MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

Manitoba Sustainable Energy Association

FINAL REPORT
September 2024

participating communities

City of BRANDON
Dauphin
De Salaberry Municipality/Municipalité
Village of Dunnottar
Killarney Turtle Mountain
Rural Municipality of PINEY
City of Selkirk

lead consultant:
Bruce Duggan
BOKE

reviewers

Eco-West Éco-Ouest CANADA

meia Manitoba Environmental Industries Association

Manitoba

EXECUTIVE SUMMARY

Manitoba Environment and Climate Change provided funding for this report.

This prefeasibility study examines the availability, costs, and benefits of using biomass and other renewable energy systems to replace at least some of the fossil fuel and grid-based electricity currently being used to heat and power municipal and community buildings in seven participating communities in Manitoba. Three of these communities—Brandon, De Salaberry, and Piney focused on existing buildings and facilities. Three others—Dunnottar, Killarney, and Selkirk—focused on buildings and projects currently on the drawing board. One community—Dauphin—focused on both existing buildings and on a planned development.

By 2050, climate change can be expected to reduce heating needs in these communities by about 15%. It can also be expected double—and perhaps even triple—air conditioning needs. As well, the new developments planned will increase the consumption of both natural gas and electricity, if they are built with the same energy systems currently in place in Manitoba.

These effects can be offset by shifting from fossil fuels to renewable energy, and by enabling communities to generate local electricity.

Each participating community has far more biomass nearby than would be needed to provide heat for all the targeted buildings, facilities, and projects in this study. However, this study does not necessarily recommend biomass heating for every building studied. Instead, it recommends the renewable energy systems which will most effectively:

- reduce greenhouse gases
- reduce municipal energy operating costs
- enable the participating communities to make significant progress towards achieving net zero by 2050

				solar		*heat pump system*			
		biomass system	*district energy system*	*solar array*	*solar wall*	*ground source*	*air source*	*process heat*	*DSM*
Brandon	Civic Services Cluster		✓	✓	✓	✓			✓
	East Landfill Cluster	✓	✓	✓				✓	✓
Dauphin	Downtown Cluster		✓	✓		✓			✓
	Railway Cluster	✓	✓	✓			✓		✓
	Vermillion Growers	✓		✓					
De Salaberry	Rec Facility (St. Malo Arena)		✓	✓	✓	✓			✓
Dunnottar	Public Works Building			✓	✓	✓			✓
Killarney	Industrial Park	✓	✓	✓	✓		✓		✓
Piney	RM Govt Office, Vassar			✓					✓
	Public Works Bldg, Vassar			✓	✓				✓
	Fire Station 1, Piney			✓					✓
	Fire Station 2, Sprague			✓					✓
	Fire Station 3, Woodridge			✓					✓
Selkirk	West End Lands	✓	✓	✓	✓	✓		✓	✓

These recommendations, when implemented, will also:

- create local, sustainable jobs
- develop the experience and expertise of local businesses
- serve as demonstration projects for municipalities throughout Manitoba wanting to implement sustainability goals

OVERVIEW

This prefeasibility study was undertaken by the Manitoba Sustainable Energy Association (ManSEA). ManSEA is a non-partisan, not-for-profit community organization, with members throughout Manitoba. It encourages and supports the increased use of sustainable, renewable energy in our province.

The research and writing team was lead for ManSEA by Bruce Duggan of Boke Consulting.

This Overview summarizes the study's detailed Supporting Documentation. This Overview is sometimes distributed without that Supporting Documentation. If that Supporting Documentation is not attached, it is available from ManSEA.

Acknowledgements

Manitoba Environment and Climate Change provided funding for this report.

In addition to acknowledging the support provided by the Province of Manitoba, ManSEA wishes to acknowledge the commitment and enthusiastic participation of the staff and elected officials of the communities involved in this study. They took time out of their demanding schedules to meet, contribute ideas, propose solutions, and review possibilities. They are leaders in the essential transformation away from fossil fuels which every community will need to undertake in the years and decades to come.

Purpose

This study was undertaken to examine the availability, costs, and benefits of using biomass and other renewable energy systems to replace at least some of the fossil fuel and electricity currently being used to heat and power municipal and community buildings in seven participating communities in Manitoba:

- City of Brandon
- City of Dauphin
- City of Selkirk
- Rural Municipality of De Salaberry
- Rural Municipality of Killarney Turtle Mountain
- Rural Municipality of Piney
- Village of Dunnottar

Numerous municipalities in Manitoba are striving to become net-zero by 2050. The communities participating in this study—like many others in Manitoba—have begun to transition their energy consumption away from fossil fuels and towards renewable sources.

As part of their transition, the seven participating communities each targeted a small number of their buildings and facilities to be studied, setting the twin goals of

- reducing greenhouse gas emissions (GHGs), and
- enhancing the use of renewable energy.

This study also examines:

- What types and volumes of biomass fuels, suitable for heating the targeted buildings, are available within or near these seven communities?
- What other renewable energy options would be appropriate for the targeted buildings?

Targets – Buildings, Facilities & Projects

Each of the participating communities have numerous municipal and community buildings that could be considered for this study. Discussions were held in each participating community to narrow the possibilities down to one or more target buildings or facilities. Those discussions included:

- municipal representatives
- Wayne Clayton and Randy Baldwin of ManSEA
- Bruce Duggan of Boke Consulting

Three participating communities—Brandon, De Salaberry, and Piney—asked that the study focus on existing buildings and facilities. They wanted to know what steps can be taken now to reduce energy consumption and GHG emissions and increase the use of renewable energy.

Three others—Dunnottar, Killarney, and Selkirk—asked that the study focus on buildings and projects currently on the drawing board. They wanted to know how their projects can best maximize renewable energy use and minimize—or even eliminate—fossil fuel consumption.

One community—Dauphin—asked the study to focus on both existing buildings and a planned development.

Table 1: Participating communities, with target buildings, facilities & projects

participating community		*targets*	*existing or planned?*	
Brandon	Civic Services Cluster	Civic Services Complex	existing	
		Meter Shop & Garage	existing	
		Public Works Equipment Garage	existing	
	East Landfill Cluster	Material Recovery Facility	existing	
		Wastewater Treatment Facility	existing	
Dauphin	Downtown Cluster	Dauphin Rec Services/Kin Aquatic Centre	existing	
		Credit Union Place	existing	
		Rotary Arena Ice Skating Rink	existing	
	Railway Cluster	CNR Place	existing	
		Watson Art Centre	existing	
		Dauphin Fire Department	existing	
	Vermillion Growers	biomass heating system		planned
De Salaberry		Recreation Facility (St. Malo Arena)	existing	
Dunnottar		Public Works Building		planned
Killarney Turtle Mountain		Killarney Industrial Park		planned
Piney		RM of Piney District Govt Office, Vassar	existing	
		Public Works Building, Vassar	existing	
		Fire Station 1, Piney	existing	
		Sprague Fire Dept (Fire Station 2), Sprague	existing	
		Fire Station 3, Woodridge	existing	
Selkirk		West End Lands Development		planned

Effect of Climate Change on Building Energy Consumption

To anticipate the heating and cooling needs of the participating communities and their target buildings, it is necessary to predict, as accurately as possible, how climate change will affect these communities.

The overall trends are easy to describe in general terms—the winters will become milder and the summers hotter, resulting in a decrease in heating needs and an increase in cooling needs.

However, this is statement is too general to be useful for making specific heating and cooling recommendations. More detailed—and more useful—numerical predictions were made for each participating community, using data primarily from the Climate Atlas of Canada.

Table 2: Climate change – estimated effect on energy demand in target buildings[1]

	1996-2005 Climate Normals				*2050*					
	Heating Degree Days	*Cooling Degree Days*	*days below -30°C*	*days above +30°C*	*Heating Degree Days*	*Cooling Degree Days*	*days below -30°C*	*days above +30°C*	*decrease in heating demand*	*increase in cooling demand*
Brandon	5,765	122	15	14	4,983	368	4	37	-14%	*202%*
Dauphin	5,923	104	15	10	5,025	329	3	31	-15%	*216%*
De Salaberry	5,677	142	15	12	4,860	398	4	36	-14%	*180%*
Dunnottar	5,878	137	15	7	5,040	356	4	25	-14%	*160%*
Killarney	5,605	121	10	13	4,754	340	2	32	-15%	*182%*
Piney	5,723	114	17	8	4,893	352	6	31	-15%	*208%*
Selkirk	5,727	159	15	12	4,928	394	4	32	-14%	*147%*
averages:	*5,757*	*128*	*15*	*11*	*4,926*	*362*	*4*	*32*	*-14%*	*185%*

Two key predictions apply to all buildings in the participating communities. Over the next 25 years:

- ***Heating requirements will decline moderately (by about 14%).***
- ***Cooling requirements can be expected at least double—and perhaps even triple.***

The decrease in Heating Degree Days means there will be a decrease in heating requirements and, for buildings heated by natural gas, a corresponding decrease in natural gas

The marked increase in Cooling Degree Days will result in a marked increase in air conditioning requirements.[2]

[1] This table is a summary of information detailed in the Participating Communities section of this study.

[2] Canada's Office of Energy Efficiency (OEE) estimates that, in Manitoba, air conditioning currently uses approximately 6% of the energy consumed by households and 17% of the energy consumed by commercial and institutional buildings.

Table 3: Current and estimated energy consumption & GHG emissions[3]

	2023			2050				
	current annual energy consumption		*GHGs CO₂e*	*expected annual energy consumption*				*GHGs CO2e*
	natural gas	*electricity*	*tonnes/*	*natural gas*		*electricity*		*tonnes/*
target buildings	*m³*	*MWh*	*year*	*m³*	*%*	*MWh*	*%*	*year*
Brandon								
Civic Centre Cluster								
Civic Services Complex	92,436	787	178	79,883	-14%	819	4%	154
Streets & Roads Dept Equip	112,784		217	97,468	-14%			188
East Landfill Cluster								
Material Recovery Facility	79,793	319	154	68,957	-14%	332	4%	133
Wastewater Treatment Facility	182,902	2,617	352	158,064	-14%	2,723	4%	304
Brandon totals:	*467,914*	*3,723*	*901*	*404,372*	-14%	*3,873*	4%	*779*
Dauphin								
Downtown Cluster								
Rec Centre/Kin Aquatic Centre	24,934	2,535	48	21,153	-15%	2,645	4%	41
Credit Union Place	170,605	19	329	144,736	-15%	20	4%	279
Rotary Arena Ice Skating Rink	10,442	284	20	8,858	-15%	297	4%	17
Railway Cluster								
CNR Place	19,822	101	38	16,816	-15%	105	4%	32
Watson Art Centre	26,780	47	52	22,719	-15%	49	4%	44
Dauphin Fire Department	17,993	78	35	15,265	-15%	82	4%	29
totals:	*270,575*	*3,064*	*521*	*229,547*	-15%	*3,196*	4%	*442*
De Salaberry								
Rec Facility (St. Malo Arena)	*11,882*	*458*	23	10,173	-14%	*476*	4%	20
Dunnottar								
Public Works Building	*0*	*0*	0	6,151		*32*		12
Killarney								
Industrial Park	*0*	*0*	0	*1,172,232*		*6,497*		2,258
Piney								
RM of Piney District Govt	0	53	0			55		0
Public Works Building, Vassar	0	54	0			56		0
Fire Station 1, Piney	0	54	0			56		0
Sprague Fire Dept (Fire Station	0	41	0			42		0
Fire Station 3, Woodridge	0	61	0			64		0
totals:	*0*	*263*	*0*			*274*	4%	*0*
Selkirk								
dwelling units	0	0	0	5,529,710		61,538		10,650
retail/commercial	0	0	0	365,414		3,413		704
Selkirk totals:	*0*	*0*	*0*	*5,895,125*		*64,951*		*11,354*
totals:	**750,372**	**7,508**	**1,445**	**7,717,599**		**79,299**		**14,864**

[3] Notes:

- The data in this and all other tables in the Activity Report are summaries of more detailed data provided in the Supporting Documentation.

To calculate the effects the recommendations would have on energy use and GHG emissions, it was necessary to:

- quantify the current energy use of existing buildings and facilities
- quantify the anticipated the energy use of planned buildings and projects, if they went ahead using the energy systems typical of similar buildings in Manitoba
- calculate GHG emissions per unit of energy used
- calculate effect of climate changes on energy demand for the target buildings
- estimate the effect on energy use of the recommendations made in this study

Quantifying the current energy use of existing buildings and facilities was fairly straightforward. The municipalities and Efficiency Manitoba[4] provided data on recent energy use, drawn from Manitoba Hydro's monthly consumption records for both natural gas and electricity.

It was also possible to estimate what the future consumption of natural gas and electricity of the planned buildings and projects would be, if they went ahead using energy systems currently in use in similar buildings. Canada's Office of Energy Efficiency (OEE) collects data on similar facilities in Manitoba. OEE's data summarizes the natural gas and electricity consumed per building footprint area (the "energy intensity").

The OEE's most recent available data (from 2021) was used to create baseline estimates the energy likely to be consumed—and the GHG emissions likely to be produced—if the planned buildings and projects went ahead using building construction standards and energy systems typical of similar buildings in Manitoba.

The average annual GHG emissions were estimated from the natural gas consumption data & estimates.

The expected decline in heating requirements and increase in cooling requirements in existing buildings are overwhelmed by the increase in demand for both natural gas and electricity due to the anticipated new developments, if they are constructed using the energy systems typical of similar buildings in Manitoba now.

We can avoid these increases by changing the source of our heat from natural gas to renewables, and by participating communities generating at least some of their own electricity.

- "CO_2e" is an abbreviation of "CO_2 equivalent", which is a standard measure of the global warming effects of all the greenhouse gases produced by combustion, scaled to the equivalent effect on global warming of CO_2 alone.

[4] In keeping with confidentiality requirements, Efficiency Manitoba provided this data only with the prior written consent of an authorized municipal representative.

Recommendations

Table 4: Summary of recommended energy systems[5]

				solar		heat pump system			
		biomass system	district energy system	solar array	solar wall	ground source	air source	process heat	DSM
Brandon	Civic Services Cluster		✓	✓	✓	✓			✓
	East Landfill Cluster	✓	✓	✓				(✓)	✓
Dauphin	Downtown Cluster		✓	✓		✓			(✓)
	Railway Cluster	✓	✓	(✓)			✓		✓
	Vermillion Growers	✓		(✓)					
De Salaberry	Rec Facility (St. Malo Arena)		(✓)	✓	(✓)	✓			✓
Dunnottar	Public Works Building			✓	✓	✓			✓
Killarney Turtle Mountain	Industrial Park	✓	✓	✓	✓		✓		✓
Piney	RM Govt Office, Vassar			✓					✓
	Public Works Bldg, Vassar			✓	✓				✓
	Fire Station 1, Piney			✓					(✓)
	Fire Station 2, Sprague			✓					(✓)
	Fire Station 3, Woodridge			✓					(✓)
Selkirk	West End Lands	✓	✓	✓	(✓)	✓		✓	✓

Implementing these recommendations would move each participating community towards a net-zero renewable energy future. However, none of them would, in themselves, achieve net zero for that community.

Implementing these recommendations should be seen as taking important steps toward net zero, rather than achieving net zero in a single, quick leap.

[5] Light green boxes indicate this recommendation is either an optional recommendation for this stage or is a recommendation for a later stage.

Investments from beyond the municipal government level will be crucial in implementing these recommendations. In part, this is because natural gas prices are low worldwide, and because electricity prices in Manitoba are amongst the lowest available anywhere. Fortunately, significant subsidies, supports, and incentives for renewable energy systems are available:

- Provincially, the first—but not the only—source of support is Efficiency Manitoba.
- Federally, the first—but, again, not the only—source of support is the Federation of Canadian Municipalities Green Fund.

BIOMASS AVAILABLE

Table 5: Potential biomass available within 30 km of each participating community – annual averages in tonnes[6]

	Brandon	Dauphin	De Salaberry	Dunnottar	Killarney Turtle Mountain	Piney	Selkirk
Agriculture By-products							
Barley straw	28,916	14,389	22,306	13,919	16,094	1081	26,796
Wheat straw	83,714	53,220	69,308	31,128	73,061	2,752	64,989
Flax shives	7,547	3,599	9,125	2,112	9,835	282	6,026
Oat straw	13,931	11,116	22,240	9,756	8,600	955	21,976
Agriculture total:	*134,108*	*82,324*	*122,979*	*56,915*	*107,590*	*5,070*	*119,787*
Forestry Residue							
harvest residue	0	0	692	2,140	0	8,768	1,280
mill residue							
chips & sawdust	0	0	0	0	0	0	122,083
bark	0	0	0	0	0	0	37,933
urban wood waste							
residential	2,434	402	768	141	276	0	14,468
non-residential	4,295	753	1,287	69	136	0	25,839
Forestry Residue total:	*6,729*	*1,155*	*2,747*	*2,350*	*412*	*8,768*	*201,603*
Municipal Waste							
paper	4,646	703	311	252	334	0	15,028
Municipal Waste total:	*4,646*	*703*	*311*	*252*	*334*	*0*	*15,028*
total potential biomass:	***145,483***	***84,182***	***126,037***	***59,517***	***108,336***	***13,838***	***336,418***

Each participating community has far more biomass nearby than would be needed to provide heat for all the targeted buildings, facilities, and projects in this study.

The suitability of using a portion of this biomass as a heat source in each target building was assessed.

[6] Source: Government of Canada. (2021, July 23). *Biomass Inventory Mapping and Analysis Tool.* Agriculture and Agri-Food Canada. https://agriculture.canada.ca/atlas/apps/aef/main/index_en.html?emafapp=bimat_ocib&mode=release&iframeheight=800

RENEWABLE ENERGY SYSTEMS PROPOSED

The recommendations do not necessarily recommend biomass heating for every building.

Instead, the recommendations propose the best renewable energy systems for each building, which in some cases use biomass for fuel and in some cases do not. If a biomass heating system is not recommended for a particular building—at least not at this time—this is explained in the section on that building.

Each set of recommendations contains further, follow-on steps that could be taken after the first steps recommended in this study are implemented.

In addition to switching from fossil fuels to renewable fuels, the study also examined other ways to reduce the GHG emissions of the target buildings and facilities. The resulting recommendations include specific net-zero design recommendations for planned buildings and projects, as well as Demand-Side Management (DSM)[7] recommendations for existing buildings and facilities.

The recommendations made in this study recommend only proven technologies, commercially available now. The expertise and experience needed to implement these recommendations is currently available in Manitoba.

Implementing these projects will:

- reduce greenhouse gases by predicable, measurable amounts
- reduce operating costs for in each municipality, by reducing natural gas and electricity consumption
- create local, sustainable jobs
- develop the experience and expertise of local businesses
- enhance community pride

These projects will also serve as demonstration projects for municipalities throughout Manitoba, showing how they, too, can achieve their sustainability goals.

[7] DSM is a rich set of tools which, together, improve the energy efficiency of existing buildings and energy systems. The best DSM resource for the buildings and facilities targeted in this study is Efficiency Manitoba's Programs For Municipally Owned Buildings, which was developed in partnership with the Association of Manitoba Municipalities.

Effects of Recommendations – Estimated Reductions & Savings

If implemented, this study's recommendations will reduce natural gas consumption, thereby reducing GHG emissions. Electricity consumption from the Manitoba Hydro grid will also be reduced.

Table 6: Estimated effects of recommendations – GHG EMISSIONS reductions

EXISTING BUILDINGS & FACILITIES			current emissions	if projects go ahead	reductions	
			tonnes/year	tonnes/year	tonnes/year	%
Brandon	Civic Services & East Landfill Clusters		901	270	-631	-70%
Dauphin	Downtown & Railway Clusters		521	232	-289	-55%
De Salaberry	Recreation Facility (St. Malo Arena)		23	0	-23	-100%
Piney	Office, Public Works & Fire Stations		0	0	0	0%
		subtotals:	*1,445*	*502*	*-943*	*-65%*
PLANNED BUILDINGS & PROJECTS			if business as usual	if projects go ahead	reductions	
			tonnes/year	tonnes/year	tonnes/year	%
Dauphin	Vermillion Growers		*146*	*15*	-132	-90%
Dunnottar	Public Works Building		14	0	-14	-100%
Killarney	Industrial Park		2,258	0	-2,258	-100%
Selkirk	West End Lands	Phase 1 Energy Initiative	2,661	*266*	-2,395	-90%
		subtotals:	*5,079*	*281*	*-4,798*	*-94%*
		totals:	***6,524***	***783***	***-5,741***	***-88%***

The larger planned projects (Vermillion Growers greenhouse in Dauphin, the Killarney Industrial Park, and the Selkirk's West End Lands development) will be developed in stages. The estimates for these three projects are estimates for completed developments.

Table 7: Estimated effects of recommendations – NATURAL GAS reductions

EXISTING BUILDINGS & FACILITIES		current consumption		if projects go ahead		reductions		
		m^3/year	MWh	m^3/year	MWh	m^3/year	MWh	%
Brandon		467,914	4,991	373,976	3,989	-93,938	-1,002	-20%
Dauphin		270,575	2,886	120,441	1,285	-150,134	-1,601	-55%
De Salaberry		11,882	127	0	0	-11,882	-127	-100%
Piney		0	0	0	0	0	0	0%
	subtotals:	*750,372*	*8,004*	*494,417*	*5,274*	*-255,955*	*-2,730*	*-34%*
PLANNED BUILDINGS & PROJECTS		anticipated consumption if business as usual		if projects go ahead		reductions		
		m^3/year	MWh	m^3/year	MWh	m^3/year	MWh	%
Dauphin	Vermillion	*2,655,752*	28,328	*265,575*	2,833	-2,390,177	-25,495	-90%
Dunnottar		*7,175*	77	0	0	-7,175	-77	-100%
Killarney		*12,504*	133	0	0	-12,504	-133	-100%
Selkirk	Phase 1	*1,381,410*	14,735	*138,141*	1,474	-1,243,269	-13,262	-90%
	subtotals:	*4,056,841*	*43,273*	*403,716*	*4,306*	*-3,653,125*	*-38,967*	*-90%*
	totals:	***4,807,213***	***51,277***	***898,133***	***9,580***	***-3,909,080***	***-41,697***	***-81%***

Table 8: Estimated effects of recommendations – operating cost savings

EXISTING BUILDINGS & FACILITIES						
	if projects go ahead					
	natural gas	*electricity*	*biomass*	*totals*	***change***	
					$	***%***
Brandon	$130,892	$68,710	$30,612	$230,214	-$147,070	-39%
Dauphin	$42,154	$45,717	$32,300	$120,171	-$240,430	-67%
De Salaberry	$0	$11,859	$0	$11,859	-$34,051	-74%
Piney	$0	$11,818	$0	$11,818	-$14,496	-55%
subtotals:	*$173,046*	*$138,104*	*$62,912*	*$374,062*	*-$436,047*	*-54%*
PLANNED BUILDINGS & PROJECTS						
	if projects go ahead					
	natural gas	*electricity*	*biomass*	*totals*	***change***	
					$	***%***
Dunottar	$0	-$318	$0	-$318	-$3,644	-110%
Killarney	$0	$329,796	$257,229	$587,025	-$75,132	-11%
Selkirk	$48,349	$715,281	$355,026	$1,118,656	-$4,008,346	-78%
subtotals:	*$48,349*	*$1,044,759*	*$612,255*	*$1,705,364*	*-$4,087,121*	*-71%*
totals:	***$221,395***	***$1,182,862***	***$675,167***	***$2,079,425***	***-$4,523,168***	***-69%***

Estimated Capital Costs

Table 9: Estimated capital costs, in $000s

EXISTING BUILDINGS & FACILITIES			***biomass***	***solar***		***heat pumps***	***totals***
				solar arrays	*solar walls*		
Brandon	Civic Services Cluster			$549	$12	$508	*$1,068*
	East Landfill Cluster		*$2,150*	$2,033			*$4,183*
		Brandon totals:	*$2,150*	*$2,582*	*$12*	*$508*	*$5,251*
Dauphin	Downtown Cluster			$976		$508	*$1,483*
	Railway Cluster		*$400*			$200	*$600*
		Dauphin totals:	*$400*	*$976*		*$708*	*$2,083*
De Salaberry	Recreation Facility (St. Malo Arena)			$49		$508	*$556*
Piney	Office, Public Works & Fire Stations			$244	$12	*$203*	*$459*
		existing buildings & facilities subtotals:	*$2,550*	*$3,851*	*$24*	*$1,926*	*$8,350*
PLANNED BUILDINGS & PROJECTS			***biomass***	***solar***		***heat pumps***	***totals***
				solar arrays	*solar walls*		
Dauphin	Vermillion Growers		$2,400	$407			*$2,807*
Dunnottar	Public Works Building			$57	$7	$58	*$122*
Killarney	Industrial Park		$2,480	$1,025	$86	$200	*$3,790*
Selkirk	West End Lands	Phase 1 Energy Initiative	$1,600	$1,025	$96	$1,880	*$4,601*
		planned buildings & projects subtotals:	*$6,480*	*$2,513*	*$188*	*$2,138*	*$11,319*
		totals:	***$9,030***	***$6,363***	***$212***	***$4,064***	***$19,669***

Next Steps

1. Meet with key stakeholders in each of the participating communities to review recommendations.
    - This process nearing completion
2. Release results of this study publicly.
    - This will be done in coordination with the Province of Manitoba and the municipal governments of the participating communities, once approval to release the results has been received from the Province.
3. Publicize the results of this study to other Manitoba municipalities and to interested stakeholders, including:
    - Association of Manitoba Municipalities (AMM)
    - Manitoba Environmental Industries Association (MEIA)
    - Eco-West|Éco-Ouest Canada
    - Sustainable Building Manitoba
4. Connect the study's participating communities with potential funders, including:
    - Efficiency Manitoba
    - Federation of Canadian Municipalities' Green Fund
    - Infrastructure Canada's Green and Inclusive Community Buildings Program
    - Environment & Natural Resources Canada's Low Carbon Economy Fund
5. Support participating communities in applying for funds to implement recommendations.
    - In addition to government funders, additional approaches could be made to:
        - Brandon Area Community Foundation
        - Dauphin & District Community Foundation
        - Francofonds
        - Killarney Foundation
        - Selkirk & District Community Foundation
        - Westshore Community Foundation
6. Support participating communities in implementing their projects.

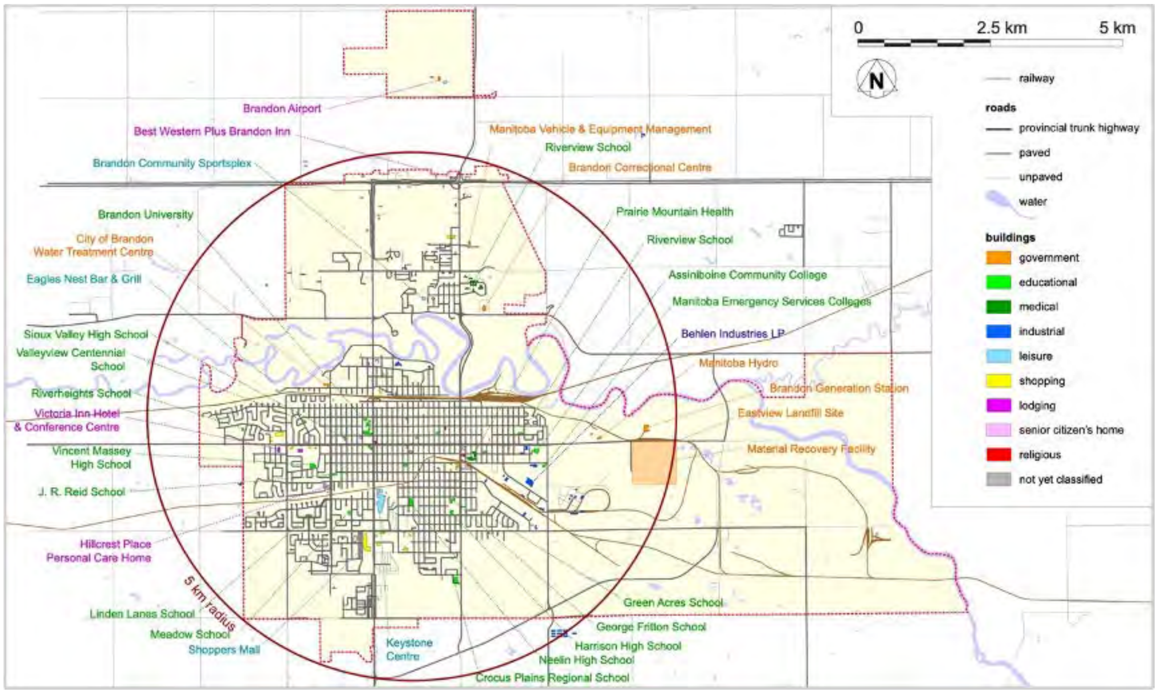
SUPPORTING DOCUMENTATION

1 TARGET BUILDINGS – DESCRIPTIONS & RECOMMENDATIONS

1.1 BRANDON – Target Facilities – Descriptions & Recommendations

Brandon has many buildings and other facilities that could benefit from renewable energy.

Figure 1: Selection of Brandon municipal and community buildings



Of course, this is far more buildings than could be included in a study of this scope.

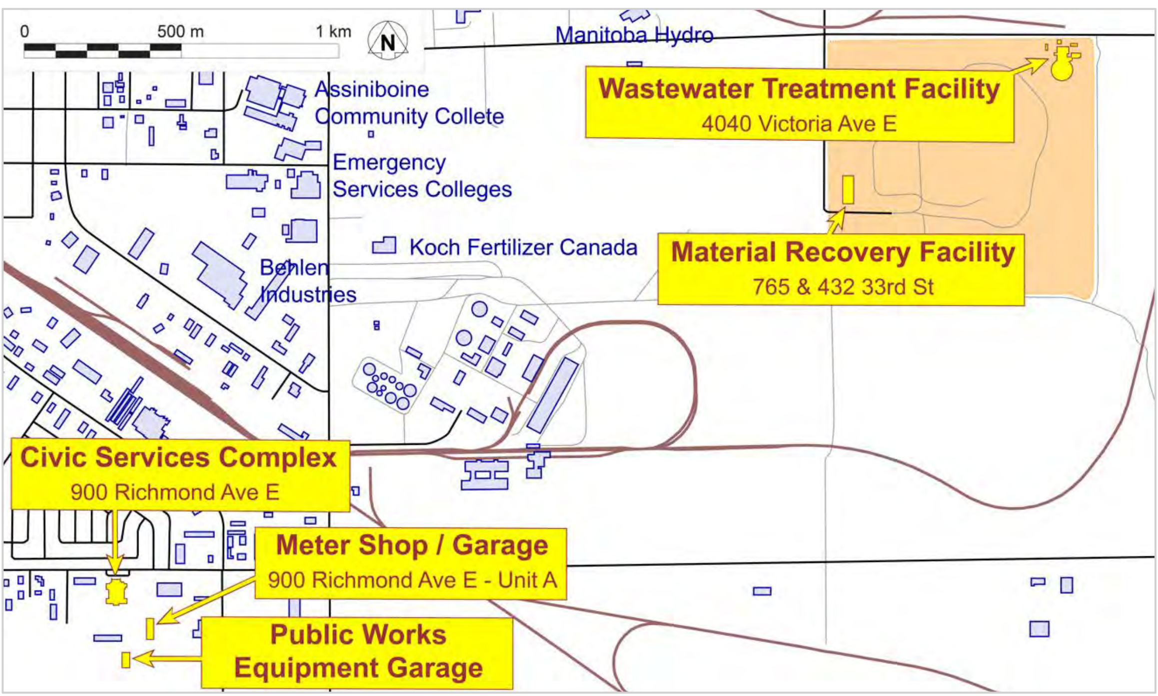
1.1.1 *Target Facilities*

Following discussions with City of Brandon staff, this study concentrated on key city-owned facilities in the south-east corner of the city:

- 3 buildings at the Civic Services Complex at 900 Richmond Ave E
- the Material Recovery Facility on 33rd Street
- the Wastewater Treatment Facility at 4040 Victoria Ave E

Figure 2: Brandon – target facilities – satellite view

Figure 3: Brandon – target facilities – map view[8]



[8] Yellow (target) buildings are owned by the City of Brandon. Other buildings (in pale blue) are commercial buildings.

Table 10: Brandon – target facilities – locations & Manitoba Hydro accounts

Facility				***Manitoba Hydro Accounts***	
name	*service address*	latitude	longitude	electricity	gas
Civic Services Complex	900 Richmond Ave E	49.8268	-99.9255	8114037 6581656	8698687 6778145
Civic Services Complex Meter Shop & Garage	Unit A - 900 Richmond Ave E	49.8258	-99.9241		7281370 6039173
Civic Services Complex Public Works Equipment Garage	900 Richmond Ave E	49.8248	-99.9251		
Material Recovery Facility	765 33rd St	49.8381	-99.8932	8236428 6588332	8236428 6588332
Material Recovery Facility Office	432 33rd St	49.8381	-99.8932	8252804 6777085	
Eastview Landfill Site	3610 Victoria Ave E	49.8387	-99.8883		7220888 6018782
Wastewater Treatment Facility (Main Lift Station)	4040 Victoria Ave E	49.8421	-99.8838	8136292 6657975	7297157 6208595
Wastewater Treatment Facility	4000 Victoria Ave E			8097347 6573257	

There are good reasons to target these facilities for renewable energy:

- They consume significant amounts of energy—both electricity and gas—so that any renewable energy additions will reduce both GHG emissions and operating costs.
- They have plenty of open land around them, so there is room for ground-source heat pumps and for solar arrays.
- The Waste Management Facility receives "waste" wood from construction and from tree trimming, which could be used for fuel.
- These facilities are surrounded by privately-owned industrial facilities that have the potential to be included in future expansions of renewable energy systems.
    - Some could be potential consumers, buying heat.
    - Equally important, facilities that produce waste heat (currently being discharged either into the air or into wastewater) could be potential process heat sources.

These 5 facilities fit into two clusters:

- the 3 Civic Services buildings on Richmond Avenue East
- the 2 facilities (Material Recovery & Wastewater Treatment) in the East Landfill area

The Material Recovery Facility and Wastewater Treatment Facility are not structurally part of a single facility and are administered separately. However, their energy needs—and their renewable energy opportunities—fit well together.

1.1.1.1 CIVIC SERVICES CLUSTER

Figure 4: Brandon – Civic Services Cluster – satellite view

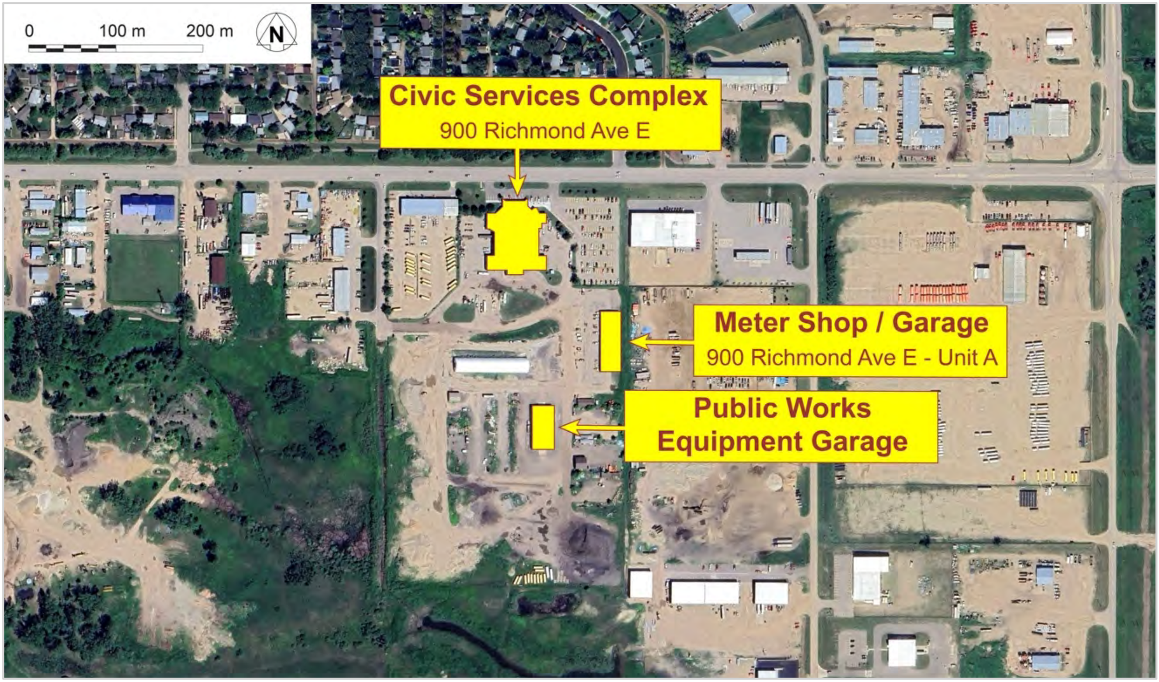


Figure 5: Brandon – Civic Services Cluster – map view

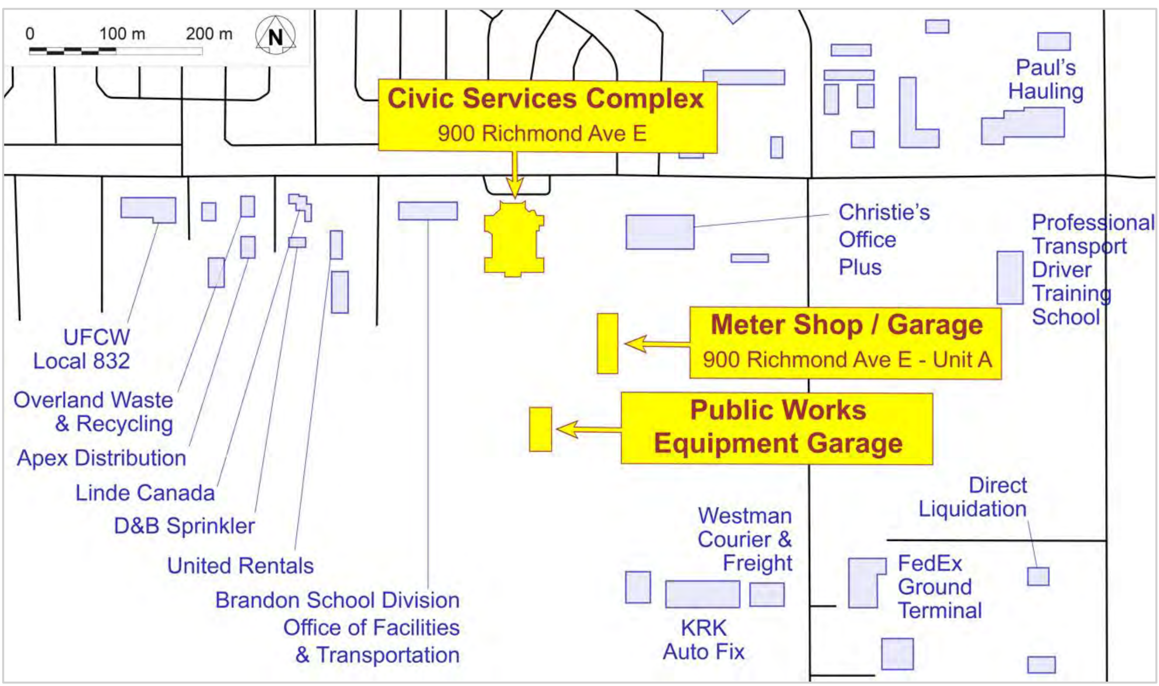


Figure 6: Brandon – Civic Services Complex – street view

1.1.1.2 EAST LANDFILL CLUSTER

Figure 7: Brandon – Material Recovery Facility – street view

Figure 8: Brandon – Wastewater Treatment Facility – street view

1.1.2 *Current Energy Use*

The City of Brandon provided monthly electricity and natural gas bills for 2023 all their target buildings and facilities. The City also provided a Facilities Energy Audit for their Civic Services Complex, completed by the consultants WSP in 2021, covering a one-year period from December 2019 to November 2020.

Brandon's target facilities consume a significant amount of energy every year.

Table 11: Brandon – Target Facilities – annual energy use[9]

		natural gas		***electricity***	***totals***
		m³	*MWh*	*MWh*	*MWh*
Civic Services Cluster	Civic Services Complex	92,436	986	787	1,773
	Streets & Roads Dept Equip Storage	112,784	1,203		1,203
	cluster totals:	*205,220*	2,189	787	2,976
East Landfill Cluster	Material Recovery Facility	79,793	851	319	1,170
	Wastewater Treatment Facility	182,902	1,951	2,617	4,568
	cluster totals:	*262,695*	2,802	2,936	5,738
	Brandon target facilities totals:	***467,914***	***4,991***	***3,723***	***8,714***

The cost for this energy is also significant—more than $400,000 in 2023.

It is also worth noting that just under $40,000 was paid to the federal government in 2023 for the Federal Carbon Charge (FCC) (commonly called the "Carbon Tax") for the use of gas in these facilities. The FCC increased in April 2024 and is scheduled to increase in future years. The FCC is not charged on renewable energy.

As expected, most of natural gas consumed in these facilities is used in the winter months. This is not surprising, as the natural gas is used for heat. Integrating renewable energy systems into these facilities can be expected to significantly reduce natural gas costs and the Federal Carbon Charge.

These is also a noticeable increase in the amount of electricity used in winter compared to summer. Some of this may be due to lighting requirements in months with fewer daylight hours, but it would appear that at least some of the electricity is being used for heat.

The 2021 Energy Audit of the main Civic Centre Complex details energy-saving (DSM) measures that could be taken to reduce energy use. The Audit does not recommend many of them be done because of the high cost/savings ratio. This remains true *only if subsidies are to offset at least some of these costs are not available*. As noted, subsidies are available and should be pursued.

[9] The energy use data for the Civic Services Complex uses 2020 data drawn from the Facilities Energy Audit; all other energy use data is from 2023 Manitoba Hydro bills.

1.1.2.1 CIVIC SERVICES CLUSTER ENERGY USE DETAILS

Table 12: Brandon – Civic Services Cluster – Civic Services Complex – energy consumption[10]

		natural gas			electricity		
	year:	*2020*	*2023*		*2019*	*2020*	*2023*
	source:	*a*	*c*		*a*		
		m³	*m³*	*MWh*	*MWh*		*MWh*
Month	Jan	18,640	4,575	49		86	76
	Feb	18,810	2,912	31		86	70
	Mar	10,311	8,271	88		56	60
	Apr	11,190	2,502	27		72	61
	May	4,844	2,553	27		55	53
	Jun	425	557	6		60	52
	Jul	255	0	0		57	66
	Aug	312	579	6		71	62
	Sep	312	293	3		57	54
	Oct	3,598	1,231	13		53	35
	Nov	12,578	2,227	24		62	92
	Dec	11,161	2,458	26	73		
annual totals:		***92,436***	*28,156*	*300*		***787***	*681*

Table 13: Brandon – Civic Services Cluster – Streets & Roads building – natural gas consumption

		natural gas	
	year:	*2023*	
	source:	*d*	
		m³	*MWh*
Month	Jan	30,904	330
	Feb	27,462	293
	Mar	23,910	255
	Apr	20,349	217
	May	8,221	88
	Jun	541	6
	Jul	641	7
	Aug	541	6
	Sep	215	2
	Oct	0	0
	Nov	0	0
	Dec		
annual totals:		*112,784*	*1,203*

[10] Cells highlighted in yellow are estimates for that month's consumption, supplied by Manitoba Hydro. The number is adjusted the next month with an in-person reading.

Table 14: Brandon – Civic Services Cluster – data sources

source		***building***	***Mb Hydro billing information***			
			address	*account #*	*energy type*	*customer detail*
a	Facilities Energy Audit	Civic Services Complex				
b	Mb Hydro bills	Civic Services Complex	900 Richmond Ave E	8114037 6581656	electricity	Building Supervisor
c	Mb Hydro bills	Civic Services Complex	900 Richmond Ave E	8698687 6778145	natural gas	Finance Department
d	Mb Hydro bills	Streets & Roads Dept Equip Storage	Unit A - 900 Richmond Ave E	7281370 6039173	natural gas	Supervisor Bldg Maint

This study uses the data from the Facilities Energy Audit as the benchmark for the Civic Services Complex, in part because the Audit separates out energy used for space heating and cooling, which enables a more accurate estimate of the effects of adding the recommended Ground-Source Heat Pump system. Data for all other Brandon target facilities is drawn from the 2023 Manitoba Hydro bills.

Table 15: Brandon – Civic Services Cluster – building floor areas

	floor area		
	ft^2	*m^2*	*source*
Civic Services Complex	48,965	4,549	Facilities Energy Audit
Streets & Roads Dept Equip Storage	15,510	1,441	drawing B1115B
Sewer & Water Dept Equip Storage	12,678	1,178	drawing B-1115M

The Streets & Roads building consumes almost 4 times as much heat energy per ft^2 (or per m^2) than the main Civic Services Complex building. This is not surprising, given the differences in use. It means that the greatest GHG and operating cost reductions can be achieved in that building. This study recommends that all three buildings in this Cluster be connected to both the solar array and the Ground-Source Heat Pump system. If, in the first stage, funds can only be secured for one of the three buildings, the Streets & Roads building should be connected first.

1.1.2.2 EAST LANDFILL CLUSTER ENERGY USE DETAILS

Table 16: Brandon – Material Recovery Facility – energy use

		natural gas				electricity		
	year:	2023				2023		
	source:	e	g	totals		e	f	totals
		m^3	m^3	m^3	MWh	MWh	MWh	MWh
Month	Jan	11,867	2,915	14,782	158	35	0.2	35
	Feb	9,799	3,226	13,024	139	33	3.2	36
	Mar	8,762	2,681	11,443	122	32	2.7	35
	Apr	7,226	2,228	9,454	101	28	2.4	30
	May	4,609	891	5,500	59	19	0.2	20
	Jun	963	784	1,747	19	18	0.7	18
	Jul	0	498	498	5	19	0.8	19
	Aug	1,142	116	1,257	13	20	0.8	21
	Sep	0	492	492	5	18	0.8	19
	Oct	3,447	778	4,226	45	20	1.4	22
	Nov	6,328	1,526	7,855	84	26	1.7	28
	Dec	7,351	2,164	9,515	101	34	2.3	36
annual totals:		61,494	18,299	79,793	851	302	17	319

Table 17: Brandon – Wastewater Treatment Facility – energy use

		natural gas		electricity		
	year:	2023		2023		
	source:	j		h	i	totals
		m^3	MWh	MWh	MWh	MWh
Month	Jan	25,549	273	3.1	293	296
	Feb	21,365	228	4.1	241	245
	Mar	22,206	237	2.5	251	254
	Apr	17,739	189	3.3	212	215
	May	8,767	94	2.1	266	268
	Jun	8,736	93	1.0	193	194
	Jul	6,790	72	2.8	218	221
	Aug	9,000	96	1.6	159	160
	Sep	13,665	146	2.2	157	159
	Oct	12,351	132	2.2	183	186
	Nov	18,810	201	2.9	185	188
	Dec	17,923	191	3.1	227	230
annual totals:		182,902	1,951	31	2,586	2,617

Table 18: Brandon – East Landfill Cluster – data sources

			Mb Hydro billing information			
source		***facility***	*address*	*account #*	*energy type*	*customer detail*
e	*Mb Hydro bills*	Material Recovery Facility	765 33rd St	8236428 6588332	electricity	Terri McLaughlin
f			432 33rd St	8252804 6777085	electricity	Customer Billing Dept
g			3610 Victoria Ave E	7220888 6018782	natural gas	Landfill Site
h	*Mb Hydro bills*	Wastewater Treatment Facility	4000 Victoria Ave E	8097347 6573257	electricity	Sanitation Supervisor
i			4040 Victoria Ave E	8136292 6657975	electricity	Water Plant Manager
j				7297157 6208595	natural gas	Waste Water Treatmt Plant Rd: Main Lift Station

1.1.3 *Renewable Energy Recommendations*

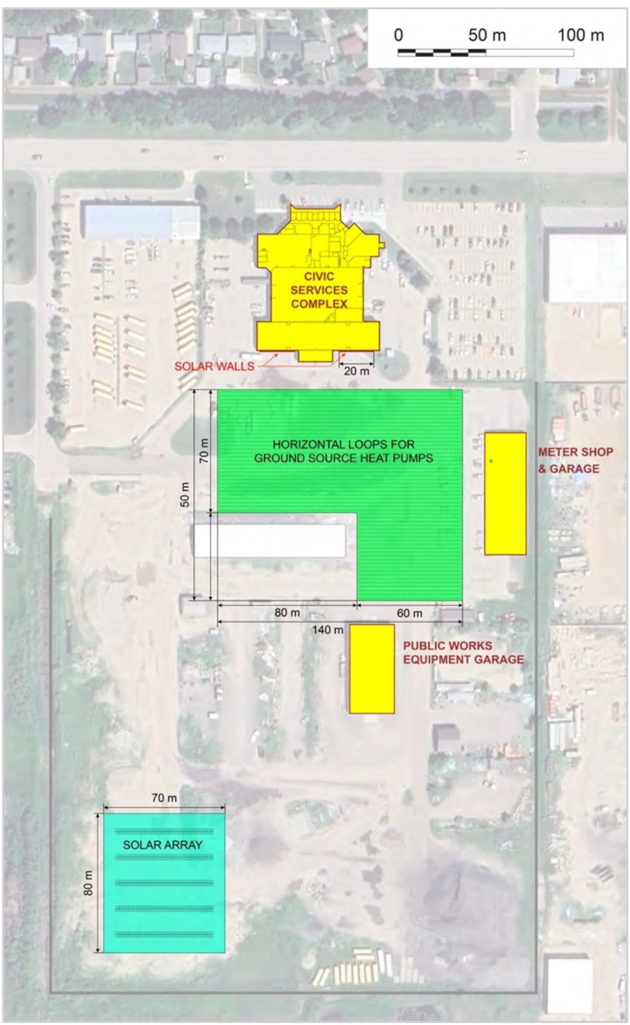
1.1.3.1 CIVIC SERVICES CLUSTER

The following recommendations will reduce natural gas and grid-based electricity consumption in the Civic Services Cluster by approximately half.

Recommendations for Brandon's Civic Services Cluster:

- *Install a district Ground-Source Heat Pump system to provide both heating and cooling to all three target buildings in the Civic Services Cluster.*
- *Install a Solar Wall on the south wall of the Civic Services Complex building.*
- *Install a ground-based Solar Array south of the Civic Services Complex.*
- *Approach Efficiency Manitoba for support to implement the Demand-Side Management retrofits recommended in the Civic Services Complex Energy Audit.*
- *Investigate Demand-Side Management retrofits for the other two target buildings in this Cluster with Efficiency Manitoba.*

Figure 9: Brandon – Civic Services Cluster – with renewables



Heat Pump System

Table 19: Brandon – Civic Services Cluster – ground-source heat pump system – capacity, cost & space requirements

system			capital cost (installed pricing)			horizontal loop space requirement	
capacity		Coefficient of Performance	heat pump systems	horizontal loops	total		
kW	tons					m^2	ft^2
175	50	3.5	$315,000	$192,500	***$507,500***	13,000	140,000

The Civic Services Clusters' Ground-Source Heat Pump (GSHP) system will need to be integrated into:

- the natural gas boiler systems providing building heat to the buildings
- the air conditioning system in the Civic Services Complex, and any air conditioning systems that may be added to the other buildings
- make-up air units supplying heated air to the wash bay, garage, weld shop, workshop, sign shop, and anywhere else make-up air is required
- the hot water system supplying hot water for washrooms and wash bays

Two options for loops are provided in these recommendations—horizontal loops and vertical loops.

- Horizontal loops are typically less expensive to install than vertical loops (estimated at $1,900/kWh vs. $2,800/kWh). However, estimates for each project should be solicited from both horizontal and vertical loop installers. As noted in the general discussion on Heat Pumps, the drilling equipment for vertical loops is the same as that used in the oil and gas industry, and in drilling water wells. During slow periods, those drilling companies may be willing to offer discounts and compete on price with horizontal loop installation.
- The space required for horizontal loops will occupy most of the open ground available between the buildings. However, these loops will not be visible, as they are buried underground.
- Vertical loop systems have advantages over horizontal loops:
  - are usually more energy-efficient
  - occupy less area (about 20% of the space required for horizontal loops)
  - are usually more convenient to service

Solar Walls

Table 20: Brandon – Civic Services Cluster – Solar Walls – dimensions & costs

dimensions										
meters		feet		area		estimated capital cost (installed pricing)				
length	height	length	height	m^2	ft^2	per m^2	per ft^2	per unit	# units	total
20	3	66	10	60	646	$100	$9	$6,000	2	**$12,000**

It is recommended that two solar walls be installed, one on each side of the wash bay, each 20 meters long and 3 meters high. If funds cannot be secured for two walls, a single wall installed as a first step will still help reduce heating costs.

The solar walls will need to be tied into the make-up air system, pre-heating the air, so that less energy is needed to warm up cold outside air when it is needed for ventilation.

Because each solar wall is custom designed to its building, it is not possible to know, at the prefeasibility stage, what the energy and cost savings will be. Therefore, no estimate of the energy savings for these walls are included in this prefeasibility study.

However, this information can be collected by requesting bids from solar wall installers for a specific building. In addition to a firm capital cost, these bids will include estimates of the energy benefits and dollar savings.

Solar Array

Table 21: Brandon – Civic Services Cluster – Solar Array[11]

# panels:	540	row width:	54	panels
configuration:	2 up		61	m
# rows:	5		201	ft
production capacity:		per panel:	0.535	kW
		array total:	289	kW
cost:		per installed kW:	$1,900	
		solar array total:	$548,910	

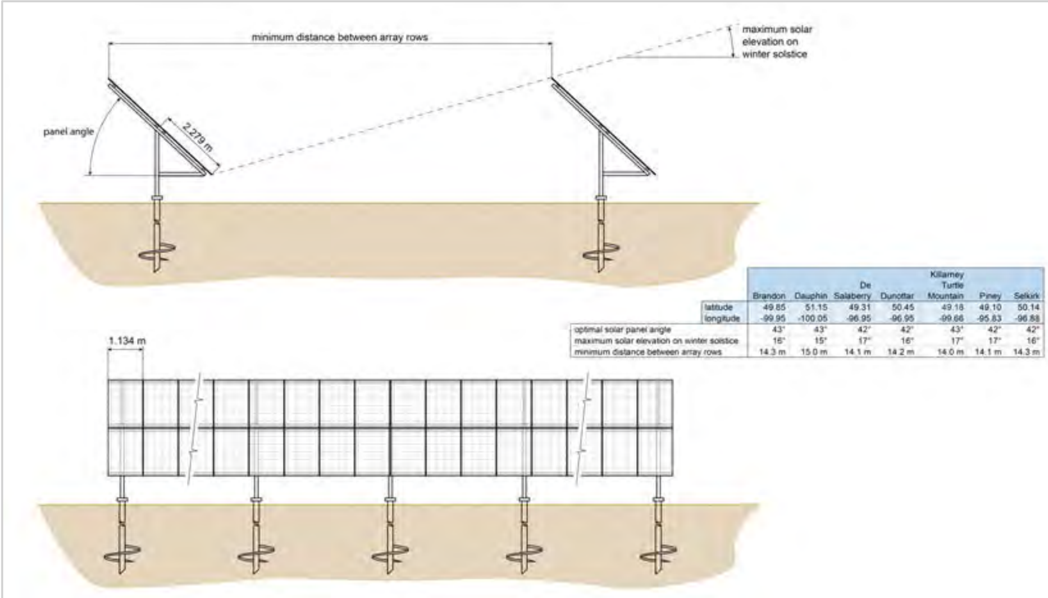
The solar panels on the array should, ideally, be angled at 43°.[12]

- The precise angle is not crucial; at Brandon's latitude, anywhere between 40° and 45° will produce roughly the same amount of electricity.
- In Brandon, the sun rises to a maximum of 16° on the winter solstice. To minimize shadowing (and so maximize production), the arrays should be spaced a minimum of 14.3 meters (47 ft) apart.

[11] It may be that the City of Brandon will not be able to secure a subsidy or grant large enough to make a solar array of this size feasible at this stage. If that is the case, it is recommended that the City install a solar array that is large as possible within the funds available. At a later stage, if more funding can be secured, expanding an existing solar array will be relatively straightforward.

[12] Solar Calculator (n.d.). *Solar Power Calculator for Brandon, Manitoba, Canada.* https://solarcalculator.ca/report/Manitoba/Brandon/

Figure 10: Recommended solar array configuration



	Brandon	Dauphin	De Salaberry	Dunottar	Killarney Turtle Mountain	Piney	Selkirk
latitude	49.85	51.15	49.31	50.45	49.18	49.10	50.14
longitude	-99.95	-100.05	-96.95	-96.95	-99.66	-95.83	-96.88
optimal solar panel angle	43°	43°	42°	42°	43°	42°	42°
maximum solar elevation on winter solstice	16°	15°	17°	16°	17°	17°	16°
minimum distance between array rows	14.3 m	15.0 m	14.1 m	14.2 m	14.0 m	14.1 m	14.3 m

Because the electricity consumption of the Civic Services Complex is relatively stable from month to month, there are no months when, net, more electricity will feed back into the Manitoba Hydro grid than is received. However, there will be times—particularly during the day in summer months—when the solar array is producing more electricity than the buildings need. During those days, it is to be expected that some electricity will be fed into the grid, offset by demand at night.

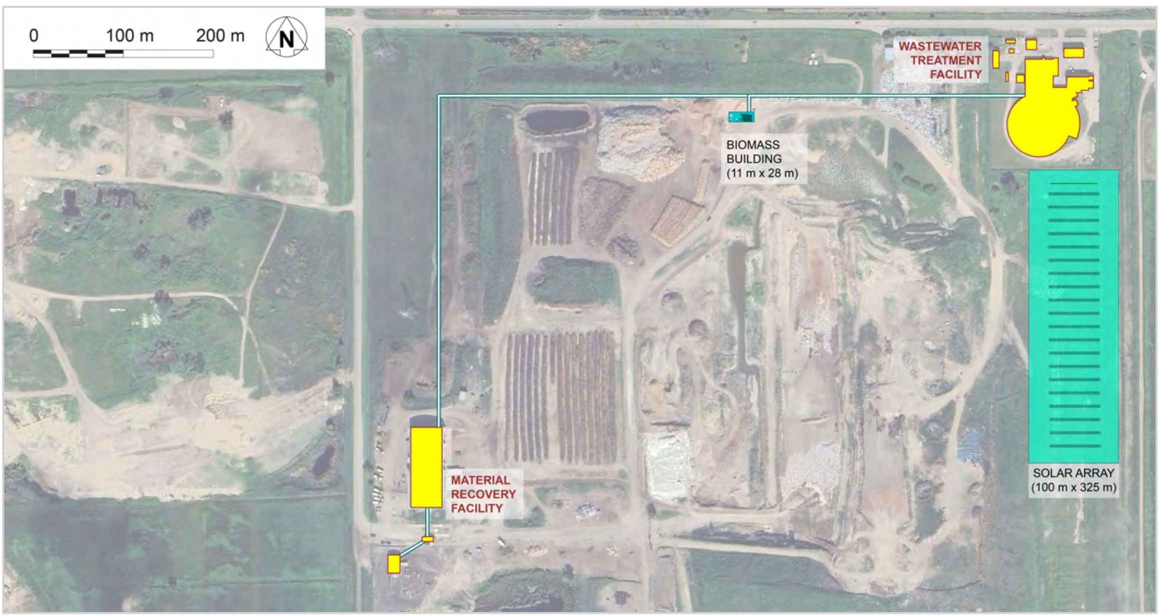
1.1.3.2 EAST LANDFILL CLUSTER

The following recommendations will reduce natural gas by approximately 90%, and grid-based electricity consumption in the East Landfill Cluster by approximately 1/2 each.

Recommendations for Brandon's East Landfill Cluster:

- *Install a Biomass heating system, connected through an underground district loop to both the Water Treatment Plant and the Material Recovery Facility buildings, using chipped waste wood as fuel.*
- *Install a ground-based Solar Array connected to the Water Treatment Plant.*
- *Investigate Demand-Side Management retrofits for all facilities in this Cluster with Efficiency Manitoba.*

Figure 11: Brandon – East Landfill Cluster – with renewables



Locations

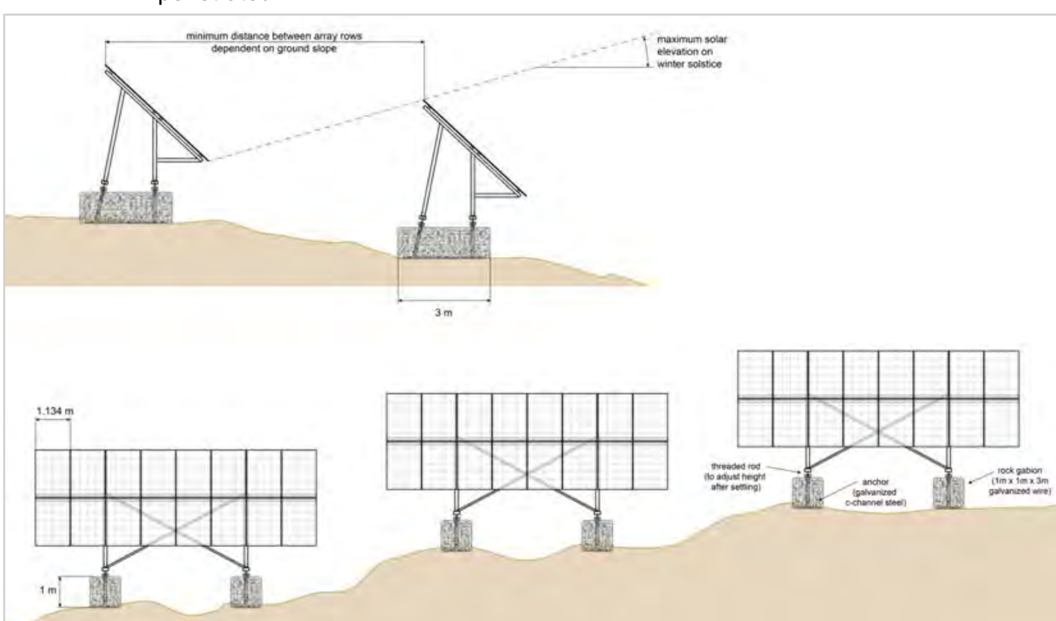
The locations shown for both the biomass building and the solar array are suggestions only. The final location for each should be based on the following criteria:

- The biomass building should be:
  - close and easily accessible to the waste wood in the material recovery area
  - between the Material Recovery Facility and the Wastewater Treatment Facility
    - It makes only a minor difference if it is closer to one of these facilities than the other.
  - close to a power source
- The solar array should be:
  - located where there will be no obstructions to its south
  - as close as possible to the Wastewater Treatment Facility, as it will be using the majority of the solar array's output

One of the options for the solar array location and configuration is to locate shorter arrays on top of the waste material cells after they are capped. A configuration using rock gabions rather than screw piles as anchors—originally developed for solar arrays on uneven, boulder-strewn ground in northern Manitoba may be useful here.

Figure 12: Racking for solar array on uneven ground – rock gabions used for anchoring[13]

Figure 13: Solar arrays anchored with gabions – for uneven surfaces or when ground cannot be penetrated



[13] Image source: Northlands Dënesųłiné First Nations Energy, Lac Brochet, Manitoba. In this configuration, each solar array rack holds 16 panels and is anchored by two rock gabions.

This anchoring system does not require penetration of the ground surface, so it will not disturb the clay cap covering the waste materials. These racks can be located on hilly and uneven ground. They can also accommodate some ground settling after installation.

Solar arrays using this anchoring system could eventually cover all the capped cells in the East Landfill, turning unusable land into a site of renewable energy production.

Biomass System

Table 22: Brandon – East Landfill Cluster – biomass fuel characteristics

material		***energy density***		***cost***
source	*form*	*kWh/kg*	*MWh/tonne*	*per tonne*
waste wood from urban forests & clean waste construction wood	chipped	2.9	2.9	$30

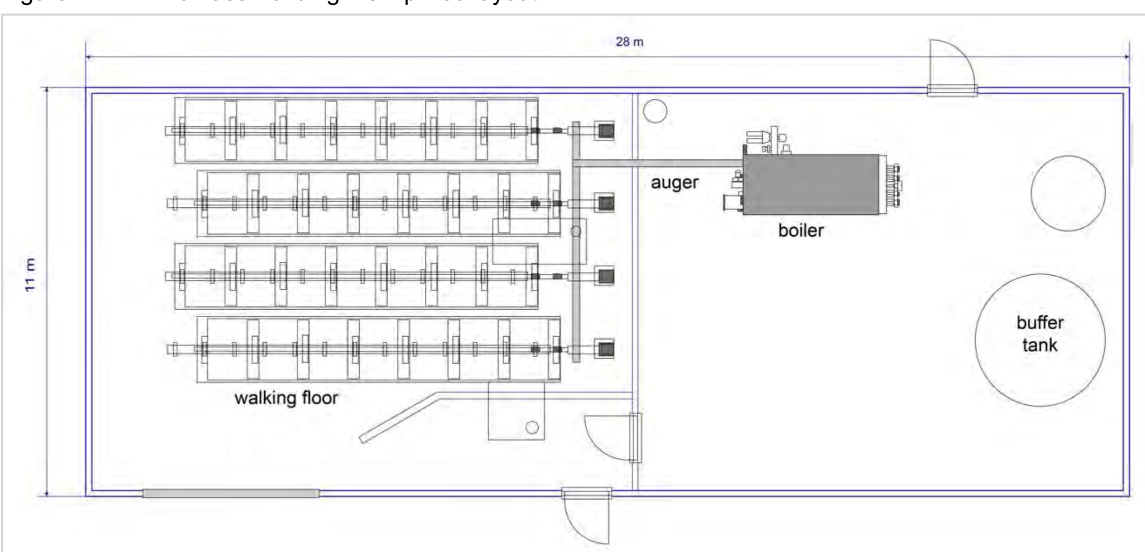
Table 23: Brandon – East Landfill Cluster – biomass system capacity & cost

capacity	***system efficiency***	***net heat production***	***capital cost (installed pricing)***	
MW		*MWh/tonne*	*per kW*	*total*
2.3	75%	2.2	$400	$900,000

Table 24: Brandon – East Landfill Cluster – biomass system components – estimated capital costs (installed pricing)

component	***capital cost (installed pricing)***
biomass system	$900,000
district loops	$450,000
building	$400,000
chipping equipment	$400,000
total:	*$2,150,000*

Figure 14: Biomass Building – simplified layout



The biomass building should be oriented east/west, with a long wall facing south. At a later stage, it may make sense to add solar panels (mounted vertically) on the south wall to offset electricity draw from the district loop's circulating pumps

Solar Array

Table 25: Brandon – East Landfill Cluster – Solar Array[14]

# panels:	2,000	row width:	50 panels
configuration:	2 up		57 m
# rows:	20		186 ft
production capacity:		per panel:	0.535 kW
		array total:	1,070 kW
capital cost:		per installed kW:	$1,900
		solar array total:	$2,033,000

The configuration of the solar array—20 rows with 100 panels per row—is suggested, but other configurations will function just as well.

1.1.3.3 NOTES ON BRANDON RECOMMENDATIONS

- *The two energy systems for the two Clusters should be integrated at a later stage, preferably with tie-ins to nearby industries.*
  - *This integration could best be achieved in partnership with industrial firms located between these two clusters that either use significant amounts of energy or have waste process heat that might currently be discharged into the air or into wastewater. Once district energy systems are in place that include ground-source heat pumps, biomass, and solar arrays, adding other energy users and sources of waste process heat is relatively simple from a technological perspective.*
    - *Based on experiences in other jurisdictions, integrating the energy systems of private corporations with energy systems run by a government requires careful and time-consuming discussions and negotiations. It is not recommended that this be attempted as a first step and should be considered for a later stage.*
  - *Installing a biomass heating system at the Civic Centre Complex is not recommended at this stage.*
    - *Using biomass to heat the Civic Centre building cluster is certainly feasible. However, a biomass system is recommended for the East Landfill Site Cluster. Operating two separate biomass systems doubles the capital cost and increases demand on staff time.*
  - *The existing heating and cooling systems should remain.*

[14] As noted above, it possible that the City of Brandon will not be able to secure a subsidy or grant large enough to make a solar array of this size feasible at this stage. If that is the case, it is recommended that the City install a solar array that is large as possible within the funds available. At a later stage, if more funding can be secured, expanding an existing solar array will be relatively straightforward.

- *It is not recommended that the existing gas-fired boilers and the existing cooling systems be removed when new renewable heating and cooling systems are installed. Instead, the existing systems should be retained and used as backups.*
- *As noted in the WSP Energy Audit, two standard-efficiency natural gas boilers provide heat for the Civic Services Complex building—one boiler operating as lead and the other as lag. (They are cycled through lead/lag positions annually.) Adding a ground-source heat pump system would move both into lag positions—lag 1 and lag 2. Installing a ground-source heat pump system has the added benefit of extending the operating life of these natural gas systems, because they will be used for fewer hours per year.*

1.1.4 *Effects of Renewable Energy Recommendations*

1.1.4.1 OVERALL EFFECTS

Table 26: Brandon – Target Facilities – estimated reductions in annual energy purchases

	natural gas			electricity from MB Hydro		reductions from outside sources	
	m^3	MWh	%	MWh	%	MWh	%
Civic Services Cluster	-91,238	-973	-44%	-114	-15%	-1,087	-37%
East Landfill Cluster	-236,425	-2,522	-90%	-1,327	-45%	-3,848	-67%
totals:	*-327,664*	*-3,495*	*-70%*	*-1,441*	*-39%*	***-4,936***	***-57%***

Table 27: Brandon – Target Facilities – estimated GHG emissions reductions

	GHG emissons CO_2e tonnes/year			
	business as usual	if projects go ahead	change	
Civic Services Cluster	*395*	*220*	*-176*	*-44%*
East Landfill Cluster	*506*	*51*	*-455*	*-90%*
totals:	*901*	*270*	***-631***	***-70%***

Table 28: Brandon – Target Facilities – estimated overall annual operating cost savings

	overall operating cost savings			
	business as usual	if projects go ahead	change	
Civic Services Cluster	*$150,523*	*$107,173*	*-$43,350*	*-29%*
East Landfill Cluster	*$385,540*	*$182,998*	*-$202,543*	*-53%*
totals:	*$536,063*	*$290,170*	***-$245,893***	*-46%*

Table 29: Brandon – Target Facilities – estimated self-generated energy – per year

	biomass		electricity	increases in self-generated energy
	tonnes	MWh	MWh	MWh
Civic Services Cluster			392	*392*
East Landfill Cluster	858	2,522	1,453	*2,522*
totals:	*858*	*2,522*	*1,845*	***2,914***

Adding the ground-source heat pump (GSHP) system to the Civic Services Cluster cuts its natural gas consumption by nearly half (44%). A larger system would reduce it even further. While the GSHP does increase this Cluster's electricity consumption, this is offset by production from this Cluster's solar array.

At the East Landfill Cluster, the biomass system will produce enough heat to replace the heat from natural gas. However, it is not recommended that the existing natural gas systems in these two facilities be removed. Instead, they should remain as backups. A reduction in natural gas consumption in the East Landfill Cluster by 90% is estimated.

1.1.4.2 DETAILS OF EFFECTS

Table 30: Brandon – Target Facilities – estimated annual natural gas cost savings

	natural gas			
	estimated savings			
	business as usual	*if projects go ahead*	*change*	
Civic Services Cluster	*$71,827*	*$39,893*	*-$31,933*	*-44%*
East Landfill Cluster	*$91,943*	*$9,194*	*-$82,749*	*-90%*
totals:	***$163,770***	***$49,088***	***-$114,682***	***-70%***

Table 31: Brandon – Target Facilities – estimated annual electricity cost savings

	electricity			
	estimated savings			
	business as usual	*if projects go ahead*	*change*	
Civic Services Cluster	*$78,696*	*$67,279*	*-$11,417*	*-15%*
East Landfill Cluster	*$293,597*	*$160,937*	*-$132,661*	*-45%*
totals:	***$372,293***	***$228,216***	***-$144,078***	*-39%*

Civic Services Cluster

Table 32: Brandon – Civic Services Cluster – Ground Source Heat Pump – estimated effect on natural gas consumption & heating cost[15]

	without heat pump system			with heat pump system						
	natural gas			heat provided by heat pump system		electricity needed CoP 3.5	still required from natural gas			change from status quo
month	m^3	MWh	kWh/hr	kWh/hr	MWh	MWh	kWh/hr	MWh	m^3	m^3
Jan	49,544	528	710	175	130	37	535	398	37,337	-12,206
Feb	46,272	494	663	175	130	37	488	363	34,066	-12,206
Mar	34,221	365	491	175	130	37	316	235	22,015	-12,206
Apr	31,539	336	452	175	130	37	277	206	19,333	-12,206
May	13,065	139	187	175	130	37	12	9	859	-12,206
Jun	966	10	14	14	10	3	0	0	0	-966
Jul	896	10	13	13	10	3	0	0	0	-896
Aug	853	9	12	12	9	3	0	0	0	-853
Sep	527	6	8	8	6	2	0	0	0	-527
Oct	3,598	38	52	52	38	11	0	0	0	-3,598
Nov	12,578	134	180	175	130	37	5	4	372	-12,206
Dec	11,161	119	160	160	119	34	0	0	0	-11,161
annual totals:	*205,220*	*2,189*			973	278		*1,216*	*113,981*	*-91,238*
averages:			*250*		*111*		*136*			

annual natural gas cost: ***$71,827***

annual natural gas cost: ***$39,893***

cost reduction: ***-$31,933*** ***-44%***

Table 33: Brandon – Civic Services Cluster – Solar Array & Ground-Source Heat Pump – estimated net effect on electricity consumption

	electricity MWh			needed from MB Hydro	
month	current consumption	additional draw by heat pump system	solar array production	net grid draw	reduction
Jan	86	37	20	103	*20%*
Feb	86	37	27	97	*12%*
Mar	56	37	32	61	*10%*
Apr	72	37	42	67	*-7%*
May	55	37	41	51	*-7%*
Jun	60	3	40	24	*-61%*
Jul	57	3	46	14	*-75%*
Aug	71	3	43	31	*-57%*
Sep	57	2	37	22	*-62%*
Oct	53	11	29	34	*-35%*
Nov	62	37	20	79	*28%*
Dec	73	34	17	90	*23%*
annual totals:	*787*	*278*	*392*	***673***	***-15%***

[15] Although the heat pump system recommended for Brandon's Civic Services Cluster has the same capacity as the one recommended for Dauphin's Downtown Cluster, the reduction in natural gas consumption is not exactly the same, because when the heat is needed is not the same.

Although the net electricity required from the grid (the "net grid draw") goes quite low in the summer (when solar array production is up), it never goes negative. As a result, no net electricity is given back to the grid, so there are no net payments from Manitoba Hydro.

Table 34: Brandon – Civic Services Cluster – Solar Array & Ground-Source Heat Pump – estimated effect on electricity cost

		financials				
		cost for Manitoba Hydro electricity:			$0.10 /kWh	
		price paid by Mb Hydro for excess energy:			$0.05 /kWh	
		Manitoba Hydro billings				***Manitoba Hydro payments***
		current consumption	*additional draw by heat pump system*	*with both heat pump system & solar array*	*billing change from status quo*	
month	Jan	$8,568	$3,720	$10,257	$1,689	$0
	Feb	$8,604	$3,720	$9,654	$1,050	$0
	Mar	$5,580	$3,720	$6,136	$556	$0
	Apr	$7,200	$3,720	$6,723	-$477	$0
	May	$5,508	$3,720	$5,146	-$362	$0
	Jun	$6,048	$294	$2,358	-$3,690	$0
	Jul	$5,688	$273	$1,410	-$4,278	$0
	Aug	$7,056	$260	$3,058	-$3,998	$0
	Sep	$5,652	$161	$2,157	-$3,495	$0
	Oct	$5,256	$1,097	$3,411	-$1,845	$0
	Nov	$6,192	$3,720	$7,946	$1,754	$0
	Dec	$7,344	$3,401	$9,021	$1,677	$0
annual totals:		*$78,696*	*$27,806*	*$67,279*	*-$11,417*	*$0*
					net annual electricity cost:	***$67,279***
					annual savings:	*-$11,417*
					cost reduction:	***15%***

East Landfill Cluster

Table 35: Brandon – East Landfill Cluster – Biomass System – estimated biomass required

		natural gas currently consumed		***average kWh required*** *(estimating natural gas system as 90% efficient)*			***biomass required***
		m^3	*MWh*	*/month*	*/day*	*/hr*	*tonnes*
month	Jan	40,330	430	387,173	13,877	578	132
	Feb	34,389	367	330,137	11,833	493	112
	Mar	33,649	359	323,033	11,578	482	110
	Apr	27,193	290	261,052	9,357	390	89
	May	14,267	152	136,967	4,909	205	47
	Jun	10,483	112	100,639	3,607	150	34
	Jul	7,288	78	69,964	2,508	104	24
	Aug	10,257	109	98,466	3,529	147	33
	Sep	14,158	151	135,913	4,871	203	46
	Oct	16,577	177	159,136	5,704	238	54
	Nov	26,664	284	255,978	9,175	382	87
	Dec	27,438	293	263,409	9,441	393	90
annual totals:		*262,695*	*2,802*	*2,521,868*			*858*
				averages:	*7,532*	*314*	

Table 36: Brandon – East Landfill Cluster – Solar Array & Biomass System – estimated effect on electricity consumption

		electricity MWh				
		current consumption	additional draw by biomass system	solar array production	needed from MB Hydro net grid draw	needed from MB Hydro reduction
month	Jan	332	19	75	276	-17%
month	Feb	281	17	99	199	-29%
month	Mar	289	16	117	188	-35%
month	Apr	245	13	155	103	-58%
month	May	288	7	151	144	-50%
month	Jun	213	5	148	70	-67%
month	Jul	240	3	169	75	-69%
month	Aug	181	5	158	28	-84%
month	Sep	178	7	135	49	-72%
month	Oct	207	8	109	106	-49%
month	Nov	216	13	73	156	-28%
month	Dec	267	13	64	216	-19%
annual averages:		2,936	126	1,453	**1,609**	**-45%**

Just as with the solar array at the Civic Services Cluster, there are no months when no net electricity is needed from the Manitoba Hydro grid, so no payments from Manitoba Hydro for excess electricity are expected.

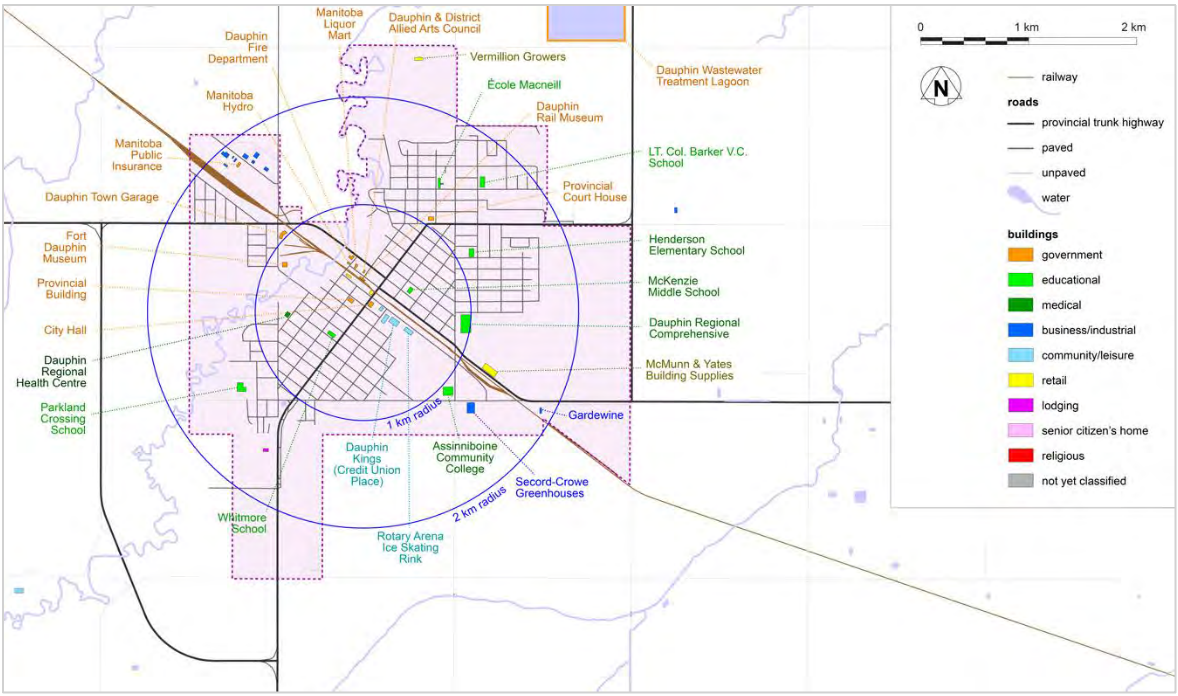
Table 37: Brandon – East Landfill Cluster – Solar Array & Biomass System – estimated effect on electricity cost

		financials				
		cost for Manitoba Hydro electricity:				$0.10 /kWh
		price paid by Mb Hydro for excess energy:				$0.05 /kWh
		Manitoba Hydro billings current consumption	additional draw by biomass system	with both heat pump system & solar array	billing change from status quo	**Manitoba Hydro payments**
month	Jan	$33,153	$1,936	$27,567	-$5,585	$0
month	Feb	$28,114	$1,651	$19,877	-$8,237	$0
month	Mar	$28,878	$1,615	$18,773	-$10,105	$0
month	Apr	$24,548	$1,305	$10,310	-$14,238	$0
month	May	$28,815	$685	$14,383	-$14,432	$0
month	Jun	$21,270	$503	$7,018	-$14,253	$0
month	Jul	$24,002	$350	$7,499	-$16,504	$0
month	Aug	$18,081	$492	$2,805	-$15,277	$0
month	Sep	$17,791	$680	$4,931	-$12,860	$0
month	Oct	$20,722	$796	$10,624	-$10,099	$0
month	Nov	$21,571	$1,280	$15,568	-$6,003	$0
month	Dec	$26,651	$1,317	$21,583	-$5,068	$0
annual totals:		$293,597	$12,609	$160,937	-$132,661	$0
					net annual electricity cost:	**$160,937**
					annual savings:	$132,661
					cost reduction:	**-45%**

1.2 DAUPHIN – Target Buildings – Descriptions & Recommendations

Dauphin has approximately two dozen community buildings that could be considered for inclusion in this study.

Figure 15: Dauphin municipal and community buildings



1.2.1 *Target Buildings*

Following discussions with city officials, this study is concentrating on the recreation facilities immediately behind city hall (the “downtown cluster”), and three community buildings clustered around CNR Place, which houses the Dauphin Rail Museum. Vermillion Growers Greenhouse, at the north edge of the city, joined this study part way through our discussions and is treated as a separate “cluster”.

The Downtown Cluster includes:

- Parkland Recreation Complex / Kin Aquatic Centre (identified on Google as “Dauphin Recreation Services”)
- Credit Union Place (home of the Dauphin Kings Hockey Club, on Google called “Dauphin Minor Hockey”)
- Rotary Arena Ice Skating Rink

The Railway Cluster includes:

- CNR Place (identified on Google as “Dauphin Rail Museum”, which is the major tenant in the building)
- Watson Art Centre (identified on Google as “Dauphin & District Allied Arts Council”)
- Dauphin Fire Department

Table 38: Dauphin – target buildings

Facility name	*service address*	*owner*	*latitude*	*longitude*	*premises #*	*energy type*
DOWNTOWN CLUSTER						
Parkland Recreation Complex / Kin Aquatic Centre	200 1st Street SE	Dauphin Recreation Services	51.1471	-100.0490	6069971	electricity
						gas
Credit Union Place			51.1469	-100.0477	?	electricity
					6229350	gas
Rotary Arena Ice Skating Rink			51.1463	-100.0462	6620688	electricity
					6044130	gas
RAILWAY CLUSTER						
CNR Place	101 - 1 Ave NW Unit A	City of Dauphin	51.1505	-100.0521	6026717	electricity
						gas
Watson Art Centre	104 - 1 Ave NW		51.1509	-100.0520	6033798	electricity
						gas
Dauphin Fire Department	121 - 2 St NW		51.1522	-100.0533	6019657	electricity
						gas
GREENHOUSE NORTH OF CITY						
Vermillion Growers	2175 Mountain Rd N	Vermillion Growers	51.1687	-100.0448		electricity
					6776224	gas

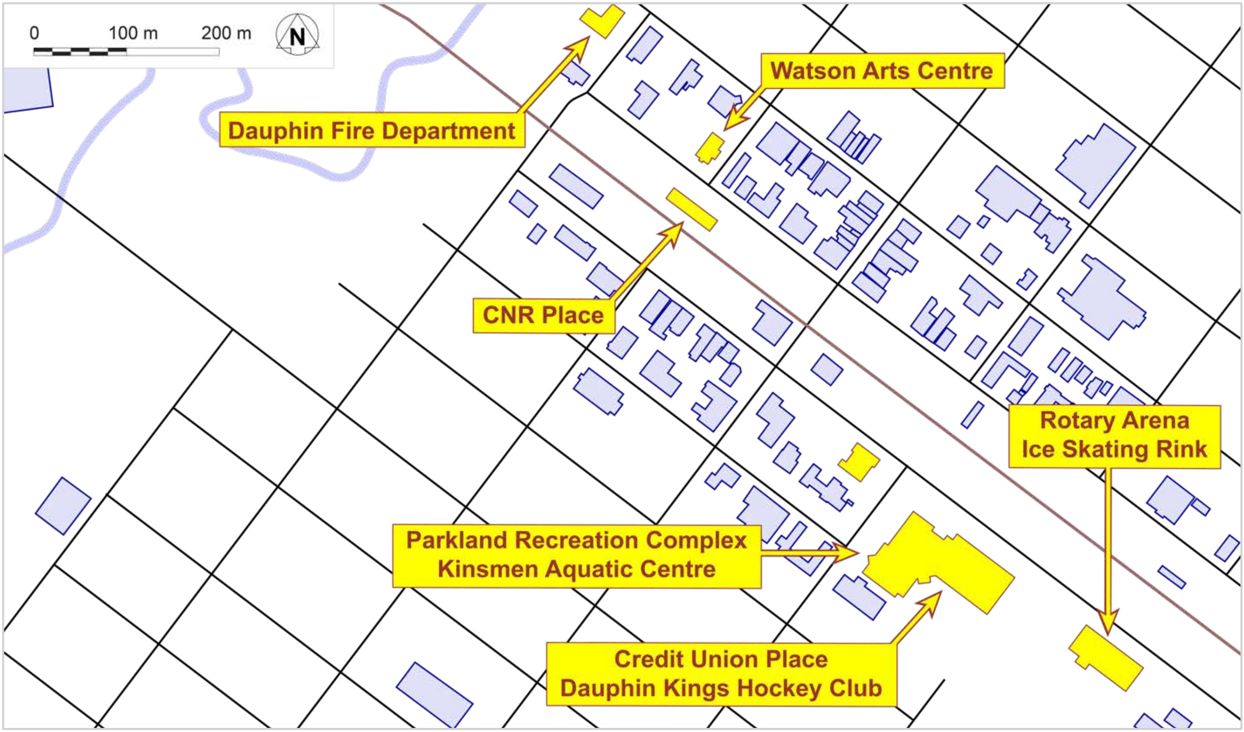
All of these buildings consume significant amounts of energy. All can benefit from renewable energy inputs.

The buildings in the Downtown Cluster and, particularly, the Railway Cluser, can benefit from DSM (Demand-Side Management) improvements to make the buildings more efficient.

There are many other buildings in Dauphin that could benefit from renewable energy upgrades, but these will be saved for a later study.

Figure 16: Dauphin – target buildings – Downtown & Railway Clusters – satellite view

Figure 17: Dauphin – target buildings – Downtown & Railway Clusters – map view



1.2.1.1 DOWNTOWN CLUSTER

Figure 18: Dauphin – Parkland Recreation Complex / Kin Aquatic Centre – interior view[16]

[16] Dauphin Recreation Services. (n.d.). Kin Aquatic Centre. https://dauphinrec.com/index.php/kinsmen-aquatic-centre. (The name of this facility was recently changed from "Kinsmen Aquatic Centre" to "Kin Aquatic Centre".)

Figure 19: Dauphin – Credit Union Place (Dauphin Kings Hockey Club) – street view

Figure 20: Dauphin – Rotary Arena Ice Skating Rink – street view

1.2.1.2 RAILWAY CLUSTER

Figure 21: Dauphin – CNR Place – street view[17]

Figure 22: Dauphin – Watson Art Centre – street view[18]

[17] Dauphin Tourism (n.d.). Dauphin Rail Museum. *Facebook.* https://www.facebook.com/photo.php?fbid=1068584684471694&set=pb.100039605180350.-2207520000&type=3

[18] Watson Art Centre (n.d.). *Welcome to The Watson Art Centre.* https://watsonartcentre.com

Figure 23: Dauphin Fire Department – street view

1.2.1.3 VERMILLION GROWERS GREENHOUSE

Figure 24: Vermillion Growers Greenhouse – aerial view[19]

[19] Vermillion Growers (n.d.). *About Us.* https://vermilliongrowers.com/about-us

1.2.2 *Current Energy Use*

1.2.2.1 DOWNTOWN CLUSTER

Table 39: Dauphin – Downtown Cluster – 6-year average natural gas consumption

		natural gas					
		Parkland Recreation Complex/ Kin Aquatic Centre		*Credit Union Place*		*Rotary Arena Ice Skating Rink*	
		m^3	*MWh*	*m^3*	*MWh*	*m^3*	*MWh*
year	2018	31,491	336	176,404	1,882	10,211	109
	2019	32,009	341	151,622	1,617	9,374	100
	2020	16,750	179	147,506	1,573	9,338	100
	2021	18,068	193	156,651	1,671	9,419	100
	2022	26,264	280	202,833	2,164	12,245	131
	2023	25,019	267	188,615	2,012	12,063	129
averages:		*24,934*	*266*	*170,605*	*1,820*	*10,442*	*111*

Table 40: Dauphin – Downtown Cluster – average monthly natural gas consumption – 2018 to 2023

		natural gas					
		Parkland Recreation Complex/ Kin Aquatic Centre		*Credit Union Place*		*Rotary Arena Ice Skating Rink*	
		m^3	*MWh*	*m^3*	*MWh*	*m^3*	*MWh*
month	Jan	2,970	32	25,175	269	2,130	23
	Feb	5,020	54	25,517	272	1,876	20
	Mar	2,706	29	23,930	255	1,974	21
	Apr	3,092	33	21,179	226	1,273	14
	May	1,702	18	11,642	124	722	8
	Jun	545	6	5,722	61	277	3
	Jul	441	5	3,982	42	24	0
	Aug	291	3	3,527	38	42	0
	Sep	458	5	5,046	54	69	1
	Oct	1,758	19	9,085	97	165	2
	Nov	1,435	15	15,903	170	954	10
	Dec	*4,515*	*48*	*19,896*	*212*	*935*	*10*
annual:		*24,934*	*266*	*170,605*	*1,820*	*10,442*	*111*

Table 41: Dauphin – Downtown Cluster – 6-year average electricity consumption [20]

		electricity MWh		
		Parkland Recreation Complex/ Kin Aquatic Centre	*Credit Union Place*	*Rotary Arena Ice Skating Rink*
year	2018	2,674		277
	2019	2,684		300
	2020	2,392		290
	2021	2,151		217
	2022	2,657		305
	2023	2,654	19	317
averages:		*2,535*	*19*	*284*
			average total:	***2,839***

Table 42: Dauphin – Downtown Cluster – average monthly electricity consumption – 2018 to 2023

		electricity MWh			
		Parkland Recreation Complex/ Kin Aquatic Centre	*Credit Union Place*	*Rotary Arena Ice Skating Rink*	*totals*
month	Jan	260	1.2	39	*300*
	Feb	245	3.3	37	*284*
	Mar	229	2.9	37	*269*
	Apr	218	2.7	27	*248*
	May	146	1.1	6	*152*
	Jun	145	0.9	5	*151*
	Jul	141	2.1	7	*149*
	Aug	207	0.7	6	*214*
	Sep	228	0.9	5	*235*
	Oct	231	0.8	33	*264*
	Nov	241	1.2	41	*283*
	Dec	245	1.3	42	*288*
annual:		*2,535*	*19*	*284*	***2,839***

[20] The electrical data from Credit Union Place is the best data available, but it cannot be considered as reliable as the electrical data from the other facilities. First, and most important, Credit Union electrical data is available for calendar year 2023, while the other facilities have data for six years. Second, the electrical data indicates that much less electricity is used at this facility than would be expected. The best available interpretation of this data is that the electrical service to the Parkland Recreation Complex/Kin Aquatic Centre also serves Credit Union Place.

1.2.2.2 RAILWAY CLUSTER

Table 43: Dauphin – Railway Cluster – 6-year average natural gas consumption

		natural gas					
		CNR Place		Watson Art Centre		Dauphin Fire Department	
		m^3	MWh	m^3	MWh	m^3	MWh
year	2018	20,592	220	29,188	311	20,567	219
	2019	18,824	201	27,313	291	20,279	216
	2020	17,665	188	26,787	286	19,020	203
	2021	17,539	187	24,557	262	16,733	178
	2022	22,165	236	30,526	326	17,212	184
	2023	22,145	236	22,307	238	14,148	151
averages:		*19,822*	*211*	*26,780*	*286*	*17,993*	*192*

Table 44: Dauphin – Railway Cluster – average monthly natural gas consumption – 2018 to 2023

		natural gas					
		CNR Place		Watson Art Centre		Dauphin Fire Department	
		m^3	MWh	m^3	MWh	m^3	MWh
month	Jan	3,518	38	5,611	60	3,519	38
	Feb	3,221	34	5,416	58	3,179	34
	Mar	2,977	32	4,437	47	2,960	32
	Apr	2,202	23	2,878	31	1,884	20
	May	1,213	13	1,084	12	1,002	11
	Jun	668	7	39	0	394	4
	Jul	36	0	16	0	28	0
	Aug	36	0	16	0	97	1
	Sep	373	4	305	3	281	3
	Oct	1,149	12	1,248	13	754	8
	Nov	1,928	21	2,480	26	1,832	20
	Dec	*2,502*	*27*	*3,248*	*35*	*2,381*	*25*
annual:		*19,822*	*211*	*26,780*	*286*	*18,311*	*195*

Table 45: Dauphin – Railway Cluster – 6-year average electricity consumption

		electricity		
		MWh		
		CNR Place	Watson Art Centre	Dauphin Fire Department
year	2018	117	54	82
	2019	114	48	84
	2020	92	33	80
	2021	89	41	76
	2022	89	44	77
	2023	103	59	69
averages:		*101*	*47*	*78*
			average total:	***225***

Table 46: Dauphin – Railway Cluster – average monthly electricity consumption – 2018 to 2023

		electricity			
		MWh			
		CNR Place	*Watson Art Centre*	*Dauphin Fire Department*	*totals*
month	Jan	12	6	11	*29*
	Feb	10	6	9	*25*
	Mar	10	5	9	*24*
	Apr	8	5	7	*20*
	May	7	3	5	*16*
	Jun	7	2	5	*14*
	Jul	8	2	5	*15*
	Aug	8	2	5	*15*
	Sep	6	2	4	*12*
	Oct	7	3	4	*15*
	Nov	9	4	7	*19*
	Dec	8	5	8	*21*
	annual:	*101*	*47*	*78*	***225***

1.2.2.3 VERMILLION GROWERS GREENHOUSE

Table 47: Dauphin – Vermillion Growers Greenhouse – natural gas – since beginning operations in September 2023

			natural gas			
year	*month*	*days requiring heat*	m^3	m^3/day	kWh	kWh/day
2023	Sep	25	3,146	126	33,557	1,342
	Oct	31	7,839	253	83,616	2,697
	Nov	30	10,185	340	108,640	3,621
	Dec	31	11,010	355	117,440	3,788
2024	Jan	31	11,915	384	127,093	4,100
	Feb	29	9,674	334	103,189	3,558
	Mar	31	9,575	309	102,133	3,295
	Apr	25	5,849	234	62,389	2,496

Table 48: Dauphin – Vermillion Growers Greenhouse – natural gas – since beginning operations in September 2023

		electricity	
year	*month*	MWh	*kWh/day*
2023	Sep	30	1,000
	Oct	41	1,236
	Nov	50	1,800
	Dec	60	2,000
2024	Jan	62	1,931
	Feb	55	1,903
	Mar	77	2,021

1.2.3 *Renewable Energy Recommendations*

These recommendations will reduce natural gas consumption in Dauphin's target buildings by approximately half.

1.2.3.1 DOWNTOWN CLUSTER

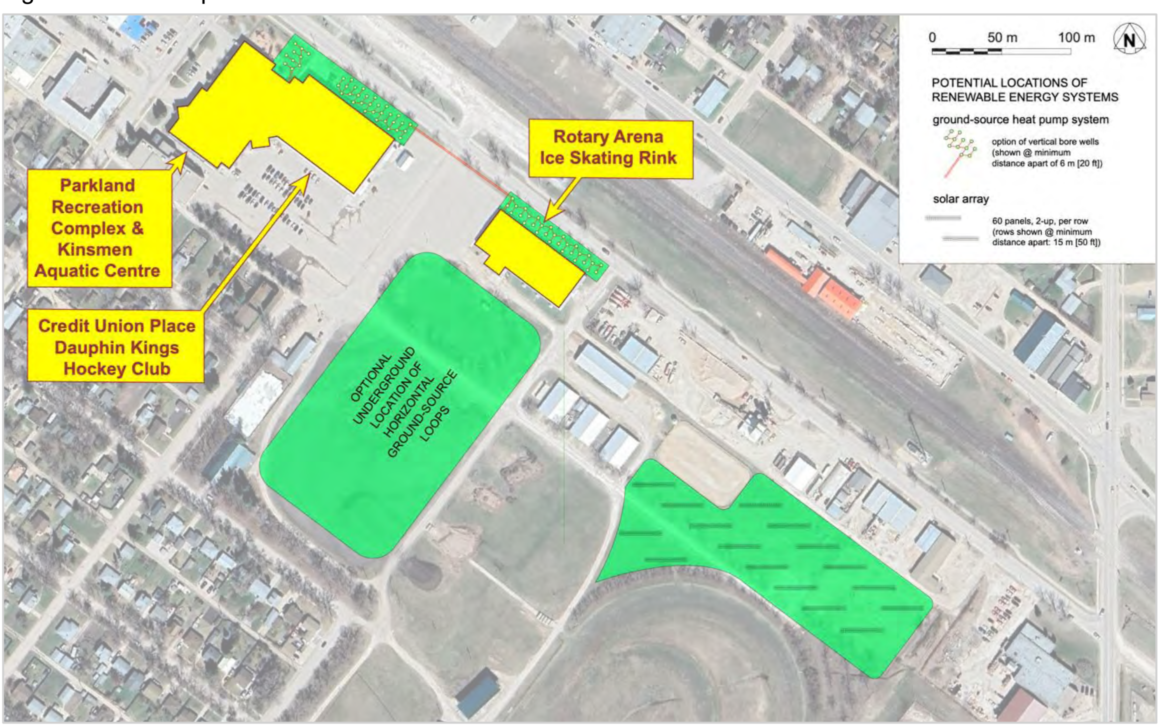
Currently, heat is extracted from ice surfaces in Credit Union Place and the Rotary Skating Rink, as well as a small curling rink in the Recreation Complex. In each case, this heat is discharged into the air. The water for the pool and the hot tub is heated by natural gas. Energy for the HVAC systems in all these buildings are powered by electricity and natural gas.

The greatest opportunity for energy use improvement in the Downtown Cluster is to link the extraction of heat from the three ice surfaces with the injection of heat into the water for the pool and hot tub in the Kin Aquatic Centre.

Recommendation for Dauphin's Downtown Cluster:

- *Install a district Ground-Source Heat Pump system connecting the cooling systems for all the ice surfaces, the heating system for the swimming pool and hot tub water, and the HVAC systems for all three buildings.*
- *Install a ground-based Solar Array.*
- *Investigate Demand-Side Management retrofits all the buildings in the Downtown Cluster with Efficiency Manitoba.*

Figure 25: Dauphin – Downtown Cluster – with renewables[21]



[21] This map shows both horizontal and vertical ground loop options.

Heat Pump System

Table 49: Dauphin – Downtown Cluster – Ground-Source Heat Pump system – capacity, cost & space requirements

system			***capital cost (installed pricing)***			***horizontal loop space requirement***	
capacity		*Coefficient of Performance*	*heat pump systems*	*horizontal loops*	*total*		
kW	*tons*					*m²*	*ft²*
175	50	3.5	$315,000	$192,500	***$507,500***	13,000	140,000

The recommended ground-source heat pump (GSHP) system will extract the heat from ice surfaces, store it in the ground if not needed immediately, and use it to heat the water for the pool and hot tub, as well as heating the air in the Downtown Cluster buildings in winter. The GSHP will also be able to provide air conditioning to these buildings as needed.

Background information on ice facilities—and the role of GSHPs in reducing energy consumption and operating costs—can be found in the appendix to this study Understanding Energy Use in Ice Facilities. Preliminary estimates indicate that more heat can be extracted from the ice than will be needed to heat the pool, the hot tub, and the air in the buildings. This provides an opportunity to add more buildings to this heat pump system at later stages.

Solar Array

Table 50: Dauphin – Downtown Cluster – Solar Array[22]

# panels:	960	row width:	30	panels
configuration:	2 up		34	m
# rows:	16		112	ft
production capacity:		per panel:	0.535	kW
		array total:	514	kW
capital cost:		per installed kW:	$1,900	
		solar array total:	$975,840	

Dauphin has the highest population density of the seven participating communities. Not surprisingly, this means downtown Dauphin has less open, unused space than the other communities. As a result, finding space for a solar array is a challenge.

The proposed location for the solar array is one of several possibilities.[23] Unused space long the railway may also be feasible and should be explored.

[22] It may be that the City of Dauphin will not be able to secure a subsidy or grant large enough to make a solar array of this size feasible at this stage. If that is the case, it is recommended that the City install a solar array that is large as possible within the funds available. At a later stage, if more funding can be secured, expanding an existing solar array will be relatively straightforward.

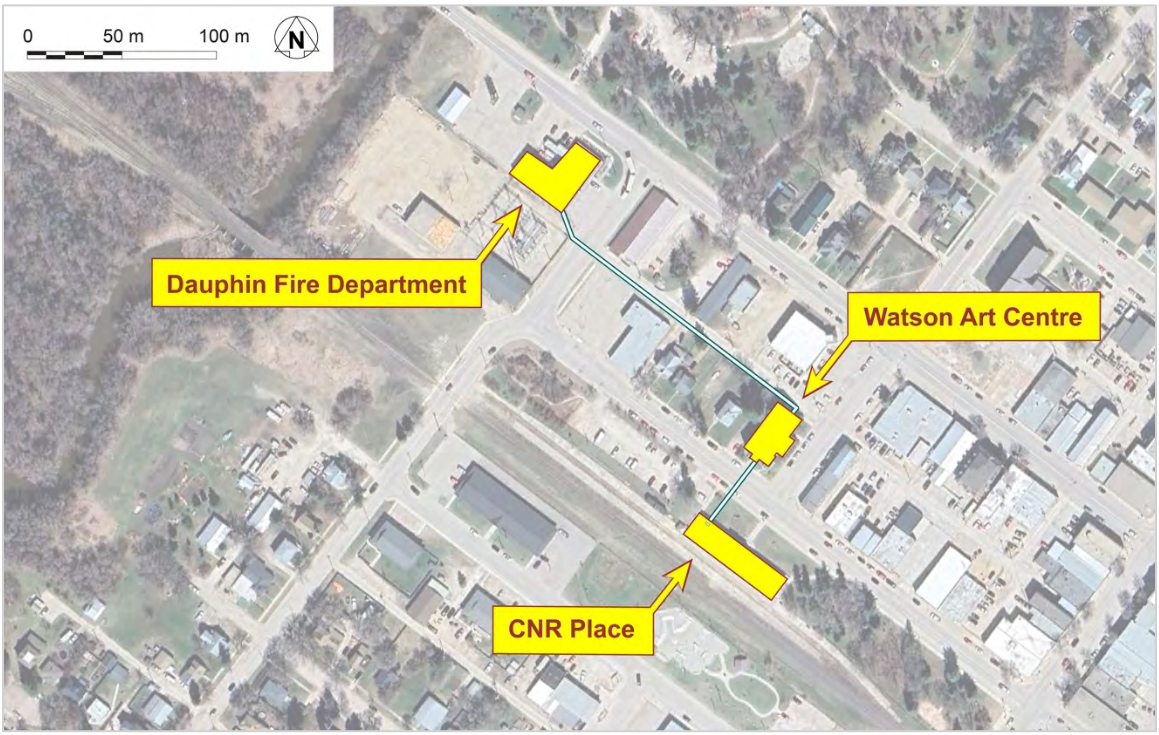
[23] It is probably worth noting that the proposed location for the solar array includes the area currently used as a dog park. A solar array can fit in well with a dog park.

1.2.3.2 RAILWAY CLUSTER

Recommendations for Dauphin's Railway Cluster:

- *Install a Biomass system, connecting all three buildings through an underground district loop.*
- *Install an Air-Source Heat Pump air conditioning system in the Walker Art Centre*
- *Investigate Demand-Side Management retrofits all three buildings in this Cluster with Efficiency Manitoba.*

Figure 26: Dauphin – Railway Cluster – with renewables



Biomass System

Table 51: Dauphin – Railway Cluster – heating energy & biomass requirements

		natural gas currently consumed		average kWh required (estimating existing natural gas systems are, on average 75% efficient)			biomass required
		m^3	MWh	/month	/day	/hr	tonnes
month	Jan	12,648	135	101,188	3,264	136	20
	Feb	11,816	126	94,531	3,346	139	19
	Mar	10,374	111	82,992	2,677	112	17
	Apr	6,964	74	55,715	1,857	77	11
	May	3,298	35	26,387	851	35	5
	Jun	1,101	12	8,809	294	12	2
	Jul	80	1	642	21	1	0
	Aug	148	2	1,186	38	2	0
	Sep	959	10	7,675	256	11	2
	Oct	3,150	34	25,203	813	34	5
	Nov	6,241	67	49,924	1,664	69	10
	Dec	8,131	87	65,049	2,098	87	13
annual totals:		*64,913*	*692*	*519,300*			*103*
				averages:	*1,432*	*60*	

Table 52: Dauphin – Railway Cluster – recommended biomass fuel

material		energy density		maximum cost
source	*form*	*kWh/kg*	*MWh/tonne*	*per tonne*
crop by-products & waste	pelletized	5.0	5.0	$100

Table 53: Dauphin – Railway Cluster – recommended biomass system

capacity	system efficiency	net heat production	capital cost (installed pricing)	
MW		*MWh/tonne*	*per kW*	*total*
500	75%	3.8	$400	$200,000

Table 54: Dauphin – Railway Cluster – biomass components – estimated capital costs (installed pricing)

component	capital cost (installed pricing)
biomass system	$200,000
district loops	$200,000
total:	*$400,000*

The boiler at the heart of this biomass system should be located in the available space in the lower level of CNR Place. A system of the size recommended for this Cluster (500 kW) will occupy roughly 4 m^2 (45 ft^2).

Figure 28: Typical Smaller Flex-Fuel Biomass System[24]

This boiler can heat CNR Place and, through an underground district loop, heat the other two buildings in the Railway Cluster—the Walker Art Centre and the Dauphin Fire Department—as well. The current heating systems in each of these buildings should remain in place as backups, with the biomass-based district loop tied into each building's heating system through heat exchangers.

Waste agricultural biomass—perhaps from hemp production—should be pelletized and used as fuel.

[24] Source: Smart Heating Technology. (n.d.). *Automatic Biomass Boiler: Smart 400 kW.* https://www.smartheating.cz/en/smart-400-kw/ (Note: Inclusion of an image in this study is not to be considered an endorsement of a product. It is included for information purposes only.)

Like the system providing supplemental heat to the University of Winnipeg natural gas boilers, the fuel can be delivered via a small silo outside CNR Place.

Figure 29: University of Winnipeg Biomass System Pellet Fuel Silo

Unlike the silo at the University of Winnipeg, the silo beside CNR Place should feature prominent signage heralding Dauphin's innovation in using local waste biomass to replace natural gas for building heat.

Demand-Side Management

The building in most urgent need of a Demand-Size Management retrofit is the Dauphin Fire Department. This is a cinder-block building; its walls have only minimal insulation value.

Air-Source Heat Pump

The building in most urgent need of air conditioning is the Walker Art Centre.

Table 55: Dauphin – Railway Cluster – Walker Art Centre - air-source heat pump system – capacity & cost

system			***capital cost (installed pricing)***		
capacity		*Coefficient of*	*heat pump*		
kW	*tons*	*Performance*	*systems*	*installation*	*total*
87	25	3.5	$156,600	$43,500	***$200,100***

Because it lacks air conditioning, this facility is missing out on significant potential revenue. The building is in demand as a wedding venue, but currently must turn down all summer wedding rental opportunities because the building is too hot in summer.

The live theatre space in the Walker Art Centre would also benefit significantly from air conditioning. The theatre lights heat up the audience space and the stage, and there is currently no way to dissipate this heat. The Board, staff & volunteers are currently fundraising to replace their incandescent stage lighting with LED stage lighting, which will help, but will not be sufficient to make the space comfortable for performers and audiences in warmer weather.

1.2.4 *Vermillion Growers Greenhouse*

Recommendations for Vermillion Growers Greenhouse:

- *Install a Biomass system, integrated into the existing heating loop system serving the greenhouse.*
- *A Solar Array is recommended, but as a lower priority than the Biomass heating system.*

Biomass System

Table 56: Dauphin – Vermillion Growers Greenhouse – past heating energy requirements[25]

		natural gas currently consumed		average kWh required (estimating natural gas system as 85% efficient)			biomass required
		m³	MWh	/month	/day	/hr	tonnes
month	Jan	11,915	127	108,029	3,485	145	37
	Feb	9,674	103	87,711	3,105	129	30
	Mar	9,575	102	86,813	2,800	117	30
	Apr	5,849	62	53,031	1,768	74	18
	May	2,000	21	18,133	585	24	6
	Jun	0	0	0	0	0	0
	Jul	0	0	0	0	0	0
	Aug	0	0	0	0	0	0
	Sep	3,146	34	28,524	951	40	10
	Oct	7,839	84	71,074	2,293	96	24
	Nov	10,185	109	92,344	3,078	128	31
	Dec	11,010	117	99,824	3,220	134	34
annual totals:		*71,193*	*759*	*645,483*			*220*
				averages:	*1,774*	*74*	

Table 57: Dauphin – Vermillion Growers Greenhouse – recommended biomass fuel

material		energy density		maximum cost
source	form	kWh/kg	MWh/tonne	per tonne
woody biomass	chipped	2.9	2.9	$100

Table 58: Dauphin – Vermillion Growers Greenhouse – recommended biomass system

capacity	system efficiency	net heat production	capital cost (installed pricing)	
MW		MWh/tonne	per kW	total
5	75%	2.2	$400	$2,000,000

[25] Data for Jan to Apr are 2024 actuals. Data for Sep to Dec are 2023 actuals. Because at least some of this was a start-up phase, it can be expected that numbers for 2024 will probably be higher. Data for May to August was not available because the facility was not operating then. Numbers in blue text are estimates only.

Table 59: Dauphin – Vermillion Growers Greenhouse – biomass system components – estimated capital costs (installed pricing)

component	***capital cost (installed pricing)***
biomass system	$2,000,000
chipping equipment	$400,000
total:	*$2,400,000*

Table 60: Dauphin – Vermillion Growers Greenhouse – Solar Array

# panels:	400		row width:	50	panels
configuration:	2	up		57	m
# rows:	4			186	ft
production capacity:			per panel:	0.535	kW
			array total:	214	kW
capital cost:			per installed kW:	$1,900	
			solar array total:	$406,600	

Table 61: Dauphin – Vermillion Growers Greenhouse – estimate of average annual electrical costs & savings

	financials				
	cost for Manitoba Hydro electricity:				$0.10 /kWh
	price paid by Mb Hydro for excess energy:				$0.05 /kWh
	Manitoba Hydro billings				***Manitoba Hydro payments***
month	*current consumption*	*additional draw by biomass system*	*with both biomass system & solar array*	*billing change from status quo*	
Jan	$6,180	$216	$5,015	-$1,165	$0
Feb	$5,520	$175	$3,868	-$1,652	$0
Mar	$7,680	$174	$5,376	-$2,304	$0
Apr	$6,000	$106	$2,904	-$3,096	$0
May	$3,000	$36	$9	-$2,991	$0
Jun	$1,000	$0	-$1,909	-$2,909	$955
Jul	$1,000	$0	-$2,271	-$3,271	$1,135
Aug	$2,000	$0	-$1,049	-$3,049	$524
Sep	$3,000	$57	$408	-$2,592	$0
Oct	$4,080	$142	$2,114	-$1,966	$0
Nov	$5,040	$185	$3,757	-$1,283	$0
Dec	$6,000	$200	$4,970	-$1,030	$0
	$50,500	*$1,291*	*$23,192*	*-$27,308*	*$2,615*
				t annual electricity cost:	***$20,578***
				annual savings:	*$29,922*
				cost reduction:	***-59%***

The biomass system initially installed needs to be expandable to at least four times the size recommended for this first stage, to accommodate future planned growth of the greenhouse.

Because the current natural-gas-based heating system for the greenhouse already has a central buffer tank and heating loops distributed throughout the greenhouse, integrating a biomass boiler system will be simple and straightforward. The natural gas system can remain as a backup, with a biomass heating system becoming the main source of heat.

Table 62: Dauphin – Vermillion Growers Greenhouse – heating energy requirements to date[26]

		natural gas currently consumed		average kWh required (estimating natural gas system as 85% efficient)			biomass required
		m³	MWh	/month	/day	/hr	tonnes
month	Jan	11,915	127	108,029	3,485	145	37
	Feb	9,674	103	87,711	3,105	129	30
	Mar	9,575	102	86,813	2,800	117	30
	Apr	5,849	62	53,031	1,768	74	18
	May	2,000	21	18,133	585	24	6
	Jun	0	0	0	0	0	0
	Jul	0	0	0	0	0	0
	Aug	0	0	0	0	0	0
	Sep	3,146	34	28,524	951	40	10
	Oct	7,839	84	71,074	2,293	96	24
	Nov	10,185	109	92,344	3,078	128	31
	Dec	11,010	117	99,824	3,220	134	34
annual totals:		*71,193*	*759*	*645,483*			*220*
				averages:	*1,774*	*74*	

Solar Array

Table 63: Dauphin – Vermillion Growers Greenhouse – Solar Array

# panels:	400	row width:	50 panels
configuration:	2 up		57 m
# rows:	4		186 ft
production capacity:		per panel:	0.535 kW
		array total:	214 kW
cost:		per installed kW:	$1,900
		solar array total:	$406,600

The solar array is recommended as a lower priority than the biomass system for at least two reasons:

- It will probably be difficult to increase the supply of natural gas to the Dauphin area significantly. For this facility to expand as planned, the need to ensure adequate heat is probably a more critical variable than the need for increased electricity.
- The longer-term solution for the electricity needs for the greenhouse is more likely to be wind turbines than a solar array.
    - Investing in a solar array now will enable some expansion, but a more thorough cost/benefit analysis is needed before a large solar array is installed rather than a wind farm.
    - A full-sized wind farm (in the 100 MW range) is almost certainly feasible in the Dauphin area. It may be more advantageous to Vermillion Growers and their investors to become part-investors in a larger wind farm than to develop a small one on their own.

[26] Data for Jan to Apr are 2024 actuals. Data for Sep to Dec are 2023 actuals; because at least some of this was a start-up phase, it can be expected that numbers for 2024 will probably be higher. Greyed-out boxes indicate this data is not available. The numbers in these boxes in blue text are estimates only.

- Another option worth exploring is an Organic Rankine Cycle (ORC) Combined Heat & Power (CHP) system. These can convert approximately 20% of the energy produced from burning biomass into electricity. This is a mature, commercially proven technology. A careful cost-benefit analysis will be needed to compare multiple wind turbines with an ORC system. Given the scale of the greenhouse when it is fully built out, both a wind farm and an ORC system may be the best long-term solution.

1.2.4.1 NOTES ON DAUPHIN RECOMMENDATIONS

Ideally, the Railway Cluster and the Vermillion Growers greenhouse should use the same fuel, from the same source. This will:

- reduce costs
- simplify deliveries
- help develop and sustain a viable biomass fuel industry in the Dauphin area

Follow-up stages should include:

➢ *Additional buildings should be considered for integration into the Ground-Source Heat Pump system in the Downtown Cluster.*

- The energy required to keep the ice surfaces frozen will almost certainly produce more heat than can be consumed by the hot water for the pool and hot tub, and by the HVAC systems for the three buildings in the Downtown Cluster. This means that there will be "free" heat available for other buildings.
- Once a district loop is in the ground, adding more buildings is not difficult or expensive. If those buildings are owned by the City, this will reduce building heating costs. If they are not owned by the City, the heat could be sold or, for community organizations, provided as an in-kind "grant".

➢ *Additional buildings should be considered for integration into the Biomass system district loop in the Railway Cluster.*

- Once the Biomass boiler and the underground district loop are in place, the incremental cost of adding additional buildings is not difficult or expensive. These buildings can be charged for the heat supplied, which will offset any increase in biomass fuel consumption they cause.

The existing heating and cooling systems should remain.

- It is not recommended that the existing gas-fired boilers and the existing cooling systems be removed when new renewable heating and cooling systems are installed. Instead, the existing systems should be retained and used as backups.

1.2.5 *Effects of Renewable Energy Recommendations*

1.2.5.1 OVERALL EFFECTS

Table 64: Dauphin – Target Facilities – estimated energy use changes

	natural gas			biomass		electricity from Mb Hydro		totals	
	m^3	MWh	%	tonnes	MWh	MWh	%	MWh	%
Downtown Cluster	113,981	1,216	-45%			2,540	-11%	3,755	-25%
Railway Cluster	6,459	69	-90%	103	304	248	10%	621	-32%
Vermillion Growers	7,603	81	-90%	220	645	232	-54%	959	-27%
totals:	*120,441*	*1,366*	-65%	*323*	*950*	*3,019*	*-15%*	***5,335***	***-27%***

Table 65: Dauphin – Target Facilities – estimated annual GHG emissions reductions

	GHG emissons CO_2e tonnes/year			
	business as usual	if proposals go ahead	change	
Downtown Cluster	397	220	-177	-45%
Railway Cluster	124	12	-112	-90%
Vermillion Growers	146	15	-132	-90%
totals:	*668*	*247*	*-421*	*-63%*

Table 66: Dauphin – Target Facilities – estimated annual cost savings

	overall energy operating costs			
	business as usual	if proposals go ahead	change	
Downtown Cluster	*$355,973*	*$293,854*	*-$62,118*	*-17%*
Railway Cluster	*$45,132*	*$27,037*	*-$18,095*	*-40%*
Vermillion Growers	*$383,513*	*$304,591*	***-$78,922***	*-21%*
totals:	*$784,618*	*$625,483*	***-$159,135***	***-20%***

Table 67: Dauphin – Target Facilities – estimated annual self-generated energy

	biomass		electricity	increases in self-generated energy
	tonnes	MWh	MWh	MWh
Downtown Cluster			655	655
Railway Cluster	103	519	0	519
Vermillion Growers	220	645	273	919
totals:	*323*	*1,165*	*928*	***2,093***

1.2.5.2 DETAILS OF EFFECTS

Table 68: Dauphin – Target Facilities – natural gas – estimated annual cost savings

	natural gas — estimated savings			
	business as usual	if projects go ahead	change	
Downtown Cluster	$72,093	$40,548	-$31,545	-44%
Railway Cluster	$22,608	$2,261	-$20,347	-90%
Vermillion Growers	$26,609	$2,661	-$23,948	-90%
totals:	$121,310	$45,470	**-$75,841**	**-63%**

Table 69: Dauphin – Target Facilities – electricity – estimated annual cost savings

	electricity — estimated savings			
	business as usual	if projects go ahead	change	
Downtown Cluster	$283,880	$253,391	-$30,489	-11%
Railway Cluster	$22,524	$24,777	$2,252	10%
Vermillion Growers	$50,500	$23,192	-$27,308	-54%
totals:	$356,904	$301,360	**-$55,544**	**-16%**

Downtown Cluster

Table 70: Dauphin – Downtown Cluster – Ground Source Heat Pump – estimated effect on natural gas consumption & heating cost

	without heat pump system			with heat pump system			
	natural gas			heat pump CoP: 3.5		natural gas	
Month	m^3	kWh	kWh/hr	kWh/hr	kWh	kWh	m^3
Jan	30,275	322,937	434	175	130,200	192,737	18,069
Feb	32,413	345,738	510	175	118,650	227,088	21,289
Mar	28,610	305,168	410	175	130,200	174,968	16,403
Apr	25,544	272,474	378	175	126,000	146,474	13,732
May	14,066	150,042	202	175	130,200	19,842	1,860
Jun	6,545	69,811	97	97	69,811	0	0
Jul	4,446	47,426	64	64	47,426	0	0
Aug	3,860	41,176	55	55	41,176	0	0
Sep	5,573	59,445	83	83	59,445	0	0
Oct	11,008	117,422	158	158	117,422	0	0
Nov	18,293	195,124	271	175	126,000	69,124	6,480
Dec	25,346	270,362	363	175	130,200	140,162	13,140
annual totals:	205,980	2,197,125			1,226,730	970,395	90,975
		averages:	251		140		
annual cost:	$72,093					annual cost:	**$31,841**
						annual savings:	$40,252
						cost reduction:	**-56%**

Although the heat pump system recommended for Dauphin's Downtown Cluster has the same capacity as the one recommended for Brandon's Civic Services Cluster, the reduction in natural gas consumption is not exactly the same, because the heat is not used for the same purposes.

Table 71: Dauphin – Downtown Cluster – Solar Array & Ground-Source Heat Pump – estimated effect on electricity consumption

		electricity MWh				
		current consumption	additional draw by heat pump system	solar array production	net grid draw	
Month	Jan	300	37	28	310	3%
	Feb	284	34	40	279	-2%
	Mar	269	37	55	251	-7%
	Apr	248	36	74	210	-15%
	May	152	37	72	118	-23%
	Jun	151	20	70	101	-33%
	Jul	149	14	79	84	-43%
	Aug	214	12	73	153	-29%
	Sep	235	17	62	189	-19%
	Oct	264	34	47	251	-5%
	Nov	283	36	31	288	2%
	Dec	288	37	25	300	4%
annual averages:		*2,839*	*350*	*655*	***2,534***	***-11%***

Although the net electricity required from the grid is lower in the summer (when solar array production is up), it never goes negative. As a result, no net electricity is given back to the grid, so there are no net payments from Manitoba Hydro.

Table 72: Dauphin – Downtown Cluster – Solar Array & Ground-Source Heat Pump – estimated effect on electricity cost

		financials				
		cost for Manitoba Hydro electricity:				$0.10 /kWh
		price paid by Mb Hydro for excess energy:				$0.05 /kWh
		Manitoba Hydro billings				
		current consumption	additional draw by heat pump system	with both heat pump system & solar array	billing change from status quo	Mb Hydro payments
Month	Jan	$30,030	$3,720	$30,954	$925	$0
	Feb	$28,448	$3,390	$27,874	-$574	$0
	Mar	$26,939	$3,720	$25,128	-$1,810	$0
	Apr	$24,826	$3,600	$20,994	-$3,831	$0
	May	$15,249	$3,720	$11,790	-$3,459	$0
	Jun	$15,121	$1,995	$10,133	-$4,988	$0
	Jul	$14,938	$1,355	$8,442	-$6,495	$0
	Aug	$21,444	$1,176	$15,303	-$6,141	$0
	Sep	$23,454	$1,698	$18,931	-$4,522	$0
	Oct	$26,428	$3,355	$25,065	-$1,363	$0
	Nov	$28,252	$3,600	$28,772	$521	$0
	Dec	$28,756	$3,720	$30,005	$1,249	$0
annual averages:		*$283,880*	*$35,049*	*$253,391*	*-$30,489*	*$0*
					net annual electricity cost:	***$253,391***
					annual savings:	*$30,489*
					cost reduction:	***-11%***

Railway Cluster

Table 73: Dauphin – Railway Cluster – estimated biomass required

		natural gas currently consumed		average kWh required (estimating existing natural gas systems are, on average 75% efficient)			biomass required
		m³	MWh	/month	/day	/hr	tonnes
Month	Jan	12,648	135	101,188	3,264	136	20
	Feb	11,816	126	94,531	3,346	139	19
	Mar	10,374	111	82,992	2,677	112	17
	Apr	6,964	74	55,715	1,857	77	11
	May	3,298	35	26,387	851	35	5
	Jun	1,101	12	8,809	294	12	2
	Jul	80	1	642	21	1	0
	Aug	148	2	1,186	38	2	0
	Sep	959	10	7,675	256	11	2
	Oct	3,150	34	25,203	813	34	5
	Nov	6,241	67	49,924	1,664	69	10
	Dec	8,131	87	65,049	2,098	87	13
annual totals:		*64,913*	*692*	*519,300*			*103*
				averages:	*1,432*	*60*	

Vermillion Growers Greenhouse

Table 74: Dauphin – Vermillion Growers Greenhouse – estimated biomass required[27]

		natural gas currently consumed		average kWh required (estimating natural gas system as 85% efficient)			biomass required
		m³	MWh	/month	/day	/hr	tonnes
month	Jan	11,915	127	108,029	3,485	145	37
	Feb	9,674	103	87,711	3,105	129	30
	Mar	9,575	102	86,813	2,800	117	30
	Apr	5,849	62	53,031	1,768	74	18
	May	2,000	21	18,133	585	24	6
	Jun	0	0	0	0	0	0
	Jul	0	0	0	0	0	0
	Aug	0	0	0	0	0	0
	Sep	3,146	34	28,524	951	40	10
	Oct	7,839	84	71,074	2,293	96	24
	Nov	10,185	109	92,344	3,078	128	31
	Dec	11,010	117	99,824	3,220	134	34
annual totals:		*71,193*	*759*	*645,483*			*220*
				averages:	*1,774*	*74*	

[27] Because the greenhouse has been running for less than a year, there are some months for which there is not data. Those months are signified by the greyed-out boxes in this and the following two tables. The blue numbers are very rough estimates.

Table 75: Dauphin – Vermillion Growers Greenhouse – estimated effect on electricity consumption

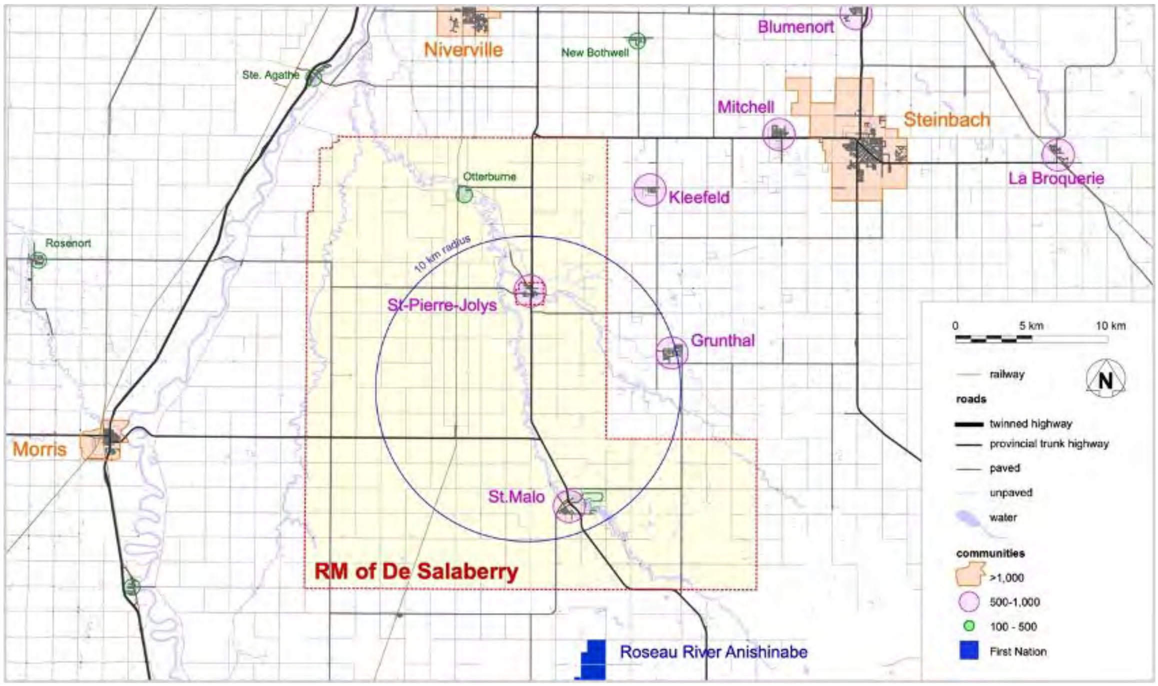
		electricity MWh				
		current consumption	additional draw by biomass system	solar array production	needed from MB Hydro: net grid draw	needed from MB Hydro: reduction
month	Jan	62	2.2	12	50	-19%
	Feb	55	1.8	17	39	-30%
	Mar	77	1.7	23	54	-30%
	Apr	60	1.1	31	29	-52%
	May	30	0.4	30	0	-100%
	Jun	10	0.0	29	-19	-291%
	Jul	10	0.0	33	-23	-327%
	Aug	20	0.0	30	-10	-152%
	Sep	30	0.6	26	4	-86%
	Oct	41	1.4	20	21	-48%
	Nov	50	1.8	13	38	-25%
	Dec	60	2.0	10	50	-17%
annual averages:		505	13	273	**232**	**-54%**

Table 76: Dauphin – Vermillion Growers Greenhouse – Solar Array & Biomass System – estimated effect on electricity cost

		financials				
		cost for Manitoba Hydro electricity:				$0.10 /kWh
		price paid by Mb Hydro for excess energy:				$0.05 /kWh
		Manitoba Hydro billings: current consumption	additional draw by biomass system	billling with both biomass system & solar array	billing change from status quo	**Manitoba Hydro payments**
month	Jan	$6,180	$216	$2,508	-$3,672	$0
	Feb	$5,520	$175	$1,934	-$3,586	$0
	Mar	$7,680	$174	$2,688	-$4,992	$0
	Apr	$6,000	$106	$1,452	-$4,548	$0
	May	$3,000	$36	$4	-$2,996	$0
	Jun	$1,000	$0	$0	-$1,000	$955
	Jul	$1,000	$0	$0	-$1,000	$1,135
	Aug	$2,000	$0	$0	-$2,000	$524
	Sep	$3,000	$57	$204	-$2,796	$0
	Oct	$4,080	$142	$1,057	-$3,023	$0
	Nov	$5,040	$185	$1,878	-$3,162	$0
	Dec	$6,000	$200	$2,485	-$3,515	$0
annual averages:		$50,500	$1,291	$14,211	-$36,289	$2,615
					net annual electricity cost:	**$11,596**
					annual savings:	$38,904
					cost reduction:	**-77%**

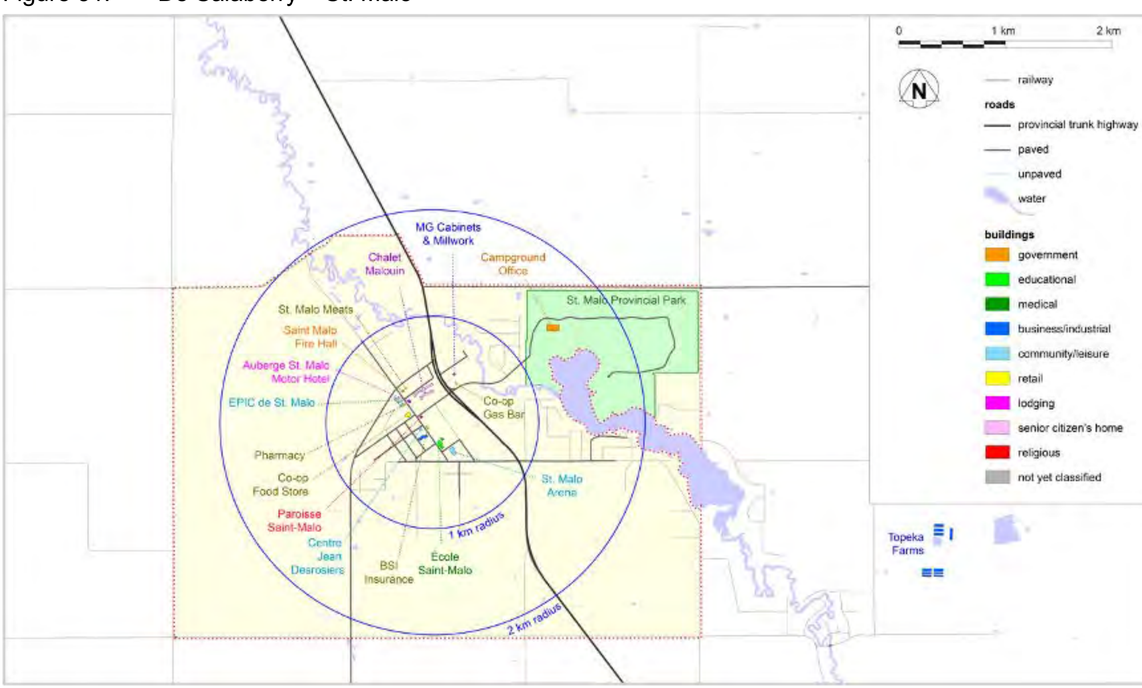
1.3 DE SALABERRY – Target Building – Description & Recommendations

Figure 30: Communities in & near RM of De Salaberry



RM of De Salaberry is concentrating its focus in this study on the community of St. Malo. There are 5 to 10 community buildings in St. Malo that could consider renewable energy retrofits.

Figure 31: De Salaberry – St. Malo



The RM of De Salaberry contacts have prioritized the St. Malo Arena (De Salaberry Recreation Facility) for this study. De Salaberry has secured funding to upgrade and expand this building and the energy enhancements can be integrated into that upgrade.

1.3.1 *Target Building*

Figure 32: De Salaberry – St. Malo – target building – satellite view

Figure 33: De Salaberry – St. Malo – target building – map view

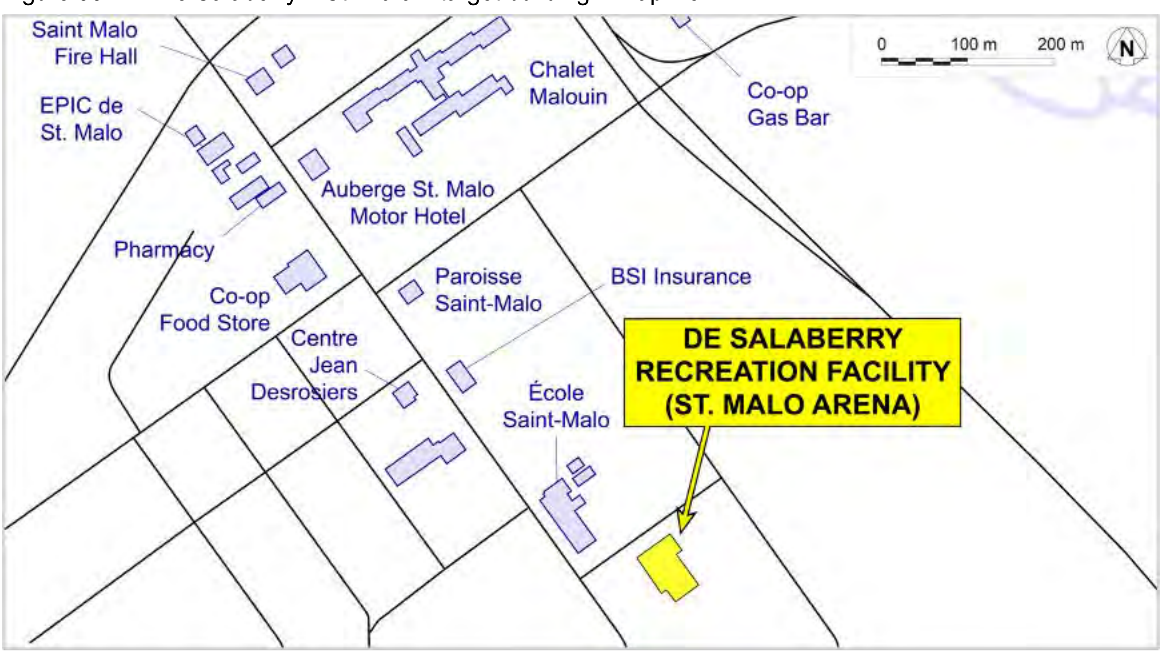


Table 77: De Salaberry – St Malo – target building

Facility					
name	*street address*	latitude	longitude	*web address*	*owner*
De Salaberry Recreation Facility (St. Malo Arena)	10 Rue Chouinard	49.312	-96.949	https://rmdesalaberry.mb.ca/m/st-malo-arena	RM of De Salaberry

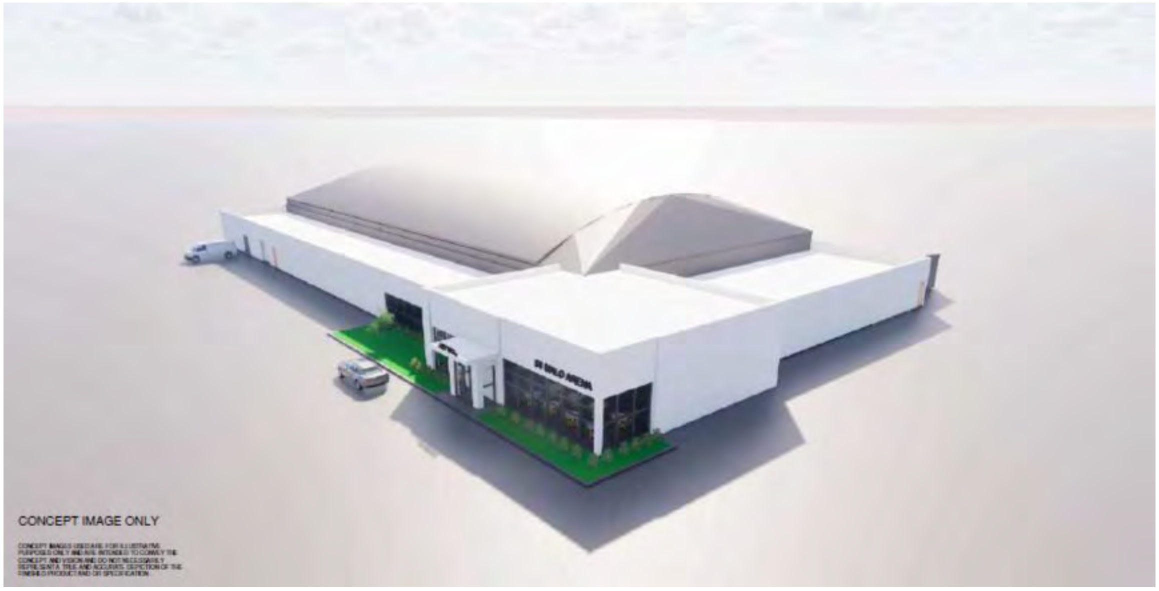
Figure 34: St. Malo Arena (De Salaberry Recreation Facility) – street view

Built in 1975 by local people, the St. Malo Arena has seen significant upgrades over the last 50 years. The facility has been enlarged, upgraded to artificial ice, and had a cement floor installed to accommodate year-round activities.

More recently, the ice plant has been upgraded, with dehumidifiers and heat exchange units installed.[28] An announcement of future upgrades has been made, but details are not yet available.

[28] RM of De Salaberry. (n.d.). *History*. De Salaberry Recreation Facility. https://rmdesalaberry.mb.ca/m/st-malo-arena/history.

Figure 35: Concept Design for the De Salaberry Recreation Facility (St. Malo Arena)[29]



[29] RM of De Salaberry. (n.d.). *Facility Renovations*. De Salaberry Recreation Facility. https://rmdesalaberry.mb.ca/m/st-malo-arena/advertising

1.3.2 *Current Energy Use*

Table 78: De Salaberry Recreation Facility – monthly energy use – January 2021 to January 2024

		natural gas		electricity
year	*month*	*m³*	*kWh*	*kWh*
2021	Jan	295	3,084	1,429
	Feb	1,540	16,114	8,185
	Mar	1,155	12,086	9,290
	Apr	1,024	10,721	6,749
	May	127	1,332	7,286
	Jun	99	1,031	4,086
	Jul	0	0	3,234
	Aug	21	221	3,612
	Sep	373	3,907	4,663
	Oct	1,250	13,081	8,552
	Nov	1,443	15,107	12,494
	Dec	2,681	28,057	16,771
2022	Jan	2,193	22,953	9,423
	Feb	1,784	18,677	13,659
	Mar	1,713	17,931	37,745
	Apr	1,974	20,661	11,287
	May	757	7,925	5,995
	Jun	169	1,774	3,982
	Jul	60	628	3,871
	Aug	34	355	3,784
	Sep	295	3,083	4,724
	Oct	834	8,730	17,824
	Nov	1,260	13,189	47,744
	Dec	1,280	13,393	41,444
2023	Jan	1,891	19,789	42,864
	Feb	1,849	19,358	46,550
	Mar	1,787	18,701	51,774
	Apr	1,380	14,441	19,089
	May	110	1,149	9,865
	Jun	98	1,021	11,746
	Jul	43	448	12,908
	Aug	67	706	17,978
	Sep	414	4,332	62,056
	Oct	1,120	11,719	67,221
	Nov	1,364	14,282	60,412
	Dec	1,760	18,423	55,363
2024	Jan	1,783	18,659	54,444

While the energy use shows a clear pattern—increased consumption in winter and decreased consumption in summer—the variation between years is also striking (This variation between years may be due, in part, to reduced activities during Covid and increased activities in 2023 with the installation of the new ice plant.)

Table 79: De Salaberry Recreation Facility – yearly energy use – 2021 to 2023

	natural gas		electricity
year	m^3	kWh	kWh
2021	10,007	104,741	86,351
2022	12,353	124,610	201,483
2023	11,882	127,173	457,827

Given that this facility is scheduled for a signficant rebuild and, once this rebuild it complete, can be expected to be used more, the 2023 data is likely to be a more reliable indicator of future consumption than either 2021 or 2022, so the 2023 data is used as the benchmark for this study.

Table 80: De Salaberry Recreation Facility – energy use – 2023

		natural gas		electricity
		m^3	MWh	MWh
Month	Jan	1,891	20	43
	Feb	1,849	20	47
	Mar	1,787	19	52
	Apr	1,380	15	19
	May	110	1	10
	Jun	98	1	12
	Jul	43	0	13
	Aug	67	1	18
	Sep	414	4	62
	Oct	1,120	12	67
	Nov	1,364	15	60
	Dec	1,760	19	55
	totals:	*11,882*	*127*	*458*

The natural gas used to heat the building. The electricity is used for multiple purposes, including:

- heating potable water
- air conditioning
- chilling the ice surface, including running pumps and compressors
- lighting over the ice surface and for the building generally
- office equipment, refrigerators

Because the electricity is not separately metered for each of these purposes, it is not possible to know with certainty what percentage goes to what purpose. However, given the research into similar facilities, it is possible to make a reasonable estimate.

Table 81: De Salaberry Recreation Facility – estimated electricity demands, by purpose & month

		electricity purpose					
		MWh					
		water heating	*space cooling*	*ice cooling*	*lighting*	*auxillary equipment*	totals
month	Jan	2.7	0.0	37	2.4	0.8	43
	Feb	2.7	0.0	41	2.1	0.8	47
	Mar	2.9	0.0	46	1.8	0.8	52
	Apr	2.8	0.1	14	1.5	0.8	19
	May	2.7	5.1	0	1.2	0.8	10
	Jun	2.7	7.2	0	1.1	0.8	12
	Jul	2.7	8.2	0	1.1	0.8	13
	Aug	2.7	7.2	6	1.4	0.8	18
	Sep	2.7	2.7	54	1.6	0.8	62
	Oct	2.7	0.4	61	1.9	0.8	67
	Nov	2.7	0.0	55	2.3	0.8	60
	Dec	2.7	0.0	49	2.4	0.8	55
annual totals:		*32*	*30*	*366*	*20*	*10*	***458***
		7%	*7%*	*80%*	*4%*	*2%*	

These estimates can be used to calculate the effect on electricity consumption of adding the heat pump system and solar array, detailed below.

1.3.3 *Renewable Energy Recommendations*

Recommendation for De Salaberry Recreation Facility:

- *Install a district Ground-Source Heat Pump system to extract heat from the ice, and to provide both heating and cooling to provide.*
    - *A full feasibility study and system design for the heat pump system and its integration into the ice chilling system is essential.*
        - *This needs to be done as an integral part of the overall building redesign.*
        - *The overall building redesign may reveal considerable energy savings that can be achieved. This may enable the GSHP system to be smaller than recommended here, which would reduce its estimated capital cost.*
- *Install a small Solar Array*
    - *It is possible that this could be integrated into the redesign of the building.*
    - *The recommendations made in this study do not assume that this is feasible, so a separate solar array is proposed,*

Figure 36: De Salaberry – Recreation Facility (St. Malo Arena) – with renewables

1.3.3.1 GROUND-SOURCE HEAT PUMP

The most useful renewable energy addition to the De Salaberry Recreation Facility (the St Malo Arena) will be a ground-source heat pump (GSHP) system, pulling heat out of the ice and using it to heat the building.

A GSHP system will also provide air conditioning, where and when it is needed in the facility.

Table 82: De Salaberry – Recreation Facility (St. Malo Arena) – Ground-Source Heat Pump System– capacity, cost & space requirements

system			***installed pricing (capital cost)***			***horizontal loops space requirement***	
capacity		*Coefficient of Performance*	*heat pump systems*	*horizontal loops*	*total*		
kW	*tons*					*m²*	*ft²*
175	50	3.5	$315,000	$192,500	***$507,500***	13,000	140,000

The horizontal loops for the ground-source heat pump are shown as being located in the open field to the east of the school. These are buried underground, so they are not visible after they are installed. This would be the simplest and lowest-cost option. If that location cannot be used, vertical bore loops could be installed adjacent to the Recreation Facility, although vertical loops typically cost more to install than horizontal loops.

Background information on ice facilities—and the role of GSHPs in reducing energy consumption and operating costs—can be found in the appendix to this study Understanding Energy Use in Ice Facilities.

1.3.3.2 SOLAR ARRAY

This facility currently uses a large amount of electricity—nearly half a million kilowatt-hours in 2023—a solar array that would produce enough electricity to match that demand would require 660 panels and have a capital cost of more than $600,000.

This is probably not realistic. It is also unnecessary. Currently, most of that electricity is being used to keep the ice frozen. The recommended Ground-Source Heat Pump will do that work instead and provide heating for the building as a side-benefit.

A small solar array is proposed—48 panels with a total capital cost of approximately $50,000.

Table 83: De Salaberry – Recreation Facility (St. Malo Arena) – Solar Array

# panels:	48	row width:	12 panels
configuration:	2 up		14 m
# rows:	2		45 ft
	production capacity:	per panel:	0.535 kW
		array total:	26 kW
	capital cost:	per installed kW:	$1,900
		solar array total:	$48,792

The configuration proposed for the solar array—two rows with panels arranged 2-up—is the recommended arrangement for a ground-mount array, which could be located just south of the building.

- Because redesign of this facility is only at the concept stage, it may be that this solar array could be integrated into the new roof design instead. This is an option which should be raised with the architect.

- In those discussions, it may be determined that the solar array could be larger than is recommended here. If the solar array is integrated into a new roof, it should be as large as can reasonably fit into the design.

1.3.3.3 NOTES ON DE SALABERRY RECOMMENDATIONS

- *This study assumes that the designers of the revamped Recreation Facility (St. Malo Arena) are working with Efficiency Manitoba to maximize energy savings—and available subsidies—for the facility.*
- *Additional buildings need to be considered for integration into the GSHP system to balance the heating loads.*
  - *If the ice is kept frozen beyond for more than just the winter months, there will be more heat extracted from the ice than is needed to heat the building. If a GSHP system is unbalanced—in this case injecting more heat into the ground than is extracted to heat the building—the efficiency of the system will deteriorate over time.*
  - *This potential problem of system imbalance can be a solution for the heating needs of nearby buildings.*
    - *The nearest building that would benefit from this heat is École Saint-Malo, 100 meters to the northwest.*[30]
    - *Additional buildings close enough to benefit from a district heating system include:*
      - *Centre Jean Desrosiers (the new Manitoba Metis Federation building)*[31]
      - *Paroisse Saint-Malo (the nearby church and the home of the Blessed Margaret Pole Catholic Community)*[32]
      - *Chalet Malouin (retirement residence)*[33]
  - *Once a district loop is in the ground, adding more buildings is not difficult or expensive.*
- *Although beyond the scope of this study, the Chalet Malouin should be considered for an Energy Audit.*
  - Climate change projections indicate that building cooling requirements can be expected to double over the next 25 years. Because the Chalet Malouin provides housing for people 55+, it is essential that the Chalet's cooling systems be able to meet this significantly increased demand.

[30] *École Saint-Malo.* (2024). https://stmalo.rrvsd.ca

[31] *Céntre Jean Desrosiers.* (n.d.). https://www.facebook.com/southeastmmf/

[32] *Paroisse St-Malo/Blessed Margaret Pole Catholic Community.* (n.d.). Archdiocese de Saint-Boniface. https://www.archsaintboniface.ca/parish_info.html?lang=en&p=162#gsc.tab=0

[33] *Chalet Malouin Inc.* (n.d.) https://www.chaletmalouin.com

1.3.4 *Effects of Renewable Energy Recommendations*

1.3.4.1 OVERALL EFFECTS

Table 84: De Salaberry – Recreation Facility (St. Malo Arena) – estimated energy use changes

	natural gas			***electricity*** from MB Hydro		***reductions*** from outside sources	
	m^3	*MWh*	*%*	*MWh*	*%*	*MWh*	*%*
De Salaberry Recreation Facility (St. Malo Arena)	-11,882	-127	-100%	-339	-74%	-466	-80%

Table 85: De Salaberry – Recreation Facility (St. Malo Arena) – estimated annual GHG emissions reductions

	GHG emissons CO_2e *tonnes/year*			
	business as usual	*if project goes ahead*	*change*	
De Salaberry Recreation Facility (St. Malo Arena)	*23*	*0*	*-23*	*-100%*

Table 86: De Salaberry – Recreation Facility (St. Malo Arena) – estimated annual operating cost savings

	overall *operating costs*			
	business as usual	*if project goes ahead*	*change*	
De Salaberry Recreation Facility (St. Malo Arena)	$49,941	$11,859	-$38,083	-76%

Table 87: De Salaberry – Recreation Facility (St. Malo Arena) – estimated annual self-generated energy

	electricity	***increase*** *in self-generated energy*
	MWh	*MWh*
De Salaberry Recreation Facility (St. Malo Arena)	34	34

1.3.4.2 DETAILED EFFECTS

Table 88: De Salaberry – Recreation Facility (St. Malo Arena) – estimated annual natural gas cost savings

	natural gas			
	estimated savings			
	business as usual	*if project goes ahead*	*change*	
De Salaberry Recreation Facility (St. Malo Arena)	$4,159	$0	-$4,159	-100%

The natural gas currently consumed in this facility is used to provide space heating. Because it is recommended that this be replaced by a ground-source heat pump system (GSHP), the natural gas cost can be expected drop to $0.

Table 89: De Salaberry – Recreation Facility (St. Malo Arena) – estimated annual electricity cost savings

	electricity			
	estimated savings			
	business as usual	*if project goes ahead*	*change*	
De Salaberry Recreation Facility (St. Malo Arena)	$45,783	$11,859	-$33,924	-74%

Table 90: De Salaberry – Recreation Facility (St. Malo Arena) – estimated annual natural gas cost savings from addition of heat pump system

					with heat pump system						
	without heat pump system			*heat provided by heat pump system*		*electricity needed*	*still required from natural gas*			*change from status quo*
	natural gas					*CoP 3.5*				
month	m^3	*MWh*	*kWh/hr*	*kWh/hr*	*MWh*	*MWh*	*kWh/hr*	*MWh*	m^3	m^3
Jan	1,891	20	27	27	20	5.8	0	0	0	-1,891
Feb	1,849	20	29	29	20	5.6	0	0	0	-1,849
Mar	1,787	19	26	26	19	5.4	0	0	0	-1,787
Apr	1,380	15	20	20	15	4.2	0	0	0	-1,380
May	110	1	2	2	1	0.3	0	0	0	-110
Jun	98	1	1	1	1	0.3	0	0	0	-98
Jul	43	0	1	1	0	0.1	0	0	0	-43
Aug	67	1	1	1	1	0.2	0	0	0	-67
Sep	414	4	6	6	4	1.3	0	0	0	-414
Oct	1,120	12	16	16	12	3.4	0	0	0	-1,120
Nov	1,364	15	20	20	15	4.2	0	0	0	-1,364
Dec	1,760	19	25	25	19	5.4	0	0	0	-1,760
annual totals:	*11,882*	*127*			127	36.2		*0*	*0*	*-11,882*
		averages:	*14*		*14*		*0*			

annual natural gas cost:	***$4,159***

annual natural gas cost:	***$0***
cost reduction:	***-$4,159***
	-100%

It can also be expected that this GSHP system will significantly reduce the facility's electricity draw from Manitoba Hydro.

The GSHP system recommended has a capacity of 175 kW (50 tons). Only about 20% of its capacity will be needed for space heating in peak heating months.[34] The remaining capacity can be used for other heating and cooling purposes, including:

- chilling ice surfaces
- air conditioning
- dehumidification
- heating potable water

Without a full feasibility and projected use study for the renovated building, it is not possible to know with certainty what portion of the GSHP's remaining capacity will be used for each purpose, for two reasons:

1. The extensive renovations planned to the building will change how it is used. Those changes will probably include:
   - increasing the number of months the ice surface is kept frozen
   - increasing the use of the building for recreation services not related to the ice surface
   - increasing the number of people using the building
2. As noted above, the electricity supplied to the building by Manitoba Hydro is not separately metered for each of the purposes it is used for now. As a result, without a full feasibility study, we cannot know with certainty what portion of the excess capacity of the GSHP system will be used for what purpose. However, we can make estimates based on data from similar facilities.[35]

[34] The heat pump system recommended for De Salaberry has a capacity of 175 kW (50 tons), which means it can provide a maximum of 175 kW per hour of heating or cooling when operating at peak capacity. A simplified calculation means an average of 29 kW of heat was required per hour in the peak demand month (February). (Of course, this is an average over a month, so there will be some hours with a higher demand than this 29 kW.) In a simplified calculation, 29/175 = 0.166 = 17%.

[35] For details on how on these estimates see the appendix Understanding Energy Use in Ice Facilities.

Table 91: De Salaberry – Recreation Facility (St. Malo Arena) – estimated reductions in electrical demand with heat pump system

		without heat pump system MWh				with heat pump system electricity needed MWh					
						for heat pump system	for other uses			change from status quo	
		water heating	space cooling	ice cooling	total	CoP 3.5	lighting	auxillary equipment	total	MWh	%
month	Jan	2.7	0.0	37.0	40	11	2.4	0.8	15	-25	-63%
	Feb	2.7	0.0	41.0	44	12	2.1	0.8	15	-28	-65%
	Mar	2.9	0.0	46.1	49	14	1.8	0.8	17	-32	-66%
	Apr	2.8	0.1	13.9	17	5	1.5	0.8	7	-10	-58%
	May	2.7	5.1	0.0	8	2	1.2	0.8	4	-3	-45%
	Jun	2.7	7.2	0.0	10	3	1.1	0.8	5	-5	-52%
	Jul	2.7	8.2	0.0	11	3	1.1	0.8	5	-6	-53%
	Aug	2.7	7.2	5.9	16	4	1.4	0.8	7	-9	-57%
	Sep	2.7	2.7	54.2	60	17	1.6	0.8	19	-40	-67%
	Oct	2.7	0.4	61.5	65	18	1.9	0.8	21	-43	-67%
	Nov	2.7	0.0	54.5	57	16	2.3	0.8	19	-38	-66%
	Dec	2.7	0.0	49.4	52	15	2.4	0.8	18	-34	-65%
annual totals:		*32*	*30*	*366*	*427*	*122*	*21*	*10*	*153*	*-274*	*-64%*

The addition of the solar array—even though it is small, will reduce the requirement for electricity from the grid even futher.

Table 92: De Salaberry – Recreation Facility (St. Malo Arena) – Heat Pump & Solar Array combined – estimated electrical production & consumption[36]

		electricity MWh				
					needed from MB Hydro	
		current consumption	net demand with heat pump pump system	solar array production	net grid draw	reduction
month	Jan	43	15	1.8	13	-70%
	Feb	47	15	2.3	13	-72%
	Mar	52	17	2.8	14	-73%
	Apr	19	7	3.7	3	-82%
	May	10	4	3.6	1	-93%
	Jun	12	5	3.6	1	-90%
	Jul	13	5	4.1	1	-92%
	Aug	18	7	3.7	3	-83%
	Sep	62	19	3.2	16	-74%
	Oct	67	21	2.5	19	-72%
	Nov	60	19	1.7	18	-71%
	Dec	55	18	1.5	17	-70%
annual averages:		*458*	*153*	*34*	***119***	***-74%***

[36] The "current consumption" column is the electricity consumed in 2023.

Table 93: De Salaberry – Recreation Facility (St. Malo Arena) – Solar Array – estimated effect on electricity costs

		financials				
		cost for Manitoba Hydro electricity:				$0.10 /kWh
		price paid by Mb Hydro for excess energy:				$0.06 /kWh
		Manitoba Hydro billings				***Manitoba Hydro payments***
		current consumption	*billing with heat pump but no solar array*	*billing with both heat pump & solar array*	*billing change from status quo*	
month	Jan	$4,286	$1,457	$1,280	-$4,110	$0
	Feb	$4,655	$1,542	$1,315	-$4,428	$0
	Mar	$5,177	$1,665	$1,386	-$4,898	$0
	Apr	$1,909	$710	$342	-$1,542	$0
	May	$987	$428	$71	-$630	$0
	Jun	$1,175	$475	$119	-$818	$0
	Jul	$1,291	$509	$104	-$885	$0
	Aug	$1,798	$669	$297	-$1,426	$0
	Sep	$6,206	$1,948	$1,630	-$5,888	$0
	Oct	$6,722	$2,116	$1,869	-$6,475	$0
	Nov	$6,041	$1,949	$1,782	-$5,875	$0
	Dec	$5,536	$1,812	$1,663	-$5,388	$0
annual averages:		*$45,783*	*$15,279*	*$11,859*	*-$42,363*	*$0*
					net annual electricity cost:	***$11,859***
					annual savings:	*$33,924*
					cost reduction:	***-74%***

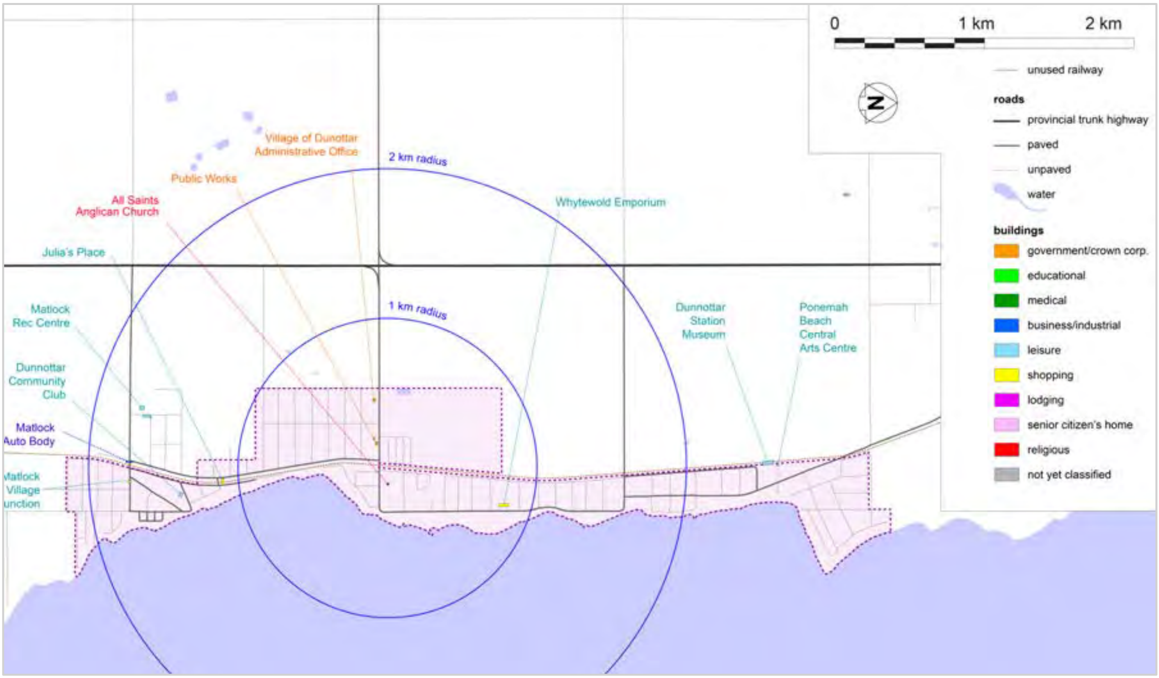
This predicition estimates the electricity required from Manitoba Hydro—and therefore the cost for that electricity—will decline by 74%. However, this is based on "status quo" use. "Status quo" means the recreation facility will be used the same amount—and for the same purposes—in the future as it was in 2023. This is almost certainly not the how the future will unfold. The central purpose of the building redesign is to increase this use of this facility.

Based on the experience of similar facilities, a reduction of 50% in electrical demand is more likley.

1.4 DUNNOTTAR – Target Building - Description & Recommendations

The Village of Dunnottar has the fewest municipal or community buildings that could be considered for renewable energy retrofits of any participating community in this study.

Figure 37: Village of Dunnottar



1.4.1 *Target Building*

The Village's contacts have prioritized the new Public Works building for this study. This will be built on the site of its current operations yard.

Figure 38: Village of Dunnottar – current Public Works building – satellite view

Figure 39: Village of Dunnottar – current Public Works building – map view

Table 94: Dunnottar – target building

Facility					
name	*street address*	town	latitude	longitude	*owner*
Public Works Building	9 Whytewold Rd	Matlock	50.4471	-96.9582	Village of Dunnottar

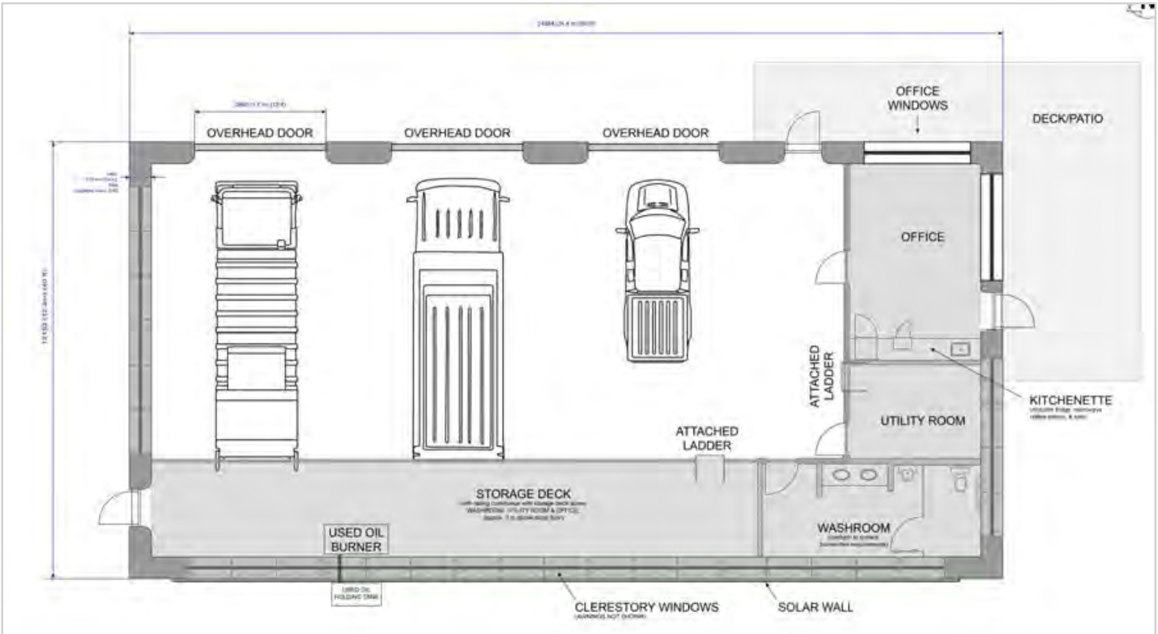
Figure 40: Village of Dunnottar – current Public Works building – street view

Because drawings of the new Public Works building have not yet been created, we have based our estimates on similar buildings, estimating that this building will be approximately 40 ft by 80 ft, and approximatley 14 ft high. Of course, once a final size is determined, the energy estimates and equipment requirements can be scaled up or down to fit.

Table 95: Dunnottar – new Public Works Building – nominal dimensions

dimensions (nominal - building not yet designed)									
meters					*feet*				
length	*width*	*area*	*height*	*volume*	*length*	*width*	*area*	*height*	*volume*
24.4	12.2	297	4.3	1,269	80	40	3,200	14	44,800

Figure 41: Nominal Dunnottar new Public Works Building layout[37]



1.4.2 *Projected Energy Use – If "Business as Usual" Principles Followed*

Because Dunnottar's current Public Works Building is very old and not used for the planned purpose of the replacement building, its current energy usage data will not provide much information that can be used to project energy savings and GHG reductions if the recommendations in this study are followed.

However, it is possible estimate what the energy usage and GHG emissions *would* be if this new building was constructed using the energy efficiency standards and energy systems typical of these types of buildings in Manitoba.

Current energy data for similar buildings is available from Canada's Office of Energy Efficiency (OEE).[38]

Not surprisingly, the data does not include a category as specific as public works buildings or garages. The closest equivalent is OEE's commercial/institutional subcategory "transportation and warehousing". OEE's data provides the average energy use intensity of this type of building, in Manitoba (367 kWh/m^2/year), as well as what percentage of that energy was derived from natural gas (69.6%) in the most recent year for which data is available—2021.

[37] The used oil burner is funded by MARRC (Manitoba Resource Recovery Corporation) is the Product Recycling Organization responsible for disposing of used vehicle oil in a safe and sustainable manner. This unit—authorized and support by MARRC provides supplemental heat and reduces the demand on the building's main heating system.

[38] Government of Canada. (2022). *Comprehensive Energy Use Database.* Natural Resources Canada, Office of Energy Efficiency. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/trends/comprehensive_tables/list.cfm. Data relevant to this study is detailed in the appendix Current Manitoba Energy Use.

From that data we can estimate how much natural gas and electricity Donnottar's new Public Works Building would consume if it was built to average Manitoba standards ("business as usual").

Table 96: Dunnottar – Public Works Building – projected energy use intensity, annual energy use, & energy mix – if business as usual

energy use intensity	total annual energy use	energy source							
		natural gas				electricity			
			m^3 of natural gas/	annual				annual	
kWh/m^2	MWh	%	m^2 of floor space	m^3	MWh	%	kWh/m^2	MWh	
367	109	70.2%	24	7,175	77	29.8%	109	32	

From this, annual GHG emissions can be estimated.

Table 97: Dunnottar – Public Works Building – projected GHG emissions – if business as usual

natural gas	GHG emissions	
	CO_2e	
	kg/m^3 of	tonnes/
m^3	natural gas	year
7,175	1.926	14

The OEE's data also details how that energy is typically used.

Table 98: Dunnottar – Public Works Building – projected energy uses & sources – if business as usual

			energy source				
	energy use		natural gas			electricity	
activity	%	MWh	%	m^3	MWh	%	MWh
space heating	81%	88	87%	7,175	77	13%	11
space cooling	3%	3	0%	0	0	100%	3
water heating	2%	3	0%	0	0	100%	3
lighting	10%	10	0%	0	0	100%	10
auxillary equipment	0.4%	0	0%	0	0	100%	0
auxillary motors	4%	5	0%	0	0	100%	5
	totals:	***109***	**70%**	*7,175*	*77*	**30%**	*32*

An estimate of when the energy is needed can also be made from the same OEE data.

Table 99: Dunnottar – Public Works Building – projected average energy demand by month – if business as usual

		natural gas		electricity	projected energy demand
		m³	MWh	MWh	MWh
month	Jan	1,274	13.6	3.8	17.4
	Feb	1,235	13.2	3.6	16.8
	Mar	939	10.0	3.0	13.1
	Apr	624	6.7	2.4	9.1
	May	311	3.3	2.0	5.3
	Jun	81	0.9	2.1	2.9
	Jul	45	0.5	2.2	2.7
	Aug	69	0.7	2.2	2.9
	Sep	185	2.0	2.1	4.0
	Oct	497	5.3	2.5	7.8
	Nov	800	8.5	3.1	11.6
	Dec	1,116	11.9	3.6	15.5
		7,175	77	32	109

Energy costs can be estimated as well.

Table 100: Dunnottar – Public Works Building – projected energy costs – if business as usual[39]

energy source					
natural gas			electricity		
m³	per m³	yearly	kWh	per kWh	yearly
7,175	$0.35	$2,511	32,496	$0.10	$3,250
				projected annual energy cost:	$5,761

All of these estimates can be compared to energy requirements for a net-zero Public Works Building.

[39] The estimates of energy costs include the Federal Carbon Charge on natural gas, but not taxes. See the appendix Estimating Energy Costs for details.

1.4.3 *Renewable Energy Recommendations*

Recommendation for Dunnottar Public Works Building:

- *Install a district Ground-Source Heat-Pump system to provide both heating and cooling for the building.*
- *Install Solar Array that will produce, in an average year, the same amount of electricity as the building is expected to consume.*
- *Include a Solar Wall as part of the design of the south wall.*
- *Build to net-zero standards.*

1.4.3.1 GROUND-SOURCE HEAT PUMP

A ground-source heat pump system (GSHP) will reduce operating costs and provide air conditioning.

Table 101: Dunnottar – Public Works Building – ground-source heat pump system – capacity, cost & space requirements

system			***capital cost (installed pricing)***			***horizontal loops space requirement***	
capacity		*Coefficient of Performance*	*heat pump systems*	*horizontal loops*			
kW	*tons*				*total*	*m^2*	*ft^2*
20	6	3.5	$36,000	$22,000	***$58,000***	1,500	16,000

1.4.3.2 SOLAR ARRAY

A solar array can produce the electricity needed to provide power to the heat pump system and the meet the building's other energy needs. This solar array can be either ground-based, as is recommended in this study or, if vehicle shelter is required, a structure like the one at the Village's nearby office can be built.

Table 102: Dunnottar – Public Works Building – solar array – configuration, capacity & estimated capital cost

# panels:	48	row width:	12 panels
configuration:	2 up		14 m
# rows:	2		45 ft
production capacity:		per panel:	0.535 kW
		array total:	26 kW
cost:		per installed kW:	$1,900
		solar array total:	**$48,792**

1.4.3.3 SOLAR WALL

A solar wall should be installed on the south wall, integrated into the make-up air system.

Table 103: Dunnottar – Public Works Building – solar wall – configuration & estimated capital cost

dimensions						***estimated capital cost (installed pricing)***		
meters		*feet*						
length	*height*	*length*	*height*	*m^2*	*ft^2*	*per m^2*	*per ft^2*	*total*
22	*3*	*72*	*10*	*66*	*720*	*$100*	*$9*	***$6,600***

Because each solar wall is custom designed to its building, it is not possible to know, at the prefeasibility stage, what the energy and cost savings will be from this particular solar wall. Therefore, no estimate of the energy savings for these walls are included in this prefeasibility study.

However, this information can be collected by requesting bids from solar wall installers for a specific building. In addition to a firm capital cost, these bids will include estimates of the energy benefits and dollar savings.

1.4.3.4 NET-ZERO BUILDING

We were not able to find any example of a net-zero public works garage. There may be one somewhere but, if so, it is not well publicized. The Village of Dunnottar could well be the first.

With the inclusion of a ground-source heat pump system and a modestly sized solar array, a net-zero Public Works Building is a realistic option. No new or radical design options are required.

A net-zero-design will increase opportunities for funding support for the building from Efficiency Manitoba,[40] the Green Municipal Fund,[41] and other sources specifically designed for municipal buildings.

There are several specific design elements that should be incorporated into the building that will lower energy costs and—perhaps more importantly—increase employee comfort. These include:

- Orient the building east-west, so that the long wall faces south.
- Integrate the ground-source heat pump system with:
  - in-floor heating
  - make-up (HRV) air ventilation system
  - hot water tank
  - wastewater heat recovery
    - If the wastewater is from the washroom and kitchenette only, this heat recovery will be minimal. However, if water is also used to wash vehicles and this is collected through a floor drain, the waste heat recovered could be quite significant.
  - solar wall on the south-facing wall
    - Because of safety requirements and fumes, this building will almost certainly require make-up air ventilation. In winter, depending on the volume of air brought in, heating the cold outside air as it is brought in will be a large energy load. The solar wall will pre-heat the outside air, reducing this heating load.

[40] A good place to start is Efficiency Manitoba. (n.d.). *Programs for Municipally-Owned Buildings* https://efficiencymb.ca/wp-content/uploads/MunicipalBrochure.pdf.

[41] Green Municipal Fund. (n.d.). *Capital project: Construction of new sustainable municipal and community buildings.* Federation of Canadian Municipalities. https://greenmunicipalfund.ca/funding/capital-project-construction-new-sustainable-municipal-community-buildings

- Build the exterior walls thicker than building code requires and fill the wall cavity with insulation.
    - Ideally, this insulation should be rock wool or slag wool, to maximize fire safety.
    - The wall should be constructed to minimize thermal bridging.
- Include high, small (clerestory) windows,[42] with awnings on the south wall, in the design.
    - These windows will reduce lighting load without reducing security.
    - The awnings reduce direct light in summer, reducing cooling load.
- Incorporate rapid closing, insulated overhead doors in the vehicle bays.
- Include lighting controls that provide supplementary lighting to the light from clerestory windows, rather than simply on/off lighting.
- The default option for a Public Works Building is to buy a prefabricated steel building. These are simple to order and are produced by several Manitoba businesses. However, if Dunnottar wants to consider embodied fossil-fuel energy,[43] building with wood instead of steel is recommended.

These building design recommendations are only preliminary. The use of LEED-certified or Passive House building designer is recommended. They will be able to maximize energy savings and minimize total lifetime building costs.

The cost of including a building designer can be at least partially offset through the Federal of Canadian Municipalities' Green Municipal Fund. Because the Village of Dunnottar has a population of less than 10,000 people, they are eligible for a grant of up to 80% of design costs.[44]

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[42] An example of a clerestory window in an industrial building follows this list of recommendations. Note that this example does not include awnings. This may be an oversight on the designers' part; more likely it is because this building is in a milder climate than ours, without the hot, consistent sunlight we experience in the summer.

[43] Embodied energy is the energy required to build the building, whereas this study focuses on the energy required to operate the building. Most steel is manufactured with fossil fuel energy, rather than renewable energy.

[44] Green Municipal Fund. (n.d.). *New construction of municipal and community buildings: Application.* Federation of Canadian Municipalities. https://greenmunicipalfund.ca/funding/study-new-construction-municipal-and-community-buildings.)

Figure 42: Clerestory windows on industrial building[45]

Clerestory windows (like all windows) typically have low R-values. Insulated Glass Units (IGUs) and glass bricks with high R-values are available.[46]

[45] Karr, S. (2018 February 18). Lofstrand Service Industrial Building. *Architecture Magazine.* https://www.architectmagazine.com/project-gallery/lofstrand-service-industrial-building. Architect: Steven J. Karr, AIA Inc.

[46] An example can be found at LiteZone Glass Inc. (n.d.). *Passive House.* https://www.litezone.ca/passive-house.html. (Note: Inclusion of an image in this study is not to be considered an endorsement of a product. It is included for information purposes only.)

1.4.4 *Effects of Renewable Energy Recommendations*

1.4.4.1 OVERALL EFFECTS

Table 104: Dunnottar – Public Works Building – estimated energy use difference – compared to "business as usual" building design & energy systems

natural gas			electricity from MB Hydro		reductions from outside sources	
m^3	MWh	%	MWh	%	MWh	%
-7,175	-77	-100%	-29	-100%	-106	-100%

Table 105: Dunnottar – Public Works Building – estimated annual GHG emissions – compared to "business as usual" building design & energy systems

GHG emissons CO_2e tonnes/year			
business as usual	if proposal goes ahead	difference	
14	0	-14	-100%

Table 106: Dunnottar – Public Works Building – estimated overall annual operating cost savings – compared to "business as usual" building design & energy systems

overall energy operating costs			
business as usual	if proposal goes ahead	difference	
$5,761	-$148	-$5,909	-103%

Table 107: Dunnottar – Public Works Building – estimated annual self-generated energy

increase in self-generated energy
MWh
33

1.4.4.2 DETAILED EFFECTS

Table 108: Dunnottar – Public Works Building – estimated annual natural gas cost saved

natural gas			
estimated savings			
business as usual	*if proposal goes ahead*	*difference*	
$2,511	$0	-$2,511	-100%

Table 109: Dunnottar – Public Works Building – estimated annual electricity cost saved

electricity			
estimated savings			
business as usual	*if proposal goes ahead*	*difference*	
$3,250	-$148	-$3,398	-105%

Table 110: Dunnottar – Public Works Building – estimated effects on energy demand of net-zero building design & Ground-Source Heat Pump

	projected energy demands if built to "business as usual" standards	**energy demand changes resulting from net zero building design**	***estimated energy demands if built to net zero standards***			
			heating & cooling requirements		*electrical demands*	
energy purpose	*MWh*		*MWh*	*CoP*	*MWh*	*% of "business as usual"*
space heating	88	-50%	44	3	15	17%
space cooling	3	-20%	2	4	1	20%
water heating	3	0%	3	4	1	30%
lighting	10	-20%			8	80%
auxillary equipment	0.4	0%			0	100%
auxillary motors	5	0%			5	100%
	109				***30***	**27%**

Table 111: Dunnottar – Public Works Building – estimated electricity required by purpose & month

		electricity purpose (MWh)							
		space heating	space cooling	water heating	lighting	auxillary equipment	auxillary motors	monthly totals	% of annual demand
month	Jan	2.6	0.0	0.1	0.9	0.0	0.4	4.0	13%
	Feb	2.5	0.0	0.1	0.8	0.0	0.4	3.8	13%
	Mar	1.9	0.0	0.1	0.7	0.0	0.4	3.1	11%
	Apr	1.3	0.0	0.1	0.6	0.0	0.4	2.4	8%
	May	0.6	0.0	0.1	0.5	0.0	0.4	1.7	6%
	Jun	0.2	0.1	0.1	0.5	0.0	0.4	1.3	4%
	Jul	0.1	0.2	0.1	0.5	0.0	0.4	1.3	4%
	Aug	0.2	0.1	0.1	0.6	0.0	0.4	1.4	5%
	Sep	0.4	0.1	0.1	0.7	0.0	0.4	1.6	5%
	Oct	1.1	0.0	0.1	0.8	0.0	0.4	2.4	8%
	Nov	1.7	0.0	0.1	0.9	0.0	0.4	3.1	10%
	Dec	2.3	0.0	0.1	0.9	0.0	0.4	3.7	13%
electricity required:		14.7	0.6	0.8	8.4	0.4	4.9		
							total electricity required:	**30**	

Table 112: Dunnottar – Public Works Building – estimated heat pump production & electricity required, by month

		without heat pump system – natural gas			with heat pump system – heat provided by heat pump system		with heat pump system – electricity needed (CoP 3.5)
		m^3	MWh	kWh/hr	kWh/hr	MWh	MWh
month	Jan	1,251	13.3	18	17.9	13.3	3.8
	Feb	1,218	13.0	19	19.2	13.0	3.7
	Mar	930	9.9	13	13.3	9.9	2.8
	Apr	617	6.6	9	9.1	6.6	1.9
	May	295	3.1	4	4.2	3.1	0.9
	Jun	86	0.9	1	1.3	0.9	0.3
	Jul	54	0.6	1	0.8	0.6	0.2
	Aug	82	0.9	1	1.2	0.9	0.3
	Sep	195	2.1	3	2.9	2.1	0.6
	Oct	518	5.5	7	7.4	5.5	1.6
	Nov	816	8.7	12	12.1	8.7	2.5
	Dec	1,115	11.9	16	16.0	11.9	3.4
annual totals:		7,175	77			77	22
			averages:	9		9	

annual natural gas cost: **$2,511**

annual natural gas cost: **$0**

cost reduction: **-$2,511** / **-100%**

Table 113: Dunnottar – Public Works Building – solar array – estimated electrical production & consumption

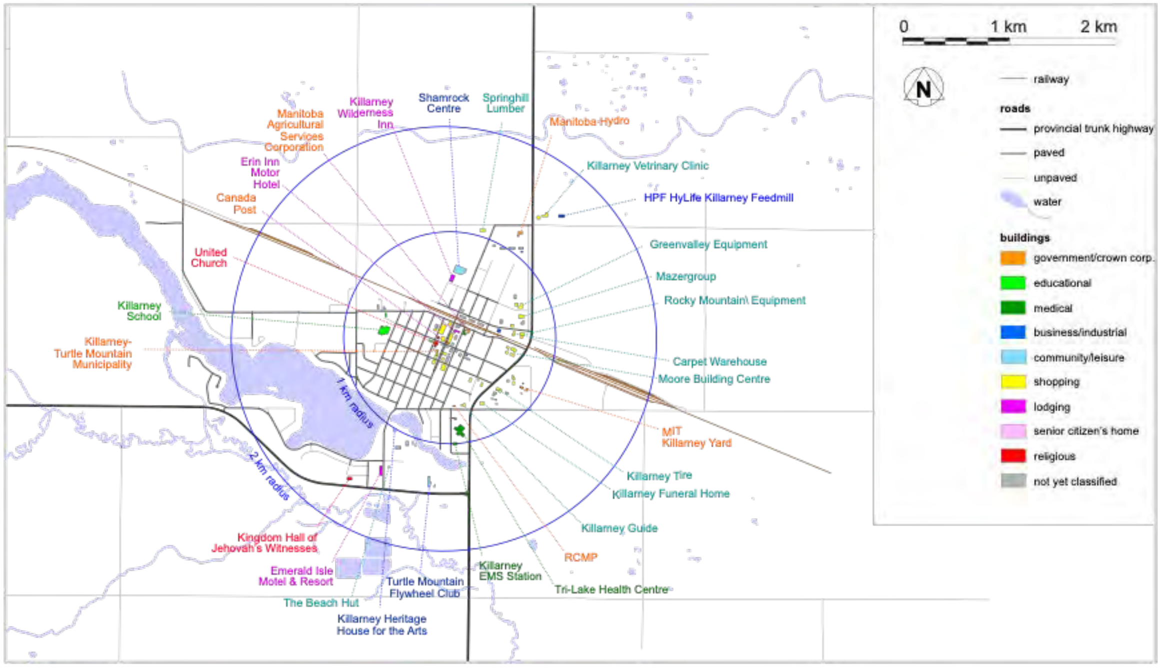
		electricity MWh				
		business as usual	net-zero construction plus heat pump & solar array			
		needed from Mb Hydro	consumption	solar array production	net grid draw	reduction
month	Jan	3.6	4.0	1.5	2.5	-33%
month	Feb	3.5	3.8	2.3	1.6	-59%
month	Mar	2.9	3.1	3.3	-0.1	-104%
month	Apr	2.3	2.4	4.5	-2.1	-189%
month	May	1.8	1.7	4.2	-2.6	-255%
month	Jun	1.9	1.3	4.2	-2.9	-329%
month	Jul	2.1	1.3	4.6	-3.3	-362%
month	Aug	2.0	1.4	4.3	-2.9	-313%
month	Sep	1.9	1.6	3.6	-2.0	-220%
month	Oct	2.4	2.4	2.7	-0.4	-116%
month	Nov	2.9	3.1	1.7	1.3	-56%
month	Dec	3.5	3.7	1.4	2.3	-38%
annual averages:		32	30	38	**-9**	**-129%**

Table 114: Dunnottar – Public Works Building – Heat Pump & Solar Array – estimated electricity cost savings

		financials				
		cost for Manitoba Hydro electricity:				$0.10 /kWh
		price paid by Mb Hydro for excess energy:				$0.05607 /kWh
		Manitoba Hydro billings				Manitoba Hydro payments
		projected cost under "business as usual"	additional draw by heat pump system	with both heat pump system & solar array	billing change from status quo	
month	Jan	$364	$1,334	$246	-$118	$0
month	Feb	$348	$1,299	$156	-$192	$0
month	Mar	$289	$992	$0	-$289	$7
month	Apr	$225	$658	$0	-$225	$118
month	May	$183	$315	$0	-$183	$144
month	Jun	$190	$91	$0	-$190	$164
month	Jul	$209	$58	$0	-$209	$187
month	Aug	$201	$88	$0	-$201	$164
month	Sep	$191	$208	$0	-$191	$109
month	Oct	$235	$552	$0	-$235	$21
month	Nov	$292	$870	$133	-$158	$0
month	Dec	$346	$1,189	$232	-$114	$0
annual averages:		$3,072	$7,653	$767	-$2,305	$915
					net annual electricity cost:	**-$148**
					annual savings:	-$3,220
					cost reduction:	**105%**

1.5 KILLARNEY TURTLE MOUNTAIN – Target Project – Description & Recommendations

Figure 43: Community of Killarney – 2 km radius



There are between a dozen and two dozen buildings in the community that could be considered for renewable energy retrofits.

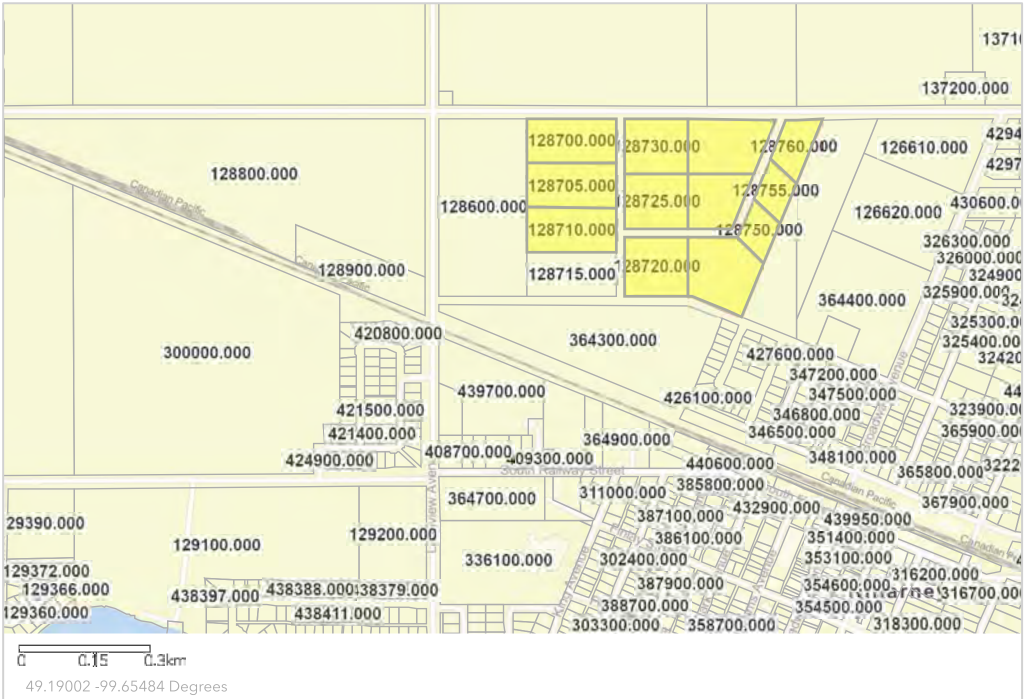
1.5.1 *Target Project*

During discussions with representatives of the RM, they chose to focus this study on an industrial park planned for the north-west corner of the community of Killarney.

Figure 44: Potential Killarney Industrial Park map, with Imagery[47]

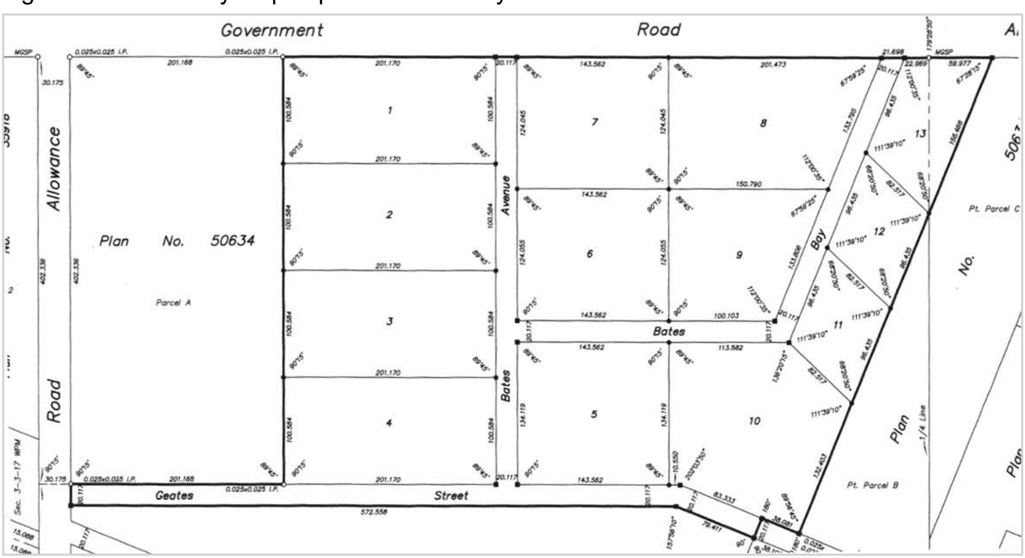
[47] Source this and the following two figures: RM of Killarney Turtle Mountain

Figure 45: Potential Killarney Industrial Park map, without Imagery



In the two maps immediately above, there are 12 parcels of land designated as part of the potential industrial park, numbered from 128700.000 to 128760.000, excluding 128715.000.

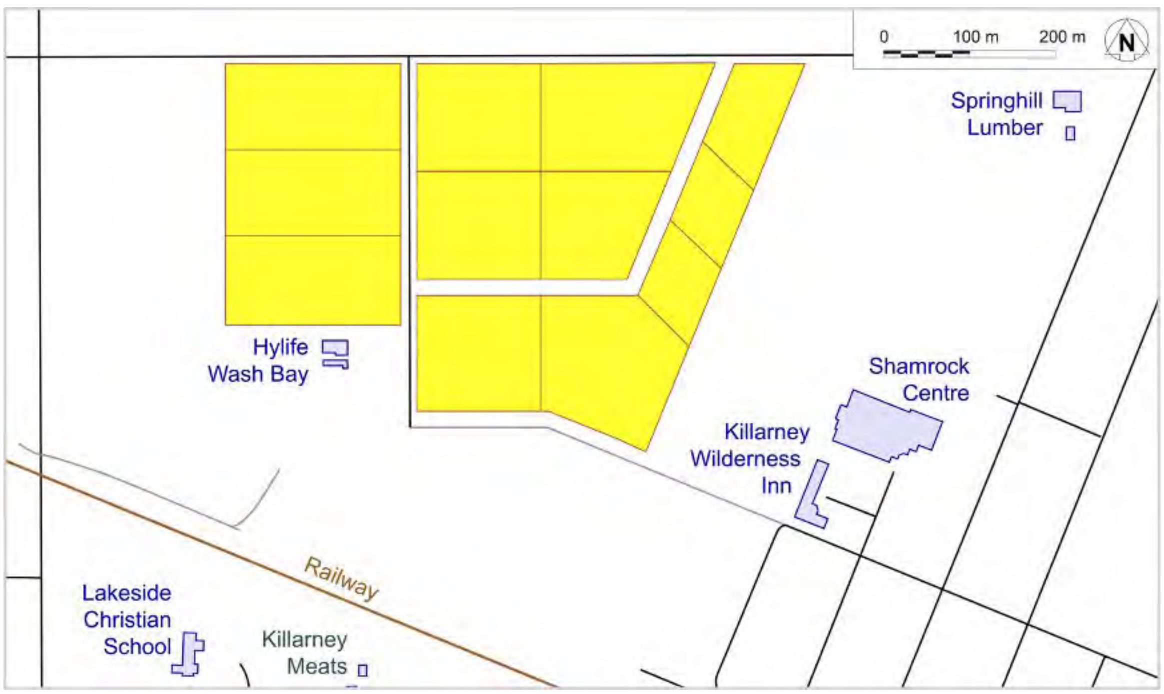
Figure 46: Survey map of potential Killarney Industrial Park area



In the Survey Map, the parcels of land on the potential site of the Killarney Industrial Park are numbered 1 through 13, excluding 4.

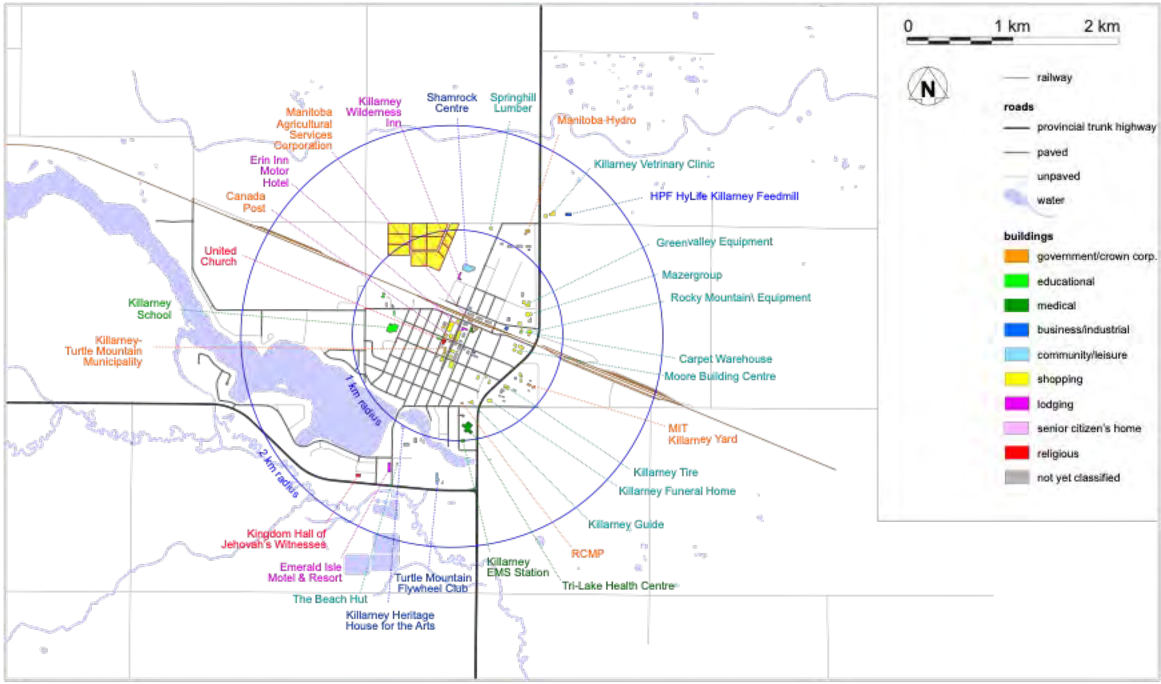
Figure 47: RM of Killarney Turtle Mountain – community of Killarney – target development – satellite view

Figure 48: RM of Killarney Turtle Mountain – community of Killarney – target development – map view



The parcel of land not included in the industrial park map (numbered 128715.000 and referred to as number 4 in the Survey Map) is the location of the HyLife Wash Bay.

Figure 49: Industrial Park location within community of Killarney



Seen within the context of the community of Killarney overall, location of the industrial park is very well chosen:

- Both the railway and trunk highways are easily accessible.
- It is far enough from residential and tourist areas that it would not interfere with the natural beauty of the area.
- It has easy access to downtown amenities.
- There is enough undeveloped land around that a solar array could be located either within the industrial park or just to its west.

1.5.2 *Anticipated Energy Use If "Business as Usual" Principles Followed*

Because the Killarney Industrial Park does not yet exist, its current energy use is zero.

However, it is possible to anticipate what the energy use and GHG emissions *would* be if this new development went ahead using the energy efficiency standards and energy systems typical of similar developments in Manitoba. We can then estimate of what the energy use of the industrial park would be if net-zero design principles and renewable energy were followed and compare the difference.

1.5.2.1 ESTIMATING FLOOR SPACE

To anticipate energy use, we first need to estimate building floor space and estimate how that floor space would be used.

The Killarney Industrial Park site occupies approximately 24 hectares (240,000 m^2; 59 acres), including existing and planned roadways.

The Government of Manitoba publishes a Municipal Planning Guide to Zoning Bylaws[48] which municipalities are encouraged to use. This document's section on Site Coverage[49] has some guidance on setting a maximum percentage of a parcel of land can be occupied by a building.

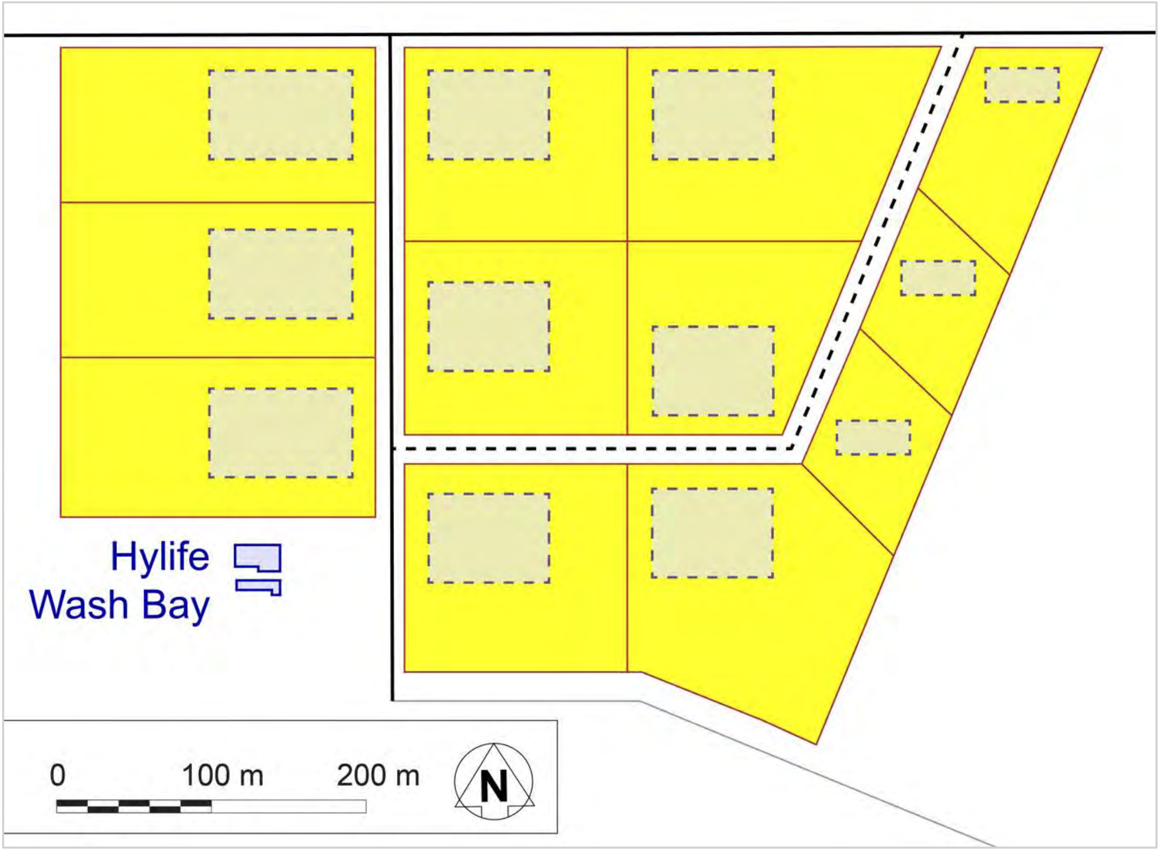
Industrial parks typically set a maximum Site Coverage ratio somewhere around 40% to 60%, not counting roadways. If we project a maximum site coverage ratio for the Killarney Industrial Park at 40% (including roadways), the maximum total of all the building floorspace in this industrial park would be 96,000 m^2 (approximately 1,000,000 ft^2).

This study is projecting, as a first phase, a Site Coverage ratio of 20%–48,000 m^2 (approximately 500,000 ft^2) of occupied space.

[48] Government of Manitoba. (2015 Nov). *Municipal Planning Guide to Zoning Bylaws.* Municipal and Northern Relations. https://www.gov.mb.ca/mr/land_use_dev/zoningbylawguide.html

[49] "Site Coverage" is also sometimes called "Lot Coverage" or "Floor Area Ratio" (FAR).

Figure 50: Killarney Industrial Park – 20% Site Coverage ratio[50]



[50] Note that is a nominal map of buildings, showing a single-story building on each current lot, with total building floor space equaling approximately 20% of the total space of the industrial park. Actual building footprint size and shape—as well as lot configurations—will change as potential businesses are recruited to the industrial park.)

Current energy use data by buildings—including those in industrial parks—is available from Canada's Office of Energy Efficiency (OEE).[51] The OEE breaks down Commercial/Institutional space use into 10 sub-categories. This data does not include a sub-category specific to industrial parks. The closest equivalent is a blend of five sub-categories[52] of the OEE's Commercial/Institutional category:

- wholesale
- retail
- transportation & warehousing
- offices
- other services

This industrial park is in the early planning stages, so it is not yet possible to know, with certainty, what percentage of the floor space will be occupied by each of these five sub-categories. We can, however, make a reasonable guess:

Table 109: Killarney Industrial Park – estimated floor space use

space use	***anticipated floor space***		
sub-category	*%*	*m^2*	*ft^2*
wholesale	25%	12,000	129,167
retail	10%	4,800	51,667
transportation & warehousing	25%	12,000	129,167
offices	15%	7,200	77,500
other services	25%	12,000	129,167
totals:	*100%*	*48,000*	*516,668*

Actual percentages will become known once businesses are recruited into the industrial park.

[51] Office of Energy Efficiency. (2022). *Comprehensive Energy Use Database.* Natural Resources Canada. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/trends/comprehensive_tables/list.cfm. Further details on OEE's energy use data relevant to this study is detailed in the appendix Current Manitoba Energy Use.

[52] The five sub-categories of Commercial/Institutional space not included here (because they are not typically found in industrial parks) are:

- information & cultural industries
- educational services
- health care & social assistance
- arts entertainment & recreation
- accommodation & food services.

1.5.2.2 ANTICIPATING ENERGY USE IF "BUSINESS AS USUAL" PRINCIPLES FOLLOWED

We can use the OEE data to give us an estimated average energy use for the Killarney Industrial Park overall.

Table 115: Killarney Industrial Park – average energy use intensity – if "business as usual"

space use		energy use intensity	
sub-category	*%*	*GJ/m²*	*MWh/m²*
wholesale	25%	1.33	0.37
retail	10%	1.69	0.47
transportation & warehousing	25%	1.32	0.37
offices	15%	1.35	0.47
other services	25%	1.45	0.38
averages:	*100%*	*1.40*	*0.40*

The OEE data also breaks down what percentage of fossil fuels and electricity are used for each of these space-use sub-categories, as well as the average GHG emissions are produced by these spaces in Manitoba. (The most recent data the OEE has for this is from 2021, so that is what is used here.)

Table 116: Killarney Industrial Park – estimated total average annual energy use, energy sources, & GHG emissions – if "business as usual"

space use		annual energy use	energy source					GHG emissions	
			natural gas			electricity		CO_2e	
				annual			annual		
sub-category	*%*	*MWh*	*%*	*m³*	*MWh*	*%*	*MWh*	*tonnes/ MWh*	*tonnes/ year*
wholesale	25%	4,444	65%	269,800	2,878	35%	1,566	0.12	520
retail	10%	2,250	60%	127,474	1,360	40%	890	0.11	246
transportation & warehousing	25%	4,401	70%	287,134	3,063	30%	1,338	0.12	553
offices	15%	3,392	58%	184,935	1,973	42%	1,419	0.10	356
other services	25%	4,514	72%	302,889	3,231	28%	1,283	0.11	583
	totals:	*19,000*		*1,172,232*	*12,504*		*6,497*		*2,258*
		averages:	*66%*			*34%*		*0.12*	

Table 117: Killarney Industrial Park – anticipated average annual energy use, by purpose – if "business as usual"

space use	projected floor space	energy purpose					
	%	*space heating*	*water heating*	*space cooling*	*lighting*	*auxillary equipment*	*auxillary motors*
wholesale	25%	72%	4%	3%	8%	9%	3%
retail	10%	69%	4%	3%	13%	8%	3%
transportation & warehousing	25%	81%	2%	3%	10%	0%	4%
offices	15%	69%	2%	3%	12%	11%	3%
other services	25%	71%	4%	3%	10%	9%	3%
	overall:	*73%*	*3%*	*3%*	*10%*	*7%*	*4%*

Table 118: Killarney Industrial Park – anticipated average annual energy costs – if "business as usual"[53]

	estimated consumption			
energy source	*m3*	*MWh*	***rate***	***annual cost***
natural gas	1,172,232	12,504	$0.35 /m^3	$410,281
electricity		6,497	$0.10 /kWh	$649,653
totals:	*1,172,232*	*19,000*		***$1,059,934***

It is important to note that:

- This is the *stationary* energy use for the buildings, only. It does not, for example, include energy use for transportation (including transportation within the industrial park), for street lighting, or for municipal infrastructure such as sewage lift stations or waste treatment.
- These are estimates of energy uses when the industrial park is fully built to a Site Coverage ratio of 20%.

[53] Estimating the rate charged per unit of energy consumed is not a simple process. These rates are based on average 2024 costs to the seven participating municipalities, including monthly service charges (charged per meter), electricity demand and per-kWh costs, natural gas commodity and delivery costs, all taxes, and the Federal Carbon Charge (FCC) as of April 2024. The FCC is only applied to natural gas and not electricity, of course.) How these costs are estimated for this study is detailed in an appendix to this study Estimating Energy Costs. The summary numbers—$0.35/m^3 for natural gas and $0.10/kWh for electricity—are used as baseline, "all-in" estimates of costs. These are used to estimate the operating cost effects of the renewable energy options proposed.

1.5.3 *Renewable Energy Recommendations*

It is recommended that this project be built in two stages

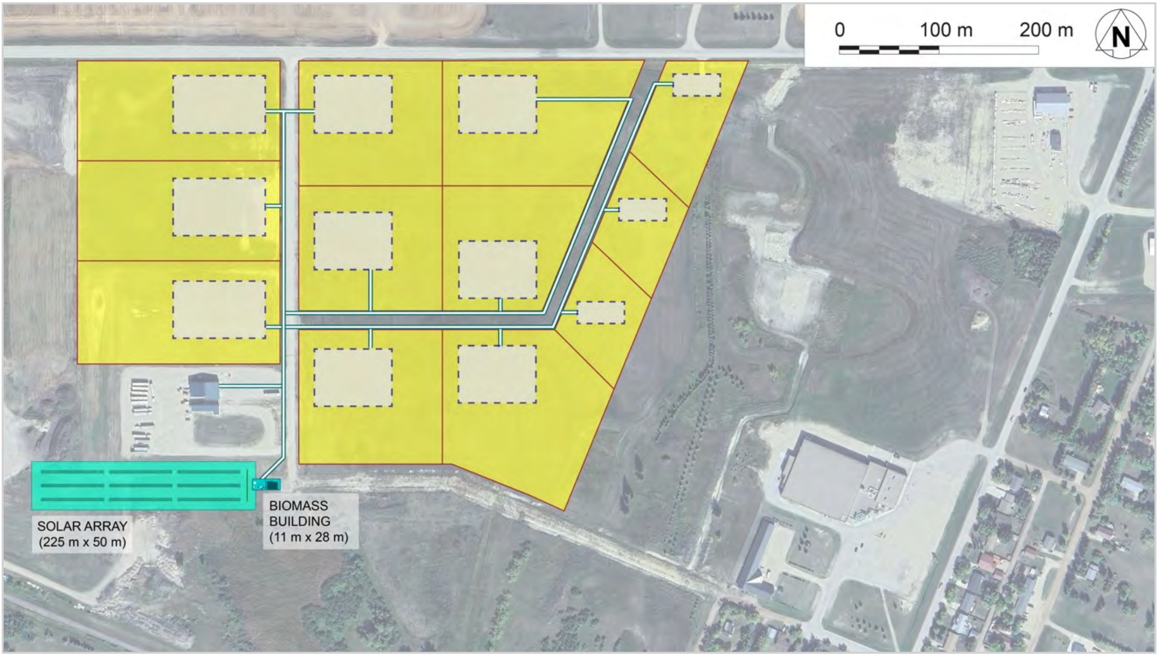
Stage 1 Recommendations for Killarney Industrial Park:

- *Install a district Biomass System providing heat to all buildings in the industrial park with the first stage of the central biomass plant—a 3.5 MW boiler.*
  - *Contract with at least two local suppliers for biomass fuel made from local crop by-products and/or crop waste.*
    - *Finding local suppliers and negotiating cost and supply requirements will be an essential next step. This should be done before the biomass building design is finalized, as the form the fuel comes in may affect the fuel-handling system design.*
- *Install a Solar Array, sized to match the Industrial Park's initial estimated electrical demand.*
- *Approach Hylife to see if they are amenable to including the land they currently occupy within the industrial park.*
- *Build buildings to net-zero standards.*
- *Connect the Industrial Park to the railway.*
  - *As many of the buildings as possible should have a rail line running right beside them.*

Stage 2 Recommendations for Killarney Industrial Park:

- *Add a 2nd biomass boiler to the central biomass plant*
- *Install an Air Source Heat Pump system in the areas of each building requiring air conditioning.*
- *Explore reviving the wind farm plan for the Killarney area.*
  - *Tie the electrical demand of the Killarney Industrial Park "behind the meter" to the wind farm.*
- *Expand the solar array to meet any electrical demand from the Industrial Park that cannot be met by the wind farm.*
- *Add electric rail movers and terminal trucks.*

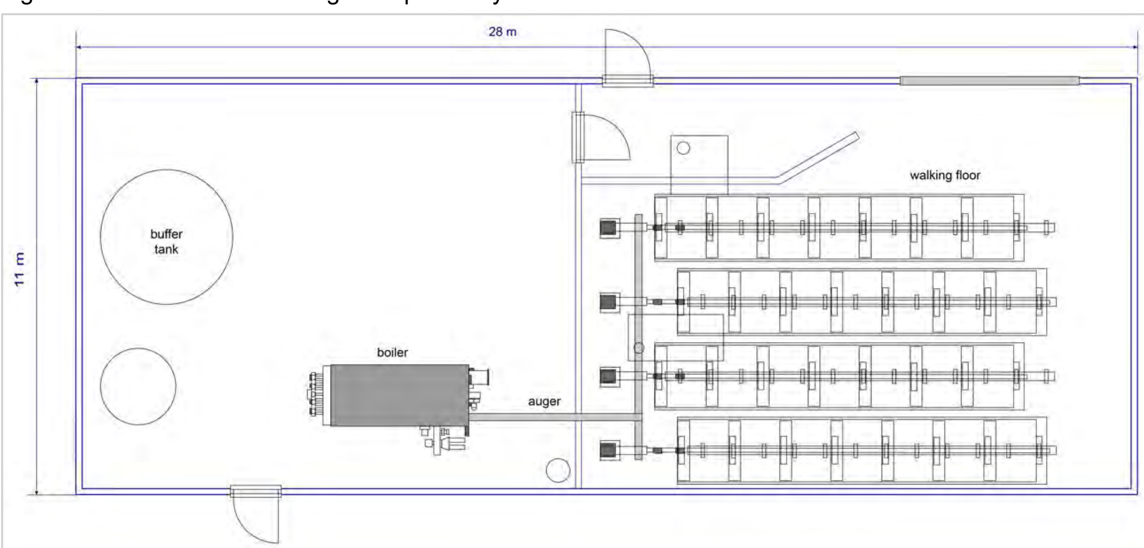
Figure 51: Killarney Turtle Mountain – Industrial Park – with renewables



1.5.3.1 BIOMASS SYSTEM

A biomass building, housing a walking floor[54] and central biomass boiler should be located as close as possible to the railway. A district energy system should go from that building to every building in the industrial park.

Figure 52: Biomass Building – simplified layout



This system should use agricultural crop by-products and/or waste as its fuel. The fuel should be sourced from suppliers as close as possible to the planned Killarney Industrial Park location.

54 Depending on the fuel sourced, it is possible that a fuel-handling system other than a walking floor may be suitable. However, given the volume of fuel required, a walking floor is the most likely option.

Table 119: Killarney Turtle Mountain – available agricultural by-products[55]

	within 30 km radius of Killarney Industrial Park (tonnes/year) average	20-year minimum
Wheat straw	73,061	19,425
Barley straw	16,094	2,349
Oat straw	8,600	2,168
Flax shives	9,835	1,274
totals:	*107,590*	*25,216*

Table 120: Killarney Turtle Mountain – estimated harvest & transport cost for non-pelletized agricultural by-products[56]

	within 30 km radius of Killarney Industrial Park (estimated cost/tonne)
harvest	$18
transport	$13
total:	*$31*

Table 121: Killarney Turtle Mountain – recommended biomass fuel – form & maximum cost

material		energy density		maximum cost
source	*form*	*kWh/kg*	*MWh/tonne*	*per tonne*
crop by-products & waste	variable	5.0	5.0	$100

The maximum cost for the biomass fuel is set at $100. This will be price-competitive with the current price (including all charges) of natural gas. If biomass suitable for use as fuel can be contracted for less than $100/tonne—delivered—heating costs will be less than they would be if natural gas is used.

Table 122: Killarney Turtle Mountain – Industrial Park – recommended biomass system

capacity	system efficiency	net heat production	capital cost (installed pricing)	
MW		*MWh/tonne*	*per kW*	*total*
1.0	75%	3.8	$400,000	$400,000
2.0				$800,000
			total:	***$1,200,000***

It is recommended that the biomass system be built in two stages.

- In the first stage, the biomass building needs to be large enough to house two boilers. The first should have a capacity of 1 megawatt; the second should be a 2-megawatt unit.
- As industrial park customers are signed up, the second system can be installed.

[55] Government of Canada. (2021 Jul 23). *Biomass Inventory Mapping and Analysis Tool.* Agriculture and Agri-Food Canada.
https://agriculture.canada.ca/atlas/apps/aef/main/index_en.html?emafapp=bimat_ocib&mode=release&iframeheight=800

[56] Ibid. As noted in the section on biomass, these costs do not include any markup a supplier may want to charge for their services.

Table 123: Killarney Turtle Mountain – Industrial Park – biomass system components – estimated capital costs (installed pricing)

component	***capital cost (installed pricing)***
phase 1	
biomass system	$400,000
district loops	$160,000
building	$400,000
chipping equipment	$400,000
phase 1 subtotal:	*$1,360,000*
phase 2	
biomass system	$800,000
district loops	$320,000
phase 2 subtotal:	*$1,120,000*
total:	***$2,480,000***

1.5.3.2 SOLAR ARRAY

If funds can be secured, this study recommends building a solar array with roughly 1,000 solar panels.[57]

Table 124: Killarney Turtle Mountain – Industrial Park – Solar Array – size & configuration

# panels:	1,008	row width:	28	panels
configuration:	2 up		32	m
# rows:	18		104	ft
production capacity:		per panel:	0.535	kW
		array total:	539	kW
capital cost:		per installed kW:	$1,900	
		solar array total:	$1,024,632	

The effect on net electrical costs for the industrial park is detailed below.

Because each solar wall is custom designed to its building, it is not possible to know, at the prefeasibility stage, what the energy and cost savings from a particular solar wall will be. Therefore, no estimate of the energy savings for these walls are included in this prefeasibility study.

However, this information can be collected by requesting bids from solar wall installers for a specific building. In addition to a firm capital cost, these bids will include estimates of the energy benefits and dollar savings.

[57] It may be that the Killarney Turtle Mountain will not be able to secure a subsidy or grant large enough to make a solar array of this size feasible at this stage. If that is the case, it is recommended that the RM install a solar array that is large as possible within the funds available. At a later stage, if more funding can be secured, expanding an existing solar array will be relatively straightforward.

1.5.3.3 NET-ZERO STANDARDS

Each building should be built to net-zero standards. In summary, these are:

- Orient each building east-west, so that the long wall faces south.
- Integrate the biomass district energy system with:
  - in-floor heating
  - make-up (HRV) air ventilation system
  - hot water tank
  - wastewater heat recovery
    - If the wastewater is from a washroom and kitchenette only, this heat recovery will be minimal. However, if water is also used to wash vehicles and this is collected through a floor drain, the waste heat recovered could be quite significant.
  - a solar wall on the south-facing wall
    - Because of safety requirements and fumes, most of the buildings in an industrial park will require make-up air ventilation. In winter, depending on the volume of air brought in, heating the cold outside air as it is brought in will be a large energy load. The solar wall will pre-heat the outside air, reducing this outside load.
- Build the exterior walls thicker than building code requires and fill the wall cavity with insulation.
  - Ideally, this insulation should be rock wool or slag wool, to maximize fire safety.
- Include high, small (clerestory) windows, with awnings on the south wall, in the design.
  - These windows will reduce lighting load without reducing security.
  - The awnings reduce direct light in summer, reducing cooling load.
- Incorporate rapid closing, insulated overhead doors in any building requiring vehicle access.
- Include lighting controls that provide supplementary lighting to light from clerestory windows, rather than simply on/off lighting.
- The default option for industrial park buildings is a prefabricated steel building. These are simple to order and are produced by several Manitoba businesses. However, if Killarney wants to consider embodied fossil-fuel energy,[58] building with wood instead of steel is recommended.

More detail on a similar net-zero building is outlined in the Dunnottar section of this study.

[58] Embodied energy is the energy required to build the building, whereas this study focuses on the energy required to operate the building. Almost all steel is produced with fossil fuel energy, rather than renewable energy.

These building design recommendations are only preliminary. The use of LEED-certified or Passive House building designer is recommended. They will be able to maximize energy savings and minimize total lifetime building costs. The cost of including a building designer can be at least partially offset through the Federal of Canadian Municipalities' Green Municipal Fund. Because Killarney has a population of less than 10,000 people, this project are eligible for a grant of up to 80% of design costs.[59]

1.5.3.4 SOLAR WALLS

It is recommended that all buildings in the industrial park be oriented east/west, so that a long wall faces south. Each of the south walls should have a solar wall as part of its design, integrated into the building's make-up air system.

Table 125: Killarney Turtle Mountain – Industrial Park – solar walls – sizes & costs

	dimensions				***area***						
	metres		*feet*		per building		***estimated capital cost (installed pricing)***				
	length	*height*	*length*	*height*	*m²*	*ft²*	*per m²*	*per ft²*	*per unit*	*# buildings*	*total*
larger buildings	*30*	*3*	*98*	*10*	*90*	*969*	*$100*	*$9*	*$9,000*	*9*	*$81,000*
smaller buildings	5		16		15	161			$1,500	3	*$4,500*
										total:	***$85,500***

1.5.3.5 AIR-SOURCE HEAT PUMPS

It is likely that there will be some need for air conditioning in the Industrial Park buildings, which biomass systems are not designed to provide. Therefore, air-source heat pump systems are recommended for the sections of buildings where air conditioning is required.

However, because we do not yet know who the tenants will be or what each building will be used for, we can only make a rough estimate on air conditioning needs at this point.

Table 126: Killarney Turtle Mountain – Industrial Park – air-source heat pump systems – capacity & costs

system			***capital cost (installed pricing)***		
capacity		*Coefficient of Performance*	*heat pump systems*	*installation*	*total*
kW	*tons*				
87	25	3.5	$156,600	$43,500	***$200,100***

1.5.3.6 ADDITIONAL RECOMMENDATIONS

Railway

Integration into the railway system would also improve the intermodal efficiency of the industrial park, potentially making it more attractive to industrial users. It would also add options for biomass fuel sources.

[59] Federation of Canadian Municipalities. (n.d.). *New construction of municipal and community buildings: Application.* Green Municipal Fund. https://greenmunicipalfund.ca/funding/study-new-construction-municipal-and-community-buildings

1.5.4 *Effects of Renewable Energy Recommendations*

1.5.4.1 OVERALL EFFECTS

Table 127: Killarney Turtle Mountain – Industrial Park – estimated energy use difference – compared to "business as usual"

natural gas			electricity from MB Hydro		reductions from outside sources	
m^3	MWh	%	MWh	%	MWh	%
-1,172,232	-12,504	-100%	-3,298	-49%	-15,802	83%

Table 128: Killarney Turtle Mountain – Industrial Park – estimated GHG emissions – compared to "business as usual" energy systems & building design

GHG emissons CO_2e tonnes/year			
business as usual	if proposal goes ahead	difference	
2,258	0	-2,258	-100%

Table 129: Killarney Turtle Mountain – Industrial Park – estimated overall annual operating cost savings – compared to "business as usual" energy systems & building design

overall energy operating costs			
business as usual	if proposal goes ahead	difference	
$1,059,934	$329,796	-$730,138	-69%

Table 130: Killarney Turtle Mountain – Industrial Park – estimated overall annual operating cost savings – compared to "business as usual" energy systems & building design

biomass		electricity	increase in self-generated energy
tonnes	MWh	MWh	MWh
1,020	3,000	743	3,743

1.5.4.2 DETAILED EFFECTS

Table 131: Killarney Turtle Mountain – Industrial Park – estimated annual natural gas cost savings – compared to "business as usual"

natural gas			
estimated savings			
business as usual	*if proposal goes ahead*	*difference*	
$410,281	$0	-$410,281	-100%

Table 132: Killarney Turtle Mountain – Industrial Park – estimated annual electricity cost savings – compared to "business as usual"

electricity			
estimated savings			
business as usual	*if proposal goes ahead*	*difference*	
$649,653	$329,796	-$319,857	-49%

Table 133: Killarney Turtle Mountain – Industrial Park – estimated energy demands[60]

	projected energy demands if buildings built to "business as usual" standards	***energy demand changes of net zero building design***	***estimated energy demands if built to net zero standards***			
			heating & cooling requirements		*electrical demands*	
energy purpose	*MWh*		*MWh*	*CoP*	*MWh*	*% of "business as usual"*
space heating	13,906	-50%	6,953	20	348	3%
water heating	610	0%	610		30	5%
space cooling	554	-20%	443	4	111	20%
lighting	1,895	-20%			1,516	80%
auxillary equipment	1,344	0%			1,344	100%
auxillary motors	692	0%			692	100%
	19,000				*4,041*	21%

[60] Because each solar wall will need to be configured to the specific dimensions of each building, and its effect on that building's heating needs will be specific to its demand for make-up air, no estimate of their overall effect on this project's energy demand is made.

The recommended biomass system will provide the heat needed for both space heating and water heating. The electrical demand on these lines (695 MWh and 61 MWh respectively) is an estimate of the electricity required to run the pumps and other sub-systems in the biomass system.

Table 134: Killarney Turtle Mountain – Industrial Park – estimated biomass system requirements

		heating requirements MWh			
		monthly			hourly
		space heating	water heating	totals	
month	Jan	1,212	51	1,263	1.7
	Feb	1,180	51	1,231	1.8
	Mar	901	51	952	1.3
	Apr	598	51	648	0.9
	May	286	51	337	0.5
	Jun	83	51	134	0.2
	Jul	52	51	103	0.1
	Aug	80	51	130	0.2
	Sep	189	51	239	0.3
	Oct	502	51	553	0.7
	Nov	791	51	841	1.2
	Dec	1,080	51	1,131	1.5
annual totals:		6,953	610	**7,563**	

Space cooling is supplied by the recommended Air-Source Heat Pumps.

Table 135: Killarney Turtle Mountain – Industrial Park – estimated Air-Source Heat Pump requirements – if all spaces in all buildings require air conditioning

		cooling requirements MWh	
		monthly	hourly
Month	Jan	0	
	Feb	0	
	Mar	0	
	Apr	1	
	May	69	0.09
	Jun	223	0.31
	Jul	289	0.39
	Aug	213	0.29
	Sep	81	0.11
	Oct	11	0.01
	Nov	0	
	Dec	0	
total:		**886**	

Table 136: Killarney Turtle Mountain – Industrial Park – estimated electricity demands, by purpose & month

		electricity purpose						
		space heating	*water heating*	*space cooling*	*lighting*	*auxillary equipment*	*auxillary motors*	*monthly totals*
Month	Jan	121	5	0	330	224	115	*796*
	Feb	118	5	0	300	224	115	*762*
	Mar	90	5	0	261	224	115	*696*
	Apr	60	5	0	220	224	115	*624*
	May	29	5	17	184	224	115	*575*
	Jun	8	5	56	165	224	115	*574*
	Jul	5	5	72	174	224	115	*596*
	Aug	8	5	53	205	224	115	*611*
	Sep	19	5	20	245	224	115	*629*
	Oct	50	5	3	286	224	115	*683*
	Nov	79	5	0	322	224	115	*745*
	Dec	108	5	0	340	224	115	*792*
totals:		*695*	*61*	*222*	*3,032*	*2,687*	*1,384*	
						total electricity required:	***8,082***	***MWh***

Table 137: Killarney Turtle Mountain – Industrial Park – estimated effect of installing recommended solar array

		electrical consujmption & production			
		consumption	*production*	*net grid draw*	
Month	Jan	795,601	77,675	717,926	*-10%*
	Feb	762,276	99,296	662,980	*-13%*
	Mar	695,589	119,067	576,522	*-17%*
	Apr	624,369	153,065	471,304	*-25%*
	May	574,698	151,133	423,565	*-26%*
	Jun	573,696	149,188	424,508	*-26%*
	Jul	595,691	170,591	425,100	*-29%*
	Aug	610,769	161,519	449,251	*-26%*
	Sep	628,518	136,824	491,694	*-22%*
	Oct	683,450	112,605	570,845	*-16%*
	Nov	745,143	76,378	668,765	*-10%*
	Dec	792,157	66,910	725,247	*-8%*
annual averages:		*8,081,958*	*1,474,252*	***6,607,706***	***-18%***

A solar array of this size would not supply all the electricity that the industrial park is likely to require once it is fully built out to mazimum capacity. It would, however, meet or exceed initial electrial demand.

Table 138: Killarney Turtle Mountain – Industrial Park – estimated effect on electrical costs of installing recommended solar array

		financials			
		cost for Manitoba Hydro electricity:		$0.10	
		price paid by Mb Hydro for excess energy:		$0.05607	
		Manitoba Hydro billings			***Mb Hydro payment***
		without solar	*with solar*	*savings*	
Month	Jan	$79,560	$71,793	$7,768	$0
	Feb	$76,228	$66,298	$9,930	$0
	Mar	$69,559	$57,652	$11,907	$0
	Apr	$62,437	$47,130	$15,306	$0
	May	$57,470	$42,356	$15,113	$0
	Jun	$57,370	$42,451	$14,919	$0
	Jul	$59,569	$42,510	$17,059	$0
	Aug	$61,077	$44,925	$16,152	$0
	Sep	$62,852	$49,169	$13,682	$0
	Oct	$68,345	$57,085	$11,260	$0
	Nov	$74,514	$66,877	$7,638	$0
	Dec	$79,216	$72,525	$6,691	$0
annual averages:		*$808,196*	*$660,771*	*$147,425*	*$0*
				net annual electricity cost:	***$660,771***
				annual savings:	*$147,425*

1.6 PINEY – Target Buildings – Descriptions & Recommendations

1.6.1 *Target Buildings*

The RM of Piney is focusing this study on five municipal buildings. These five buildings are not all in one community:

- The District Government Office and the Public Works Building are both in Vassar
- The 3 fire stations are in 3 other communities:
  - Fire Station 1 in Piney
  - Fire Station 2 (also referred to as the Sprague Fire Department) in Sprague
  - Fire Station 3 just north of Woodridge

Table 139: Piney – target buildings

Facility						
name	*street address*	town	latitude	longitude	*web address*	*owner*
RM of Piney District Government Office	6092 Boundary St	Vassar	49.0976	-95.8452	https://rmofpiney.mb.ca	RM of Piney
Public Works Building	195 Boutin St.	Vassar	49.0926	-95.8270	https://rmofpiney.mb.ca/wp-content/uploads/2021/11/Public-Works-Open-House.pdf	
Fire Station 1	5001 MB-89 HWY	Piney	49.0752	-95.9781	https://fire.fandom.com/wiki/Piney_Rural_Municipality_Volunteer_Fire_Department_(Manitoba)?veaction=edit&section=2	
Sprague Fire Department (Fire Station 2)	81045 Morden Sprague Rd	Sprague	49.0309	-95.6369		
Fire Station 3	10 Pinewood Drive	Woodridge	49.2960	-96.1498		

Figure 53: RM of Piney District Government Office – street view

Figure 54: Piney Public Works Building – street view

Figure 55: Fire Station 1, Piney, Manitoba – street view

Figure 56: Fire Station 2, Sprague, Manitoba – street view

Figure 57: Fire Station 3, Woodridge, Manitoba – street view

Figure 58: RM of Piney – Target Buildings – map view

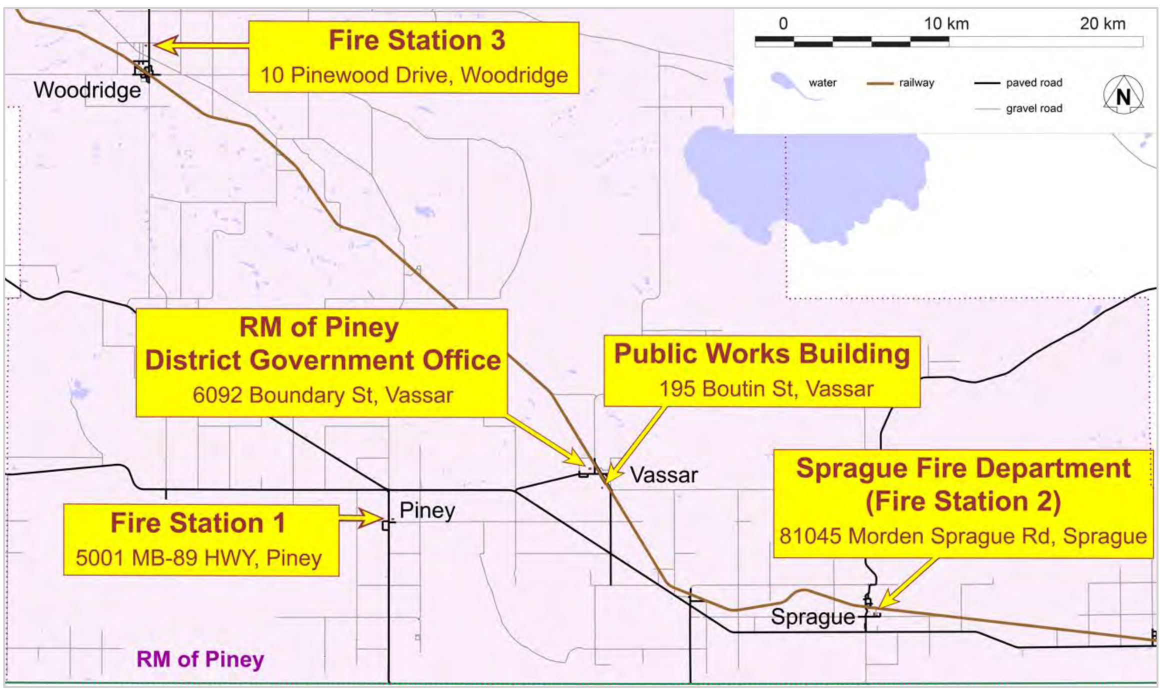


Figure 59: RM of Piney – Community of Vassar – Target Buildings – satellite view

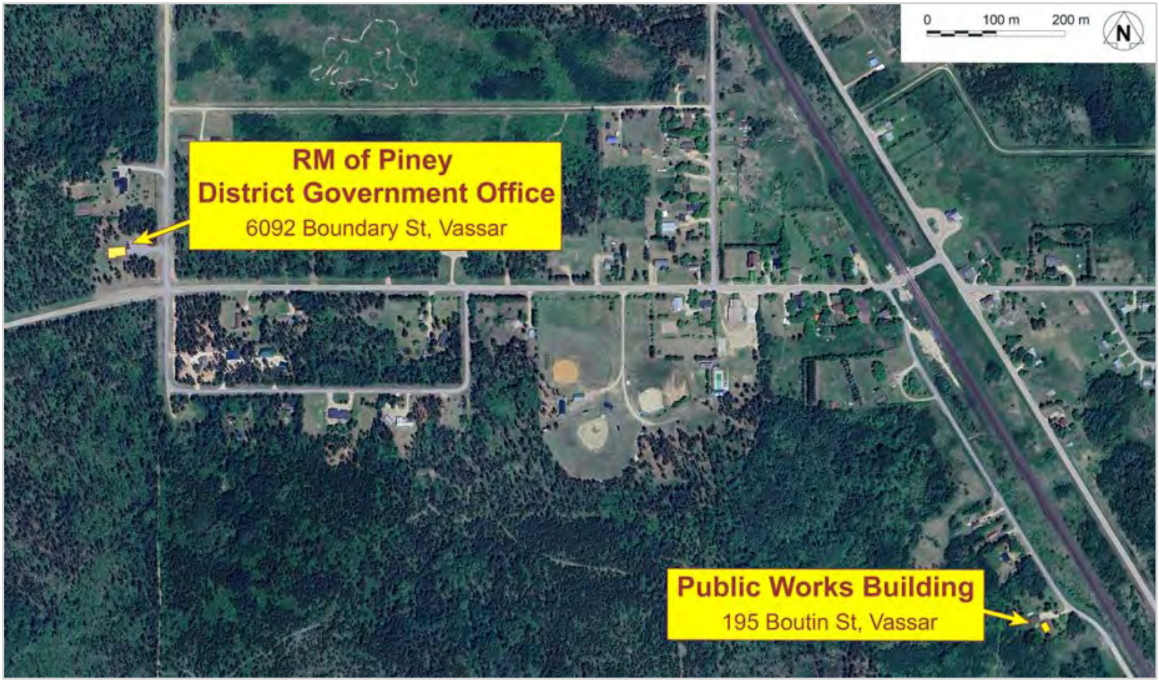


Figure 60: RM of Piney – Community of Vassar – Target Buildings – map view

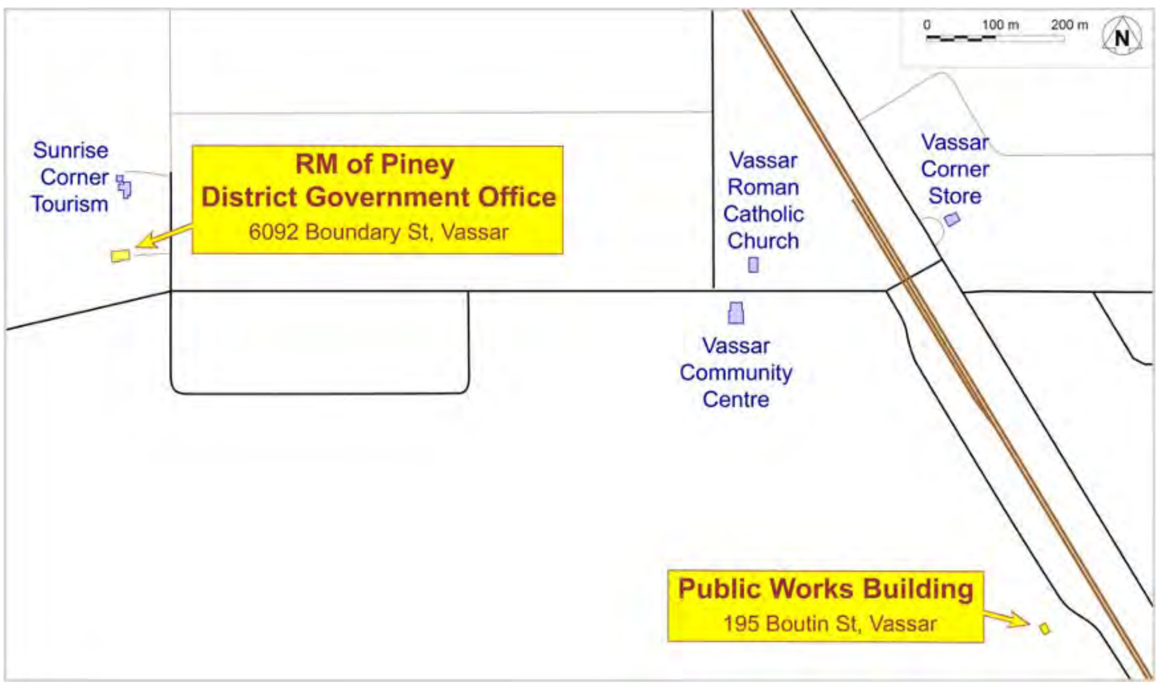


Figure 61: RM of Piney – Community of Piney – Target Building – satellite view

Figure 62: RM of Piney – Community of Piney – Target Building – map view

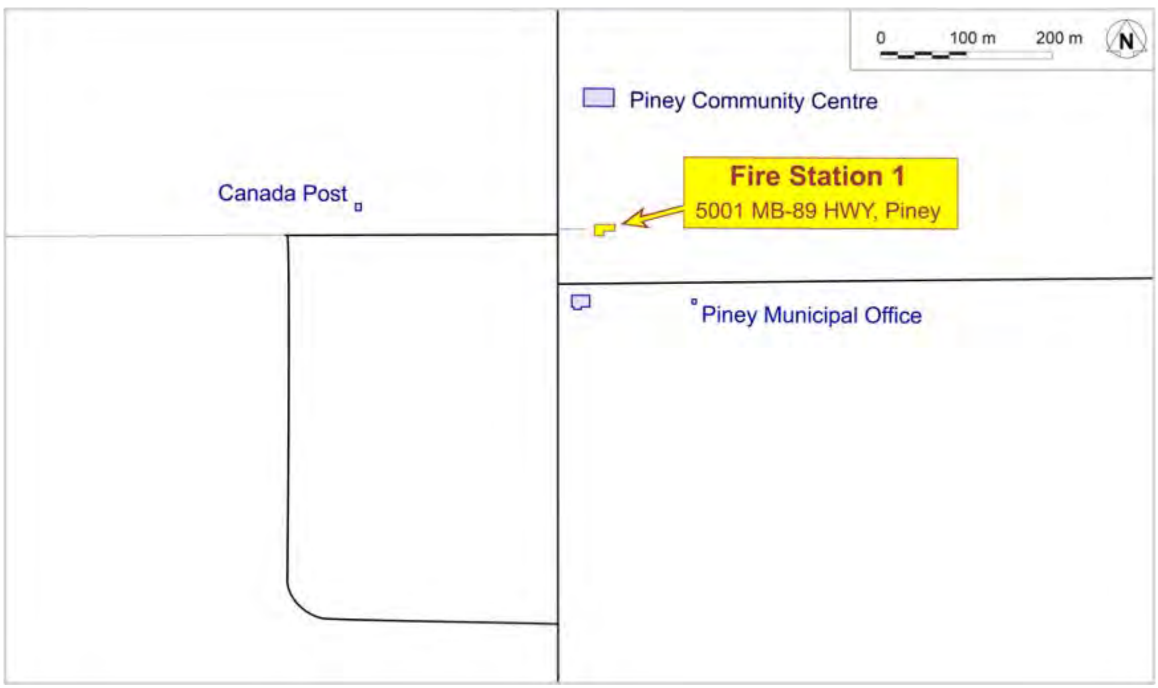


Figure 63: RM of Piney – Community of Sprague – Target Building – satellite view

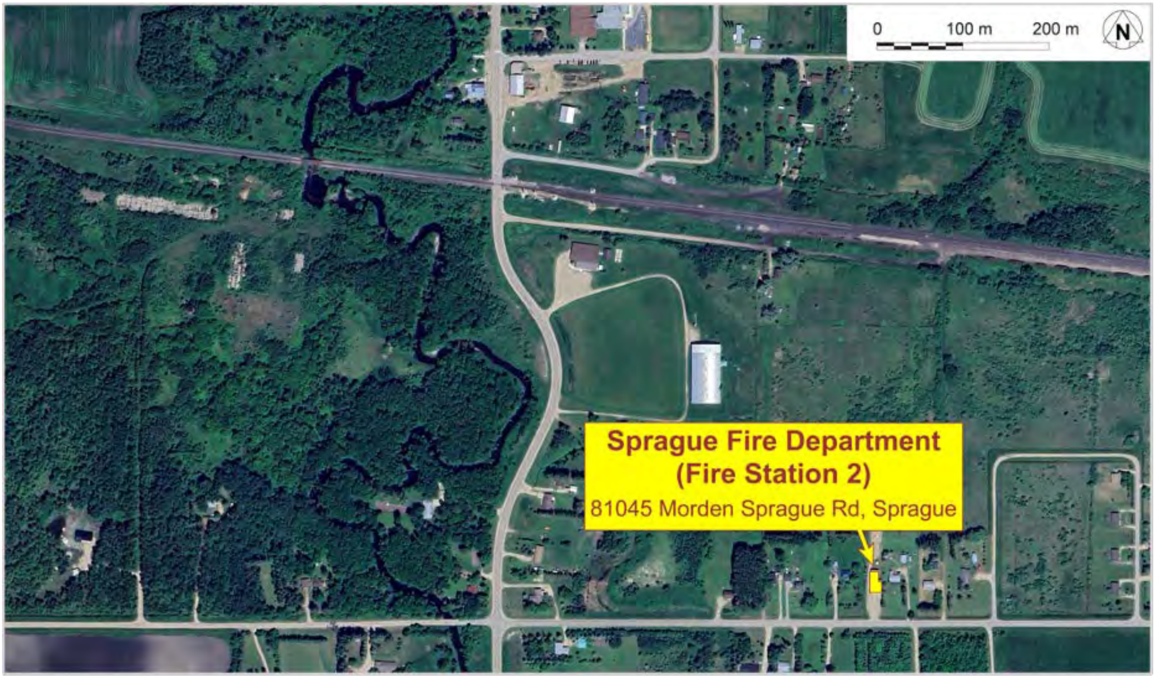


Figure 64: RM of Piney – Community of Sprague – Target Building – map view

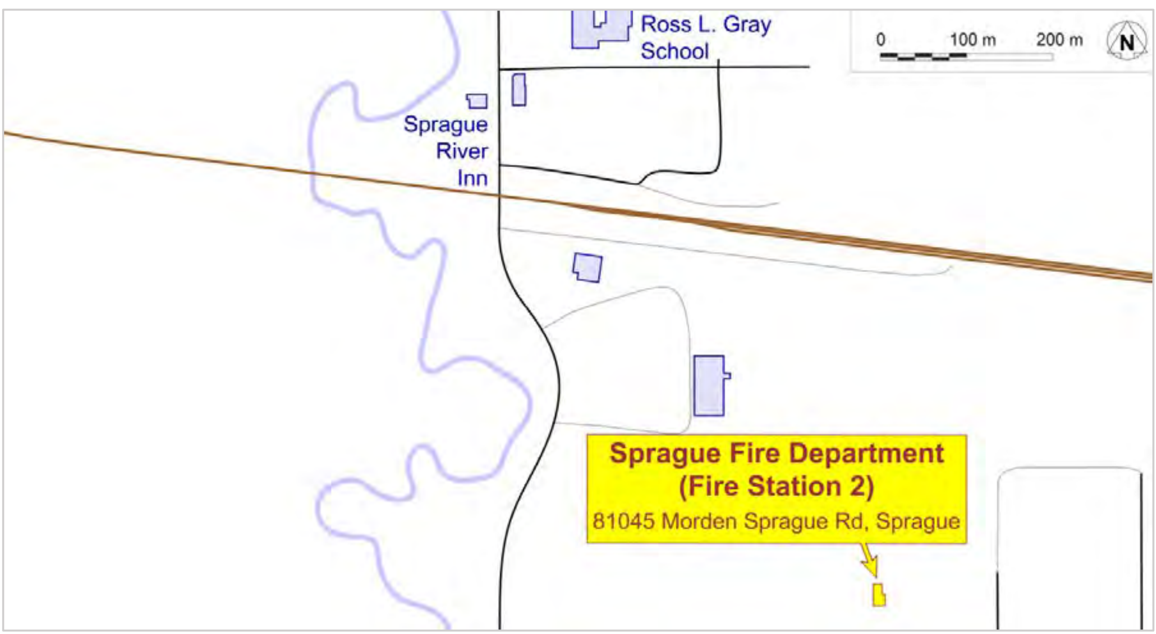
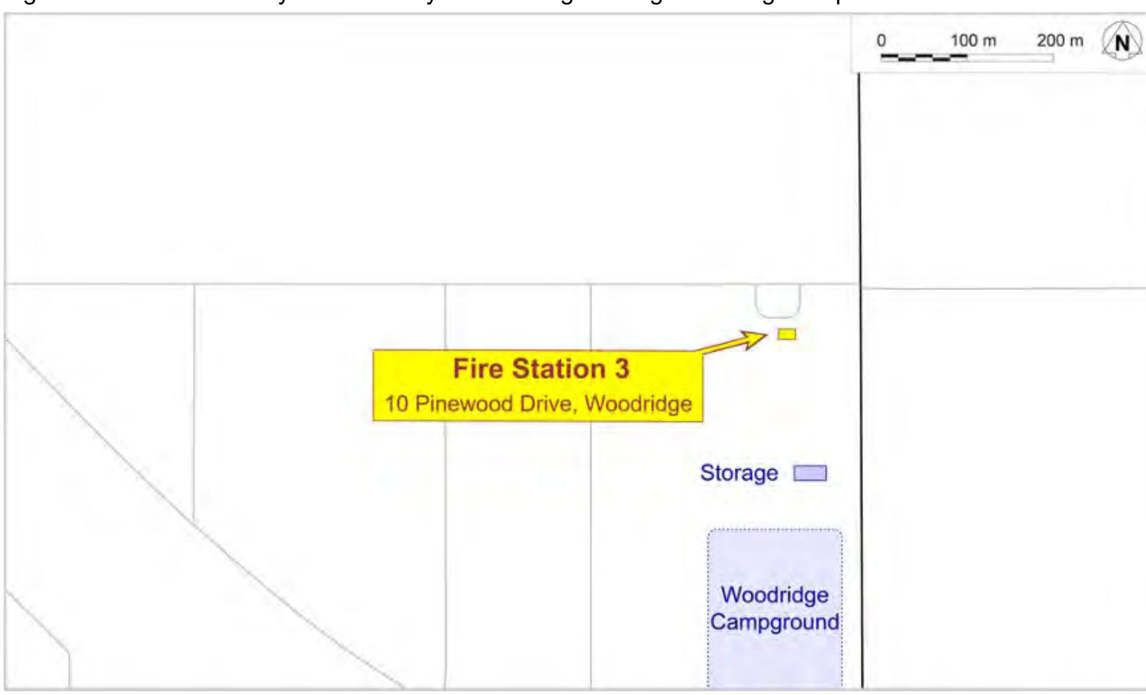


Figure 65: RM of Piney – Community of Woodridge – Target Building – satellite view

Figure 66: RM of Piney – Community of Woodridge – Target Building – map view



1.6.2 *Current Energy Use*

All five target buildings use only electricity for all energy needs, including heating and cooling.

Table 140: Piney – target buildings – average annual energy consumption

facility:	*RM of Piney District Govt Office*	*Public Works Building*	*Fire Station 1*	*Sprague Fire Dept (Fire Station 2)*	*Fire Station 3*
location:	*6092 Boundary St, Vassar*	*195 Boutin St., Vassar*	*5001 MB-89 HWY, Piney*	*81045 Morden Sprague Rd, Sprague*	*10 Pinewood Drive, Woodridge*
premise #:	*6485256*	*6799059*	*6482022*	*6475156*	*6726554*
year	*MWh*				
2018	68		60	24	68
2019	55		57	15	67
2020	51		64	81	61
2021	47		50	38	59
2022	53	62	51	46	56
2023	46	46	42	40	57
averages:	*53*	*54*	*54*	*41*	*61*
				average total:	***263***

Table 141: Piney – target buildings – average monthly energy consumption[61]

facility:	*RM of Piney District Govt Office*	*Public Works Building*	*Fire Station 1*	*Sprague Fire Dept (Fire Station 2)*	*Fire Station 3*
location:	*6092 Boundary St, Vassar*	*195 Boutin St., Vassar*	*5001 MB-89 HWY, Piney*	*81045 Morden Sprague Rd, Sprague*	*10 Pinewood Drive, Woodridge*
premise #:	*6485256*	*6799059*	*6482022*	*6475156*	*6726554*
month	*MWh*				
Jan	9.9	11.7	10.3	5.8	8.4
Feb	8.1	12.4	8.1	4.3	9.0
Mar	5.9	5.1	8.1	12.6	5.4
Apr	4.8	6.6	6.3	3.4	5.7
May	2.5	2.5	4.9	2.0	3.0
Jun	1.8	0.9	1.8	1.0	3.5
Jul	2.1	0.6	1.0	0.9	3.5
Aug	2.0	0.8	1.0	1.2	4.2
Sep	1.6	0.7	0.4	0.6	3.3
Oct	3.1	1.3	1.8	1.6	3.9
Nov	5.2	4.4	4.7	2.9	4.8
Dec	6.2	7.1	5.6	4.2	6.7
annual averages:	***53***	***54***	***54***	***41***	***61***

[61] Data is for 6 years (2018 to 2023) for all buildings except the Public Works Garage in Vassar. The Public Works Garage was built in 2021, so it only has data from 2022 and 2023 is available.

Although each of the Piney target buildings uses roughly the same amount of electricity per year, they each have distinctive use patterns. For example, the Public Works Building and Fire Stations 1 and 2 use virtually no electricity during the summer while the other two buildings have summer electrical loads. As well, the Public Works Building consumes a large percentage of its electricity in January and February. This may be due to the need to open the large garage doors even in winter, losing significant amounts of heat. These differences in use patterns are almost certainly not a sign that some buildings are being used "better" than others, only that they are not all used the same way.

As well, although the energy use in these buildings has remained relatively steady for the last six years, it is likely that their electricity consumption will increase over the next two decades, driven by the need for increased air conditioning due to climate change.

1.6.2.1 ESTIMATING ENERGY USE FOR HEATING & COOLING IN PINEY'S DISTRICT GOVERNMENT OFFICE

When considering adding heat pump systems to buildings, it is useful to know what percentage of energy is currently being used for heating, ventilation and air conditioning (HVAC). However, because the HVAC systems in Piney's target buildings are not metered separately, it is not possible to know definitively how much electricity is currently being used to power the HVAC systems.

However, Canada's Office of Energy Efficiency (OEE) does separate out the percentage of energy is used for various purposes Manitoba buildings similar to Piney's target buildings.[62] These percentages can be used to make a reasonable estimates for Piney's target buildings.

Buildings fitting the OEE's "offices" sub-category use energy for the following purposes:

Table 142: Manitoba – offices – energy purposes – 2021

energy purpose	*%*
space heating	69%
space cooling	3%
water heating	2%
lighting	12%
auxillary equipment	11%
auxillary motors	3%

Combining this energy purpose data with the data on the average energy use by month for RM of Piney District Government Office and with Heating Degree Days (HDD) and Cooling Degree Days (CDD) data from the nearby weather station in Sprague,[63] we can estimate how much electricity is used each month in Piney's Government Office for heating and cooling.

[62] This data is detailed in the appendix Current Manitoba Energy Use.

[63] BizEE Degree Days https://www.degreedays.net

Table 143: RM of Piney – RM of Piney District Government Office, Vassar – estimated current heating & cooling consumption

		average energy consumed per month	% of total energy used					
			space heating: 69%			space cooling: 3%		
			HDD			CDD		
		kWh	average per month	% of annual	estimated kWh	average per month	% of annual	estimated kWh
month	Jan	9,867	988	18%	6,525	0	0%	0
	Feb	8,106	945	17%	6,241	0	0%	0
	Mar	5,896	710	13%	4,684	0	0%	0
	Apr	4,797	473	9%	3,119	0	0%	1
	May	2,484	220	4%	1,452	20	7%	117
	Jun	1,827	68	1%	446	70	26%	414
	Jul	2,062	43	1%	285	89	33%	529
	Aug	1,983	60	1%	393	68	25%	401
	Sep	1,615	152	3%	1,005	22	8%	130
	Oct	3,110	393	7%	2,594	5	2%	31
	Nov	5,201	641	12%	4,229	0	0%	1
	Dec	6,235	849	15%	5,606	0	0%	0
annual totals:		*53,181*	*5,541*	*100%*	*36,579*	*274*	*100%*	*1,623*

These estimates are used below to calculate the effects of adding a Ground-Source Heat Pump system to this building.

We can use similar process to estimate how the energy consumed by Piney's other 4 target buildings is used, and the effect adding a Ground-Source Heat Pump system would have on their energy use.

Canada's Office of Energy Efficiency (OEE) data does not include a category as specific as a public works building or fire hall. The closest equivalent is OEE's commercial/institutional subcategory "transportation and warehousing".

Table 144: Manitoba - transportation & warehousing – energy use breakdown – 2021[64]

activity	energy use %
space heating	81%
space cooling	3%
water heating	2%
lighting	10%
auxillary equipment	0.4%
auxillary motors	4%
total:	*100%*

[64] Government of Canada. (2022). *Comprehensive Energy Use Database.* Natural Resources Canada, Office of Energy Efficiency. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/trends/comprehensive_tables/list.cfm. Data relevant to this study is detailed in the appendix Current Manitoba Energy Use.

Table 145: RM of Piney – Public Works Building, Vassar – estimated current heating & cooling consumption

		average energy consumed per month	% of total energy used					
			space heating: 81%			space cooling: 3%		
			HDD			CDD		
		kWh	average per month	% of annual	estimated kWh	average per month	% of annual	estimated kWh
month	Jan	11,685	988	18%	7,782	0	0%	0
	Feb	12,435	945	17%	7,445	0	0%	0
	Mar	5,085	710	13%	5,587	0	0%	0
	Apr	6,630	473	9%	3,721	0	0%	1
	May	2,475	220	4%	1,732	20	7%	98
	Jun	915	68	1%	532	70	26%	349
	Jul	630	43	1%	340	89	33%	445
	Aug	765	60	1%	469	68	25%	337
	Sep	660	152	3%	1,198	22	8%	109
	Oct	1,290	393	7%	3,094	5	2%	26
	Nov	4,440	641	12%	5,044	0	0%	1
	Dec	7,065	849	15%	6,687	0	0%	0
annual totals:		*54,075*	5,541	*100%*	*43,630*	*274*	*100%*	*1,366*

Table 146: RM of Piney – Fire Station 1, Piney – estimated current heating & cooling consumption

		average energy consumed per month	% of total energy used					
			space heating: 81%			space cooling: 3%		
			HDD			CDD		
		kWh	average per month	% of annual	estimated kWh	average per month	% of annual	estimated kWh
month	Jan	10,275	988	18%	7,772	0	0%	0
	Feb	8,093	945	17%	7,434	0	0%	0
	Mar	8,142	710	13%	5,579	0	0%	0
	Apr	6,337	473	9%	3,716	0	0%	1
	May	4,930	220	4%	1,730	20	7%	98
	Jun	1,762	68	1%	531	70	26%	348
	Jul	973	43	1%	340	89	33%	444
	Aug	956	60	1%	468	68	25%	337
	Sep	438	152	3%	1,197	22	8%	109
	Oct	1,818	393	7%	3,090	5	2%	26
	Nov	4,698	641	12%	5,037	0	0%	1
	Dec	5,580	849	15%	6,678	0	0%	0
annual totals:		*54,002*	5,541	*100%*	*43,571*	*274*	*100%*	*1,364*

Table 147: RM of Piney – Sprague Fire Department (Fire Station 2) – estimated current heating & cooling consumption

		average energy consumed per month	% of total energy used					
			space heating: 81%			space cooling: 3%		
			HDD			CDD		
		kWh	average per month	% of annual	estimated kWh	average per month	% of annual	estimated kWh
month	Jan	5,765	988	18%	5,841	0	0%	0
	Feb	4,279	945	17%	5,587	0	0%	0
	Mar	12,649	710	13%	4,193	0	0%	0
	Apr	3,440	473	9%	2,793	0	0%	1
	May	2,006	220	4%	1,300	20	7%	74
	Jun	1,023	68	1%	399	70	26%	262
	Jul	866	43	1%	255	89	33%	334
	Aug	1,219	60	1%	352	68	25%	253
	Sep	558	152	3%	900	22	8%	82
	Oct	1,630	393	7%	2,322	5	2%	19
	Nov	2,909	641	12%	3,785	0	0%	1
	Dec	4,240	849	15%	5,019	0	0%	0
annual totals:		*40,586*	5,541	*100%*	*32,747*	*274*	*100%*	*1,025*

Table 148: RM of Piney – Fire Station 3, Woodridge – estimated current heating & cooling consumption

		average energy consumed per month	% of total energy used					
			space heating: 81%			space cooling: 3%		
			HDD			CDD		
		kWh	average per month	% of annual	estimated kWh	average per month	% of annual	estimated kWh
month	Jan	8,440	988	18%	8,822	0	0%	0
	Feb	9,030	945	17%	8,439	0	0%	0
	Mar	5,350	710	13%	6,333	0	0%	0
	Apr	5,670	473	9%	4,218	0	0%	1
	May	3,040	220	4%	1,964	20	7%	111
	Jun	3,450	68	1%	603	70	26%	395
	Jul	3,520	43	1%	386	89	33%	504
	Aug	4,152	60	1%	531	68	25%	382
	Sep	3,309	152	3%	1,359	22	8%	124
	Oct	3,850	393	7%	3,507	5	2%	29
	Nov	4,780	641	12%	5,717	0	0%	1
	Dec	6,710	849	15%	7,580	0	0%	0
annual totals:		*61,300*	5,541	*100%*	*49,460*	*274*	*100%*	*1,548*

1.6.3 *Renewable Energy Recommendations*

Recommendations for Piney Target Buildings:

- *Install 5 Solar Arrays, each one connected to one of the target buildings.*
- *Add a Ground Source Heat Pump system to each of the 5 target buildings, beginning with the District Government Office*
    - *This, combined with each buildings' solar array, will make them net-zero.*
- *Investigate the benefits of adding a Solar Wall to the Public Works Building.*
- *Investigate Demand-Side Management retrofits to the District Government Office & the Public Works Building with Efficiency Manitoba.*

1.6.3.1 SOLAR ARRAYS

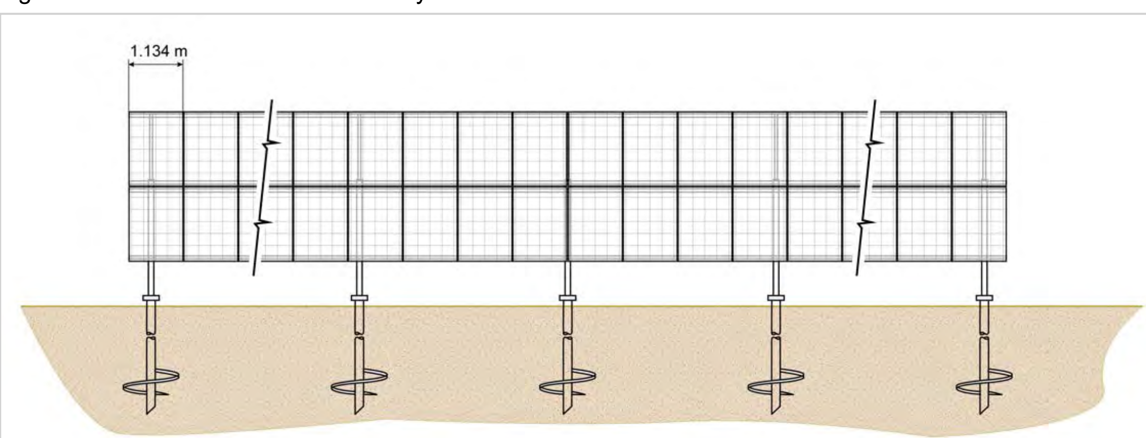
Because each of the 5 target buildings in Piney is heated (and in some cases cooled) entirely by electricity, the simplest step is to add a solar array to each one. All the solar arrays should be the same size and configuration.

Table 149: RM of Piney – five solar arrays – configuration, capacity, & space requirements – one for each target building

# panels:	48	row width:	12	panels
configuration:	2 up		14	m
# rows:	2		45	ft
production capacity:		per panel:	0.535	kW
		array total:	26	kW
capital cost:		per installed kW:	$1,900	
		solar array total:	$48,792	

Using the same configuration for all five arrays will minimize design and construction costs. However, if necessary, the number of rows recommended for each solar array can be adapted to best fit the space beside each building. The most important criterion is to minimize shading, both from the building and from nearby trees. Depending on the space available, a single row—or even 4 rows—of solar panels may be preferable. In each case, though, a "2 up" racking arrangement is recommended.

Figure 67: Ground mount solar array – front view



This study's general section on Solar makes additional recommendations on solar array configurations and short-term battery storage.

The angle that will maximize energy production in Piney is 42°.

- The precise angle is not crucial; at Piney's latitude, anywhere between 40° and 45° will produce roughly the same amount of electricity.
- In Piney, the sun rises to a maximum of 17° on the winter solstice. To minimize shadowing (and so maximize production), the arrays should be spaced just a minimum of 14.1 meters (46 ft) apart.

1.6.3.2 GROUND-SOURCE HEAT PUMP SYSTEMS

Because it is occupied for 40 hours per week, the District Government Office should be prioritized for a ground-source heat pump system. In addition to cutting heating costs, this will enable the building to have adequate air conditioning, both now and in the future.

Although they are not occupied as much, each of the other four target buildings would have lower costs and operate more efficiently if they also ground-source heat pump systems installed. Because they have in-floor heating loops, integrating a heat pump system into each of the four building's heating systems will be straightforward.

Table 150: RM of Piney – five ground-source heat pump systems – capacity, & space requirements – one for each target building

system			***costs***			***horizontal loops space requirement***	
capacity		*Coefficient of Performance*	*heat pump systems*	*horizontal loops*	*total*	*m^2*	*ft^2*
kW	*tons*						
14	4	3.5	$25,200	$15,400	***$40,600***	1,000	10,000

The total capital cost for the heat pump systems for the five buildings is estimated at $200,000.

1.6.3.3 SOLAR WALL

If a solar wall can be retrofitted to the Public Works Building's air intake system, this should be done as soon as possible.

Table 151: RM of Piney – Public Works Building, Vassar – solar wall – dimensions & cost estimates

dimensions						***estimated capital cost (installed pricing)***		
meters		*feet*						
length	*height*	*length*	*height*	*m^2*	*ft^2*	*per m^2*	*per ft^2*	*total*
30	*4*	*98*	*13*	*120*	*1274*	*$100*	*$9*	***$12,000***

The solar wall will need to be tied into the make-up air system, pre-heating the air, so that less energy is needed to warm up cold outside air when it is needed for ventilation.

Because each solar wall is custom designed to its building, it is not possible to know, at the prefeasibility stage, what the energy and cost savings of this particular solar wall will be. Therefore, no estimate of the energy savings for this wall is included in this prefeasibility study.

However, this information can be collected by requesting bids from solar wall installers for a specific building. In addition to a firm capital cost, these bids will include estimates of the energy benefits and dollar savings.

1.6.3.4 NOTES ON PINEY RECOMMENDATIONS

Of all the communities participating in this study, the RM of Pine is the one most suited to take advantage of locally grown woody biomass to reduce natural gas consumption and GHG emissions and, in the process, generate sustainable local economic development.

It currently harvests timber within the RM from mature, well-managed forests. More than 8,000 tonnes of harvest residue is generated annually by timber operations.[65] This material goes largely unused. And, because the timber leaves the community as whole logs, potential spin-off benefits milling this wood do not benefit the community.

It may be surprising, then, that this study does not recommend the use of biomass to heat the target buildings. Unfortunately, the buildings are simply too small to take advantage of currently available biomass systems. The systems licensed for use in Canada require manual feeding, which would add to staff workload.

Although biomass is not the recommended solution for the target buildings, there a number of opportunities which need to be explored in follow-on stages.

- *The East Borderland Community Housing development in Sprague is scheduled for upgrade and expansion. This complex would benefit from the installation of a system similar to the biomass system recommended for the Dauphin Railway Cluster.*
  - *A significant economic development opportunity exists if locally sourced woody biomass is used as fuel for this facility. Pellets and/or wood chips could be produced for this facility, and the local business producing these pellets or chips could sell this fuel to users:*
    - *inside the RM*
    - *throughout Manitoba*
    - *to cottages and homeowners around Lake of the Woods*
  - *There is also the opportunity to add a similar system to the Ross L Gray School in Sprague and use the fuel there.*
- *Woody sticks and twigs are a by-product of Sun-Gro Horticulture's harvesting and processing facility just outside Vassar.*
  - *Properly processed, this waste material could be a source of fuel.*
- *Because the pine trees harvested in Piney are from a mature, managed forest, they are of remarkably uniform size and so could potentially be used as components of log cabins or homes.*
  - *Processing these logs will produce mill residue, including sawdust, which could be ideal for wood pellet production.*
- *Trees left after forest fires will have lower moisture content than green trees. As a result, they may be a superior product for fuel.*

[65] Source: Government of Canada. (2021, July 23). *Biomass Inventory Mapping and Analysis Tool.* Agriculture and Agri-Food Canada. https://agriculture.canada.ca/atlas/apps/aef/main/index_en.html?emafapp=bimat_ocib&mode=release&iframeheight=800

1.6.4 *Effects of Renewable Energy Recommendations*

1.6.4.1 OVERALL EFFECTS

Table 152: RM of Piney – estimated energy use changes

	reduction *of electricity from MB Hydro*	
	MWh	*%*
RM of Piney District Govt Office, Vassar	-59	-111%
Public Works Building, Vassar	-64	-118%
Fire Station 1, Piney	-64	-118%
Sprague Fire Dept (Fire Station 2)	-56	-137%
Fire Station 3, Woodridge	-68	-111%
	-310	***-118%***

Table 153: RM of Piney – estimated annual operating cost savings

	overall *energy operating costs*			
	business as usual	*if proposal goes ahead*	*savings*	
RM of Piney District Govt Office, Vassar	$5,408	-$59	-$5,466	-101%
Public Works Building, Vassar	$5,400	-$317	-$5,717	-106%
Fire Station 1, Piney	$4,059	-$320	-$4,378	-108%
Sprague Fire Dept (Fire Station 2)	$6,130	-$747	-$6,877	-112%
Fire Station 3, Woodridge	$6,130	-$87	-$6,217	-101%
	$27,126	***-$1,529***	***-$28,655***	***-106%***

Table 154: RM of Piney – estimated annual self-generated energy

	increase *in self-generated energy*
	MWh
RM of Piney District Govt Office, Vassar	32
Public Works Building, Vassar	32
Fire Station 1, Piney	32
Sprague Fire Dept (Fire Station 2)	32
Fire Station 3, Woodridge	32
	158

The solar array and the heat pump systems, together, make each of the RM's target buildings net-zero.

The projections show a small negative overall energy operating costs of $1,529. In other words, the projections show Manitoba Hydro paying the RM a small net fee for electricity from the proposed solar arrays of $1,529. Because of increases in air conditioning requirements in future years, this number is more likely to approach $0.

1.6.4.2 DETAILED EFFECTS

Table 155: RM of Piney – Piney District Government Office, Vassar – ground-source heat pump (without solar array) – estimated effect on heating & cooling electricity consumption & cost

						with heat pump system		
						CoP: *3.5*		
		without heat pump system				*HVAC energy provided by heat pump system*		electricity needed
		heating	*cooling*	*combined*				
		kWh/month		*kWh/month*	*kW/hr*	*kW/hr*	*kWh/month*	*kWh/month*
month	Jan	6,525	0	6,525	8.8	8.8	6,525	1,864
	Feb	6,241	0	6,241	9.2	9.2	6,241	1,783
	Mar	4,684	0	4,684	6.3	6.3	4,684	1,338
	Apr	3,119	1	3,121	4.3	4.3	3,121	892
	May	1,452	117	1,569	2.1	2.1	1,569	448
	Jun	446	414	860	1.2	1.2	860	246
	Jul	285	529	814	1.1	1.1	814	233
	Aug	393	401	794	1.1	1.1	794	227
	Sep	1,005	130	1,134	1.6	1.6	1,134	324
	Oct	2,594	31	2,625	3.5	3.5	2,625	750
	Nov	4,229	1	4,230	5.9	5.9	4,230	1,208
	Dec	5,606	0	5,606	7.5	7.5	5,606	1,602
annual totals:		*36,579*	*1,623*					*10,915*
			averages:	*3,184*	*4.4*	*4.4*	*3,184*	***910***

annual HVAC electricity cost:	***$3,658***

annual HVAC electricity cost:	***$1,091***
annual HVAC savings:	*-$2,566*
HVAC cost reduction:	***-70%***

Table 156: RM of Piney – Public Works Building, Vassar – ground-source heat pump (without solar array) – estimated effect on heating & cooling electricity consumption & cost

		without heat pump system				with heat pump system (CoP: 3.5)		
		heating	cooling	combined		HVAC energy provided by heat pump system		electricity needed
		kWh/month		kWh/month	kW/hr	kW/hr	kWh/month	kWh/month
month	Jan	7,782	0	7,782	10.5	10.5	7,782	2,224
	Feb	7,445	0	7,445	11.0	11.0	7,445	2,127
	Mar	5,587	0	5,587	7.5	7.5	5,587	1,596
	Apr	3,721	1	3,722	5.2	5.2	3,722	1,063
	May	1,732	98	1,831	2.5	2.5	1,831	523
	Jun	532	349	880	1.2	1.2	880	251
	Jul	340	445	785	1.1	1.1	785	224
	Aug	469	337	806	1.1	1.1	806	230
	Sep	1,198	109	1,308	1.8	1.8	1,308	374
	Oct	3,094	26	3,120	4.2	4.2	3,120	891
	Nov	5,044	1	5,045	7.0	7.0	5,045	1,441
	Dec	6,687	0	6,687	9.0	9.0	6,687	1,911
annual totals:		*43,630*	*1,366*					*12,856*
			averages:	*3,750*	*5.2*	*5.2*	*3,750*	***1,071***

annual HVAC electricity cost: ***$4,363***

annual HVAC electricity cost:	***$1,286***
annual HVAC savings:	*-$3,077*
HVAC cost reduction:	***-71%***

Table 157: RM of Piney – Fire Station 1, Piney – ground-source heat pump (without solar array) – estimated effect on heating & cooling electricity consumption & cost

		without heat pump system				with heat pump system (CoP: 3.5)		
		heating	cooling	combined		HVAC energy provided by heat pump system		electricity needed
		kWh/month		kWh/month	kW/hr	kW/hr	kWh/month	kWh/month
month	Jan	7,772	0	7,772	10.4	10.4	7,772	2,221
	Feb	7,434	0	7,434	11.0	11.0	7,434	2,124
	Mar	5,579	0	5,579	7.5	7.5	5,579	1,594
	Apr	3,716	1	3,717	5.2	5.2	3,717	1,062
	May	1,730	98	1,828	2.5	2.5	1,828	522
	Jun	531	348	879	1.2	1.2	879	251
	Jul	340	444	784	1.1	1.1	784	224
	Aug	468	337	805	1.1	1.1	805	230
	Sep	1,197	109	1,306	1.8	1.8	1,306	373
	Oct	3,090	26	3,116	4.2	4.2	3,116	890
	Nov	5,037	1	5,038	7.0	7.0	5,038	1,439
	Dec	6,678	0	6,678	9.0	9.0	6,678	1,908
annual totals:		*43,571*	*1,364*					*12,839*
			averages:	*3,745*	*5.2*	*5.2*	*3,745*	***1,070***

annual HVAC electricity cost: ***$4,357***

annual HVAC electricity cost:	***$1,284***
annual HVAC savings:	*-$3,073*
HVAC cost reduction:	***-71%***

Table 158: RM of Piney – Sprague Fire Department (Fire Station 2) – ground-source heat pump (without solar array) – estimated effect on heating & cooling electricity consumption & cost

		without heat pump system				with heat pump system (CoP: 3.5)		
		heating	cooling	combined		HVAC energy provided by heat pump system		electricity needed
		kWh/month	kWh/month	kWh/month	kW/hr	kW/hr	kWh/month	kWh/month
month	Jan	5,841	0	5,841	7.9	7.9	5,841	1,669
month	Feb	5,587	0	5,587	8.2	8.2	5,587	1,596
month	Mar	4,193	0	4,193	5.6	5.6	4,193	1,198
month	Apr	2,793	1	2,793	3.9	3.9	2,793	798
month	May	1,300	74	1,374	1.8	1.8	1,374	393
month	Jun	399	262	661	0.9	0.9	661	189
month	Jul	255	334	589	0.8	0.8	589	168
month	Aug	352	253	605	0.8	0.8	605	173
month	Sep	900	82	981	1.4	1.4	981	280
month	Oct	2,322	19	2,342	3.1	3.1	2,342	669
month	Nov	3,785	1	3,786	5.3	5.3	3,786	1,082
month	Dec	5,019	0	5,019	6.7	6.7	5,019	1,434
annual totals:		*32,747*	*1,025*					*9,649*
			averages:	*2,814*	*3.9*	*3.9*	*2,814*	***804***

annual HVAC electricity cost: ***$3,275***

annual HVAC electricity cost:	***$965***
annual HVAC savings:	*-$2,310*
HVAC cost reduction:	***-71%***

Table 159: RM of Piney – Fire Station 3, Woodridge – ground-source heat pump (without solar array) – estimated effect on heating & cooling electricity consumption & cost

		without heat pump system				with heat pump system (CoP: 3.5)		
		heating	cooling	combined		HVAC energy provided by heat pump system		electricity needed
		kWh/month	kWh/month	kWh/month	kW/hr	kW/hr	kWh/month	kWh/month
month	Jan	8,822	0	8,822	11.9	11.9	8,822	2,521
month	Feb	8,439	0	8,439	12.4	12.4	8,439	2,411
month	Mar	6,333	0	6,333	8.5	8.5	6,333	1,810
month	Apr	4,218	1	4,219	5.9	5.9	4,219	1,205
month	May	1,964	111	2,075	2.8	2.8	2,075	593
month	Jun	603	395	998	1.4	1.4	998	285
month	Jul	386	504	890	1.2	1.2	890	254
month	Aug	531	382	913	1.2	1.2	913	261
month	Sep	1,359	124	1,482	2.1	2.1	1,482	424
month	Oct	3,507	29	3,537	4.8	4.8	3,537	1,010
month	Nov	5,717	1	5,719	7.9	7.9	5,719	1,634
month	Dec	7,580	0	7,580	10.2	10.2	7,580	2,166
annual totals:		*49,460*	*1,548*					*14,574*
			averages:	*4,251*	*5.9*	*5.9*	*4,251*	***1,214***

annual HVAC electricity cost: ***$4,946***

annual HVAC electricity cost:	***$1,457***
annual HVAC savings:	*-$3,489*
HVAC cost reduction:	***-71%***

Table 160: RM of Piney – District Government Office, Vassar – heat pump & solar array combined – estimated effect on electricity consumption & production

		electricity kWh					
		current consumption	draw by heat pump system for HVAC	draw for other building requirements	solar array production	needed from MB Hydro net grid draw	needed from MB Hydro reduction
month	Jan	9,867	1,864	1,412	1,470	1,805	-82%
	Feb	8,106	1,783	1,348	2,049	1,082	-87%
	Mar	5,896	1,338	1,266	2,673	-69	-101%
	Apr	4,797	892	1,179	3,611	-1,541	-132%
	May	2,484	448	1,104	3,379	-1,827	-174%
	Jun	1,827	246	1,064	3,366	-2,057	-213%
	Jul	2,062	233	1,082	3,736	-2,422	-217%
	Aug	1,983	227	1,148	3,463	-2,089	-205%
	Sep	1,615	324	1,232	2,927	-1,370	-185%
	Oct	3,110	750	1,319	2,206	-137	-104%
	Nov	5,201	1,208	1,394	1,415	1,187	-77%
	Dec	6,235	1,602	1,432	1,241	1,793	-71%
annual averages:		*53,181*	*10,915*	*14,979*	*31,537*	***-5,644***	***-111%***

Table 161: RM of Piney – Public Works Building, Vassar – heat pump & solar array combined – estimated effect on electricity consumption & production

		electricity kWh					
		current consumption	draw by heat pump system for HVAC	draw for other building requirements	solar array production	needed from MB Hydro net grid draw	needed from MB Hydro reduction
month	Jan	11,685	2,224	889	1,470	1,642	-86%
	Feb	12,435	2,127	838	2,049	915	-93%
	Mar	5,085	1,596	771	2,673	-305	-106%
	Apr	6,630	1,063	700	3,611	-1,847	-128%
	May	2,475	523	639	3,379	-2,217	-190%
	Jun	915	251	607	3,366	-2,508	-374%
	Jul	630	224	621	3,736	-2,891	-559%
	Aug	765	230	675	3,463	-2,558	-434%
	Sep	660	374	743	2,927	-1,810	-374%
	Oct	1,290	891	814	2,206	-501	-139%
	Nov	4,440	1,441	875	1,415	901	-80%
	Dec	7,065	1,911	906	1,241	1,575	-78%
annual averages:		*54,075*	*12,856*	*9,079*	*31,537*	***-9,602***	***-118%***

Table 162: RM of Piney – Fire Station 1, Piney – heat pump & solar array combined – estimated effect on electricity consumption & production

		electricity (kWh)					
		current consumption	draw by heat pump system for HVAC	draw for other building requirements	solar array production	needed from MB Hydro: net grid draw	needed from MB Hydro: reduction
month	Jan	10,275	2,221	888	1,470	1,638	-84%
	Feb	8,093	2,124	836	2,049	911	-89%
	Mar	8,142	1,594	770	2,673	-309	-104%
	Apr	6,337	1,062	699	3,611	-1,850	-129%
	May	4,930	522	639	3,379	-2,218	-145%
	Jun	1,762	251	606	3,366	-2,509	-242%
	Jul	973	224	621	3,736	-2,892	-397%
	Aug	956	230	674	3,463	-2,559	-368%
	Sep	438	373	742	2,927	-1,811	-514%
	Oct	1,818	890	813	2,206	-503	-128%
	Nov	4,698	1,439	874	1,415	898	-81%
	Dec	5,580	1,908	905	1,241	1,572	-72%
annual averages:		54,002	12,839	9,067	31,537	**-9,632**	**-118%**

Table 163: RM of Piney – Sprague Fire Department (Fire Station 2) – heat pump & solar array combined – estimated effect on electricity consumption & production

		electricity (kWh)					
		current consumption	draw by heat pump system for HVAC	draw for other building requirements	solar array production	needed from MB Hydro: net grid draw	needed from MB Hydro: reduction
month	Jan	5,765	1,669	667	1,470	866	-85%
	Feb	4,279	1,596	629	2,049	176	-96%
	Mar	12,649	1,198	579	2,673	-896	-107%
	Apr	3,440	798	526	3,611	-2,287	-166%
	May	2,006	393	480	3,379	-2,507	-225%
	Jun	1,023	189	455	3,366	-2,722	-366%
	Jul	866	168	466	3,736	-3,102	-458%
	Aug	1,219	173	507	3,463	-2,784	-328%
	Sep	558	280	558	2,927	-2,088	-474%
	Oct	1,630	669	611	2,206	-926	-157%
	Nov	2,909	1,082	657	1,415	323	-89%
	Dec	4,240	1,434	680	1,241	873	-79%
annual averages:		40,586	9,649	6,814	31,537	**-15,074**	**-137%**

Table 164: RM of Piney – Fire Station 3, Woodridge – heat pump & solar array combined – estimated effect on electricity consumption & production

		electricity (kWh)					
		current consumption	draw by heat pump system for HVAC	draw for other building requirements	solar array production	needed from MB Hydro: net grid draw	needed from MB Hydro: reduction
month	Jan	8,440	2,521	1,008	1,470	2,058	-76%
	Feb	9,030	2,411	949	2,049	1,311	-85%
	Mar	5,350	1,810	874	2,673	11	-100%
	Apr	5,670	1,205	794	3,611	-1,612	-128%
	May	3,040	593	725	3,379	-2,062	-168%
	Jun	3,450	285	688	3,366	-2,393	-169%
	Jul	3,520	254	704	3,736	-2,778	-179%
	Aug	4,152	261	765	3,463	-2,437	-159%
	Sep	3,309	424	843	2,927	-1,660	-150%
	Oct	3,850	1,010	923	2,206	-273	-107%
	Nov	4,780	1,634	992	1,415	1,211	-75%
	Dec	6,710	2,166	1,027	1,241	1,952	-71%
annual averages:		*61,300*	*14,574*	*10,292*	*31,537*	***-6,671***	***-111%***

Table 165: RM of Piney – District Government Office, Vassar – heat pump & solar array combined – estimated effect on costs

		financials			
		cost for Manitoba Hydro electricity:			$0.10 /kWh
		price paid by Mb Hydro for excess energy:			$0.05607 /kWh
		Manitoba Hydro billings			***Manitoba Hydro payments***
		current consumption	*billings with solar array*	*change from status quo*	
month	Jan	$987	$181	-$806	$0
	Feb	$811	$108	-$702	$0
	Mar	$590	$0	-$183	$4
	Apr	$480	$0	-$480	$86
	May	$248	$0	-$248	$102
	Jun	$183	$0	-$183	$115
	Jul	$206	$0	-$206	$136
	Aug	$198	$0	-$198	$117
	Sep	$161	$0	-$161	$77
	Oct	$311	$0	-$311	$8
	Nov	$520	$119	-$401	$0
	Dec	$624	$179	-$444	$0
annual averages:		*$5,318*	*$587*	*-$4,324*	*$645*
				net annual electricity cost:	***-$59***
				annual savings:	*-$5,377*
					-101%

Table 166: RM of Piney – Public Works Building, Vassar – heat pump & solar array combined – estimated effect on costs

		financials			
		cost for Manitoba Hydro electricity:			$0.10 /kWh
		price paid by Mb Hydro for excess energy:			$0.05607 /kWh
		Manitoba Hydro billings			Manitoba Hydro payments
		current consumption	billings with solar array	change from status quo	
month	Jan	$1,169	$164	-$1,004	$0
	Feb	$1,244	$92	-$1,152	$0
	Mar	$509	$0	-$509	$17
	Apr	$663	$0	-$663	$104
	May	$248	$0	-$248	$124
	Jun	$92	$0	-$92	$141
	Jul	$63	$0	-$63	$162
	Aug	$77	$0	-$77	$143
	Sep	$66	$0	-$66	$101
	Oct	$129	$0	-$129	$28
	Nov	$444	$90	-$354	$0
	Dec	$707	$158	-$549	$0
annual averages:		*$5,408*	*$503*	*-$4,904*	*$821*
				net annual electricity cost:	**-$317**
				annual savings:	*-$5,725*
					-106%

Table 167: RM of Piney – Fire Station 1, Piney – heat pump & solar array combined – estimated effect on costs

		financials			
		cost for Manitoba Hydro electricity:			$0.10 /kWh
		price paid by Mb Hydro for excess energy:			$0.05607 /kWh
		Manitoba Hydro billings			Manitoba Hydro payments
		current consumption	billings with solar array	change from status quo	
month	Jan	$1,028	$164	-$864	$0
	Feb	$809	$91	-$718	$0
	Mar	$814	$0	-$814	$17
	Apr	$634	$0	-$634	$104
	May	$493	$0	-$493	$124
	Jun	$176	$0	-$176	$141
	Jul	$97	$0	-$97	$162
	Aug	$96	$0	-$96	$143
	Sep	$44	$0	-$44	$102
	Oct	$182	$0	-$182	$28
	Nov	$470	$90	-$380	$0
	Dec	$558	$157	-$401	$0
annual averages:		*$5,400*	*$502*	*-$4,898*	*$821*
				net annual electricity cost:	**-$320**
				annual savings:	*-$5,720*
					-106%

Table 168: RM of Piney – Sprague Fire Department (Fire Station 2) – heat pump & solar array combined – estimated effect on costs

		financials			
		cost for Manitoba Hydro electricity:		$0.10 /kWh	
		price paid by Mb Hydro for excess energy:		$0.05607 /kWh	
		Manitoba Hydro billings			Manitoba Hydro payments
		current consumption	billings with solar array	change from status quo	
month	Jan	$577	$87	-$490	$0
	Feb	$428	$18	-$410	$0
	Mar	$1,265	$0	-$1,265	$50
	Apr	$344	$0	-$344	$128
	May	$201	$0	-$201	$141
	Jun	$102	$0	-$102	$153
	Jul	$87	$0	-$87	$174
	Aug	$122	$0	-$122	$156
	Sep	$56	$0	-$56	$117
	Oct	$163	$0	-$163	$52
	Nov	$291	$32	-$259	$0
	Dec	$424	$87	-$337	$0
annual averages:		*$4,059*	*$224*	*-$3,835*	*$971*
				net annual electricity cost:	***-$747***
				annual savings:	*-$4,805*
					-118%

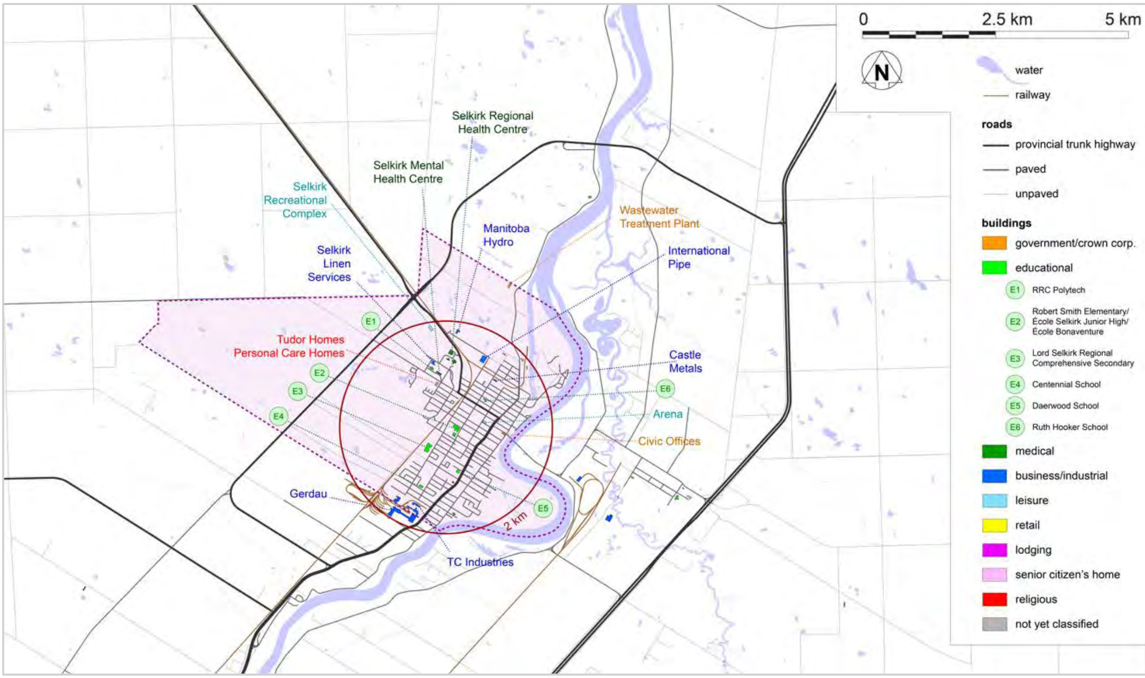
Table 169: RM of Piney – Fire Station 3, Woodridge – heat pump & solar array combined – estimated effect on costs

		financials			
		cost for Manitoba Hydro electricity:		$0.10 /kWh	
		price paid by Mb Hydro for excess energy:		$0.05607 /kWh	
		Manitoba Hydro billings			Manitoba Hydro payments
		current consumption	billings with solar array	change from	
month	Jan	$844	$206	-$638	$0
	Feb	$903	$131	-$772	$0
	Mar	$535	$1	-$534	$0
	Apr	$567	$0	-$567	$90
	May	$304	$0	-$304	$116
	Jun	$345	$0	-$345	$134
	Jul	$352	$0	-$352	$156
	Aug	$415	$0	-$415	$137
	Sep	$331	$0	-$331	$93
	Oct	$385	$0	-$385	$15
	Nov	$478	$121	-$357	$0
	Dec	$671	$195	-$476	$0
annual averages:		*$6,130*	*$654*	*-$5,476*	*$741*
				net annual electricity cost:	***-$87***
				annual savings:	*-$6,217*
					-101%

1.7 SELKIRK – Target Project – Descriptions & Recommendations

Like Dauphin and Brandon, the City of Selkirk has quite a few municipal and community buildings that could benefit from renewable energy.

Figure 68: Selkirk municipal and community buildings



1.7.1 *Target Project*

Selkirk's focus for this study is the integration of sustainable energy into its West End development plans.

Figure 69: Selkirk – target development area – satellite view

Figure 70: Selkirk – target development area – map view

Selkirk's West End Lands development plan calls for 5,000 dwelling units and at least 200,000 ft^2 of retail and commercial space.[66] The goals and priorities of this plan fit very well with the goals of this study. The City of Selkirk's intention is to create a model sustainable community. The first Guiding Principle for this development is:

> *Promote development that enhances community health and wellbeing, while minimizing environmental impact, energy use and reliance on non-renewables.*

Some of the principles in the body of the Plan include that are relevant to this study include:

> ***Section 5.0 Green Design and Development***
>
> *This section establishes strategic directions that promote green building technologies, renewable and alternative energy options, waste management efforts and other sustainable design options for development with the aim of supporting the City's objectives for a healthy, vibrant and sustainable community. Key green design and development objectives include:*
>
> - *Demonstrate leadership in sustainable forms of development and green technologies to mitigate and adapt to climate change.*
> - *Encourage development proposals that include energy efficient neighbourhood and/or building design and practices in all new development.*
> - *Establish made-in-Selkirk green development and design standards that apply to all public and private sector developments.*
> - *Control and, where possible, eliminate water, soil, noise and air pollution to safeguard the natural and human environment.*
> - *Reduce per-capita consumption of energy, water, land and other non-renewable resources.*
> - *Reduce per-capita generation of storm water run-off, sanitary sewage and solid and hazardous waste.*
> - *Develop policies and programs designed to reduce per-capita greenhouse gas emissions.*

[66] Sources:

- City of Selkirk (2020, August 12). *Visionary plan for Selkirk's West End puts City in control of its own destiny*. https://www.myselkirk.ca/blog/2020/08/12/visionary-plan-for-selkirks-west-end-puts-city-in-control-of-its-own-destiny/
- City of Selkirk. (2020, April). *Draft West End Concept Plan.* https://selkirknow.ca/wp-content/uploads/2021/06/Selkirk-West-End-Concept-Plan.pdf

6.3 Energy

Energy conservation is a key objective of this Plan. The aim of the energy strategy for the West End is the promotion of renewable energy systems that minimize, or even eliminate, the use of fossil fuels.

Strategic Directions:

- *Establish targets for reduction in design energy consumption benchmarked against the National Energy Code for Buildings (NECB);*
- *Work with partners, like the Federation of Canadian Municipalities, Manitoba Hydro, Efficiency Manitoba, and Province of Manitoba, to promote and invest in innovative building approaches and technologies that reduce energy consumption and generate renewable energy on site (zero net energy);*
- *Design and orient buildings to optimize solar exposure to promote passive solar design;*
- *Examine the viability of developing an adaptable and scalable district utility that provides centralized and efficient heating and cooling for the West End development.*
- *Engage the community about ways to conserve energy.*

This study is used an opportunity to develop those energy design principles in more detail.

1.7.2 *Anticipated Energy Use If "Business as Usual" Principles Followed*

Because the West End Lands development does not yet exist, its current energy use is zero. However, it is possible to estimate what the energy use and GHG emissions *would* be if this new development went ahead using the energy efficiency standards and energy systems currently typical of households and of retail and commercial spaces in Manitoba.

1.7.2.1 ANTICIPATED RESIDENTIAL ENERGY CONSUMPTION & GHG EMISSIONS IF "BUSINESS AS USUAL"

Statistics Canada tracks energy use by household.

Table 170: Manitoba households – average annual energy use & GHG emissions – 2021[67]

energy source					annual energy use	GHG emissions CO_2e	
natural gas			electricity			kg/m³ of natural gas	tonnes/ household
MWh	m³	% of total	MWh	% of total	MWh		
14	1,285	54%	12	46%	26	1.926	2.48

Statistics Canada defines "household" as "a person or group of persons who occupy the same dwelling and do not have a usual place of residence elsewhere in Canada or abroad."[68]

Selkirk's Concept Plan uses the term "dwelling units" but has not yet defined that term in detail. While a "dwelling unit" and a "household" may not have identical definitions, they are similar enough that anticipated household energy use is the best available proxy for anticipated dwelling unit energy use.

Table 171: Manitoba households – average annual energy use by purpose – 2021[69]

	average consumption if built to "business as usual" standards			
	energy demands	energy sources		
		natural gas		electricity
energy purpose	MWh	m³	MWh	MWh
space heating	13.9	1,285	13.7	0.2
space cooling	1.5			1.5
water heating	4.4			4.4
lighting	1.0			1.0
appliances	4.8			4.8
	25.5	*1,285*	*13.7*	*11.8*

[67] Statistics Canada. (2024 Mar 19). *Household energy consumption, Canada and provinces.* Data, Table: 5-10-0060-01 https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2510006001. Further details on Statistics Canada's household energy use relevant to this study is detailed in the appendix Current Manitoba Energy Use.

[68] Statistics Canada. (2022, March 3). *Household: Definition.* Statistical Units. https://www23.statcan.gc.ca/imdb/p3Var.pl?Function=Unit&Id=96113.

[69] Government of Canada. (2022). *Comprehensive Energy Use Database.* Natural Resources Canada, Office of Energy Efficiency. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/trends/comprehensive_tables/list.cfm. Further details on OEE's residential space energy use data relevant to this study is detailed in the appendix Current Manitoba Energy Use.

Table 172: Selkirk – West End Lands – households (dwelling units) – estimated annual energy use – if development proceeds using “business as usual” principles

# of dwelling units (households)	**energy source**					**average annual energy use**
	natural gas			*electricity*		
	MWh	*m^3*	*% of total*	*MWh*	*% of total*	*MWh*
5,000	68,548	6,426,334	54%	59,171	46%	127,719

Table 173: Selkirk – West End Lands – households (dwelling units) – estimated annual GHG emissions – if development proceeds using “business as usual” principles

# of dwelling units (households)	**GHG emissions** CO_2e	
	kg/m^3 of natural gas	*tonnes/ year*
5,000	1.926	12,377

If the 5,000 dwelling units planned for Selkirk’s West End Lands consume energy the same way as average Manitoba’s households currently do, they can be expected to consume more than 6 million cubic metres of natural gas and emit more than 12,000 tonnes of GHGs.

It is important to note that this is the anticipated *stationary* energy use and GHG emissions for households only; it does not include energy used for transportation.

1.7.2.2 ANTICIPATED RETAIL & COMMERCIAL SPACE ENERGY CONSUMPTION & GHG EMISSIONS IF “BUSINESS AS USUAL”

It is also possible to estimate what the energy use and GHG emissions *would* be for the planned retail and commercial spaces, if this new development followed current Manitoba practise. Current energy use data by similar buildings is available from Canada’s Office of Energy Efficiency (OEE).[70]

The data most relevant to the West End Lands retail and commercial space lands is OEE’s commercial/institutional use data, specific to Manitoba. OEE breaks down Commercial/Institutional space use into 10 sub-categories:

- wholesale
- retail
- transportation & warehousing
- information & cultural industries
- offices
- educational services
- health care & social assistance
- arts entertainment & recreation
- accommodation & food services
- other services

[70] Government of Canada. (2022). *Comprehensive Energy Use Database.* Natural Resources Canada, Office of Energy Efficiency. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/trends/comprehensive_tables/list.cfm. Further details on OEE’s commercial/institutional space energy use data relevant to this study is detailed in the appendix Current Manitoba Energy Use.

It is not yet possible to know what percentage of the commercial and retail space in Selkirk's West End Lands development will be occupied by each of these 10 sub-categories. Based on the Concept Plan, it is reasonable to estimate that the West End Lands development will not include much (if any) wholesale or transportation & warehousing space, but that the percentages of floor space of the remaining sub-categories will mirror those of Manitoba overall.

Table 174: Selkirk – West End Lands – retail & commercial space – space use breakdown & energy use intensity – if "business as usual"

space use	**% of retail & commercial space**	***energy use***					
		natural gas			*electricity*		*total*
sub-category		*%*	*m³/m²*	*kWh/m²*	*%*	*kWh/m²*	*kWh/m²*
retail	17%	60%	27	283	40%	186	469
information & cultural industries	2%	62%	28	293	38%	178	471
offices	45%	58%	21	219	42%	157	376
educational services	18%	63%	25	267	37%	155	422
health care & social assistance	8%	50%	47	496	50%	498	995
arts, entertainment & recreation	2%	64%	23	250	36%	140	390
accommodation & food services	5%	64%	41	441	36%	245	686
other services	2%	72%	27	287	28%	114	401
	weighted averages:	*60%*	*26*	*276*	*40%*	*194*	*469*

Table 175: Selkirk – West End Lands – retail & commercial space – anticipated total average annual energy use, energy sources, & GHG emissions – if "business as usual"

space use	***GHG emissions***	
	CO_2e	
sub-category	*tonnes/TJ*	*kg/kWh*
retail	31.99	0.1075
information & cultural industries	29.85	0.1155
offices	34.36	0.1043
educational services	32.08	0.1130
health care & social assistance	28.98	0.0898
arts, entertainment & recreation	31.40	0.1138
accommodation & food services	24.93	0.1146
other services	31.62	0.1129
weighted averages:	*32*	*0.1063*

Table 176: Selkirk – West End Lands – retail & commercial space – anticipated average annual energy use, by activity – if "business as usual"

activity	***annual energy use*** %	kWh/m³
space heating	68%	321
space cooling	17%	79
water heating	1%	5
lighting	3%	16
auxillary equipment	9%	40
auxillary motors	3%	13
totals:	*100%*	*469*

It is important to note that this is the *stationary* energy use for the commercial and retail buildings only. It does not, for example, include energy use for transit or municipal infrastructure.

1.7.3 *Renewable Energy Recommendations*

Selkirk's West End Lands development will develop over multiple decades.

What follows are recommendations for what might be called the "Phase 1 Energy Initiative"—the first 20% of development, with 1,000 dwelling units and 40,000 ft^2 (3,716 m^2) of retail/commercial space being constructed.

It follows the approach envisioned in the Concept Plan, focusing on the initial energy systems that should be put in place now to the achieve Plan's goals over its lifespan.

Recommendations for Selkirk's West End Lands development:

- *Install a Biomass heating system, using chipped waste wood as fuel.*
- *Install a district Ground-Source Heat Pump system.*
- *Connect the biomass-based district loop and the heat-pump-based loop together and integrate them into the initial buildings planned for Selkirk's West End Lands development.*
- *Install a Solar Array to provide electrical power to both the biomass and the heat pump systems.*
- *Install Solar Walls in as many of the new community, retail, and commercial buildings as possible.*
- *Develop Building Design Guidance for building construction that will enable integration into the biomass and heat pump extension lines.*
    - *"Guidance", in this context means detailed suggestions which are encouraged—and in some cases incentivized—but not mandatory.*
    - *The Concept Plan calls for establishing "targets for reduction in design energy consumption benchmarked against the National Energy Code for Buildings". This study proposes targets of:*
        - *space heating at least 25% more efficient than current average Manitoba building performance*
        - *space cooling at least 10% more efficient*
        - *lighting at least 10% more efficient*

Biomass System

Table 177: Selkirk – West End Lands development – Phase 1 Energy Initiative – biomass fuel characteristics

material		***energy density***		***cost***
source	*form*	*kWh/kg*	*MWh/tonne*	*per tonne*
waste wood from urban forests & clean waste construction wood	chipped	2.9	2.9	$30

Table 178: Selkirk – West End Lands development – Phase 1 Energy Initiative – biomass system capacity & cost

capacity	***system efficiency***	***net heat production***	***capital cost (installed pricing)***	
MW		*MWh/tonne*	*per kW*	*total*
1.0	75%	2.2	$400	$400,000

Table 179: Selkirk – West End Lands development – Phase 1 Energy Initiative – biomass components – estimated capital costs (installed pricing)

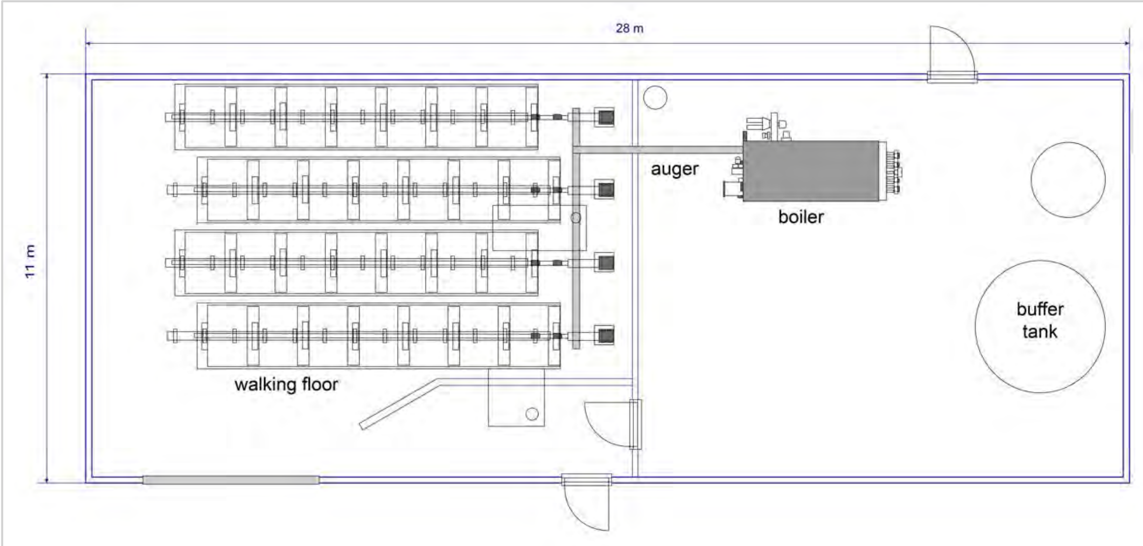
component	***capital cost (installed pricing)***
biomass system	$400,000
extension lines	$400,000
building	$400,000
chipping equipment	$400,000
total:	*$1,600,000*

Because the biomass system is designed to provide heating to multiple buildings in a community, rather than only to pre-existing buildings, there needs to be provisions for extension lines. These can extend out through at least part of the development. They can also be stubbed to receive heat from Process Heat sources, in preparation for possible integration in the follow-on phases.

These lines should be set in place at the same time as water and sewer lines are laid.

$400,000 is included in this capital budget for the biomass loop extension lines. This will not be enough to reach all the buildings that could be heated by biomass in the full West End Lands development, but will make a significant start.

Figure 71: Biomass Building – simplified layout



The biomass building should be oriented east/west, with a long wall facing south. At a later stage, it may make sense to add solar panels (mounted vertically) on the south wall to further offset electricity draw from the district loop's circulating pumps.

Heat Pump System

Table 180: Selkirk – West End Lands development – Phase 1 Energy Initiative – ground-source heat pump system – capacity, cost & space requirements

system			***costs***			***horizontal loops space requirement***	
capacity		*Coefficient of Performance*	*heat pump systems*	*horizontal loops*	*total*		
kW	*tons*					*m^2*	*ft^2*
400	114	3.5	$720,000	$440,000	***$1,160,000***	30,000	320,000

Just as with the biomass system, the heat-pump system is designed to provide heating and cooling across a community, rather than only to pre-existing buildings.

To prepare for this build-out, extension lines are needed. These can extend out through at least part of the development and to pre-existing sources of heat, such as the wastewater lines. And, as with the biomass extension lines, the heat pump's extension lines should be set in place at the same time as water and sewer lines are laid.

Table 181: Selkirk – West End Lands development – Phase 1 Energy Initiative – ground-source heat pump system, with extension lines

component	***capital cost (installed pricing)***
heat pump systems	$720,000
horizontal loops	$440,000
extension lines	$720,000
total:	*$1,880,000*

Just over $700,000 is included in this capital budget for these extension lines. This will not be enough to connect all the potential buildings that could be heated and cooled by ground-source heat pumps in the entire West End Lands development, but it will put the infrastructure in place now to enable integration during build-out.

Solar Array

Table 182: Selkirk – West End Lands development – Phase 1 Energy Initiative – Solar Array[71]

# panels:	1,008	row width:	28	panels
configuration:	2 up		32	m
# rows:	18		104	ft
production capacity:		per panel:	0.535	kW
		array total:	539	kW
capital cost:		per installed kW:	$1,900	
		solar array total:	$1,024,632	

The configuration of the solar array—18 rows with each row being 28 panels wide is a suggestion only. It should be adapted to best utilize the land available.

If there are lands nearby designated as brownfield sites, funding may be available to develop those into a location for the solar array.[72]

Some of the panels can be located on buildings, as Selkirk has done with its new wastewater treatment plant.

[71] The configuration "2-up" is explained in more detail in the section "Recommended Panel Configuration", below.

[72] Federation of Canadian Municipalities. (2015). *Getting started on your brownfield sites: Committing to action.* Green Municipal Fund. https://greenmunicipalfund.ca/sites/default/files/documents/resources/guide/guidebook-getting-started-on-your-brownfield-sites-committing-to-action-gmf.pdf

Solar Walls

Solar walls are suitable for most commercial and some retail spaces. Depending on the building configuration, they may also be suitable for multi-dwelling buildings.

The solar walls will need to be tied into the make-up air system, pre-heating the air, so that less energy is needed to warm up cold outside air when it is needed for ventilation.

It is recommended that $96,000 be allocated to solar walls. This will promote the inclusion of solar walls in the first buildings to be constructed in the West Lands development.

Table 183: Selkirk – West End Lands development – Phase 1 Energy Initiative – solar walls – dimensions & costs

dimensions										
metres		*feet*		***area***		***estimated capital cost (installed pricing)***				
length	*height*	*length*	*height*	*m²*	*ft²*	*per m²*	*per ft²*	*per unit*	*# units*	*total*
16	*3*	*52*	*10*	*48*	*517*	*$100*	*$9*	*$4,800*	*20*	***$96,000***

Because the configuration of those buildings is not yet known, the configurations of the solar walls cannot at this point either. The estimate of 20 solar walls, each 16 metres long and 3 metres high is included here to give a sense of proportion and possibilities. Actual configurations will depend on the building configurations.

It may be possible to increase the benefit of this solar wall recommendation by offering to subsidise the installation of solar walls in buildings not owned by the City of Selkirk at a percentage rate—perhaps offering to cover 50% of the cost.

Because the buildings in the West End Lands development are not yet built, integrating solar walls into their design will be easier than retrofitting solar walls onto existing buildings, as is proposed in Brandon and Piney.

Because each solar wall is custom designed to its building, it is not possible to know, at the prefeasibility stage, what the energy and cost savings will be. Therefore, no estimate of the energy savings for these walls are included in this prefeasibility study.

However, this information can be collected by requesting bids from solar wall installers for a specific building. In addition to a firm capital cost, these bids will include estimates of the energy benefits and dollar savings.

Building Design Guidance

As noted above, this study proposes minimum energy efficiency targets for buildings constructed in the West End Lands. These should be benchmarked against current average Manitoba building performance:

- space heating at least 25% more efficient
- space cooling at least 10% more efficient
- lighting at least 10% more efficient

Table 184: Selkirk – West End Lands – current Manitoba building energy performance & proposed targets[73]

	current Manitoba average building performance		***proposed building performance targets***		
	residential	*retail/commercial*		*residential*	*retail/commercial*
energy purpose	*MWh/household*	*kWh/m²*		*MWh/household*	*kWh/m²*
space heating	13.9	319	-25%	10.4	239
space cooling	1.5	78	-10%	1.3	70
lighting	1.0	16	-10%	0.9	14

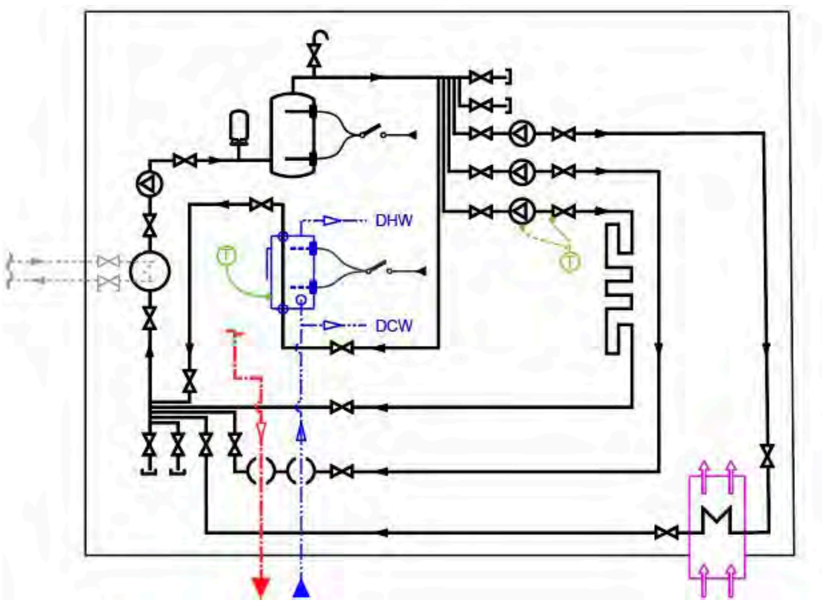
These targets are deliberately modest and well short of net-zero standards (including those proposed for the Dunnottar Public Works Building). If the improvements projected here can be exceeded, energy demand can be even less than is anticipated in this study.

[73] Source of current Manitoba building performance data: Government of Canada. (2022). *Comprehensive Energy Use Database.* Natural Resources Canada, Office of Energy Efficiency. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/trends/comprehensive_tables/list.cfm. (Note that these performance standards are *in addition* to the enhanced building performance achieved by integrating the building's heating and cooling systems into the heat pump and/or biomass system district loops.)

Integration into the biomass and/or heat pump district loops needs to be integral to the building design process. This includes integrating the following building systems:

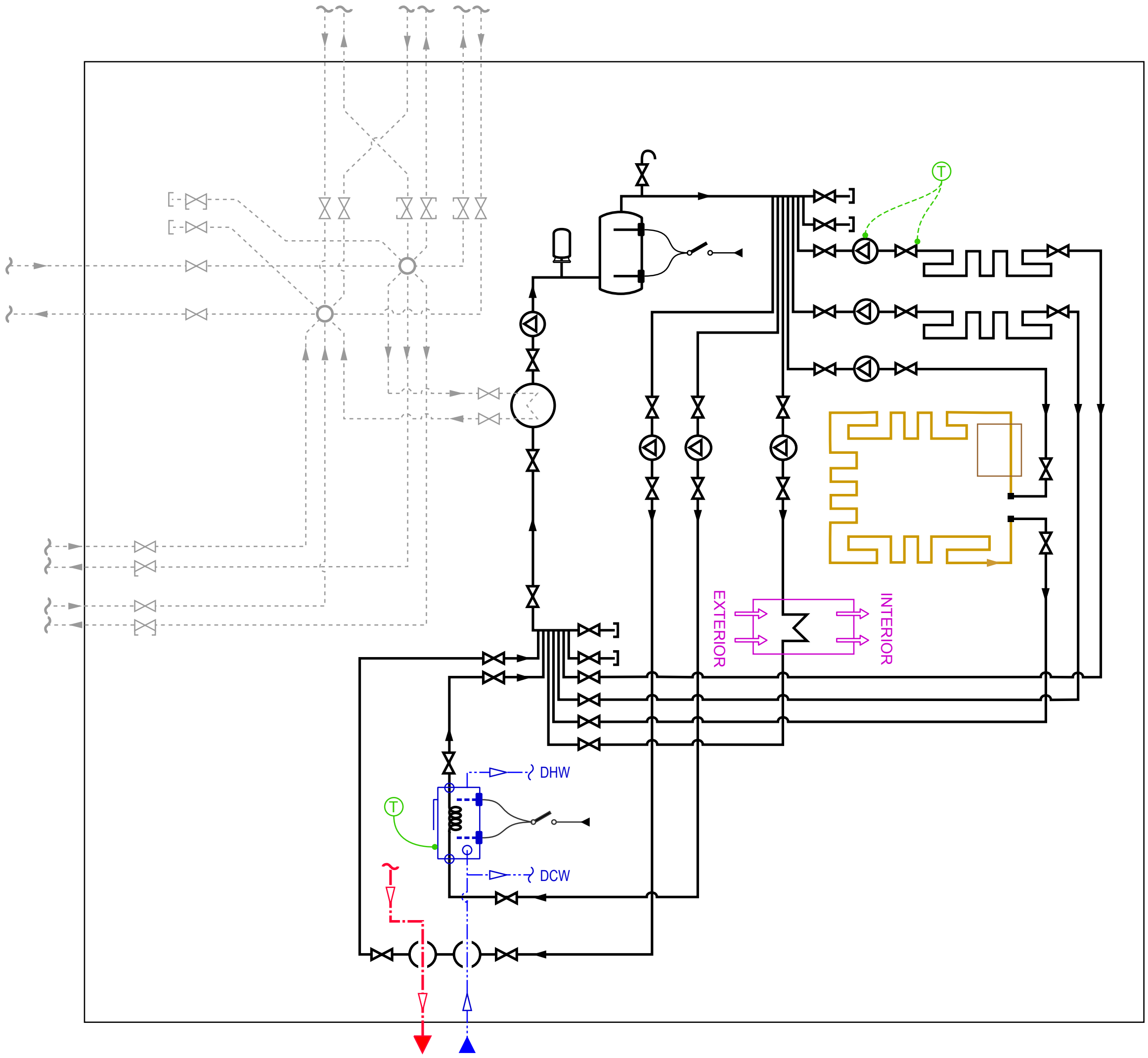
- in-floor heating and cooling
- hot water tank
- Air Handler Unit (AHU or make-up air system)
- Heat Recovery Ventilation (HRV)

Figure 72: Schematic for typical house or other small building, with integrated heating, cooling, domestic hot water, & heat recovery ventilation[74]



[74] See drawings MMB 081 and MMB 082 for integration into community district loops and drawing keynotes for this and the following figure.

Figure 73: Schematic for typical larger building, serving as hub for district energy system



1.7.3.1 NOTES ON SELKIRK RECOMMENDATIONS

Significant work can and should be done at during this first phase to prepare for follow-on phases.

- *Process Heat from local Selkirk industries represents a significant opportunity for bringing additional heat the West End Lands development.*
    - *Because this heat may not be available throughout the year, this heating source needs to be integrated into the district loops proposed for Phase 1. The most likely integration is probably with the biomass-based heating system as biomass heat can be turned up or down as needed to complement variations in heat from industrial sources.*
    - *Because Process Heat systems require integrating municipal and community systems with production systems of private corporations, cross-jurisdictional negotiations to achieve this integration can take time.*
    - *Fortunately, process heat is not needed for the Phase 1 to go ahead. Starting discussions now will increase the chances that this heat will come on stream in time to be integrated into follow-on phases.*
- *Although adding a Solar Array in this first phase will offset the electricity needed to operate the equipment and circulating pumps for the Biomass System and the Ground-Source Heat Pump system, meeting the entire electrical needs of the West End Lands development through solar alone would probably use up too much land. As with the Vermillion Growers Greenhouse in Dauphin, integrating a Wind Farm into the Selkirk development is a reasonable and attainable solution.*
    - *A wind farm should not be located within the West End Lands physical space. Suitable farmland is available nearby. Use of this land*
        - *Under certain weather conditions, ice can form on wind turbine blades and then, when the weather warms up, melt. If the melting occurs during windy conditions, ice fragments can be propelled up to several hundred metres. This is a well-known issue with wind turbines, with well-established mitigation measures.*[75] *The best solution—and a solution used in both of Manitoba's existing wind farms—is to locate the turbines in farm fields, set back from buildings, roads, and rail lines.*
    - *The City of Selkirk could own this wind farm, either on its own or with community partners in a publicly owned, non-profit cooperative.*

[75] See, for example: Wahl, D. & Giguere, P. (2006). *Ice Shedding and Ice Throw – Risk and Mitigation.* GE Energy. https://www.gevernova.com/content/dam/gepower-new/global/en_US/downloads/gas-new-site/resources/reference/ger-4262-ice-shedding-ice-throw-risk-mitigation.pdf

  - *The ownership structure could be modelled on the Pembina Valley Water Cooperative, which provides drinking water to 14 cities, towns and rural municipalities in south-central Manitoba while ensuring public ownership and the maximization of benefits to the communities served.*
  - *Negotiating this will require discussions between the City of Selkirk, the Association of Manitoba Municipalities, and the Province of Manitoba (and perhaps Manitoba Hydro) to ensure that this wind farm meets the provisions of the Manitoba Hydro Act. These negotiations will take time. To ensure that this electricity is available when required as the West End Lands project develops, discussions should start now.*

- *There are numerous buildings in Selkirk with ice sheets, currently used for skating, hockey and curling. Additional ice facilities are planned. All of these use significant amounts of energy extracting heat from the ice. Instead of venting this heat into the air, these buildings are potential sources of building heat in the West End Lands development, if that heat can be captured and integrated into the district heating loops.*

The challenges the Concept Plan will face in achieving its energy targets are not technical; all the renewable energy systems proposed are mature and commercially available, and there is expertise currently available in Manitoba (and elsewhere) to design, construct and operate these systems.

The core challenge is social: Will people involved in building the West End Lands development want to achieve this vision?

1.7.4 *Effects of Renewable Energy Recommendations*

1.7.4.1 OVERALL EFFECTS

It is not assumed that all buildings constructed during this first phase follow the guidelines exactly. The Concept Plan proposes guidelines, not strict building code requirements. These estimated effects are based on a projection that 10% of the buildings constructed follow the guidelines and connect to the district energy loops, rather than using natural gas.

Table 185: Selkirk – West End Lands – Phase 1 Energy Initiative – estimated energy use difference – compared to "business as usual" building design & energy systems

	natural gas			electricity from MB Hydro		reductions from outside sources	
	m^3	MWh	%	MWh	%	MWh	%
Phase 1 Energy	-1,243,269	-13,262	-90%	-8,950	-56%	-8,950	-56%

Table 186: Selkirk – West End Lands – Phase 1 Energy Initiative – estimated GHG emissions reductions

	GHG emissons CO_2e tonnes/year			
	business as usual	if project goes ahead	change	
Phase 1 Energy Initiative	2,661	266	-2,395	-90%

Table 187: Selkirk – West End Lands – Phase 1 Energy Initiative – estimated overall annual operating cost savings

	overall energy operating costs			
	business as usual	if project goes ahead	change	
Phase 1 Energy Initiative	$2,093,755	$794,243	-$1,299,512	-62%

Table 188: Selkirk – West End Lands – Phase 1 Energy Initiative – estimated self-generated energy – per year

	biomass		electricity	increases in self-generated energy
	tonnes	MWh	MWh	MWh
Phase 1 Energy Initiative	1,020	3,000	732	3,732

1.7.4.2 DETAILS OF EFFECTS

Table 189: Selkirk – West End Lands – Phase 1 Energy Initiative – estimated annual natural gas cost saved

	natural gas			
	estimated savings			
	business as usual	if project goes ahead	change	
Phase 1 Energy Initiative	$483,494	$48,349	-$435,144	-90%

Table 190: Selkirk – West End Lands – Phase 1 Energy Initiative – estimated annual electricity cost saved

	electricity			
	estimated savings			
	business as usual	if project goes ahead	change	
Phase 1 Energy Initiative	$1,610,261	$715,281	-$894,980	-56%

Table 191: Selkirk – West End Lands – Phase 1 Energy Initiative – Biomass System – estimated biomass required & natural gas consumption avoided

		biomass consumed	heat produced		electricity required	natural gas replaced		GHG emissions avoided
			/month	/hr				CO_2e
		tonnes	MWh	kWh	MWh	MWh	m^3	tonnes
month	Jan	178	523	703	26	523	49,036	94
	Feb	173	509	751	25	509	47,730	92
	Mar	132	389	522	19	389	36,442	70
	Apr	88	258	358	13	258	24,175	47
	May	42	123	166	6	123	11,562	22
	Jun	12	36	50	2	36	3,359	6
	Jul	8	23	30	1	23	2,120	4
	Aug	12	34	46	2	34	3,222	6
	Sep	28	81	113	4	81	7,629	15
	Oct	74	217	291	11	217	20,298	39
	Nov	116	341	474	17	341	31,981	62
	Dec	159	466	626	23	466	43,697	84
annual totals:		1,020	3,000		150	3,000	281,250	542
			average:	344				

Table 192: Selkirk – West End Lands – Phase 1 Energy Initiative – Heat Pump System – estimated heating & cooling produced, electricity required, & natural gas consumption avoided

	heat provided		cooling provided		electricity needed	natural gas replaced	
	/month	/hr	/month	/hr	CoP 3.5		
month	MWh	kWh	MWh	kWh	MWh	MWh	m^3
Jan	174	234	0	0	9	174	16,345
Feb	170	250	0	0	8	170	15,910
Mar	130	174	0	0	6	130	12,147
Apr	86	119	0	0	4	86	8,058
May	41	55	2	3	2	41	3,854
Jun	12	17	7	10	1	12	1,120
Jul	8	10	9	12	0	8	707
Aug	11	15	7	9	1	11	1,074
Sep	27	38	3	4	1	27	2,543
Oct	72	97	0	0	4	72	6,766
Nov	114	158	0	0	6	114	10,660
Dec	155	209	0	0	8	155	14,566
annual totals:	*1,000*		*28*		50	*1,000*	*93,750*
average:		*115*		*3*			

The Concept Plan proposes to establish targets for reductions in design energy. These have not yet been quantified. Combining moderate targets with heat pump systems can cut energy demand by more than half.

Table 193: Selkirk – West End Lands – Phase 1 Energy Initiative – estimated residential energy use – per dwelling unit

energy purpose	average consumption if built to "business as usual" standards (MWh)	energy demand changes resulting from improved building design	estimated energy demands if built with improved building design: heating & cooling requirements MWh	CoP	electrical demands MWh	% of as usual"
space heating	13.9	-25%	10.4	3.0	3.5	25%
space cooling	1.5	-10%	1.3	4.0	0.3	23%
water heating	4.4	0%	3.0	4.0	0.8	17%
lighting	1.0	-10%			0.9	90%
appliances	4.8	0%			4.8	100%
	25.5				***10.3***	**40%**

Table 194: Selkirk – West End Lands – Phase 1 Energy Initiative – estimated retail/commercial energy use – per m^2 of building footprint

energy purpose	average consumption if built to "business as usual" standards	energy demand changes resulting from improved building design	estimated energy demands if built with improved building design: heating & cooling requirements		electrical demands	
	kWh/m²		kWh/m²	CoP	kWh/m²	% of as usual"
space heating	319	-25%	239	3.0	80	25%
space cooling	78	-10%	70	4.0	17	23%
water heating	5	0%	5	4.0	1	25%
lighting	16	-10%			14	90%
auxillary equipment	40	0%			40	100%
auxillary motors	*13*	0%			*13*	100%
totals:	*469*				***165***	***35%***

energy purpose	energy required: development type: residential space	retail & commercial space		totals	energy sources: heat pumps			biomass system		
	# units	ft²	m²		% of load	CoP	electricity required	% of load	"CoP"	electricity required
	1,000	40,000	3,716							
	MWh		MWh	MWh			MWh			MWh
space heating	10,450		888	11,338	20%	3.0	756	80%	20	454
space cooling	1,309		259	1,568	100%	4.0	392	100%		0
water heating	3,000		17	3,017	0%	4.0	0	100%	20	151
	14,759		*1,164*	*15,923*			*1,148*			*604*
electricity required to run heat pumps & biomass system:										***1,752***

2 RENEWABLE ENERGY OPTIONS

2.1 What is Renewable Energy?

Defining renewable energy might seem quite straightforward. It is not. This study uses the Intergovernmental Panel on Climate Change's (IPCC's) definition of renewable energy:

> *Any form of energy that is replenished by natural processes at a rate that equals or exceeds its rate of use.*[76]

While this definition may appear abstract, it is both specific and useful. It excludes fossil fuels because, while those were created through natural processes, they are being used over hundreds of years, while being replenished over hundreds of millions of years. It also excludes energy from nuclear fission, because radioactive fuel is not replenished.[77]

This definition also has the merit of fitting the definition of renewable energy that any potential funders would use.

There are many types of renewable energy. They include:

- electricity from
  - wind turbines
  - solar photovoltaic systems
  - hydro dams
  - hydrokinetic energy[78]
- energy from solar thermal systems, including both systems that heat water and those that generate electricity.[79]

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[76] Intergovernmental Panel on Climate Change (IPCC). (2023, March 20). *Glossary – Renewable Energy (RE).* https://apps.ipcc.ch/glossary/.

[77] This study takes no position on the merits of nuclear energy, nor on its potential role in reducing global warming.

[78] "Hydrokinetic technologies produce renewable electricity by harnessing the kinetic energy of a body of water—the energy that results from its motion."

- Union of Concerned Scientists. (2007, July 14). *How hydrokinetic energy works.* https://www.ucsusa.org/resources/how-hydrokinetic-energy-works.)

This energy is usually captured using in-water turbines and is sometimes referred to as "run-of-river". For more information on this technology see the Canadian Hydrokinetic Turbine Test Centre (CHTTC).

[79] Solar thermal systems that generate electricity are described by the U.S. Energy Information Administration (EIA) as: "Solar thermal power/electric generation systems collect and concentrate sunlight to produce the high temperature heat needed to generate electricity. All solar thermal power systems have solar energy collectors with two main components: *reflectors* (mirrors) that capture and focus sunlight onto a *receiver*. In most types of systems, a heat-transfer fluid is heated and circulated in the receiver and used to produce steam. The steam is converted into mechanical energy in a turbine, which powers a generator to produce electricity."

- EIA (U.S. Energy Information Administration). (2022, April 15). *Solar thermal power plants.* https://www.eia.gov/energyexplained/solar/solar-thermal-power-plants.php

- deep-source geothermal energy (both electricity and heat)[80]
- heating (and cooling) from ground, water and air heat pumps[81] (provided the electricity to operate the pumps is from a renewable source)
- bioenergy

> *Bioenergy is energy produced from renewable, biological sources such as biomass. Biomass is plant material that can be turned into fuel (also known as biofuel when it is made from biological material) to supply heat and electricity."*[82]

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[80] "Geothermal technology extracts the heat found within the subsurface of the earth, which can be used directly for heating and cooling, or converted into electricity."

- IRENA. *Geothermal energy*. https://www.irena.org/Energy-Transition/Technology/Geothermal-energy

[81] Although the terms are often used interchangeably, geothermal energy is not the same as heat from ground-source heat pumps. Ground-source heat pumps do not rely on the heat from deep within the earth. Instead, a ground-source heat pump functions as a heat battery, extracting heat from a building during the summer (to cool the building) and then returning that heat to the building in winter.

[82] Government of Canada. (2020, July 20). *Bioenergy from biomass.* Natural Resources Canada. https://natural-resources.canada.ca/our-natural-resources/forests/industry-and-trade/forest-bioeconomy-bioenergy-bioproducts/bioenergy-biomass/13323.

2.2 Criteria for a Renewable Energy Option to be Considered in this Study

Not all possible forms of renewable energy were considered in this study. To be included in the study, the technology producing the renewable energy had to be:

- commercially available
- approved for use in Manitoba
- suitable for Manitoba's climate
- suitable for at least one of the participating communities
- suitable for use in the targeted buildings within those communities

2.3 Renewable Energy Options Considered in this Study

In addition to biomass, this study also examined the feasibility of using other renewable energy options to meet some of these municipalities' energy needs. Some of those other renewable energy options included:

- photovoltaic solar energy
- solar walls
- heat pumps, with a particular focus on ground-source heat pumps
- capturing process heat from local industrial activities for use in heating buildings

Suggestions for reducing energy consumption through Demand-Side Management (DSM) measures are also noted for some buildings. However, a thorough examination of DSM possibilities for all the buildings considered was beyond the scope of this study.

2.4 Biomass

While "biomass" is a common term in renewable energy discussions, it may be less familiar to the public. The U.S. Energy Information Administration (EIA) has a good, broad definition:

> *Biomass is renewable organic material that comes from plants and animals. Biomass contains stored chemical energy from the sun that is produced by plants through photosynthesis. Biomass can be burned directly for heat or converted to liquid and gaseous fuels through various processes.*[83]

Prior to the planet-wide adoption of fossil fuels only 200 years ago, biomass was the predominant fuel throughout human history. It is still an essential fuel in many places on Earth. It is used to generate both heat and electricity.

Because biomass produces CO_2 when burned, it cannot be considered an ideal renewable fuel. It is considered renewable by most jurisdictions (including the United Nations,[84] the IPCC, Canada, and Manitoba) if the CO_2 it produces was extracted from the air only recently (usually between 1 and 50 years). Because of this recent extraction, it is not considered to be a net contributor to total greenhouse gas emissions (GHGs).

Manitoba lags other jurisdictions in using biomass as a renewable fuel source. For example, more than 50% of Europe's renewable energy comes from biomass, where it is used to generate electricity (to complement variable renewables such as wind and solar) and for heating and cooling.[85]

The IPCC goes into more detail on sources and on types of biomass fuel:

> *Biomass sources include forest, agricultural and livestock residues, short-rotation forest plantations, dedicated herbaceous energy crops, the organic component of municipal solid waste (MSW), and other organic waste streams. These are used as feedstocks to produce energy carriers in the form of solid fuels (chips, pellets, briquettes, logs), liquid fuels (methanol, ethanol, butanol, biodiesel), gaseous fuels (synthesis gas, biogas, hydrogen), electricity and heat….*
>
> *Bioenergy carriers range from a simple firewood log to a highly refined gaseous fuel or liquid biofuel. Different biomass products suit different situations and specific objectives for using biomass are affected by the quantity, quality and cost of feedstock available, location of the consumers, type and value of energy services required, and the specific co-products or benefits.*
>
> *Prior to conversion, biomass feedstocks tend to have lower energy density per volume or mass compared with equivalent fossil fuels. This makes collection, transport, storage and handling more costly per unit of energy….These costs can be minimized if the biomass can*

[83] EIA. (2023, June 30). *Biomass explained*. https://www.eia.gov/energyexplained/biomass/.

[84] United Nations. (n.d.). *UNFCCC (United Nations Framework Convention on Climate Change)*. https://unfccc.int/.

[85] European Commission. (2019). *Biomass*. Energy. https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/biomass_en.

be sourced from a location where it is already concentrated, such as wood-processing residues…

The diversity of biomass fuels can be confusing.[86]

Table 195: Main biomass fuels

		SOURCE				
		forestry	**agriculture**		**other**	
			animals	*plants*	*algae*	*cattails*
FORM	*solid*	logs & branches charcoals & briquettes chips pellets		bales silage & shives hulls & husks pellets		bales silage
		waste: slash (harvesting residue) sawdust (processing residue) woody construction waste	*waste:* manure biosolids	*waste:* seed-cleaning residue plant stalks		
	liquid	pyrolysis oil black liquor	FAME diesel			
			HDRD diesel			
				ethanol		
				biobutanol		
	gas	syngas	renewable natural gas (biomethane)			

The use of some of these fuels is as old as human civilization; others are active fields of research and are not yet fully commercialized. Some are suitable for the Manitoba climate; others are not. Some are better suited to use in transportation, while other are better suited to stationary use.

Not all these fuels are suitable for use in the buildings targeted in this study. The criteria for inclusion in this study is made explicit in *Biomass – Criteria for Inclusion in Study*, below. A listing of the biomass fuels available in Manitoba and considered in this study is given in the *Biomass – Fuels Considered in this Study*, below.

2.4.1 *Biomass Available to the Participating Communities*

There is a large volume of biomass available within a 30 km radius of each of the participating communities—far more than would be needed to heat the target buildings in this study. The three main sources are:

- agricultural by-products
- forestry by-products
- municipal waste

The proportions between these three sources are different for each community, because both the environments and the industries around each community are different.

[86] One of the issues that can cause additional confusion is the various types—and names—for diesel. This issue is addressed in the appendix Understanding Diesel, attached to this study.

Table 196: Potential biomass available within 30 km of each participating community – annual averages in tonnes[87]

	Brandon	Dauphin	De Salaberry	Dunottar	Killarney Turtle Mountain	Piney	Selkirk
latitude	*49.85*	*51.16*	*49.31*	*50.46*	*49.18*	*49.17*	*50.14*
longitude	*-99.95*	*-100.05*	*-96.94*	*-96.95*	*-99.66*	*-95.73*	*-96.89*
Agriculture By-products							
Barley straw	28,916	14,389	22,306	13,919	16,094	1081	26,796
Wheat straw	83,714	53,220	69,308	31,128	73,061	2,752	64,989
Flax shives	7,547	3,599	9,125	2,112	9,835	282	6,026
Oat straw	13,931	11,116	22,240	9,756	8,600	955	21,976
Agriculture total:	*134,108*	*82,324*	*122,979*	*56,915*	*107,590*	*5,070*	*119,787*
Forestry Residue							
harvest residue	0	0	692	2,140	0	8,768	1,280
mill residue							
chips & sawdust	0	0	0	0	0	0	122,083
bark	0	0	0	0	0	0	37,933
urban wood waste							
residential	2,434	402	768	141	276	0	14,468
non-residential	4,295	753	1,287	69	136	0	25,839
Forestry Residue total:	*6,729*	*1,155*	*2,747*	*2,350*	*412*	*8,768*	*201,603*
Municipal Waste							
paper	4,646	703	311	252	334	0	15,028
Municipal Waste total:	*4,646*	*703*	*311*	*252*	*334*	*0*	*15,028*
total potential biomass:	***145,483***	***84,182***	***126,037***	***59,517***	***108,336***	***13,838***	***336,418***

This data comes the Biomass Inventory Mapping and Analysis Tool, produced by Agriculture and Agri-Food Canada. This data is the best available, but does require some notes of explanation.

2.4.1.1 NOTES ON BIOMASS INVENTORY TOOL

- The information on agricultural sources is more detailed and comprehensive than the data from forestry and municipal sources.
- The agriculture by-product volumes shown are for the straw produced when these crops are grown.
  - There is a market for some of this straw already, so not all of this will be available for biomass-based heat production.
  - Even if we are only able to access as little of 10% of this material, this would be much more than would be needed for biomass heat for the target buildings in this study.
- Not all crops are shown. There is a potential to use by-products from other crops, including:
  - hemp stalks & stems
  - soybean stems

[87] Government of Canada. (2021, July 23). *Biomass Inventory Mapping and Analysis Tool.* Agriculture and Agri-Food Canada. https://agriculture.canada.ca/atlas/apps/aef/main/index_en.html?emafapp=bimat_ocib&mode=release&iframeheight=800

  - canola stems
- Waste material left over from agricultural processing is also not shown. Particularly relevant is:
  - dockage from seed cleaning
  - plant material left over after extracting oils from crops such as soybeans and canola
  - husks and hulls left over from processing crops such as oats[88]
  - trimmed material in greenhouse operations
    - When using biomass to make heat, the lower the moisture content the better, although almost any plant material with moisture less than 50% can be used.
    - Moisture content can be reduced by drying, but produce discards such as tomatoes, cucumbers, and fruit are generally better suited to composting than to heat production.
- The forestry volume estimates are not the volume of all wood and residue that could be available if the forests within 30 km radii of the participating communities were fully harvested to a sustainable level.
  - Very few of the trees available for sustainable harvest in southern Manitoba are currently harvested.
  - Significant potential for additional fuel from forestry is available within the 30 km radii from forests on private lands and from any tree culling and trimming done in parks.
- The forestry residue includes only the residue left from commercial scale harvesting for dimensional lumber and products like particle board. Harvesting firewood also produces residue not included here.
- Firekill and blow-down wood is not included in these estimates.
- Mill residue from wood harvested in the area but sent elsewhere to a mill is not shown.
    - This is particularly relevant for wood harvested in Piney, which has an active logging industry but no mill.
- The urban wood waste volumes are an estimate of the potential available; less that this comes to the municipal landfill.
- The category "urban wood waste – non-residential" might be more naturally categorized as "Municipal Waste" rather than forestry waste.
- The category "Municipal Waste – paper" shows the estimated volume of discarded paper that could be available.
  - This study does not recommend using this paper to produce heat.
  - Much of this paper could be better used in composting and to produce blown cellulose insulation.

[88] Some husks and hulls are used as amendments in animal feed and—sometimes—in human food. Use for those purposes should take priority over using husks and hulls for biomass heating. Only biomass for which there is no feed or food use should be used for heat.

- Cattail biomass is not shown.
  - As noted in the section on Cattails, these are an excellent potential source of biomass for heat, but are not included in this study because a commercially viable method of harvesting them at scale is not yet available.

All these notes add up to a simple idea:

- *There is much more biomass potentially available even than the very large volumes documented in this table.*

2.4.2 *Not All Biomass is Considered a Renewable Fuel*

Although most fuel produced from biomass is considered renewable, there are some important exceptions:

- Wood from old growth forests is not usually considered renewable, because the trees are not replaced as quickly as the fuel is consumed.
- Peat is also not considered a renewable fuel, because it can take thousands of years to replace it.
- Diesel derived from biomass is considered renewable only if it is made from renewable, sustainable raw materials.
  - If made from waste animal fat the fuel usually considered renewable
  - Diesel made from palm oil harvested from tropical plantations—where tropical forests are cleared to make room for the plantations—is usually considered renewable.
  - More detail on diesel is included in the appendix Understanding Diesel

2.4.3 *Criteria for Biomass Fuel Inclusion in Study*

To be considered in this study, the biomass had to be:

- readily available in or near the participating communities
- sustainably harvested
- able to be processed into useable fuel with mature, commercially available equipment.[89]
- able to be easily and safely transported and stored
- suitable for heating buildings
- not purpose-grown[90]

[89] Because the use of biomass for fuel is not widespread in Manitoba, the processing equipment might not be well-known here. However, to qualify for this study, processing equipment had to be in common use in other countries.

[90] This means that crops grown specifically to produce fuels like ethanol are not included in this study. If a crop was grown for another purpose (food or feed), residue that cannot be used for the intended purpose can be included as a biomass fuel in this study. This criterion also excludes purpose-grown willows.

2.4.3.1 CRITERIA FOR PREFERENCE IN STUDY

In this study, preference is given to biomass that is currently a waste material. These waste materials are found in the agricultural and forest industries. As well, in many cases, municipalities have waste biomass accumulating in their landfills, waste management facilities or transfer stations. Currently, many municipalities face challenges in properly disposing of this waste.

Characterizing some biomass as “waste” can be controversial. After all, biomass is an integral part of virtually all ecosystems. If not used or discarded by people, it is reabsorbed into its ecosystem. How then, is it “waste”? The term “waste biomass” is used in this study with a particular definition. It is “waste” if:

1. is collected in municipal waste management facilities or is a by-product of agricultural or forestry processes,
2. has little or no current commercial use, and
3. if left unused, there is a high risk that the material will rot and produce methane, which is a potent greenhouse gas.

2.4.4 *Biomass Fuels Included in This Study*

Table 197: Biomass fuels included in this study

Crop by-products & waste
barley straw
wheat straw
flax shives
oat hull pellets
hemp pellets
Woody by-products & waste
wood chips
wood pellets
waste wood from urban forests
clean waste construction wood

There is no single, definitive source of information on the properties of the biomass fuels available in Manitoba and considered in this study. The following tables summarize the best data available.

2.4.5 *Biomass Fuel Properties*

Table 198: Energy properties of biomass fuels included in this study[91]

	High Heating Value by Mass			
	kWh/kg		*BTU/lbm*	
crop by-products & waste				
barley straw	4.7		7,480	
wheat straw	5.0		7,710	
flax shives	5.0		7,810	
oat hull pellets	5.3		7,960	
hemp pellets	5.1		7,898	
averages:	*5.0*		*7,772*	
	kWh/kg		*BTU/lbm*	
woody by-products & waste	*median*	*range*	*median*	*range*
wood chips	2.9	2.8 - 3.1	4,500	4,300 - 4,700
wood pellets	5.3	5.0 - 5.6	8,100	7,700 - 8,500
waste wood from urban forests	2.9	2.8 - 3.1	4,500	6,200 - 6,500
clean waste construction wood	4.1	3.9 - 4.2	6,350	6,200 - 6,500
averages:	*3.8*		*5,863*	

Wood density varies by tree species and the climate where the wood was grown.

- Because they are usually denser, hardwoods typically produce more energy per tonne than softwoods.
- Because slow-growing wood is denser than fast-growing wood, slow-growing wood usually produces more energy per tonne. Cold and dry climates—especially at higher latitudes—will usually produce denser wood, with more energy per tonne.

[91] Data in greyed-out boxes are still pending.

The values for kWh/kg (kiloWatt-hours per kilogram) are the same as the values for MWh/t (MegaWatt-hours per tonne). To convert these values to kWh/tonne, multiply by 1,000.

Sources:

- *For crop by-products & waste:* Government of Ontario. (2011, June). *Biomass Burn Characteristics.* Ministry of Agriculture, Food and Rural Affairs. ISSN 1198-712X. https://www.ontario.ca/page/biomass-burn-characteristics#section-2. These values are "on a dry matter basis". The higher the moisture content, the lower these values will be.
- *For woody by-products & waste:* Government of Canada. *Solid Biofuels Bulletin No. 2: Primer for Solid Biofuels Definitions, Classes/Grades and Fuel Properties, table 2*. Natural Resources Canada. https://natural-resources.canada.ca/sites/nrcan/files/files/NRCAN_BB_no2_e13.pdf. Wood chips vary considerably by energy density, based on the type of tree being chipped and the moisture content. There is no reliable data available for waste wood from urban forests. Because this wood is typically harvested and chipped while green, the data for wood chips is used as a proxy. There is also no reliable data available for clean waste construction wood, the data for air-dried firewood from Natural Resources Canada is used as a proxy.

Table 199: Density (mass/volume) of woody biomass fuels included in this study

	Density			
	kg/m³		lbm/ft³	
Fuel Type	median	range	median	range
wood chips	350	300 - 400	22	19 - 25
wood pellets	675	550 - 800	42	34 - 50
clean waste construction wood	400	300 - 500	25	19 - 31

2.4.5.1 BIOMASS FUEL MOISTURE CONTENT

The lower the moisture content, the more useable heat energy is produced when biomass fuel is burned.

Table 200: Estimated moisture content of biomass fuels included in this study[92]

	Estimated Moisture Content
crop by-products & waste	
barley straw	variable
wheat straw	variable
flax shives	variable
oat hull pellets	<10%
hemp pellets	<10%
woody by-products & waste	
wood chips	~45%
wood pellets	<10%
waste wood from urban forests	~45%
clean waste construction wood	~25%

Fresh-cut wood has a higher moisture content, reducing the amount of energy available from burning.

2.4.5.2 BIOMASS FUEL COST

Table 201: Average cost per tonne to harvest and transport agriculture by-product biomass

	Brandon	Dauphin	De Salaberry	Dunottar	Killarney Turtle Mountain	Piney	Selkirk
harvest	$17.95	$18.16	$17.72	$17.94	$18.03	$18.69	$18.07
transport	$13.10	$12.76	$13.31	$13.10	$12.93	$13.39	$13.39
total cost	*$31.05*	*$30.92*	*$31.03*	*$31.04*	*$30.96*	*$32.08*	*$31.46*

[92] Moisture content has a critical effect on the useable heat derived from using biomass as fuel. The more water present in the fuel, the more heat is consumed in the boiler drying the fuel while it is being burnt. Pellets—both from crop and woody material—are a more standardized product and usually have lower moisture content. Because wood chips are usually produced from fresh-cut trees, their moisture content is typically quite high. The source from Natural Resources Canada estimates a moisture content of 45%. If the wood being chipped has been dried before chipping, its moisture content will be lower and, therefore, the useable heat will be higher.

2.4.6 *Biomass Suppliers in Manitoba*

Table 202: Established biomass suppliers in Manitoba

company	products	location	contact
Buffalo Creek Mills	oat hull pellets	Altona	https://buffalocreekmills.ca/pellets/
Firewood Manitoba	logs, wood pellets, wood chips	Swan River	https://sprucewoodloggers.ca/index.php
Hemp Sense	hemp & hemp/wood pellets	Gilbert Plains	https://www.hempsense.net
Prairie Pellets	wood pellets	Elm Creek	https://www.prairiepellet.com
Riehl's Lumber & Logging	logs, mulch	Durban	https://riehlslumber.ca
Richardson Milling	oat hull pellets	Portage la Prairie	https://www.richardson.ca/places/portage-la-prairie/
South East Logging	logs	Stony Mountain	*https://www.sefp.ca*

This is not intended as a definitive or complete list. There are numerous farmers and woodlot owners within 30 km of each participating community who would be interested in supplying biomass, provided a multi-year contract was available. Two initial points of contact worth pursuing are:

- Woodlot Association of Manitoba
- Keystone Agricultural Producers

Details on pricing from suppliers is available in the appendix Biomass Pricing.

2.4.7 *Biomass CO_2 emissions*

As noted earlier in this section, all the biomass recommended in this study is considered GHG emissions neutral. It qualifies as neutral because the plants will have recently extracted CO_2 from the atmosphere through photosynthesis and then return to the air when burnt as fuel.

There is a *small* amount of CO_2 that is emitted in harvesting and transporting this fuel. The Biomass Inventory Mapping and Analysis Tool also contains useful estimates of the CO_2 that would be emitted to harvest and transport biomass to each participating community.

Table 203: Average CO_2 emissions, *in grams*, per tonne produced from harvesting and transporting agriculture by-product biomass within 30 km of each community[93]

	Brandon	Dauphin	De Salaberry	Dunottar	Killarney Turtle Mountain	Piney	Selkirk
harvest	7.52	7.52	7.43	7.51	7.55	7.79	7.56
transport	37.05	37.05	37.58	37.04	36.60	37.59	37.80
total CO_2 emissions:	*44.57*	*44.57*	*45.01*	*44.55*	*44.15*	*45.38*	*45.36*

Havesting and transporting agricultural by-products produces only very modest CO_2 emissions—less than *50 grams* per tonne of material.

93 Biomass Inventory Mapping and Analysis Tool.

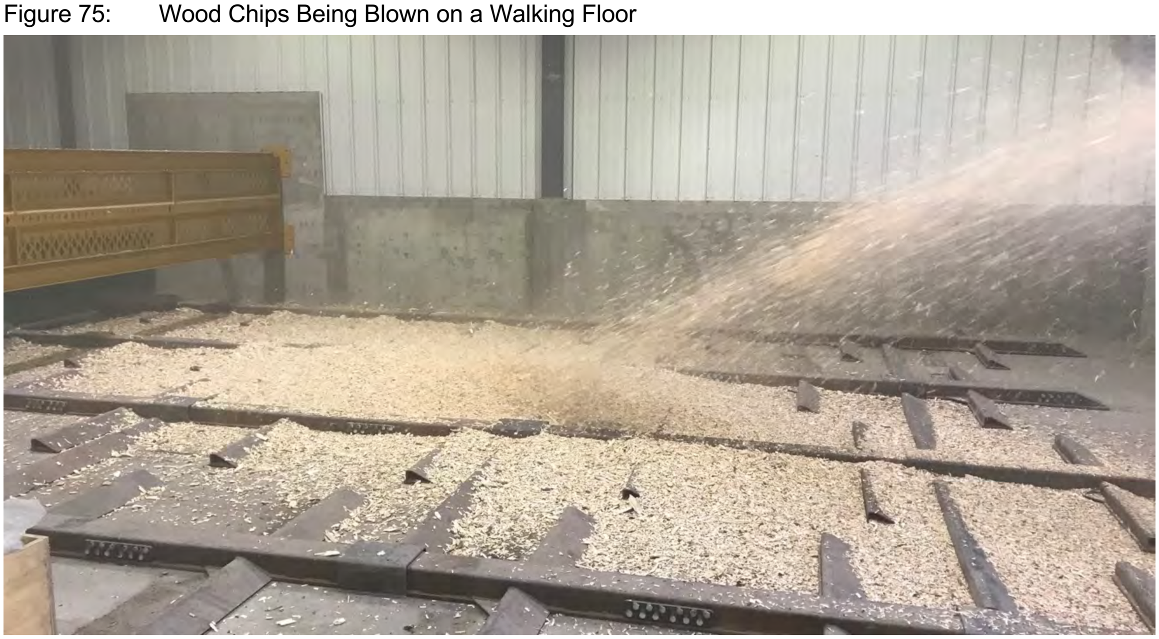
2.4.8 *Biomass Systems – Configurations*

Simplifying somewhat, there are two basic configurations for biomass systems.

Larger biomass systems typically use chipped wood or chopped straw and stems as fuel. They require a walking floor and augers to feed the fuel into the boiler. The boiler and the walking floor are typically (but not always) contained in their own building.

Figure 74: Typical Larger Biomass Boiler (> 500 kW)[94]

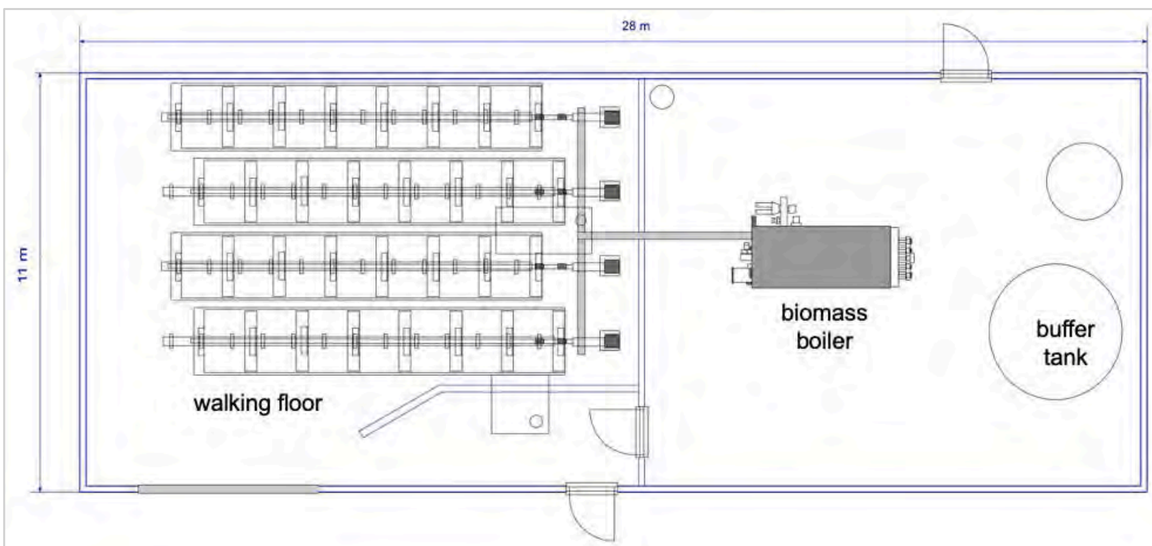
Figure 75: Wood Chips Being Blown on a Walking Floor



[94] Source for this and the next two pictures: Northlands Dënesųłiné First Nations Energy, Lac Brochet Manitoba.

Figure 76: Biomass Building Log Yard

Figure 77: Typical Building Layout for Larger Biomass System



Smaller systems typically use pellets, although some can accommodate wood chips, if the chips are of near-uniform size. A walking floor is not needed, and the fuel is fed directly into the boiler from either a hopper or a silo.

Figure 78: Typical Smaller Flex-Fuel Biomass System (400 kW)[95]

Figure 79: Typical Smaller Pellet-Fuelled Biomass System (100 kW)[96]

[95] Source: Smart Heating Technology. (n.d.). *Automatic Biomass Boiler: Smart 400 kW.* https://www.smartheating.cz/en/smart-400-kw/. (Note: Inclusion of an image in this study is not to be considered an endorsement of a product. It is included for information purposes only.)

[96] Source: Kotly.Com.Pl. *Pellet boiler EkoPell Max 100 kW.* https://kotly.com.pl/produkt-pellet-boiler-ekopell-max-100-kw-5639.html?l=en. (Note: Inclusion of an image in this study is not to be considered an endorsement of a product. It is included for information purposes only.)

Figure 80: University of Winnipeg Biomass System Pellet Fuel Silo

2.4.9 *Biomass Delivery & Storage*

Two general rules apply for biomass handling & storage:

- Handling should be minimized.
    - Handling adds cost.
    - Transportation in bulk—rather than in bags or totes—is almost always preferred.
- Exposure to rain and snow should be minimized.
    - Moisture reduces the efficiency of combustion.

2.4.9.1 HOPPER-BASED TRANSPORTATION & HANDLING SYSTEMS

If shipping pellets or a biomass material that can be handled by augers, the most efficient system (and therefore the lowest cost) is usually a hopper car (if transporting by rail) or a hopper trailer (if transporting by road).

Figure 81: Covered hopper railcar[97]

[97] Freight Car America. (n.d.). *Covered hopper railcar*. https://freightcaramerica.com/covered-hoppers/. (Note: Inclusion of an image in this study is not to be considered an endorsement of a product. It is included for information purposes only.)

Hopper trailers—often paired together and called a “b-train” or “super-b”, are the best for on-road transportation, if the site where the biomass will be used is able to receive the pellets through a below-grade receiver.

Figure 82: Single hopper[98]

Figure 83: Tandem hopper trailers[99]

This delivery & storage equipment is common in the agricultural industry and is easily adapted to biomass.

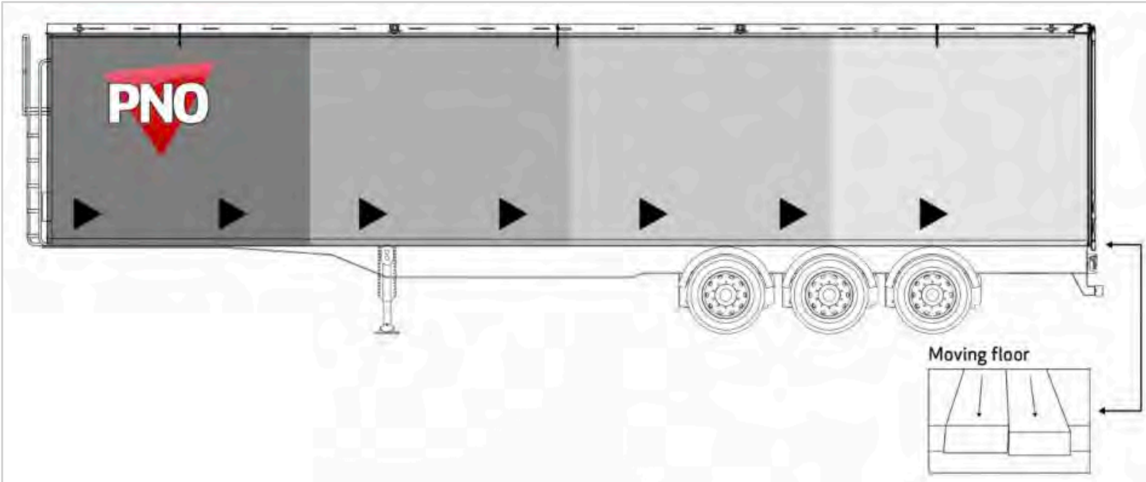
[98] Source: Prestige Trailers. (n.d.). *Hoppers.* https://prestigetrailers.com/sand-king/. (Note: Inclusion of an image in this study is not to be considered an endorsement of a product. It is included for information purposes only.)

[99] Source: Lode King. (n.d.). *Hopper Trailer.* https://www.lodeking.com/hoppers/. (Note: Inclusion of an image in this study is not to be considered an endorsement of a product. It is included for information purposes only.)

2.4.9.2 MOVING-FLOOR BASED TRANSORTATION SYSTEMS

Wood chips are often transported by trailers equipped with a moving floor.

Figure 84: Trailer with moving floor[100]



Moving floor trailers are not as common in the agricultural industry as hopper trailers. If biomass is being transported in chip form, either the supplier, the transportation company, or the entity consuming the biomass will usually need to buy a moving floor trailer and factor its use into the fuel price.

[100] PNO. (n.d.). *Moving floor.* https://pnorental.com/portfolio-item/moving-floor/. (Note: Inclusion of an image in this study is not to be considered an endorsement of a product. It is included for information purposes only.)

2.4.10 *Woody Biomass Fuel Forms*

To be efficiently burned in bulk, woody biomass must be transformed into a form that can be handled automatically. Because there does not seem to be a commercially available system for feeding logs automatically into boilers, this means that biomass must be either pelletized or chipped.

2.4.10.1 PELLETIZATION

Pelletization machinery is widely available. If a source of sawdust can be found—waste left over from sawmill production, for example—the energy input required to turn the sawdust into pellets is not high and, because most pelletization machines run on electricity, manufacturing pellets in Manitoba results in only minimal GHG emissions. It costs roughly $60/tonne to produce woody pellets from sawdust.

Producing woody pellets from whole logs is much more energy intensive and the wood must first be chipped.

2.4.10.2 CHIPPING

There are three main options for chipping woody biomass:

- grinders
- drum or disc chippers
- screw chippers

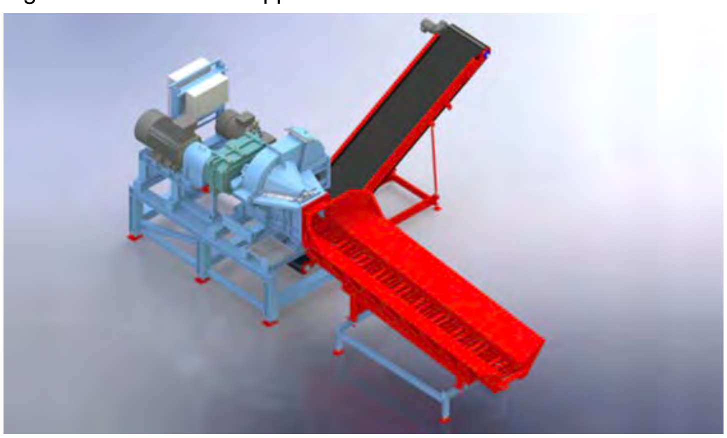
Grinders and blow-in chippers are usually powered by diesel or gasoline, although electric-driven options are available. Grinders & chippers are a mature technology, used for a variety waste-processing purposes.

Screw chippers are commercially available. They are a more innovative technology than grinders and drum or disc chippers.

Figure 85: Mid-sized grinder[101]

Figure 86: Drum chipper[102]

Figure 87: Screw chipper[103]



[101] Image source: Rotochopper. (n.d.). https://www.rotochopper.com/ (Note: Inclusion of an image in this study is not to be considered an endorsement of a product. It is included for information purposes only.)

[102] Image source: Bandit Chippers. (n.d.). https://banditchippers.com/hand-fed-chippers/ (Note: Inclusion of an image in this study is not to be considered an endorsement of a product. It is included for information purposes only.)

[103] Image source: Laimet. (n.d.). https://www.laimet.com/en/chippers/ (Note: Inclusion of an image in this study is not to be considered an endorsement of a product. It is included for information purposes only.)

2.4.11 *Biomass Systems – Financial Implications*

2.4.11.1 ESTIMATING CAPITAL COSTS

Capital costs for Biomass heating systems are the lowest cost per kW of any of the renewable energy systems recommended in this study.

Table 204: Biomass systems – estimated capital costs[104]

installed pricing (capital cost)
per kW
$400

2.4.11.2 ESTIMATING OPERATING COSTS

Biomass systems have two ongoing operating costs—the cost of fuel and the cost of operations.

The ideal biomass fuel to use is a waste material that is currently costing a municipality to manage and dispose of. Turning this problem into a fuel is, essentially, free.

In this study, the only situation where this applies is in the Brandon East Landfill Cluster. In our discussions with City of Brandon staff, they reported that they receive approximately 7,000 tonnes of woody biomass a year and have a challenge to safely dispose of it. The system recommended for Brandon would use wood chips as a fuel, so the only fuel cost would be the cost of chipping. The tipping fee the City of Brandon can charge to receive at least some of this woody material can help offset the chipping cost.

Purchasing suitable biomass from third parties can range from a low of $30/tonne for unpelletized waste agricultural material to more than $160/tonne for wood pellets.

The Biomass Inventory Mapping and Analysis Tool contains useful estimates of average to harvest and transport loose (non-pelletized) agriculture by-products & waste.

Table 205: Estimated costs of biomass fuels included in this study

	Brandon	Dauphin	De Salaberry	Dunottar	Killarney Turtle Mountain	Piney	Selkirk
Crop by-products & waste (for non-pelletized materials)							
harvest	$17.95	$18.16	$17.72	$17.94	$18.03	$18.69	$18.07
transport	$13.10	$12.76	$13.31	$13.10	$12.93	$13.39	$13.39
total cost	*$31.05*	*$30.92*	*$31.03*	*$31.04*	*$30.96*	*$32.08*	*$31.46*

[104] Installed pricing for Biomass systems used throughout this study are based on data provided through the databases bundled with RETScreen Expert Clean Energy Management Software. The latest version of this software (version 9.1) with the most up-to-date data was used for this study. This software provides the most accurate current price available without soliciting bids from individual suppliers and contractors. The RETScreen term "Installed Pricing" is equivalent to what municipalities would call a "Capital Cost" and includes design and installation costs, as well as all the equipment required for operation.

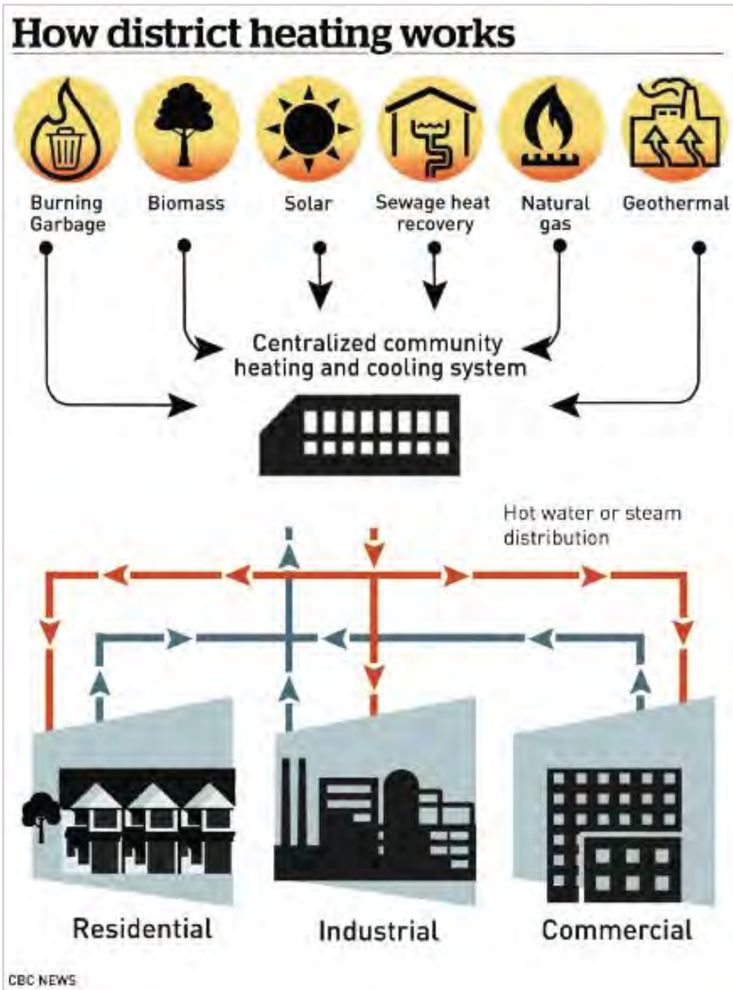
It costs between $30 and $33 per tonne to harvest and transport agriculture by-products that could be used in a biomass system. This is cost only; it does not reflect any markup a farmer or trucking company would charge to profitably supply these materials.

The Biomass Inventory Mapping and Analysis Tool does not estimate the cost to pelletize either crop or woody by-products or waste, or to harvest and transport woody material.

2.5 District Heating Systems

District heating systems[105] are not, technically, a renewable energy source. Rather, they are a mechanism for moving heat energy from one or more locations to other locations, using a liquid flowing through a system of underground pipes to carry that heat. Typically, these systems move heat generated at a central location to multiple buildings connected by those underground pipes. These systems are common in Europe[106] and are growing in use in North America.

Figure 88: Schematic: "How district heating works"[107]



[105] Somewhat confusingly, some district heating systems can also provide cooling to the buildings and facilities connected to it. They should more properly be called "district heat transfer systems", although this is not a term commonly used either by the public or in renewable energy literature.

[106] See, for example:

- Johansen, K., & Werner, S. (2022, January 21). *Something is sustainable in the state of Denmark: A review of the Danish District Heating Sector.* Renewable and Sustainable Energy Reviews. https://doi.org/10.1016/j.rser.2022.112117

[107] Drawing source: Chung, E. (2019, December 3). *Canadian communities are tapping into greener ways to heat and cool buildings.* CBCnews. https://www.cbc.ca/news/science/district-energy-1.5378650.

While a district heating system can deliver non-renewable heat energy—for example, from a fossil fuel source—these are not considered or recommended in this study.

Within the scope of this study, three central sources of energy considered are:

1. a biomass plant
2. process heat
3. a central heat pump system

2.5.1 *A Biomass Plant at the Centre of a District Heating System*

This is the most common configuration for district heating systems.

These systems can deliver reliable, affordable and renewable heat. Because the biomass material is almost always locally sourced, they contribute to the local economy and to community resilience. Multi-year contracts can be signed with fuel suppliers, enabling municipalities to stabilize and predict their future heat costs.

There are many examples of district heating systems using a central biomass plant that are relevant to this study. To pick only 3 examples:

- The City of Yellowknife implemented a district heating system in 2018, which provides heat to 5 community buildings.[108] This project was funded, in part, by the Federation of Canadian Municipalities' Green Municipal Fund.[109]
- The City of Revelstoke is using waste forestry material from a local forestry business, Downie Timber, to heat 10 community facilities[110].
- Many Hutterite colonies have district energy systems, delivering heat from a central plant to residences and other buildings within the colony. Most of these originally burned coal in their central plant. Over the last decade, Manitoba colonies converted their systems to use biomass as fuel. One of the effects of this conversion has been the development of Manitoba-based expertise in the manufacture of biomass boilers, in the design and construction of central plants and district heating systems, the integration into building heating systems, and the operation of these systems. This expertise is an important resource that Manitoba municipalities can draw on when implementing district heating systems.

[108] Federation of Canadian Municipalities (2018). *Case study: Switch to biomass cuts costs and GHG emissions in Yellowknife.* Green Municipal Fund. https://greenmunicipalfund.ca/case-studies/case-study-switch-biomass-cuts-costs-and-ghg-emissions-yellowknife.

[109] Federation of Canadian Municipalities (2023). *Helping municipalities create a sustainable and prosperous future.* Green Municipal Fund. https://greenmunicipalfund.ca/.

[110] Compass Resource Management. (2011, January). *City of Revelstoke District Energy Expansion Pre-feasibility Study.* http://www.cityofrevelstoke.com/DocumentCenter/View/180/District-Energy-Expansion-Pre-feasibility-Study?bidId=.

Figure 89: Installing district heating system in Yellowknife[111]

[111] Source: Atik, T. (2019, May 2). *Yellowknife wins sustainability award for switching to biomass.* Canadian Biomass Magazine. https://www.canadianbiomassmagazine.ca/yellowknife-wins-sustainability-award-for-switching-to-biomass-6714/.

Figure 90: City of Revelstoke current district heating system, with potential expansion[112]

[112] Source: Figure 4 from Compass Resource Management. (2011, January). *City of Revelstoke District Energy Expansion Pre-feasibility Study*. http://www.cityofrevelstoke.com/DocumentCenter/View/180/District-Energy-Expansion-Pre-feasibility-Study?bidId=.

Figure 91: Wood chips on walking floor at Vermillion Hutterite Colony's biomass plant[113]

Central biomass plants typically come in one of two variants, depending on the form of the biomass fuel:

- Smaller facilities typically use biomass pellets. These pellets can be sourced from either forestry or agricultural sources. They are typically delivered using agricultural infrastructure—grain cars if delivered by rail or Super-B trailers if delivered by road. Once delivered, they are usually stored on site in one or more silos and fed into the biomass boiler as needed.
- Larger facilities typically use loose chips (if sourced from forestry) or loose chopped material (if sourced from agriculture) as their fuel. This loose material is placed on a walking floor, which feeds the fuel into the biomass boiler, as needed.

The liquid which carries the heat through the pipes from the central biomass plant to the buildings on the district energy system are typically a water/glycol mix. The typical mixture is 50/50. A lower percentage of glycol makes the liquid more viscous, reducing the pumping requirements.

The pipes carrying the liquid are typically made of HDPE plastic. These pipes are insulated to enable the heat to be transported without a significant loss of heat. Distances of 1 to 2 kilometers between the central plant and the most distant connected buildings are quite common. Distances beyond 2 kilometers can be achieved by adding more insulation around the piping. Because the liquid in the pipes is heated, the pipes do not need to be located below the frost line. A depth of one metre is typical—deep enough to prevent the pipes from being inadvertently dug up, but not as deep as typical sewer and water lines.

[113] Krause, K. (2018, March 28). *Hutterite colony takes a step into the future with biofuel.* CTV News Winnipeg. https://winnipeg.ctvnews.ca/hutterite-colony-takes-a-step-into-the-future-with-biofuel-1.3861501.

2.5.2 *Process Heat at the Centre of a District Heating System*

Using process heat from industrial sources to provide heat in district energy systems is underutilized, particularly in North America. Several European studies identified dozens of these systems currently installed in Austria, Germany and France[114], while other studies have begun to map out the potential for hundreds more.[115] Two related initiatives in Canada should also be highlighted:

- The False Creek Neighbourhood Energy Utility (NEU), which captures waste heat from sewage to provide building heat for 600,000 m^2 of building space in downtown Vancouver.[116] Launched in 2010, they recently announced plans to triple their waste heat capture.[117]
- The Hamilton Chamber of Commerce led a study to examine the opportunities for capturing excess process heat from industries in Hamilton's Bayfront Industrial Area to provide building heat.[118]

[114] See:

- Moser, S., & Lassacher, S. (2020, April 22). *External use of industrial waste heat – an analysis of existing implementations in Austria.* Journal of Cleaner Production. https://www.sciencedirect.com/science/article/abs/pii/S095965262031578X.
- Moser, S., & Jauschnik, G. (2023, July 4). *Using industrial waste heat in district heating: Insights on Effective Project Initiation and business models.* Sustainability. https://doi.org/10.3390/su151310559.
- Fritz, M., Savin, M., & Aydemir, A. (2022, May 30). *Usage of excess heat for district heating – analysis of enabling factors and barriers.* Journal of Cleaner Production. https://doi.org/10.1016/j.jclepro.2022.132370.

[115] Fleiter, T., Manz, P., Neuwirth, M., Mildner, F., Persson, U., Kermeli, K., Crijns-Graus, W., & Rutten, C. (2020, February 28). *Excess heat potentials of industrial sites in Europe*. sEEnrgies. https://www.seenergies.eu/wp-content/uploads/sites/25/2020/04/sEEnergies-WP5_D5.1-Excess_heat_potentials_of_industrial_sites_in_Europe.pdf.

[116] City of Vancouver. (n.d.). *False Creek Neighbourhood Energy Utility.* https://vancouver.ca/home-property-development/southeast-false-creek-neighbourhood-energy-utility.aspx.

[117] Bennett, N. (2022, December 15). *District Energy System to expand waste heat capture.* Vancouver Is Awesome. https://www.vancouverisawesome.com/technology/district-energy-system-to-expand-waste-heat-capture-6256944.

[118] Hamilton Chamber of Commerce. (2020). *Industrial waste heat recovery report.* https://www.hamiltonchamber.ca/industrial-waste-heat-recovery-report/.

Figure 92: False Creek Neighbourhood Energy Utility Centre

Figure 93: Hamilton Bayfront Industrial Area

2.5.3 *A Heat Pump System at the Centre of a District Energy System*

Many heat pump systems are designed to provide heating and cooling to a single home or other building. Larger-scale heat pump systems are also a well-established technology and can provide important benefits that single-home and single-building heat pumps do not. For example, they can transfer heat from data centre's server room to rooms and buildings that need heat.

A good case study for a larger scale heat pump system is Colorado Mesa University in Grand Junction, Colorado.[119],[120] Their system takes in 16 buildings and approximately 5 km of heat loops. The university estimates the system saves it approximately US$1.5 million in energy costs each year.

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[119] Woodroof, E. (2021, February 25). *Meet the District Energy Loop: A larger-scale geothermal heat pump.* Buildings. https://www.buildings.com/building-systems-om/article/10186232/meet-the-district-energy-loop-a-larger-scale-geothermal-heat-pump.

[120] Colorado Mesa University. (n.d.). *Geo-grid system.* https://www.coloradomesa.edu/sustainability/initiatives/geo-grid.html.

Figure 94: Central Pumping Station in Colorado Mesa University's Wubben Science Hall[121]

These larger scale systems are particularly useful in recreation buildings that have diverse heating and cooling needs, such as ice surfaces, swimming pools, and hot tubs, in addition to the need to heat and cool the building. For example, heat extracted to make ice can be used directly to warm the water in the swimming pool or stored in a ground loop for later use.

[121] Image source: Oh, H., & Beckers, K. (2023, July). *Cost and performance analysis for five existing geothermal heat pump-based district energy systems in the United States.* NREL. https://www.nrel.gov/docs/fy23osti/86678.pdf.

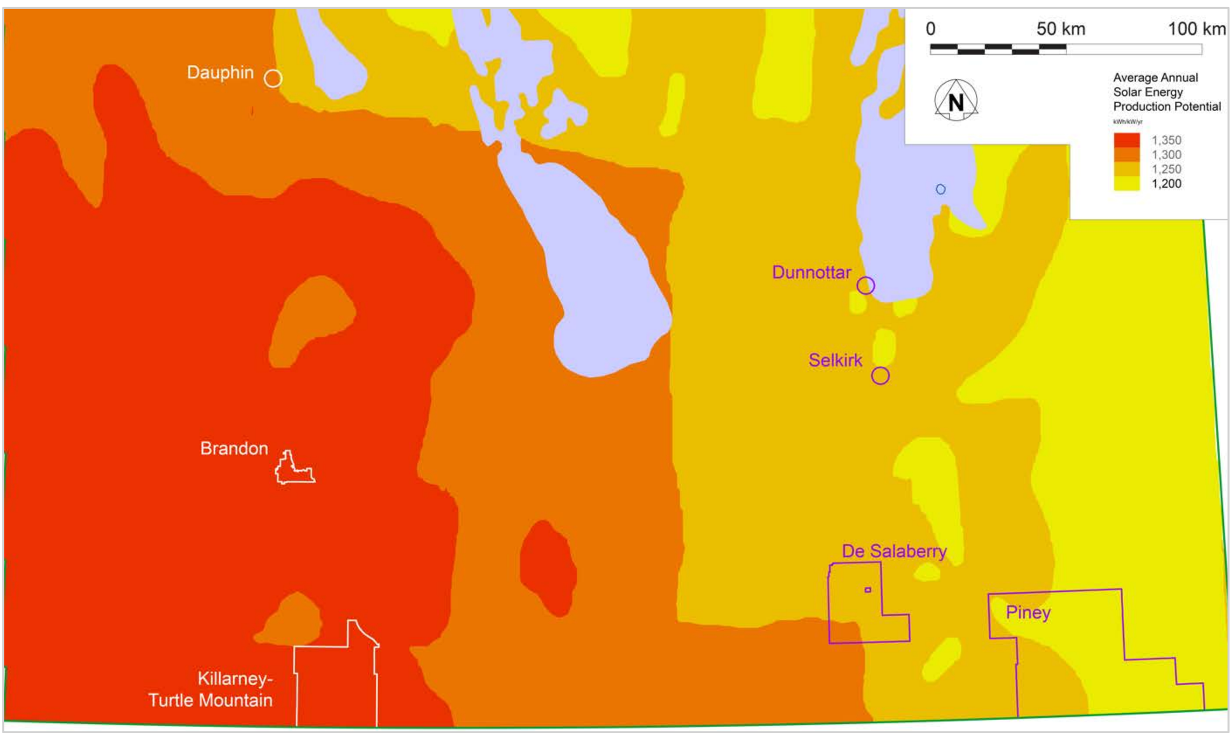
2.6 Solar

This study uses the term "solar" to refer to Photovoltaic Solar (PV Solar) energy generation systems. PV Solar is, of course, a widely used form of renewable energy generation. Solar systems range in size from small portable systems used for recharging electronics when camping to very large arrays of thousands of panels covering many hectares. The ones recommended in this study are mid-sized, ranging in size from 20 kW to 800 kW.

Table 206: Average yearly solar irradiance in kWh per square meter[122]

Brandon	*Dauphin*	*De Salaberry*	*Dunnottar*	*Killarney Turtle Mountain*	*Piney*	*Selkirk*
1,587	1,510	1,553	1,493	1,611	1,441	1,517

Figure 95: Average annual solar energy production potential in kWh per installed kW[123]



[122] Simplified, "solar irradiance" is the energy from the sun arriving at a given location.

[123] Data source: Solar Energy Hubs. (n.d.). *Solar Maps Canada.* https:///www.energyhub.org

2.6.1 *Solar Arrays*

This study uses the term "solar array" to mean assemblies of photovoltaic solar panels, with inverters and all other required equipment, able to turn light into electricity through the photovoltaic effect.[124]

The amount of useable electricity a solar array produces on a given day will vary depending on location and variations in cloud cover. However, it is possible to make estimates of averages.

Table 207: Estimated average output of a solar array in each participating community, per installed kilowatt[125]

	Brandon	*Dauphin*	*De Salaberry*	*Dunnottar*	*Killarney Turtle Mountain*	*Piney*	*Selkirk*
per year	1,358	1,276	1,331	1,278	1,378	1,228	1,293
per month	113	106	111	107	115	102	108
per day	3.7	3.5	3.6	3.5	3.8	3.4	3.5

Table 208: Estimated monthly average output of a solar array in each participating community, per installed kilowatt, broken down by month

		Brandon	*Dauphin*	*De Salaberry*	*Dunnottar*	*Killarney Turtle Mountain*	*Piney*	*Selkirk*
estimated monthly AC electricity output in kWh per installed kW of solar panels								
Month	Jan	70	54	69	51	73	57	60
	Feb	92	77	88	75	93	80	84
	Mar	110	108	109	109	111	104	110
	Apr	145	145	143	149	143	141	148
	May	141	140	139	141	141	132	139
	Jun	138	136	139	140	139	131	138
	Jul	158	153	158	154	159	146	153
	Aug	147	142	145	143	151	135	142
	Sep	127	121	124	120	128	114	120
	Oct	102	92	96	91	105	86	90
	Nov	68	60	65	58	71	55	58
	Dec	60	48	58	47	63	48	51

[124] For a fuller explanation of photovoltaic solar power, see: EIA. (n.d.). *Solar Explained: Photovoltaics and electricity.* US Energy Information Administration. https://www.eia.gov/energyexplained/solar/photovoltaics-and-electricity.php#:~:text=Photovoltaic%20cells%20convert%20sunlight%20into,convert%20artificial%20light%20into%20electricity.

[125] Data source for the tables in this section: Solar Calculator (n.d.). *Solar Calculator Canada.* *https://solarcalculator.ca*

- Note: The closest available data for Piney is from Steinbach. Given the data available from the solar map (immediately above this table), the Piney area very probably has less sunlight available that Steinbach figures have been reduced by 5% to more accurately estimate Piney

Table 209: Estimated daily average output of a solar array in each participating community, per installed kilowatt, broken down by month

		Brandon	*Dauphin*	*De Salaberry*	*Dunnottar*	*Killarney Turtle Mountain*	*Piney*	*Selkirk*
estimated daily AC electricity output in kWh per installed kW of solar panels								
Month	Jan	2.3	1.8	2.2	1.6	2.3	1.8	1.9
	Feb	3.3	2.8	3.2	2.7	3.3	2.9	3.0
	Mar	3.5	3.5	3.5	3.5	3.6	3.4	3.5
	Apr	4.8	4.8	4.8	5.0	4.8	4.7	4.9
	May	4.6	4.5	4.5	4.6	4.6	4.2	4.5
	Jun	4.6	4.5	4.6	4.7	4.6	4.4	4.6
	Jul	5.1	4.9	5.1	5.0	5.1	4.7	4.9
	Aug	4.8	4.6	4.7	4.6	4.9	4.4	4.6
	Sep	4.2	4.0	4.1	4.0	4.3	3.8	4.0
	Oct	3.3	3.0	3.1	2.9	3.4	2.8	2.9
	Nov	2.3	2.0	2.2	1.9	2.4	1.8	1.9
	Dec	1.9	1.6	1.9	1.5	2.0	1.6	1.6

2.6.2 *Solar Arrays – Sizing Recommendations*

Unless noted otherwise, solar arrays recommended in this study are sized to offset approximately half the electrical energy used by each target building. This recommendation is a compromise between an ideal situation and the reality of limited funds.

If funds were available, it would be ideal to size the solar arrays so that they produced, on average, the same amount of electricity as each target building consumed. This would make these buildings “net zero electricity”.

Like all recommendations in this study, subsidies will be necessary to make the installation of solar arrays financially attractive in the short to medium term.

Because some of the target facilities use significant amounts of electricity, some of the recommended arrays are quite large. It is possible that available subsidies or grants may not yet be available to make arrays of the recommended size feasible at this stage. If that is the case, it is recommended that a solar array be installed that is large as possible within the funds available. At a later stage, if more funding can be secured, expanding an existing solar array will be relatively straightforward.

2.6.3 *Solar Arrays – Configuration Recommendations*

Table 210: Solar Array – configuration recommendations

	Brandon	Dauphin	De Salaberry	Dunnottar	Killarney Turtle Mountain	Piney	Selkirk
latitude	49.85	51.15	49.31	50.45	49.18	49.10	50.14
longitude	-99.95	-100.05	-96.95	-96.95	-99.66	-95.83	-96.88
optimal solar panel angle	43°	43°	42°	42°	43°	42°	42°
maximum solar elevation on winter solstice	16°	15°	17°	16°	17°	17°	16°
minimum distance between array rows	14.3 m	15.0 m	14.1 m	14.2 m	14.0 m	14.1 m	14.3 m

2.6.3.1 FIXED MOUNTS RECOMMENDED

Fixed mounts are recommended because the benefits of moveable mounts do not outweigh the drawbacks in the recommended projects.

- Some moveable mounts can have their angle manually adjusted to accommodate the changing angle of the sun in different seasons. This usually requires manual adjustment either twice or four times a year. The cost in staff time usually outweighs the benefits.
- Some moveable mounts have automatic tracking systems to turn the solar panels to face the sun throughout the day. These tracking systems can break down, particularly in climates where freeze/thaw cycles are common. In our climate, the downtime and costs usually outweigh the benefits.

2.6.3.2 GROUND MOUNTS RECOMMENDED OVER ROOF MOUNTS

This study recommends that the solar arrays be mounted on the ground, rather than on rooftops.

Buildings designed with integrated solar arrays as part of the roofing system are certainly feasible and should be considered in new builds.

Retrofitting solar arrays onto existing buildings present significant challenges that ground-based solar arrays do not. These include:

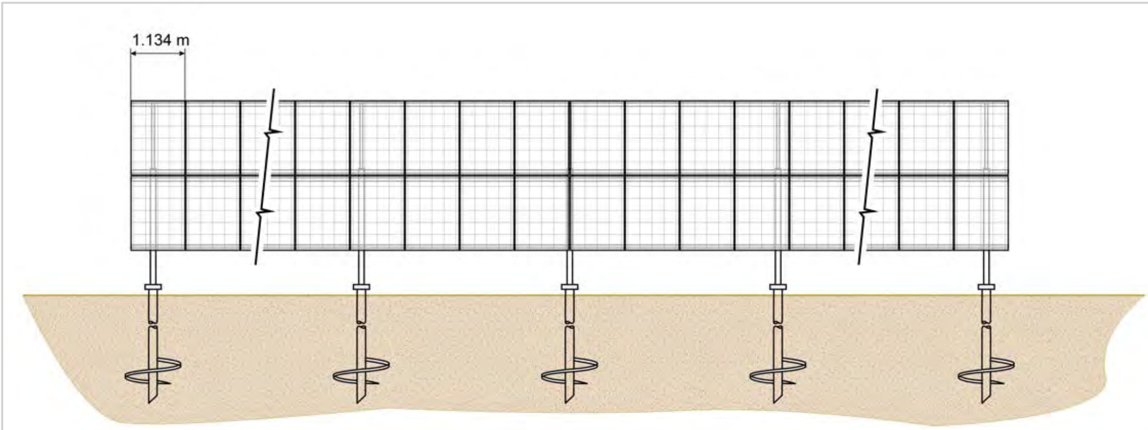
- Cleaning the snow off roof-top solar panels is much more of a challenge than clearing snow of ground-mounted panels.
- The solar array needs to be anchored to the roof, which increases the chances of leaks.
- If the solar array is mounted on a flat roof:
    - The solar panels will interrupt wind flow, increasing snow retention—and therefore snow load—on the roof.
    - The freeze-thaw cycle of that snow load is likely to result in increased ice buildup on the roof, which may affect roof drainage.
    - Piercing the roofing membrane (which would be required to anchor the solar array to the building) will almost certainly shorten the life of the membrane.

Using screw piles to anchor the ground mounts is recommended over installing concrete footings mainly because:

- They can be installed quickly.
- In the unlikely event that an array needs to be moved, screw piles are easier to remove and reuse than concrete footings.

2.6.3.3 RECOMMENDED PANEL CONFIGURATION

Figure 96: Ground mount solar array – front view



Mounting the solar panels in 2 strips on each row—one above the other ("2 up")—is quite common and probably best for the projects recommended in this study.

- Putting them only "1 up" results in the rows being very long and requires more mounting hardware per kilowatt-hour of electricity produced.
- Putting them "3 up" doesn't really reduce the space area required, because the rows must be spaced further apart to avoid each row shading the one behind it. There is some savings in mounting hardware, but this is offset by the challenge of having to reach higher up to clear snow and dust.

2.6.3.4 RECOMMENDED PANEL ANGLE

The recommendations for each participating community include a recommendation on the angle that will maximize electricity production.[126] Because all the participating communities are within 2° latitude, they will all have similar recommended angles.

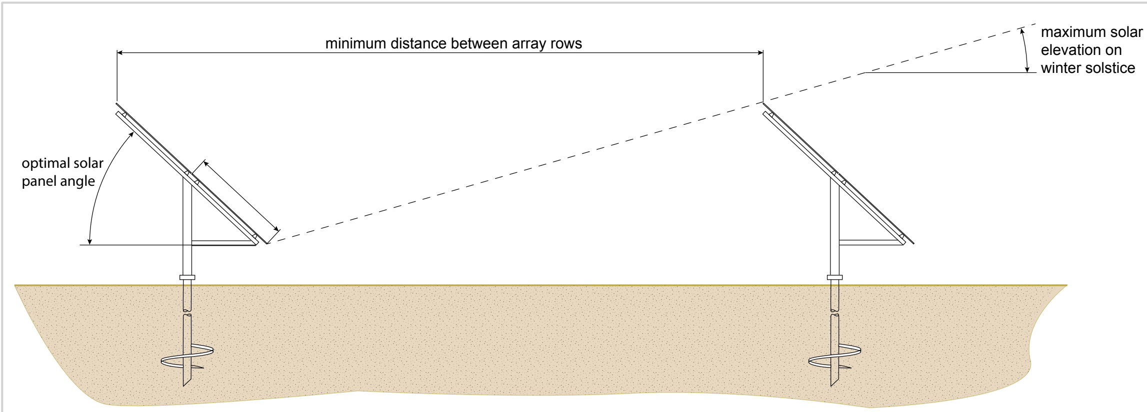
The precise angle is not crucial. An angle anywhere between 40° and 45° will produce roughly the same amount of electricity on the participating communities.

[126] Solar Calculator (n.d.). *Solar Calculator Canada.* https://solarcalculator.ca

2.6.3.5 RECOMMENDED ROW SPACING

Solar arrays are typically laid out in rows. To maximize energy production, rows should be spaced far enough apart so that each the panels in row casts little or no shadow on the row behind. Typically, rows are spaced far enough apart so no shadow is cast by the sun at its highest point at the winter solstice. This does not eliminate shadowing completely, but it does minimize it.

Figure 97: Solar Arrays – side view – panel angle & spacing



Location-specific spacing is calculated for each participating community.

2.6.4 *Indicative Solar Panels*

Table 211: Indicative solar panel – type, dimensions, efficiency & output

indicative solar panel				*dimensions (in meters)*		*output*	
supplier	*type*		*model #*	*height*	*width*	*efficency*	*kW/panel*
Canadian Solar	bifacial	mono-Si	CS6W-535MB-AG	2.279	1.134	20.80%	0.535

Other makes, models and sizes are available. This make and model of solar panel is chosen as "indicative"[127] for this study because:

- It is widely available.
- It is bi-facial, meaning it can absorb light through both the front and back surfaces.
  - This increases the efficiency of the panels, enabling more energy generation per panel.
  - Light absorption from the back of the panel is particularly important in winter, when sunlight bounces off snow.
- It uses a mature, commercially proven technology—monocrystalline silicon (often abbreviated as "mono-Si" or "c-Si")
- Its dimensions (2,279 mm by 1,134 mm) are the most common in the market.

[127] "Indicative" is a term used in bidding and contracting to specify a particular item in drawings and bills of materials. It means that the actual item chosen must meet or exceed the standards of this item. This is done so that lower-priced equivalents can be considered, and to accommodate changes in manufacturers, makes and models in the market. Including a product as "indicative" in this study does not imply that this specific make and model must be used, nor that this study endorses this company's products over their competitors.

- This enables the use of standard, widely available mounts and frames, rather than requiring customed-designed mounting systems.

2.6.5 *Short-Term Battery Storage*

One of the issues with solar arrays connected to individual buildings is a problem of timing—when they generate electricity is not matched by when that electricity is needed.

Some of this mismatch between supply and demand can be smoothed out by Battery Energy Storage Systems (usually abbreviated at "BESS"). These systems include the batteries themselves, control systems, as well as connection to the solar array, the electrical systems of the buildings, and (when needed) connection to the larger electrical grid.

However, we need to be realistic about how much battery storage is affordable, and how much smoothing it can be expected to provide. To take an example:

- The RM of Piney District Government Office consumes an average of about 8,500 kWh of electricity for the month of January. A typical Battery Storage System such as a Tesla Powerwall, with a storage capacity of 13.5 kWh costs about $20,000 installed and would provide backup power for about an hour at a typical January consumption rate.

Battery costs are still too high to affordably store electricity produced during the day by the solar array to provide the electricity needed overnight.

If a program offering financial support for solar arrays also provides funding for battery storage, a small, short-term Battery Energy Storage System (BESS) could be helpful to even out demand, particularly on days with intermittent sun and cloud.

The solar array systems recommended in this study are all bi-directional and grid-tied, which means they can send excess electricity to the main Manitoba electricity grid and draw grid electricity when needed, in effect using the grid as a battery. While this is not ideal—particularly because it will not provide power during a grid outage—it is the most realistic option at this time.

A discussion of longer-term battery storage system can be found in the appendices under Commercial Battery Storage Systems.

2.6.6 *Solar Arrays – Financial Implications*

2.6.6.1 ESTIMATING CAPITAL COSTS

Figure 98: Solar Arrays – estimated capital costs[128]

estimated capital cost (installed pricing)
per kW
$1,900

2.6.6.2 ESTIMATING OPERATING SAVINGS

Adding a solar array to a target building or facility will reduce its net cost of electricity. The amount of reduction will depend on:

- the size of the solar array
- the amount of electricity it generates (which will vary by location, as noted above)
- the cost of grid-supplied electricity from Manitoba Hydro
    - Currently, Manitoba Hydro charges approximately $0.10 per kWh for grid-supplied electricity.
- the price Manitoba Hydro will pay for any excess electricity, produced by the solar array but not needed by the target building or facility, and therefore fed into the grid
    - For solar arrays smaller than 100 kW, Manitoba Hydro pays $0.05607/kWh for any excess electricity the solar array provides to the grid.
    - For solar arrays larger than 100 kW, Manitoba Hydro currently negotiates a price on a case-by-case basis, through a Purchase Power Agreement. Because this price is not known at this stage, this study makes an estimate of $0.05/kWh. [129]

Tables detailing these calculations for each solar array are included in this study whenever a solar array is recommended.

[128] Estimated capital costs for solar arrays used throughout this study are based on data provided through the databases bundled with RETScreen Expert Clean Energy Management Software. The latest version of this software (version 9.1) with the most up-to-date data was used for this study. This software provides the most accurate current price available without soliciting bids from individual suppliers and contractors. The RETScreen term "Installed Pricing" is equivalent to what municipalities would call a "Capital Cost" and includes design and installation costs, as well as the solar panels, mounting systems, inverters, and system connection requirements.

[129] Manitoba Hydro. (n.d.). *Generate your own electricity.* https://www.hydro.mb.ca/service/generate-your-own-electricity/

2.6.6.3 "NET ZERO ELECTRICITY" DOES NOT MEAN ZERO ELECTRICITY COSTS

If funds were available to size the solar arrays so that production equalled consumption of each target building and target facility, it is important to recognize that this would not eliminate all electrical costs for these facilities.

Manitoba Hydro—like all utilities—charges more for the electricity is supplies than it pays for excess electricity a solar array would feed into the grid. (This would typically happen in the summer, when solar production is higher and electricity consumption by a target building might be lower.) So even though a "net zero electricity" system means that the target facility takes as much electricity from the grid as it feeds back in an average year, there is still a net cost to the user.

2.6.6.4 STANDARD MUNICIPAL PURCHASE POWER AGREEMENT RECOMMENDED

It would be beneficial for all parties if a standard Municipal Purchase Power Agreement (MPPA) could be negotiated for Manitoba municipalities.

A standard MPPA would:

- *save negotiation and legal costs for both Manitoba Hydro and participating municipalities*
- *speed up the inclusion of solar arrays in municipal infrastructure*
- *reduce total electrical demand from the Manitoba Hydro grid*

These negotiations will need to include municipalities interested in adding solar arrays to their facilities, the Association of Manitoba Municipalities, Manitoba Hydro and the Government of Manitoba.

It is not necessary to delay the installation of the solar arrays recommended in this study until a standard MPPA has been agreed. Purchase Power Agreements negotiated on a case-by-case basis can be amended to conform with a standard MPPA once one is agreed upon

2.7 Solar Walls

> *Solar walls are a technology used to passively heat a building….These walls can be installed on new buildings or can be retrofitted….The solar wall is constructed first by placing metal solar cladding on the exterior wall of a building. This cladding is perforated and built in front of an already present building wall. In the Northern hemisphere this wall is south facing….An air channel is present between these two walls to allow for the exchange of warmed air…[T]hese walls are fairly inexpensive because of their simplistic construction, and are equal in cost to the installation of a brick wall.*[130]

Solar walls are particularly useful in buildings with make-up air—fresh air brought in from the outside. In winter, this cold air must be heated before it can be vented into the building. The solar wall can pre-heat this air, significantly reducing the heating load on the building's HVAC (Heating, Ventilation, and Air Conditioning) system.

Figure 99: Solar wall on Assiniboine Credit Union, 2659 Pembina Hwy, Winnipeg[131]

[130] University of Calgary. *Solar wall*. Energy Education. https://energyeducation.ca/encyclopedia/Solar_wall.

[131] Climate Change Connection. (2015, December 29). *Passive solar heating*. https://climatechangeconnection.org/solutions/alternative-heat-energy/passive-solar-energy/.

2.7.1 *Solar Walls – Financial Implications*

2.7.1.1 ESTIMATING CAPITAL COSTS

Standardized pricing information for solar walls is not as available as it is for other renewable energy technologies, in part because solar walls are typically custom designed for each installation. However, some reasonable estimates are available.

AMR Technologies, one of the leading manufacturers and installers of solar walls estimates installed costs at roughly \$100 (Canadian) per m^2; this is the solar wall pricing used in this study.[132]

Table 212: Solar Walls – estimated capital costs

estimated capital cost (installed pricing)
per m^2
\$100

2.7.1.2 ESTIMATING OPERATING COSTS & SAVINGS

Because they have no moving parts, solar walls have no operating costs.

Because it pre-heats the make-up air going into the building, installing a solar wall will result in some building operations cost savings. The savings are site-specific and can be estimated by installers when their bids are solicited; they are not estimated in this study.

[132] AMR Technologies. (n.d.). *Cost of a solarwall*. https://amrtechsolar.com/collections/solarwall-1

2.8 Heat Pumps[133]

Heat pumps are a ubiquitous, mature technology. Every refrigerator and freezer contains a heat pump (often called a "compressor"), cooling its contents by extracting heat from inside the box and pumping it out into the house. Air conditioners extract heat from buildings and pump it out to the atmosphere. They all use electricity to drive the pumps.

Heat pumps can extract heat from the air, from the ground, or from water.[134,135] Pumping heat from air, ground or water into a building heats the building; extracting heat from a building into air, ground or water cools they are building. They can also heat domestic water.

Heat pumps are only considered a renewable energy technology if the electricity they use comes from a renewable source. Because more than 98% of Manitoba's electricity comes from renewable sources,[136] heat pumps are considered renewable energy technology in Manitoba. They are widely used in our province.[137]

2.8.1.1 HEAT PUMP CAPACITIES

Heat pump capacities are sized using several different measurement units, which often causes confusion.

- A "ton" is the heat required to melt one ton (2,000 pounds) of ice in a 24-hour period.[138]
  - It is equivalent to 12,000 Btu/hr.
  - 1 ton of heating (or cooling) capacity = 12 MBH.

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[133] Ground source heat pumps are sometimes said to provide geothermal energy; and systems using ground source heat pumps are often referred to as "geothermal systems." This is not technically correct. Properly used, "geothermal energy" refers to energy derived from heat usually found deep within the earth. Ground-source heat pumps do not use this source of energy. Instead, they transfer heat between buildings and the ground, using the earth as a heat "sink" or battery.

[134] For a further introduction to heat pumps see: Government of Canada. (2022, August 9). *Heating and Cooling with a Heat Pump.* Natural Resources Canada. https://natural-resources.canada.ca/energy-efficiency/energy-star-canada/about/energy-star-announcements/publications/heating-and-cooling-heat-pump/6817#a. In addition to a comprehensive introduction to how heat pumps function, this document provides information on ground-source and air-source heat pumps, with a focus on application to homes.

[135] For information on water-source heat pumps, see:

- Chung, E. (2023, June 22). *Waterfront homes tap into lakes for cheaper geothermal heating.* CBC News Science. https://www.cbc.ca/news/science/what-on-earth-lake-front-geothermal-1.6885023
- Government of Manitoba. *Hydroelectricity.* Department of Environment and Climate Change. https://www.gov.mb.ca/sd/environment_and_biodiversity/energy/initiatives/hydro.html.
- Government of Manitoba. *Geothermal in Action.* Department of Environment and Climate Change. https://www.gov.mb.ca/sd/environment_and_biodiversity/energy/geothermal/action.html.

[138] Wikipedia. (n.d.). *Ton of refrigeration*. https://en.wikipedia.org/wiki/Ton_of_refrigeration To make matters even more confusing, this "ton" should not be confused with the imperial short ton (2,000 pounds—also sometimes called a US ton, nor with the imperial long ton (2,240 pounds—also sometimes called a UK ton). This "ton" is an idiosyncratic measurement used only measuring cooling. This study converts this and other cooling measurements to kilowatt-hours (kWh) to make comparisons between heating and cooling technologies easier.

- “MBH” is the abbreviation for thousands of BTUs (British Thermal Units) per hour.
  - 1 MBH = 0.2930710702 kWh
  - 12 MBH = 3.5168528421 kWh
- “kWh” is the abbreviation for kilowatt-hour.
  - If a system produces (or consumes) one kWh, it is producing (or consuming) the equivalent of one kW of energy for one hour.
  - 1 kWh = 3.4121416331 MBH

2.8.2 *Ground-Source Heat Pumps*

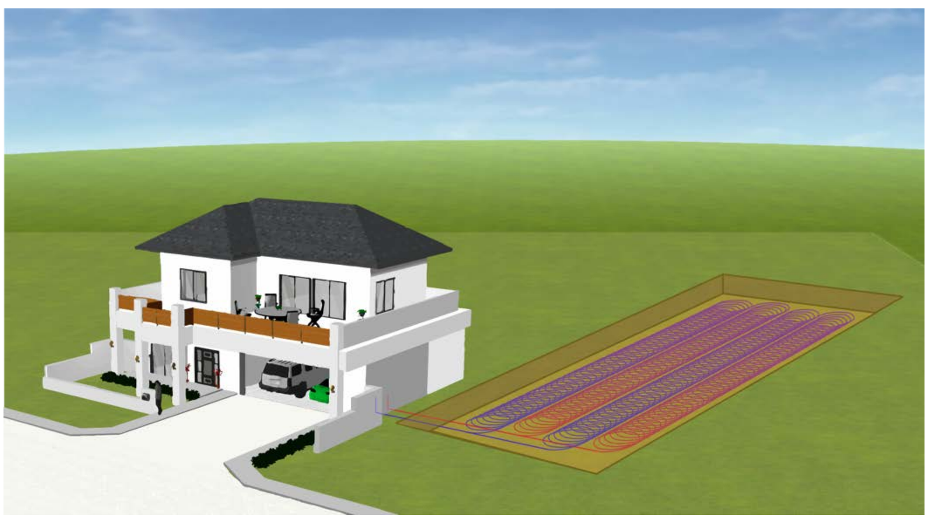
Most of the heat pumps recommended for installation in this study are Ground-Source Heat Pumps (GSHP), which means they extract and deposit heat into the ground.[139]

2.8.2.1 2 TYPES OF GROUND-SOURCE HEAT PUMP SYSTEMS

Ground-source heat pumps all use pipes with fluid in them. The two main types of ground-source heat pump systems are:

- horizontal loops
- vertical loops

Figure 100: Schematic of horizontal loop ground source heat pump system[140]



[139] Although focused on GSHPs for residential use, a good introduction to GSHPs can be found at:

- Government of Canada. (2018, June 11). *Grounds-source heat pumps.* Natural Resources Canada. https://natural-resources.canada.ca/energy-efficiency/products/heating-equipment-for-residential-use/ground-source-heat-pumps/16028

[140] Not drawn to scale. Actual size of horizontal loop field dependent climate and on the heating & cooling requirements of a specific building.

Figure 101: Schematic of vertical loop ground source heat pump system[141]

Older versions of vertical systems sometimes used two open wells—one to extract ground water and one to return it. Closed systems—as shown here—are now generally preferred.

2.8.2.2 GROUND SOURCE HEAT PUMPS – CALCULATIONS & PRICING

Table 213: Ground-Source Heat Pump (GSHP) systems – capacity equivalents, pricing estimates & space estimates

heat pump capacities			installed pricing			horizontal loops space requirement	
tons	MBH	kW/h	heat pump systems	horizontal loops	totals	ft^2	m^2
0.0833	1	0.2931					
0.2843	3.4	1	$1,800	$1,100	$2,900	786	73
1	12	3.5	$6,330	$3,869	$10,199	2,763	257
3	36	10.6	$18,991	$11,606	$30,597	8,288	770
5	60	18	$31,652	$19,343	$50,994	13,814	1,283
50	600	176	$316,517	$193,427	$509,944	138,137	12,833
100	1,200	352	$633,034	$430,697	$1,063,731	276,274	25,667

2.8.2.3 GROUND SOURCE LOOP SPACE REQUIREMENTS

Calculating exactly how much area horizontal loops will take up is not an exact science. Total system capacity, loop configuration, loop depth, climate conditions, and soil type all play a role.

When these systems are being built, the feasibility study must include a geotechnical investigation of the ground where the loops will be located will be required. This is not a complex or complicated investigation, but it can make the difference between a system which lasts for decades and one which faces difficulties right from the start.

[141] Not drawn to scale. Number and depth of vertical loops depend on the climate, and on the heating &and cooling requirements of a specific building. Typical depth is around 100 metres.

A typical rule of thumb is that a 3-ton (10.6 kWh) system will require about 700 m^2 of space for the horizontal loops. Converting to kilowatt-hours, this rule of thumb indicates that a horizontal ground loop system will require approximately 75 m^2 of space per kWh of system capacity. This study builds in a 10% "safety factor" on horizontal space requirements.

Table 214: Typical loop space requirements

capacity		horizontal loop		vertical loop	
kW	tons	m^2	ft^2	m^2	ft^2
1.0	0.28	75	800	12	130
3.5	1	260	2,800	43	500
10.6	3	770	8,300	770	8,300

Horizontal loops are buried below ground, so the ground surface can be waste land, lawn, parking space, or even temporary building structures. However, because, on rare occasions, ground loops may require servicing, it is not recommended that the surface above them be paved or have permanent buildings on it.

Vertical loops require much less ground space than horizontal loops. The space requirements for vertical loops will also vary based on factors like those required for horizontal loops. There are, however, typical rules of thumb. Vertical loop boreholes:

- typically vary in depth between 200 and 500 feet (60 to 200 meters)
- typically provide 1 ton (3.5 kWh) of capacity per borehole
- should be spaced roughly 20 feet (6 meters) apart

Vertical bore heat loops typically require about 20% of the space required for horizontal loops.

As with horizontal loops, these are rough guides only. A geotechnical investigation will be required as part of the design process.

2.8.3 Air-Source Heat Pumps

Air-Source Heat Pumps (ASHP) transfer heat to and from the air.[142] These are typically used to heat and cool buildings. In this study, ASHPs are recommended when heat pump technology is used only for cooling. Air source heat pumps are more appropriate—because they are less expensive to install—than ground-source heat pumps—when only cooling is required. When heat pumps are recommended for both heating and cooling, Ground-Source Heat Pumps are recommended instead.

Recommendations for two of this study's projects include ASHPs:

- the Walker Art Centre and the Dauphin Fire Department in Dauphin's Railway Cluster
- the Killarney Industrial Park

[142] A good introduction to ASHPs can be found at:

- Government of Canada. (2024, January 11). *Air source heat pumps.* Natural Resources Canada. https://natural-resources.canada.ca/energy-efficiency/products/heating-equipment-for-residential-use/air-source-heat-pumps/16022

This study recommends using biomass systems for heating in these two projects, and biomass systems are not easily adaptable for cooling.

2.8.4 *Heat Pump Systems – Financial Implications*

2.8.4.1 ESTIMATING CAPITAL COSTS

Table 215: Heat Pump Systems – estimated capital costs[143]

Estimated Capital Cost per kW						
	Ground Source Systems					
	horizontal loop configuration		*vertical loop configuration*		*Air Source Systems*	
Heat Pump	*loop cost*	*total cost*	*loop cost*	*total cost*	*installation*	*total cost*
$1,800	$1,100	$2,900	$2,800	$4,600	$500	$2,300

Although pricing for vertical loops is typically more expensive than for horizontal loops, the difference may not be as great as indicated here. The drilling equipment for vertical loops is the same as that used in the oil and gas industry, and in drilling water wells. During slow periods in oil and gas, drilling companies may be willing to bring their price closer to that of horizonal loop installation.

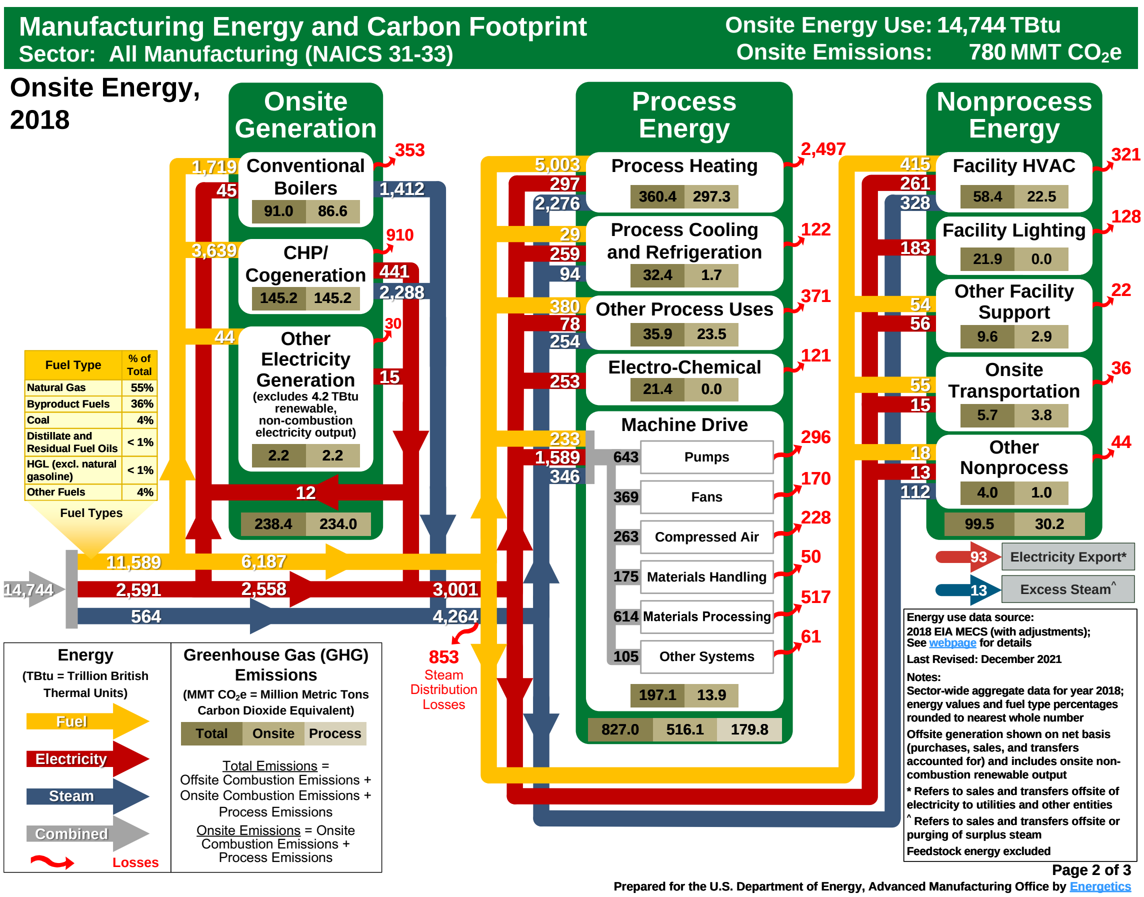
- *It is strongly recommended that a price quote be solicited for both vertical and horizontal loops before a final choice is made between them.*

[143] Installed pricing for Heat Pump systems used throughout this study are based on data provided through the databases bundled with RETScreen Expert Clean Energy Management Software. The latest version of this software (version 9.1) with the most up-to-date data was used for this study. This software provides the most accurate current price available without soliciting bids from individual suppliers and contractors. The RETScreen term "Installed Pricing" is equivalent to what municipalities would call a "Capital Cost" and includes design and installation costs, including the of cost the heat pumps, installation of the horizontal or vertical loops, and connection to the building's existing heating and cooling systems.

2.9 Process Heat

Virtually all industrial processes produce waste heat. Capturing and using this heat for other purposes holds great potential.

Figure 102: U.S. manufacturing energy consumption, GHG emissions & waste heat[144]



The three sectors that produce the most amount of wasted process heat are petroleum and coal products manufacturing, chemical manufacturing, and primary metal manufacturing.

[144] Office of Energy Efficiency and Renewable Energy. (2021, December). *Manufacturing Energy and Carbon Footprints (2018 MECS).* Energy.gov. https://www.energy.gov/eere/iedo/manufacturing-energy-and-carbon-footprints-2018-mecs. (Note that, except for Greenhouse Gas emissions (GHGs), all numbers in this figure, including those for waste heat, are given in trillions of British thermal units (TBtu). To convert these to megawatt hours (MWh), multiply by 293.)

Table 216: Top 3 US industries producing waste heat[145],[146],[147]

INDUSTRY			Waste Heat Estimate (United States, annual)	
	NAICS number	includes	TBtu	MWh
petroleum & coal products manufacturing	324	refining fossil fuels	1,032	302,449
chemical manufacturing	325	petrochemicals chlorine plastic fertilizers pesticides	600	175,843
primary metal manufacturing	331	iron & steel aluminum metal casting silicon & ferrosilicon	366	107,264

Other sectors produce significant amounts of wasted process heat, although at smaller levels that the top 3 sectors listed above.

Table 217: Additional industries producing significant waste heat

INDUSTRY		
	NAICS number	includes
oil & gas extraction	211	gas flaring
utilities	221	gas pipeline pumping stations
food processing	311	
wood product manufacturing	321	
paper manufacturing	322	
non-metallic mineral products manufacturing	327	cement lime glass & glass products clay tile & brick
data processing, hosting, & related services	518	server farms
waste management & remediation services	562	landfill gas flaring wastewater waste incineration

[145] Office of Energy Efficiency and Renewable Energy. (2021, December). *Manufacturing Energy and Carbon Footprints (2018 MECS).* Energy.gov. https://www.energy.gov/eere/iedo/manufacturing-energy-and-carbon-footprints-2018-mecs.

[146] "TBtu" = "one trillion British thermal units"; "MWh" = "one million watt hours"; 1 TBtu = 293 MWh.

[147] Note that the numbers in this table and other tables in this study are rounded. When used in calculations in this study, the exact numbers (rather than the rounded numbers) are used.

Only a small fraction of the wasted heat from all the sectors listed in the previous two tables is currently captured and put to productive use as either heat or electricity. The rest is either lost to the atmosphere or to wastewater.

These sources of wasted heat are not unique to the United States. Parallel work has been done to understand the potential of using wasted heat in the United Kingdom (UK)[148] and in the European Union (EU).[149]

There are encouraging signs that this technology is being adopted in Canada.

> *So far, 615,000 square feet of residential and office space on either side of the [Ottawa] river are being heated with waste heat from the nearby Kruger Products Plant in Gatineau, Que., and more buildings are under construction.*[150]

Figure 103: Common at Zibi – building heated with waste process heat

[148] See, for example:

- Albert, M. D. A., Bennett, K. O., Adams, C. A., & Gluyas, J. G. (2022, March 5). *Waste heat mapping: A UK study.* Renewable and Sustainable Energy Reviews. https://doi.org/10.1016/j.rser.2022.112230
- Smith, A. (2020, April 30). *Wasted opportunity: Using UK waste heat in district heating.* CIBSE Journal. https://www.cibsejournal.com/technical/wasted-opportunity-using-uk-waste-heat-in-district-heating/.

[149] See, for example:

- Papapetrou, M., Kosmadakis, G., Cipollina, A., La Commare, U., & Micale, G. (2018, April 9). *Industrial waste heat: Estimation of the technically available resource in the EU per industrial sector, temperature level and country.* Applied Thermal Engineering. https://doi.org/10.1016/j.applthermaleng.2018.04.043.
- Oluleye, G., Jobson, M., Smith, R., & Perry, S. J. (2015, July 23). *Evaluating the potential of process sites for waste heat recovery.* Applied Energy. https://doi.org/10.1016/j.apenergy.2015.07.011.

[150] Chung E. (2024, Feb 17.) *How industrial waste is keeping these Ottawa-area buildings warm.* CBC News. https://www.cbc.ca/news/science/zibi-waste-heat-recovery-1.7117832. (Photo from same source.)

While still underutilized in most countries (including in Canada), technologies for capturing this wasted heat and putting it to productive use are mature and commercially available.[151]

[151] Jouhara, H., Khordehgah, N., Almahmoud, S., Tassou, S. A., Chauhan, A., & Delpech, B. (2018, April 27). *Waste heat recovery technologies and applications.* Thermal Science and Engineering Progress. https://doi.org/10.1016/j.tsep.2018.04.017.

3 PARTICIPATING COMMUNITIES – CHARACTERISTICS & CLIMATE

Figure 104: Participating communities

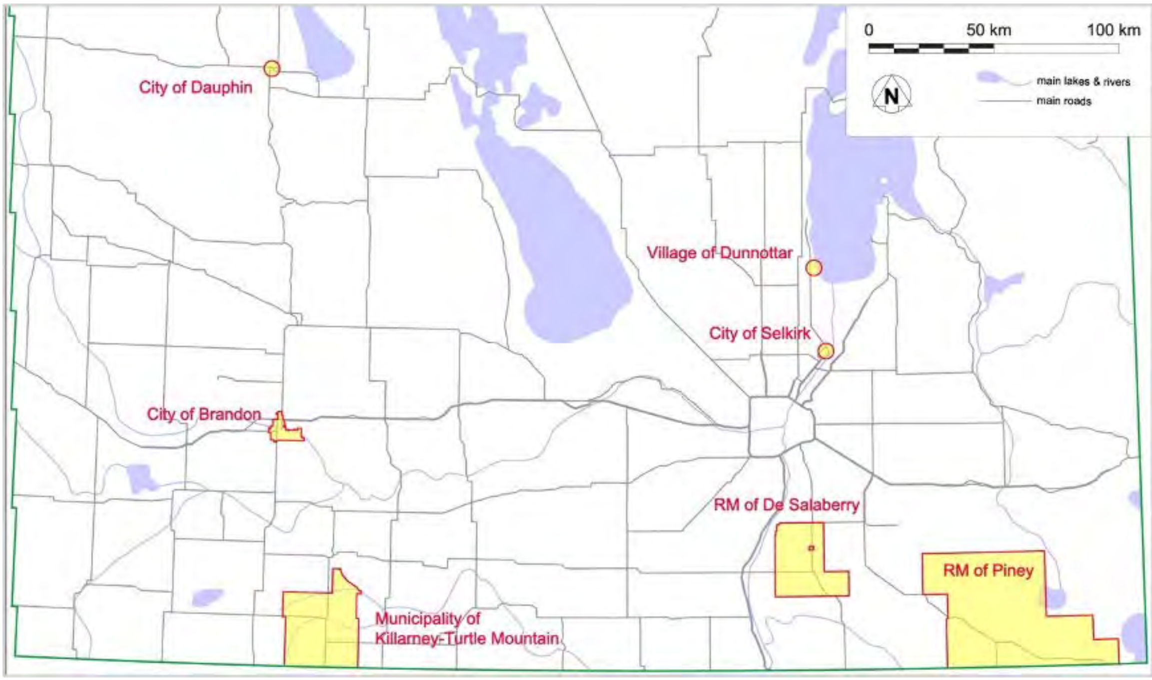


Table 218: Participating communities[152]

Participating Communities		*Population*		*Land Area*	*Density*
		2021 census	*annual change*	*km²*	*pop/km²*
Brandon	city	51,313	1.0%	79	649
Dauphin	city	8,368	0.0%	13	660
DeSalaberry	rural municipality	3,918	1.9%	668	6
Dunottar	village	989	5.9%	3	353
Killarney-Turtle Mountain	rural municipality	3,520	0.5%	930	4
Piney	rural municipality	1,843	1.4%	2,430	1
Selkirk	city	10,504	0.4%	24	429

An economic profile for each participating community is included later in this study, when each community is considered separately. What follows is an overall comparison of these participating communities' economies.

One way to understand communities is to compare the percentage of people who work in each industrial sector. Statistics Canada, in the 2021 Census, collected data on the number of people employed in each industry sector and calculated percentage of people employed in each sector. The table below shows which industrial sectors predominate in each community, compared to the province overall.

[152] Data from 2021 Census. (Government of Canada. (2022, June 14). *Census of Population.* Statistics Canada. https://www12.statcan.gc.ca/census-recensement/index-eng.cfm.) "Annual change" derived from population growth from 2016 to 2021 census, divided by 5.

Table 219: Percentages of people employed in each industry sector in each participating community, compared to Manitoba overall[153]

NAICS	*industry*	***Manitoba***	*Brandon*	*Dauphin*	*De Salaberry*	*Dunnottar*	*Killarney*	*Piney*	*Selkirk*
11	Agriculture, forestry, fishing & hunting	4%	**1%**	4%	**13%**	5%	**21%**	**24%**	**1%**
21	Mining, quarrying, & oil & gas extraction	1%	1%	1%	1%	**0%**	**2%**	**5%**	1%
22	Utilities	1%	1%	**0%**	**2%**	**0%**	**2%**	**0%**	1%
23	Construction	8%	7%	5%	**17%**	9%	6%	5%	8%
31-33	Manufacturing	8%	11%	**2%**	11%	**4%**	6%	11%	7%
41	Wholesale trade	3%	3%	2%	3%	**0%**	**5%**	**0%**	3%
44-45	Retail trade	11%	14%	**19%**	6%	11%	12%	8%	14%
48-49	Transportation & warehousing	6%	4%	**3%**	6%	**10%**	5%	5%	5%
51	Information & cultural industries	1%	2%	2%	1%	**0%**	**1%**	**0%**	1%
52	Finance & insurance	4%	3%	2%	3%	2%	4%	3%	3%
53	Real estate & rental & leasing	1%	1%	1%	1%	**4%**	**0%**	**0%**	1%
54	Professional, scientific & technical services	5%	3%	4%	**1%**	**0%**	**2%**	3%	**2%**
55	Management of companies & enterprises	0%	0%	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
56	Admin. & support, waste management & remediation services	4%	3%	2%	**2%**	5%	2%	5%	3%
61	Educational services	8%	9%	8%	8%	11%	6%	7%	8%
62	Health care & social assistance	15%	17%	**25%**	10%	15%	12%	**7%**	20%
71	Arts, entertainment & recreation	2%	2%	1%	1%	**0%**	**1%**	1%	2%
72	Accommodation & food services	6%	7%	7%	**2%**	**2%**	6%	5%	7%
81	Other services (except public administration)	4%	4%	5%	5%	4%	4%	3%	4%
91	Public administration	7%	6%	6%	5%	10%	4%	6%	5%
-	*classification not applicable*	*2%*	*2%*	***1%***	*1%*	***7%***	*3%*	*2%*	*3%*

% of people employed in this industry	**15%**	more than 150% greater than provincial average
	10%	more than 120% greater than provincial average
	4%	near provincial average (80% to 120% of provincial average)
	2%	less than 80% of provincial average
	1%	less than 50% of provincial average

The participating communities represent a diverse cross-section of southern Manitoba communities.

- They have diverse governance structures (city, rural municipality, village).
- They range from small to large. Their areas range 3 km2 to 2,430 km2 and their populations range from <1,000 to <50,000).
- Their populations vary significantly in their rates of growth.
- They are both urban and rural, with a diverse range of buildings that could take advantage of renewable energy.
- Some have significant industrial activity (Selkirk and Brandon) while others have very little (Dunnottar).
- Some are dominated by a single economic sector (agriculture, for example) while others are economically diverse.
- While all have access to biomass sources. some have predominantly agricultural biomass nearby, others have access primarily to forestry biomass, others have access to both.

One benefit of the diversity of the participating communities is that a broad spectrum of renewable energy options will be suitable for these communities.

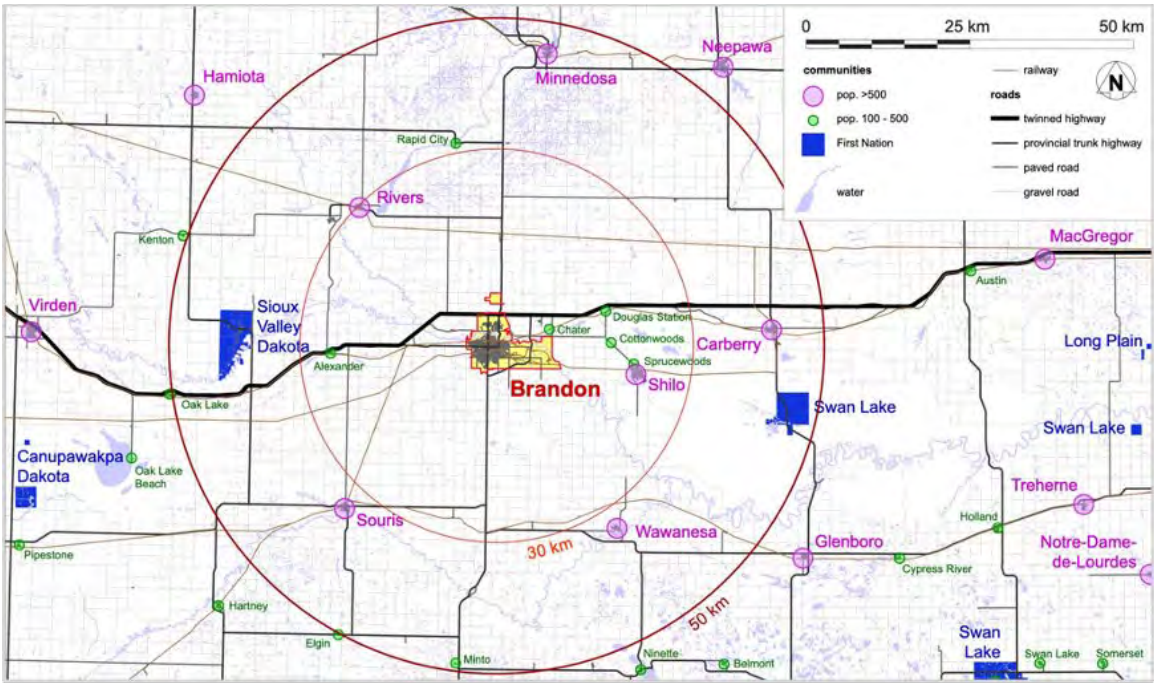
Another benefit is that they can serve as a representative sample of southern Manitoba communities, so what is feasible in at least one of these communities may well be feasible in many other communities in our province.

[153] Data from 2021 Census. NAICS (North American Industry Classification System) uses standard definitions of industry sector to enable comparison between jurisdictions. "Classification not applicable" defined as "unemployed persons aged 15 years and over who have never worked for pay or in self-employment, or who had last worked prior to January 1, 2020."

3.1 Brandon

Brandon is Manitoba's second-largest city. Brandon's economy was initially built on meeting the needs of area farmers. As the City has grown, it has become much more economically diverse. The population has also become more diverse.

Figure 105: Brandon – 50 km radius



3.1.1 *Population & Economy*[154]

Table 220: Brandon – population & density

	Population		Land Area	Density
	2021 census	annual change	km^2	pop/km^2
City of Brandon	51,313	1.0%	79	649
Manitoba overall	1,342,153	1.0%	540,310	2.5

The population of Brandon is growing at the same rate as Manitoba overall—1.0% per year.

Table 221: Brandon – basic demographics – individuals[155]

	Individuals				
	average age	completed postsecondary	indigenous identity	immigrant	neither indigenous nor immigrant
City of Brandon	39.0	50%	14%	18%	69%
Manitoba overall	39.7	50%	18%	19%	63%

[154] Data from 2021 Census.

[155] See 2021 Census for definitions of demographic categories.

Brandon's population closely matches the overall Manitoba population in average age, educational attainment, and the percentage of the population that are immigrants. A lower percentage of Brandon people identify as indigenous (14%) compared to the province overall (18%).

Table 222: Brandon – basic demographics – households

	Households	
	average size	median income
City of Brandon	2.4	$76,000
Manitoba overall	2.6	$79,500

Average household size and median household income in Brandon are both slightly less than the Manitoba average.

Table 223: Percentages of people employed in each industry sector in Brandon, compared to Manitoba overall[156]

NAICS	industry	Manitoba	Brandon
11	Agriculture, forestry, fishing & hunting	4%	1%
21	Mining, quarrying, & oil & gas extraction	1%	1%
22	Utilities	1%	1%
23	Construction	8%	7%
31-33	Manufacturing	8%	11%
41	Wholesale trade	3%	3%
44-45	Retail trade	11%	14%
48-49	Transportation & warehousing	6%	4%
51	Information & cultural industries	1%	2%
52	Finance & insurance	4%	3%

NAICS	industry	Manitoba	Brandon
53	Real estate & rental & leasing	1%	1%
54	Professional, scientific & technical services	5%	3%
55	Management of companies & enterprises	0%	0%
56	Admin. & support, waste management & remediation	4%	3%
61	Educational services	8%	9%
62	Health care & social assistance	15%	17%
71	Arts, entertainment & recreation	2%	2%
72	Accommodation & food services	6%	7%
81	Other services (except public administration)	4%	4%
91	Public administration	7%	6%
-	classification not applicable	2%	2%

% of people employed in this industry		
	15%	more than 150% greater than provincial average
	10%	more than 120% greater than provincial average
	4%	near provincial average (80% to 120% of provincial average)
	2%	less than 80% of provincial average
	1%	less than 50% of provincial average

156 Data from 2021 Census. The data indicates that Brandon's agriculture, forestry, fishing and hunting sector (NAICS 11) employs a lower percentage of people than in the province overall. This is misleading; while the percentage of people employed within the city limits in this sector is low, the city is the primary support centre for the region's agricultural sector and so the percentage of people within Brandon who are employed in support of agriculture is likely to be higher than the provincial average. Unfortunately, the 2021 Census data does not capture this.

Much like Manitoba overall, Brandon has a diversified and stable economy. The sectors of where Brandon's economy outperforms the provincial average are:

- manufacturing
- retail trade
- accommodation and food services

Economic Development Brandon's Townfolio website provides a fuller picture of the economic life of the city:

> *…diversification provides an extremely stable and positive environment for businesses to compete within the global economy.*
>
> *Brandon acts as the service centre for some 180,000 people, including the entire Southwest Economic Region which has a total population of nearly 110,000. The primary trading area includes roughly 60,000 people within a 30 km radius of the City of Brandon. Included within the trading area is Canadian Forces Base Shilo, located approximately 30 km from Brandon employing approximately 1,800 Military and civilian personnel. Located an hour's drive from the Bakken Formation oil field, Brandon's businesses continue adapting to service the oil & gas industry. A centre for education, Brandon is home to three post-secondary institutions…157*

Economic Development Brandon highlights five industrial sectors.

- agriculture
- food processing
- manufacturing
- tourism
- transportation

[157] Townfolio. (n.d.). *Brandon*. https://townfolio.co/mb/brandon/overview

It also highlights more than two dozen firms.

Table 224: Brandon firms highlighted by Economic Development Brandon[158]

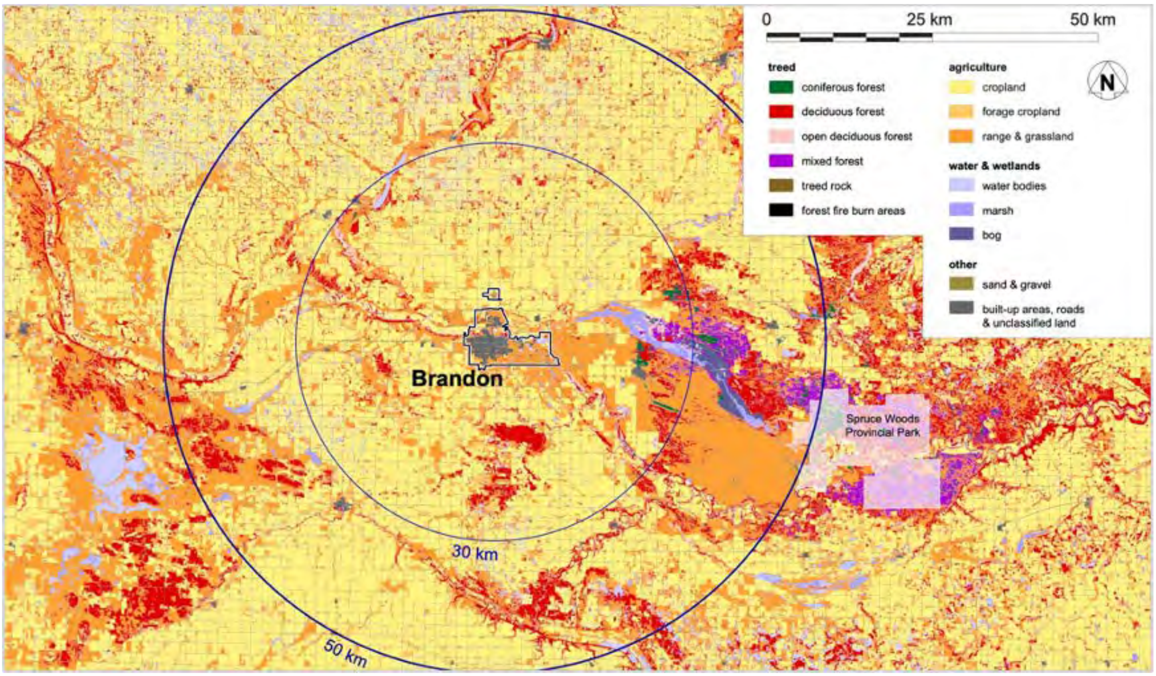
NAICS	company	focus	# Brandon employees	Brandon revenues
22 | 221	Manitoba Hydro	energy utility	338	not available
31 | 311	Maple Leaf Foods	hog processing	2,200	not available
	Saputo Dairy	dairy products	140	
	Shape Foods	flax producers	<25	$7.1m
32 | 325	Chemtrade Logistics	manufactures sodium chlorate	75	not available
	Pfizer Global Supply	produces conjugated estrogens	80	
	Koch Fertilizer	manufactures fertilizer	260	
32 | 321	Modern Industrial Structures	modular building construction	<25	<$5m
32 | 323	Leech Printing	printer	20	$5.7m
33 | 331	Behlen Industrie	steel building manufacturer	301	$81.5m
33 | 339	Atom Jet Group	ground engagement tools manufacture	<25	$10.1m
42 | 423	Greenstone Building Products	building envelope construction	<25	$6.6m
	Mazer Group	farm equipment dealership	300+	not available
	Murray Chevrolet Cadillac Buick GMC	vehicle dealership	90	$13.8m
48 | 482	Cando Rail Services	railway support services provider	80	$104.4m
51 | 517	BellMTS	telecommunications	175	not available
51 | 518	NetSet (Westman) Communications	internet provider	124	$20m
52 | 522	Westoba Credit Union	commercial banking ervices	130	$51.3m
53 | 531	Genesis Hospitality	hotel operator	325	$54.6m
61 | 611	Brandon School Division	education	1,150	$135.3m
	Assiniboine Community College		500	$52.6m
	Brandon University		495	$64.2m
62 | 621	Shared Health	health care services	135	not available
62 | 622	Prairie Mountain Health	hospital, health care services	4,887	1,200m
62 | 624	Child & Family Services Westman	social assistance	150	$12.2m
91 | 911	Government of Canada	government services	225	not available
91 | 912	Government of Manitoba		688	
91 | 913	City of Brandon		500	

[158] Data sources: The listed firms' websites and:

- Economic Development Brandon. (n.d.). http://economicdevelopmentbrandon.com
- Townfolio. (n.d.). *Brandon*. https://townfolio.co/mb/brandon/overview
- Zoominfo. (n.d.). https://www.zoominfo.com

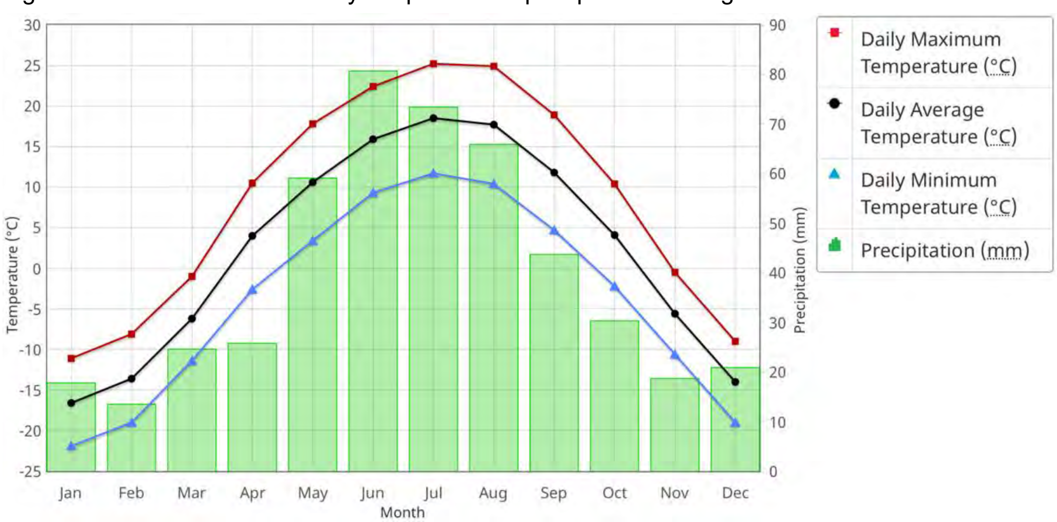
3.1.2 *Environment*

Figure 106: Brandon – land cover – 50 km radius



3.1.2.1 BRANDON CLIMATE NORMALS

Figure 107: Brandon – monthly temperature & precipitation averages – 1981 to 2010[159]



159 Graph copied from Government of Canada. (2024, March 27). *1981-2010 Climate Normals & Averages.* Environment and Natural Resources. https://climate.weather.gc.ca/climate_normals/index_e.html

3.1.2.2 BRANDON CLIMATE PROJECTIONS

The following graphs[160] provide projections for how the climate of Brandon is projected to change. Graphs with green lines project what will happen if, globally, we make significant reductions in our CO_2 emissions. Graphs with red lines project what will happen if, globally, we continue on our current course.

Figure 108: Brandon – average annual daily minimum temperature – if significant progress made

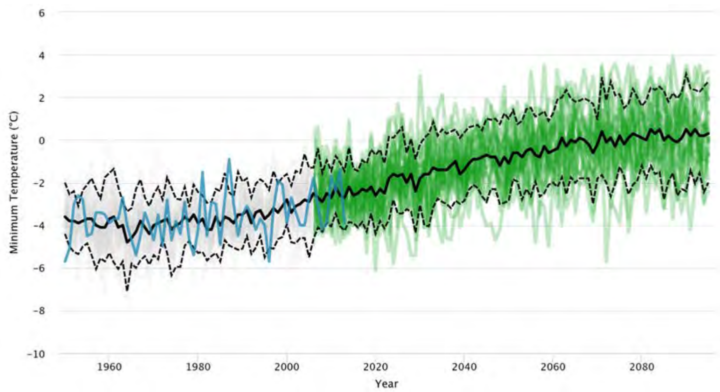


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Figure 109: Brandon – average annual daily mean temperature – if significant progress made

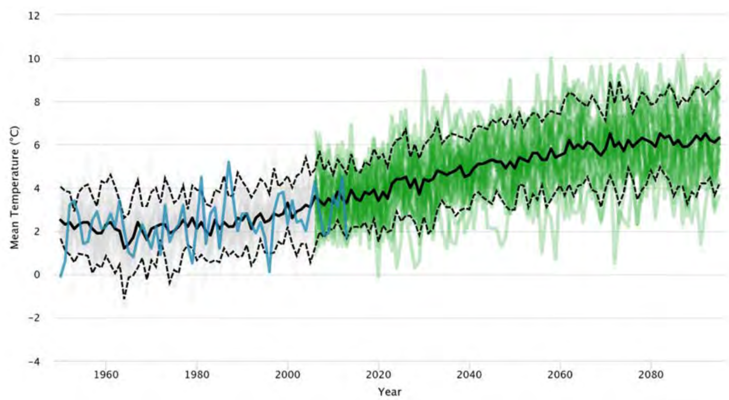
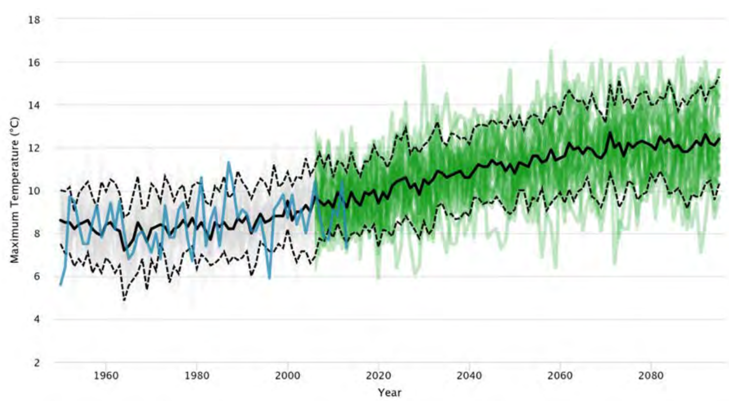


Figure 110: Brandon – average annual daily maximum temperature – if significant progress made



160 Source of graphs: *Climate Atlas of Canada.* (n.d.). https://climateatlas.ca/

Figure 111: Brandon – total annual Heating Degree Days – if significant progress made

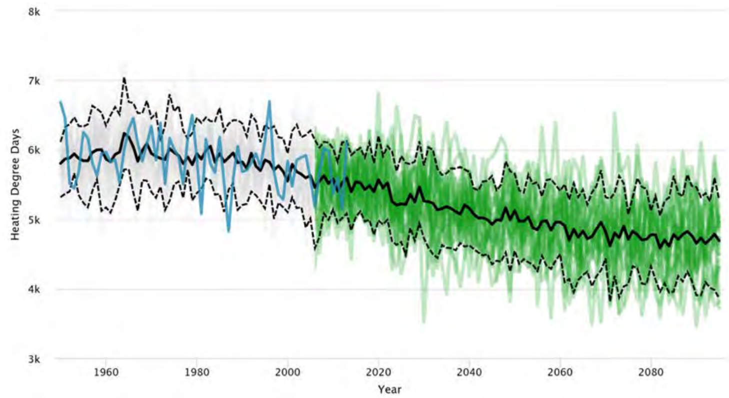


Figure 112: Brandon – total annual Cooling Degree Days – if significant progress made

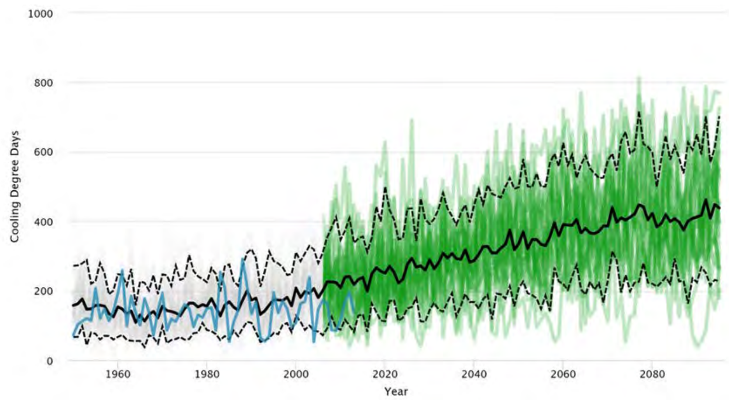


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Figure 113: Brandon – Days below -30ºC per year – if significant progress made

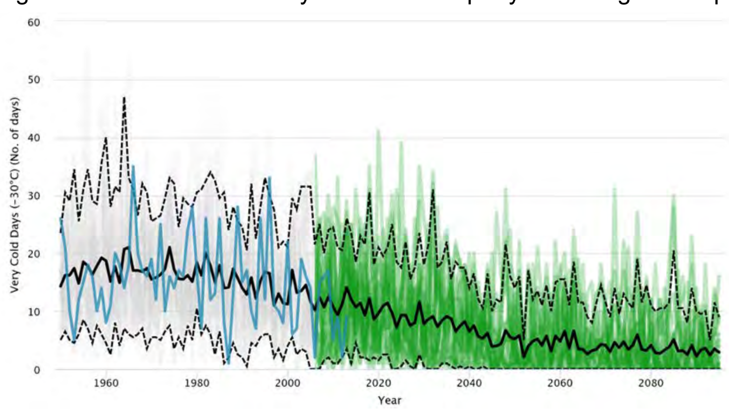


Figure 114: Brandon – days above +30ºC per year – if significant progress made

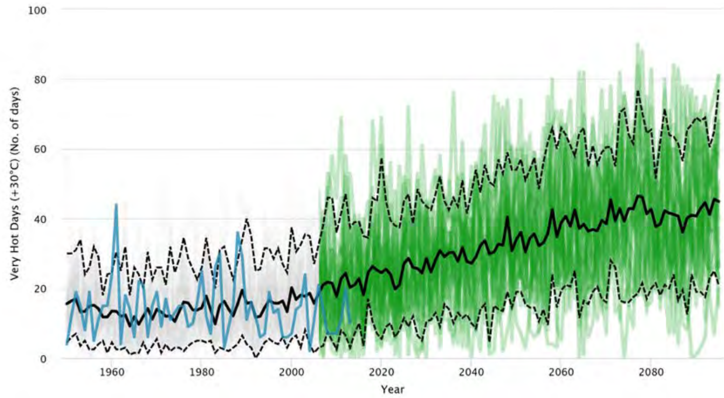


Figure 115: Brandon – Annual average daily minimum temperatures – If business as usual

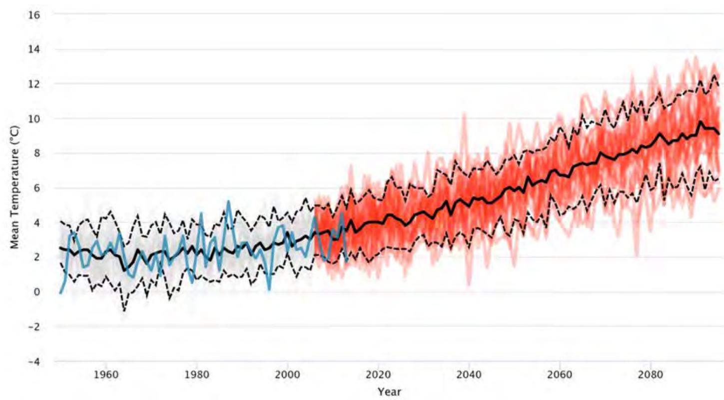


Figure 116: Brandon – Annual average daily mean temperatures – If business as usual

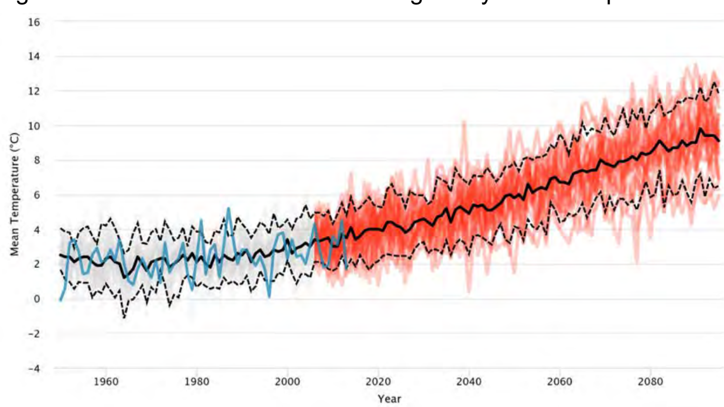


Figure 117: Brandon – Annual average daily maximum temperatures – If business as usual

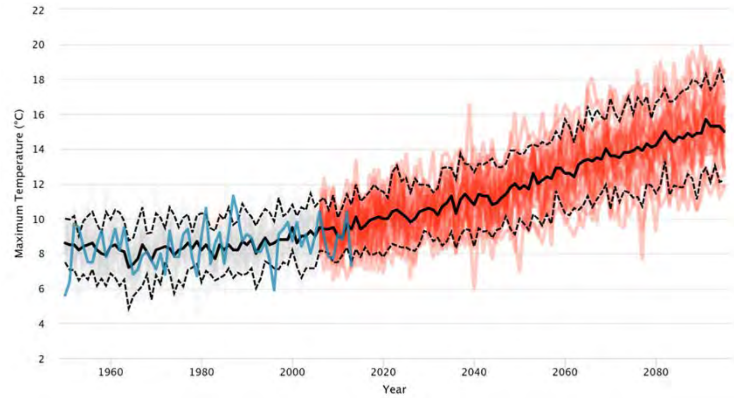


Figure 118: Brandon – total annual Heating Degree Days – If business as usual

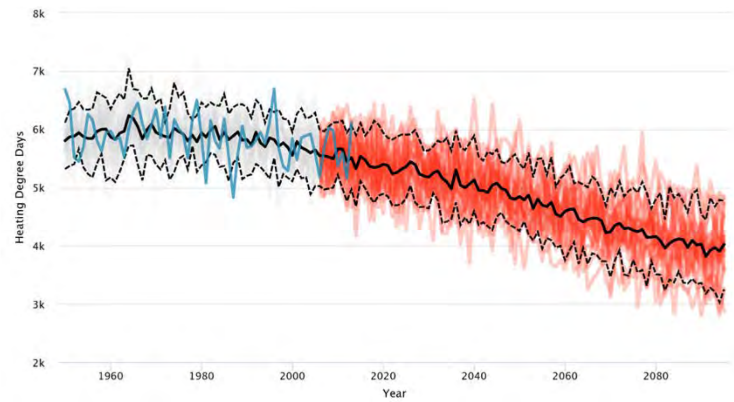


Figure 119: Brandon – total annual Cooling Degree Days – If business as usual

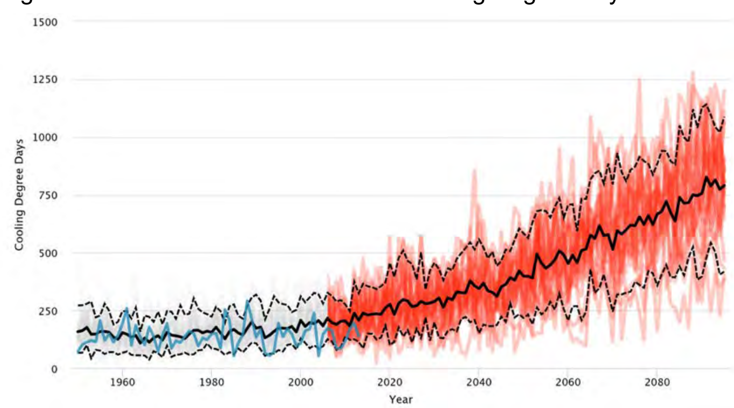


Figure 120: Brandon – Days below -30ºC per year – If business as usual

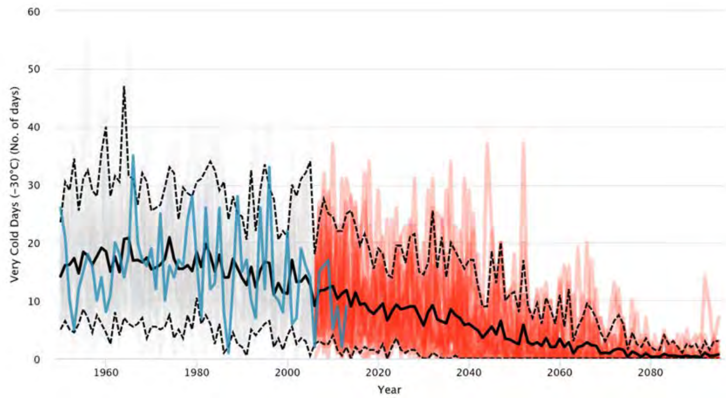
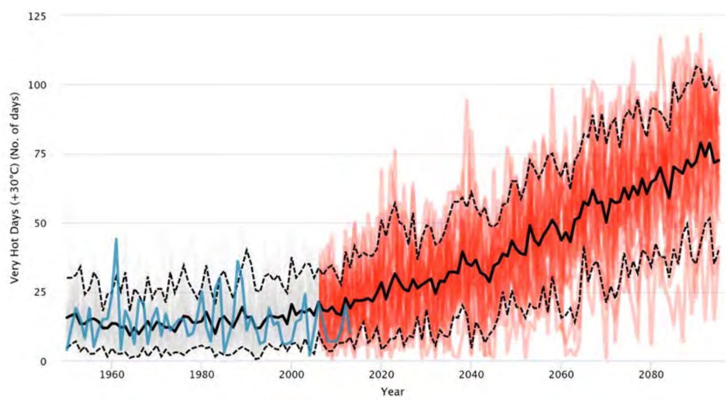


Figure 121: Brandon – days above +30ºC per year – If business as usual



3.1.2.3 COMBINING BRANDON CLIMATE NORMALS AND CLIMATE PROJECTIONS

Table 225: Brandon – Actual and projected annual averages[161]

	ANNUAL AVERAGES						
	actual			*projected if significant progress made in emissions reductions*		*projected if business as usual*	
	1890	*2023*	*change*	*2050*	*change from 2023*	*2050*	*change from 2023*
Temperatures							
minimum	-5.75°C	-3.55°C	2.20°C	-1.00°C	2.55°C	0.00°C	5.75°C
mean	0.80°C	2.55°C	1.75°C	4.90°C	2.35°C	5.80°C	5.00°C
maximum	7.30°C	8.60°C	1.30°C	11.00°C	2.40°C	12.00°C	4.70°C
Degree Days							
Heating Degree Days	6,380	5,780	-9%	5,125	-11%	4,840	-16%
Cooling Degree Days	100	125	25%	335	168%	400	220%
Days Experiencing Extreme Temperatures							
Days below -30°C	27	12	-56%	5	-58%	3	-75%
Days above +30°C	14	12	-14%	23	92%	40	233%

161 Source of past data: Historical Data: Past Weather and Climate. Source of projected estimates: *Climate Atlas of Canada*.

Combining the data from Canadian Climate Normals and the Climate Atlas of Canada enables us to project how each much Brandon's climate is likely to change in the coming years.

Crucially for this study, combining these two data sources enables us to estimate the changes in heating and cooling needs for buildings in Brandon, including those targeted in this study.

Brandon can expect to see a modest decline in building heating needs (in the range of 13% to 18%) and a very significant increase in building cooling needs (in the range of 197% to 242%) over the next 25 years.

3.1.3 *Sustainability Initiatives to Date*

The City of Brandon has taken significant steps towards sustainability. The latest—and most comprehensive initiative was the adoption of the Climate Change Action Plan for Brandon,[162] adopted by Brandon City Council on May 15, 2023.

This Action Plan builds on build on Brandon's earlier Environmental Strategic Plan, which was first adopted in 2007, and received a comprehensive update in 2013.[163]

The 2023 Action Plan is grouped into seven key themes (dubbed "7 big moves"):

1. Become a Carbon Free Corporation
2. Transition to Renewable Energy
3. Rethink Transportation
4. Build Resilient Infrastructure
5. Conserve and Protect Nature
6. Prepare for Emergencies & Recovery
7. Consume and Produce Sustainably

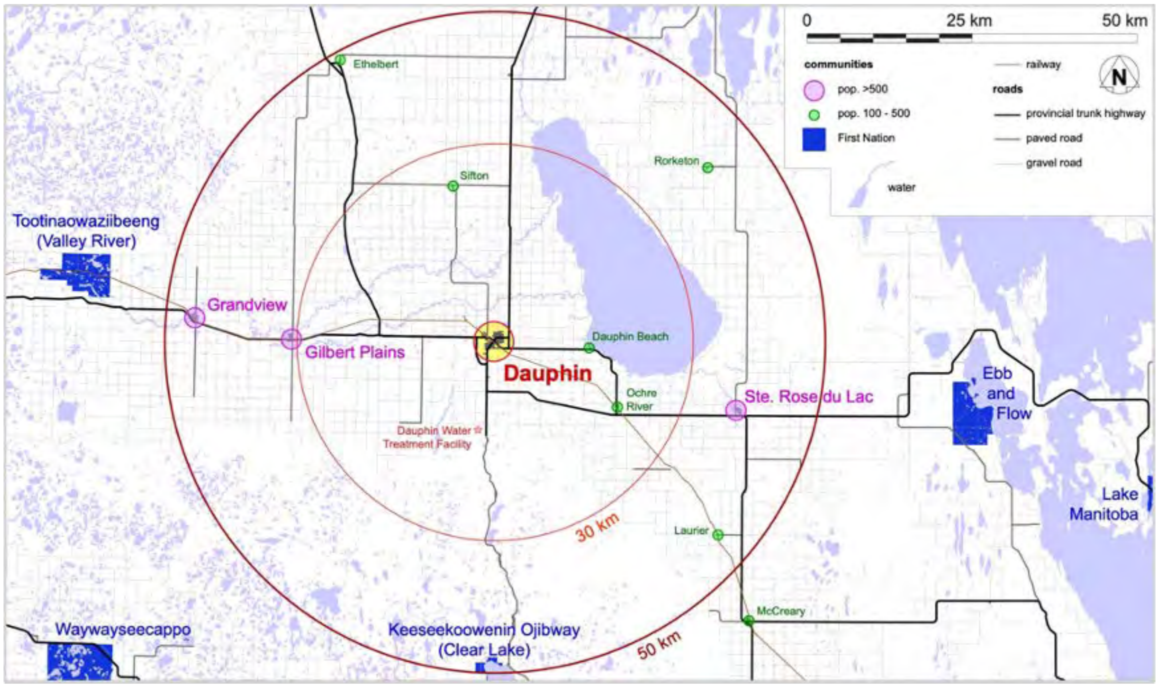
The current prefeasibility study should be seen as one step in the implementation of Brandon's Action Plan, making progress on "big moves" 1, 2 and 7—becoming a carbon-free corporation, transitioning to renewable energy, and consuming and producing sustainably.

[162] City of Brandon. (2023, May 15). *Climate Change Action Plan*. https://brandon.ca/climate-action/climate-action-plan

[163] City of Brandon. (2013). *Environmental Strategic Plan*. https://brandon.ca/climate-action/2013-environmental-strategic-plan

3.2 Dauphin

Figure 122: Dauphin – 50 km radius



3.2.1 *Population & Economy*[164]

Table 226: Dauphin – population & density

	Population		***Land Area***	***Density***
	2021 census	*annual change*	*km^2*	*pop/km^2*
City of Dauphin	8,368	0.0%	13	660
Manitoba overall	1,342,153	1.0%	540,310	2.5

According to the 2021 Census, the City of Dauphin did not see population growth from 2016 to 2021.

On the other hand, Dauphin had the highest population density of any of the communities participating in this study—660 people/km^2

Table 227: Dauphin – basic demographics – individuals[165]

	Individuals				
	average age	*completed postsecondary*	indigenous identity	immigrant	neither indigenous nor immigrant
City of Dauphin	42.4	46%	27%	7%	67%
Manitoba overall	39.7	50%	18%	19%	63%

[164] Data from 2021 Census.

[165] See 2021 Census for definitions of demographic categories.

The population of the City of Dauphin is slightly older than the provincial average (42.4 vs. 39.7) and a slightly lower average level of educational attainment.

The percentage of people in Dauphin who identify as indigenous is higher than the provincial average (27% vs. 18%). Of those who identify as indigenous, just under half identify as First Nations and just over half identify as Metis.

Dauphin has a much lower percentage of immigrants than the province overall (7% vs. 19%).

Table 228: Dauphin – basic demographics – households

	Households	
	average size	*median income*
City of Dauphin	2.2	$60,800
Manitoba overall	2.6	$79,500

The average household size in Dauphin is less than the average in Manitoba (2.2 vs. 2.6 people/household).

The median household income is nearly $20,000 less than the provincial median.

Table 229: Percentages of people employed in each industry sector in the City of Dauphin and the RM which surrounds it, compared to Manitoba overall[166]

NAICS	*industry*	***Manitoba***	*City of Dauphin*	*RM of Dauphin*
11	Agriculture, forestry, fishing & hunting	4%	4%	**18%**
21	Mining, quarrying, & oil & gas extraction	1%	1%	**0%**
22	Utilities	1%	**0%**	1%
23	Construction	8%	5%	7%
31-33	Manufacturing	8%	**2%**	**3%**
41	Wholesale trade	3%	2%	4%
44-45	Retail trade	11%	**19%**	14%
48-49	Transportation & warehousing	6%	**3%**	**2%**
51	Information & cultural industries	1%	2%	**0%**
52	Finance & insurance	4%	2%	2%
53	Real estate & rental & leasing	1%	1%	1%
54	Professional, scientific & technical services	5%	4%	3%
55	Management of companies & enterprises	0%	**0%**	**0%**
56	Admin. & support, waste management & remediation services	4%	2%	**2%**
61	Educational services	8%	8%	6%
62	Health care & social assistance	15%	**25%**	16%
71	Arts, entertainment & recreation	2%	1%	**3%**
72	Accommodation & food services	6%	7%	5%
81	Other services (except public administration)	4%	5%	6%
91	Public administration	7%	6%	7%
-	*classification not applicable*	2%	**1%**	**1%**

% of people employed in this industry		
	15%	more than 150% greater than provincial average
	10%	more than 120% greater than provincial average
	4%	near provincial average (80% to 120% of provincial average)
	2%	less than 80% of provincial average
	1%	less than 50% of provincial average

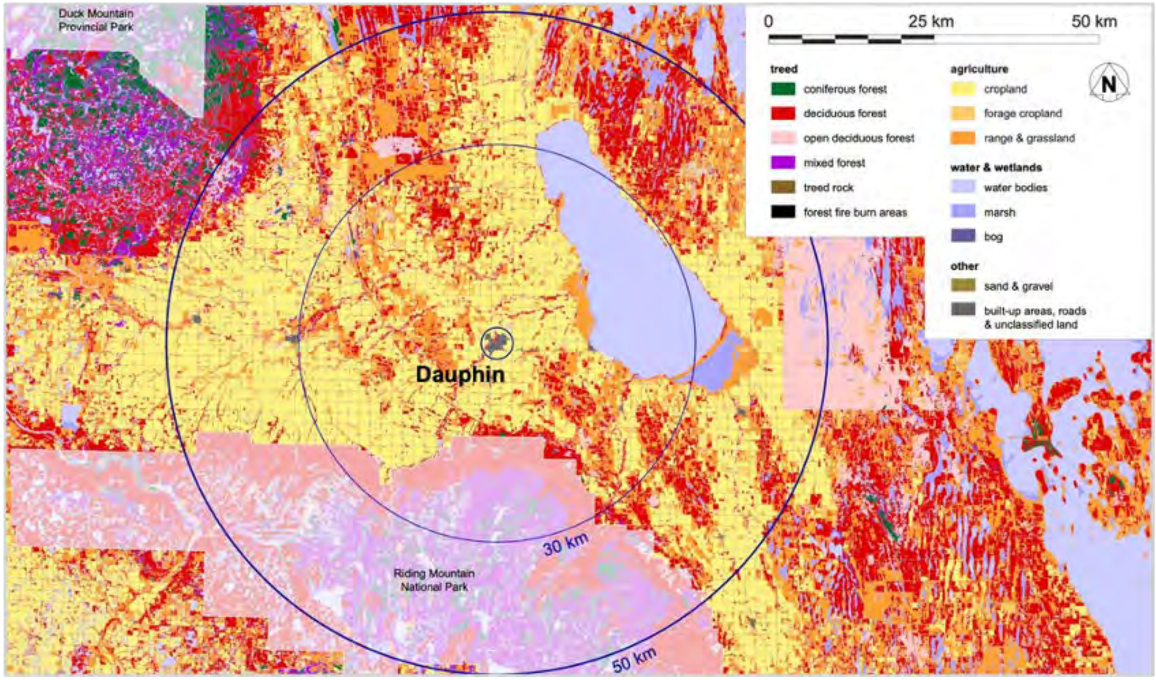
The agricultural sector predominates in the RM of Dauphin; the City of Dauphin is the regional centre which supports that sector. Other sectors employing a greater percentage of people in Dauphin compared to the province overall include:

- retail trade
- health care
- services, including accommodation & food services
- recreation

[166] Data from 2021 Census. NAICS (North American Industry Classification System) uses standard definitions of industry sector to enable comparison between jurisdictions. "Classification not applicable" defined as "unemployed persons aged 15 years and over who have never worked for pay or in self-employment, or who had last worked prior to January 1, 2020."

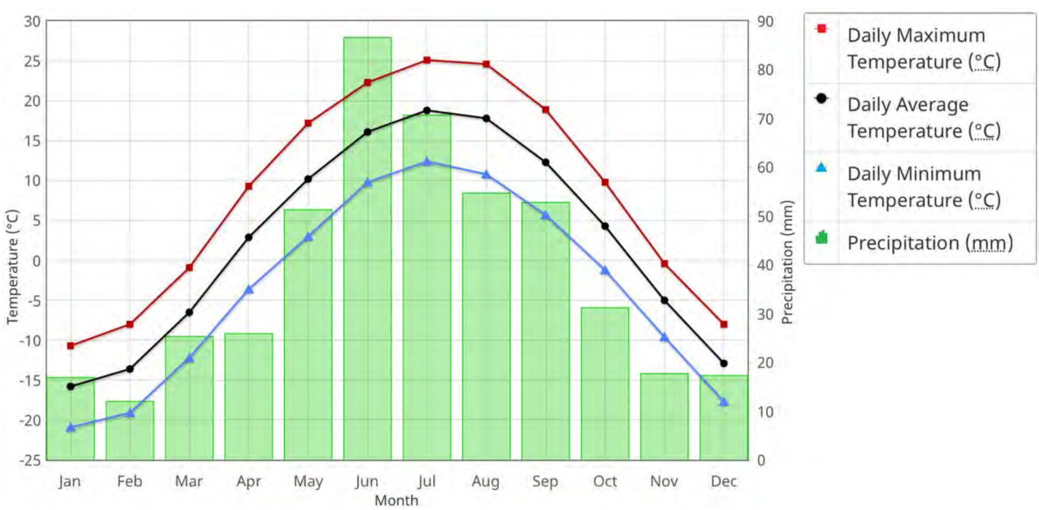
3.2.2 *Environment*

Figure 123: Dauphin – land cover – 50 km radius[167]



3.2.2.1 DAUPHIN CLIMATE NORMALS

Figure 124: Dauphin – monthly temperature & precipitation averages – 1981 to 2010[168]



[167] The pink area to the east of Lake Dauphin is probably not all open deciduous forest; it appears to be gap in the mapping data.

[168] Graph copied from Government of Canada. (2024, March 27). *1981-2010 Climate Normals & Averages.* Environment and Natural Resources. https://climate.weather.gc.ca/climate_normals/index_e.html

3.2.2.2 DAUPHIN CLIMATE PROJECTIONS

The following graphs[169] provide projections for how the climate of Dauphin is projected to change. Graphs with green lines project what will happen if, globally, we make significant reductions in our CO_2 emissions. Graphs with red lines project what will happen if, globally, we continue on our current course.

Figure 125: Dauphin – average annual daily minimum temperature – if significant progress made

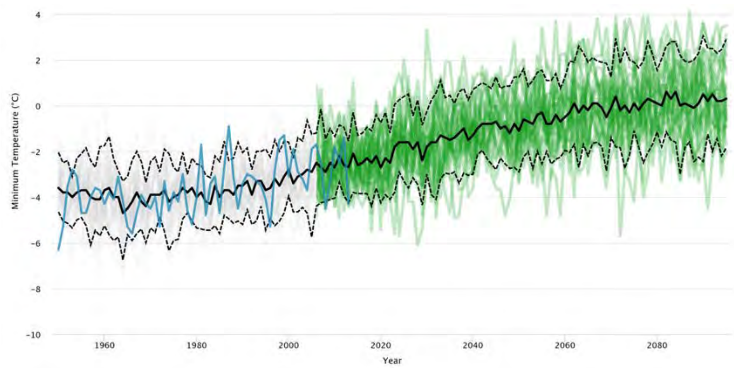


Figure 126: Dauphin – average annual daily mean temperature – if significant progress made

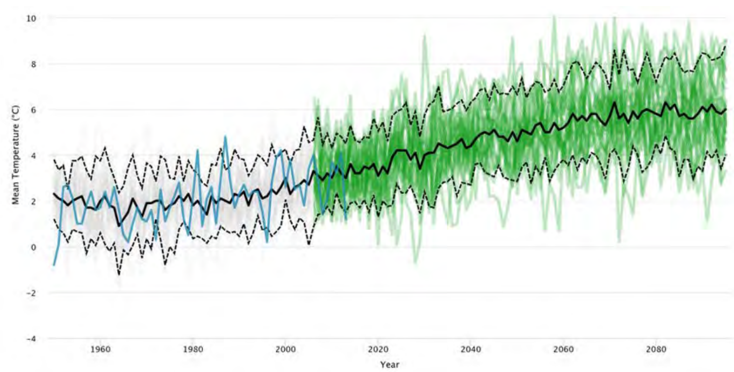
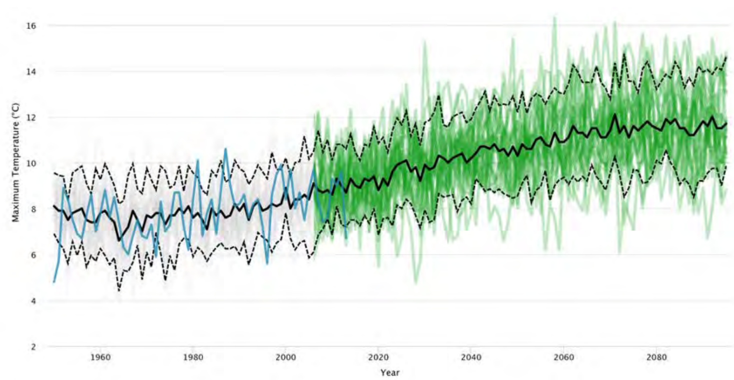


Figure 127: Dauphin – average annual daily maximum temperature – if significant progress made



[169] Source of graphs: *Climate Atlas of Canada.* (n.d.). https://climateatlas.ca/

Figure 128: Dauphin – total annual Heating Degree Days – if significant progress made

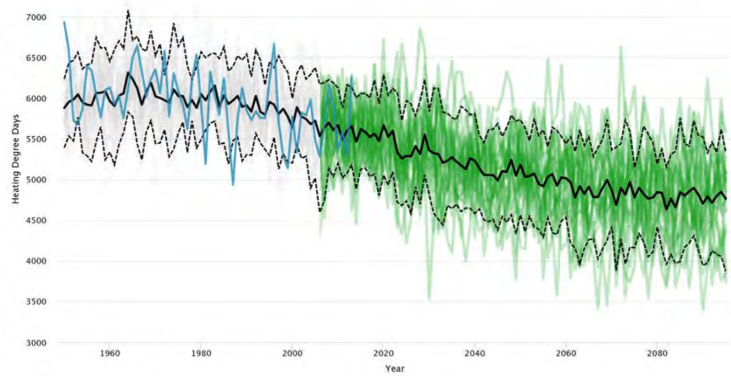


Figure 129: Dauphin – total annual Cooling Degree Days – if significant progress made

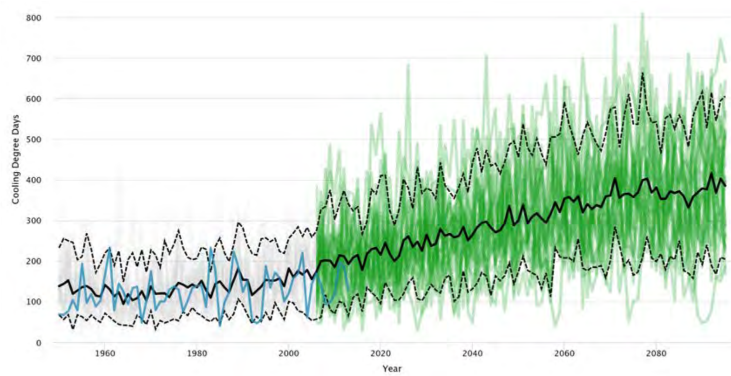


Figure 130: Dauphin – Days below -30ºC per year – if significant progress made

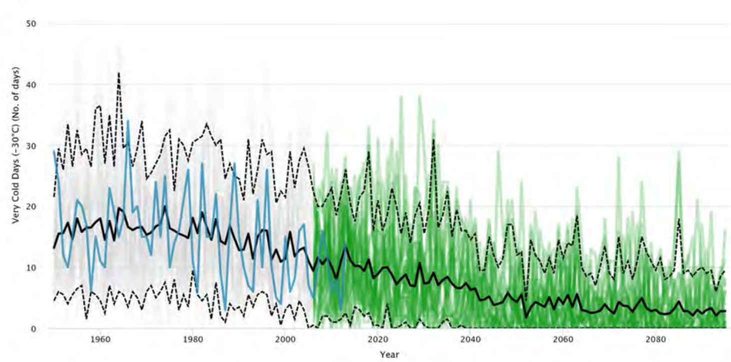


Figure 131: Dauphin – days above +30ºC per year – if significant progress made

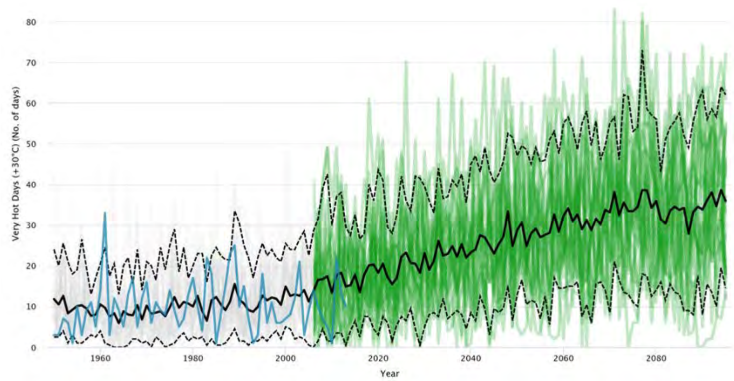


Figure 132: Dauphin – Annual average daily minimum temperatures – If business as usual

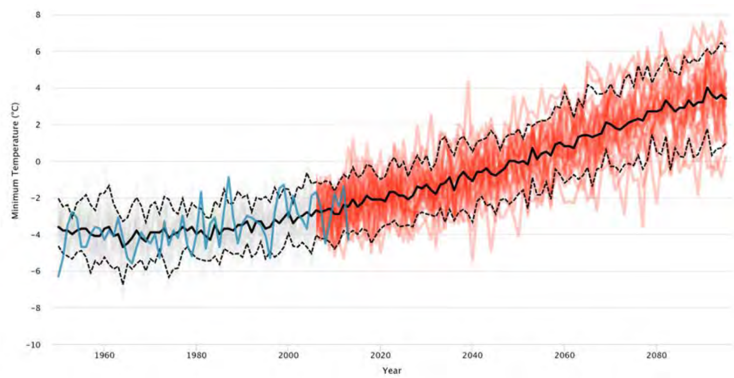


Figure 133: Dauphin – Annual average daily mean temperatures – If business as usual

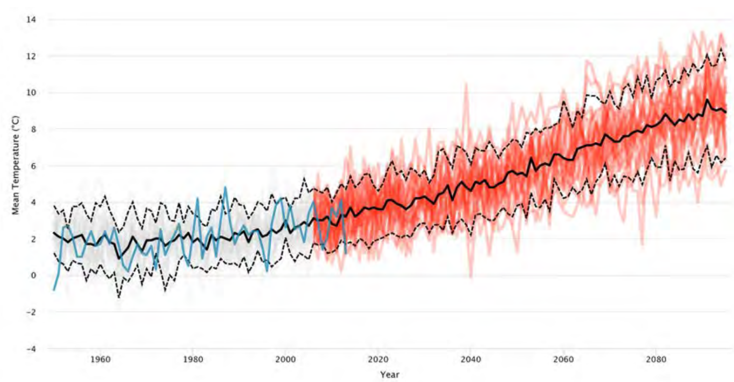


Figure 134: Dauphin – Annual average daily maximum temperatures – If business as usual

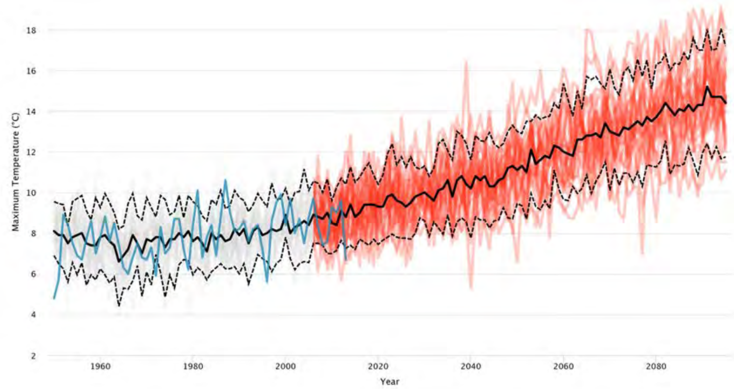


Figure 135: Dauphin – total annual Heating Degree Days – If business as usual

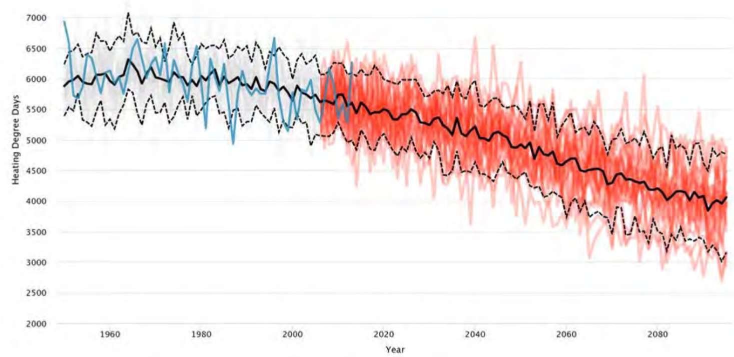


Figure 136: Dauphin – total annual Cooling Degree Days – If business as usual

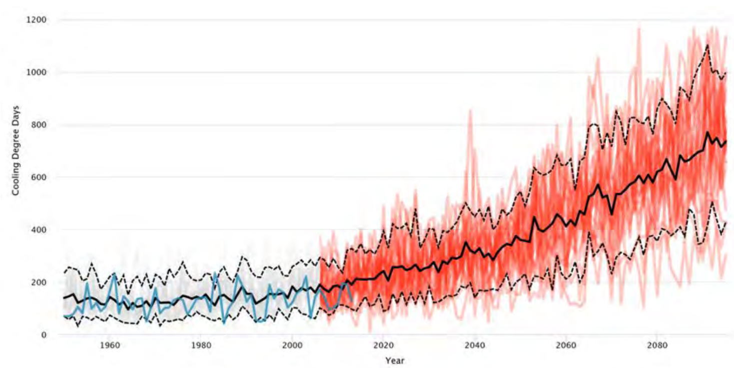


Figure 137: Dauphin – Days below -30ºC per year – If business as usual

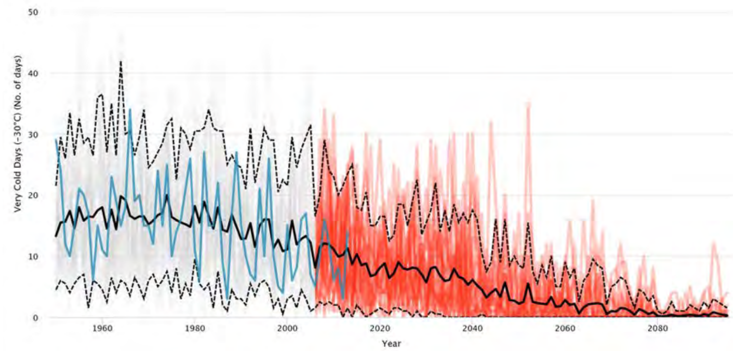
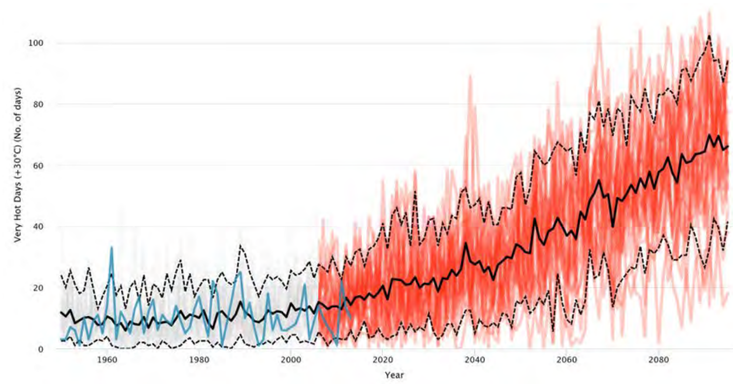


Figure 138: Dauphin – days above +30ºC per year – If business as usual



3.2.2.3 COMBINING DAUPHIN CLIMATE NORMALS AND CLIMATE PROJECTIONS

Table 230: Dauphin – actual average temperatures and projected changes

	Annual Averages								
	climate normals	*projected if significant prograss made in emissions reductions*				*projected if business as usual*			
	1976-2005	*2021-2050*	*2050*	*2051-2080*	*change from 1975-*	*2021-2050*	*2050*	*2051-2080*	*change from 1975-2005*
Temperaturea									
minimum	-3.5°C	-1.4°C	-1.1°C	-0.2°C		-1.1°C	-0.1°C	1.4°C	0.0
mean	2.2°C	4.4°C	4.6°C	5.5°C		4.6°C	5.5°C	7.0°C	0.0
maximum	8.0°C	10.1°C	10.3°C	11.2°C		10.2°C	11.1°C	12.6°C	0.0
Degree Days									
Heating Degree Days	5,923	5,240	5,182	4,900	-13%	5,195	4,867	4,520	-18%
Cooling Degree Days	104	263	300	347	187%	289	359	492	244%
Days Experiencing Extreme Temperatures									
Days <-30°C	15	7	4	4	-71%	6	2	2	-85%
Days >30°C	10	23	29	32	197%	25	33	45	242%

Combining the data from Canadian Climate Normals and the Climate Atlas of Canada enables us to estimate how each much Dauphin's climate is likely to change in the coming years.

Crucially for this study, combining these two data sources enables us to predict the changes in heating and cooling needs for buildings in Dauphin, including those targeted in this study.

Dauphin can expect to see a modest decline in building heating needs (in the range of 13% to 18%) and a very significant increase in building cooling needs (in the range of 197% to 242%) over the next 25 years.

3.2.3 *Sustainability Initiatives to Date*

Dauphin has already taken steps to become more sustainable, include initiatives to reduce energy consumption and move to more renewable sources of energy. They include:

- 2016 Launch of Community Energy Initiative, in partnership with Manitoba Hydro

  > *"The project involves engaging stakeholders in the creation and implementation of a Community Energy Plan. This plan will act as a guideline for lowering energy consumption throughout the community. The advocate role will involve assessing residential, commercial and municipal buildings in Dauphin to determine their eligibility for existing Power Smart programs."*[170]

- 2019 Release of Community Energy and Emissions Plan, developed with the support of Federation of Canadian Municipalities (FCM)

  > *The vision for the City [of Dauphin] is to become Manitoba's most sustainable City by becoming the first MB City to reach Carbon Neutrality and Net Zero Energy Status for Municipal operations.*[171]

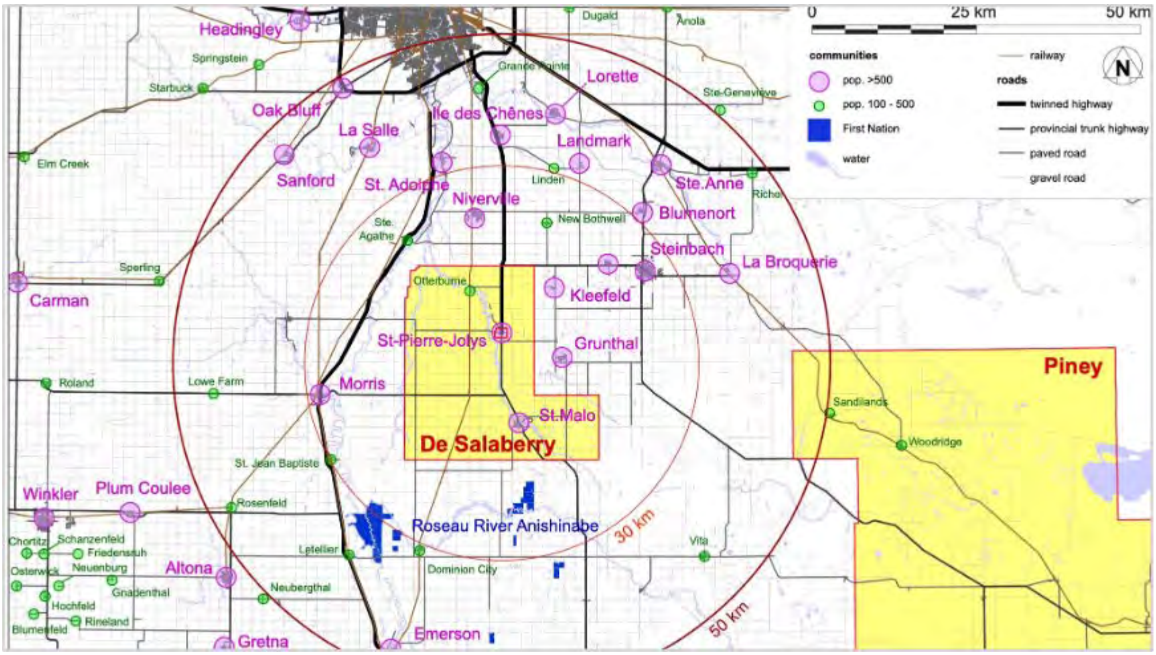
The current prefeasibility study should be seen as a continuation of Dauphin's energy initiatives, focusing on one specific facet of the community's overall sustainability plans, not as a new departure.

[170] City of Dauphin. (2016). Community Energy Initiative announcement. https://www.dauphin.ca/p/community-energy-initiative

[171] Sobering, S. (2019, October 30). *Community Energy and Emissions Plan.* City of Dauphin.

3.3 De Salaberry

Figure 139: De Salaberry – 50 km radius



De Salaberry describes itself very well on its website:

> *Nestled in the heart of South Eastern Manitoba, the Rural Municipality of De Salaberry is blessed by the most fertile agricultural regions of Manitoba's Red River Valley to the west, the natural beauty of oak and poplar woodlands on the eastern escarpment and the scenic Rat River that slowly meanders northwards. It is with these qualities that the municipality, founded by the fur trade and farming pioneers in the mid-1800s has embraced not only agriculture but also tourism and recreation as their primary resources.*
>
> *Situated 30 minutes south of the City of Winnipeg and 30 minutes north of the United States border via Highway 59, the location of the Local Urban District of St. Malo, De Salaberry's largest community, and the hamlets of Otterburne, Dufrost, La Rochelle and Carey makes De Salaberry, with a population of 3,918 residents, an attractive area to work, live and play.*
>
> *The municipality holds the jewel of southeastern Manitoba in Lake St. Malo along with the St. Malo Provincial Park, one of the busiest Provincial Parks in Manitoba enjoyed by over 250,000 visitors every year. With these natural settings and peaceful country living it is no wonder why De Salaberry has quickly become one of the most sought rural residential and cottage country destinations in the Province.*[172]

[172] De Salaberry. (n.d.). https://www.rmdesalaberry.mb.ca

3.3.1 *Population & Economy*[173]

Table 231: De Salaberry – population & density

	Population			Land Area	Density
	2021 census	annual change	% of RM	km^2	pop/km^2
De Salaberry overall	3,918	1.9%		667.6	5.9
St Malo	1,323	1.6%	34%	6.9	191.5
rest of RM	2,595	2.1%	66%	660.7	3.9
Manitoba overall	1,342,153	1.0%		540,310	2.5

The population of De Salaberry is growing at nearly twice the provincial rate (1.9%/year vs. 1.0%/year). St Malo is not growing quite as fast as De Salaberry overall, but its rate of growth (1.6%/year) still exceeds the provincial average.

Table 232: De Salaberry – basic demographics – individuals[174]

	Individuals				
	average age	completed postsecondary	indigenous identity	immigrant	neither indigenous nor immigrant
De Salaberry overall	45.0	40%	28%	7%	65%
St Malo	43.8	43%	45%	2%	54%
Manitoba overall	39.7	50%	18%	19%	63%

The average age of people in De Salaberry is higher than the provincial average (45.0 vs. 39.7).

A higher percentage of people in De Salaberry identify as indigenous (28% vs. 18%) and in St. Malo the percentage is even higher (45% vs. 18%). Of the people who identify as indigenous, the overwhelming majority in De Salaberry identify as Metis (88%). In St. Malo, the percentage is even higher (92%); 41% of the people who live in St. Malo identify as Metis.

On the other hand, the percentage of people in De Salaberry who are immigrants is much lower than the provincial average (7% vs. 19%).

Table 233: De Salaberry – basic demographics – households

	Households	
	average size	median income
De Salaberry overall	2.8	$86,000
St Malo	2.5	$84,000
Manitoba overall	2.6	$79,500

Households in De Salaberry are slightly larger than the provincial average (2.8 people/household vs. 2.6 people/household. The median income in De Salaberry is significantly higher than the province overall ($86,000 vs. $79,500).

173 Data from 2021 Census.

174 See 2021 Census for definitions of demographic categories.

Table 234: Percentages of people employed in each industry sector in De Salaberry and St Malo, compared to Manitoba overall[175]

NAICS	*industry*	***Manitoba***	*De Salaberry*	*St Malo*
11	Agriculture, forestry, fishing & hunting	4%	**13%**	4%
21	Mining, quarrying, & oil & gas extraction	1%	1%	**0%**
22	Utilities	1%	**2%**	**3%**
23	Construction	8%	**17%**	**22%**
31-33	Manufacturing	8%	11%	10%
41	Wholesale trade	3%	3%	4%
44-45	Retail trade	11%	6%	8%
48-49	Transportation & warehousing	6%	6%	**3%**
51	Information & cultural industries	1%	1%	1%
52	Finance & insurance	4%	3%	5%
53	Real estate & rental & leasing	1%	1%	**0%**
54	Professional, scientific & technical services	5%	**1%**	**1%**
55	Management of companies & enterprises	0%	**0%**	**0%**
56	Admin. & support, waste management & remediation services	4%	**2%**	**0%**
61	Educational services	8%	8%	11%
62	Health care & social assistance	15%	10%	13%
71	Arts, entertainment & recreation	2%	1%	**0%**
72	Accommodation & food services	6%	**2%**	**2%**
81	Other services (except public administration)	4%	5%	4%
91	Public administration	7%	5%	5%
-	*classification not applicable*	2%	1%	1%

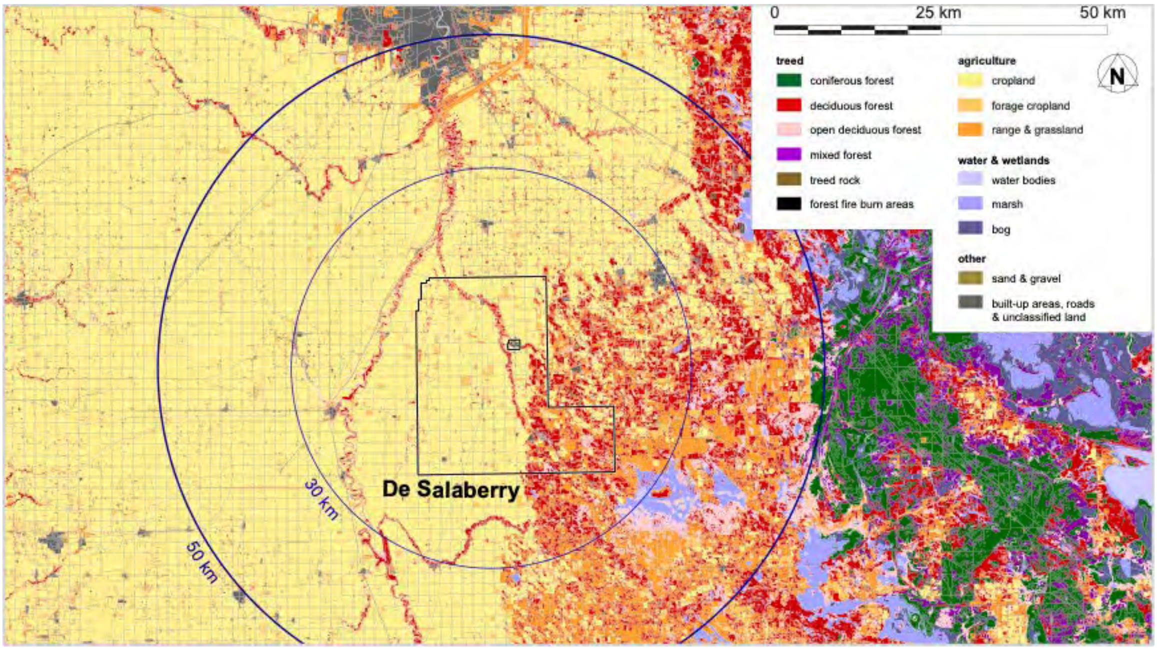
% of people employed in this industry	**15%**	more than 150% greater than provincial average
	10%	more than 120% greater than provincial average
	4%	near provincial average (80% to 120% of provincial average)
	2%	less than 80% of provincial average
	1%	less than 50% of provincial average

Sectors employing a greater percentage of people in De Salaberry compared to the province overall include agriculture and construction, with additional strengths in finance, insurance and education.

[175] Data from 2021 Census. NAICS (North American Industry Classification System) uses standard definitions of industry sector to enable comparison between jurisdictions. “Classification not applicable” defined as “unemployed persons aged 15 years and over who have never worked for pay or in self-employment, or who had last worked prior to January 1, 2020.”

3.3.2 *Environment*

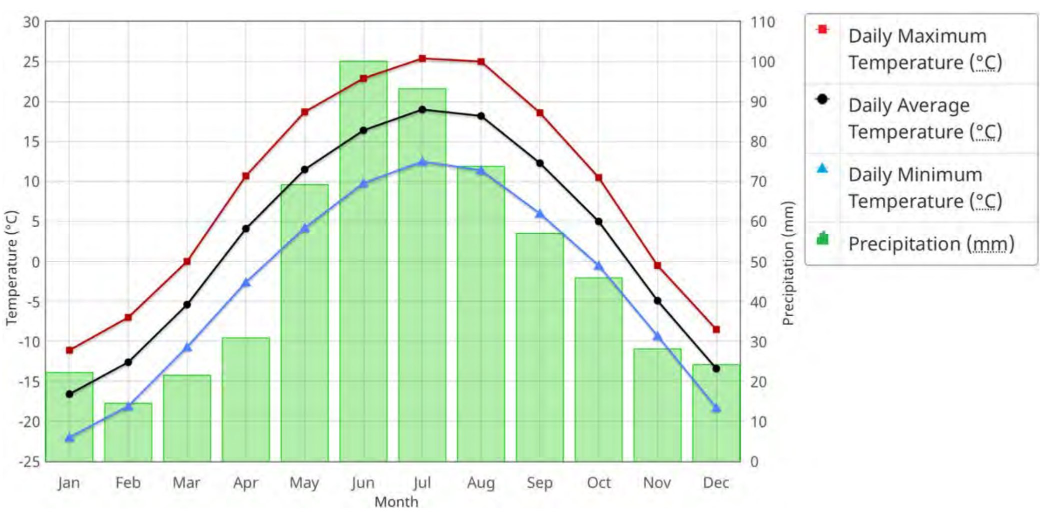
Figure 140: De Salaberry – land cover – 50 km radius



3.3.2.1 DE SALABERRY CLIMATE NORMALS

[Canadian Climate Normals](https://climate.weather.gc.ca/climate_normals/index_e.html) does not contain data for the RM of De Salaberry. The closest location is for which data is available is Steinbach, 20 km to the east.

Figure 141: Steinbach – monthly temperature & precipitation averages – 1981 to 2010[176]



[176] Graph copied from Government of Canada. (2024, March 27). *1981-2010 Climate Normals & Averages.* Environment and Natural Resources. https://climate.weather.gc.ca/climate_normals/index_e.html

3.3.2.2 DE SALABERRY CLIMATE PROJECTIONS

The following graphs[177] provide projections for how the climate of De Salaberry is projected to change. Graphs with green lines project what will happen if, globally, we make significant reductions in our CO_2 emissions. Graphs with red lines project what will happen if, globally, we continue on our current course.

Figure 142: De Salaberry – average annual daily minimum temperature – if significant progress made

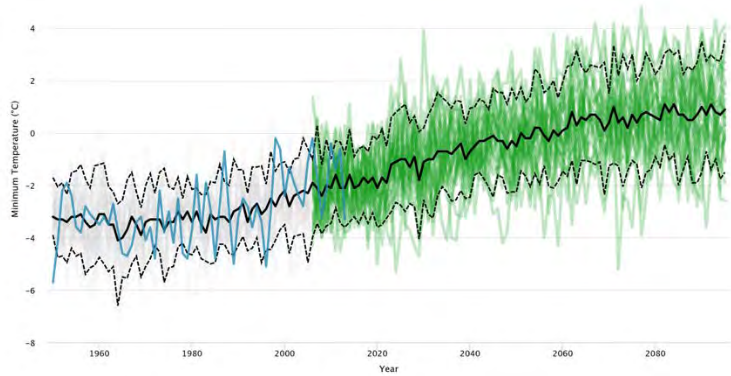


Figure 143: De Salaberry – average annual daily mean temperature – if significant progress made

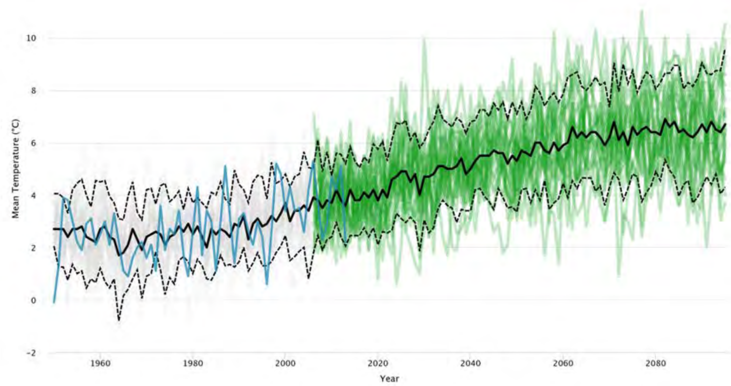
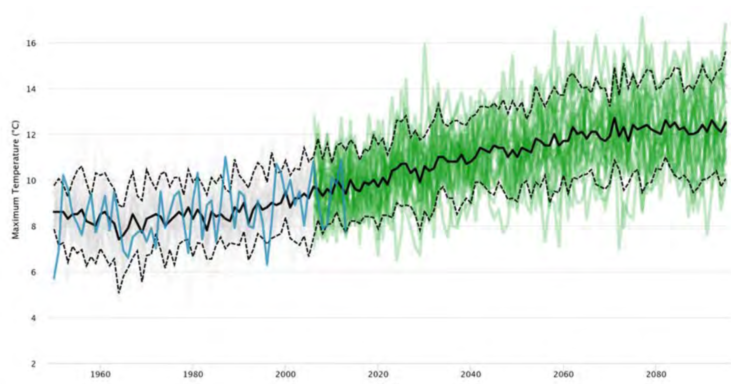


Figure 144: De Salaberry – average annual daily maximum temperature – if significant progress made



177 Source of graphs: *Climate Atlas of Canada.* (n.d.). https://climateatlas.ca/

Figure 145: De Salaberry – total annual Heating Degree Days – if significant progress made

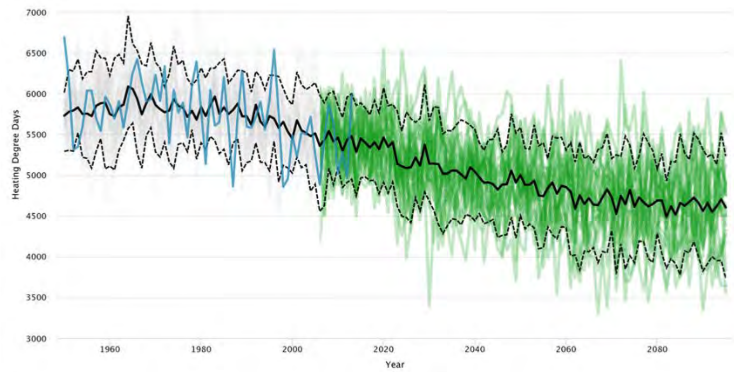


Figure 146: De Salaberry – total annual Cooling Degree Days – if significant progress made

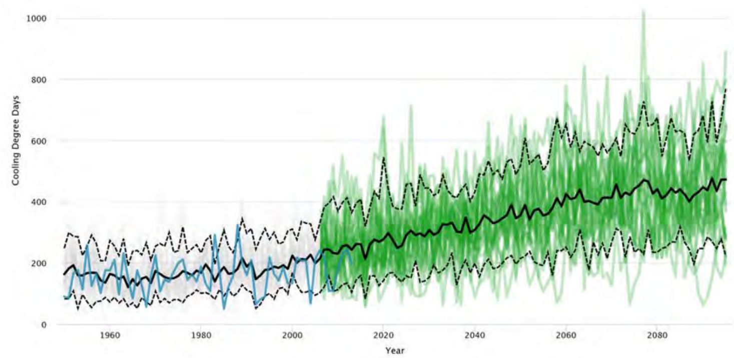


Figure 147: De Salaberry – Days below -30ºC per year – if significant progress made

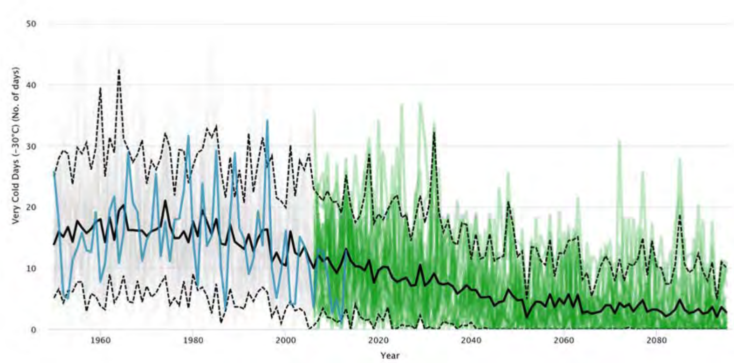


Figure 148: De Salaberry – days above +30ºC per year – if significant progress made

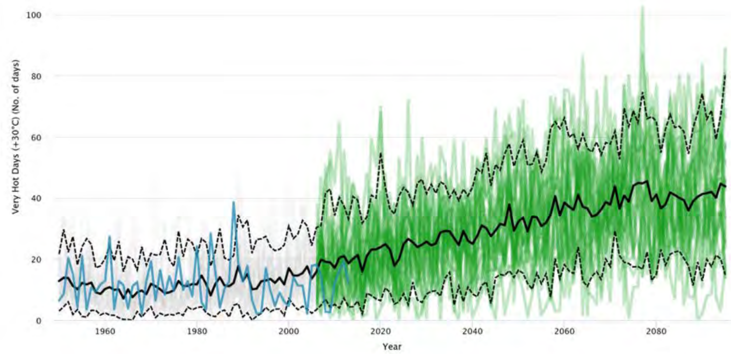


Figure 149: De Salaberry – Annual average daily minimum temperatures – If business as usual

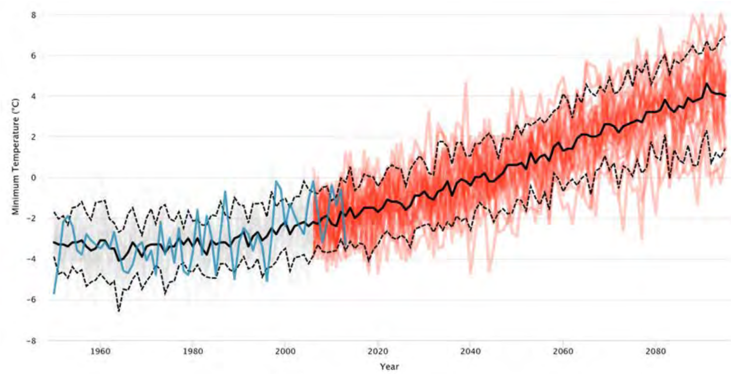


Figure 150: De Salaberry – Annual average daily mean temperatures – If business as usual

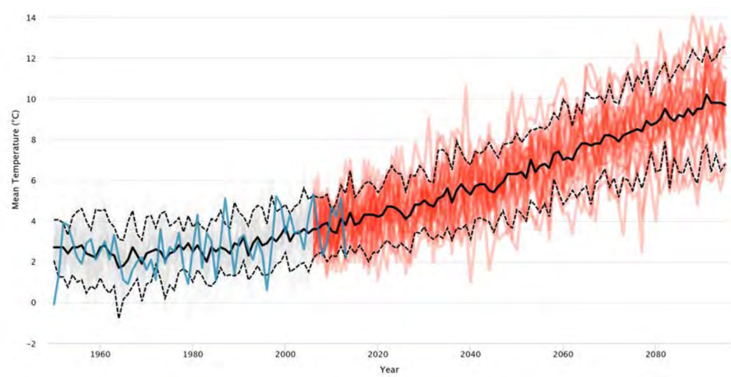


Figure 151: De Salaberry – Annual average daily maximum temperatures – If business as usual

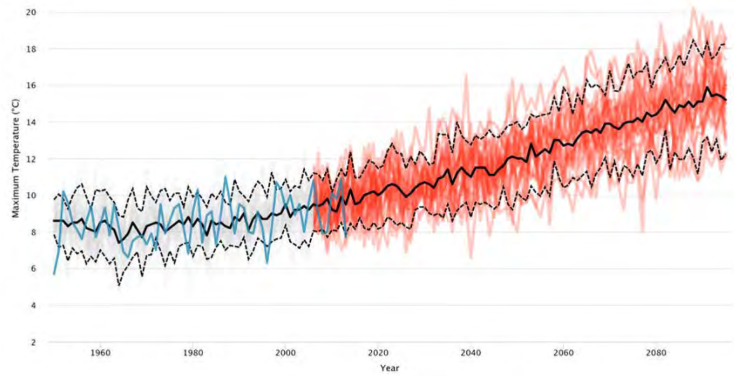


Figure 152: De Salaberry – total annual Heating Degree Days – If business as usual

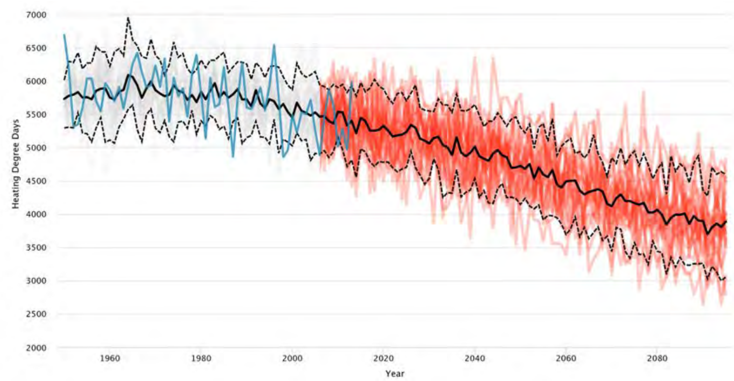


Figure 153: De Salaberry – total annual Cooling Degree Days – If business as usual

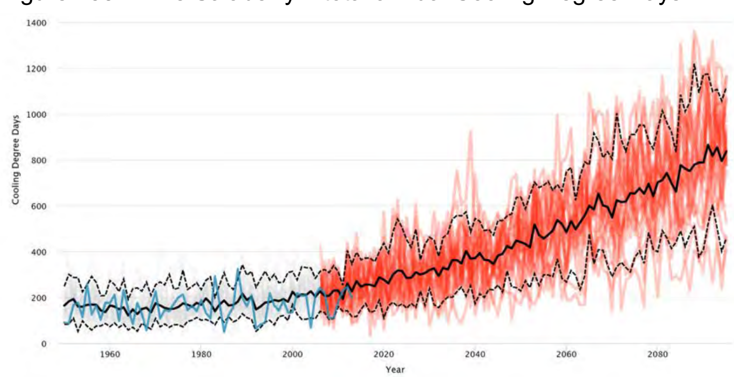


Figure 154: De Salaberry – Days below -30ºC per year – If business as usual

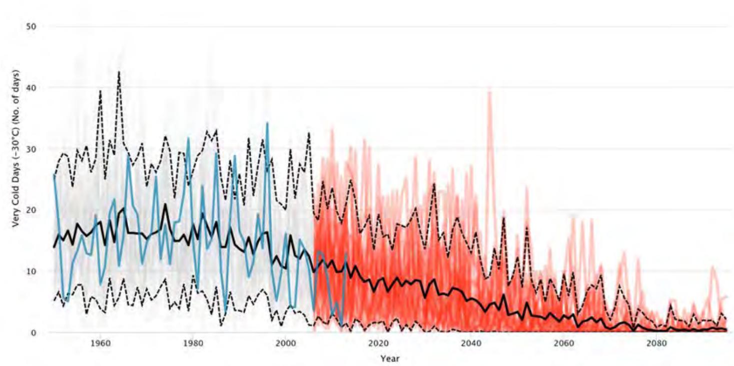
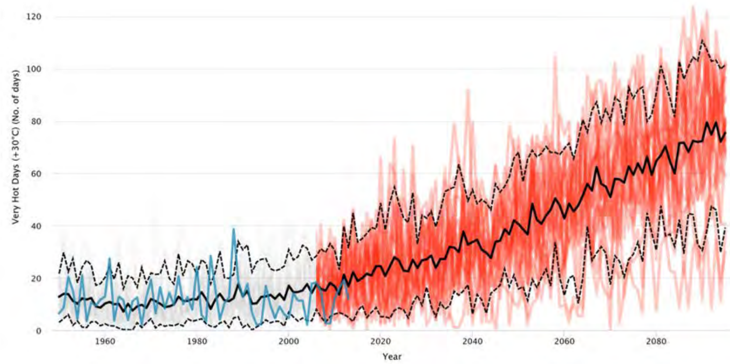


Figure 155: De Salaberry – days above +30ºC per year – If business as usual



3.3.2.3 COMBINING DE SALABERRY CLIMATE NORMALS AND CLIMATE PROJECTIONS

Table 235: De Salaberry – actual average temperatures and projected changes

	Annual Averages								
	climate normals	*projected if significant prograss made in emissions reductions*				*projected if business as usual*			
	1976-2005	*2021-2050*	*2050*	*2051-2080*	*change from 1975-*	*2021-2050*	*2050*	*2051-2080*	*change from 1975-2005*
Temperaturea									
minimum	-2.9°C	-0.8°C	-0.5°C	0.4°C	-0.5°C	-0.5°C	0.6°C	1.9°C	0.0°C
mean	2.9°C	5.0°C	5.3°C	6.1°C	5.2°C	5.2°C	6.1°C	7.6°C	0.0°C
maximum	8.7°C	10.8°C	11.0°C	11.9°C	11.0°C	11.0°C	12.0°C	13.3°C	0.0°C
Degree Days									
Heating Degree Days	5,677	5,059	4,999	4,738	-12%	5,007	4,721	4,352	-17%
Cooling Degree Days	142	316	356	410	150%	348	441	567	211%
Days Experiencing Extreme Temperatures									
Days <-30°C	15	7	5	4	-70%	6	3	2	-79%
Days >30°C	12	27	32	38	174%	30	41	52	244%

Combining the data from Canadian Climate Normals and the Climate Atlas of Canada enables us to project how each much De Salaberry's climate is likely to change in the coming years.

Crucially for this study, combining these two data sources enables us to estimate the changes in heating and cooling needs for buildings in the RM, including those targeted in this study.

De Salaberry can expect to see a modest decline in building heating needs (in the range of 12% to 17%) and a very significant increase in building cooling needs (in the range of 174% to 244%) over the next 25 years.

3.3.3 *Sustainability Initiatives to Date*

De Salaberry developed and, in 2018, passed a Development Plan.[178]

> *This Plan sets a framework for development in which both economic diversity and environmental sustainability are priorities. Reconciling these two priorities is not always easy, but that is the standard the municipality has set itself when considering development. For the recommendations in this study to be adopted, it must further both*

[178] De Salaberry. (2018). *Development Plan.* https://rmdesalaberry.mb.ca/Home/DownloadDocument?docId=668b514e-b771-4b8f-9c5a-609c27891504

> *priorities. This Plan is an update of the 2013 Development Plan and is being further updated now.*[179]

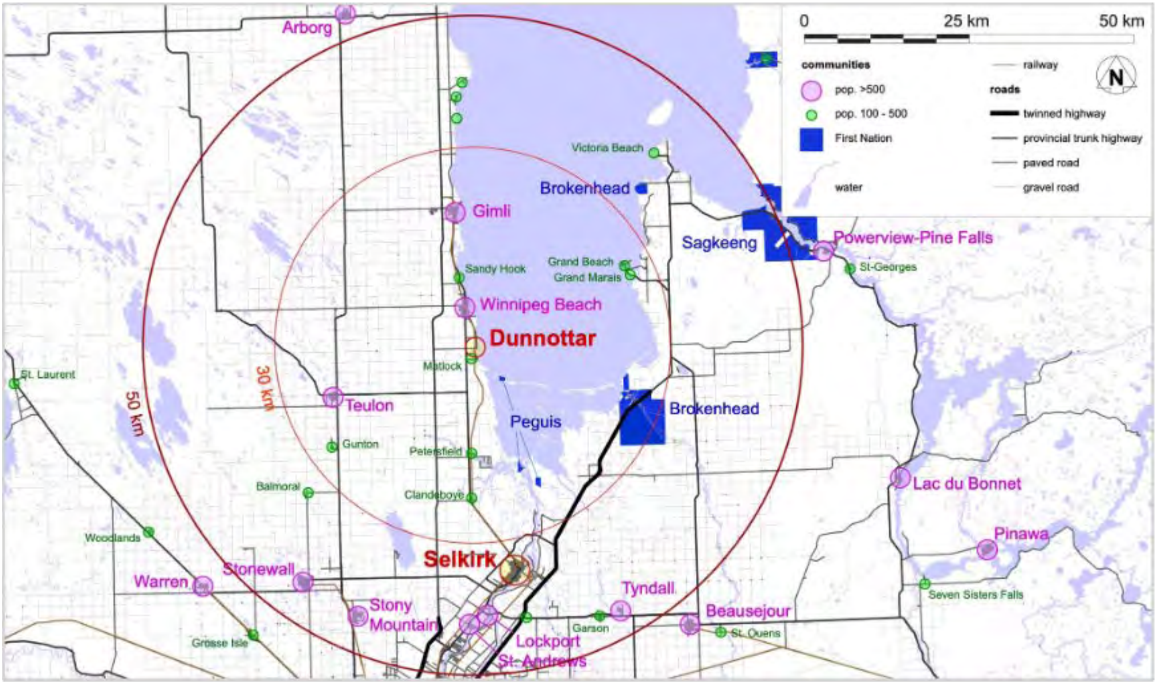
Some of the excerpts from the 2018 Plan that are directly relevant to this study include:

> *Goal 1: Create Complete and Compact Urban Centres*
>
> *Creating compact, complete communities and managing growth to protect environmental quality and preserve agricultural lands have been identified as priorities to guide growth and development in the RM.*
>
> *Goal 2: Promote Sustainable Agricultural Practices and Protect Related Land Use*
>
> *Agricultural and natural environments are important assets that contribute to the quality of life, economic resilience, and sense of place within the RM of De Salaberry….Given that more than half of De Salaberry's land area is devoted to agricultural uses, this Development Plan contains policies promoting sustainable agricultural land use and development, including sustainable livestock development and practices, to protect agricultural and natural assets.*
>
> *Goal 7: Encourage Resilient and Diverse Economic Growth*
>
> *…Economic development goes hand in hand with availability of services, vibrant residential and commercial sectors, recreational opportunities, and environmental protection….*
>
> *Goal 8: Plan for Resiliency in a Changing Climate*
>
> *Climate Change has been identified as a major issue facing municipalities in Manitoba. Anticipated impacts in southern Manitoba include warmer, drier summers accompanied by increased precipitation in the winter and spring. These factors are particularly relevant to the RM of De Salaberry which partially falls within the Red River Valley Designated Flood Area and contains substantial crop land. The RM has therefore identified climate change as a concern, adopting a Local Climate Action Plan in 2009 and joining the Federation of Canadian Municipalities' Partners for Climate Protection (PCP). The RM of De Salaberry has taken steps to address Greenhouse Gas emissions and set milestones for measuring and monitoring as part of their Aspects of PCP membership. Aspects of Planning Goals 1-7 from this Development Plan will work towards achieving a higher level of climate resiliency and many of the policies throughout this Plan will work towards achieving these goals.*

[179] De Salaberry Development Plan and Zoning By-Law Review. (2023, July 5). *MERX*. https://www.merx.com/mbgov/rmofdesalaberry/solicitations/07-2023-Development-Plan-and-Zoning-By-Law-Review/0000251356?purchasingGroupId=699163402&origin=2

3.4 Dunnottar

Figure 156: Dunnottar – 50 km radius



3.4.1 *Population & Economy*[180]

Table 236: Dunnottar – population & density

	Population		Land Area	Density
	2021 census	annual change	km^2	pop/km^2
Village of Dunnottar	989	1.2%	2.8	353
Manitoba overall	1,342,153	1.0%	540,310	2.5

Table 237: Dunnottar – basic demographics – individuals[181]

	Individuals				
	average age	completed postsecondary	indigenous identity	immigrant	neither indigenous nor immigrant
Village of Dunnottar	52.1	50%	18%	3%	80%
Manitoba overall	39.7	50%	18%	19%	63%

The average age in Dunnottar is significantly older than the provincial average (52.1 vs. 39.7), while the average educational attainment matches the provincial average.

The percentage of people in Dunnottar who identify as indigenous also matches the provincial average (18%). Of resident of Dunnottar who identify as indigenous, 40% identify as First Nations and 60% identify as Metis.

[180] Data from 2021 Census.

[181] See 2021 Census for definitions of demographic categories.

Table 238: Dunnottar – basic demographics – households

	Households	
	average size	*median income*
Village of Dunnottar	2.0	$72,000
Manitoba overall	2.6	$79,500

The average household size in Dunnottar is significantly lower than the provincial average (2.0 vs. 2.6 people/household). The median household income is slightly lower than the provincial average.

Table 239: Percentages of people employed in each industry sector in Dunnottar, compared to Manitoba overall[182]

NAICS	*industry*	***Manitoba***	*Dunnottar*
11	Agriculture, forestry, fishing & hunting	4%	5%
21	Mining, quarrying, & oil & gas extraction	1%	**0%**
22	Utilities	1%	**0%**
23	Construction	8%	9%
31-33	Manufacturing	8%	**4%**
41	Wholesale trade	3%	**0%**
44-45	Retail trade	11%	11%
48-49	Transportation & warehousing	6%	**10%**
51	Information & cultural industries	1%	**0%**
52	Finance & insurance	4%	2%

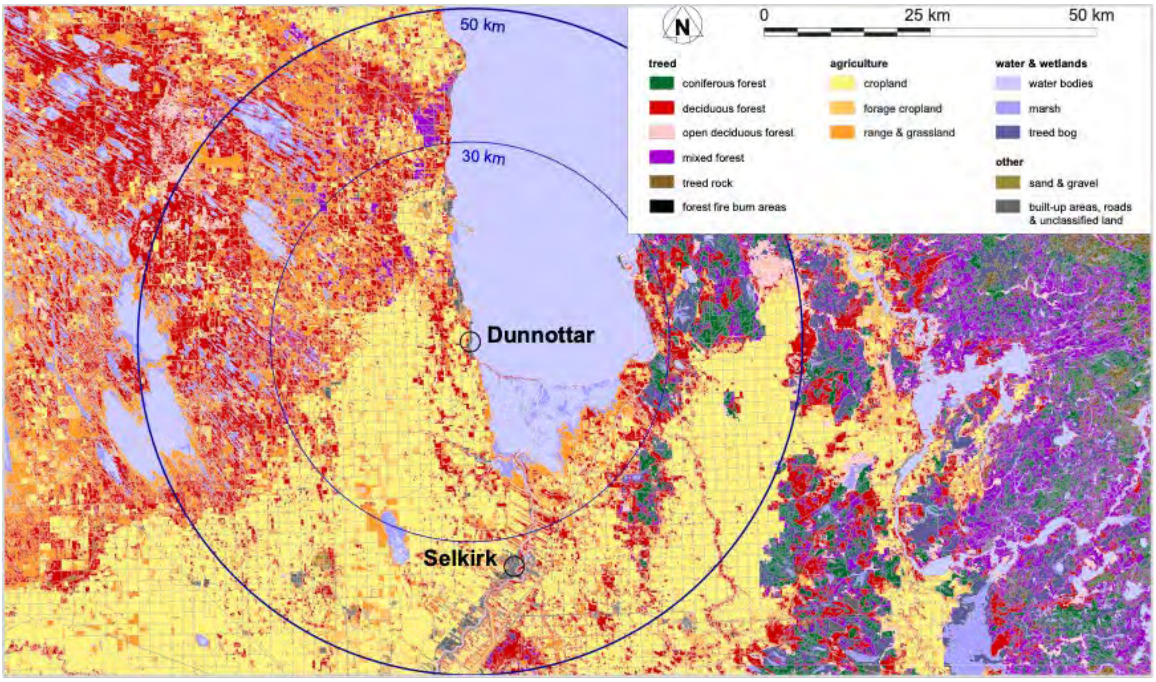
NAICS	*industry*	***Manitoba***	*Dunnottar*
53	Real estate & rental & leasing	1%	**4%**
54	Professional, scientific & technical services	5%	**0%**
55	Management of companies & enterprises	0%	**0%**
56	Admin. & support, waste management & remediation	4%	5%
61	Educational services	8%	11%
62	Health care & social assistance	15%	15%
71	Arts, entertainment & recreation	2%	**0%**
72	Accommodation & food services	6%	**2%**
81	Other services (except public administration)	4%	4%
91	Public administration	7%	10%
-	*classification not applicable*	2%	**7%**

% of people employed in this industry		
	15%	more than 150% greater than provincial average
	10%	more than 120% greater than provincial average
	4%	near provincial average (80% to 120% of provincial average)
	2%	less than 80% of provincial average
	1%	less than 50% of provincial average

[182] Data from 2021 Census. NAICS (North American Industry Classification System) uses standard definitions of industry sector to enable comparison between jurisdictions. "Classification not applicable" defined as "unemployed persons aged 15 years and over who have never worked for pay or in self-employment, or who had last worked prior to January 1, 2020."

3.4.2 *Environment*

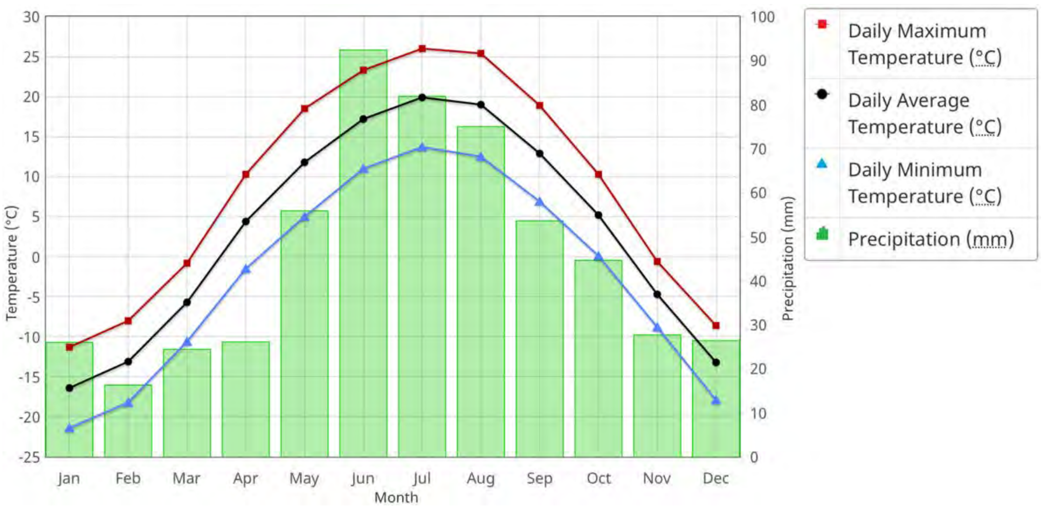
Figure 157: Dunnottar – land cover – 50 km radius



3.4.2.1 DUNNOTTAR CLIMATE NORMALS

Canadian Climate Normals does not contain data for Dunnottar. The closest location is for which data is available is Stony Mountain, 50 km to the southwest. Given the distance between Dunnottar and Stony Mountain, and the likely effects of Lake Winnipeg on Dunnottar's climate, this data is likely to be less representative of Dunnottar than the data for other participating communities is for them.

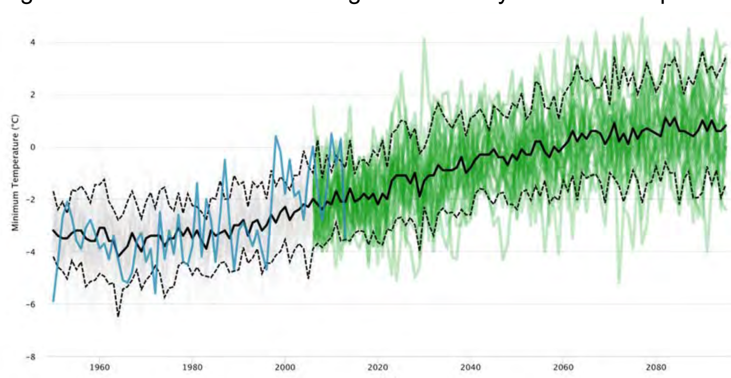
Figure 158: Stony Mountain – monthly temperature & precipitation averages – 1981 to 2010[183]



3.4.2.2 DUNNOTTAR CLIMATE PROJECTIONS

The following graphs[184] provide projections for how the climate of Dunnottar is projected to change. Graphs with green lines project what will happen if, globally, we make significant reductions in our CO_2 emissions. Graphs with red lines project what will happen if, globally, we continue on our current course.

Figure 159: Dunnottar – average annual daily minimum temperature – if significant progress made



[183] Graph copied from Government of Canada. (2024, March 27). *1981-2010 Climate Normals & Averages.* Environment and Natural Resources. https://climate.weather.gc.ca/climate_normals/index_e.html

[184] Source of graphs: *Climate Atlas of Canada.* (n.d.). https://climateatlas.ca/

Figure 160: Dunnottar – average annual daily mean temperature – if significant progress made

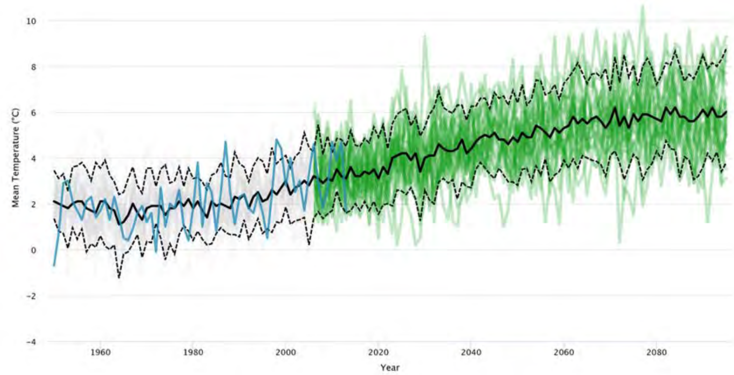


Figure 161: Dunnottar – average annual daily maximum temperature – if significant progress made

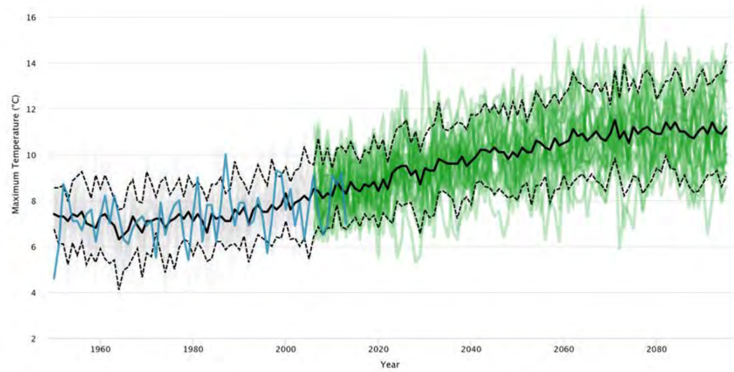


Figure 162: Dunnottar – total annual Heating Degree Days – if significant progress made

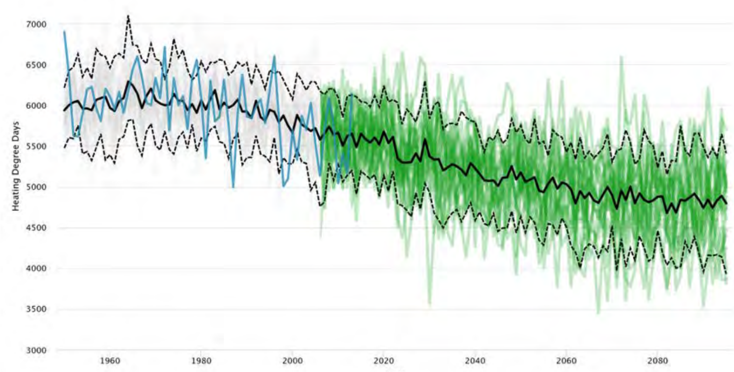


Figure 163: Dunnottar – total annual Cooling Degree Days – if significant progress made

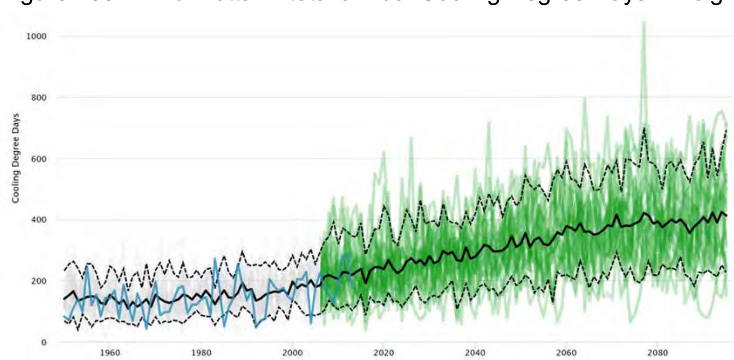


Figure 164: Dunnottar – Days below -30ºC per year – if significant progress made

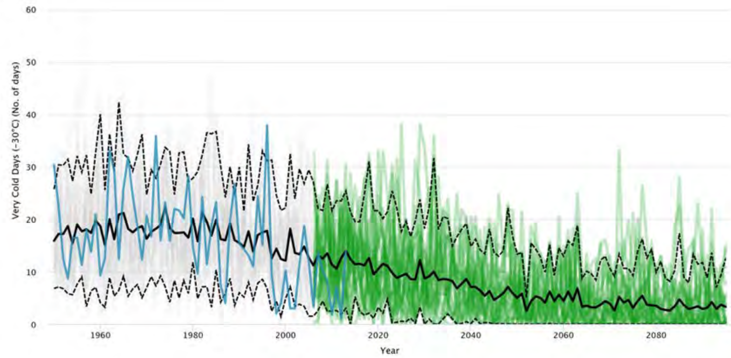


Figure 165: Dunnottar – days above +30ºC per year – if significant progress made

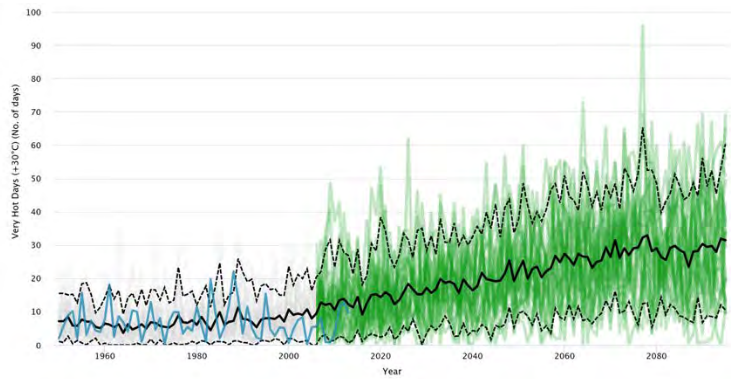


Figure 166: Dunnottar – Annual average daily minimum temperatures – If business as usual

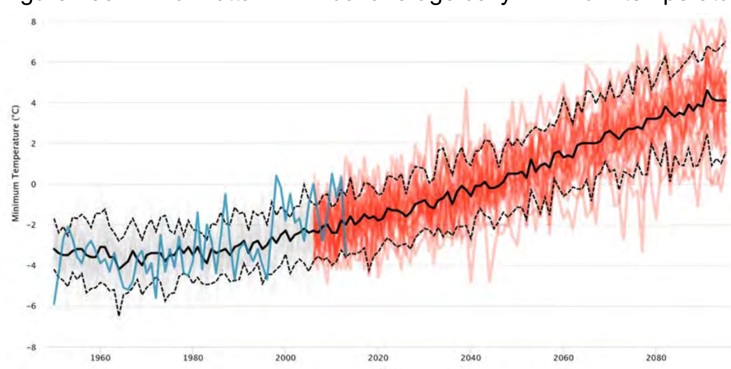


Figure 167: Dunnottar – Annual average daily mean temperatures – If business as usual

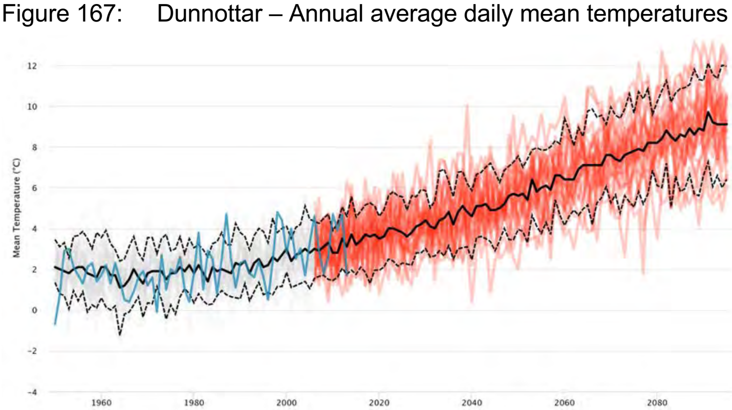


Figure 168: Dunnottar – Annual average daily maximum temperatures – If business as usual

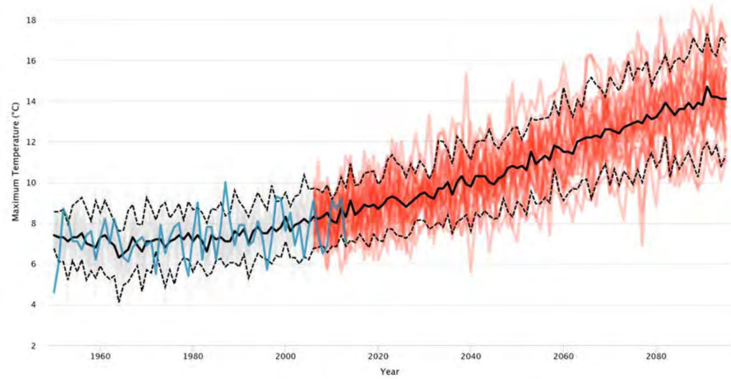


Figure 169: Dunnottar – total annual Heating Degree Days – If business as usual

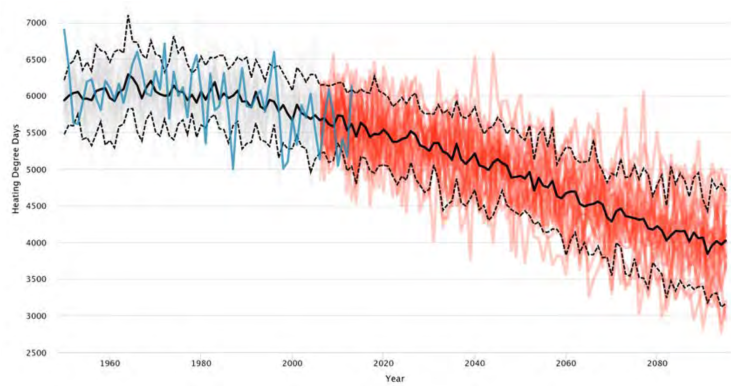


Figure 170: Dunnottar – total annual Cooling Degree Days – If business as usual

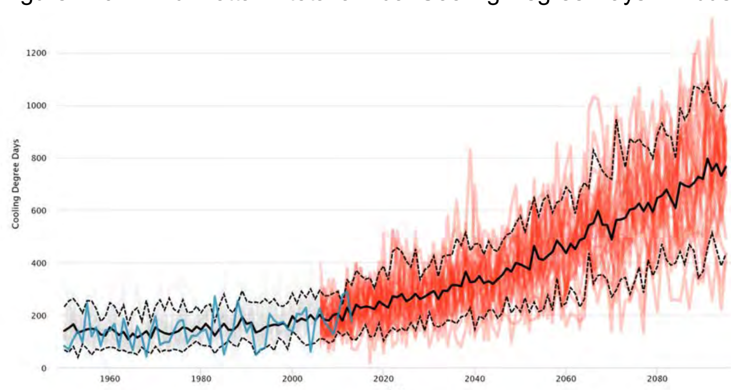


Figure 171: Dunnottar – days below -30ºC per year – If business as usual

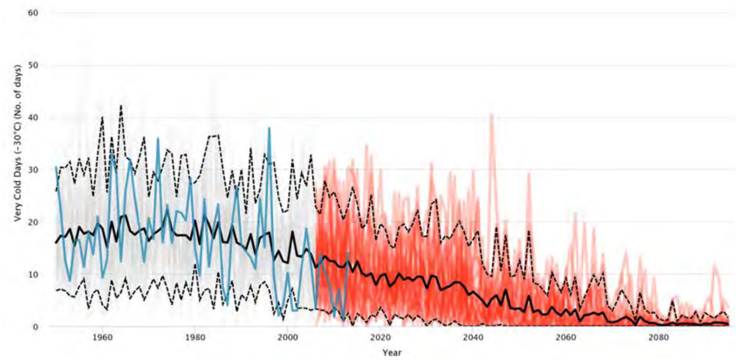
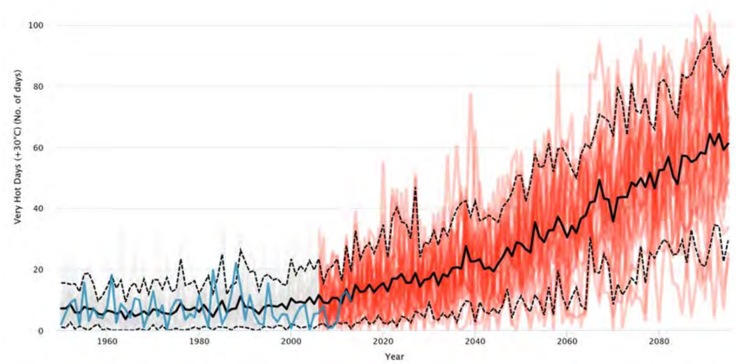


Figure 172: Dunnottar – days above +30ºC per year – If business as usual



3.4.2.3 COMBINING DUNNOTTAR CLIMATE NORMALS AND CLIMATE PROJECTIONS

Table 240: Dunnottar – actual average temperatures and projected changes

	Annual Averages								
	climate normals	*projected if significant prograss made in emissions reductions*				*projected if business as usual*			
	1976-2005	*2021-2050*	*2050*	*2051-2080*	*change from 1975-*	*2021-2050*	*2050*	*2051-2080*	*change from 1975-2005*
Temperaturea									
minimum	-3.0°C	-0.9°C	-0.5°C	0.3°C	-0.6°C	-0.6°C	0.5°C	1.9°C	0.0°C
mean	2.2°C	4.4°C	4.7°C	5.5°C	4.6°C	4.6°C	5.6°C	7.0°C	0.0°C
maximum	7.5°C	9.6°C	9.9°C	10.7°C	9.7°C	9.7°C	10.7°C	12.1°C	0.0°C
Degree Days									
Heating Degree Days	5,878	5,255	5,174	4,928	-12%	5,204	4,905	4,530	-17%
Cooling Degree Days	137	281	320	367	134%	310	393	515	187%
Days Experiencing Extreme Temperatures									
Days <-30°C	15	8	5	4	-67%	7	3	2	-78%
Days >30°C	7	18	22	26	215%	20	28	39	298%

Combining the data from Canadian Climate Normals and the Climate Atlas of Canada enables us to project how each much Dunnottar's climate is likely to change in the coming years.

Crucially for this study, combining these two data sources enables us to estimate the changes in heating and cooling needs for buildings in Dunnottar, including those targeted in this study.

Dunnottar can expect to see a modest decline in building heating needs (in the range of 12% to 17%) and a very significant increase in building cooling needs (in the range of 215% to 298%) over the next 25 years.

3.4.3 *Sustainability Initiatives to Date*

Dunnottar has already taken a series of steps to become more sustainable. To date, these steps include:

- 2016 Acting Today to Change Tomorrow: Climate Change Local Action Plan, developed in partnership with Eco185
- 2018 Integrated Community Sustainability Plan186
- 2017 Innovative passive filtration system for wastewater[187]
- Installation of vehicle charging stations
- A solar array at the Village's municipal office

[185] Village of Dunnottar. (2016). *Acting Today to Change Tomorrow: Climate Change Local Action Plan.* Files and Documents. https://www.dunnottar.ca/p/files-and-documents

[186] Village of Dunnottar. (2018). *Integrated Community Sustainability Plan.* Files and Documents. https://www.dunnottar.ca/p/files-and-documents

[187] Stevenson, L. (2017, March 1). *Commitment to a cleaner lake and greener living earns community recognition.* Manitoba Co-operator. https://www.manitobacooperator.ca/country-crossroads/manitoba-community-has-clear-commitment-to-a-cleaner-lake-winnipeg/

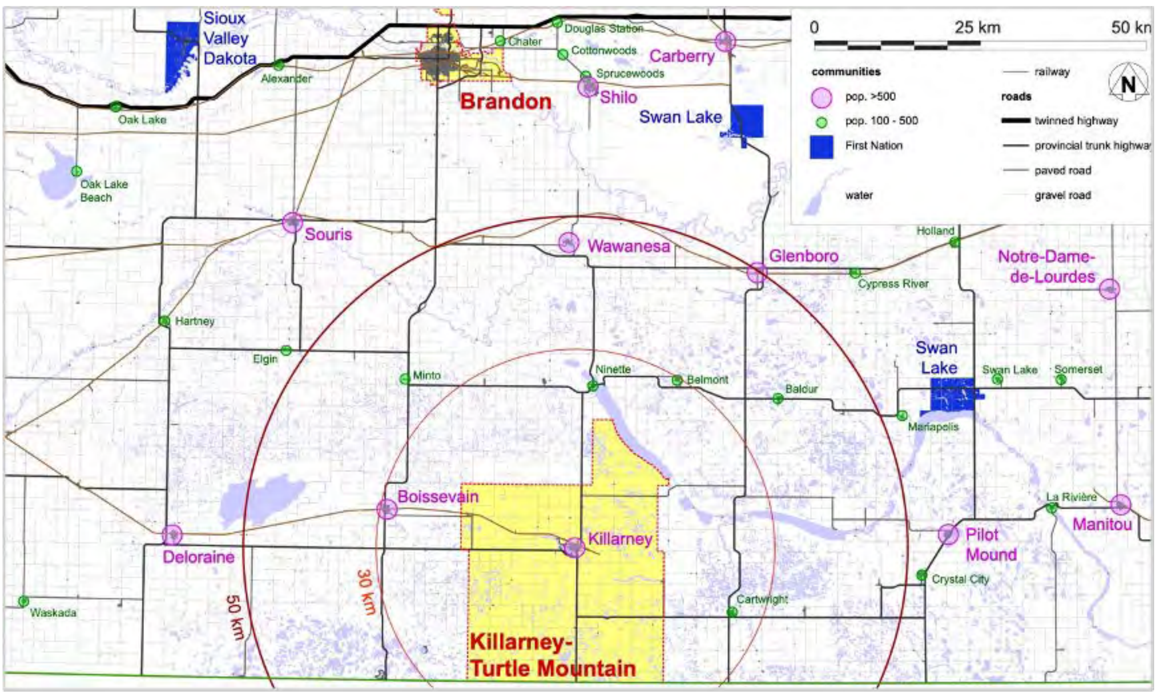
3.5 Killarney Turtle Mountain

The Rural Municipality of Killarney Turtle Mountain lies in south-west Manitoba. Brandon is approximately 50 km north of the RM's northern boundary. The US state of North Dakota is directly below the RM's southern boundary. Saskatchewan is 90 km to the west; Winnipeg is just over 150 km to the east.

Killarney's 2022 Visitor and Relocation Guide paints an attractive—and accurate—picture of the community:

> *Nestled along the shores of beautiful Killarney Lake, the prairie oasis of Killarney offers ample opportunity to relax and enjoy the amenities. known for its traditional links style 18-hole golf course, complete with lush green fairways that border the lake. Winter recreation abounds with scenic snowmobile and cross-country ski trails and the Shamrock Centre recreation complex.*[188]

Figure 173: Killarney Turtle Mountain – 50 km radius



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[188] Killarney. (2022). *Visitor and Relocation Guide*. http://killarneyguide.ca/wp-content/uploads/2022/04/Visitor-Guide-2022-web-120-dpi.pdf

3.5.1 *Population & Economy*[189]

Table 241: RM of Killarney Turtle Mountain – population & density

	Population			Land Area	Density
	2021 census	annual change	% of RM	km^2	pop/km^2
RM overall	3,520	0.5%		930	3.8
community of Killarney	2,490	1.0%	71%	5.11	487
rest of RM	1,030	-0.6%	29%	925	1.1
Manitoba overall	1,342,153	1.0%		540,310	2.5

The RM's population is located primarily in the unincorporated community of Killarney.

The population of the RM is growing at about half the rate of Manitoba overall (0.5%/year vs. 1.0%/year. The community of Killarney has grown at the same as that of the province overall, while the population in the rest of the RM has shrunk slightly (-0.6%/year, which is a decline of 33 people over 5 years).

Table 242: RM of Killarney Turtle Mountain – basic demographics – individuals[190]

	Individuals				
	average age	completed postsecondary	indigenous identity	immigrant	neither indigenous nor immigrant
RM overall	45.0	44%	6%	7%	87%
community of Killarney	45.5	42%	8%	8%	84%
rest of RM	*data not available*		2%	4%	94%
Manitoba overall	39.7	50%	18%	19%	63%

Killarney Turtle Mountain has much lower proportions of people who identify as indigenous and who are immigrants than the provincial averages.

Table 243: RM of Killarney Turtle Mountain – basic demographics – households

	Households	
	average size	median income
RM overall	2.3	$72,000
community of Killarney	2.2	$66,000
rest of RM	*data not available*	
Manitoba overall	2.6	$79,500

The average household size in the RM overall—and in the community of Killarney specifically—is lower than the provincial average. The median household income is slightly lower in the RM overall, and significantly lower within the community of Killarney.

189 Data from 2021 Census.

190 See 2021 Census for definitions of demographic categories.

Table 244: Percentages of people employed in each industry sector in the RM of Killarney Turtle Mountain and in the dissolved municipality of Killarney, compared to Manitoba overall[191]

NAICS	*industry*	*Manitoba*	*RM of Killarney-Turtle Mountain*	*Killarney (dissolved municipality)*
11	Agriculture, forestry, fishing & hunting	4%	**21%**	**15%**
21	Mining, quarrying, & oil & gas extraction	1%	**2%**	**1%**
22	Utilities	1%	**2%**	1%
23	Construction	8%	6%	6%
31-33	Manufacturing	8%	6%	6%
41	Wholesale trade	3%	**5%**	**5%**
44-45	Retail trade	11%	12%	16%
48-49	Transportation & warehousing	6%	5%	4%
51	Information & cultural industries	1%	**1%**	1%
52	Finance & insurance	4%	4%	5%
53	Real estate & rental & leasing	1%	**0%**	**0%**
54	Professional, scientific & technical services	5%	**2%**	**2%**
55	Management of companies & enterprises	0%	**0%**	**0%**
56	Admin. & support, waste management & remediation services	4%	2%	3%
61	Educational services	8%	6%	5%
62	Health care & social assistance	15%	12%	11%
71	Arts, entertainment & recreation	2%	**1%**	1%
72	Accommodation & food services	6%	6%	7%
81	Other services (except public administration)	4%	4%	5%
91	Public administration	7%	4%	4%
-	*classification not applicable*	*2%*	3%	3%

% of people employed in this industry		
	10%	more than 150% greater than provincial average
	4%	more than 120% greater than provincial average
	2%	near provincial average (80% to 120% of provincial average)
	1%	less than 80% of provincial average
	0%	less than 50% of provincial average

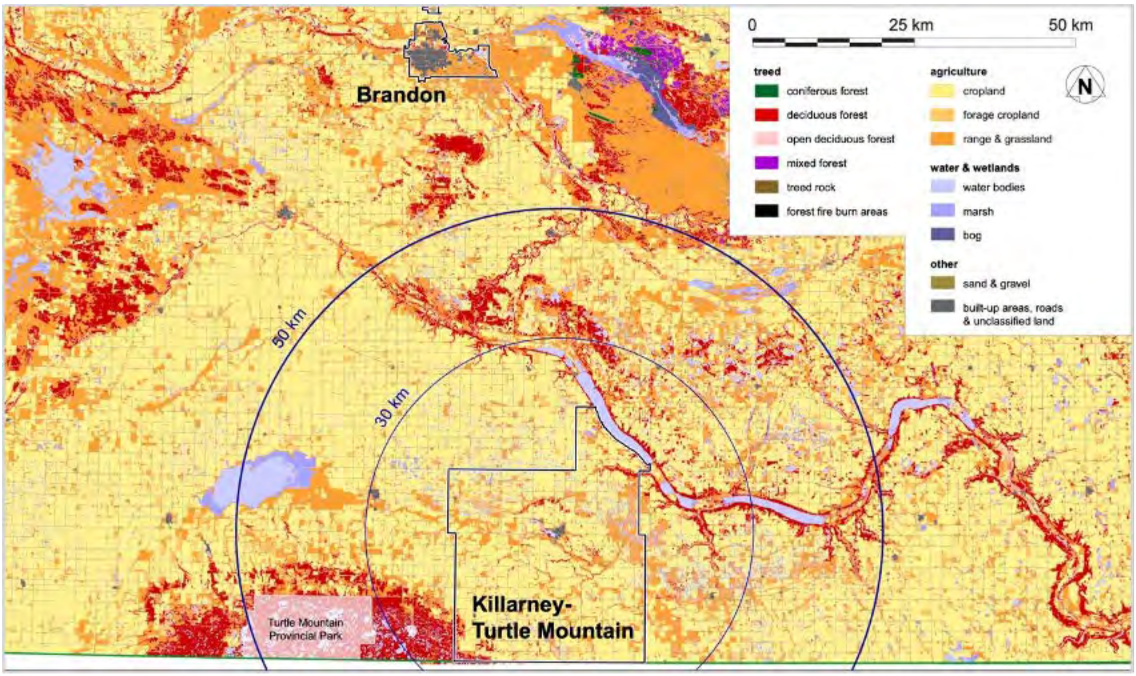
[191] Data from 2021 Census. Notes on terminology in this table:

- NAICS (North American Industry Classification System) uses standard definitions of industry sectors to enable comparison between jurisdictions.
- “Classification not applicable” is defined as “unemployed persons aged 15 years and over who have never worked for pay or in self-employment, or who had last worked prior to January 1, 2020.”
- “Killarney (dissolved municipality)” refers to the town of Killarney. Formerly, the Town of Killarney was an incorporated municipality, distinct from the Rural Municipality of Turtle Mountain. The Town and the RM amalgamated in 2007, but Statistics Canada still distinguishes the town from the RM overall in its data. Placing the town and overall RM data side-by-side shows how they are similar and how they differ.

3.5.2 *Environment*

Virtually all the land in the Killarney Turtle Mountain RM is agricultural, and is a mixture of cropland, forage cropland, and range & grassland.

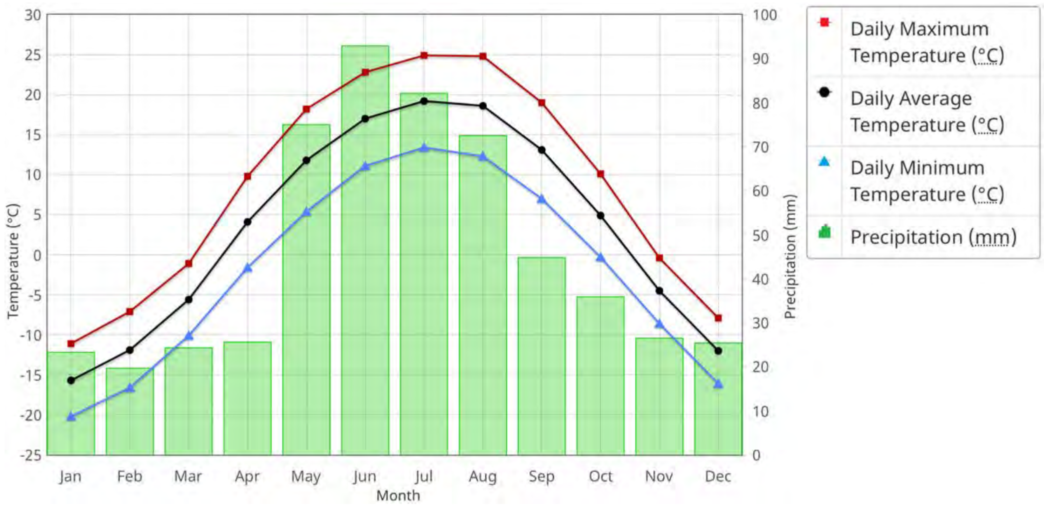
Figure 174: RM of Killarney Turtle Mountain – land cover – 50 km radius



3.5.2.1 KILLARNEY TURTLE MOUNTAIN CLIMATE NORMALS

Canadian Climate Normals does not contain data for the RM of Killarney Turtle Mountain. The closest location is for which data is available is Pilot Mound, 45 km to the east.

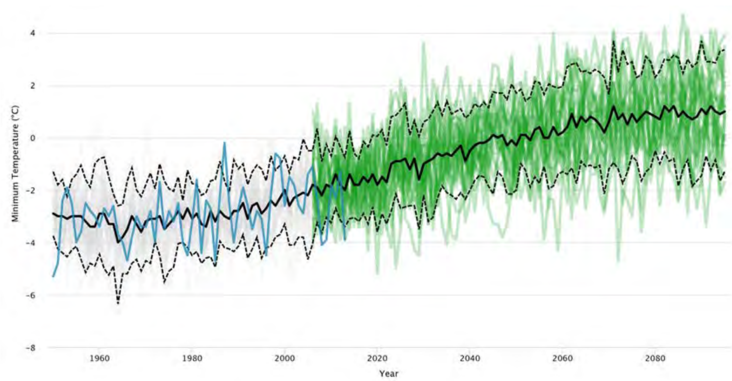
Figure 175: Pilot Mound – monthly temperature & precipitation averages – 1981 to 2010[192]



3.5.2.2 KILLARNEY TURTLE MOUNTAIN CLIMATE PROJECTIONS

The following graphs[193] provide projections for how the climate of Killarney Turtle Mountain is projected to change. Graphs with green lines project what will happen if, globally, we make significant reductions in our CO_2 emissions. Graphs with red lines project what will happen if, globally, we continue on our current course.

Figure 176: Killarney Turtle Mountain – average annual daily minimum temperature – if significant progress made



[192] Graph copied from:

- Government of Canada. (2024, March 27). *1981-2010 Climate Normals & Averages.* Environment and Natural Resources. https://climate.weather.gc.ca/climate_normals/index_e.html

[193] Source of graphs: *Climate Atlas of Canada.* (n.d.). https://climateatlas.ca/

Figure 177: Killarney Turtle Mountain – average annual daily mean temperature – if significant progress made

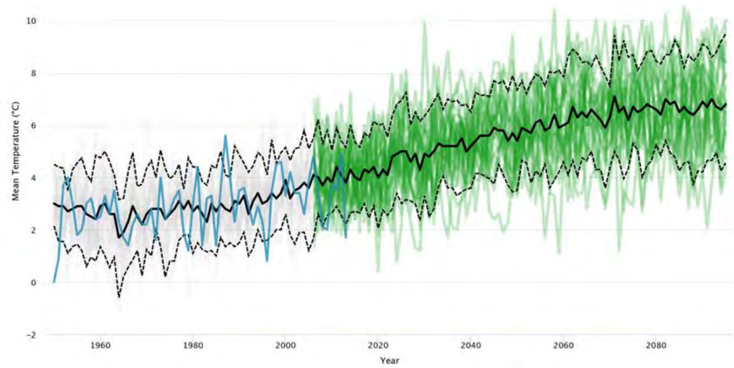


Figure 178: Killarney Turtle Mountain – average annual daily maximum temperature – if significant progress made

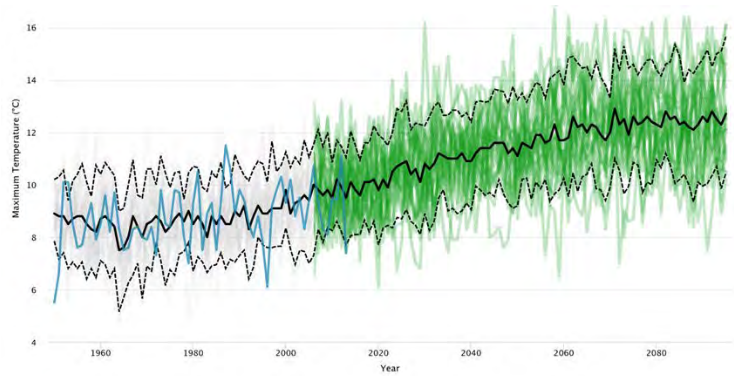


Figure 179: Killarney Turtle Mountain – total annual Heating Degree Days – if significant progress made

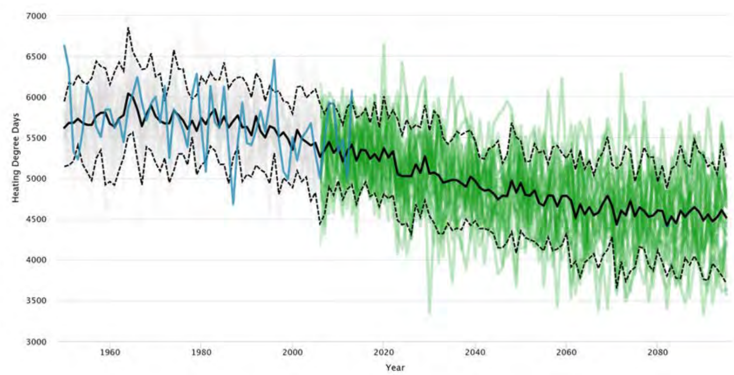


Figure 180: Killarney Turtle Mountain – total annual Cooling Degree Days – if significant progress made

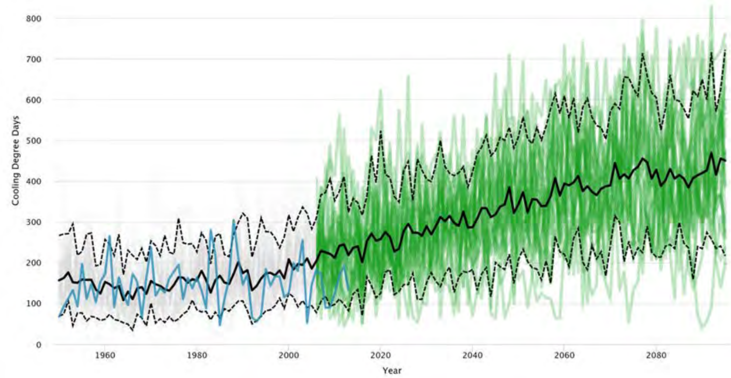


Figure 181: Killarney Turtle Mountain – days below -30ºC per year – if significant progress made

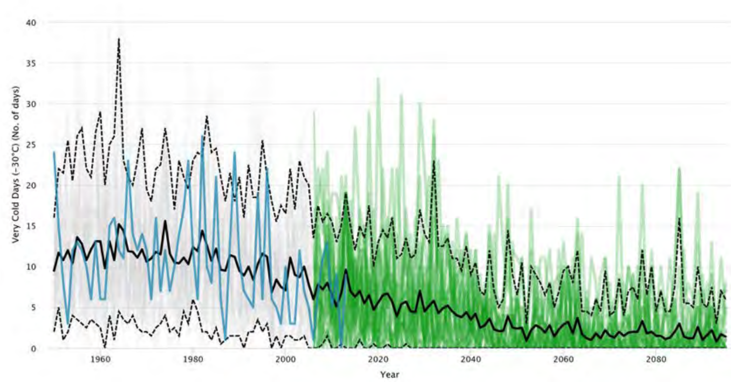


Figure 182: Killarney Turtle Mountain – days above +30ºC per year – if significant progress made

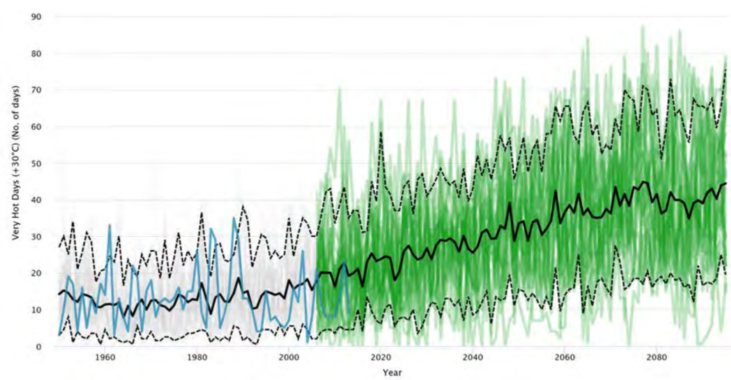


Figure 183: Killarney Turtle Mountain – annual average daily minimum temperatures – If business as usual

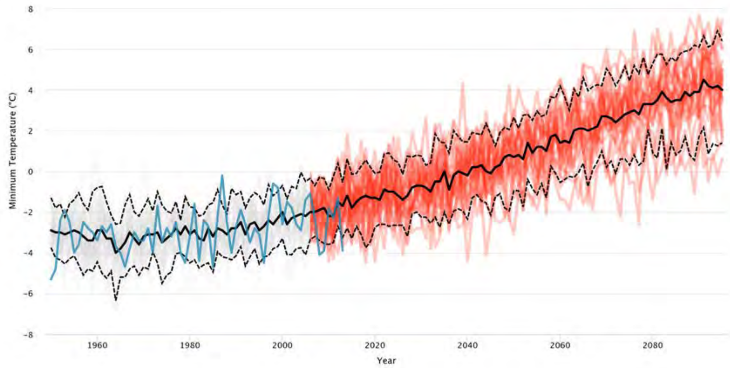


Figure 184: Killarney Turtle Mountain – annual average daily mean temperatures – If business as usual

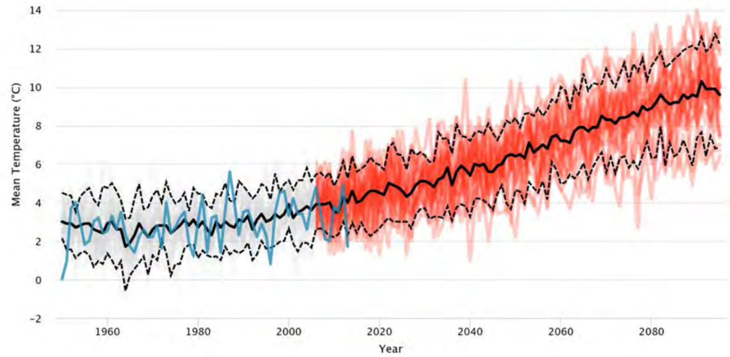


Figure 185: Killarney Turtle Mountain – annual average daily maximum temperatures – If business as usual

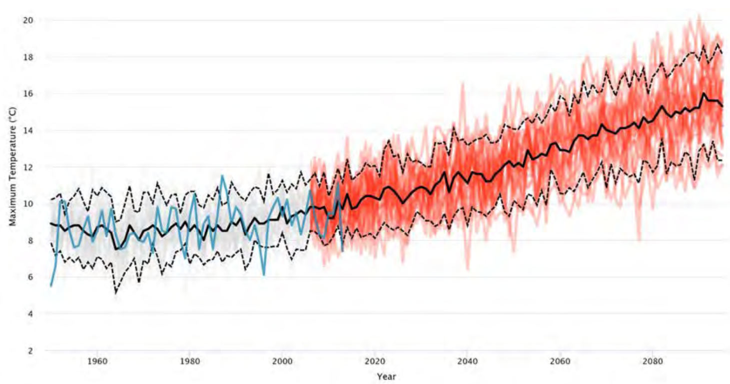


Figure 186: Killarney Turtle Mountain – total annual Heating Degree Days – If business as usual

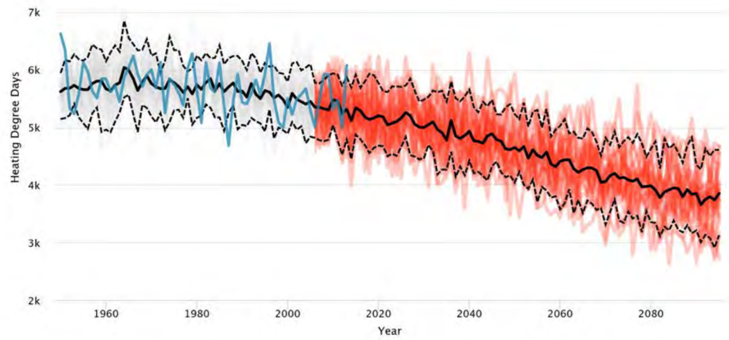


Figure 187: Killarney Turtle Mountain – total annual Cooling Degree Days – If business as usual

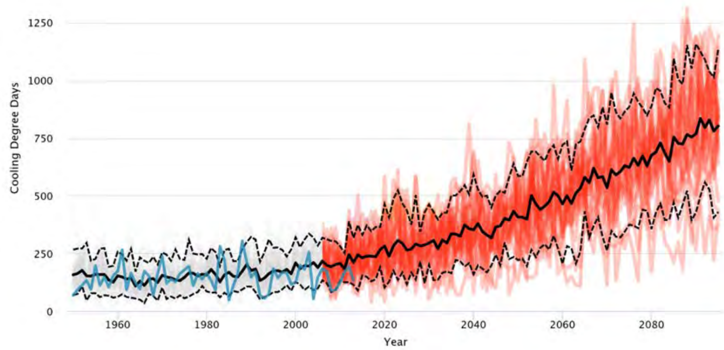


Figure 188: Killarney Turtle Mountain – days below -30ºC per year – If business as usual

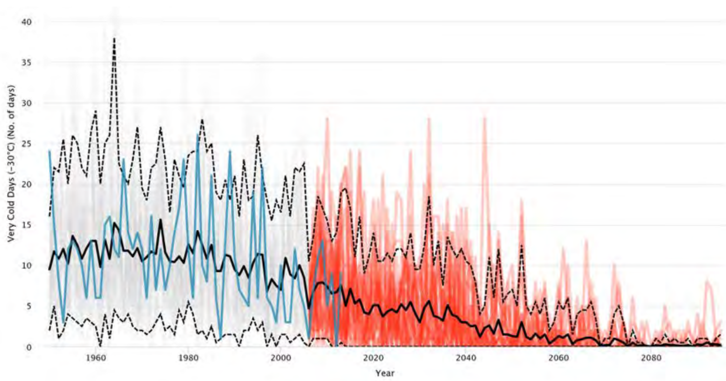
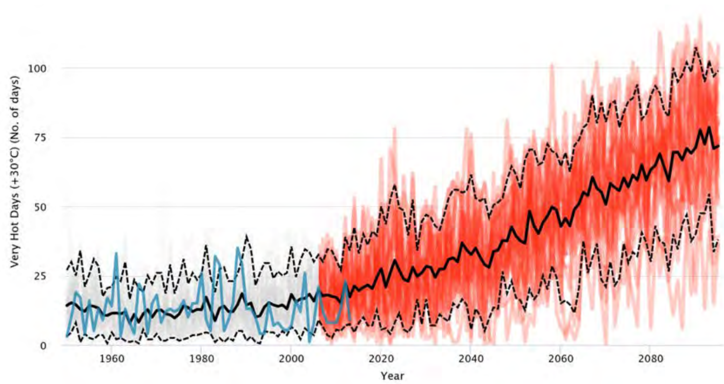


Figure 189: Killarney Turtle Mountain – days above +30ºC per year – If business as usual



3.5.2.3 COMBINING KILLARNEY TURTLE MOUNTAIN CLIMATE NORMALS AND CLIMATE PROJECTIONS

Table 245: Killarney Turtle Mountain – actual average temperatures and projected changes

	Annual Averages								
	climate normals	*projected if significant prograss made in emissions reductions*				*projected if business as usual*			
	1976-2005	*2021-2050*	*2050*	*2051-2080*	*change from 1975-*	*2021-2050*	*2050*	*2051-2080*	*change from 1975-2005*
Temperaturea									
minimum	-2.8°C	-0.7°C	-0.3°C	0.5°C	-0.4°C	-0.4°C	0.6°C	2.0°C	0.0°C
mean	3.0°C	5.1°C	5.6°C	6.2°C	5.3°C	5.3°C	6.3°C	7.7°C	0.0°C
maximum	8.8°C	10.8°C	11.0°C	12.0°C	11.0°C	11.0°C	12.0°C	13.4°C	0.0°C
Degree Days									
Heating Degree Days	5,605	4,995	4,848	4,669	-14%	4,939	4,660	4,287	-17%
Cooling Degree Days	121	288	331	378	175%	314	393	531	226%
Days Experiencing Extreme Temperatures									
Days <-30°C	10	4	2	2	-78%	3	1	1	-88%
Days >30°C	13	26	32	36	153%	29	37	50	198%

Combining the data from Canadian Climate Normals and the Climate Atlas of Canada enables us to project how each much Killarney Turtle Mountain's climate is likely to change in the coming years.

Crucially for this study, combining these two data sources enables us to estimate the changes in heating and cooling needs for buildings in the RM, including those targeted in this study.

Killarney Turtle Mountain can expect to see a modest decline in building heating needs (in the range of 14% to 17%) and a very significant increase in building cooling needs (in the range of 153% to 198%) over the next 25 years.

3.5.3 *Sustainability Initiatives to Date*

The community of Killarney Turtle Mountain has a multi-decade history of advocacy in renewable energy. Two of the three founding Directors of ManSEA—Les Routledge and Mark Witherspoon—were long-time residents of Killarney Turtle Mountain.

Interest in sustainability initiatives in general—and renewable energy initiatives in particular--goes well beyond ManSEA involvement. Other initiatives that were pursued in the Killarney Turtle Mountain area included:

- 1992 – a prefeasibility study on the use of flax shives as fuel.
- early 2000s – a proposal for a wind farm
    - The community worked hard to be one of the five sites of the wind farms planned for Manitoba in the early 2000s.
    - Very significant time, effort and money went into this initiative. Members in the community remain frustrated that a wind farm was not developed at that time, and that there are two wind farms just across the border in North Dakota. One in particular—the Langdon Wind Energy Centre—is still seen as missed opportunity for renewable energy economic development.[194]
    - Although the effort to establish a wind farm in the RM of Killarney Turtle Mountain was not successful in its initial effort, it is still on the community's agenda for future development.
- 2004 – a proposal for an animal mortality composting facility
    - A proposal to properly and safely dispose of any large-animal mortality within the Westman region. (3,000 tonnes (14,000 head)
- 2006 – ethanol plant
    - Proposal developed for a 100 million litre/year ethanol plant.

The community is eager to develop this current proposal past the prefeasibility stage to implementation.

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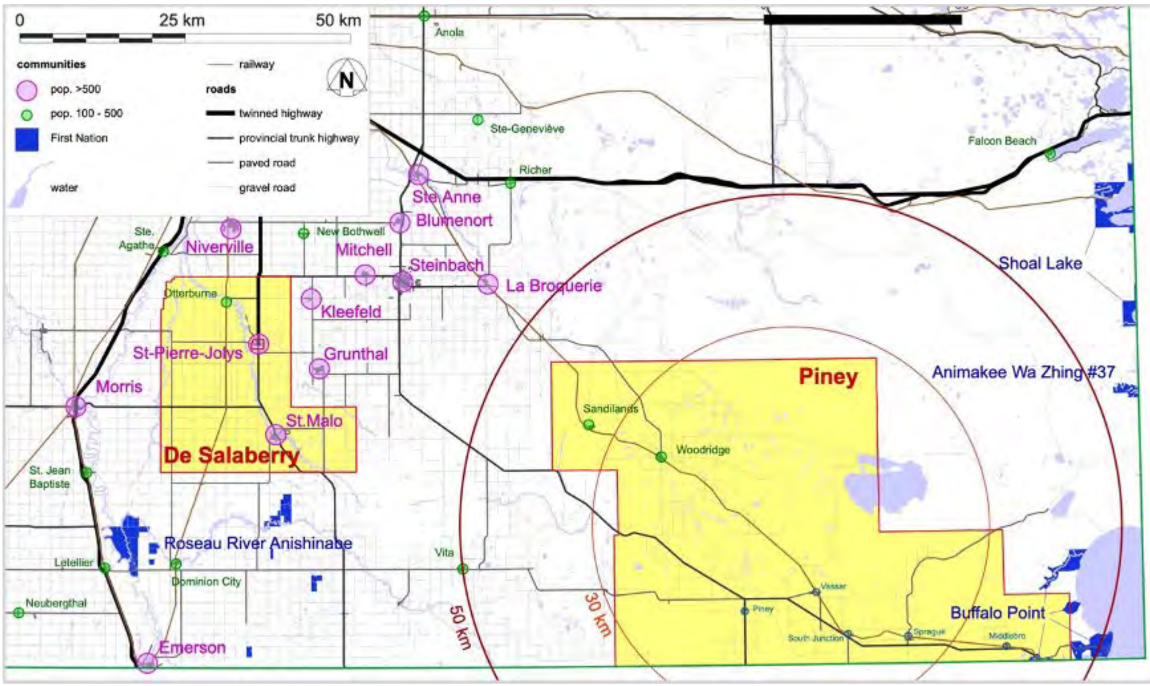
[194] For details on the benefits this wind farm has brought to the region just south of Killarney Turtle Mountain see: Leistritz, F. L. & Coon, R. C. (2008). *Socioeconomic Impacts of the Langdon Wind Energy Center.* Agribusiness & Applied Economics Report 37285, North Dakota State University, Department of Agribusiness and Applied Economics. https://ideas.repec.org/p/ags/nddaae/37285.html. Documented benefits from this report include:

- The peak construction work force of 269 workers.
- 10 permanent employees.
- Construction was estimated to have resulted in payments of more than $56 million to entities within North Dakota. Secondary impacts were estimated at an additional $169 million.
- During operation, the facility makes payments of about $1.4 million annually to North Dakota entities, including $413,000 in payments to landowners with easement agreements.
- During operation, the county receives approximately $191,000 annually in direct property tax payments.
- Langdon school district receives an estimated $265,000 in property tax revenues annually.

3.6 Piney

Figure 190: Piney – 50 km radius



3.6.1 *Population & Economy*[195]

Table 246: RM of Piney – population & density[196]

	Population		Land Area	Density
	2021 census	annual change	km^2	pop/km^2
RM of Piney	1,843	1.4%	2,430	0.8
Manitoba overall	1,342,153	1.0%	540,310	2.5

The population of Piney is growing slightly faster than the provincial average (1.4%/year vs 1.0%/year. Piney stands out from the other participating communities in having a very low population density, lower even than the provincial average.

Table 247: RM of Piney – basic demographics – individuals

	Individuals				
	average age	completed postsecondary	indigenous identity	immigrant	neither indigenous nor immigrant
RM of Piney	45.0	44%	27%	7%	67%
Manitoba overall	39.7	50%	18%	19%	63%

The average age in Piney is higher than the average in Manitoba overall (45.0 vs. 39.7). The average educational attainment is somewhat less.

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195 Data from 2021 Census.

196 See 2021 Census for definitions of demographic categories.

The percentage who identify as indigenous is significantly higher than the provincial average (27% vs. 18%). Just under 30% of those who identify as indigenous are First Nations people, while just over 70% are Metis.

Table 248: RM of Piney – basic demographics – households

	Households	
	average size	*median income*
RM of Piney	2.3	$72,000
Manitoba overall	2.6	$79,500

Table 249: Percentages of people employed in each industry sector in the RM of Piney, compared to Manitoba overall[197]

NAICS	*industry*	*Manitoba*	*Piney*
11	Agriculture, forestry, fishing & hunting	4%	**24%**
21	Mining, quarrying, & oil & gas extraction	1%	**5%**
22	Utilities	1%	**0%**
23	Construction	8%	5%
31-33	Manufacturing	8%	11%
41	Wholesale trade	3%	**0%**
44-45	Retail trade	11%	8%
48-49	Transportation & warehousing	6%	5%
51	Information & cultural industries	1%	**0%**
52	Finance & insurance	4%	3%

NAICS	*industry*	*Manitoba*	*Piney*
53	Real estate & rental & leasing	1%	**0%**
54	Professional, scientific & technical services	5%	3%
55	Management of companies & enterprises	0%	**0%**
56	Admin. & support, waste management & remediation	4%	5%
61	Educational services	8%	7%
62	Health care & social assistance	15%	**7%**
71	Arts, entertainment & recreation	2%	1%
72	Accommodation & food services	6%	5%
81	Other services (except public administration)	4%	3%
91	Public administration	7%	6%
-	*classification not applicable*	*2%*	*2%*

% of people employed in this industry		
	15%	more than 150% greater than provincial average
	10%	more than 120% greater than provincial average
	4%	near provincial average (80% to 120% of provincial average)
	2%	less than 80% of provincial average
	1%	less than 50% of provincial average

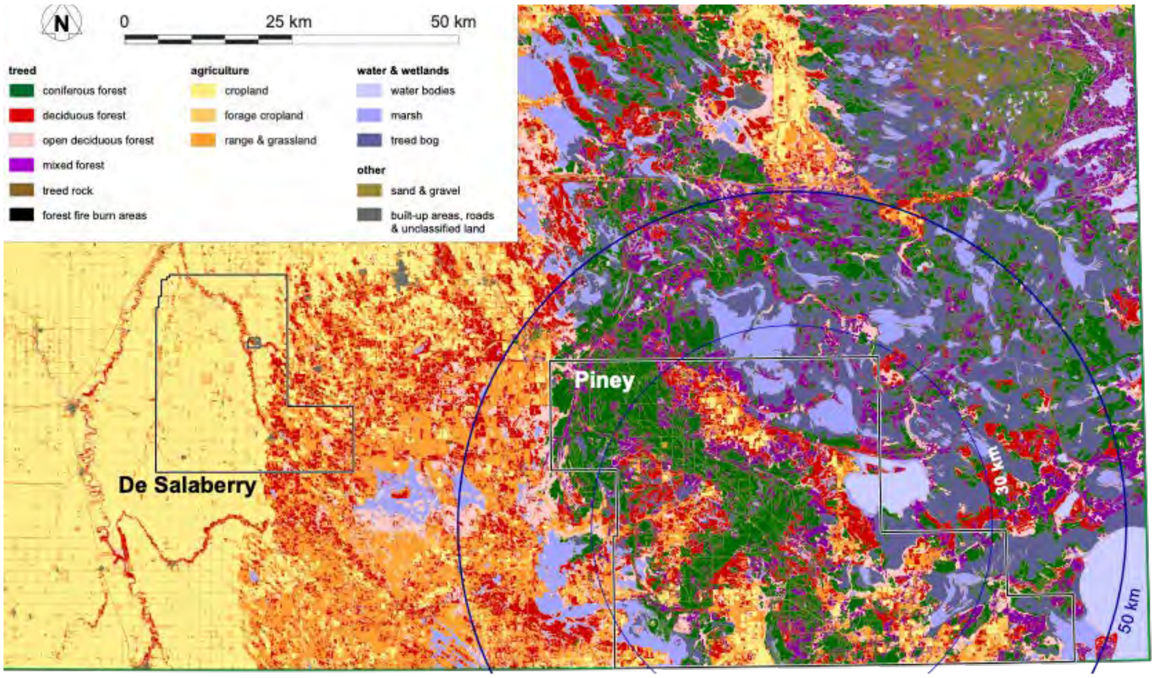
Agriculture and forestry employ a much higher percentage of people in the RM of Piney than they do in Manitoba as a whole. Perhaps surprisingly, manufacturing also employs a somewhat larger percentage in Piney than in the province overall.

The industry that employs a significantly smaller percentage of people in Piney than in Manitoba overall is health care and social services (7% vs. 15%).

[197] Data from 2021 Census. NAICS (North American Industry Classification System) uses standard definitions of industry sectors, enabling comparison between jurisdictions. "Classification not applicable" is defined as "unemployed persons aged 15 years and over who have never worked for pay or in self-employment, or who had last worked prior to January 1, 2020."

3.6.2 *Environment*

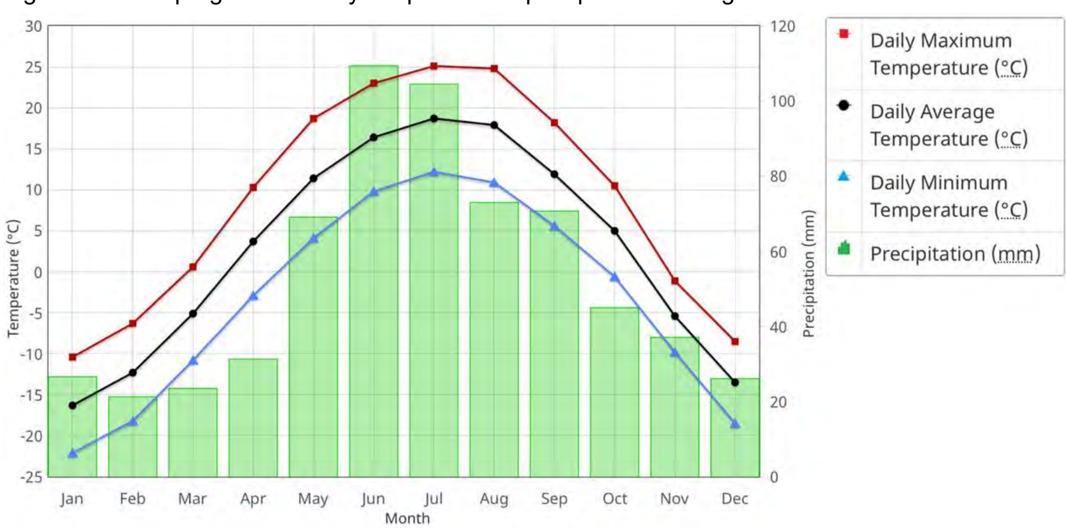
Figure 191: Piney – land cover – 50 km radius



3.6.2.1 PINEY CLIMATE NORMALS

The community of Sprague is in the RM of Piney. It is reasonable to use the climate normal data from its weather station as representative of the RM overall,

Figure 192: Sprague – monthly temperature & precipitation averages – 1981 to 2010[198]



[198] Graph copied from:

- Government of Canada. (2024, March 27). *1981-2010 Climate Normals & Averages.* Environment and Natural Resources. https://climate.weather.gc.ca/climate_normals/index_e.html

3.6.2.2 PINEY CLIMATE PROJECTIONS

The following graphs[199] provide projections for how the climate of Piney is projected to change. Graphs with green lines project what will happen if, globally, we make significant reductions in our CO_2 emissions. Graphs with red lines project what will happen if, globally, we continue on our current course.

Figure 193: Piney – average annual daily minimum temperature – if significant progress made

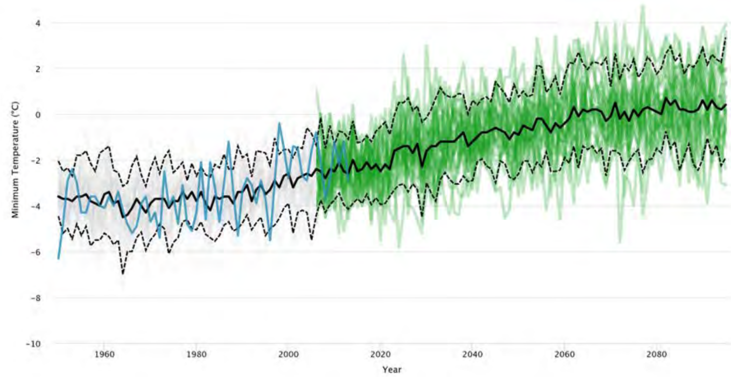


Figure 194: Piney – average annual daily mean temperature – if significant progress made

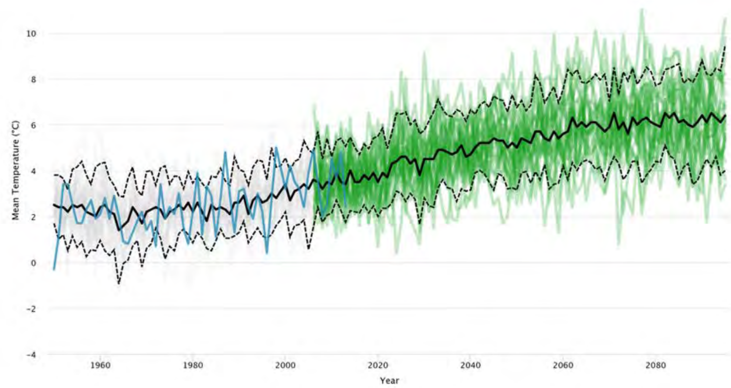
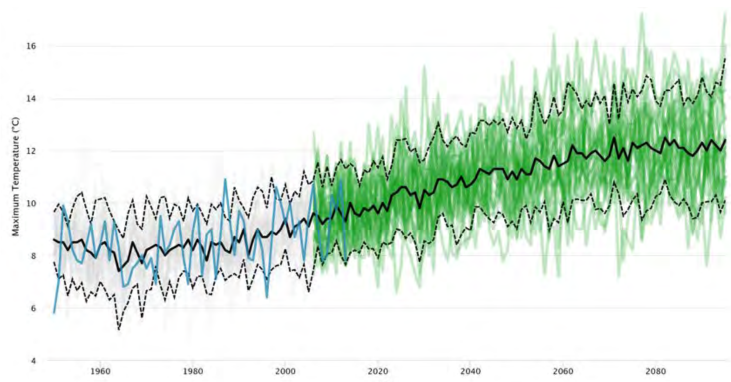


Figure 195: Piney – average annual daily maximum temperature – if significant progress made



[199] Source of graphs: *Climate Atlas of Canada.* (n.d.). https://climateatlas.ca/

Figure 196: Piney – total annual Heating Degree Days – if significant progress made

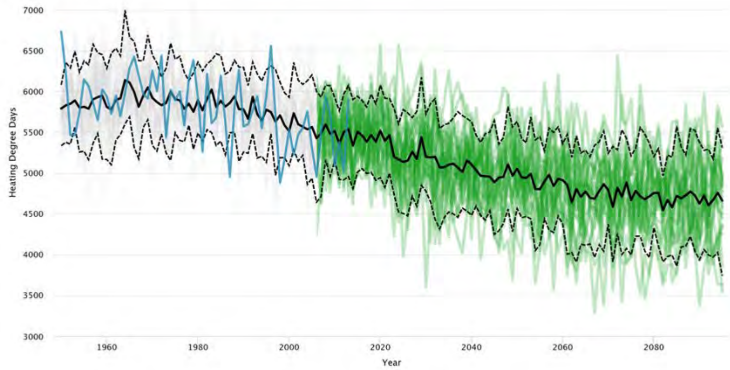


Figure 197: Piney – total annual Cooling Degree Days – if significant progress made

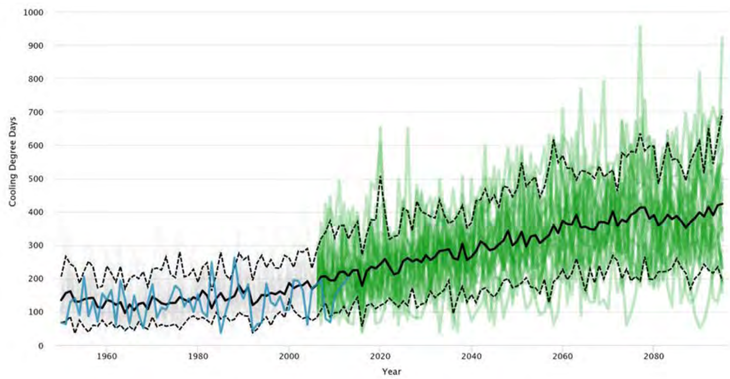


Figure 198: Piney – Days below -30ºC per year – if significant progress made

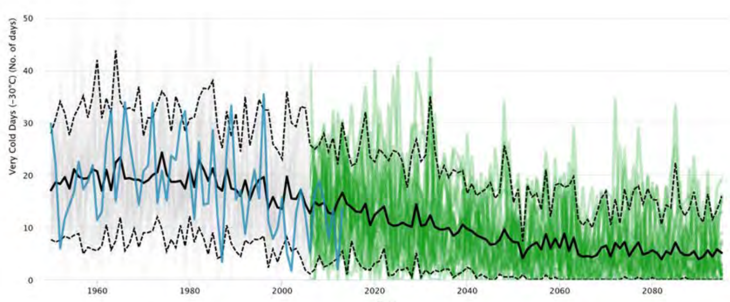


Figure 199: Piney – days above +30ºC per year – if significant progress made

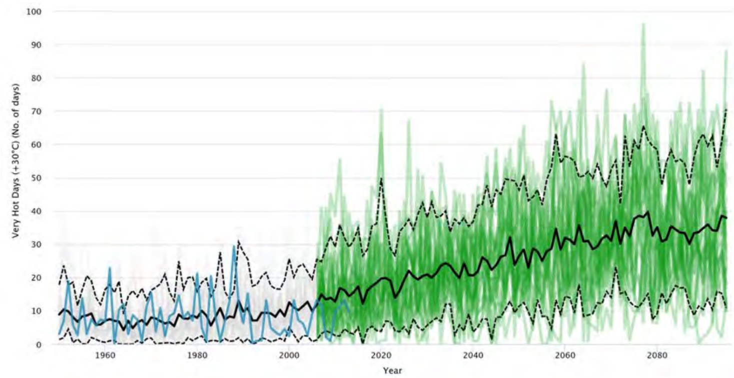


Figure 200: Piney – Annual average daily minimum temperatures – If business as usual

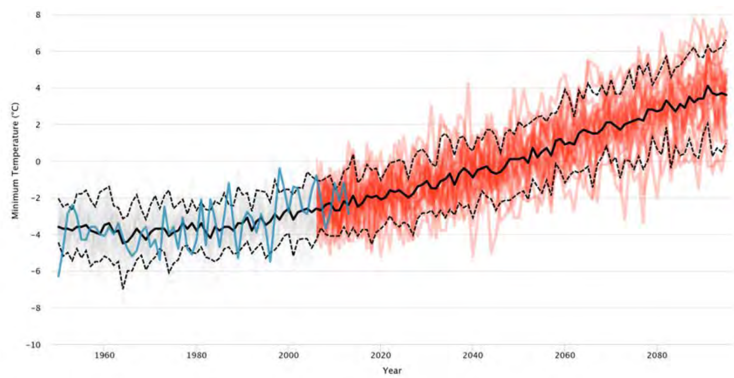


Figure 201: Piney – Annual average daily mean temperatures – If business as usual

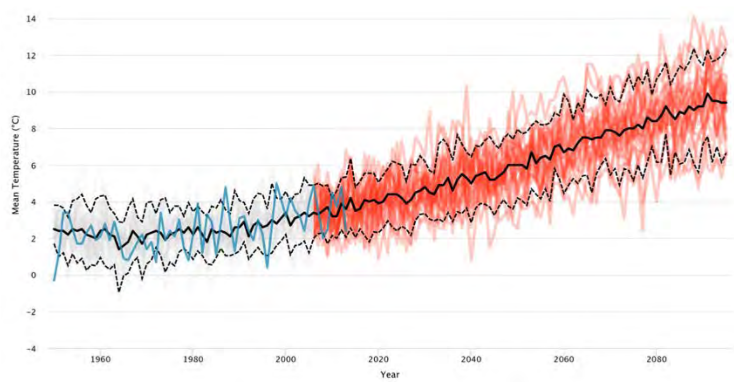


Figure 202: Piney – Annual average daily maximum temperatures – If business as usual

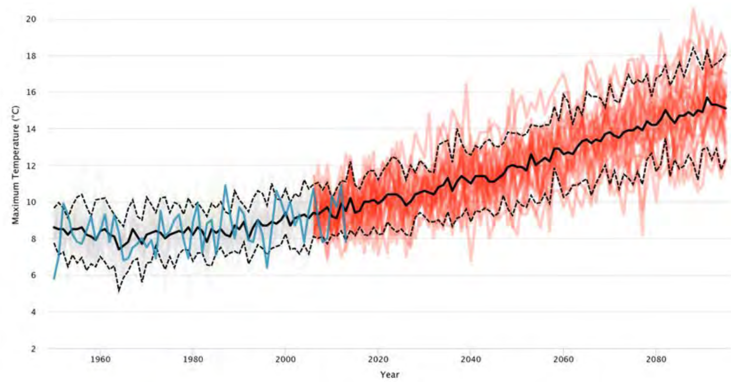


Figure 203: Piney – total annual Heating Degree Days – If business as usual

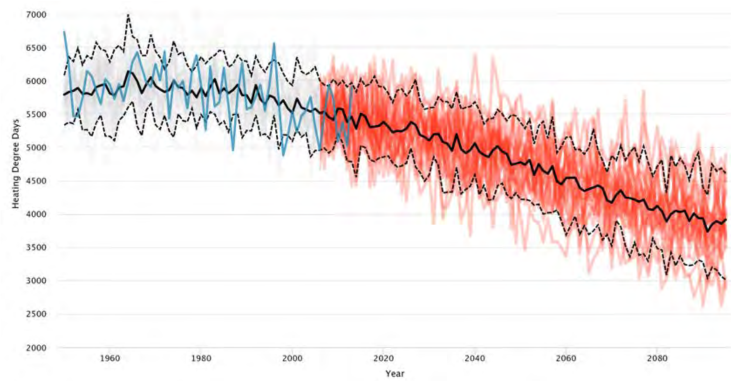


Figure 204: Piney – total annual Cooling Degree Days – If business as usual

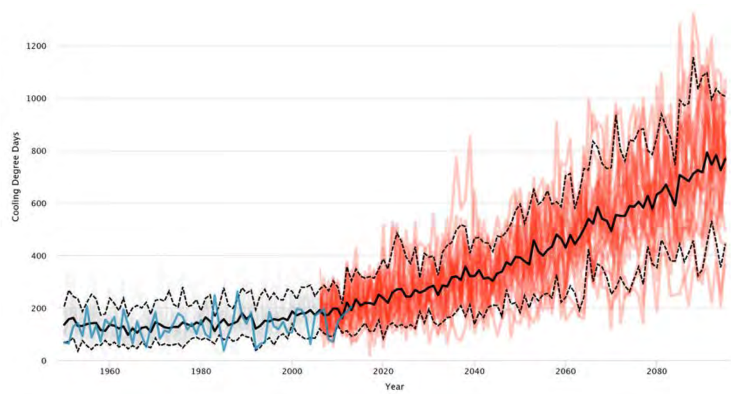


Figure 205: Piney – Days below -30ºC per year – If business as usual

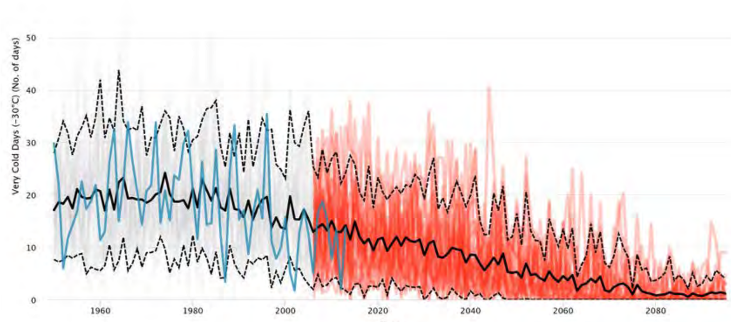
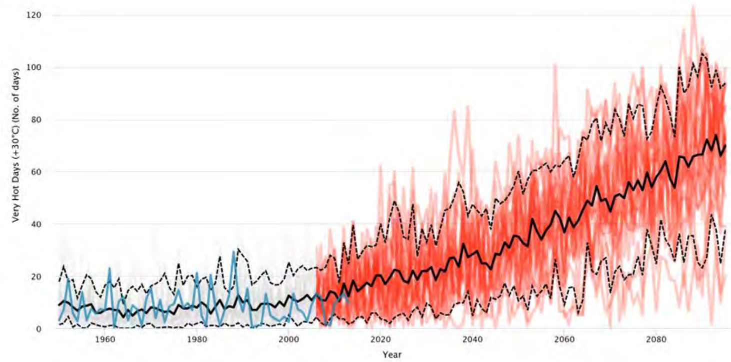


Figure 206: Piney – days above +30ºC per year – If business as usual



3.6.2.3 PINEY CLIMATE NORMALS AND PROJECTIONS

Table 250: Piney – actual average temperatures and projected changes

	Annual Averages								
	climate normals	*projected if significant prograss made in emissions reductions*				*projected if business as usual*			
	1976-2005	*2021-2050*	*2050*	*2051-2080*	*change from 1975-*	*2021-2050*	*2050*	*2051-2080*	*change from 1975-2005*
Temperaturea									
minimum	-3.3°C	-1.3°C	-0.9°C	-0.1°C	-1.0°C	-1.0°C	0.1°C	1.5°C	0.0°C
mean	2.6°C	4.7°C	5.0°C	5.8°C	5.0°C	5.0°C	6.0°C	7.3°C	0.0°C
maximum	8.6°C	10.7°C	10.9°C	11.8°C	10.9°C	10.9°C	11.9°C	13.2°C	0.0°C
Degree Days									
Heating Degree Days	5,723	5,114	5,049	4,795	-12%	5,058	4,736	4,402	-17%
Cooling Degree Days	114	274	312	361	172%	302	392	506	243%
Days Experiencing Extreme Temperatures									
Days <-30°C	17	10	7	6	-58%	9	5	3	-70%
Days >30°C	8	22	27	32	217%	25	35	46	320%

Combining the data from Canadian Climate Normals and the Climate Atlas of Canada enables us to project how each much Piney's climate is likely to change in the coming years.

Crucially for this study, combining these two data sources enables us to estimate the changes in heating and cooling needs for buildings in the RM, including those targeted in this study.

Piney can expect to see a modest decline in building heating needs (in the range of 12% to 17%) and a very significant increase in building cooling needs (in the range of 217% to 320%) over the next 25 years.

3.6.3 *Sustainability Initiatives to Date*

The RM of Piney's sustainable initiatives and priorities are integrated into its overall strategic plans.

For example, in its 2020 Development Plan, one of its Planning Goals was "to grow and develop in a sustainable manner and green the Municipality", which was explained as:

> *The RM of Piney recognizes the importance of protecting our environment and developing responsibly. It is of utmost importance to ensure that all growth and development within the Municipality is done in a sustainable manner. The RM of Piney will support development and growth that will place as little impact upon the environment as possible. Support will be given to initiatives that will reduce carbon output and protect the environment. The plan looks to support alternative transportation routes, to promote the protection of recreational interests and to reduce impact on the environment and counteract climate change. Green policies will be pursued. Any proposed development will be evaluated to ensure that the Municipality can support the proposed land use – that it will not negatively impact the Municipality and that it will be done in an environmentally sustainable manner.*[200]

The RM of Piney's 2022 Strategic Plan (an update of the 2016 Strategic Plan) includes as one of its six Guiding Principles "incorporate sustainability in our actions."[201] Expanding on this Guiding Principle, under the Strategic Topic "Environmental Stewardship", the Strategic Plan includes key points compatible with this study:

- *To better understand the vulnerabilities of our municipality, its resources, natural resources and the communities within them.*
- *To meet changing environmental, climatic and social expectations while maintaining sustainability. Climate and community resilience include fires droughts, floods, recycling programs and energy conservation.*
- *To keep our communities, safe, sustainable and looking forward for our piece in a changing world.*
- *Piney is 75% crown lands, with significant natural lands. Green programs should include plans which maintain diversity in our green spaces as this diversity will help address environmental uncertainty.*

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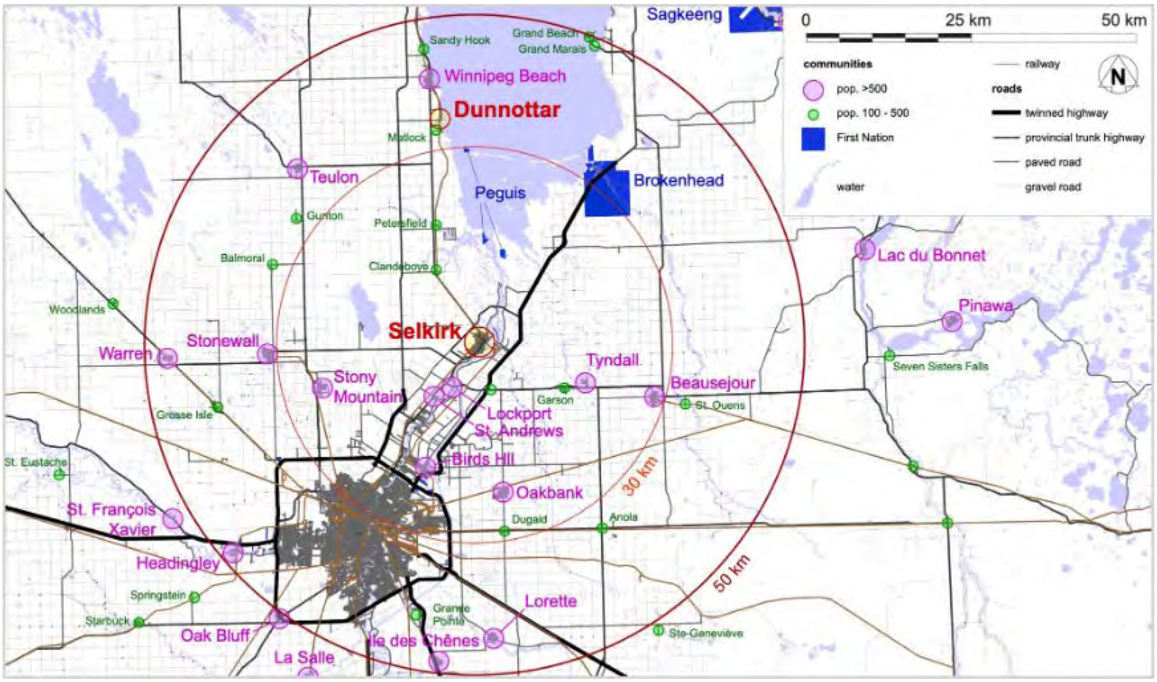
[200] Rural Municipality of Piney. (2020). *Development Plan.* https://rmofpiney.mb.ca/wp-content/uploads/2021/12/RM-of-PINEY-Development-Plan-third-reading.pdf

[201] Rural Municipality of Piney. (2022). Strategic Plan. https://rmofpiney.mb.ca/wp-content/uploads/2023/01/Strategic-Plan-2023.pdf

3.7 Selkirk

Figure 207: Selkirk – 50 km radius



3.7.1 *Population & Economy*[202]

Table 251: Selkirk – population & density

	Population		Land Area	Density
	2021 census	annual change	km^2	pop/km^2
City of Selkirk	10,504	0.4%	24	429
Manitoba overall	1,342,153	1.0%	540,310	2.5

The population of the City of Selkirk is growing at only half the rate of the province overall—0.4%/year.

Table 252: Selkirk – basic demographics – individuals[203]

	Individuals				
	average age	completed postsecondary	indigenous identity	immigrant	neither indigenous nor immigrant
City of Selkirk	44.1	42%	33%	7%	60%
Manitoba overall	39.7	50%	18%	19%	63%

Selkirk's population is, on average, older than the provincial overall. Nearly twice as many people in Selkirk identify as indigenous as in the province overall. Of those who identify as indigenous, just under half identify as First Nations and just over half identify as Metis.

The percentage of people in Selkirk who are immigrants is less than half the provincial average.

[202] Data from 2021 Census.

[203] See 2021 Census for definitions of demographic categories.

Table 253: Selkirk – basic demographics – households

	Households	
	average size	median income
City of Selkirk	2.4	$68,000
Manitoba overall	2.6	$79,500

Households in Selkirk are slightly smaller than the provincial average, and have a median income that is $11,500 less.

Table 254: Percentages of people employed in each industry sector in the City of Selkirk, compared to Manitoba overall[204]

NAICS	industry	Manitoba	Selkirk
11	Agriculture, forestry, fishing & hunting	4%	1%
21	Mining, quarrying, & oil & gas extraction	1%	1%
22	Utilities	1%	1%
23	Construction	8%	8%
31-33	Manufacturing	8%	7%
41	Wholesale trade	3%	3%
44-45	Retail trade	11%	14%
48-49	Transportation & warehousing	6%	5%
51	Information & cultural industries	1%	1%
52	Finance & insurance	4%	3%

NAICS	industry	Manitoba	Selkirk
53	Real estate & rental & leasing	1%	1%
54	Professional, scientific & technical services	5%	2%
55	Management of companies & enterprises	0%	0%
56	Admin. & support, waste management & remediation	4%	3%
61	Educational services	8%	8%
62	Health care & social assistance	15%	20%
71	Arts, entertainment & recreation	2%	2%
72	Accommodation & food services	6%	7%
81	Other services (except public administration)	4%	4%
91	Public administration	7%	5%
-	*classification not applicable*	*2%*	*3%*

% of people employed in this industry		
	15%	more than 150% greater than provincial average
	10%	more than 120% greater than provincial average
	4%	near provincial average (80% to 120% of provincial average)
	2%	less than 80% of provincial average
	1%	less than 50% of provincial average

There are few areas where Selkirk employs a higher percentage of people than in the province overall:

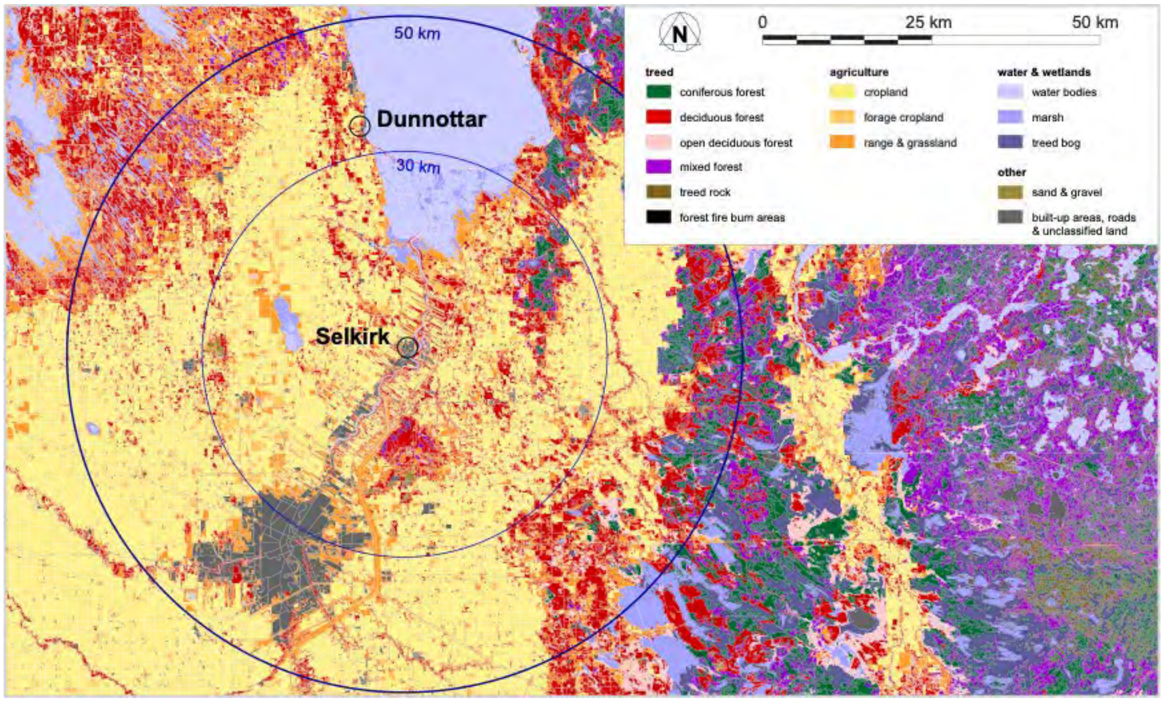
- retail trade
- health care & social assistance
- accommodation & food services

[204] Data from 2021 Census. NAICS (North American Industry Classification System) uses standard definitions of industry sector to enable comparison between jurisdictions. "Classification not applicable" defined as "unemployed persons aged 15 years and over who have never worked for pay or in self-employment, or who had last worked prior to January 1, 2020."

However, these differences are not large. Of the 7 communities participating in this study, employment proportions in Selkirk most closely resemble Manitoba as a whole.

3.7.2 *Environment*

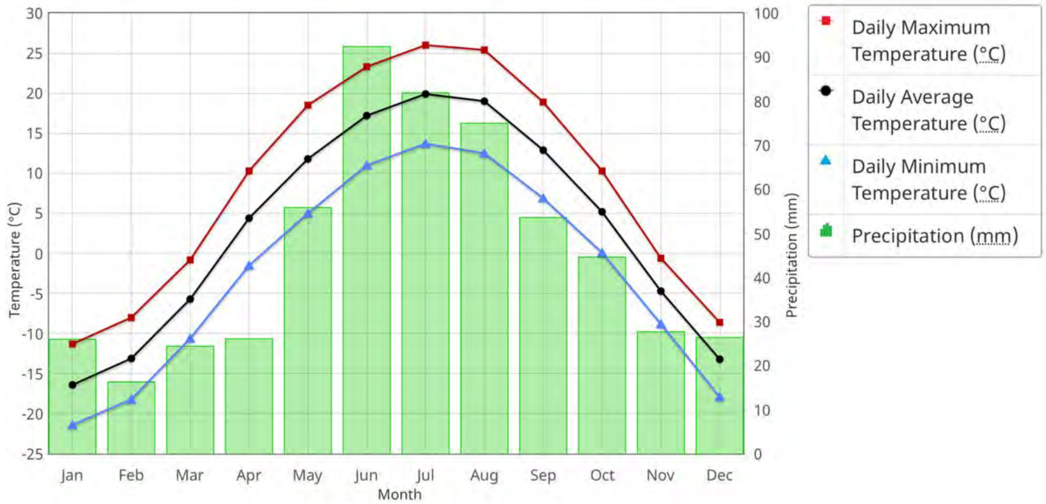
Figure 208: Selkirk – land cover – 50 km radius



3.7.2.1 SELKIRK CLIMATE NORMALS

Surprisingly, Canadian Climate Normals does not contain data for Selkirk. The closest location is for which data is available is Stony Mountain, 25 km to the west.

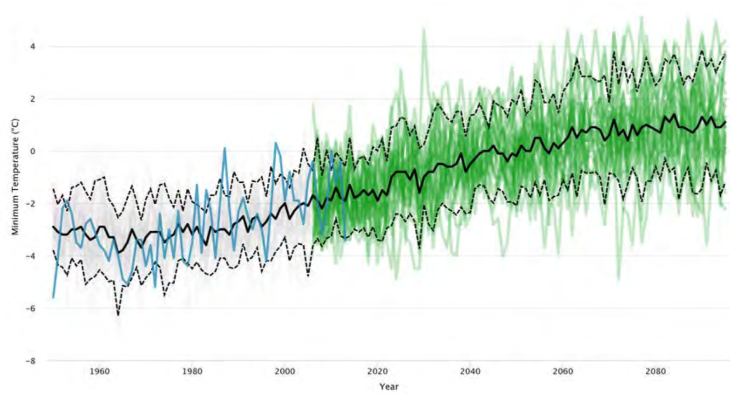
Figure 209: Stony Mountain – monthly temperature & precipitation averages – 1981 to 2010[205]



3.7.2.2 SELKIRK CLIMATE PROJECTIONS

The following graphs[206] provide projections for how the climate of Selkirk is projected to change. Graphs with green lines project what will happen if, globally, we make significant reductions in our CO_2 emissions. Graphs with red lines project what will happen if, globally, we continue on our current course.

Figure 210: Selkirk – average annual daily minimum temperature – if significant progress made



[205] Graph copied from:

- Government of Canada. (2024, March 27). *1981-2010 Climate Normals & Averages.* Environment and Natural Resources. https://climate.weather.gc.ca/climate_normals/index_e.html

[206] Source of graphs: *Climate Atlas of Canada.* (n.d.). https://climateatlas.ca/

Figure 211: Selkirk – average annual daily mean temperature – if significant progress made

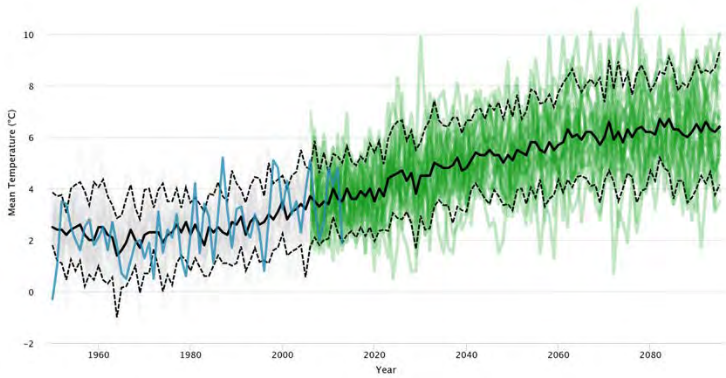


Figure 212: Selkirk – average annual daily maximum temperature – if significant progress made

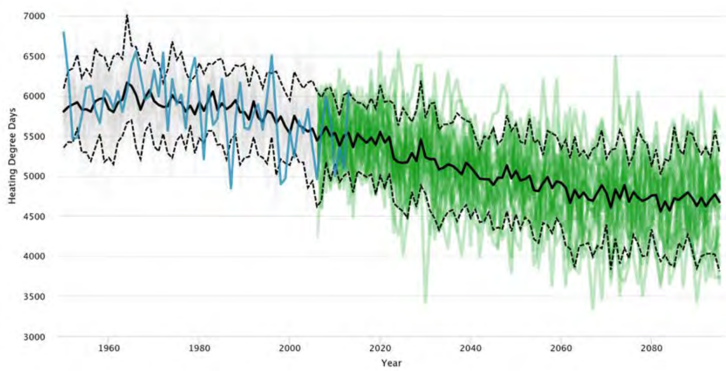


Figure 213: Selkirk – total annual Heating Degree Days – if significant progress made

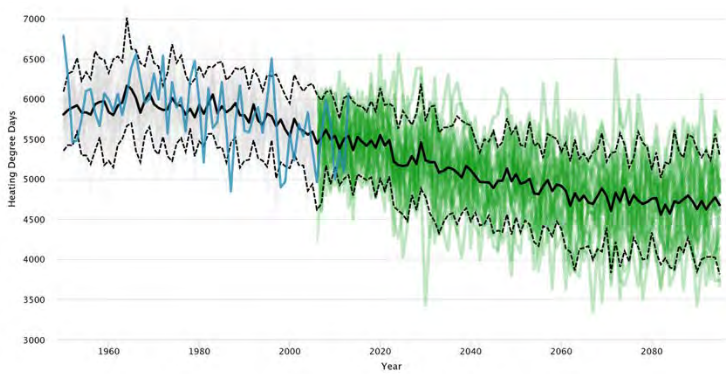


Figure 214: Selkirk – total annual Cooling Degree Days – if significant progress made

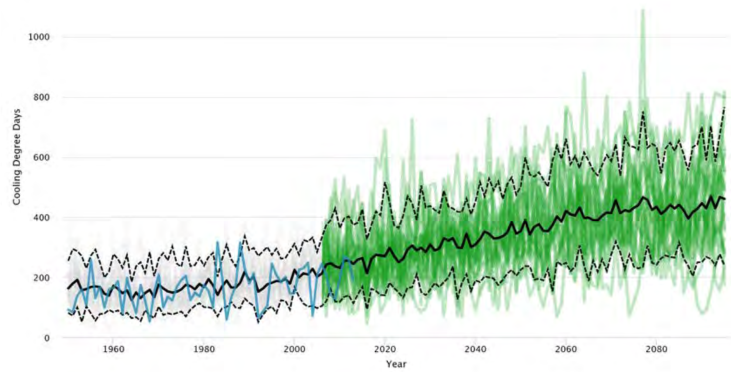


Figure 215: Selkirk – Days below -30ºC per year – if significant progress made

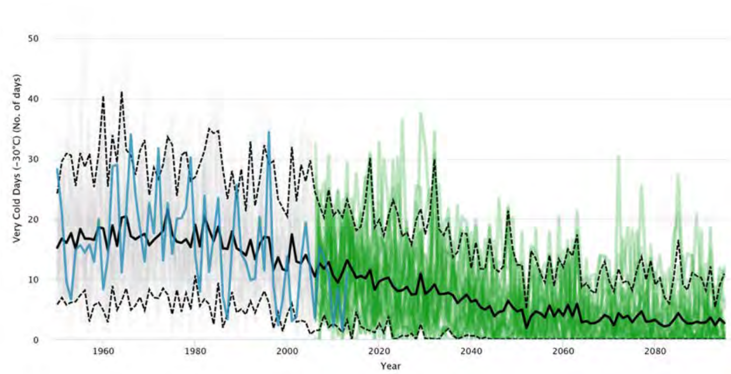


Figure 216: Selkirk – days above +30ºC per year – if significant progress made

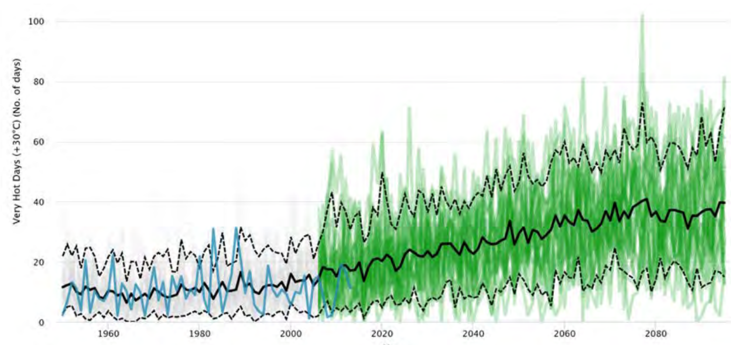


Figure 217: Selkirk – Annual average daily minimum temperatures – If business as usual

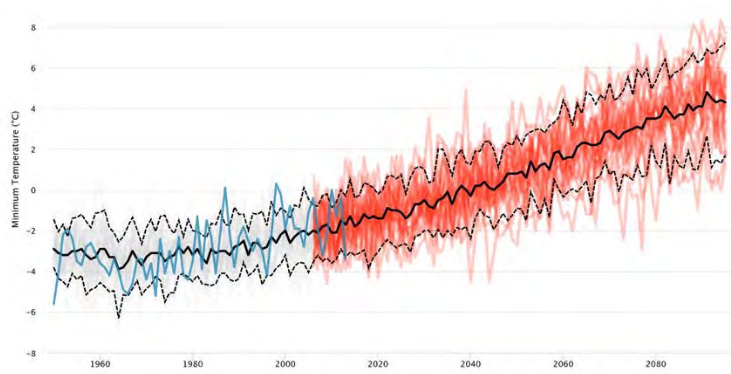


Figure 218: Selkirk – Annual average daily mean temperatures – If business as usual

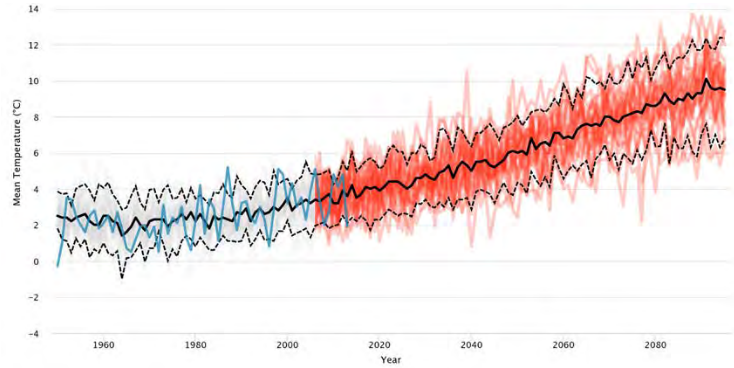


Figure 219: Selkirk – Annual average daily maximum temperatures – If business as usual

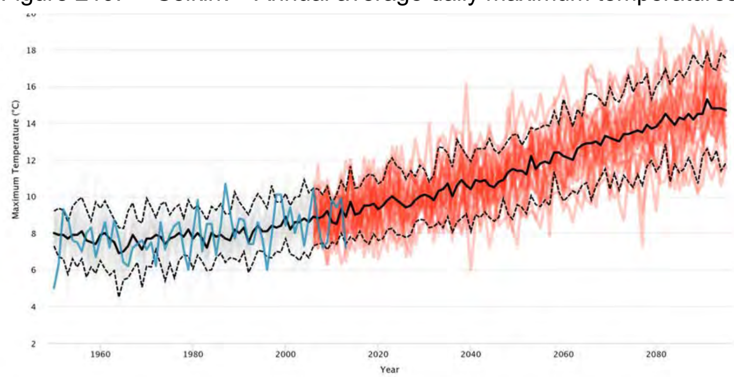


Figure 220: Selkirk – total annual Heating Degree Days – If business as usual

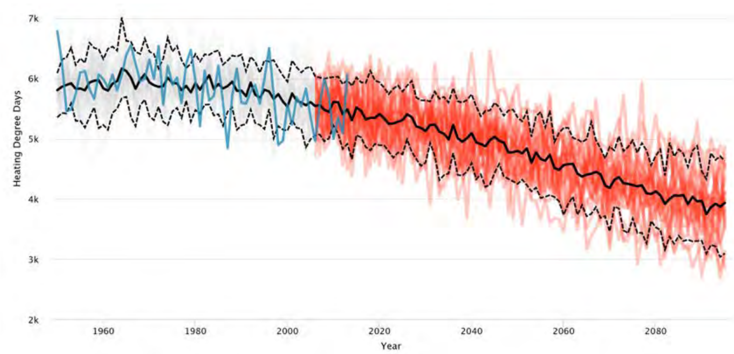


Figure 221: Selkirk – total annual Cooling Degree Days – If business as usual

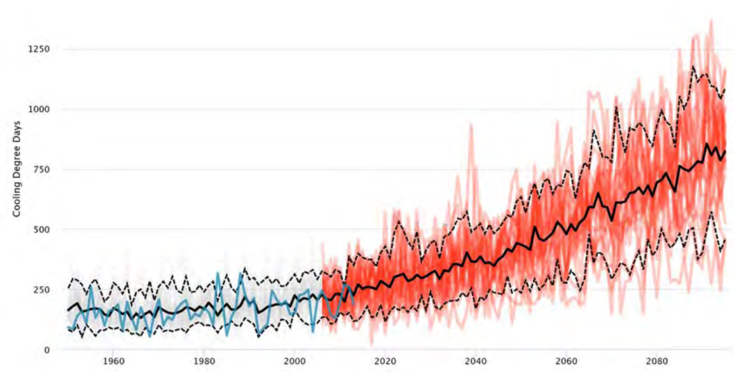


Figure 222: Selkirk – Days below -30ºC per year – If business as usual

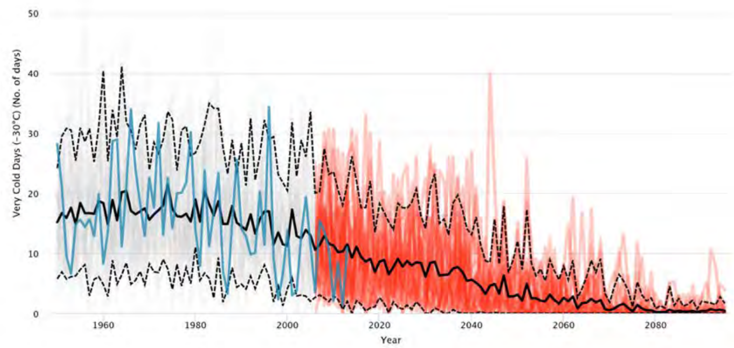
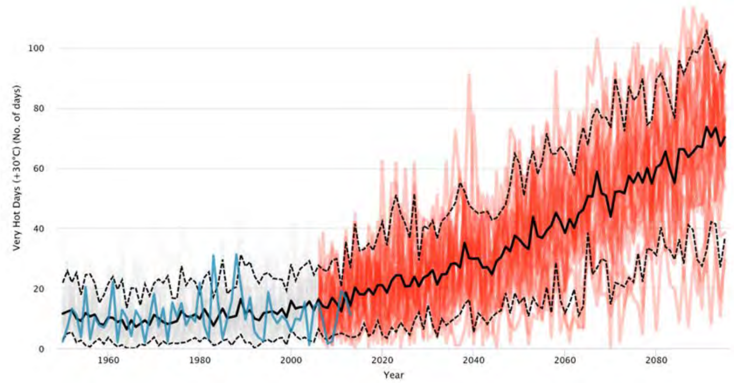


Figure 223: Selkirk – days above +30ºC per year – If business as usual



3.7.2.3 SELKIRK CLIMATE NORMALS AND PROJECTIONS

Table 255: Selkirk – actual average temperatures & projected changes

	Annual Averages								
	climate normals	*projected if significant prograss made in emissions reductions*				*projected if business as usual*			
	1976-2005	*2021-2050*	*2050*	*2051-2080*	*change from 1975-*	*2021-2050*	*2050*	*2051-2080*	*change from 1975-2005*
Temperaturea									
minimum	-2.7°C	-0.6°C	-0.3°C	0.6°C	-0.3°C	-0.3°C	0.7°C	2.2°C	0.0°C
mean	2.7°C	4.8°C	5.1°C	6.0°C	5.0°C	5.0°C	6.0°C	7.4°C	0.0°C
maximum	8.1°C	10.2°C	10.5°C	11.4°C	10.4°C	10.4°C	11.4°C	12.7°C	0.0°C
Degree Days									
Heating Degree Days	5,727	5,126	5,061	4,801	-12%	5,081	4,795	4,417	-16%
Cooling Degree Days	159	317	353	410	121%	348	435	566	173%
Days Experiencing Extreme Temperatures									
Days <-30°C	15	7	5	4	-69%	6	3	2	-79%
Days >30°C	12	24	29	34	153%	27	34	47	195%

Combining the data from Canadian Climate Normals and the Climate Atlas of Canada enables us to project how each much Selkirk's climate is likely to change in the coming years.

Crucially for this study, combining these two data sources enables us to estimate the changes in heating and cooling needs for buildings in Selkirk, including those targeted in this study.

Selkirk can expect to see a modest decline in building heating needs (in the range of 12% to 16%) and a very significant increase in building cooling needs (in the range of 153% to 195%) over the next 25 years.

3.7.3 *Sustainability Initiatives to Date*

The City of Selkirk is a leader in sustainability initiatives in Manitoba.

Their Climate Change Adaptation Strategy[207] includes:

- Joining the Federation of Canadian Municipalities' Climate and Asset Management Network.
- Assembling a team to lead its Capital Asset Management Strategy, which integrates capital planning with the expected effects of climate change.
- Working with the Prairie Climate Centre to ensure planning takes note of climate change projections, identifying and ranking the likely impacts on Selkirk's assets and infrastructure, including:
  - Increased number of very hot days
  - Increased heat wave severity
  - Potential for increased storm severity
  - Increased drought risks
  - Shifts in polar vortex events and timing
  - Wetter, heavier snow

In addition to the environmental and renewable energy planning guiding the West End Lands development, some of the other specific sustainability initiatives include:

- 2019 Adding rooftop solar to the Selkirk Rec Complex[208]
- 2021 Integrating a solar array into the new wastewater treatment facility.[209]
- 2022 Installing electric vehicle charging station[210]
- 2023 Replacing fossil fuels with a ground-source heat pump system at the water treatment plant.[211]
- 2024 Expanding its urban forest canopy[212]

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[207] City of Selkirk. (2019). *Climate Change Adaptation Strategy.* https://selkirknow.ca/wp-content/uploads/2021/06/Climate-Change-Adaptation-Strategy-Final-May2019.pdf

[208] City of Selkirk. (2019, May 13). *City takes lead in solar energy with install at Rec Complex.* https://www.myselkirk.ca/blog/2019/05/13/city-takes-lead-in-solar-energy-with-install-at-rec-complex-2/

[209] Kwong, D. & Guilbault. S. (2022). *Selkirk: Investing in a state-of-the-art wastewater treatment plant.* Institute for Catastrophic Loss Reduction. https://www.iclr.org/wp-content/uploads/2022/12/21_Selkirk.pdf

[210] City of Selkirk. (2022, Aug 15). *Selkirk's New Electric Vehicle Charging stations attract visitors and reduces city's GHG emissions.* https://www.myselkirk.ca/blog/2022/08/15/selkirks-new-electric-vehicle-charging-stations-attract-visitors-and-reduces-citys-ghg-emissions/

[211] City of Selkirk. (2023, Jun 26). *Selkirk says goodbye to fossil fuels in water treatment plant.* https://www.myselkirk.ca/blog/2023/06/26/wtpfossilfuelfree/

[212] City of Selkirk. (2024, May 14). *New street trees taking root in Selkirk.* https://www.myselkirk.ca/blog/2024/05/14/new-street-trees-taking-root-in-selkirk/

4 APPENDICES

Appx. A Communities' Participation Letters

City of BRANDON
Serving & Building Community

Pam Richardson
Director of Public Works
900 Richmond Avenue East
Brandon, MB R7A 7M1

May 18, 2023

Dear Wayne,

RE: Municipal Biomass Pre-feasibility Study

This letter serves to inform you that the City of Brandon agrees to participate in the pre-feasibility study being conducted by the Manitoba Sustainable Energy Association. We understand that the study is to assess options for renewable energy community-owned buildings within the municipality with biomass, ground source heat pumps systems and solar being considered among the options.

We are excited to have the opportunity to partner with you to learn what options the City may have regarding the use of biomass energy projects. As you may be aware the City of Brandon, through its proposed Climate Change Action Plan, has already identified that renewable energy sources for municipal buildings is a method which will assist us in the move towards being a carbon free corporation.

The City of Brandon currently has a large stockpile of construction and demolition wood waste at its landfill facility. Our hopes are that part of this feasibility study may provide options on how this material could be used as a useful end product for potential heating options.

We hope that this project is able to move forward in securing funding to partner together in this initiative.

Sincerely,

Pam Richardson
Director of Public Works

Dauphin
City Hall

File: 09 09.

May 17, 2023

Wayne Clayton
Manitoba Sustainable Energy Association
600 Banning Street
Winnipeg, MB R3G 2G1
wclayton@mansea.org

Dear Mr. Clayton:

RE: Manitoba Municipal Biomass Pre-Feasibility Study

Thank you for providing the City of Dauphin with the information regarding ManSEA and previous work completed by ManSEA and Boke Consulting.

The City of Dauphin agrees to participate in the pre-feasibility study being conducted by the Manitoba Sustainable Energy Association. The study is to assess options for renewable energy community-owned building within the municipality, with biomass, ground source heat pumps and solar being considered among the options.

The City of Dauphin is proud of its previous efforts to consider sustainable activities in all aspects of the City's operations and look forward to learning more about the potential for further efficiencies.

Sincerely,

Mike VanAlstyne
Director of Public Works & Operations

Cc: Mayor & Council

Ec: Sharla Griffiths, BSc CE, CMMA, City Manager

MV/gc

www.dauphin.ca
Ph: 204.622.3200
Fax: [illegible]
100 Main Street South
Dauphin MB R7N 1K1

De Salaberry
Municipality/Municipalité

Friday, May 19, 2023

Manitoba Sustainable Energy Association
c/o Wayne Clayton
wclayton@mansea.org

Boke Consulting
c/o Bruce Duggan
bruce.duggan@bokeconsulting.com

To Whom it May Concern,

RE: Manitoba Municipal Biomass Pre-Feasibility Study

The Rural Municipality of De Salaberry agrees to participate in the pre-feasibility study being conducted by the Manitoba Sustainable Energy Association. The study is to assess options for renewable energy community-owned buildings within the municipality, with biomass, ground source heat pumps and solar being considered among the options.

Please contact me if you have any further requirements in carrying out this funding application.

Sincerely,

Denise Parent
Chief Administrative Officer

466 Sabourin Street P.O. Box 40 St-Pierre-Jolys Manitoba R0A 1V0
Telephone: 204-433-7406 Fax: 204-433-7063
E-mail Address: info@rmdesalaberry.mb.ca Website: www.rmdesalaberry.mb.ca

5/17/23, 9:28 AM

All-Net Meetings V2

VILLAGE OF DUNNOTTAR

Resolution No. 2023 0054

Agenda Item # 15.3 ManSea

Council Meeting of May 17, 2023

Moved by Councillor : Bob Campbell

Seconded by Councillor : R. Howard

WHEREAS Manitoba Sustainable Energy Association (ManSEA) is conducting a pre-feasibility study to assess options for renewable energy community owned buildings within municipalities with biomass, ground source heat pump systems, and solar being considered among the options

AND WHEREAS The Village of Dunnottar has been invited to participate in this study

THEREFORE BE IT RESOLVED That Council for the Village of Dunnottar agrees to participate in the pre-feasibility study being conducted by ManSEA

Name	Yes	No	Abstained	Absent
Bob Campbell	✓			
Jim Kolowich	✓			
Kathy Magnusson	✓			
Richard Gamble	✓			
Rosalyn Howard	✓			

Mayor

Carried 5 to 0

https://dunnottar.allnetmeetings.com/admin/Agenda/adminResolutionPrintAll.aspx?aid=5A460DBE-224E-495C-AB47-65CBB0EDDE93 10/16

Killarney Turtle Mountain

Meghan Cuvelier Klassen, CMMA
Chief Administrative Officer

May 11, 2023

Manitoba Sustainable Energy Association
Email: wclayton@mansea.org

Dear Wayne,

The Municipality of Killarney – Turtle Mountain agrees to participate in the pre-feasibility study being conducted by the Manitoba Sustainable Energy Association. The study is to assess options for renewable energy community-owned buildings within the municipality with biomass, ground source heat pumps and solar being considered among the options.

Killarney – Turtle Mountain is especially excited to explore the possibility of turning our partially developed industrial park into a "green" industrial park. In addition to this being an eco-conscious decision, it would also be a great economic driver to inspire and promote economic development opportunities in our community.

We look forward to working with you on this project.

Sincerely,

M. Cuvelier Klassen

Meghan Cuvelier Klassen, CMMA
Chief Administrative Officer

PO Box 10, 415 Broadway Ave., Killarney, MB R0K 1G0 P (204)523-7247 F (204)-523-4637 E info@killarney.ca www. killarney.ca

Phone: 204-437-2284
or 204-437-2060
Fax: 204-437-2556
office@rmofpiney.mb.ca

Rural Municipality of
PINEY

RM of Piney
PO Box 48
Vassar, Manitoba
R0A 2J0

May 16th, 2023

Wayne Clayton
Manitoba Sustainable Energy Association
wclayton@mansea.org

The Rural Municipality of Piney agrees to participate in the Pre-Feasibility Study being conducted by the Manitoba Sustainable Energy Association. The study is to assess options for renewable energy community-owned buildings within the municipality with biomass, ground source heat pumps systems and solar being considered among the options.

The Municipal Biomass Pre-Feasibility Study is immensely important to the Rural Municipality of Piney and, if funded, it will have a lasting beneficial impact on our area. If you have any questions in regards to this matter, please do not hesitate to ask.

Yours truly,

Martin Van Osch
Chief Administrative Officer

CITY OF Selkirk
Where it all comes together

May 16, 2023

Wayne Clayton
Manitoba Sustainable Energy Association
600 Banning Street
Winnipeg, MB
R3G 2G1

Dear Wayne,

The City of Selkirk welcomes the opportunity to participate in the Manitoba Municipal Bio-Mass Pre-Feasibility Study. This study, being conducted by the Manitoba Sustainable Energy Association will assess options for renewable energy in community-owned buildings within municipalities. Biomass, ground source heat pumps and solar solutions are some of the options being considered. It is our understanding that all expenses associated with this effort will be the sole responsibility of the Manitoba Sustainable Energy Association. It is also our understanding that this effort will require only nominal dedicated staff time from participating jurisdictions. Once articulated, we will need to confirm available resources in this regard.

We look forward to project start up and specific participation requirements associated with our involvement.

Where it all comes together. Best wishes,

Tim Feduniw
Director Sustainable Economic Development
204.795.4953
tfeduniw@cityofselkirk.com

City of Selkirk, 200 Eaton Ave, Selkirk, Manitoba, Canada R1A 0W6 | Phone: 204-785-4900 Email: citizensupport@cityofselkirk.com

Appx. B **Letters of Support**

ÉcoOuest
EcoWest

May 23, 2023

Wayne Clayton, Director
Manitoba Sustainable Energy Association
Winnipeg, MB

Re: Municipal Biomass Pre-Feasibility Study – Letter of Support

Dear Wayne,

On behalf of Eco-West Canada, we are pleased to provide this letter of support to Manitoba Sustainable Energy Association (ManSEA) for your CCF application for the Municipal Biomass Pre-Feasibility Study project.

Eco-West Canada is a national not-for-profit organization based in Winnipeg, Manitoba, and a member of the AMBM Group. Since 2008, Eco-West Canada's mandate has consisted of promoting the sustainable economic development of Canada's rural municipalities through the planning and implementation of a green economy infrastructure. In order to achieve these goals, Eco-West Canada is active in several sectors, including municipal waste management and the circular economy.

As a result of our pre-existing relationship with ManSEA and municipalities in Manitoba, Eco-West Canada is also prepared to offer its support to this project by assisting with the meetings with the municipalities as well as doing a peer review of the final results of the study. We believe that findings from the municipal biomass pre-feasibility study will be of great value to all Manitoba municipalities and should also allow them to maximize their opportunities to access additional funding in the future for the development and implementation of Pilot and/or Capital projects.

If you require any further information, please do not hesitate to reach out to us.

Sincerely,

Dany Robidoux

Executive Director, Eco-West Canada

Appx. C Study Mandate

Manitoba Environment and Climate Change provided funding for this study. The Study Mandate is specified in the Grant Funding Agreement between the Province of Manitoba and ManSEA.

C.1 Objectives[213]

This study's objectives are to:

1. Contribute to overall potential future GHG emissions reductions for Manitoba
2. Contribute to effective forecasting in a changing climate
3. Determine the types and volumes of biomass within 30 km of each of the seven participating municipalities
4. Determine what biomass may be most feasible for use in each municipality and estimate what the delivered cost would be
5. Determine what biomass energy systems are most feasible for use in the target buildings in each municipality, and the costs and benefits of those systems.
6. Determine if heat pumps and/or solar would be appropriate additions to the energy systems of the participating communities' target buildings.
7. Assess the costs and benefits of the current energy systems to the alternatives of biomass, heat pumps and (where appropriate) solar.
8. Recommend energy systems for the target buildings in each participating community.
9. Stimulate carbon-emission reductions in all of Manitoba's municipalities.

C.2 Deliverables[214]

The final report of this study is to include:

1. Inventory of municipal and community buildings that each participating community wants to have considered for renewable energy consideration (the "target buildings").
2. Documentation of the energy systems currently used in each target building, and the energy currently used to heat, cool and power those buildings.
3. Annual data on past energy consumption, by individual target building, and summarized by participating community.
4. Estimated annual future energy consumption, by individual target building, and summarized by participating community.
5. Inventory of types and volumes of biomass available within 30 km of the target buildings.

[213] These Project Objectives are quoted directly from pages 7 and 8 of the Grant Funding Agreement.

[214] These Deliverables are extracted from page 8 to 11 of the Grant Funding Agreement. They have been slightly reformatted for presentation consistency.

6. Estimated volume (in tonnes) of biomass required to heat the target buildings.
7. Estimated costs of providing locally sourced biomass, in a form suitable for use as fuel, to the target buildings.
8. Estimated costs and benefits of the most feasible biomass energy systems recommended, by individual target building, and summarized by participating community.
9. Review of heat pump and solar options, by individual target building, and summarized by participating community.
10. Comparisons of the status quo to the considered renewable energy options.
11. Estimated greenhouse gas reductions for all assessed energy systems, calculated as tonnes of carbon dioxide equivalent (C02e), per year, and over the lifespan of the buildings assessed. Data sources and collection methods are to be specified.
12. Publication and dissemination of this prefeasibility study.

All estimates are to include calculations.

Appx. D Financial Report

This financial report was submitted to the Province of Manitoba in partial fulfillment of the grant funding agreement between ManSEA and the Province of Manitoba

Project Title	MANITOBA MUNICIPAL BIOMASS PRE-FEASIBILITY STUDY	**Agreement #**	7311 2023/24
Contact & Title:	**Grant Recipient:**	**Phone:**	(204) 730-0559
Wayne Clayton - Co-Lead	Manitoba Sustainable Energy Association	**Email:**	wclayton@mansea.org
Randy Baldwin - Co-Lead			rbaldwin@acornhill.ca
Reporting Period			
From: May 22, 2023	**To:** March 31, 2024		

PROJECT CONTRIBUTIONS	CASH (year to date)	IN-KIND (year to date)	TOTAL	BUDGET (as submitted)	VARIANCE (more or <less>)
Funds received to date	$37,720		$37,720	$37,720	$0
Holdback funds	$9,430		$9,430	$9,430	$0
Applicant cash contributions		$2,064	$2,064	$2,000	$64
In-kind contribtions		$25,283	$25,283	$21,800	$3,483
TOTAL	**$47,150**	**$27,347**	**$74,497**	**$70,950**	**$3,547**

TOTAL PROJECT EXPENDITURES	CASH (year to date)		IN-KIND (year to date)	TOTAL	BUDGET (as submitted)	VARIANCE (more or <less>)
	Manitoba CASH	**Applicant CASH**				
Staffing & Personnel costs			$16,530	$16,530	$14,000	$2,530
Professional Services	$36,876		$5,650	$42,526	$40,000	$2,526
Materials, Supplies & Equipment Costs	$662	$6		$668	$550	$118
Administration Costs	$5,499	$922	$450	$6,871	$6,750	$121
Transportation Costs	$3,475	$1,136	$1,353	$5,964	$7,650	<$1,686>
Communication Costs						
Other Costs	$638		$1,300	$1,938	$2,000	<$62>
TOTAL EXPENDITURES	**$47,150**	**$2,064**	**$25,283**	**$74,497**	**$70,950**	**$3,547**

ITEM	TOTAL COST				DETAILED BREAKDOWN (of Total Cost)
	Manitoba CASH	Applicant CASH	IN-KIND	TOTAL	
STAFFING & PERSONNEL COSTS:					In-kind is time contributed by: - 18 individuals from the RMs - 7 staff from Efficiency MB - 4 staff from Vermillion Energy - accounting services, fulfilling reporting requirements, administative support, editing, and document reviews by ManSEA Board members, including the Secretary-Treasurer & the Project Co-Leads.
			$16,530	$16,530	
PROFESSIONAL SERVICES:					Professional Services are higher than originally budgeted due to 2.additions to the original Scope of Work: 1. The inclusion of the research on the actual weather data from the 3 weather stations in Brandon over the last 100+ years, which enabled an data-based cross-check of climate change effects in southern Manitoba. 2: The addition of Vermillion Growers in Dauphin, who are wanting to replace natural gas consumption with biomass. Both were unanticipated but valuable contributions to the project scope. This increase is offset by reductions in Administration and Transportation Costs, as well as increased In-Kind contributions from ManSEA Board members. MANITOBA Cash for Professional Services is as originally budgeted.
Translation				$0	
Interpretation				$0	
Professional Fees – Technical	$36,876	$0	$5,650	$42,526	
Professional Fees – Other				$0	
Professional Services subtotals:	*$36,876*	*$0*	*$5,650*	*$42,526*	
MATERIALS, SUPPLIES & EQUIPMENT COSTS:					Project Funds/MB Cash - To pay Boke Consulting for printing of some copies of the final report
	$662	$6		$668	
ADMINISTRATION COSTS:					In-kind contribution to Administration Costs is for cell phone, computer, internet, and Zoom costs, Contributed by ManSEA Board members, including the Secretary-Treasurer & Project Co-Leads. **ManSEA - Cash** - The GST was not included in the original budget for the project. The total GST is $1,844, half of which ManSEA will laim as a GST rebate. The remainder is paid from reallocated funds from the ManSEA CASH Transportion, which was under budger.
	$5,499	$922	$450	$6,871	
TRANSPORTATION COSTS:					Mileage, meals, & hotels for ManSEA Co-Leads & Consultant travel to the 7 communities across Manitoba is under budget. ManSEA and the Consultant strove to minimize GHG Emissions through Zoom car-pooling for travel. We still able to travel in-person 3 times to the communities discuss options with staff in person, and to see the facilities' existing energy systems directly.
	$3,475	$1,136	$1,353	$5,964	
COMMUNICATION COSTS:					
OTHER COSTS:					Project Funds - Funds to bring RMs staff together to receive an update on the interim report on the project from the consultant. The excess funds were used to pay the additional printing costs.
	$638		$1,300	$1,938	
TOTAL	**$47,150**	**$2,064**	**$25,283**	**$74,497**	

Appx. E Current Manitoba Energy Use

E.1 Household Data

Statistics Canada collects data on actual energy use per household and provides a breakdown for each province.

Table 256: Manitoba – households – average annual per-household energy use, energy sources, & GHG emissions – 2021[215]

annual energy use		energy source							GHG emissions CO_2e	
		natural gas				electricity			kg/m^3 of natural gas	tonnes/ household
GJ	MWh	GJ	MWh	m^3	% of total	GJ	MWh	% of total		
92	26	49	14	1,285	54%	42.6	12	46%	1.926	2.48

Statistics Canada tracks energy use by household. It defines "household" as "a person or group of persons who occupy the same dwelling and do not have a usual place of residence elsewhere in Canada or abroad."[216] Selkirk's Concept Plan uses the term "dwelling units", but has not yet defined that term in detail. While a "dwelling unit" and a "household" may not have identical definitions, they are similar enough that household energy use is the best available proxy for dwelling unit energy use.

As well, while average energy use by a household in Selkirk will not exactly match average household energy use in Manitoba, they are similar enough that the Manitoba data can be used as a proxy for Selkirk.

Statistics Canada provides this data in gigajoules (GJ). To enable comparison in this study, a conversion to megawatt-hours (MWh) is used, with 1 GJ = 0.2778 MWh.

Cubic metres (m^3) of natural gas are estimated, with 1 m^3 of natural gas equivalent to 10.6667 kWh of energy.

The energy and volume of gas is estimated by dividing the total number amount of gas consumed by Manitoba households (25,534,284 GJ) in 2021 by the number of Manitoba households (518,050).

[215] Statistics Canada. (2024 Mar 19). *Household energy consumption, Canada and provinces.* Data, Table: 5-10-0060-01 https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2510006001 *Notes:*

- While a "dwelling unit" and a "household" may not have identical definitions, they are similar enough that household energy use can be used as a proxy for dwelling unit energy use.
- As well, while average energy use by a household in Selkirk will not exactly match average household energy use in Manitoba, they are similar enough that the Manitoba data can be used as a proxy for Selkirk.
- Statistics Canada provides this data in gigajoules (GJ). To enable comparison in this study, a conversion to megawatt-hours (MWh) is used, with 1 GJ = 0.2778 MWh.
- Cubic meters (m^3) of natural gas is estimated, with 1 m^3 of natural gas equivalent to 10.6667 kWh of energy.
- The energy and volume of gas is estimated by dividing the total number amount of gas consumed by Manitoba households (25,534,284 GJ) in 2021 by the number of Manitoba households (518,050).

[216]Government of Canada (2022, March 3). *Household: Definition.* Statistical Units. Statistics Canada. https://www23.statcan.gc.ca/imdb/p3Var.pl?Function=Unit&Id=96113

This data is used in this study to estimate what per-dwelling unit energy use and GHG emissions would be if the Selkirk West End Lands development went ahead using the building standards and energy systems currently used in Manitoba residential buildings.

Natural Resources Canada's Office of Energy Efficiency collects data on what this energy is used for in the average household in Manitoba.

Table 257: Manitoba – households – average annual per-household energy use, by purpose – 2021[217]

	average consumption if built to "business as usual" standards			
	energy demands	*energy sources*		
		natural gas		*electricity*
energy purpose	*MWh*	*m^3*	*MWh*	*MWh*
space heating	13.9	1,285	13.7	0.2
space cooling	1.5			1.5
water heating	4.4			4.4
lighting	1.0			1.0
appliances	4.8			4.8
	25.5	*1,285*	*13.7*	*11.8*

[217] Government of Canada. (2022). *Manitoba: Residential Sector: Secondary Energy Use and GHG Emissions by End-Use*. Office of Energy Efficiency, Natural Resources Canada. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=mb&year=2021&rn=2&page=0

E.2 Commercial/Institutional Data[218]

Natural Resources Canada's Office of Energy Efficiency collects data on current energy use by commercial/institutional space—broken down by province and by 10 sub-categories of commercial/institutional space.[219]

Table 258: Manitoba – commercial/institutional – floor space – 2021[220]

space use	***floor space***	
commercial sub-category	*millions m^2*	*%*
wholesale	2.0	7%
retail	4.2	15%
transportation & warehousing	1.7	6%
information & cultural industries	0.5	2%
offices	11.1	39%
educational services	4.4	16%
health care & social assistance	2.1	7%
arts, entertainment & recreation	0.5	2%
accommodation & food services	1.1	4%
other services	0.5	2%
totals:	*28.1*	*100%*

218 It is important to note that this is the *stationary* energy use for businesses and institutional space. It does not include energy used by these firms for transportation or other purposes. As well, it does not include energy use data for streetlights and municipal infrastructure.

219 Government of Canada. (2022). *Manitoba: Commercial/Institutional Sector: Secondary Energy Use and GHG Emissions by Energy Source.* Office of Energy Efficiency, Natural Resources Canada. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=com&juris=mb&year=2021&rn=1&page=0

220 Notes:

- The Commercial/Institutional sub-category "offices" includes "activities related to finance and insurance; real estate and rental and leasing; professional, scientific and technical services; public administration; and others".
- The Commercial/Institutional sub-category "other services" is not defined.
- The energy source category "other" includes fuel oil, kerosene, coal, propane—all fossil fuels.

Table 259: Manitoba – commercial/institutional – energy use & sources – 2021

space use	total annual energy use		energy source								
			fossil fuels					electricity			
				natural gas		other					
commercial sub-category	*PJ*	*GWh*	*%*	*PJ*	*GWh*	*PJ*	*GWh*	*%*	*PJ*	*GWh*	
wholesale	2.6	723	65%	1.6	451	0.1	18	35%	0.9	255	
retail	7.1	1,982	60%	4.1	1,152	0.2	45	40%	2.8	784	
transportation & warehousing	2.2	611	70%	1.5	410	0.1	15	30%	0.7	186	
information & cultural industries	0.9	248	62%	0.5	133	0.1	22	38%	0.3	94	
offices	15.0	4,164	58%	8.2	2,280	0.5	142	42%	6.3	1,742	
educational services	6.7	1,858	63%	4.0	1,115	0.2	62	37%	2.5	682	
health care & social assistance	7.3	2,040	50%	3.4	933	0.3	85	50%	3.7	1,022	
arts, entertainment & recreation	0.7	205	64%	0.5	127	0.0	5	36%	0.3	74	
accommodation & food services	2.8	780	64%	1.7	476	0.1	25	36%	1.0	279	
other services	0.8	216	72%	0.5	132	0.0	5	28%	0.3	79	
totals:	*46.2*	*12,828*	*59%*	*26.0*	*7,209*	*1.5*	*423*	*41%*	*18.7*	*5,196*	

Table 260: Manitoba – commercial/institutional – energy use intensity & GHG emissions – 2021

space use	energy use intensity		GHG emissions			
			CO_2e			
			intensity		total	
commercial sub-category	*GJ/m²*	*kWh/m²*	*tonnes/TJ*	*kg/kWh*	*Mt*	*tonnes*
wholesale	1.3	370	31.99	0.1152	0.08	83,296
retail	1.7	469	29.85	0.1075	0.21	212,958
transportation & warehousing	1.3	367	34.36	0.1237	0.08	75,550
information & cultural industries	1.7	471	32.08	0.1155	0.03	28,671
offices	1.4	376	28.98	0.1043	0.43	434,404
educational services	1.7	483	31.40	0.1130	0.21	210,014
health care & social assistance	3.2	875	24.93	0.0898	0.18	183,087
arts, entertainment & recreation	1.4	390	31.62	0.1138	0.02	23,358
accommodation & food services	2.5	686	31.84	0.1146	0.09	89,445
other services	1.4	401	31.36	0.1129	0.02	24,435
				total:	*1.37*	*1,365,218*

This data is used in this study to estimate what energy use and GHG emissions would be if the following projects went ahead using current "business as usual" building standards and energy systems:

- Killarney Industrial Park project
- Dunnottar Public Works Building
- Selkirk West End Lands Development project

The data scaled from all the floor space for these uses in all of Manitoba down to the estimated floor space used for each of these purposes in each project.

E.2.1 ENERGY PURPOSE DATA

To estimate the effects of adding renewable energy systems a building, it is necessary to understand what the energy currently being consumed by that building is used for. It is crucial to understand what percentage is going to heat. It is less crucial—but still useful—to understand how the rest of the energy is being divided up. Few buildings—and none of the target buildings in this study have detailed-enough metering to be able to determine this directly. The best proxy is also from Canada's Office of Energy Efficiency.

Table 261: Manitoba – residential – energy purpose – 2021

energy purpose	*%*
space heating	55%
space cooling	6%
water heating	17%
lighting	4%
appliances	19%
	100%

Table 262: Manitoba – commercial/institutional – energy purpose – 2021[221]

	energy purpose					
space use *sub-category*	*space heating*	*space cooling*	*water heating*	*lighting*	*auxillary equipment*	*auxillary motors*
wholesale	72%	3%	4%	8%	9%	3%
retail	69%	3%	4%	13%	8%	3%
transportation & warehousing	81%	3%	2%	10%	0.4%	4%
information & cultural industries	71%	3%	4%	10%	9%	3%
offices	69%	3%	2%	12%	11%	3%
educational services	71%	3%	4%	8%	11%	3%
health care & social assistance	56%	2%	10%	10%	18%	3%
arts, entertainment & recreation	72%	4%	3%	9%	8%	3%
accommodation & food services	70%	3%	4%	9%	10%	3%
other services	71%	3%	4%	10%	9%	3%
commercial/insitutional sector overall:	*68%*	*3%*	*4%*	*11%*	*11%*	*3%*

This data is used to estimate the percentage of a target building's energy consumption that goes to each of the purposes listed. It is also used in estimating the effects of implementing the study's recommendations.

E.2.2 TIMING OF ENERGY USE

It is intuitive that more space heating is required in winter than summer and that the opposite is true for space cooling. This study uses average Heating Degree Days (HDD) and Cooling Degree Days (CDD) per month to estimate what percentage of the energy is used for these two purposes in each month.

[221] "Auxiliary equipment" includes stand-alone equipment powered directly from an electrical outlet such as computers, photocopiers, refrigerators and desktop lamps. It also includes equipment that can be powered by natural gas, propane or other fuels, such as clothes dryers and cooking appliances.

"Auxiliary motors" refers to devices used to transform electric power into mechanical energy to provide a service, such as pumps, ventilators, compressors and conveyors.

Table 263: Average percentages of Heating Degree Days and Cooling Degree Days in each month[222]

	HDD	*CDD*
Jan	17%	
Feb	17%	
Mar	13%	
Apr	9%	
May	4%	8%
Jun	1%	25%
Jul	1%	33%
Aug	1%	24%
Sep	3%	9%
Oct	7%	1%
Nov	11%	
Dec	16%	

This data is used to estimate the monthly heating and cooling demand.

[222] BizEE Degree Days. https://www.degreedays.net. The data covers a 5-year period—June 2019 to May 2023.

Appx. F Estimating Energy Costs

$$cost = price\ per\ unit\ of\ energy \times number\ of\ units\ of\ energy$$

This may seem like an obvious and simple equation. It is not, because pricing energy is not simple.

This study uses simplified pricing to enable comparison between options:

- *natural gas* .... $0.35/m^3
- *electricity*
  - purchased from Manitoba Hydro $0.10/kWh
  - sold to Manitoba Hydro:
    - if the solar array has a capacity of less than 100 kw $0.05607/kWh
    - if the solar array has a capacity of greater than 100 kw $0.05/kWh

This appendix explains how these simplified numbers are derived.

These prices include:

- *the basic charge*
  - Manitoba Hydro charges a monthly fee—usually applied per meter—to provide energy. On their bills, this is called the "Basic Charge".
  - On the bills supplied for this study which have this detailed, this charge averaged $52/meter/month
- *the energy charge*
  - an amount charged per unit of energy consumed
  - For example, Manitoba Hydro charges "general service medium" customers $0.08769/kWh for the first 19,500 kWh of electricity they consume in a month, and $0.04546/kWh for any additional kWh they consume in that month.[223]
  - On electricity bills, this is usually labelled the "Energy Charge".
  - On natural gas bills, it is labelled "Gas Commodity (Centra)" or simply "Gas Commodity".
    - On the bills supplied for this study which have this detailed, this charge average $52/meter/month ($0.15/m3)
- *the demand charge*
  - This appears on Manitoba Hydro's commercial electricity bills as "Demand".
  - Demand charges can add substantially to the price of energy, beyond the energy charge.
  - Manitoba Hydro's Commercial rates webpage details how "demand charges" for electricity vary by commercial general service rate options, based on kVA (kilovolt amperes), but does not explain what a demand charge is.

[223] Manitoba Hydro. (2024). *Commercial rates.* https://www.hydro.mb.ca/account/billing/rates/commercial/

    - Manitoba Hydro's website defines "Demand" for natural gas as "A monthly charge that recovers costs incurred by Manitoba Hydro for the use of capacity on pipeline and storage facilities to transport natural gas to Manitoba for distribution."[224]
    - Other websites[225] explain that a "demand charge" for electricity is a charge for the peak demand required by a customer over a given period of time.
- *the price of delivery*
  - On natural gas bills, this is labelled "Delivery".
  - Manitoba Hydro's webpage explains this as "The Delivery cost on your bill includes the costs to transport natural gas to Manitoba and distribute the gas to your home or business. Transportation costs include pipeline charges and the costs to store gas purchased in the summer for use in the winter. Distribution costs include the costs of installed pipeline and facilities, operation and maintenance costs, and other services provided to you." [226]
- *the Federal Carbon Charge (FCC)*
  - Charged on natural gas, but not on electricity,
  - As of April 1, 2024, this is \$80 per tonne of greenhouse gas—\$0.1525/m^3 for natural gas.[227]
  - This charge, commonly called "the carbon tax" is not considered by either the federal provincial or provincial governments as a tax, so it is not classified as a tax in this study.

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[224] Manitoba Hydro. (n.d.). *Glossary of bill terms.* https://www.hydro.mb.ca/account/billing/how-to-read-your-bill/

[225] See, for example:

- Government of Alberta. (n.d.). *Understanding Demand Charges.* Utilities Consumer Advocate. https://ucahelps.alberta.ca/understanding-demand-charges.aspx
- Fields, S. (2024, February 27). *Demand charges explained: What you need to know.* Energy Sage. https://www.energysage.com/electricity/how-do-demand-charges-work/

[226] Manitoba Hydro. (n.d.). *How to understand your bill.* https://www.hydro.mb.ca/account/billing/how-to-read-your-bill/. This helpful webpage explains bills sent to residential customers. If there is a similar web page for commercial customers, we were not able to find it. Manitoba Hydro's Commercial Rate page advises readers to "Contact your Energy Service Advisor for general service rate information, and terms and conditions."

[227] Manitoba Hydro. (2024). *What the federal carbon charge means for you.* https://www.hydro.mb.ca/account/billing/rates/carbon-charge/#:~:text=The%20federal%20carbon%20charge%20puts,natural%20gas%20that%20we%20sell.

F.1 Biomass Pricing

Biomass is not a standardized commodity like natural gas or electricity. The best approach is to find at least one—and ideally three—local suppliers and agree on multi-year contracts.

Table 264: Biomass pricing & energy density[228]

material	average energy density MWh/tonne	price per tonne	price per MWh	suppliers
crop by-products & waste				
barley straw	4.7	$50	$21	*local supply available near every participating community*
wheat straw	5.0	$50	$21	
oat hull pellets	5.3	$110	$21	Richardson Milling
		$150	$28	Buffalo Creek Mills
hemp pellets	5.0	*pending*		Hemp Sense
woody by-products & waste				
wood logs	*varies by tree species & moisture percentage*			Firewood Manitoba
				Riehl's Lumber & Logging
				South East Logging
				Spruce Wood Loggers
wood chips	2.9	$100	$34	Spruce Wood Loggers
wood pellets	5.5	$175	$32	Prairie Pellets
waste wood from urban forests	2.9	*variable*		*may be available at municipal waste management facilities*
clean waste construction wood	4.1			

Depending on the travel distance required, biomass prices may not include delivery.

Contact information for suppliers is found in the section above—Biomass Suppliers in Manitoba.

F.2 Natural Gas Pricing

Table 265: Natural Gas – 2023 – average amount charged per cubic metre for each component the overall price[229]

basic charge	$0.015
energy charge	$0.152
delivery charge	$0.085
Federal Carbon Charge	$0.096
	$0.349

[228] Note: Inclusion of company in listing should not be considered endorsement. Listing is for information only.)

[229] Not all billing information supplied for this study detailed the pricing of each component of the natural gas price. These are the averages of the prices for each component, from the bills which contained these details.

F.4 Taxes

These prices do not include taxes applied on energy. These taxes include:

- 5% federal GST
    - usually shown on Manitoba Hydro bills as "G"
- 7% provincial RST (retail sales tax)[230]
    - usually shown on Manitoba Hydro bills as "P"

[230] For more detail on RST rates for energy see:

- Province of Manitoba. (n.d.). Electricity and Piped Gas. Department of Finance, Taxation Division. https://www.gov.mb.ca/finance/taxation/electricity.html#:~:text=The%207%25%20Retail%20Sales%20Tax,monthly%20on%20their%20RST%20return.

Appx. G Methodology for Measuring GHG Emissions

At least one year of monthly statements detailing energy use for both heat and power for each target building was provided through the participating communities.

From this, energy used for both heat and electricity was determined for each month.

This data was then integrated with Heating Degree Days and Cooling Degree Days for each location, both for those 12 specific months, and for a 10-year annual average.

From this, energy consumption for an average year for each building target building was estimated.

GHG emissions for each fuel were be calculated using the latest data from the Government of Canada and the International Panel on Climate Change.

G.1 Calculating CO_2e

Three gases emitted by burning fuel are particularly relevant to understanding global warming—carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Together, these are commonly referred to as "greenhouse gas emissions" (GHGs).

Each fuel emits these three gases in particular proportions, and each of these gases has its own effect on global warming.

> *All greenhouse gases (GHGs) are not equal. Each one has a unique atmospheric lifetime and heat-trapping potential.*
>
> *The Global Warming Potential (GWP) metric examines each greenhouse gas's ability to trap heat in the atmosphere compared to carbon dioxide (CO_2). We measure this over a specified time horizon. Often, we calculate GHG emissions terms of how much CO_2 is essential to produce a similar warming effect over the chosen time horizon. This is the carbon dioxide equivalent (CO_2 eq)[231] value. We calculate it by multiplying the amount of gas by its accompanying global warming potential (GWP).*
>
> *The Intergovernmental Panel on Climate Change (IPCC) provided 100-year GWPs in its Fourth Assessment Report (SAR)….They are required for inventory reporting under the United Nations Framework Convention on Climate Change (UNFCCC). GWPs are also required to be used for facility GHG reporting under Section 46 (S.46) of the Canadian Environmental Protection Act.*[232]

[231] Three different abbreviations for "carbon dioxide equivalent" are used in various sources. This Government of Canada quote uses "CO_2 eq"; many other sources use "CO_2e"; the IPCC uses "CO_2-eq". All these abbreviations have the same meaning. This study uses "CO_2e".

[232] Government of Canada. (2023, January 31). Global warming potentials. *Environment and Climate Change.* https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/quantification-guidance/global-warming-potentials.html.

Roughly every seven years, the IPCC issues a Climate Change Assessment Report, providing comprehensive updates each time, and incorporating the latest data into its calculations. Part of that data is the best current estimate of the Global Warming Potential (GWP) of each of these three gases. This study uses the GWP of each gas from the latest IPCC Assessment Report (AR6), issued in 2021.

Table 266: Estimates of Global Warming Potential (GWP) of relevant greenhouse gases[233]

		Global Warming Potential (GWP100)		
IPCC Assessment Report		*carbon dioxide*	*methane*	*nitrous oxide*
edition	*year issued*	CO_2	CH_4	N_2O
4th	2007	1	25	298
5th	2014	1	28	265
6th	2021	1	30	273

Essentially, GWP numbers for methane and nitrous oxide estimate how much more potent those greenhouse gases are than carbon dioxide.

The fact that these numbers changed in updated editions of the IPCC's Assessment Report is not a cause for concern. Instead, it reflects the fact that, as research occurs, the estimates can become more accurate.

To calculate the overall carbon dioxide equivalent (CO_2e) of a given fuel, the amount of each of the component gases in that fuel is multiplied by that gas's GWP.

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233 "GWP100" is the standard metric for estimating global warming potential of a gas. It estimates the potential of a gas to contribute to global warming over a 100-year period. Data sources:

- 4th Assessment Report: Table 2.14, page 33, IPCC. (2007). *AR4 Climate change 2007: The Physical Science Basis.* https://www.ipcc.ch/site/assets/uploads/2018/02/ar4_syr_full_report.pdf.
- 5th Assessment Report: Table 8.7, page 714, IPCC. (2013). *AR 5 Climate change 2013: The Physical Science Basis.* https://www.ipcc.ch/report/ar5/wg1/.
- 6th Assessment Report: Table 7.15, page 1017, IPCC. (2021). *AR6 Climate Change 2021: The Physical Science Basis.* https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.

Table 267: Components of GHG emissions by fuel type[234]

	Component Gases						Greenhouse Gas Emissions (GHGs)
	carbon dioxide CO_2		methane CH_4		nitrous oxide N_2O		
Fuel	EF	GWP	EF	GWP	EF	GWP	CO_2e
natural gas	1,915		0.037		0.035		1,926 g/m^3
propane	1,515	1	0.024	30	0.108	273	1,545 g/m^3
fossil diesel	2,753		0.026		0.031		2,762 g/L
renewable natural gas			0.037		0.035		11 g/m3
biodiesel	0	0	0.026	30	0.031	273	9 g/m3
renewable diesel							
woody biomass			0.09		0.06		19 g/kg
electricity							1.9 g/kWh

[234] Notes:

- "EF"="Emission Factor"
- "GWP"="Global Warming Potential"
- In this study, the term "natural gas" is used to refer to natural gas extracted from non-renewable sources. Some sources use the term "fossil natural gas" or "fossil gas" to refer this fuel.
- "Fossil diesel" is used in this study to refer to diesel refined from non-renewable sources.
- "Renewable natural gas" refers to natural gas derived from renewable sources.
- "Biodiesel diesel" refers to FAME diesel derived from renewable sources and "renewable diesel" refers to HDRD diesel derived from renewable sources. More detail on the different types of diesel can be found in the appendix Understanding Diesel.
- Data for natural gas and for electricity are specific to Manitoba.
- Data for CH_4 and N_2O in natural gas are specific to the residential, construction, commercial/institutional, and agriculture sectors.
- Data for woody biomass presumes the biomass has 50% moisture content.

Sources:

- Government of Canada. (2023, June 14). *Emission Factors and Reference Values.* Tables 1, 2 & 6. Environment and Natural Resources. https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/output-based-pricing-system/federal-greenhouse-gas-offset-system/emission-factors-reference-values.html#toc9.
- Government of Canada. (2024). *National inventory report: greenhouse gas sources and sinks in Canada 1990 – 2022, Part 3.* Environment and Climate Change Canada. https://publications.gc.ca/collections/collection_2024/eccc/En81-4-2022-3-eng.pdf
- Government of British Columbia. (2021, April*). 2020 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions.* Tables 1 & 2. Ministry of Environment and Climate Change Strategy. https://www2.gov.bc.ca/assets/gov/environment/climate-change/cng/methodology/2020-pso-methodology.pdf.
- IPCC. (2021). *AR6 Climate Change 2021: The Physical Science Basis.* Table 7.15. https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.

Table 268: GHG emissions by fuel type

	Greenhouse Gas Emissions (GHGs)	
Fuel	CO_2e	
natural gas	1.926 kg/m^3	0.001926 t/m^3
propane	1.545 kg/m^3	0.001545 t/m^3
fossil diesel	2.762 kg/L	0.002762 t/L
renewable natural gas	0.011 kg/m^3	0.000011 t/m^3
biodiesel renewable diesel	0.009 kg/m^3	0.000009 t/m^3
woody biomass	0.019 kg/kg	0.000019 t/t
electricity	0.0019 kg/kWh	0.0000019 t/MWh

Appx. H Methodology to Measure Reductions If a Renewable Fuel Replaces Fossil Fuels

If a renewable fuel was recommended to replace a fossil fuel, the study estimated how much fossil fuel would be replaced in an average year, and that fuel's CO_2-equivalent (CO_2e) GHG emissions.

Then an estimate was made of the renewable fuel that would be consumed in an average year if it replaced that fossil fuel, and that renewable fuel's GHG emissions.

Then, to estimate the net GHG reduction, the GHG emissions of the renewable fuel was subtracted from the replaced fossil fuel's emissions.

Appx. I Understanding Energy Use in Ice Facilities

In this study, "ice facility" refers to a building with one or more ice surfaces.[235] *These ice surfaces are used for a variety of purposes, including curling and various forms of skating, including hockey.*

In this study "ice facility" does not include ice surfaces which do not use energy to freeze the ice surfaces and keep them frozen for at least part of the year.

Two the participating communities (Dauphin & De Salaberry) included ice facilities in their targets for this study. Three other participating communities (Brandon, Killarney, Selkirk) have ice facilities, but did not include them as targets in this study. These may or may not be subject to future studies.

Ice facilities in the participating communities—and throughout Manitoba—have some commonalities:

- They are almost always expensive to operate and maintain.
    - Earned revenues rarely cover operating expenses.
- They usually consume large amounts of energy.
- A significant portion of a community's population see these ice facilities as critical to their community's quality of life and attractiveness.
- Ice chilling technologies have an expected lifespan of 20 to 25 years.
- Because the capital cost to replace ice facilities is high, upgrades are usually preferred over replacement.
- Many ice facilities require significant upgrades now (or in the very near future) to extend their useable life.

They are also diverse:

- The refrigerants used vary. They vary in their global warming potential, their toxicity, and their handling requirements. They include:
    - R-12 (CCl_2F_2)
        - also referred to as CFC, Freon-12, dichlorodifluoromethane, and chlorofluorocarbon halomethane
    - R-22 ($CHClF_2$)
        - also referred to as HCFC, HCFC-22, Freon, chlorodifluoromethane, difluoromonochloromethane, and hydrochlorofluorocarbon

[235] Sources do not use consistent terms for ice facilities. Some use "ice rink", but may or may not include curling rinks in this term. Some use "ice arena" or simply "arena" but, again, may or may not including ice sheets used for curling in this term. Some use "skating rink", but may or may not include hockey arenas in this category. Some exclude facilities for professional teams, or with accommodations for large numbers of fans.

  - R-134A ($C_2H_2F_4$)
    - also referred to as tetrafluoroethane, norflurane, Klea 134a, Freon 134a, Forane 134a, Genetron 134a, Green Gas, Florasol 134a, Suva 134a, HFA-134a, and HFC-134
  - R-410A (CH_2F_2 and CHF_2CF_3)
  - R-507A (C_2HF_5 and $C_2H_3F_3$)
  - R-717 (NH_3 – ammonia)
    - also referred to as anhydrous ammonia and refrigerant grade ammonia
  - R-744 (CO_2 – carbon dioxide)
- The slab fluid (the liquid circulating under the ice) varies and can include brine, methanol, and ethelyne glycol.
- Some are operated year-round, some for most of the year, and some only for a few months each year.
- Some have change rooms and shower facilities; some do not.
- Many are used for a diverse array of recreation activities beyond curling and skating.
- Many play a crucial role in community life.
- Some are used as shelters in emergencies.

For all these reasons:

- They are of significant concern to the municipalities and community organizations which operate them.
- They have been the subject of considerable research and investigation at the federal, provincial, and municipal level.

Despite their diversity, some general statements can be made:

- Adding GSHP system and solar arrays to these facilities is an effective way to reduce operating costs.
- Integration of a GSHP system into an existing ice facility usually reduces energy consumption by *roughly* half.
- If existing refrigeration systems ("chillers") or building heating systems are powered by natural gas, adding a GSHP system will reduce GHG emissions significantly—usually by more than 50%.
  - In some cases, a GSHP system can eliminate natural gas consumption entirely.
- To get the most benefit out of integrating a GSHP system into an existing facility, a feasibility study and building-specific design is essential.
  - The feasibility study must include
    - a geotechnical investigation of the ground where the loops will be installed
    - specifics of the existing cooling systems
    - details of the proposed GSHP system and its integration into the ice chilling systems

- The feasibility study and design must be done by a specialist with expertise in integrating GSHP with ice facilities.
  - Benefits will not be maximized if they are expert in GSHP systems only.
  - The Manitoba professional generally recognized as having the most expertise in integrating GSHP systems into ice facilities is Ed Lohrenz of GEOptimize.236

Useful sources include:

- Bryson, M. (2007, March). *Conventional Ice Rink Refrigeration versus Geothermal Ice Rink Systems.* Recreation Facilities Association of British Columbia. https://rfabc.com/wp-content/uploads/2022/08/rinkrefr.pdf
- Government of Canada. (2019). *Energy Benchmarking Data Snapshot for Ice/Curling Rinks.* Natural Resources Canada. Cat. No. Energy Star Portfolio Manager. M144-280/3-2019E-PDF. https://publications.gc.ca/collections/collection_2021/rncan-nrcan/M141-28-2019-eng.pdf
- Government of Canada. (2013, July). *Comparative study of refrigeration systems for ice rinks*. CanmetENERGY, Natural Resources Canada. https://natural-resources.canada.ca/sites/www.nrcan.gc.ca/files/energy/pdf/comparative-study-arenas_EN.pdf
- Government of Canada. (2000, April). *Case Study: Geothermal Ice Plant Efficiently Replaces Aging Ammonia System — Oliver Curling Club, Oliver, B.C.* Renewable Energy, Vol. 1 Issue 3. https://publications.gc.ca/collections/Collection/M143-4-1-3E.pdf
- Government of the United States. (2017, August). *ENERGY STAR Score for Ice Rinks.* Environmental Protection Agency, Energy Star Portfolio Manager Technical Reference. https://www.energystar.gov/sites/default/files/tools/Ice_Rinks_August_2017_EN_508.pdf
- Lohrenz, E. (2023). *Geothermal Modelling Case Study - Winnipeg's Dakota Community Centre.* Sustainable Building Manitoba. https://www.youtube.com/watch?v=YxuAe2gpzMc
- Lohrenz, E. (2021). *Geothermal Ice Rinks.* Clean Air Council. https://council.cleanairpartnership.org/wp-content/uploads/2021/07/GeoIceRinks.pdf

[236] Lohrenz, E. *LinkedIn.* https://www.linkedin.com/in/edlohrenz?originalSubdomain=ca

Appx. J Understanding Diesel

There are three types of commercially available diesel. Unfortunately, not all sources use the same terms for these three types of diesels, often causing confusion.

Table 269: Types of diesels[237]

	term used in this study	*common terms in other sources*	*production process*	*production process result*	*renewable?*
1.	fossil diesel	diesel petroleum diesel	petroleum refining	hydrocarbon mixture	no
2.	FAME diesel	biodiesel green diesel 1st generation biodiesel B100 B100 biodiesel RME	transesterification	fatty acid methyl esters (FAME)	***may*** be considered renewable, depending on whether feedstock source is considered renewable
3.	HDRD diesel	renewable diesel green diesel 2nd generation biodiesel HVO100 renewable diesel	hydrogenation	hydrogenation -derived renewable diesel (HDRD)	

Additional details on each type of diesel:

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[237] Sources:

- Awogbemi, O., Kallon, D. V. V., & Pelemo, J. (2022, May 25). Performance and emission characteristics of hydrogenation derived renewable diesel as diesel engine fuel. *Diesel Engines and Biodiesel Engines Technologies.* https://www.intechopen.com/chapters/81895.
- Gerveni, M., Irwin, S., & Hubbs, T. (2023, February 9). Biodiesel and renewable diesel: What's the difference? *farmdoc daily.* https://farmdocdaily.illinois.edu/2023/02/biodiesel-and-renewable-diesel-whats-the-difference.html.
- Biofuel Express. (2021, March 8). https://www.biofuel-express.com/en/what-is-the-difference-between-1st-and-2nd-generation-biodiesel/.
- Government of Canada. (2020, May 15). *Biodiesel.* Natural Resources Canada. https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/alternative-fuels/biofuels/biodiesel/3509.
- Majewski, W. A. & Jääskeläinen, H. (n.d.). *What is the difference between 1st and 2nd generation biodiesel?* DieselNet. https://dieselnet.com/tech/fuel_diesel.php.
- Soomro, A. (n.d.). *Biodiesel; Definition, Advantages and Disadvantages.* Environment Buddy. https://www.environmentbuddy.com/energy/biomass-energy/biodiesel-definition-advantages-and-disadvantages/.
- U.S. Department of Energy. (n.d.). *Renewable Diesel.* Alternative Fuels Data Center. https://afdc.energy.gov/fuels/renewable_diesel.html.

1. *Fossil diesel*
   - the default form of diesel in the marketplace
   - refined from crude oil
   - widely used in heavy equipment and in electricity production
   - because it is very similar in chemical composition, often used as a substitute for light fuel oil for heating buildings
2. *FAME diesel*
   - widely used form of biomass-derived diesel
   - often blended with fossil diesel
   - produced from:
     - plant oils
     - canola, camelina, soy, flax, jatropha, mahua, pinnata, mustard, coconut, palm, hemp and sunflower
     - waste cooking oil
     - yellow or tap grease
     - animal fats:
     - beef or sheep tallow, pork lard, or poultry fat
   - additional potential sources (not yet commercially mature)
     - algae
     - agriculture and forest biomass
   - has both benefits and drawbacks when compared to fossil diesel
     - benefits:
     - biodegradable
     - emits less carbon monoxide & particulate matter than fossil diesel
     - ignites at a higher temperature than fossil diesel, so is less likely to ignite accidently, making transportation & storage easier and safer
     - increases fuel lubricity, resulting in fewer deposits in the engine, improving engine functioning, and may therefore extend engine life
     - drawbacks:
     - gels at lower temperatures, so may cause engines to cease functioning in cold climates
     - may grow mold if stored at room temperature
     - engine seals and gaskets may degrade over time
     - higher cost
3. *HDRD diesel*
   - a newer form of biomass-derived diesel
   - produced from same feedstocks as FAME diesel
   - unlike FAME diesel

- is not biodegradable
- does not gel at lower temperatures
- does not grow mold at room temperature

Adding to the confusion, in some sources, "1st generation biodiesel" refers to diesel derived from purpose-grown crops and "2nd generation biodiesel" refers to diesel derived from residual and waste biomass. This study does not follow that practice.

Appx. K Renewable Energy Options Beyond the Scope of this Study

K.1 Cattails

One of the most promising sources of sustainable biomass in Manitoba are the many thousands of tonnes of cattails (scientific name: *Typha*) that grow in marshes and ditches in and around the communities participating in this study.

Figure 224: Cattails near RM of Killarney Turtle Mountain

Research on this fuel source, led by Richard Grosshans and advanced by the IISD (International Institute for Sustainable Development), show that cattails could be developed into an abundant, renewable source of biomass fuel throughout much of southern Manitoba.[238],[239]

In addition to providing a new, local renewable biomass fuel source, there are significant social and environmental benefits[240] for Manitoba that would result from harvesting cattails at scale. These include:

- extracting nitrogen and phosphorous nutrients from Manitoba wetlands, marshes, lakes and rivers, which has the benefits of:
  - reducing algal blooms

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[238] Grosshans, R. (2014). Cattail (*Typha* spp.) biomass harvesting for nutrient capture and sustainable bioenergy for integrated watershed management. *University of Manitoba.* https://mspace.lib.umanitoba.ca/server/api/core/bitstreams/efd56a5c-90ae-4515-a9b3-9d8541b5f2d3/content.

[239] Grosshans, R., & Grieger, L. (2015, January 19). Cattail biomass to energy: Commercial scale harvesting of cattail biomass for biocarbon and solid fuel. *IISD (International Institute for Sustainable Development).* https://www.iisd.org/publications/report/cattail-biomass-energy-commercial-scale-harvesting-cattail-biomass-biocarbon.

[240] Sometimes called "co-benefits" or "Ecological Goods and Services (EGS)".

  - reducing eutrophication
  - reducing oxygen depletion in river and lake water
  - increasing wetland biodiversity[241]
  - enabling fertilizer recycling[242]
- creating jobs
- diversifying farm income
- stimulating rural economic development

Figure 225: Cattails in ditch in RM of De Salaberry

Because commercial-scale cattail harvesting is not yet occurring in North America, cattails are not proposed as a source of biomass fuel for the buildings studied in this study. Two main obstacles stand in the way of cattails becoming a commercial-scale biomass fuel in Manitoba:

- suitable harvesting equipment
- efficient method for processing into fuel

Neither of these obstacles are insurmountable. Once these issues have been addressed, cattails should become a major biomass fuel source in Manitoba, at a scale comparable to the biomass available from forestry and agriculture.

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[241] When nutrient levels are elevated in wetlands, cattails grow more aggressively than other plants, crowding them out and reducing biodiversity. Harvesting cattails in wetlands—especially if they can be cut below the water line—can help restore the wetland to a more diverse ecosystem.

[242] The nutrients remain behind in the ash after the biomass is burned as fuel. The ash can then be used as a component in fertilizer.

K.1.1 OVERCOMING OBSTACLES – SUITABLE HARVESTING EQUIPMENT

Cattails grow primarily in wet ditches and marshes.

To maximize the ecological benefits of cattail harvesting, harvesting should occur while the stalks and leaves are still green because, once the first hard frost kills the leaves and stems, the plant pulls nutrients down into the roots. Harvesting when they are green ensures that the nutrients are removed.

Harvesting in wet ditches requires equipment adapted for soft and watery ground, including balloon tires on tractors.

Harvesting in marshes will require either floating harvesting equipment, or the creation of artificial cattail "islands" that can be pulled to shore for harvesting.

Figure 226: Harvesting cattails in wetlands[243]

[243] Austin, A. (2011, April 27). An unconventional pellet feedstock. *Biomass Magazine.* https://biomassmagazine.com/articles/an-unconventional-pellet-feedstock-5461

K.1.2 OVERCOMING OBSTACLES – PROCESSING CATTAILS INTO USEABLE FUEL

Cattail bales are very dense.

Figure 227: A cattail bale[244]

To be used as fuel, this material must be chopped into a form suitable for use on a walking floor or processed into pellets. It currently costs more to process cattail biomass into fuel than processing forestry or agricultural biomass materials.

Again, this is not an insurmountable problem, but suitable equipment and efficient processes require further development and commercialization. Typha Company, based in Manitoba, has developed mulch, a soilless growing media and biodegradable flowerpots from cattails. They could be valuable partners in the development of financially viable biomass fuel.[245]

[244] Austin, A. (2011, April 27). An unconventional pellet feedstock. *Biomass Magazine.* https://biomassmagazine.com/articles/an-unconventional-pellet-feedstock-5461.

[245] Typha Company. (n.d.). https://typhacompany.com/.

K.2 Commercial Battery Storage Systems[246]

A discussion of short-term battery storage is included in the body of this report, at *Short-Term Battery Storage*. This section deals with longer-term storage.

Battery Energy Storage Systems scaled for buildings, commercial operations, and local municipal infrastructure are often called "Commercial Battery Storage Systems".

- Larger-scale BESS are usually called "Utility-Scale Battery Storage" or "Grid-Scale Battery Storage".

The current state of battery technology can enable smoothing between daytime production and nighttime demand, as well as some smoothing between sunny and cloudy days. Battery technology can also be used to sustain the short power outages. To be useful for these purposes, a Battery Energy Storage System should be able to supply the electricity needs of a building for 24 to 48 hours.

The current state of battery technology is not feasible for longer-term electricity storage—such as storing production from the summer to supply demand in the winter.

Although Battery Energy Storage Systems would be useful for virtually all the solar arrays recommended in this study, the cost is still too high to be recommended for installation at this stage. Recent media announcements give the impression that battery storage costs less than $200/kWh.[247] A more realistic estimate is that commercial-scale systems still cost more than $1,000/kWh,[248] while Utility- and Grid-Scale Battery Storage is still more than $500/kWh.[249]

To take an example of what it would cost to provide 48 hours of storage capacity, the Brandon Civic Centre Complex uses an average of 875 kWh of electricity per day, so a Battery Energy Storage System associated with that building would require 1,750 kWh of storage to supply the electricity needs of that Complex for 40 hours. If the price of a Commercial Battery Storage System dropped to $1,000/kWh, the capital cost of a Battery Energy Storage System to for this Complex would be more than $1.7 million.

These costs are continuing to come down, declining between 5% and 10% per year.

There are other promising energy storage systems under development,[250] but most of these are not yet ready for commercial deployment.

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[246] To simplify comparisons, all prices in this section are given in Canadian dollars.

[247] A typical example of a media story on this issue is:

- Bloomberg NEF. (2023 Nov 26). *Lithium-Ion Battery Pack Prices Hit Record Low of $139/kWh.* https://about.bnef.com/blog/lithium-ion-battery-pack-prices-hit-record-low-of-139-kwh/

[248] National Renewable Energy Laboratory. (2023). *Commercial Battery Storage.* https://atb.nrel.gov/electricity/2023/commercial_battery_storage

[249] Cole, W., Karmakar, A. (2023). *Cost Projections for Utility-Scale Battery Storage: 2023 Update*. National Renewable Energy Laboratory. NREL/TP-6A40-85332. https://www.nrel.gov/docs/fy23osti/85332.pdf

[250] For a recent overview of developments, see:

- Ross. K.M. (2024 Apr 24). *Battery energy storage developments that are electrifying the sector.* Power Technology. https://www.power-technology.com/features/battery-energy-storage-developments-that-are-electrifying-the-sector/?cf-view

The recommended approach to Battery Storage for the communities participating in this study is to review the prices periodically (at least every five years). If Battery Energy Storage Systems do come down enough in price to be viable for these communities, priority should be given to facilities designated as essential services and emergency shelters.

K.3 Non-Photovoltaic Solar

This study includes photovoltaic solar (PV solar) arrays to offset electricity demand for most projects recommended. It does not, at least at this stage, recommend other forms of solar energy generation.

The most common system for solar energy generation other than PV solar is usually called "Active Solar Heating".[251] This is a well-established form of energy generation but is not recommended in this study as including it would add another energy system for municipalities to manage and the benefits of systems of this sort are likely to be less than the benefits of the other systems recommended. However, active solar heating could be a useful addition to the renewable energy systems recommended as an additional, later stage.

"Thermal Solar". Thermal solar systems are also often referred to as "solar arrays". This is not done in this study.

K.4 Using Process Heat to Generate Electricity

This study has considered industrial process waste heat as a potential source of building heat. There is an additional potential use for industrial process waste heat—to generate electricity. A comprehensive US study examines the feasibility of using waste heat for this purpose:

> *Waste heat to power (WHP) is the process of capturing heat discarded by an existing process and using that heat to generate electricity. In the industrial sector, waste heat streams are generated by kilns, furnaces, ovens, turbines, engines, and other equipment. In addition to processes at industrial plants, waste heat streams suitable for WHP are generated at field locations, including landfills, compressor stations, and mining sites.* [252]

> *[T]he U.S. alone has the potential to produce 15 gigawatts [15,000 MWh per year] of power [electricity] from its industrial waste heat….Since converting waste heat to electricity would result in zero additional emissions, waste heat conversion projects can also generate carbon offsets and lower the carbon intensity of the industries that develop them.*[253]

Not all waste heat is suitable for electricity generation; it must be hot enough to drive either steam turbines or Organic Rankin Cycle (ORC) systems—typically above 200°C. Fortunately, many industrial processes produce these high temperatures.

An added advantage of these industrial processes is that they can produce reliable "firm" electricity, providing a crucial complement to renewable energy systems such as wind farms and larger solar arrays which provide variable power.

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[251] Government of the United States. *Active Solar Heating.* Department of Energy. https://www.energy.gov/energysaver/active-solar-heating

[252] ICF International. (2015, March). Waste heat to power market assessment. *Oak Ridge National Laboratory.* https://info.ornl.gov/sites/publications/files/Pub52953.pdf.

[253] Terrapin. (2022, January 11). What produces waste heat & how can it power our planet? https://www.terrapingeo.com/what-produces-waste-heat.

While generating electricity at scale may not be a suitable project for a municipality to develop on its own, generating electricity from waste industrial heat very likely could provide economic development opportunities for public/private partnerships.

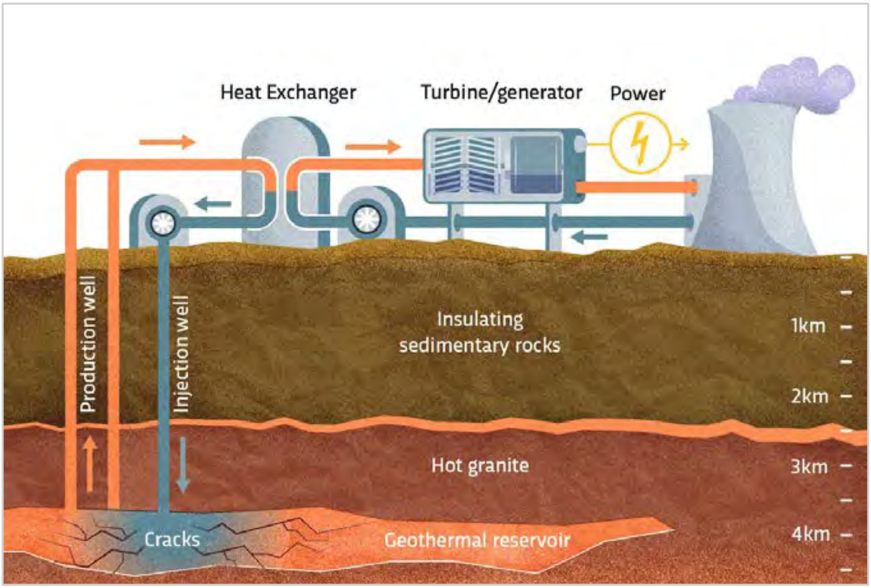
It is strongly recommended that further study be undertaken on using waste industrial heat to generate electricity in Manitoba.

K.5 Deep-Source Geothermal

Although the term “geothermal” is often used to refer to ground-source heat pumps, it should properly be applied only to the extraction of heat arising from deep within the earth.

When close to the surface, this heat produces natural phenomenon such as hot springs. (When it rises right to the surface, it can produce lava flows.) Depending on the geology of a particular area, the heat can be harnessed to provide heat and, if hot enough, electricity.

Figure 228: Schematic of deep-source geothermal energy production[254]



Iceland is an excellent example of a location where the geology—combined with a society’s commitment to renewable energy—is harnessed in this way.[255]

[254] Drawing source: Spanner, H. (2022, February 13). How does geothermal energy work to produce electricity? *BBC Science Focus Magazine.* https://www.sciencefocus.com/science/how-does-geothermal-energy-work-to-produce-electricity.

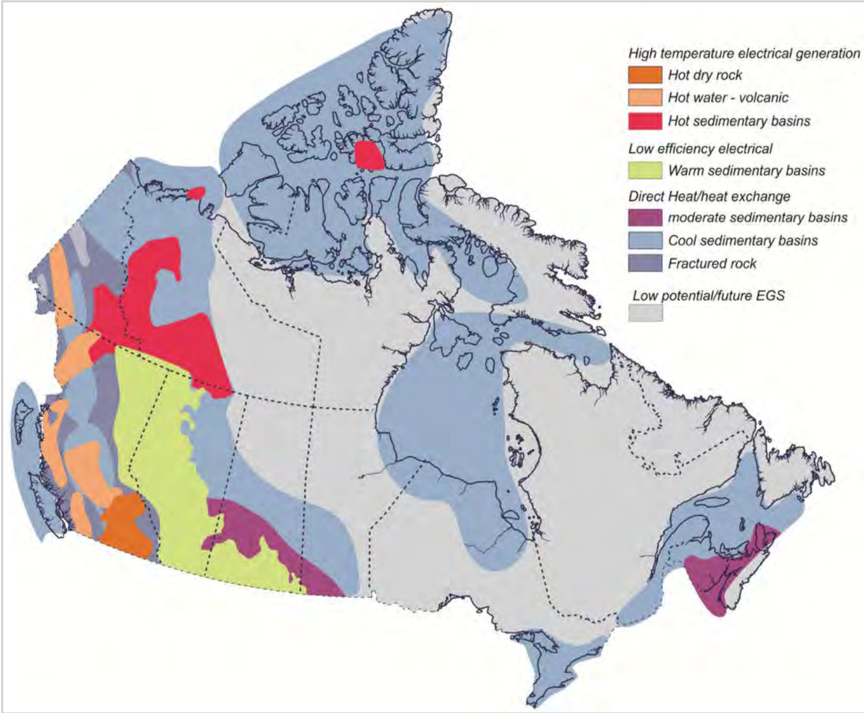
[255] Mims, C. (2008, October 20). *One Hot Island: Iceland’s Renewable Geothermal Power*. Scientific American. https://www.scientificamerican.com/article/iceland-geothermal-power/.

Figure 229: Krafla geothermal power plant in Iceland[256]

Although Canada cannot match the near-ideal deep-source geothermal conditions of Iceland, promising research and development is being done to explore the potential for deep-source geothermal energy here.

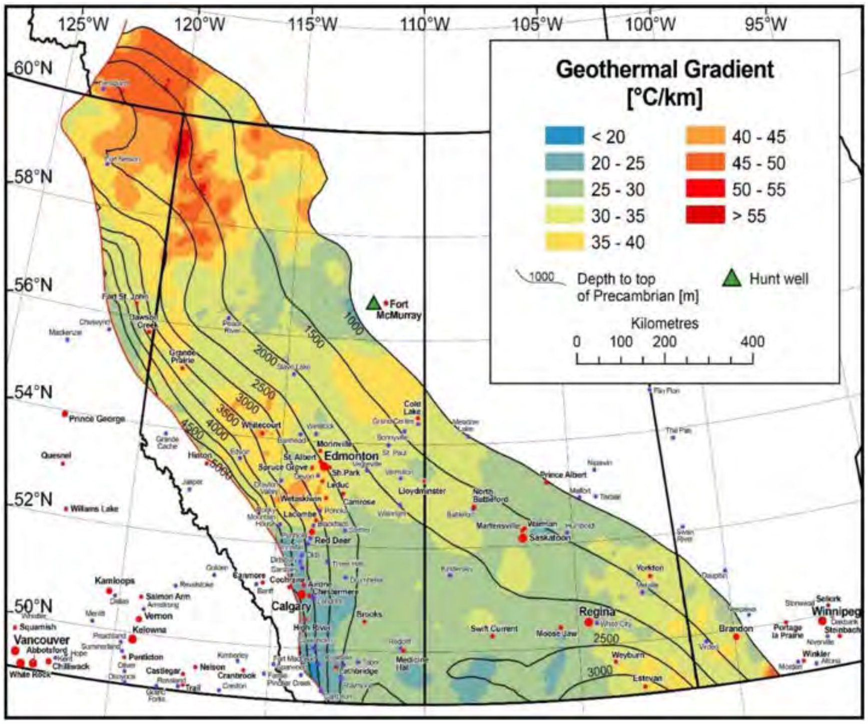
[256] Photo by Ásgeir Eggertsson, CC BY-SA 3.0. Source: Buchsbaum, L. M. (2023, March 28). *Geothermal Iceland: This land of fire and ice is pushing the limits of its natural energy.* EnergyTransition.org. https://energytransition.org/2023/03/geothermal-iceland-this-land-of-fire-and-ice-is-pushing-the-limits-of-its-natural-energy/.

Figure 230: Distribution of geothermal potential in Canada based on end use.[257]



[257] Source: Figure 2 of Grasby, S. E., Allen, D. M., Bell, S., Chen, Z., Ferguson, G., Jessop, A., Kelman, M., Ko, M., Moore, J., Moore, M., Raymond, J., & Therrien, R. (2012). *Geothermal Energy Resource Potential of Canada.* Natural Resources Canada. https://publications.gc.ca/collections/collection_2013/rncan-nrcan/M183-2-6914-eng.pdf.

Figure 231: Geothermal gradient within Western Canadian Sedimentary Basin[258]



Significant progress has been made by DEEP Earth Energy Production Corp.[259] in developing this potential source of energy into a viable commercial operation in southeast Saskatchewan.

[258] Source: Figure 4 of Majorowicz, J., & Grasby, S. E. (2021, January 30). *Deep geothermal heating potential for the communities of the Western Canadian Sedimentary Basin.* Energies 14(3): 706. https://doi.org/10.3390/en14030706.

[259] Cariaga, C. (2023, July 11). *Deep provides detailed updates on Saskatchewan, Canada geothermal project.* Think GeoEnergy. https://www.thinkgeoenergy.com/deep-provides-detailed-update-on-geothermal-project-in-saskatchewan-canada/.

Figure 232: Drilling rig at the DEEP project site

Their project is currently in an advanced stage of development. It is located near Estevan, Saskatchewan, approximately 250 km west of two of our participating communities—Brandon and Killarney Turtle Mountain).

While this may not be a suitable project for a municipality to develop, if the project in Saskatchewan proves out, it *could* be a model for an economic development initiative in southwest Manitoba.

K.6 Large Scale Solar Arrays & Wind Farms

Federal, provincial, and municipal governments have made statements committing to a transition away from fossil fuels and towards renewables.

To make this transition, many large-scale solar arrays and wind farms will need to be built in Manitoba.

Given that, by law, Manitoba Hydro has the monopoly on the retail sale of electricity in Manitoba, these systems will need to be designed, primarily, for the sale of electricity into the grid.

If we are to make this transition, the commitments made by all three levels of government will need to be turned into actions.

We will also need to grapple with some practical questions, such as:

- How many of these facilities will be needed?
- Where will they be located?
- How will their capital costs be covered?
- Who will build, own, and operate them?

There has been some recent work done in answering these questions, but we are behind other provinces.[260]

It appears unlikely that Manitoba municipalities will be the owners of these facilities. Instead, they will need to play crucial supporting roles.

Although a discussion of how municipalities will play these supporting roles is beyond the scope of this study, this discussion is urgently needed. It is strongly recommended that the communities participating in this study—and other municipalities in Manitoba—help initiate and play a role in that discussion.

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[260] See, for example:

- Manitoba Hydro. (2023, July). *Integrated Resource Plan*. https://www.hydro.mb.ca/corporate/planning/.
- Kives, B. (2023, July 28). Manitoba plans to use wind power to double or triple energy-generating capacity over next 2 decades. *CBC News.* https://www.cbc.ca/news/canada/manitoba/manitoba-energy-policy-1.6921091.
- *Global News.* (2023, July 28). Manitoba Hydro Foreshadows Integrated Resource Plan as a part of Provincial Clean Energy Initiative. *Global News.* https://globalnews.ca/video/9864022/manitoba-hydro-foreshadows-integrated-resource-plan-as-a-part-of-provincial-clean-energy-initiative.
- Sala, A. (2023, December 4). Manitoba Hydro mandate letter. *Government of Manitoba.* https://www.manitoba.ca/asset_library/en/executivecouncil/mandate/hydro_mandate_letter_2023.pdf.
- Da Silva, D. (2023, December 5). Province replaces all but one member of Manitoba Hydro Board. *Winnipeg Free Press.* https://www.winnipegfreepress.com/breakingnews/2023/12/04/province-replaces-all-but-one-member-of-manitoba-hydro-board.
- Kives, B. (2023, December 23). The time has come for a serious conversation about Manitoba's electricity needs. *CBC News Analysis.* https://www.cbc.ca/news/canada/manitoba/manitoba-clean-energy-plan-analysis-1.7068574.

Appx. L Local Climate Change

The scientific consensus is that global warming is occurring now and, unless we significantly reduce the amount of CO_2 we put into the atmosphere, modelling predicts that warming will accelerate in future years.

Organizations with the ability to compile world-wide weather data report that 2023 was the hottest year on record.[261]

And, anecdotally, many people in Manitoba report that our climate is warming already. Our winters seem to be less severe than they were in the past.

Fortunately, we do not have to rely on either the scientific consensus, global data, or anecdotes to know if the climate in southern Manitoba is getting warmer.

Weather stations throughout Manitoba have recorded daily weather data for decades. Some of these weather stations have been recording this data since 1890, providing us with a local, daily record stretching over more than 130 years. The appendix Analysis of Historical Daily Weather Station Data examines this data and compiles the results.

L.1 Key Data

Five key data points are relevant to understanding how the energy needs of the participating communities can be expected to change over the next 30 years.

13. average annual is minimum daily temperature
14. average annual maximum daily temperature
15. average annual mean daily temperature
16. total annual Heating Degree Days
17. total annual Cooling Degree Days

The first three are straightforward:

- Amongst other data, a weather station records the minimum and maximum temperatures occurring at a specific location each day.
- The minimum daily temperature is the coldest temperature recorded over the 24 hours of that day. Similarly, the maximum daily temperature is the hottest temperature recorded over the 24 hours of that day.
- The mean daily temperature is the temperature halfway between the minimum temperature recorded that day and the maximum temperature recorded that day.
- Adding all the minimum (or mean, or maximum) daily temperatures in a year and then dividing that total by the number of days in the year yields the average annual minimum (or mean, or maximum) daily temperature.

[261] U.S. Department of Commerce. (2024 Jan 12). *2023 was the world's warmest year on record, by far.* National Oceanic and Atmospheric Administration, National Centers for Environmental Information (NCEI). https://www.noaa.gov/news/2023-was-worlds-warmest-year-on-record-by-far#:~:text=It's%20official%3A%202023%20was%20the,a%20record%20low%20in%202023

The last two—which are particularly relevant to this study—may need some explanation.

> *Heating Degree Days are a measure of how much heating is required in a year. 18°C is the temperature below which heating is required to maintain a comfortable temperature inside buildings. A place that gets many days with average temperatures below 18°C or that gets mean temperatures much below 18°C will require a relatively large amount of energy (and thus money) to heat buildings for comfort and safety. If a location shows a decrease in projected HDD values, this implies that it will experience shorter periods of cold weather, or that it will experience less severe cold.*[262]
>
> *Cooling Degree Days are often used to estimate how much air-conditioning is required in a year. If a location shows an increase in projected CDD values, this implies that it will experience hotter or longer summers. 18°C is the temperature at which air conditioning is required to maintain a comfortable temperature inside buildings. A place that gets many days with average temperatures above 18°C or that gets mean temperatures much higher than 18°C will require a relatively large amount of energy (and thus money) to cool buildings for comfort and safety.*[263]

The results show a clear warming trend for southern Manitoba. Temperatures have increased between 1.3ºC and 2.2ºC. Heating Degree Days (HDD) have declined by 9%, while Cooling Degree Days (CDD) have increased by 25%.

These data very closely match the modelling complied in the Climate Atlas of Canada[264] for southern Manitoba in general, and for the participating communities in particular. As a result, we can have confidence that the Atlas models are the best prediction available for our climate future. Those models project that the warming trends we have experienced so far will continue—and very probably accelerate—resulting in a moderate decline in heating requirements and a very significant increase in cooling requirements.

Three sources are relevant in developing a more detailed understanding of the past, present, and estimated future of the climate for each participating community:

- historical daily weather station data[265]
- Canadian Climate Normals[266]

[262] This quote is the Climate Atlas of Canada's non-technical explanation of Heating Degree Days. (Heating Degree Days. (n.d.). *Climate Atlas of Canada.* https://climateatlas.ca/map/canada/hdd_2060_85#). This link also provides a technical description of Heating Degree Days.

[263] This quote is the Climate Atlas of Canada's non-technical explanation of Cooling Degree Days. (Cooling Degree Days. (n.d.). *Climate Atlas of Canada.* https://climateatlas.ca/map/canada/cooldd_2060_85#). This link also provides a technical description of Heating Degree Days.

[264] *Climate Atlas of Canada.* (n.d.). https://climateatlas.ca/

[265] Government of Canada. (2024 January 30). *Historical Data: Past Weather and Climate.* Environment and Natural Resources. https://climate.weather.gc.ca/historical_data/search_historic_data_e.html.

[266] Government of Canada. (2024 January 30). *Canadian Climate Normals.* Environment and Natural Resources. https://climate.weather.gc.ca/climate_normals/index_e.html

- Climate Atlas of Canada[267]

L.2 Historical Daily Weather Station Data

Historical weather station data is useful for this study because it can tell us, in specific detail, if climate change is already occurring. Because climate models predict that temperatures are increasing, if this change is observed, over the long term, in actual daily data, this give us increased confidence that the climate models are predictive for our local climate.

There are weather stations distributed throughout Manitoba that have recorded daily weather data for decades. Each of the communities in this study have at least one weather station that has been recording this data every day. Some of weather stations have been recording this data since 1890, providing us with a daily record stretching over more than 130 years.

All this data is compiled together in a very large database by Environment Canada.[268] This study has used that database to determine if the average temperature has, in fact, increased and, if so, by how much.

This data strongly indicates that southern Manitoba is already experiencing a climate warming trend, with the number of very cold days already showing significant decline.

The participating community with the longest continuous daily weather data is Brandon, which has daily data from 1890 to the present day. As a result, Brandon's data can provide crucial insight into how our climate is changing over the long term.

L.2.1 RELEVANT BRANDON WEATHER STATIONS

Brandon has three weather stations that are relevant for this study:[269]

- Brandon CDA ("CDA") collected daily data from 1890 to 2007.
- Brandon A ("A") collected data intermittently from 1941 to 1951, and then every day from 1952 to today.
- Brandon RCS ("RCS") began collecting data every day starting in 2012 and is still collecting data today.

[267] *Climate Atlas of Canada.* (n.d.). https://climateatlas.ca/, made available through *Prairie Climate Centre.* (2023, September 25). https://prairieclimatecentre.ca/

[268] Source: Government of Canada. (2023, November 30). Station Data Download. *Climate Data Canada.* https://climatedata.ca/download/#station-download. (Note that the date given for this source is November 30, 2023; that is the date the site was last updated. The data itself was downloaded in January 2024 and includes data up to December 31, 2023.)

[269] There are other Brandon weather stations, but they are less relevant to our study because they have not been collecting data for as long, and they are further away than these three.

Figure 233: Operational years of relevant Brandon-area weather stations

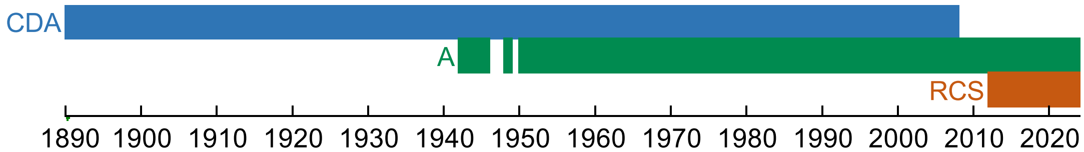
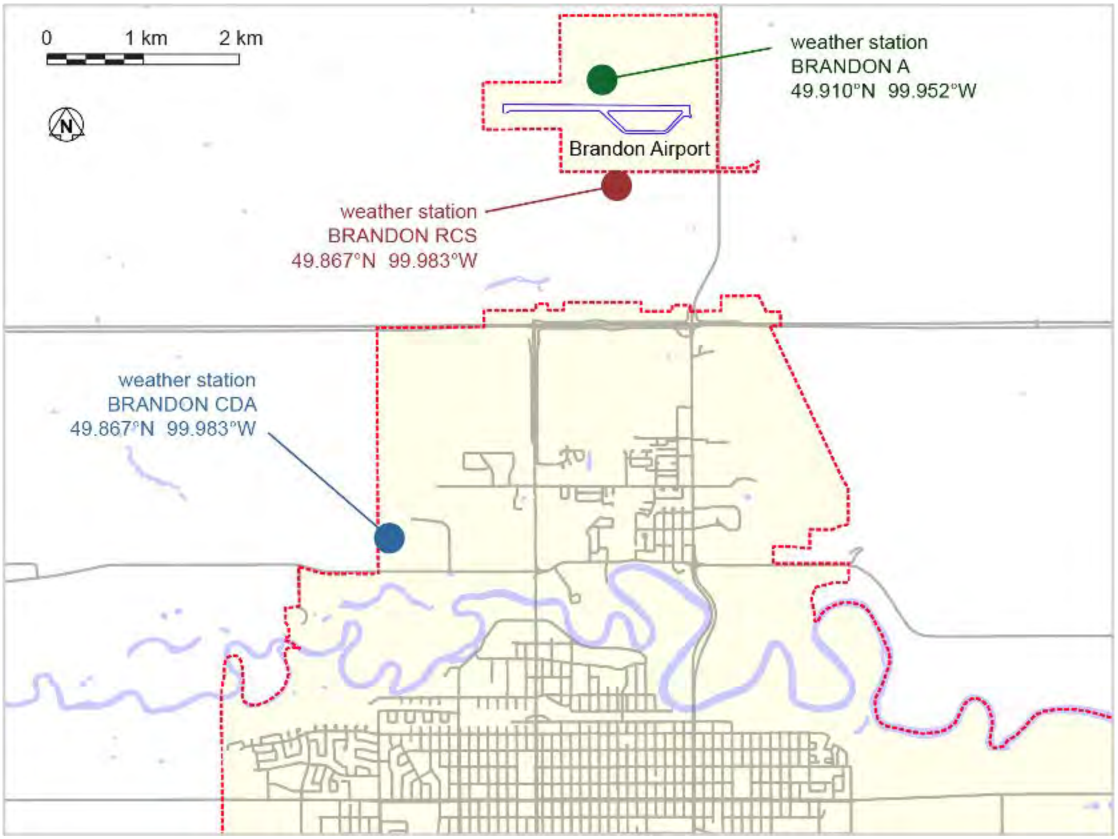


Figure 234: Relevant Brandon-area weather stations



L.2.2 DATA AVAILABLE

Each day they were operating, each of these three weather stations collected five data points that are relevant to this study (minimum daily temperature, mean daily temperature, maximum daily temperature, daily Heating Degree Days, daily Cooling Degree Days)

Table 270: Days data available from BRANDON A & BRANDON CDA weather stations in the years when both were collecting data

	days data available	
year	A	CDA
1949	301	365
1950	301	365
1951	363	366
1952	330	365
1953	332	365
1954	302	365
1955	363	366
1956	360	365
1957	307	365
1958	364	365
1959	366	366
1960	364	365
1961	365	365
1962	365	365
1963	366	366
1964	365	365
1965	365	364
1966	365	365
1967	366	366
1968	365	365

	days data available	
year	A	CDA
1969	365	365
1970	365	364
1971	365	365
1972	366	366
1973	365	365
1974	365	364
1975	365	365
1976	366	366
1977	365	365
1978	365	363
1979	321	365
1980	365	364
1981	365	364
1982	365	363
1983	365	358
1984	366	359
1985	364	362
1986	365	360
1987	365	365
1988	366	365

	days data available	
year	A	CDA
1989	365	365
1990	365	364
1991	365	360
1992	357	366
1993	315	364
1994	365	365
1995	363	365
1996	360	364
1997	360	365
1998	360	365
1999	365	365
2000	366	366
2001	365	365
2002	365	365
2003	365	365
2004	366	366
2005	365	365
2006	365	365
2007	365	334

Table 271: Days data were available from BRANDON A & BRANDON RCS weather stations in the years when both were collecting data

	days data available	
year	A	RCS
2012	347	358
2013	346	365
2014	363	365
2015	365	365
2016	365	366
2017	364	365
2018	365	365
2019	362	365
2020	363	366
2021	362	365
2022	353	365
2023	364	365

L.2.3 DATA COMPARISON

Because of the long overlap between the operations of weather stations BRANDON A and BRANDON CDA (1949 to 2007) there were more than 20,000 days when both were collecting data.

Table 272: Days BRANDON A & BRANDON CDA weather stations both collected data and the average values on those days[270]

	days both stations collected data	daily averages on days both stations collected data (in °C)		
		A	CDA	differences
Temperatures				
minimum	22,568	-3.916	-3.702	-0.214
mean	22,541	2.280	2.669	-0.389
maximum	22,734	8.366	8.929	-0.563
Degree Days				
Heating Degree Days	19,227	18.954	18.602	0.352
Cooling Degree Days	2,791	2.796	3.210	-0.414

As is to be expected, the readings at the two stations were not identical on the days when they both collected data.

On average, temperatures recorded at BRANDON A were slightly cooler than at BRANDON CDA, with:

- slightly lower average daily minimum temperatures (-0.214ºC)
- slightly lower average daily mean temperatures (-0.389ºC)
- slightly lower average daily maximum temperatures (-0.563ºC).

As a result, the Heating Degree Days for BRANDON A were slightly higher than for BRANDON CDA (0.352ºC) and the Cooling Degree Days were slightly lower (-0.414ºC).

BRANDON A and BRANDON RCS also had an overlapping collection period—2012 to 2023. There were over 4,000 days in this period when both stations collected data.

Table 273: Days BRANDON A & BRANDON RCS weather stations both collected data and the average values on those days[271]

	days both stations collected data	daily averages on days both stations collected data (in °C)		
		A	RCS	differences
Temperatures				
minimum	4,318	-3.932	-3.193	-0.739
mean	4,313	2.435	2.718	-0.284
maximum	4,313	8.803	8.638	0.165
Degree Days				
Heating Degree Days	3,609	18.737	18.386	0.351
Cooling Degree Days	569	2.493	2.777	-0.283

[270] It is to be expected that these two weather stations would have many more Heating Degree Days measurements in common (19,227) than Cooling Degree Days in common (2,791). Heating is much more often required in Manitoba than cooling.

[271] As with A and CDA, because more heat is required in Manitoba than cooling, it is to be expected that A and RCS would have more Heating Degree Days measurements in common (3,609) than Cooling Degree Days in common (569).

As with the BRANDON A and BRANDON CDA, temperatures recorded at BRANDON A and BRANDON RCS varied slightly from each other. BRANDON RCS had:

- lower average daily minimum temperatures (-0.739ºC)
- slightly lower average daily mean temperatures (-0.284ºC)
- slightly higher average daily maximum temperatures (-0.165ºC).

Heating Degree Days for BRANDON A were slightly higher than for BRANDON RCS (0.351ºC) and the Cooling Degree Days were slightly lower (-0.283ºC).

L.2.4 DATA BASELINE, PROXIES & ADJUSTMENTS

To amalgamate the data from the three weather stations into a single, unbroken daily record of the temperatures and degree days for the years 1890 to 2023, one station (BRANDON A) was used as a baseline, and the other two stations (BRANDON CDA and BRANDON RCS) were used as proxies when BRANDON A data was not available.

The five daily data points from weather station BRANDON A, collected from March 3, 1951 to December 31, 2023, were used as a baseline.

To use BRANDON CDA data as proxies for BRANDON A data, the daily data for each of the five data points from BRANDON CDA were adjusted by the average differences between A and CDA noted in the A/CDA comparison table, above.

These adjusted BRANDON CDA proxies were used in the long early period (January 1, 1890 to February 28, 1950) when BRANDON A data was not available. BRANDON CDA proxies were also used as adjusted proxies in the years when both A and CDA were collecting daily data (July 1, 1949 to November 30, 2007) but BRANDON A, for whatever reason, was not providing daily data.

Similarly, BRANDON RCS data were used as proxies for BRANDON A data on days when BRANCON RCS data were available, but BRANDON A data was not. Data from BRANDON RCS for each of these data were adjusted by the average differences noted in A/RCS comparison table above.

L.2.5 DATA USED

Table 274: Days data were used from BRANDON A & BRANDON CDA weather stations in years when both were collecting data

	days data used			days data used			days data used	
year	A	CDA	year	A	CDA	year	A	CDA
1949	122	243	1969	365	0	1989	365	0
1950	301	64	1970	365	0	1990	365	0
1951	300	65	1971	365	0	1991	365	0
1952	363	3	1972	366	0	1992	336	30
1953	330	35	1973	365	0	1993	9	356
1954	332	33	1974	365	0	1994	365	0
1955	302	63	1975	365	0	1995	363	2
1956	363	3	1976	366	0	1996	359	7
1957	360	5	1977	365	0	1997	360	5
1958	268	97	1978	365	0	1998	360	5
1959	364	1	1979	321	44	1999	365	0
1960	366	0	1980	365	0	2000	366	0
1961	364	1	1981	365	0	2001	365	0
1962	365	0	1982	365	0	2002	365	0
1963	365	0	1983	365	0	2003	365	0
1964	366	0	1984	366	0	2004	366	0
1965	365	0	1985	364	1	2005	365	0
1966	365	0	1986	365	0	2006	365	0
1967	365	0	1987	365	0	2007	365	0
1968	366	0	1988	366	0			

Table 275: Days data were used from BRANDON A & BRANDON RCS weather stations in years when both were collecting data

	days data used	
year	A	RCS
2012	347	19
2013	346	19
2014	363	2
2015	365	0
2016	365	1
2017	364	1
2018	365	0
2019	362	3
2020	363	3
2021	362	3
2022	353	11
2023	364	1

L.2.6 DATA INTERPOLATIONS

There were two time periods when data from only one of the three stations were available:

- From January 1, 1890 to December 31, 1948, only data from BRANDON CDA was available.
- From December 1, 2007 to January 8, 2012, only data from BRANDON A was available.

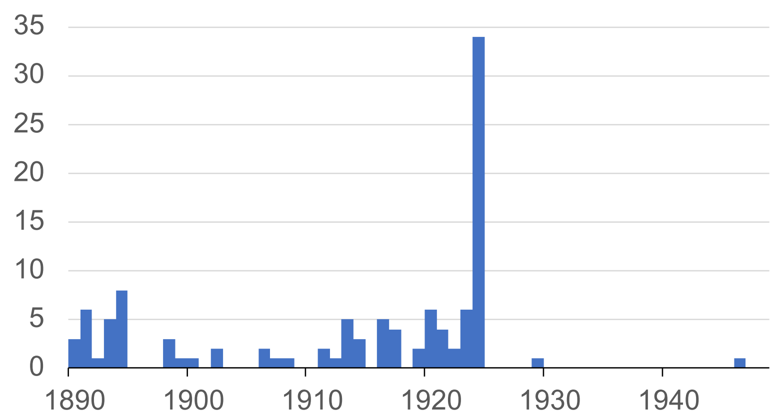
The second period (2007 to 2012) does not present a problem, because the BRANDON A weather station collected data every day during this period.

The first period (1890 to 1948) did have a small number of days (less than 2% per average year) when, for whatever reason, data was not collected by BRANDON CDA.

Table 276: Days when data was missing from weather station BRANDON CDA

	missing data			missing data			missing data	
year	days	%	year	days	%	year	days	%
1890	3	0.8%	1910	0	0.0%	1930	0	0.0%
1891	6	1.6%	1911	2	0.5%	1931	0	0.0%
1892	1	0.3%	1912	1	0.3%	1932	0	0.0%
1893	5	1.4%	1913	5	1.4%	1933	0	0.0%
1894	8	2.2%	1914	3	0.8%	1934	0	0.0%
1895	0	0.0%	1915	0	0.0%	1935	0	0.0%
1896	0	0.0%	1916	5	1.4%	1936	0	0.0%
1897	0	0.0%	1917	4	1.1%	1937	0	0.0%
1898	3	0.8%	1918	0	0.0%	1938	0	0.0%
1899	1	0.3%	1919	2	0.5%	1939	0	0.0%
1900	1	0.3%	1920	6	1.6%	1940	0	0.0%
1901	0	0.0%	1921	4	1.1%	1941	0	0.0%
1902	2	0.5%	1922	2	0.5%	1942	0	0.0%
1903	0	0.0%	1923	6	1.6%	1943	0	0.0%
1904	0	0.0%	1924	34	9.3%	1944	0	0.0%
1905	0	0.0%	1925	0	0.0%	1945	0	0.0%
1906	2	0.5%	1926	0	0.0%	1946	1	0.3%
1907	1	0.3%	1927	0	0.0%	1947	0	0.0%
1908	1	0.3%	1928	0	0.0%	1948	0	0.0%
1909	0	0.0%	1929	1	0.3%			

Figure 235: Number of days missing data per year



The longest period of missing data was October 1 to 31, 2024. The second-longest was for five days in October 1894. A typical interruption lasted for only one or two days.

To fill in the missing data, the average of the five data points (minimum, mean, maximum, heating degree days, and cooling degree days) of the day before and the day after each day or days of missing data were used as interpolations (stand-ins) for the days' missing data.

L.2.7 DATA RESULTS

The three daily temperature measurements (minimum, mean, and maximum) enable us to determine if average temperatures have increased, decreased, or remained the same over the decades.

Figure 236: Brandon – average annual minimum daily temperature (°C)[272]

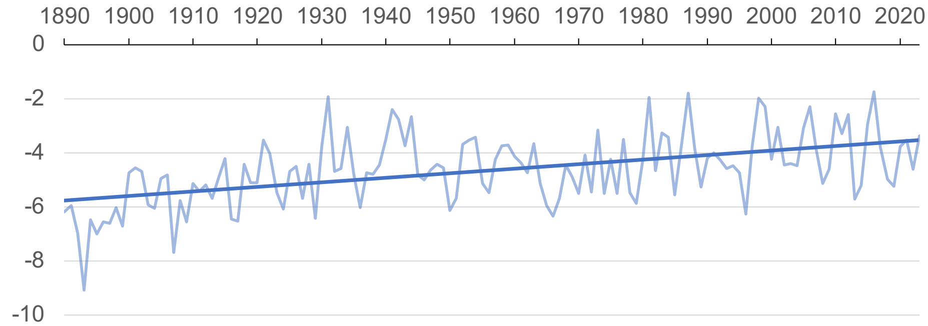
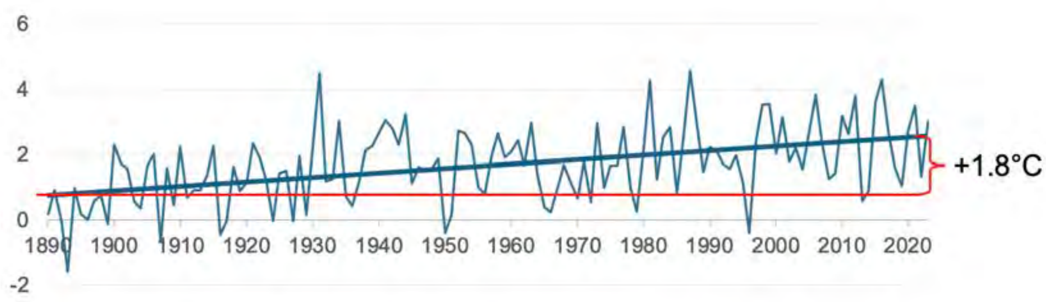
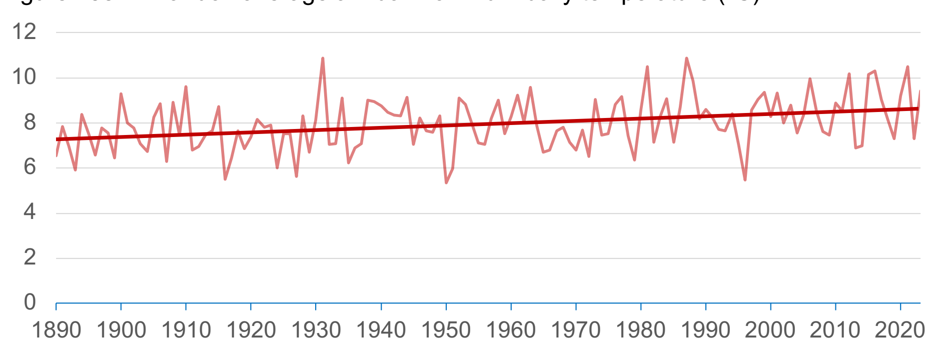


Figure 237: Brandon – average annual mean daily temperature (°C)



This is probably the most revealing of the Brandon graphs, showing that actual temperatures in Brandon have increased more than average global temperatures.

Figure 238: Brandon average annual maximum daily temperature (°C)



272 For each of the three average daily temperature charts, the pale line is the average daily temperature for each year and the darker straight line is a linear trendline of the annual averages from 1890 to 2023, inclusive.

Figure 239: Brandon total annual Heating Degree Days

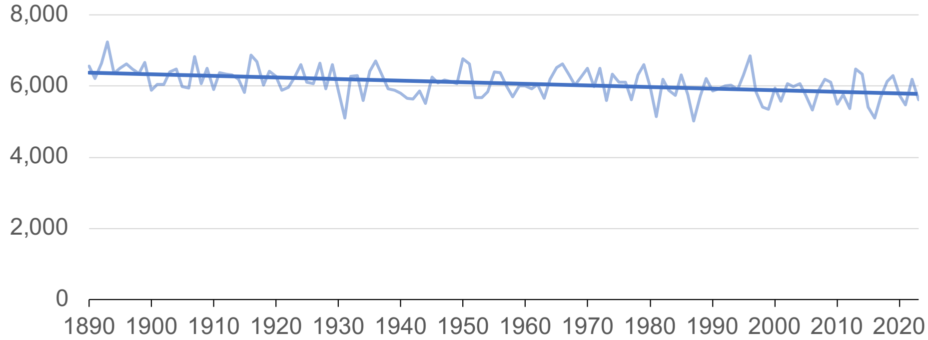


Figure 240: Brandon total annual Cooling Degree Days

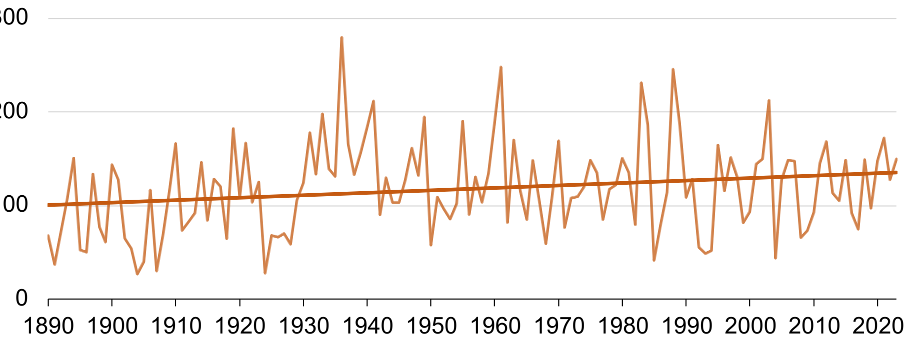


Figure 241: Brandon days below -30ºC

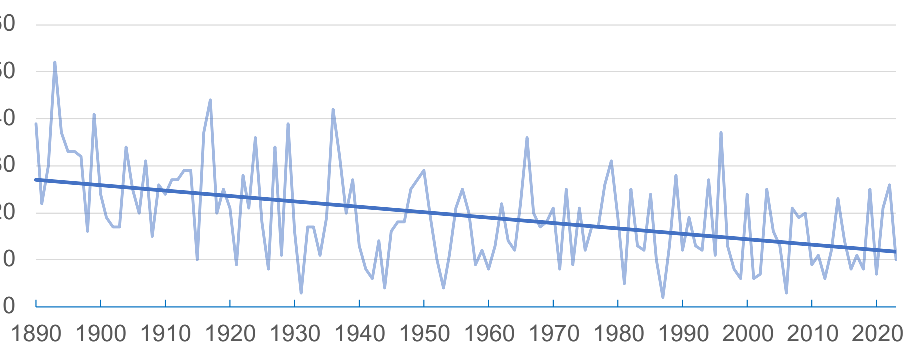
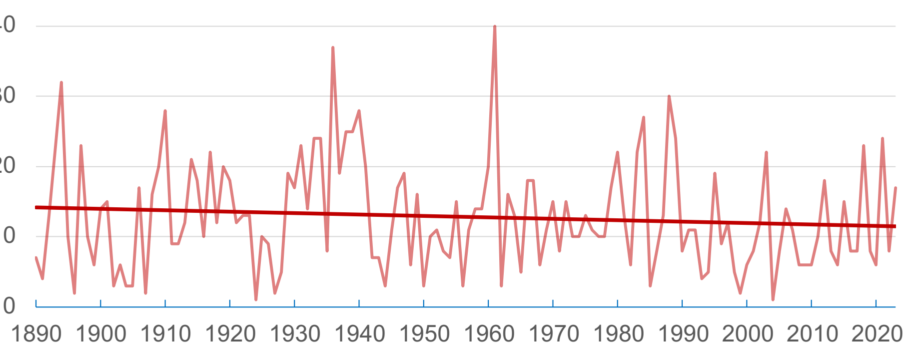


Figure 242: Brandon days above +30ºC



The daily average temperturess from 1890 to 2024 all showed increases:

- minimum temperatures increased 2.2ºC
- mean temperatures increased 1.8ºC
- maximum daily temperatures increased 1.3ºC

In keeping with this rise in average temperatures, Heating Degree Days declined by 9% and Cooling Degree Days increased by 25%.

The data also confirms that the winters have become milder, with the number of days with minimum temperatures below -30ºC declining from an average of 27 to an average of 12 per year.

Interestingly, however, Brandon has not yet seen an increase in the average number of very hot days. If anything, these have seen a slight decline from an average of 14 per year to an average of 12 per year.

Table 277: Brandon – changes in annual temperature, HDD & CDD averages – 1890 to 2023

	annual averages		
	1890	*2023*	*change*
Temperatures			
minimum	-5.75°C	-3.55°C	2.20°C
mean	0.80°C	2.55°C	1.75°C
maximum	7.30°C	8.60°C	1.30°C
Degree Days			
Heating Degree Days	6,380	5,780	-9%
Cooling Degree Days	100	125	25%
Days Experiencing Extreme Temperatures			
Days below -30°C	27	12	-56%
Days above +30°C	14	12	-14%

L.2.8 CONCLUSION FROM DATA

Given its long time-line (130 years), its frequency (daily) and its completeness (very few gaps) we can have high confidence in the Brandon data. It clearly shows that a significant warming trend is already occuring, confirming the climate modelling of the Climate Atlas of Canada.

L.3 Canadian Climate Normals[273]

Canadian Climate Normals summarize climate averages for specific locations for a period of years. The most recent period for which multi-year averages are available from this source is 1981 to 2010.

If a participating community's data is available from this source, it is used for this study. If a participating community's data is not available, the nearest location is used.

This data is useful for this study because it provides a baseline for current heating and cooling energy needs in this study's target buildings.

Not surprisingly, the differences in climate normals for the seven participating communities are quite similar.

[273] Graphs in this section copied from Canadian Climate Normals.

L.4 Climate Atlas of Canada[274]

The Climate Atlas of Canada makes detailed climate change projections for each participating community, giving projections on the five key data points relevant in this study:

- minimum daily temperature
- maximum daily temperature
- mean daily temperature
- daily Heating Degree Days
- daily Cooling Degree Days

These projections enable us to predict on how energy demand is likely to change for this study's target buildings.

The Atlas provides projections for two scenarios—if we make significant reductions to our carbon output and if we continue business as usual. In keeping with the standards followed by the Canadian government (and international bodies such as the IPCC):

- "Significant progress" means we make moderately aggressive emissions reductions—not the most aggressive possible scenario. In technical terms, this is defined moving on an RCP (Representative Concentration Pathway) of 4.5.[275] It would result stabilizing CO_2 in the atmosphere by 2100.[276]
- "Business as usual" means we continue with the very modest progress we have made to date. In technical terms, this is defined as an RCP of 8.5.

Modelling from the Climate Atlas of Canada projects that the warming trends noted in the Historical Daily Weather Station Data will continue—and very probably accelerate.

[274] Graphs in this section copied from *Climate Atlas of Canada* https://climateatlas.ca/map/canada/plus30_2030_85/#

[275] Details on Representative Concentration Pathways are available at: Government of Canada. (2019, March 1). *Representative Concentration Pathways.* Canadian Climate Data and Scenarios. https://climate-scenarios.canada.ca/?page=scen-rcp

[276] Although this pathway would see a stabilization of atmospheric CO_2 levels the level would be at approximately 530 ppm (parts per million), this is far above the level before the industrial revolution—280 ppm.

Appx. M Figures

Appx. N Tables

Appx. O Maps & Drawings

GENERAL DRAWINGS

MMB 010	PARTICIPATING COMMUNITIES - MANITOBA
MMB 011	COOLING DEGREE DAYS - MANITOBA
MMB 020	PARTICIPATING COMMUNITIES - SOUTHERN MANITOBA
MMB 021	LAND COVER - SOUTHERN MANITOBA
MMB 022	WIND - SOUTHERN MANITOBA
MMB 023	SUNLIGHT - SOUTHERN MANITOBA
MMB 024	PARKS, PROVINCIAL FORESTS, & FOREST MANAGEMENT UNITS - SOUTHERN MANITOBA
MMB 030	ECOZONES - SOUTHERN MANITOBA
MMB 031	ECOREGIONS - SOUTHERN MANITOBA
MMB 032	ECODISTRICTS - SOUTHERN MANITOBA
MMB 050	BIOMASS BUILDING - SIMPLIFIED DRAWING
MMB 060	PUBLIC WORKS BUILDING - NET ZERO - SIMPLIFIED DRAWING
MMB 070	SCHEMATIC OF TYPICAL DISTRICT ENERGY HYDRONIC SYSTEM
MMB 071	SCHEMATICS OF TYPICAL BUILDING HYDRONIC SYSTEMS
MMB 090	SOLAR ARRAY

BRANDON

MMB 101	MAP VIEW - 50 KM RADIUS
MMB 111	LAND USE - 50 KM RADIUS
MMB 121	MAP VIEW - 5 KM RADIUS
MMB 131	WEATHER STATIONS
MMB 141	TARGET BUILDINGS - SATELLITE VIEW
MMB 142	CIVIC SERVICES CLUSTER - SATELLITE VIEW
MMB 143	EAST LANDFILL CLUSTER - SATELLITE VIEW
MMB 151	TARGET BUILDINGS - MAP VIEW
MMB 152	CIVIC SERVICES CLUSTER - MAP VIEW
MMB 153	EAST LANDVIEW CLUSTER - MAP VIEW
MMB 162	CIVIC SERVICES CLUSTER - WITH RENEWABLES - SATELLITE VIEW
MMB 163	EAST LANDFILL CLUSTER - WITH RENEWABLES - SATELLITE VIEW

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MMB 201	MAP VIEW - 50 KM RADIUS
MMB 211	LAND COVER - 50 KM RADIUS
MMB 221	MAP VIEW - 2 KM RADIUS
MMB 241	TARGET BUILDINGS - SATELLITE VIEW
MMB 251	TARGET BUILDINGS - MAP VIEW
MMB 262	DOWNTOWN CLUSTER - WITH RENEWABLES - SATELLITE VIEW
MMB 263	RAILWAY CLUSTER - WITH RENEWABLES - SATELLITE VIEW

DE SALABERRY

MMB 301	MAP VIEW - 50 KM RADIUS
MMB 312	LAND COVER - 30 KM RADIUS
MMB 321	MAP VIEW - 10 KM RADIUS
MMB 331	ST MALO - 2 KM RADIUS
MMB 332	ST-PIERRE-JOLYS - 2 KM RADIUS
MMB 333	OTTERBURNE - 2 KM RADIUS
MMB 341	ST MALO - TARGET BUILDING - SATELLITE VIEW
MMB 351	ST MALO - TARGET BUILDING - MAP VIEW
MMB 361	ST MALO - WITH RENEWABLES - SATELLITE VIEW

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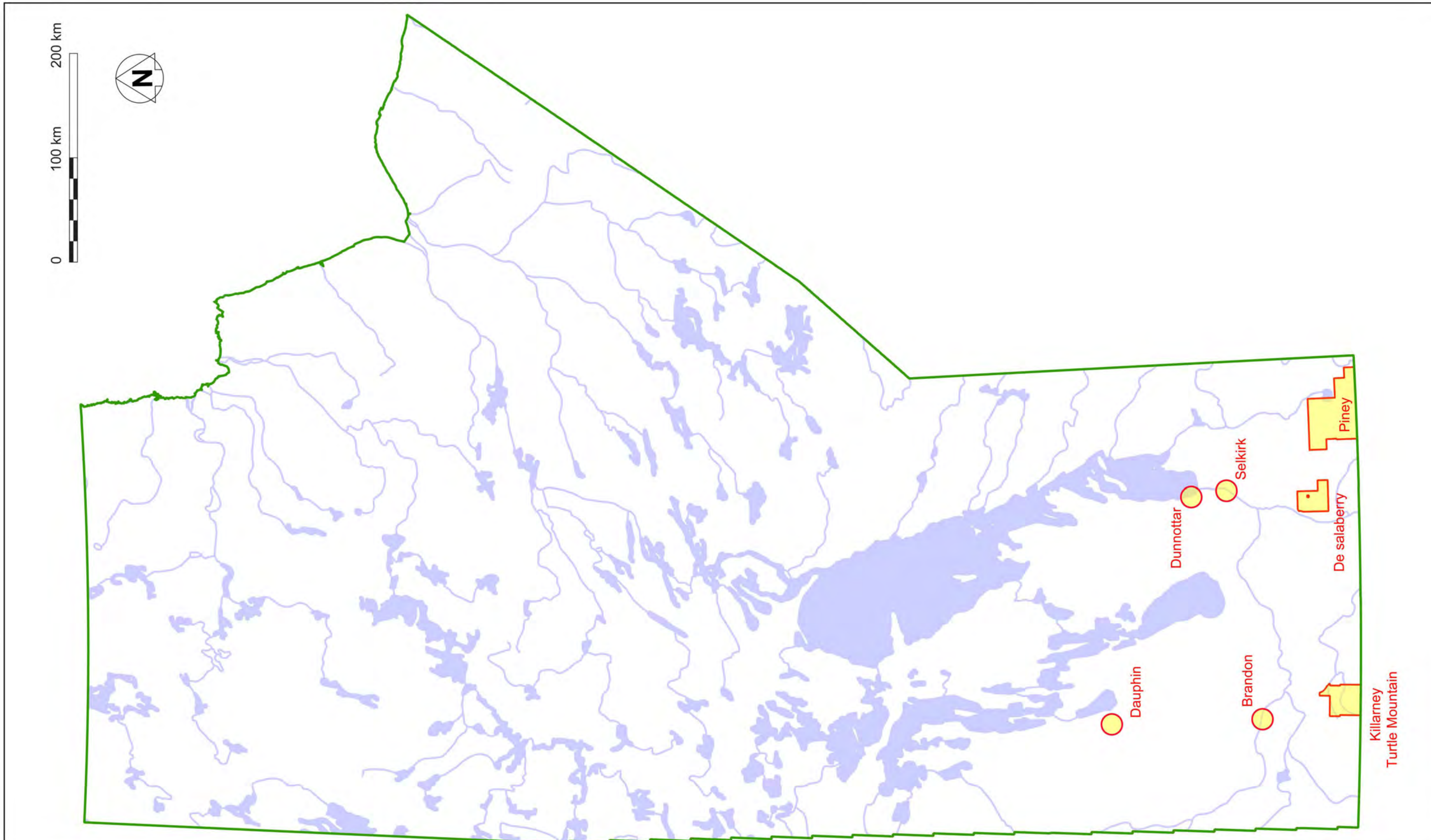
MMB 401	MAP VIEW - 50 KM RADIUS
MMB 411	LAND COVER - 50 KM RADIUS
MMB 421	MAP VIEW - 2 KM RADIUS



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
B	ISSUED FOR REVIEW	2023 NOV 01			
A	ISSUED FOR REVIEW	2023 SEP 04			

sources: Government of Manitoba. *Data MB.*
https://geoportal.gov.mb.ca
Commission for Environmental Cooperation. *North America Rivers and Lakes.*
https://www.sciencebase.gov

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 NOV 01
DESIGNED BY:		
CHECKED BY:		
SCALE: AS SHOWN		

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: PARTICIPATING COMMUNITIES

DRAWING NUMBER	REVISION
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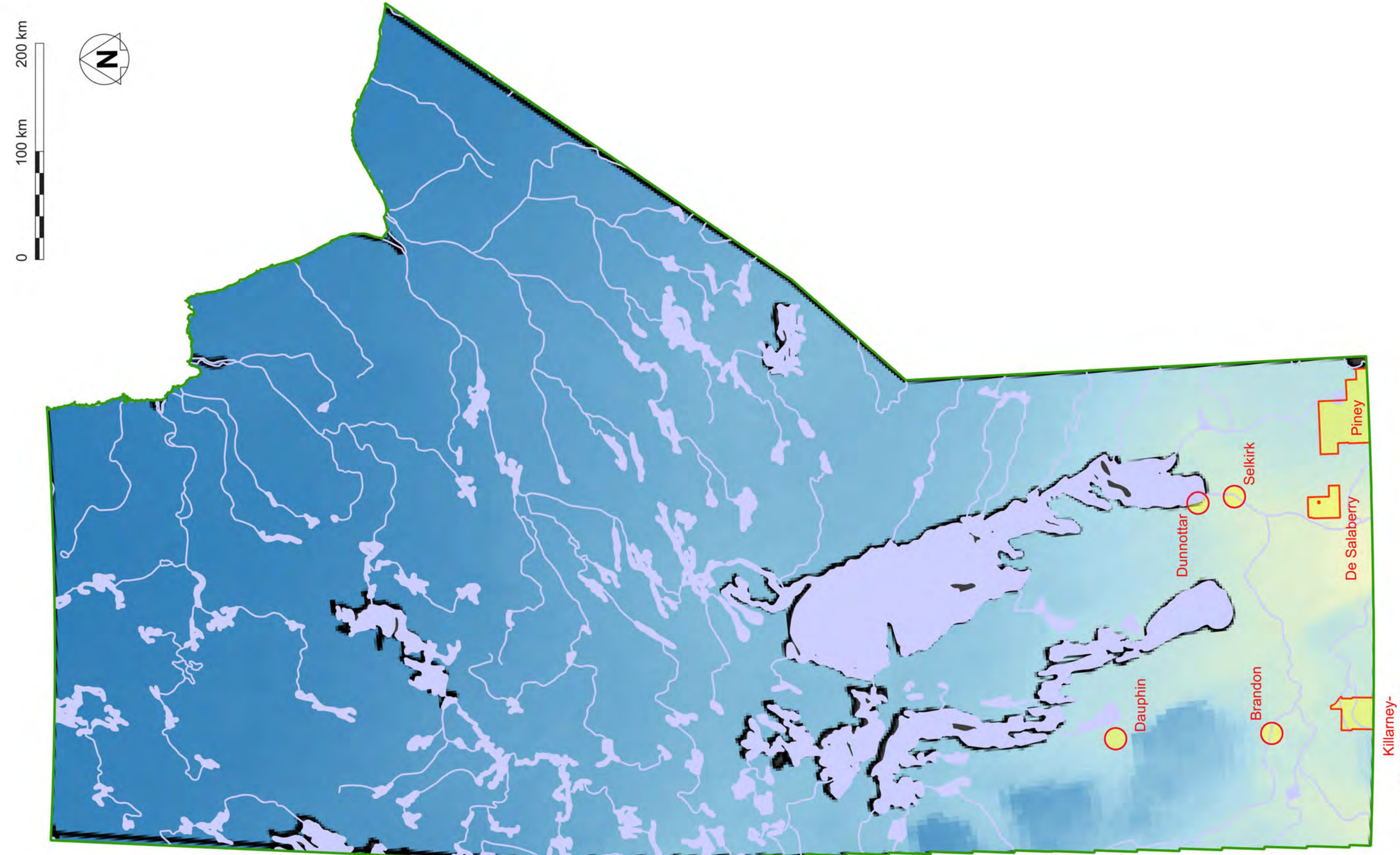

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A	ISSUED FOR REVIEW	2023 OCT 25			
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sources: Climate Atlas of Canada
https://climateatlas.ca/map/canada/cooldd_baseline#z=5&lat=53.01&lng=-101.1
Government of Manitoba. *Data MB.*
https://geoportal.gov.mb.ca
Commission for Environmental Cooperation. *North America Rivers and Lakes.*
https://www.sciencebase.gov

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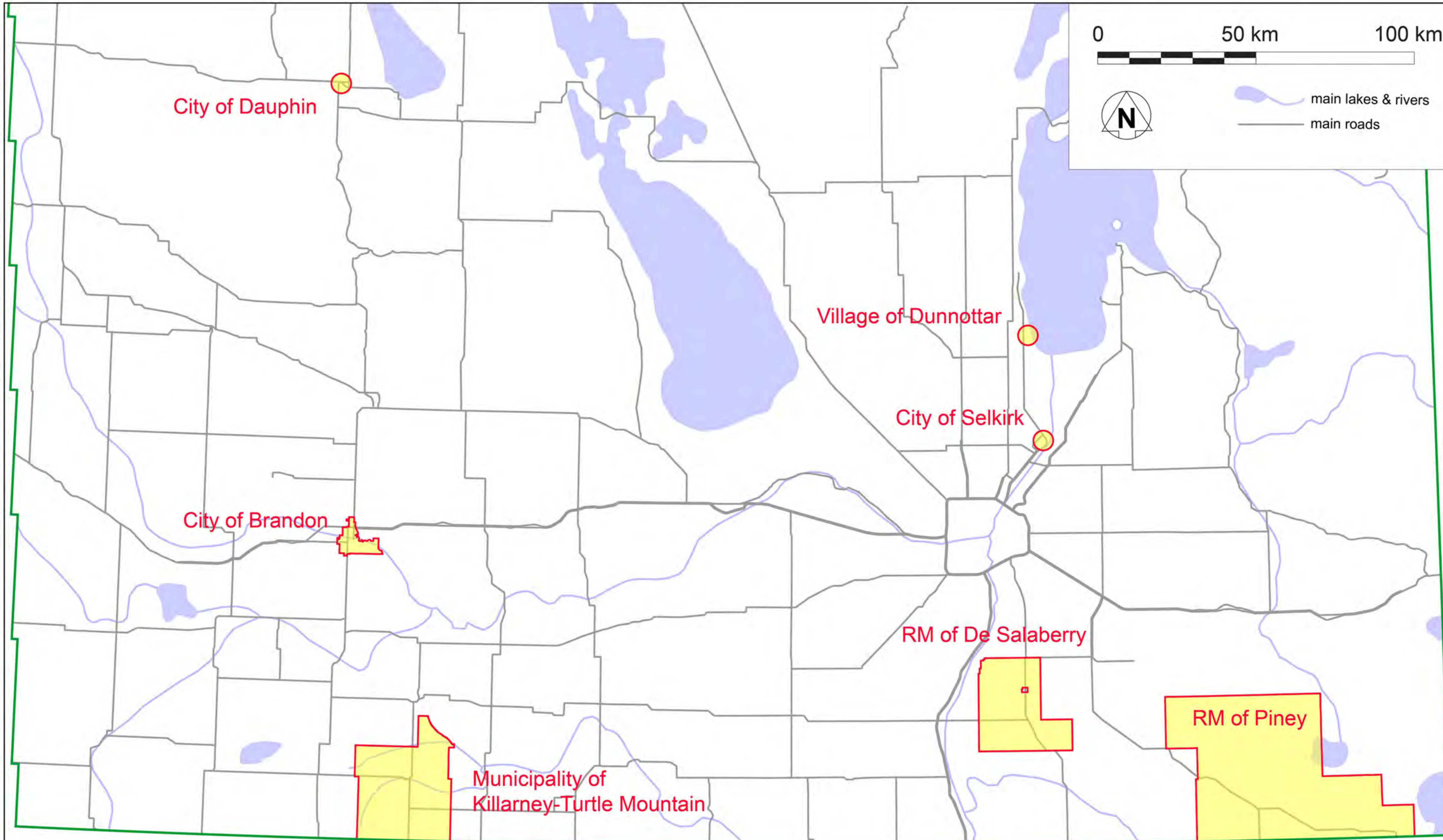
CLIENT MANITOBA SUSTAINABLE ENERGY ASSOCIATION

MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE COOLING DEGREE DAYS - 1976 TO 2005

DRAWING NUMBER	REVISION
MMB 011	B



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B	ISSUED FOR REVIEW	2023 NOV 01			
A	ISSUED FOR REVIEW	2023 SEP 04			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Commission for Environmental Cooperation. *North America Rivers and Lakes.* https://www.sciencebase.gov

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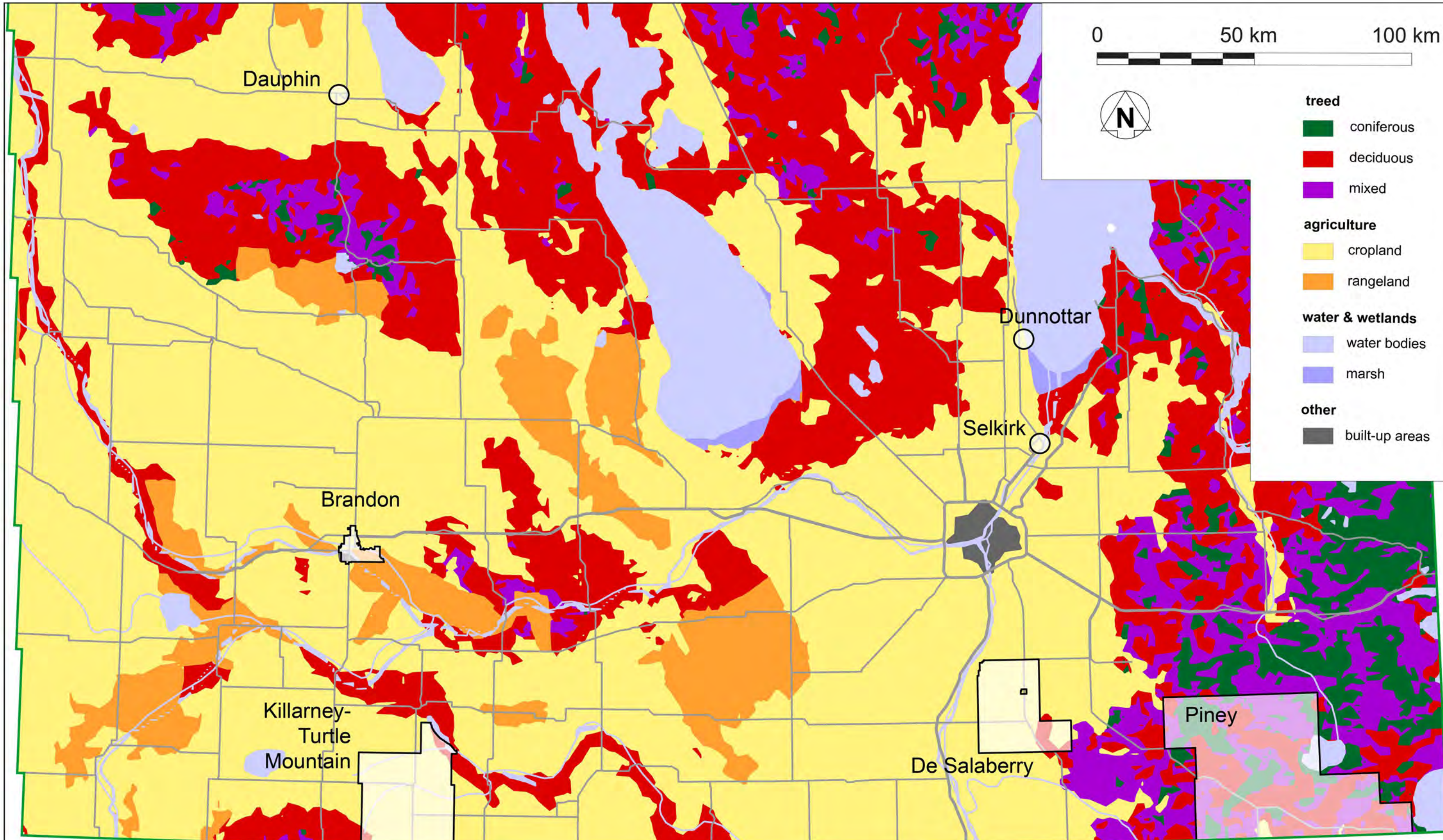
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: PARTICIPATING COMMUNITIES
SOUTHERN MANITOBA

DRAWING NUMBER: MMB 020

REVISION: B



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A	ISSUED FOR REVIEW	2023 SEP 19			
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sources: Government of Manitoba. *Data MB.*
https://geoportal.gov.mb.ca
Government of Canada. *2020 Land Cover of Canada.*
https://open.canada.ca

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DESIGNED BY:		
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SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: LAND COVER
SOUTHERN MANITOBA

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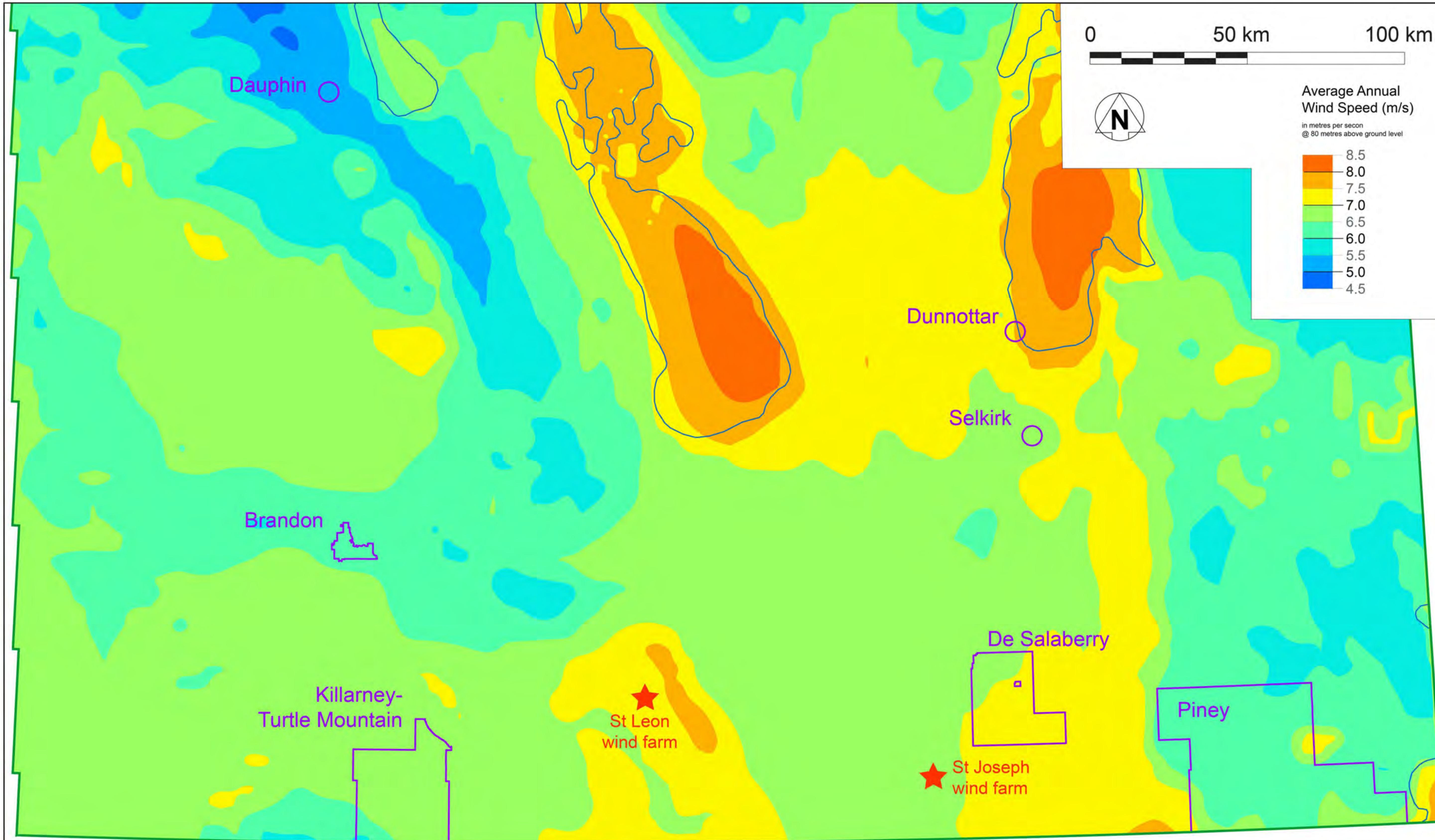

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NUMBER	DESCRIPTION

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A	ISSUED FOR REVIEW	2023 OCT 18			
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Commission for Environmental Cooperation. *North America Rivers and Lakes.* https://www.sciencebase.gov

	NAME	DATE
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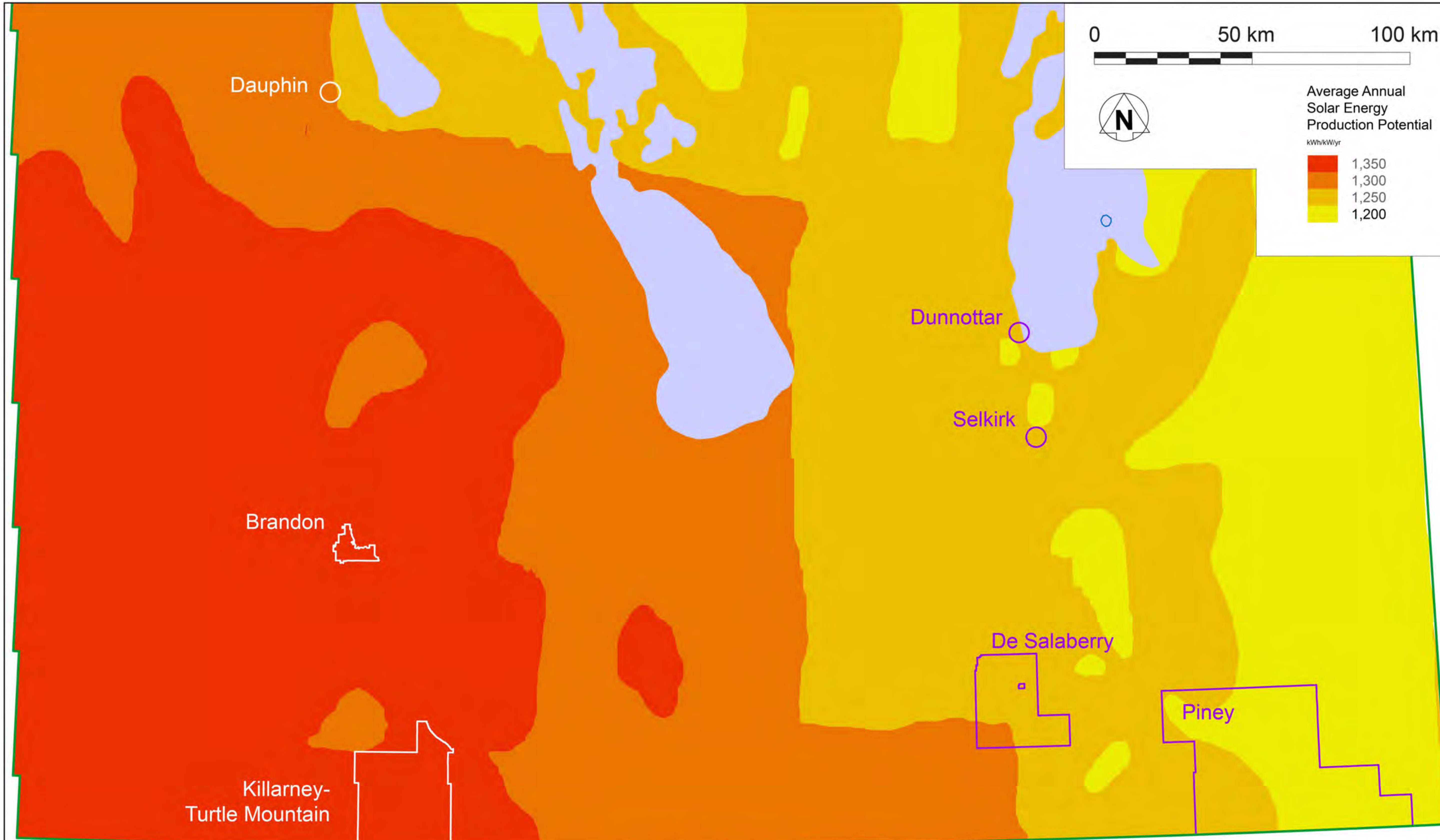
CLIENT	MANITOBA SUSTAINABLE ENERGY ASSOCIATION
PROJECT	MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY
TITLE	MEAN ANNUAL WIND SPEED @ 80M SOUTHERN MANITOBA
DRAWING NUMBER	MMB 022
REVISION	A



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A	ISSUED FOR REVIEW	2023 OCT 18			

sources: Government of Manitoba. *Data MB.*
https://geoportal.gov.mb.ca
Commission for Environmental Cooperation. *North America Rivers and Lakes.*
https://www.sciencebase.gov
Solar Energy Hubs
https://www.energyhub.org

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DESIGNED BY:		
CHECKED BY:		
SCALE: AS SHOWN		

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: AVERAGE ANNUAL SOLAR ENERGY PRODUCTION POTENTIAL SOUTHERN MANITOBA

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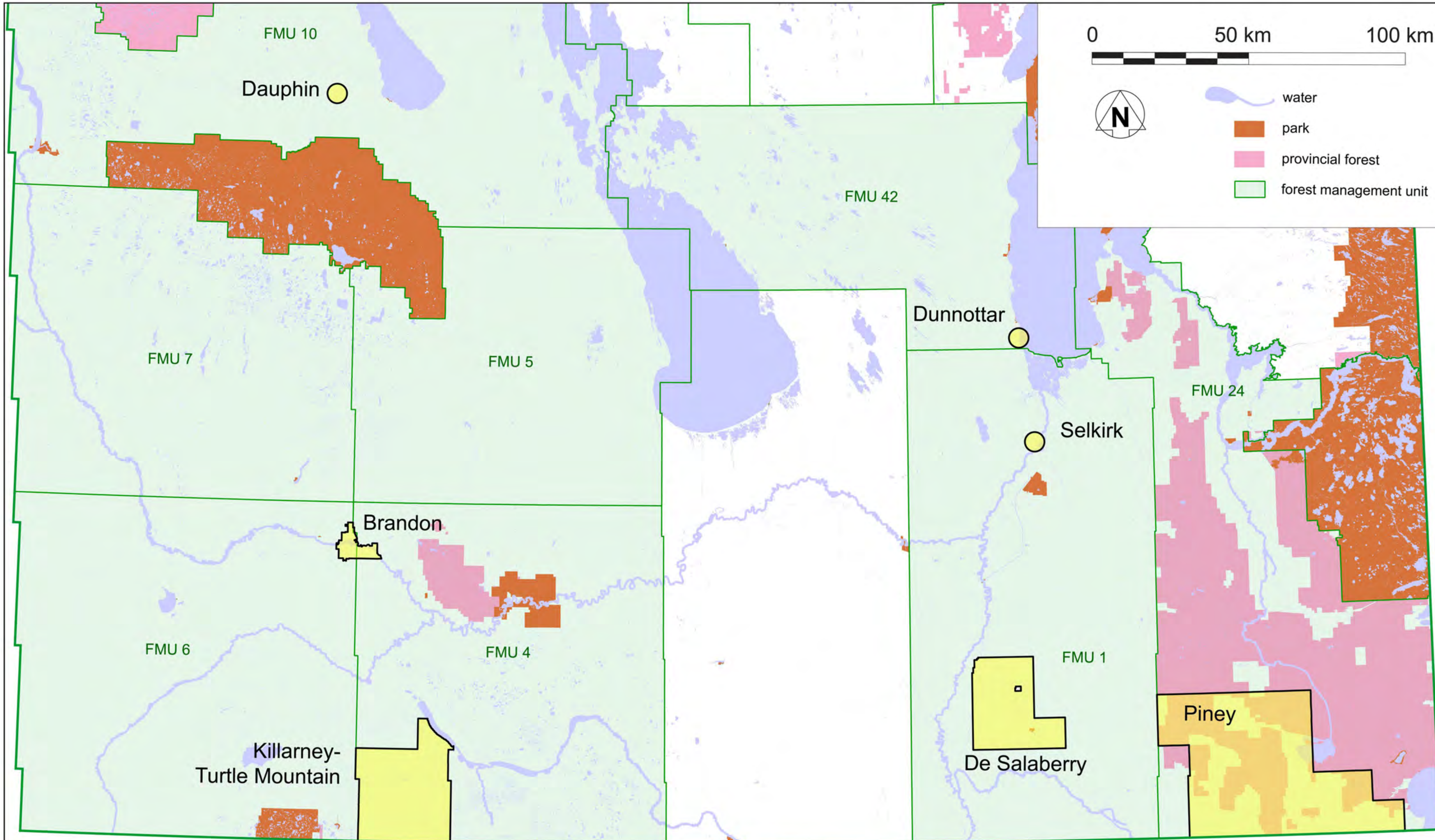

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NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
B	ISSUED FOR REVIEW	2023 NOV 01			
A	ISSUED FOR REVIEW	2023 SEP 04			

sources: Government of Manitoba. *Data MB.*
https://geoportal.gov.mb.ca
Commission for Environmental Cooperation. *North America Rivers and Lakes.*
https://www.sciencebase.gov

	NAME	DATE
DRAWN BY:	BD	2023 NOV 01
DESIGNED BY:		
CHECKED BY:		

SCALE: AS SHOWN

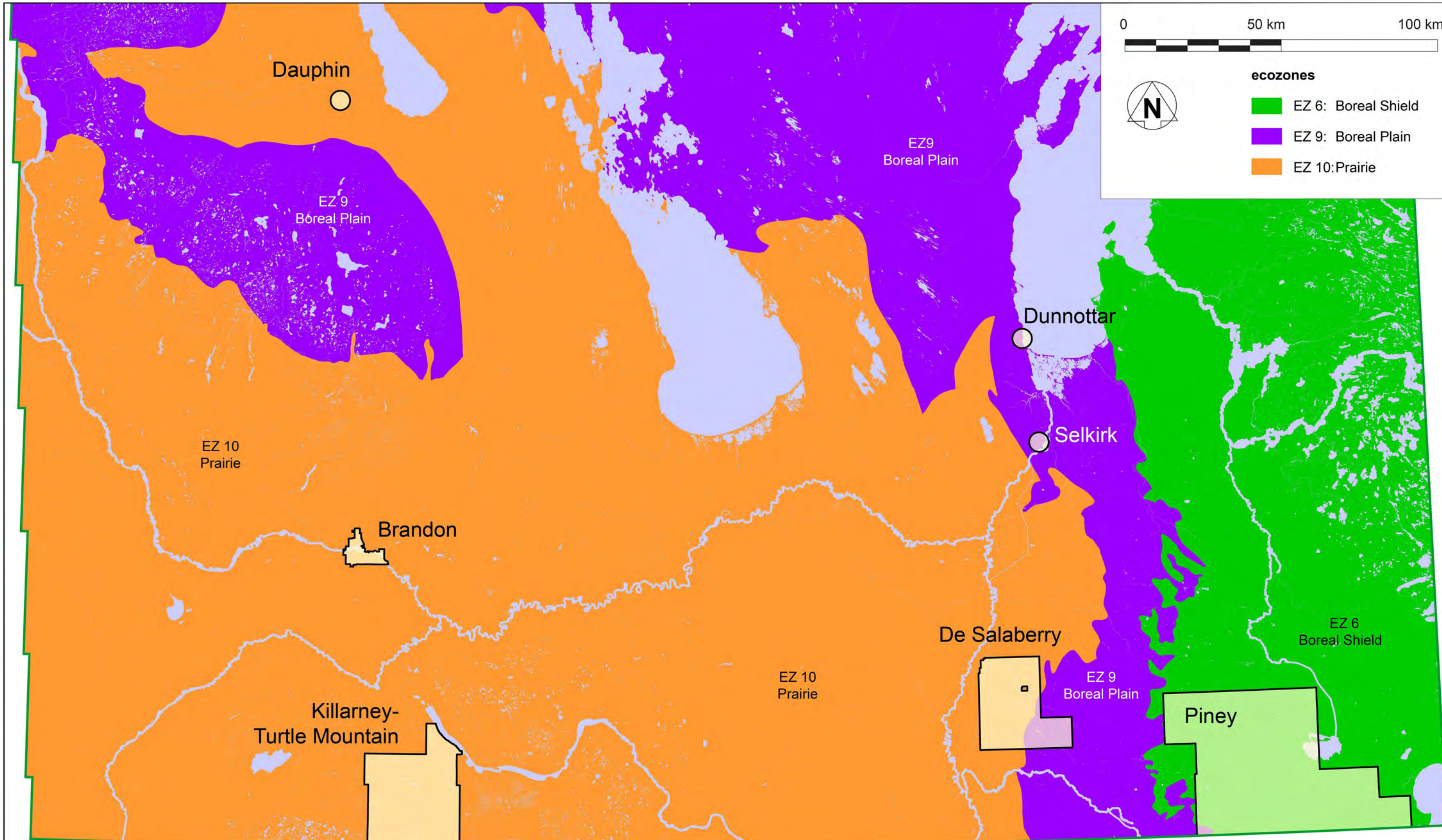
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: PARKS & PROVINCIAL FORESTS
SOUTHERN MANITOBA

DRAWING NUMBER: MMB 024

REVISION: B



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NUMBER	DESCRIPTION

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A	ISSUED FOR REVIEW	2023 SEP 04			

sources: Government of Manitoba. *Data MB.*
https://geoportal.gov.mb.ca
Commission for Environmental Cooperation. *North America Rivers and Lakes.*
https://www.sciencebase.gov
Government of Canada. *2020 Land Cover of Canada.*
https://open.canada.ca

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CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION
PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY
TITLE: ECOZONES
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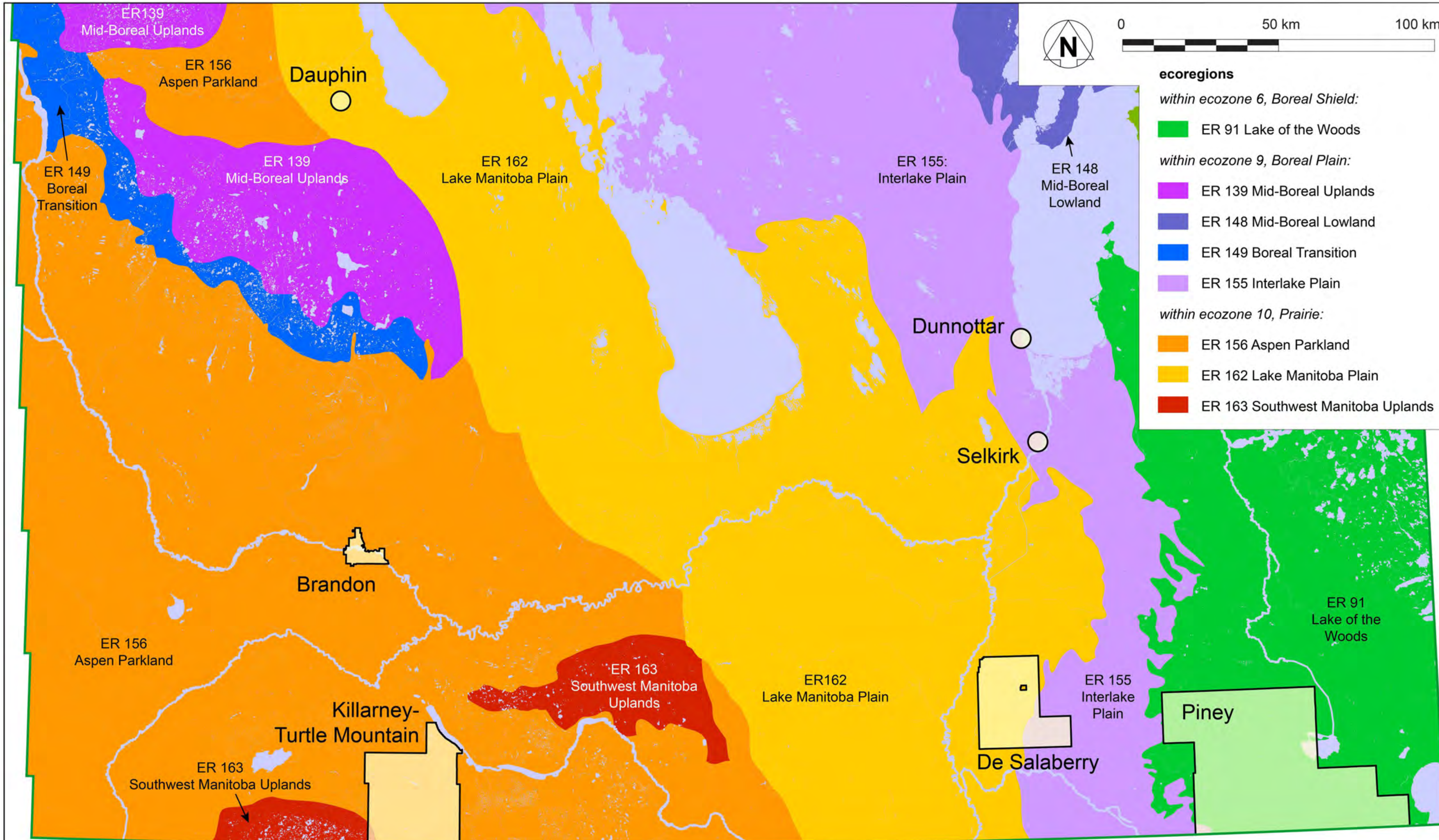

REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 SEP 04			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Commission for Environmental Cooperation. *North America Rivers and Lakes.* https://www.sciencebase.gov
Government of Canada. *2020 Land Cover of Canada.* https://open.canada.ca

BOKE

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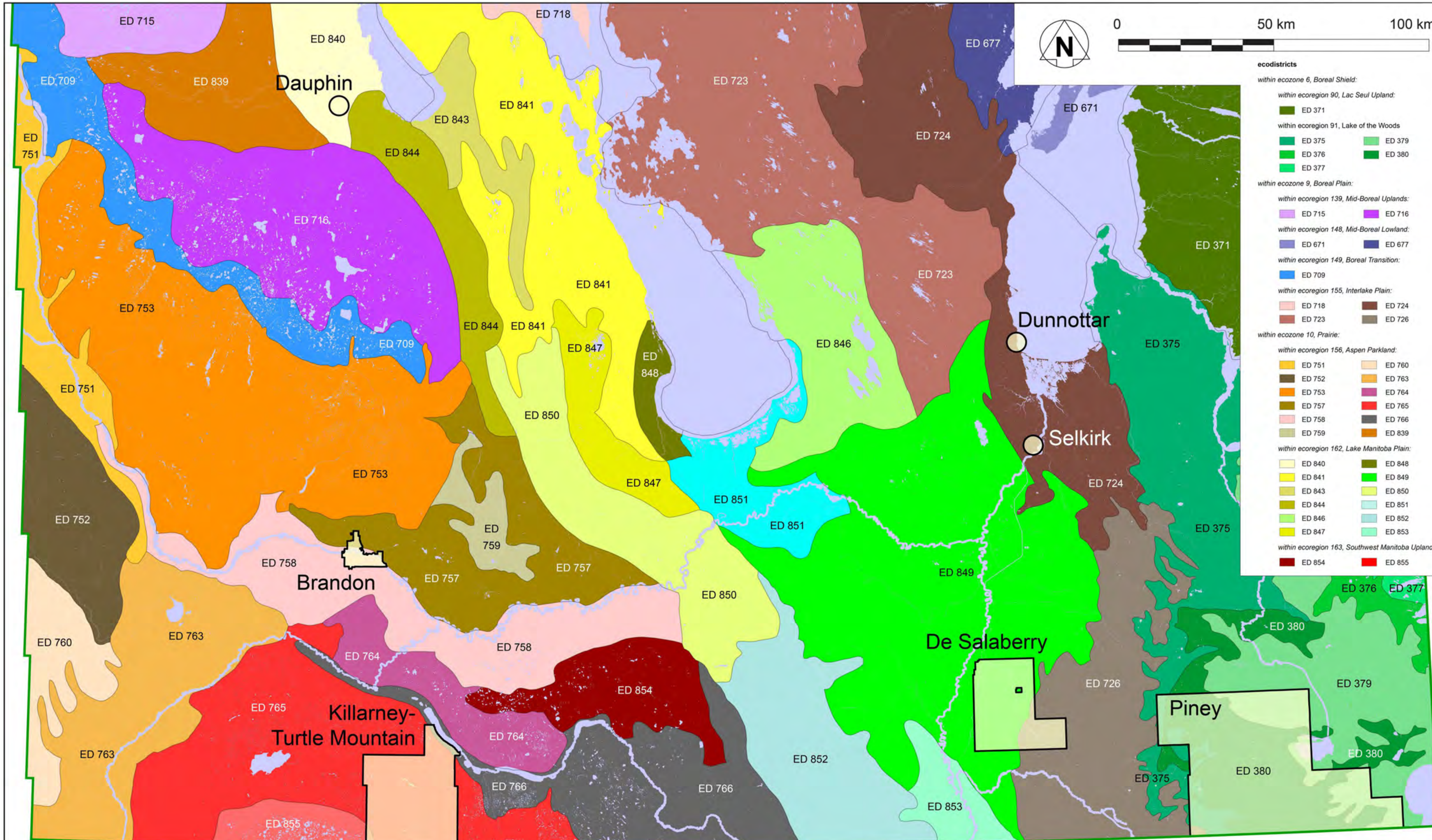
DESIGNED BY:		
CHECKED BY:		
SCALE:	AS SHOWN	

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION
PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY
TITLE: ECOREGIONS
SOUTHERN MANITOBA

DRAWING NUMBER	REVISION
MMB 031	A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 SEP 04			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Commission for Environmental Cooperation. *North America Rivers and Lakes.* https://www.sciencebase.gov
Government of Canada. *2020 Land Cover of Canada.* https://open.canada.ca

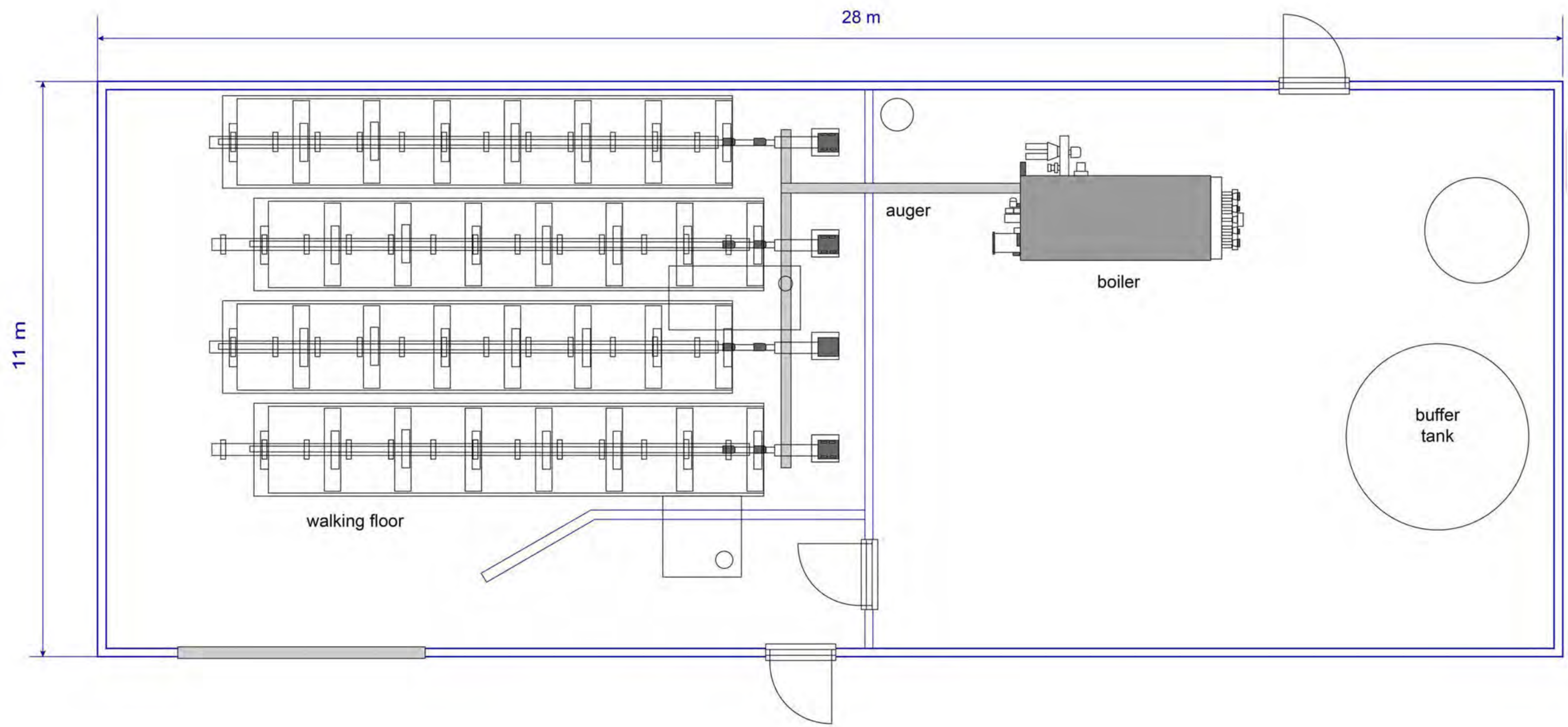
BOKE

	NAME	DATE
DRAWN BY:	BD	2023 SEP 22
DESIGNED BY:		
CHECKED BY:		

SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION
PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY
TITLE: ECODISTRICTS SOUTHERN MANITOBA

DRAWING NUMBER	REVISION
MMB 032	A



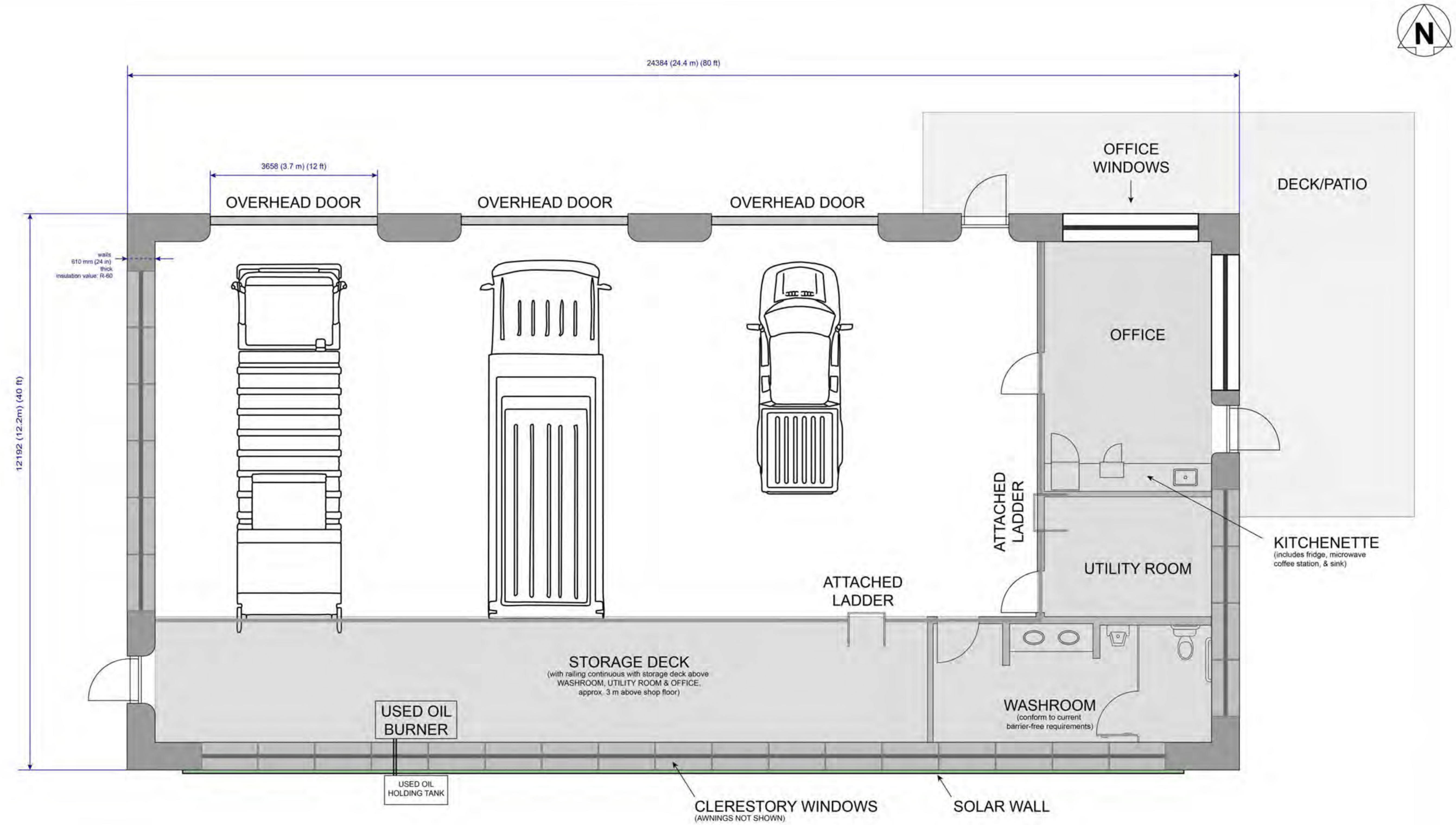
REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 MAR 22			

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 MAR 22
DESIGNED BY:	BD	2024 MAR 22
CHECKED BY:		
SCALE: AS SHOWN		

CLIENT	MANITOBA SUSTAINABLE ENERGY ASSOCIATION
PROJECT	MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY
TITLE	BIOMASS BUILDING SIMPLIFIED LAYOUT
DRAWING NUMBER	MMB 050
REVISION	A



OFFICE, UTILITY ROOM & WASHROOM approx. 9 ft (2743) ceilings, with storage deck above
SLAB ON GRADE, in-floor heating, insulation value: R-50
ROOF insulation value: R-90

NOT FOR CONSTRUCTION

REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
B	ISSUED FOR REVIEW	2024 APR 11			
A	ISSUED FOR REVIEW	2024 MAR 01			

sources: Ioannides, S.C. (2013 May 03). *A practical guide to barrier-free washrooms*. Construction Canada. https://www.constructioncanada.net/a-practical-guide-to-barrier-free-washrooms/

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 APR 11
DESIGNED BY:	BD	2024 APR 11
CHECKED BY:		

SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

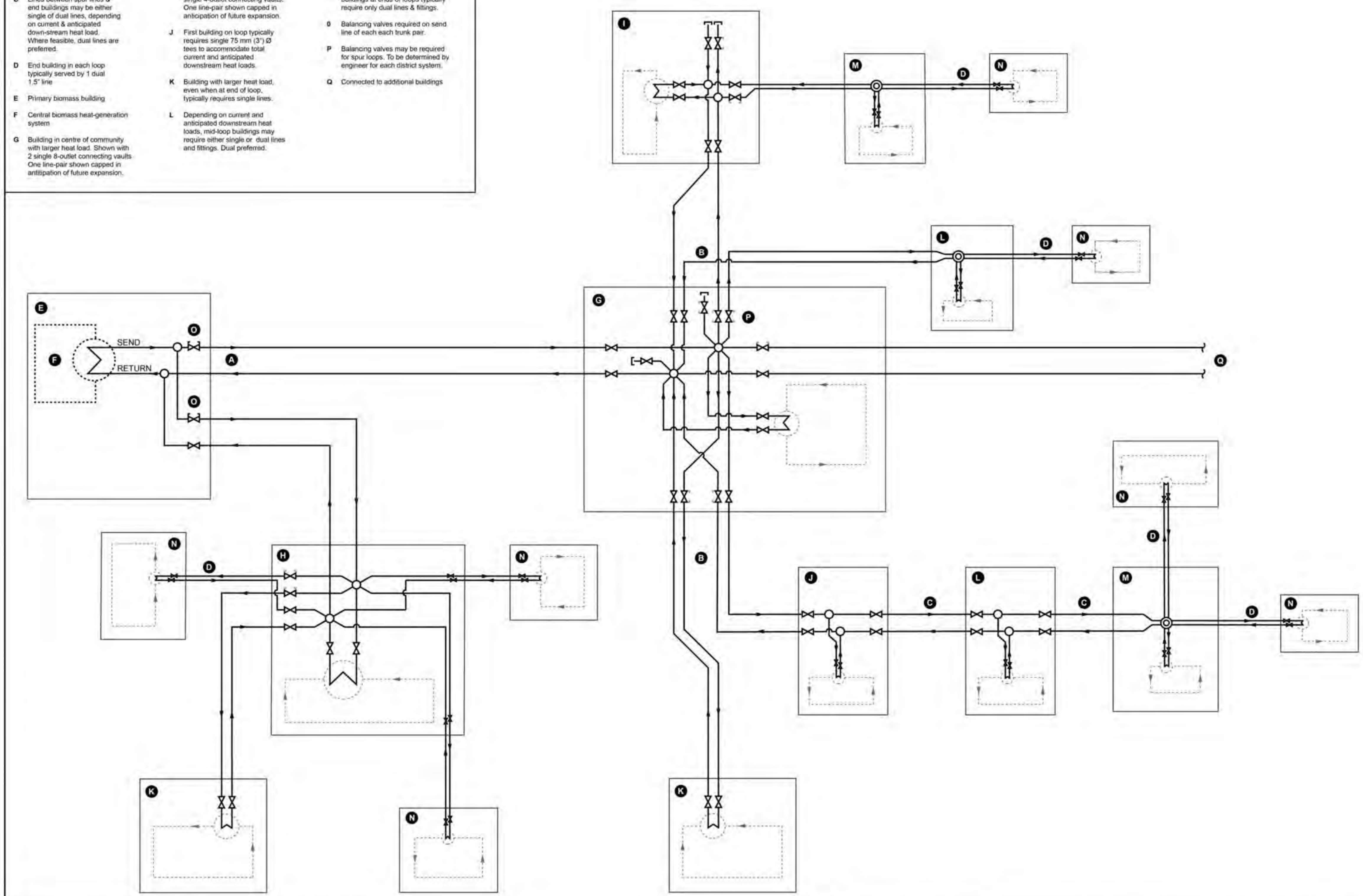
PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: PUBLIC WORKS BUILDING
NET ZERO DESIGN

DRAWING NUMBER	REVISION
MMB 060	B

KEYNOTES

- **A** Trunk lines typically 2 single 100 mm (4") Ø pipes. Pairs of single lines are laid in the same trench
- **B** Spur lines typically 2 single. 75 mm (3") Ø pipes
- **C** Lines between spur lines & end buildings may be either single of dual lines, depending on current & anticipated down-stream heat load. Where feasible, dual lines are preferred.
- **D** End building in each loop typically served by 1 dual 1.5" line
- **E** Primary biomass building
- **F** Central biomass heat-generation system
- **G** Building in centre of community with larger heat load. Shown with 2 single 8-outlet connecting vaults. One line-pair shown capped in antitipation of future expansion.
- **H** Building with larger heat load, not at end of loop. Shown with 2 single 6-outlet connecting vaults. One line-pair shown capped in antitipation of future expansion.
- **I** Buildng with larger heat load in middle of loop. Shown with two single 4-outlet connecting vaults. One line-pair shown capped in anticipation of future expansion.
- **J** First building on loop typically requires single 75 mm (3") Ø tees to accommodate total current and anticipated downstream heat loads.
- **K** Building with larger heat load, even when at end of loop, typically requires single lines.
- **L** Depending on current and anticipated downstream heat loads, mid-loop buildings may require either single or dual lines and fittings. Dual preferred.
- **M** Depending on current and anticipated downstream heat loads, buildings near end of loops may be able to use dual lines and fittings. Shown here with dual lines and dual 8-outlet connecting vault.
- **N** Unless they have high heat loads, buildings at ends of loops typically require only dual lines & fittings.
- **0** Balancing valves required on send line of each each trunk pair.
- **P** Balancing valves may be required for spur loops. To be determined by engineer for each district system.
- **Q** Connected to additional buildings



MECHANICAL SYMBOLS SCHEDULE

- SINGLE HYDRONIC PIPING LINE
- DUAL HYDRONIC PIPING LINE
- LINE CONTINUES (CONTINUTION NOT SHOWN)
- VALVE
- BALANCING VALVE
- POTENTIAL BALANCING VALVE (NEED TO BE DETERMINED BY ENGINEER CASE-BY-CASE)
- CAP
- SINGLE LINE TEE
- SINGLE LINE 4-OUTLET CONNECTING VAULT
- SINGLE LINE 6-OUTLET CONNECTING VAULT
- SINGLE LINE 8-OUTLET CONNECTING VAULT
- DUAL LINE 6-OUTLET CONNECTING VAULT
- DUAL LINE 8-OUTLET CONNECTING VAULT
- HEAT EXCHANGER
- IN-BUILDING HYDRONIC HEATING LOOP

NOT ISSUED FOR CONSTRUCTION

REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
D	ISSUED FOR REVIEW	2024 MAR 31			
C	ISSUED FOR REVIEW	2020 MAR 21			

Originally developed in collaboration with Eugene Gala of EngLogic & Eric Bibeau of SoftWhite60 for Barren Lands First Nation, Northlands Denesųłiné First Nation and Sayisi DenéFirst Nation for their Renewable Energy Feasibility Studies.

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 MAR 31
DESIGNED BY:	EG	2020 MAR 21
CHECKED BY:	EB	2020 MAR 21

SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: SCHEMATIC OF TYPICAL DISTRICT ENERGY HYDRONIC SYSTEM

DRAWING NUMBER: MMB 070

REVISION: D

KEYNOTES

A Dashed, greyed-out lines are part of the community-wide district hydronic loop and are covered in drawing B/N/S/ REFS 211.

B Greyed-out fittings are treated as part of the community-wide district hydronic loop and are covered in drawing B/N/S REFS 211.

C Connected to central biomass plant.

D Connected to additional buildings.

E Electrical switch default position is off (open). Electronic (remote) controller (if present) can both close and open. Capable of manual override. Controller sends continuous error signal when switch is on (closed.) Comes on automatically if temperature falls below set-point minus Δ.

F Number of heating zones in each building determined by engineer on case-by-case basis.

G Send & return lines in manifolds to be have same sequence (i.e.: send line #1 looped with return line #1.) Manifolds to be sized for potential additional lines.

H The thermostat for each zone controls either a pump or valve, as specified by engineer for specific installation. Repeat for each zone, as needed.

I Air Handler Unit (AHU), if present.

J Existing building water/glycol heating system, if present.

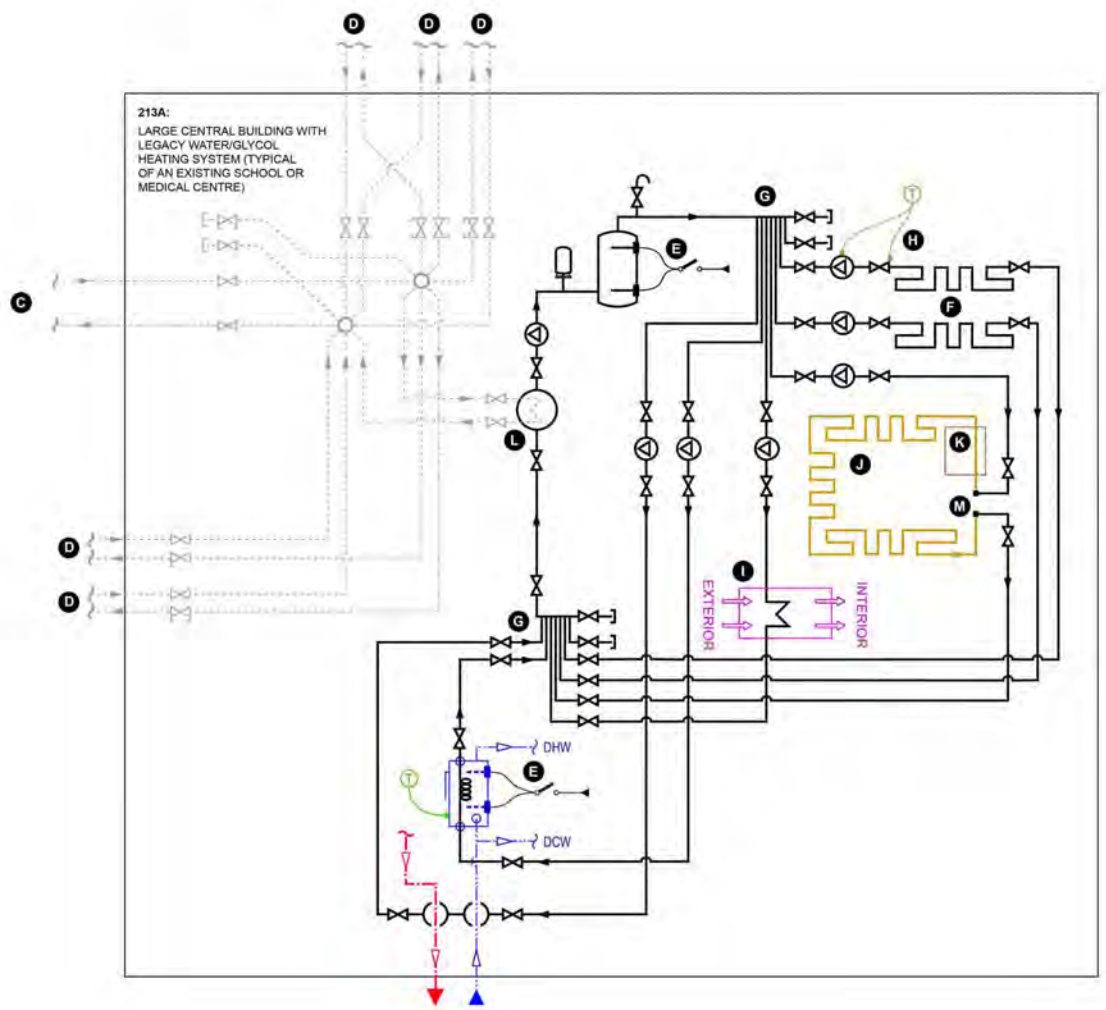
K Existing (legacy) furnace. If kept, becomes backup, that comes on automatically if building loop temperature falls below set-point minus Δ.

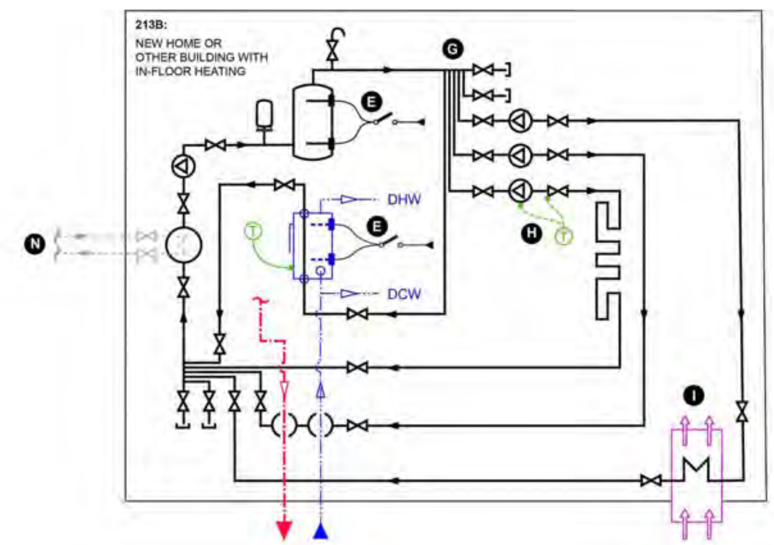
L Primary heat exchanger for connection of building to community district energy loop. Ensures that, if there is a leak anywhere else in the community district energy loop, building loop is isolated.

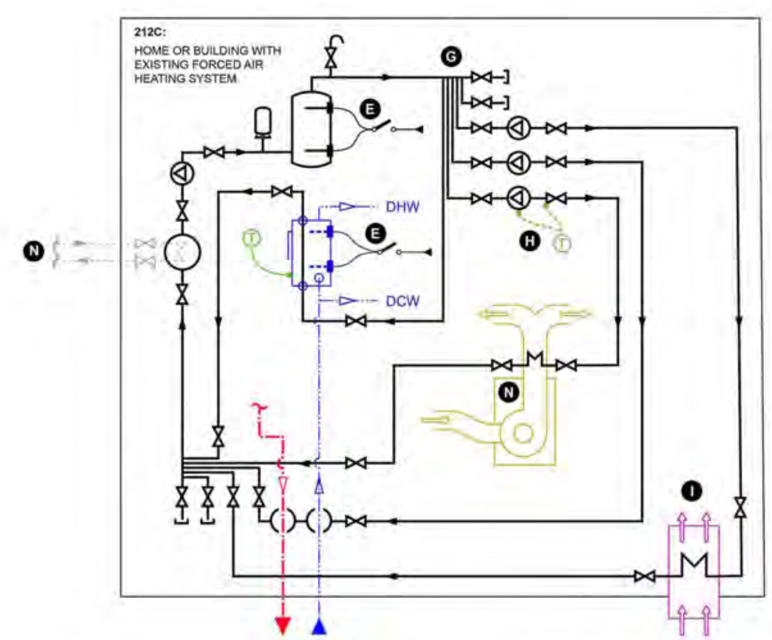
M If isolation of the building's primary space heating system from the rest of the building's hydronic heating system is desired, a heat exchanger can be added here.

N Connected to community district energy loop.

O Existing forced-air heating system (if present).







MECHANICAL SYMBOLS SCHEDULE

- SINGLE HYDRONIC PIPING LINE
- DUAL HYDRONIC PIPING LINE
- LINE CONTINUES (CONTINUTION NOT SHOWN)
- VALVE
- BALANCING VALVE
- CAP
- SINGLE LINE 8-OUTLET CONNECTING VAULT
- HEAT EXCHANGER
- WATER/GLYCOL CIRCULATING PUMP
- WATER/GLYCOL BUFFER TANK
- FILL TANK
- AIR BLEEDER
- HEAT EXCHANGE COIL (SUITABLE FOR POTABLE WATER)
- VALVED MANIFOLD
- ZONE HEATING LOOP (MAY BE IN-FLOOR OR RADIATOR)
- NEW IN-BUILDING HYDRONIC HEATING LOOPS
- LEGACY IN-BUILDING HYDRONIC HEATING SYSTEM (IF PRESENT)
- LEGACY FORCED-AIR HEATING SYSTEM (IF PRESENT)
- AIR FLOW
- CENTRIFUGAL FAN
- DHW TANK
- POTABLE WATER LINE WITH DOMESTIC COLD WATER (DCW) & DOMESTIC HOT WATER (DHW)
- ELECTRIC HEATING ELEMENT SUITABLE FOR POTABLE WATER
- ELECTRIC HEATING ELEMENT SUITABLE FOR WATER/GLYCOL MIX
- ELECTRICAL LINE WITH CONNECTION TO BREAKER PANEL
- ELECTRICAL SWITCH
- THERMOSTAT
- WASTE WATER SEWER LINE
- HEAT TRACE (BELOW BUILDING)

NOT ISSUED FOR CONSTRUCTION

REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
B	ISSUED FOR REVIEW	2024 MAR 21			
A	ISSUED FOR REVIEW	2020 MAR 21			

Originally developed in collaboration with Eugene Gala of EngLogic & Eric Bibeau of SoftWhite60 for Barren Lands First Nation, Northlands Dënesųłiné First Nation and Sayisi DenéFirst Nation for their Renewable Energy Feasibility Studies.

BOKE

	NAME	DATE
DRAWN BY:	EG	2020 MAR 21
DESIGNED BY:	EG	2020 MAR 21
CHECKED BY:	EB	2020 MAR 21

SCALE: N/S

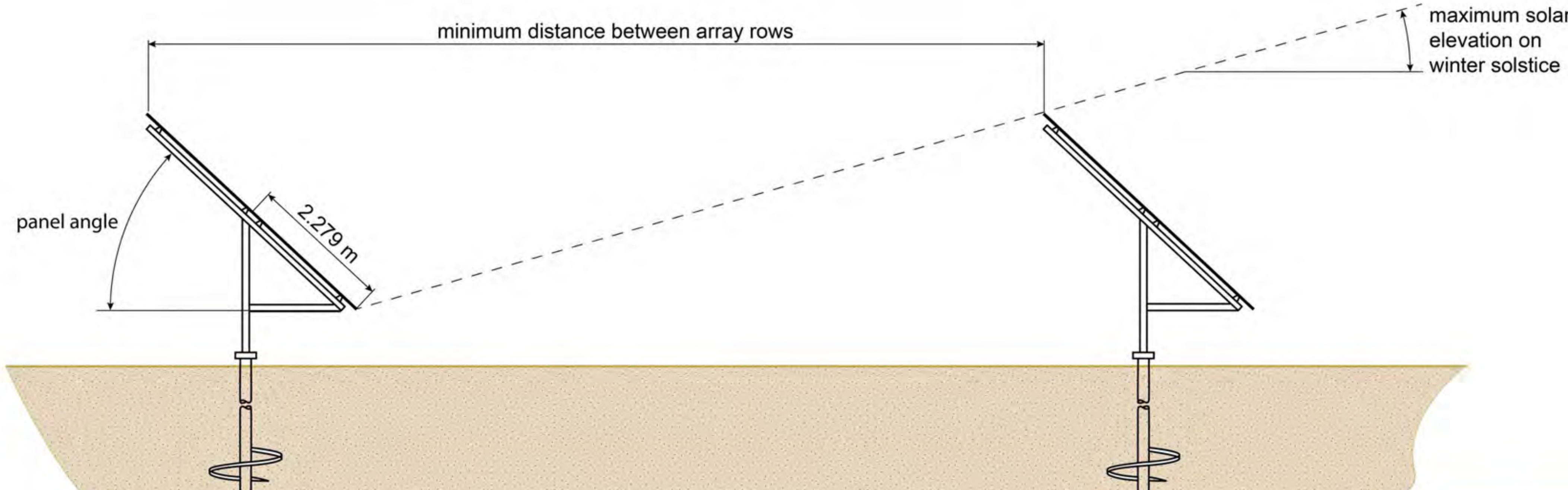
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

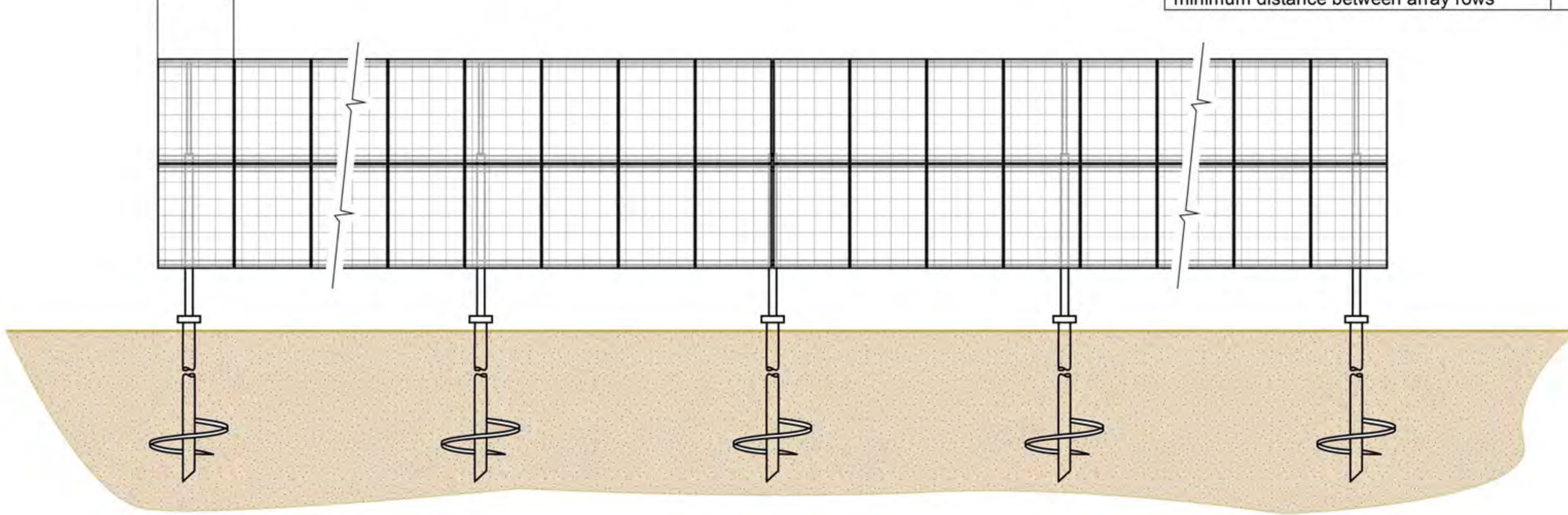
TITLE: SCHEMATIC OF TYPICAL HYDRONIC HEATING SYSTEMS IN NEW BUILDINGS

DRAWING NUMBER: MMB 071

REVISION: C



		Brandon	Dauphin	De Salaberry	Dunottar	Killarney Turtle Mountain	Piney	Selkirk
	latitude	49.85	51.15	49.31	50.45	49.18	49.10	50.14
	longitude	-99.95	-100.05	-96.95	-96.95	-99.66	-95.83	-96.88
optimal solar panel angle		43°	43°	42°	42°	43°	42°	42°
maximum solar elevation on winter solstice		16°	15°	17°	16°	17°	17°	16°
minimum distance between array rows		14.3 m	15.0 m	14.1 m	14.2 m	14.0 m	14.1 m	14.3 m



REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
B	ISSUED FOR REVIEW	2024 MAY 24			
A	ISSUED FOR REVIEW	2024 MAR 17			

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 MAY 24
DESIGNED BY:	BD	2024 MAY 24
CHECKED BY:		

SCALE: AS SHOWN

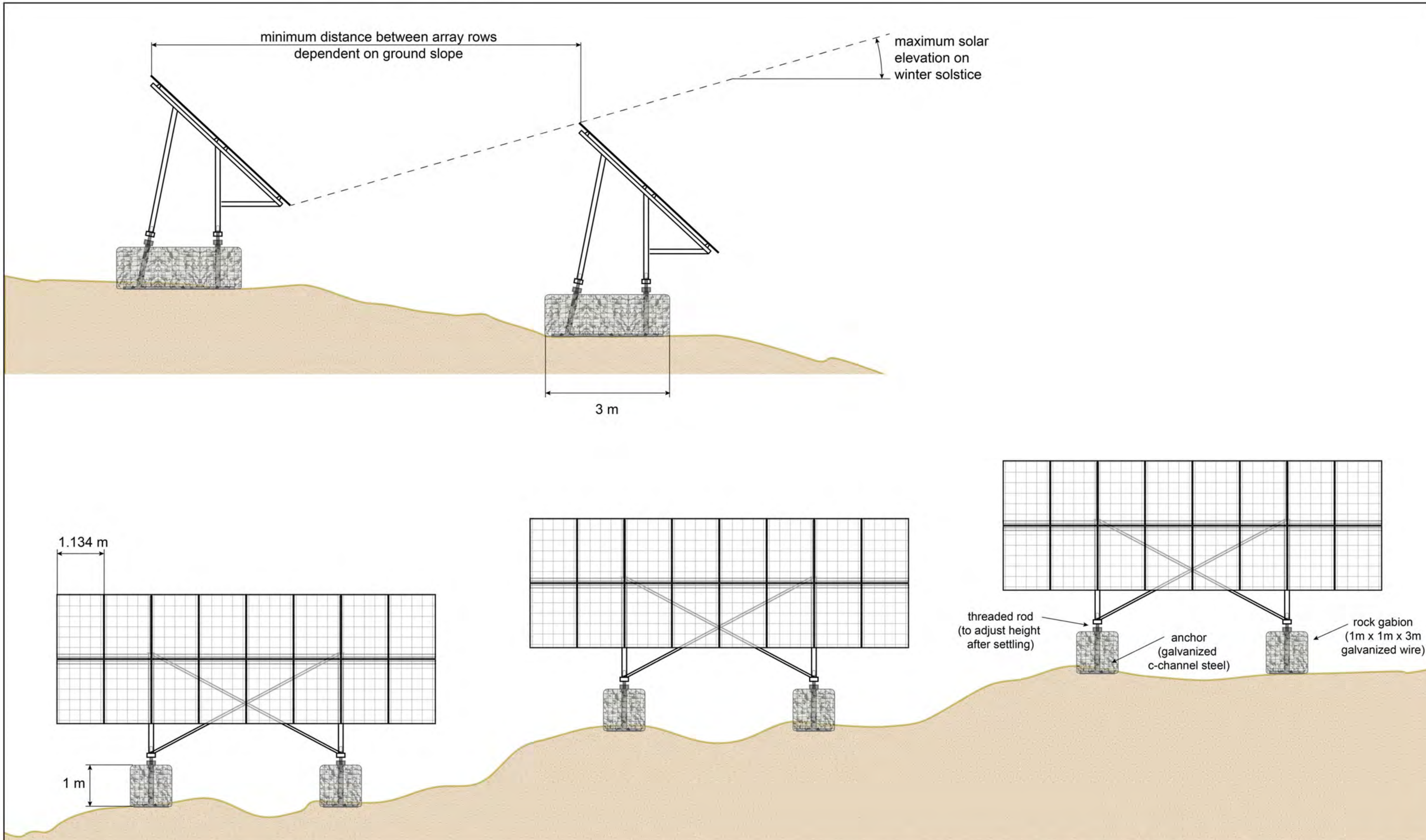
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: SOLAR ARRAY

DRAWING NUMBER: MMB 620

REVISION: B



REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 AUG 02			

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 AUG 02
DESIGNED BY:	BD	2024 AUG 02
CHECKED BY:		

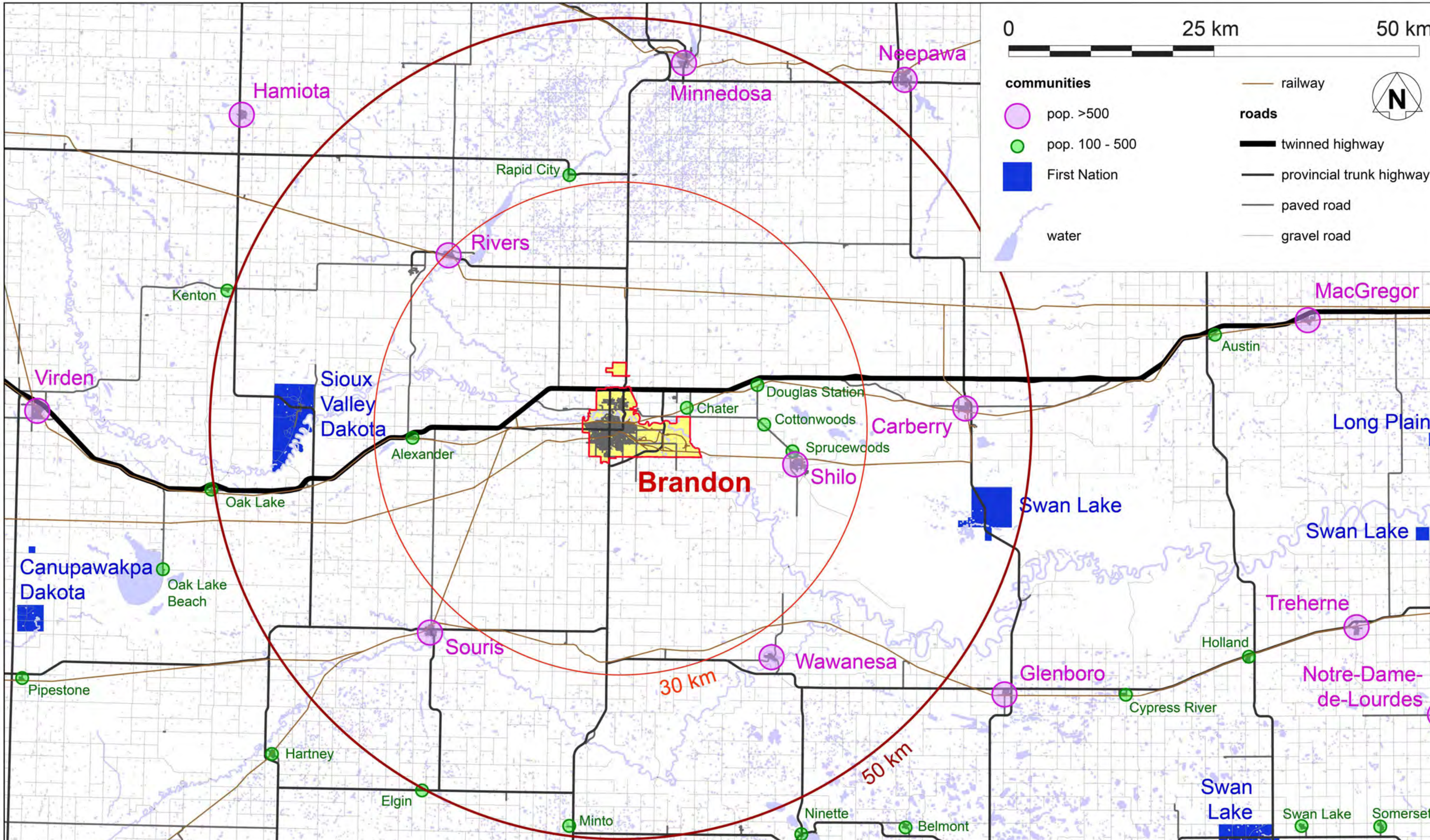
SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: SOLAR ARRAY WITH GABIONS

DRAWING NUMBER	REVISION
MMB 091	A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 01			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 01
DESIGNED BY:	BD	2023 OCT 01
CHECKED BY:		

SCALE: AS SHOWN

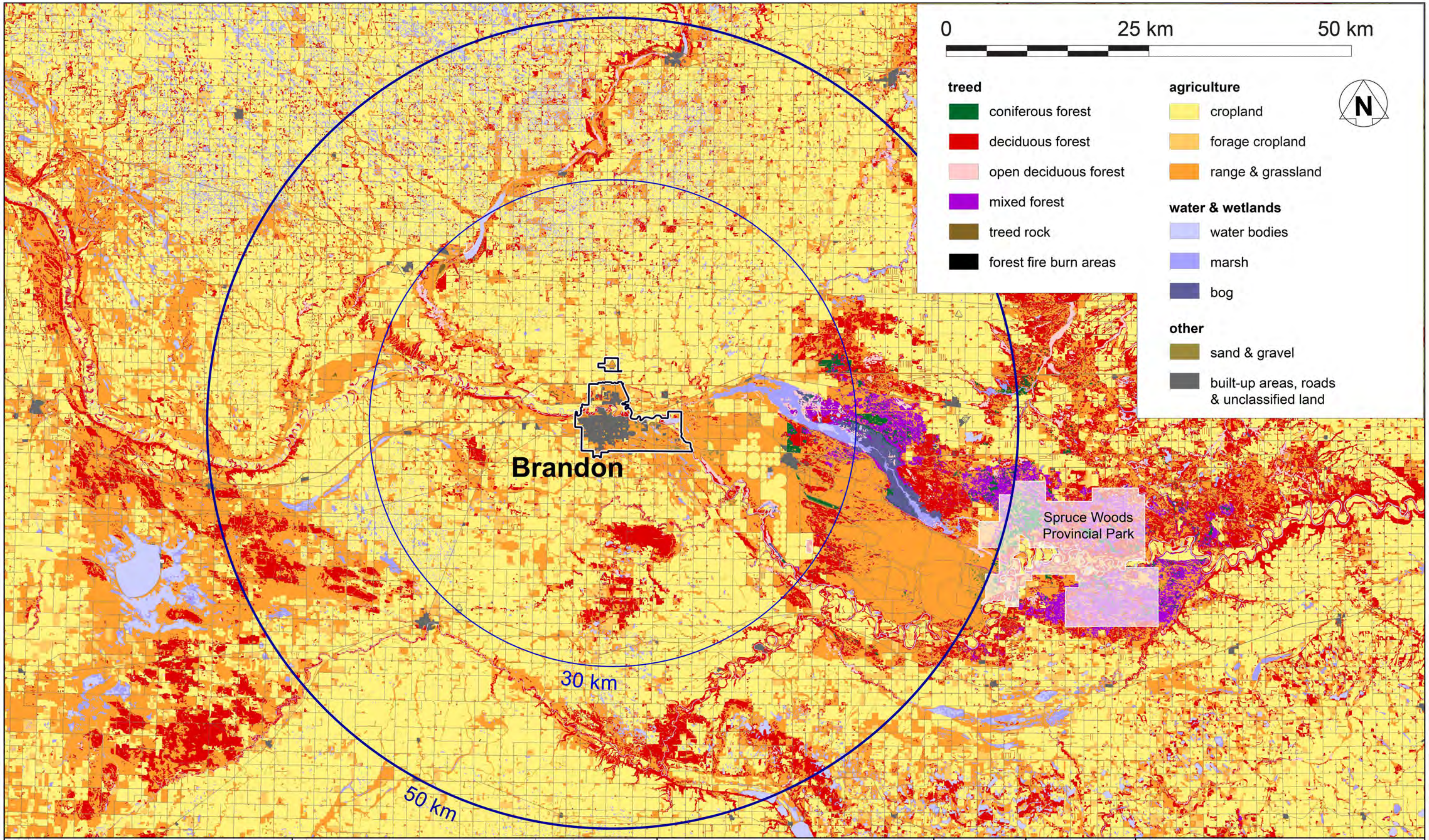
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: BRANDON
MAP VIEW
50 KM RADIUS

DRAWING NUMBER: MMB 101

REVISION: A



REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 01			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 06
DESIGNED BY:	BD	2023 OCT 06
CHECKED BY:		

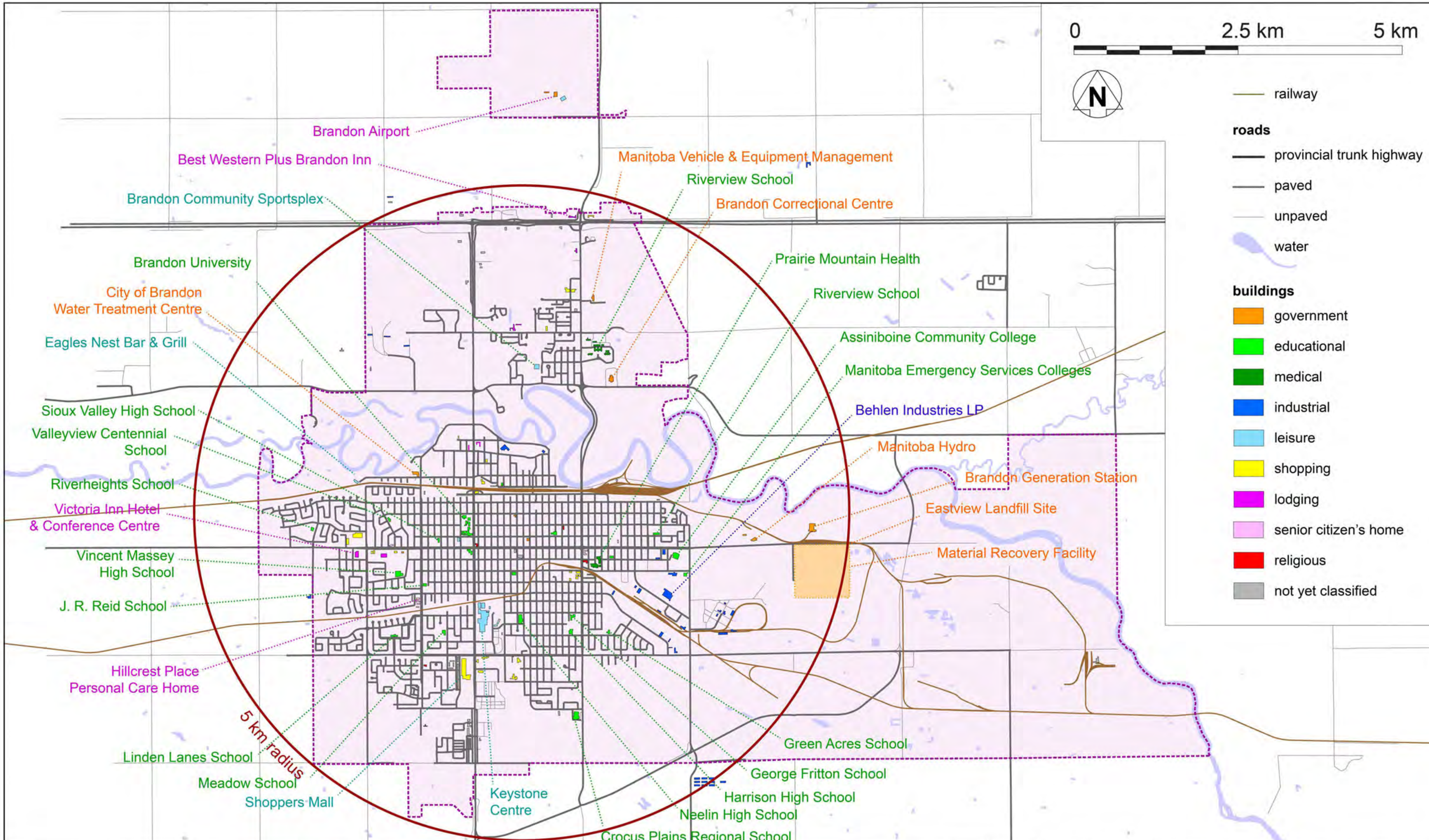
SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: BRANDON LAND COVER 50 KM RADIUS

DRAWING NUMBER	REVISION
MMB 111	A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 18			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 18
DESIGNED BY:	BD	2023 OCT 28
CHECKED BY:		

SCALE: AS SHOWN

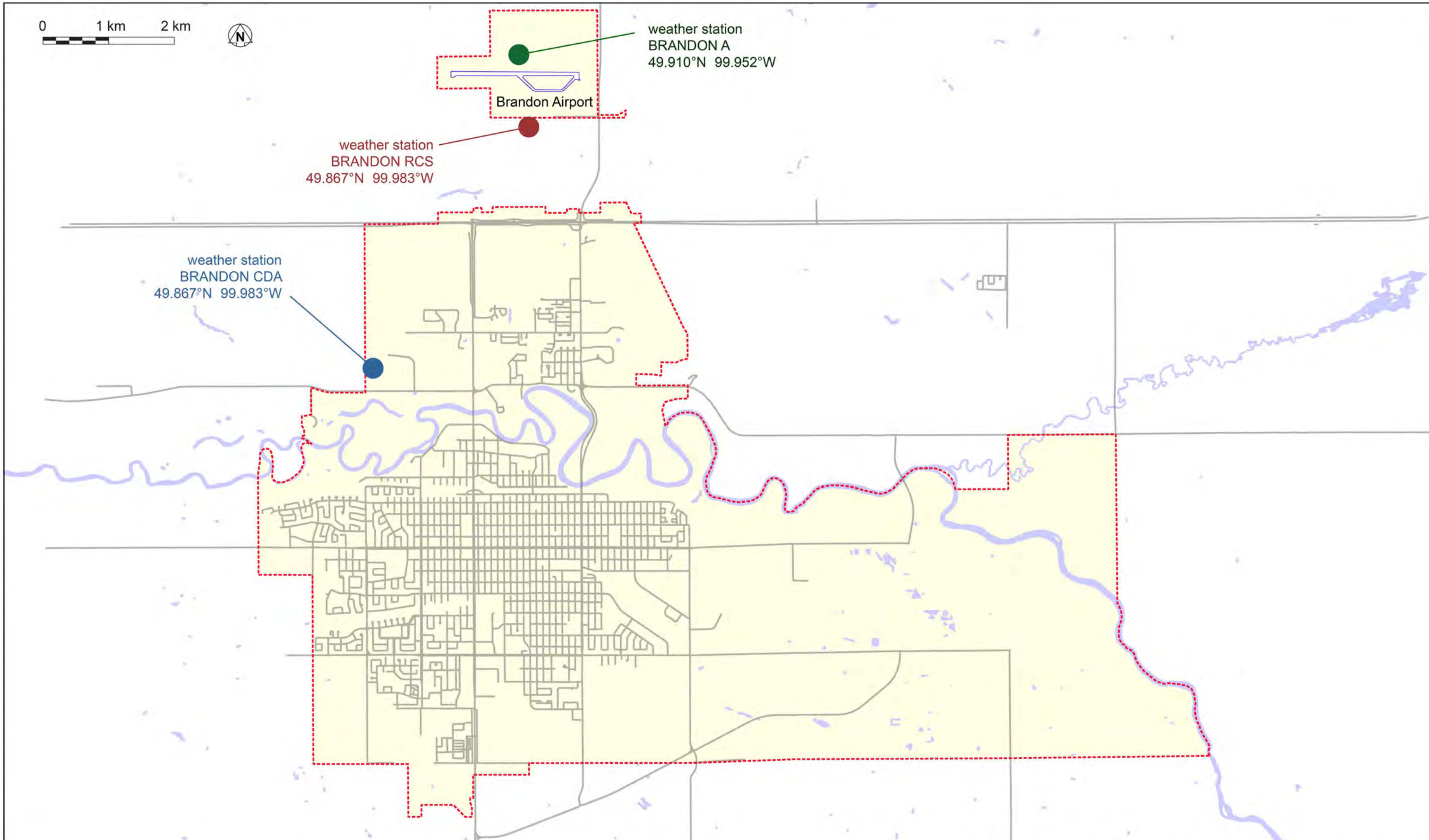
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: BRANDON
MAP VIEW
5 KM RADIUS

DRAWING NUMBER: MMB 121

REVISION: A



REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 JAN 19			

sources: Government of Manitoba. *Data MB.*
https://geoportal.gov.mb.ca
Government of Canada. Environment and Natural Resources & Climate Data Canada
https://climate.weather.gc.ca/historical_data/search_historic_data_e.htm.
https://climatedata.ca/download/#station-download

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 JAN 19
DESIGNED BY:	BD	2024 JAN 19
CHECKED BY:		

SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: BRANDON WEATHER STATIONS

DRAWING NUMBER: MMB 131

REVISION: A

REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 MAR 05			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, 2022

	NAME	DATE
DRAWN BY:	BD	2024 MAR 05
DESIGNED BY:	BD	2024 MAR 05
CHECKED BY:		

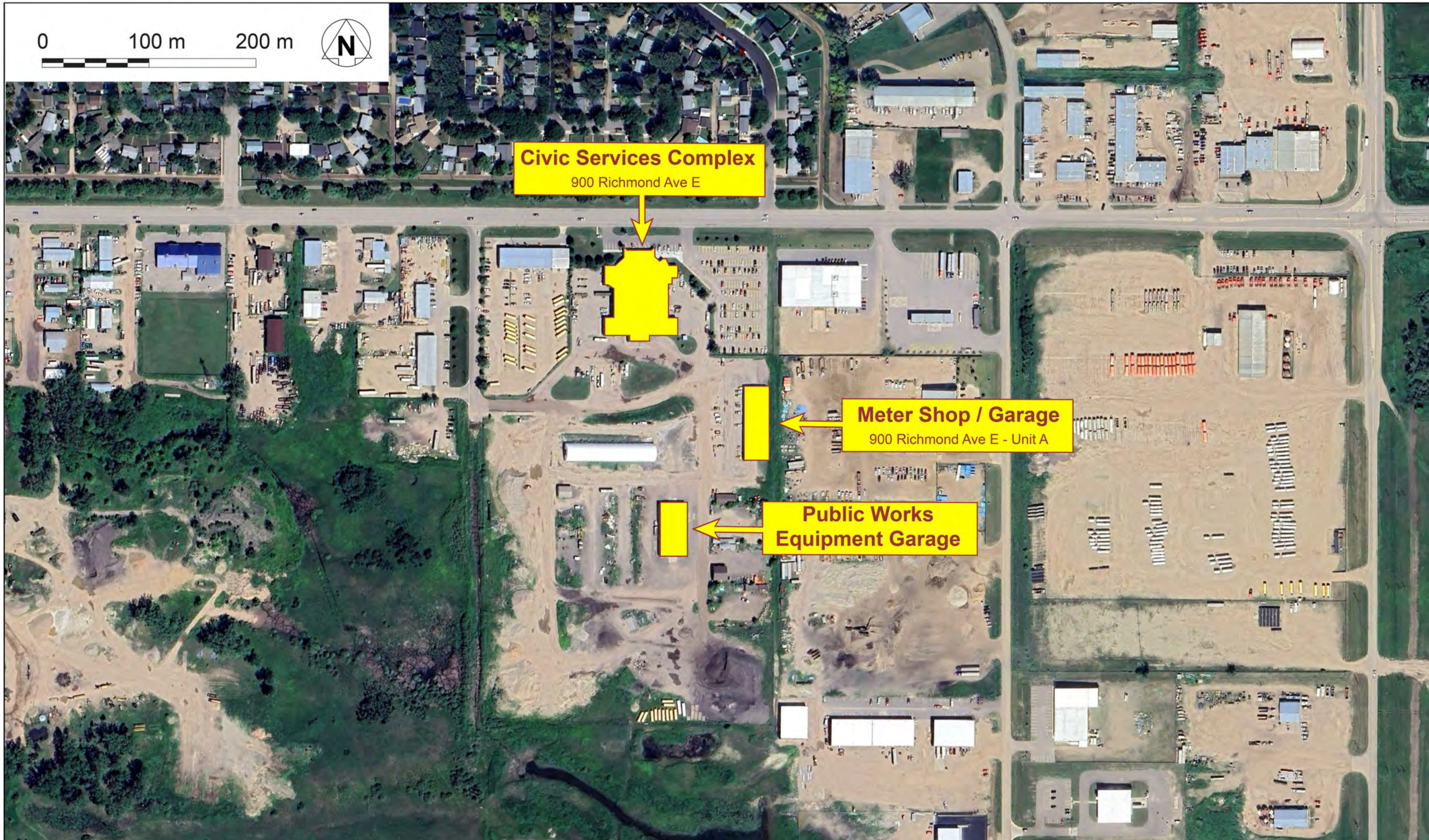
SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: BRANDON
TARGET BUILDINGS
SATELLITE VIEW

DRAWING NUMBER	REVISION
MMB 141	A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 FEB 01			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, 2022

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 FEB 01
DESIGNED BY:	BD	2024 FEB 01
CHECKED BY:		

SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: BRANDON
TARGET FACILITIES - CIVIC SERVICES CLUSTER
SATELLITE VIEW

DRAWING NUMBER: MMB 142

REVISION: A

REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 MAR 10			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, 2022

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 MAR 10
DESIGNED BY:	BD	2024 MAR 10
CHECKED BY:		

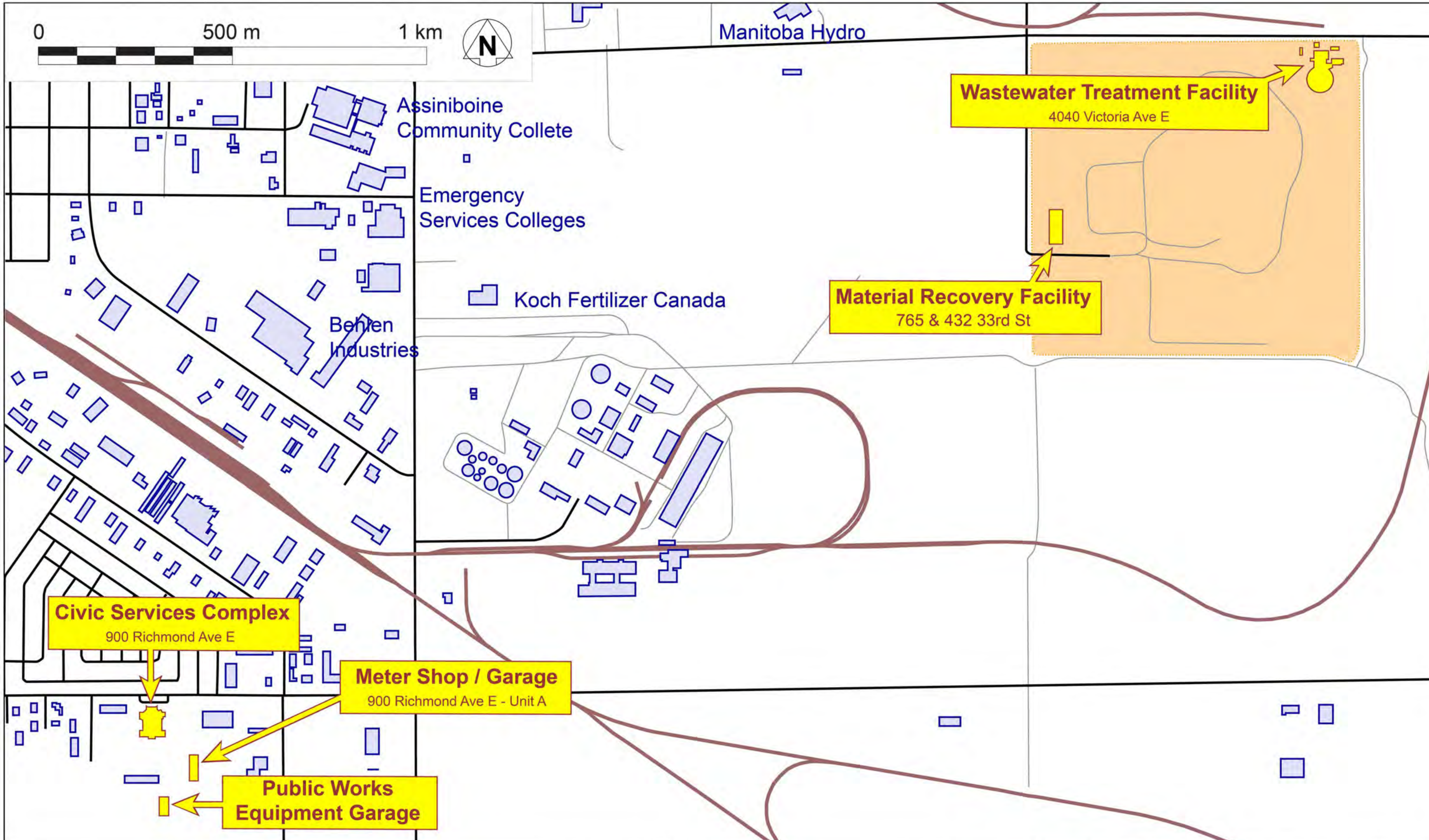
SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: BRANDON
TARGET FACILITIES - EAST LANDFILL CLUSTER
SATELLITE VIEW

DRAWING NUMBER	REVISION
MMB 143	A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 MAR 05			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, 2022

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 MAR 05
DESIGNED BY:	BD	2024 MAR 05
CHECKED BY:		

SCALE: AS SHOWN

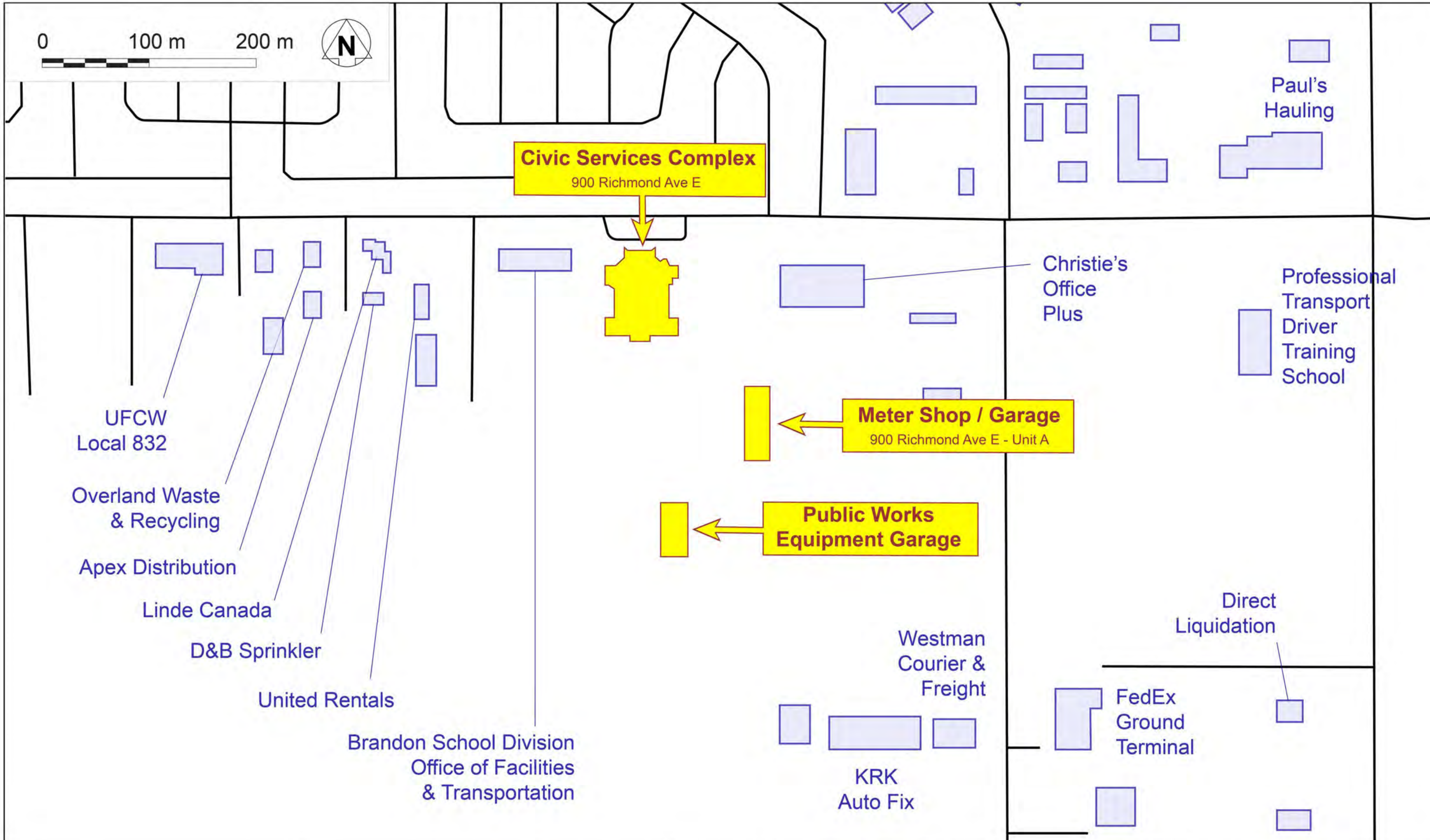
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: BRANDON
TARGET BUILDINGS
MAP VIEW

DRAWING NUMBER: MMB 151

REVISION: A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 FEB 01			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, 2022

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 FEB 01
DESIGNED BY:	BD	2024 FEB 01
CHECKED BY:		

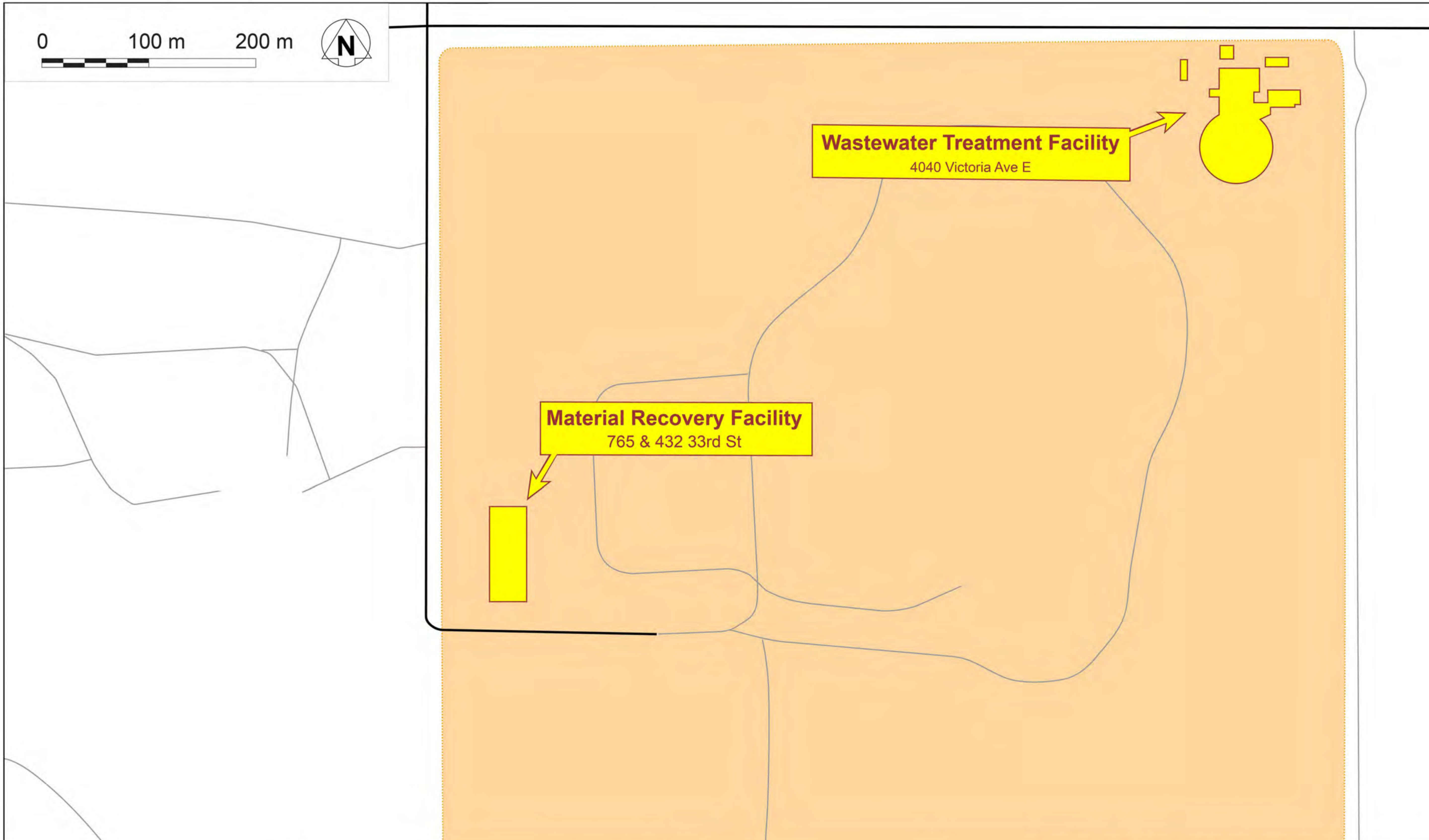
SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: BRANDON
TARGET FACILITIES - CIVIC SERVICES CLUSTER
MAP VIEW

DRAWING NUMBER	REVISION
MMB 152	A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 MAR 10			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, 2022

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 MAR 10
DESIGNED BY:	BD	2024 MAR 10
CHECKED BY:		

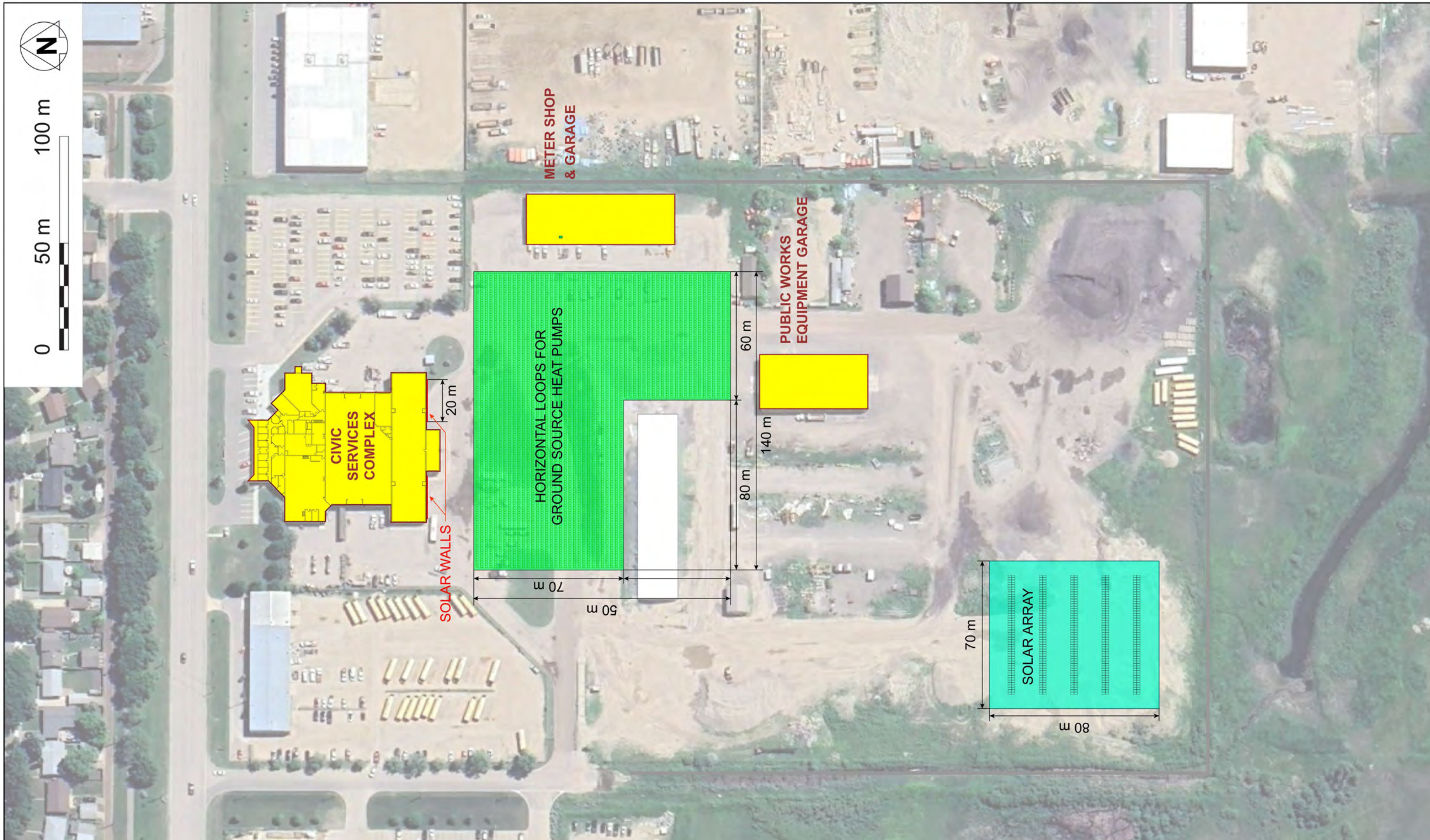
SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE:
BRANDON
TARGET FACILITIES - EAST LANDFILL CLUSTER
MAP VIEW

DRAWING NUMBER	REVISION
MMB 153	A



REFERENCES	
NUMBER	DESCRIPTION

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 MAR 18			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca Google Earth, 2022

	NAME	DATE
DRAWN BY:	BD	2024 MAR 18
DESIGNED BY:	BD	2024 MAR 18
CHECKED BY:		
SCALE: AS SHOWN		

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: BRANDON
TARGET BUILDINGS - CIVIC SERVICES CLUSTER - WITH RENEWABLES
SATELLITE VIEW

DRAWING NUMBER	REVISION
MMB 162	A

REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
B	ISSUED FOR REVIEW	2024 JUL 15			
A	ISSUED FOR REVIEW	2024 MAR 20			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, 2022

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 JUL15
DESIGNED BY:	BD	2024 JUL 15
CHECKED BY:		

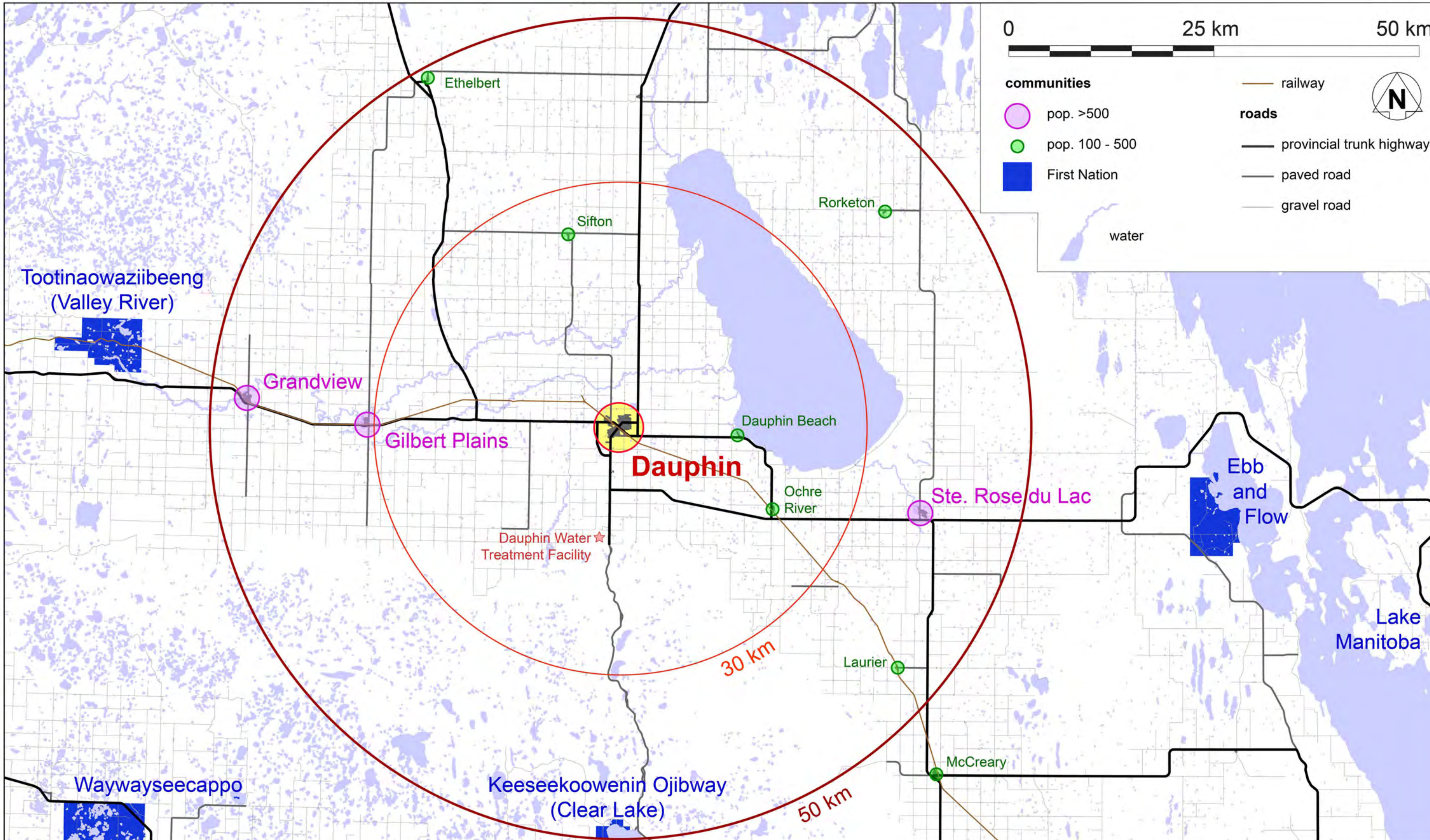
SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: BRANDON
TARGET FACILITIES - EAST LANDFILL CLUSTER - WITH RENEWABLES
SATELLITE VIEW

DRAWING NUMBER	REVISION
MMB 163	B



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS						
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED	
A	ISSUED FOR REVIEW	2023 OCT 01				

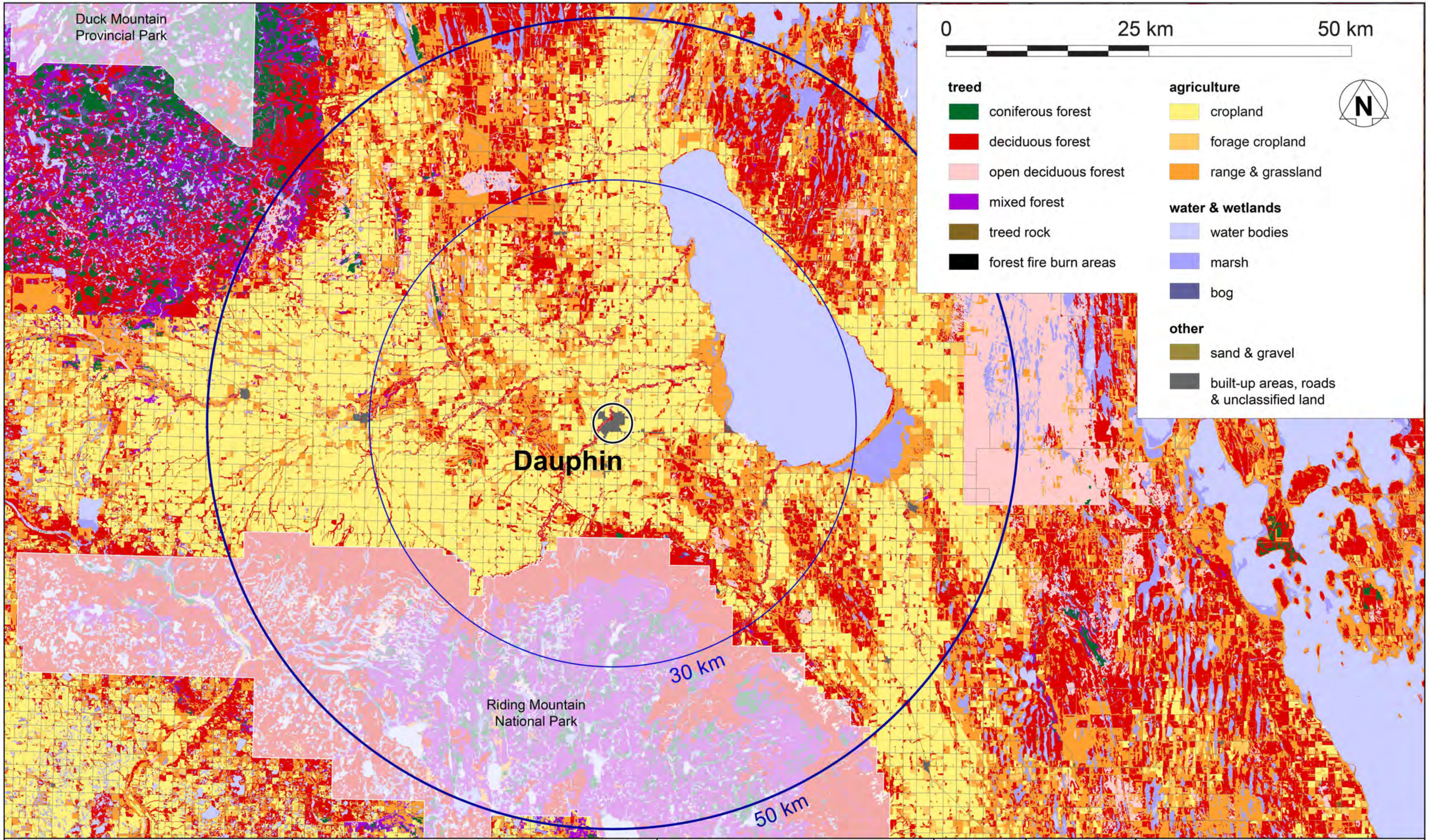
sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 01
DESIGNED BY:	BD	2023 OCT 01
CHECKED BY:		
SCALE:	AS SHOWN	

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION
PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY
TITLE: DAUPHIN
MAP VIEW
50 KM RADIUS

DRAWING NUMBER	REVISION
MMB 201	A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 06			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 06
DESIGNED BY:	BD	2023 OCT 06
CHECKED BY:		

SCALE: AS SHOWN

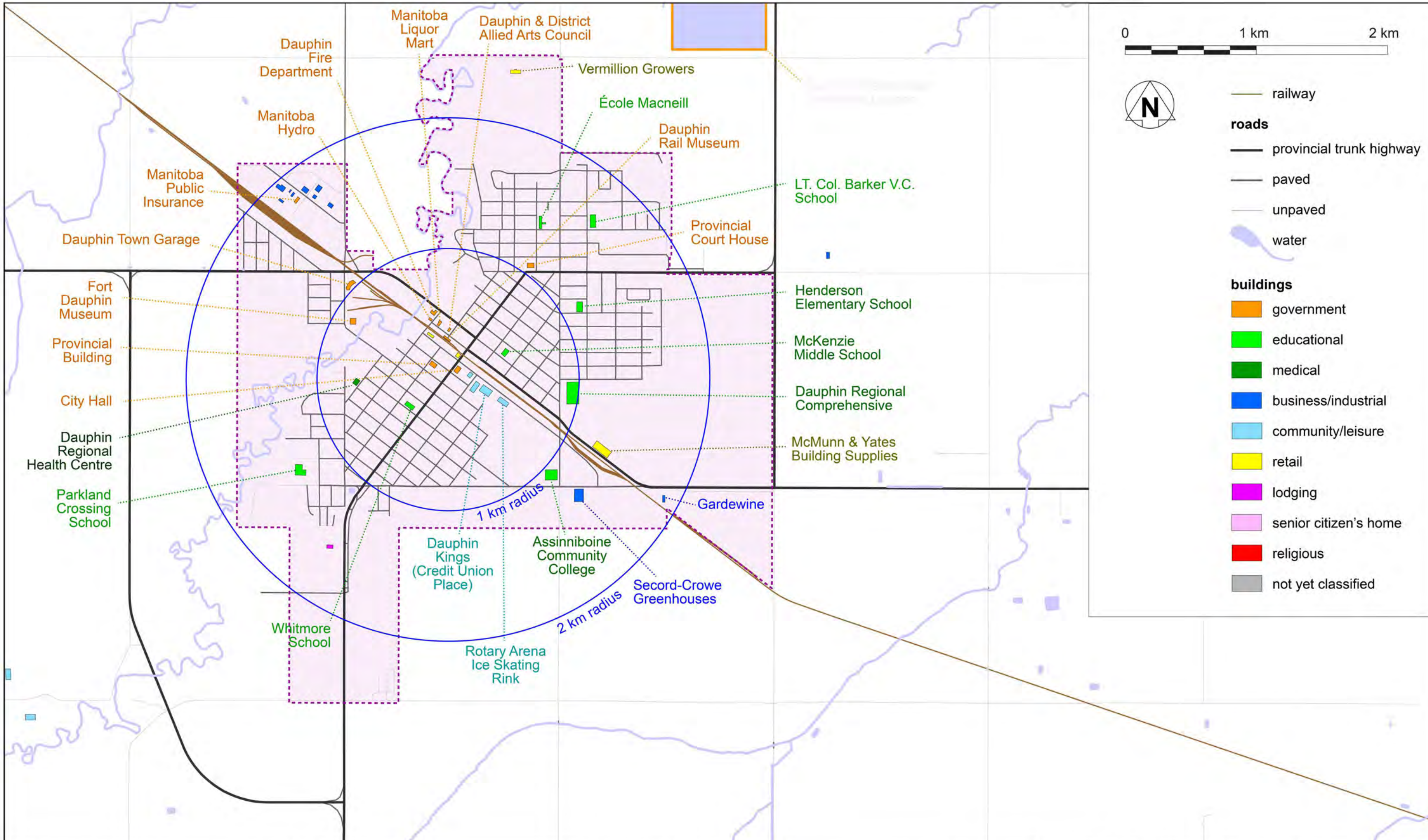
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: DAUPHIN LAND COVER 50 KM RADIUS

DRAWING NUMBER: MMB 211

REVISION: A



REFERENCES	
NUMBER	DESCRIPTION

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
B	ISSUED FOR REVIEW	2023 NOV 22			
A	ISSUED FOR REVIEW	2023 OCT 08			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 NOV 22
DESIGNED BY:	BD	2023 NOV 22
CHECKED BY:		

SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: DAUPHIN MAP VIEW 2 KM RADIUS

DRAWING NUMBER: MMB 221

REVISION: B

REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
C	ISSUED FOR REVIEW	2024 JUL 23			
B	ISSUED FOR REVIEW	2024 APR 24			
A	ISSUED FOR REVIEW	2024 FEB 01			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, 2024

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 JUL 23
DESIGNED BY:	BD	2024 JUL 23
CHECKED BY:		

SCALE: AS SHOWN

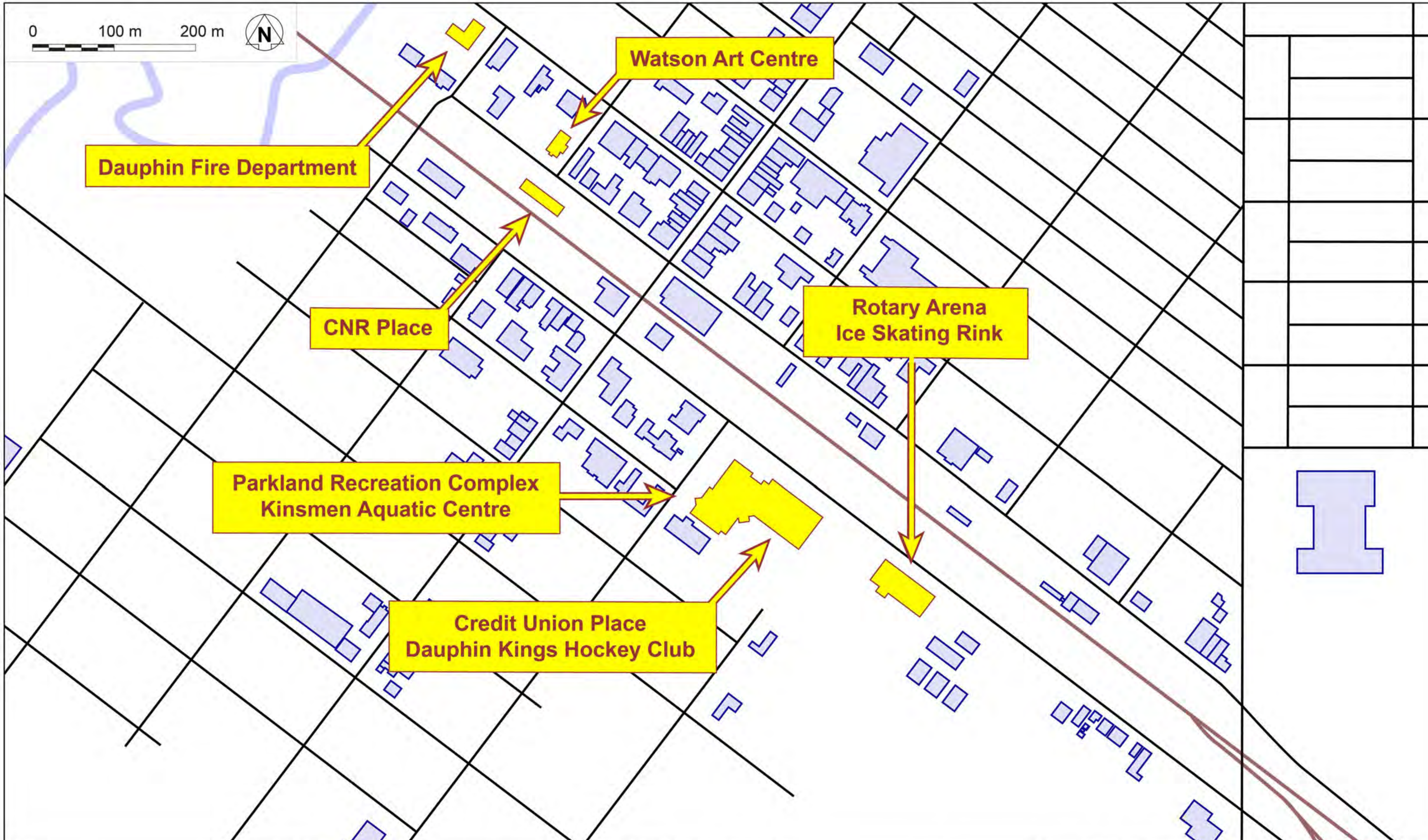
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE:
DAUPHIN
TARGET BUILDINGS
SATELLITE VIEW

DRAWING NUMBER: MMB 241

REVISION: C



REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
B	ISSUED FOR REVIEW	2024 JUL 23			
B	ISSUED FOR REVIEW	2024 APR 24			
A	ISSUED FOR REVIEW	2024 FEB 01			

sources: Government of Manitoba, *Data MB.*
https://geoportal.gov.mb.ca
Google Earth, 2024

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 JUL 23
DESIGNED BY:	BD	2024 JUL 23
CHECKED BY:		

SCALE: AS SHOWN

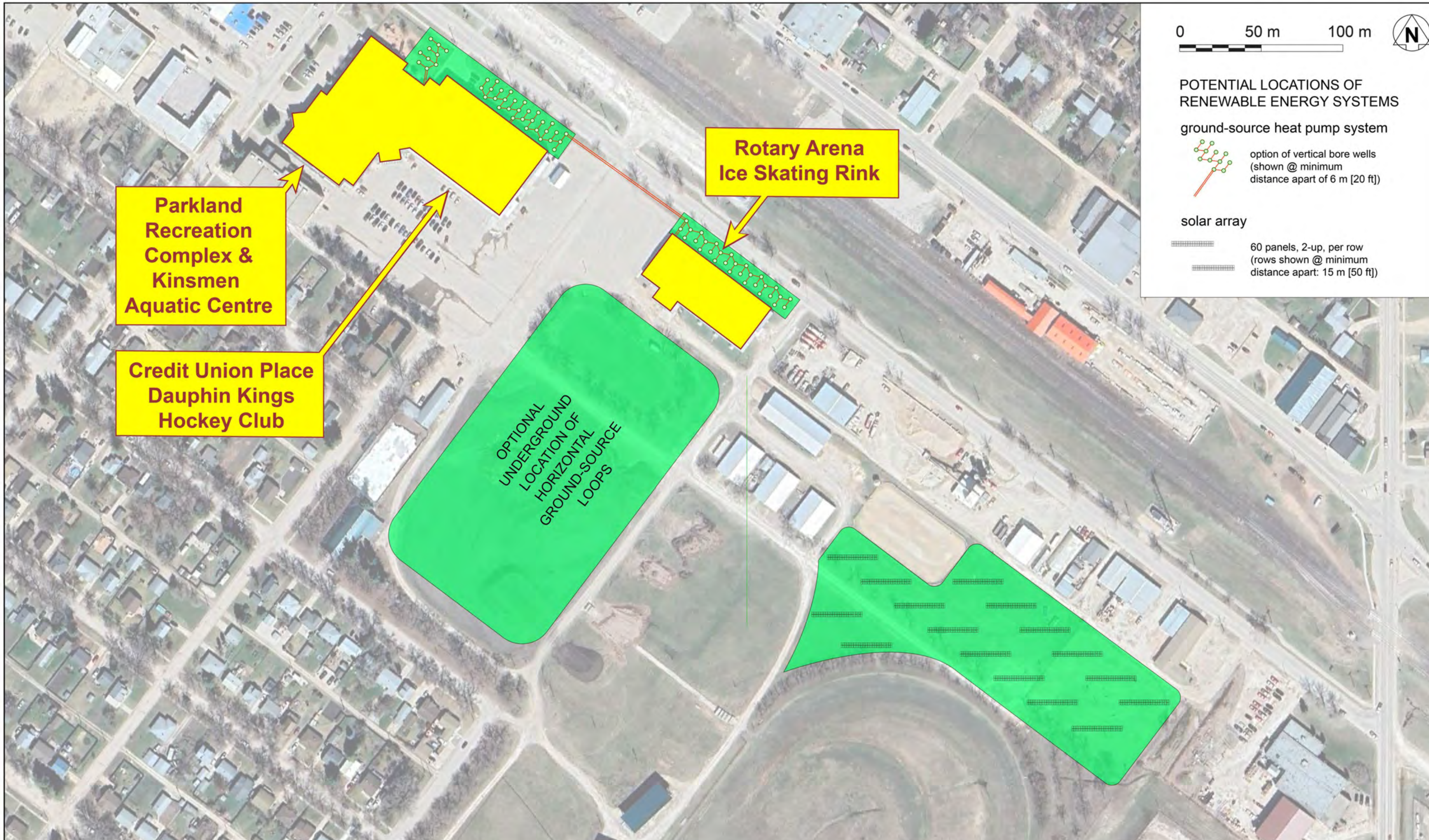
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE:
DAUPHIN
TARGET BUILDINGS
MAP VIEW

DRAWING NUMBER: MMB 251

REVISION: B



REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
B	ISSUED FOR REVIEW	2024 JUL 23			
A	ISSUED FOR REVIEW	2024 APR 24			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, 2024

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 JUL 23
DESIGNED BY:	BD	2024 JUL 23
CHECKED BY:		

SCALE: AS SHOWN

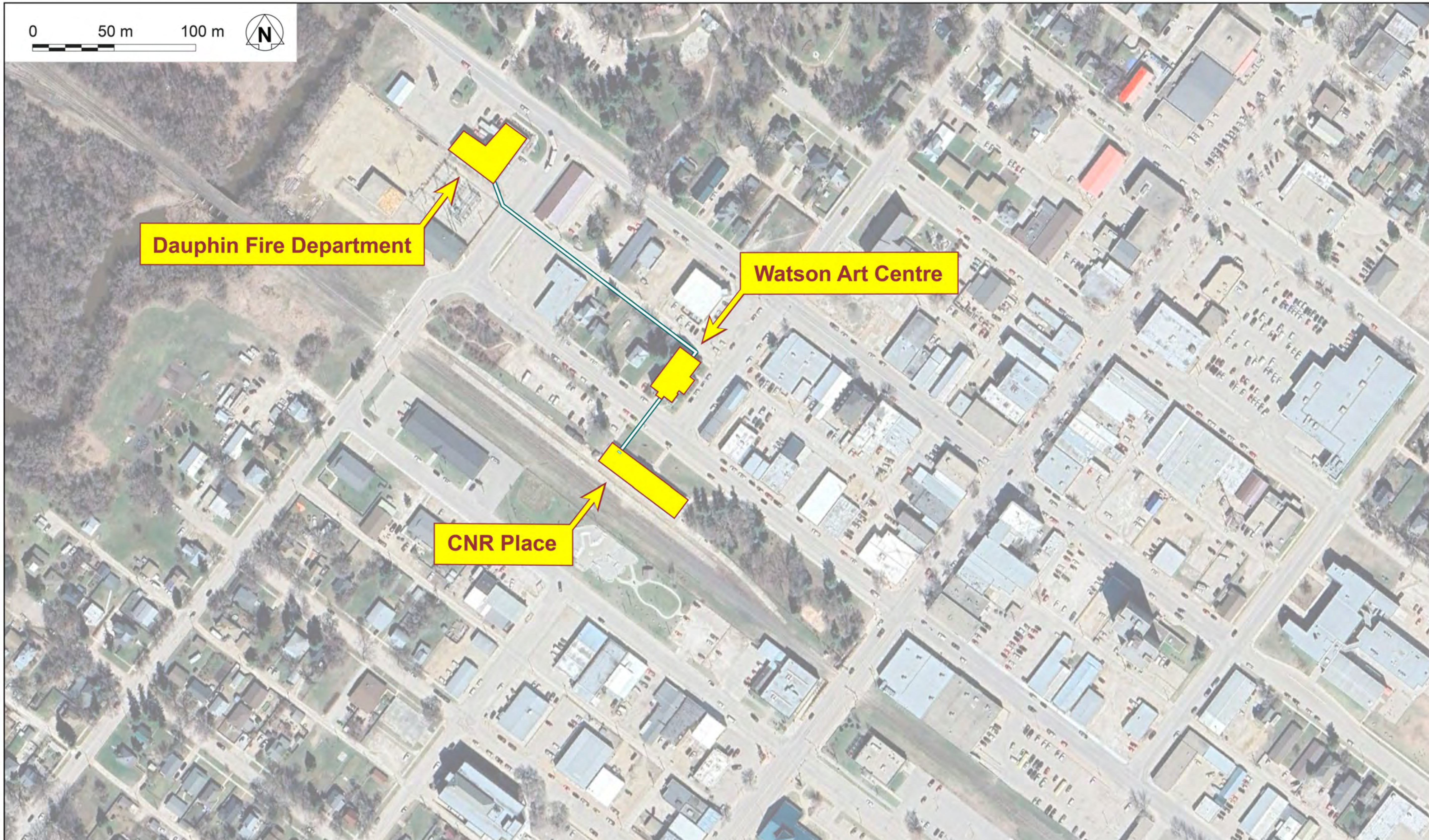
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: DAUPHIN
TARGET BUILDINGS - DOWNTOWN CLUSTER - WITH RENEWABLES
SATELLITE VIEW

DRAWING NUMBER: MMB 262

REVISION: B



REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
B	ISSUED FOR REVIEW	2024 APR 24			
A	ISSUED FOR REVIEW	2024 APR 24			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, 2024

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 JUL 23
DESIGNED BY:	BD	2024 JUL 23
CHECKED BY:		

SCALE: AS SHOWN

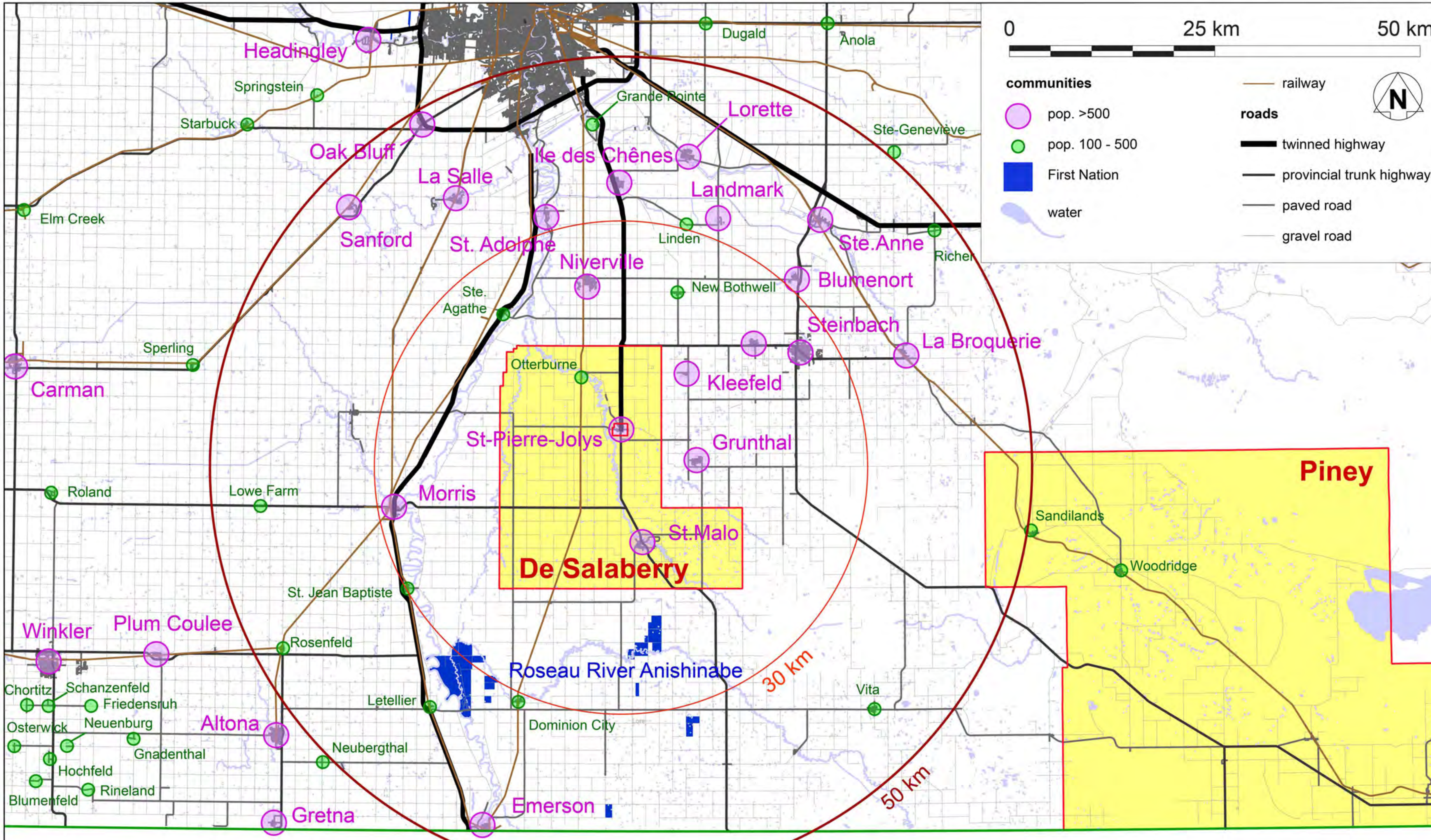
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: DAUPHIN
TARGET BUILDINGS - RAILWAY CLUSTER - WITH RENEWABLES
SATELLITE VIEW

DRAWING NUMBER: MMB 263

REVISION: B



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 01			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca

BOKE

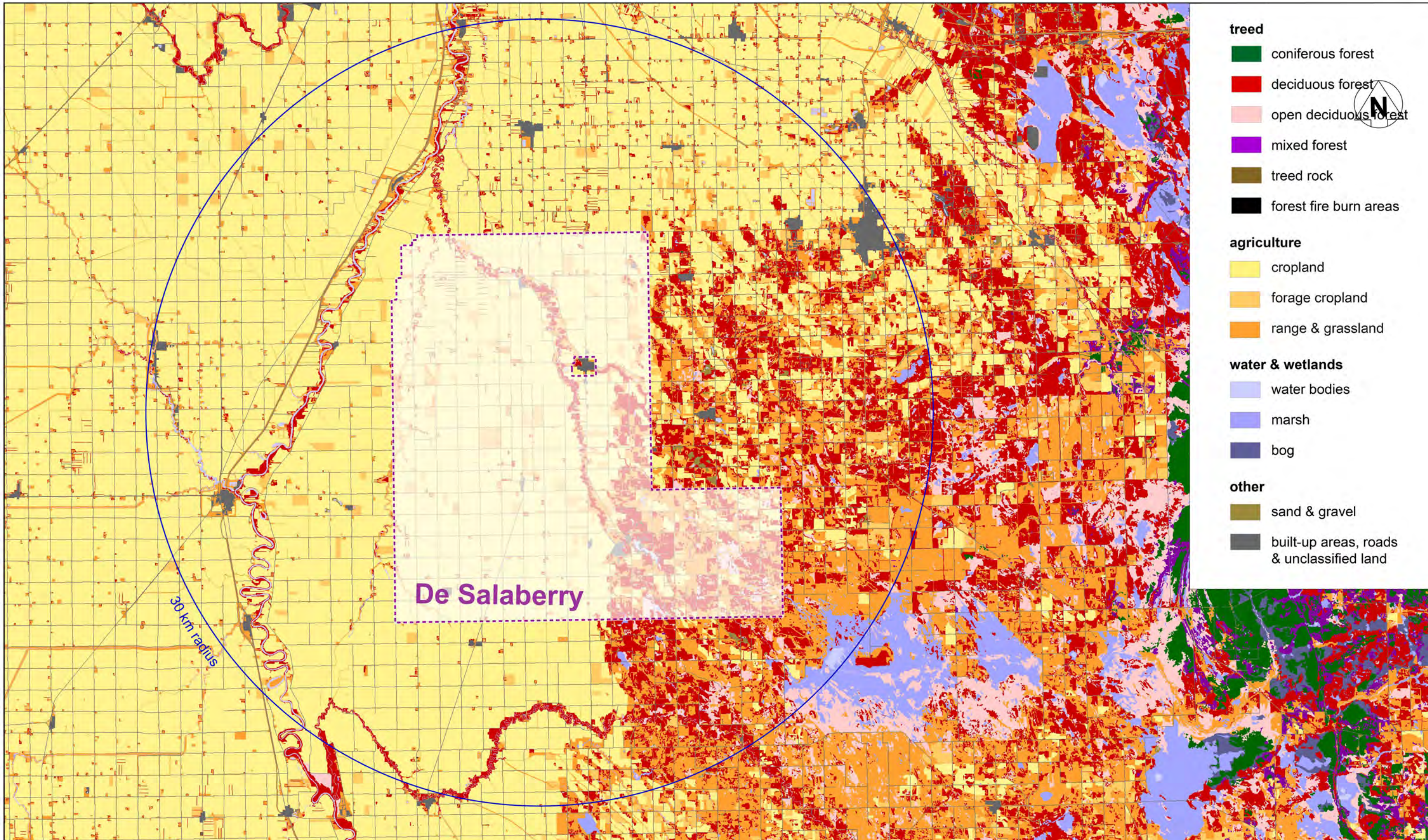
	NAME	DATE
DRAWN BY:	BD	2023 OCT 01
DESIGNED BY:	BD	2023 OCT 01
CHECKED BY:		
SCALE:	AS SHOWN	

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: DE SALABERRY
MAP VIEW
50 KM RADIUS

DRAWING NUMBER	REVISION
MMB 301	A



REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 05			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 05
DESIGNED BY:	BD	2023 OCT 05
CHECKED BY:		

SCALE: AS SHOWN

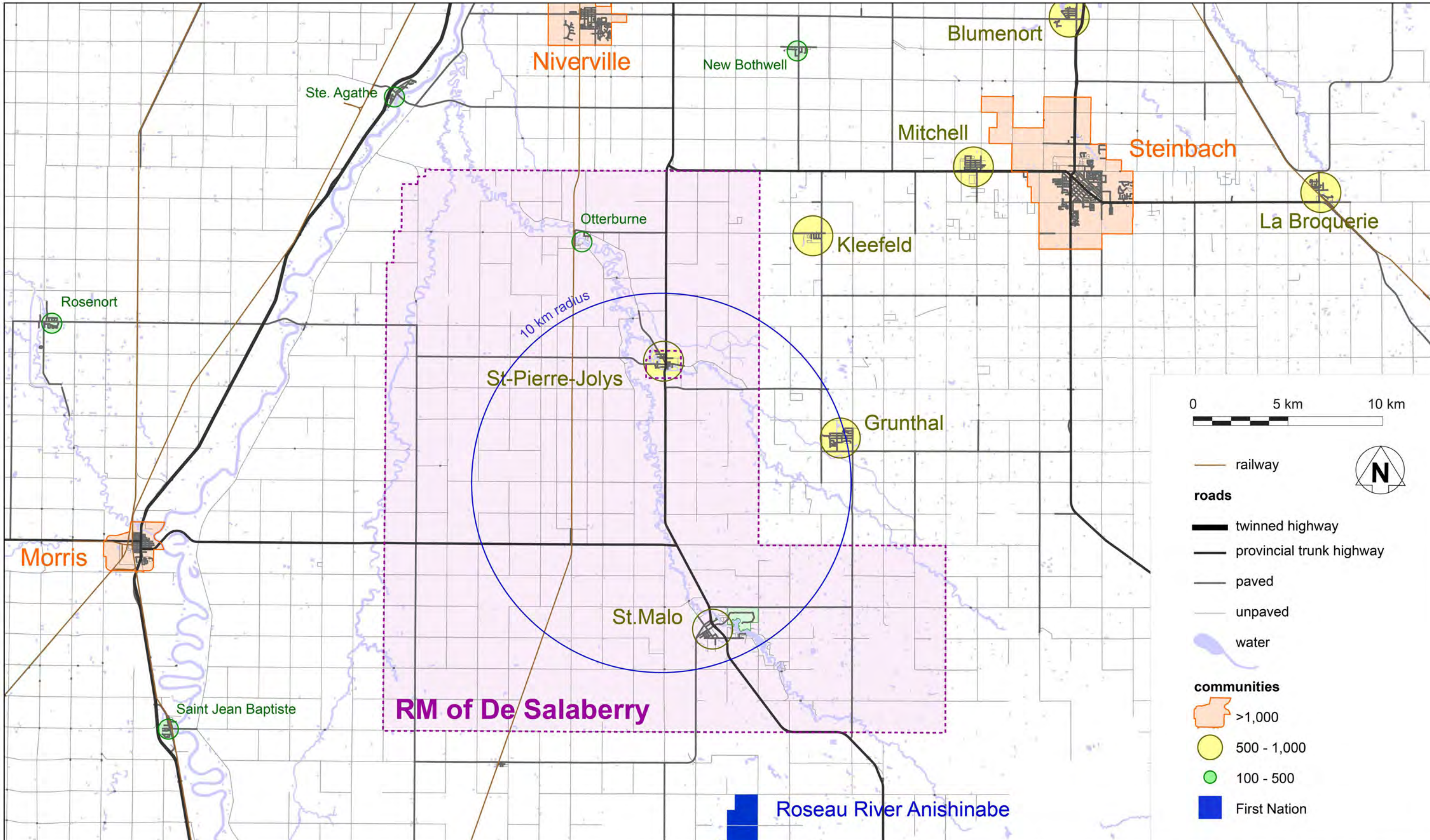
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE:
DE SALABERRY
LAND COVER
30 KM RADIUS

DRAWING NUMBER: MMB 312

REVISION: A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 20			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 10
DESIGNED BY:	BD	2023 OCT 10
CHECKED BY:		
SCALE:	AS SHOWN	

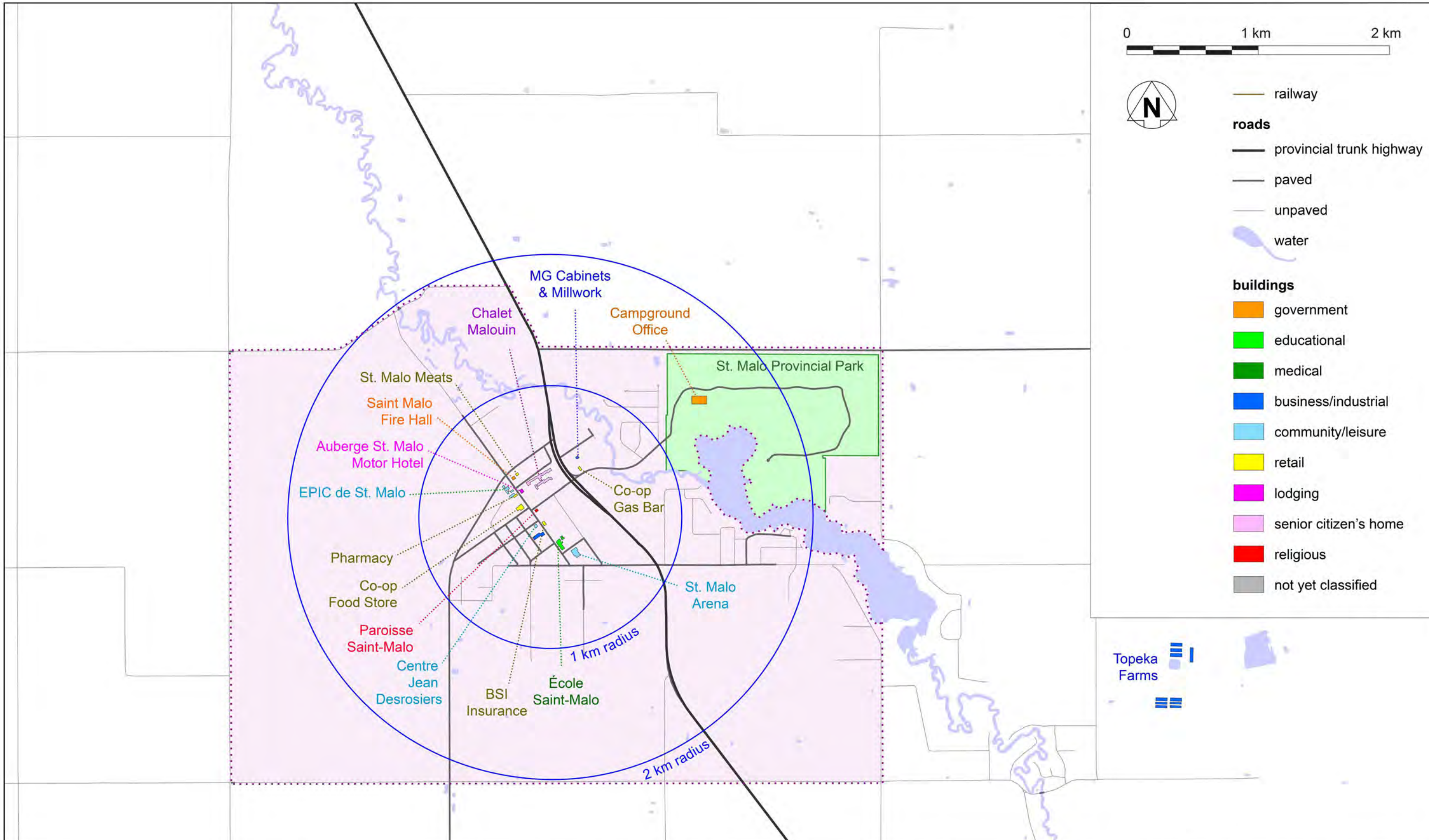
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: DE SALABERRY
MAP VIEW
10 KM RADIUS

DRAWING NUMBER: MMB 321

REVISION: A



REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
B	ISSUED FOR REVIEW	2024 FEB 09			
A	ISSUED FOR REVIEW	2023 OCT 20			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca
Google Earth, 2024

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 FEB 09
DESIGNED BY:	BD	2023 FEB 09
CHECKED BY:		

SCALE: AS SHOWN

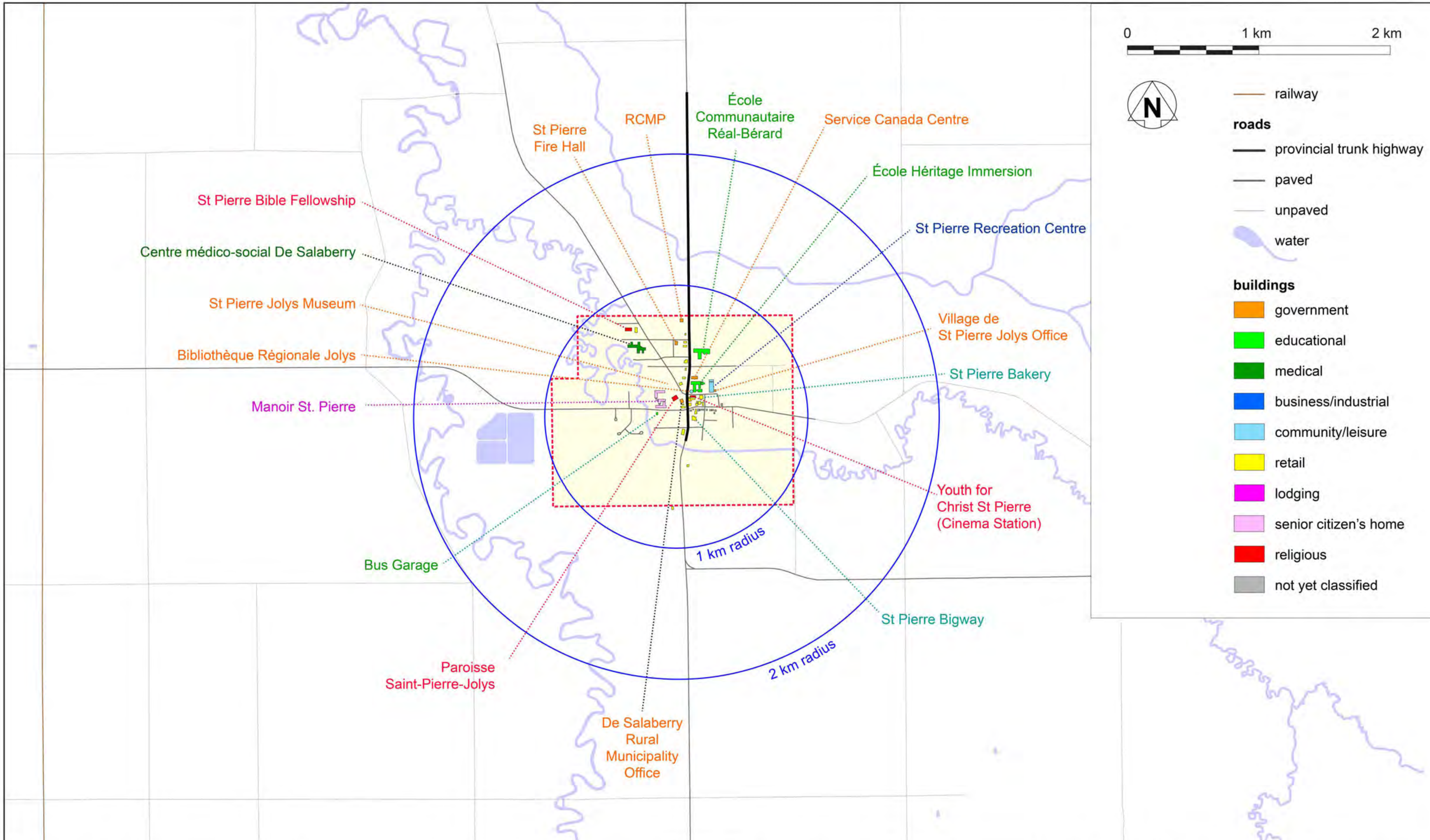
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: DE SALABERRY
ST MALO
2 KM RADIUS

DRAWING NUMBER: MMB 331

REVISION: B



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 20			

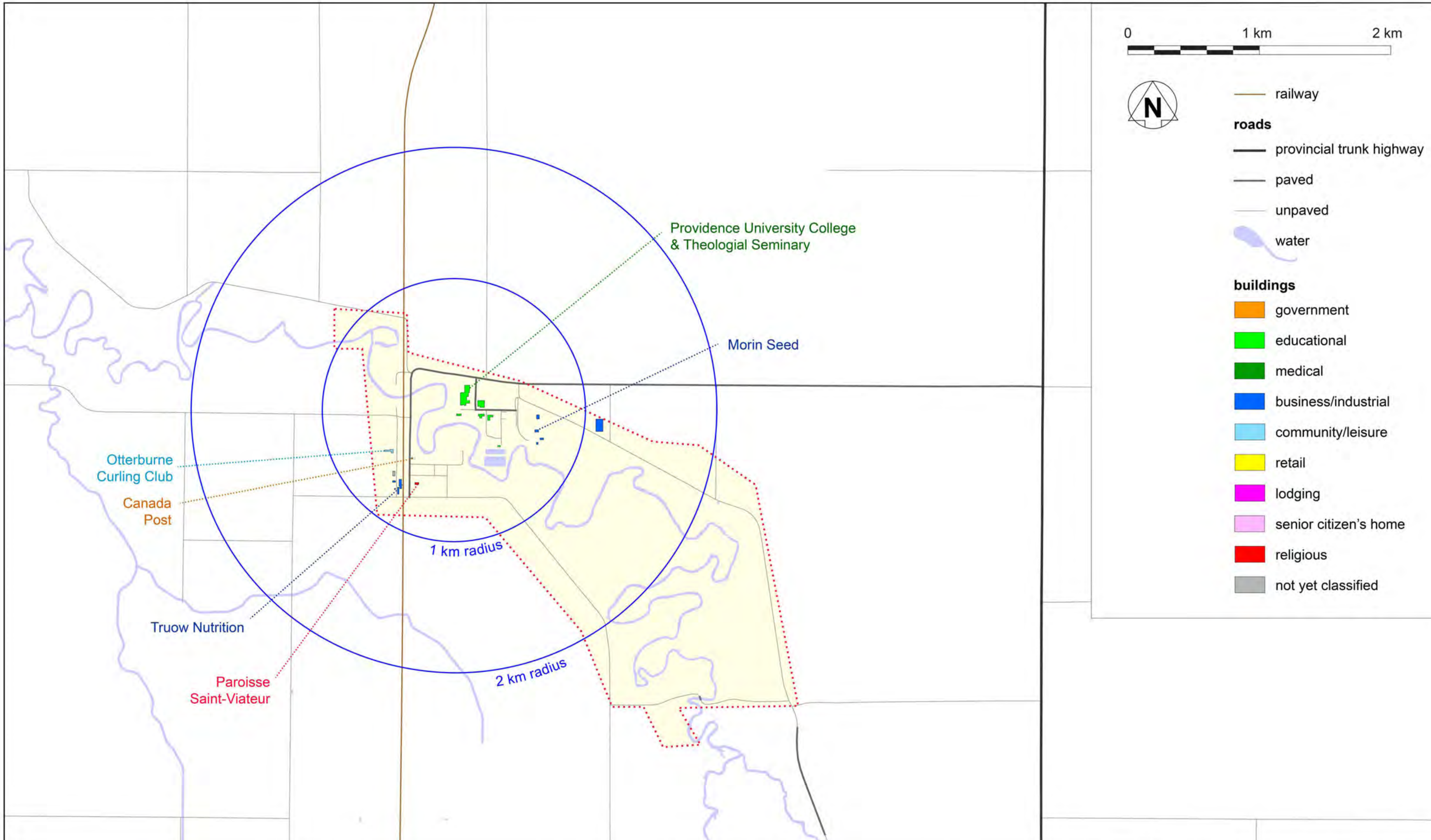
sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 10
DESIGNED BY:	BD	2023 OCT 10
CHECKED BY:		
SCALE:	AS SHOWN	

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION
PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY
TITLE: DE SALABERRY
ST-PIERRE-JOLYS
2 KM RADIUS

DRAWING NUMBER: MMB 332
REVISION: A



REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 13			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 13
DESIGNED BY:	BD	2023 OCT 13
CHECKED BY:		

SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: DE SALABERRY
OTTERBURNE
2 KM RADIUS

DRAWING NUMBER: MMB 333

REVISION: A

REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 FEB 09			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca
Google Earth, 2024

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 FEB 09
DESIGNED BY:	BD	2024 FEB 09
CHECKED BY:		

SCALE: AS SHOWN

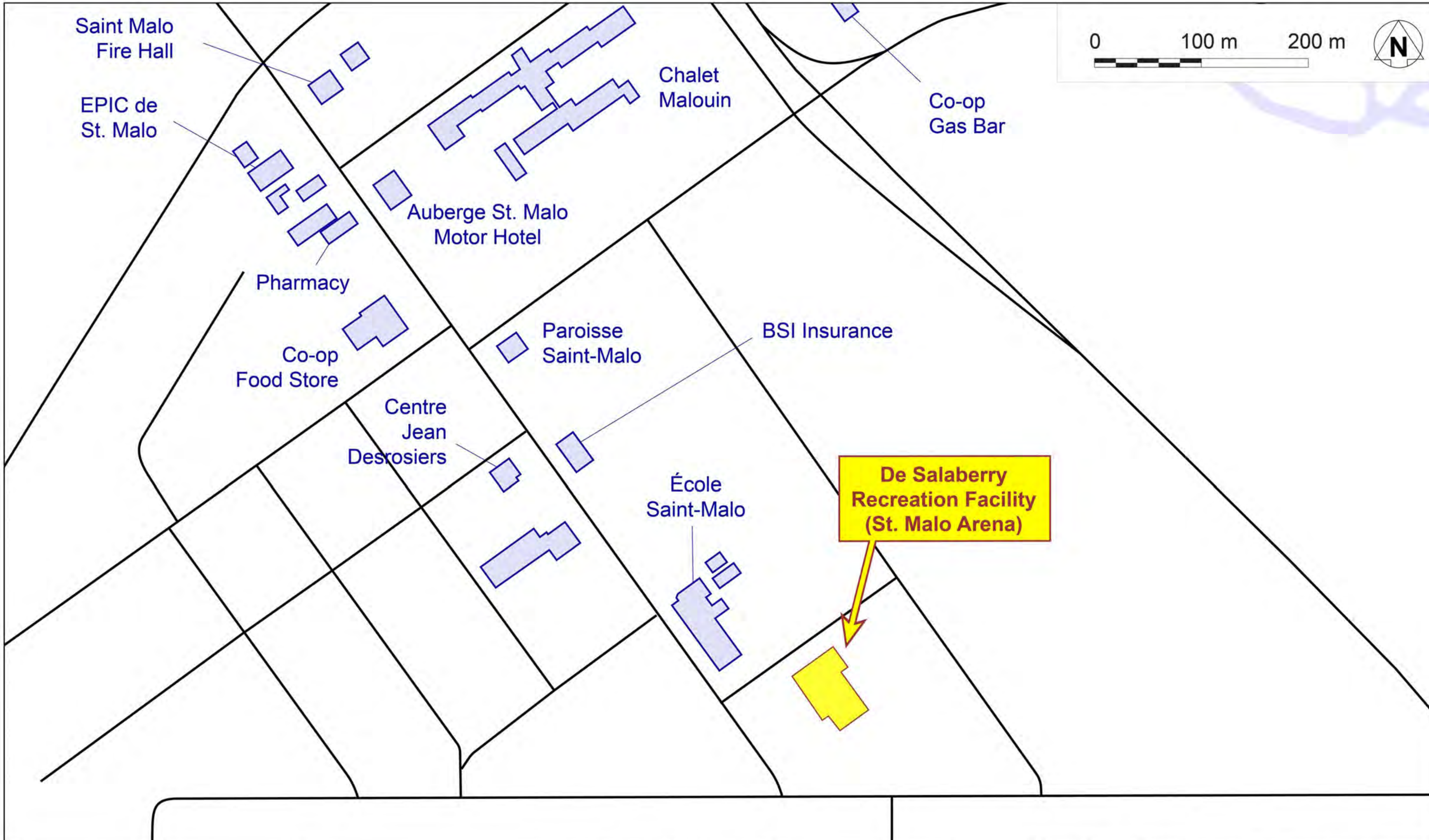
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE:
DE SALABERRY
ST MALO - TARGET BUILDING
SATELLITE VIEW

DRAWING NUMBER: MMB 341

REVISION: A



REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 FEB 09			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca
Google Earth, 2024

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 FEB 09
DESIGNED BY:	BD	2023 FEB 09
CHECKED BY:		

SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: DE SALABERRY
ST MALO - TARGET BUILDING
SATELLITE VIEW

DRAWING NUMBER: MMB 351

REVISION: A

REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 JUL 23			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca
Google Earth, 2024

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 JUL 23
DESIGNED BY:	BD	2024 JUL 23
CHECKED BY:		

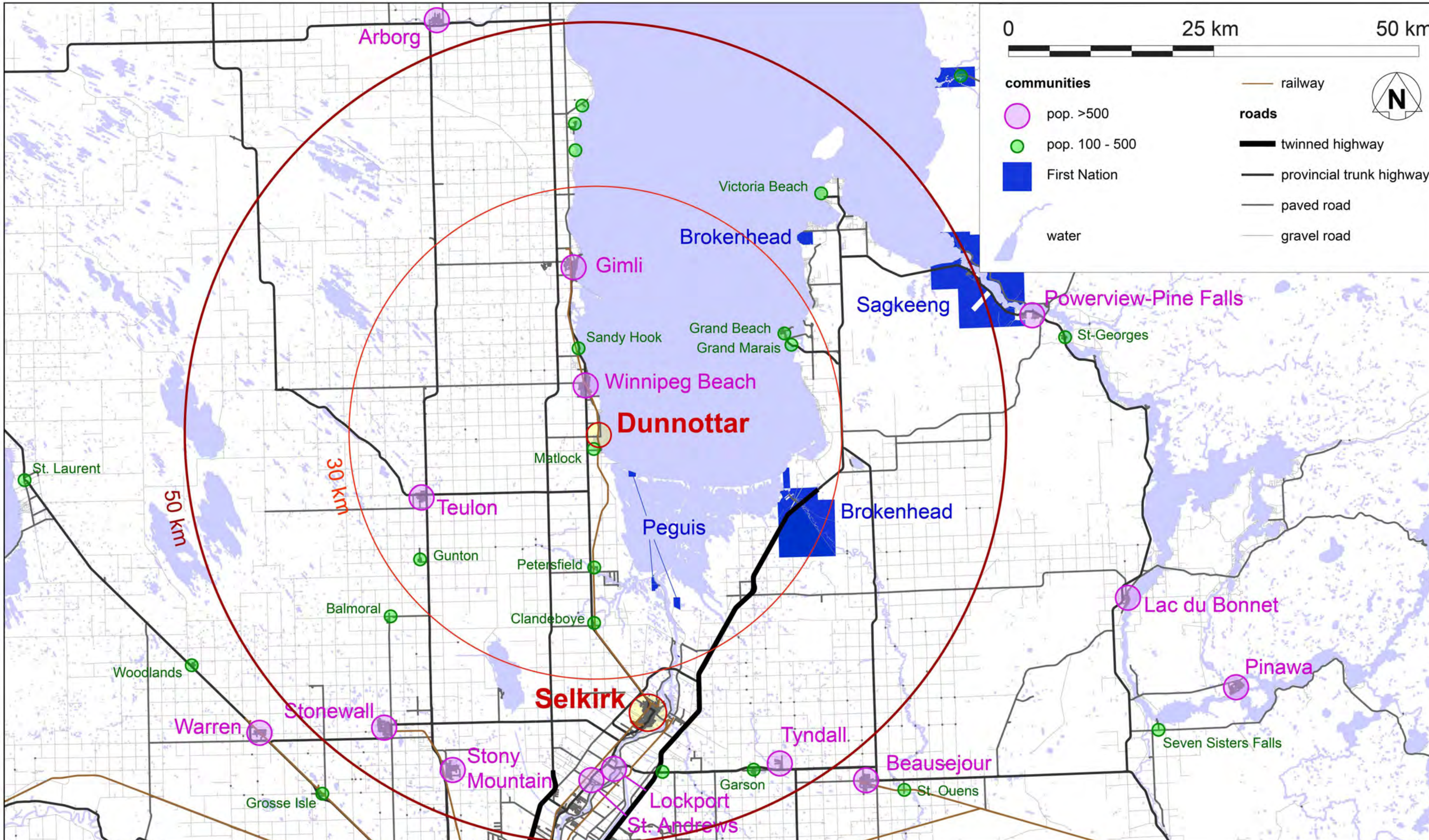
SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: DE SALABERRY
ST MALO - TARGET BUILDING - WITH RENEWABLES
SATELLITE VIEW

DRAWING NUMBER	REVISION
MMB 361	A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS						
A	ISSUED FOR REVIEW	2023 OCT 02				
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED	

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca

BOKE

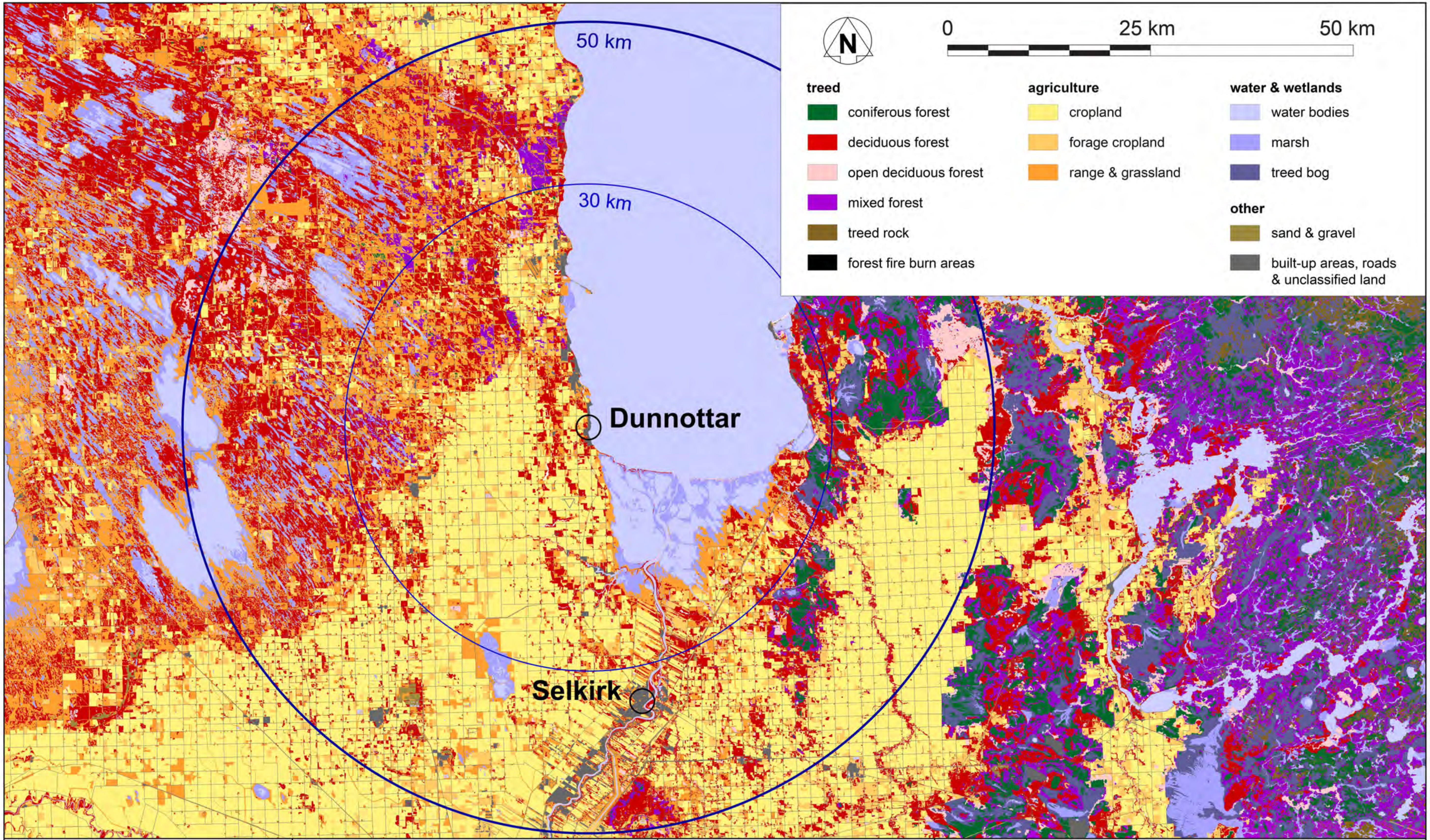
	NAME	DATE
DRAWN BY:	BD	2023 OCT 02
DESIGNED BY:	BD	2023 OCT 02
CHECKED BY:		
SCALE:	AS SHOWN	

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: DUNNOTTAR
MAP VIEW
50 KM RADIUS

DRAWING NUMBER	REVISION
MMB 401	A



REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 02			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 02
DESIGNED BY:	BD	2023 OCT 02
CHECKED BY:		

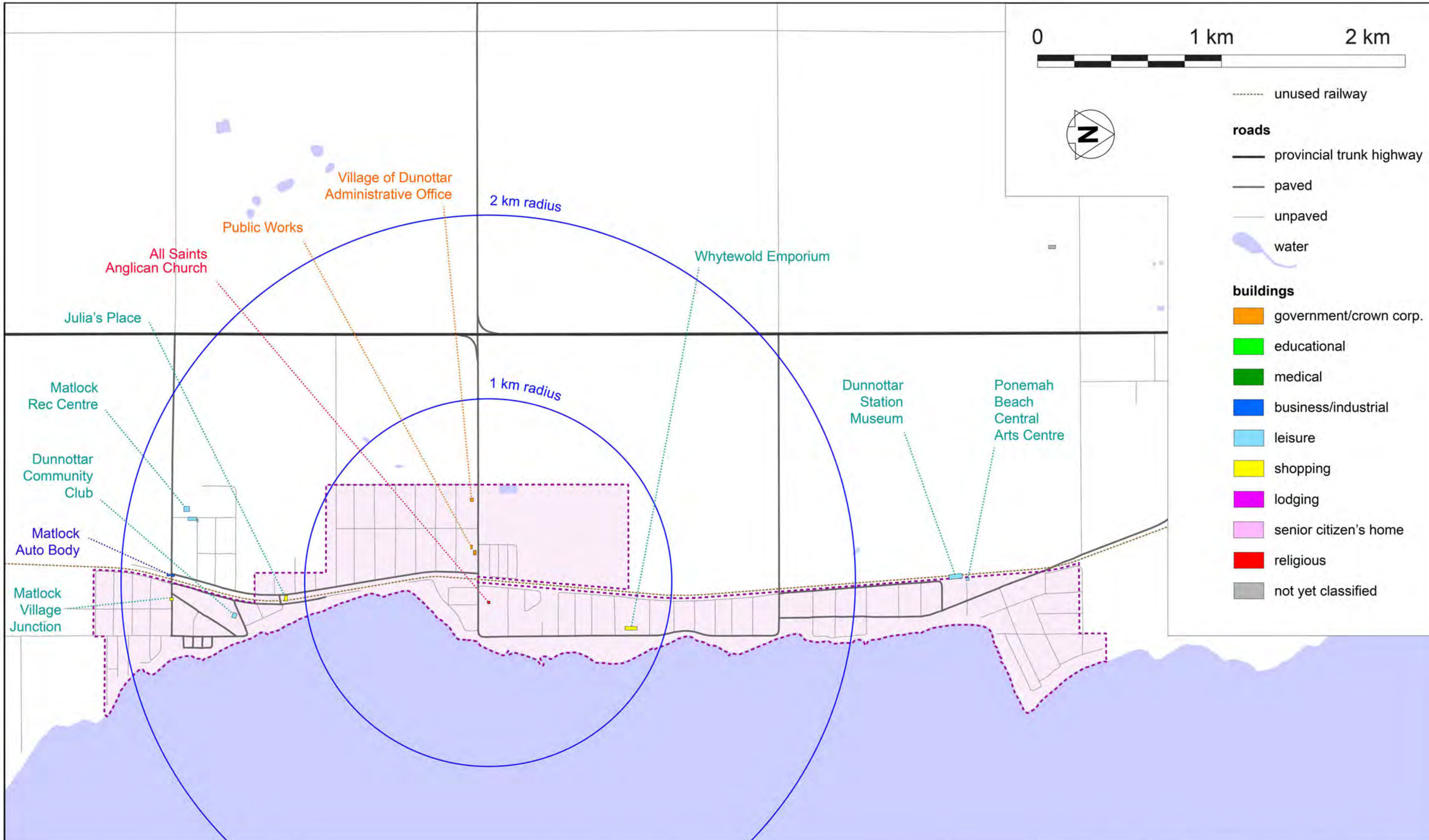
SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: DUNNOTTAR LAND COVER 50 KM RADIUS

DRAWING NUMBER	REVISION
MMB 411	A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 08			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 08
DESIGNED BY:	BD	2023 OCT 08
CHECKED BY:		

SCALE: AS SHOWN

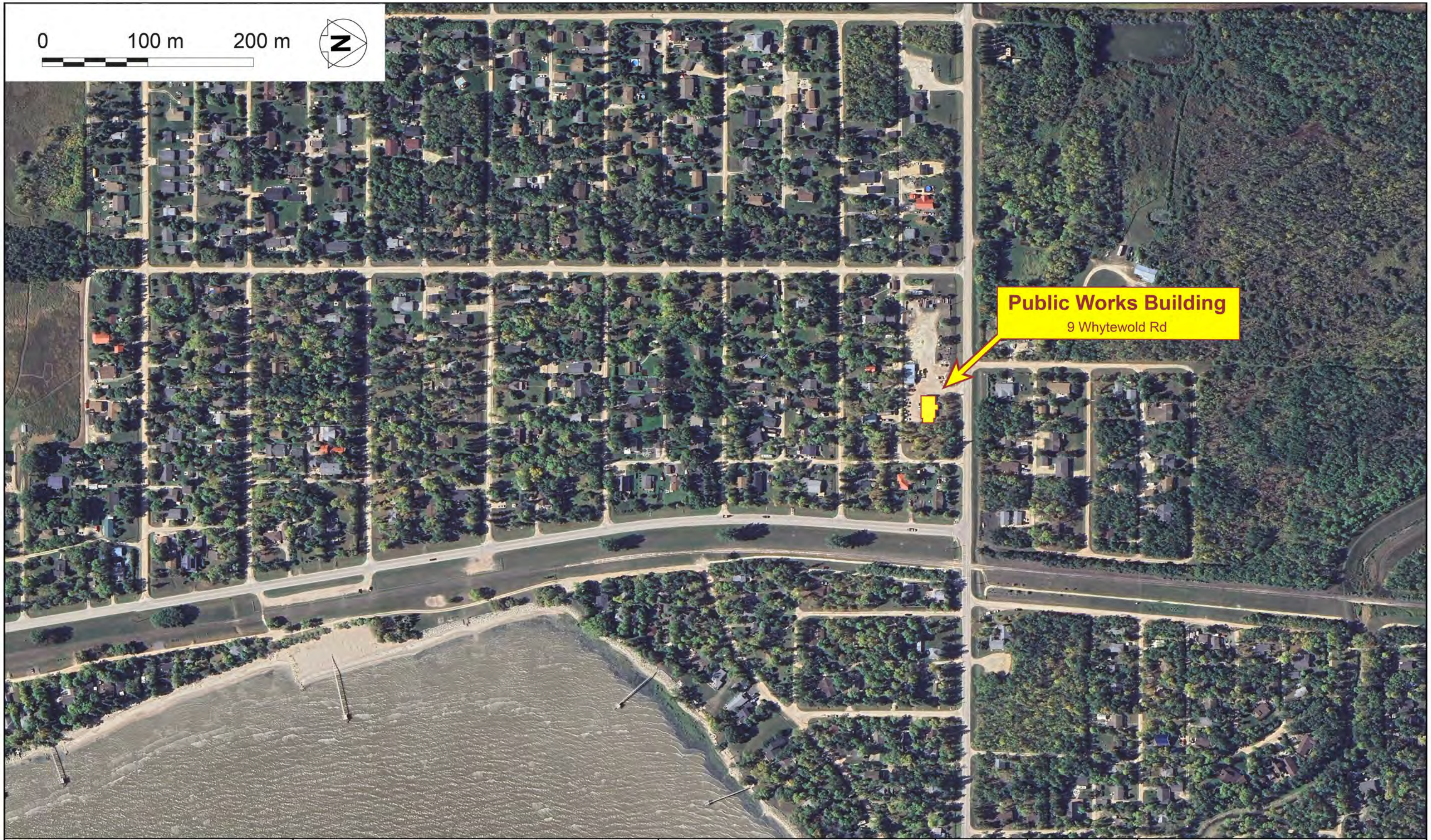
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: DUNNOTTAR
MAP VIEW
2 KM RADIUS

DRAWING NUMBER: MMB 421

REVISION: A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 FEB 08			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, 2023

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 FEB 08
DESIGNED BY:	BD	2024 FEB 08
CHECKED BY:		

SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: DUNNOTTAR
TARGET BUILDING
SATELLITE VIEW

DRAWING NUMBER: MMB 441

REVISION: A

REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 FEB 08			

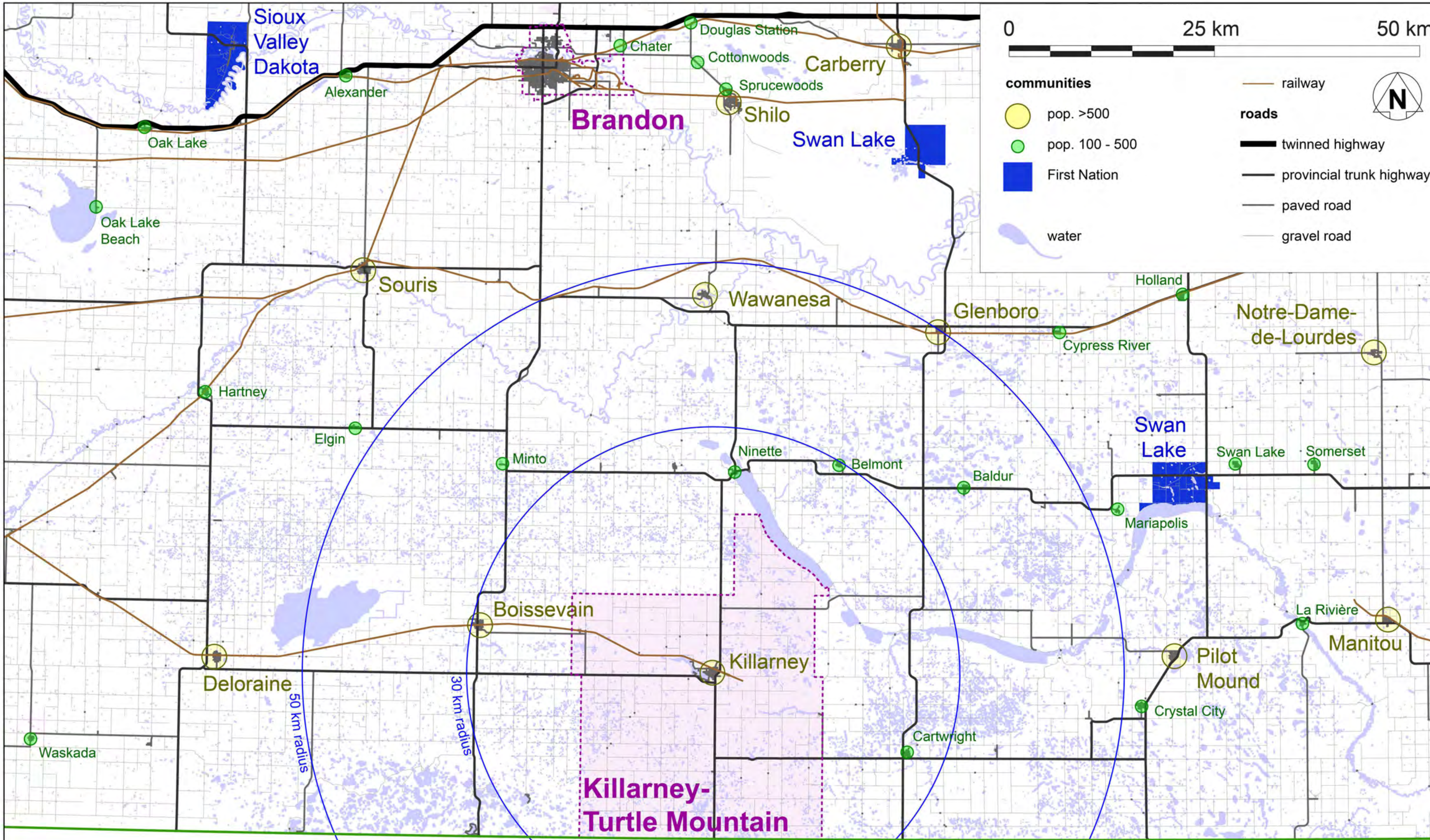
sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, 2023

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 FEB 08
DESIGNED BY:	BD	2024 FEB 08
CHECKED BY:		
SCALE:	AS SHOWN	

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION
PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY
TITLE: DUNNOTTAR
TARGET BUILDING
MAP VIEW

DRAWING NUMBER	REVISION
MMB 451	A



REFERENCES	NUMBER	DESCRIPTION	
REVISIONS	A	ISSUED FOR REVIEW	2023 OCT 02
	NO.	DESCRIPTION	DATE / DESIGNED / CHECKED / APPROVED

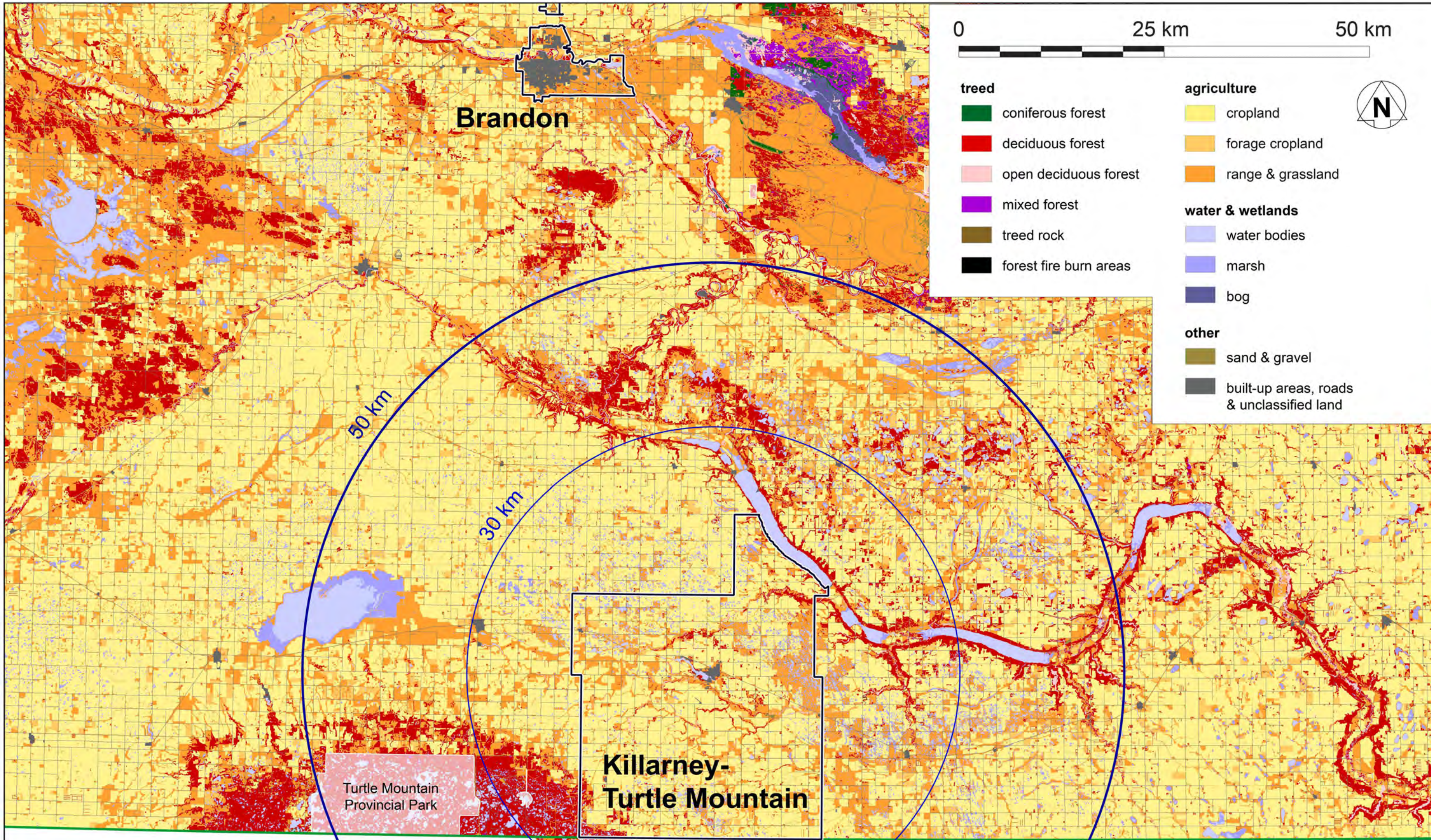
sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 02
DESIGNED BY:	BD	2023 OCT 02
CHECKED BY:		
SCALE: AS SHOWN		

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION
PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY
TITLE: KILLARNEY TURTLE MOUNTAIN
MAP VIEW
50 KM RADIUS

DRAWING NUMBER: MMB 501
REVISION: A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 06			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 06
DESIGNED BY:	BD	2023 OCT 06
CHECKED BY:		

SCALE: AS SHOWN

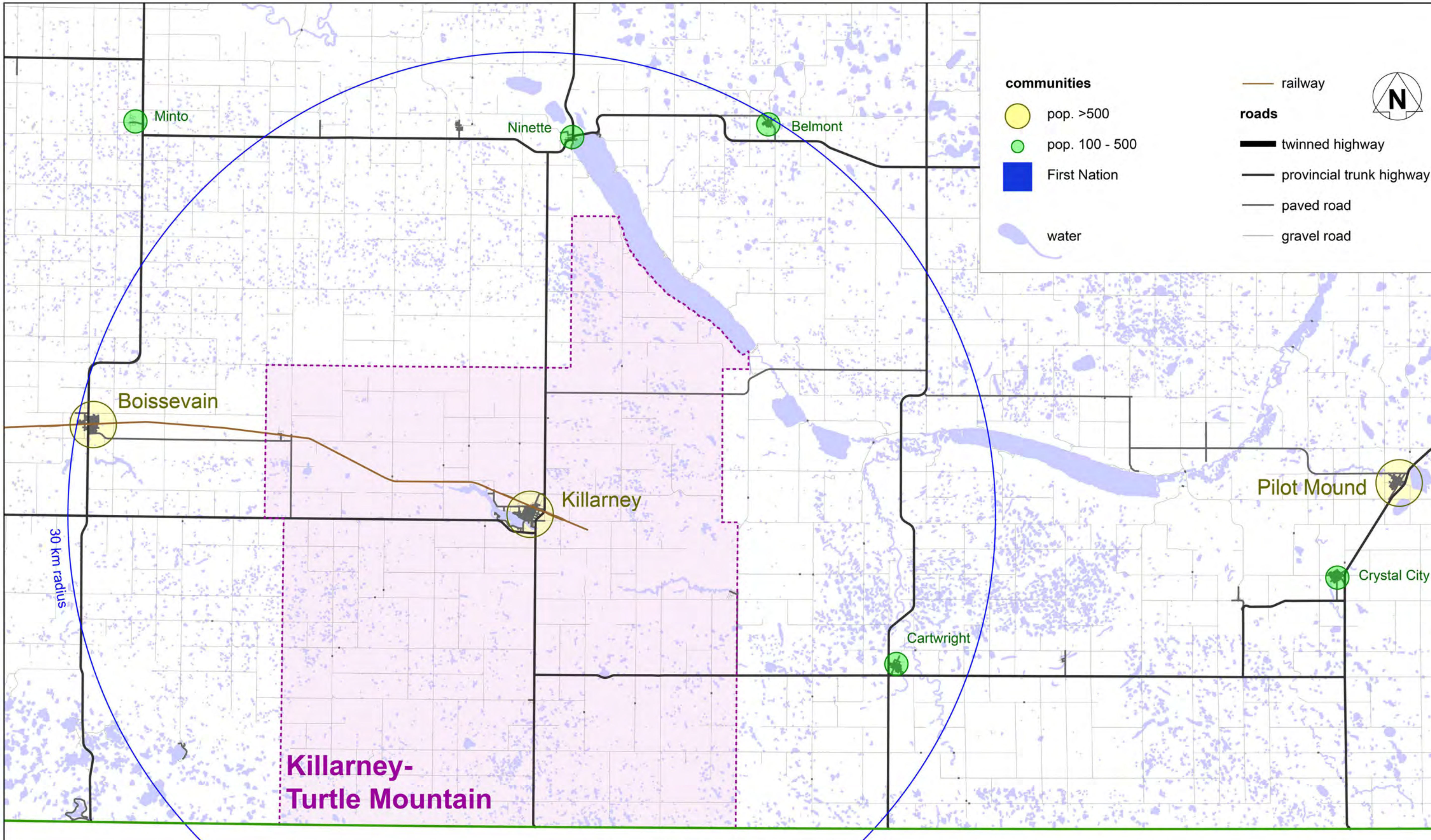
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: KILLARNEY TURTLE MOUNTAIN LAND COVER 50 KM RADIUS

DRAWING NUMBER: MMB 511

REVISION: A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 02			

sources: Government of Manitoba. *Data MB.*
https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.*
https://open.canada.ca

BOKE

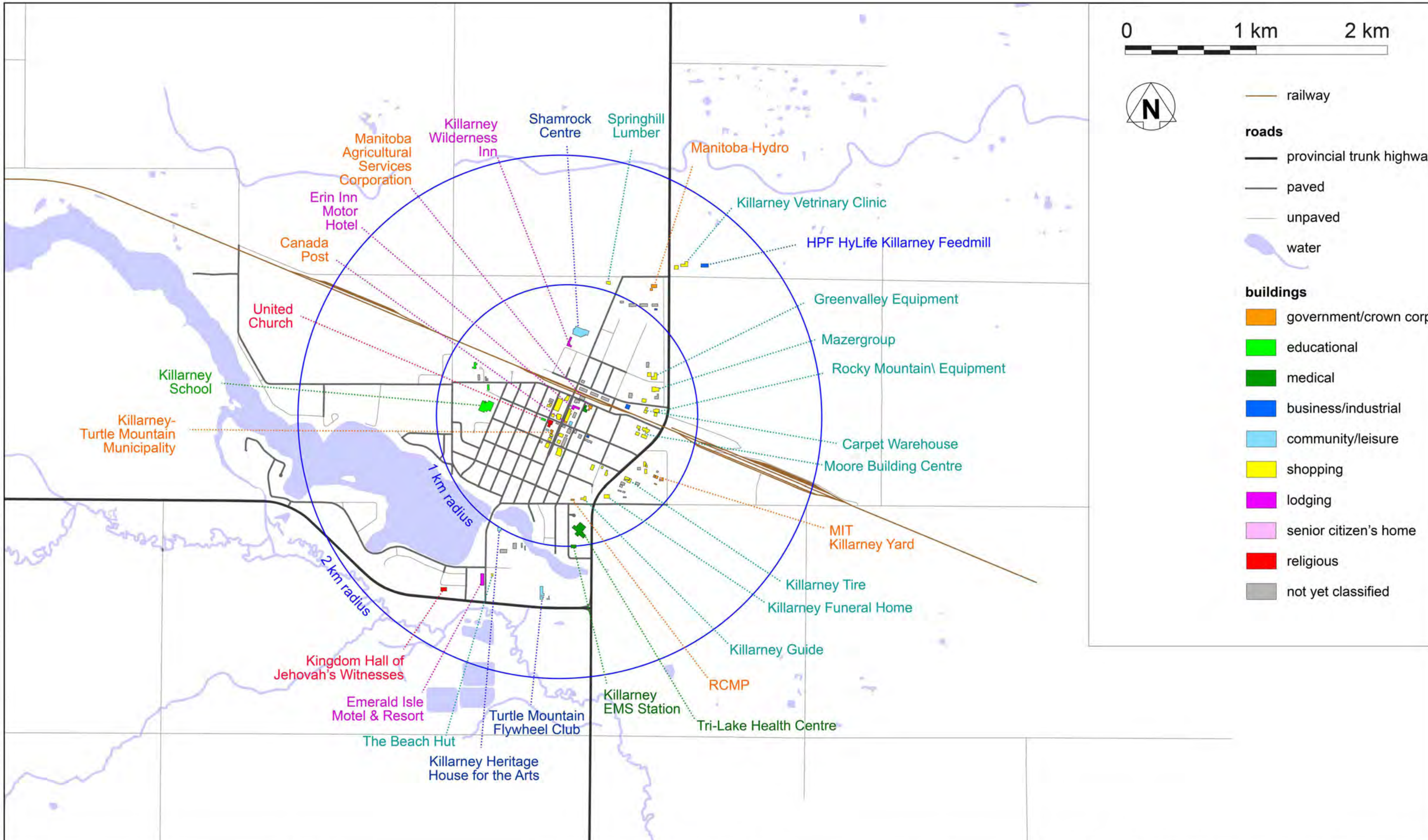
	NAME	DATE
DRAWN BY:	BD	2023 OCT 02
DESIGNED BY:	BD	2023 OCT 02
CHECKED BY:		
SCALE: AS SHOWN		

CLIENT MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE
KILLARNEY TURTLE MOUNTAIN
MAP VIEW
30 KM RADIUS

DRAWING NUMBER	REVISION
MMB 521	A



REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 08			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 08
DESIGNED BY:	BD	2023 OCT 08
CHECKED BY:		

SCALE: AS SHOWN

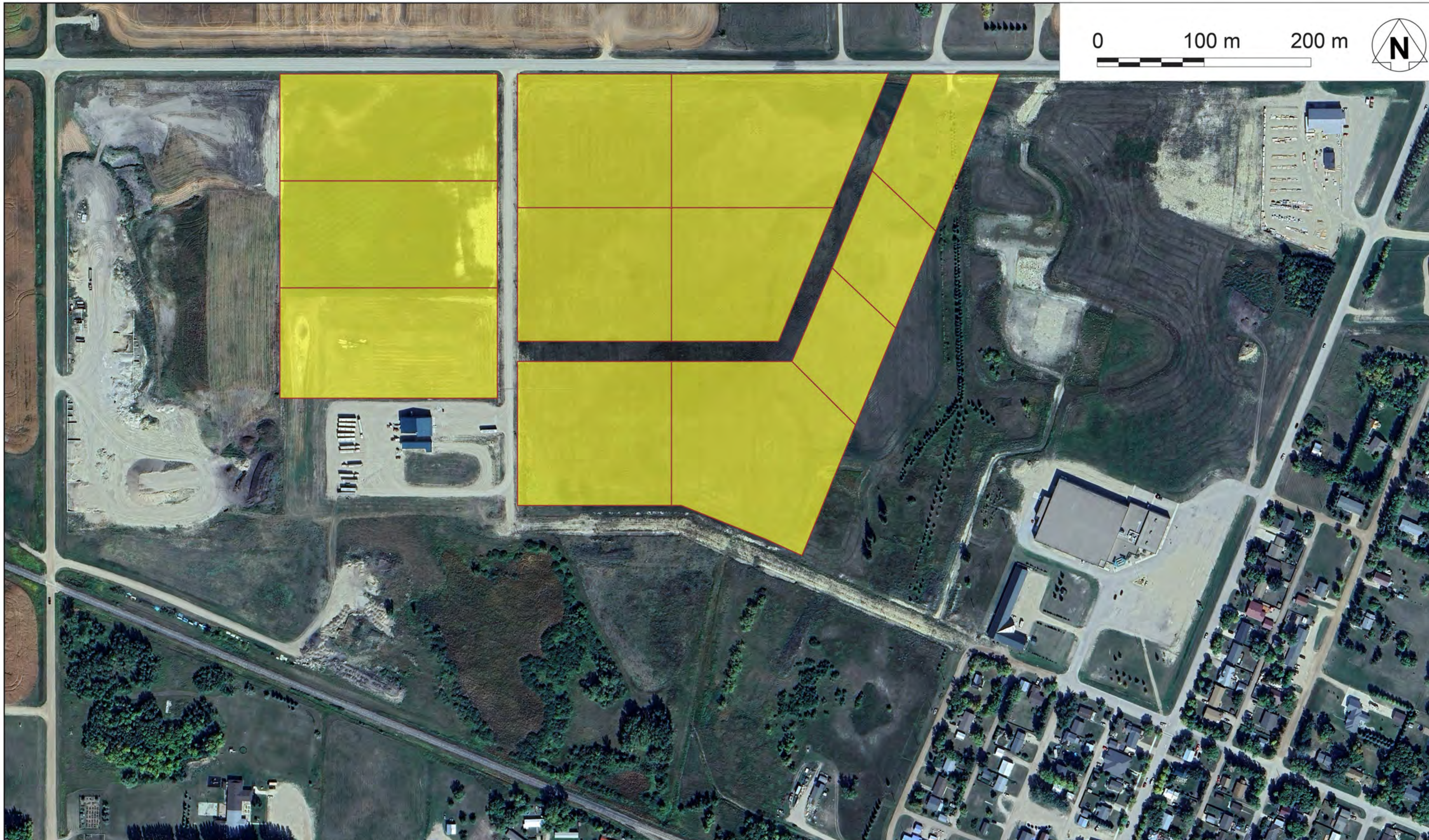
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: KILLARNEY TURTLE MOUNTAIN
MAP VIEW
2 KM RADIUS

DRAWING NUMBER: MMB 522

REVISION: A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
A	ISSUED FOR REVIEW	2024 FEB 14			
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, accessed 2024

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 FEB 14
DESIGNED BY:	BD	2024 FEB 14
CHECKED BY:		
SCALE: AS SHOWN		

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE:
KILLARNEY TURTLE MOINTAIN
TARGET DEVELOPMENT
SATELLITE VIEW

DRAWING NUMBER	REVISION
MMB 541	A

REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 FEB 14			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, accessed 2024

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 FEB 14
DESIGNED BY:	BD	2024 FEB 14
CHECKED BY:		

SCALE: AS SHOWN

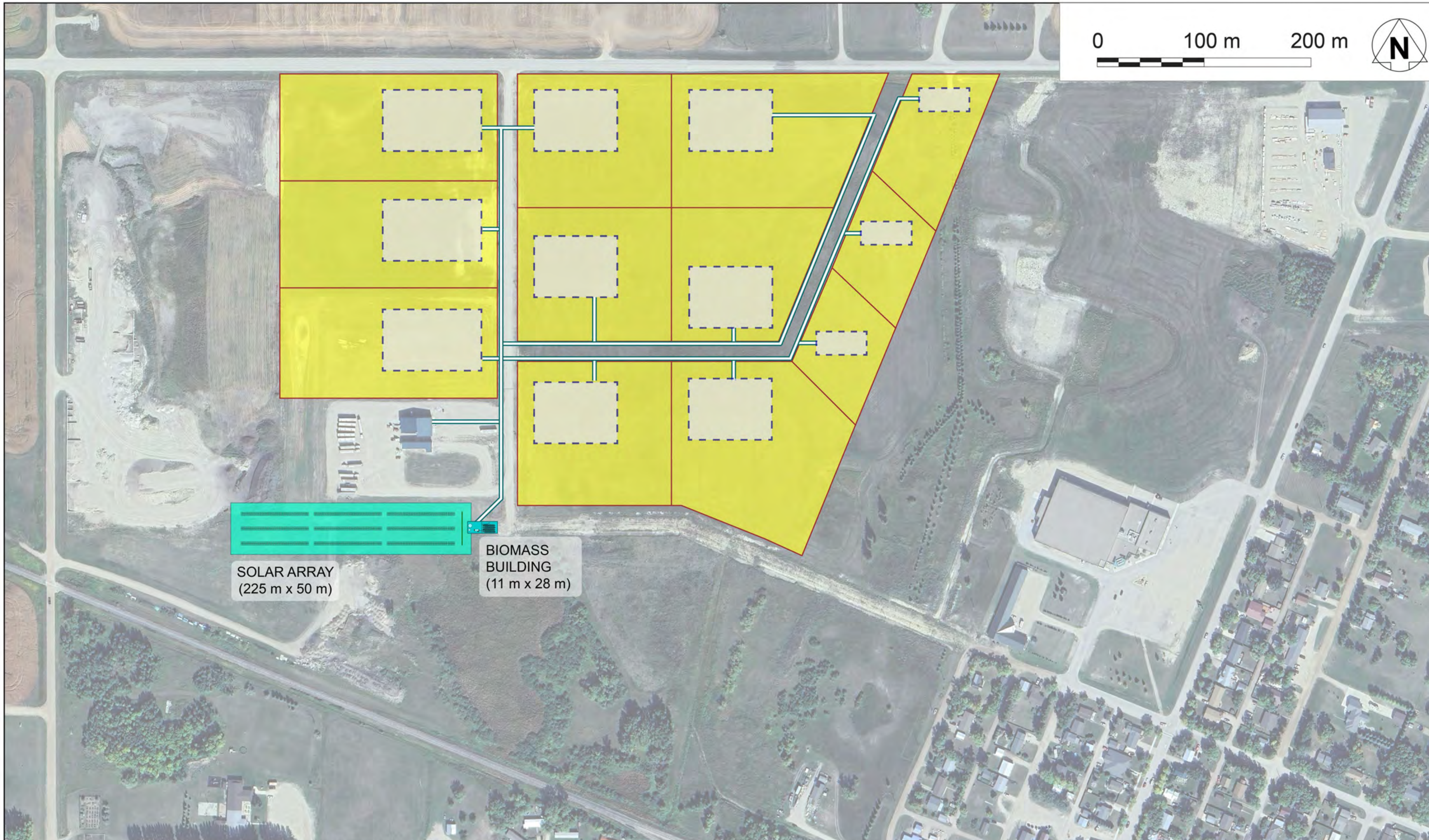
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: KILLARNEY TURTLE MOUNTAIN
TARGET DEVELOPMENT
MAP VIEW

DRAWING NUMBER: MMB 551

REVISION: A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
A	ISSUED FOR REVIEW	2024 JUL 22			
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, accessed 2024

BOKE

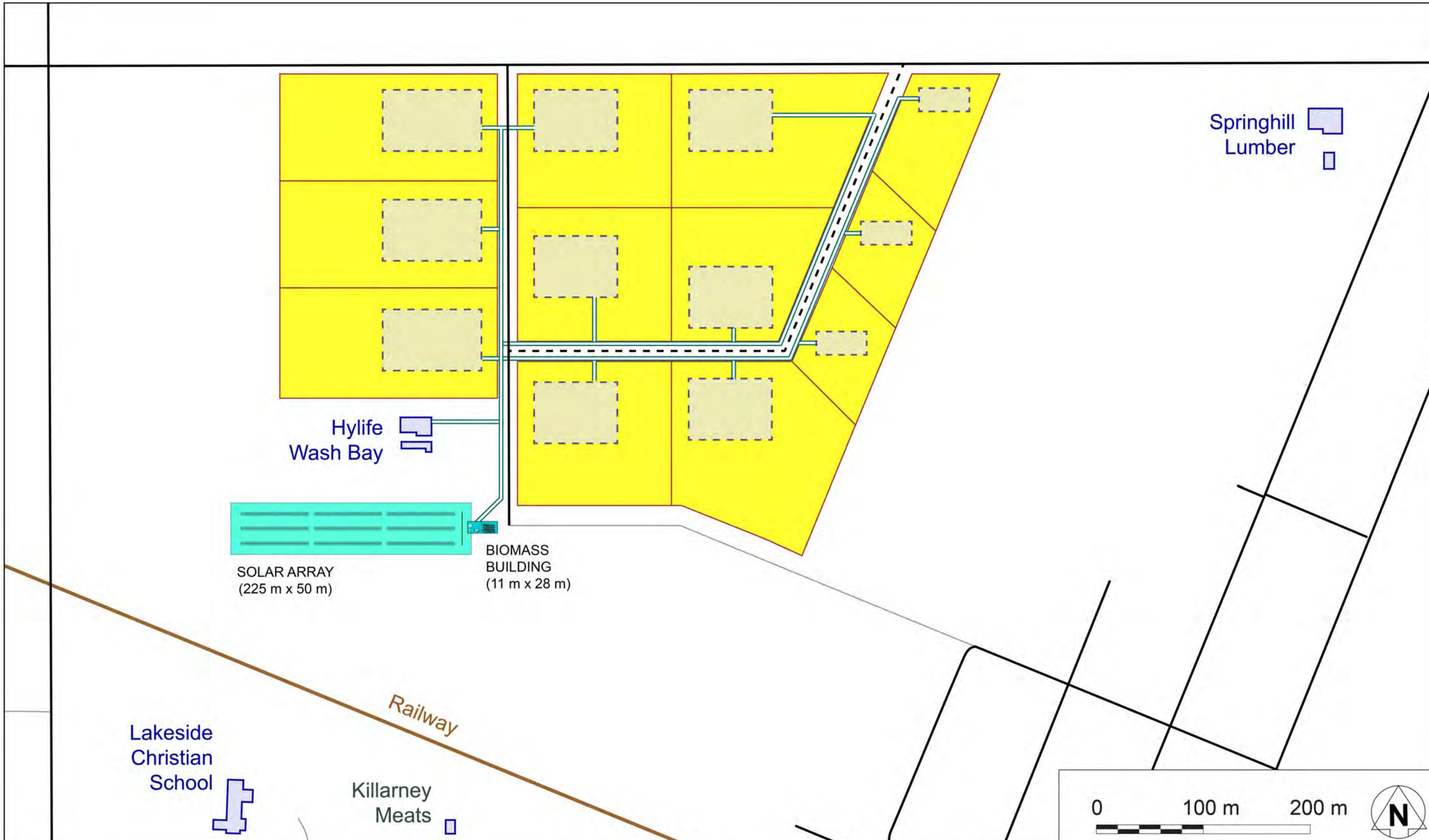
	NAME	DATE
DRAWN BY:	BD	2024 JUL 22
DESIGNED BY:	BD	2024 JUL 22
CHECKED BY:		
SCALE: AS SHOWN		

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE:
KILLARNEY TURTLE MOINTAIN
TARGET DEVELOPMENT - WITH RENEWABLES
SATELLITE VIEW

DRAWING NUMBER	REVISION
MMB 561	A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
B	ISSUED FOR REVIEW	2024 JUN 23			
A		2024 FEB 14			
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, accessed 2024

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 JUN 23
DESIGNED BY:	BD	2024 JUN 23
CHECKED BY:		

SCALE: AS SHOWN

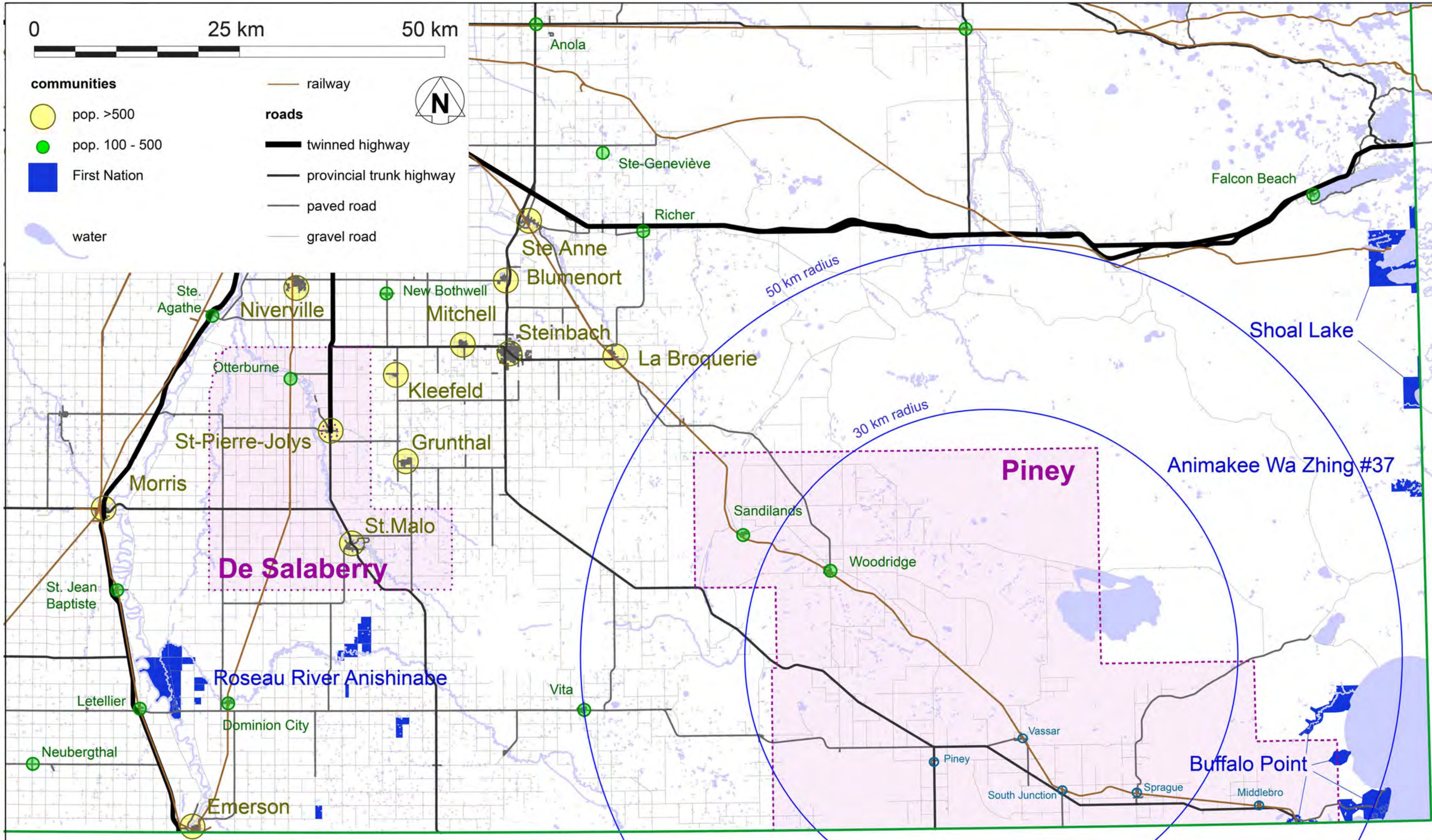
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: KILLARNEY TURTLE MOUNTAIN
TARGET DEVELOPMENT - WITH RENEWABLES
MAP VIEW

DRAWING NUMBER: MMB 571

REVISION: B



REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
B	ISSUED FOR REVIEW	2023 NOV 04			
A	ISSUED FOR REVIEW	2023 OCT 02			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 NOV 04
DESIGNED BY:	BD	2023 NOV 04
CHECKED BY:		

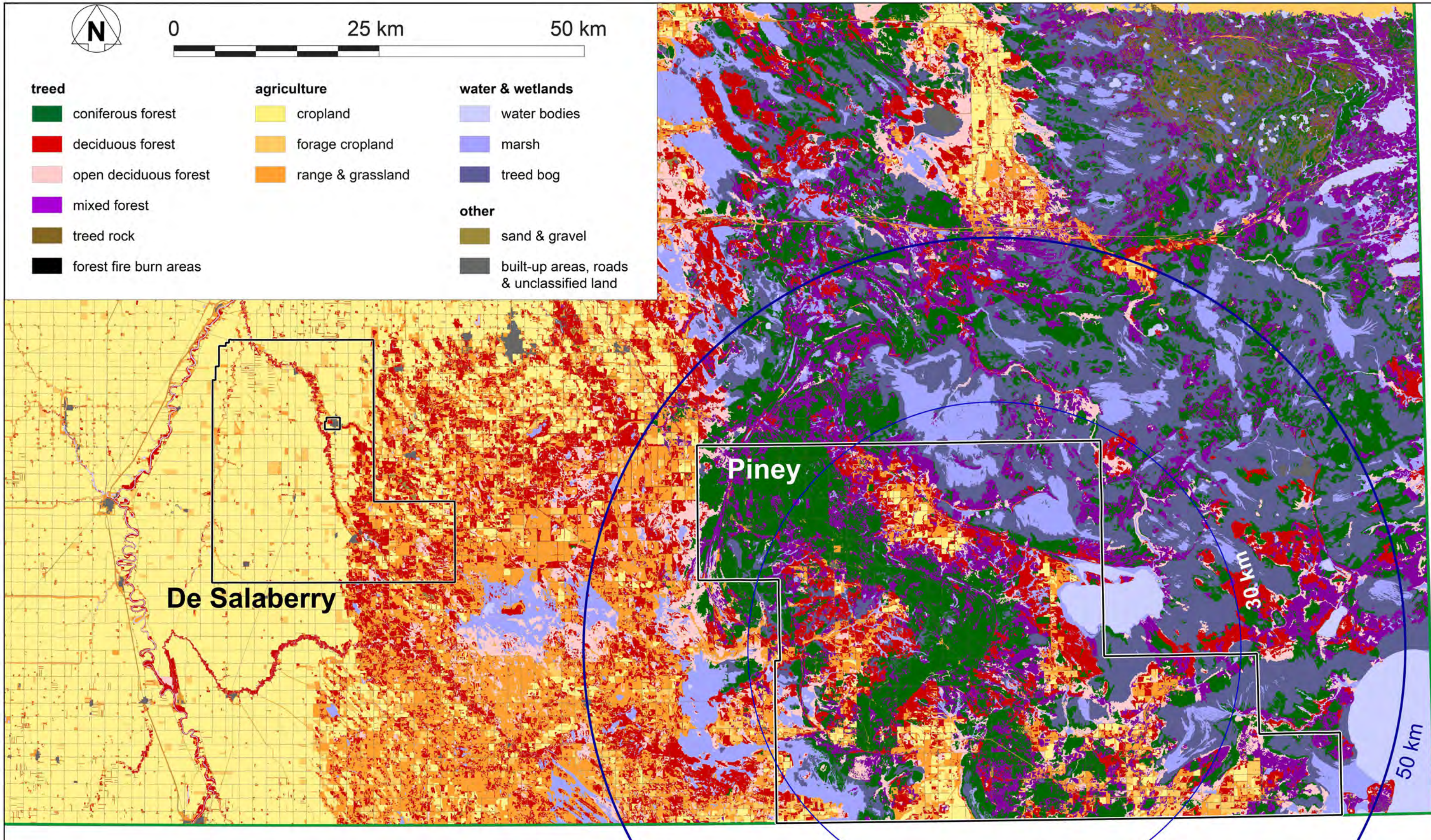
SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: RM OF PINEY
MAP VIEW
50 KM RADIUS

DRAWING NUMBER	REVISION
MMB 601	B



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
B	ISSUED FOR REVIEW	2023 NOV 04			
A	ISSUED FOR REVIEW	2023 OCT 05			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 NOV 04
DESIGNED BY:	BD	2023 NOV 04
CHECKED BY:		
SCALE:	AS SHOWN	

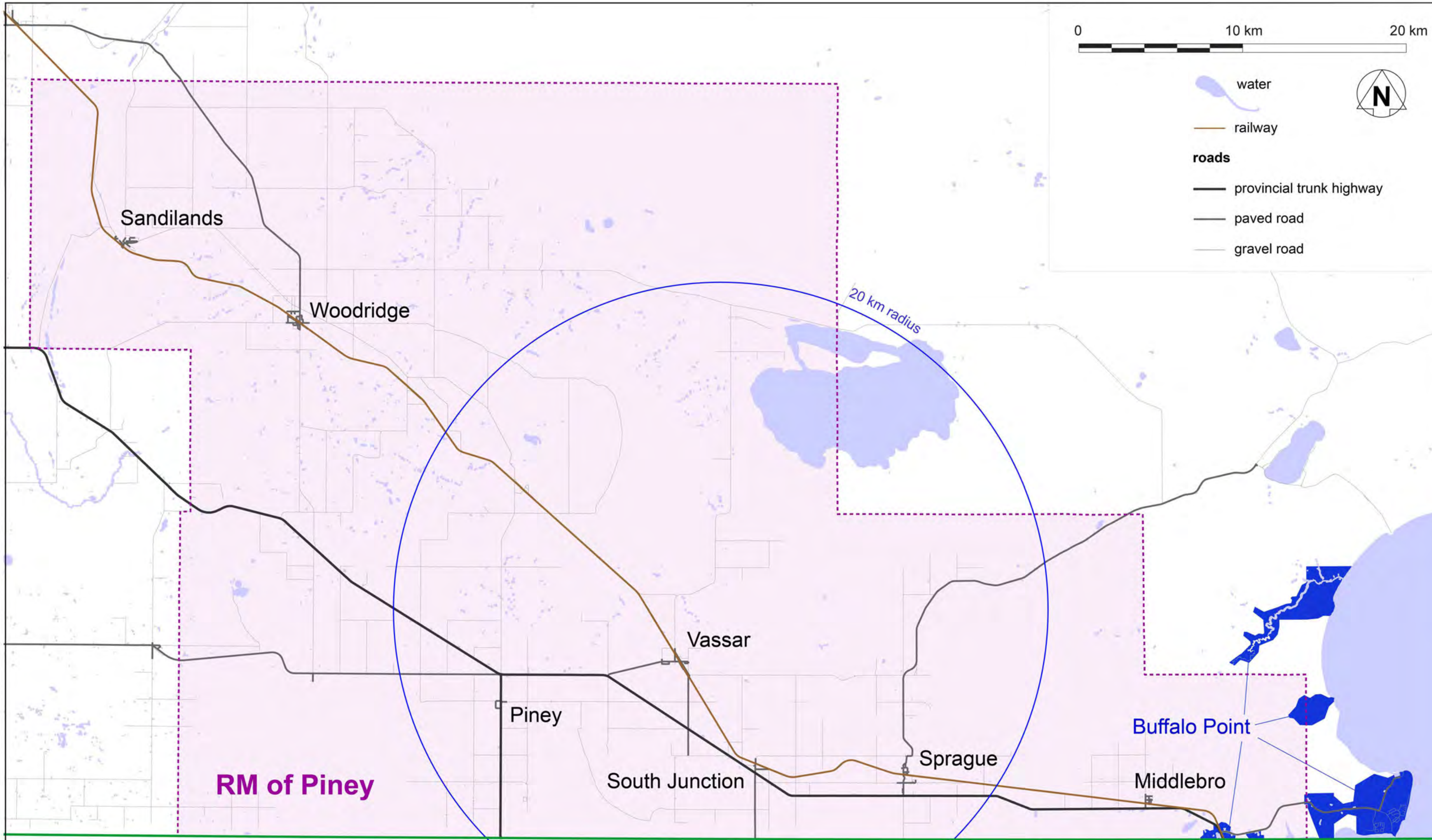
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: RM OF PINEY
LAND COVER
50 KM RADIUS

DRAWING NUMBER: MMB 611

REVISION: B



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
B	ISSUED FOR REVIEW	2023 NOV 04			
A	ISSUED FOR REVIEW	2023 OCT 02			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 NOV 04
DESIGNED BY:	BD	2023 NOV 04
CHECKED BY:		

SCALE: AS SHOWN

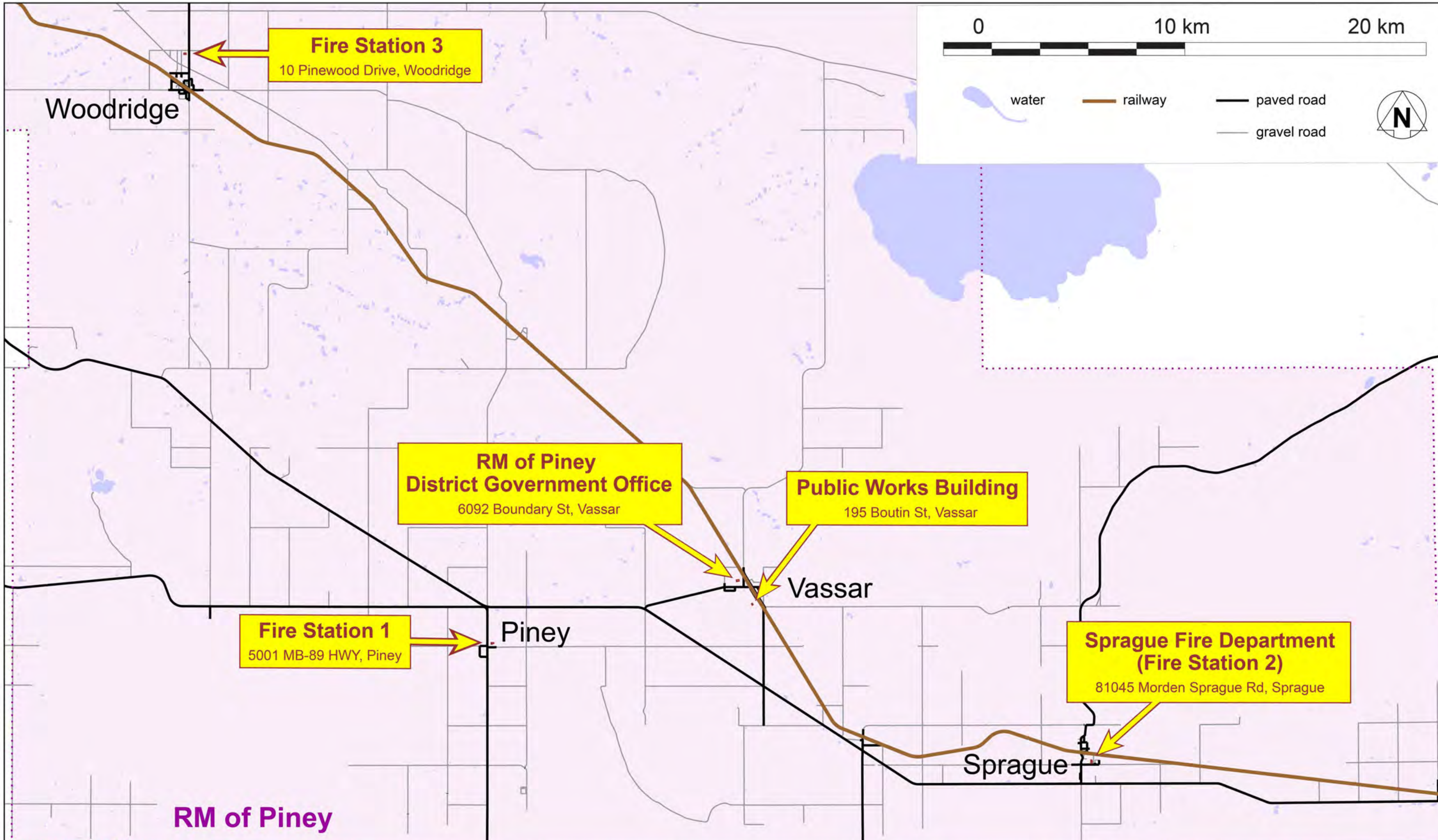
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: RM OF PINEY
MAP VIEW
20 KM RADIUS

DRAWING NUMBER: MMB 621

REVISION: B



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 FEB 15			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 FEB 15
DESIGNED BY:	BD	2024 FEB 15
CHECKED BY:		

SCALE: AS SHOWN

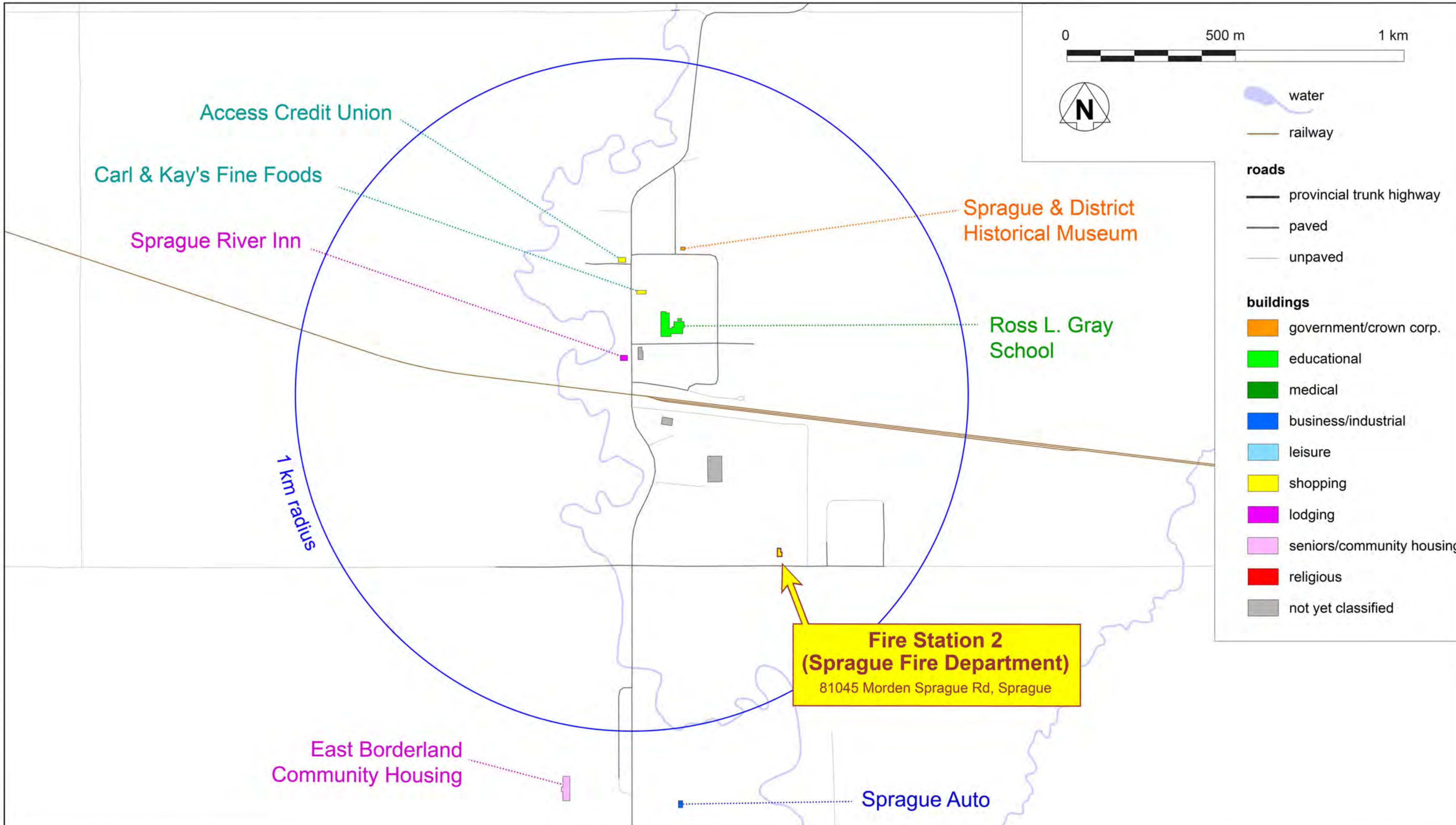
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: RM OF PINEY
COMMUNITES - WITH TARGET BUILDINGS

DRAWING NUMBER: MMB 631

REVISION: A



REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 02			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Manitoba. *Manitoba Land Initiative.* https://mli.gov.mb.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 08
DESIGNED BY:	BD	2023 OCT 08
CHECKED BY:		

SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: RM OF PINEY
SPRAGUE
MAP VIEW - 1 KM RADIUS

DRAWING NUMBER: MMB 632

REVISION: A

REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 FEB 17			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Manitoba. *Manitoba Land Initiative.* https://mli.gov.mb.ca
Google Earth, 2019

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 FEB 17
DESIGNED BY:	BD	2024 FEB 17
CHECKED BY:		

SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE:
RM OF PINEY
PINEY - TARGET BUILDING
SATELLITE VIEW

DRAWING NUMBER: MMB 642

REVISION: A

REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 FEB 17			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Manitoba. *Manitoba Land Initiative.* https://mli.gov.mb.ca
Google Earth, 2022

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 FEB 17
DESIGNED BY:	BD	2024 FEB 17
CHECKED BY:		

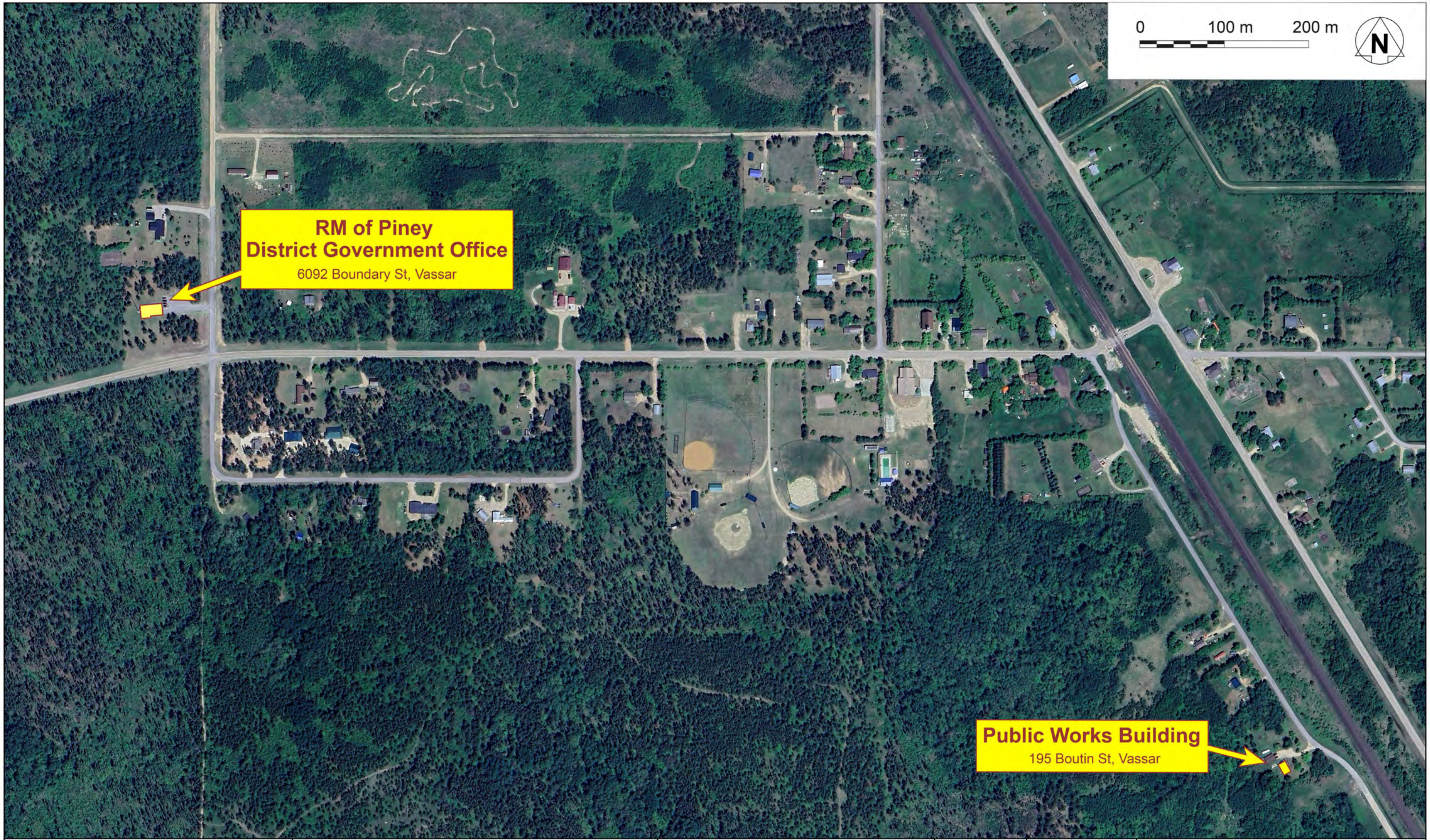
SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: RM OF PINEY
SPRAGUE - TARGET BUILDING
SATELLITE VIEW

DRAWING NUMBER	REVISION
MMB 643	A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
A	ISSUED FOR REVIEW	2024 FEB 16			
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Manitoba. *Manitoba Land Initiative.* https://mli.gov.mb.ca
Google Earth, 2022

BOKE

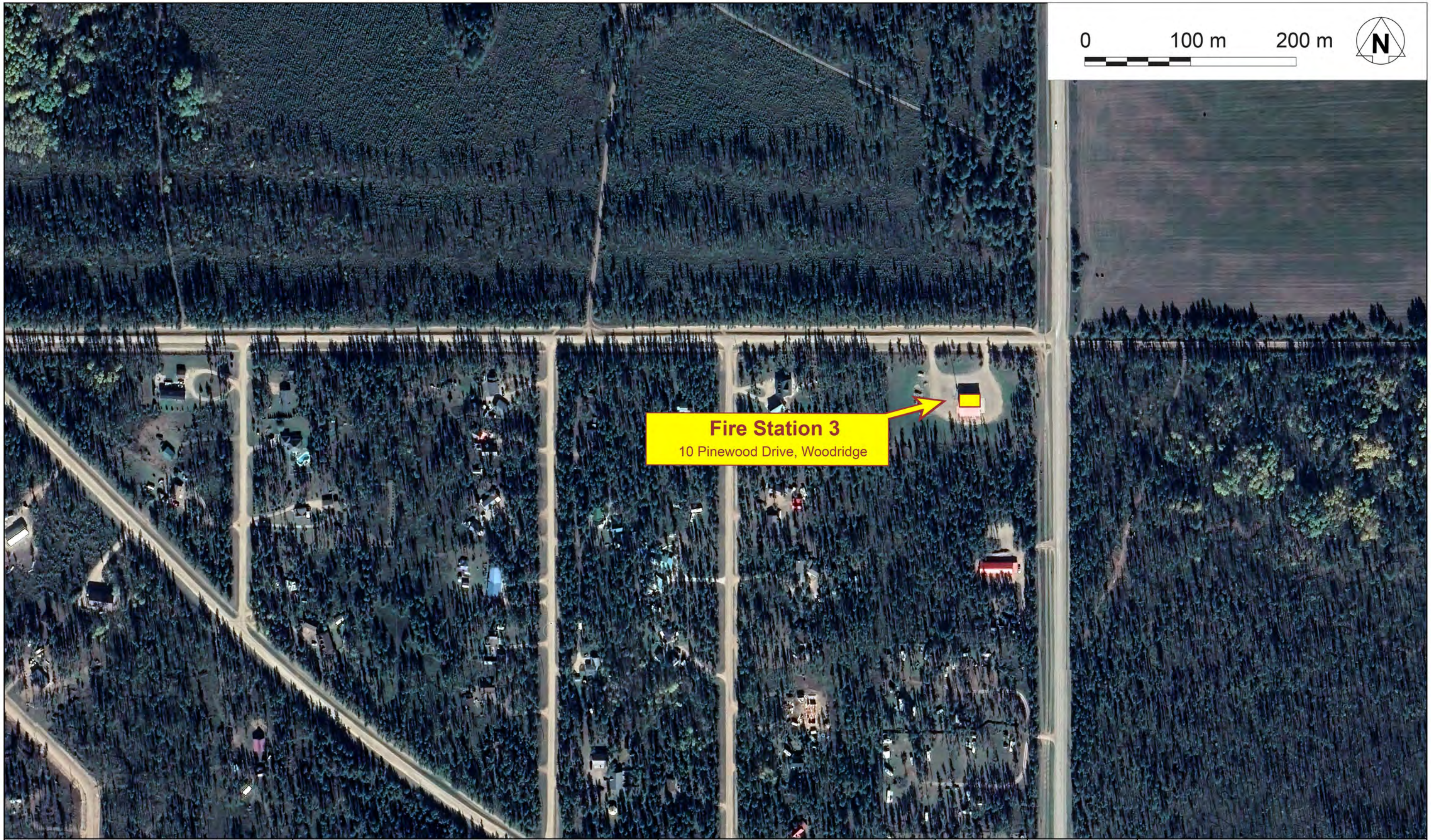
	NAME	DATE
DRAWN BY:	BD	2024 FEB 16
DESIGNED BY:	BD	2024 FEB 16
CHECKED BY:		
SCALE: AS SHOWN		

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: RM OF PINEY
VASSAR - TARGET BUILDINGS
SATELLITE VIEW

DRAWING NUMBER	REVISION
MMB 644	A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 FEB 15			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca
Google Earth, 2021

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 FEB 15
DESIGNED BY:	BD	2024 FEB 15
CHECKED BY:		

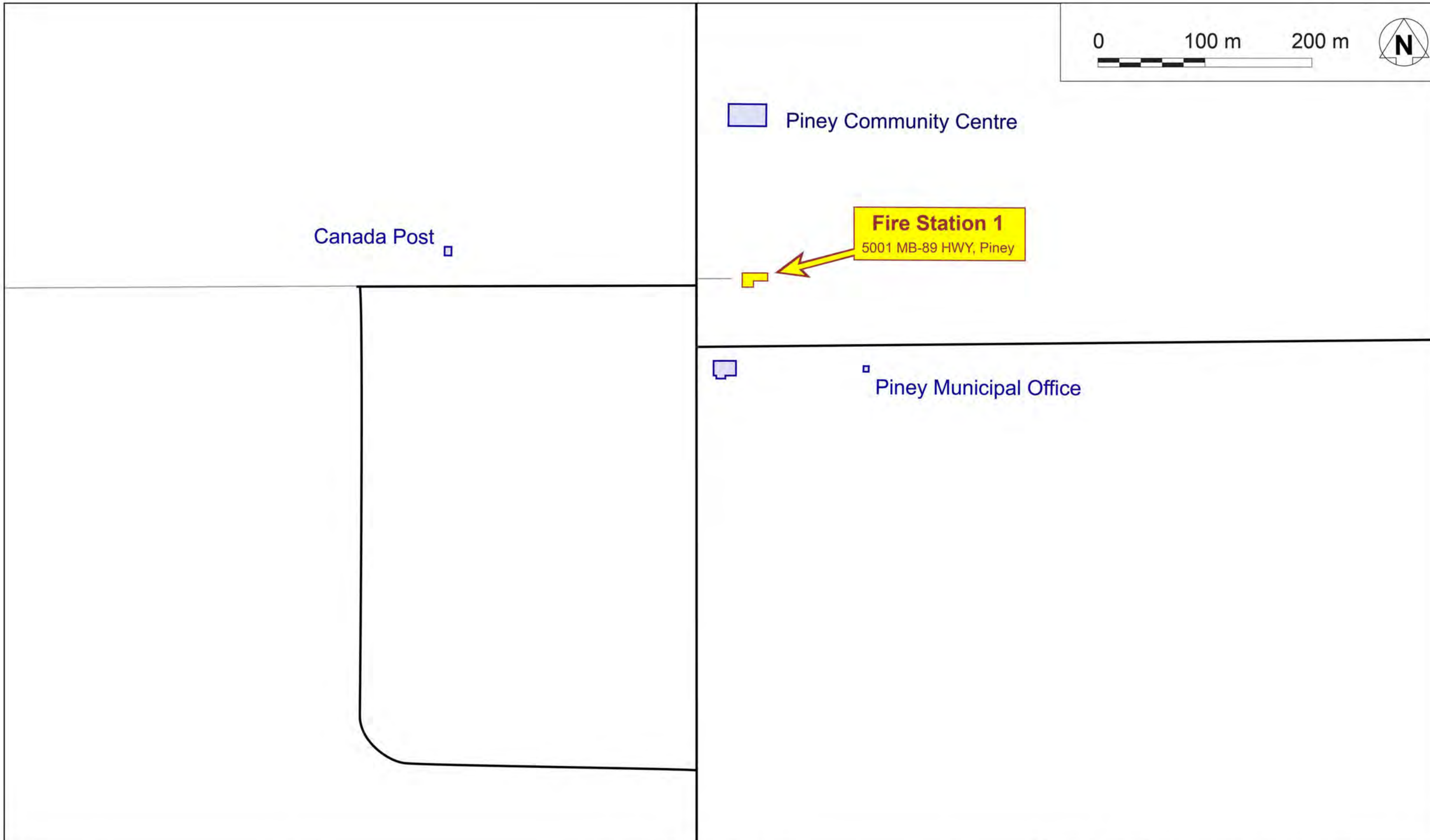
SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE:
RM OF PINEY
WOODRIDGE - TARGET BUILDING
SATELLITE VIEW

DRAWING NUMBER	REVISION
MMB 645	A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 FEB 17			

sources: Government of Manitoba. *Data MB.*
https://geoportal.gov.mb.ca
Government of Manitoba. *Manitoba Land Initiative.*
https://mli.gov.mb.ca
Google Earth, 2019

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 FEB 17
DESIGNED BY:	BD	2024 FEB 17
CHECKED BY:		

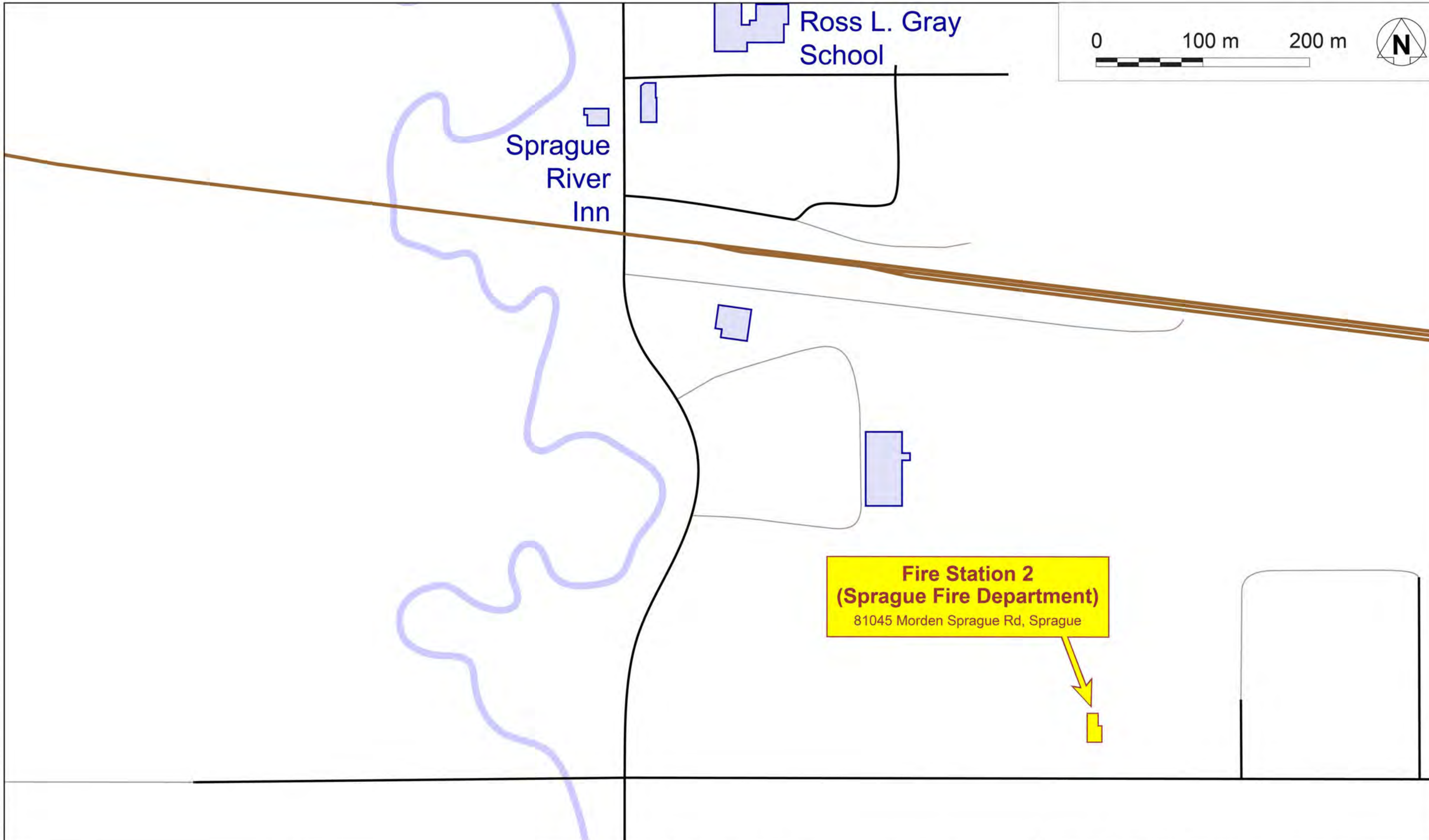
SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE:
RM OF PINEY
PINEY - TARGET BUILDING
MAP VIEW

DRAWING NUMBER	REVISION
MMB 652	A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 FEB 17			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Manitoba. *Manitoba Land Initiative.* https://mli.gov.mb.ca
Google Earth, 2022

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 FEB 17
DESIGNED BY:	BD	2024 FEB 17
CHECKED BY:		

SCALE: AS SHOWN

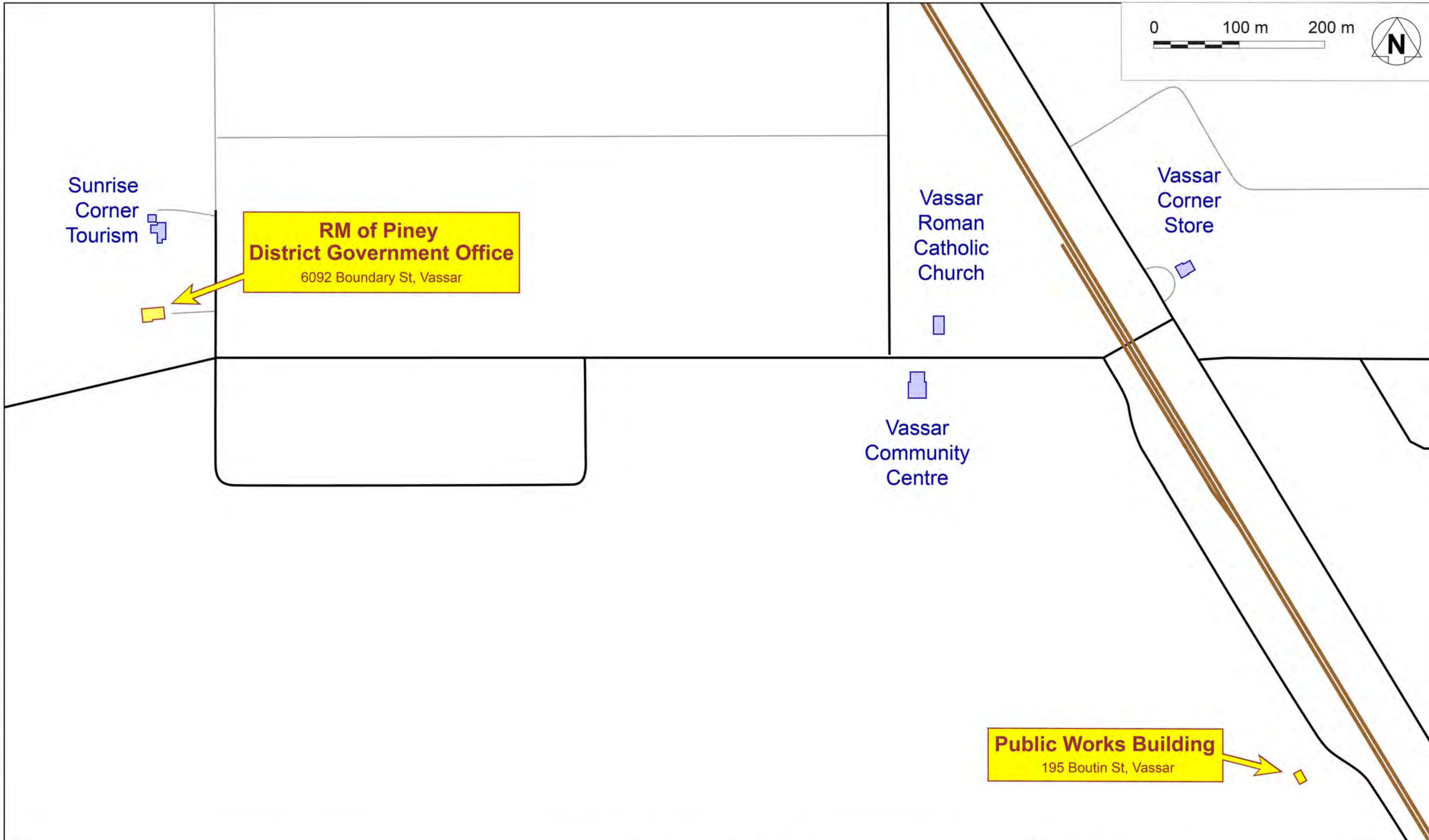
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE:
PINEY
SPRAGUE - TARGET BUILDING
MAP VIEW

DRAWING NUMBER: MMB 653

REVISION: A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 FEB 16			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Manitoba. *Manitoba Land Initiative.* https://mli.gov.mb.ca
Google Earth, 2022a

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 FEB 16
DESIGNED BY:	BD	2024 FEB 16
CHECKED BY:		

SCALE: AS SHOWN

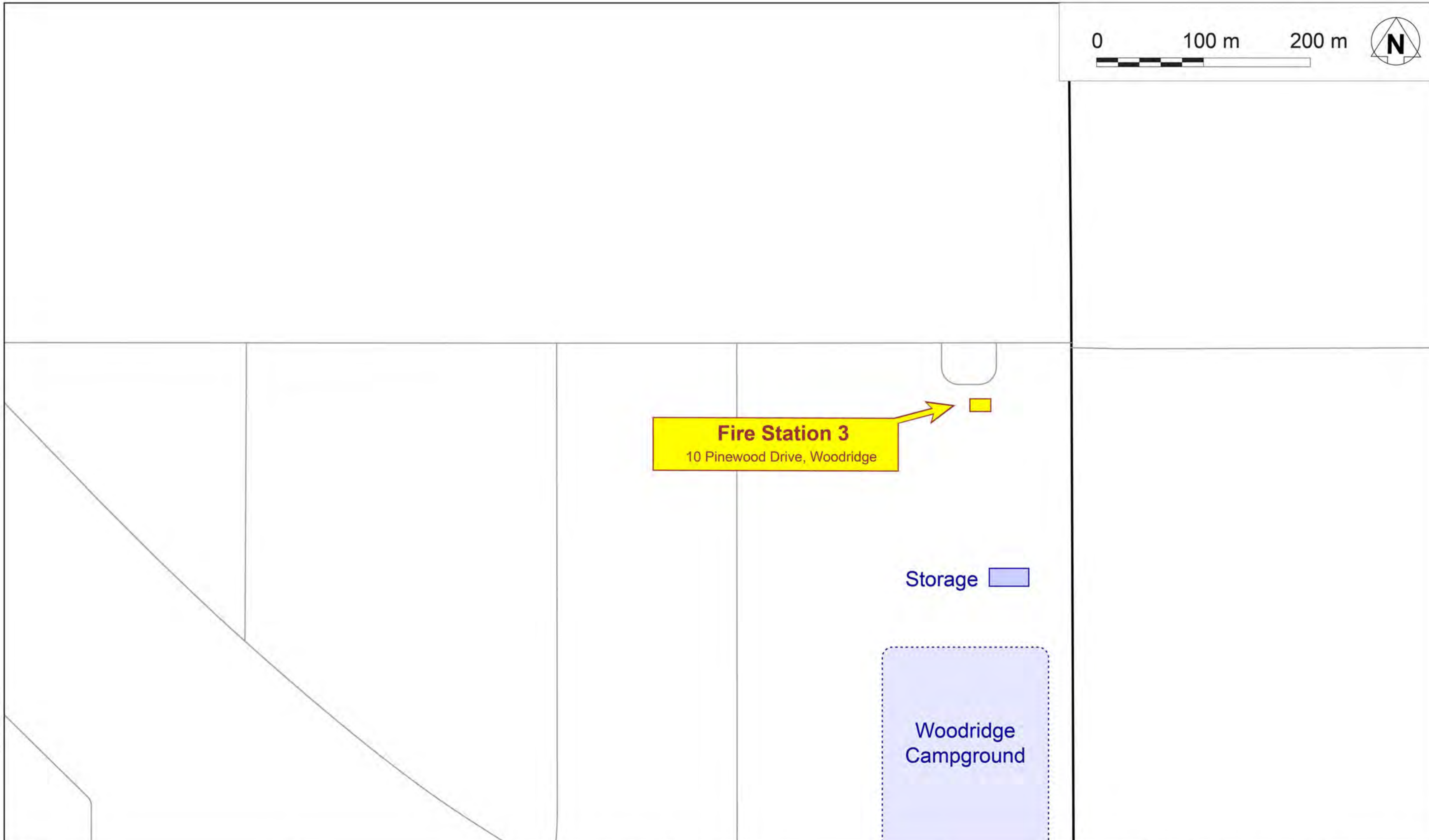
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: RM OF PINEY
VASSAR - TARGET BUILDINGS
MAP VIEW

DRAWING NUMBER: MMB 654

REVISION: A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 FEB 15			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca
Google Earth, 2021

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 FEB 15
DESIGNED BY:	BD	2024 FEB 15
CHECKED BY:		

SCALE: AS SHOWN

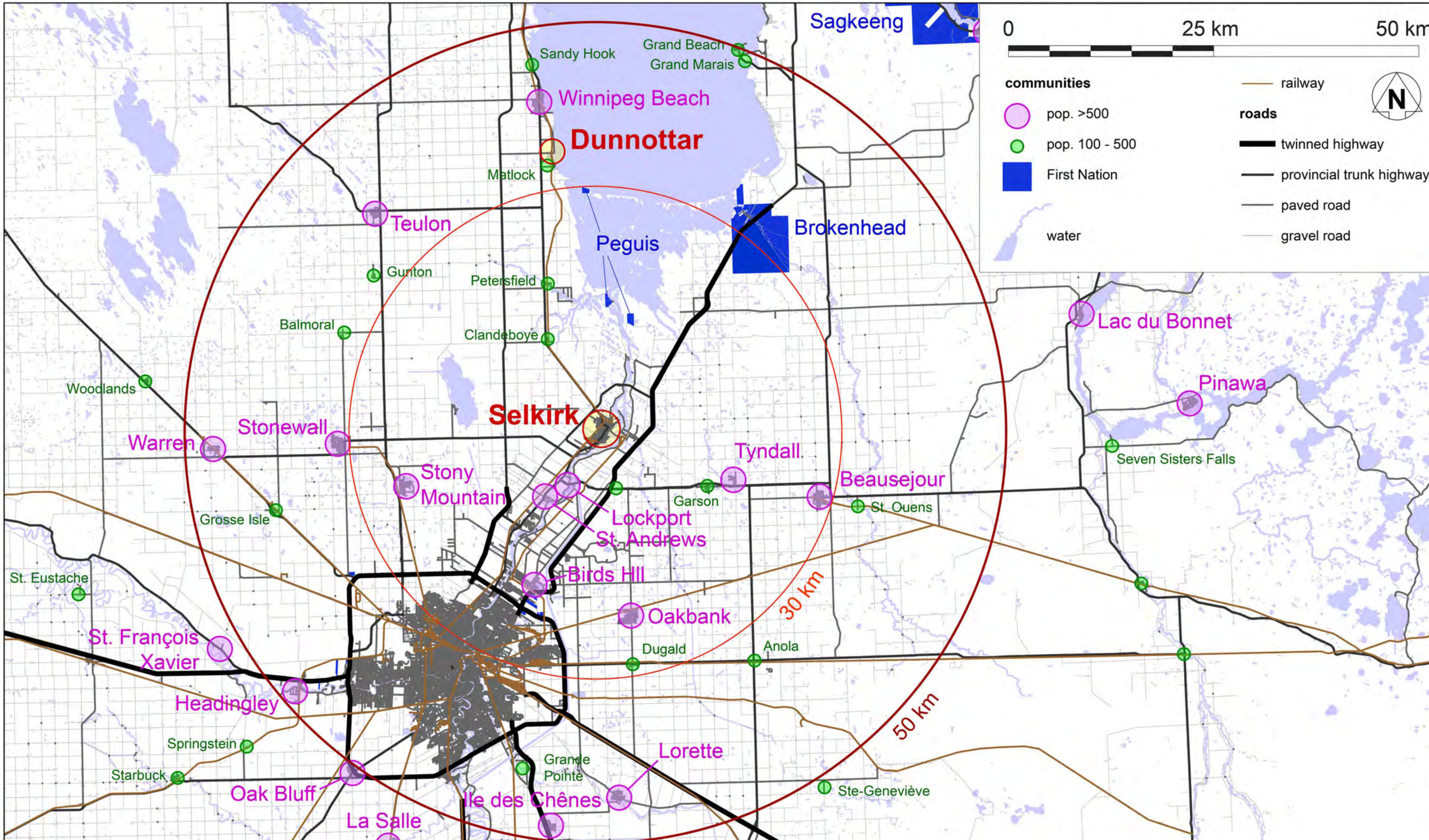
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE:
RM OF PINEY
WOODRIDGE - TARGET BUILDING
MAP VIEW

DRAWING NUMBER: MMB 655

REVISION: A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS						
A	ISSUED FOR REVIEW	2023 OCT 02				
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED	

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Government of Canada. *Open Government Portal.* https://open.canada.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 02
DESIGNED BY:	BD	2023 OCT 02
CHECKED BY:		

SCALE: AS SHOWN

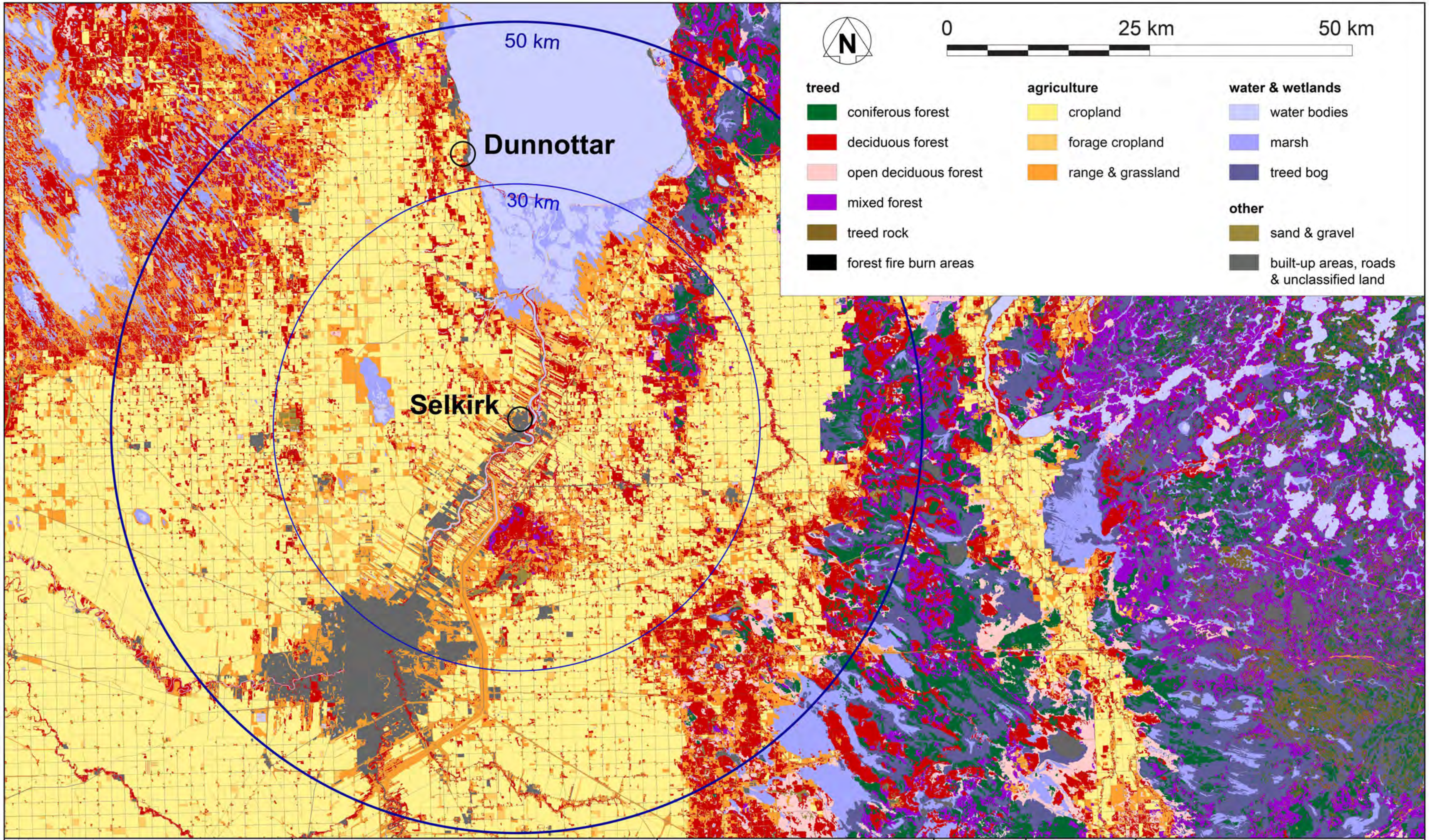
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: SELKIRK MAP VIEW 50 KM RADIUS

DRAWING NUMBER: MMB 701

REVISION: A



REFERENCES

NUMBER	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 02			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2023 OCT 02
DESIGNED BY:	BD	2023 OCT 02
CHECKED BY:		

SCALE: AS SHOWN

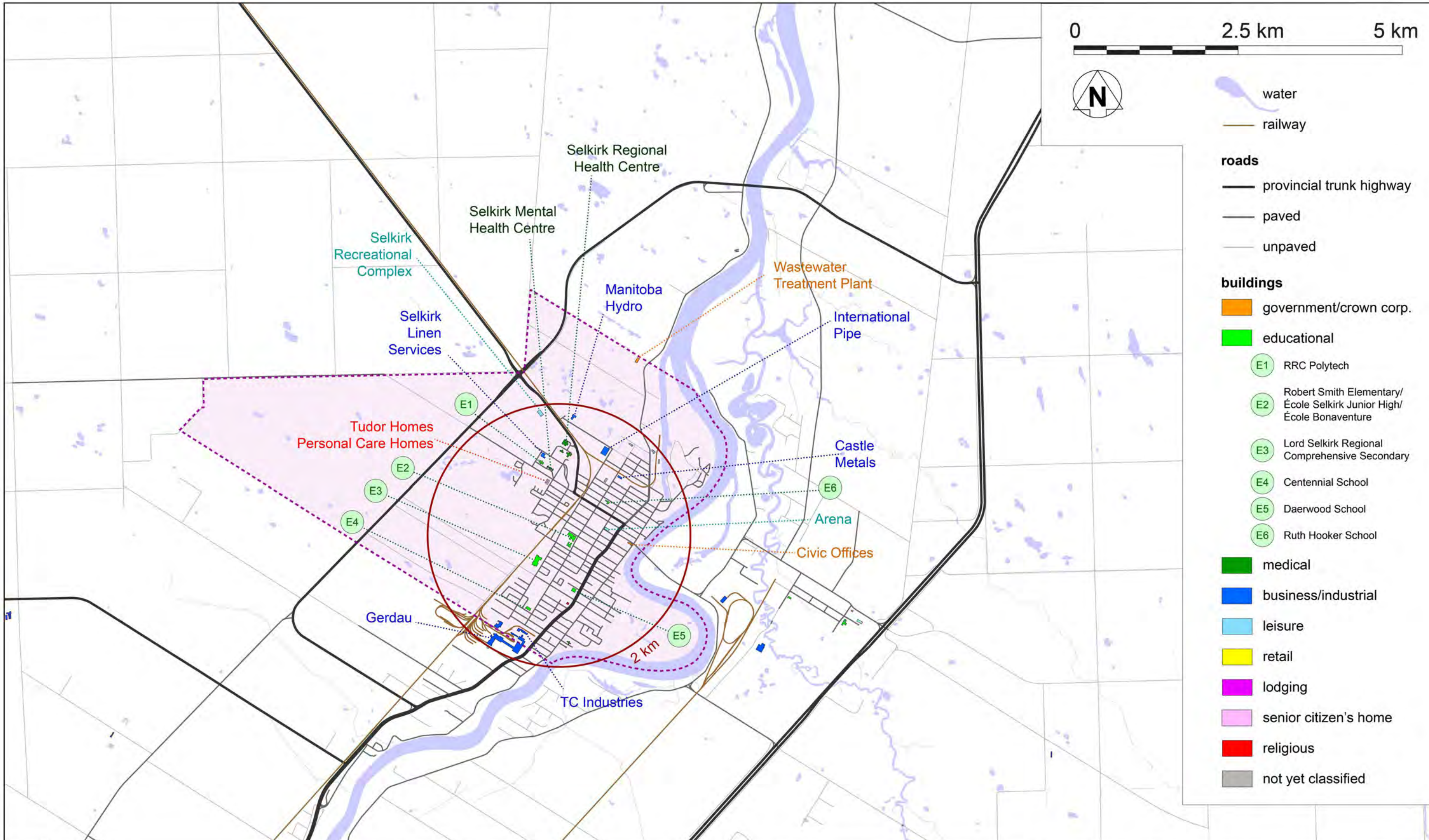
CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: SELKIRK
LAND COVER
50 KM RADIUS

DRAWING NUMBER: MMB 711

REVISION: A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2023 OCT 08			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca
Google Earth, 2022

	NAME	DATE
DRAWN BY:	BD	2023 OCT 08
DESIGNED BY:	BD	2023 OCT 08
CHECKED BY:		
SCALE: AS SHOWN		

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: SELKIRK
MAP VIEW
2 KM RADIUS

DRAWING NUMBER: MMB 721

REVISION: A

REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
A	ISSUED FOR REVIEW	2024 FEB 18			
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca

BOKE

	NAME	DATE
DRAWN BY:	BD	2024 FEB 18
DESIGNED BY:	BD	2024 FEB 18
CHECKED BY:		

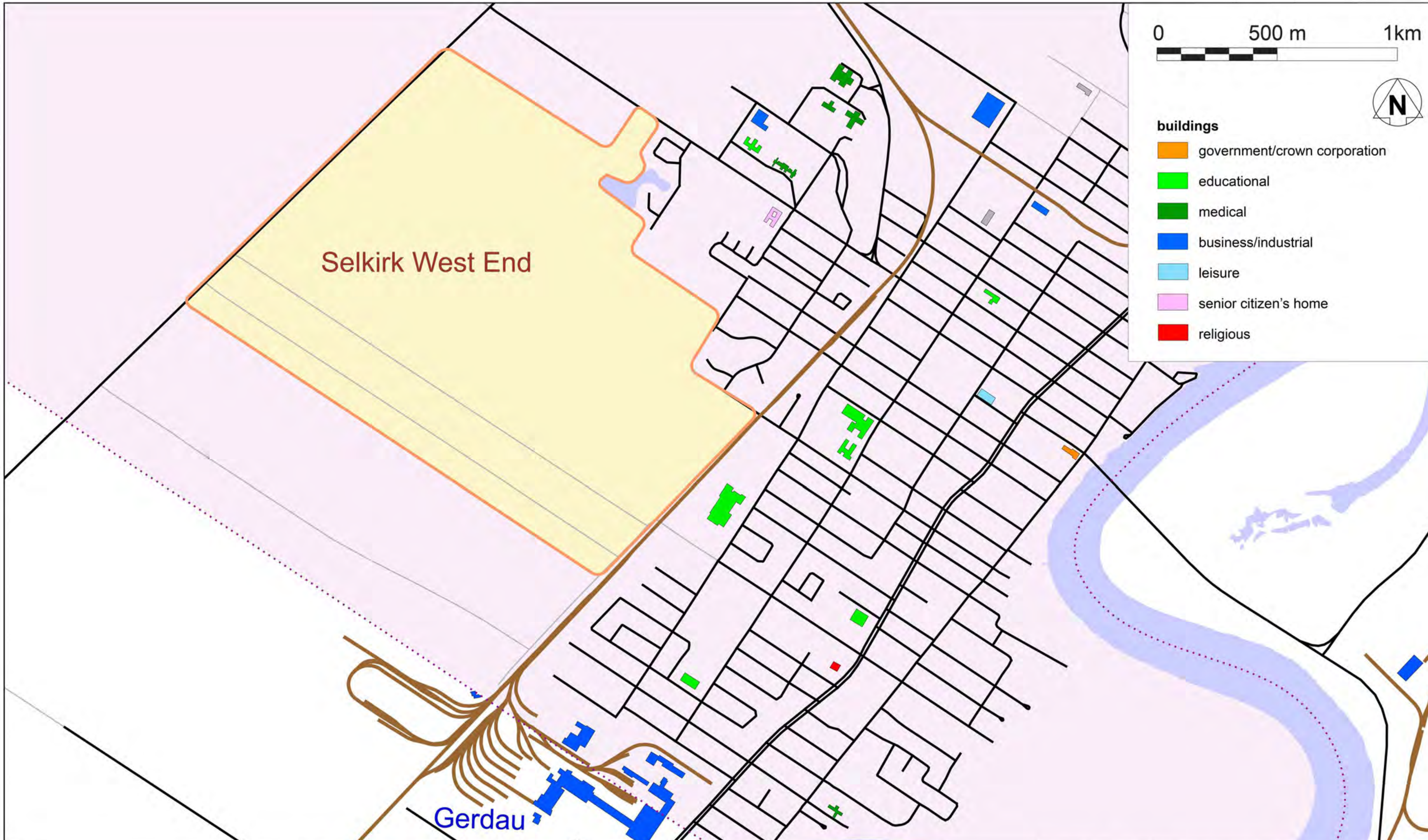
SCALE: AS SHOWN

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE:
SELKIRK
TARGET DEVELOPMENT
SATELLITE VIEW

DRAWING NUMBER	REVISION
MMB 741	A



REFERENCES	
NUMBER	DESCRIPTION

REVISIONS					
NO.	DESCRIPTION	DATE	DESIGNED	CHECKED	APPROVED
A	ISSUED FOR REVIEW	2024 FEB 18			

sources: Government of Manitoba. *Data MB.* https://geoportal.gov.mb.ca

	NAME	DATE
DRAWN BY:	BD	2024 FEB 18
DESIGNED BY:	BD	2024 FEB 18
CHECKED BY:		
SCALE: AS SHOWN		

CLIENT: MANITOBA SUSTAINABLE ENERGY ASSOCIATION

PROJECT: MANITOBA MUNICIPAL BIOMASS PREFEASIBILITY STUDY

TITLE: SELKIRK
TARGET DEVELOPMENT
MAP VIEW

DRAWING NUMBER	REVISION
MMB 751	A