

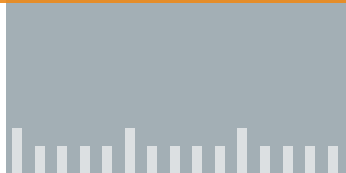


Toward natural asset management in the City of Markham Ontario



Summary of inventory results and implications April 2021

This document features interactive elements! Clicking on a heading or sub-heading in the Table of Contents (ToC) will take you directly to that page. Also, clicking on page numbers in the footer will bring you back to the ToC.



Municipal Natural Assets Initiative





Invest in Nature

The Municipal Natural Assets Initiative (MNAI) is a Canadian not-for-profit that is changing the way municipalities deliver everyday services - increasing the quality and resilience of infrastructure at lower costs and reduced risk. The MNAI team provides scientific, economic and municipal expertise to support and guide local governments in identifying, valuing and accounting for natural assets in their financial planning and asset management programs, and developing leading-edge, sustainable and climate-resilient infrastructure.

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1 Purpose

This document summarizes the results of a project to develop a natural asset inventory in the City of Markham and documents steps the local government can take to proceed to a full natural asset management initiative.

2 Introduction

What are municipal natural assets

The term *municipal natural assets* refers to the stock of natural resources or ecosystems that a municipality, regional district, or other form of local government could rely upon or manage for the sustainable provision of one or more local government services¹.

Why manage natural assets

A growing number of local governments recognize that it is as important to understand, measure, manage and account for natural assets as it is for engineered ones. Doing so can enable local governments to provide *core* services such as stormwater management, water filtration, and protection from flooding and erosion, as well as *additional* services such as those related to recreation, health and culture. Outcomes of what is becoming known as *municipal natural asset management* can include cost-effective and reliable delivery of services, support for climate change adaptation and mitigation, and enhanced biodiversity. In Ontario, natural asset management supports the implementation of O. Reg. 588/17, *Asset Management Planning for Municipal Infrastructure*, which requires local governments to include green infrastructure into asset management plans².

How to manage natural assets

There are numerous ways for local governments to manage natural assets. The Municipal Natural Assets Initiative (MNAI) uses methodologies and tools rooted in standard asset management, and provides a range of advisory services to help local governments implement them. MNAI has developed the methods and tools with significant investments, piloting, refinement, peer review, and documentation of lessons in multiple Canadian provinces. MNAI's mission is to make natural asset management a mainstream practice across Canada, and in support of this, for local governments to accept and use the methodologies and tools in standard ways across the country.

1 mnai.ca/media/2018/02/finaldesignedsept18mnai.pdf

2 See for example MNAI (2019)

What is a natural asset inventory

Inventories provide details on the type of natural assets a local government relies upon³, their condition, and the risks they face. As depicted in Figure 1 and explained in detail in the Annex, a natural asset inventory is the first component of the Assessment phase. The Assessment phase, in turn, is the first of three phases of a full natural asset management project. By itself, an inventory will not give a sense of asset value, but is an essential first step in the full natural asset management project.

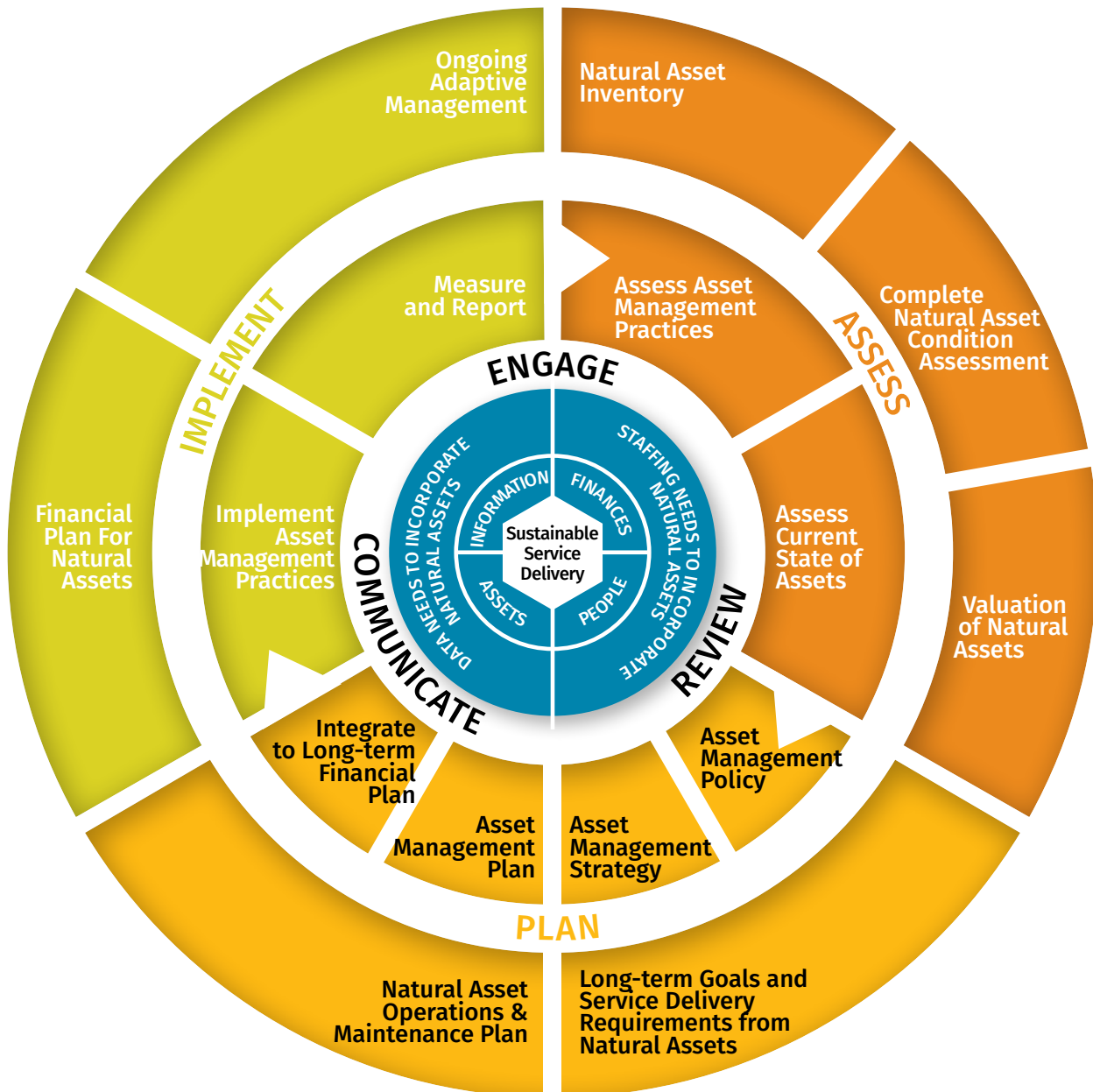


Figure 1: The Asset Management Process. MNAI has adapted this for use with natural assets.

³ Note that many local governments rely on services from natural assets they do not own.

3 Local government context

3.1. General



Figure 2: City of Markham

The City of Markham (population ~329,000) is located in the Regional Municipality of York, approximately 30 kilometres northeast of downtown Toronto. It is the fourth largest city by population in the Greater Toronto Area (GTA). Markham is mostly urbanized; however, its northern and eastern portions remain rural and agricultural.

Markham owns approximately 950 hectares of natural open spaces including woodlands, wetlands, valley lands and grasslands. Many of these natural assets are open and accessible to the public and are local community landmarks.

Markham has three main interests in natural asset management. First, it would like to obtain a better understanding of the ecological services provided by natural areas and better communicate quantifiable benefits to Council and the public. Second, Markham would like to better support decision-making related to managing and prioritizing investments in natural assets and maximize benefits to residents. Third, it wants to identify the risks to the services it receives from natural assets.

Markham's Corporate Strategy 'Building Markham's Future Together' and its Greenprint Sustainability Plan and the Official Plan provide the necessary direction to protect and enhance the natural heritage system.

A large proportion of Markham is located on Class 1 farmland. Historical clearing has led to low woodland and wetland cover, which is of growing concern. Markham has recently embarked on a city-wide Natural Heritage Inventory to assess and map terrestrial natural features. This will include

ecological land classification on public and private lands, wildlife surveys, and detailed botany inventories. This, together with the inventory, will support the development of a Natural Asset Management Plan.

Markham's asset management plan currently includes streets and park trees and stormwater management facilities. Markham has also completed an urban canopy study in 2012 which identified a relatively low canopy cover (18 per cent) and concluded that the urban forest is fairly young. Thus, tree planting and afforestation have been identified as a priority for Markham. Markham currently invests approximately \$100,000 per year through the Trees for Tomorrow initiative for naturalization and restoration efforts.

Climate change-related risks to stormwater management and flood control infrastructure are a concern. Climate change projections indicate that more frequent rainfall events will lead to greater strain on stormwater infrastructure, and longer heat waves and associated health risks will lead to a greater need for shade structures or trees in parks and public spaces. Markham aims to develop a Wildlife and Biodiversity Strategy and an Urban Forest Management plan to increase the tree canopy to mitigate the effects of climate change. The Official Plan also identifies the need to protect, expand and integrate urban forests in existing and new communities. The Markham Greenprint Sustainability Plan has set a 30 per cent target for tree canopy and vegetation coverage.

3.2. Asset management readiness assessment

As part of inventory development, MNAI helps local governments determine their overall state of asset management maturity. To do this, MNAI has adapted the Federation of Canadian Municipalities (FCM)'s asset management readiness assessment tool⁴ to help local governments measure their progress on both asset management and natural asset management in four competency areas, with each area describing outcomes based on five levels of progress or maturity.

The completed assessment will, in turn, help the local government prioritize actions that will increase its effectiveness in managing all assets, including natural ones.

Markham's readiness assessment indicates it is generally at an intermediate level of progress in adopting asset management for engineered assets and is at an early stage of incorporating natural asset considerations in all competency areas. Markham has an asset management policy that is aligned with organizational objectives, but the policy does not reference natural assets specifically.

While Markham has a cross-functional asset management team, that team does not specifically include roles and responsibilities for natural asset management. Resources for management of natural areas (outside of street and park trees) are limited and natural areas are treated as passive spaces and not actively managed. Specialists (e.g., ecologists or foresters) are limited and retained on an as-needed basis.

⁴ See [fcm.ca/sites/default/files/documents/resources/tool/asset-management-readiness-scale-mamp.pdf](https://www.fcm.ca/sites/default/files/documents/resources/tool/asset-management-readiness-scale-mamp.pdf) for details

There is some small, annual funding dedicated towards protecting and enhancing natural features⁵ (reforestation, invasive species management), but this funding is not provided through an asset management framework or through the corporate asset management plan.

4 Natural asset inventory

4.1. Inventory overview

MNAI's natural asset inventories have two main components to express natural asset information: an asset registry (which is a tabular representation of the data) and an online dashboard. MNAI provided the registry to Markham in an Excel file and the dashboard as a website address. Information on the condition of the assets is a subset of the inventory and is depicted in both the registry and dashboard.

4.2. Inventory data

To establish the inventory, MNAI obtained spatial data layers from Markham and combined them to establish a comprehensive depiction of natural assets. Table 1 describes the data sources used to develop the inventory and condition assessment.

TABLE 1: DATA SOURCES SUMMARY		
DATA	SOURCE	PURPOSE
ELC_MarkhamNH_FINAL_20201122.shp	City of Markham	Used to create base natural asset inventory
TRCA_Landuse_NaturalCover_2017.shp	City of Markham	Used to fill in gaps where the ELC layer was unavailable (urban, agricultural areas)
Waterbodies_TRCA.shp	City of Markham	Used to add waterbody details to base natural asset inventory
Contour.shp	City of Markham	Used to interpolate to a 2m DEM and assign mean elevation to each asset
Greenbelt_Plan_Markham.shp	City of Markham	Used to assign area of asset overlapping with the greenbelt plan
Greenway.shp	City of Markham	Used to assign area of asset overlapping with the cities natural heritage system
Markham_owned_Parks_and_open_Space.shp	City of Markham	Used to determine which assets are owned by Markham
Natural_Heritage_Network.shp	City of Markham	Used to assign area of assets within the Natural Heritage Network

⁵ Markham uses the term 'natural features' in some planning documents; the term can be considered interchangeable with natural assets for the purposes of this document.

TABLE 1: DATA SOURCES SUMMARY

DATA	SOURCE	PURPOSE
Oak_Ridges_Moraine_Conservation_Plan_Area.shp	City of Markham	Used to assign area of asset overlapping with the ORMCP
OP_Land_Use_designation.shp	City of Markham	Used to assign general OP land use designation to assets where possible for assets covered by this dataset
Proposed_Rouge_National_Park_boundary.shp	City of Markham	Used to assign assets to relevant watershed and summarize assets by watershed in dashboard
Rouge_Watershed_Protection_Area_2013.shp	City of Markham	Used to assign area of asset overlapping with the Rouge Watershed Protection Area
Soil_Survey_Complex.shp	Ontario GeoHub	Used to assign drainage type of soil and Canada Land Inventory (CLI) rating for the soil component to assets
Trails	City of Markham	Used to summarize length of trails (km) within assets
Roads	City of Markham	Used to perform road density condition assessment for natural assets
Watersheds	City of Markham	Used to assign appropriate watershed to asset and summarize assets by watershed in the dashboard

A natural asset is defined as a continuous area of the same land cover type. The inventory project defined a total of 4,793 individual assets, covering 9,155 hectares (ha) of the municipal area, as noted in Table 2. The majority of this area was agriculture, followed by forest.

TABLE 2: SUMMARY OF NATURAL ASSETS BY TYPE

NATURAL ASSET TYPE	NUMBER OF ASSETS	TOTAL AREA (HA)	AVERAGE ASSET AREA (HA)	MARKHAM-OWNED PARKS AND NATURAL ASSETS (HA)
Agriculture	521	5,763	11.06	37
Beach/bluff	17	2.73	0.16	1
Forest	2,002	1,480	0.74	356
Open space and successional	927	1,080	1.17	200
Water	216	172	0.80	72
Wetland	1,110	657	0.59	82
Total	4,793	9,155	1.91	748

4.3. Asset registry

Each asset within the inventory has a unique identification number that allows individual assets to be selected, analyzed, and the corresponding data manipulated as required. For example, changes in condition can be noted for individual assets. Information on each asset is housed in an asset registry. Table 3 is an excerpt from Markham's registry showing natural asset characteristics and details.

TABLE 3: EXCERPT FROM THE REGISTRY

Markham Natural Asset Inventory																			Summary	Asset Registry	Condition	Decomposition
Natural Asset Registry																						
Asset ID	Asset Type	Asset Area (ha)	Sub Asset Area (ha)	Watershed	Is Asset in Greenway	Op Landuse	Detailed Landcover	ELC Description	Canopy Height	Majority Soil Drainage	Greenbelt Plan (ha)	Markham Owned Parks (ha)	Interior Forest %	Adjacent Land Use Score	Permeability Score	Relative Size Score	Road Density Score	Total Score				
AGR100	Agriculture	31.99	31.99	Rouge	No	Residential Low Rise	Agricultural			Imperfectly	0.00	0.00	0	5	5	1	1	12				
AGR101	Agriculture	0.07	0.07	Duffins	No	Other	Agricultural			Well	0.07	0.00	0	6	5	1	5	17				
AGR104	Agriculture	160.06	160.06	Rouge	No	Residential Low Rise	Agricultural			Imperfectly	0.01	0.00	0	6	5	5	1	17				
AGR106	Agriculture	0.54	0.39	Duffins	No	Other	Agricultural			Well	0.54	0.00	0	6	5	1	5	17				
AGR106	Agriculture	0.54	0.15	Rouge	No	Other	Agricultural			Well	0.54	0.00	0	6	5	1	5	17				
AGR108	Agriculture	2.28	2.28	Rouge	No	Other	Agricultural			Imperfectly	2.27	0.00	0	6	5	1	1	13				
AGR109	Agriculture	0.01	0.01	Rouge	No	Other	Agricultural			Imperfectly	0.01	0.00	0	9	5	1	1	16				
AGR110	Agriculture	71.03	71.03	Rouge	No	Other	Agricultural			Imperfectly	0.00	0.00	0	7	5	5	10	27				
AGR111	Agriculture	14.44	14.44	Rouge	No	Other	Agricultural			Imperfectly	0.06	0.00	0	7	5	1	1	14				
AGR112	Agriculture	1.14	1.14	Rouge	No	Other	Agricultural			Well	0.00	0.00	0	8	5	1	10	24				
AGR114	Agriculture	2.69	2.69	Rouge	No	Other	Agricultural			Well	0.00	0.00	0	7	5	1	10	23				
AGR115	Agriculture	0.25	0.25	Rouge	No	Other	Agricultural			Well	0.00	0.00	0	7	5	1	10	23				
AGR116	Agriculture	0.08	0.08	Duffins	No	Other	Agricultural			Poorly	0.08	0.00	0	8	5	1	5	19				
AGR119	Agriculture	14.52	0.01	Rouge	No	Other	Agricultural			Imperfectly	0.00	0.00	0	7	5	1	1	14				
AGR12	Agriculture	24.34	24.10	Rouge	No	Other	Agricultural			Imperfectly	0.00	0.00	0	7	5	1	10	23				
AGR120	Agriculture	43.37	43.37	Rouge	Yes	Mixed Use Low Rise	Agricultural			Imperfectly	0.00	0.00	0	6	5	1	1	13				
AGR121	Agriculture	0.07	0.07	Rouge	No	Other	Agricultural			Imperfectly	0.07	0.00	0	5	5	1	1	12				
AGR123	Agriculture	0.32	0.32	Rouge	No	Other	Agricultural			Poorly	0.32	0.00	0	6	5	1	1	13				
AGR125	Agriculture	34.18	34.18	Rouge	No	Other	Agricultural			Imperfectly	0.21	0.00	0	7	5	1	10	23				
AGR126	Agriculture	10.39	10.39	Rouge	No	General Employment	Agricultural			Imperfectly	0.00	0.00	0	7	5	1	1	14				
AGR127	Agriculture	0.24	0.24	Rouge	No	Other	Agricultural			Poorly	0.24	0.00	0	7	5	1	1	14				
AGR130	Agriculture	1.09	1.09	Rouge	No	Other	Agricultural			Poorly	1.09	0.00	0	7	5	1	1	14				
AGR134	Agriculture	0.14	0.14	Rouge	No	Other	Agricultural			Well	0.14	0.00	0	7	5	1	10	23				
AGR137	Agriculture	27.22	27.22	Rouge	No	Other	Agricultural			Imperfectly	0.20	0.00	0	7	5	1	10	23				
AGR139	Agriculture	1.22	1.22	Rouge	No	Other	Agricultural			Imperfectly	0.00	0.00	0	7	5	1	5	18				
AGR140	Agriculture	1.22	1.22	Rouge	No	Other	Agricultural			Imperfectly	0.00	0.00	0	7	5	1	5	18				
AGR141	Agriculture	25.15	25.15	Rouge	No	Other	Agricultural			Imperfectly	0.19	0.00	0	6	5	1	1	13				
AGR142	Agriculture	16.11	16.11	Rouge	No	General Employment	Agricultural			Imperfectly	0.00	0.00	0	6	5	1	1	13				
AGR144	Agriculture	0.13	0.13	Rouge	No	Other	Agricultural			Well	0.13	0.00	0	6	5	1	5	17				
AGR145	Agriculture	246.72	246.72	Rouge	No	Residential	Agricultural			Well	0.32	0.00	0	6	5	10	1	22				

4.4. Online dashboard

Inventories may provide more insights when characterized visually in a dashboard, which enables users to explore different aspects of the data. For instance, natural asset information can be quickly summarized by watershed area, or, if users want to dive into the specifics of forest assets, they can quickly filter the data to focus on that particular asset. Figure 3 is a screen shot from the dashboard that MNAI provided to Markham. The full version can be accessed at go.greenanalytics.ca/Markham.

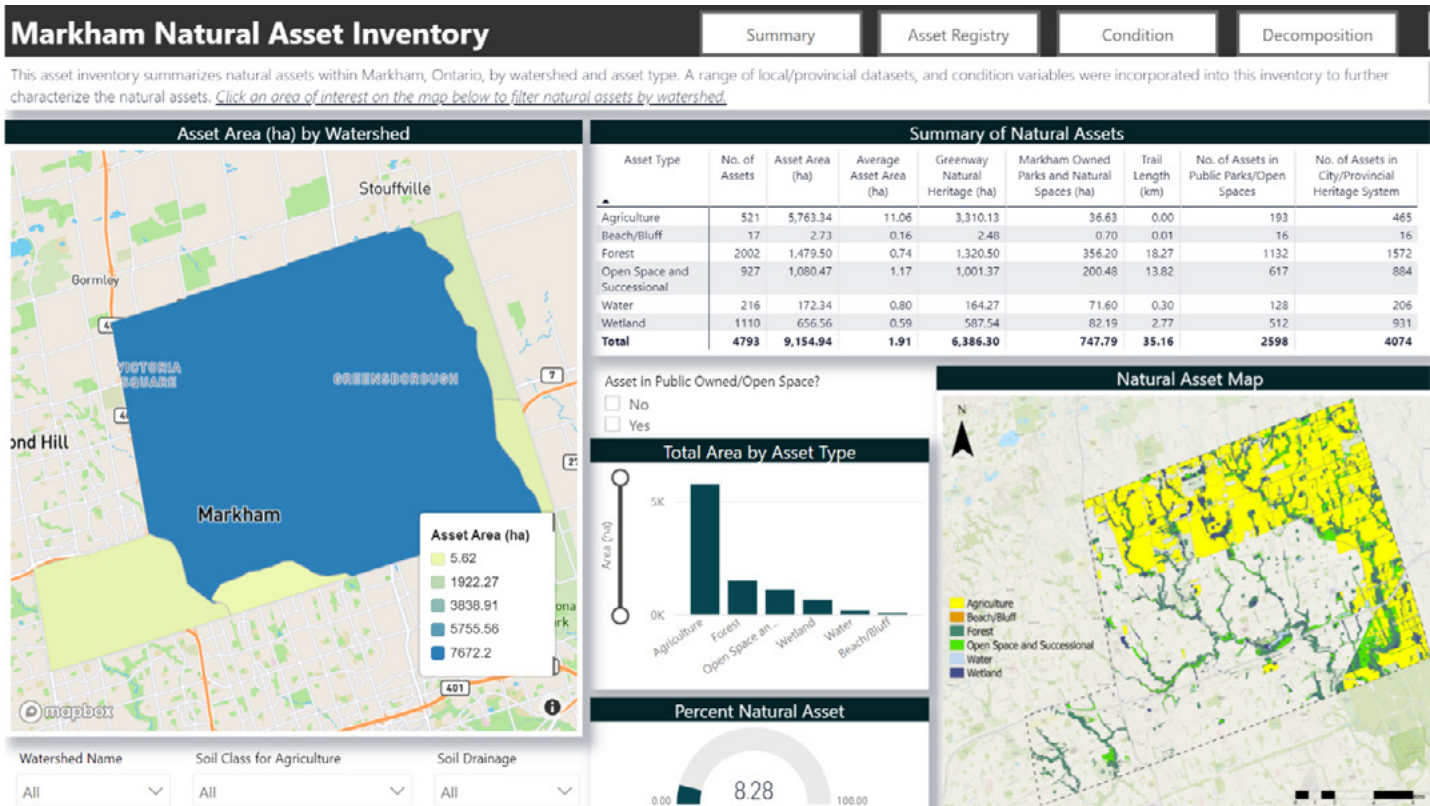


Figure 3: Screenshot of main inventory summary

4.5. Condition of natural assets

Documenting the condition of natural assets is a key aspect of natural asset inventories. A natural asset condition assessment provides an understanding of both the ecological health of natural assets, and the ability of natural assets to provide services. This information, in turn, can support the effective management of natural assets, be reflected in the registry and the dashboard, and updated over time.

MNAI completed a desktop-based condition assessment and built it into the inventory to provide an initial understanding of the status of the natural assets for Markham. Table 4 summarizes the condition assessment steps and indicators.

TABLE 4: CONDITION ASSESSMENT APPROACH AND INDICATORS

Indicator	Description & Methods for Quantification	Data used to Quantify Indicator
Relative asset size	For each natural and semi-natural asset type, total area is calculated and a rank is assigned to the assets within each class based on its percentile score. Natural assets within the top third of the ranking (e.g., the largest assets within a class) received a 3, those within the middle third of the ranking received a 2, and those within the bottom third of the ranking received a 1.	Natural asset inventory
Road density	Measures the density of the roads in and around the assets according to high density (assets with more than 2km of roads per square km), medium density (assets with between 1km and 2km of roads per square km) and low density (assets with less than 1km of roads per square km).	Natural asset inventory plus spatial representations of roads.
Surface permeability	The permeability of surfaces is ranked on a scale of nil to high depending on the type of landcover present. Urban areas, roads and industrial areas are ranked as nil. Assets within impervious surfaces are assigned as low permeability. Agriculture and shrublands are ranked as medium. Wetlands, waterbodies and forests are ranked as high.	Natural asset inventory, spatial representations of land uses and roads, as well as the Global Man-made impervious surfaces dataset from NASA data.nasa.gov/dataset/Global-Man-made-Impervious-Surface-GMIS-Dataset-Fr/dkf4-4bi3
Adjacent land use (nearest neighbours)	Considers the distance to, and the nature of, the area surrounding natural assets. Intense land uses (e.g., airports) in close proximity to natural assets result in a poor rating, while distant land uses that are less intense (e.g., agriculture) result in a good rating.	Natural asset inventory plus spatial representation of land use as well as intensity rankings of land uses.

Once conditions were allocated to each asset, an overall score was derived for the project area. The maximum possible score for an asset was 40, based on a possible 10 points for each of 4 categories:

- Road density as low (10), medium (5) or high (1).
- Surface permeability rated as high (10), medium (5), low (1), or nil (0).
- Adjacent intensive land use (0 for intense land uses, otherwise 10).
- Relative asset size where the largest 3rd areas receive 10, 5 for middle 3rd, and 1 point for the lowest 3rd.

The total condition score was then converted into a rating scale:

- **Good** - assets with a score of 30 or higher
- **Moderate** - assets with a score between 20 to 29
- **Poor** - assets with a score between 10 to 19
- **Very Poor** - assets with a score lower than 10

Figure 4 is a screenshot of the condition assessment results for Markham from the online dashboard.

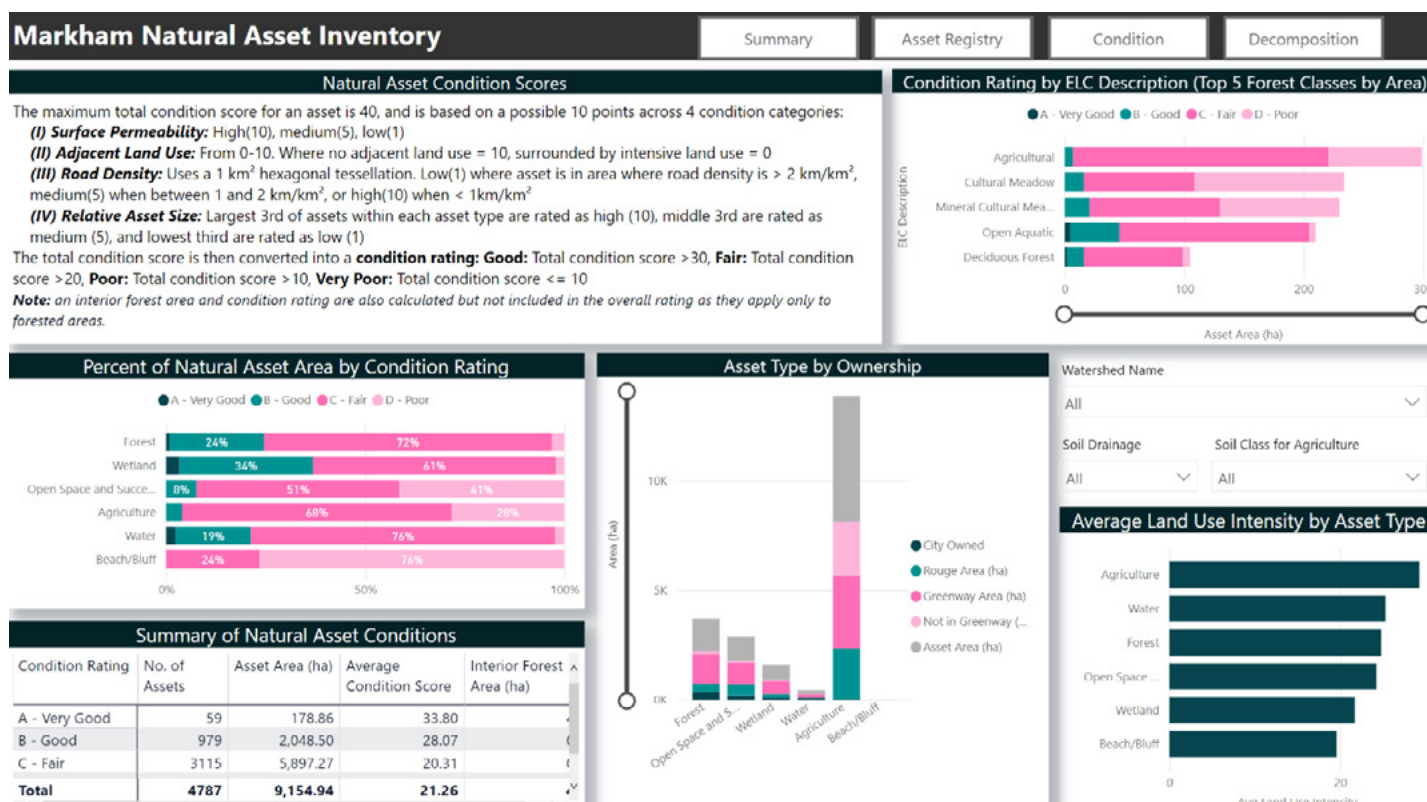


Figure 4: Screenshot of condition assessment results

About 179 ha (or 2 per cent) of natural assets were assessed in very good condition and 2,049 ha (or 23 per cent) were assessed in good condition.

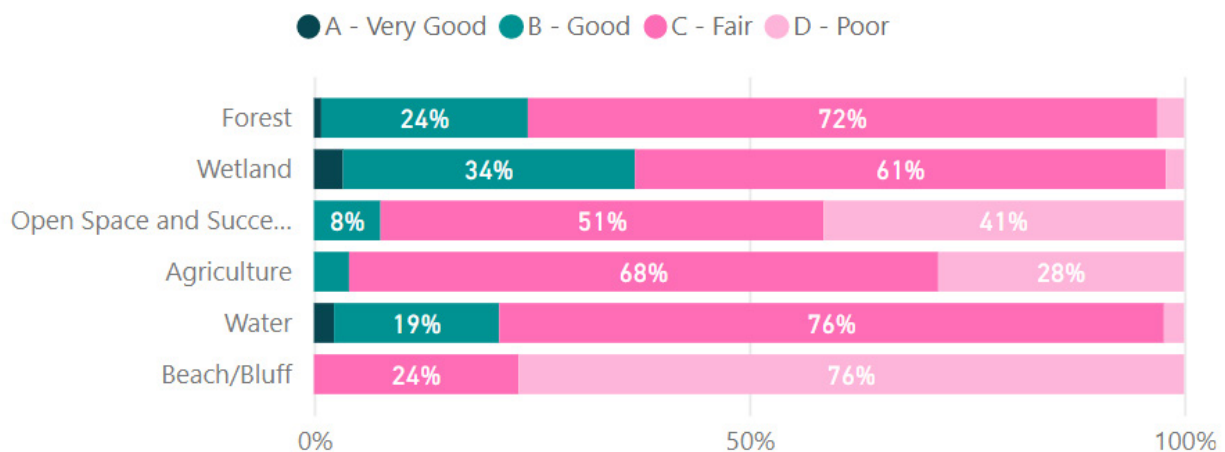
Forests and wetlands were largely rated fair. This is due to a combination of these assets being relatively small and in close proximity to dense roads.

Table 5 summarizes condition ratings and Figure 6 summarizes condition by natural asset type.

TABLE 5: SUMMARY OF NATURAL ASSET CONDITION RATINGS

Condition Rating	Number of Assets	Total Area (ha)	Average Total Score
Very Good	59	179	33.80
Good	979	2,049	28.07
Fair	3,115	5,897	20.31
Poor	634	1,030	14.21
Total	4,787	9,155	21.26

Percent of Natural Asset Area by Condition Rating

*Figure 5: Summary of condition rating by natural asset type*

4.6. Maintaining the inventory

Inventories are not static. Both the registry and the dashboard can be expanded as new information becomes available. For example, asset condition might improve as a result of restoration efforts or new studies may add insights on the condition of the assets. New data can be reflected in the asset registry and subsequently in the online dashboard as it becomes available. Furthermore, the level of desired detail may evolve as asset management readiness increases, or as areas of natural asset management focus emerge. However, inventories should grow in detail and sophistication only insofar as they remain aligned with the capacity of the communities to maintain them, and the uses to which they will be put. Their evolution and development should be a function of the monitoring, reporting and lessons of the asset management cycle and be driven by the imperative of ensuring sustainable, cost-effective delivery of services to the community, which is the core of asset management.

5 Risk identification

5.1. Risk identification tool overview

Identifying risks facing natural assets can help local governments prioritize management of natural assets. To this end, MNAI provides local governments with a tool entitled *Risk Identification Process in the Development of Natural Asset Inventories* and guidance in self-administering it.

Risk management is a four-stage process that includes risk identification, analysis of probability and consequence, development of risk mitigation strategies, and control and documentation. The use of the risk identification tool informs the first and second stages of risk management through the identification of top risks to natural assets and their associated services, and a high-level analysis of impacts and consequences.

Risk types relevant to natural asset management typically include:

- **Service risk:** the risk of an asset failure that directly affects service delivery.
- **Strategic risk:** the risk of an event occurring that impacts the ability to achieve organizational goals.
- **Operations and maintenance risk:** risks related to poor asset controls and oversight, which can lead to poor record-keeping and poor monitoring of asset.
- **Financial risk:** risks related to the financial capacity of Markham to maintain municipal services.
- **Political risk:** risks related to the nature of municipal politics.

5.2. Using the risk identification tool

Using the risk tool, Markham staff considered possible risks that the loss of natural asset functions could pose to built infrastructure, personal health and safety, and private property, including:

- Encroachment (dumping, mowing, extension of backyards from adjacent owners)
- Invasive species
- Development pressure (both legal and illegal impact or removal of natural assets)
- Recreational pressures
- Pollutant loading
- Natural processes (forest fire, flooding, erosion, drought, ice jams, storm)

- Lack of consistent monitoring and land management plans for public natural areas
- Political policy change

Each risk was then ranked low, medium or high according to the probability of an impact occurring, and the relative magnitude of its negative consequences. To assess impact and consequence, Markham considered four questions:

- 1/ what impact is likely to happen?
- 2/ what is the consequence of that impact happening?
- 3/ what can be done to mitigate the impact probability and/or consequence?
- 4/ what cues will signal the need for mitigation?

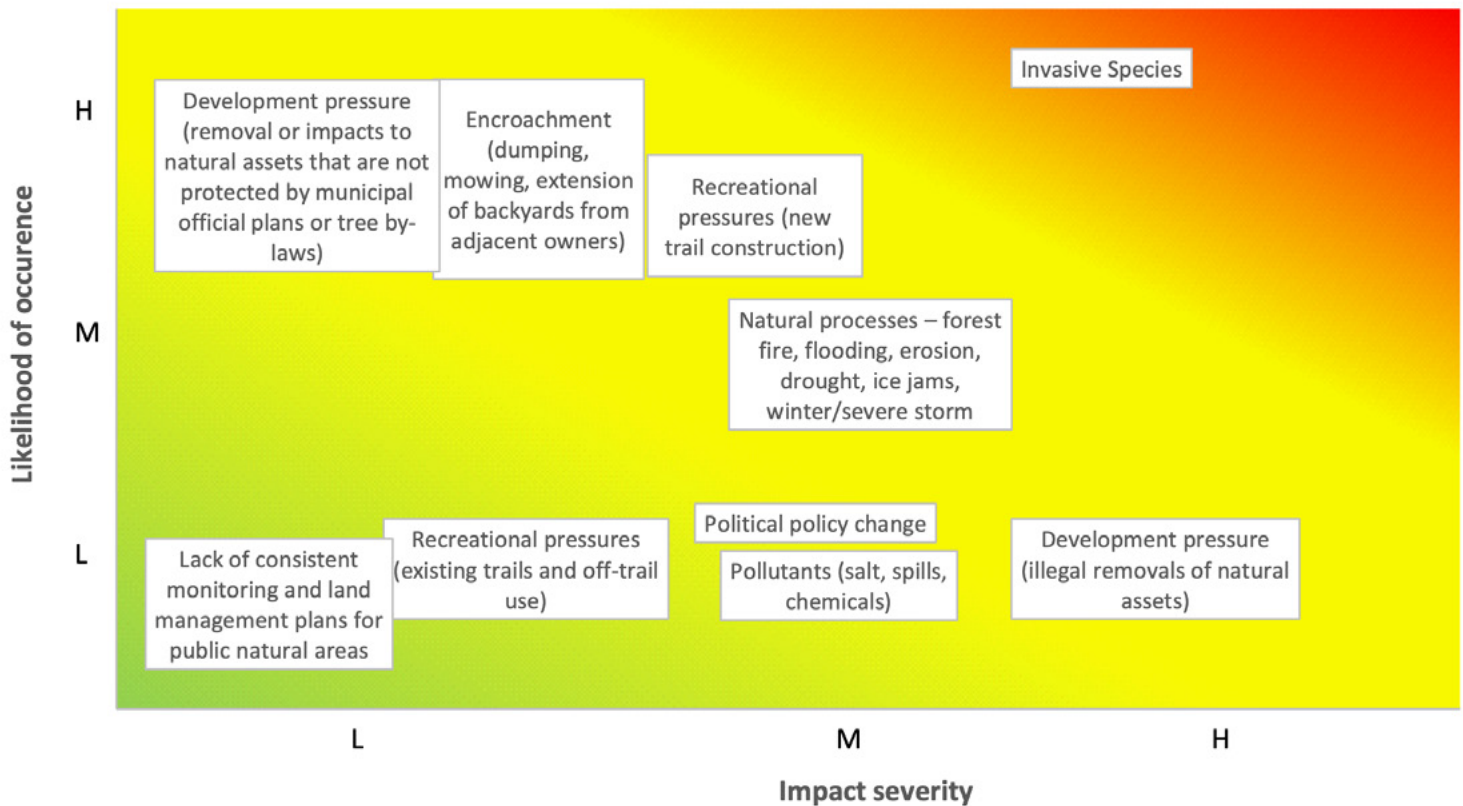
5.3. Results of the risk identification process

The risk identification process revealed:

- 1 high-level risk (*invasive species*)
- 6 medium-level risks (*encroachment, development pressure* - legal removal or impact to natural assets, *development pressure* - illegal removals of natural assets, *recreational pressures* - new trail construction, *natural processes*, and *political policy change*)
- 3 low-level risks (*recreational pressures* - existing trails and off-use trails, *pollutants*, *lack of consistent monitoring and land management plans for public natural areas*)

The identified risks affect natural assets across the entire area within Markham's boundaries, although northern portions of Markham have been identified as areas under heightened risk from development pressures.

Risk Matrix



Legend
Minor
Moderate
Major
Severe

Figure 6: Results of risk management process

6 Implications

This section provides insights that can be gained from considering both the inventory - including the condition and risk assessments - and the asset management readiness assessment. It is divided into (a) potential priorities for the local government (b) possible actions for the further development of the inventory, and (c) issues the community can consider to advance to a full natural asset management initiative.

6.1. Potential priorities for the local government

Combining the results of the condition assessment with the outcomes of the risk identification highlights potential priorities on which Markham could focus natural asset management efforts. These are:

- **Invasive species:** Invasive species were identified as a high-level risk that impacts natural assets throughout Markham. The presence of invasive species negatively impacts ecological function and, over time, the negative impacts can increase exponentially⁶. The Natural Heritage Inventory⁷ identified wide-spread presence of invasive species in Markham but noted they are not yet a dominating presence on the landscape. Mitigation on public lands include plans to undertake invasive species management, such as the one completed for Emerald Ash Borer, and monitoring new species. On private lands, Markham can consider education and outreach and landscaping standards for native plants⁸.
- **Encroachments:** Encroachments were identified as a medium-level risk. Markham has begun to quantify and identify the cumulative impacts of vegetation removal, backyard extensions, and illegal private structures on public land. Education, outreach and enforcement tools should be considered to rectify and address illegal encroachments.
- **Natural processes:** Natural processes such as forest fire, flooding, erosion, drought, ice jams and severe winter storms were ranked as a medium-level risk. Such events can impact natural assets throughout the municipality, as well as impacts to grey infrastructure. Currently, no mitigation measures have been identified. Given climate change projections of increased frequency and intensity of severe weather events, a climate adaptation plan that includes the role of natural assets is recommended.
- **Development pressures:** The illegal removal of, or impacts to, natural assets on private lands were identified as a medium-level risk, primarily in northern Markham. The probability of illegal removal or impact to natural assets is considered low, but consequences could be high, particularly if Markham relies on these assets for service delivery. Currently, illegal removal of protected natural assets is not recognized unless a planning approval is submitted, at which time restoration is required. While Conservation Authorities regulate alterations to wetlands, Markham's Official Plan also encourages that natural assets be acquired and brought into public ownership or conservation easements be considered for significant natural heritage features (see Chapter

6 *During an expansion phase when invasive species become dominant species, there is potential for unregulated exponential growth in abundance until their habitat is saturated. Source: Arim et al. (2006)*

7 *The natural heritage inventory is a component of the Natural Environment Report (City of Markham, 2020).*

8 *See for example Chapter 3 of Markham (2014).*

3 of Markham (2014). Such measures could be considered in the Don and Highland watersheds, where the condition assessment indicates restorative measures are needed.

TABLE 6: RISK MITIGATION STRATEGIES

Accept	Risk may be acceptable if probability and consequences are small
Minimize	Risk under local government's control that warrants exposure reduction
Share	Partners in a project permit the sharing of larger risks to reduce it for each
Transfer	Insurance, fixed price contracts, and other risk transfer tools

Table 6 lists and provides brief descriptions of risk mitigation strategies.

Opportunities to strengthen natural asset management at an organization-wide level

Markham is interested in identifying the necessary resources required to advance natural asset management based on the key learnings from the natural asset inventory. An important next step mentioned in the readiness assessment was to identify a department to champion this initiative, and training needs for natural asset management. To develop staff capacity in natural asset management, a next step could be to complete a staff competency review to identify required skills for natural asset management and to fill gaps.

The readiness assessment also pointed to the need to build awareness of the importance of natural asset management across the organization.

Trees are considered an asset class in Markham's corporate asset management framework, but natural areas are not. Thus, next steps could be to describe both the condition of natural assets and their performance in relation to service delivery and improving data for natural areas, particularly where critical natural assets have been identified. It will be important for Markham to identify data gaps that still exist in its natural asset inventory, including replacement values of key natural assets, their condition and the level of service they are providing.

Strengthening data and analysis in the above areas for natural assets will support Markham's goal of incorporating related considerations in asset management plans. It will also help ensure resources are allocated appropriately to regular monitoring and measurement of the ecological health of city-owned natural areas, which in turn helps ensure that resources are allocated to manage and protect them.

6.2. Possible actions for the further development of the inventory

Markham could consider the following, regardless of whether or not it pursues a full natural asset management process. These are mostly incremental measures.

- Expand the risk identification to include to field verification of results.
- Determine acceptable levels of risk to inform Markham's risk mitigation strategies (see Table 6).
- Further develop the condition assessment and risk assessment using local climate projections, land use modelling, and other data already at Markham's disposal.
- Based upon the above, develop a climate adaptation plan that includes the role of natural assets.
- Identify linkages between services and assets, and assess the condition of, and risks to, the assets from the perspective of their ability to deliver services.
- Share the inventory with adjacent local governments to stimulate collaboration.
- Initiate or enhance monitoring - for example, using gauges, water level sensors and loggers to improve understanding of trends, feed into condition ratings of assets, and gather information for modelling.
- Schedule regular updates (e.g., every 3-5 years) of the inventory, condition assessment and risk identification to understand trends.
- Maintain interest and momentum in natural asset management to move towards a full natural asset management project.
- Review progress against O. Reg. 588/17, Asset Management Planning for Municipal Infrastructure, including the requirement that municipalities provide summary-level information for each asset category in a municipal asset management plan (see MNAI 2019 for details).

6.3. Steps to a full natural asset management project

If Markham wishes to proceed with a full natural asset management project, including implementation, they would need to consider the following steps:

- 1/ Confirm scope, roles and responsibilities.** Undertake a meeting or workshop to confirm (a) assumptions [for example, that water management and development pressure are the primary services of concern] (b) roles, responsibilities and capacities (c) community capacity to undertake a larger project.

- 2/ Fill essential knowledge gaps.** If discussions on scope and certainty and related data needs for modelling indicate the need for additional data, these could be filled.
- 3/ Modelling.** Modelling the levels of service that natural assets currently provide, and the levels of service under different potential management, local climate change projections, and rehabilitation or restoration scenarios, is central to natural asset management as it gives communities the ability to explore how different actions will affect the health and corresponding performance of natural assets.
- 4/ Economic assessment.** The economic assessment component provides a market-based indication of (a) the current value of the services from natural assets if they had to be provided by an engineered means, and (b) the costs and values of different interventions in terms of service delivery.
- 5/ Planning.** This step allows local governments to explore different scenarios such as “what happens to the services provided by the wetland if there is significant building upstream?” or “what happens to the services if the forest is restored?” Using modelling, changes in service levels can be understood and quantified. Corresponding values can also be determined through continued economic assessment. Based on the foregoing, local governments can begin to consider and prioritize actions ranging from status quo to planning, regulatory, financial operations, maintenance, acquisition, and monitoring interventions.
- 6/ Implementation.** The natural asset implementation phase is part of an adaptive management cycle, not a finite journey. It is during this time that actions identified based on the previous steps can begin to be implemented. MNAI can provide ongoing advice / guidance on policy pieces and integration of the above information for 12-18 months. After this point, the local government, together with local partners and service providers, would ideally have the capacity to continue these efforts on their own.
- 7/ Ongoing monitoring.** Project monitoring is essential to learn whether interventions are working and to share lessons and learnings from other communities undertaking natural asset management. MNAI would typically stay involved with the community for three years through a monitoring arrangement to be established with the communities.

Sources

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Annex: Results of Markham's risk identification

This Annex contains the results of Markham's use of MNAI's risk identification tool, which they self-administered with guidance from MNAI. Table 1 was the main product, developed by Markham personnel, that resulted from the exercise.

Step 1: Identification of risks

Common Risks to Natural Assets:

- Overuse of trails/dumping
- Flooding (current and future)
- Forest fire
- Invasive species
- Development pressure
- Pollutant loading from urban, agricultural, or industrial sources (e.g., overuse of salt on roads)
- Drought (current and future)
- Erosion
- Ice jams
- Storm surge
- Lack of flood hazard mapping
- Lack of land management plans
- Lack of monitoring reports
- Construction activity
- Political policy change

Step 2: Complete survey

TABLE 1: SIMPLIFIED RISK IDENTIFICATION SURVEY

Risk	Ranking (L/M/H)	Assets Affected	Location	Notes
1/ Encroachment (dumping, mowing, extension of backyards from adjacent owners)	M	Publicly owned natural assets	Throughout municipality	<p>Likely to be hundreds of encroachments on city-owned natural areas; generally small in area.</p> <ul style="list-style-type: none"> ■ Probability: high ■ Consequences: low at each site, however cumulative impact needs to be considered <p>Potential future mitigation: education/outreach; detailed surveys for all city-owned natural areas; ongoing inspection programs; respond to resident complaints. Generally, mitigation is very labour-intensive and requires follow-up.</p> <p>Current mitigation: currently dealing with this by responding to resident complaints (reactive).</p>
2/ Development pressure (removal or impacts to natural assets that are not protected by municipal official plans or tree by-laws.	M	Privately owned natural assets	Primarily in Northern Markham	<p>Removal or impacts to natural assets that are not protected by municipal policies (e.g., meadows, hedgerows, agricultural fields)</p> <ul style="list-style-type: none"> ■ Probability: high ■ Consequences: low. It is assumed that removal of these natural assets are permitted. ■ Generally, impacts would be to natural assets that perform a lower amount of ecological function <p>Mitigation: n/a</p>

TABLE 1: SIMPLIFIED RISK IDENTIFICATION SURVEY

Risk	Ranking (L/M/H)	Assets Affected	Location	Notes
3/ Development pressure (illegal removals of natural assets)	M	Privately owned natural assets	Primarily in Northern Markham	<p>Removal or impacts to natural assets illegally.</p> <ul style="list-style-type: none"> ■ Probability: low ■ Consequences: high <p>Illegal removals of protected natural features are not recognized. Areas would generally be required to be restored before any planning approvals.</p> <p>Mitigation: n/a</p>
4/ Invasive species	H	All natural assets	Throughout municipality	<p>Impacts of invasive species.</p> <ul style="list-style-type: none"> ■ Probability: high ■ Consequences: Medium-high. Invasive species generally reduce ecological function of natural areas, but rarely eliminate all ecological function. Over time, negative impacts of invasive species increase at an exponential rate. ■ Natural Heritage Inventory (2020) identified invasive species as a wide-spread threat, but not as a dominating presence. Level of invasive species is lower than other GTA municipalities. <p>Mitigation: on public lands – undertake invasive species management; monitoring new invasive species that may establish</p> <p>Mitigation: on private lands – education/outreach; provide technical assistance</p>

TABLE 1: SIMPLIFIED RISK IDENTIFICATION SURVEY

Risk	Ranking (L/M/H)	Assets Affected	Location	Notes
5/ Recreational pressures (existing trails and off-trail use)	L	Public natural assets	Throughout municipality	<p>Probability: low</p> <p>Consequences: low</p> <p>Off-trail uses have not been widely reported; there are some informal foot paths, but the impact to natural areas is relatively low at this time.</p> <p>Mitigation: monitor and identify potential off-trail use in sensitive areas</p>
6/ Recreational pressures (new trail construction)	M	Public natural assets	Throughout municipality	<p>Probability: high</p> <p>Consequences: low – medium.</p> <p>Consequences will depend on the mitigation. Trails should be carefully designed to avoid sensitive areas. Restoration should occur to offset any negative impacts such as vegetation removal.</p> <p>Mitigation: ensure environmental studies are completed and that best practices are employed to avoid sensitive areas and to provide for a net environmental benefit through replanting and restoration</p>
7/ Pollutants (salt, spills, chemicals)	L	All natural assets	Throughout municipality	<p>Probability: low</p> <p>Consequences: low – high.</p> <p>Depends on the amount of type of pollutants. Generally, spills are accidents that cannot be mitigated beforehand. The impacts of salt use is not well understood; however, impacts to aquatic wildlife is present.</p> <p>Mitigation: n/a</p>

TABLE 1: SIMPLIFIED RISK IDENTIFICATION SURVEY

Risk	Ranking (L/M/H)	Assets Affected	Location	Notes
8/ Natural processes – forest fire, flooding, erosion, drought, ice jams, winter/severe storm	M	All natural assets	Throughout municipality	<p>Probability: medium Consequences: low – high.</p> <p>These are natural processes. There may be impacts to grey infrastructure through these processes (e.g., erosion to existing sewers). Previous ice storms (Dec 2013) impact on trees and woodlands.</p> <p>Mitigation: not available</p>
9/ Lack of consistent monitoring and land management plans for public natural areas	L	Public natural assets	Throughout municipality	<p>Currently, the understanding of natural asset condition is based on anecdotal information through staff experience and knowledge. Currently, natural areas are left alone to “go wild” and lack of a consistent monitoring of ecological values is not a threat or risk. Should natural assets be relied upon to provide a certain municipal service or a minimum ecological condition be required, lack of monitoring and management plans may become a greater threat</p>
10. Political policy change	M	All natural assets	Throughout municipality	<p>Probability: low Consequences: low – high</p> <p>Land values in Markham increase the probability of policy changes to the detriment of natural assets. Consequences are an unknown</p>

Municipal Natural Assets Initiative

