - 5%
<p>Enhanced Management Scenario</p> <ul style="list-style-type: none"> <li>• Identify and manage at least two additional areas for meadow habitat creation and maintenance</li> <li>• Mow sites, install signage, develop and maintain pathway fencing once per three year outside of the breeding bird window (additional staff time)</li> <li>• Seek locations that can leverage community stewardship groups that contribute to management</li> </ul> <p>Coordinate volunteer management support on public lands where safe and feasible</p>	None (i.e., expected to be undertaken entirely by City staff)	Operations (OPS) 150-day staff (1) - 5%  Note: Stewardship Coordinator accounted for in T.6 would also provide support here
<p>Target Management Scenario</p> <ul style="list-style-type: none"> <li>• Anticipated that target LOS can be met with the Enhanced Management Scenario actions</li> </ul>	None	No additional staff resources beyond the Enhanced Management Scenario

Table 6-7. Management scenarios related to basic maintenance of city-owned natural areas (technical level of service T.8).

Summary of Scenarios	Annual Management Implications	
	Capital Costs	Staff Resources
<p>Current Management Scenario</p> <ul style="list-style-type: none"> <li>Mulching is done on all reforestation projects by project proponents</li> <li>Weeding/garbage removal in natural areas are facilitated by staff as corporate/volunteer groups are available. Watering is completed based on staff inspections. Garbage removals are also completed by staff as resources are available</li> <li>Watering can be covered, except during drought conditions in the summer</li> </ul>	None	<p><b>Maintenance (Trees for Tomorrow Sites)</b> Parks Planner (1) - 35% Operations (OPS) 150-day staff (1) - 45%</p> <p><b>Garbage Removal (all natural areas)</b> Operations (OPS) 150-day staff (8) - 5%; cleaning litter in natural areas, storm ponds, trails</p> <p><b>Trail inspections (natural areas)</b> Operations (OPS) 150-day staff (4) - 4%; trail inspections and maintenance</p>
<p>Enhanced Management Scenario</p> <ul style="list-style-type: none"> <li>Mulching - same as existing LOS</li> <li>Weeding/garbage removal - build additional capacity to be able to weed 25% of sites and/or facilitate additional volunteer groups</li> <li>Watering - build additional capacity to be able to water during drought conditions</li> <li>Coordinate volunteer management support on public lands where safe and feasible</li> <li>Add 1 additional 150-day staff to build capacity to water TFT sites during drought and to complete additional weeding/mulching</li> </ul>	None (i.e., expected to be undertaken entirely by City staff)	<p>NEW Operations (OPS) 150-day staff (1) - 100%</p> <p>Note: Stewardship Coordinator accounted for in T.6 would also provide support here</p>
<p>Target Management Scenario</p> <ul style="list-style-type: none"> <li>To be assessed in an ongoing annual basis</li> </ul>	None	GAP To be reviewed

Table 6-8. Management scenarios related to high-risk tree management within and adjacent to city-owned natural areas (technical levels of service T.9 and T.10).

Summary of Scenarios	Annual Management Implications	
	Capital Costs	Staff Resources
<p>Current Management Scenario</p> <ul style="list-style-type: none"> <li>Address risks of hazard trees in a reactive manner.</li> <li>Little to no pre-active management to reduce hazard tree risks</li> </ul>	None	<p>Arborists (3) - 12%, clean-up, pruning, removal, etc. of trees within natural areas.</p> <p>Working Supervisor (1) - 8%, responding to calls and coordinating staff response</p>
<p>Enhanced Management Scenario</p> <ul style="list-style-type: none"> <li>To be determined through the in-progress Urban Forest Management Plan</li> </ul>	GAP To be determined	GAP To be determined
<p>Target Management Scenario</p> <ul style="list-style-type: none"> <li>To be determined through future Urban Forest Management Plan</li> <li>To be reviewed on an ongoing annual basis</li> </ul>	GAP To be determined	GAP To be determined

### 6.3.3 Rehabilitate

Table 6-9. Management scenarios related to forest restoration and expansion (technical level of service T.11a).

Summary of Scenarios	Annual Management Implications	
	Capital Costs	Staff Resources
<p>Current Management Scenario</p> <ul style="list-style-type: none"> <li>Currently, reforestation occurs through two programs. (1) Planning administers contracts funded through cash-in-lieu of tree removal; (2) Operations administers <i>Trees for Tomorrow Program</i> that facilitates community tree planting events and reforestation projects by non-profits</li> <li>Forest Creation (contractors) - \$400,000/yr. Planting of 4 hectares of woodland/yr</li> <li>Forest Creation/Trees for Tomorrow Stewardship Program - \$125,000/yr. Planting of 4 ha of woodland/yr</li> <li>8 hectares per year until 2051</li> </ul>	<p>Contractor: 4ha/yr @ \$400,000/yr = \$100,000/ha</p> <p>Non-profit based: 4ha/yr @ \$62,500/yr = \$15,625/ha</p> <p>(TFT half of amount in Table 5-5 as shared with T.6)</p> <p>Mean of Contractor and Non-Profit (assume split equally between the planting groups): (4ha*\$100,000/ha + 4ha*\$15,625/ha)/8ha = \$57,812.50/ha</p> <p>Forest Creation: (8ha/yr@\$57,812.50/ha) \$462,500/yr</p>	<p>Staff Time (Two programs)</p> <p>Program 1 - Forest Creation (contractors): Sr Planner (1) - 10% Manager (1) - 2%</p> <p>Program 2 - Forest Creation (TFT Stewardship Program): Parks Planner (1) - 10% Operations (OPS) 150-day staff (1) - 17.5% Forestry 150-day staff (4) - 2.5% Forestry Supervisor (1) - 0.5% Urban Forestry Technologist (1) - 0.5%</p> <p>(TFT half of amounts in Table 5-5 as shared with T.6)</p>
<p>Enhanced Management Scenario</p>	<p>1. Mini-Forests: (0.1ha/yr@\$200,000/ha) \$20,000/yr</p>	<p>NEW Restoration coordinator – 75%</p>

Summary of Scenarios	Annual Management Implications	
	Capital Costs	Staff Resources
<ul style="list-style-type: none"> <li>Additional activities per Markham’s Natural Assets and Climate Change Guide applicable to woodland cover: <ul style="list-style-type: none"> <li>(1) Expand naturalized spaces - plant 0.1 ha mini-forests per year in parks</li> <li>(2) Additional targeted planting with residents of lower socioeconomic status. 1-2 plantings per year to create an additional 0.5 ha of forest</li> <li>(3) Increase rate of new natural feature creation and prioritize afforestation in headwater areas; install riparian vegetation along watercourse corridors. 0.5 ha per year (\$100,000/ha)</li> </ul> </li> <li>8 ha of woodland creation (from Current Management) + 1.1 ha of woodland creation = 9.1 ha /yr = 254.8</li> <li>1961 ha = 9.2% woodland cover</li> </ul>	<p>2. Targeted Planting: (0.5ha/yr@\$15,625/ha) \$7,812.50/yr</p> <p>(TFT half of amount in Table 5-5 as shared with T.6)</p> <p>3. Riparian: 0.5ha/yr@\$100,000/ha = \$50,000/yr</p> <p>Forest Expansion (sum of min-forests, targeted, and riparian planting): \$70,738.64/ha*1.1 ha/yr = \$77,812.5/yr</p>	<p>NEW Operations (OPS) 150-day staff - 75%</p> <p>Note: 1<sup>st</sup> Restoration Coordinator also to be supported by Stewardship Coordinator (see T6) as part of the Forest Creation (Stewardship Program)</p>
<p>Target Management Scenario</p> <ul style="list-style-type: none"> <li>10% woodland cover - 2140 ha of woodland = 430 ha of new woodland by 2051 (15.3 ha of new woodland/yr)</li> <li>This is 7.3 ha/yr above the current rate and 6.2ha/yr beyond the Enhanced Management Scenario</li> </ul>	<p>Forest Expansion (assume same capital cost as Current Management Scenario): \$57,812.50/ha * 6.2 ha/yr = \$358,437.50/yr</p>	<p>NEW Restoration coordinator– 75%</p> <p>NEW Operations (OPS) 150-day staff - 75%</p> <p>Note: 2<sup>nd</sup> Restoration Coordinator also to be supported by Stewardship Coordinator (see T6) as part of the Forest Creation (Stewardship Program)</p>

Table 6-10. Management scenarios related to wetland restoration and expansion (technical level of service T.11b).

Summary of Scenarios	Annual Management Implications	
	Capital Costs	Staff Resources
<b>Current Management Scenario</b> <ul style="list-style-type: none"> <li>Wetland creation</li> <li>0.2 ha per year of wetlands resulting in city-wide wetland cover of 637 ha by 2051</li> </ul>	Wetlands: \$100,000/ha* 0.2 ha/yr = \$20,000/yr	Wetland Creation (contractors) Sr Planner (1) - 5% Manager (1) - 1%
<b>Enhanced Management Scenario</b> <ul style="list-style-type: none"> <li>Additional activities per Markham’s Natural Assets and Climate Change Guide applicable to wetland cover:                             <ul style="list-style-type: none"> <li>Create wetlands - Consider increase from 0.2 to 0.5 ha created per year. So additional 0.3 ha beyond current management</li> <li>Install riparian vegetation along watercourse corridors. 0.5 ha per year</li> </ul> </li> </ul>	Wetlands: \$100,000/ha* 0.3 ha/yr = \$30,000/yr  Riparian: \$100,000/ha* 0.5 ha/yr = \$50,000/yr  Total (Wetlands + Riparian): \$80,000/yr	New Restoration Coordinator – 25% NEW Operations (OPS) 150-day staff - 25%
<b>Target Management Scenario</b> <ul style="list-style-type: none"> <li>4.0% wetland cover = 850 ha wetland or 217 ha additional wetlands = 8 ha wetlands created per year**</li> <li>This is a net increase of 7.8 ha beyond the current management and 7 ha beyond the Enhanced Management Scenario</li> </ul>	Wetlands: (1ha@\$100,000) \$100,000/ha * 7 ha/yr = \$700,000/yr	New Restoration Coordinator – 25% NEW Operations (OPS) 150-day staff - 25%

\*\* Additional analysis will be required to determine whether it is technically feasible to achieve this level of wetland creation on City-owned lands (i.e., whether there are enough wetland creation opportunities).

## 6.4 Management Scenario Cost Estimates and Financial Analysis

**In total, we estimated that the City currently invests about \$1 million each year in both staff time and capital costs to maintain, manage and monitor its natural assets.**

The results of the annual management implications for the management scenarios for the 10 Technical LOS – as outlined in Section 6.2 – have been summarized and rolled up to annual average overall management cost estimates in Table 6-11. Capital and staff components of the annual average overall management cost estimates are separated out in Table 6-12.

The results of the management implications from 2024 to 2051 (26 years) for each of the management scenarios for each of the 10 Technical LOS – as outlined in Section 6.2 – have been summarized and rolled up to total overall management cost estimates in Table 6-13. Capital and staff components of the annual total overall management cost estimates are separated out in

Table 6-14.

Reported costs have accounted for both capital costs and staffing costs and are reported in 2024 dollars.

Table 6-11. Average annual estimated costs of management scenarios.

Life Cycle Activity	Supporting Level of Service	Scenario Cost		
		1: Current	2: Enhanced	3: Target
Acquisition / Expansion	T.1a: Land Acquisition*	\$35,128	\$35,128	\$35,128
	T.1b: Land Securement**	\$0	\$0	\$0
Maintenance	T.2: Natural Areas Monitoring	\$74,680	\$74,680	\$74,680
	T.6: Stewardship Activities	\$85,572	\$275,440	\$275,440
	T.7a: Invasive Plant Management	\$65,932	\$206,968	\$206,968
	T.7b: Meadow (Invasive/ Woody Plant) Management	\$1,972	\$3,945	\$3,945
	T.8: Basic Natural Areas Maintenance	\$78,579	\$118,026	\$118,026
	T.9 & T.10: High Risk Tree Management	\$37,822	\$37,822	\$37,822
Rehabilitation and Renewal	T.11a: Forest Restoration	\$504,010	\$694,417	\$1,165,449
	T.11b: Wetland/Riparian Restoration	\$29,219	\$146,750	\$884,282
<b>TOTAL</b>		<b>\$912,913</b>	<b>\$1,593,175</b>	<b>\$2,801,739</b>

\*A total of \$250,000 is allocated annually to the “Environmental Land Acquisition Fund” for acquisition of Greenway System lands. Actual spending on acquisition varies depending on acquisition opportunities and therefore has not been included in the annual capital costs.

\*\* Assumes staffing costs are and will continue to be covered by the planning process.

Table 6-12. Average annual estimate capital and staff costs of management scenarios.

Life Cycle Activity	Supporting Level of Service	Scenario Cost					
		1: Current		2: Enhanced		3: Target	
		Capital	Staff	Capital	Staff	Capital	Staff
Acquisition / Expansion	T.1a: Land Acquisition*	\$0	\$35,128	\$0	\$35,128	\$0	\$35,128
	T.1b: Land Securement**	\$0	\$0	\$0	\$0	\$0	\$0
Maintenance	T.2: Natural Areas Monitoring	\$53,571	\$21,108	\$53,571	\$21,108	\$53,571	\$21,108
	T.6: Stewardship Activities	\$62,500	\$23,072	\$112,500	\$162,940	\$112,500	\$162,940
	T.7a: Invasive Plant Management	\$35,000	\$30,932	\$65,357	\$141,611	\$65,357	\$141,611
	T.7b: Meadow (Invasive/ Woody Plant) Management	\$0	\$1,972	\$0	\$3,945	\$0	\$3,945
	T.8: Basic Natural Areas Maintenance	\$0	\$78,579	\$0	\$118,026	\$0	\$118,026
	T.9 & T.10: High Risk Tree Management	\$0	\$37,822	\$0	\$37,822	\$0	\$37,822
Rehabilitation and Renewal	T.11a: Forest Restoration	\$462,500	\$41,510	\$540,313	\$154,104	\$898,750	\$266,699
	T.11b: Wetland/Riparian Restoration	\$20,000	\$9,219	\$100,000	\$46,750	\$800,000	\$84,282
<b>TOTAL</b>		<b>\$633,571</b>	<b>\$279,342</b>	<b>\$871,741</b>	<b>\$721,434</b>	<b>\$1,930,179</b>	<b>\$871,560</b>

\* A total of \$250,000 is allocated annually to “Environmental Land Acquisition Fund” to support acquisition of Greenway System lands. Actual spending on acquisition will vary depending on acquisition opportunities.

\*\* Assumes staffing costs are and will continue to be covered by the planning process.

Table 6-13. Total estimated costs to 2051 of management scenarios.

Life Cycle Activity	Supporting Level of Service	Scenario Cost		
		1: Current	2: Enhanced	3: Target
Acquisition / Expansion	T.1a: Land Acquisition*	\$983,587	\$983,587	\$983,587
	T.1b: Land Securement**	\$0	\$0	\$0
Maintenance	T.2: Natural Areas Monitoring	\$2,091,031	\$2,091,031	\$2,091,031
	T.6: Stewardship Activities	\$2,396,016	\$7,712,320	\$7,712,320
	T.7a: Invasive Plant Management	\$1,846,091	\$5,795,103	\$5,795,103
	T.7b: Meadow (Invasive/Woody Plant) Management	\$55,226	\$110,452	\$110,452
	T.8: Basic Natural Areas Maintenance	\$2,200,215	\$3,304,731	\$3,304,731
	T.9 & T.10: High Risk Tree Management	\$1,059,004	\$1,059,004	\$1,059,004
Rehabilitation and Renewal	T.11a: Forest Restoration	\$14,112,272	\$19,443,669	\$32,632,565
	T.11b: Wetland/Riparian Restoration	\$818,128	\$4,109,010	\$24,759,892
<b>TOTAL</b>		<b>\$25,561,570</b>	<b>\$44,608,906</b>	<b>\$78,448,684</b>

\* A total of \$250,000 is allocated annually to “Environmental Land Acquisition Fund” to support acquisition of Greenway System lands. Actual spending on acquisition will vary depending on acquisition opportunities.

\*\* Assumes staffing costs are and will continue to be covered by the planning process.

Table 6-14. Total estimated capital and staff costs to 2051 of management scenarios.

Life Cycle Activity	Supporting Level of Service	Scenario Cost					
		1: Current		2: Enhanced		3: Target	
		Capital	Staff	Capital	Staff	Capital	Staff
Acquisition / Expansion	T.1a: Land Acquisition*	\$0	\$983,587	\$0	\$983,587	\$0	\$983,587
	T.1b: Land Securement**	\$0	\$0	\$0	\$0	\$0	\$0
Maintenance	T.2: Natural Areas Monitoring	\$1,500,000	\$591,031	\$1,500,000	\$591,031	\$1,500,000	\$591,031
	T.6: Stewardship Activities	\$1,750,000	\$646,016	\$3,150,000	\$4,562,320	\$3,150,000	\$4,562,320
	T.7a: Invasive Plant Management	\$980,000	\$866,091	\$1,830,000	\$3,965,103	\$1,830,000	\$3,965,103
	T.7b: Meadow (Invasive/ Woody Plant) Management	\$0	\$55,226	\$0	\$110,452	\$0	\$110,452
	T.8: Basic Natural Areas Maintenance	\$0	\$2,200,215	\$0	\$3,304,731	\$0	\$3,304,731
	T.9 & T.10: High Risk Tree Management	\$0	\$1,059,004	\$0	\$1,059,004	\$0	\$1,059,004
Rehabilitation and Renewal	T.11a: Forest Restoration	\$12,950,000	\$1,162,272	\$15,128,750	\$4,314,918	\$25,165,000	\$7,467,564
	T.11b: Wetland/Riparian Restoration	\$560,000	\$258,128	\$2,800,000	\$1,309,010	\$22,400,000	\$2,359,892
<b>TOTAL</b>		<b>\$17,740,000</b>	<b>\$7,821,570</b>	<b>\$24,408,750</b>	<b>\$20,200,156</b>	<b>\$54,045,000</b>	<b>\$24,403,684</b>

\* A total of \$250,000 is allocated annually to “Environmental Land Acquisition Fund” to support acquisition of Greenway System lands. Actual spending on acquisition will vary depending on acquisition opportunities.

\*\* Assumes staffing costs are and will continue to be covered by the planning process.

This preliminary assessment found that:

- Maintaining the current practices will likely be adequate for meeting established target levels of service related to land acquisition/securement for natural assets
- BUT there will be significant gaps in investment for natural areas maintenance and renewal over the long term.

For example, Increased investment in volunteer stewardship, and staffing to coordinate and oversee this stewardship and ecosystem restoration, would be required to sustain and accelerate the maintenance and rehabilitation of natural assets as the City’s population grows.

Overall, the current management costs for natural assets are estimated to be \$0.9 million annually, that is assumed to be sufficient to meet the current levels of service. Sixty nine percent of this annual cost is due to capital expenditures with the remaining 29% attributable to staff. However, to meet enhanced or target levels of service would require additional funding. The initial management cost analysis estimated close to an additional \$0.7 million per year may be required to meet enhanced levels of service; 35% of this addition cost is due to capital outlays with the remainder due to labour. Further, an additional \$1.9 million per year

— of which 69% is for capital and 31% for staff — may be required to meet target levels of service compared to the current levels.

Notably, the preliminary activities and costing developed for the “enhanced” and “target” scenarios are expected to be refined in the context of the City’s overall financial strategy (under development) and once other related strategic documents (such as Markham's Urban Forest Management Plan, also in progress) are finalized.

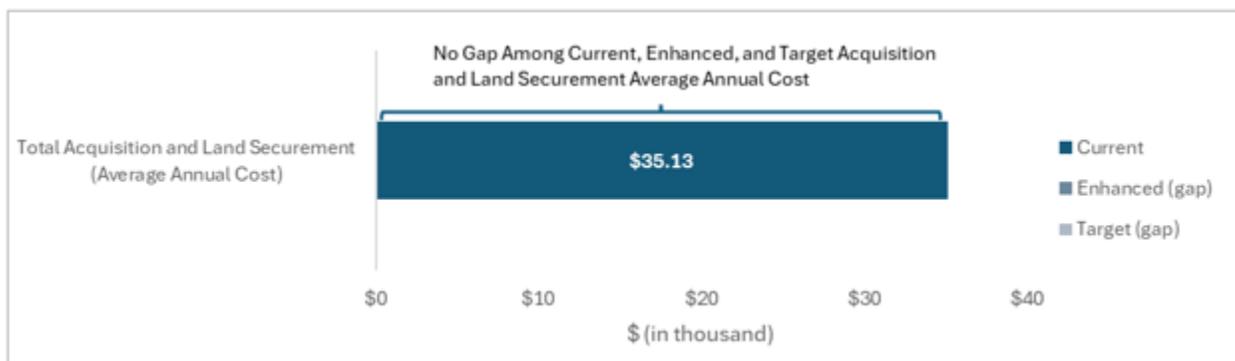
These scenarios, along with other elements of the work completed for this project and consideration for the financial strategies outlined in the following sub-sections, are expected to help the City formally recognize the services and value provided by their natural assets, and thereby provide a basis for City staff to inform their financial strategy and for decision-makers at the City to decide on an appropriate level of investment in these assets.

It is recommended that the City use these scenarios to inform the assessment of future/desired Levels of Service as part of its 2025 Asset Management Plan and Financial Strategy.

#### 6.4.1 Acquisition and Expansion

- Based on the management cost scenario analysis, an estimated \$35,000 is allocated annually to acquisition and land securement. Notably, a total of \$250,000 is allocated annually to the “Environmental Land Acquisition Fund” for acquisition of Greenway System lands but has not been included in this analysis as actual spending on acquisition varies from year to year depending on acquisition opportunities.
- No funding gap was identified to meet current levels of service, as defined by the identified technical LOS.
- On average, an annual growth of 17.8 ha secured per year is anticipated to continue.
- There is also no anticipated funding gap associated with enhancing or meeting target levels of service, as maintaining the current situation is defined as the target for acquisition and land securement.

Figure 6.1 summarizes the results of the acquisition and land securement actions.



Note: A total of \$250,000 is allocated annually to the “Environmental Land Acquisition Fund” for acquisition of Greenway System lands but has not been included in this analysis as actual spending on acquisition varies from year to year depending on acquisition opportunities.

Figure 6-1. Summary of acquisition and land securement funding by management scenario.

## 6.4.2 Maintenance

- Based on the management cost scenario analysis an estimated \$345,000 per year is allocated to the operation and maintenance of natural assets.
- No funding gap was identified to meet current levels of service, as defined by the chosen technical LOS. However, it is important to note that the management actions and associated funding may not be sufficient to ensure the level of environmental and ecosystem service benefits are maintained over the long run.
- Furthermore, to meet enhanced and targeted levels of service, an additional \$372,000 per year has been identified. This represents an 108% increase over the current rate of annual funding.

Figure 6.2 summarizes the results of operation and maintenance actions.

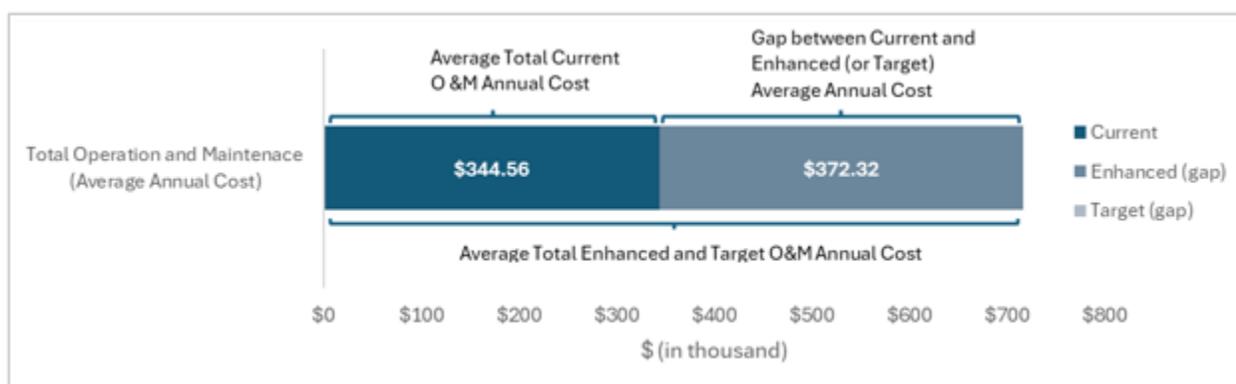


Figure 6-2. Summary of operation and maintenance funding by management scenario.

## 6.4.3 Rehabilitation and Renewal

- Based on the management cost scenario analysis an estimated \$533,000 per year is allocated to the rehabilitation and renewal of natural assets.
- No funding gap was identified to meet current levels of service, as defined by the chosen technical LOS.
- To meet enhanced and targeted levels of service an additional \$1,516,000 per year has been identified. This represents a 284% increase over the current rate of annual funding.

Figure 6.3 summarizes the results of rehabilitation and renewal actions.

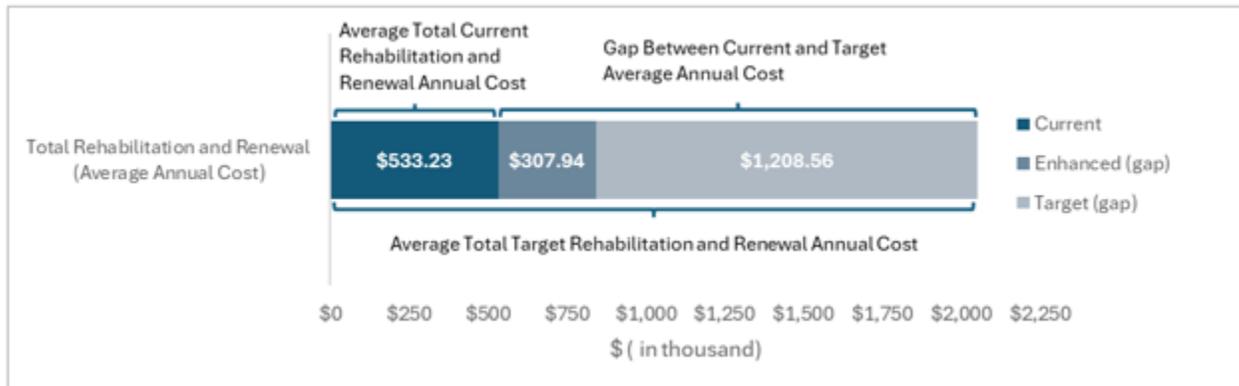


Figure 6-3. Summary of rehabilitation and renewal funding by management scenario.

#### 6.4.4 Current Funding Sources in Planning and Parks

The City's current service levels associated with Planning Department staff who support and implement natural asset management are primarily funded through development fees.

Capital funding for natural asset management currently comes from a variety of funding sources, but primarily through cash-in-lieu from tree/woodland removals as part of the planning process.

Notably, service levels provided by City Operations staff related to natural assets are not formally accounted for under the existing parkland funding model. This funding model will require review in order to provide adequate support of both full-time and seasonal staff to support natural asset management activities, outside of their primary responsibilities.

The continuation of existing service levels is also expected to have an impact to the City's Parks maintenance budget and should be considered as part of its 2025 Asset Management Plan and Financial Strategy.

## 7 Ecosystem Service Valuation

In conventional asset management, replacement costs are typically used for capital planning and/or high-level financial planning to account for the anticipated costs when an asset has reached the end of its useful life and needs to be disposed of and replaced. As discussed in Section 2.2.1, replacement costs for natural assets have been developed for this project based on per hectare costs provided by TRCA to restore/create different types of natural assets. However (as also noted in Section 2.2.1), many types of natural assets and natural asset functions cannot simply be “removed and replaced”. Furthermore, these basic replacement costs do not capture the value of any of the many ecosystem services provided by natural assets to the City and the community as a whole.

To address this gap, a new practice/science has developed around trying to estimate the value of the various services provided by natural assets, typically referred to as “ecosystem services”. This practice seeks to assign a monetary value to the benefits/services which tend not to be accounted for in traditional accounting but which contribute significantly to human wellbeing and quality of life. Having values for these services can then be used to help provide context for and/or validate investment decisions related to natural assets. This valuation is independent of the restoration/replacement valuation of the assets.

Table 7-1 summarizes the ecosystem services that have been valued for the City of Markham’s natural assets. In each case, the focus of the valuation in terms of the benefit derived by humans is identified. Figure 7-1 illustrates the results of this valuation exercise.

The details of the approaches and methods used to undertake these valuations are provided in Appendix G.

*Table 7-1. Ecosystem services valued and the focus of the valuation exercise.*

Ecosystem Service	Focus of the Valuation
Provision of Recreation Opportunities	Enjoyment of recreation activities
Carbon Sequestration	Avoided atmosphere carbon concentrations
Air Quality Regulation	Avoided costs associated with health issues from air pollution
Stormwater Regulation	Avoided stormwater management infrastructure costs
Regulation of Extreme Heat Events	Avoided health impacts associated with extreme heat provided by proximity to natural areas
Preservation Values	Value people place on knowing certain areas (and associated biodiversity) are protected from development
Aesthetic appreciation	Increased property values associated with proximity to natural spaces.
Contribution to Crop Productivity	Improved crop productivity generated from wild pollinators



Figure 7-1. Valued ecosystem services in the City of Markham.

These valuations are largely based on the current Levels of Service. As such, these values (and their related LOS) would be expected to increase should the condition and/or extent of natural assets in Markham be improved. Conversely, these values (and their related LOS) would be expected to decrease should the condition and/or extent of natural assets in Markham decline.

It should be noted that the valuations above are conservative and do not capture all the ecosystem services provided by the natural assets in Markham. For example, nutrient cycling and hydrological services beyond stormwater management, were out of scope of this analysis as were other ecosystem services for which no appropriate methods for undertaking valuation have yet been developed. Nonetheless, the overall value of the ecosystem services valued for Markham were between \$114 M and \$120 M per year, while the services provided by the City-owned proportion of the natural assets were valued between \$60 M and \$62 M per year.

## 7.1 The Business Case for Natural Assets

From this project we know that more than half of Markham’s City-owned natural assets are at risk and should be better managed to mitigate / reduce the risk of degradation.

Maintaining current levels of investment and enhancing this investment going forward as the City’s population grows will be critical to maintaining the current services provided by these assets, which among other things, help the community adapt to climate change.

A comparison of the management cost estimates (see Table 6-11 in Section 6.3) with the overall replacement costs (see Table 2-3 in Section 2.2.1) and the estimated ecosystem service values for natural assets in Markham helps build the case for enhanced investment in these assets.

- The replacement cost of City-owned natural assets was estimated to be \$169 million overall, while the current annual investment in managing these assets is \$1 million, about 0.6% of their replacement cost.
- The estimated annual management costs of meeting enhanced or target levels of service (i.e., \$2 million and \$3 million, respectively), are less than 2% of the estimated asset replacement costs.
- The case for greater investment in natural asset management is further demonstrated by the flow of ecosystem services provided by the City-owned natural assets, that was conservatively estimated to be about \$60 million per year. In other words, investing \$3 million in the maintenance of natural assets to help ensure the annual ecosystem service benefits, valued at 20 times that, are maintained is an excellent return on investment.



## 8 Summary of Recommendations

The following recommendations have emerged from this project to support the continued integration and advancement of natural assets in Markham's asset management planning and related financial strategy:

1. **ESTABLISH AN INTERNAL NATURAL ASSETS TECHNICAL ADVISORY COMMITTEE (NATAC):** Create a permanent Natural Asset Technical Advisory Committee (NATAC) that meets on a regular basis to provide a forum for the kinds of multi-disciplinary and inter-departmental information sharing, discussions and problem-solving required to continue to advance natural asset planning and management in Markham.

This NATAC should include the appropriate City staff from: Corporate Asset Management, Engineering, Information Technology, Operations, Parks (including Forestry), Planning and Urban Design (including Natural Heritage), Sustainability and Environmental Services (including Stormwater Services), and may include representation from Toronto and Region Conservation Authority (TRCA) when appropriate.

2. **ESTABLISH AN EXTERNAL NATURAL ASSETS WORKING GROUP (NAWG):** Create a permanent Natural Asset Working Group (NAWG) that meets on a semi-regular basis to facilitate the information sharing and multi-landowner collaboration required to continue to advance natural asset planning and management in Markham.

This NAWG should include key City staff from the NATAC and also include representatives from TRCA, York Region, Parks Canada (i.e., the Rouge National Urban Park), the Nature Conservancy of Canada (NCC), the Oak Ridges Moraine Land Trust (ORMLT), the Ontario Ministry of Natural Resources and Forestry (MNR), Ontario Nature (ON) and the York Federation of Agriculture (YFA).

3. **ENGAGE WITH INDIGENOUS PEOPLES:** Connect with local First Nations, Métis, Inuit and urban Indigenous organizations to seek their insights related to Markham's natural assets and gauge their interest in becoming partners in advancing natural asset management in Markham. Note: this outreach may be done as part of a comprehensive City-led Indigenous engagement strategy on a range of environmental topics.
4. **FUTURE INTEGRATION OF NATURAL ASSETS AS PART OF CITY'S GREEN INFRASTRUCTURE:** Continue to review the integration of natural assets in relation to the City's other green infrastructure assets in future Asset Management Plans. This should include consideration of various Low Impact Development features (e.g., bioswales) that may not be captured in the Parks or Stormwater Management Asset category.
5. **UPDATE THE CONDITION ASSESSMENT:** The City should work with its natural asset partners (e.g., TRCA, York Region) to develop a field-based condition assessment checklist / field form tailored to Markham's natural assets and the key measures of their condition as well as risk. For example, such a checklist should include a measure of invasive plant species types and levels of cover to help inform future management. This approach, once developed, should then be used as a basis for natural asset monitoring and updates going forward.
6. **UPDATE THE RISK ASSESSMENT:** The preliminary hazards and asset risk assessments should be updated going forward by:

- a. Incorporating the updated and refined condition assessment outcomes (Section 3).
  - b. Considering additional variables (such as relative asset size, asset shape, and asset proximity to humans) in the risk assessment process.
  - c. Exploring ways to make the cost estimates more inclusive of the full value of services that would be lost and potentially also account for the inherent resilience of natural assets.
7. **GETTING COMMUNITY INPUT TO LEVELS OF SERVICE:** In the future, the City of Markham should consider expanding its customer satisfaction survey to gather input specifically related to green infrastructure – including City-owned natural areas management. For example, it could include questions related to the City's:
    - Response time in addressing hazards from extreme weather events, such as flooding, fallen trees and erosion.
    - Diligence in removing waste and/or encroachments and addressing hazard trees, follow-up maintenance and monitoring of restoration areas, etc.
  8. **ONGOING UPDATES TO NATURAL ASSETS REGISTRY AND PLAN:** Update the natural assets registry, mapping, condition assessment, risk assessment, management actions and management costing as information gaps are filled and new information becomes available. This should include, but not be limited to, new data and guidance from:
    - The City's recently completed Invasive Plant Species Management Plan (CBCL 2024a).
    - The City's Urban Forest Management Plan (in progress when this report was finalized) with a specific need to fill the gaps in the management actions and cost for Technical LOS T.9 and T.10.
    - Changes to the status of natural assets not owned by the City, agricultural lands and/or enhanced assets owned by the City.
    - Periodic monitoring of the City's natural assets and Natural Heritage System (e.g., once every five years).
  9. **BUILD ON PRELIMINARY NATURAL ASSET MANAGEMENT SCENARIOS:** As part of this project a significant amount of effort was allocated to outlining the actions and costs associated with a Current Management Scenario, Enhanced Management Scenario and Target Management Scenario. It is recommended that the City use these scenarios to inform the assessment of future/desired Levels of Service as part of its 2025 Asset Management Plan and Financial Strategy.
  10. **COORDINATED FINANCIAL PLANNING:** The 2025 Asset Management Plan and Financial Strategy should ensure that current and projected capital cost and staffing needs related to natural assets in the various City departments (e.g., Planning, Parks, Stormwater Management) are accounted for in a coordinated and integrated manner.
  11. **OFFICIAL PLAN:** Ensure the City's Natural Asset Plan and the updates to the City's Official Plan are aligned.

## 9 Concluding Remarks

This report provides a summary of the approach to and the outcomes of the City of Markham's first comprehensive natural assets inventory and evaluation. This work included:

- A registry and inventory of Markham's natural, green space and agricultural land assets not captured in other asset registries (e.g., such as parks or stormwater management) (Section 2).
- Condition assessments (Section 3) and risk assessments (Section 4) for Markham's natural assets.
- Articulating corporate, community and technical levels of service (LOS) for Markham's natural assets (Section 5).
- Estimating current municipal natural asset management costs as well as preliminary estimates of the levels of additional investment required to (a) enhance natural asset service provision in the face of climate change, and (b) meet established natural asset targets (Section 6).
- Extensive engagement with a Technical Advisory Committee and more targeted engagement with selected partners over the course of this project.
- Provision of some analyses and materials to help engage staff, partners, decision-makers and the community on this topic including:
  - A valuation of some of the ecosystem services provided by Markham's natural assets (Section 7).
  - A guide titled "Markham's Natural Assets and Climate Change Guide" (provided under separate cover).

This comprehensive natural asset project is the first of its kind in Markham. It is expected to provide a foundation for ongoing natural asset planning and management, and to be refined and updated as needed to help inform long-term planning, particularly as it relates to natural heritage, as well as operational management of the natural assets owned by the City. While an increasing number of municipalities in Ontario, and elsewhere have started to integrate natural assets into their municipal planning frameworks (e.g., MNAI 2021a-g), the City of Markham is one of the first to explore using the asset management framework to inform long range planning. The information and analyses provided through this project is intended to support financial planning that will recognize and leverage the services and co-benefits that are, and could be, provided by natural assets in Markham.

Ecosystem services provided by the City-owned natural assets were conservatively estimated to be about \$60 million per year. The replacement cost of City-owned natural assets was estimated to be almost \$170 million overall, while the current annual investment in managing these assets is about \$1 million, about 0.6% of their replacement cost. The estimated annual management costs of meeting enhanced or target levels of service (i.e., \$2 million and \$3 million respectively), are less than 2% of the estimated asset replacement costs. Investing \$1 million in maintenance of natural assets to help ensure the annual ecosystem service benefits (valued at 60 times that) are maintained is an excellent investment.

Markham's population is expected to nearly double over the next 30 years (i.e., from 349,000 in 2021 to 618,000 in 2051). While this will create opportunities for investing in community amenities, including public natural areas, and for increasing stewardship efforts, it will also put more pressure on public open spaces and natural areas. This growth will make proactive and adaptive management of Markham's natural assets more important than ever if these assets are to continue to provide core services to the community and help the community adapt to climate change. A suite of strategies and high-level guidance to help the City and the community in Markham sustain and enhance its natural assets (both owned by the City and by others) is provided in the Natural Asset and Climate Change Guide developed as a separate stand alone deliverable as part of this project.

## 10 References

AE (Associated Engineering). 2022. Yukon Natural Asset Framework. Written in partnership with the Government of Yukon, Association of Yukon Communities and Council of Yukon First Nations.

Aizen, M. A., Aguiar, S., Biesmeijer, J. C., Garibaldi, L. A., Inouye, D. W., Jung, C., ... & Seymour, C. L. (2019). Global agricultural productivity is threatened by increasing pollinator dependence without a parallel increase in crop diversification. *Global change biology*, 25(10), 3516-3527.

Bloomberg, M. R. and C. Holloway. 2018. NYC Green Infrastructure Plan: A Sustainable Strategy for Clean Waterways. Published by New York Environmental Protection. Accessed at: <https://brookcc.com/book/2953717/7c6e35>

Brander, L. M., & Koetse, M. J. (2011). The value of urban open space: Meta-analyses of contingent valuation and hedonic pricing results. *Journal of environmental management*, 92(10), 2763-2773.

CBCL. 2021. Natural Heritage Inventory and Assessment Study (NHIAS). Prepared for the City of Markham.

CBCL. 2022. Natural Heritage Management Study, City of Markham. 2022 Vegetation Analysis, Technical Memorandum. Dec. 8, 2022. 59 pp.

CBCL. 2024a. Invasive Plant Species Management Plan. Prepared as part of the Natural Heritage Management Study for the City of Markham, May 2024.

CBCL. 2024b. Natural Area Management Guidebook. Prepared as part of the Natural Heritage Management Study for the City of Markham, May 2024.

CCME (Canadian Council of Ministers of the Environment). 2021. Natural Infrastructure Framework: Key Concepts, Definitions and Terms. 52 pp. Accessed 2022-08-04 at: <https://ccme.ca/en/resources#>

Chen, H., Wang, J., Li, Q., Yagouti, A., Lavigne, E., Foty, R., ... & Copes, R. (2016). Assessment of the effect of cold and hot temperatures on mortality in Ontario, Canada: a population-based study. *Canadian Medical Association Open Access Journal*, 4(1), E48-E58.

City of Markham. 2011. Markham's Greenprint Sustainability Plan.

City of Markham. 2014. Official Plan. Planning Markham's Future.

City of Markham. 2021. Asset Management Plan (AMP).

City of Markham. 2022. Satisfaction Survey.

[C40 Cities Urban Nature Accelerator Performance Indicators.](#)

CSA Group. 2022. CSA/W218-23 Specifications for Natural Asset Inventories. Final Draft. 31 p.

Environment Canada. 2013. How Much Habitat Is Enough Third Edition. Accessed at: <https://www.documentcloud.org/documents/2999368-THUNDER-BAY-How-Much-Habitat-Is-Enough-3rd-Ed-2013.html>

GIO (Green Infrastructure Ontario). 2021. Advancing Municipal Action on Green Infrastructure. 2 pp. Accessed 2022-08-04 at: [https://greeninfrastructureontario.org/app/uploads/2021/03/AMA\\_GIO\\_ExecutiveSummary.pdf](https://greeninfrastructureontario.org/app/uploads/2021/03/AMA_GIO_ExecutiveSummary.pdf)

Government of Ontario. 2006. ORMCP Technical Paper Series 13 – Subwatersheds – Impervious Surfaces. Accessed at: [www.oakridgesmoraine.org](http://www.oakridgesmoraine.org)

Government of Ontario. 2018. Watershed Planning in Ontario: Guidance for land-use planning authorities, Draft, Government of Ontario, Feb. 2018, 159 p.

ISO 37120 Series core and supporting indicators. World Council on City Data.

Klein, A. M., Vaissiere, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C., and Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society of London B: Biological Sciences*, 274(1608), 303-313.

Kroeger, T., McDonald, R. I., Boucher, T., Zhang, P., & Wang, L. (2018). Where the people are: Current trends and future potential targeted investments in urban trees for PM10 and temperature mitigation in 27 US cities. *Landscape and Urban Planning*, 177, 227-240.

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. SCSS Field Guide FG-02. 225 pp.

Mazzotta, Marisa & Besedin, Elena & Speers, Ann. (2014). A Meta-Analysis of Hedonic Studies to Assess the Property Value Effects of Low Impact Development. *Resources*. 3. 31-61.

MNAI (Municipal Natural Assets Initiative). 2021a. Toward natural asset management in the City of Charlottetown, Prince Edward Island. April 2021, 30 pp. Accessed 2022-08-08 at: <https://mnai.ca/media/2021/05/MNAI-Inventory-Cluster-Charlottetown-report-102.pdf>

MNAI (Municipal Natural Assets Initiative). 2021b. Toward natural asset management in the City of Mississauga, Ontario. December 2021, 34 pp. Accessed 2022-08-08 at: <https://mnai.ca/media/2022/03/MNAI-Inventory-Cluster-2-Mississauga-report-102.pdf>

MNAI (Municipal Natural Assets Initiative). 2021c. Toward natural asset management in the City of Peterborough, Ontario. April 2021, 30 pp. Accessed 2022-08-08 at: <https://mnai.ca/media/2021/05/MNAI-Inventory-Cluster-Peterbrough-report-102.pdf>

MNAI (Municipal Natural Assets Initiative). 2021d. Toward natural asset management in the City of Surrey, British Columbia. June 2021, 32 pp. Accessed 2022-08-08 at: <https://mnai.ca/media/2022/01/MNAI-Inventory-Cluster-Surrey-report-203.pdf>

MNAI (Municipal Natural Assets Initiative). 2021e. Toward natural asset management in the City of West Kelowna, British Columbia. April 2021, 32 pp. Accessed 2022-08-08 at: <https://mnai.ca/media/2021/05/MNAI-Inventory-Cluster-West-Kelowna-report-101.pdf>

MNAI (Municipal Natural Assets Initiative). 2021f. Toward natural asset management in the City of Yellowknife, Northwest Territories. November 2021, 31 pp. Accessed 2022-08-08 at: <https://mnai.ca/media/2021/11/MNAI-Inventory-Cluster-2-Yellowknife-report-101.pdf>

MNAI (Municipal Natural Assets Initiative). 2021g. Toward natural asset management in the Halifax Regional Municipality, Nova Scotia. October 2021, 34 pp. Accessed 2022-08-08 at: <https://mnai.ca/media/2021/11/MNAI-Inventory-Cluster-2-Halifax-report-103.pdf>

MNAI (Municipal Natural Assets Initiative). 2022. Developing Levels of Service for Natural Assets: A Guidebook for Local Governments. 94 pp. Accessed 2022-08-08 at: <https://mnai.ca/media/2022/01/MNAI-Levels-of-Service-Neptis.pdf>

MNRF (Ministry of Natural Resources and Forestry). 2010. Natural Heritage Reference Manual. Accessed at: <https://www.ontario.ca/document/natural-heritage-reference-manual>

NAI (Natural Assets Initiative). 2023. Natural Asset Infrastructure in British Columbia: Barriers and Opportunities. January 2023. 58 pp. Accessed at: <https://mnai.ca/media/2023/02/BC-Barriers-Report-FINAL-3.pdf>

Natural Resources Canada Office of Energy Efficiency (2000). 1997 Survey of Household Energy Use (SHEU) – Summary Report. Ottawa, ON.

Natural Resources Canada Office of Energy Efficiency (2006). 2003 Survey of Household Energy Use (SHEU) – Summary Report. Ottawa, ON.

Natural Resources Canada Office of Energy Efficiency (2010). Survey of Household Energy Use, 2007 – Detailed Statistical Report. Ottawa, ON.

Nowak, D.J., Hirabayashi, S., Bodine, A., & Greenfield, E. (2014). Tree and Forest Effects on Air Quality and Human Health in the United States. *Environmental Pollution*, 193, 119-129.

NSEI and DAI (North-South Environmental Inc. and Dougan and Associates Inc.) 2021. Markham Natural Heritage Inventory and Assessment Study.

Park, H. 2020. Measuring & Managing Park Carrying Capacity. Final report August 2020. Prepared for: Deanne Manzer, Park Planner, Metro Vancouver. Accessed at: <https://sustain.ubc.ca>

Regional Municipality of York. 2022. Green Infrastructure Asset Management Plan, Appendices.

Regional Municipality of York. 2023. Regional Forest Climate Change Mitigation and Adaptation Plan

Saini, S., Singh, A., Koveshnikova, T., Paudel, K. 2018. Municipal Natural Assets Initiative: Region of Peel Pilot. [https://mnai.ca/media/2018/07/MNAI\\_Peel-final.pdf](https://mnai.ca/media/2018/07/MNAI_Peel-final.pdf)

Sarabi, S., Q. Han, A. G. L. Romme, B. de Vries, R. Valkenburg and E. den Ouden. 2020. Uptake and implementation of Nature-Based Solutions: An analysis of barriers using Interpretive Structural Modeling. *Journal of Environmental Management* 270: 110749. Accessed at: <https://pubmed.ncbi.nlm.nih.gov/32721286/>

Sawicz, E. 2011. Summertime control of temperature in Canadian homes: How Canadians keep their cool. *EnviroStats Services Bulletin*. 5(2): 3-8. Accessed at: <https://www150.statcan.gc.ca/n1/en/pub/16-002-x/16-002-x2011002-eng.pdf?st=xCMprjY3>

Statistics Canada. 2023a. Table 13-10-0800-01 Deaths and mortality rate (age standardization using 2011 population), by selected grouped causes. DOI: <https://doi.org/10.25318/1310080001-eng>

Statistics Canada. 2023b. Table 13-10-0708-01 Deaths, by month  
DOI: <https://doi.org/10.25318/1310070801-eng>

Statistics Canada. 2023c. Table 38-10-0019-01 Air conditioners  
DOI: <https://doi.org/10.25318/3810001901-eng>

TRCA. 2020. Greenway System Restoration Framework: Protecting and Enhancing Biodiversity, Wildlife Habitat and Natural Ecosystems in the North Markham Planning District. DRAFT. July 2020.

TRCA 2023. Markham Forest Study 2022: Technical Report.

Treasury Board Secretariat of Canada. 2022. Canada's Cost-Benefit Analysis Guide for Regulatory Proposals. Ottawa, ON. <https://www.canada.ca/en/government/system/laws/developing-improving-federal-regulations/requirements-developing-managing-reviewing-regulations/guidelines-tools/cost-benefit-analysis-guide-regulatory-proposals.html>

USEIA (United States Energy Information Administration) (n.d.). Residential Energy Consumption Survey (RECS). <https://www.eia.gov/consumption/residential/index.php>

Voigt, B., Troy, A., & Johnson, G. 2013. Mapping the off-site benefits from protected areas' ecosystem services: Final Report. Spatial Informatics Groups, LLC. DOI: <https://www.ontario.ca/page/ecosystem-service-values>