A Spatial Analysis of Drinking Water Advisories on First Nations Reserves in Ontario

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Abstract:

Canada is one of the most water-rich countries in the world, however not all Canadians have reliable access to potable drinking water (Galway 1). First Nations communities are disproportionately impacted by unsafe drinking water. This problem is compounded by underlying social, political, and economic marginalization of Indigenous peoples (Galway 2), and exists partially as a result of "the legacy of colonialism, forced relocation, residential schools and systemic racism in Canada" (David Suzuki Foundation Report 8). Safe and reliable drinking water for all First Nations communities is a public health and safety issue, as well as an environmental justice issue, across Canada (Galway 8). The province of Ontario illustrates this problem particularly well; as of November 2016, Ontario had the highest number of Drinking Water Advisories (DWAs) in First Nations reserves in Canada (David Suzuki Foundation Report 7). DWAs are issued when a community's water may be unsafe or is known not to be safe. Our project attempts to analyze the grossly high number of DWAs on First Nations reserves in the Province of Ontario, particularly focusing on the length of time that DWAs have been in effect and the proximity of reserves with DWAs to sources of surface freshwater and census metropolitan areas.

Description of Project:

Canada is one of the most water-rich countries in the world, however not all Canadians have access to reliable potable drinking water (Galway 1). First Nations communities are disproportionately impacted by unsafe drinking water; they are 90 times more likely to be without safe and reliable drinking water (Thomson et. al. 378; Galway 2). Additionally, the number of water-borne illnesses and infections in First Nations communities is 26 times higher than the national average (Galway 2). This disturbing inequity cannot be viewed in isolation. This problem is compounded by underlying social, political, and economic marginalization of Indigenous peoples (Galway 2), and exists partially as a result of "the legacy of colonialism, forced relocation, residential schools and systemic racism in Canada" (David Suzuki Foundation Report 8). Safe and reliable drinking water for all First Nations communities is a public health and safety issue, as well as an environmental justice issue, across Canada (Galway 8).

The province of Ontario illustrates this problem particularly well; as of November 2016, Ontario had the highest number of Drinking Water Advisories (DWAs) in First Nations reserves in Canada (David Suzuki Foundation Report 7). DWAs are issued when a community's water may be unsafe or is known not to be safe. The three types of drinking water advisories, defined by Health Canada, are: Boil Water Advisory, Do Not Consume, and Do Not Use (Galway 3; David Suzuki Foundation Report 10). Currently, there are no Do Not Use orders in Ontario, therefore we have excluded this category from our maps. The majority of DWAs are Boil Water Advisories (Thomson et. al. 383), these are issued when "the microbiological quality of drinking water is suspected or confirmed to be compromised, meaning disease-causing micro-organisms, such as bacteria, viruses or parasites, could be in the drinking water" (Galway 3). Do Not Consume orders represent a smaller proportion of DWAs and are issued when "contaminants are present that cannot be removed through boiling" (Galway 3). Human Rights Watch states that

contaminants in drinking water on First Nations reserves include coliform, Escherichia coli (E. coli), cancer-causing Trihalomethanes, and uranium (9).

The existing body of research on this issue highlights the social, political, and economic factors that have created this problem. Our project highlights the spatial factors that contribute to the grossly high number of DWAs on First Nations reserves in the Province of Ontario. After years of advocacy by First Nations and social justice organizations, as well as growing media attention and the Truth and Reconciliation Commission of Canada, Justin Trudeau's liberal government committed to ending all long-term DWAs on First Nations reserves by the year 2021, (David Suzuki Foundation Report 7; Galway 11; Human Rights Watch 4). The David Suzuki Foundation found that, as of February 2017, "the federal government is not on track to fulfill its promise of ending all drinking water advisories in First Nations within the five year commitment" (David Suzuki Foundation Report 26). This project investigates the breadth of this dire problem in the province of Ontario. We present the problem in a spatial context to visualize the proximity of reserves with DWAs to sources of surface freshwater, and census metropolitan areas. Our research is guided by the following questions: Are the most rural reservations more likely to be facing DWAs? Does their proximity to metropolitan areas with proper drinking water quality affect the likelihood of a reserve having longer or more extreme advisories? Are there any issues concerning proximity to sources of freshwater?

Methodology:

We divided our methodology based on Ben Fry's data visualization model. He outlines seven stages of data visualization, in our project we follow the first five: 1) *Acquire,* obtain the data; 2) *Parse*, provide some structure for the data's meaning, and order it into categories; 3) *Filter*, remove all but the data of interest; 4) *Mine,* apply methods from statistics or data mining as a way to discern patterns or place the data in mathematical context; and 5) *Represent*, choose a basic visual model (Fry 5).

1) *Acquire*

The base layers of our map documents were compiled from a shapefile of Canadian provincial boundaries, acquired from Government of Canada Open Data, and a shapefile of state boundaries in the United States, acquired from UBC Department of Geography data files.

The Government of Ontario's data catalogue provided a source of open data pertaining specifically to the province. Files from Ontario's data catalogue included a comprehensive province-wide hydrology dataset with numerous shapefiles of watercourses and waterbodies, both intermittent and perennial. Shapefile data of all First Nations reserves as polygons was acquired from Ontario's open database.

Tabular data of reserve DWAs, including type and start date of DWA, was acquired through the Government of Canada's Open Government open database. These files delivered names, locations and area of all First Nations reserves.

Point data of Ontario cities was obtained through Natural Resources Canada and Census Metropolitan Area (CMA) polygon data was obtained from CanMap Content Suite, available through the UBC Dataverse.

2) *Parse* and 3) *Filter*

As much of our shapefile data provided superfluous information, we modified our data to filter out any unnecessary elements. An individual layer isolating the provincial boundaries of Ontario was made from the Canadian province data. This process involved a simple search by attribute for "Ontario" and then the creation of a new layer in ArcGIS.

Hydrology data was filtered to identify shapefiles with features relevant to our final product. Because our intention was to show the abundance of freshwater in the province, attribute searches were used to identify lakes, rivers, and reservoirs, which were isolated and exported into a map layer.

A comprehensive dataset of Ontario's geographic place names, including administration areas, townships, water features and terrain features among others, was queried to isolate cities, which were then represented as points. To avoid unnecessary clutter on the map document, 10 cities were labeled to provide some spatial reference to the map user. As most large Ontario cities are clustered together in the south, Sudbury, Thunder Bay and Kenora were included to show proximity relations between the more northern, remote reserves and an urban center.

CMAs for Ontario were isolated with a simple query for "Ontario" and then the creation of a new map layer from the selected data.

First Nations reserve data and drinking water advisory (DWA) data required a significant amount of work in order to join the tabular DWA dataset to the Reserves shapefile. As the Reserves dataset contained the locations and boundaries of every First Nations reserve in Ontario, we modified the attribute table to include columns to indicate whether or not a reserve had a DWA, and if applicable, the type of DWA and the length of time calculated from the date the DWA was ordered. Reserves listed on the DWA list were matched with the Reserves attribute table and manually inputted using a spreadsheet. This process encountered some challenges, as the naming conventions of reserves did not always match. When unmatched DWAs were encountered, we performed web searches on all names attached to the DWA entry in order to confidently match the entry to a particular reserve. Additionally, some reserve boundaries contained more than one parcel of land and the DWA list simply identified the reserve had a DWA; in these cases, every parcel of land associated with that reserve was attributed the same DWA.

4) *Mine*

Once DWA data was attached to the Reserve shapefile, we were able to analyze distances between reserves and watercourses and waterbodies from our layer of lakes, rivers, and reservoirs data. Using the "Near" tool from the Proximity toolset we were able to determine how

close reserves under DWAs were to a freshwater feature. Further analysis using the "Select by Location" tool allowed us to determine the number of reserves that were farther than 1 km from a freshwater feature.

Using the "Ruler" tool, we were able to calculate the distance between reserves with lengthy DWAs to their nearest CMA. Distances were calculated for the northernmost affected reserve and its nearest CMA.

Area calculations were performed for all bodies of freshwater, reserve boundaries, and provincial area using the summary function in the attribute tables of each layer.

5) *Represent*

With the reserve and DWA datasets merged, we were able to visualize the data through the GIS. To show the entire scope of the DWA issue in Ontario, Map 1 was produced with all reserve polygons converted to points. Points were then categorized by DWA type and length of DWA. This required changing the symbology of the points to show the DWA type as a color and the length of time as a graduated symbol. Maps 2A and 2B provide a larger scale product with a more detailed look at Southern Ontario and Northwestern Ontario, respectively. This required a clip for inset of the boundaries of each region and then reclassifying reserve polygons to identify DWA type by color. Maps 3A and 3B used the same clipped boundaries with reserve polygons reclassified to show the length of DWA in years in a graduated color scheme.

Color choices for symbology were intended to convey the severity of a given DWA. Grey was used to show reserves with no DWA; this color choice was made so that these reserves were represented on the map without drawing attention. Yellow was used for Boil Water Advisories to indicate caution and red was used for Do Not Consume advisories. These color were chosen because of the colors' association with levels of hazard; red is typically perceived as high hazard, with orange and yellow hues associated with warnings (Zielinska et al, 2017). With this in mind, a color ramp showing the length of DWA employed a graduated color scheme moving from the shortest DWAs in yellow to the longest in deep red. Symbol transparency was set to ensure that all symbols could be seen, even when overlapped by longer running DWAs.

Discussion and Results:

As stated by the World Health Organization, "(w)ater is the essence of life and human dignity" (Galway 1). Water is a key determinant of human health, ecosystem function, and plays a major role in sustainable development. For many Indigenous peoples in Canada, water hold spiritual and cultural significance (Galway 1). Safe and reliable drinking water has thus been designated as a human right by the United Nations Human Rights Council (UNHRC). The UNHRC states that the right to water "entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses" (Galway 1). And yet, the Canadian Constitution does not explicitly recognize the right to water (Galway 1). Human Rights Watch has found that "the Canadian government has violated a range of international human

rights obligations toward First Nations persons and communities by failing to remedy the severe water crisis" (9).

Canada is one of the most water-rich countries and the province of Ontario shares the Great Lakes with the US which account for 18% of the world's fresh surface water (Human Rights Watch 3), in addition to the province's 250,000 smaller lakes (Government of Ontario np). Ontario also contains roughly 18% of Canada's freshwater by area and using GIS we calculated that the province itself is roughly 25% freshwater. Even with the vast amount of freshwater available within the province, Ontario has the most First Nation reserves with DWAs in Canada. DWAs affect 81 out of 207 reserves in the province, with long-term advisories in place for 68. Proximity analyses conducted using the GIS revealed that all DWA affected reserves are within 5 km of a freshwater feature and only 22 reserves are farther than 1 km.

And yet, the province has the highest number of DWAs in the country (David Suzuki Foundation Report 7) with the poorest-quality water found on First Nations reserves (Galway 2). In January 2016, out of the 134 water systems with DWAs in Canada, 90 of them were in the Province of Ontario (Human Rights Watch 4). Many of these DWAs exist for years, and sometimes even for decades (Human Rights Watch 4). As of November 2016, Ontario had 81 DWAs in 44 First Nations, 68 of which are long-term (1 year or longer) advisories (David Suzuki Foundation Report 7).Various initiatives and programs, legislative changes, and funding aimed at improving water and wastewater system infrastructure have been directed at this problem; however, the problem persists (Galway 2). Numerous studies have shown that DWAs have not been improving in First Nations communities over the last decade and claim that there has actually been an increase in DWAs over the last 10 years (Thomson et. al. 387; Galway 2). This is, in part, attributed to increased monitoring (through efforts such as the First Nations Water Management Strategy), aging infrastructure, population growth, and climate change (Thompson et al 387). Additionally, this is due to inadequate funding for water treatment plants, infrastructure, operations, maintenance and training (David Suzuki Foundation Report 12).

Although Indigenous people belonging to a number of nations lived, used and co-existed with the entirety of area now known as Ontario for thousands of years before reserve boundaries were imposed by colonial policies, Figure 1 shows that reserves allocated for First Nations to reside in only represent 0.76% of Ontario, their traditional territory. These reserves were most often the lowest-quality land, and First Nations people were forced into them, only allowed to live or work on this land, leaving most of their traditional territory and resources claimed by the Canadian government. Figure 2 shows that of that small 0.76%, almost one-third (27.29%) of that land is currently under a long-term DWA, illustrating again the widely disproportionate situation of reserves.

Because the land area of reserves is so small, it was impossible to visually represent the entire province with reserve polygons. In Map 1, all reserves in Ontario are represented to show length of DWA and type of DWA on a province wide scale with proportional points. Length of time of DWA is illustrated by size of circle, and type of advisory by colour of circle. Reserves without DWAs and cities are shown for perspective. To address this, the remaining maps are insets of two regions of Ontario on a larger scale, which show reserve boundaries next to Census

Metropolitan Area boundaries. Map 2A shows a region of Southern Ontario capturing the largest cities, and classifies reserves by type of DWA. Map 2B also shows DWA type, in a region of Northern Ontario capturing more remote reserves. Map 3A shows the Southern Ontario region again, but with reserves classified by length of time of DWA, and Map 3B shows length of time of DWA for the Northern Ontario region.

A large portion of First Nations communities in Ontario are in rural and remote locations in Northwestern Ontario (Galway 3). Out of the ten longest standing Boil Water Advisories, our analysis has shown that only one is located in Southern Ontario, this being Tyendinaga Mohawk Territory reserve, which is located 3 km from Belleville. Tyendinaga Mohawk Territory has had a Boil Water Advisory for 14 years, making it the 9th longest standing Boil Water Advisory in Ontario. The other 9 of the 10 longest standing Boil Water Advisories in the province are located in rural areas of Northern Ontario, near to or further north of Kenora. This demonstrates a pattern of more remote reserves being prone to longer Boil Water Advisories. Along these lines, the longest standing Boil Water Advisory of 23 years is found in Neskantaga, which is located roughly 390 km from Thunder Bay, the nearest Census Metropolitan Area to this reserve.

Additionally, Do Not Consume advisories were more prevalent among First Nation reserves in Northern Ontario than in the south of the province. The longest running advisory of this type affects the English River reserve, 53 km northeast of Kenora, and has been in place for 14 years. Bearskin Lake reserve is the most remote reserve with a Do Not Consume advisory. This advisory has been in place for 12 years and the reserve is 515 km north of Kenora, the nearest CMA. The shortest Do Not Consume advisory affecting the northern region of Ontario is for the Northwest Angle reserve, 62 km from Kenora. This advisory has been in place for 6 years.

The only reserve with a Do Not Consume advisory in Southern Ontario is the Wahta Mohawk Territory reserve. This reserve is situated 41 km from Kawartha Lakes and 60 km from Orillia and has had this advisory in place for 4 years.

However, despite the pattern of the longest standing Boil Water Advisories and a higher proportion of Do Not Consume Advisories being located in remote areas of Northern Ontario, mapping the distribution of DWAs also showed that a surprising amount of reserves close to urban centers in Southern Ontario face DWAs. As aforementioned, Tyendinaga Mohawk Territory, which has faced a Boil Water Advisory for 14 years is located a mere 3 kilometers from the Census Metropolitan Area of Belleville. Another instance of this visible in map Map2A and Map3A, is the close proximity of reserves with longstanding DWAs to the Census Metropolitan Area of Peterborough.

Many First Nations experience DWAs while neighbouring municipalities have access to safe and reliable drinking water (David Suzuki Foundation Report 8; Human Rights Watch 4); “access to safe drinking water [in First Nations reserves is] far more dire than in the rest of the Province” (Collins et al 2). One of the main barriers to addressing drinking water conditions in First Nations communities is the complex and overlapping issues of jurisdiction and regulation (Thompson et al 379; Collins et al 4). Provincial water standards do not apply to reserve

communities as municipalities fall under provincial jurisdiction while First Nations reserves fall under federal jurisdiction (Galway 10). In non-First Nations, water and wastewater are regulated by provincial/territorial governments and are managed by municipalities (Thompson et al 379), whereas on First Nations reserves they managed through a complex web of federal jurisdiction and the First Nation community (David Suzuki Foundation Report 18). It is complicated because First Nations Band Councils work in partnership with Indigenous and Northern Affairs Canada (INAC), Health Canada, and Environment and Climate Change Canada (ECCC) to provide drinking water for their communities (Thompson et al 379). Thus, while municipalities in Ontario are protected by several pieces of provincial legislation and enforceable safe drinking water regulations, there are no enforceable federal regulations to hold anyone accountable to safe drinking water standards on First Nations reserves (David Suzuki Foundation Report 14; Human Rights Watch 3). The federal government provides only guidelines for drinking water quality (Thompson et al 379), whereas provincial governments create actual enforceable standards. First Nations drinking water thus exists in a "regulatory void" wherein there has never been any enforceable legal regulations (David Suzuki Foundation Report 14). Further, "[t]he *Indian Act* directly limits the authority of the First Nations to address the regulatory gap themselves (Human Rights Watch 56). As such, the proximity to municipalities does not affect water quality and access on reserves.

Error and Uncertainty:

Although all effort went into ensuring the integrity of the data represented on our maps, there are some areas of uncertainty that need to be addressed. The first pertains to joining DWA data to the Reserves shapefile. When merging these two datasets we encountered inconsistencies with the naming conventions of certain reserves. Often we would find a DWA assigned to a particular Band name that would not appear on the attribute table of reserves, or a reserve name that did not align with any Band names. In these situations web searches for Band names were performed to ascertain any information pertaining to associated reserves. Ultimately, we were able to match each DWA with an associated reserve, yet it speaks to the inconsistency in the record keeping of these datasets. Another issue with the merging of these datasets was that some reserves were composed of several parcels of land attributed to the same Band while the DWA list simply stated that there was an advisory in place for that band, without providing any details regarding what parcels were affected. In these cases we attached the same DWA data to each parcel of an affected reserve.

It is also important to note that while our maps show the location and length of existing DWAs for Ontario First Nation reserves, the maps do not take any other circumstantial considerations into account. For example, while we can identify the proximity of an affected reserve to the nearest city or CMA, we do not have details about drinking water supply or quality of non-reserve communities that may lie within the same geographic region. Moreover, because the number of DWAs in place fluctuates, the data can never be exhaustive and this poses a problem with presenting the data with absolute certainty (David Suzuki Foundation Report 10).

Another area of uncertainty exists in the calculations of total freshwater area in the province. Using polygon vector data for all lakes, rivers, and reservoirs, we summed the total

area of freshwater to 269,492 km^2 using the GIS. Although our calculations excluded several watercourse types, such as creeks and canals, the total area of freshwater area calculated through the GIS exceeds the provincial freshwater area provided by the Government of Canada (Statistics Canada, 2005). By our calculation, 25% of the total provincial area (1,076,395 km^2) is freshwater; using data from Statistics Canada, the total area of freshwater in Ontario is 158,654 km^2, or 14.74% of the total area of the province (Stats Can, np). The difference between the two datasets is quite significant, yet for our report the GIS calculations have been used, hence the need to address this area of possible error.

Further Research/Recommendations:

Our analysis demonstrates spatial distribution of the longest-standing and most-severe DWAs on reserves in Ontario, but we did not explore causes. In addition to lack of or mis-allocation of funding for proper water infrastructure on reserves, pollution and damage to water source, "such as resource extraction, forestry practices, and agriculture," (Galway 10) also threaten drinking water sources. Drinking water is compromised by government and industry through fracking, mega-dams, mining, oilsands development and pipelines (David Suzuki Foundation Report 23). Documented cases in Northern Ontario find reserve water treatment plants that have been built downstream from sewage lagoons (Galway 10). By including spatial data of large industrial development and extractive industries, distance between these sites and reserves with DWAs could be explored for potential correlations. Groundwater data may help to reveal contamination patterns in this analysis.

Further, we found that most of the longest standing and Do Not Consume DWAs in Ontario are in the northern region of the province. Due to their distance from metropolitan areas, they likely also face the greatest cost and difficulty in accessing drinking water. By adding road networks, data on seasonal access, and store locations to our maps, GIS analysis could be used to determine the proximity of reserves with DWAs to affordable drinking water. This would be particularly informative for the four reserves with Do Not Consume advisories, as their population relies completely on buying bottled water. By incorporating population data for each reserve, the number of people affected by DWAs could be examined.

Many watersheds in Southern Ontario have source water protection plans, but most in Northern Ontario do not (Human Rights Watch 60). As the David Suzuki Foundation argues, if governments are truly committed to ensuring clean drinking water for First Nations, the impacts of these projects must be considered (David Suzuki Foundation Report 23). Protecting water sources, both surface and groundwater, particularly those upstream of communities, is vital in addressing the issue of DWAs (Collins et al 15). These methods should be "informed by First Nations' traditional views on water and indigenous ways of knowing and living" (Galway 10) and "any law or regulations involving safe drinking for First Nations should be developed with the free, prior and informed consent of First Nations" (David Suzuki Foundation Report 14). Further research on correlation between industrial activities and DWAs will help inform such protection plans.

Appendices

i. Bibliography

Data:

see Data Source Table, page 10-11

Journal Articles:

Collins, Leslie, and Stephanie Allen, Craig Murray, and Chris Metcalfe. "Source Water Protection Planning for Ontario First Nations Communities: Case Studies Identifying Challenges and Outcomes." *MDPI Water,* vol. 9, 2017, pp. 1-19.

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Indigenous and Northern Affairs Canada. "Ending long-term drinking water advisories in First Nation communities." 2018, np. http://www.aadnc-aandc.gc.ca/eng/1506514143353/1506514230742

Statistics Canada. "Land and freshwater area, by province and territory" 2005. http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/phys01-eng.ht

ii.

Table 1: Data Sources

Layer / datafile name	Source	Uses	Entity/data model	Attributes	Modifications *all data was projected to Canadian Lambert Conformal Conic
Canada_ Provinces *used for all maps	Government of Canada Open Data, 2011, Canadian Province Shapefile	For Canadian Provincial and Country borders	polygon	Province Names	- Query for "Ontario" - Clip and create new layer: "Ontario_Boundary" *Later added other surrounding provincial borders so that there was more context to our final maps - Edited Symbology
USA_States *used for all maps	UBC Geography Geodatabase, American State Shapefile	For USA State borders to provide context	polygon		- Edited Symbology
Ontario Integrated Hydrology Ontario_ Water *used for all maps	Ontario Open Data Catalogue, 2010, Lakes, rivers, and reservoirs in Ontario	To show accessibility to fresh water, as well as to provide context for the maps	polygon	Lakes, Rivers, Reservoirs	- Search attribute for Lake, River, Reservoir - Save selections as layer
Ontario_Cities_ Points *used in Map 1	Natural Resources Canada, 2017, Geographical Names Data > Ontario	To give landmarks for viewers to orient themselves to the map as well as to show proximity of reserves to urban areas	points	Ontario City Names	- The data contained all geographical place names - Queried for "CITY" - Created new layer from city selection - Chose 10 cities to represent with labels, this decision was based off of population size, as well as geographic location
Ontario_ Reserves	Shapefile: Ontario Open Data Catalogue, 2013, 'Indian Reserve' Boundaries	To show area of reserves	polygon	Names of Reserves and Reserve Areas	- joined Drinking Water Advisory tabular data *see row below
Reserves_ DWA_ Provincial_ Points *used for Map 1	See "Reserves_ DWA_Join" Layer	Due to the small size of the reserves, they were barely visible when our map was at a provincial scale so we decided to show DWAs provincially using point features	point	Names of Reserves, Type of DWA, Length of DWA	**MAP 1:** - Convert polygons to points - Edit symbology/classification to indicate type of DWA based on colour and length of time based on point size

Table 1: Data Sources Continued

Layer / datafile name	Source	Uses	Entity/data model	Attributes	Modifications **all data was projected to Canadian Lambert Conformal Conic*
Census_ Metropolitan_ Areas **used for Map 2A, 2B, 3A, and 3B*	CanMap Content Suite, 2011, Borders for Ontario CMAs	To show the distance of DWAs on reserves with CMAs	polygon	Names of CMAs	- Queried for "Ontario" - Erased all data outside of Ontario provincial boundary
Reserves_ DWA_Type_ Polygons **used for Map 2A and 2B*	See "Reserves_ DWA_Join" Layer	To show more detailed insets of key regions and corresponding Reserve DWAs by Type, including proximity to Census Metropolitan Areas (CMAs)	polygon	Names of Reserves, Type of DWA, Length of DWA	**MAP 2A:** - Clip for inset boundary of Southern Ontario - Query for DWA Types and Reclassify - Classify with Manual Breaks, categories = 0, 0.1-1, 1.1-3 - Change labels to: no DWA, Boil Water Advisory, and Do Not Consume - Edit Symbology - Copy and Paste for MAP 2B **MAP 2B:** - Clip for inset boundary of Northern Ontario (Kenra Region)
Reserves_ DWA_Length_ Polygons **used for Map 3A and 3B*	See: "Reserves_ DWA_Join" Layer	To show more detailed insets of key regions and corresponding Reserve DWAs by Length of Time, including proximity to Census Metropolitan Areas (CMAs)	polygon	Names of Reserves, Type of DWA, Length of DWA	**MAP 3A:** - Use clip from Map2A - Query for DWA Length of Time and Reclassify - Classify with Manual Breaks, Ranges = 0, 12, 60, 120, 180, 240, 240-278 (months) - Change labels to: no DWA, 1 year or less, 1-5 years, 5-10 years, 10-15 years, 15-20 years, 20-24 years. (Longest DWA is 23.16 years, aka 278 months) - Edit Symbology - Copy and Paste for MAP 3B **MAP 3B:** - Use clip from Map2B

iii. Figures

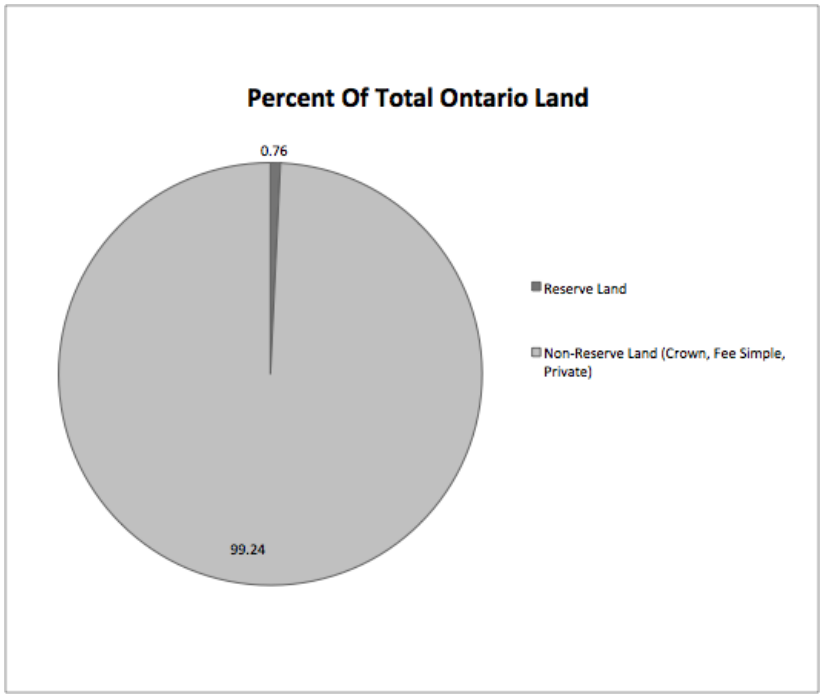


Figure 1. Proportion of allocated First Nations Reserve land to non-reserve land (including Crown, Fee Simple, and privately owned land), represented by percentage of the total land area of the province of Ontario.

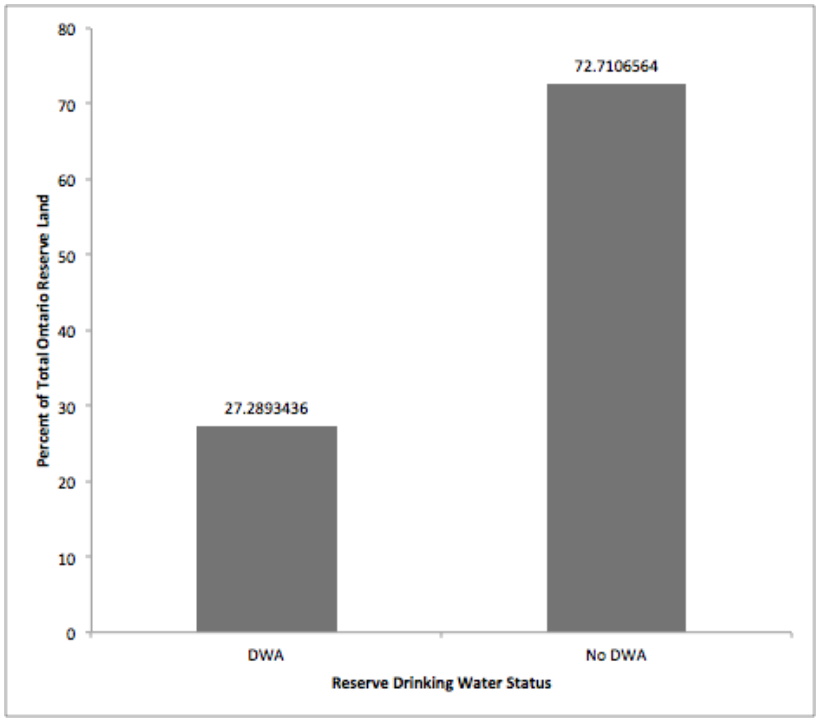


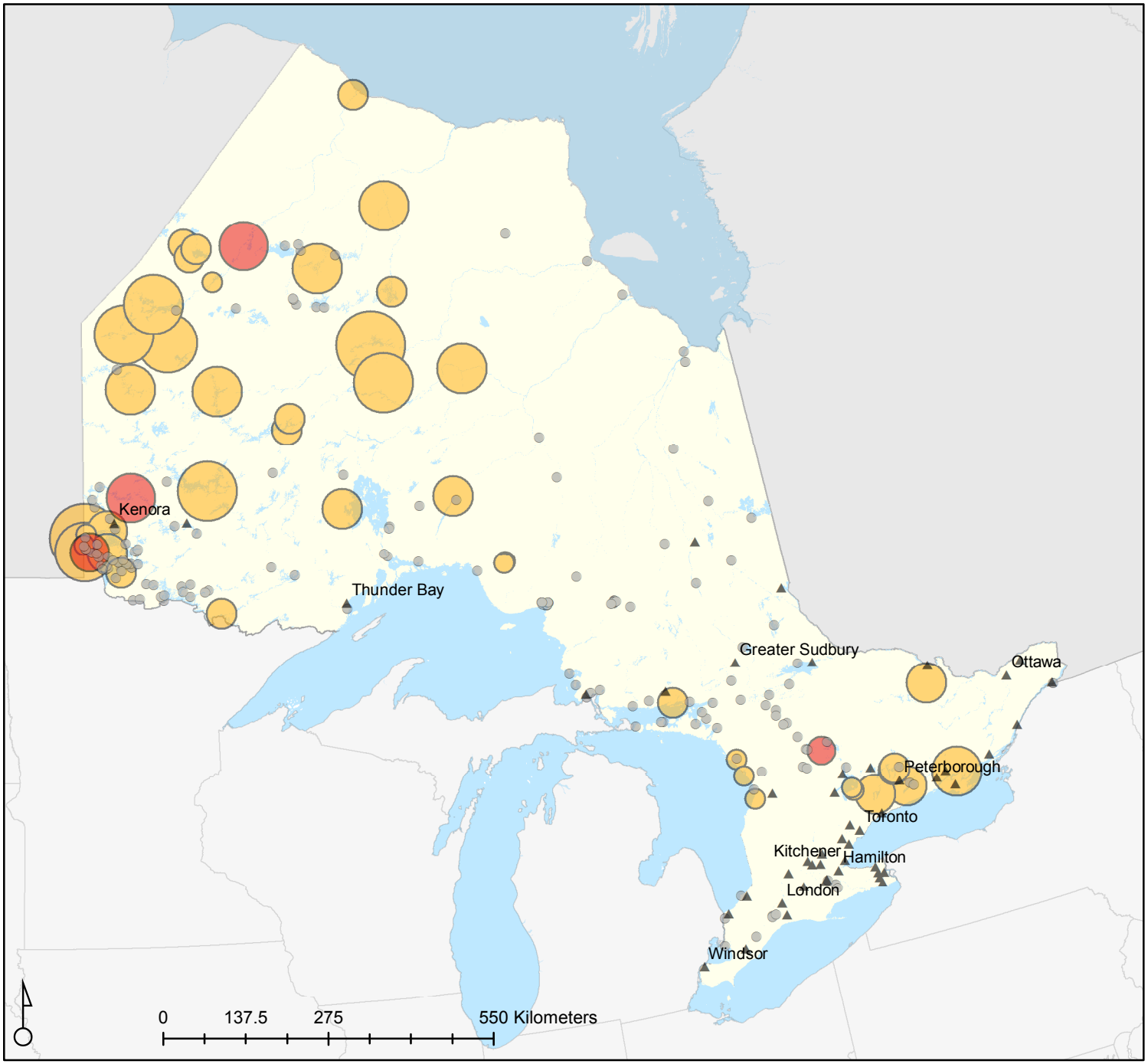
Figure 2. Percentage of total First Nations Reserve Land area that has a drinking water advisory (DWA).

iv. Maps

Map 1

Drinking Water Advisories (DWA) on First Nations Reserves in Ontario

Niisii Guujaaw, Kihan Yoon-Henderson, John Drummond, and Kaymi Yoon-Maxwell I UBC Geography I April 10, 2018



Type of DWA

- No DWA
- Boil Water Advisory
- Do Not Consume

Length of DWA

- No DWA
- 1 year or less
- 1-5 years
- 5-10 years
- 10-15 years
- 15-20 years
- 20-24 years

- Cities (Not Reserve)

Data Source: Government of Canada Open Data, UBC Geography Geodatabase, Ontario Open Data, Natural Resources Canada
Coordinate System: GCS_North_American_1983
Map Projection: Canadian Lambert Conformal Conic; Datum: D_North_American_1983

Map 2A

Type of Drinking Water Advisories on First Nations Reserves in Southern Ontario

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Type of Drinking Water Advisory (DWA)

- No DWA
- Boil Water Advisory
- Do Not Consume

Census Metropolitan Area (Not Reserve)

Data Source: Government of Canada Open Data, UBC Geography Geodatabase, Ontario Open Data, CanMap Content Suite
Coordinate System: GCS_North_American_1983; Map Projection: Canadian Lambert Conformal Conic; Datum: D_North_American_1983

Map 2B

Type of Drinking Water Advisories on First Nations Reserves in Northern Ontario (Kenora Region)

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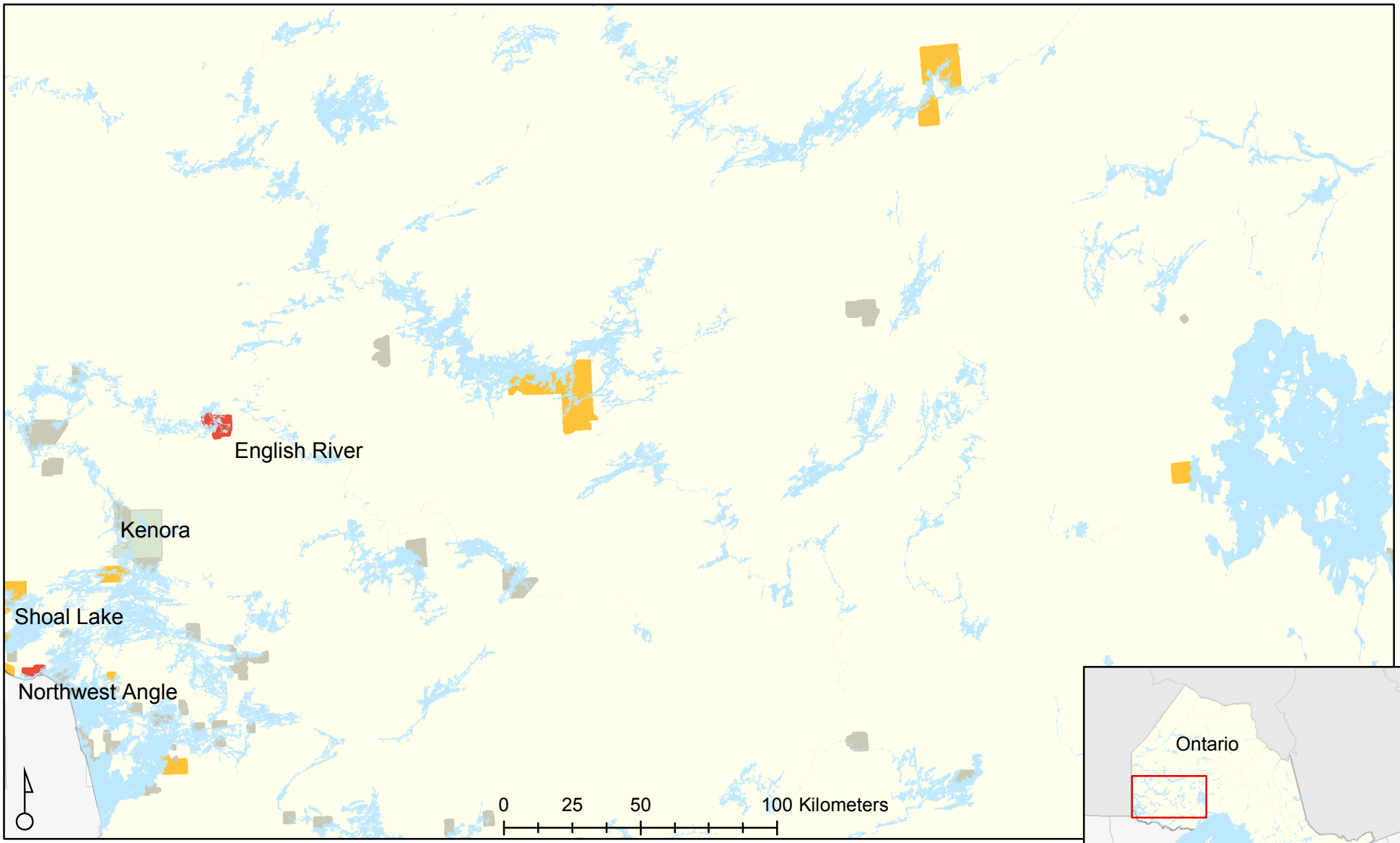


Type of Drinking Water Advisory (DWA)

- No DWA
- Boil Water Advisory
- Do Not Consume

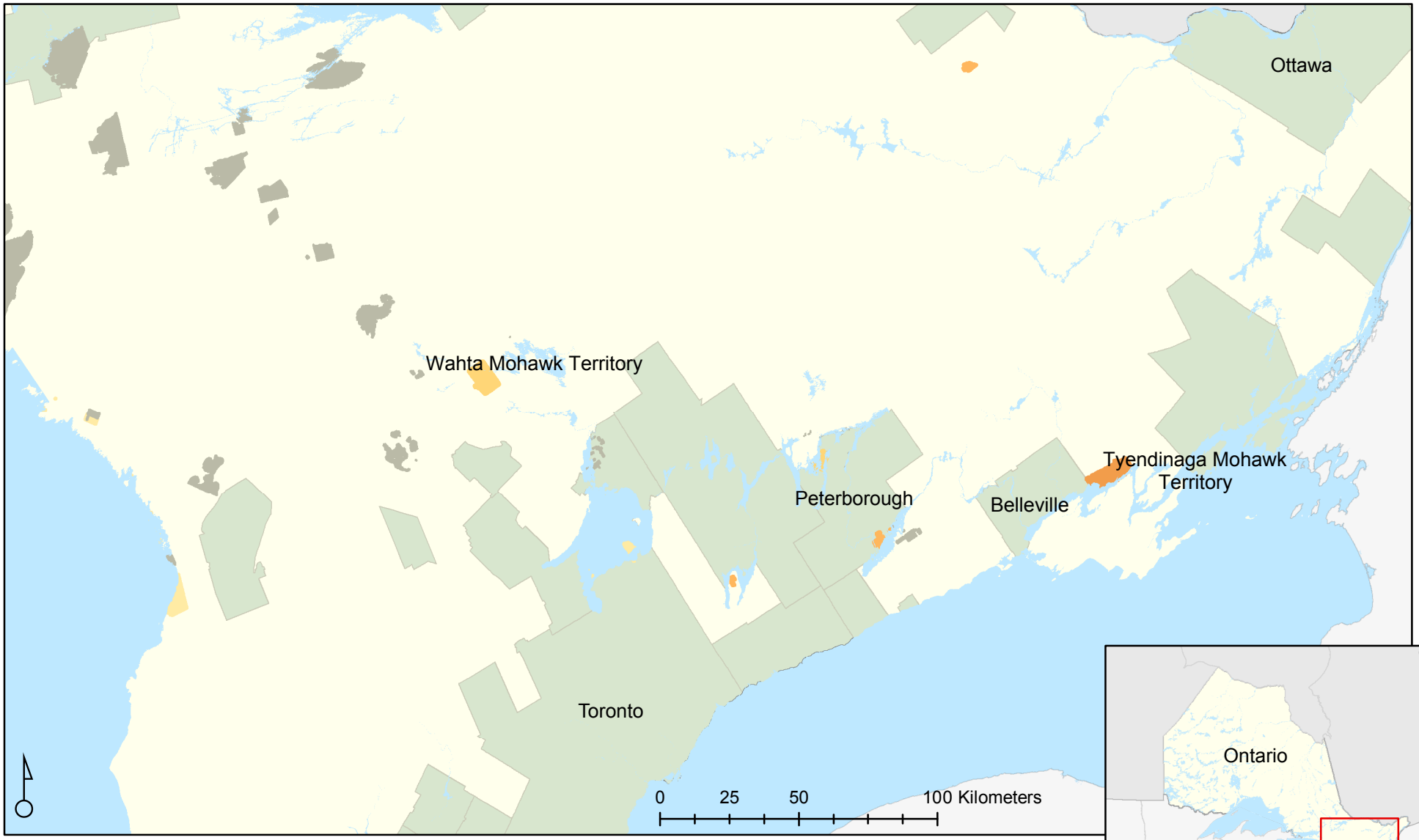
Census Metropolitan Area (Not Reserve)

Data Source: Government of Canada Open Data, UBC Geography Geodatabase, Ontario Open Data, CanMap Content Suite
Coordinate System: GCS_North_American_1983; Map Projection: Canadian Lambert Conformal Conic; Datum: D_North_American_1983

Map 3A

Length of Drinking Water Advisories on First Nations Reserves in Southern Ontario

Niisii Guujaaw, Kihan Yoon-Henderson, John Drummond, and Kaymi Yoon-Maxwell I UBC Geography I April 10, 2018

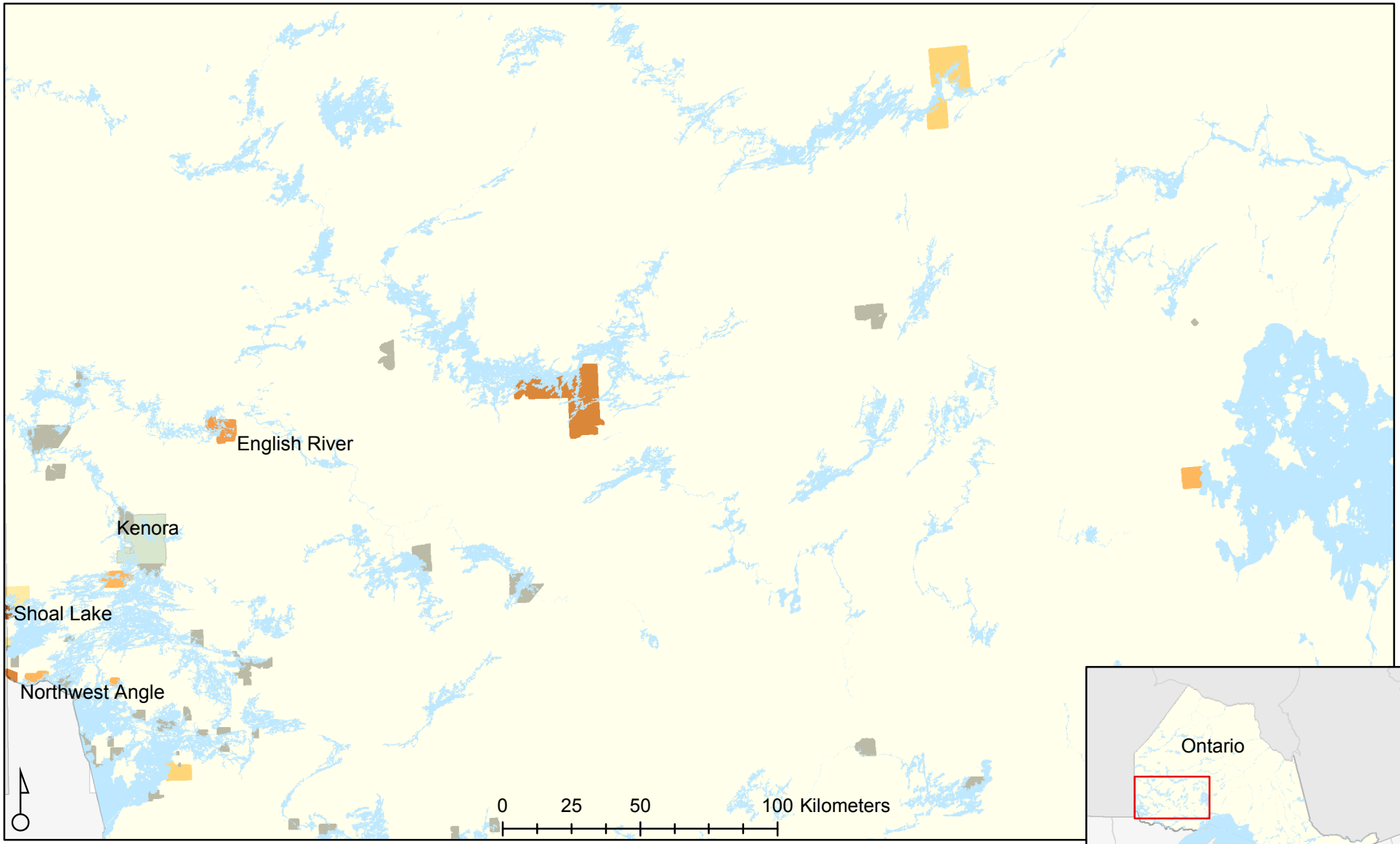


Data Source: Government of Canada Open Data, UBC Geography Geodatabase, Ontario Open Data, CanMap Content Suite
Coordinate System: GCS_North_American_1983; Map Projection: Canadian Lambert Conformal Conic; Datum: D_North_American_1983

Map 3B

Length of Drinking Water Advisories on First Nations Reserves in Northern Ontario (Kenora Region)

Niisii Guujaaw, Kihan Yoon-Henderson, John Drummond, and Kaymi Yoon-Maxwell I UBC Geography I April 10, 2018



Data Source: Government of Canada Open Data, UBC Geography Geodatabase, Ontario Open Data, CanMap Content Suite
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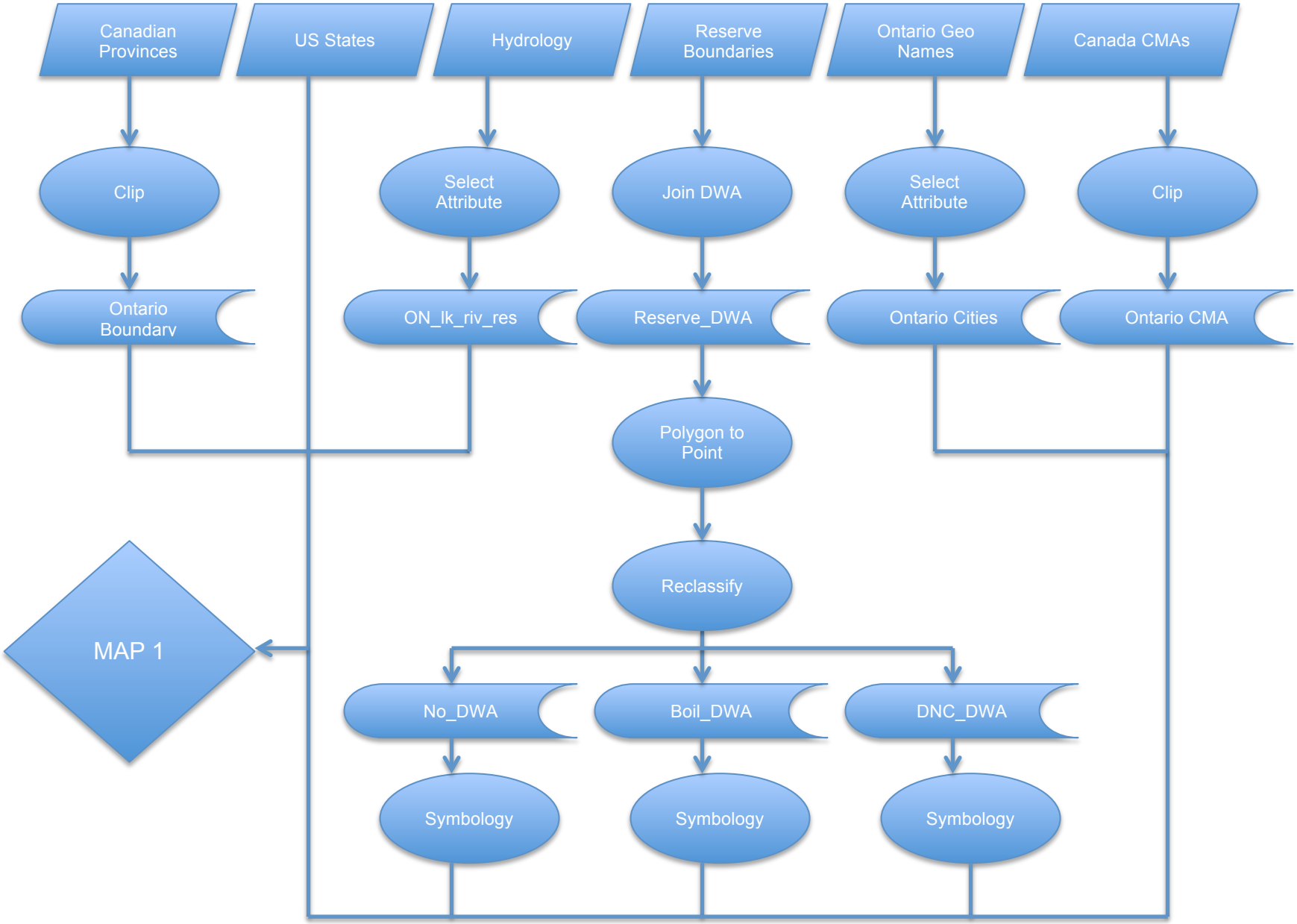
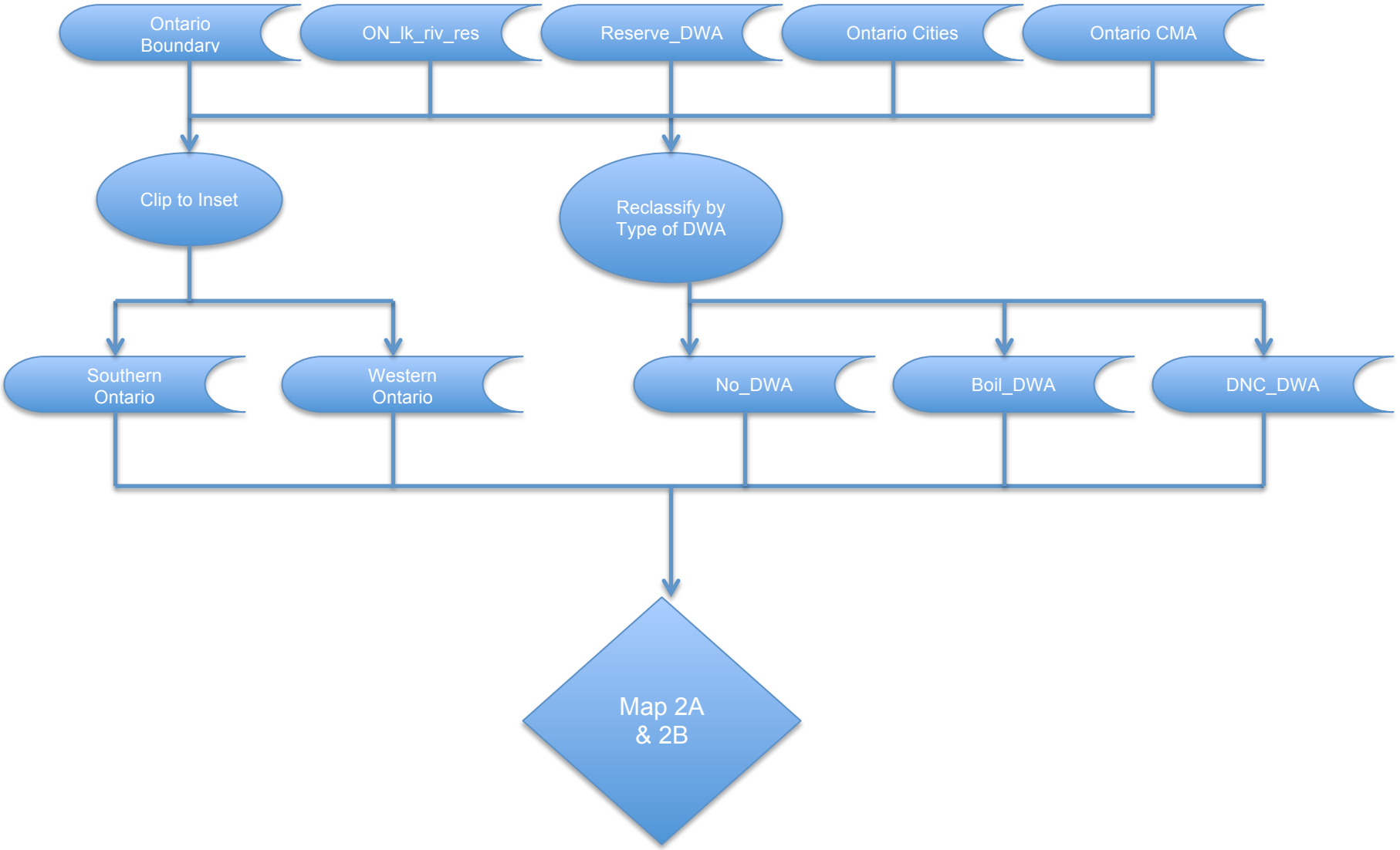
v. Flowcharts

Flowchart for Map 1



Flowchart for Map 2A and 2B



Flowchart for Map 3A and 3B