GIS analysis of the Agricultural Land Reserves (ALR) in the Central Okanagan subpanel region

GEOB 270 - Geographic Information Science
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Table of Contents

1. Executive Summary

Agriculture in British Columbia currently contributes $11 billion to the regional economy, and is expected to contribute $14 billion by 2017. Agricultural Land Reserves (ALR) are thus vital for agricultural production in British Columbia. Although estimates of the total area of ALR have been made, these numbers may contain errors due to the lack of consideration for various spatial features and non-agricultural use within the ALR. This results in inaccuracies in terms of the usable areas for agricultural production within the ALR. This project aims to improve estimates of ALR land, including only land used for agricultural or farming purposes. This was done through GIS analysis of datasets obtained from various government and academic databases. Our findings demonstrated that original estimates of the land available in the ALR for agricultural production (about 21780 ha) in the Central Okanagan region is not accurate—after eliminating non-agricultural use, only about 20950 ha of land. We found that potential threats to further reduction of such land for agriculture and farming include expanding urban infrastructure, logging activities and recreational areas. In addition, a small extent of hazardous areas (from mining activities and waste management) that could pollute arable land is a cause for concern. (200 words)

2. Introduction

Agriculture in British Columbia currently contributes $11 billion to the regional economy, and is expected to contribute $14 billion by 2017 (Government of British Columbia, 2015). Agricultural Land Reserves (ALR) are thus vital for agricultural production in British Columbia. Nevertheless, the resulting rapid urban development within and around these prime agricultural regions are resulting in a range of threats that are aiding in the decline of the area of ALR (Geography Open Textbook Collective, 2014).

Although estimates of the total area of ALR have been made, these numbers may contain errors due to the lack of consideration for various spatial features and non-agricultural use within the ALR, such as water features, urban infrastructure, etc. This results in inaccuracies in terms of the usable areas for agricultural production within the ALR (Geography Open Textbook Collective, 2014).

It is thus necessary to improve the precision and accuracy of estimates of the ALR, through the exclusion of areas where agricultural production is inhibited or not recommended due to certain ‘threats’, or where the area is being used for non-agricultural infrastructure or activities. It also becomes necessary to get a sense for the expected urban development that may further compromise the ALR’s potential in the future by projecting demographic changes and their effect on development demand. We used ArcGIS as a tool to analyze the layers of geospatial and demographic data, which forms the basis for our revised estimates of ALR areas and projections of the future potential of these ALR areas.

ArcGIS shape files were parsed from Canadian government databases, open source databases, and private databases (TRIM). TRIM data was processed into polygons. Demographic data was available from the UoT CHASS database, and was joined to shape files from the Census Canada database. (290 words)

3. Analysis

3.1 Overview

Map 1 (Appendix) shows the Agricultural Land Reserves (ALR) in the Central Okanagan. The area of ALR[1] in the Central Okanagan Census Division is about 27,180 ha. With the area of the Central Okanagan Census Division[2] being about 315000 ha, the percentage of ALR land[3] in the Central Okanagan Census Division is about 8.6%.

Map 2 (Appendix) shows the estimated land area used for agriculture and farming, after eliminating non-agricultural use of ALR land. Total land left that is currently or potentially used for agriculture and farming is about 20950 ha, representing about 6.7% of the Central Okanagan Census Division[4]. Of this 20950 ha, it is estimated that about 6,400 ha is currently being used to produce a variety of agricultural products, such as hay crops, vegetables, nursery products, mushrooms, and fruits, berries and nuts (StatisticsCanada, 2013) (Table 1).

Table 1. Estimates of agricultural production within the ALR.

Agricultural products	**Area** (ha)
Hay crops	1,870
Field crops	154
Fruits, berries and nuts	3,409
Vegetables	163
Nursery products	468
Sod grown for sale	77
Mushrooms	(data suppressed for confidentiality)
Christmas trees	47
Greenhouse flower production	2.64
Greenhouse vegetable production	0.14
Other greenhouse production	1.04
Total crop area	**6,379**

[1] Area of Central Okanagan subpanel region $= 27180.583\ ha$

[2] Area of Central Okanagan Census Division $= 314489.834\ ha$

[3] Percentage of ALR land in original shapefile
$= 27180.583\ ha \div 314489.834\ ha \times 100\%$
$= 8.643\% \approx 8.6\%$

[4] Percentage of ALR land in final shapefile
$= 20947.898\ ha \div 314489.834\ ha \times 100\%$
$= 6.66\% \approx 6.7\%$

3.2 Biogeographical

Land cover

Map 3 (refer to Appendix) shows the landuse cover within the ALR of the Central Okanagan. In order to determine the different types of land cover within the ALR, vector data from Natural Resource Canada (2015) was obtained for our analysis. The land cover information is the result of vectorization of raster thematic data originating from classified Landsat 5 and Landsat 7 ortho-images, that covers imagery of the Earth's surface. Table 2 shows the 17 types of land cover present within the ALR based on the dataset, and their areas and percentage of the ALR.

Table 2. Biogeographical land classification and their area of coverage

Land cover	**Area** (ha)	**Percentage of Central Okanagan ALR** $(\%)$
Water	46.191	0.170[5]
Exposed land	98.204	0.361
Developed	1699.339	6.252
Shrub - low	2265.706	8.336
Wetland tree	3.009	0.011
Wetland shrub	8.131	0.030
Wetland herb	5.517	0.020
Herb	5629.891	20.713
Grassland	1752.481	6.448
Annual crops	3296.834	12.129
Perennial crops and pasture	2837.073	10.438
Coniferous – dense	721.214	2.653
Coniferous - open	5643.691	20.764
Coniferous - sparse	54.089	0.199
Broadleaf - open	1277.678	4.701
Broadleaf – sparse	0.961	0.004
Mixed wood - open	970.423	3.570

Agricultural land capabilities and water features

Map 4 (refer to Appendix) shows the agricultural land capabilities and water features within the ALR of the Central Okanagan. Data for water features (lakes and rivers) was obtained from the GeoBC (2015) Terrain Resource Information Management (TRIM) Program. After giving both lakes and rivers layers a buffer of 10 metres each, the total area of water in the ALR

[5] (Example calculation) Percentage of water (land cover) of Central Okanagan ALR
$=$ Total area of water (land cover) $\div$ Area of Central Okanagan ALR $\times$ 100%
$=$ 46.191 $ha \div$ 27180.583 $ha \times$ 100%
$=$ 0.170% $\approx$ 0.17%

subpanel amounted to 853 ha. The percentage of water[6] in the ALR subpanel represented 3.14% of the land surface.

Soils have varying potential to grow agricultural crops, and thus face certain limitations in terms of their agricultural production potential due to natural factors such as climate, soil variability and topography. Soils within the ALR are divided into seven "Agricultural Land Capability Classes" based on these factors which varies across the ALR of Central Okanagan: Class 1 to Class 7 (http://www.alc.gov.bc.ca/alc/content/alr-maps/agricultural-land). Class 1 type soil would be able to support the widest range of crops, whereas Class 7 type soil is deemed non-arable. Intermediate classes within this range may appeal to certain types of agricultural crops; this being determined by the farmers.

Data for agricultural land capabilities was obtained from the B.C. Ministry of Environment (2015). Analysis showed that the Central Okanagan ALR subpanel area (refer to Table 3) exhibited a total lack of Class 1 type soil (0%), with the vast majority concentrated on Class 4 (32.5%), Class 5 (35.3%) and Class 6 (14.1%) type soil and minimal areas of Class 2 (0.6%), Class 3 (4.1%) and Class 7 (0.6%) type soil. Small areas of Class ? and Class W type soil were merged using the Editor tool and given a class of "No data".

Table 3. Soil classifications and their area of coverage.

Soil types	**Area** (ha)	**Percentage of Central Okanagan ALR** (%)
Class 2	168.903	0.621
Class 3	1119.367	4.118
Class 4	8837.914	32.516
Class 5	9605.259	35.3390
Class 6	3843.998	14.142
Class 7	168.370	0.619
Class ?	18.745	0.069
Class W	1.444	0.005
Total	**23764.000**	**87.429**

Slope angle

Map 5 (refer to Appendix) shows the slope angle within the ALR of the Central Okanagan. Slope angle is a factor that may affect the feasibility of agricultural activities and growth of agricultural crops. Thus, investigating the slope angle of the region may reveal areas that are considered to be too steep for agricultural activities. Based on guidelines provided by the UBC Department of Geography (2015), 30 degrees slope angle to be considered suitable for agriculture. Using Digital Elevation Model (DEM) data from CDEM (Natural Resources

[6] Percentage of water in original ALR subpanel
$=$ Total hectares of water in original ALR subpanel $\div$ Total hectares in original ALR subpanel $\times$ 100%
$=$ 853.420 $ha \div$ 27180.583 $ha \times$ 100%
$=$ 3.14%

Canada, 2012), we were able to determine the different slope angles of the topography across the ALR. Table 4 shows that approximately 170 ha of land has >30 degree slope angle, which is considered to be too steep for agriculture. This figure contributes to less than 1% (i.e. 0.63%) of the entire ALR area[7], which is a good indication that the land within the ALR is mostly favourable for agricultural activities in terms of slope angle.

Table 4. Classification of ALR according to slope angle and the area of coverage.

Slope angle	**Area** (ha)
>30 degrees	171.713
<30 degrees	27008.869

3.3 Social

Map 6 (refer to Appendix) shows the road networks found in the ALR of the Central Okanagan. TRIM data (GeoBC, 2015) showed that there are three main types of roads within the ALR subpanel area (refer to Table 5). These were namely; gravel roads (350 km), paved roads (320 km) and rough roads (500 km). We are of the opinion that agricultural production may not be suitable within the proximity of road networks due to possible pollution by vehicles, road surface runoffs, etc. Therefore, a buffer of 10 metres was given to road networks to reduce potential sources of pollution of agricultural products. It was determined that the total area of buffered roads that falls within the ALR is approximately 1200 ha, which represents approximately 4.33% of the ALR[8].

Table 5. Different road types in central Okanagan ALR.

Road type	**Length covered** (km)
Gravel Road 1 Lane	276.836
Gravel Road 1 Lane (Under Construction)	0.278
Gravel Road 2 Lane	77.877
Paved Road 1 Lane (One Way)	0.699
Paved Road 2 Lane	286.497
Paved Road 2 Lane (One Way)	25.104
Paved Road 4 Lane	6.405
Paved Road 4 Lane (Divided)	0.0929
Rough Road	502.507
Total	**1176.296**

[7] Percentage of area too steep for agriculture
= Area with >30 degrees slope angle ÷ Area of Central Okanagan ALR × 100%
= 171.714 ha ÷ 27180.583 ha × 100%
= 0.63%

[8] Percentage of buffered roads in the ALR
= Area of buffered roads ÷ Area of Central Okanagan ALR × 100%
= 1176.296 ha ÷ 27180.583 ha × 100%
= 4.33%

Parks, reserves and golf courses

Map 7 (refer to Appendix) shows the parks, reserves and golf courses found in the ALR of the Central Okanagan. We considered parks (i.e. provincial and protected areas) and ecological reserves to be non-agricultural lands, since these areas are legally protected and agricultural activities are usually prohibited. There are a total of four different provincial parks and one ecological reserve within the ALR. With a total area of about 150 ha, parks and reserves constitute about 0.56% of the ALR[9] (Table 6). Golf courses that fall within the ALR should also be excluded, since they are not contributing to any agricultural production. Within our ALR, the total area consisting of golf courses aggregated to about 250 ha, which represents approximately 0.93% of the ALR[10] (Table 6).

Table 6. Areas of different types of parks, reserves and golf courses within the ALR.

Park type	**Area** (ha)
Provincial park	146.452
Protected area	6.548
Ecological reserve	0.202
Sub-total	**153.202**
Golf courses	253.741
Total	**406.943**

Demographic characteristics

Demographic characteristics are of interest because changing demographic characteristics may potentially affect urban development of the ALR in the future. To study the demographic characteristics within the Central Okanagan ALR, 2011 profiles of census dissemination areas were obtained from Computing in the Humanities and Social Sciences (CHASS) database (University of Toronto, 2015). It was determined that a population size of about 524,000 live within the ALR subpanel of Central Okanagan. Other demographic characteristics include a median age of 43.5 years, an average household size of 2.16, and housing affordability index of 6.98. The CHASS data was modified and analyzed through the following process:

1. The demographic data was joined to shapefiles containing polygons for each dissemination area, using the unique ID for each dissemination area to connect the data to the right polygon to create the demographic layer.

[9] Percentage of parks and reserves in the ALR
= Area of parks and reserves ÷ Area of Central Okanagan ALR × 100%
= 153.202 ha ÷ 27180.583 ha × 100%
= 0.56%

[10] Percentage of golf courses in the ALR
= Area of golf courses ÷ Area of Central Okanagan ALR × 100%
= 253.741 ha ÷ 27180.583 ha × 100%
= 0.93%

2. This layer was then clipped to the ALR shape file. Since the relevant demographic data is not only about the populations directly in the ALR, but also those immediately surrounding the ALR, we buffered the clipped layer by 100 metres.
3. Since the demographic area is representing an entire dissemination area, for which the layer only included a small portion of some dissemination area, the data may not be representative of what is actually found near the ALR. To solve this, we joined the clipped, buffered layer to the original layer to compare the areas for the portion of the dissemination areas within the buffered ALR versus the entire dissemination area. A new field was created where the ratio between the two areas were calculated. It was decided that if the dissemination area found in the ALR was less than 10% of the entire dissemination area, the demographic data from those areas is to be excluded. Essentially, if only 5% of the dissemination area were relevant to the ALR, the population data for that dissemination area was dismissed. Statistics for the demographic data were calculated, including a sum of the population affecting the ALR. 619 dissemination areas were included in the final dataset for the ALR.

The median age of the ALR is 43.5 years, whereas for British Columbia the median age is 41.4 years. This means that this ALR has an older population, with some dissemination areas having a median age of ~70 years. The average household size was calculated by dividing the total population by the total amount of dwellings. For the ALR, the average household size was estimated to be 2.16, in contrast to British Columbia's average of 2.5. This is a significant reduction in household sizes affecting the ALR. Lastly, a housing affordability index was calculated by taking the average dwelling values divided by the median housing income. A higher score for this index represents less affordability. The ALR scored 6.9848, whereas British Columbia scored 6.0550. This represents the fact that housing in this ALR is far less affordable than expected for British Columbia.

Overall, these statistics allow us to conclude that this ALR has a significantly older population, living as small family units, in a significantly less affordable area compared to the rest of British Columbia. The projected future demand for development in this area depends on the projected population size and income per capita. Smaller and older families in the ALR allow us to project a declining population. Also, unaffordability projects for greater emigration out of the ALR, which also means a declining population. Given the unaffordability and projected declining population, the economic incentive to develop in the ALR is projected to decrease. Thus, the ALR agricultural potential is not likely to change due to demographic reasons.

Non-agricultural use of ALR land

Maps 8a to 8e (refer to Appendix) show non-agricultural use of land in the ALR of the Central Okanagan. We researched on non-agricultural use of land within the ALR because they may represent a substantial threat to the gradual decline of the extent and or quality of the ALR for agricultural use. We define non-agricultural areas as non-crop producing areas, including any of the activities and infrastructure pertaining to the Central Okanagan ALR subpanel area. Data for spatial features such as tailing ponds, waste and sewage areas, trailer parks, building infrastructure, as well as developed areas were obtained from Natural Resources Canada (2015) and GeoBC (2015). These spatial features were grouped into five main categories (Table 7): water features, recreational activities, logging activities, urban infrastructure, and hazardous areas.

Table 7. Non-agricultural use of ALR in the Central Okanagan and their areas of coverage.

Non-agricultural use type	Includes	Area (ha)
Water features	Lakes (10 m buffer) Rivers (10 m buffer)	853.420
Recreational areas	Parks and reserves Campgrounds or campsites Golf driving ranges Golf courses Sports field	438.950
Logging activities	Cut blocks Cut blocks – regenerating Selective logging Lumber yards Log landings	1,640.134
Urban infrastructure	Cemeteries Trails, earthworks and brdiges Buildings (5 m buffer) Builtup areas Transmission lines (10 m buffer) Trailer parks Electrical substation complex Rail (10 m buffer) Roads (10 m buffer)	4,165.170
Hazardous areas	Decommissioned mining pits (10 m buffer Tailing ponds (10 m buffer) Sewage treatment areas (10 m buffer) Dumpsites (10 m buffer)	127.508
Total		7,225.182
Total (dissolved)		6230.000

Table 7 also shows that the most common threats in the Central Okanagan ALR was urban infrastructure (4170 ha), followed by logging activities (1640 ha) and recreational areas (440 ha). Additionally, golf courses, driving ranges and dumps were found to be the most prolific non-farm use threats. Urban infrastructure represents about 15.3% of the total ALR area; if urban development continues, it will significantly affect the true extent of ALR that can be used for agricultural activities. Logging activities represent about 7.5% of the total ALR area. While not yet extensive, continued clear cutting will affect the quality of soils in the timber project area as trees are no longer present to hold the soil together and maintain soil nutrient levels. Recreational areas represent about 2.0% of the total ALR area. Although not yet a significant threat, it could expand if demographic characteristics shift towards population expansion within the ALR.

Although hazardous areas constitutes only a small fraction of the ALR (0.58%), their presence is a serious issue because it could adversely affect soil quality significantly through contamination and pollution through waste. This pollution could seep into the groundwater and

affect an area much larger than what the hazardous material cover on the ground surface. If the pollution enters water features (rivers and lakes) around the region, it could negatively impact agricultural production that relies on water drawn from these water features.

3.4 Summary

In conclusion, we have determined many attributes and spatial features (e.g. rivers, roads, buildings, etc.) that should be excluded from the estimation of the area of ALR as they do not contribute to agricultural production, despite being permitted. The original estimate of the ALR according to the shapefile is 27180.58 ha, which is about 8.64% of the entire Central Okanagan Census District. This estimate is not a good representation of the actual land available within the ALR for agricultural production.

In the final shapefile of the Central Okanagan ALR, all non-agricultural use of land from Maps 8a to 8e were eliminated from the original shapefile. Non-agricultural uses eliminated were (Table 7): water features (850 ha), recreational activities (440 ha), logging activities (1640 ha), urban infrastructure (4170 ha), and hazardous areas (130 ha). After dissolving all the non-agricultural use layers, the combined area of extractions is about 6230 ha. Eliminating this from the original shapefile of the ALR (27180 ha), the final shapefile of the ALR produced showed that only 20950 ha of land represents current or potential agricultural use of land.

4. Error and Uncertainty

There was a certain degree of uncertainty throughout our research project regarding the sources of our data. This included the date of when the data was captured, the suppression of data, and consequently an overestimation of data averages in certain dissemination areas e.g. some data censoring was encountered for mushroom production. The suppression of data in certain dissemination areas could also cause possible overestimations of the aggregate statistics from our data results.

It is important to take into consideration who produced the data and for what purpose it was produced. Data production for specific purposes will skew the data towards to objective of those purposes. Nevertheless, most of the data was acquired from the regional government data banks, which conveys less of a bias than other data sources used.

A potential source of error would be our assumptions of buffer areas. Although a 10-metre buffer was used in most cases, more research would have to be done in order to establish a good estimate of the extent of buffer required for different spatial features. For example, a more better buffer extent for hazardous areas and tailing ponds and sewage areas may be higher than 10 metres, due to the nature of toxic chemicals and the ability of agricultural crops to take in these toxins through groundwater. When we calculated the demographics of central Okanagan ALR subpanel area, we used a 100 metre buffer as there may be households which are located between two different dissemination areas which could skew our data results.

We also have to consider other potential non-agricultural land use, features and activities that might be permitted within the ALR, but are absent from our analysis. The data obtained from GeoBC TRIM (2015) and Natural Resource Canada (2015) might not reveal all

the non-agricultural spatial features within the ALR region. Therefore, the actual land area of the ALR for current or potential agricultural use of land may in fact be lower than the estimated value of 20950 ha suggested by our research findings.

5. Recommendations

The data that the Government of B.C. currently provides to its citizens as open-source data is not up-to-date, hence 2011 Census Data had to be used in this study. Although we examined certain variables of the demographics of Central Okanagan from 2011, these figures could have changed considerably in the past four years, possibly resulting in inaccuracies. It is therefore recommended that there be a sustained increase in the quality and amount of research by the Government of B.C. This would not only aid in improving knowledge related to the ALR of Central Okanagan, but could also improve estimates of ALR land currently and potentially used for agricultural and farming activities.

The Government of B.C. should also make public information related to land swapping and non-agricultural use of land within the ALR. Our research found that there was a total lack of Class 1 type soil in the ALR of Central Okanagan, which although may be true but there is also a possibility that such land with rich soil ideal for agriculture has been obtained by private owners for development through land swaps. Also, in the “Social” section of this study, a key highlight was that a large extent of the ALR was being used for non-agricultural activities. It may be beneficial for the Government of B.C. to clarify exactly what types of non-agricultural activities are permitted on the ALR and the justifications for permitting such land use on the ALR. Lastly, hazardous areas (from mining activity and waste management) were identified in the ALR. Although relatively small in area, toxic wastes from such activity have the potential for severe consequences on agricultural production. It is unclear why such activity have been found on the ALR. It may be beneficial for the Government of B.C. to clarify this issue. (299 words)

6. Appendices

6.1 References

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6.2 List of data sources

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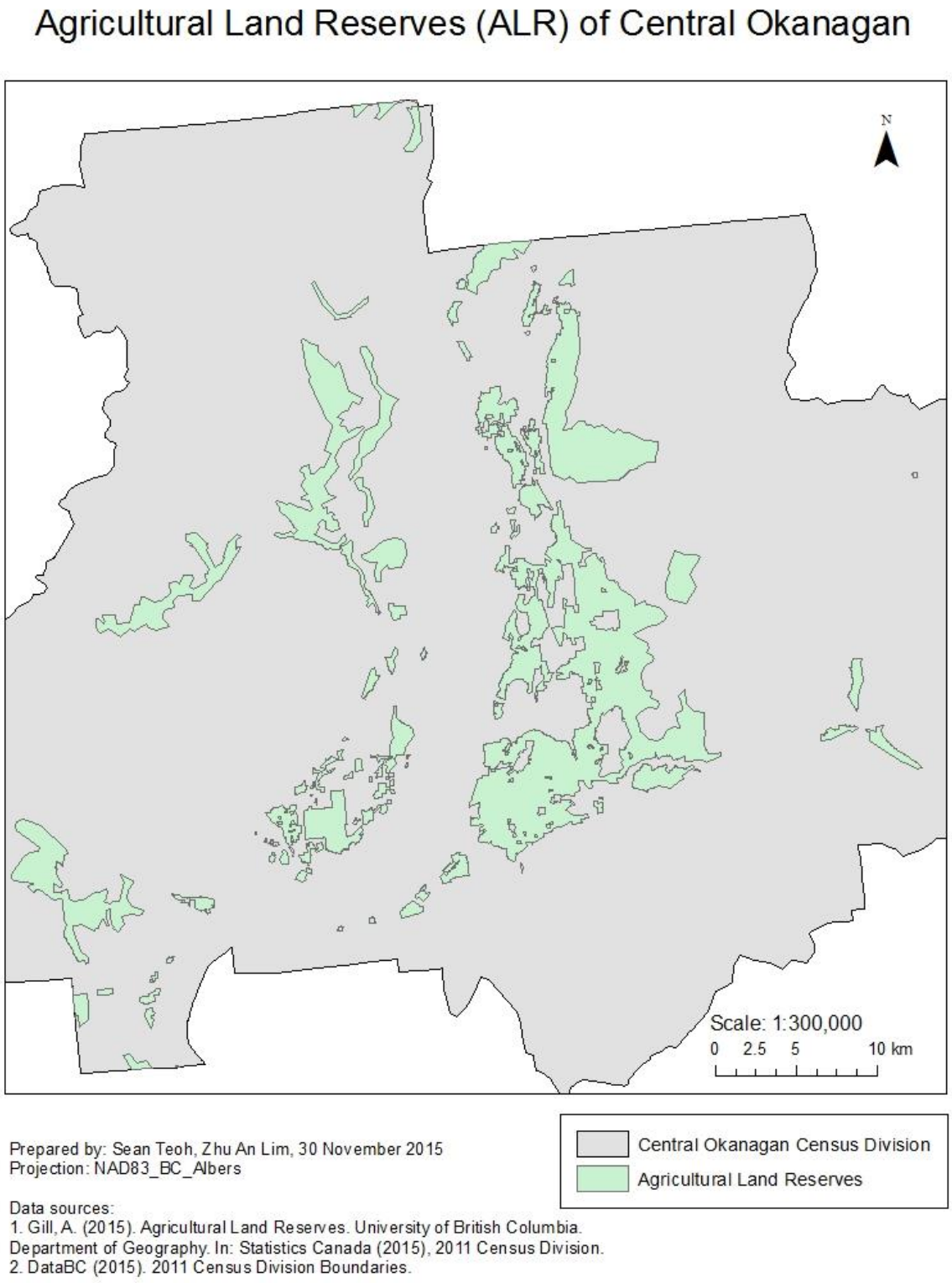
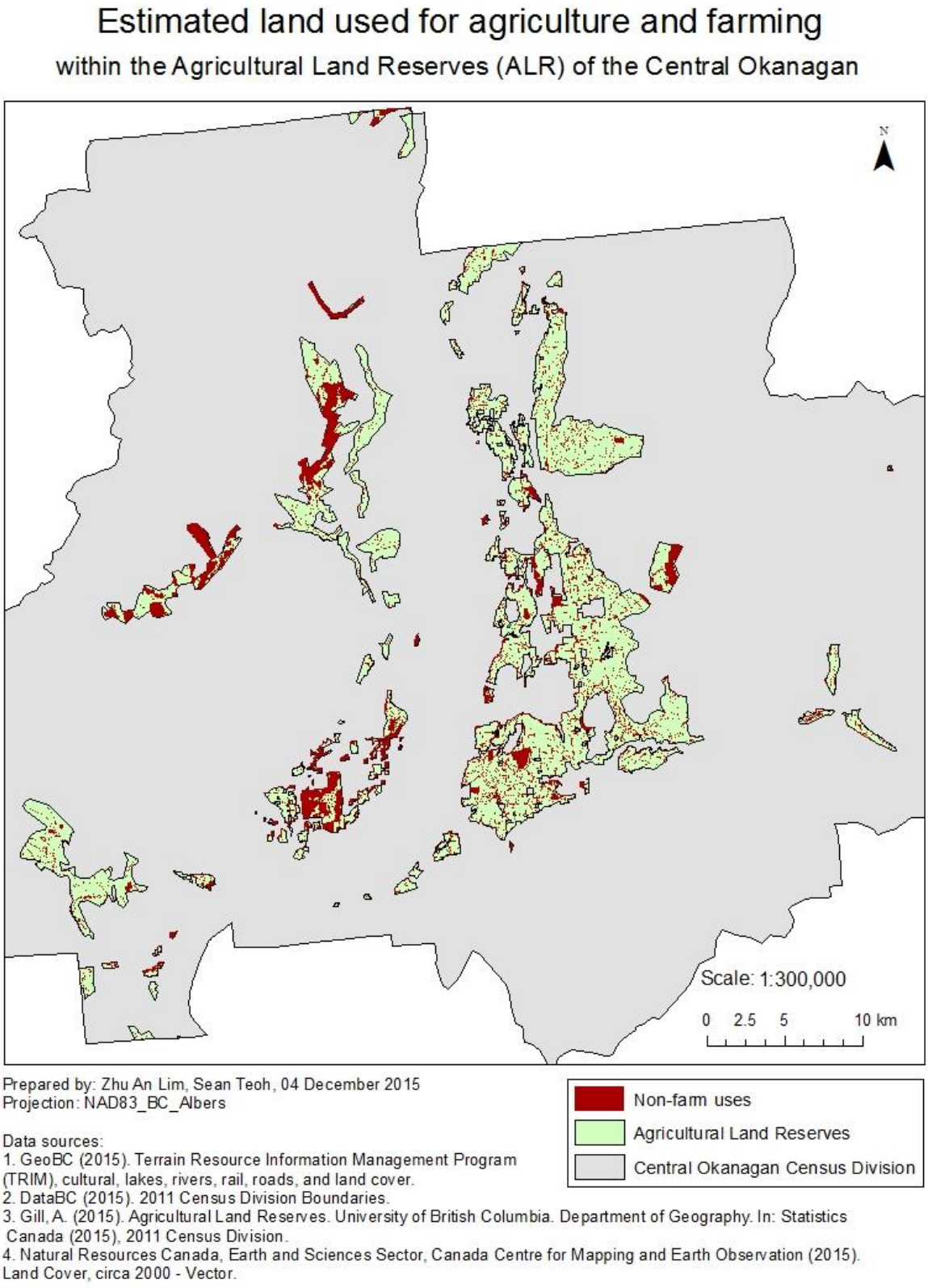
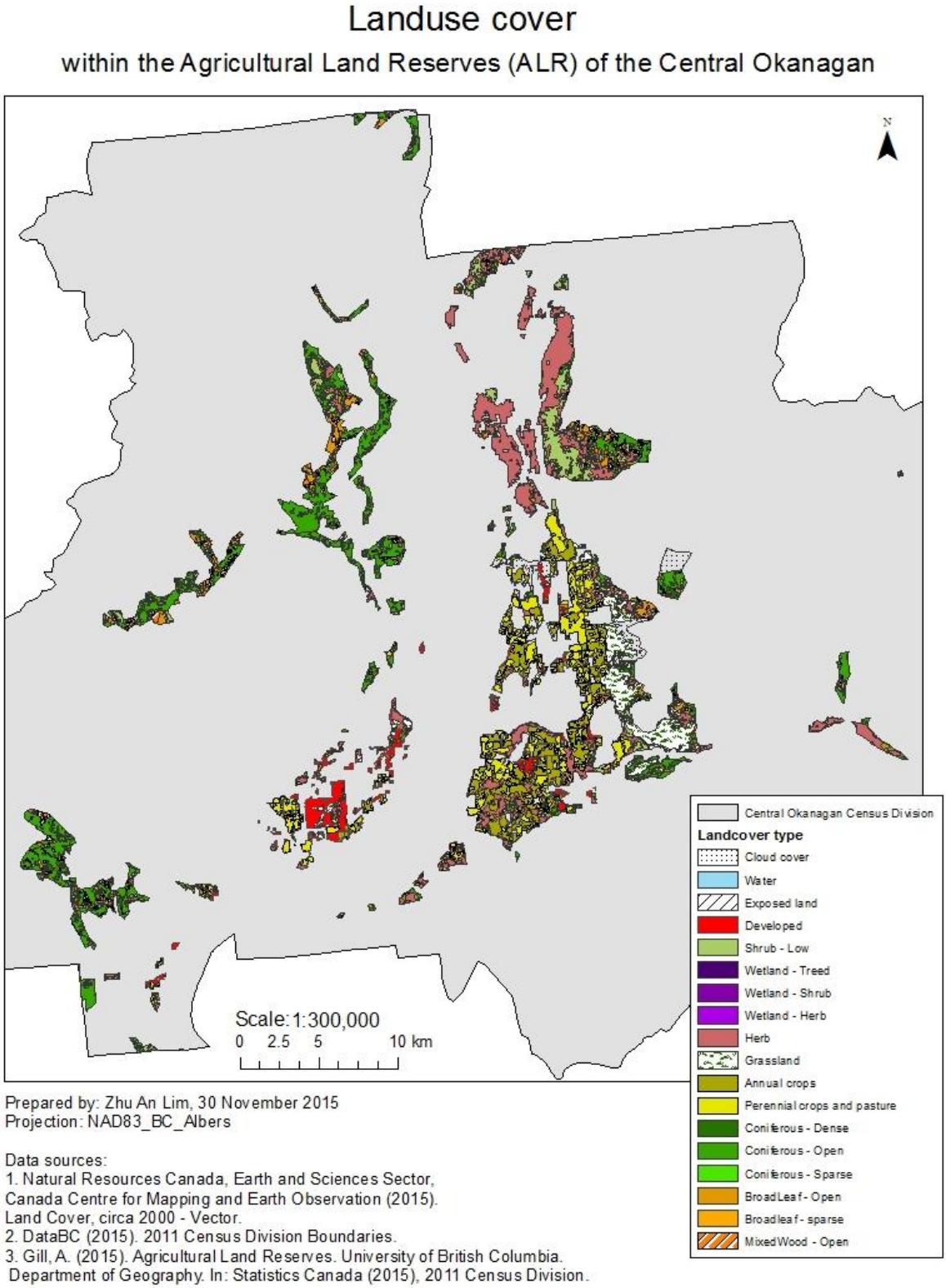
6.3 Maps



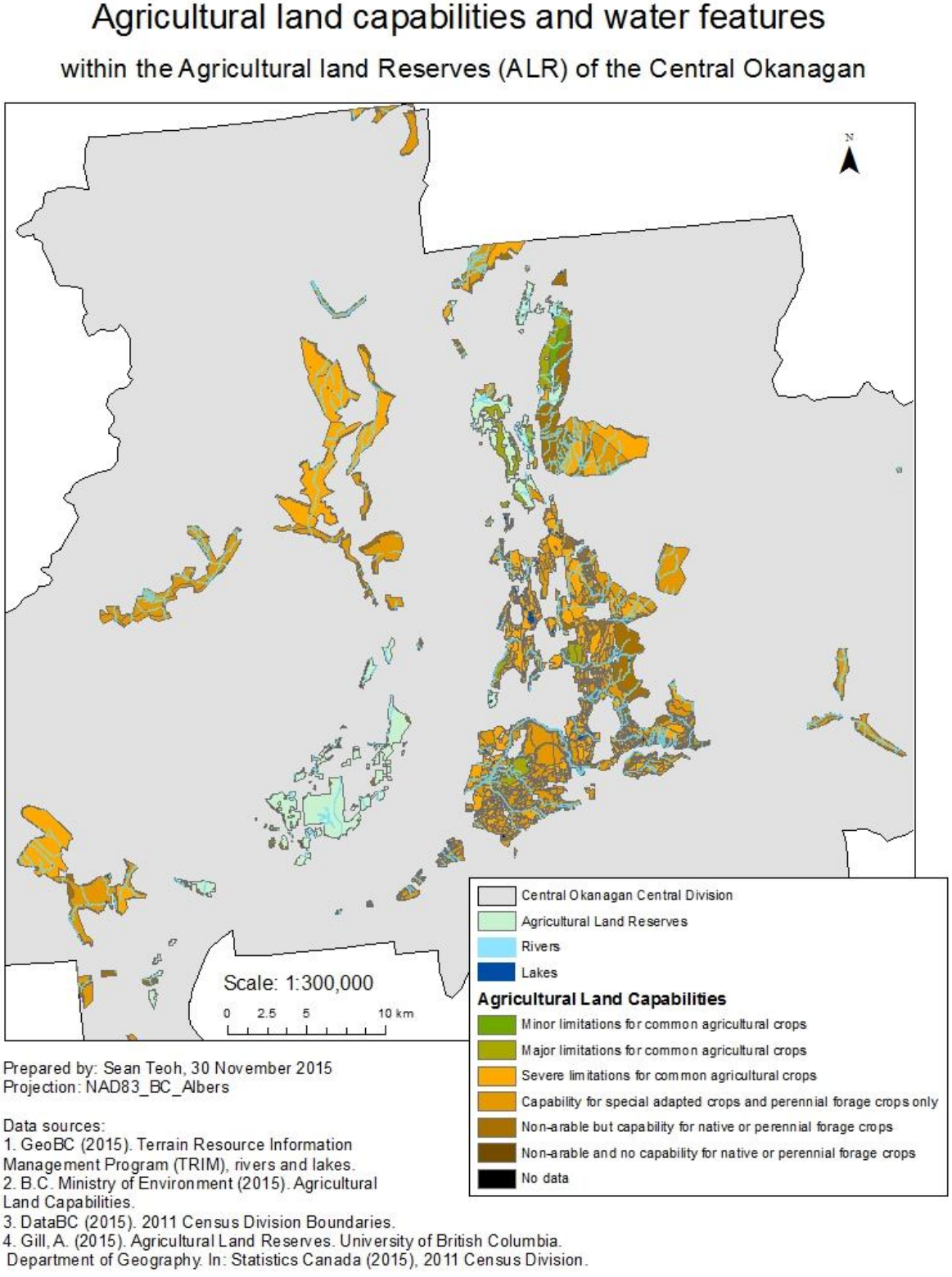
Map 1. Agricultural Land Reserves (ALR) of the Central Okanagan.



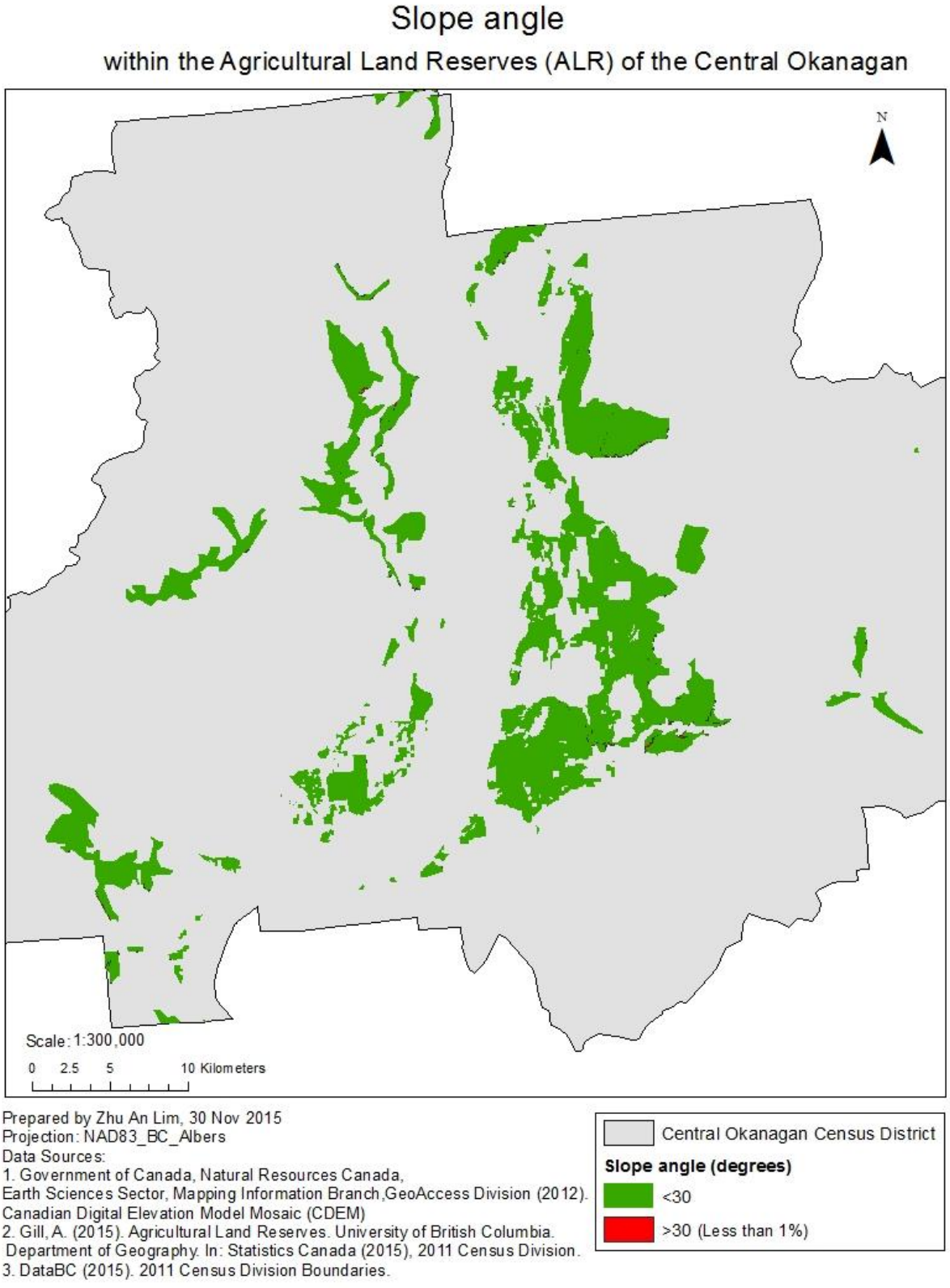
Map 2. Estimated land area used for agricultural and farming of the Agricultural Land Reserves of the Central Okanagan.



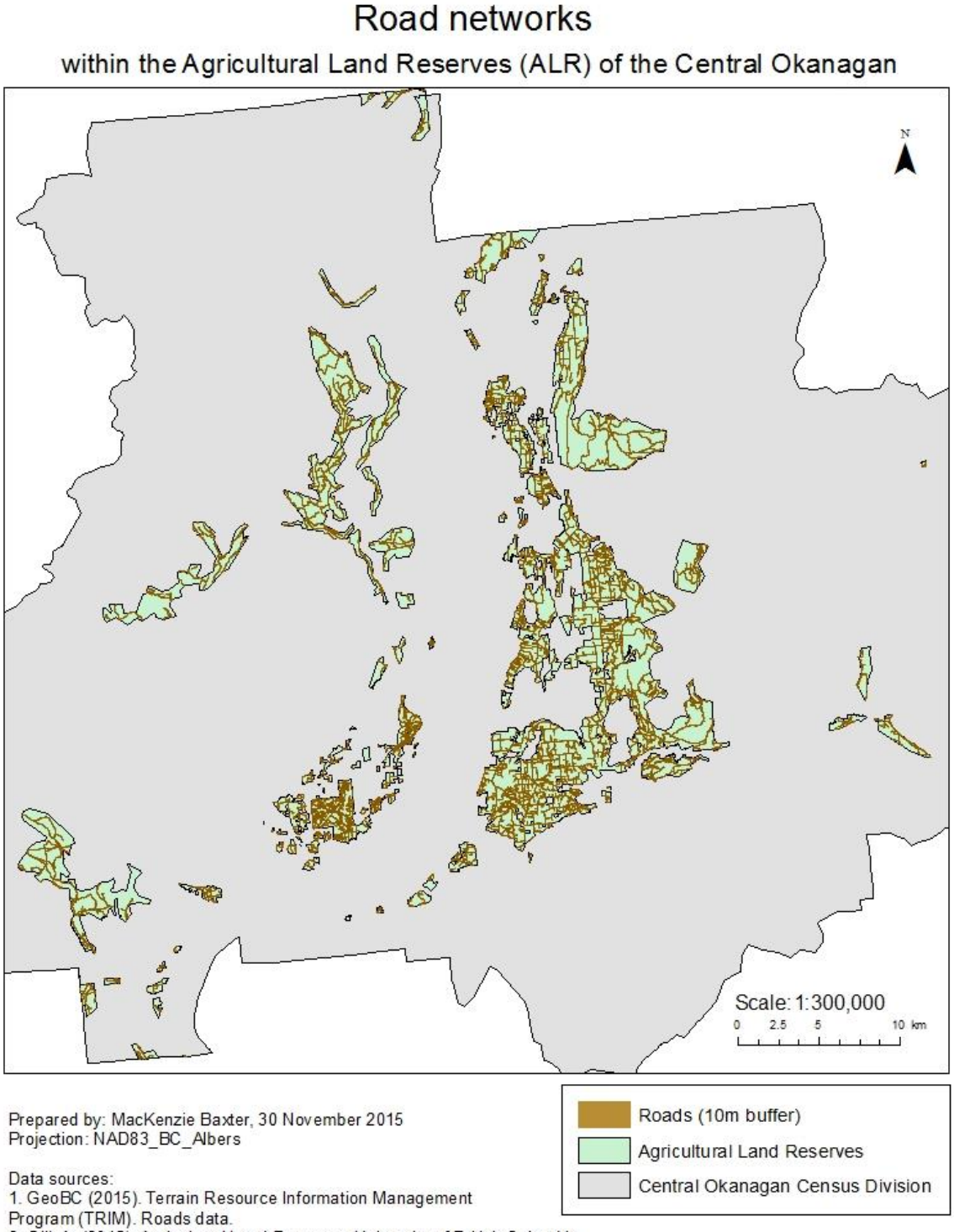
Map 3. Landuse cover within the Agricultural Land Reserves (ALR) of the Central Okanagan.



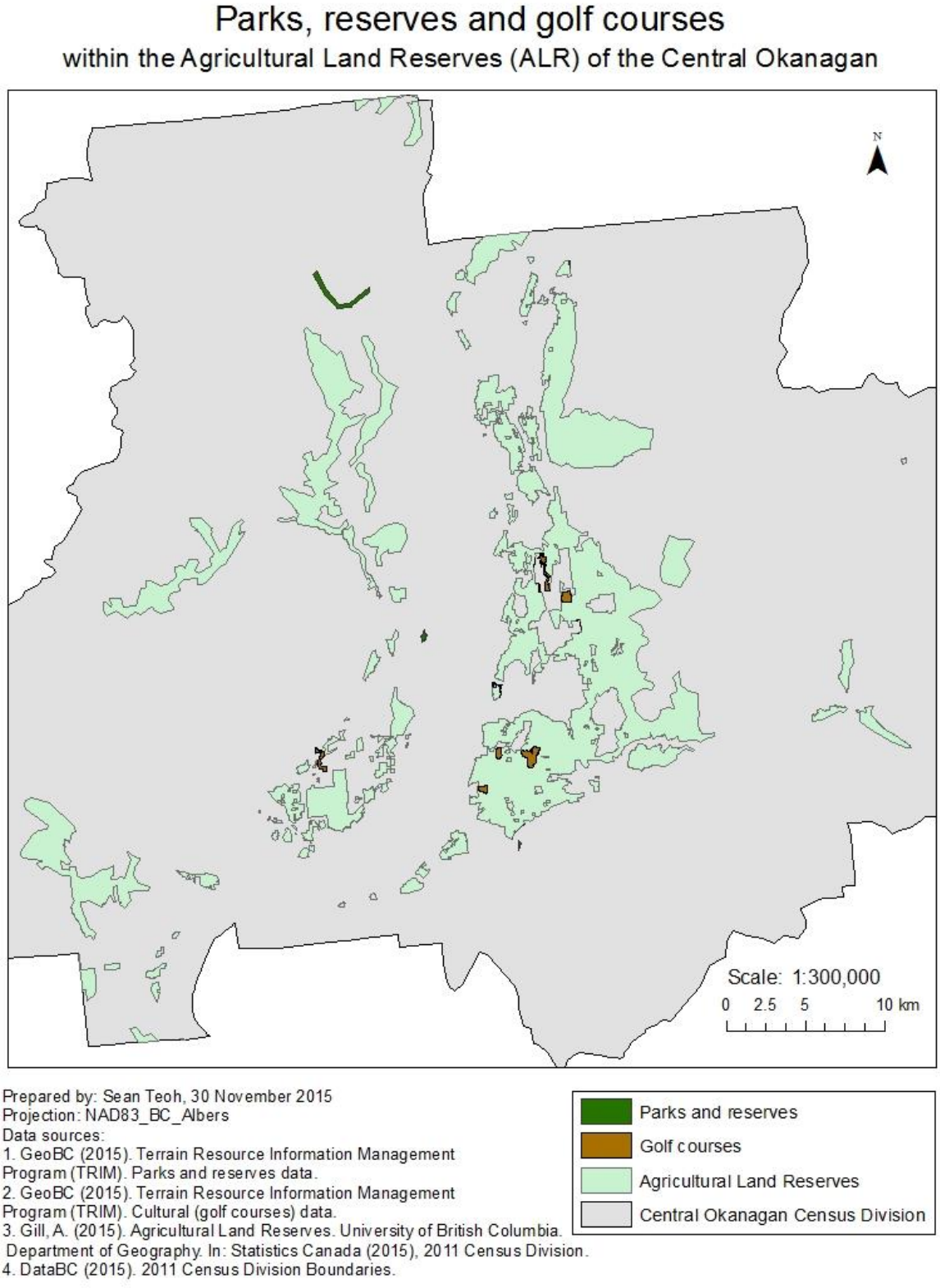
Map 4. Agricultural land capabilities and water features (lakes and rivers) within the Agricultural Land Reserves (ALR) of the Central Okanagan.



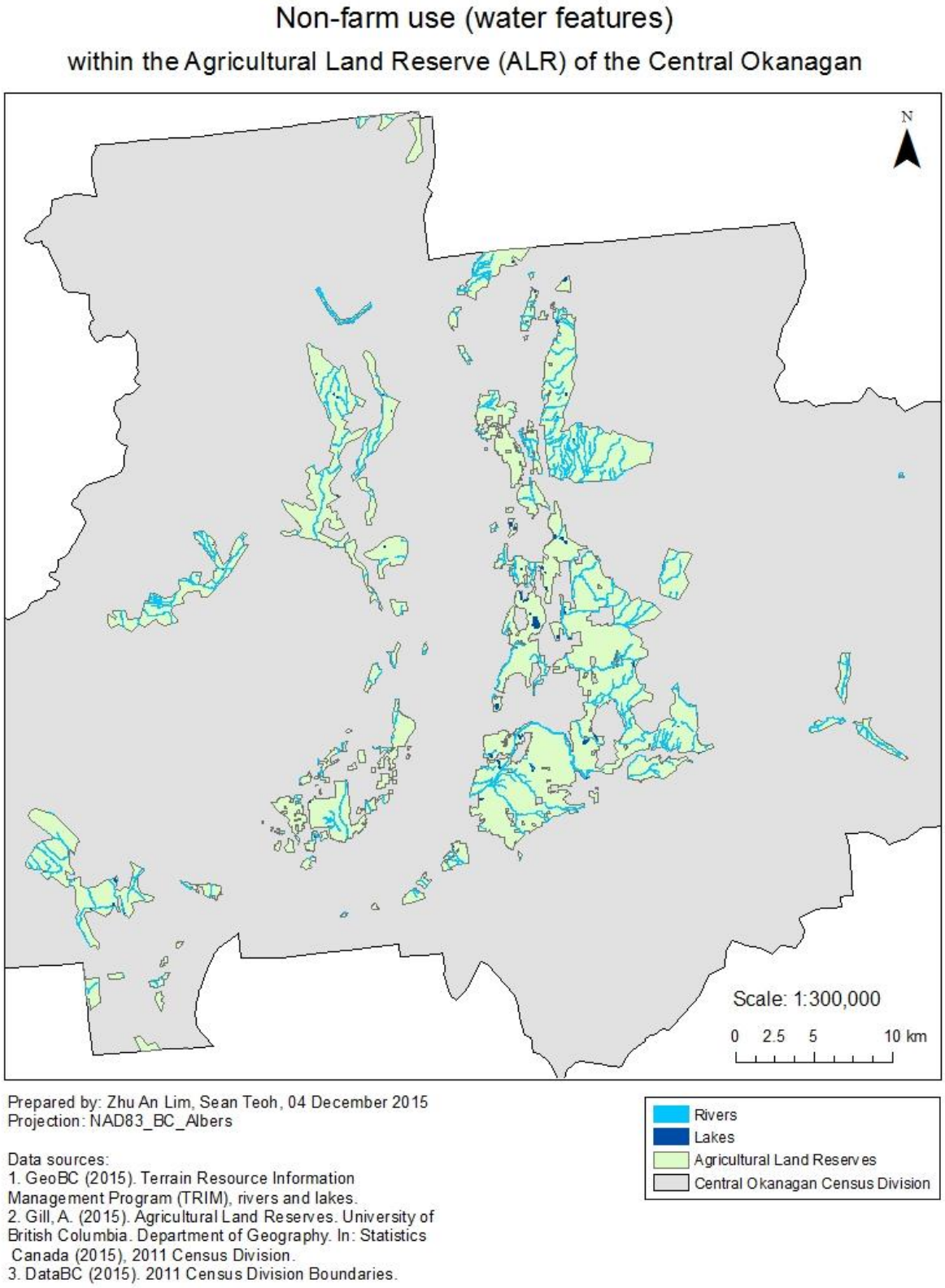
Map 5. Slope angle within the Agricultural Land Reserves (ALR) of the Central Okanagan.



Map 6. Road networks within the Agricultural Land Reserves (ALR) of the Central Okanagan.



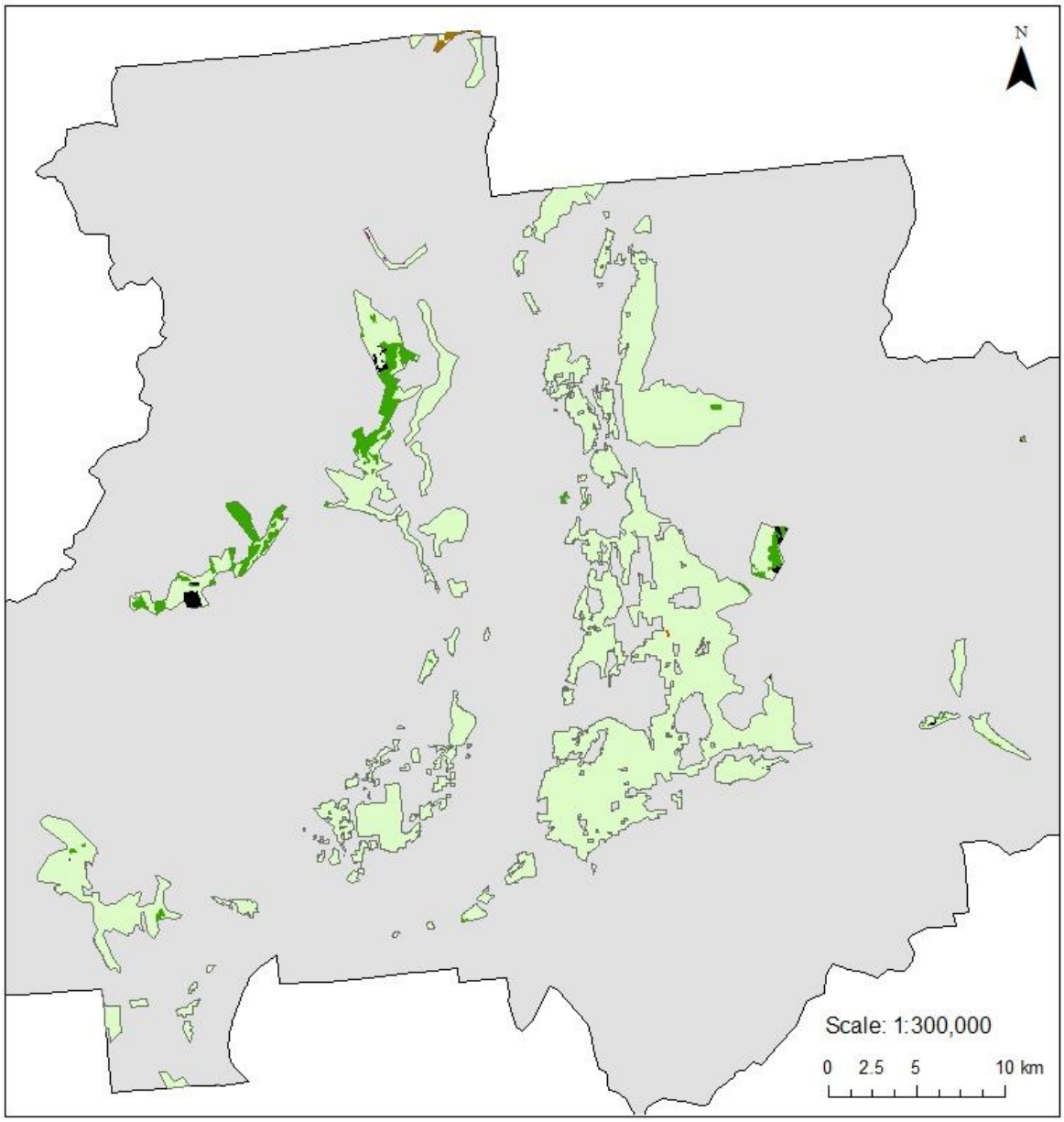
Map 7. Parks, reserves and golf courses within the Agricultural Land Reserves (ALR) of the Central Okanagan.



Map 8a. Non-agricultural use of land (water features) within the Agricultural Land Reserves (ALR) of the Central Okanagan.

Non-farm use (logging activities)

within the Agricultural Land Reserve (ALR) of the Central Okanagan

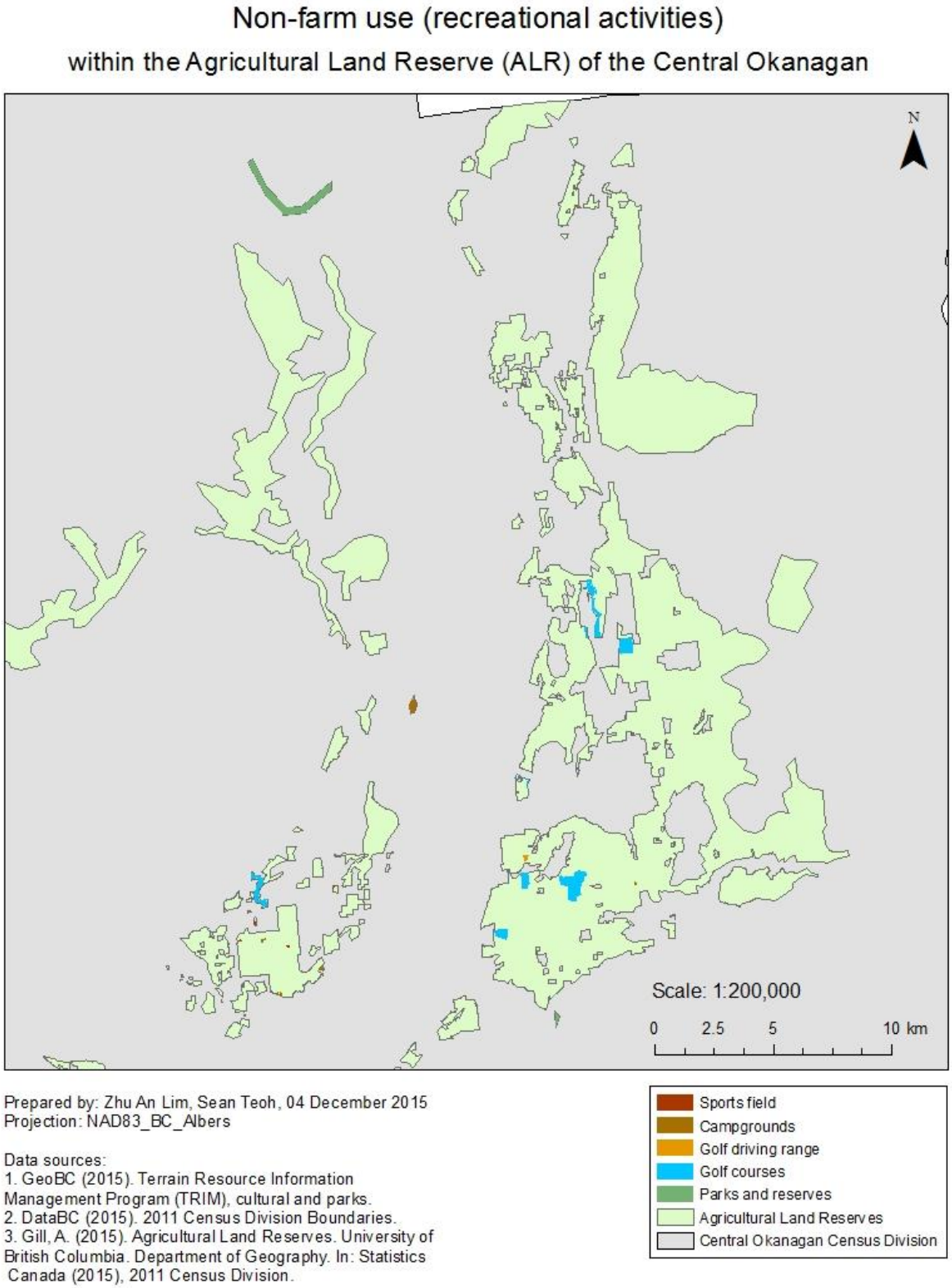


Prepared by: Zhu An Lim, Sean Teoh, 04 December 2015
Projection: NAD83_BC_Albers

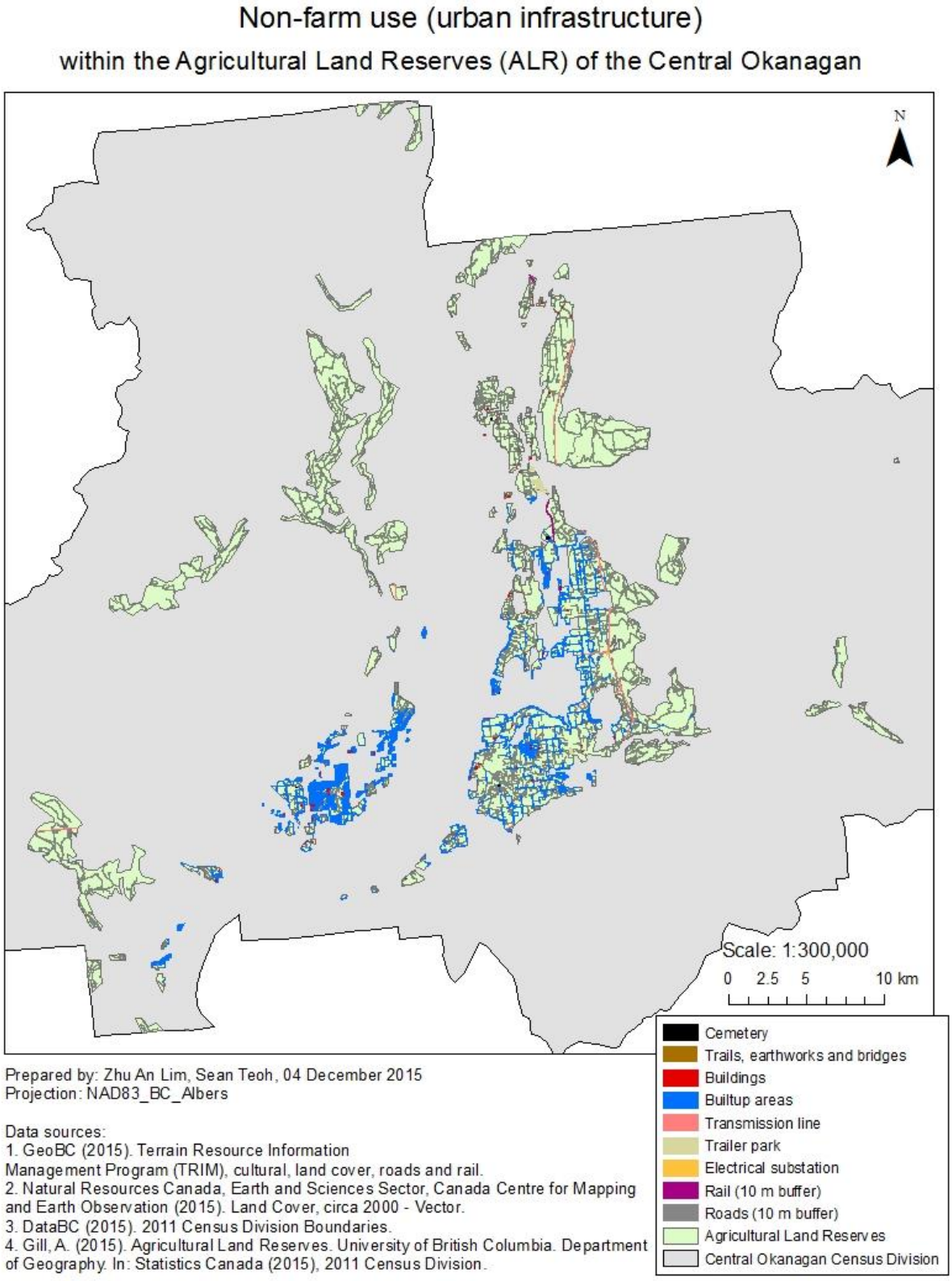
Data sources:
1. GeoBC (2015). Terrain Resource Information Management Program (TRIM), cultural.
2. Gill, A. (2015). Agricultural Land Reserves. University of British Columbia. Department of Geography. In: Statistics Canada (2015), 2011 Census Division.
3. DataBC (2015). 2011 Census Division Boundaries.

Cut block
Cut block - regenerating
Selective logging
Lumber yard
Log landing
Agricultural Land Reserves
Central Okanagan Census Division

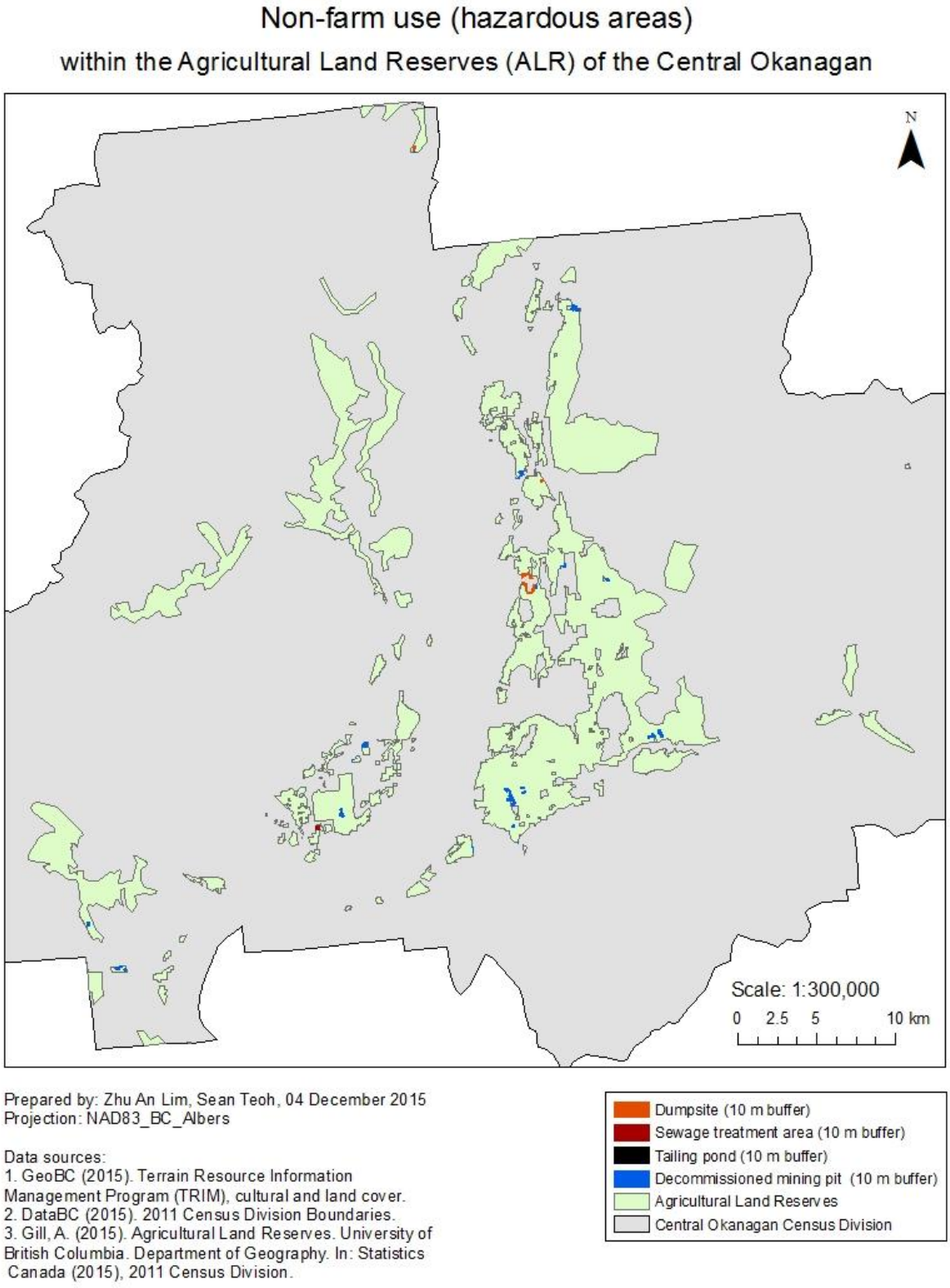
Map 8b. Non-agricultural use of land (logging activities) within the Agricultural Land Reserves (ALR) of the Central Okanagan.



Map 8c. Non-agricultural use of land (urban infrastructure) within the Agricultural Land Reserves (ALR) of the Central Okanagan.



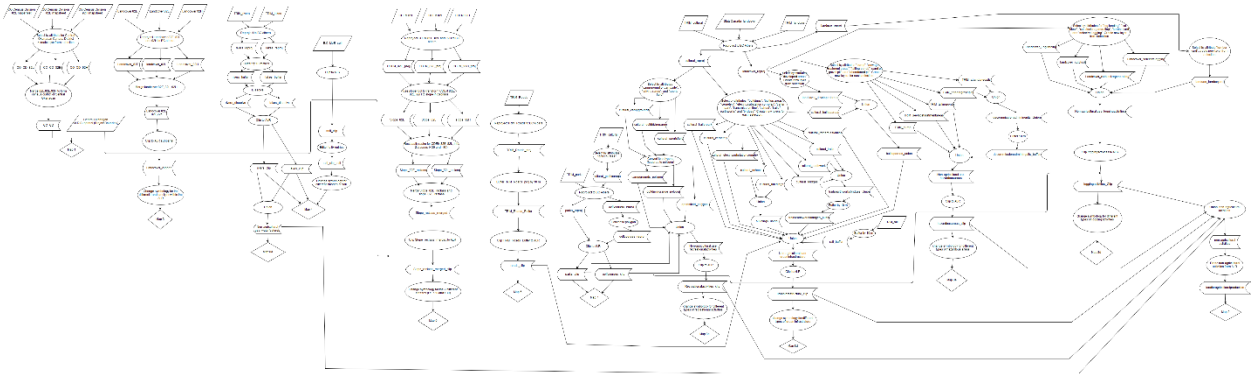
Map 8d. Non-agricultural use of land (recreational activities) within the Agricultural Land Reserves (ALR) of the Central Okanagan.



Map 8a. Non-agricultural use of land (hazardous areas) within the Agricultural Land Reserves (ALR) of the Central Okanagan.

6.4 Flowchart of analyses used for final shapefile

Please refer to the attached PDF for an enlarged version of the flowchart of analyses.



6.5 Review of team member contributions

MacKenzie Baxter:

- Data collection: DataBC, soil classification data from BC government (although provided by Jose Aparicio as well);
- Analysis: Social (Questions 13, 14, 19, 20, 21)
- Write-up for Report: Introduction;
- Write-up for Report: Social (Questions 13, 14, 16, and 17);
- Write-up for Report: Biogeographical (Question 9);
- Write-up for Report: Summary (Question 24).
- Write-up for Report: Recommendations.

Ron Blutrich:

- Data collection: Attempted to obtain TRIM datasets before it was made available by Jose Aparicio;
- Data collection: Demographic data from UoT CHASS;
- Analysis: Created geodatabase for demographic data that mapped the demographics to dissemination areas;
- Analysis: Overview (Map 8b)
- Analysis: Social (Questions 19 and 20)
- Write-up for Report: Introduction;
- Write-up for Report: Biogeographical (Question 9);
- Write-up for Report: Social (Questions 19, 20 and 21);
- Write-up for Report: Summary (Question 24).

Sean Teoh:

- Data collection: Regional District of Central Okanagan (RDCO) data;
- Analysis: Overview (Questions 1, 2, 3, and 4);
- Analysis: Biogeographical (Questions 8, 9, and 10);
- Analysis: Social (Questions 15, 16, 17, 18 and 22);
- Analysis: Review of maps for standardizations and error rectification;

- Write-up for Report: Executive Summary;
- Write-up for Report: Biogeographical (Questions 6, 8, 9, and 10);
- Write-up for Report: Social (Questions 16, 17, and 21);
- Write-up for Report: Summary (Question 23).
- Write-up for Report: Appendices (references, list of data sources, flowchart of analyses, maps);
- Coordinator: Edited group project proposal before submission;
- Coordinator: Compiled report sections;
- Coordinator: Edited group report.

Zhu An Lim:

- Data collection: Statistics Canada (StatsCanada) data;
- Analysis: Overview (Questions 1, 2, 3, and 4);
- Analysis: Biogeographical (Questions 13);
- Analysis: Social (Questions 15, 16, 17, 18 and 22);
- Analysis: Review of maps for standardizations and error rectification;
- Write-up for Report: Introduction;
- Write-up for Report: Biogeographical (Questions 6, 8, 9, and 10);
- Write-up for Report: Social (Questions 16, 17, and 21);
- Write-up for Report: Summary (Question 23);
- Write-up for Report: Appendices (flowchart of analyses).