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Siting of NIFSC Regional Centres Through GIS Analysis

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This report draws on data that is currently in place that was available for First Nations Populations on Reserve. There is a goal in moving beyond this current state and wherever possible by implementing new forms of data collection, drawing upon different data sources, and framing research questions that include Inuit and Métis populations and communities and First Nations residents on reserve.

UNIVERSITY OF THE FRASER VALLEY

COMMUNITY HEALTH AND SOCIAL INNOVATION HUB

Turning knowledge into action

EXECUTIVE SUMMARY

Responsiveness is the key performance indicator that is valued most by any agency or office that is in the business of helping people, and it is the main determinate used in the Geographic Information Systems (GIS) analysis carried out to locate future National Indigenous Fire Safety Council (NIFSC) Regional Centres. This document reports the GIS analysis where responsiveness was built into two approaches to inform site selection carried out in the GIS.

The first approach employed to integrate responsiveness in the placement of future regional centres is by focusing on the people who will need the service. Their real needs are based on the risks that they are exposed to while living in their communities. Incorporating the results of the recent risk assessment carried out by the Community Health and Social Innovation (CHASI) Hub of the University of the Fraser Valley (UFV) from hereon referred to as the CHASI Risk Assessment[1] report, was the basis of the first approach.

The second approach centred on the provision of service, asserting that the future regional centre should be more responsive by reducing response time. GIS was used to determine the total length of road distance needed to be traveled from a particular location in the cluster of Census Subdivisions (CSDs) to all the other areas in the cluster. This provided a way for the selected sites to be compared with those that can optimize their location.

Standard GIS procedures, Cluster Analysis, and Distance Analysis were applied on the results of the CHASI Risk Assessment as the basis of finding the location of the Regional Centres where responsiveness will be its main performance indicator. As such, the Proportion of the Population at Risk were culled from the CHASI Risk Assessment and used in weighting of various spatial statistics carried out in the ArcGIS 10.7 software.

The GIS analyses were carried out on clusters of Tribal Council Units with matching geographic attribute and spatial data as Census Subdivisions in each of the provinces of Canada, as published by Statistics Canada. The discussions in this report will be based on the clusters of Census Subdivisions, but for this executive summary, Figure 1 is shown as the collection of all the candidates for all the provinces in one map.

The GIS model created and used in several ways, revealed that a selection process that involved integrating risk assessment early in the process is successful as proven by the fact that the total road distance to travel is not affected significantly, and yet, the site selected has been optimized to be as close as possible to all the people who need service from the regional centre.

1 Huesken, S., Xiao, R., Jennings, C. and Dow, M. (2020). Moving from Risk Assessment to Risk Reduction: An analysis of Fire-related Risk Factors in First Nation/Indian Band or Tribal Council Areas across Canada. A report prepared for the Aboriginal Firefighters Association of Canada.

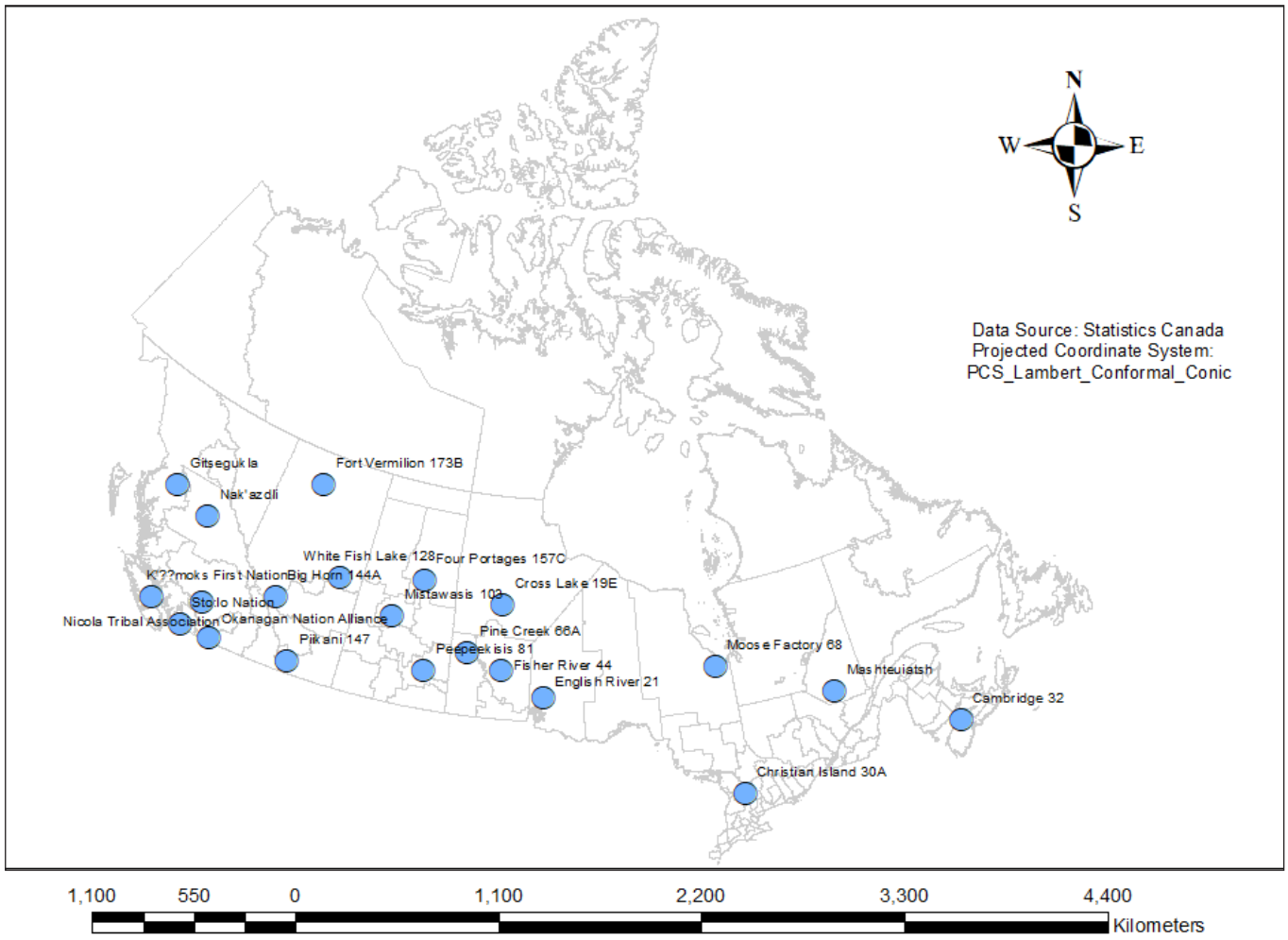

Figure 1. Distribution of Candidate Sites for the NIFSC Regional Centres

The following chart summarizes the report findings and lists the recommended Census Subdivisions as site selections based on two methods as described in the Methods section and in each provincial Results section. Those methods are Central Feature (Census Subdivision that is closest to the median centre) and Shortest Distance between the candidate and all the other Tribal Council Areas in the cluster.

		Method used to rank Census Subdivisions (CSDs) for site selection	
	Region	Centre of Risk	Shortest Distance
Alberta	Northwest	Fort Vermillion 73B	Loon Lake (1st) / Fort Vermillion 73B (11th)
	Northeast	White Fish Lake 128	Heart Lake 7 (1st) / White Fish Lake 128 (9th)
	Central	Bit Horn 144a	Erminesin 128 (1st) / Big Horn 144a (13th)
	Southern	Piikani 147	Peden Valley 216 (1st) / Piikani 147 (2nd)
Atlantic Region	Atlantic Cluster	Cambridge 32	Fort Folly 1 (1st) / Cambridge 32 (8th)
British Columbia	Northwest	Gitzegukla 1	Gitzegukla 1
	Northeast	Nak'azdli	Tl'azt'en Nation (1st) / Nak'azdli (2nd)
	Central	Yawaucht 11	River Bridge (1st) / Yawaucht 11 (7TH)
	South Interior	Okanagan 1	Okanagan 1
	Lower Mainland	Lakahahmen 11	Spawkum Creek 3 / Lakahahmen 11
	South Coast	Comox 1	Tsahahe 1 (1st) / Comox 1 (6th)
Manitoba	North	Cross Lake 19E	Cross Lake 19E
	Southeast	Fisher River 44	Peguis (1st) / Fisher River 44 (2nd)
	Southwest	Pine Creek 66A	Rolling River 67 (1st) / Pine Creek 66A (11th)
Ontario	Northwest	English River 21	Whitefish A (1st) / English River 21 (9th)
	Northeast	Moose Factory 68	Mattagami 71 (1st) / Moose Factory 68 (9th)
	Southeast	Christian Island 30A	Christian Island 30 (1st) / Christian Island 30A (2nd)
Quebec	Province-wide	Mashteuiatsh	Mashteuiatsh Wemotaci
Saskatchewan	Northern	Four Portages 157C	Four Portages 157C
	Western	Mistawasis 103	Witchekan Lake 117D (1st) / Mistawasis 103 (8th)
	Southern	Peepeekisis 81	Star Blanket 83(1st) / Peepeekisis 81 (67th of 88)

Table 1. Summary of recommended Census Subdivisions as site selections based on report findings

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PURPOSE

The main goal of the project is to identify candidate sites for the National Indigenous Fire Safety Council (NIFSC) Project's Regional Centres through Geographic Information Systems (GIS) that would enhance responsiveness to any natural or human-caused disasters and emergencies and community health planning for people in Tribal Council Areas (TCAs).

METHOD

In the following section we detail our methodology for the GIS analysis, which includes several key tasks to fulfill the information needs outlined by the NIFSC. These tasks include: the development of the GIS analysis from the CHASI Risk Assessment, the use of Cluster Analysis tools, the use of Proximity Analysis tools, the use of GIS broadband and Human Resource Capacity overlays, and landscape analysis of the candidate sites through Google Earth Pro.

TASK 1. DEVELOPMENT OF THE GIS FROM THE CHASI RISK ASSESSMENT

Accurate data drives a GIS, and in this project, the results from the CHASI Risk Assessment provided data of the highest granularity. Table 1 shows the different data used in the construction of the project's base GIS, and the sources of the data.

Dataset	Purpose	Remarks	Source
Proportion of Population at Risk	Used as weights in the spatial statistics used in identifying candidate sites	There are some limitations as not all the TCAs have been enumerated in 2016, and some enumerations occurred at different levels than the boundary files.	CHASI Risk Assessment
Boundary files[1]	Provided the accurate geographic locations of the TCAs, the provinces, the health districts, the roads, the bandwidth	The native projection of PCA Lambert Conformal was preserved until the end of analysis, but some maps were created using UTM for more familiarity to map readers	Statistics Canada

1 Boundary Files, 2016 Census. Statistics Canada Catalogue no. 92-160-X.

Table 2. Dataset for the GIS created for the NIFSC Regional Centre Siting Project

The Total Population and Proportion of Population at Risk were selected from the CHASI Risk Assessment report. Although the report provided 625 data points for the GIS, it included aggregated data from Tribal Councils and other designations, as well as data at the TCA level. The values of the TCAs were derived from the higher level data. Aggregated values on Total Population were divided by the number of the TCAs and the resulting average was assigned to each of the comprising TCAs.

Important data manipulations were carried out for the Proportion of Population at Risk. The values reported for a higher-level aggregation were assigned to the comprising TCAs without any change. Since there are TCAs used in the GIS without data, a null value was conservatively assigned a 1-person value in estimated number of people at risk (ENPAR) for a TCA to participate in the Spatial Statistics for the selection of the candidate sites. Finally, the proportion of the population at risk for CSDs without values was assigned through the average from their neighbours.

The base GIS is divided into sub-components that follow provincial geography. With the limited number of TCAs in the eastern provinces, data were from the four provinces were pooled for a regional instead of provincial analysis.

TASK 2. CLUSTER ANALYSIS

Cluster Analysis tools in the Spatial Statistics extension of ArcGIS 10.7.1 were used to find unbiased grouping of the TCAs based on their proximity to each other with the ENPAR values as weights. Three spatial statistics were used to assess the distribution: Median Centre (physical centre that divides the Census Subdivision—or Indian Reserve—into two parts based on the estimated number of people at risk), Standard Directional Deviation (Standard Directional Ellipse), and the Central Feature (Census Subdivision that is closest to the median centre), with all three statistics shown in the maps provided in the results section of this report.

From the initial run of the model using the above as parameters, it became apparent that various numbers of clusters can be carried out without compromising the validity of the results. This points to the robustness of the GIS model which allows decision makers to modify the clusters if required.

Initially, the transportation districts of the different provinces were, appropriately, used to determine the extent of the clusters of CSDs, as the emphasis on responsiveness means the road network is a prime consideration for the project. Unfortunately, transportation regions or districts of the different provinces are not uniform and would create an unstable basis of the clusters. The health districts, with boundaries provided by Statistics Canada from the data provided by the province offered not only a more stable reason for the extent of the clusters but

also a theoretical rationale for the clusters as essentially, the mandate of the NIFSC Regional Centres would be aligned with that of the health services.

The number of clusters then became a compromise among the different data: the number of TCAs in the province, the Total Population of to the TCAs in the province, the Proportion of the Population at Risk, and the boundary of the health districts. The cluster analysis identified the flagship candidate site (optimum location) for each cluster as well as its closest neighbours as other possible candidates.

TASK 3. ROAD NETWORK (DISTANCE) ANALYSIS

The Proximity Analysis tools of ArcGIS 10.7.1 were used to determine the distances between the flagship candidate sites and all the TCAs in the cluster. A "Near Distance" table was created for each of the candidate sites and these can be used by the decision makers in their final selection of the sites or for planners when planning activities to ensure responsiveness is attained through creating the shortest route to the different TCAs in the cluster.

TASK 4. GIS OVERLAY OF BROADBAND (INTERNET SERVICE PROVIDERS)

Although the spatial statistics and the road network analyses are the most important considerations in the project, an attempt to include other factors into the analyses was made.

The road network is of prime consideration to the site selection as the respondents will most likely travel through the road network, however other important forms for connecting with people at risk are through the Internet and wireless services. The location and extent of these services were overlaid on the selected candidate sites to see if these considerations point to advantages of certain sites over other TCAs. These maps for each province/region are attached in Appendix A.

TASK 5. OVERLAY OF HUMAN RESOURCE CAPACITY

There is an advantage to a TCA if selected as a candidate site to also have the human capacity to manage and optimize the responsiveness of a Regional Centre. Therefore, post-secondary training data from Statistics Canada were overlaid on the GIS layer of the selected candidate sites. These maps for each province/region are attached in Appendix B.

TASK 6. LANDSCAPE ANALYSIS OF THE CANDIDATE SITES THROUGH GOOGLE EARTH PRO

Finally, the GIS layers of the candidate sites were exported as KMZ files for visual inspection using Google Earth Pro. These files will summarize this report's basic data to Google Earth. A list of links for each considered recommendation can be found in Appendix C.

RESULTS

The results were grouped by province—or region, in the case of eastern Canada. A summary is provided at the beginning of each section.

1. ALBERTA

The ENPAR of the CSD units in Alberta are quite different from each other. Some are quite high and others are quite low. There seems to be lower numbers of moderate values. This has an impact in creating the clusters for this province.

1.1 Cluster Analysis

Figure 2 presents four distinct clusters of CSD units, with very clear separation of the clusters. The Median Centre, which divides the cluster into two based on their ENPARs, correlated to the Central Feature, the CSD that is closest to the Median Centre. The initial four Central Features, while statistically favoured in the cluster due to their positions, should be considered flagships of the clusters while those CSDs falling inside the ellipse should be considered as alternatives should the flagships not be selected due to different screening. These secondary choices are shown in Figure 3.

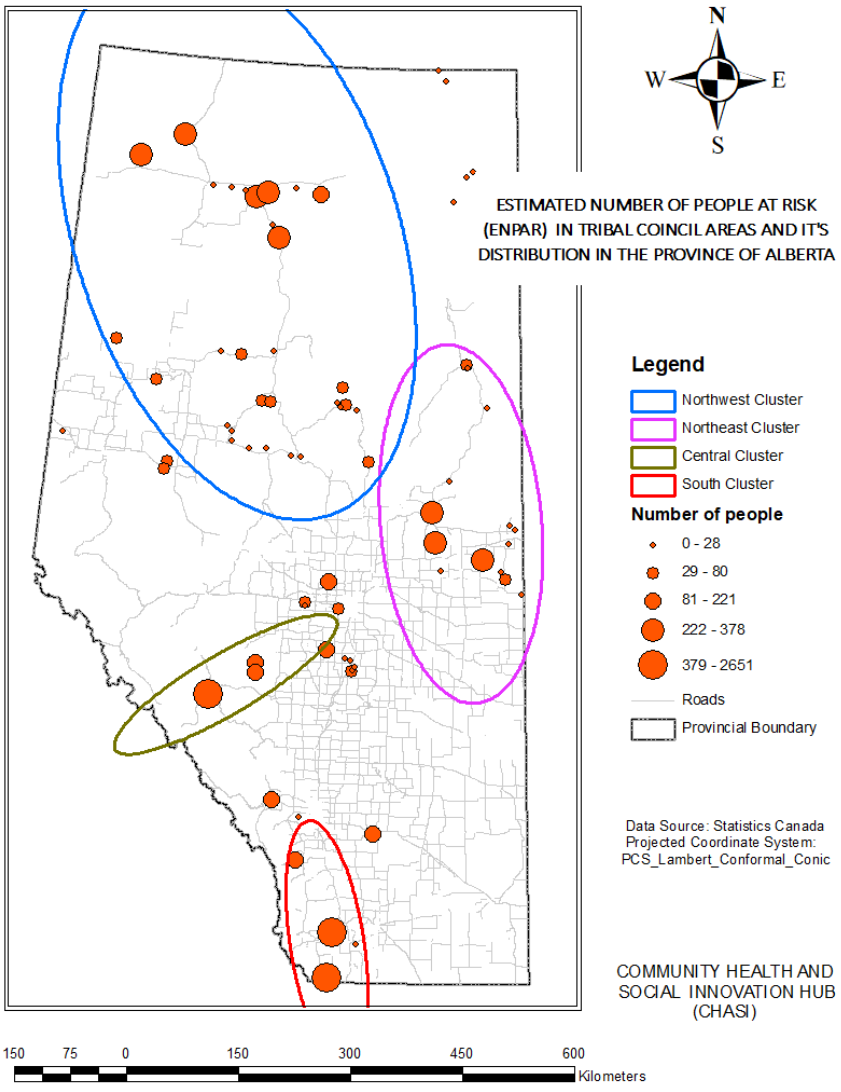


Figure 2. The Estimated Number of Persons at Risk in the Tribal Council Areas and their distribution in Alberta, Canada

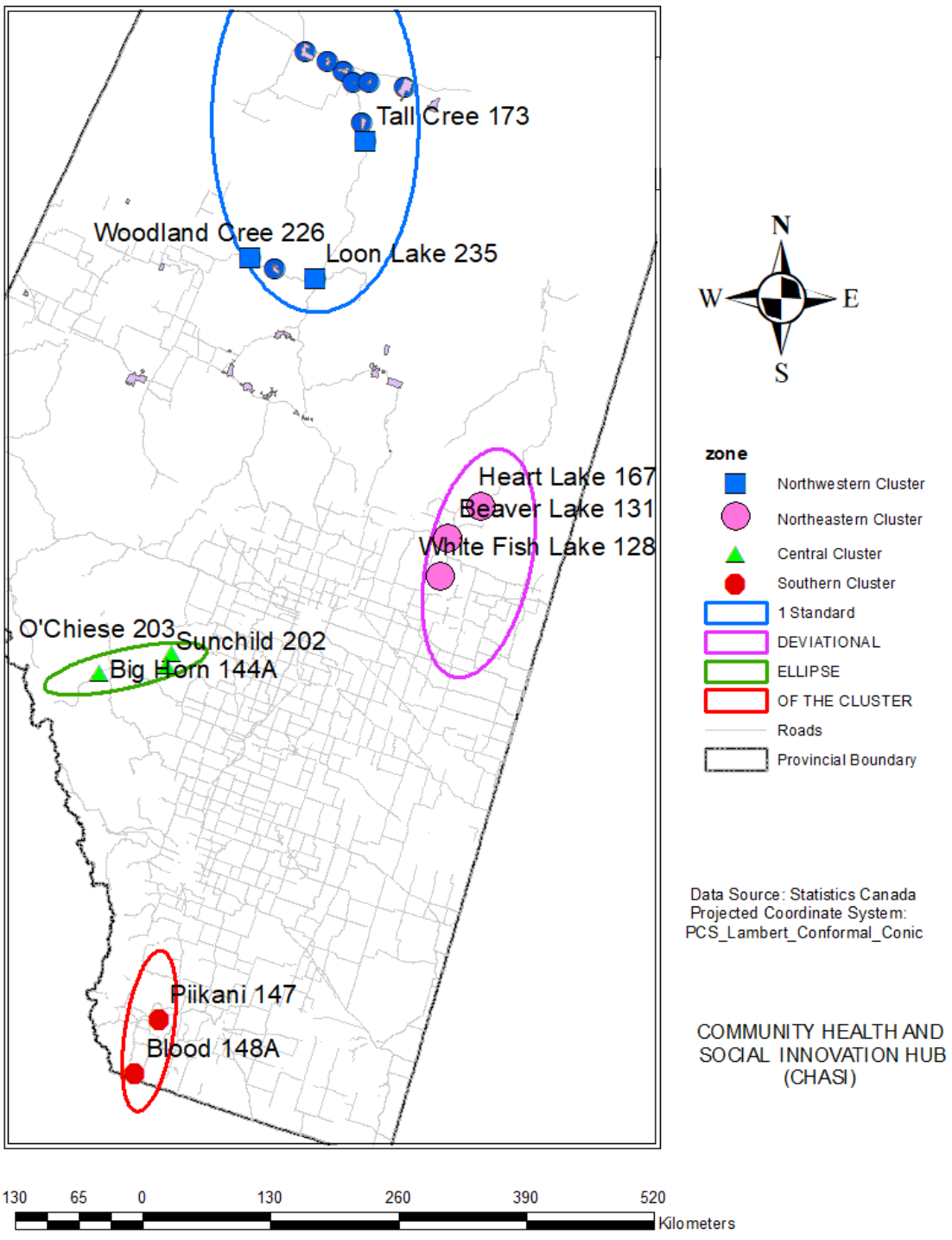


Figure 3. Flagship Candidate Sites and their neighbours as alternative candidate sites

1.2 Shortest Distance Comparisons

Due to the desire for responsiveness, it was expected that the future regional centre would be close to the TCAs that need services most. It meant that the GIS used in selecting the candidate sites force the selection of units that are closest to those most in need. This will have an indirect effect on the distance of travel from one CSD to all the other CSDs because the GIS will not optimize the cluster as it will prioritize being closest to the units with high risk.

It is still important to compare the CSDs selected through cluster analysis to those CSDs that might have shorter distances to travel to know if the selected sites have been disadvantaged by selecting for proximity to higher levels of risks.

Figures 4 (a-d) reveals the comparison of the selected flagship sites to those which can be optimized for shorter distance.

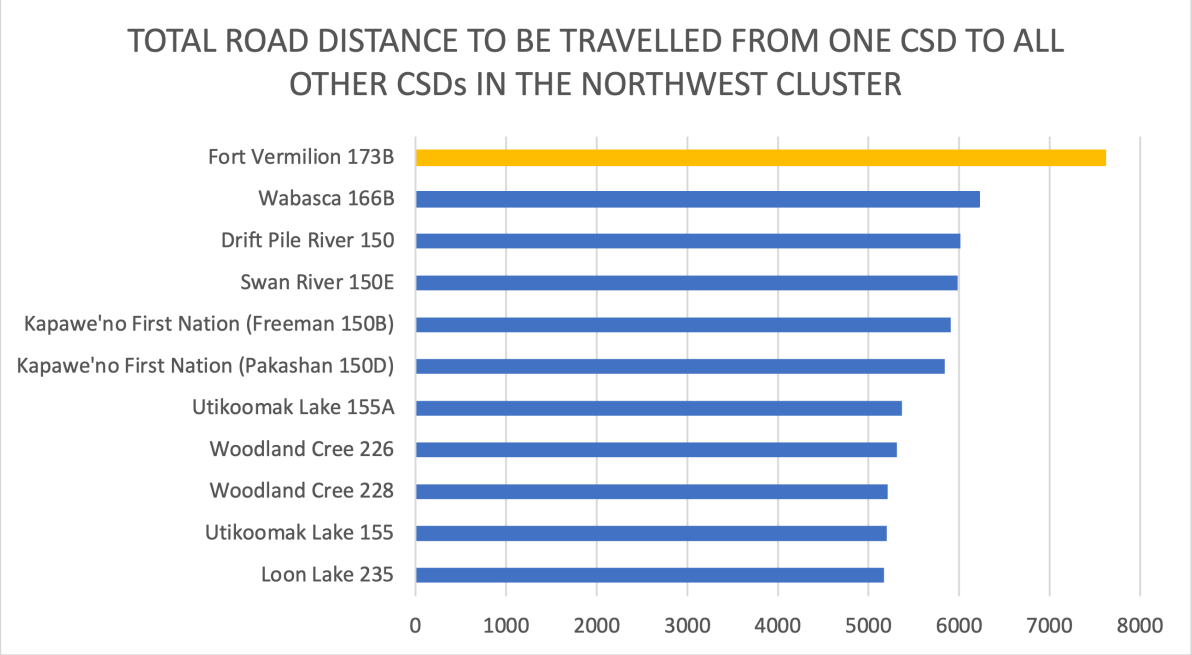


Figure 4a. Comparison of Fort Vermillion 73B with other locations in the northwest cluster in terms of total road distance in km

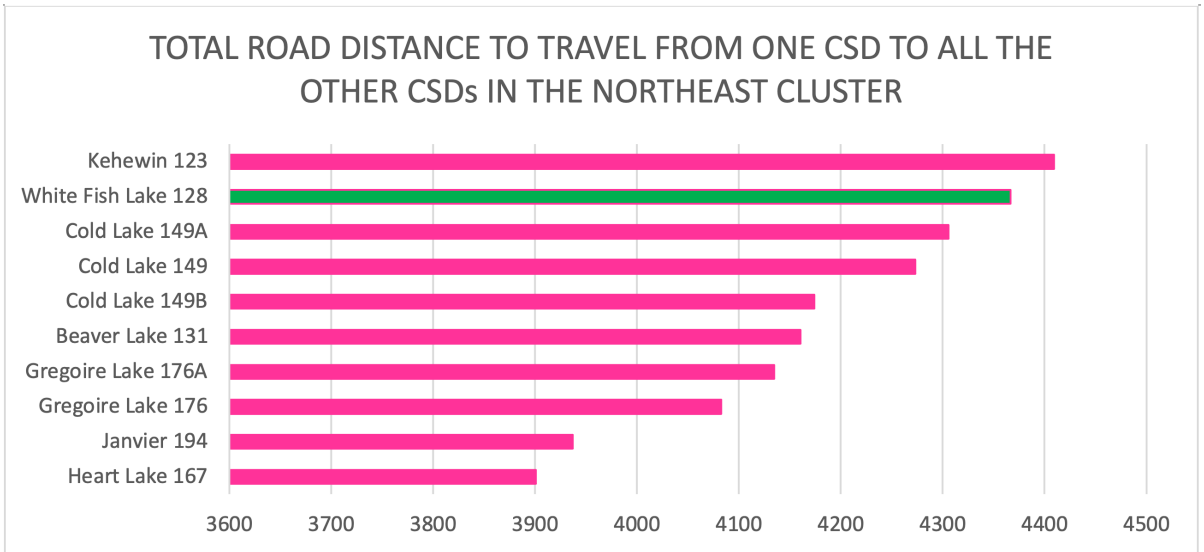


Figure 4b. Comparison of White Fish Lake 128 with other locations in the northeastern cluster in km

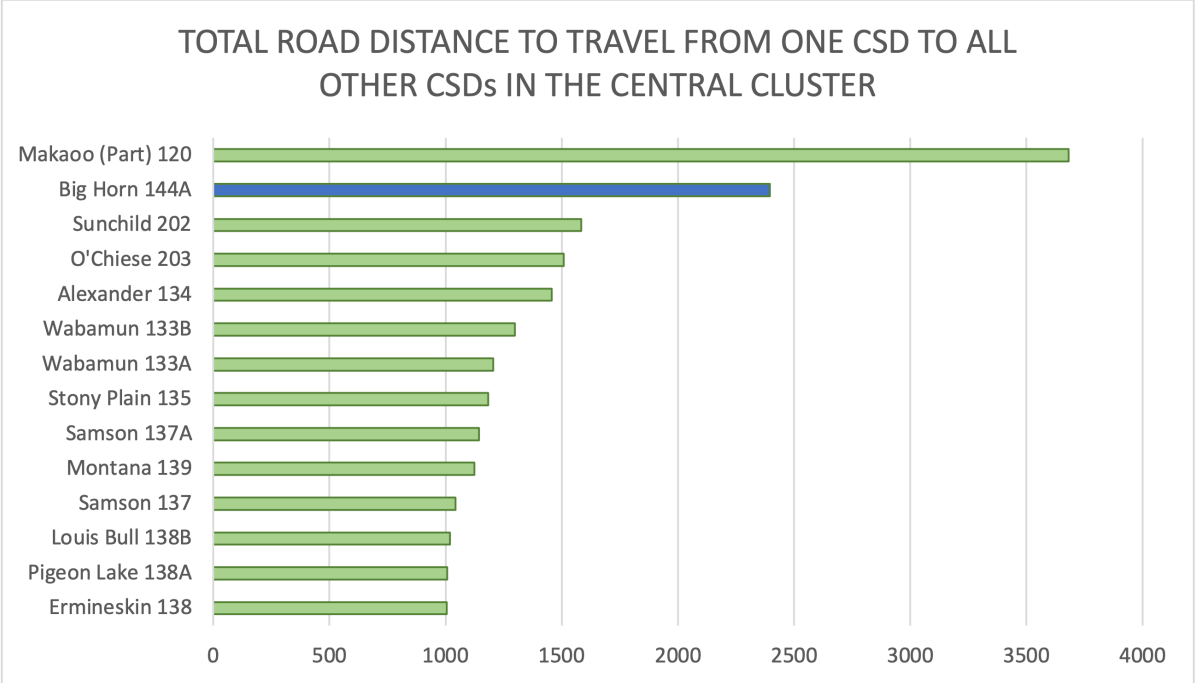


Figure 4c. Comparison of Big Horn 144A with other locations in the central cluster in km

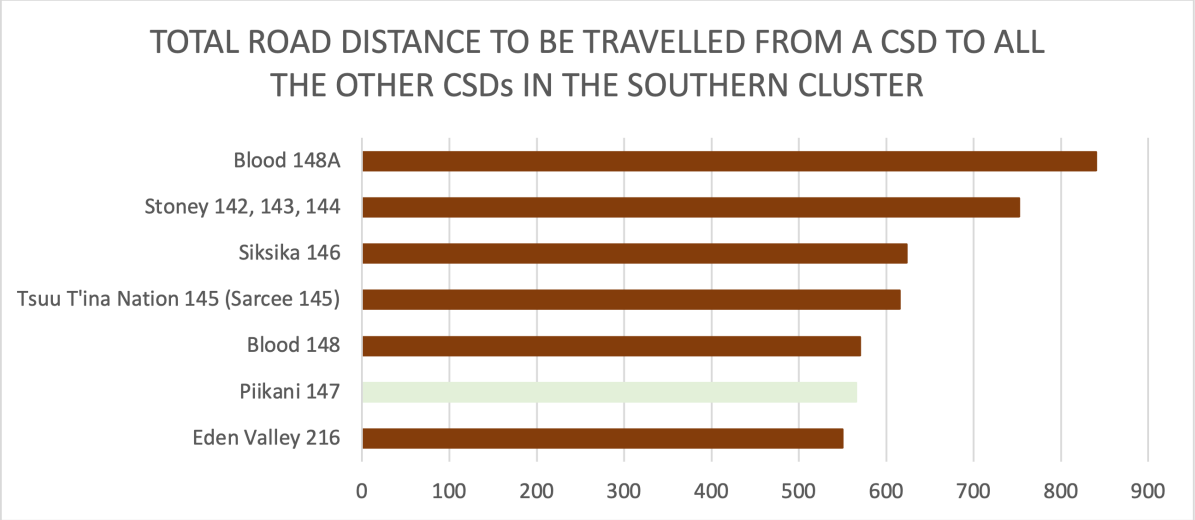


Figure 4d. Comparison of Piikani 147 with other locations in the southern cluster in terms of total road distance in km

1.3 Final List of Candidates

Only Piikani 147 came close to matching the CSD with the shorted distance to travel. As it was mentioned previously, the distribution of the ENPAR in Alberta made the method of clustering more disadvantageous. This is due to a highly skewed statistical distribution of the risks (ENPAR). The Central Feature is the Census Subdivision that is closest to the median centre.

	Method	
Cluster	Centre of Risk	Shortest Distance
Northwest	Fort Vermillion 73B	Loon Lake (1st) Fort Vermillion 73B (11th)
Northeast	White Fish Lake 128	Heart Lake 7 (1st) White Fish Lake 128 (9th)
Central	Bit Horn 144a	Erminesin 128 (1st) Big Horn 144a (13th)
Southern	Piikani 147	Peden Valley 216 (1st) Piikani 147 (2nd)

Table 3. Comparison of candidate sites for a regional centre in Alberta

2. ATLANTIC PROVINCES

As a result of fewer Tribal Council Areas in the Atlantic Provinces as compared to the other parts of the country, only one Regional Centre was deemed necessary to respond to the needs of the populations in Tribal Council Areas. The Estimated number of Persons at Risk (ENPAR) in the Census Subdivision Units in the Atlantic Provinces is shown in Figure 16, which indicates that most of the risks are found predominantly in the mainland.

2.1 Cluster Analysis

Cluster Analysis revealed the Median Centre, which divides the cluster into two based on their ENPAR values, correlated to the Central Feature, the Census Subdivision that is closest to the Median Centre, Cambridge 32 (see Figures 5, 6). However, the Standard Deviational Ellipse covers a relatively large area meaning that there are several options for the Regional Centre.

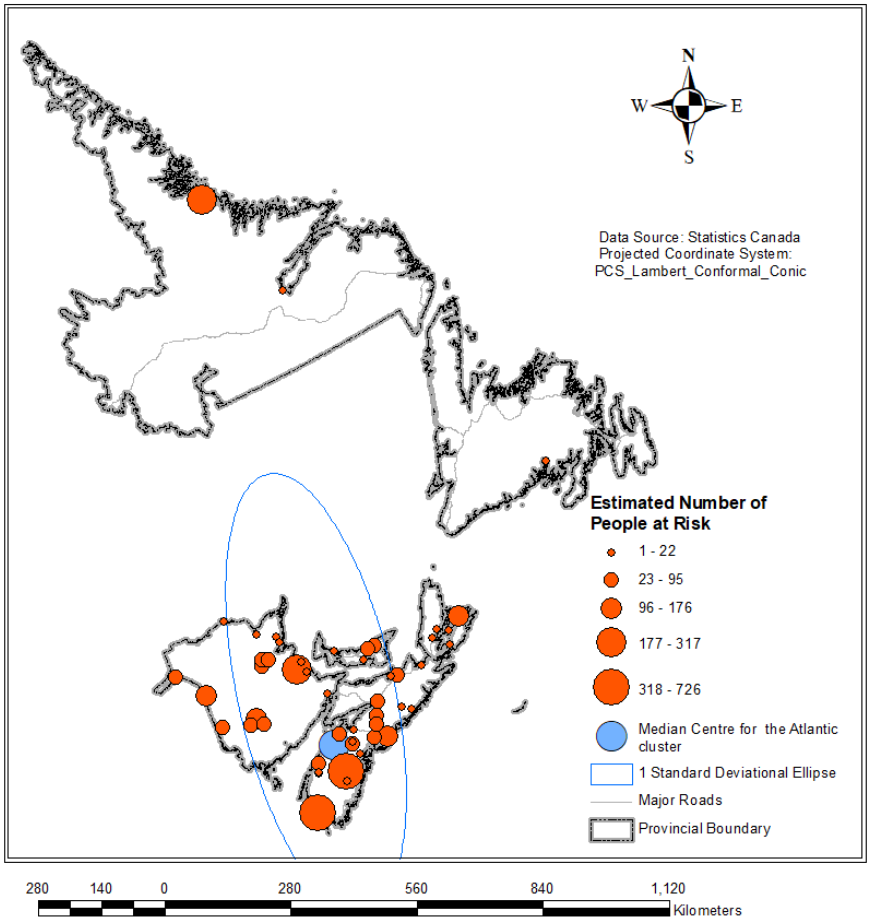


Figure 5. The Estimated Number of Persons at Risk in the Tribal Council Areas and their distribution in the Atlantic Region, Canada

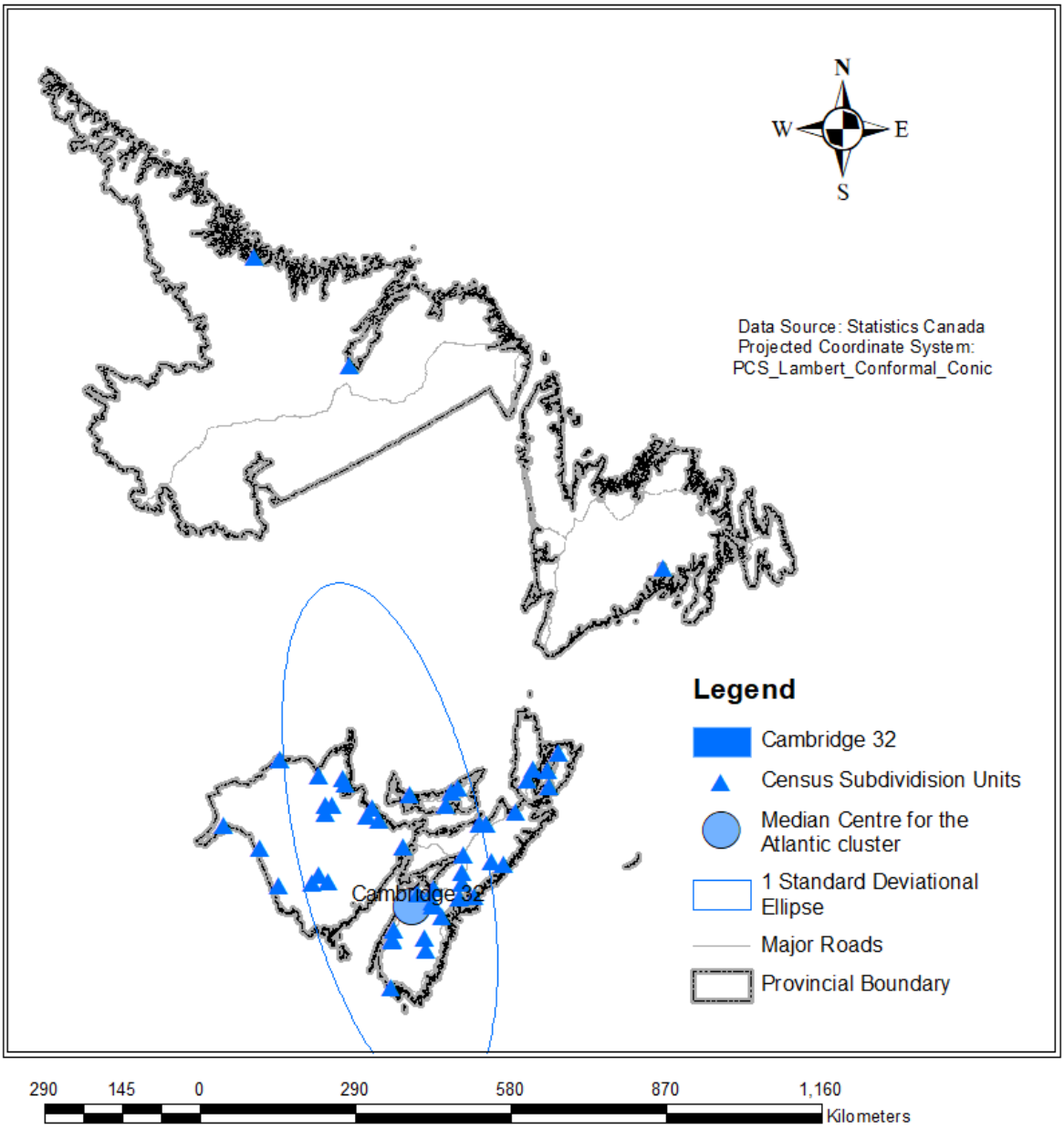


Figure 6. Map resulting from cluster analysis of Atlantic Provinces Census Subdivision (CSD) units using the Estimated Number of Persons at Risk (ENPAR) as weights

2.2 Shortest Distance Comparisons

Cambridge 32 was compared with the rest of the CSDs in the Atlantic cluster. While it did not receive the best total road distance score, the value was in the top ten in a group of 50 CSDs and only 7 scores were better than Cambridge 32.

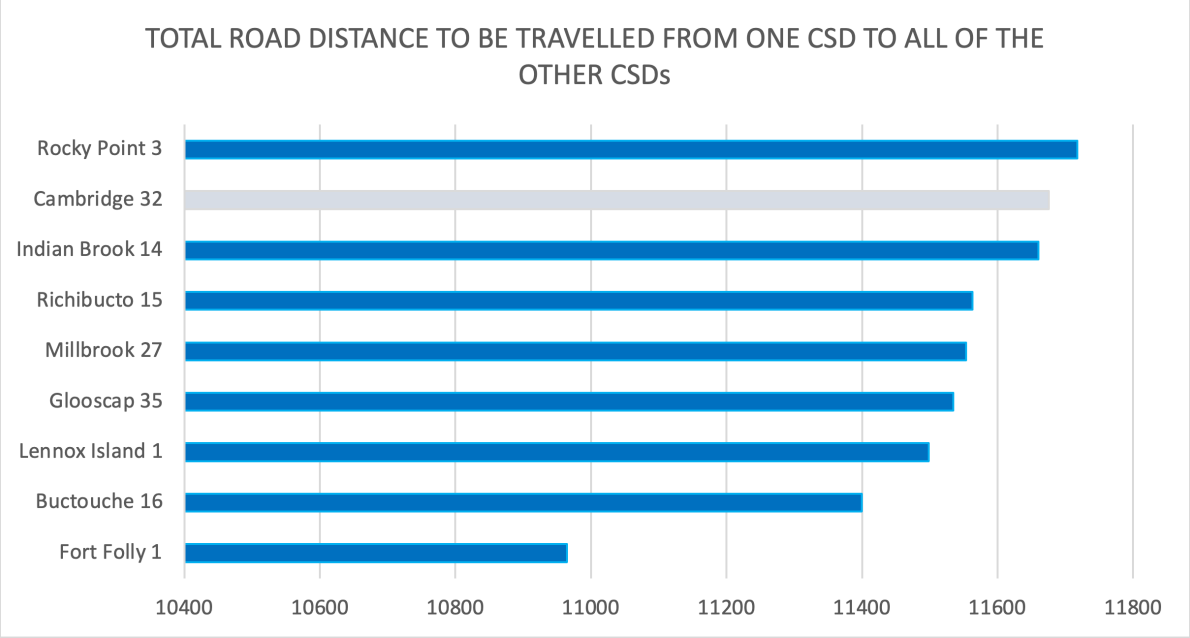


Figure 7. Comparison of Cambridge 32 with other locations in the Atlantic cluster in terms of total road distance in km

2.3 Final List of Candidates

Cambridge 32 was compared with the rest of the CSDs in the Atlantic cluster. While it did not receive the best total road distance score, the value was in the top ten in a group of 50 CSDs and only 7 scores were better than Cambridge 32.

	Method	
Cluster	Centre of Risk	Shortest Distance
Atlantic Cluster	Cambridge 32	Fort Folly 1 (1st) Cambridge 32 (8th)

Table 4. Comparison of candidate sites for a regional centre in the Atlantic Provinces

3. BRITISH COLUMBIA

Almost half of all the data on Indian Reserves used in the project are in British Columbia and this number is reflected in Figure 8 where the distribution of the Estimated Number of Persons at Risk (ENPAR) for the Tribal Council Areas as estimated from the values of the CHASI Risk Assessment is shown. The initial selection process involved the creation of three clusters in the province, each one with a Regional Centre as shown in Figure 9.

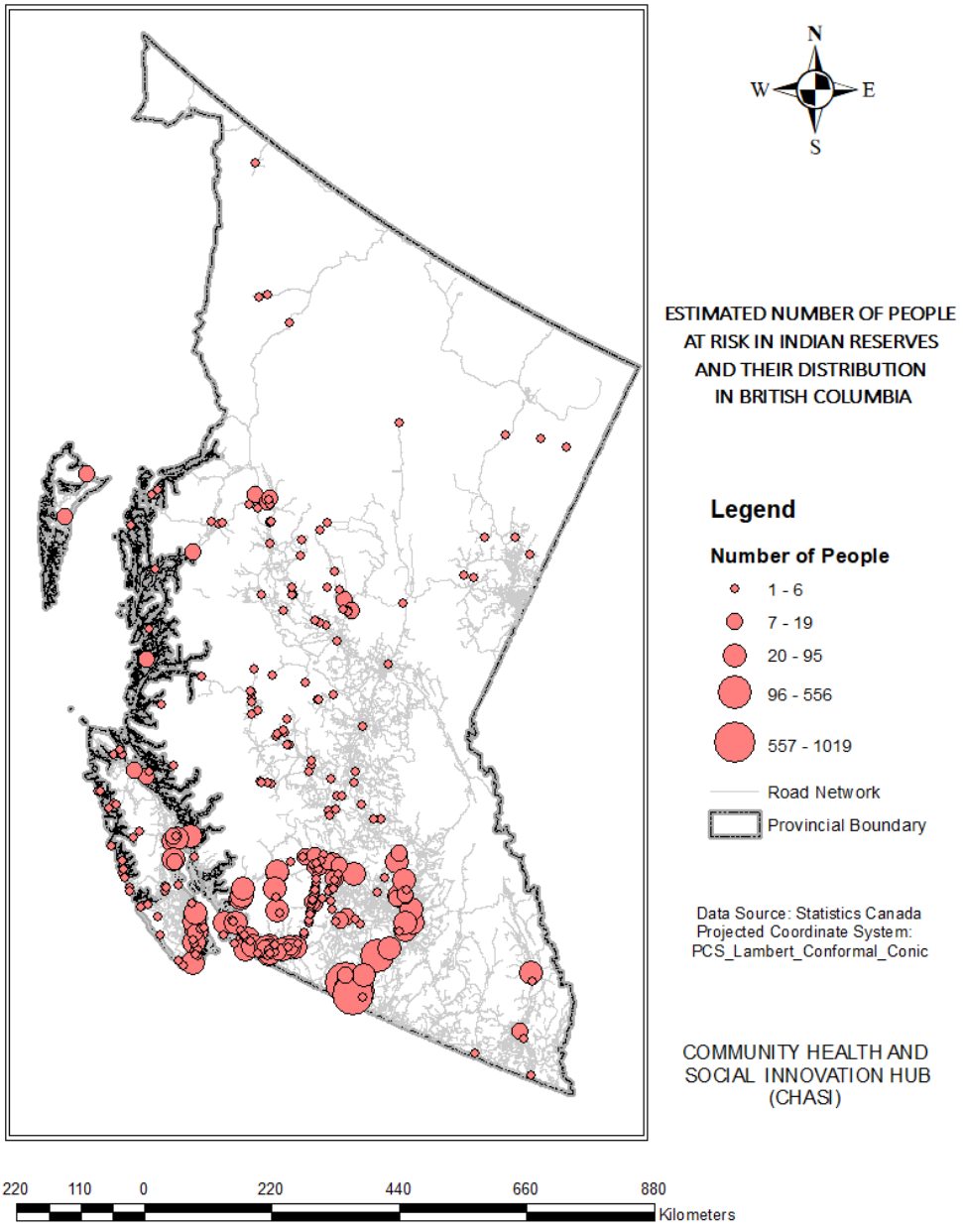


Figure 8. The Estimated Number of People at Risk (ENPAR) in Tribal Council Areas (Census Subdivision Units) and their distribution in British Columbia

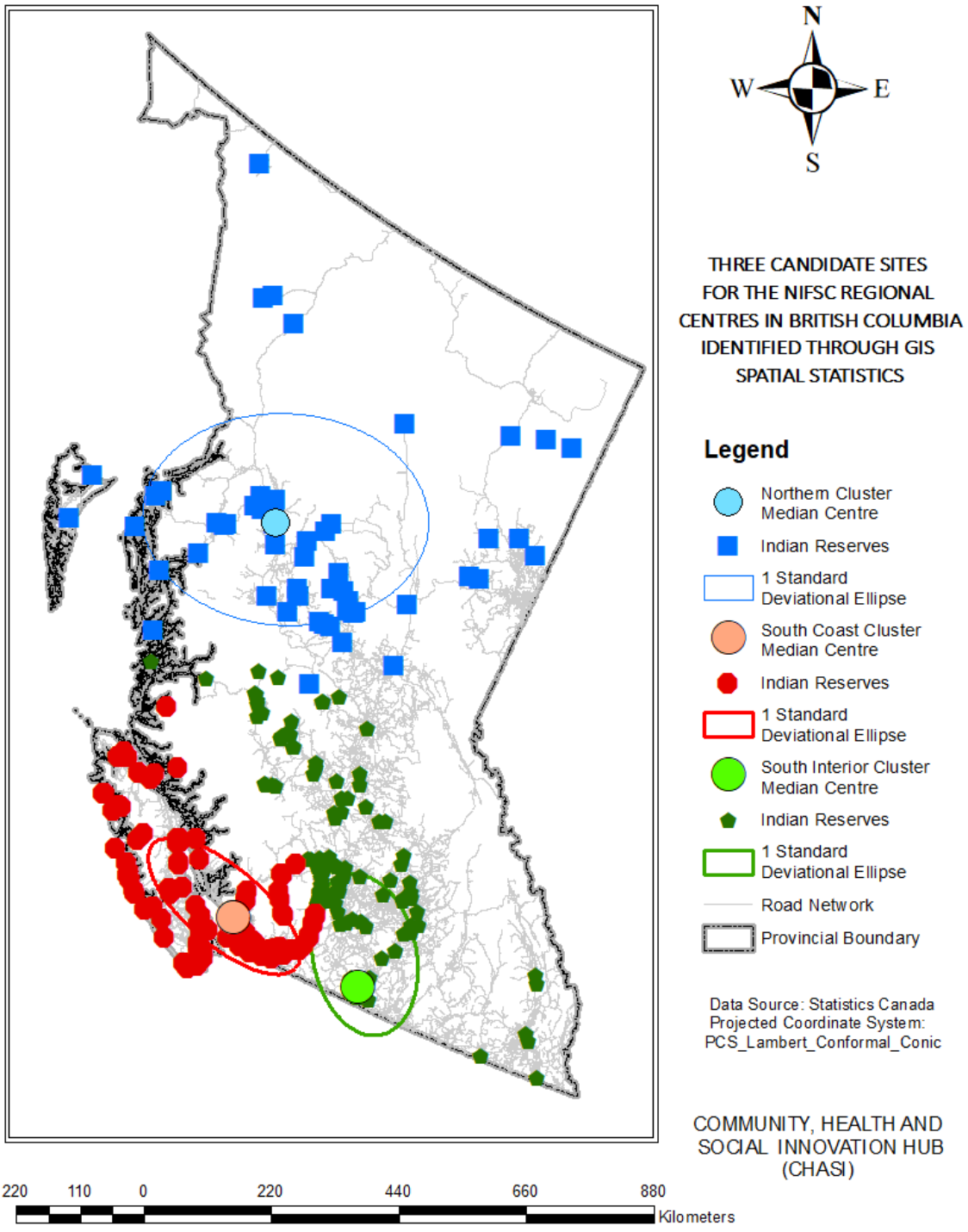


Figure 9. Map resulting from cluster analysis of British Columbia Census Subdivision (CSD) Units using the Estimated Number of Persons at Risk (ENPAR) as weights

3.1 Cluster Analysis

Figure 11 (page 25) shows the six clusters identified through GIS. It should be recognized that adding three more Regional Centres to three previously identified Regional Centres does not necessarily result in the same site selection. It is therefore advisable to identify six site and construct sites based on a six site plan. For example, if there are two centres to be built in the near future, then decision makers should build two from the six identified on the map and then add the others as applicable.

The six flagship candidate sites are shown also on the map. The southern portion of the map seems crowded, but the topography of the area requires these areas to be treated separately. After identifying the Central Feature of the cluster, proximity analysis on the cluster followed.

3.2 Shortest Distance Comparisons

Figures 10 (a to f) show how the six selected sites compare with other sites in terms of the total road distance to travel to all the other CSDs. The graphs show that the selected sites are comparable to, or sometimes better than, the other unselected sites.

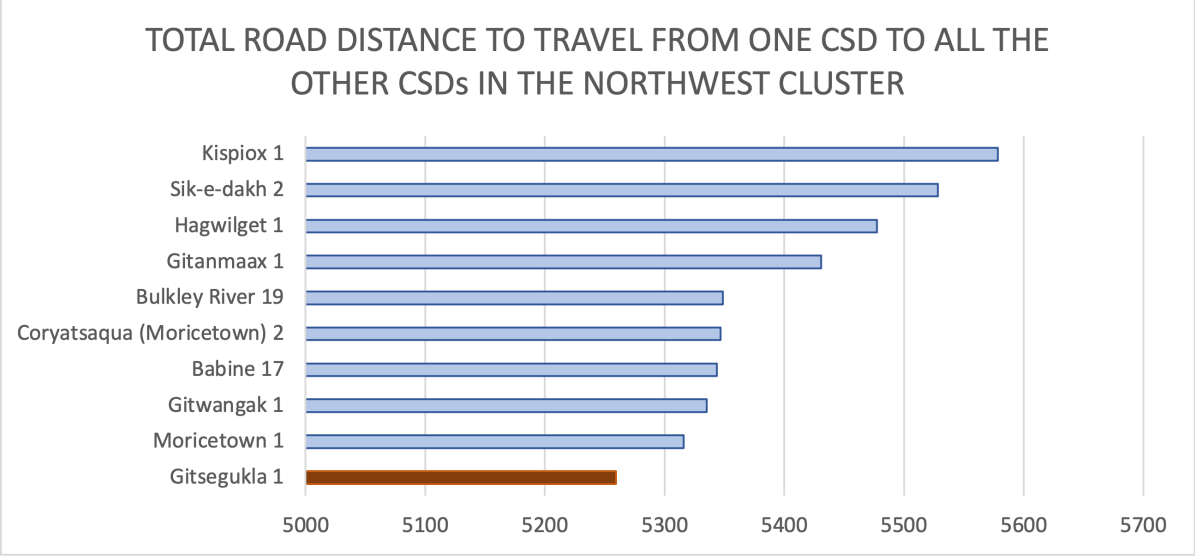


Figure 10a. Comparison of English River 21 with other 10 locations in the northwest cluster in terms of total road distance in km

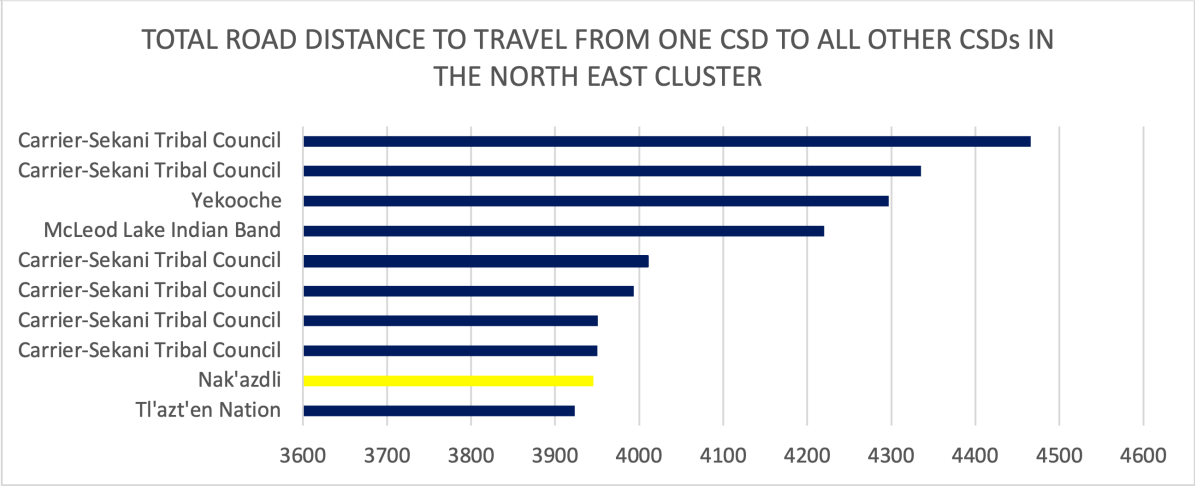


Figure 10b. Comparison of Nak'azdli, the selected site with other locations in the north east cluster in terms of total road distance in km

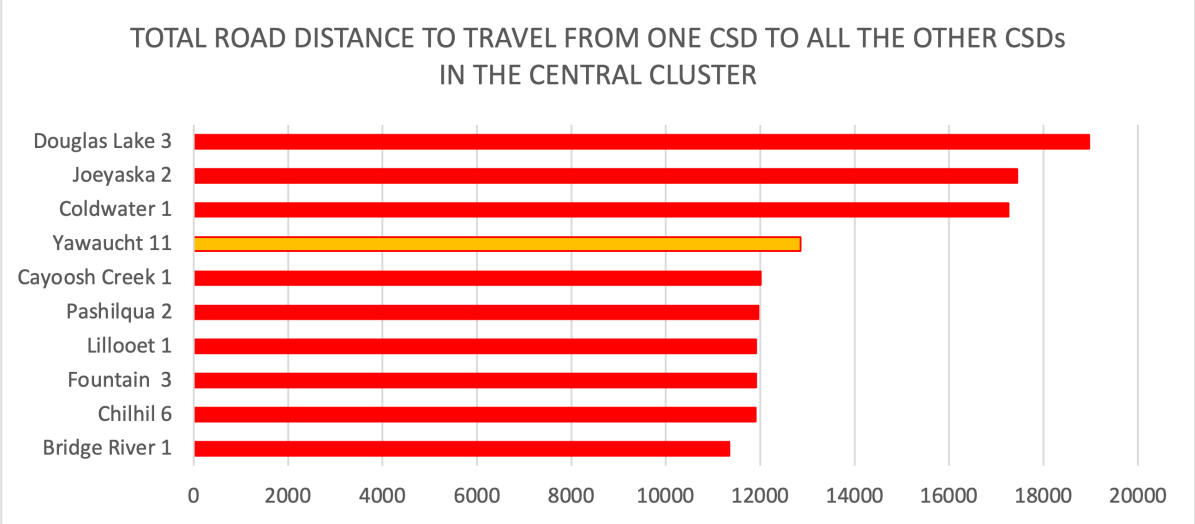


Figure 10c. Comparison of Yawaucht 11, the selected site with other locations in the central cluster in terms of total road distance in km

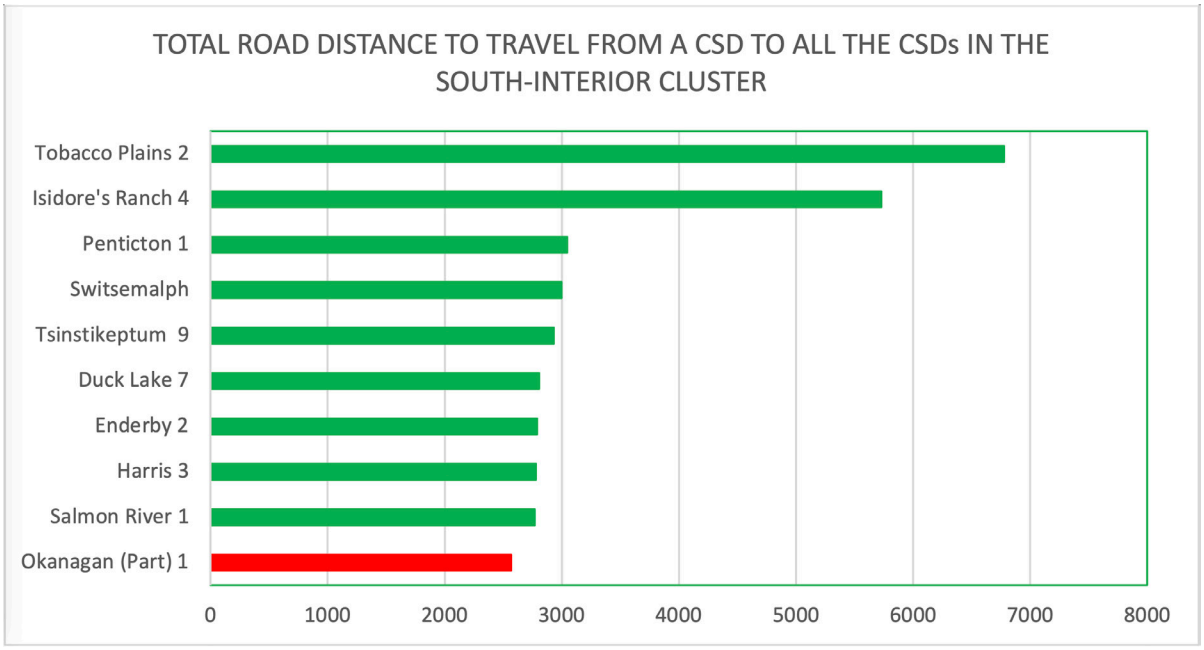


Figure 10d. Comparison of Okanagan 1, the selected site with other locations in the south-interior cluster in terms of total road distance in km

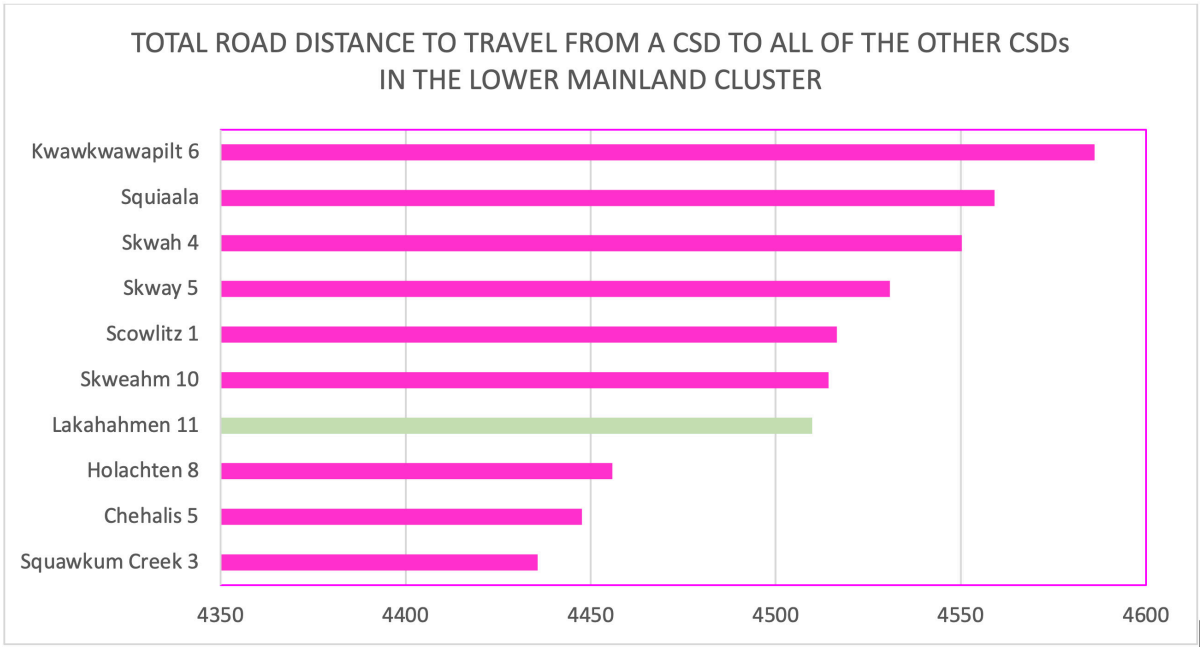


Figure 10e. Comparison of Lakahahmen 11 with other locations in the Lower Mainland cluster in terms of total road distance in km

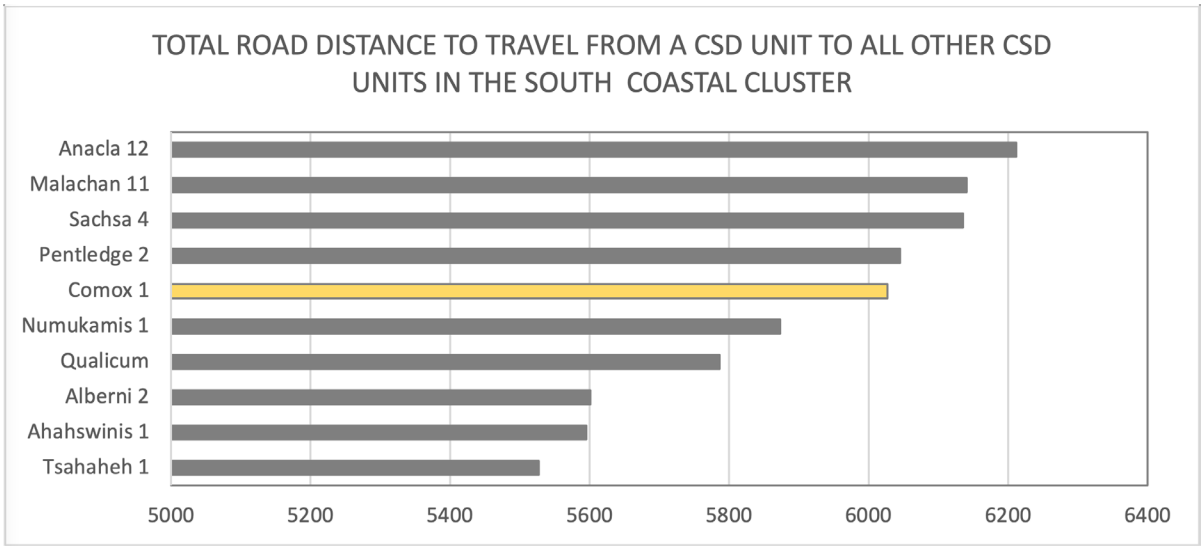


Figure 10f. Comparison of Comox 1 with other locations in the south coastal cluster in terms of total road distance in km

3.3 Final List of Candidates

The following table presents the final list of candidate sites and the ones selected through cluster analysis proved to be comparable to the ones with the shortest distance. The main difference is that the sites that have the shortest distance might not be able to reach the most in need of service better than the ones selected through cluster analysis. Figure 11 shows the geographic location of the selected sites.

	Method	
Cluster	Centre of Risk	Shortest Distance
Northwest	Gitzegukla 1	Gitzegukla 1
Northeast	Nak'azdli	Tl'azt'en Nation (1st) Nak'azdli (2nd)
Central	Yawaucht 11	River Bridge (1st) Yawaucht 11 (7th)
South Interior	Okanagan 1	Okanagan 1
Lower Mainland	Lakahahmen 11	Spawkum Creek 3 Lakahahmen 11
South Coast	Comox 1	Tsahahe 1 (1st) Comox 1 (6th)

Table 5. Comparison of candidate sites for a regional centre in British Columbia

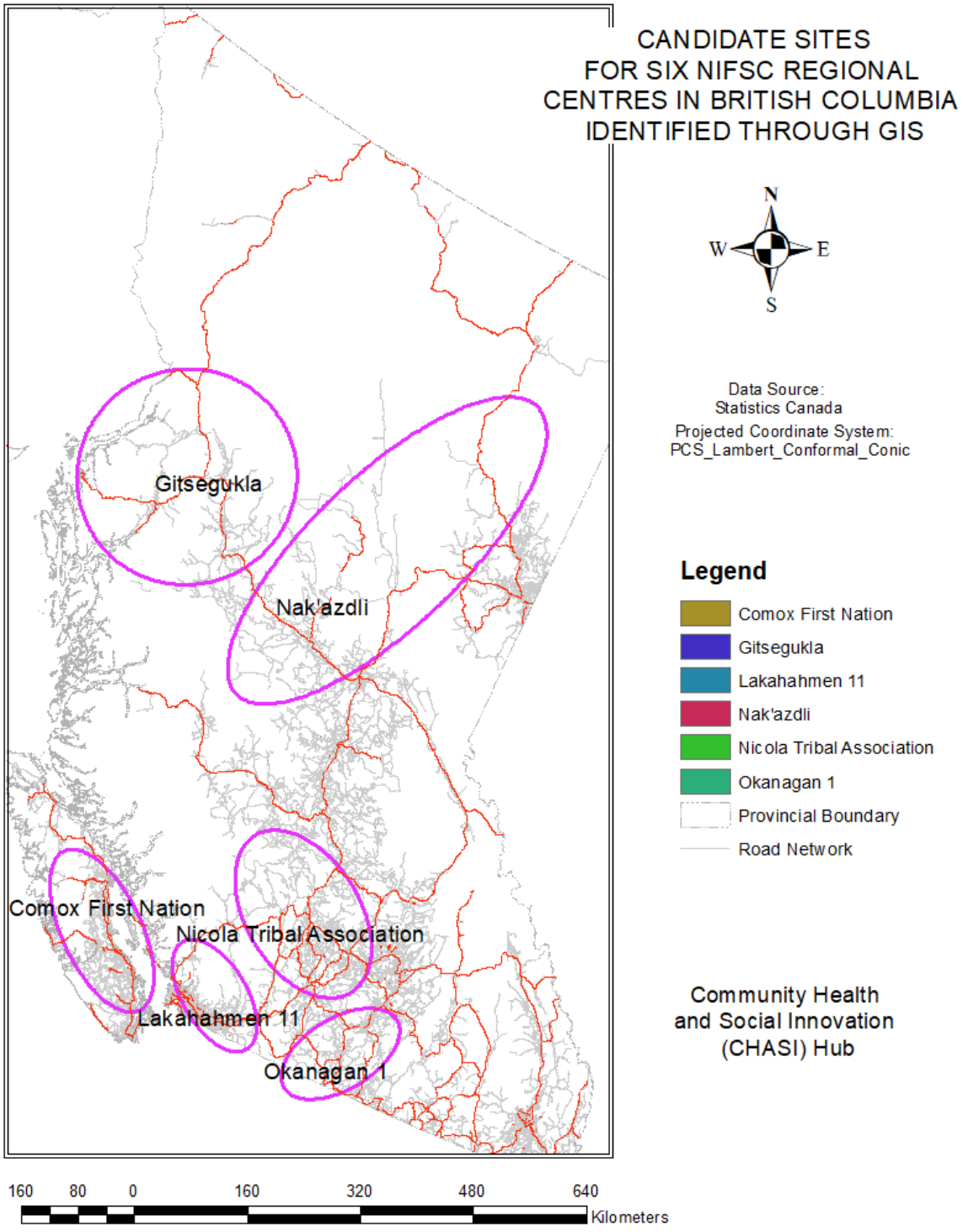


Figure 11. Map resulting from cluster analysis of British Columbia Census Subdivision (CSD) units

4. MANITOBA

The GIS Analysis for the province of Manitoba began with the study on the distribution of the Estimated Number of People at Risk (ENPAR) and Figure 12 shows this distribution. Initially, four clusters were used in Manitoba for the study, but one was eliminated in favour of more reliable and robust results for the three clusters.

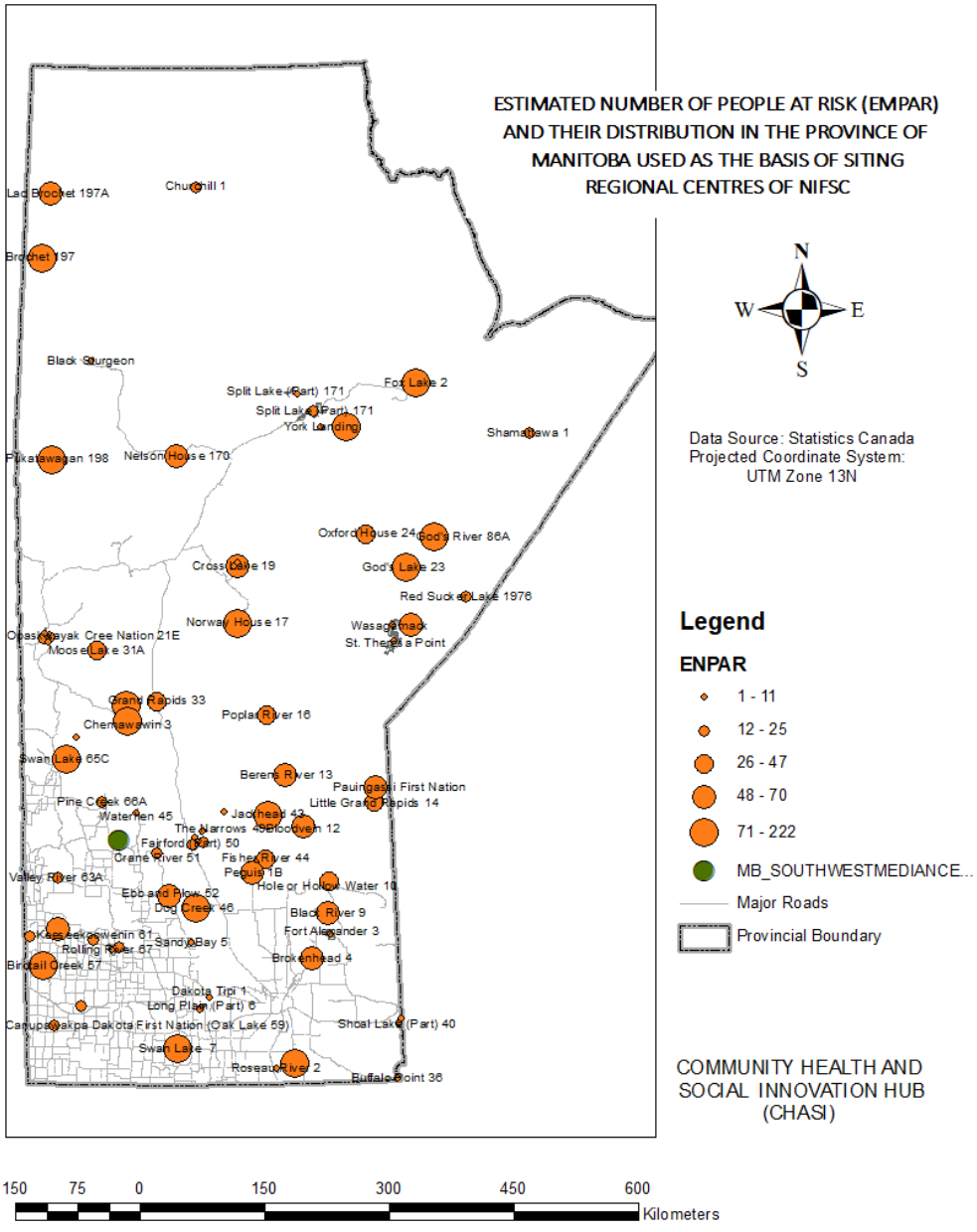


Figure 12. The variation and location of the ENPAR was used to create clusters for study in the Province of Manitoba

4.1 Cluster Analysis

Measuring the distribution of the CSDs with their ENPAR as the basis for the spatial distribution revealed three site candidates from the three Manitoba clusters: Cross Lake 19E, Fisher River 44, and Pine Creek 66A.

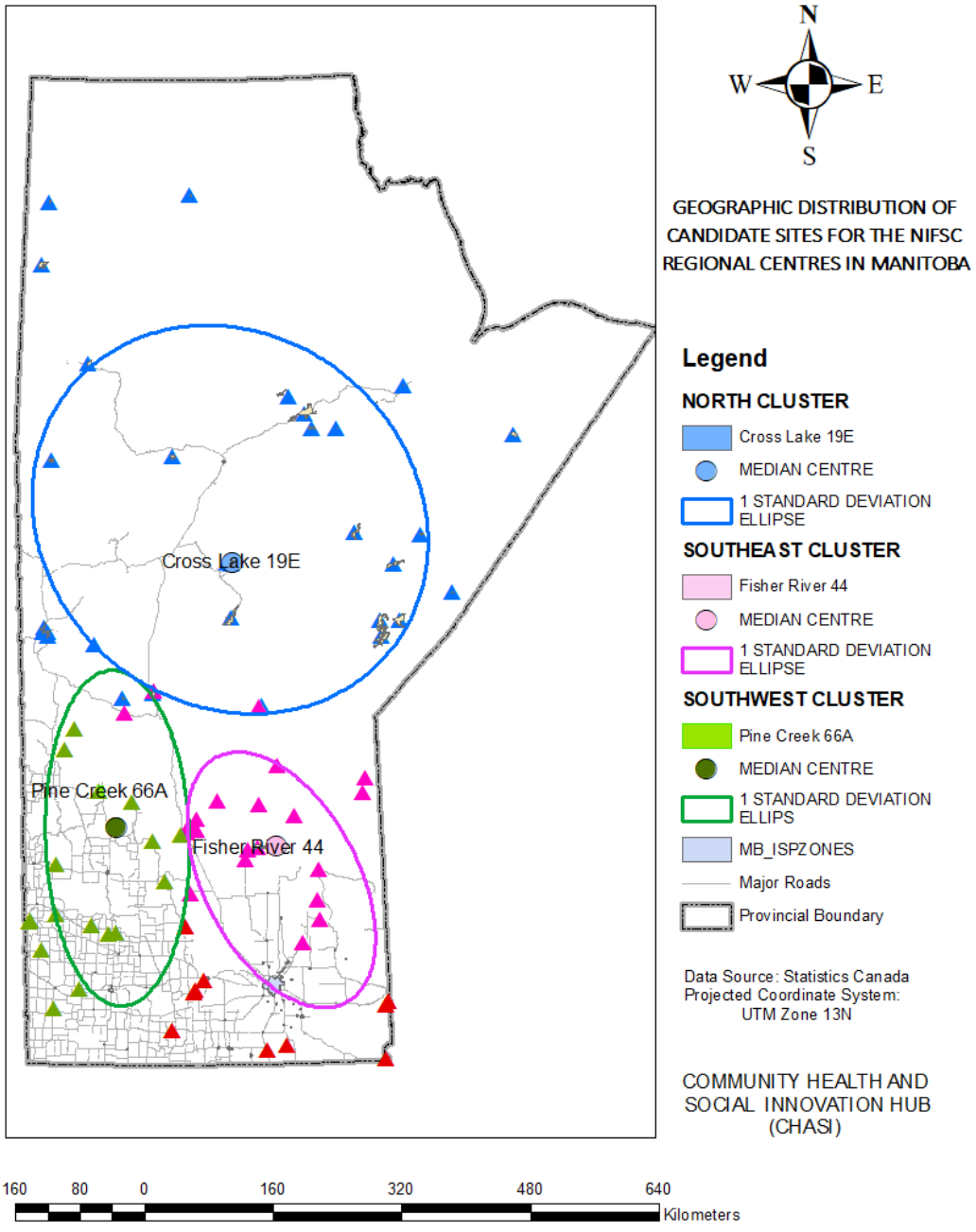


Figure 13. The variation and location of the ENPAR was used to create clusters for study in the Province of Manitoba

4.2 Shortest Distance Comparisons

Since the ENPAR was used as weights in statistical analysis, it is expected that there will be some discrepancies on the total length of road travel for the selected sites and the expected result if the selected sites were determined based on distance alone.

Figures 14 a, b, and c show the comparisons among sites in a cluster.

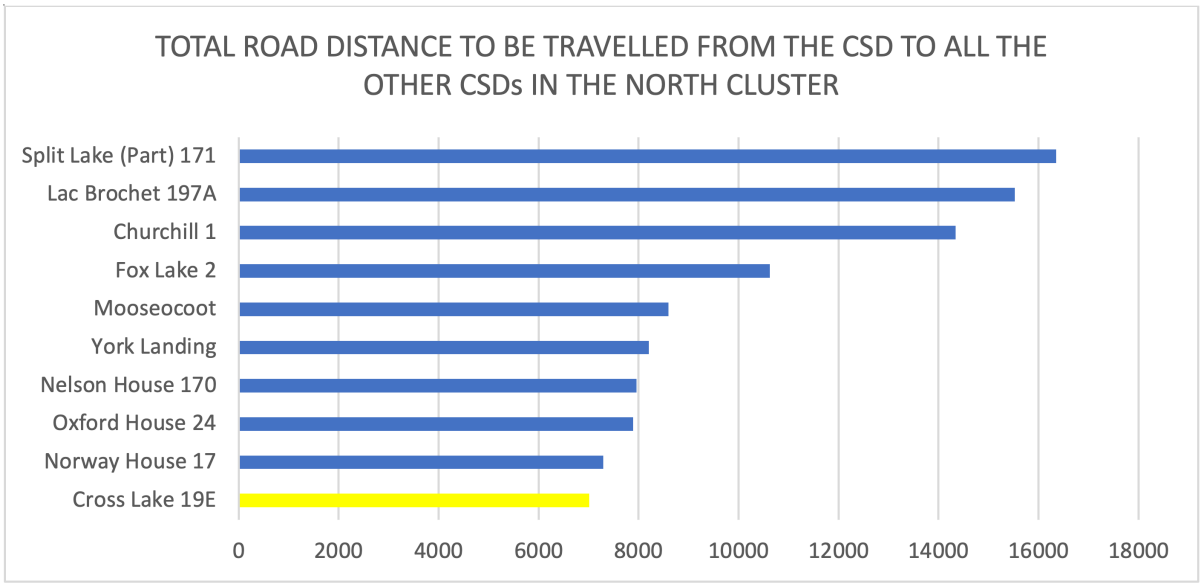


Figure 14a. A comparison of the total road distance to be travelled from one CSD to all other CSDs in the north cluster in km

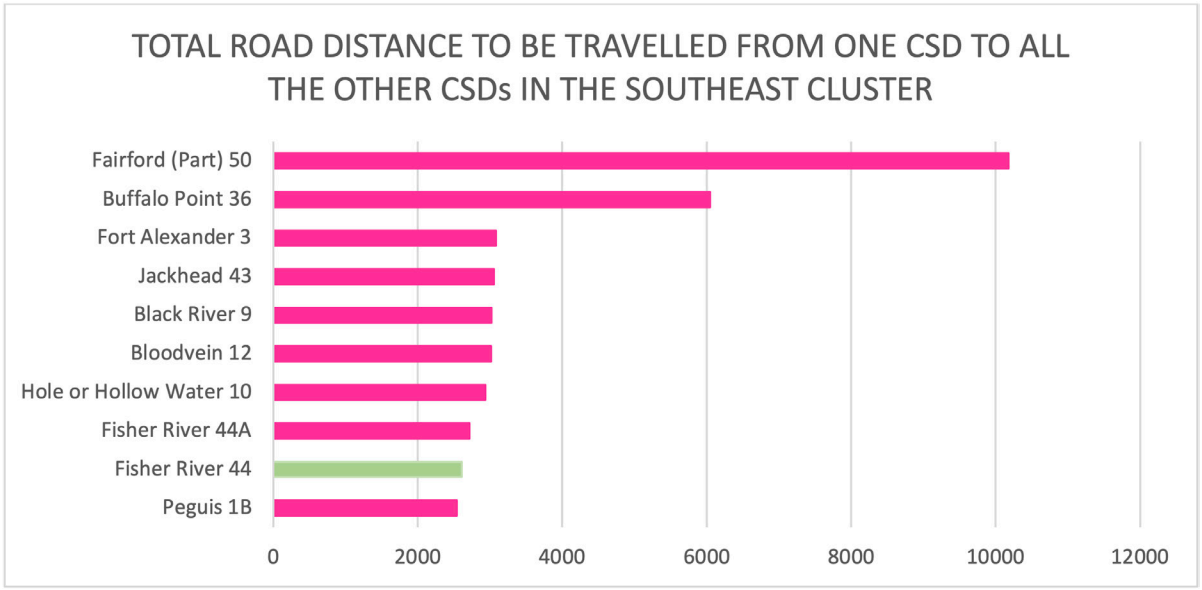


Figure 14b. A comparison of the total road distance to be travelled from one CSD to all other CSDs in the southeast cluster in km

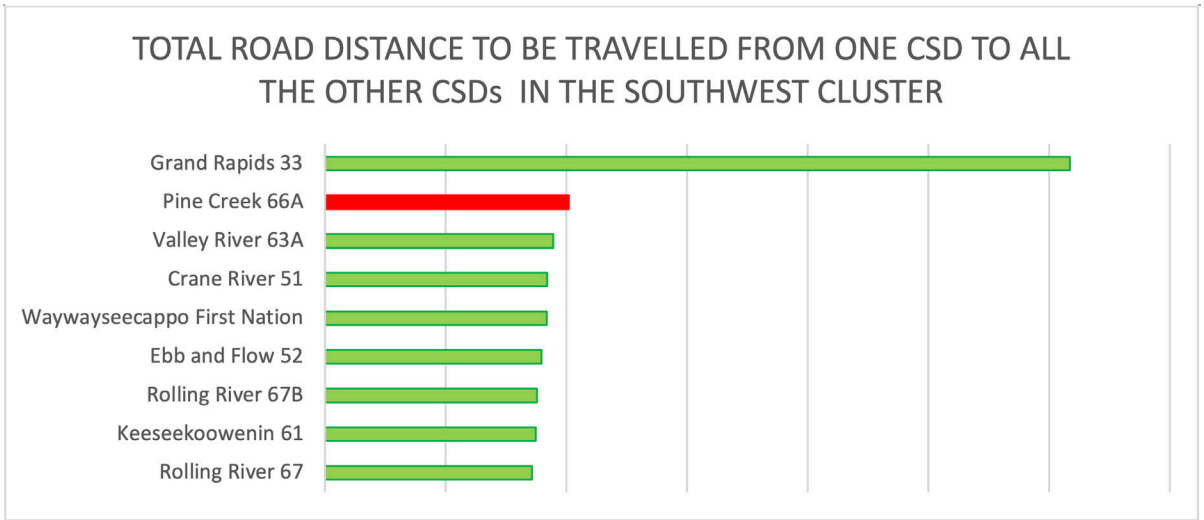


Figure 14c. A comparison of the total road distance to be travelled from one CSD to all other CSDs in the southwest cluster in km

4.3 Final List of Candidates

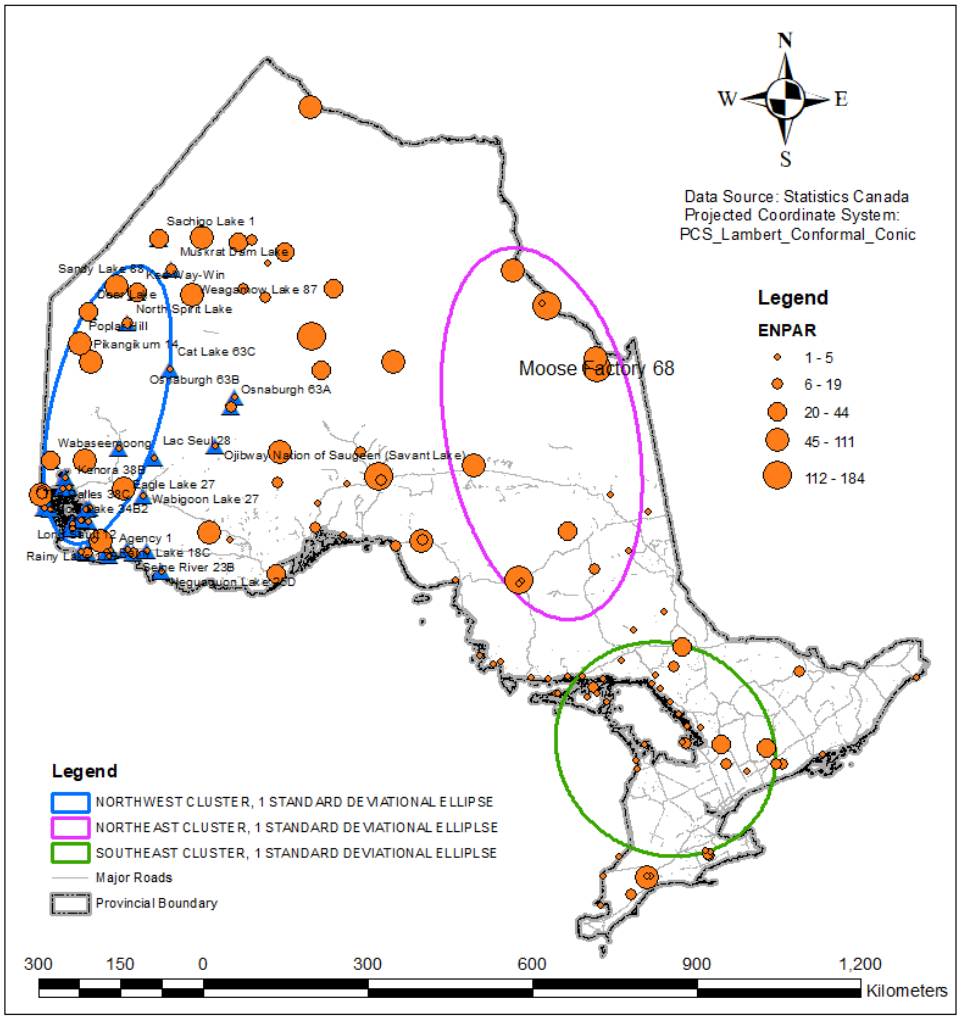
Table 4 shows how the selected sites based on ENPAR of the CSDs in the cluster, in other words, the needs of the people, compare with other CSDs. For the North and Southeast clusters, the selected sites based on the Central Feature were in fact also the ones that had the shortest distance to cover. It was with the southwest cluster that the rank of the Central Feature was just above the average of the cluster.

	Method	
Cluster	Centre of Risk	Shortest Distance
North	Cross Lake 19E	Cross Lake 19E
Southeast	Fisher River 44	Peguis (1st) Fisher River 44 (2nd)
Southwest	Pine Creek 66A	Rolling River 67 (1st) Pine Creek 66A (11th)

Table 6. Comparison of candidate sites for a regional centre in Manitoba

5. ONTARIO

Ontario is second to British Columbia in terms of number of Tribal Council Areas/Census Subdivision (CSD) Units used in the study, and the proportion between the two was also used to decide three clusters for Ontario as compared to BC's six clusters. At the start, five clusters were developed for Ontario, but the separation of the clusters were not as clear. The cluster formation started with the distribution of the Estimated Number of People at Risk (ENPAR) as shown in Figure 15.

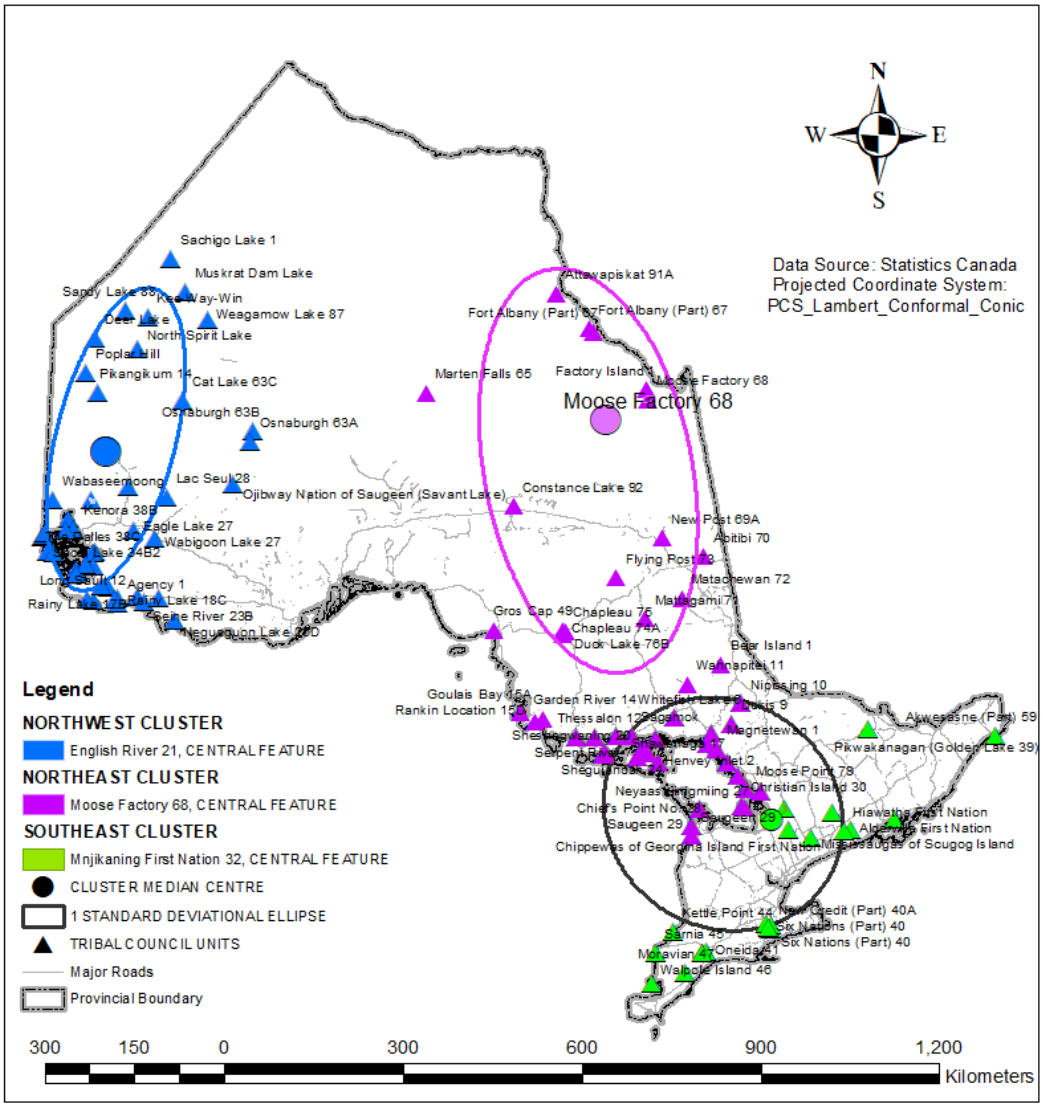


TRIBAL COUNCIL UNITS AND THEIR ESTIMATED NUMBER OF PEOPSONS AT RISK,
AS THE GEOGRAPHIC UNITS FOR THE SITE SELECTION OF THE
NISFC REGIONAL CENTRES IN ONTARIO IDENTIFIED THROUGH GIS

Figure 15. The distribution of the Estimated Number of People at Risk (ENPAR) in the Province of Ontario

5.1 Cluster Analysis

The location that is most sensitive to the needs of the people at risk in the cluster is the one that is at the centre of the locations based on the risks, and not the centre based on distances alone. When the Geographic Distribution of the CSDs were measured using the Estimated Number of People at Risk (EMPAR), three candidate sites through the Central Features of each cluster were identified: English River 21, Moose Factory 68, and Christian Island 30A. See Figure 16.



TRIBAL COUNCIL UNITS AND THEIR CLUSTERS AS CANDIDATE SITES FOR THE NISFC REGIONAL CENTRES IN ONTARIO IDENTIFIED THROUGH GIS

Figure 16. Three site locations identified as candidate sites for regional centres in Ontario

5.2 Shortest Distance Comparisons

The three locations above, which are meant to address the issues on the demand side (Tribal Council Areas), were also compared with other locations in terms of distance of travel. (Figures 17a, b, and c show the results of ten comparisons)

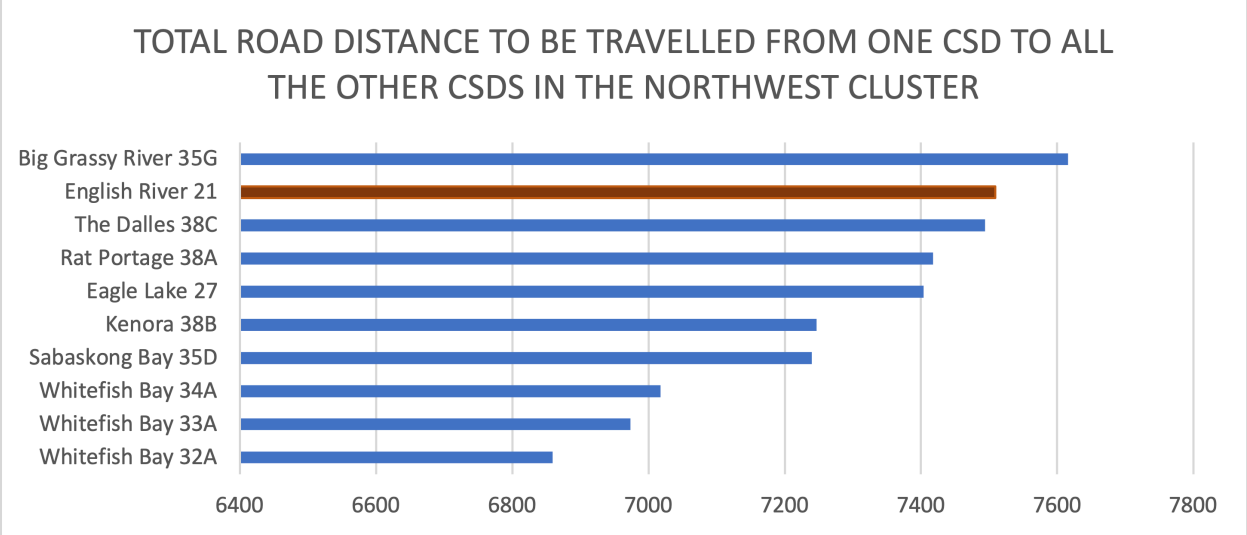


Figure 17a. Comparison of English River 21 with other locations in the northwest cluster in terms of total road distance in km

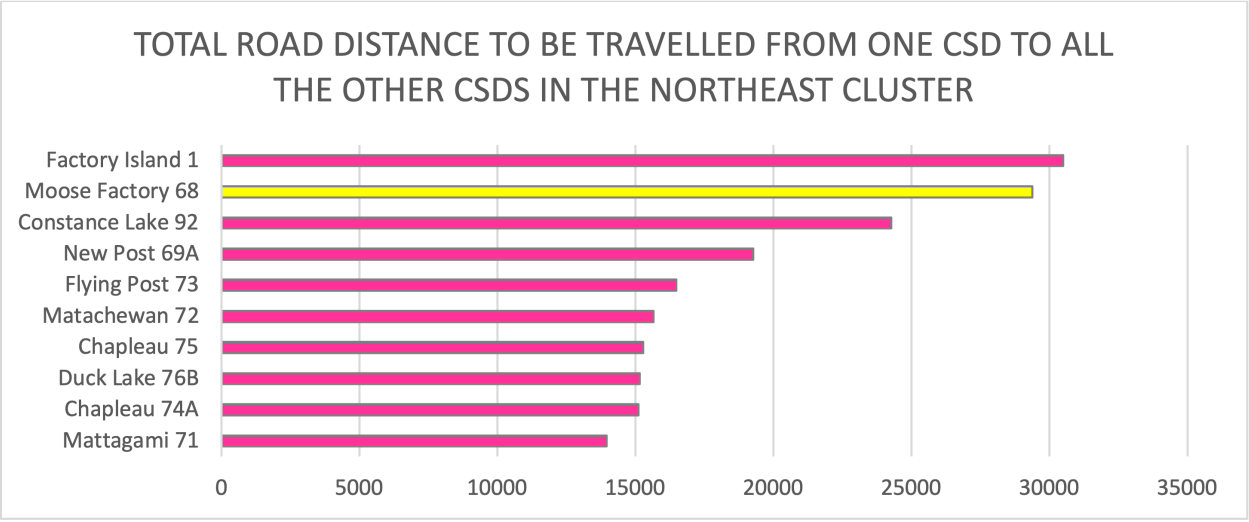


Figure 17b. Comparison of Moose Factory 68 with other locations in the northeast cluster in terms of total road distance in km

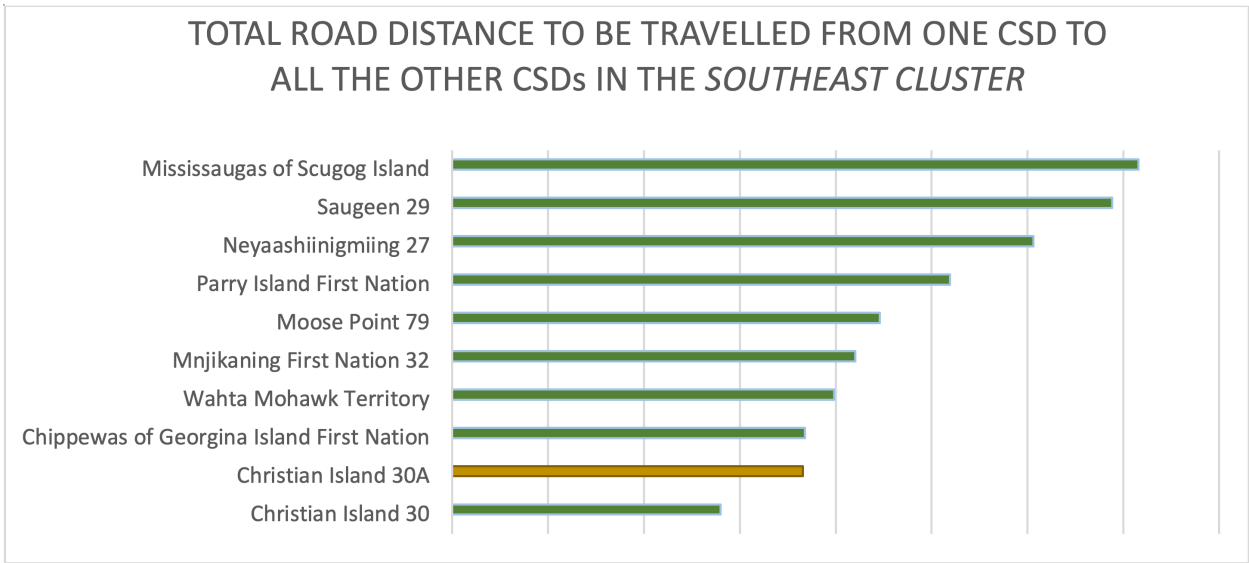


Figure 17c. Comparison of English River 21 with other locations in the southeastern cluster in terms of total road distance in km

5.3 Final List of Candidates

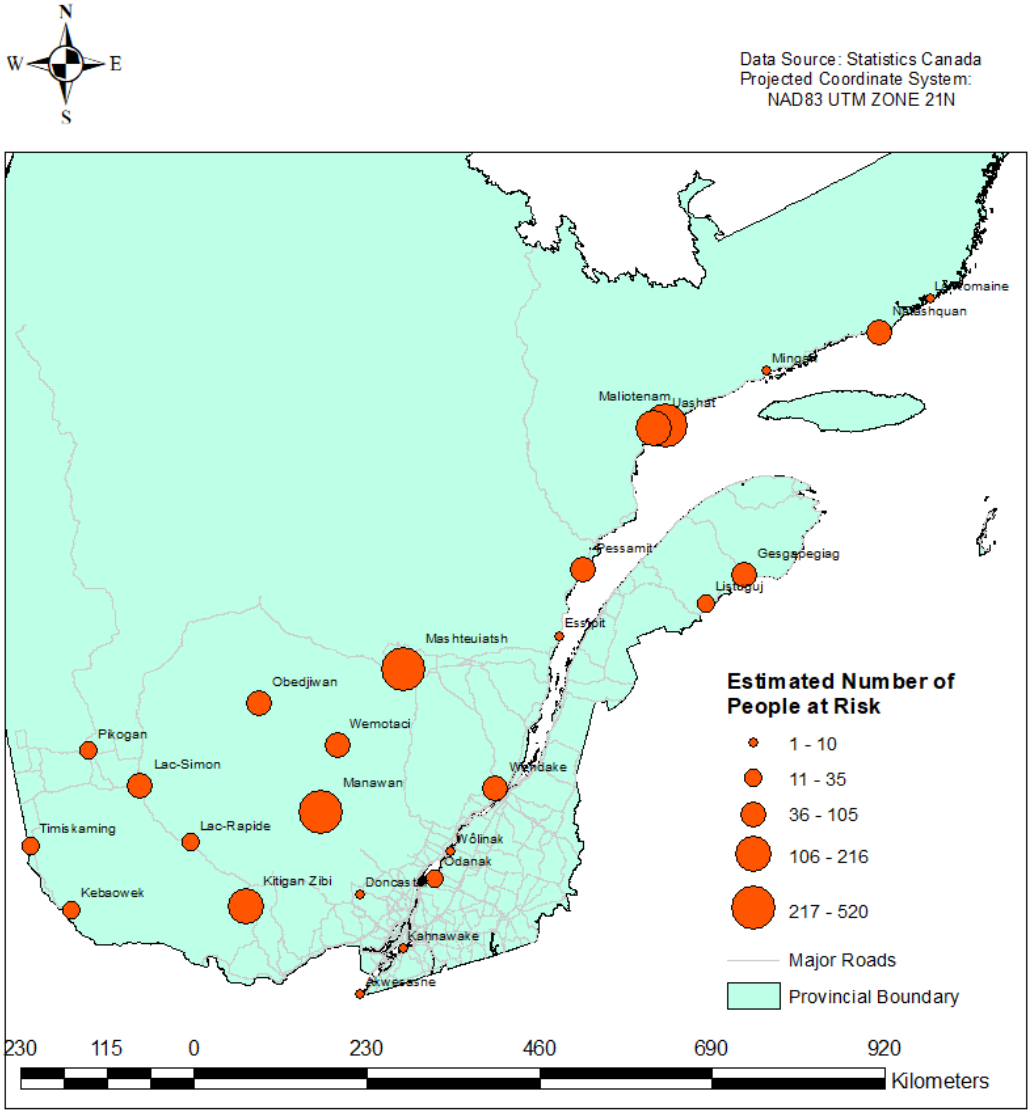
Because of inherent differences in the topography of the land and how the roads are built, there will be differences between the selected sites (Central Feature) as compared to the ones with shortest road distances. Christian Island 30A has practically the same travel distance as Christian Island, while English River 21 and Moose Factory also have comparably short distances given that there are 47 and 59 CSDs being compared in these two clusters.

	Method	
Cluster	Centre of Risk	Shortest Distance
Northwest	English River 21	Whitefish A (1st) English River 21 (9th)
Northeast	Moose Factory 68	Mattagami 71 (1st) Moose Factory 68 (9th)
Southeast	Christian Island 30A	Christian Island 30 (1st) Christian Island 30A (2nd)

Table 7. Comparison of candidate sites for a regional centre in Ontario

6. QUEBEC

Although the Province of Quebec is large relative to other Canadian provinces, most of the Tribal Council Units/Census Subdivision (CSD) units studied in the project are limited to the southern portion of the province and consequently, there are only 27 CSDs. As such, only one cluster was deemed appropriate based on the ENPAR. See Figure 18.

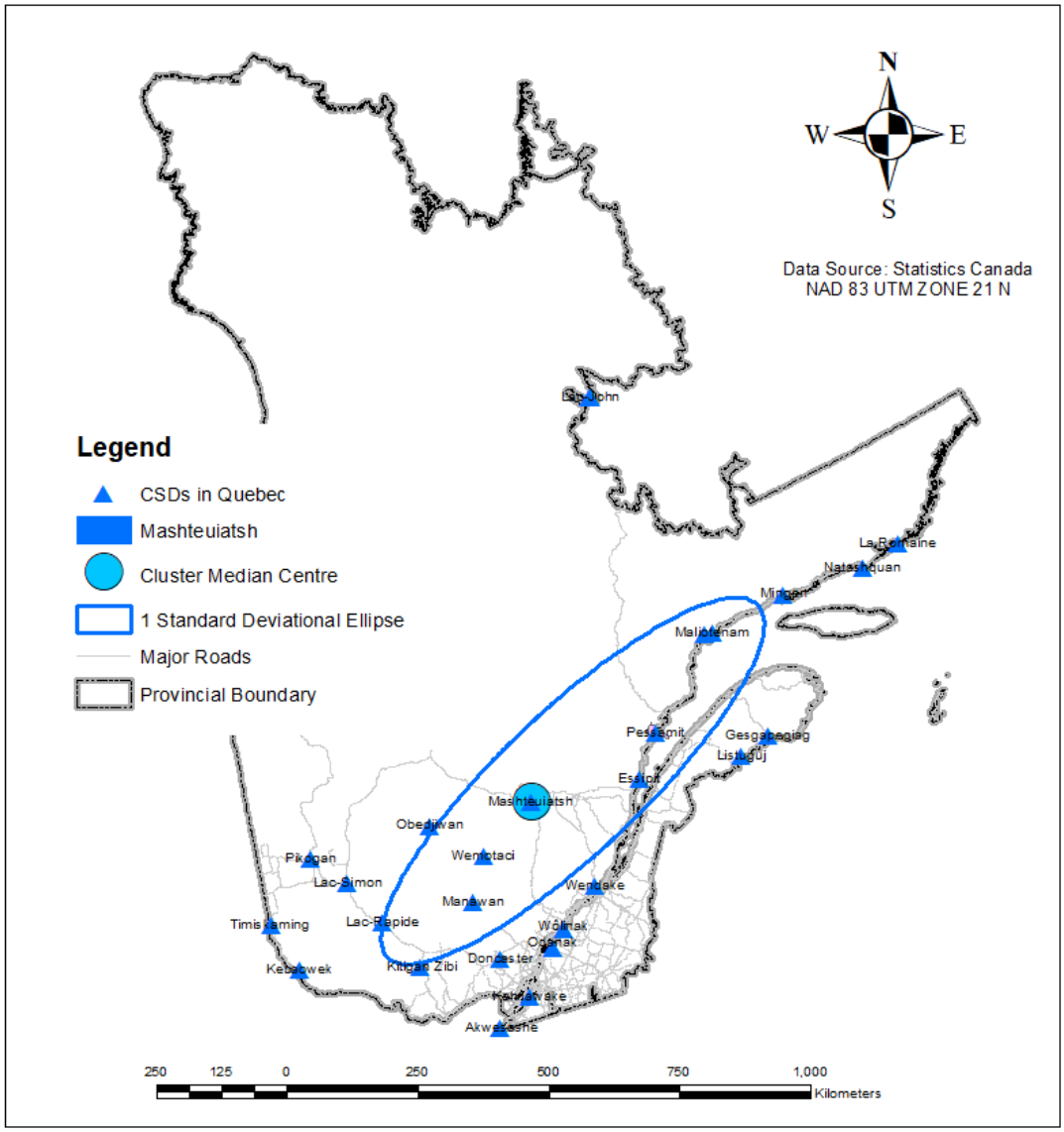


ESTIMATED NUMBER PEOPLE AT RISK (ENPAR) IN CENSUS SUBDDIVISION CSD) AND THEIR DISTRIBUTION IN QUEBEC

Figure 18. The distribution of the Estimated Number of People at Risk (ENPAR) in the Province of Quebec

6.1 Cluster Analysis

For Quebec, the cluster that was created followed the natural distribution of the CSDs along the south of the province. This is most noticeable with the direction of the 1 Standard Deviational Ellipse. The first candidate site was determined to be Mashteuiatsh because it was the Central Feature of the spatial distribution of the CSDs. There are eight CSDs inside the ellipse zone that can also be considered. However, the Central Feature will always be the best.



THE CANDIDATE SITE FOR THE NIFSC REGIONAL CENTRE IN QUEBEC IDENTIFIED THROUGH GEOGRAPHIC INFORMATION SYSTEMS ANALYSIS

Figure 19. Site location identified as candidate site for regional centre in Quebec

6.2 Shortest Distance Comparisons

A NEAR-TABLE was created in ArcGIS for all 27 CSDs to identify the shortest distance traveling the connecting roads. Figure 20 summarizes the NEAR-TABLE and as expected, the CSD units inside the ellipse produced the shortest road distance to travel to all the other CSD units. Table 20 (next page) shows that the Central Feature also provided the lowest total road time.

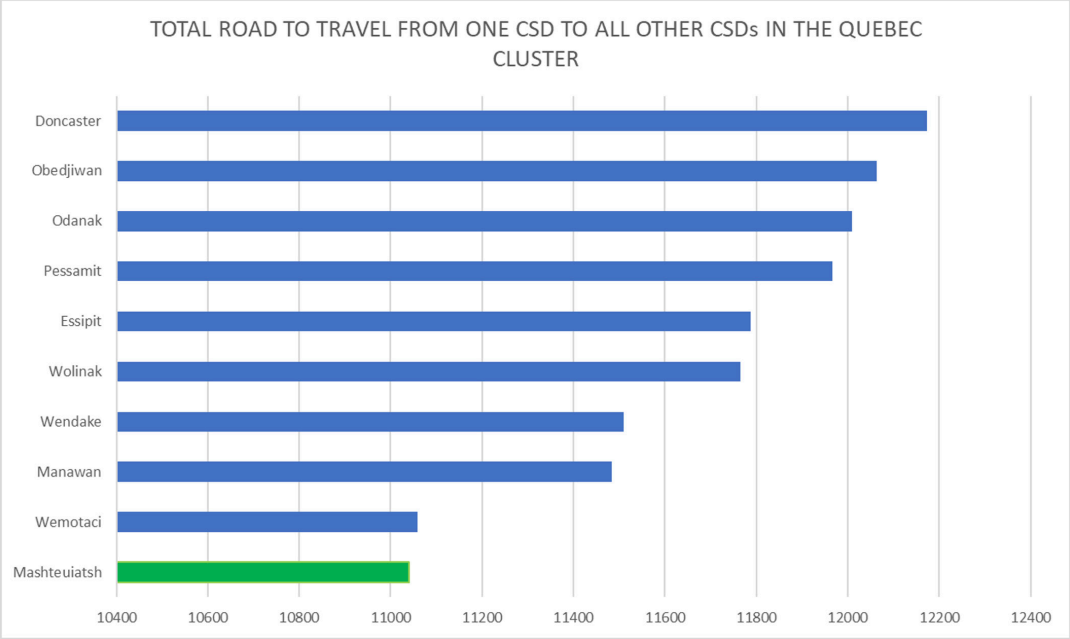


Figure 20. Comparison of Mashteuiatsh with other locations in the Quebec cluster in terms of total road distance in km

6.3 Final List of Candidates

The final list of the site candidates for the Quebec cluster is shown in the table below.

	Method	
Cluster	Centre of Risk	Shortest Distance
Quebec	Mashteuiatsh	Mashteuiatsh Wemotaci

Table 8. Comparison of candidate sites for a regional centre in Quebec

A metric that can be used to compare not only within the clusters but across clusters is the Estimated Number of People at Risk that can be reached from a CSD within 1,000 km of road travel. For Quebec, this is shown in Figure 21. The CSD units inside the ellipse are expected to reach at least 200 people in their first 100 km of road travel.

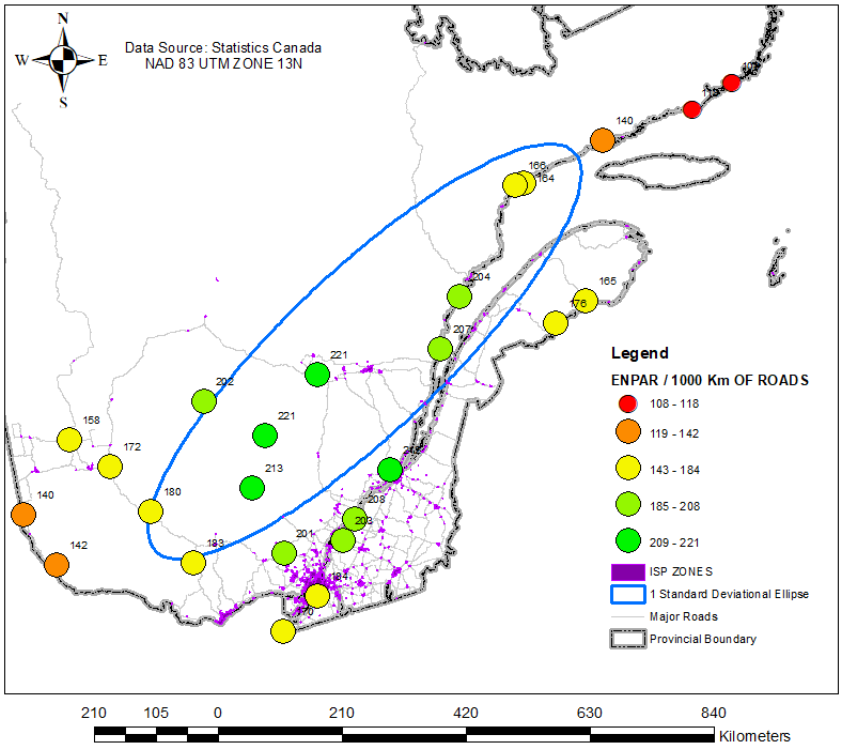


Figure 21. Estimated number of people at risk reached from a Census Subdivision Unit within 1,000 km of roads in Quebec

7. SASKATCHEWAN

7.1 Cluster Analysis

The 2016 boundary files (shapefiles) of the Census Subdivisions (CSDs) for the Province of Saskatchewan that correlated with the Tribal Council Units, were assigned the attributes from the CHASI Risk Assessment. Three clusters were created from these files (CSD units) based on the Estimated Number of Persons at Risk (ENPAR) as weights, and Figure 22 shows the relationship between the ENPAR and the geographic distribution statistics measured for each cluster.

The Median Center, the 1- Standard Deviational Ellipse, and the Central Feature, visually shows the relationships of the different CSD units in the cluster, aiding the correct interpretation of the spatial statistics that ArcGIS reports. Immediately, the three Central Features are identified as strong candidates for the NIFSC Regional Center for their own cluster. The map in Figure 22 shows the three Central Features as well as the location of other site candidates, especially those inside the ellipse.

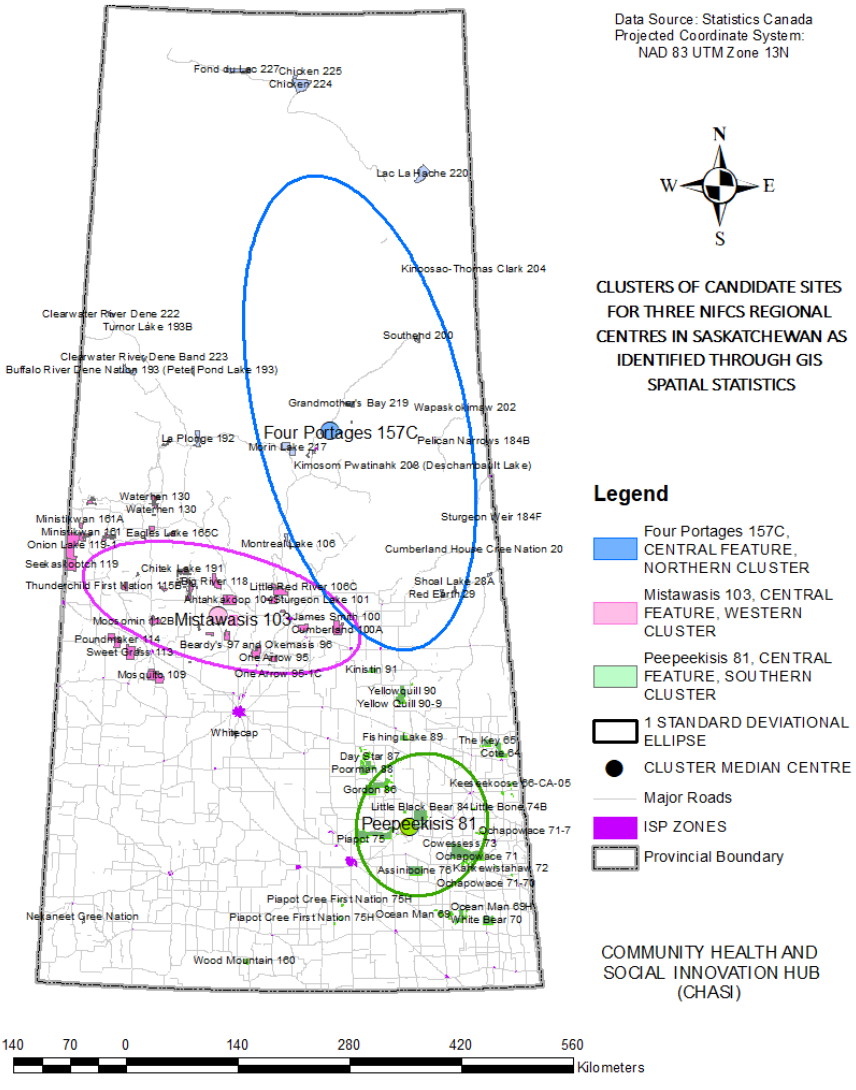


Figure 22. Clusters of Candidate Sites for Regional Centres in Saskatchewan

7.2 Shortest Distance Comparisons

Each cluster had its own proximity/distance analysis. The geodesic distance through the road network between two CSD units was calculated by ArcGIS 10.7.1 resulting in a square matrix, called a "NEAR-TABLE". The tables are quite large with the following files: 1056, 3660, and 7140, for the Northern, Western and Southern clusters.

The graphs in Figures 23(a-c) show that there are differences in the distribution which is the effect of the topography of the land but the importance of the distances when sorted, makes it easy to identify the CSD that will give the shortest possible distance to travel to all the CSD units in the cluster.

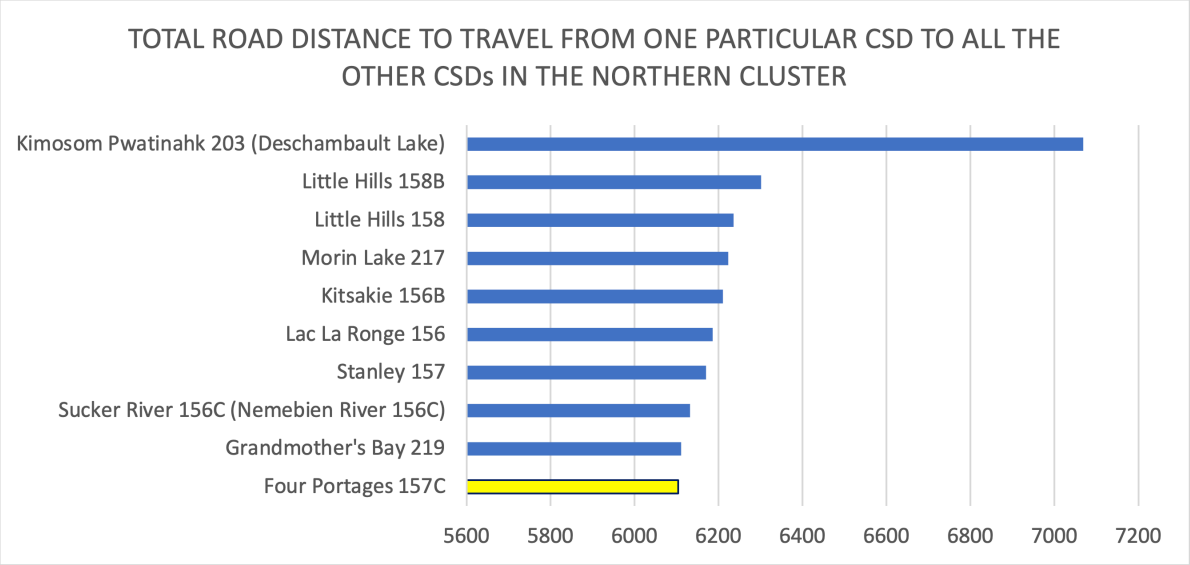


Figure 23a. The cumulative distance travelling by road to every CSD unit in the northern Saskatchewan cluster in km

Figure 23b. The cumulative distance traveling by road to every CSD unit in western Saskatchewan in km

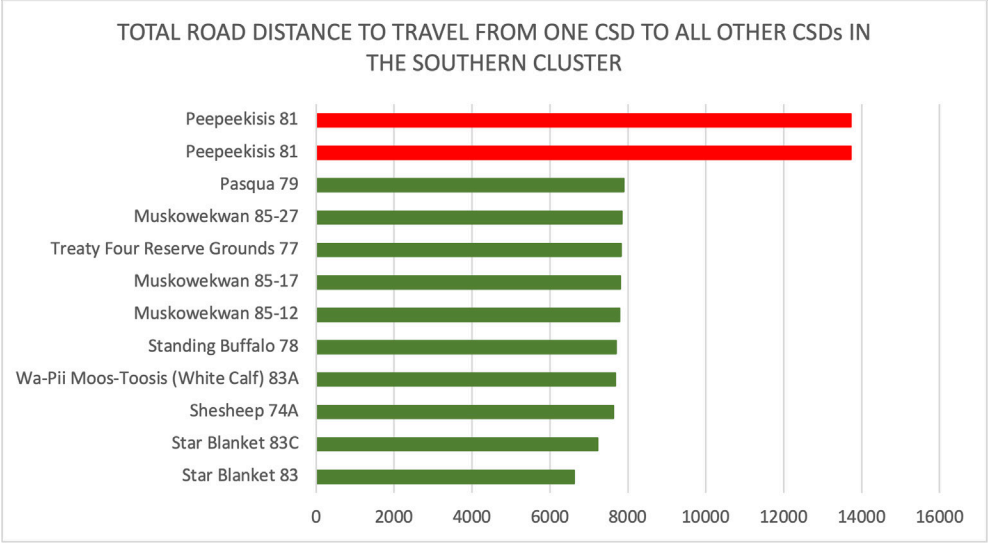


Figure 23c. The cumulative distance traveling by road to every CSD unit in the southern cluster of Saskatchewan in km

7.3 Final List of Candidates

The risk component of the selection (ENPAR) can be combined with the shortest distance to travel through the cluster. This is presented in Figure 24, as theoretically, the estimated number of people at risk that can be reached after travelling through 1,000 km.

	Method	
Cluster	**Centre of Risk**	**Shortest Distance**
Northern	Four Portages 157C	Four Portages 157C
Western	Mistawasis 103	Witchekan Lake 117D (1st) Mistawasis 103 (8th)
Southern	Peepeekisis 81	Star Blanket 83(1st) Peepeekisis 81 (67th of 88)

Table 9. Comparison of candidate sites for a regional centre in Saskatchewan

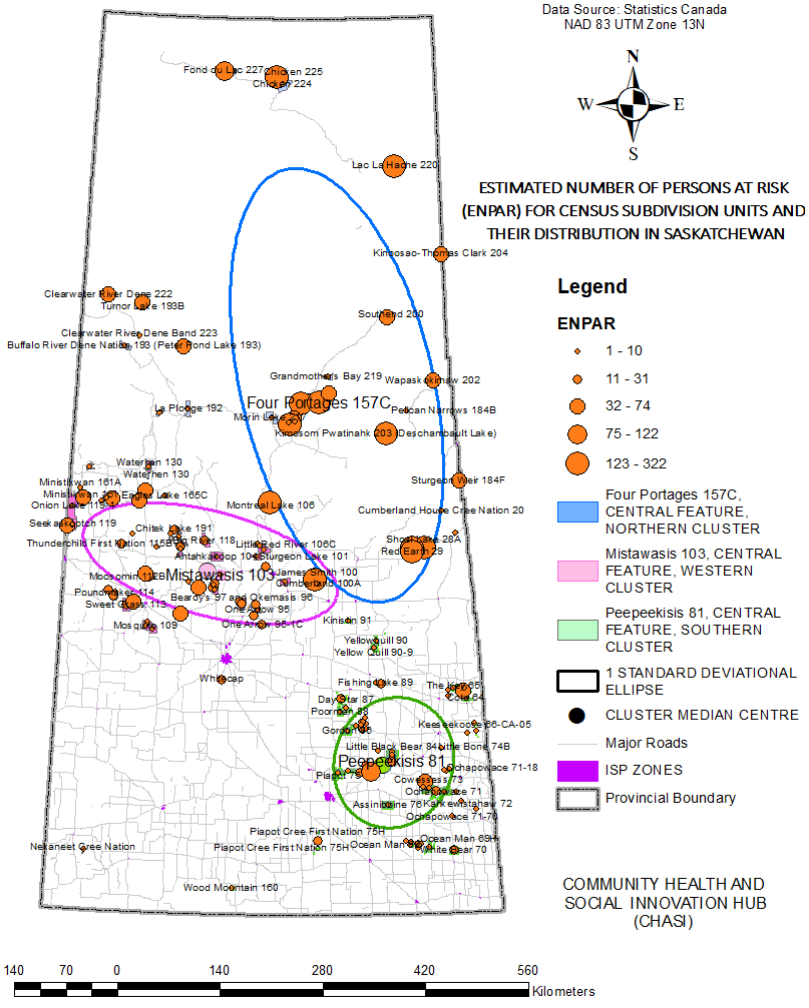


Figure 24. Site location identified as candidate site for regional centre in Saskatchewan

CONCLUSIONS AND RECOMMENDATIONS

The maps, tables, and graphs, in the previous sections all attest to the success of the analysis. While a lot of lessons have been learned in this process, the following are the most salient.

- A practical procedure that integrated individual risk assessment into the spatial statistics capability of GIS consistently arrived at the best locations in the cluster, mostly the Feature Centre of the spatial units, and most often the closest to the Median Centre.
- Using individual risk assessment, a selection design for siting the regional centre is instructive as it provides decision-makers with this information at the beginning of the planning process.
- There are many factors to consider in the siting of the regional centre, but one covering the location of the people who need help most, and another covering the optimal distance that help needs to travel would be the most important.
- A metric that can be used to compare CSD units within the clusters and even from different clusters is the Estimated Number of Persons at Risk (ENPAR) that can be reached from a CSD unit travelling by road 1,000 km on the road. The simple formula is:

  ENPAR/1000 = ENPAR THAT CAN BE REACHED /NEAR-DISTANCE value for the CSD x 1000

  The unit will be number of people at risk per 10,000 km of road distance.
- Finally, the key recommendations relate to site selecting and are summarized in the Summary Table on page 4 of this report.

APPENDIX A — GIS MAPS: OVERLAY OF BROADBAND

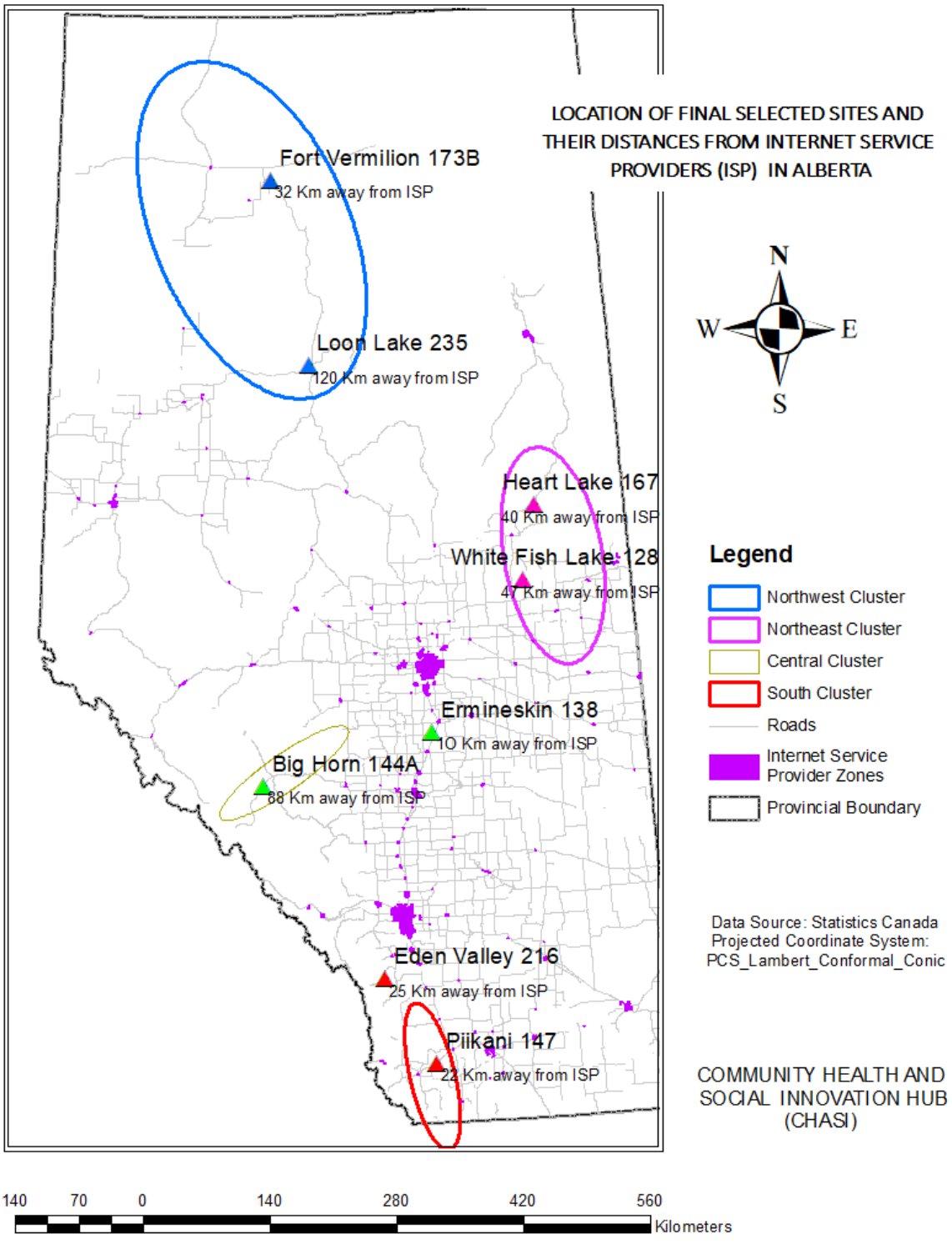
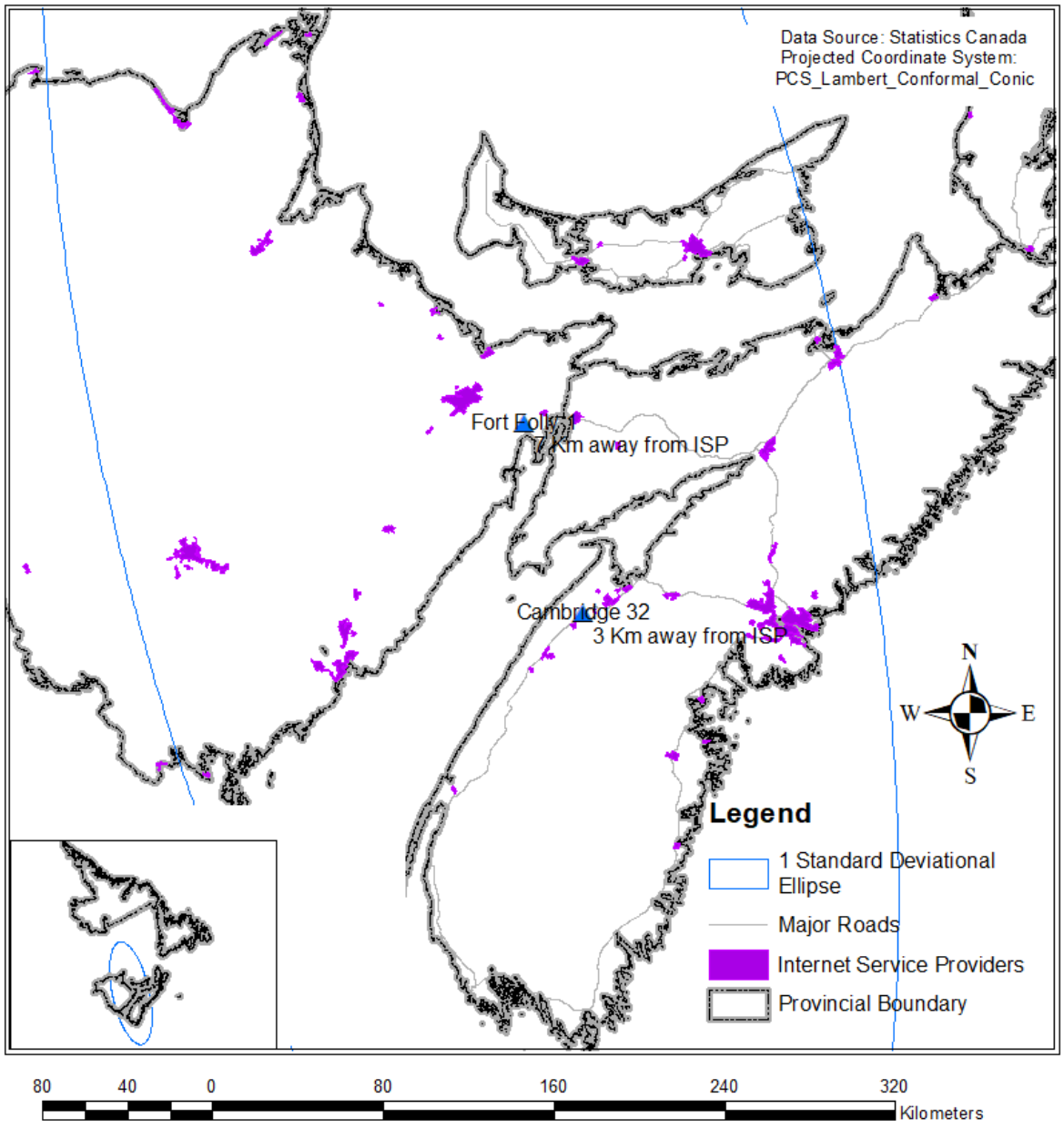


Figure 25. Selected sites distances from internet service providers in Alberta



LOCATION OF FINAL SELECTED SITES AND THEIR DISTANCES
FROM INTERNET SERVICE PROVIDERS (ISP) IN ATLTANTIC CANADA

Figure 26. Selected sites distances from internet service providers in Atlantic region

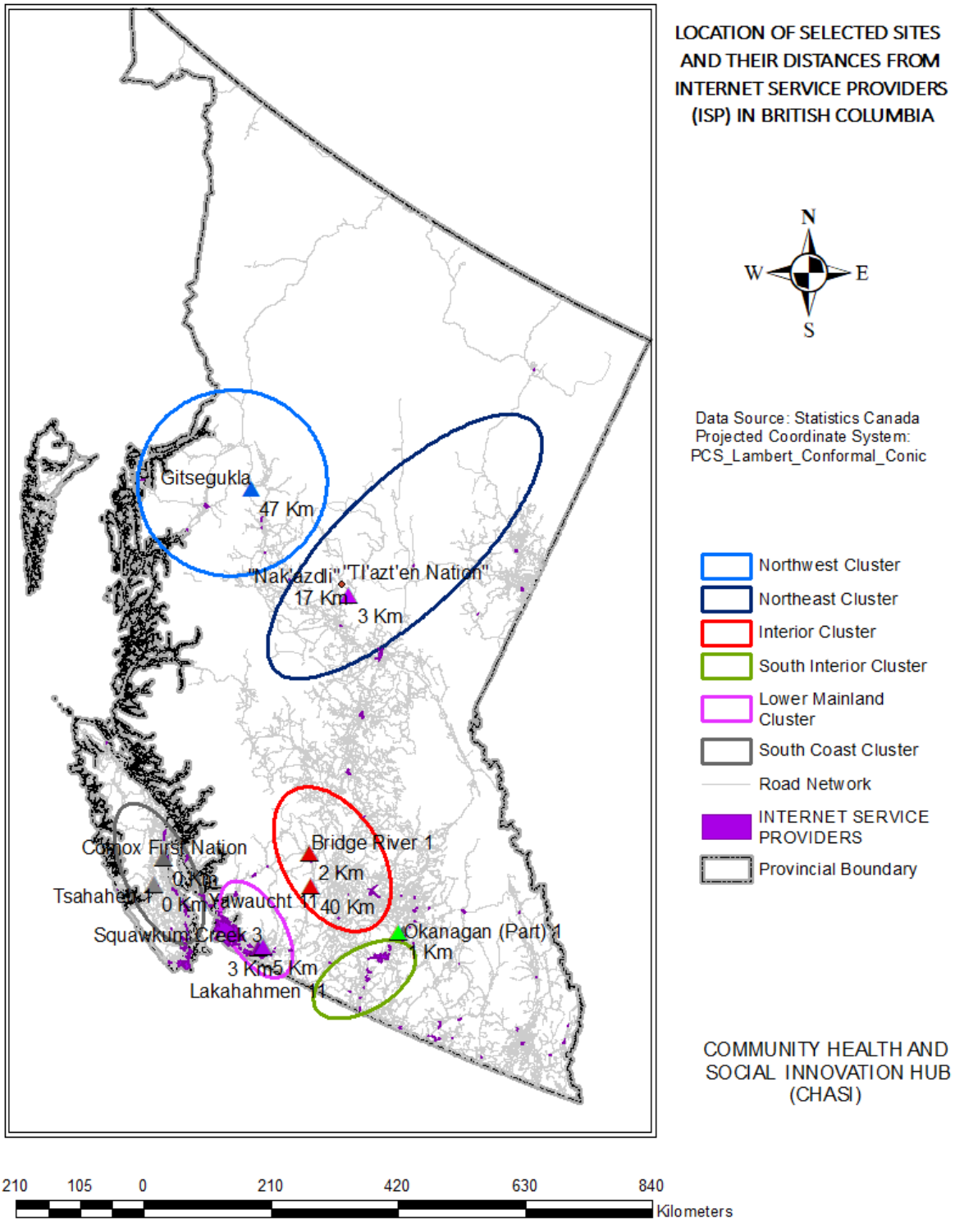


Figure 27. Selected sites distances from internet service providers in British Columbia

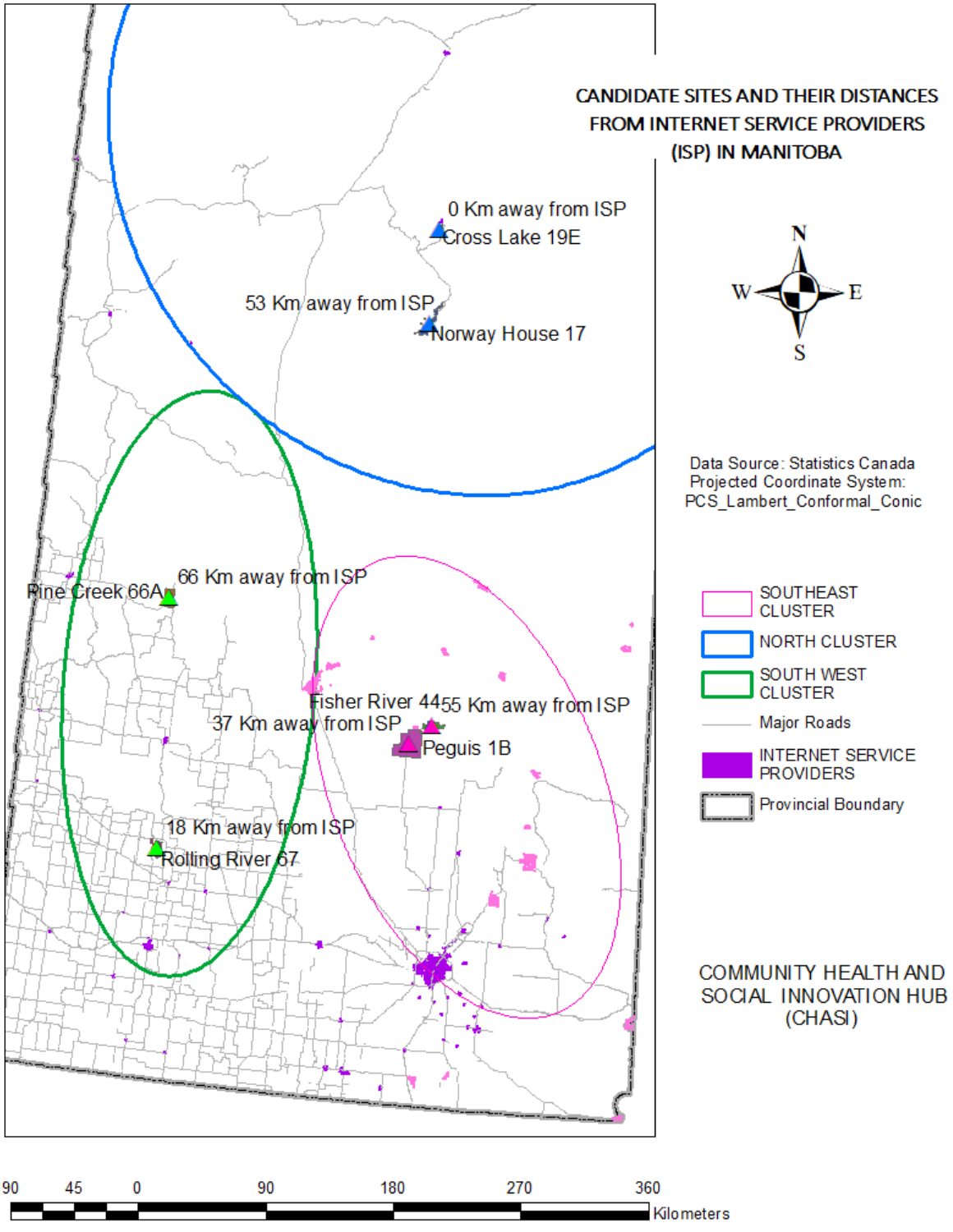


Figure 28. Selected sites distances from internet service providers in Manitoba

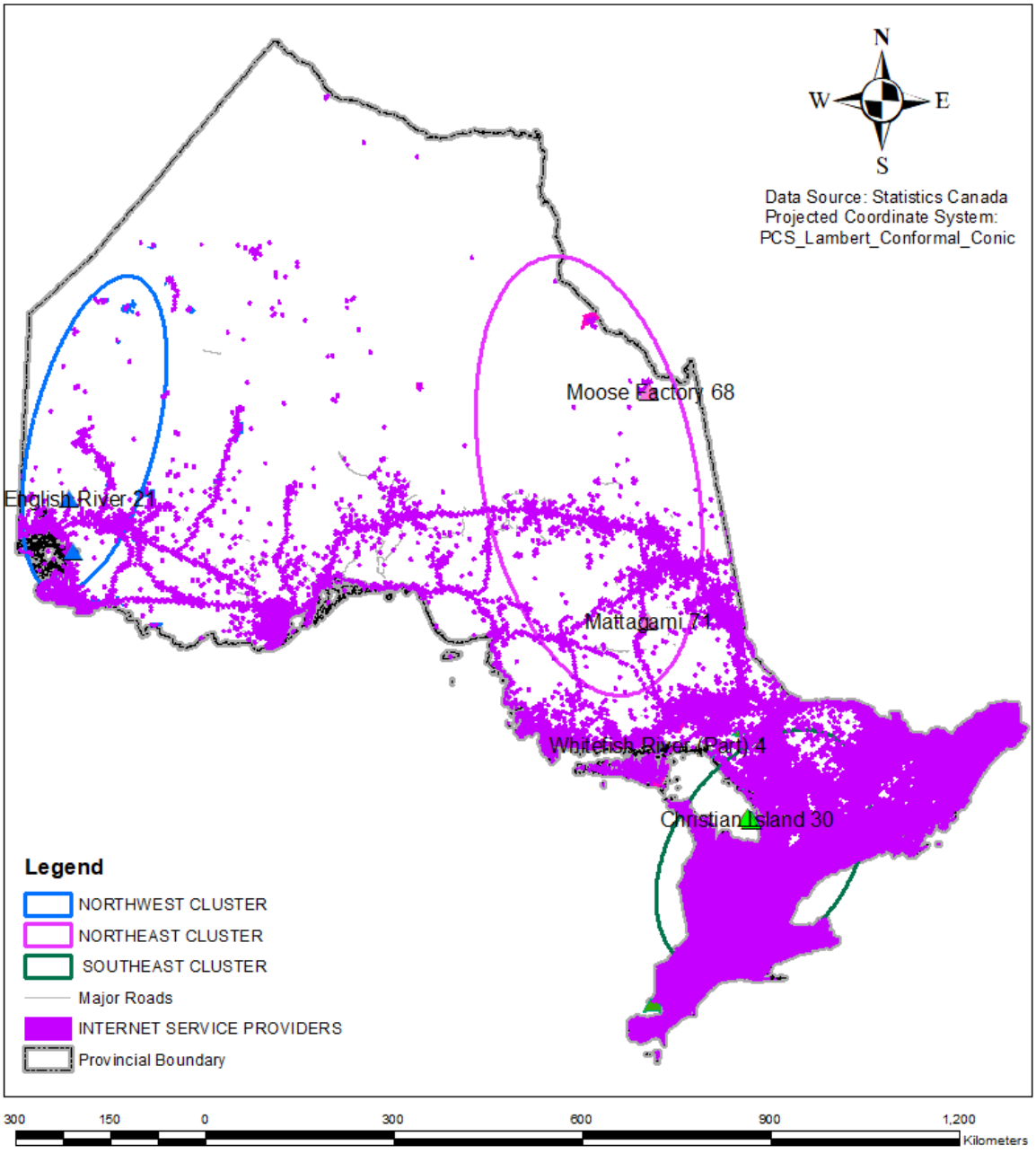


Figure 29. Selected sites distances from internet service providers in Ontario

SELECTED SITES ARE WITHINT A KILOMETER FROM AN INTERNET SERVICE PROVIDER IN QUEBEC

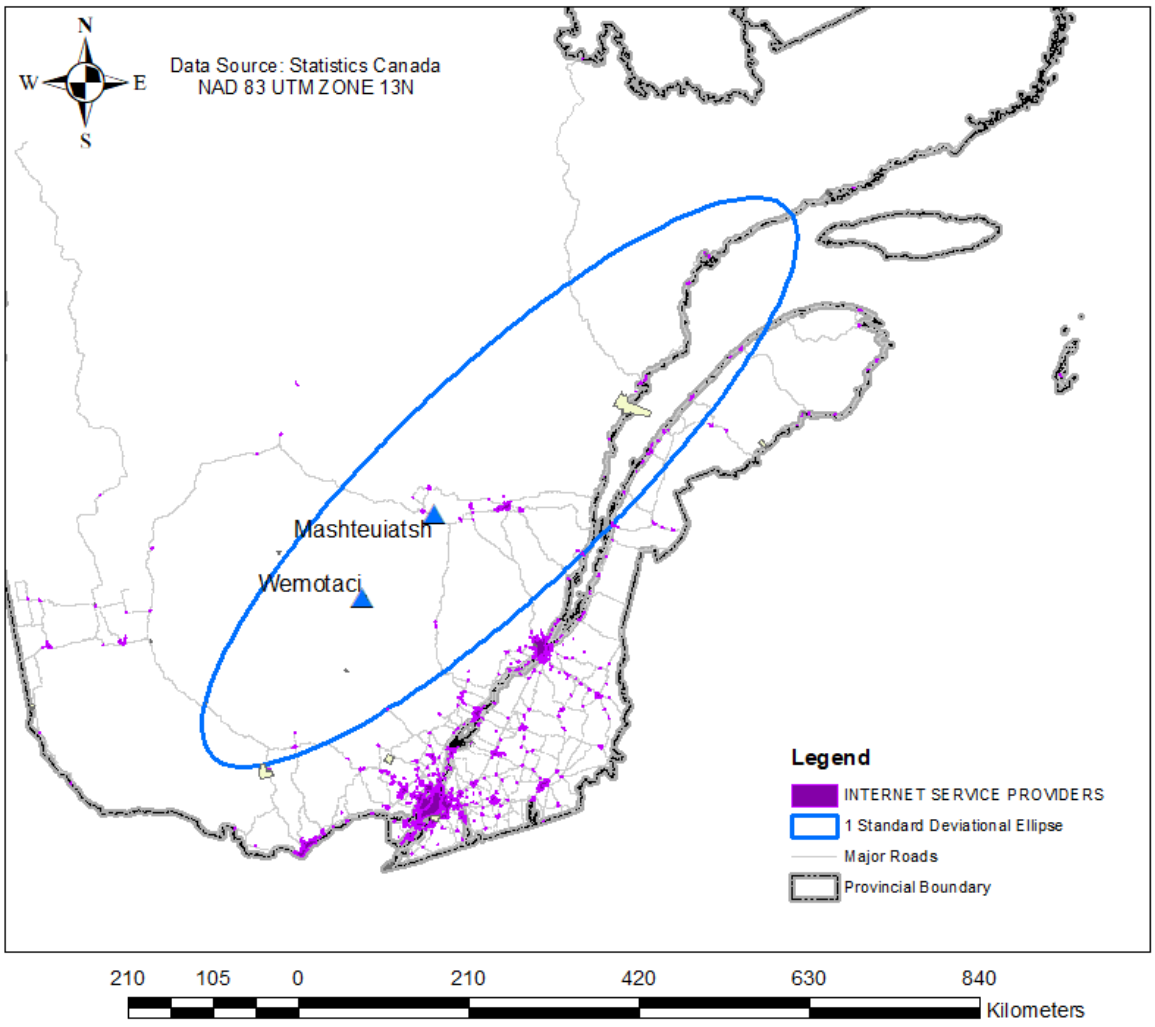


Figure 30. Selected sites distances from internet service providers in Quebec

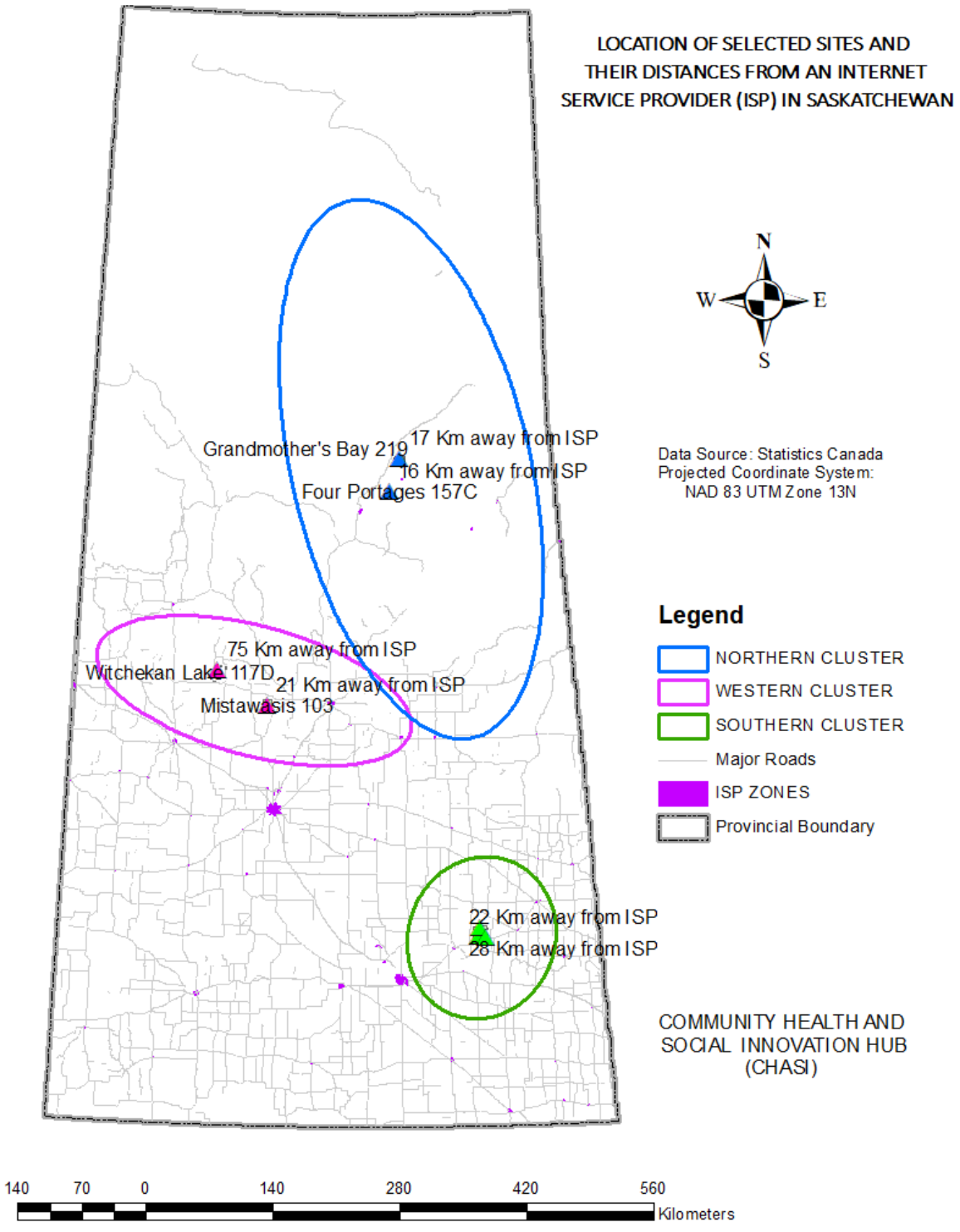


Figure 31. Selected sites distances from internet service providers in Saskatchewan

APPENDIX B — GIS MAPS: OVERLAY OF HUMAN RESOURCE CAPACITY

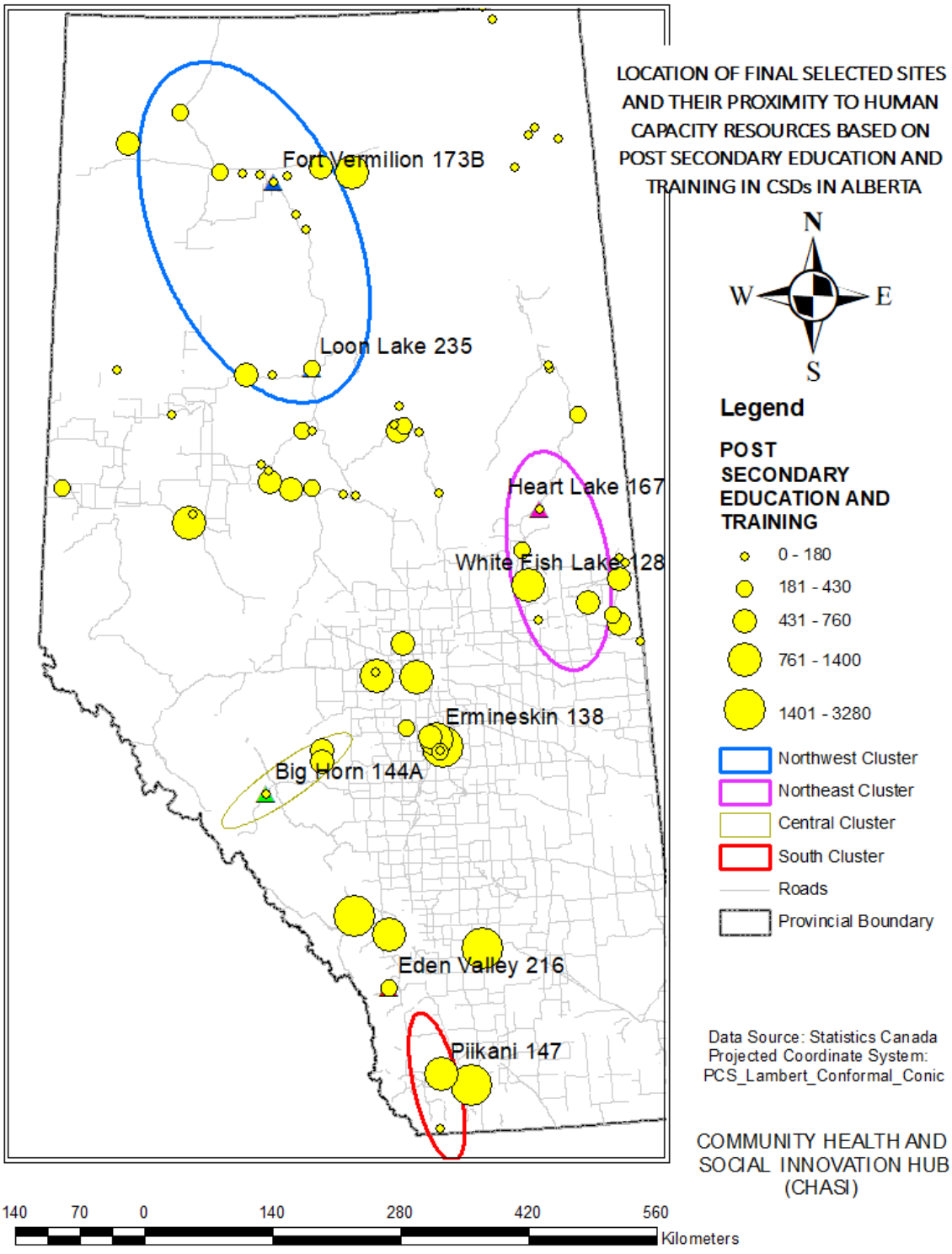
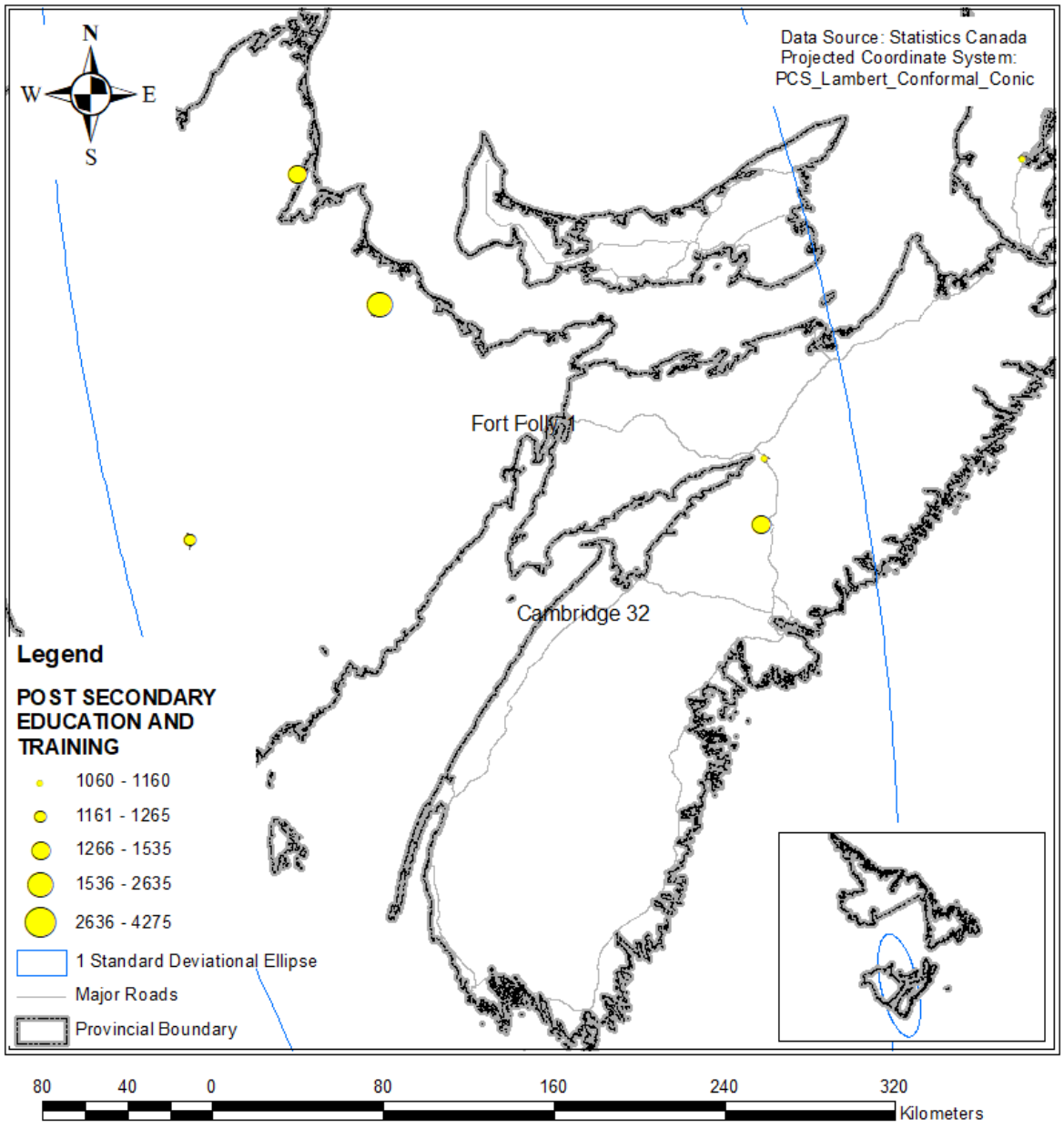


Figure 32. Selected sites with human resources capacity overlay in Alberta



LOCATION OF FINAL SELECTED SITES AND THEIR PROXIMITY TO HUMAN CAPACITY RESOURCES IN CSDs IN THE ATLANTIC PROVINCES

COMMUNITY HEALTH AND SOCIAL INNOVATION HUB (CHASI)

Figure 33. Selected sites with human resources capacity overlay in the Atlantic region

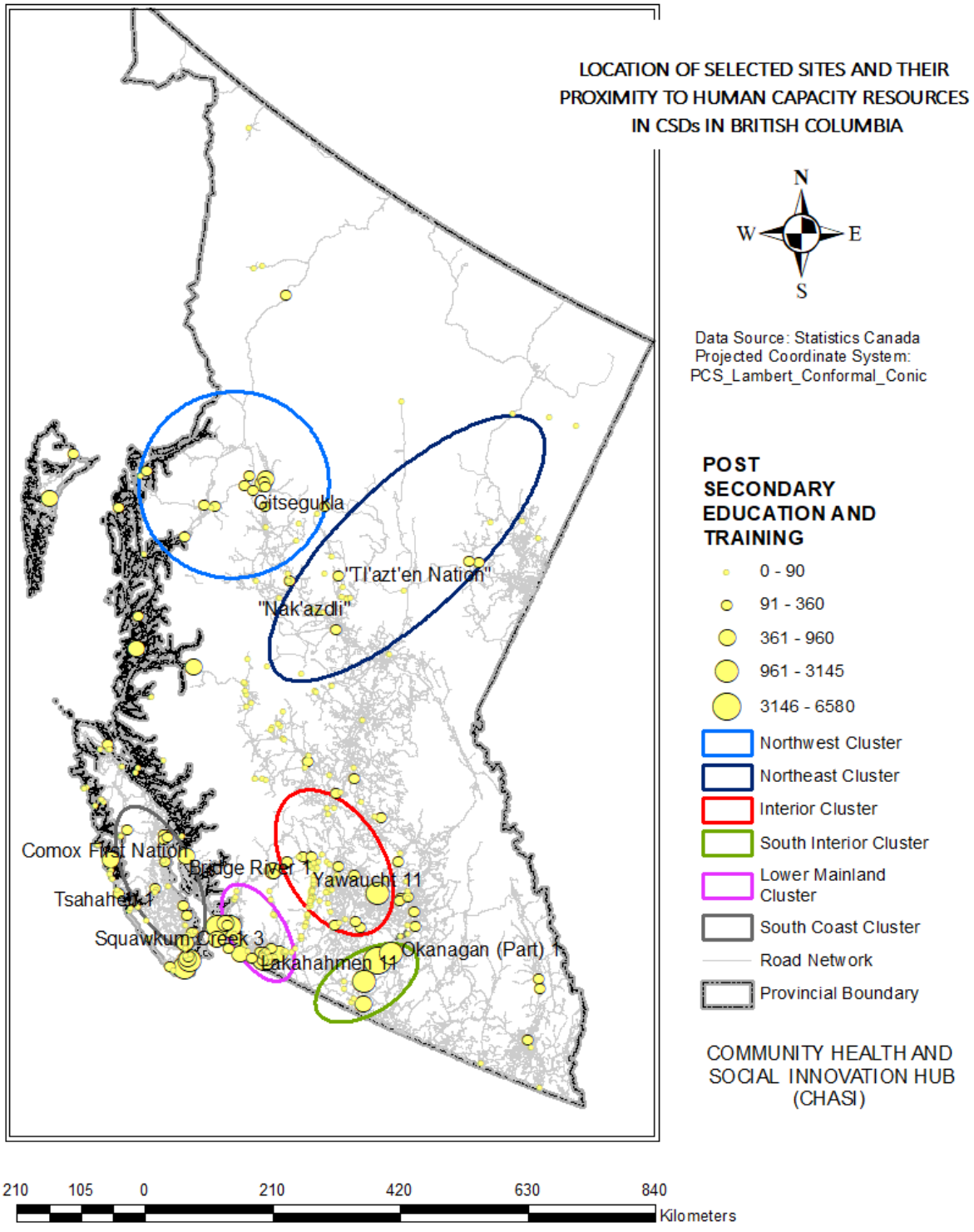


Figure 34. Selected sites with human resources capacity overlay in British Columbia

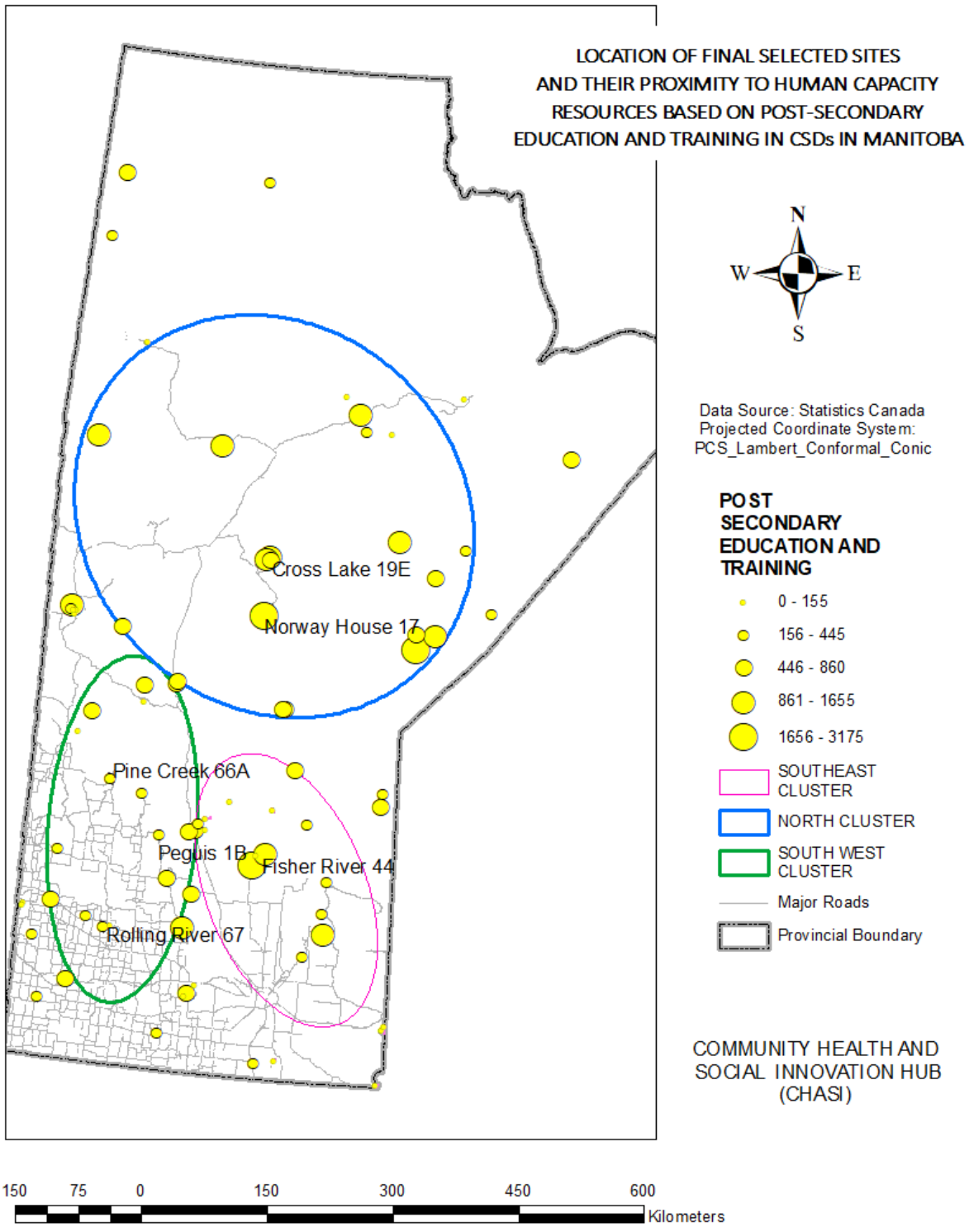


Figure 35. Selected sites with human resources capacity overlay in Manitoba

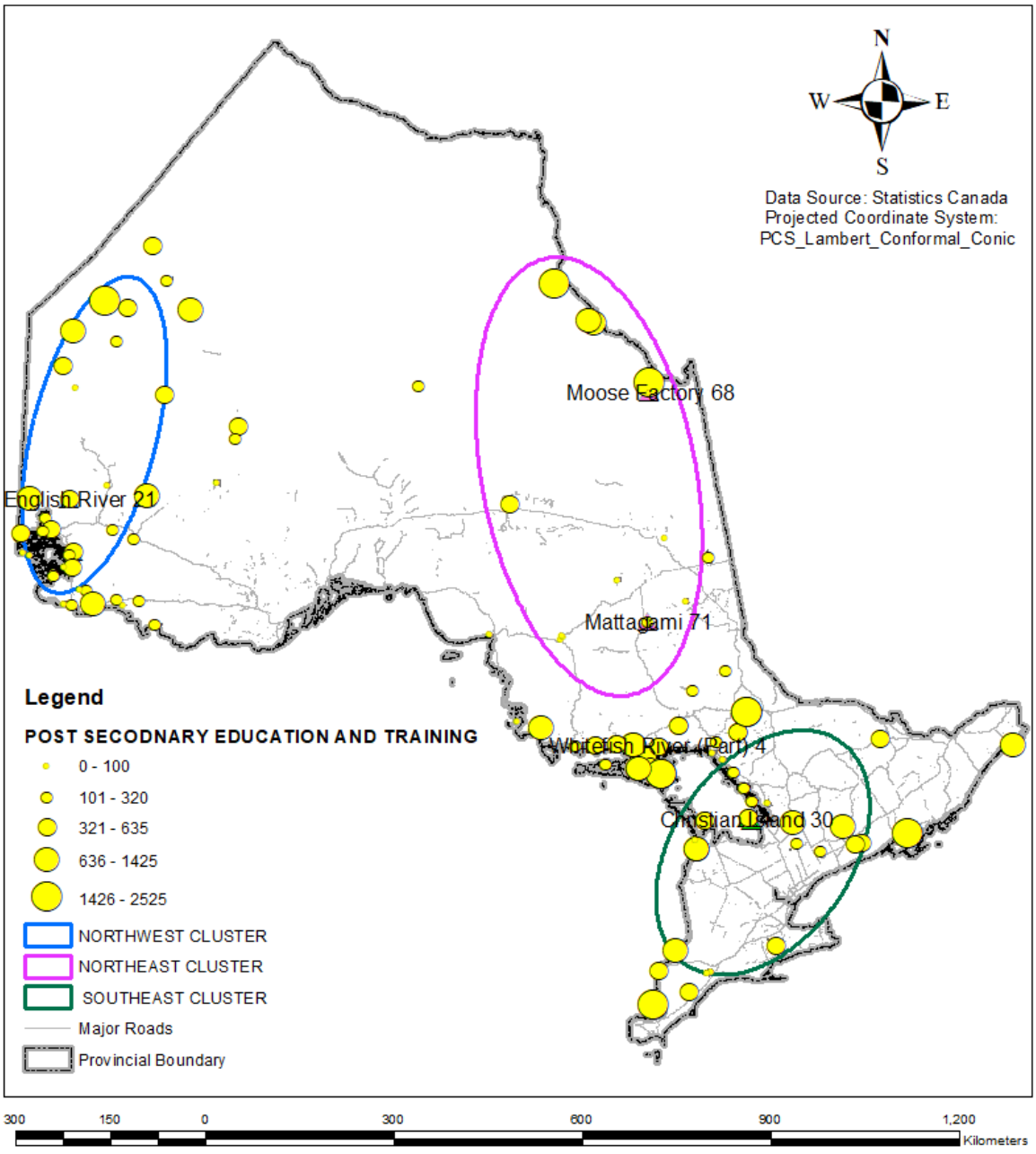


Figure 36. Selected sites with human resources capacity overlay in Ontario

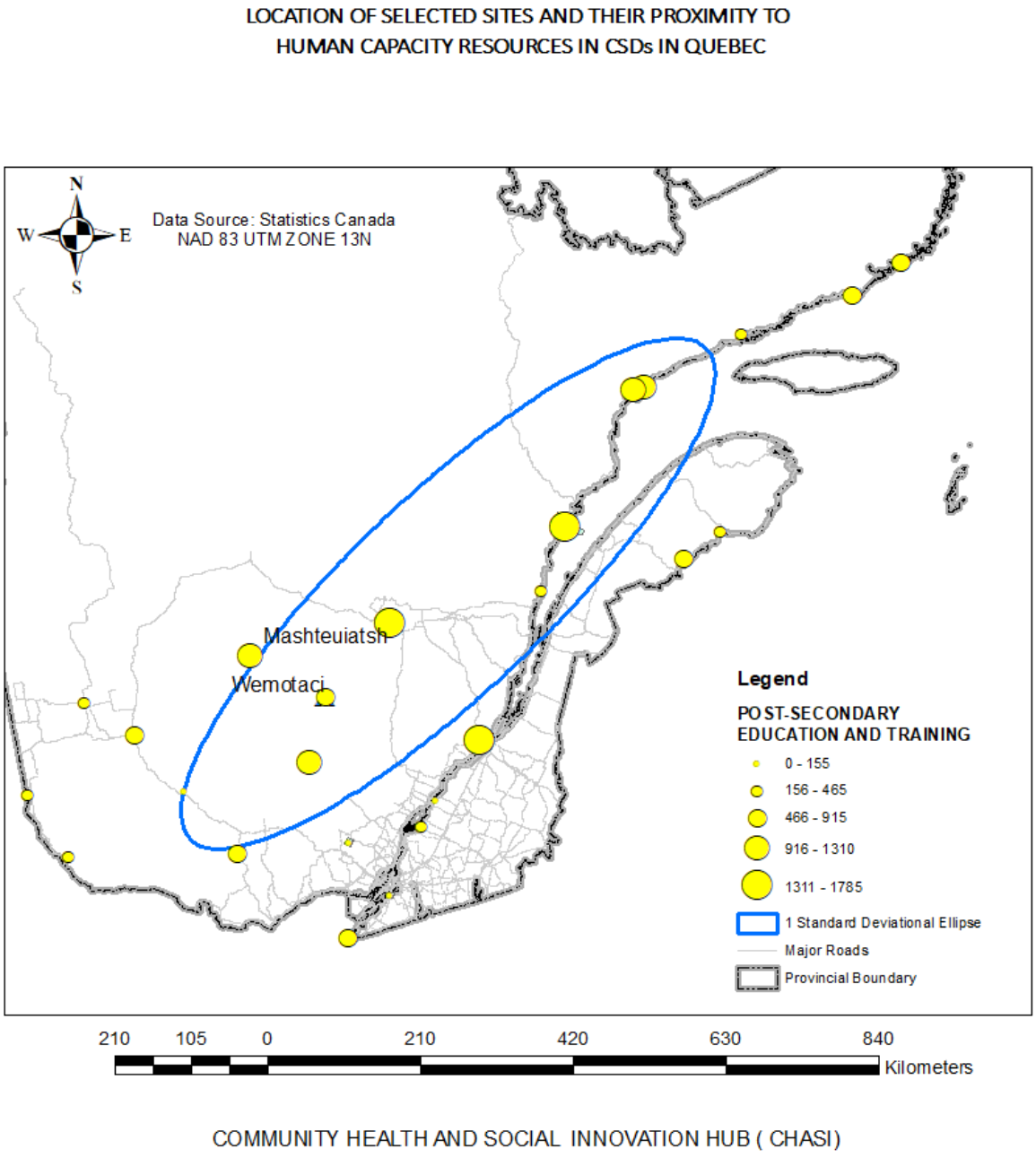


Figure 37. Selected sites with human resources capacity overlay in Quebec

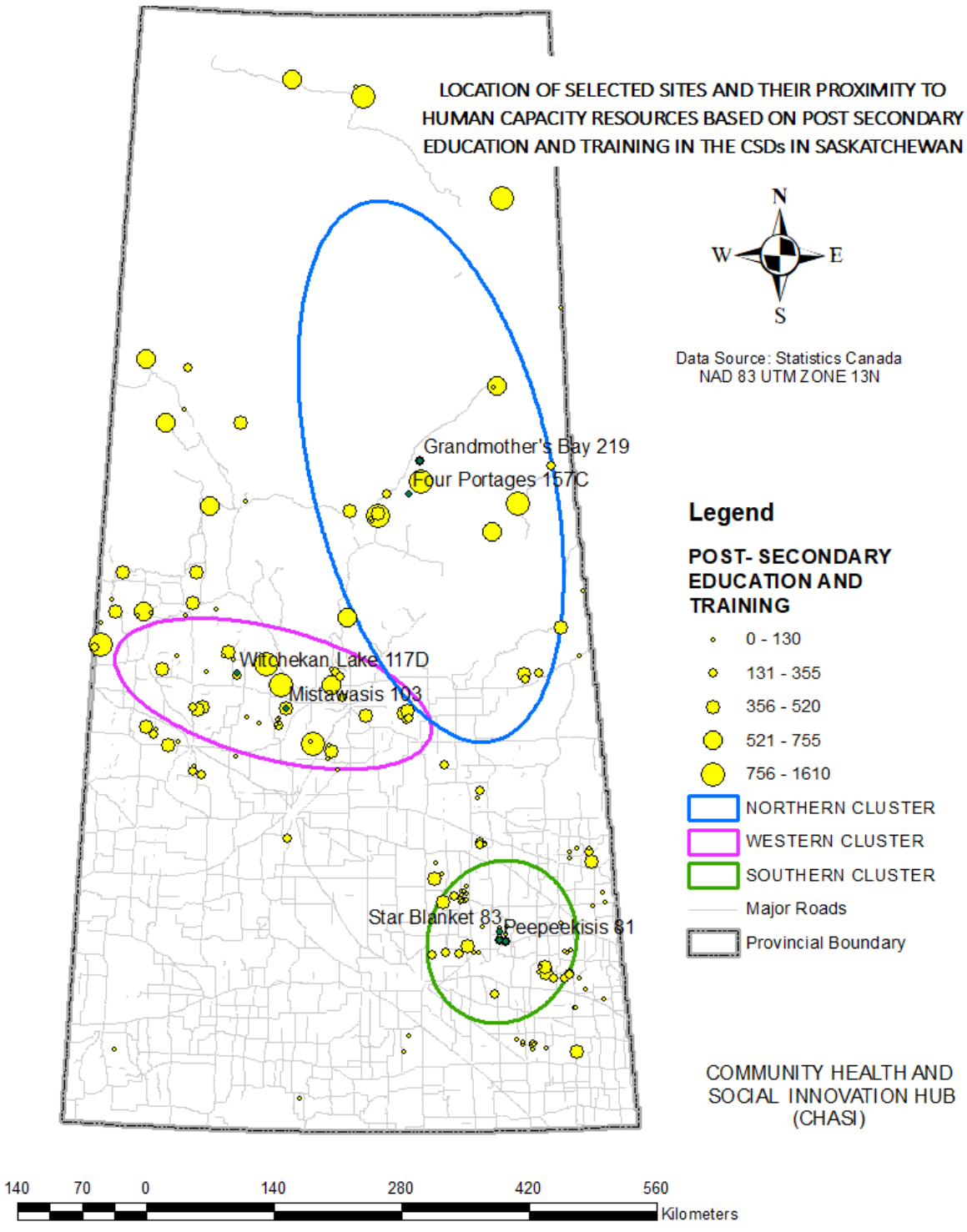


Figure 38. Selected sites with human resources capacity overlay in Saskatchewan

APPENDIX C — KMZ LINKS

To view KMZ files download and install Google Earth Pro from https://www.google.com/earth/versions/. With the latest version of Google Earth Pro installed, double-clicking the KMZ file will open the interactive map.

Once opened in Google Earth Pro, clicking on the individual sites (represented by coloured circles) will bring up additional information about the corresponding location.

The KMZ files are available to download at the links below:

All selected sites - https://drive.google.com/file/d/1fbEd61HSVIe2xCymZbhqyNga1UPXV0H0/view?usp=sharing

Alberta - https://drive.google.com/file/d/12tv4I7LRdTIs4p2VH7A5YZ1FLI8Pvy3A/view?usp=sharing

Atlantic Region - https://drive.google.com/file/d/1iS905w_8x6sXjQNSC_MJYs20IXfiUhwh/view?usp=sharing

British Columbia - https://drive.google.com/file/d/161lTRv5WUeNcKa0Ein_ZIntEjPUnaFVY/view?usp=sharing

Manitoba - https://drive.google.com/file/d/1ZmoTKQI-hnSLgzh38ImeOwD6E_yaZoJJ/view?usp=sharing

Ontario - https://drive.google.com/file/d/1_UKdpAJkD4vNHuc9S8Vb3GG4-wA3m7Ve/view?usp=sharing

Quebec - https://drive.google.com/file/d/1nAYik8pm98hlEFN0eGlCHa9FGVgsZkNk/view?usp=sharing

Saskatchewan - https://drive.google.com/file/d/1NDp39qrH2ApHfm-hG6aX7DizouiLnMCI/view?usp=sharing

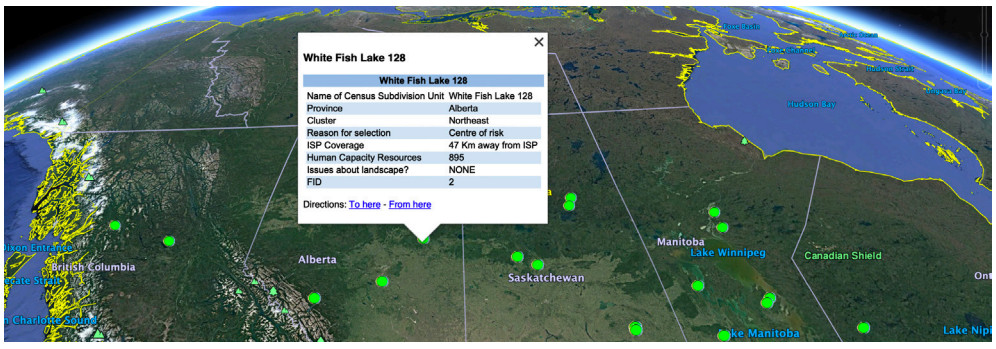


Figure 39. Sample of KMZ file open in Google Earth Pro

REFERENCES

Huesken, S., Xiao, R., Jennings, C. and Dow, M. (2020). Moving from Risk Assessment to Risk Reduction: An analysis of Fire-related Risk Factors in First Nation/Indian Band or Tribal Council Areas across Canada. A report prepared for the Aboriginal Firefighters Association of Canada.

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