

Cumulative Effects Assessment Best Practices Paper for Below Water Table Aggregate Operations within the Grand River Watershed

May 07, 2009

Preamble

In Ontario, aggregate extraction is governed by the Aggregate Resources Act (ARA). The Ministry of Natural Resources (MNR) is responsible for the implementation and enforcement of the ARA.

The geologic conditions found in the Grand River watershed combined with the economic health of the region and the proximity to the Greater Toronto Area makes the watershed one of the most important and productive sources of aggregate in the Province.

Approximately 975,000 people currently reside within the Grand River watershed, the majority living in the cities of Kitchener, Waterloo, Cambridge, Guelph and Brantford. About 3 percent of the land use is urban, 79 percent is rural and agricultural and 18 percent is natural area. The watershed represents a diverse area, ranging from intense agricultural production to large, and rapidly expanding urban areas.

Approximately 82 percent of the population of the Grand River watershed relies on groundwater for water supply, while the remainder depends on surface water sources, mostly the Grand River. The City of Brantford and the Six Nations of the Grand River Territory extract 100 percent of their domestic water supply from the Grand River.

According to the 2006 census, the Regional Municipality of Waterloo was the fourth-fastest growing urban area in the province, with a growth rate of nearly nine per cent between the years 2001-2006. The *Growth Plan for the Greater Golden Horseshoe*, released by the province in 2006, anticipates continued high rates of growth and intensification of use in the watershed's cities over the next 25 years. With the recent economic downturn and the ensuing emphasis on infrastructure renewal and development, there may be an increase in demand for aggregate resources.

The wise management of all of the natural resources in the watershed is essential to ensure a sustainable and healthy watershed which continues to meet the ongoing needs of a growing population.

Given the importance of water quality and water quantity to the health and well-being of watershed residents as well as the natural ecosystem, the nature and extent of cumulative effects related to aggregate extraction were raised as potential concerns by the Grand River Conservation Authority (GRCA) in 2005 after receiving requests from the Townships of North Dumfries and Puslinch. At that time, the two municipalities asked the Grand River Conservation Authority to *support the Resolutions of the Townships of North Dumfries and Puslinch and that the GRCA request support from the Grand River Watershed Municipalities for a moratorium on the extraction of aggregate below the water table until such time as appropriate studies have*

been completed on the cumulative effect on the water table on critical ground water and surface water resources.

GRCA staff were directed by their Board members *to work with the Ministry of Natural Resources and the aggregate industry to develop a plan that avoids the issuing of any new licences for aggregate extraction below the water table and avoids amending any existing licences to allow aggregate extraction below the water table in the Grand River watershed until a study identifying the cumulative impact of aggregate extraction below the water table is conducted and an aggregate extraction strategy that minimizes the impact on the watershed's water resources is developed.* Furthermore, the GRCA members requested: *1) that MNR and MOE secure the appropriate resources and funding to conduct the study and lead the multi-stakeholder initiative, 2) that MNR involve the GRCA, watershed municipalities, Ontario Stone Sand and Gravel Association (OSSGA), the aggregate industry and the public in this study; and 3) that the GRCA request that the proposed Source Water Protection Committee consider the impacts of aggregate extraction below the water table in developing the Source Protection Plan for the Grand River watershed (Res. No. 126-05).*

Subsequently, the GRCA, MNR and the OSSGA met to cooperatively address the concerns of the GRCA Board. After some discussion and preliminary analysis, the feasibility of undertaking a cumulative effects assessment for the entire Grand River watershed was re-evaluated for a number of reasons including lack of resources, data and science required to conduct a comprehensive study. Instead, a set of principles to guide future dialogue and action was developed collectively by representatives from MNR, OSSGA and the Grand River Conservation Authority and are included in Appendix A. The principles include: 1) the importance of water and aggregate resources to the Grand River watershed, 2) the need for more comprehensive and consistent data collection protocols in order to assess cumulative impacts on a subwatershed basis and ongoing monitoring, and 3) a commitment by the MNR to work cooperatively with the GRCA and the aggregate industry to develop a best practices guide for assessing and addressing cumulative effects. These principles were accepted by the GRCA in 2007 (Res. No. 149-07). At that time, the GRCA members requested that MNR include opportunities for watershed municipalities and the public to review and comment on the best practices guide and be encouraged to complete this work as quickly as possible.

This draft best practices guide has been developed collaboratively by representatives of the MNR, GRCA and OSSGA in the spirit of the agreed-to principles for addressing aggregate extraction below the water table in the Grand River watershed.

This paper was developed for the purpose of addressing cumulative impacts from below-water sand and gravel (aggregate) extraction developments within the Grand River watershed.¹ The concepts presented here are specific to the Grand River watershed and are not inherently transferable to other watersheds which may have different geological, hydrogeological and hydrological characteristics.

It is important to note that this draft paper outlines a general direction and process for assessing cumulative effects of aggregate extraction below the water table in the Grand River watershed.

¹ While this paper was developed for sand and gravel operations, these concepts may be cautiously applied to quarry operations. Quarry operations however, typically undergo a much more comprehensive assessment due to the complexity of bedrock geology and the common activity of dewatering during operations.

Comments from watershed municipalities, other agencies, aggregate producers, non-government organizations and the public regarding this general approach will be used to refine this draft paper as necessary and to develop an implementation plan.

Since the assessment of cumulative impacts represents an evolving science, MNR, OSSGA and the GRCA have agreed to revisit the approach on an annual basis to evaluate its effectiveness and to consider modifications as new information becomes available and as accepted methodologies develop.

1.0 Introduction

The Grand River watershed is experiencing many pressures that impact water quality and water quantity. These pressures include population growth, shifting land uses and climate change. Over 975,000 residents within the Grand River watershed rely on surface and groundwater sources for their water needs. The central watershed has high quality aggregate resource deposits and landform features that act as important groundwater resources and recharge/discharge zones (e.g. some moraines and outwash deposits). These aggregate deposits are also the mainstay of construction activity within the watershed. Under the ARA and Provincial Policy Statement (PPS), consideration must be given to protecting these resources and making them available as “close-to-market” supplies. By not supporting a “close to market” system, there is a potential to increase environmental and economic pressure as a result of hauling aggregate from more distant sources.

Given this background, it is important to assess the potential cumulative effects of aggregate extraction below the water table on water quality, quantity and ecosystem health from the site scale to the subwatershed scale using sound scientific principles and experience. In addition, the full life cycle of the operation needs to be considered so that appropriate development plans, mitigation measures, and, in some cases, avoidance can be identified and implemented.

This draft best practices guide has been prepared as a joint effort between the GRCA, the MNR, and the OSSGA and specifically applies to **priority subwatersheds** in the Grand River watershed. The purpose of this draft best practices guide is to outline a reasonable, consistent and scientifically-defensible approach to assessing potential cumulative effects of aggregate extraction below the water table (both new operations and expansions to existing operations) as part of the MNR review/approval process under the ARA.

Cumulative effects are defined in the herein accepted principles as “*the combined environmental effects or potential environmental effect of one or more development activities, including natural resource utilization or extraction, in a defined area over a particular time period*”. Cumulative impacts may occur simultaneously, sequentially, or in an interactive manner.

Where multiple activities occur in relative proximity to each other there is potential for individual site-specific effects to overlap and combine with the effects of other activities. This cumulative effect may contribute to environmental degradation. An assessment of cumulative effects needs to occur over multiple scales (e.g. from the local to subwatershed scale) and time frames, in part dictated by the scale and scope of the potential impact.

Priority subwatersheds within the Grand River watershed are subwatersheds where:

- The potential for significant aggregate extraction below the water table is high but extraction has not yet occurred or has occurred on a limited basis, or
- The subwatershed has significant aggregate extraction occurring below the water table and data is available or could be made available (by enhancing existing monitoring) for analysis.

This paper outlines the process an applicant is expected to follow for the assessment of cumulative impacts associated with proposed below water table extraction in the priority subwatersheds identified in Appendix B.

Cumulative effects assessment is good professional practice and should occur as part of the ARA and Planning Act application review processes. Where site specific activities occur in relative proximity to each other, the applicant has a direct responsibility to assess their proposal taking into account other existing and future land uses in the local area. These requirements are set out in Section 2.2 of this guide. The proponent may also be required to put the effects of their proposal into a subwatershed context as set out in Section 2.3 of this guide.

This draft Best Practices Paper represents a general approach to cumulative effects assessment associated with below water aggregate operations and includes guidance for initial screening, data collection, monitoring protocols, groundwater modeling, mitigation and data sharing.

The appropriate scale to collect and analyze data and determine cumulative effects assessment includes both the local and subwatershed levels. The review and/or collection of data at appropriate locations and over an appropriate time frame are essential in order to establish a baseline from which to measure the impacts of changes in land use activities. Where available, recent subwatershed studies, other regional studies, and source water protection water budget analyses may provide useful baseline information.

In each subwatershed, there are a wide variety of land uses that combine and contribute to the overall water balance, such as agricultural and golf course irrigation, urban development, municipal water takings, industrial water use and aggregate extraction. Changes to the land use patterns in the subwatershed can in turn induce changes in the overall water balance to various degrees, both positive and negative.

With regards to below-water sand and gravel extraction, potential effects on water resources (quantity) can typically arise from a combination of three things:

- The dredging operation itself, where groundwater and precipitation replaces the sand and gravel that is extracted from the pit pond;
- Evaporation from the pit pond and other processing operations (e.g., a washing plant), which can be somewhat greater than the evapotranspiration from the land surface prior to extraction; and
- The levelling of the groundwater table across the pit pond, which can create adjustments in adjacent areas.

With regards to below-water sand and gravel extraction, the following water quality parameters should be considered:

- Temperature;
- Biological (nutrients);
- General chemistry

The hydrogeological studies required in support of a licence application or amendment under the ARA currently characterizes these effects for each site. Through the use of this paper, hydrogeological studies will now require incorporation of a cumulative effects assessment in priority subwatersheds where two or more pits are operating in close proximity, or where it has been determined that there may be broader cumulative effects at a watershed scale.

Further to this statement, the MNR and OSSGA will work with existing licensees to encourage their participation in the approaches outlined by this guideline.

The overall assessment of cumulative impacts of all types of development within a subwatershed (where aggregate extraction is only one of several types of land uses), is best addressed at the subwatershed or watershed scale and is beyond the scope of these guidelines which establish application specific requirements. Where Subwatershed Plans² are being undertaken, pit operators and other land owners or stakeholders may be requested to participate in the Study and provide funding support.

2.0 Assessment of Cumulative Effects Related to Aggregate Operations Below the Water Table in the Grand River Watershed

The cumulative effects assessment has several components. The assessment must primarily place the site in context with the surrounding landscape. In most cases, this should be based on the local subwatershed as a basic geographical unit. The level of subwatershed considered (i.e. secondary, tertiary, quaternary, etc.) in relation to the application needs to be established. To make this determination, an *initial assessment* should be undertaken including an evaluation of the *spatial*, *temporal*, and *incremental* effects.

Further to this, *data collection* needs must be addressed. Subsequent to data acquisition, other requirements including *monitoring programs*, *survey data*, *reporting format* (i.e., common database), and use of *groundwater modelling* applications (if warranted) for the assessment need to be outlined. Also, a consistent protocol for *monitoring effects and taking potential mitigative action* will be required.

² A subwatershed plan is a technical report which describes how water, groundwater, streams, terrestrial and aquatic ecosystems function within a defined drainage area and recommends strategies and targets which protect, restore and enhance water resources and natural systems before major land use changes take place.

Finally, if cumulative effects are to be properly assessed, **data sharing** amongst aggregate producers and regulatory authorities will be necessary in order to obtain a comprehensive view of groundwater/surface water effects in the subwatershed.

A discussion of these issues is provided below.

2.1 Initial Assessment

The initial assessment should be carried out in consultation with the MNR, Ministry of Environment (MOE), local municipalities and the GRCA; however, additional sources of information such as from nearby aggregate operations and other studies should also be investigated. Points to be considered include the following:

- Description of existing site(s) under consideration.
- Whether there is the potential for multiple below water aggregate extraction operations in relative proximity (for the present, these areas will include the 11 pilot subwatersheds identified in Appendix B).
- The proximity to existing above and below-water aggregate extraction operations and potential for overlapping cumulative effects including changes to surface water drainage patterns and water balance.
- The proximity to aggregate operations are approved or proposing to extract aggregate from below water table (but not yet doing so).
- The degree of environmental degradation (ground water/surface water quantity and quality, impacts on natural features and function; ecosystem health) currently existing within the subwatershed. Some of this information may be available from the GRCA, local municipality, MOE or MNR.
- The existing degree/level of subwatershed stress and the affect that the proposed below water aggregate operation would have on the overall stress assessment. The existing stress assessment information may be available from the GRCA, as part of their water budget analysis conducted through the MOE's Source Water Protection Program. Because of the new application, it may be appropriate that the proponent work with the GRCA to re-assess the potential subwatershed stress level (in accordance with MOE Source Water Protection Program guidelines and rules).
- Other activities or features in the study area that could significantly affect or rely on groundwater resources (e.g. water supply systems, water bottling operations or coldwater fisheries) that may need to be considered in the cumulative effect assessment.
- Proximity to municipal water supplies and water intakes.
- The vulnerability of the groundwater resources in the subwatershed and the effect, if any, that the proposed below water table aggregate operation may have on vulnerability.

Once screening and scoping is completed, the cumulative effects assessment for aggregate applications should be dealt with at two scales: local and subwatershed as set out below.

2.2 *Local Scale Cumulative Effects*

Responsibility for assessing local-scale cumulative effects regarding new applications largely rests with the individual aggregate producers in accordance with an ARA application, with review by the GRCA, other agencies (i.e. MOE and Fisheries and Oceans Canada (DFO)), and MNR. The concept of what is “local scale” needs to be dealt with on a site-by-site basis, although it is generally implied that “local scale” would be the area affected or with reasonable potential to be affected by the proposed operation. The “local scale” may not be limited to property boundaries.

A local-scale cumulative effects assessment should include four basic components:

1. Characterize the existing conditions under current approvals, including current, future, and rehabilitation stages;
2. Assess the potential impacts to groundwater and surface water resources from the proposed operations relative to the impacts of the existing operations for all development stages.
3. Establish monitoring requirements to identify and distinguish individual and cumulative effects, as appropriate.
4. Establish a plan to implement mitigation measures as appropriate.

The ARA Provincial Standards set out requirements for Level 1 and Level 2 hydrogeological studies for below-water pits. Understanding of the major elements of local-scale cumulative effects can be attained based on technical assessment of the following items, namely

- waterwells;
- springs;
- groundwater aquifers;
- surface water courses and bodies; and
- discharge to surface water.

These are items that could be subject to hydrogeological effects related to below water aggregate extraction. Any of these above items should further be dealt with as detailed in the Provincial Standards, namely:

- monitoring and management plans;
- mitigation measures including trigger mechanisms, if necessary; and
- contingency plans.

The responsibility for local-scale cumulative effect assessment should be based on the order of applications and approvals. In other words, each successive applicant should address any overlapping effects between their proposal and any existing pits or quarries in the same geographic area. There is a possibility of multiple applications being received within the same time frame and these application scenarios should be dealt with on a case-by-case basis.

The cumulative effects assessment should consider effects from both a spatial and a temporal perspective. Spatial effects would consider where effects from a proposed aggregate operation would overlap with those from another nearby aggregate operation. This could include overlapping zones of influence and resulting potential effects such as water well drawdown, wetland hydroperiod alterations, surface water levels, stream baseflow, groundwater upwelling, etc. as well as thermal and chemical impacts on surface water and groundwater.

Temporal effects should consider where the operational effects overlap in time and duration. The applicant must not solely consider cumulative effects resulting from the current conditions at adjacent pits and quarries, but also those that could reasonably be expected to occur in the future (according to site plans or other available information) at different stages of each site's operation and rehabilitation. It must be recognized that it may not be possible to obtain all the desired information regarding other operations and reasonable assumptions may need to be used.

2.3 Watershed/Subwatershed Scale Cumulative Effects

The appropriate scale for this assessment is typically the quaternary-level watersheds (e.g., Mill Creek watershed). A broader scale approach may be required if the proposed aggregate operation drains directly to a higher-level watershed or if reasonably-anticipated potential cumulative effects are likely to occur at a broader scale.

Each successive applicant for a below-water aggregate extraction licence or amendment will be expected to provide as part of its hydrogeological assessment, information and analyses that will place the effects of their proposal on the annual, and seasonal water balance into a watershed context (or sub-watershed, as deemed appropriate). This should entail a comparison of the pre-extraction, operational and post-rehabilitation water balances for the site, making estimates in each case for precipitation, evapotranspiration/evaporation, run-off and infiltration/recharge. The net gain or loss in the water budget for the site should then be identified and characterized by a comparison to the average annual, and/or seasonal rate of discharge flow from the watershed, where the data are available or can be reasonably estimated. The GRCA and MNR should be consulted for access to the most current watershed flow gauging data for this purpose.

Furthermore, each successive applicant should prepare an inventory of other below-water aggregate extraction operations in the same subwatershed (either licenced or with an active licence application) and prepare an estimate of the cumulative net gain or loss in the annual water budget for all aggregate extraction activity. This estimate should be based on each site at its full operational size (i.e., maximum open water exposure, usually at the end of operations). The analysis will ideally be based on the water balance prepared for each site by its owner as part of its application. Access to this information will be facilitated through the MNR. However, where no water balance has been previously prepared for a site, the applicant is expected to make a reasonable estimate based on its own water balance assessment (e.g., by proportion of open water area, or similar).

The GRCA will evaluate the cumulative effects assessment provided by the applicant with respect to any thresholds that have been established for minimum flow in the watershed considering all of the various water takings and uses, and make a recommendation to the MNR

as part of its comments on the licence application on the acceptability of the cumulative effects at the watershed scale. Where minimum flow thresholds have not been established, the GRCA should make a recommendation to the MNR based on the likely significance of the cumulative effects to watershed flow. In either case the GRCA should also comment on how the cumulative effects and the proposed monitoring program for the site (see later sections in this paper) should be incorporated into any ongoing watershed monitoring programs for verification. The GRCA may recommend to the MNR that additional gauging stations be established for the watershed where insufficient data exists for this purpose.

In the event that the cumulative effects within the watershed are deemed to significantly affect minimum flow thresholds in the watershed, then the applicant should develop and propose a staged contingency plan, or mitigation plan (similar to the current low water response program), in collaboration with the GRCA, MOE, watershed municipalities, and other water takers in the watershed.

3.0 Other Assessment Considerations

3.1 Data Collection

Data collection is one of the most important aspects of a cumulative effect assessment. Data collection efforts are needed to **support assessment of the following two components.**

1) The water quantity (ie. water balance) component should assess the following, as appropriate:

- Interference to municipal or private wells;
- Lowering of the water table (temporary, seasonally, yearly);
- Quantity of groundwater discharging to or recharging from surface water features including, but not limited to, ponds, streams, wetlands, and springs / seeps;
- Effect of water taking and changes in hydraulics from aggregate washing, inflow due to aggregate removal;
- Changes in the quantity or pattern of groundwater recharge and discharge;
- Change in hydraulics from the creation of surface ponds;
- Effect of permanent surface ponds on surface water or groundwater quantity.

2) The water quality component should address the following, as appropriate:

- Changes in groundwater/surface water temperature, chemistry and biology (i.e. nutrients);
- Degradation of groundwater/surface water due to changes in the ability of the water resources to assimilate contaminants (i.e. decrease in the ability of ground/surface water to assimilate contaminants due to changes in flow and temperature);
- Changes in the vulnerability of groundwater resources; and
- Effect of the anthropogenic creation of ponds on existing surface water or groundwater quality or temperature.

3.2 *Establishing a Monitoring Program*

Of particular importance to the assessment of potential cumulative effects is the coordinated collection and storage of data between and among aggregate operators and the various agencies. The complexity of assessing potential cumulative impacts is increased where data are referenced to different benchmarks, established using different coordinate systems, collected at different times or at different frequencies, or collected using different methodologies.

The following steps are proposed as a method of allowing agencies to create and maintain a common monitoring database. Where possible, the existing databases of the agencies and aggregate operators should be reviewed for their potential to aid in the assessment of potential cumulative effects.

- **Select Monitoring Area**

The monitoring area will be defined taking into account the area potentially affected by existing and proposed mineral aggregate operations. The monitoring program should be designed to detect impacts to the groundwater and surface water systems. Collection of data at appropriate locations throughout the monitoring area should commence prior to extraction taking place in order to establish a baseline from which to measure the nature and extent of change.

- **Establish a Common Survey Datum**

A common survey datum, NAD83 (or as may be updated), would be established so that new data collected can be easily compared. Where possible, data collected as part of existing operations should be converted to the common datum.

- **Create a Common Data Collection Database**

A standardized digital relational database should be developed that sorts and merges all new data from all new sites by category type. The design will need to accommodate all monitoring points, all categories of data and different data collection scheduling (frequency), and should be able to integrate historical data as well. Use of a common database will facilitate comparisons between sites for the purposes of cumulative effects assessment.

- **Synchronization of Monitoring Events and Streamlining Data Collection Points**

A data collection schedule should be coordinated amongst the various aggregate operations so that data is collected on a synchronous basis. Monitoring requirements could also be streamlined where duplication of data collection occurs (i.e. a monitoring point on one site may be very close to a similar point on an adjacent site).

- **Data Collection**

Synchronized data from each operation would be collected, compiled, reduced as needed and merged with the historical data in the newly created Standardized Digital Data Collection

Database. The data could then be used by agencies, operators and the local municipality to assist in any assessment of the groundwater and surface water regime.

- **Data Sharing/Access**

Access to the common database should be streamlined to ensure ready and reliable access to all relevant data.

3.3 Use of Groundwater Models

The use of numerical groundwater, surface water, or integrated models is one method to quantitatively predict potential cumulative effects. Numerical modelling may be particularly useful in areas with a heavy concentration of existing operations and/or sensitive areas with a lower tolerance for environmental impacts.

Modelling activities could be conducted at either or both of the study scales if/where it is required. At the site-specific study scale, it is likely that the proponent would develop a new (or adapt an existing) detailed site-specific model to address the proposed site and cumulative effect assessment analyses. At the broader scale, the GRCA or local municipality may have an existing model that is applicable.

3.4 Monitoring Effects and Taking Mitigative Action

Interpretation of the monitoring data will have to be conducted to determine if changes to the groundwater and surface water systems represent an impact that warrants mitigative action. If mitigative action is deemed necessary, it will by necessity, have to be on a site-by-site basis and must be, at a minimum, consistent with the conditions specified in the operators existing Permit To Take Water (PTTW), should one exist. Such action could include (but not be limited to) additional monitoring, a change in extraction methods, a change to extraction phasing (as defined by the site plan but would require a minor amendment), or possibly cessation of water takings that have been shown to have an impact that cannot be mitigated effectively. This process (impact and mitigation) would be governed by the adaptive management plan developed in consultation with all parties involved.

3.5 Data Sharing

Each applicant that is required to address cumulative effects should provide sufficient documentation in the hydrogeological assessment to permit subsequent applicants to extend the cumulative effects assessment, as necessary. Furthermore, any ongoing monitoring data necessary to characterize and confirm the extent of cumulative effects should be shared (preferably in a consistent and common database) so that both agencies and other operators/applicants can address cumulative effects issues.

Similarly, all potentially-relevant agency data should be shared in a consistent and timely manner to ensure the best and most current information is available to all parties.

APPENDIX A

PRINCIPLES

Ontario Ministry of Natural Resources/Grand River Conservation Authority/OSSGA June 22, 2007

1. Water is an essential resource. The Grand River watershed faces many pressures which impact water quality and water quantity, including population growth, shifting land uses and climate change. Most of the water supply for watershed residents is from surface and ground water. Therefore, it is important that water be protected and managed effectively in order to meet human needs and maintain ecosystem health.
2. Aggregate resources are an essential economic resource to the Province of Ontario and should be protected and made available from close-to-market deposits. Use of close-to-market resources has environmental and health benefits as compared to hauling aggregate from more distance sources.
3. In the Grand River watershed, there is an overlap of significant high quality aggregate resource deposits and landform features that are important for ground water recharge (e.g. some moraines and outwash deposits). It is important to determine the impacts of aggregate extraction below the water table on water quality and quantity and ecosystem health from the site to the subwatershed³ scale over the full life cycle of the operation so that appropriate avoidance or mitigation measures can be identified and implemented.
4. Ontario has comprehensive legislation and policy in place that governs the review of proposals for aggregate extraction. In order to be approved, proposals for aggregate extraction below the water table must demonstrate that water resources will be protected and that potential impacts will be avoided or mitigated at geographic scales from the site to the subwatershed scale.
5. Review of potential impacts associated with aggregate extraction below the water table should be based on sound scientific principles and experience. Appropriate data collection and ongoing monitoring is a critical component of a science-based approach.

³ A subwatershed means a subunit of a watershed, often defined as the drainage area of a tributary of a watercourse. www.waterfronttrail.org/library-glossary.html

6. An appropriate scale to collect data and determine impact is the subwatershed. The collection of data at appropriate locations throughout a subwatershed is important in order to establish a baseline from which to measure the nature and extent of change as a result of various land use activities. There should be enough data collection points in order to establish change as a result of aggregate extraction or other land use activities.
7. It is appropriate to focus data collection and cumulative⁴ impact assessment in subwatersheds within the Grand River system where:
 - The potential for significant aggregate extraction below the water table is high but extraction has not yet occurred or has occurred on a limited basis, or
 - The subwatershed has significant aggregate extraction occurring below the water table and data is available or could be made available (by enhancing existing monitoring) for analysis.
8. MNR will work cooperatively with the GRCA and the aggregate industry to develop a guide to cumulative impact assessment and best practices from the site to the subwatershed scale. This guide will provide a vital analytical tool for evaluating the potential cumulative impacts of new aggregate extraction below the water table and expansions of existing operations below the water table, for identifying the best avoidance and mitigation measures from the site to the subwatershed scale, and for monitoring results. MNR will encourage and advise applicants of the benefits of completing a cumulative impact assessment when applying for new aggregate extraction and expansions of existing operations below the water table in the Grand River watershed.
9. MNR, GRCA and other experts will examine existing data and monitoring programs and suggest alterations to ensure consistent and reliable collection procedures, methods, and reporting protocols in support of cumulative impact assessment. MNR will work with the aggregate industry to develop a standard protocol for providing electronic information.
10. Monitoring is important for identifying whether or not avoidance or mitigation measures are effective and for identifying corrective actions if problems are encountered. MNR and the aggregate industry will continue to work cooperatively to ensure that monitoring data is available and accessible to inform future decision-making from the site to the subwatershed scale.

⁴ Cumulative impact means the combined environmental effects or potential environmental effect of one or more development activities, including natural resource utilization or extraction, in a defined area over a particular time period. Cumulative impacts may occur simultaneously, sequentially, or in an interactive manner.

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APPENDIX B



GRAND RIVER WATERSHED PRIORITY SUBWATERSHEDS

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**Figure B-1
Aggregate Resources
of the
Big Creek
Subwatershed**

Legend

-  Licensed Pits and Quarries
-  Subwatershed Boundary

**Sand and Gravel Resource Areas
Significance ***

-  Primary
-  Secondary
-  Tertiary

* Complete coverage for this map layer is currently unavailable.



Scale 1:100 000

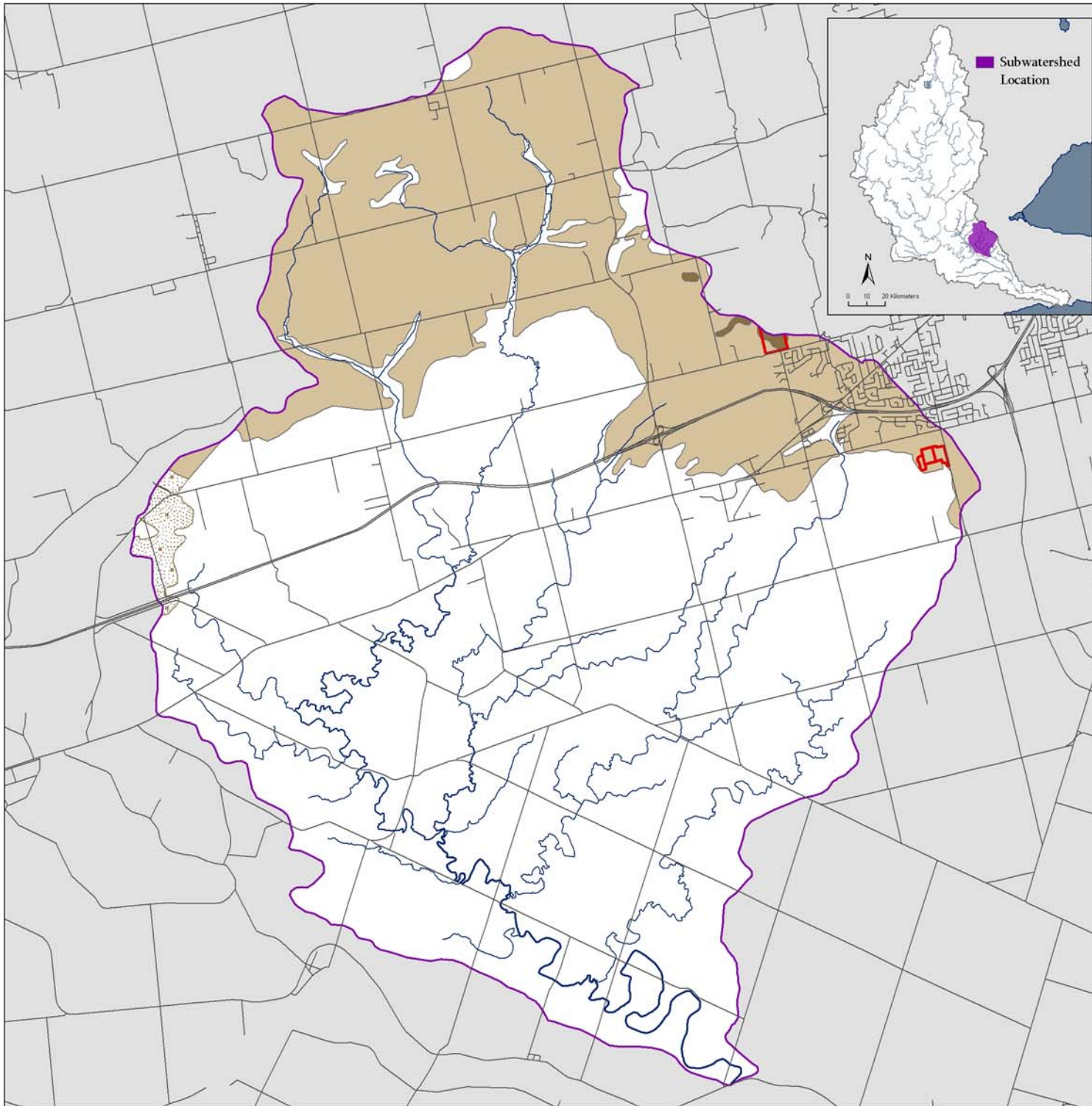


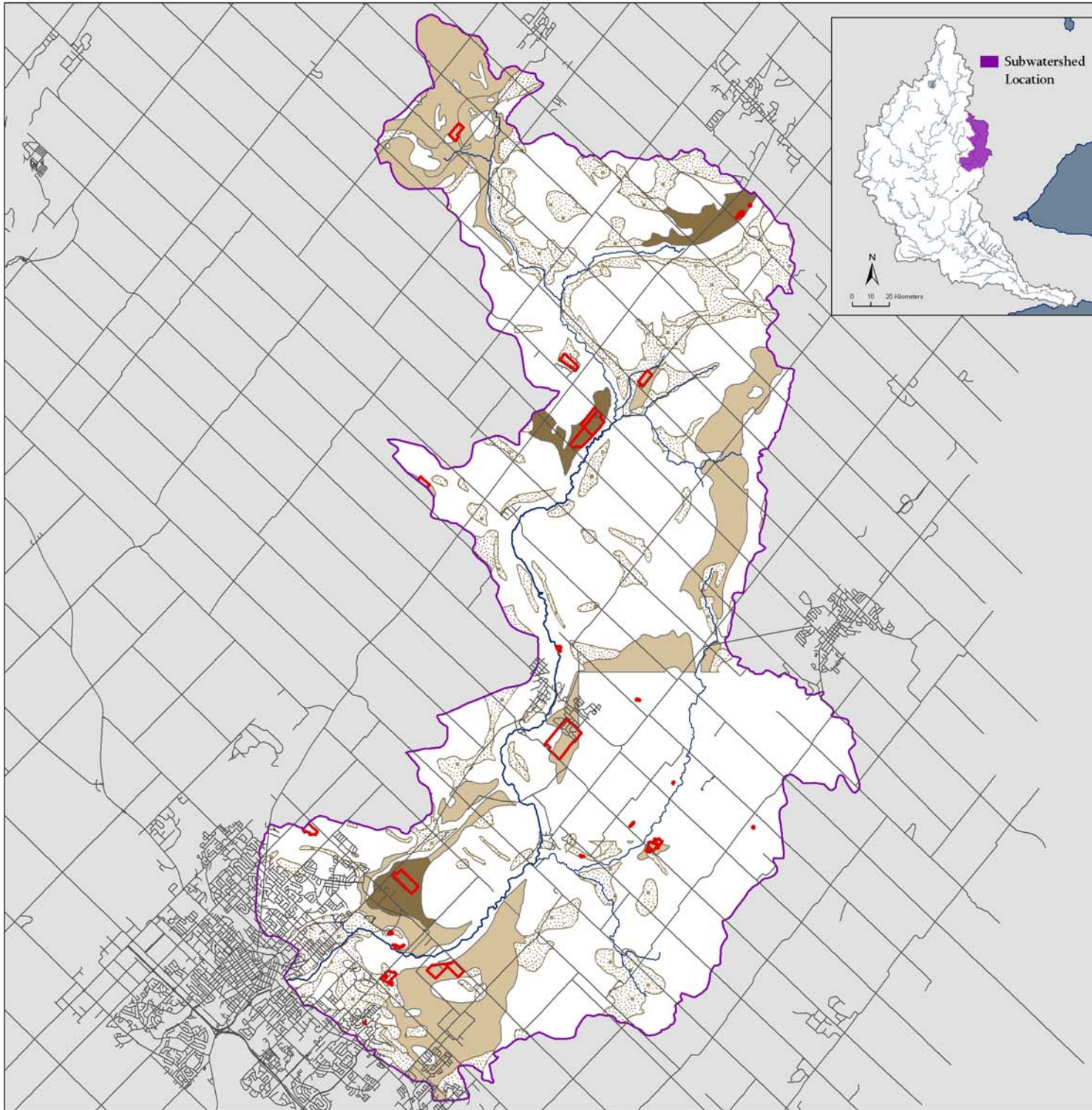
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**Figure B-2
Aggregate Resources
of the
Eramosa River
Subwatershed**

Legend

-  Licensed Pits and Quarries
-  Subwatershed Boundary

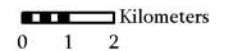
**Sand and Gravel Resource Areas
Significance ***

-  Primary
-  Secondary
-  Tertiary

* Complete coverage for this map layer is currently unavailable.



Scale 1:165 000

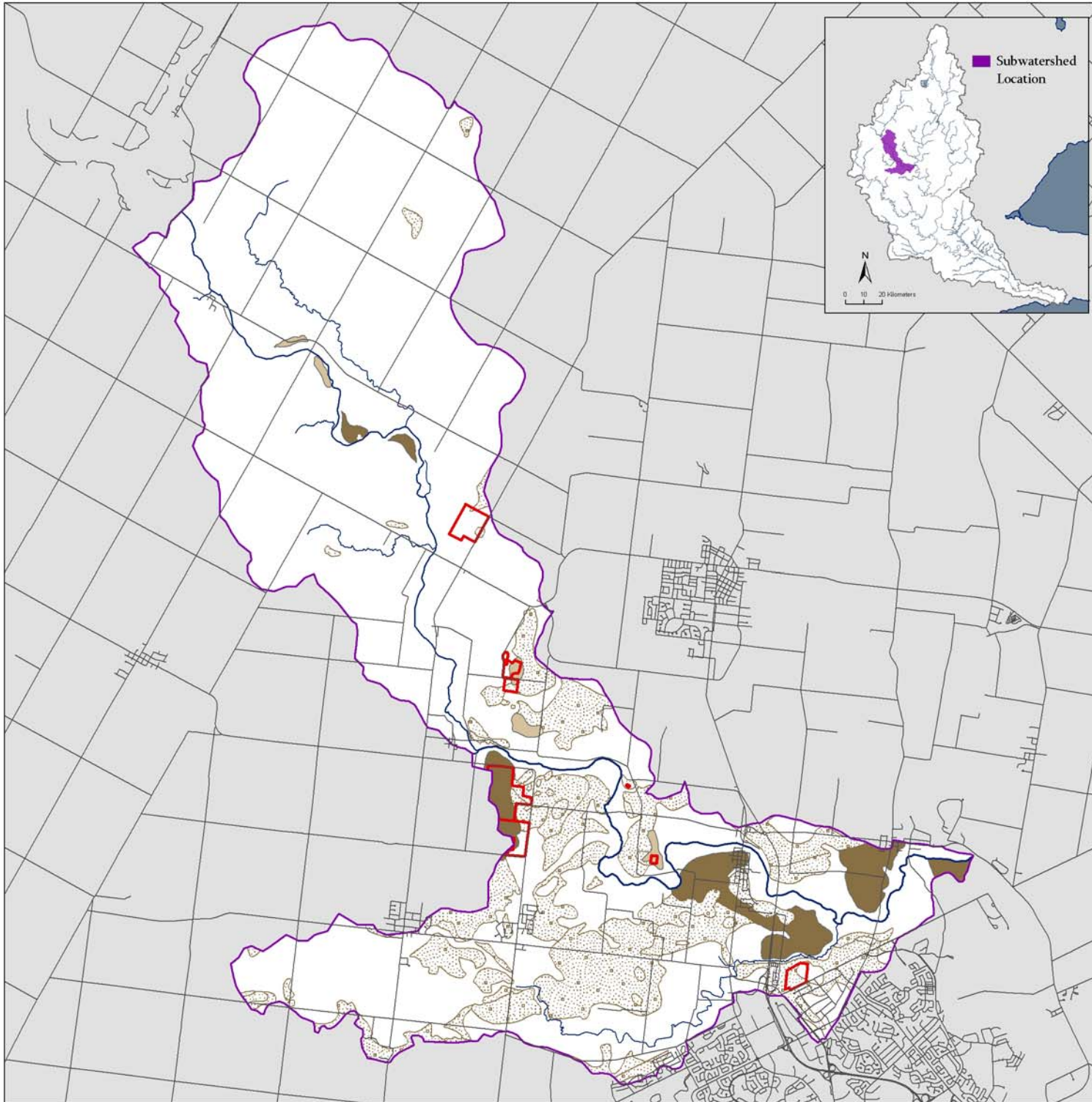


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**Figure B-3
Aggregate Resources
of the
Lower Conestogo River
Subwatershed**

Legend

-  Licensed Pits and Quarries
-  Subwatershed Boundary

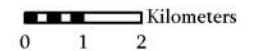
**Sand and Gravel Resource Areas
Significance ***

-  Primary
-  Secondary
-  Tertiary

* Complete coverage for this map layer is currently unavailable.



Scale 1:130 000

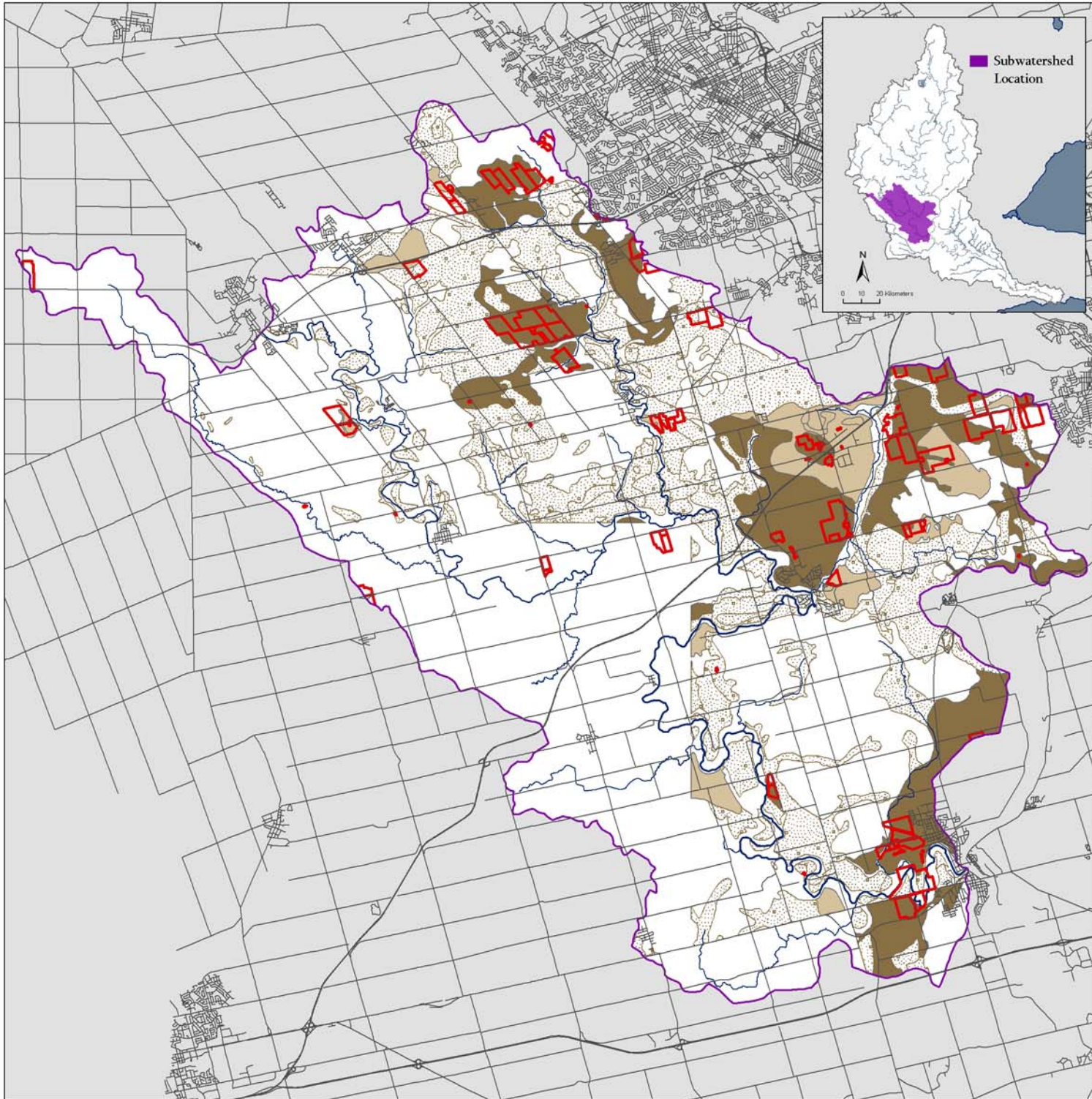


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**Figure B-4
Aggregate Resources
of the
Lower Nith River
Subwatershed**

Legend

-  Licensed Pits and Quarries
-  Subwatershed Boundary

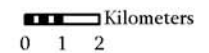
**Sand and Gravel Resource Areas
Significance ***

-  Primary
-  Secondary
-  Tertiary

* Complete coverage for this map layer is currently unavailable.



Scale 1:205 000



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Figure B-5 Aggregate Resources of the Lower Speed River Subwatershed

Legend

- Licensed Pits and Quarries
- Subwatershed Boundary

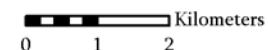
Sand and Gravel Resource Areas Significance *

- Primary
- Secondary
- Tertiary

* Complete coverage for this map layer is currently unavailable.



Scale 1:105 000

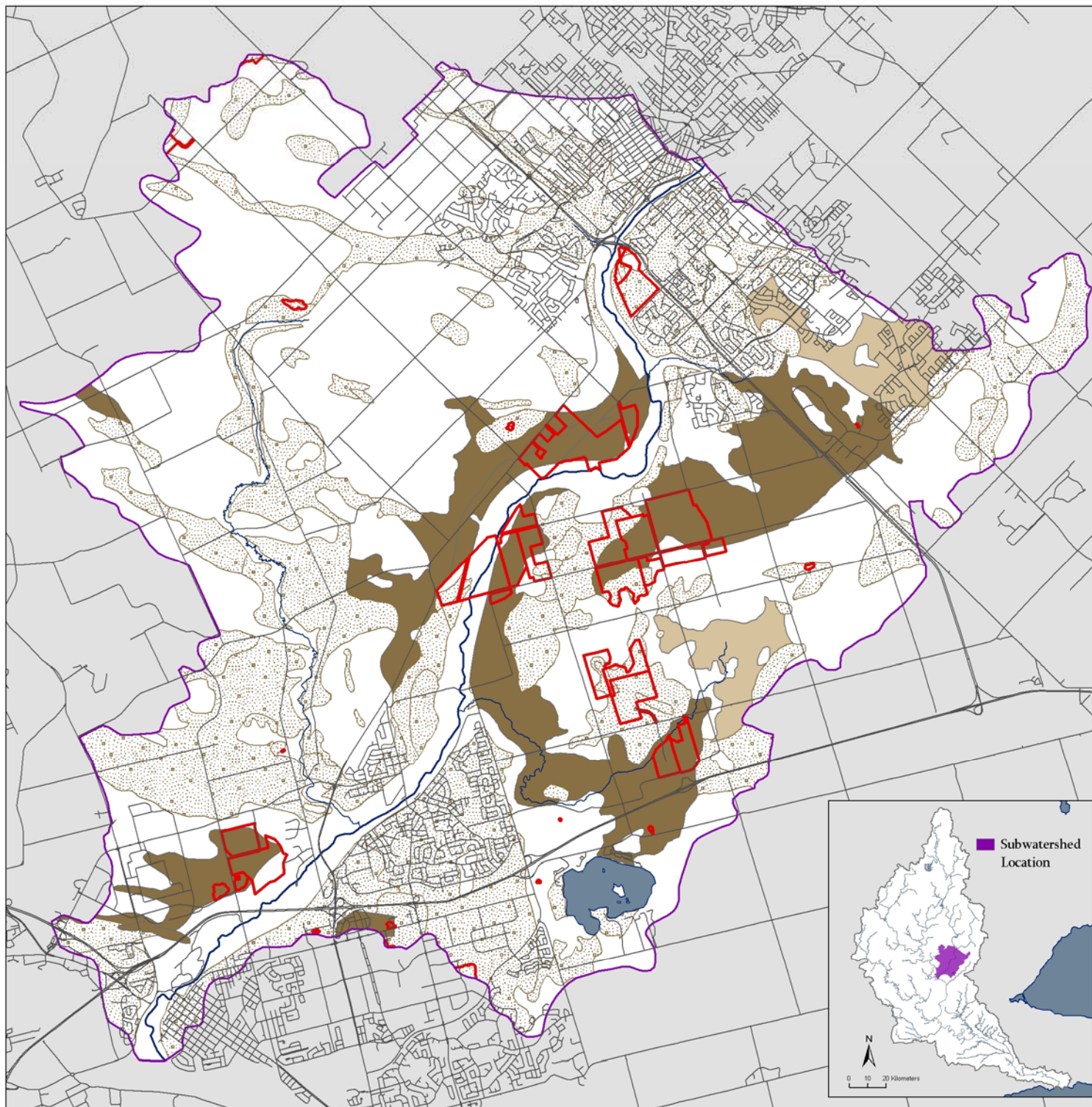


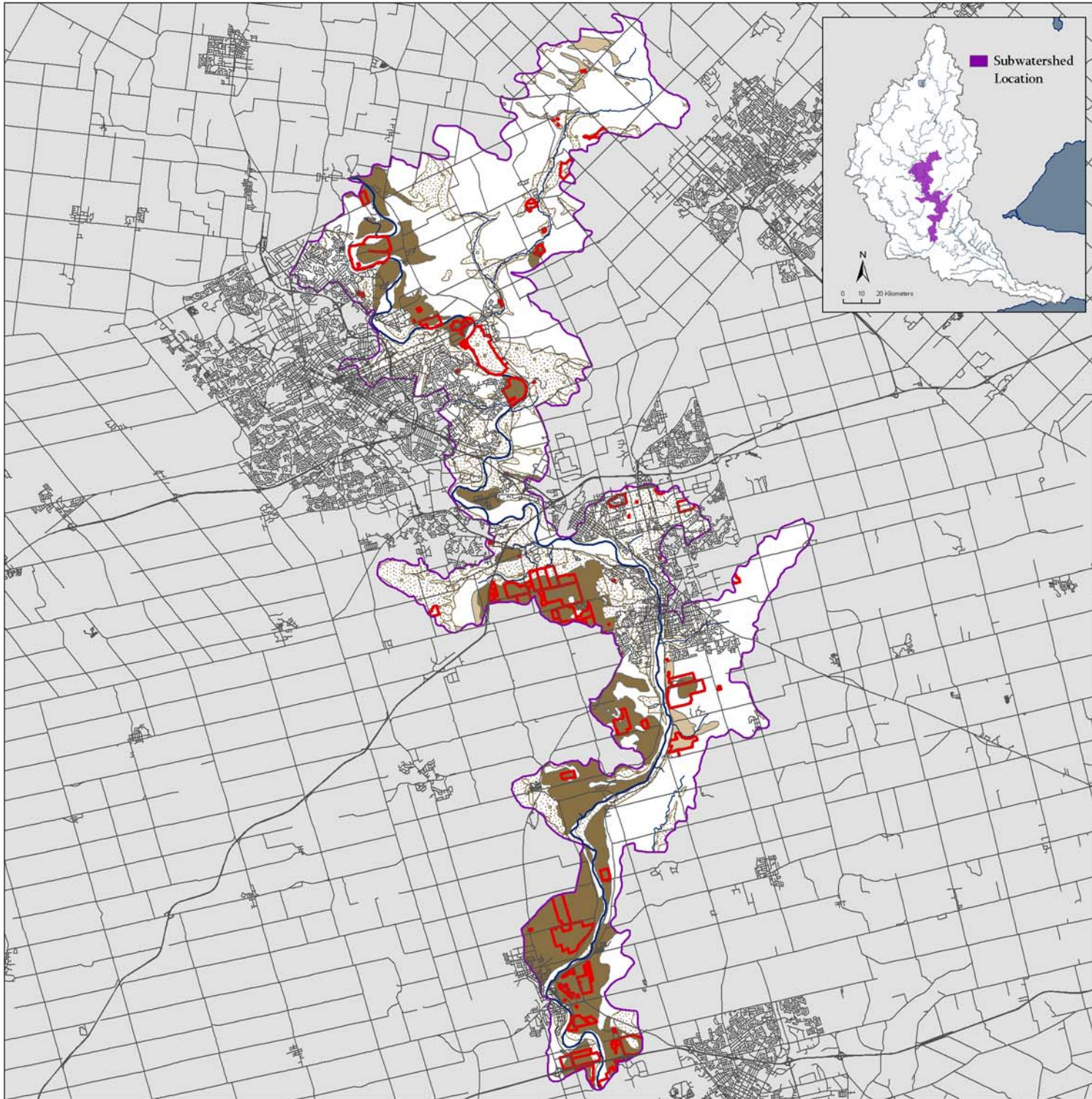
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**Figure B-6
Aggregate Resources
of the
Middle Grand River
Subwatershed**

Legend

-  Licensed Pits and Quarries
-  Subwatershed Boundary

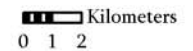
**Sand and Gravel Resource Areas
Significance ***

-  Primary
-  Secondary
-  Tertiary

* Complete coverage for this map layer is currently unavailable.



Scale 1:260 000



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Figure B-7 Aggregate Resources of the Upper Canagagigue Creek Subwatershed

Legend

- Licensed Pits and Quarries
- Subwatershed Boundary

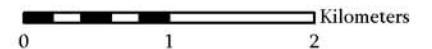
Sand and Gravel Resource Areas Significance *

- Primary
- Secondary
- Tertiary

* Complete coverage for this map layer is currently unavailable.



Scale 1:52 000

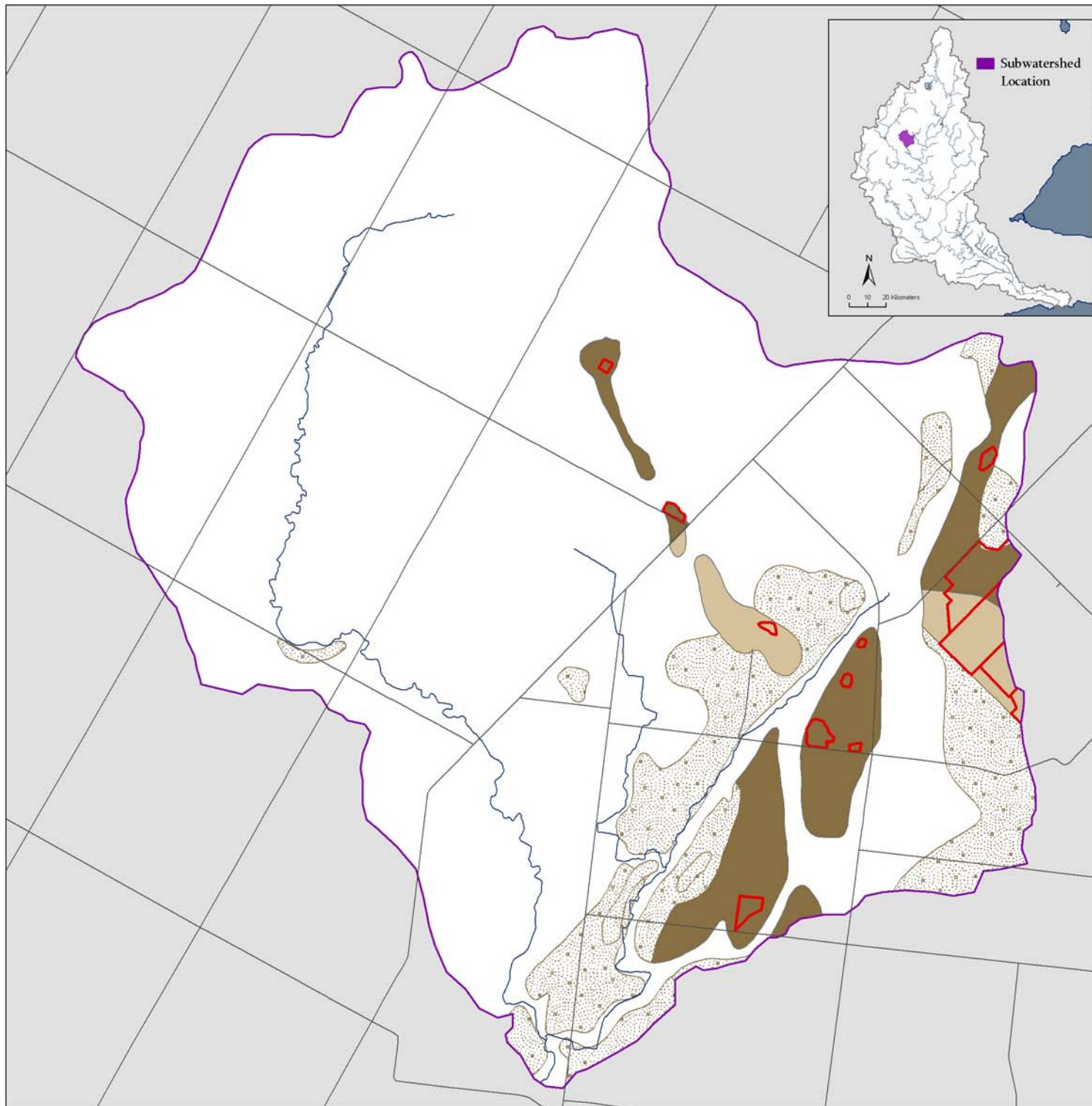


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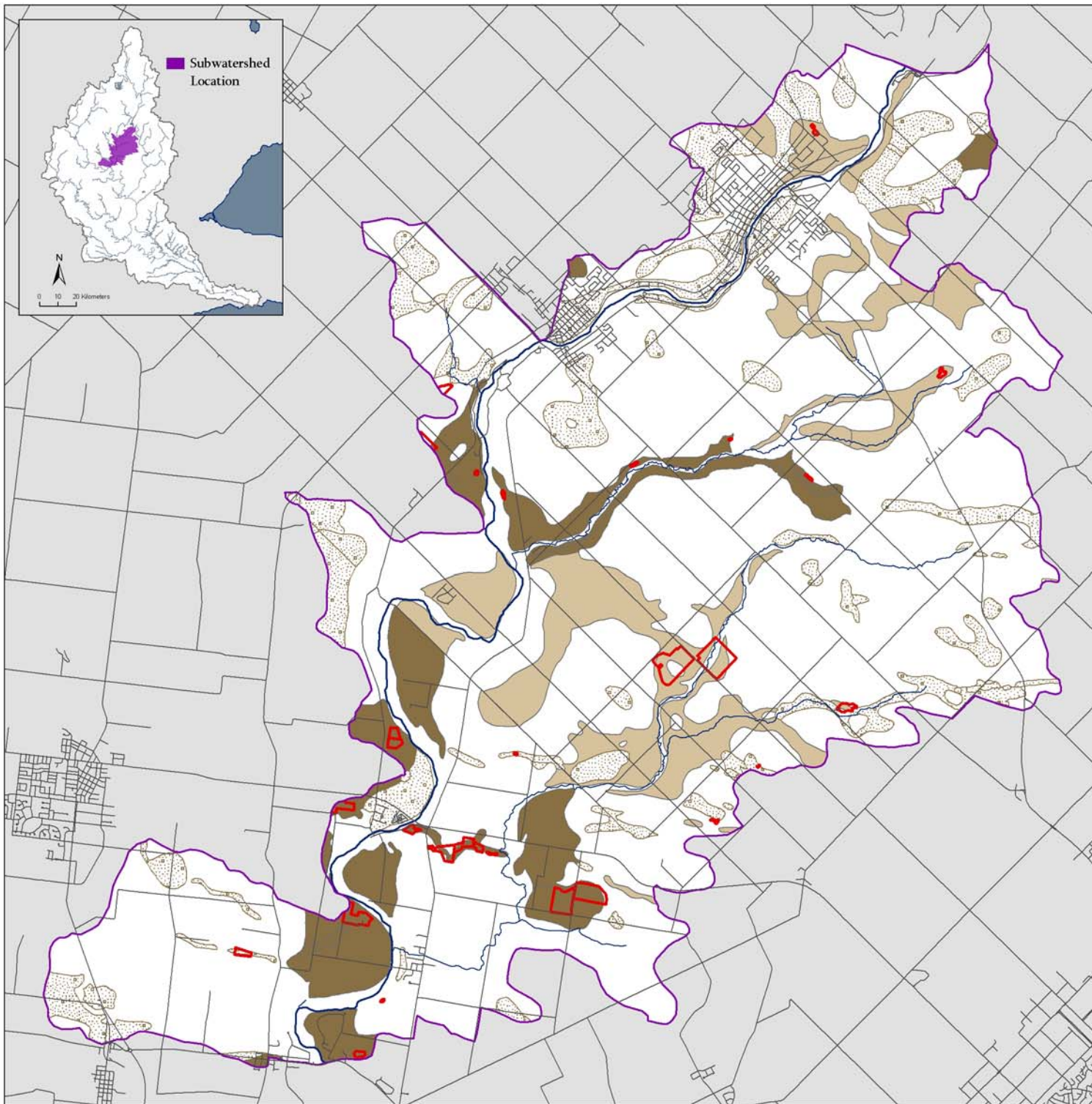






Figure B-8
Aggregate Resources
of the
Upper Middle Grand River
Subwatershed

Legend

-  Licensed Pits and Quarries
-  Subwatershed Boundary

Sand and Gravel Resource Areas
Significance *

-  Primary
-  Secondary
-  Tertiary

* Complete coverage for this map layer is currently unavailable.



Scale 1:120 000



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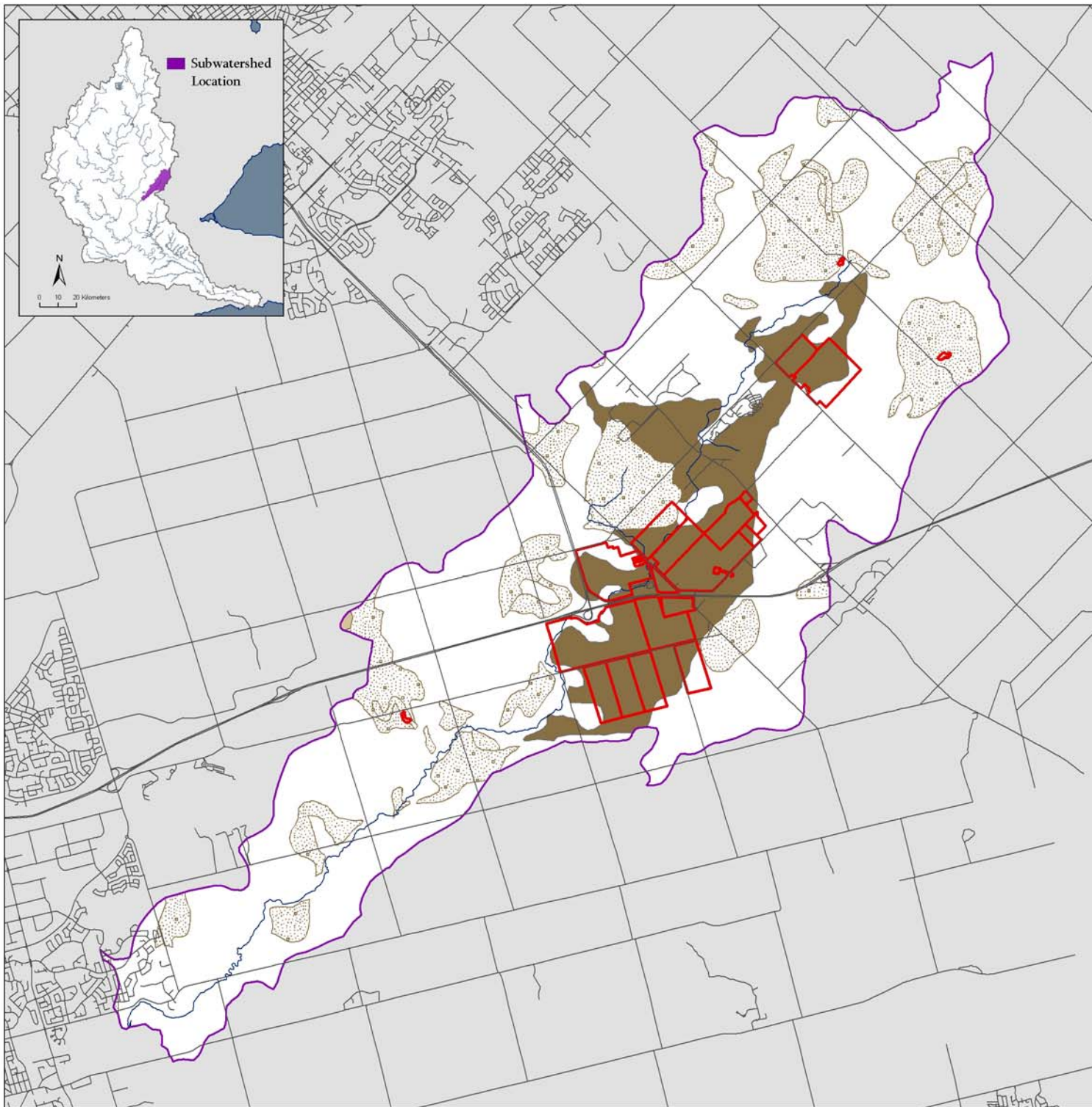






Figure B-9
Aggregate Resources
of the
Upper Mill Creek
Subwatershed

Legend

-  Licensed Pits and Quarries
-  Subwatershed Boundary

Sand and Gravel Resource Areas
Significance *

-  Primary
-  Secondary
-  Tertiary

* Complete coverage for this map layer is currently unavailable.



Scale 1:100 000



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Figure B-10
Aggregate Resources
of the
Upper Speed River
Subwatershed

Legend

-  Licensed Pits and Quarries
-  Subwatershed Boundary

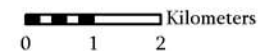
Sand and Gravel Resource Areas
Significance *

-  Primary
-  Secondary
-  Tertiary

* Complete coverage for this map layer is currently unavailable.



Scale 1:112 000



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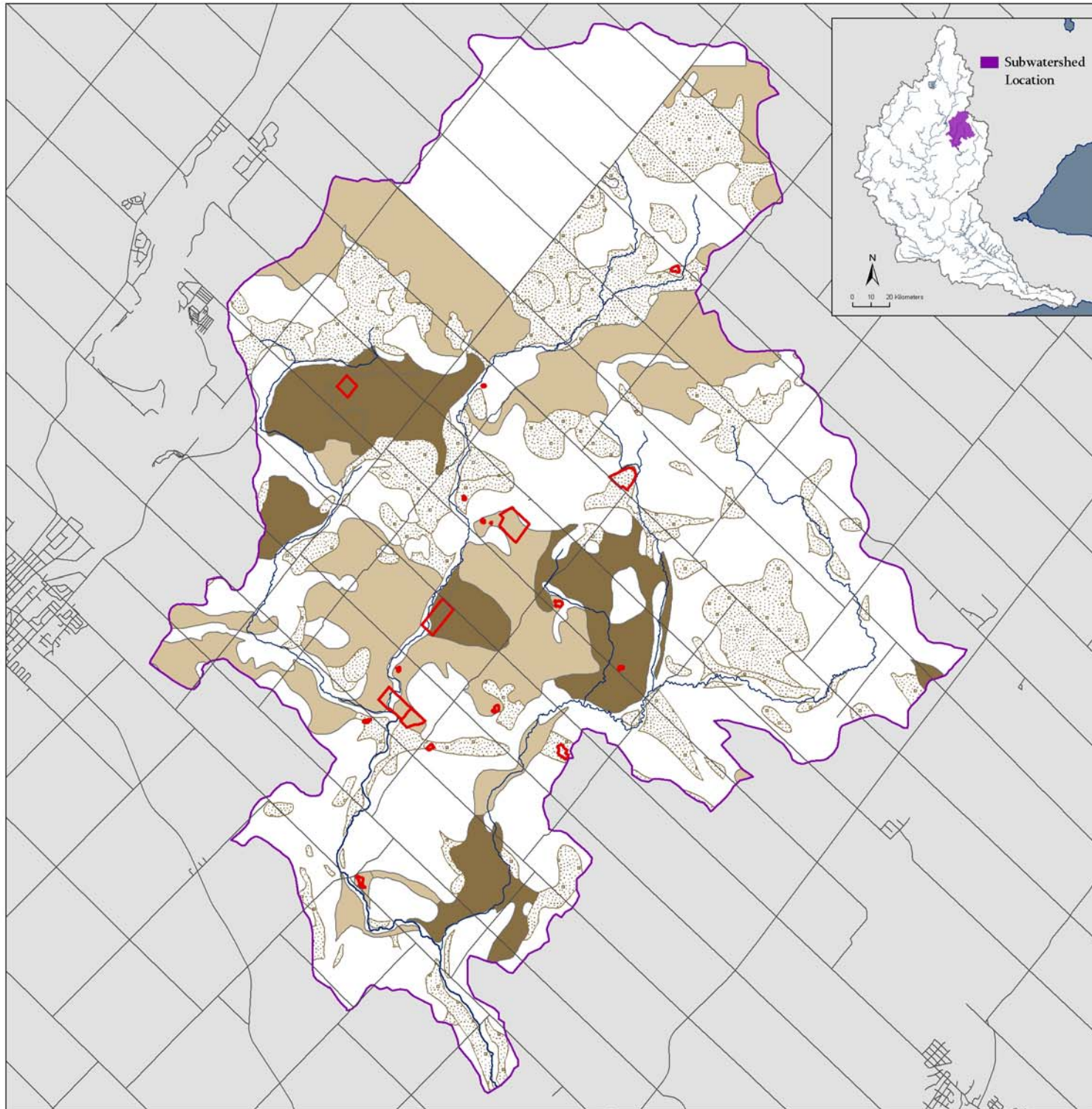




Figure B-11 Aggregate Resources of the Whitemans Creek Subwatershed

Legend

- Licensed Pits and Quarries
- Subwatershed Boundary

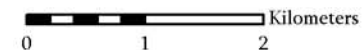
Sand and Gravel Resource Areas Significance *

- Primary
- Secondary
- Tertiary

* Complete coverage for this map layer is currently unavailable.



Scale 1:64 000



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