

FINAL REPORT Spatial Allocation of Agricultural Activity Data in the Prairie and Northern Region EDMONTON, ALBERTA

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1.0 INTRODUCTION

RWDI West Inc. (RWDI) was retained by Environment Canada to prepare and assemble gridded agricultural emission source data in support of gridded emission calculation analyses to be performed by Environment Canada, as per Environment Canada Contract No. KA511-3-1084, RWDI Reference Number W03-213.

Project deliverables include this report and gridded activity data in database and GIS (ARCGIS shapefile) formats on the accompanying CD-ROM.

2.0 GENERAL BACKGROUND

The federal government, in co-operation with provincial governments, has been investigating the impacts of anthropogenic and natural emissions on regional air quality across western Canada. Regional air quality modelling is an effective scientific venue to assess the air quality impacts of these emissions since it is capable of addressing such complex issues as possible non-linearities between emission reductions and air quality improvements. That is, changes in emissions do not necessarily result in proportional changes in air quality.

Considerable effort has been made over the past three years to improve emission data in Prairie and Northern Region (PNR). Under Environment Canada Contract number KA511-2-0654, RWDI allocated activity data for 34 different types of agricultural activities from the 2001 Agriculture Census to the CWEI 4-km model grid. Census data were provided for each Consolidated Census Division (CCD) across western Canada. Although these were the best data available at the time, spatially it is too coarse to resolve the location of major Intensive Livestock Operations (ILOs). Environment Canada recently obtained point source livestock data for the Old Man River Basin region from Agriculture and Agri-Food Canada, and point source livestock data from the County of Lethbridge, Alberta. These data, represented as point sources in the GIS files provided, are considered to be more accurate than the data from Statistics Canada, and are to be used for the regions they cover.

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The objective of this work was to incorporate the specific ILO data with the census agricultural data to better resolve the spatial allocation of agricultural activity data, gridded to the PNR 4-km modelling domain which extends further north than the CWEI model domain.

3.0 METHODOLOGY

3.1 Domain

The PNR 4-km resolution model domain used for this assessment is described in Table 1; a map of the model domain is provided as Figure 1. To maintain consistency with previous work, a Lambert Conic Conformal projection as described in Table 2 was adopted in this study.

Table 1. PNR 4-km Domain Coordinates and Extents

Coordinate Name	Easting (m)	Northing (m)	Latitude	Longitude	Domain Size
Lower Left Corner	-810,000	-926,000	39° 55'	130° 49'	2868 km
Lower Right Corner	2,050,000	-926,000	37° 30'	96° 48'	(width)
Upper Right Corner	2,050,000	1,766,000	60° 32'	82° 7'	2692 km
Upper Left Corner	-810,000	1,766,000	64° 18'	137° 28'	(height)

 Table 2. PNR 4-km Projection Parameters

Projection	Lambert Conformal Conic
False Easting	0.00
False Northing	0.00
Central Meridian	-121.00
1 st Standard Parallel	30.00
2 nd Standard Parallel	60.00
Latitude Of Origin	49.00
Linear Unit	Meter (1.00)
Geographic Coordinate System	GCS Sphere
Angular Unit	Degree (0.0174)
Prime Meridian	Greenwich (0.00)
Datum	Sphere
Spheroid	Sphere
Semimajor Axis	6370997.00
Semiminor Axis	6370997.00
Inverse Flattening	0.00



3.2 Agriculture Census Activity Data

Two types of agricultural activity data were used in this assessment: census data (purchased by Environment Canada from Statistics Canada) and Intensive Livestock Operation (ILO) data, some of which was provided by Agriculture and Agri-Food Canada and some of which was purchased by Environment Canada from Lethbridge County.

The activity data from Statistics Canada were obtained in the form of IVT tables (a unique Statistics Canada database format) and converted into dBASE IV files, which could then be used in ARCGIS version 8.3. Table 3 lists the 34 unique activity data variable names and corresponding IVT table column name from which the data were obtained.

Stats Can. Activity Name	Units	IVT	Table Description
Total Area of Farms	Hectares (ha)	5	Total area of farms
Irrigation	Hectares (ha)	8	Use of irrigation
Commercial Fertilizer	Hectares (ha)	8	Use of commercial fertilizer
Manure - Solid Spreader	Hectares (ha)	9	Manure application using a solid spreader
Manure - Irrigation System	Hectares (ha)	9	Manure application using an irrigation system
Manure - Liquid Spreader (surface)	Hectares (ha)	9	Manure application using a liquid spreader surface
Manure - Liquid Spreader (injected)	Hectares (ha)	9	Manure application using a liquid spreader injected
Total Cattle and Calves	Number	19	Total cattle and calves
Bulls*	Number	19	Bulls, 1 year and over
Steers*	Number	19	Steers, 1 year and over
Beef Cows	Number	19	Beef cows
Dairy Cows	Number	19	Diary cows
Heifers (1 year and older)	Number	19	Total Heifers, 1 year and older
Calves (under 1 year)	Number	19	Calves, under 1 year
Total Pigs	Number	20	Total pigs
Boars	Number	20	Boars
Sows	Number	20	Sows and gilts for breeding
Weaners	Number	20	Nursing and weaner pigs
Finishing Pigs	Number	20	Grower and finishing pigs
Horses and Ponies	Number	22	Horses and ponies
Sheep and Lambs	Number	21	Sheep and lambs
Laying Hens (> 19 weeks)	Number	23	Laying hens, 19 weeks and over
Chicks (< 19 weeks)	Number	23	Pullets under 19 weeks, intended for laying
Broilers, Roasters and Cornish	Number	23	Broilers, roasters and cornish

Table 3. Input Activity Data Variables



Stats Can. Activity Name	Units	IVT	Table Description
Laying Hens in Hatchery Supply Flocks	Number	23	Laying hens in hatchery supply flocks
Turkeys	Number	23	Turkeys
Other Poultry	Number	23	Other poultry
Canola	Hectares (ha)	13	Canola (rapeseed)
Wheat	Hectares (ha)	13	Wheat
Hay	Hectares (ha)	13	All other tame hay and fodder crops
Barley	Hectares (ha)	13	Barley
Oats	Hectares (ha)	13	Oats
Alfalfa	Hectares (ha)	13	Alfalfa & alfalfa mixtures
Lentils	Hectares (ha)	13	Lentils

The PNR 4-km domain extends into a portion of the west end of Ontario and north into the Yukon and Territories. Activity data were obtained for most census divisions in the western provinces (Manitoba, Saskatchewan, Alberta, and British Columbia).

There were missing input data (flagged as 'suppressed to protect confidentiality') in the records for some of the CCDs as provided by Statistics Canada. For these records, values were estimated from Census Division (CD) totals, by subtracting the known / available CCD data and apportioning the remainder to the suppressed data records according to the percentage of the 'Total Area of Farms' attribute in each CCD. Figure 2 is a plot depicting those census divisions for which data were available.

During processing, a problem with the 'Total Area of Farms' activity / attribute data was uncovered. In some cases, the Total Area of Farms attribute from the IVT tables is actually larger than the geographical area of the corresponding CCD region. This does not affect the apportioning of the Activity Data to the unknown CCD regions directly as the calculation deals strictly with the ratio of total farm area. For example, in CCD 'Sherwood No. 159' (in Saskatchewan), the 'Total Area of Farms' in the census data table is 88,930 ha; whereas the total area calculated from the corresponding GIS shapefile is only 68,246 ha, a difference of 20,684 ha. This can also be seen in Figure 4, which depicts the gridded 'Total Area of Farms', where the attribute value for 'Total Area of Farms' is larger than the area of the grid cell (1600 ha).

3.3 ILO Activity Data

The point source data for the Old Man River Basin region were used in place of the corresponding data provided by Statistics Canada. Two sets of point source data were provided: Old Man River Basin region data from Agriculture and Agri-Food Canada; and, a more accurate subset of points for Lethbridge from the County of Lethbridge. A plot depicting the ILO point source data overlayed onto the PNR 4-km resolution model grid and Alberta census-division boundaries is shown in Figure 3.

Because the activity data were provided from two different information sources, the activity names / descriptors did not result in a one-to-one match between the Statistics Canada and ILO data. A cross-reference table defining how the ILO data were reclassified to match the Statistics Canada groupings is provided in Table 4. Reclassification for these activities was performed using best judgement and was based on input from Environment Canada and Agriculture and Agri-Food Canada.

Stats Can. Activity Name	Units	Table Description	ILO Specific
Total Cattle and Calves	Number	Total cattle and calves	Buffalo, Beef, Dairy, Cow/Calf
Bulls	Number	Bulls, 1 year and over	
Steers	Number	Steers, 1 year and over	
Beef Cows	Number	Beef cows	Beef
Dairy Cows	Number	Diary cows	Dairy
Heifers (1 year and older)	Number	Total Heifers, 1 year and older	
Calves (under 1 year)	Number	Calves, under 1 year	Cow/Calf
Total Pigs	Number	Total pigs	Feeder Hog, Boars, Farrow/Wean, Farrow/Finish
Boars	Number	Boars	Boars
Sows	Number	Sows and gilts for breeding	
Weaners	Number	Nursing and weaner pigs	Farrow/Wean
Finishing Pigs	Number	Grower and finishing pigs	Farrow/Finish
Horses and Ponies	Number	Horses and ponies	Horse
Sheep and Lambs	Number	Sheep and lambs	Sheep, Goats, Lamas
Laying Hens (> 19 weeks)	Number	Laying hens, 19 weeks and over	Layer/Chicken

Table 4. Cross-Reference between Statistics Canada and ILO Activity Names / Classes.



Stats Can. Activity Name	Units	Table Description	ILO Specific
Chicks (< 19 weeks)	Number	Pullets under 19 weeks, intended for laying	Pullets
Broilers, Roasters and Cornish	Number	Broilers, roasters and cornish	Broiler/Chicken
Laying Hens in Hatchery Supply Flocks	Number	Laying hens in hatchery supply flocks	
Turkeys	Number	Turkeys	Turkey
Other Poultry	Number	Other poultry	Poultry/Unknown, Ostrich, Ducks/Geese, Ducks
Canola	Hectares (ha)	Canola (rapeseed)	
Wheat	Hectares (ha)	Wheat	
Hay	Hectares (ha)	All other tame hay and fodder crops	
Barley	Hectares (ha)	Barley	
Oats	Hectares (ha)	Oats	
Alfalfa	Hectares (ha)	Alfalfa & alfalfa mixtures	
Lentils	Hectares (ha)	Lentils	
Total Area of Farms	Hectares (ha)	Total area of farms	
Irrigation	Hectares (ha)	Use of irrigation	
Commercial Fertilizer	Hectares (ha)	Use of commercial fertilizer	
Manure - Solid Spreader	Hectares (ha)	Manure application using a solid spreader	
Manure - Irrigation System	Hectares (ha)	Manure application using an irrigation system	
Manure - Liquid Spreader (surface)	Hectares (ha)	Manure application using a liquid spreader surface	
Manure - Liquid Spreader (injected)	Hectares (ha)	Manure application using a liquid spreader injected	

3.4 Gridding Methodology

3.4.1 Statistics Canada Data

The process for gridding the Statistics Canada Activity Data to the domain involved the creation of an ARCGIS coverage of the PNR 4-km domain (fishnet coverage) and overlaying it onto the Statistics Canada Activity Data shapefile. The census-based Activity Data, by CCD, were then apportioned to the 4-km grid by first computing a ratio multiplier, which is the area for the current CCD for the current grid cell, divided by the total CCD area. This results in a decimal value between 0 and 1 for each grid cell that can be multiplied to the corresponding

CCD Activity Data to arrive at the total activity in that particular grid cell. Gridded Activity Data for the various CCDs that touch on a given grid cell were then summed to obtain the total activity from all CCDs in that grid cell.

This same process was repeated using the GIS-based census-division boundaries in place of the CCDs to generate a similar output but at the census-division level for subsequent analysis by Environment Canada.

3.4.2 ILO Data

Because the ILO data were provided as points in ARCGIS format, a slightly different approach was required. The following steps outline the gridding process used for the ILO data.

- Step 1. All data from the Old Man River Basin dataset that were located within Lethbridge County were removed so that these data could be replaced with more accurate ILO data from Lethbridge County.
- Step 2. The point sources from the County of Lethbridge were merged into the resulting Old Man River Basin data to arrive at a combined, ILO dataset.
- Step 3. The activity data in the ILO dataset were re-classified to match the Statistics Canada Activity Names as per the cross-reference scheme shown in Table 4.
- Step 4. The point source data were overlaid onto the PNR 4-km model grid. The activity for all points (ILOs) falling within each grid cell was summed to arrive at the total activity from ILOs in each grid cell.
- Step 5. The gridded ILO and Statistics Canada data were then merged at the grid cell level. The merge process involved determining the difference between the total activity from the Statistics Canada data and the total activity from the ILO data by county. For counties containing ILO data, the ILO total activity was assigned to each grid cell



as described above. If Statistics Canada totals for that county were greater than the sum of the ILO data, the gridded Statistics Canada values were reduced using a constant ratio for the county, such that the combined total of the gridded ILO and Statistics Canada data sum up to the original Statistics Canada total. The already gridded ILO totals were then added to the modified gridded Statistics Canada data. If not, the ILO data were assigned as described above, with no activity value assigned to the remaining (i.e., non-ILO data) grid cells. This approach was based on the fundamental assumption that the ILO data are the more comprehensive and complete dataset and that adding the ILO and Statistics Canada datasets would result in double-counting.

Activities at each ILO are quite extensive (i.e., the activity numbers are very large). However, because ILO data were only available for a relatively small area, the legends used to display the results in the corresponding figures were modified slightly to cover the full range of values. Figures 38 - 52 plot the zoomed-in ILO region to show the relative impact of incorporating the gridding of the ILO data along with the CCD data as described above.

Also, using ARCGIS, each grid cell was assigned to one or more CCDs and CDs based on the location of the grid cell. The activity within a given grid cell that spans more than one CD or CCD was allocated based on a simple area-weighted approach that is consistent with spatial surrogate gridding techniques. In this way, the same grid cell (identified by its unique ICELL, JCELL coordinates) may appear multiple times in the same dataset. Therefore, the total activity occurring in each grid cell is equal to the sum of the activities (i.e., occurrences) for that grid cell. The names of the CCDs and CDs were exported, along with the Activity Data for each grid cell to dBase IV files.

4.0 **RESULTS AND DELIVERABLES**

Maps showing each of the Activity Data variables are plotted in Figures 4 - 37. In addition, a database file containing multiple tables (one for each Activity) is also provided on the accompanying CD-ROM. Each table contains one or more records per grid cell, each with the following fields:

- I-Cell grid coordinate corresponding to the PNR 4-km grid
- J-Cell grid coordinate corresponding to the PNR 4-km grid
- Total gridded Agricultural Activity
- CCD name or Census Division (CD) name
- CCD Unique identifier (ID) or Census Division (CD) Unique identifier (ID)

5.0 ACKNOWLEDGEMENTS

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FIGURES



PNR 4-km Domain		Figure I	No. 1	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	KVVDI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Available Activity Data within the PNR 4-km Domain		Figure	No. 2	
		Scale:	N.T.S	KVVDI
Spatial Allocation of Agricultural Activity Data in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



ILO Point Sources		Figure 1	No. 3	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	KVVDI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Total Area of Farms Activity Data Units = Hectares (ha)		Figure	No. 4	
4 km Grid Spacing		Scale:	N.T.S	KVVDI
Spatial Allocation of Agricultural Activity Data in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	







Commercial Fertilizer Activity Data Units = Hectares (ha)		Figure	No. 6	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	NVUI
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Bulls Activity Data Units = Number		Figure	No. 12	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	RVVDI
Spatial Allocation of Agricultural Activity Data in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	











Dairy Cows Activity Data Units = Number		Figure	No. 15	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	
Activity Data Units = Number 4 km Grid Spacing Spatial Allocation of Agricultural Activity Data in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	







Calves (Under 1 Year) Activity Data Units = Number		Figure 1	No. 17	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	NVU
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Total Pigs Activity Data Units = Number		Figure 1	No. 18	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	RVVDI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Boars Activity Data Units = Number		Figure	No. 19		
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	RVVDI	
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004		



Sows Activity Data Units = Number		Figure I	No. 20	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	RVVDI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Weaners Activity Data Units = Number		Figure	No. 21		
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	RVVDI	
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004		



Finishing Pigs Activity Data Units = Number		Figure	No. 22	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	NVUI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Horses Activity	and Ponies Data Units = Number		Figure 1	No. 23	
Spatial Al	llocation of Agricultural Activity Data		Scale:	N.T.S	
in the Pra	irie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Sheep and Lambs Activity Data Units = Number		Figure 1	No. 24	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	NVUI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Laying Hens (>19 Weeks) Activity Data Units = Number		Figure 1	No. 25	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	NVUI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Chicks (<19 Weeks) Activity Data Units = Number		Figure	No. 26	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	NVUI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	







Laying Hens in Hatchery Supply Flocks Activity Data Units = Number		Figure I	No. 28	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	NVUI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Turkeys Activity Data Units = Number		Figure	No. 29		
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	RVVDI	
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004		



Other Poultry Activity Data Units = Number		Figure I	No. 30	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	RVVDI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Canola Activity Data Units = Hectares (ha)		Figure	No. 31	
4 km Grid Spacing		Scale:	N.T.S	RVVDI
Spatial Allocation of Agricultural Activity Data in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Wheat Activity Data Units = Hectares (ha)		Figure	No. 32	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	







Barley Activity Data Units = Hectares (ha)		Figure	No. 34		
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	RVVDI	
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004		







Alfalfa Activity Data Units = Hectares (ha)		Figure	No. 36	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	RVVDI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	







	Scale:
Project #W04-213	Date:





Beef Cows (ILO) Activity Data Units = Number		Figure 1	No. 39	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Dairy Cows (ILO) Activity Data Units = Number		Figure 1	No. 40	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	NVUI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Calves (Under 1 Year) (ILO) Activity Data Units = Number		Figure 1	No. 41	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	RVVDI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Total Pigs (ILO) Activity Data Units = Number		Figure 1	No. 42	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Boars (ILO) Activity Data Units = Number		Figure 1	No. 43	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	RVVDI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Weaners (ILO) Activity Data Units = Number		Figure 1	No. 44	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	NVUI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



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Horses and Ponies (ILO) Activity Data Units = Number		Figure 1	No. 46	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	NVUI
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March 29, 2004



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Chicks (<19 Weeks) (ILO) Activity Data Units = Number		Figure 1	No. 49	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	RVVDI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



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March 29, 2004



Turkeys (ILO) Activity Data Units = Number		Figure	No. 51	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	KVVDI
in the Prairie and Northern Region - March 29, 2004	Project #W04-213	Date:	March 29, 2004	



Other Poultry(ILO) Activity Data Units = Number		Figure	No. 52	
Spatial Allocation of Agricultural Activity Data		Scale:	N.T.S	
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