2020

Blumengart Colony Irrigation Project Environment Act Proposal

Blumengart Colony Farms Ltd.

PBS Water Engineering Ltd.

4/23/2020

PBS Water Engineering   agriearth consulting ltd.

Submission Sheet

The Blumengart Colony Irrigation Project -- Environmental Act Proposal, was prepared by PBS Water Engineering Ltd. for the Proponent; Blumengart Colony Farms Ltd. The report reflects the opinion of PBS Water Engineering Ltd. based on information and data available at the time of the report preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. PBS Water Engineering Ltd. accepts no responsibility for damages suffered by any third party because of decisions and actions based on this report.

Prepared by:

P.B. Shewfelt, M.Sc., P.Eng.

PBS Water Engineering Ltd.

APEGM

Certificate of Authorization

PBS Water Engineering Ltd.

No. 5696 Date Apr 20/20

PROVINCE OF MANITOBA
P.B. SHEWFELT
20/04/20
REGISTERED PROFESSIONAL ENGINEER

Contributions from:

MANITOBA
David Whetter, P.Ag
MIA
#1093
AGROLOGIST

D. Whetter, M.Sc., P.Ag.

AgriEarth Consulting Ltd.

Accepted for:

Blumengart Colony Farms Ltd.

Date: April 20, 2020

Executive Summary

Blumengart Colony Farms Ltd. (Blumengart Colony) is proposing to construct an irrigation project in the Rural Municipality (RM) of Rhineland, which will consist of irrigated fields, off-stream storage reservoir storage, a pipeline delivery system, and pump works for filling the reservoir and delivering water to overhead irrigation units (the Project). The irrigation system will be capable of providing water to up to 26 fields, which are currently under annual, dryland agricultural production. These fields encompass some 1,209 ha (2,988 acres). The Project proposes to store spring snowmelt and rainfall runoff water from the Rosenheim Drain watershed in an off-stream reservoir to be constructed central to their irrigated land base and in close proximity to the Blumengart Colony itself. Blumengart Colony has been issued a Development Authorization Permit for the off-stream reservoir in NW-15-2-3 W, also known as Site ROS15. The permit authorizes Blumengart Colony to divert up to 222 cubic decameters (180 acre-feet) of water from the Rosenheim Drain to Site ROS15 and to store up to 333 cubic decameters (270 acre-feet). This will allow for the irrigation of approximately 220 hectares (540 acres), annually. Given the size of the proposed water diversion and storage, the Project is considered a Class 2 development in relation to The Environment Act.

The land base identified for the Project will support additional water resource development (e.g. Hespler Drain); should the Colony decide to expand their irrigated acres. Blumengart Colony also has consideration for lease of water from an existing reservoir, known as Site S14, along the Buffalo Drain in SW-2-2-3 W. That existing reservoir, S14, stores 124 decameters (100 acre-feet) and is Licensed for a 98 decameter (80 acre-feet) diversion from the Buffalo Drain and the Buffalo Creek. Capture and re-use of tile drainage water may also be considered.

The Rosenheim Drain is a tributary to the Hespler Drain and the Deadhorse Creek. The Deadhorse Creek enters the Plum River and then the Red River at St. Jean. Water will be pumped from the Rosenheim Drain to fill reservoir ROS15 using high volume pump(s), which will be PTO driven off existing farm tractors. Spring runoff on the Rosenheim Drain is flashy and can include high volume volumes over short periods of time. Withdrawal periods will be during early spring runoff, with emphasis on the rising limb of the hydrograph and will last for 5 – 10 days. Withdrawal rates are proposed to be in the order of 0.5 m^3/sec (8000 USgpm).

Water will be pumped from the reservoir(s) and distributed to the irrigated areas using underground PVC piping. High efficiency irrigation systems (e.g., center pivots, linear, and travelling guns) will be used to apply water to the fields. Three phase electric power is being considered for the pumping systems. Creek crossings will be directionally bored. Rural Municipality road crossings will be open cut where possible, but all regulations and by-laws will be adhered to (e.g. liner pipe, backfill, etc.). Provincial Road crossings will be directionally bored.

The Project will be developed over a 1-3-year construction period. Engineering is ongoing and continuing this spring (2020), with initial design of Site ROS15. The RM of Rhineland and Manitoba Infrastructure have been contacted regarding permits/approvals for this reservoir (or an alternate site ½ mile to the northeast (also located in NW-15-2-3W). Neighbours to the

Project site will be consulted individually and/or can request any information provided to the RM and will have the opportunity to review this report online when it is posted to the Public Registry. Construction of the storage reservoir (Site ROS15) would begin in late July 2020, pending an Environmental License, RM and Manitoba Infrastructure approvals. Construction of pipelines and pump works would be started in fall 2020 and continue through 2021.

Irrigation in 2020 is planned to consist of only 130 acres, utilizing water made available from Southern Potato Co.'s S15b reservoir. Consideration to replace Southern Potato Co.'s shared water with water from the existing S14 reservoir in SW 2-2-3 W will be made as required. Any pumping from the S14 reservoir in NW 2-2-3 W will be carried out using mobile (diesel) units. Temporary piping (aluminum) would be utilized in 2020.

The land use within the Project region has been almost completely altered for agricultural production, from the predominance of annual cropping fields to altered surface water drainage networks and supporting infrastructure such as the intensive road network. The nature and degree of development of the existing environment for annual crop production is owing to the soil-landscape and agri-climatic conditions that are well suited to a wide range of annual crops. The predominantly loamy, non-stony soil landscape is well suited for irrigated potato production. The major constraint to the growing climate for potatoes is having adequate moisture for optimum growing conditions. Average moisture deficits are in the 125 – 150 mm (5"-6") range; with maximum demand projected at 200 mm (8").

The landscape and geology are largely reflections of the glacial Lake Agassiz. The lacustrine sediments include extensive layers of relatively impervious silty clays which can be used to construct water storage reservoirs; but include surficial loams associated with near-shore environments, which are ideal for horticulture production. The soil-landscape within the 26 fields comprising the Project study area are predominantly considered Good (76%) to Fair (20%) for general irrigation suitability, with slight to moderate limitations for irrigation due to wetness (imperfect drainage), restricted soil water movement (low hydraulic conductivity) and topography (sloping land associated with minor surface water drainage courses). The soil-landscape is generally suited to irrigated potato production, with approximately 90% of the soils within fields proposed for irrigation considered Class 1 to 3 for land suitability for irrigated potato production. The primary limitation in these soils is imperfect internal drainage. Approximately 11% of the soils are rated as Class 5 due to the occurrence of fine (clay) textures, affecting a significant portion of six fields. These Class 5 soils are considered to have low desirability for irrigated potato production.

Several Project fields have previously been tile drained (under separate drainage approvals) to improve risk management, and agronomic and environmental performance (e.g., better use of inputs). Ultimately, the Proponent plans to tile drain all of the irrigated land base, pending future permits and necessary approvals.

Given the proximity of the proposed reservoir site (ROS15) to the Blumengart Colony and lack of undisturbed natural habitat associated with the parcel, it is not anticipated to have rare and endangered plants and/or birds, mammals, amphibians, reptiles or invertebrates. To confirm this assumption contact has been made with the Manitoba Conservation Data Center, and steps to confirm site conditions would be undertaken this spring as required by the EAP review.

Similarly, contact has be made with Historic Resources Branch to determine the potential for archaeological impacts of the reservoir and pipeline construction. The proponents will undertake any historic resources field reconnaissance requested.

The habitat value for fish of the channelized Rosenheim Creek in W 15-2-3 W is mapped as Type D – not supporting commercial, recreational, aboriginal, or SARA species with simplified habitat. The proposed withdrawals from Rosenheim Drain will be made during the spring freshet (March to May), when fish migration upstream from the Red River is typically partially blocked by snow and manmade structures (e.g., drop structures). The Rosenheim Drain is an ephemeral stream with flashy peak flows resulting from snowmelt or rainfall runoff and little to no base flows from groundwater. The withdrawals rates are considered a small percentage of the channel forming flows (< 6%) for the Deadhorse Creek downstream of the ROS15 site.

The impacts of the Project on fisheries are mitigated by the following considerations. Minimum in stream flows will be maintained during pumping to support the recessional limb of the hydrograph, when fish are expected to be migrating and spawning. Manitoba Conservation and Climate is responsible to establish the target minimum in stream flow on the Water Rights License. A previous Environmental Act license (2093R), issued for an unrelated project, established a minimum instream flow for the first reservoir upstream of ROS15 at 0.18 m^3/sec. It is anticipated this will be the required minimum flow downstream of the ROS15 withdrawal point. Given the lack of fish habitat and the position of the proposed intake in the watershed, it is not proposed to screen the intake on the Rosenheim Drain.

Navigation along the Rosenheim Drain is not considered a primary activity in the area, given the limited width of the creek and the ephemeral flows (high/low) at the withdrawal location. Furthermore, Rosenheim Drain is not on the Transport Canada list of protected navigable waters.

The Project is not located over known aquifers and is located to the east of the major, buried valley Winkler Aquifer. No water is to be withdrawn from any aquifer, and there appears to be geologic aquitards immediately below the entire Project that limits vertical percolation. The Project soils are considered imperfectly drained due to near-surface aquitards (i.e. lacustrine clay deposits) and the Colony has plans to tile drain the Project fields. The Project activities, including water use, irrigation and other crop production activities are not expected to impact groundwater. Blumengart Colony will adopt Beneficial Management Practices aimed at protecting surface water resources. These will include nutrient management (e.g. fertigation) and potentially drainage water management.

The socio-economic effects of the Project are either positive or mitigable. Project construction will support local jobs during the construction phase, as well as help secure the financial viability of the Blumengart Colony. Given that the producers currently grow crops (e.g., canola, wheat, corn soybeans) in rotation on much of the identified land, it is anticipated that a small but non-significant increase in traffic will occur, in the immediate Project area relative to pre-Project conditions. In the wider area, potato production occurs on large scale in the RM of Rhineland and the adjacent RM of Stanley. Traffic routes include Road 9N, Road 15W, PR 201, PR 306, PTH 32, and PTH 14, as well as other local grid roads.

Potential adverse environmental impacts of the Project during construction and/or operation can be mitigated as follows:

- Employing an appropriate sediment and erosion control plan on all construction sites.
- Employing Beneficial Management Practices for growing of irrigated potatoes on the specific fields approved under licenses.
- Gearing any near water construction (e.g., intakes, stream crossings) to avoid timing windows specified by DFO.
- Adherence to minimum instream flows, anticipated to be included in the Environment Act licence, during pumping to fill the reservoirs. Monitoring if required could be in relation to measured flows at the existing Water Survey of Canada flow stations on the Deadhorse Creek (Station 05OC016).
- Comply with regulations respecting Storage and Handling of Gasoline and Associated Products.
- Consulting with Municipal officials on routing of potato trucks.
- Adhering to other Provincial regulations, Municipal by-laws and other permits and approvals, as appropriate.

The Project is not anticipated to result in a significant increase to greenhouse gas contributions, given that the farming activity is largely ongoing, and construction is short term in duration. Where economically feasible, renewable hydro-electric power will be employed for pumping (e.g., long-term goal). If this is not feasible, and/or over the short-term, the use of diesel power for pumping will result in an incremental increase in emissions.

Blumengart Colony is committed to sustainable agricultural crop production and to implementing steps to ensure that they are protecting the local environment during design, construction, operation and repairs of the Project to expand their current production system to include irrigation for potato production. These include:

- Implement measures identified in the Environment Act License related to monitoring and environmental protection.
- Build into each construction contract environmental protection and worker safety measures.
- Establish standard operating procedures for implementation of recommended BMPs for irrigated potato production.
- Maintain equipment, environmental controls and monitoring devices in good working order.
- Provide access to environmental monitoring data on request.
- Correct any noted deficiencies in a timely manner.
- Protect the environment against hazards (e.g., fuel spills).
- Promptly report significant environmental incidents to Manitoba Conservation and Climate for guidance in finding appropriate remedies.

Amendments to this proposal and/or additional information will be issued upon further investigations and engineering feasibility determinations for water storage site(s), as required, as well as to document any additional field investigations that may be required, if requested.

Table of Contents

Appendices

Figures

Tables

1.0 Introduction and Background

1.1 Proponents

Blumengart Colony Farms Ltd. is planning to begin production of potatoes for the processing market in 2020. Blumengart Colony Farms Ltd. has not grown potatoes commercially in the past but have a significant farming history. They have an ethos of working closely with their neighbours and landowners within the Project area. Blumengart Colony Farms Ltd. will be referred to as "Blumengart Colony" or "the Proponent" herein.

For further information about Blumengart Colony, please contact:

Blumengart Colony Farms Ltd.
Box 375
Plum Coulee, MB.
R0G 1R0

Mark Tschetter mark@blumengart.ca
204 362 8450

1.2 Project Overview

The Project area is shown in Map 1 (Appendix A). The Project area is north of Gnadenthal, Manitoba and includes land along the Rosenheim Drain. To secure production against the risk of drought, and to meet the quality requirements of their customer base, the Proponent needs to develop the capacity to irrigate as part of their new potato production operation. The proposed water source for the Project is the Rosenheim Drain which is fed by the Manitoba Escarpment to the west and local runoff in the Red River Valley lands. This water will be stored in an off-stream reservoir. The Project will also take advantage of an existing water storage reservoir on the Buffalo Drain to the south. The Project may share water with a neighbouring project belonging to Southern Potato Co., which stores water on the Hespler and Rosenheim Drains.

Irrigation will be used to offset peak moisture deficits to potato production of 125 to 200 mm (5 to 8 inches). Moisture deficits have implications for potato size, yield and quality. The Proponent plans to irrigate up to 219 ha (540 acres) of land each year in rotation (i.e., 3- or 4-year rotation). The total current water requirement is 320 cubic decameters (i.e., 260 acre-feet) to irrigate 219 ha (540 acres). Future expansion is dependent on securing additional water sources. Options going forward could include working with others to develop additional water storage and/or capturing and recycling of tile drainage waters from the Colony land base. Current application to Water Stewardship for site ROS15 in NW 15-2-3 W on the Rosenheim Drain is for 180 acre feet (222 cubic decameters); and arrangements are being made to secure longer term access to the reservoir water stored in SW 2-2-3 W for an additional 80 acre feet (98 cubic decameters). Storage reservoirs will contain an additional reserve amount for higher demand (i.e. drought) years.

The Project will involve withdrawal of water from the Rosenheim Drain during spring snowmelt and runoff from spring rainfalls and storing the water in reservoir site ROS15. A preferred location for site ROS15 has been established (NW-15-2-3-W) with an optional site ½ mile to the northeast of the preferred site (also within NW-15-2-3-W. Water will be distributed to up to a 1,209 ha (2,988 ac) irrigable land base (see Map 2, Appendix A; including future land locations which can not be currently met by the proposed water developments). Water distribution will be through buried pressure pipelines, pumping facilities, and moveable on farm irrigation systems.

The Proponent does not currently own and operate irrigation projects in the immediate area, but there is potato production nearby using water from the Hespler, Rosenheim, Buffalo Drains/Creeks. These projects service similar land types and production systems and have been successfully operated in excess of 20 years. Blumengart Colony are experienced farming operators.

Blumengart Colony plan to make use of the most current irrigation technologies, including highly efficient, low pressure linear and center pivot irrigation systems, and travelling boom carts or guns, as well as irrigation scheduling technologies, such as weather and soil moisture irrigation scheduling techniques. Precision control of inputs and intensive risk management are required to maintain profitable and sustainable production.

1.3 <u>Previous Studies and Licenses</u>

The Proponent does not have previous water rights licenses or water studies in this area related to irrigation.

Manitoba Conservation and Climate has provided a review of the Rosenheim Drain water availability, and have issued a Development Authorization Permit for up to 220 cubic decameters (180 acre-feet) of water to be withdrawn from the Rosenheim Drain during the period March – May (Appendix C.1 contains a copy of this permit). The permit allows for storage of up to 50% above the amount of the approved withdrawal (i.e., 110 cubic decameters or 90 acre-feet).

Appendix C.1 also contains a copy of the Water Rights License for the irrigation reservoir in SW 2-2-3 W, known as S14; which is for a withdrawal of 98 cubic decameters (80 acre-feet). The design drawing of the S14 reservoir indicates it stores 124 cubic decameters (100 acre-feet). Copy of the design drawing for the reservoir in SW 2-2-3 W is included in Appendix H.

The nearest water storage project on the Rosenheim Drain is S9 – Southern Potato Co. in SW 9-2-3 W. The nearest water storage project to the north on the Hespler Drain is S15b – Southern Potato Co. in SW 32-2-3 W. Pipelines from these two projects parallel the western and southern extent of the Blumengart Colony Project. Both of these other projects have an Environment Act License (2093R).

1.4 *Project Alternatives*

The selected water source for the Project is Rosenheim Drain. Other available water sources in the area include groundwater, such as the Winkler aquifer, and local runoff such as comes from the surface runoff and discharge from tile drainage systems installed on the Project land base. The Winkler Aquifer is currently fully allocated, although the City of Winkler has more recently been considering methods to enhance recharge. Local runoff and tile drainage outflow is limited due to the small drainage area and is insufficient to support the proposed level of irrigation without a supplemental water supply. The most readily actionable option was determined to be capture of spring snowmelt and rainfall runoff from Rosenheim Drain in an off-stream reservoir, and leasing water from the existing reservoir on the Buffalo Drain. Figure 1 shows the optional location for the proposed reservoir while Figure 2 shows the preferred location. The preferred reservoir location and a preliminary pipeline route to the fields to be irrigated are shown in Map 3 (Appendix A). Currently the Proponent has insufficient water to match the potential future demand and this Project is limited to approximately 4 center pivots (or equivalents) for a total of 540 acres of irrigated production. The land base would support close to 1000 acres of irrigated potato production on a 1:3 year rotation.

2.0 Regulatory Submissions and Approval Status

2.1 Local Permits

2.1.1 RM of Rhineland

The Proponent has notified the RM of Rhineland of their intentions to build off-stream reservoirs to capture spring runoff on the Rosenheim Drain, and will file the appropriate application to obtain a Conditional Use Permit (see Appendix B). This submission awaits consultation with Manitoba Infrastructure relative to the proximity of the reservoir footprint to the Provincial Drain and further engineering feasibility work.

Additional submissions to the RM may be required for approval of road crossings and location of pipeline or fittings in the Road Allowances, which require resolutions or legal agreements.

2.1.2 Building Permits

Building permits will be sought as required by Municipal bylaws for any permanent buildings (e.g., pumphouses).

2.2 Provincial Permits

2.2.1 Provincial Water Rights License Applications

The Proponent has applied for Water Rights through the Manitoba Conservation and Climate for withdrawal of up to 220 cubic decameters (180 acre-feet). The Province maintains records of all Water Rights applications. The Proponent currently has been issued a Development Authorization Permit (Appendix C (C.1)).

The Proponent has approached neighbouring farms for consideration of additional water; including Southern Potato, WJ Siemens and M. Nickel. Current tentative plans include leasing water from Southern Potato for 2020, and consideration to pumping water from S14 reservoir on the Buffalo Drain in SW 2-2-3 W. The Water Rights License for S14 is contained in Appendix C (C.1).

No plans have been made for requesting for additional allocation for future expansion to irrigated acres. Expansion beyond 540 acres would require additional water source identification and licensing.

2.2.2 Manitoba Infrastructure Permits

A request has been made to Manitoba Infrastructure with respect to location of the off-stream reservoir in NW 15-2-3 W relative to the Manitoba Infrastructure Rosenheim Drain dykes/channel; as well as to secure access to pump from the Drain.

The pipeline distribution system may include crossings of the Provincial Drains. Individual applications will be made for all crossings and for location of pipeline delivery systems in Manitoba Infrastructure rights of way, if required.

2.2.3 Provincial Environment Act License Applications

The Environment Act outlines the environmental assessment and licensing process for developments in Manitoba that may have potential for significant effects on the environment. Under the Classes of Development Regulation (M.R. 164/88), the Project is considered a Class 2 development as it proposes to withdraw more than 200 cubic decameters of water and to store more than 50 decameters. The Project requires a valid and subsisting Environment Act Licence from Manitoba Conservation and Climate – Environmental Approvals Branch. This report forms the basis of the application. A cover letter, Environment Act Proposal Form, and application fee have been submitted separately to satisfy the requirements of a complete Environment Act Proposal (EAP).

2.2.4 The Water Protection Act

The Nutrient Management Regulation (M.R. 62/2008) under *The Water Protection Act* is pertinent to nutrient management requirements for the Project. The regulations stipulate residual soil nitrogen limits according to nutrient management zones (N1-N5) and limit phosphorus applications based on residual concentrations, which necessitate nutrient management planning and other management practices be employed in growing a crop. The Act also defines the nutrient buffer zones around surface and groundwater features. The buffer applies to any surface water body (e.g., lake, river, creek, drains [Order 3, 4, 5], major wetlands) within or adjacent to fields receiving nitrogen or phosphorus. The Proponent is responsible to adhere to this regulation as part of their operations. Discussion on nutrient management is provided in Section 5.1 and Appendix G.

2.2.5 The Heritage Resources Act

A heritage site refers to a location that is protected under the provisions of *The Heritage Resources Act*, due to its known archaeological significance. In addition, human remains discovered outside a formal burial grounds are protected by the Act. The Act prescribes the processes to be followed by the Proponents and Authorities.

Correspondence with the Historic Resources Branch is included in Appendix C (C.2).

2.2.6 Provincial Drainage Permits

Application may be made to Manitoba Conservation and Climate for a drainage permit to allow for improved drainage around the reservoir dykes. This would be applied for as a water control work in accordance with the Water Rights Regulation of *The Water Rights Act*. The improved drainage will remove ponded water from the toe of the dykes. The drainage may include HDPE tile drains c/w filter sock and will exit to existing pumped tile drainage system to existing waterways (i.e., local waterways or the Rosenheim Drain or the reservoir).

In addition, any in-field tile drainage (to improve production) is required to be permitted individually by the farm/landowner in question. All currently tiled fields have been individually licensed.

2.3 Federal Regulations

2.3.1 Federal Department of Fisheries and Oceans Authorization

The Federal *Fisheries Act* was last amended in August 2019 (available at: https://www.dfo-mpo.gc.ca/campaign-campagne/fisheries-act-loi-sur-les-peches/index-eng.html). Under the Fisheries Act, harmful alteration, disruption or destruction (HADD) is prohibited and impacting fish and fish habitat is only allowed following an authorization.

If, after a project review, it is determined that a project will cause serious harm to fish that ***are part of or that support a commercial, recreational or Aboriginal fishery***, the proponent can apply for an Authorization (Paragraph 35(2)(*b*) *Fisheries Act* Authorization from the Minister of Fisheries and Oceans).

Follow up to this Environment Act Proposal may include further consultation with Department of Fisheries if required by review. The Federal law regarding protection of fish habitat will be reviewed with respect to the withdrawals, sediment control, and intake development.

The Department of Fisheries and Oceans recently issued guidelines on the classification of fishery habitat in Southern Manitoba that indicate the potential habitat value of the Rosenheim Drain at the proposed withdrawal points with respect to commercial, recreational or Aboriginal fisheries. These guidelines are discussed in Section 4.3.

2.3.2 Navigation Protection Act

The Federal law regarding navigable waterways was reviewed with respect to the intake design.

> *For the purposes of the NPA, "likely to substantially interfere with navigation" means that the work will, for example, significantly change the way vessels pass down a navigable waterway or may make passage dangerous to the public. When a work is assessed as substantially interfering with navigation, section 6 of the NPA applies.*

It is not anticipated that the Rosenheim Drain is considered navigable, and it is assumed that it is a minor water not intended for navigation and are therefore exempt from the Act. ***The Rosenheim Drain is not listed in the schedule of waters under the revised Navigation Protection Act, enacted by Parliament in 2014.*** The list of scheduled waters is provided on the Transport Canada web site (available at: https://laws-lois.justice.gc.ca/eng/acts/N-22/FullText.html#h-365179)

The Proponent does not intend to "opt in" for assessment.

2.3.3 Migratory Birds Convention Act

Disturbance or destruction of migratory bird nests or eggs is prohibited pursuant to this Act. Any construction will need to take this Act into consideration.

2.3.4 Species at Risk Act

The *Species at Risk Act* (SARA) is intended to prevent human activity from impacting species of special concern, to prevent them from becoming endangered or threaten their extinction. The Manitoba Conservation Data Center was informed of the Project and asked for an opinion on the potential for Species at Risk at areas of anticipated disturbances to the existing environment, namely are of construction at the site of the reservoir ROS15 in NW 15-2-3 W. Copy of the correspondence is included in Appendix C (C.3).

2.4 Other Permits and Considerations

2.4.1 Water, Gas and Oil Pipelines

There is a Centra gas main that comes to the Colony from the North along the east side of Road 15 W.

There are water pipeline networks within the Project area including the Pembina Valley Water Cooperative and RM of Rhineland pipeline network.

Reservoir and pipeline design and construction will take all existing infrastructure crossings into account. All in ground construction will be cleared through Manitoba Click before you Dig process, including MTS, Manitoba Hydro, RM of Rhineland and Pembina Valley Water Coop.

2.4.2 Local Conservation Groups

Currently there are no Watershed Districts active in the RM of Rhineland to consult.

2.5 Public Consultations and Submissions

Information and informal presentations on the Blumengart Colony Irrigation Project will be offered to the RM of Rhineland for their consideration and comments as part of the Conditional Use Permit process. The RM is responsible to determine if a public hearing is required.

A copy of the pertinent information (this report) will be made available at the RM office for local government and public review. Copies of all feasibility reports (e.g., engineering) on the reservoirs associated with the Project are available on request.

Neighbours will be actively and directly consulted by the Proponent; to allay concerns and/or address potential impacts and mitigative measures.

PBS Water Engineering Ltd. is responsible for filing this EAP, along with RM and Manitoba Infrastructure applications on behalf of the Proponent. AgriEarth Consulting Ltd. has been given responsibility for assessing and recommending the land suitability for irrigation. Any licenses will be issued in the name of Blumengart Colony Farms Ltd. who will have sole responsibility to meet license conditions.

3.0 Description of Proposed Development

3.1 Project Summary

The Project will initially store up to 330 cubic decameters (i.e., 270 acre- feet) of water in the proposed reservoir, referred to as Site ROS15. Water may be transferred to the reservoir (in season) from the existing licensed reservoir, known as S14, located in SW 2-2-3 W on the Buffalo Drain. Water from the reservoir ROS15 will be piped in a common underground pipeline to a portion of the 26 current parcels of land, which encompass 1,209 ha (2,988 acres) of potentially irrigable land. The initial reservoir storage capacity (i.e., ROS15) will provide sufficient water to irrigate up to 219 ha (540 acres) annually.

Map 3 (Appendix A) shows the currently proposed land base, ROS15 reservoir location and currently proposed pipeline infrastructure. In 2020 one pivot will be operated on Field 22. Starting in 2021 up to 4 modern sprinkler irrigation systems (e.g. pivots, linears, travelling guns) will be operated.

Ultimately, irrigated acreage would approach 1,000 acres annually, if additional water requirements can be met. Future irrigation will expand only at such time as additional water sources are identified for development and all licenses and permits have been approved or amended.

Power sources will be electric and/or diesel power. Hydro electric power is preferred.

The system will be managed by the Proponent, Blumengart Colony Farms Ltd.

3.2 Project Area

The Project area is highlighted in Map 1 (Appendix A), located north of Gnadenthal, Manitoba within the Rosenheim Drain watershed within the Red River Valley. The Project area is currently limited to the RM of Rhineland. The Project area is located within the Winkler Ecodistrict portion of the Manitoba Plain Ecoregion.

3.3 Land Base and Irrigation System Components

The land base to be irrigated is described in Table 1 and shown in Map 2 (Appendix A). The Project irrigation system infrastructure components are illustrated in relation to the land base in Map 3 (Appendix A). Those components include, irrigated land base, water delivery system, water storage, water diversion, and power supply. The following sections describe the proposed development components and reference the additional development information as required in the Environmental Act Proposal Guidelines.

Table 1: Project Field Number, Land Parcel Description and Acres (Irrigated)

Legal Land Location	Field ID	Acres	Hectares
SE-20-2-3-W1	1/2 E	135	55
SW-20-2-3-W1	1/2 W	135	55
S-21-2-3-W1	3a	100	40
S-21-2-3-W1	3b	160	65
NE-21-2-3-W1	5E	135	55
NW-21-2-3-W1	5W	98	40
SW-28-2-3-W1	6	135	55
SE-28-2-3-W1	8	116	47
SW-27-2-3-W1	9	135	55
SW-26-2-3-W1	10	135	55
NE-22-2-3-W1	11	135	55
NW-26-2-3-W1	12	135	55
SE-26-2-3-W1	13	135	55
S-22-2-3-W1	15/16W	100	40
E-15-2-3-W1	17b	108	44
15-2-3-W1	18a	108	44
SW-15-2-3-W1	18c	62	25
S-16-2-3-W1	19a	119	48
S-16-2-3-W1	19c	130	53
N-16-2-3-W1	20/21b	119	48
N-16-2-3-W1	20/21c	121	49
NE-17-2-3-W1	22	135	55
SW-17-2-3-W1	23	71	29
NW-17-2-3-W1	24	71	29
NW-10-2-3-W1	25b	80	32
NW-10-2-3-W1	26a	80	32
Irrigated Area Totals		**2,988**	**1,209**

3.3.1 Irrigation Systems

Each of the quarter sections or portions of will be irrigated using an on-farm irrigation system, including but not necessarily limited to:

- Center pivot irrigation systems
- Linear irrigation systems
- Travelling boom carts or guns
- Drip irrigation

Each individual irrigation system is considered an irrigation parcel. There are 26 irrigation parcels (Table 1; Map 2, Appendix A) encompassing 1,209 ha (2,988 acres).

The maximum current farm irrigation will be 219 ha (540 acres) per year, at an average duty of 150 mm (6 inches) and a maximum duty of 200 mm (8 inches), for a total average demand of 320 cubic decameters (260 acre-feet) and a peak demand (including water from storage) of 456 decameters (370 acre-feet). The average demand is made annually from the two reservoirs allocations (180 + 80 = 260 acre-feet) and the peak demand is made from additional (90 + 20 = 110 acre-feet) storage capacity for dry years (e.g. carry over for drought).

3.3.2 Water Delivery Systems

Water will be delivered to each irrigation parcel by means of pressurized pipeline. The preliminary pipeline routes are shown in Map 3 (Appendix A); subject to change associated with final reservoir and field locations, crop rotations, and land access. The pipeline system will be constructed of pressure rated PVC pipe, shallow buried using chain trenchers and backhoes. Turnouts to pipeline laterals and to irrigation parcels will consist of galvanized steel pipe fittings. Wet creek crossings and paved and gravelled roads will be directionally bored. Dry waterway crossings and non gravelled RM roads will be open cut where feasible and acceptable. All road crossings will be provided with liner pipes to safely convey any leakage to the road ditches and ensure public safety. Provincial Drain crossings will be accomplished by directional boring using fused HDPE pipe.

3.3.3 Water Storage

As the demand of water is in June to September period and spring snowmelt runoff occurs in March, April and May; there is a need to build water storage facilities. One new water storage site is under active consideration – designated at ROS15 in Section 15-2-3 W. This site is located relative to the land base per Map 3 (Appendix A), and two alternative sites are shown in Figure 1. The preferred site is shown in Figure 2. If the preferred site is not feasible the alternative site will be explored, ½ mile to the north east.

Feasibility studies and consultations (i.e. RM, MI) are ongoing for this site. Further pre-design work, including surveying, test drilling, and design are required to confirm feasibility, storage capacity and engineering details. All reservoir sites will be engineered with the following elements:

- Seepage control including clay keyway and/or clay liner
- Seepage interception and liner monitoring (e.g., tile drainage)
- Wave and erosion protection
- No key or liner penetrations (pipes)

Pre-design geotechnical investigations and final design engineering are planned for Site ROS15 in spring, 2020. Pre-design investigations may be conducted simultaneously on the alternative site. Total planned storage for site ROS15 is 330 cubic decameters (270 acre-feet) (Appendix H).

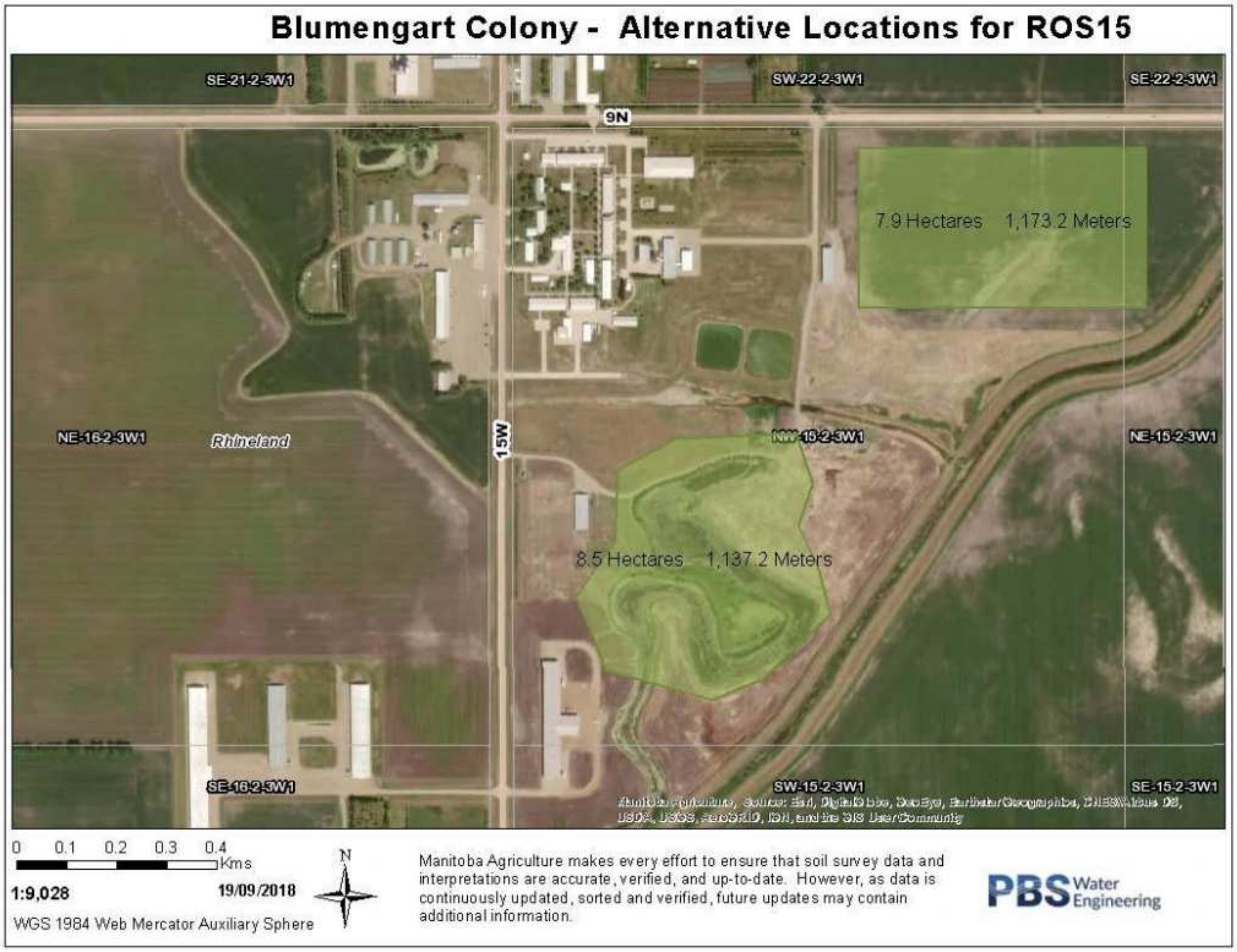


Figure 1 - Alternative Site Locations for Reservoir ROS15 - NW 15-2-3W

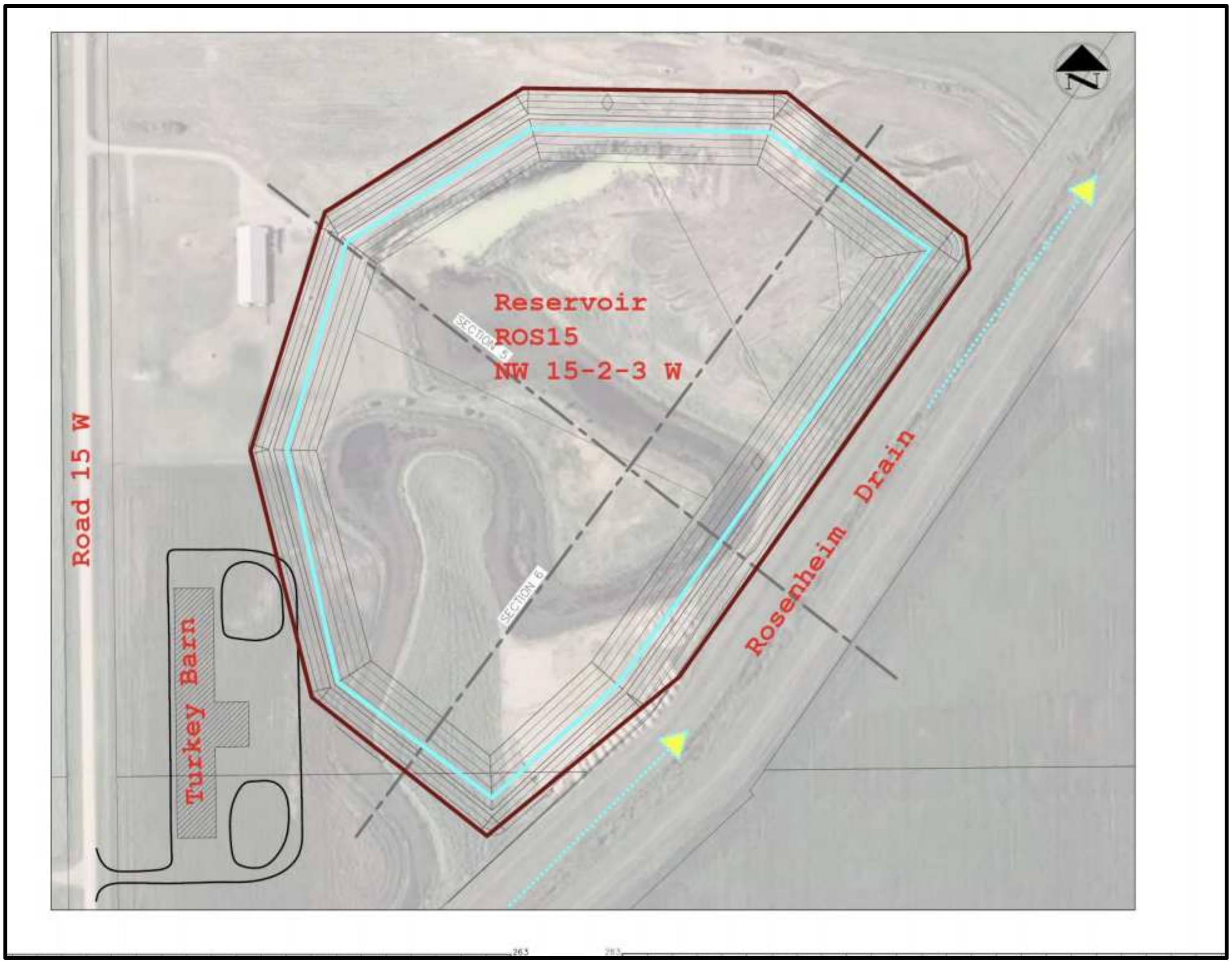


Figure 2 – Preliminary Layout Map for Preferred Location of Potential Water Storage Site ROS15 Adjacent to Rosenheim Drain in NW 15-2-3 W

3.3.4 Water Diversion

Water to site ROS15 will be the Rosenheim Drain, with some local surface runoff from Blumengart Colony Farm and fields, available for capture prior to entering the Rosenheim Drain. The Proponent plans to study capture and recycling of tile water, if water quality is suitable.

Filling pump systems will be high volume low head transfer pumps. PTO driven, Crissafulli type propeller pumps will be utilized for filling. Total maximum withdrawal rates will in the order of 520 l/s (8,000 USGPM). Depending on flow variability a smaller (e.g. 130 l/s; 2,000 USGPM) low volume low head electric transfer pump will also be set up. A variable frequency drive can be utilized with the smaller electric pump to vary the withdrawal rate to maintain the required minimum instream flow (e.g., slower speed results in lower withdrawal rate).

Interconnecting pipeline will allow water sharing with other neighbouring reservoirs during or prior to filling from Rosenheim Drain and or during irrigation season. Specifically, the 124 cubic decameters (100 acre-feet) S14 reservoir located in SW 2-2-3 W will provide an additional 98 cubic decameters (80 acre-feet) water to recharge the reservoir at ROS15. This will increase the total available water to 370 acre-feet (456 cubic decameters).

3.4 Land Use and Access

Table 1 and Map 2 (Appendix A) provide a summary of the field locations and field areas for the fields proposed for irrigation.

3.4.1 Certificates of Title and Mineral Rights

Certificates of Title for the land base will be compiled to document land ownership and forwarded separately ***if requested***. Blumengart Colony has ownership of all fields identified in Table 1 and Map 2 (Appendix A) for irrigation or water storage. Mineral rights will be reported ***if required***, as they are not impacted by the Project.

3.4.2 Existing Land Use

The land proposed for ROS15 reservoir development, is currently an abandoned/remnant oxbow, and unutilized pasture area (Figure 2; Maps 3 & 4, Appendix A), whereas the alternative site for ROS15 is cultivated and tile drained (Figure 1).

Water delivery system (pipelines) will cross natural features such as creeks. Potential creek crossings are evident on Map 3 (Appendix A).

The fields proposed for irrigation are all currently under annual, dryland agricultural crop production land use. Some of the fields have previously been developed for tile drainage (i.e., 10, 15/16W, 17b, 18a, 18c, 19a, 19c, 20/21b, 20/21c, 22). Additional fields are planned for tile drainage improvements in the future (see tile drainage plan in Appendix H).

3.4.3 Land Use Designation

The Project does not propose to change the existing cultivated land base other than to provide irrigation to some proportion of the land depending on the irrigation system, and to potentially convert some cultivated land to constructed irrigation reservoirs. There is no planned increase to cultivated acres. The riparian zone associated with the abandon oxbow will be modified and potentially enhanced through the creation of a dyked, pumped irrigation reservoir. Additional tree plantings and pasture/grassland revegetation has potential to increase the habitat value of the reservoir adjacent to the Rosenheim Drain, especially as it relates to waterfowl.

The alternative site for ROS15 is 100 % cultivated currently. If it is chosen it would add wetland habitat to the Project area, which is a rare feature in this drained environment.

3.5 Development Schedule/Phases

The following describes the currently proposed development schedules associated with the major components of the work.

3.5.1 *Irrigation Systems*

One irrigation system has been purchased for spring 2020 and the other 3 irrigation systems (pivots, laterals), will be purchased in 2021 and 2022, until the water storage and delivery systems are fully developed to maximum of the water available. It is anticipated that a 1:3 or 1:4 rotation will require development of pipeline systems to 1,620 to 2,080 acres of land for this phase of the development.

3.5.2 *Water Delivery Systems*

The pipeline delivery systems will be scheduled to start construction in the spring of 2020, with one mile of connecting pipe to the S15b irrigation reservoir. Southern Potato Co. will lease water to Blumengart Colony for 135 acres of irrigated potato production in 2020. In the fall of 2020, additional pipe will be installed to service more land, depending on the number of irrigation systems and the size of the potato contract for 2021.

3.5.3 *Water Storage Systems*

Site ROS15 is proposed for development in summer 2020, with first filling in late fall 2020 and/or spring 2021.

3.5.4 *Water Diversion*

Water diversion facilities (e.g., Rosenheim Drain access, intake, pump site) will be developed in fall 2020 for site ROS15.

Pipeline and pumping facilities to transfer water from reservoir in SW 2-2-3 W will be constructed in fall 2021.

3.5.5 *Engineering*

PBS Water Engineering Ltd. is currently undertaking feasibility and pre-design investigations with assistance from VRK Consulting Ltd. (Geotechnical) and ProFessional Resources Assessment (PFRA) Ltd. (Hydrogeology).

The site ROS15 feasibility report is scheduled for completion in June 2020, with additional test drilling to confirm conditions in May 2020.

Signed and stamped engineering plans will be submitted as they become available to appropriate agencies requiring approvals.

PBS Water Engineering Ltd., VRK Consulting Ltd. and PFRA Ltd. are partnering to complete the required engineering investigations, reports and designs. PBS Water Engineering Ltd. and partners will assist the owners through the construction and commissioning phases.

3.6 *Operation Phase*

Operation of the Project will commence with irrigation of Field 22 (135 acres) in 2020. Water will be leased from Southern Potato Co. and will flow from the S15b pipeline (Map 3; Appendix A). Filling of the site ROS15 reservoir will occur in fall 2020 or spring 2021. Planned irrigation for 2021 is 270 acres or 50% of this first phase of development, depending on contracts.

Additional storage, irrigation systems and distribution pipeline will be brought on-line over a three to five-year period.

3.7 Repair, Renewal, Decommissioning Phase

The Project is designed to be sustainable over the long term. The life expectancy of the components is as follows:

Pumps – 20 years

Electrical (Hydro) - 30 years

Off Stream Reservoirs – 50 years

Pipelines - 50 years (PVC); 25 years (steel fittings)

Irrigation systems - 25 years (aluminum)

Tile drainage – 50 years (HDPE)

The Project components will be maintained to ensure maximum life expectancy, and as required will be replaced. Where possible (e.g., steel, aluminum) parts will be recycled. PVC pipeline will be abandoned in place and replaced with new pipe. Off stream reservoirs will be drained and liner and excavation will be renewed; based on past projects net siltation is not expected to be a large issue.

Off stream reservoirs will require adoption of a dam safety program carried out in consultation with engineering consulting firms. Further details can be made available through VRK Consulting Ltd. The dam safety program will include inspection and monitoring of the embankments and associated elements (e.g., liners, crest, stability, and tile drainage interceptor).

3.8 Funding

The Project is 100% funded by Blumengart Colony Farm Ltd.

4.0 Environmental Settings

4.1 Physical Environment

The Project is in the Rosenheim Drain Watershed south and east of Winkler, Manitoba, below the Manitoba Escarpment in the southern portion of the Red River Valley.

Map 1 (Appendix A) shows the Rosenheim Drain and its location in the Winkler Ecodistrict. The Rosenheim Drain carries surface water (snowmelt, rainfall runoff) from uplands associated with the Manitoba Escarpment to the west, and from the Red River Valley flatlands within the local Project area below the escarpment.

Figure 3 shows the location of the Project storage site ROS15 in relation to the nearest upstream reservoir S9 on the Rosenheim Drain, and to S14 on the Buffalo Drain and S15b on the Hespler Drain. Figure 3 also shows the location of the Water Survey of Canada 05OC016 on the Deadhorse Creek near Rosenfeld in relation to the Project site.

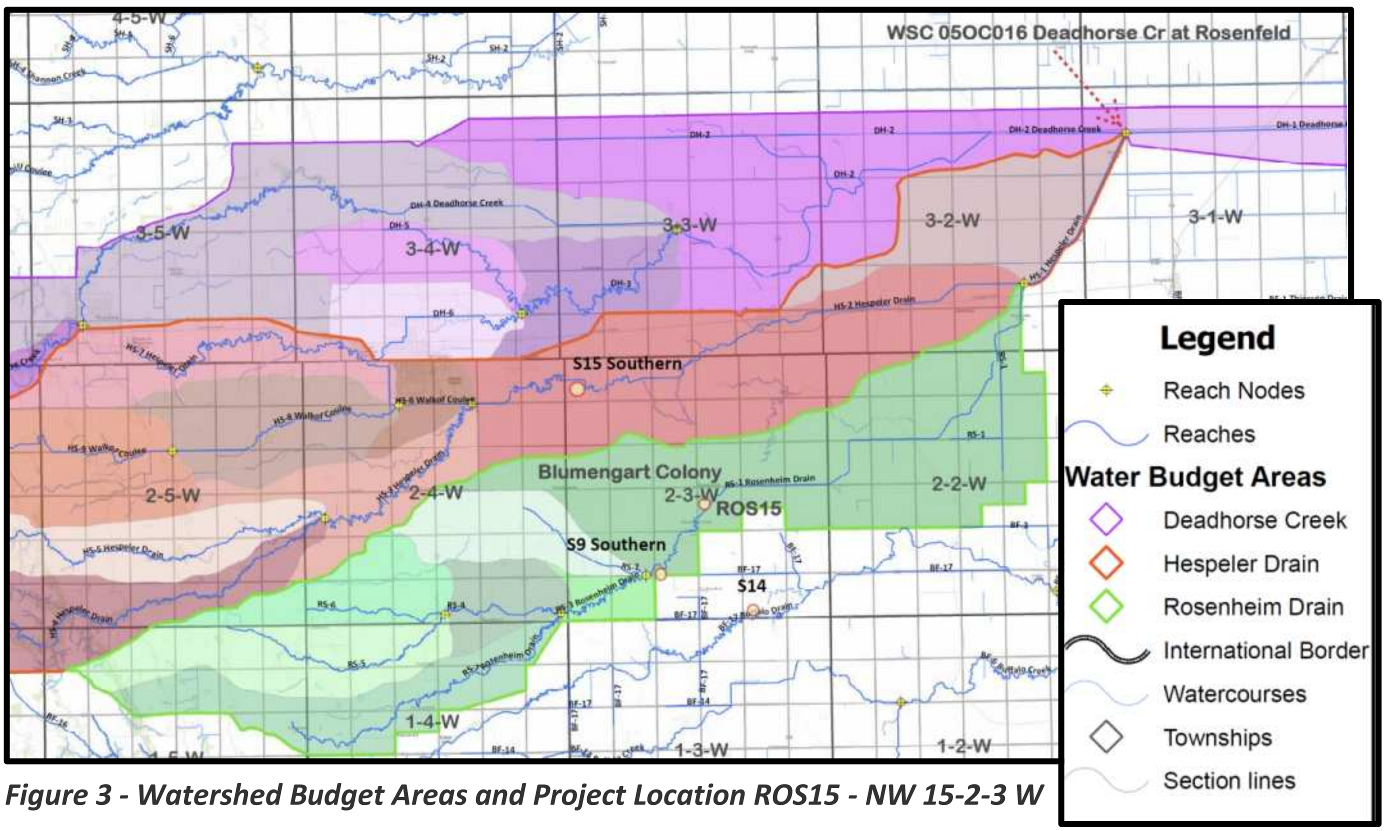


Figure 3 - Watershed Budget Areas and Project Location ROS15 - NW 15-2-3 W

4.1.1 *Terrain, Soils and Landscape*

The Project area is contained within Red River Valley physiographic sub-section of the Red River Plain section within the Manitoba Plain (i.e. Section D1.2) (Smith, Michalyna, 1971; Podolsky, 1991). The Manitoba Plain represents the lowest level plain on the Prairies. It is underlain by limestone bedrock and covered by glacial till and lacustrine clays and silts deposited by Lake Agassiz (Smith et al., 1998). Figure 4 depicts these map units in relation to the Pembina Escarpment to the west.

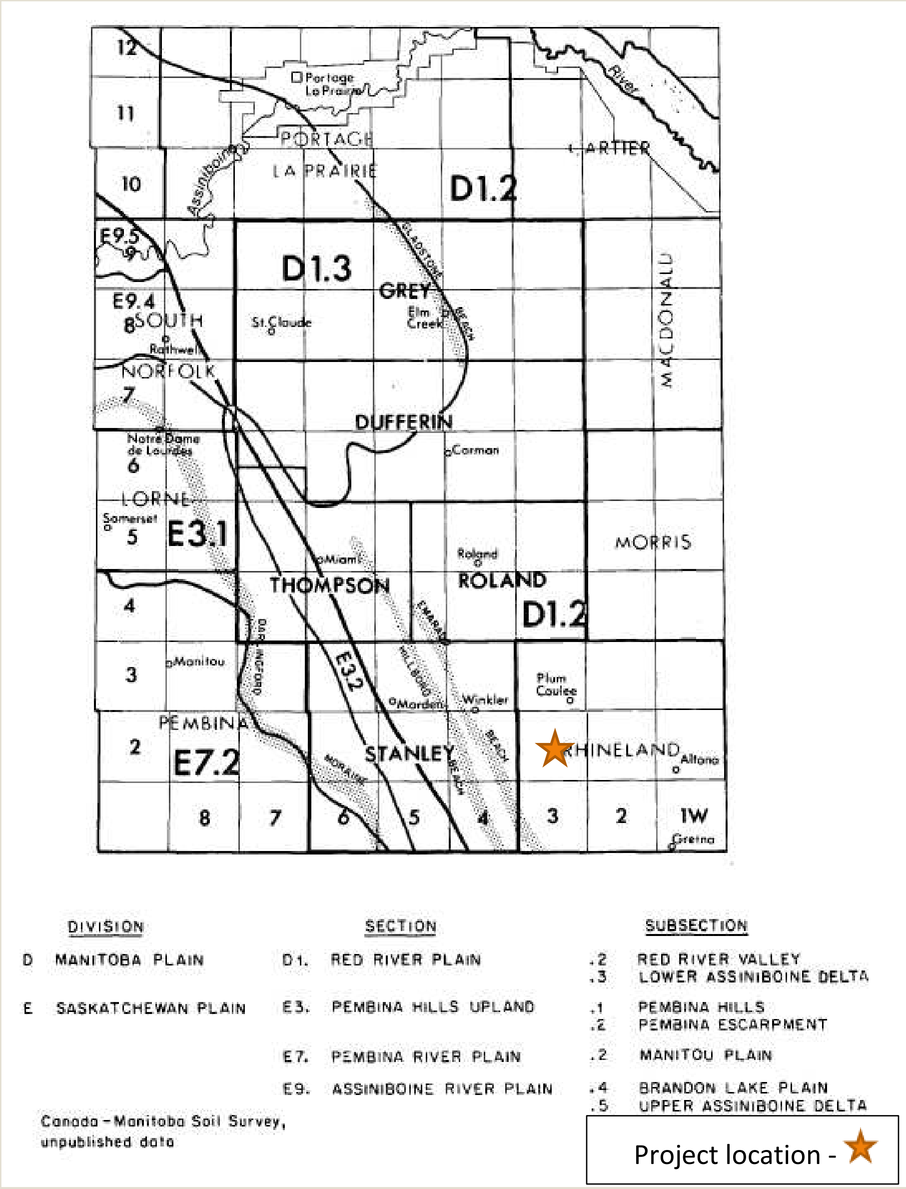


Figure 4 - Physiographic Map of the Project Area (Smith, Podolsky and St. Jacques, 1988) and the Project Site in 15-2-3 W.

Smith, Michalyna (1971) describe the soils, landscape and terrain of the Project area. The topography is smooth level to very gently sloping. Surface runoff is slow, as is internal drainage due to low permeability. The soil parent material overlying the deep bedrock at this location is characteristic of lacustrine sediments associated with glacial Lake Agassiz. The surficial soils range in texture from moderately coarse (fine sandy loam) to fine (clay), but are dominantly medium textured (loam). Soils within the study area are almost completely imperfectly drained, with a minor portion well drained.

Within the study area (Map 1; Appendix A) the significant surface features are the naturally meandering creeks (e.g. Rosenheim, Hespler, Buffalo) which are alternatively channelized and dyked to prevent breakout flooding of adjacent cultivated fields. Surface drainage in the region has been significantly altered by drainage ditches and channels, which supplement the discharge into the natural (and altered) stream network (Podolsky, 1991). The Emarado Beach ridge (Figure 2) is the closest remnant Lake Agassiz beach and is located several miles west. The relic beaches represent the successively lower water levels of Lake Agassiz (Smith et al.,1998).

The terrain, landscape and soils are major factors in the feasibility of the proposed Project. The Project area is noted to have some of the most productive soils in the Province (Smith, Michalyna, 1971) with excellent yields of grains, oilseeds and horticultural crops (e.g. potatoes). The major challenges to crop production are maintaining adequate surface and subsurface drainage and prevention of wind and water erosion. Generally speaking, the soils in the study area are considered suitable for irrigation (Smith, Michalyna, 1971; Podolsky, 1991); with the main limitation being slow permeability and high water table. Additional information on irrigation suitability and suitability for irrigated potato production, including mapping and evaluation of detailed suitability ratings, is provided in Sections 4.17 and 4.18.

The suitability of the soils and landscape for high value agriculture has led to the predominance of annual agricultural crop production in current land use in the Project study area. Land use/land cover is discussed in more detail in Section 4.1.6.

The Winkler Aquifer is a major buried sand and gravel aquifer that traverses the region. The footprint of the Winkler Aquifer is outlined in Appendix A Map 1, and the aquifer is further described in the next section.

4.1.2 Geology of the Project Area

Podosky (1991) describes the bedrock geology of the RM of Rhineland.

> A major portion of the municipality is underlain by rock exposures of the Jurassic period. This includes dolomitic siltstone, sandstone and gypsum or anhydrite of the Amaranth formation; limestone, dolomite and shale of the Reston formation and sandstone, shale and limestone of the Melita formation. An exposure to the south of Altona includes dolomites of the Silurian period. The bedrock in the southeast corner of Rhineland is Ordovician in age. A sequence of formations occurs here, including the Stonewall, Stony Mountain and Red River. The individual members include a dolomitic, calcareous shale and limestone lithology. These Post-Cambrian Paleozoic and Mesozoic rocks overlie the steeply tilted Precambrian bedrock.

The geology of the proposed reservoir sites and to an extent the Project study area will be confirmed and reported on as part of the geotechnical feasibility studies for site ROS15 (pending PBS Water Engineering Ltd., VRK Consulting Ltd., PFRA Ltd). The Project study area surficial deposits are associated with the glacial Lake Agassiz lacustrine environment and are comprised of relatively thick layers of silts and clays, with near surface stone free loamier soils suited to potato production. Closer to the current creeks, soils may include alluvial deposits. Glacial till is at significant depth (e.g., 30 + m). A GWDRILL log from NW 15-2-3 W illustrates the stratigraphy of surficial soils (silty clay over blue clay), transitioning to hard till at 135 feet and to limestone and shale starting at 360 feet.

```
Location:  NW15-2-3W

Well_PID:          101737
Owner:          BLUMENGART COLONY
Driller:        Echo Drilling Ltd.
Well Name:      COOLING WELL
Well Use:       PRODUCTION
Water Use:      Livestock
UTMX:      588219.5130
UTMY:      5442587.90
Date Completed: 1996 Oct 09

WELL LOG
  From   To       Log
  (ft.)  (ft.)
      0   15.0    SILTY CLAY
   15.0  135.0    BLUE CLAY
  135.0  280.0    HARD GREY TILL
  280.0  360.0    SANDY TILL
  360.0  523.0    LIMESTONE
  523.0  537.0    SHALE
  537.0 1166.0    LIMESTONE

WELL CONSTRUCTION
  From   To    Casing       Inside   Outside  Slot     Type       Material
  (ft.)  (ft.) Type         Dia.(in) Dia.(in) Size(in)
      0  363.0 CASING           5.00                   INSERT     PVC
  363.0  515.0 OPEN HOLE        4.50
  515.0 1166.0 OPEN HOLE        4.00
      0   63.0 CASING GROUT                                       CEMENT


Top of Casing: 2.000 ft. above ground

PUMPING TEST

Date:
Pumping Rate:                  10.000 Imp. gallons/minute
Water level before pumping:    3.0 ft. above ground
Pumping level at end of test: 63.0 ft. below ground
Test duration:                  hours, 30 minutes
Water temperature:             ?? degrees F

REMARKS

WATER USED FOR COOLING PIG BARN
```

The reservoir site ROS15 is anticipated to be contained geologically against deep seepage by the lacustrine clay. This aquitard has proven to be an effective barrier in many off stream reservoirs located in the immediate vicinity of this proejct (see Appendix A; Map 3). An EM31 map for the proposed reservoir site (Figure 5) will be used to target test drilling in May 2020 to confirm stratigraphy at the proposed reservoir site ROS15.

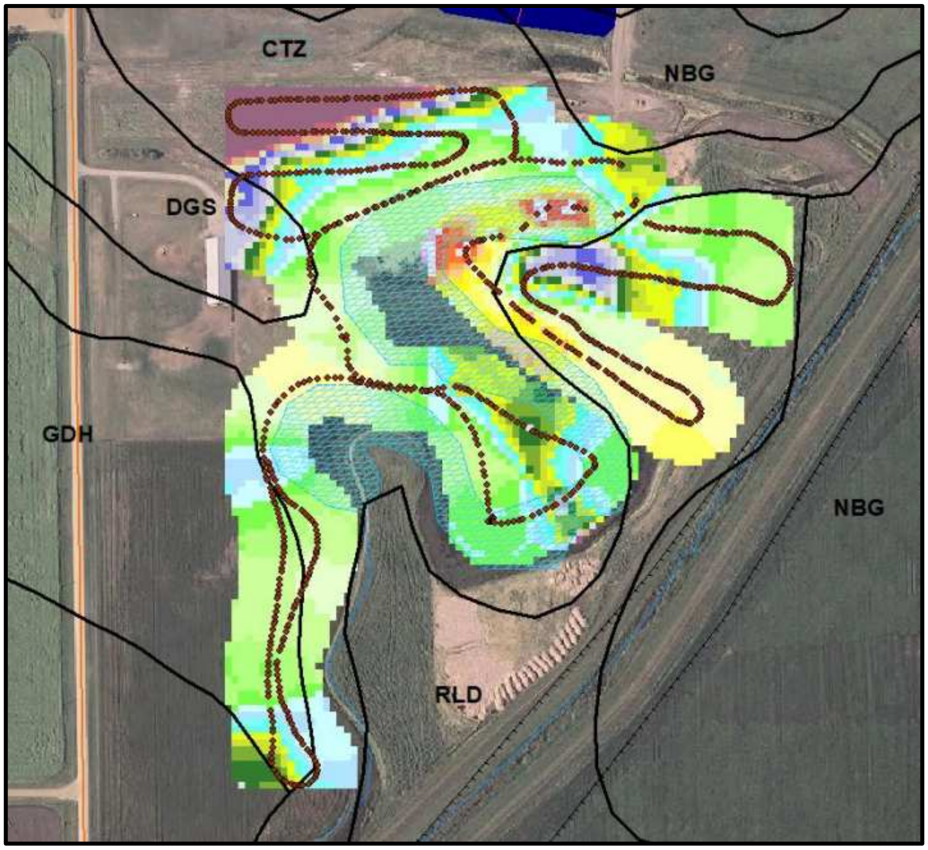


Figure 5 - EM31 Mapping of NW 15-2-3 W

4.1.3 Groundwater

The groundwater in the Project area can be characterized as follows. Deep wells into the shale bedrock are typically saline (Michalayna, Smith, 1971) and hence remain undeveloped, except for non potable uses. Shallow groundwater associated with the near shore sediments, perched on top of the lacustrine clay, varies in quality depending on the position in the landscape and the time of year. During spring snowmelt this perched water can cause issues with agricultural production, causing near surface water tables and hence imperfect drainage. This water table falls during the growing season, due to crop evapotranspiration, to levels below 2 m; only to be recharged in the fall with rain or during the next spring season (Cordeiro, 2013). These water tables are typically unreliable for water supply and of low capacity with respect to recharge.

Podolsky (1991) elaborated on conditions in the RM of Rhineland.

> In general, the potable groundwater supply in the R.M. of Rhineland is minimal, inadequate for local requirements and not uniformly distributed. Fairly extensive areas of potable groundwater are available in Township 1, a few occur in the central part (Township 2) and are almost totally absent in the northern townships of the study. The near surface aquifers are formed by fine to very fine sand and silt layers interbedded in the surface deposits. The yield of these aquifers is very low and suitable for domestic for farm use only. Water quality ranges from good to very poor.
>
> The only significant deep fresh-water aquifer, formed by sand and gravel at 30 to 40 m below ground level, occurs in a narrow zone along the western boundary in Twp. l-Rge. 3W. This aquifer (Rosengart - Rhineland) appears to correspond with the southern extension of the high yield Winkler aquifer. At this point the aquifer has thinned out and is only a few metres thick. The water quality in this aquifer ranges from good to poor depending on the location of the fresh and salt-water boundary. Throughout most of the municipality, particularly in the northern part, shallow aquifers are uncommon and water in the deep aquifers is salty.

Significantly, the RM's of Rhineland and Stanley have developed rural water pipelines to service the farms in the Project area, due to the lack of potable groundwater. The only other source of potable water is the Winkler Aquifer. However, to a large extent the Winkler Aquifer is utilized only by those farms, rural acreages and small businesses directly over its footprint and it is a major water source for nearby City of Winkler. The primary recharge to the Winkler Aquifer is well outside the Project area to the west and north, adjacent to the Paterson Pit located in SW 11-4-5W. Figure 6 illustrates the cross section of a covered portion of the Winkler Aquifer, where recharge is impeded by overlaying silty clay lacustrine soils and glacial till. The Reservoir sites ROS15 are approximately 3 miles to the east of the Aquifer boundary (Appendix A, Map 1).

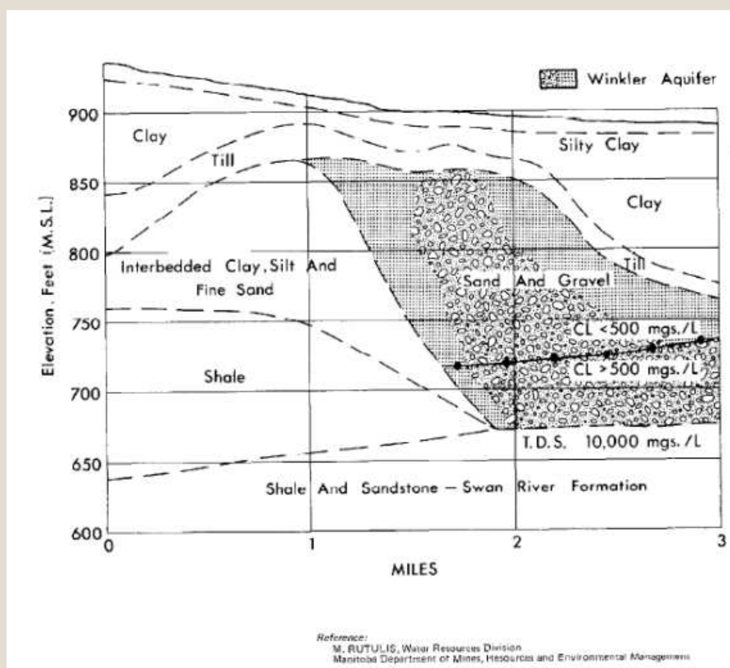


Figure 6 - Cross Section of Winkler Aquifer (Michalayna, Smith, 1971)

.

4.1.4 Climate and Meteorological Conditions and Eco-climate

The Morden CDA is a long-term climatic station maintained in conjunction with Environment Canada. Reported climatic parameters (Michalayna, Smith, 1971) are as follows:

Temperature 3.3^{0}C (mean annual)

Precipitation 530 mm (mean annual)

Rainfall 336 mm (mean annual)

During the growing season, potato crop evapotranspiration generally exceeds available precipitation. Based on climate data available from Manitoba Agriculture (Table 2); the water deficit ranges from as little as 75 mm (3 inches) or less in half of the years to 150 mm (6 inches) or more in 1 year out of 10. This information along with local experience has been utilized to estimate Project water demand. It is estimated that maximum irrigation demand will be in the order of 200 mm (8 inches).

Table 2 – Growing Season Precipitation, Potato Water Demand and Water Deficit.

Variable	Risk Level (%)	Description	Water (inches (mm))
Growing Season Precipitation	50	In 1 of 2 years precipitation will be less than given values	9.5-10.5 (240 to 270)
	25	In 1 of 4 years precipitation will be less than given values	7.1-7.5 (180 to 190)
	10	In 1 of 10 years precipitation will be less than given values	4.6-5.5 (115 to 140)
Potato Water Demand	50	In 1 of 2 years water demand for potatoes at maturity will exceed the given value	14.6 – 15.5 (370 to 395)
	20	In 1 of 4 years water demand for potatoes at maturity will exceed the given values	16.1 – 17.0 (410 to 430)
	10	In 1 of 10 years water demand for potatoes at maturity will exceed the given values	17.1 – 18.0 (435 to 460)
Potato Water Deficit	50	In 1 of 2 years water deficit will be exceed the given values	3.1 – 4.0 (80 to 100)
	25	In 1 of 4 years water deficit will exceed the given values	4.1 – 5.0 (105 to 125)
	10	In 1 of 10 years water deficit will be exceed the given values	5.1 – 6.0 (130 to 150)
Source: Manitoba Agriculture - http://www.gov.mb.ca/agriculture/weather/climatic-information-for-potatoes-in-mb.html			

Table 3 (Smith and Michalyna, 1973), reveals that water balance as represented by the ratio of precipitation to potential evaporation, ranges from a weekly high of 0.87 (precipitation/ potential evapotranspiration) in the first week of September to a weekly low of 0.37 (precipitation/potential evapotranspiration) in the last week in July. Short term moisture deficits are made up from soil moisture; but extended dry periods can quickly deplete available soil moisture and bring the crop under stress. Crop stress has impacts on potato yield, tuber diseases, and tuber quality.

The need for irrigation is clearly supplemental to the existing precipitation and soil moisture reserves, but none the less has been shown to be critical to optimal production conditions and to achieve more uniform product quality, and a level of quality that processing clients require.

Table 3 – Weekly Potential Evaporation (PE) and Water Balance (Precipitation/Potential Evapotranspiration) (Smith and Michalyna, 1973)

Long-term Weekly Means of Maximum and Minimum Temperatures
and Weekly Totals of Precipitation for the Period May 1st to September 30th*

Week Ending	Maximum Temperature Mean	Maximum Temperature S.D.	Minimum Temperature Mean	Minimum Temperature S.D.	Precipitation Inches Mean	Precipitation Inches S.D.	PE** Inches	Water Balance Precipitation / PE
May 7	60.1	13.5	37.2	9.6	0.49	0.66	1.04	0.47
14	62.4	12.4	37.3	8.8	0.43	0.53	1.02	0.42
21	66.5	11.7	41.3	7.8	0.40	0.45	1.11	0.36
28	68.9	11.7	44.2	8.0	0.69	1.07	1.23	0.56
June 4	71.3	11.4	47.6	8.2	0.88	1.01	1.33	0.66
11	72.2	10.4	49.1	7.5	0.70	0.76	1.27	0.55
18	74.9	9.3	51.6	7.1	0.61	0.61	1.28	0.48
25	75.6	8.6	52.6	6.5	0.69	0.66	1.29	0.53
July 2	78.0	8.4	54.6	6.6	0.64	0.71	1.35	0.47
9	80.0	8.2	56.3	6.6	0.77	0.77	1.39	0.55
16	81.6	8.2	57.4	6.5	0.69	0.75	1.43	0.48
23	82.6	7.6	58.4	5.8	0.56	0.60	1.39	0.40
30	82.3	8.1	56.9	6.4	0.52	0.61	1.40	0.37
Aug. 6	82.0	8.2	57.1	5.7	0.81	0.82	1.35	0.60
13	80.3	8.9	55.4	6.7	0.56	0.64	1.27	0.44
20	79.6	8.9	54.1	6.9	0.51	0.71	1.22	0.42
27	77.3	9.6	53.4	7.4	0.48	0.63	1.09	0.44
Sept. 3	74.1	9.6	51.5	6.9	0.82	1.17	0.94	0.87
10	71.7	10.5	48.8	7.8	0.42	0.60	0.86	0.49
17	68.6	10.1	45.8	8.0	0.37	0.40	0.71	0.52
24	64.6	10.4	42.8	7.5	0.48	0.63	0.54	0.89
30	61.5	12.9	38.9	8.3	0.29	0.35	0.38	0.76

Other Weather Parameters

Average Precipitation May 1st to September 30th	–	12.7 inches
Average Annual Precipitation	–	20.3 inches
Corn Development Units (C.D.U.) May 15 to date of first killing frost in autumn	–	2497

* C. F. Shaykewich, Dept. of Soil Science, Univ. of Manitoba. Values were calculated using daily data from the Morden Research Station, C.D.A., for the period 1931 to 1968.

** PE – Potential evapotranspiration is the maximum quantity of water capable of being lost as water vapor in a given climate, by a continuous stretch of vegetation covering the whole ground and well supplied with water. PE was calculated on a daily basis by means of a formula that involved daily values of maximum temperature, temperature range, energy at the top of the atmosphere and vapor pressure deficit estimated from maximum and minimum temperatures.

4.1.5 Surface Water

The major surface water source to the Project area is the Rosenheim Drain. The Rosenheim Drain watershed bisects the Poject area and water flow data is estimated by the Province of Manitoba Drainage and Water Rights Licencing Branch. The nearest measured flow data provided are by the Water Survey of Canada at the Deadhorse Creek gauging stations 05OC015 (near Morden) and 05OC016 (near Rosenfeld). These gauging stations have respective drainage areas as follows.

DEADHORSE CREEK NEAR MORDEN	1966-1996 05OC015	137 km2
DEADHORSE CREEK NEAR ROSENFELD	1967-2020 05OC016	926 km2

From the Project location in NW 15-2-3-W, water flows north easterly towards the Hespler Drain which then joins the Deadhorse Creek near Rosenfeld and thereafter joins the Red River near St. Jean (see Figure 3 and Figure 7). The drainage area of the Rosenheim Drain at the Project location is close to 110 square kilometers, with the reach downstream to the Hespler having another 92 square kilometers.

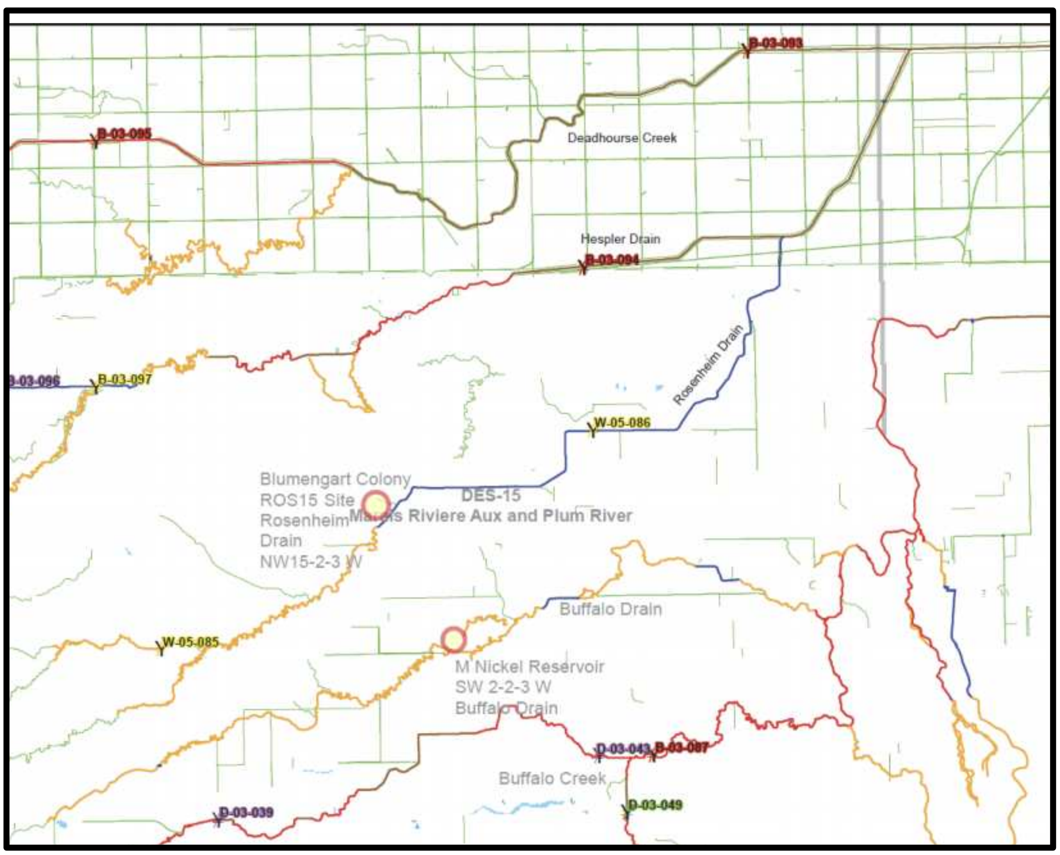


Figure 7 - Deadhorse, Hespler, Rosenheim, Buffalo Drainage Courses

By the time the Rosenheim Drain has reached Deadhorse Creek near Rosenfeld Station, the total drainage area, including the Rosenheim, Hespler and Deadhorse is 937 square kilometers (WSC 05OC016) (see Figure 7); a factor of 8 times larger then at the ROS15 site. In comparison the Deadhorse Creek near Morden (WSC 05OC015) has a similar watershed area to the ROS15 site, albeit with significantly more unit runoff resulting from its location at the base of the escarpment.

The Rosenheim Drain is ephemeral in nature with intermittent large flows in spring associated with snow melt runoff and rainfall. There is essentially no base flow at this location, with the stream drying over the summer period up in many years. However, late spring and early summer rainfalls can result in significant flood flows, as shown on the selected hydrographs in Appendix D for the Deadhorse Creek at Morden and Rosenfeld WSC stations. Spikes in Deadhorse Creek discharge rates above and below the escarpment (see Appendix D) indicate a significant response to rainfall/snowmelt runoff events extending all the way to the Red River. The Rosenheim is expected to behave in a similar fashion. The peak flow at Morden (median/upper quartile) appears to be about 0.5 to 1.5 m^3/s (late winter) and increasing at Rosenfeld (median/upper quartile) to about 1.5 to 8.0 m^3/s; or about a 3 to 5 times increase, reflecting an increase in drainage area of about 675%. The flow of the Deadhorse Creek at Morden is impacted (regulated) by Lake Minnewasta, especially for drought years.

The Provincial Government is responsible for allocation of water during spring and summer flows along the Rosenheim Drain. Representatives of the Province of Manitoba Drainage and Water Rights Licencing Branch have indicated an initial allocation of 180 acre-feet (220 cubic decameters) to Blumengart Colony, reflecting an availability factor of about 70% (e.g. water volume available in 7 of 10 years). Significantly, the Blumengart Colony is the last major water user expected to be licensed on the Rosenheim Drain prior to entering the Deadhorse system. As the junior and most downstream license the importance of capacity for carry over water in the Project Water Rights Licence and in reservoir storage to provide for drought years (e.g. no runoff) can not be overstated.

Given the nature of the hydrographs, it is suggested that initially a withdrawal rate of ***up to 0.5 m^3/s (520/s; 8,000 US gpm)*** be considered. This would allow pumping of 180 acre-feet (220 cubic decameters) in approximately 5 days. Examining the Deadhorse Creek at Morden hydrograph (Appendix D), this rate does not appear to be unreasonable. Special consideration (e.g. year by year exemption) could be applied for in order to extend the pumping period and volume diverted, should the carry over storage be depleted due to drought.

Ultimately the Province will be responsible for establishing the maximum pump withdrawal rate and the minimum flow past this point. The existing Environmental Act License issued to Agassiz Resource Management Ltd. (dated June 2015; EAL 2093 R) has a stated minimum instream flow for the Rosenheim Drain of 0.18 m3/s at S9 which is in SW 9-2-3 W.

Given that the peak flows on the Rosenheim Drain - median peak on Deadhorse near Morden and Rosenfeld Stations are in the order of 0.5 m3/sec and 1.5 m3/s respectively - withdrawal rates in the order of 0.5 m^3/sec (+/- 0.2) appear to be a reasonable upper limit. Given the availability of hydro electric power, the Proponent is considering variable withdrawal rate technology (e.g., VFD) tied to water levels to help automate the withdrawals and maintain minimum instream flows (i.e., reduce withdrawal rates with flow and extend withdrawal period).

In small rural Manitoba watersheds snow and ice block the waterways, culverts and bridges after a long winter, and water must typically make its way from upstream to downstream prior to any connection being made to overwintering fisheries (e.g., the Red River and Lake Winnipeg). This reinforces the importance of the recessional limb of the hydrograph in fostering fish movement upstream. It was concluded by Agassiz Irrigation Association in the 1990's that it is important to withdraw water as close to the start of upstream runoff (e.g., rising limb of the hydrograph) as possible, using high volume pumps.

4.1.6 Land Use/Land Cover Classes

The soil landscape in the Project study area, discussed in detail below, is generally suited to produce annual crops, hence the predominance of annual cropping in the current land use/land cover classes (Map 4, Appendix A). Other agricultural land cover classes, occupying a minor portion of the Project study area, include forage and grassland. Deciduous forest cover consists primarily of planted shelterbelts utilized within agricultural fields to reduce soil erosion and create microclimates for crop production. Shelterbelts are also common around yard sites. Riparian zones are often grazed grassland, due to their typically wetter soils, unsuitability for cultivation, to offer protection for surface water courses. Remnants of natural bush are not present in the Project study area along the Rosenheim and Buffalo Drains, and only exist along the Hespler Drain upstream towards the escarpment and removed from the Project study area. Also of note is the land cover in NW-15-2-3 W, immediately south of the Colony yard site, which is mapped as a mix of grassland/wetland land cover (Map 4, Appendix A).

Cropping in the area includes the typical range of annual crops, including such crops as wheat and canola. High-value crop production also occurs, including such crops as corn, beans and potatoes.

4.1.7 Soil-Landscape Limitations

The soil-landscape in its natural and modified forms determine capabilities and limitations for the intended purpose of the Project, namely irrigated potato production. The soil-landscape limitations are discussed in the context of the proposed irrigated crop production system. These limitations ultimately guide the land suitability assessment for irrigation (Stantec, 2011). To achieve this assessment, desktop mapping and interpretation was undertaken for the 26 proposed irrigation fields comprising the Project land base using existing soil resource information (Smith, Michalyna, 1973; Podolsky, 1991).

A general discussion of soil-landscape conditions within the Project study area is presented below and provides the basis for the subsequent effects assessment and beneficial management practices recommendations certified by a Professional Agrologist (AgriEarth Consulting Ltd., 2020).

4.1.7.1 Soil Surficial Deposits, Drainage and Salinity

As described above, the soils within the Red River Valley physiographic sub-section occur on level to very gently sloping topography. The soil parent material overlying the deep bedrock at this location is characteristic of lacustrine sediments associated with glacial Lake Agassiz. The surficial soils range in texture from moderately coarse (fine sandy loam) to fine (clay) but are dominantly medium textured (loam). Depth to bedrock through the RM of Rhineland generally ranges from 50 to 60 metres (Podolsky, 1991). Across the RM, surficial lacustrine and deltaic materials range in depth from 27 to 42 metres and overlie glacial till which ranges in thickness from approximately 18 to 26 m.

Soil salinity is not indicated to be a limitation in fields proposed for irrigation based on existing soil resource information, and, therefore, is not a management concern for this Project.

Slow surface runoff and low permeability of soils have resulted in the predominance of imperfectly drained throughout the Project footprint (95%; Table 4; Map 5, Appendix A). A minor portion of soils (5%) are considered well drained.

Producers in the region have long recognized the impact of variable soil-landscape conditions on their crop production system, and, where feasible, have implemented practices to remove limitations. For example, land levelling, surface drainage and tile drainage are commonly used in the region to minimize limiting areas (e.g., salinity, wetness). This results in more uniform crop production and improved crop productivity, and, in turn, makes better use of crop inputs, including nutrients, pesticides and soil water. These improvements practices can, therefore, improve overall environmental sustainability and performance of cropping systems in the soil-landscapes of the Project study area.

Table 4 – Drainage Classes of Project Soils

Drainage Class	Areal Extent		Proportion of Project Footprint (%)
	hectares (ha)	acres (ac)	
Very Rapid	0	0	0.0
Rapid	0	0	0.0
Well	60	148	5.0
Moderately Well	0	0	0.0
Imperfect	1149	2839	95.0
Poor	0	1	0.0
Very Poor	0	0	0.0
Totals:	**1,209**	**2,988**	**100.0**

4.1.7.2 Soil Erosion

The soils in the Project study area are prone to erosion losses by both wind and water, as a result of surficial soil textures and slope factors, as well as through management practices, namely tillage.

The dominantly medium (64% of Project footprint; loam, very fine sandy loam) and moderately fine (15%; clay loam) textures are generally well protected from wind erosion losses, particularly if surface soils are well structured. However, other texture classes, including fine (14%; clay) and moderately coarse (7%; fine sandy loam) are more susceptible to loss by wind erosion, particularly if they are not well-structured (e.g., pulverized by tillage) and if soils are left bare of cover and exposed to the wind.

The medium (loam, very fine sandy loam) and moderately fine (clay loam loam) textured soils on level to nearly level slopes (i.e., 3%) generally have a low risk rating for water erosion; a risk classes that represents approximately 86% of the Project footprint (Table 5). The 11% of soils under the Project footprint at moderate risk of water erosion include the moderately coarse (fine sandy loam) textured soils and the moderately fine (clay loam) textured soils on very gently slopes (i.e., 2-5% slope gradient) in association with the minor surface water drainage courses that dissect the Project study area.

Manitoba producers have long recognized the inherent erosion risk in these soils, which is supported by the significant number of mature shelterbelts within the Project area. The agronomic assessment includes a recommendation for consideration of erosion BMPs for those soils most susceptible (see Table 10).

Table 5 – Water Erosion Risk Classes of Project Soils

Water Erosion Risk Class	Areal Extent		Proportion of Project Footprint (%)
	hectares (ha)	acres (ac)	
None	36	89	3.0
Low	1040	2571	86.0
Moderate	133	328	11.0
High	0	0	0.0
Totals:	1,209	2,988	100

4.1.8 Soil-Landscape Irrigation Suitability Assessment

The soils of the Project study area have been reviewed for irrigation suitability in accordance with a draft guideline developed in conjunction with Agriculture and Agri-Food Canada (AAFC) and Manitoba Agriculture Food and Rural Development (MAFRD) (Stantec, 2011).

4.1.8.1 General Irrigation Suitability

General irrigation suitability ratings are based on guidelines published by AAFC (Working Group on Irrigation Suitability Classification 1987) and provide an indication of suitability of the soil-landscape for irrigated crop production of a range of crops. The ratings are developed based on consideration of a range of soil and landscape characteristics and limitations to irrigated crop production. Soils are rated as Excellent, Good, Fair or Poor.

Soils within the Project study area are generally suited for irrigation without significant limitations, as indicated by predominantly Good ratings (Map 6, Appendix A). Table 6 reveals that 76% of the soils in the Project footprint are rated as Good and 2% are rated as Excellent for irrigation suitability. These soils are considered to have slight to no limitations for general irrigation suitability.

Approximately 20% of the soils are rated as Fair for general irrigation, due to limitations from wetness (“w” limitation; imperfect drainage class), restricted soil water movement (“k” limitation; low hydraulic conductivity) and topography (“t” limitation; sloping land associated with minor surface water drainage courses). These limitations are primarily the result of the combination of fine (clay) soil textures and imperfect drainage. Soils with these limitations can be irrigated but with precaution. Fields affected by a significant amount of clayey soils include 3a, 5E, 6, 8, 9 and 15/16W (Map 6, Appendix A). Drainage improvements, particularly tile drainage, may be used to reduce the limitations associated with drainage. However, drainage improvements will not improve the rate at which water movement through the soil profile, which is inherently limited by the fine (clay) soil textures. Careful soil and irrigation management on fine (clay) textured soils, as well as soils with topography limitations, will reduce the potential for surface runoff and soil water erosion losses.

Approximately 2% of the Project soils are considered Poor for irrigation due to restricted soil water movement (“k” limitation; low hydraulic conductivity) and drainability (“x” limitation) due to a combination of poor drainage and fine (clay) soil texture. While these soils only affect a small portion of the overall Project footprint, they occupy most of the west half of field 5E (NW-21-2-3-W), so the irrigation suitability of this field is considered severely limited.

Table 6 - Irrigation Suitability Class of Project Soils

Irrigation Suitability Class	Areal Extent		Proportion of Project Footprint (%)
	hectares (ha)	acres (ac)	
Excellent	25	61	2.0
Good	916	2262	75.7
Fair	241	596	20.0
Poor	28	69	2.3
Totals:	**1,209**	**2,988**	**100.0**

4.1.8.2 Suitability for Irrigated Potato Production

The soils of the Project area have been reviewed for land suitability for irrigated potato production in accordance with Manitoba Agriculture (1999). This system provides ratings for the production of irrigated potatoes based on soil and landscape limitations, and rates soils from Class 1 (most desirable characteristics) to Class 5 (least desirable characteristics).

Soil landscapes rated as Class 1 – 3 are well suited for potato production. The soils in the proposed irrigated areas are predominantly Class 1 to 3 (Map 7, Appendix A), with approximately 90% of the Project soils in these classes (Table 7). Approximately 11% of the Project soils are rated as Class 5 due to the occurrence of fine (clay) textures. The fields significantly affected by these ratings include 3a, 5E, 6, 8, 9 and 15/16W. These soils are considered to have low desirability for irrigated potato production; while not explicitly stated in the guideline this is presumably due to concerns related to harvestability of the potatoes (i.e., separation of soil and potatoes).

Table 7 – Land Suitability for Irrigated Potato Production Class of Project Soils

Land Suitability for Irrigated Potato Production	Areal Extent		Proportion of Project Footprint (%)
	hectares (ha)	acres (ac)	
1	25	61	2.0
2	36	88	2.9
3	1022	2526	84.6
4			0.0
5	127	313	10.5
Totals:	**1,209**	**2,988**	**100.0**

4.1.8.3 Soil Water and Nutrient Holding Capacity

The ability of soils to hold water and nutrients with the soil matrix allows the plant to draw on these as needed for growth and also determines, in part, the environmental risk associated with the potential for nutrient loss. Individual soil-landscape units have specific water holding capacities that relate to soil structure and texture. Water holding capacity can be utilized to determine the frequency and amount of irrigation required to maintain optimum crop growth. Generally, the higher the water holding capacity in a given soil, the higher the nutrient holding capacity and lower the risk of soluble nutrient (i.e. nitrogen) leaching losses.

The predominantly medium to moderately fine textured soils in the Project study area are considered to have medium to high water holding capacity. Water holding capacities can be expected to range from approximately 21 to 22% (2.1 to 2.2 mm/cm or 2.5 to 2.6 in/ft). Soil water holding capacity should be considered in relation to irrigation management. The moderately coarse and fine textured soils would have lower and higher water holding capacities, respectively. Irrigation volumes should be tailored to how much water soils within a given soil management unit or field can hold considering water holding capacity and residual soil water content.

The Nutrient Management Regulation (M.R. 62/2008) makes use of basic soil information (including soil water holding capacity/soil moisture limitations accounted for in agricultural capability ratings and classes) to determine allowable soil nutrient residual concentrations for nitrogen and nutrient application rates for phosphorus. Management practices should be tailored as appropriate considering nutrient management zones within each field. Soil-landscapes in the Project study area are predominantly in nutrient management zone N1 and N2 (Table 8; Map 8, Appendix A) owing to the soil and topographic factors favourable for annual cropping and nutrient management. Approximately 10 % of the Project study area is considered to be in zone N3 due to limitations in soil water holding capacity, topography and wetness limitations. An almost negligible area is classified as N4 – these are associated with steeply sloping lands and organic soils at margins of proposed irrigated fields and in association with surface drainage courses in the southwestern portion of the Project study area.

Table 8 – Nutrient Management Zones of Project Soils

Nutrient Management Zone	Areal Extent		Proportion of Project Footprint (%)
	hectares (ha)	acres (ac)	
N1	1184	2926	97.9
N2	25	61	2.0
N3	0	1	0.0
N4	0	0	0.0
Totals:	**1,209**	**2,988**	**100**

4.1.8.4 Beneficial Management Practices

The soil landscape assessment guideline (Stantec, 2011) provides a list of Beneficial Management Practices (BMPs) that can be adopted by producers to address the noted limitations associated with irrigated crop production, including potatoes. These BMPs form part of the mitigation strategy to minimize environmental effects from irrigated cropping activities while optimizing productivity and production. Adherence to BMPs are also crucial to maintaining contracts with processors and clients who are requiring their products be grown in a an environmentally sustainable manner (e.g., Unilever, 2010).

4.2 Terrestrial Environment

Most of the Winkler Ecodistrict (Maps 1, 2 & 4, Appendix A) is cropland. The overall natural habitat within this ecodistrict is impacted by its dispersed nature and lack of continuity, even along the existing creek systems (e.g., Rosenheim, Hespler, Buffalo) (Map 4, Appendix A). The Project area is largely confined to the cultivated and pastured areas of the Project footprint (Map 4, Appendix A), including all irrigated lands, most of the planned pipelines, which will be typically located along road allowances and/or in easement (Map 3, Appendix A). Creek crossings and intakes will impinge on riparian zones, but impact will be mitigated through careful construction methods. Road crossings are mainly through maintained road/drainage ditches. Site ROS15 has potential to impact positively and adversely the localized ecosystem associated with the abandon oxbow on the Rosenheim Drain, due the construction disturbance and change in land use.

4.2.1 Vegetation

Smith, Michalyna (1973) and Smith et al. (1998) describe the native vegetation of the Red River Valley, which applies to a large percentage of the Project area.

> *The native vegetation within the Red River Valley is dominantly mixed tall prairie grasses, meadow prairie grasses and herbs. This has largely disappeared due to cultivation (Smith et al, 1998). Groves of white elm, Manitoba maple and green ash occur along many of the better*

developed streams and creeks through the area (Smith et al., 1998). Bur oak is found on banks not prone to flooding. Poorly drained areas support slough and marsh grasses, willows, cattails and sedges. (Smith et al., 1998).

Crops and planted shelterbelts have largely replaced the native vegetation except along the existing stream channels and associated flood plains (dyked and natural) and particularly along the Rosenheim Drain. At the proposed location Site ROS15, the vegetation is largely pastureland associated with poor or poorly drained soils at the abandoned/remnant oxbow and is devoid of any significant wooded vegetation (Map 4, Appendix A). In certain years the proposed reservoir ROS15 site may be marshy in nature, but in most years the oxbow dries up due to limited water supply. The Rosenheim Drain is 100% re-constructed at this location and has little aquatic or significant wildlife habitat.

4.2.2 Wildlife

The Red River Valley region includes habitat for white-tailed deer, coyotes, rabbits, ground squirrels, and waterfowl. (Smith et al., 1998). The MSTW Planning District (i.e., RMs of Morden, Stanley, Thompson, Winkler) study contained as part of Bylaw 4-05 contains a description of the wildlife within the Winkler Ecodistrict (e.g. RM of Thompson and RM or Stanley):

> *The Canada Land Inventory rates the Planning District as having moderate limitations for the production of waterfowl because of either adverse topography, poor water holding soil capacity, poor distribution or interspersion of marshes or basins or a combination thereof. This should not suggest however, that the Planning District does not provide habitat to other wildlife species. In fact, the Escarpment* (i.e. upslope from the Winkler Ecodistrict in the Manitou Ecodistrict [west of area shown in Map 1 Appendix A]) *is the most critical wildlife habitat in the Planning District, as it provides varied habitats to wildlife, ranging from wetlands, oak-aspen forest to sheltered river valleys. It is important for deer and wild turkey habitats since the slopes are attractive for warmth and winter shelter. The transition between the Escarpment and arable cropland is also noted for sharp-tailed grouse, ruffed grouse, fox, coyote and various songbirds, while the Tobacco Creek, Shannon Creek, Dead Horse Creek and the Pembina River provide for vegetated wildlife habitat, with potential for songbirds, shorebirds, small game and furbearers such as muskrat, beaver, mink and weasel.*

Clearly, as one transitions from the Escarpment to the Red River Valley, land use includes an increase in arable land and a decrease in habitat, and consequently a significant decrease in wildlife. In the specific Project area, habitat is extremely limited, with the major water bodies being the irrigation reservoirs, the creeks/drains having limited riparian zones. Continuity of habitat is further disrupted by highways, roads and farm activities.

4.2.3 Species at Risk

Contact was made with the Manitoba Conservation Data Centre (CDC) manager to determine the potential for existence of rare and endangered species, or other species of conservation concern (Appendix C [C.3]). A response has not been received to date. The Project is mainly being constructed on cultivated land as detailed above. Section 4.3 discusses aquatic species at risk.

4.3 Aquatic Environment

Previous Environment Act Licenses (EALs) in this vicinity were reviewed with respect to Federal Department of Fisheries and Oceans (DFO) requirements, and the license clauses pertaining to fisheries. Minimum in stream flows were identified in a previously issued EAL for Rosenheim Drain (e.g., EAL 2093R- Agassiz Resource Management Ltd.).

An EAL issued for Rosenheim Drain (2093R) was reviewed for conditions included to minimize aquatic impacts (available at: https://www.gov.mb.ca/sd/eal/registries/3636.2agassiz/licence2093r.pdf). The following clauses are pertinent to the Rosenheim Drain and further downstream towards the Deadhorse Creek and Red River.

Operation – Matters Respecting Water Management and Water Quality Protection

17. The Licencee shall divert water into the reservoirs of the Development as specified in Water Rights licences issued for the Development by Manitoba Conservation and Water Stewardship.

18. The Licencee shall limit the capacities of pumps used to divert water into the reservoirs of the Development:
    a) to pump capacities not exceeding 0.75 m^3/s at sites with storage capacities less than 125 cubic decameters;
    b) to pump capacities not exceeding 1.5 m^3/s at sites with storage capacities between 125 and 313 cubic decameters; and
    c) to pump capacities not exceeding 2.25 m^3/s at sites with storage capacities greater than 313 cubic decameters.

19. The Licencee shall, while diverting water into the reservoirs of the Development, maintain minimum instream flows on waterways below the diversion points of the Development:
    a) Hespeler Drain: 0.36 m^3/s below the S15a site in SW 32-2-3W;
    b) Rosenheim Drain: 0.18 m^3/s below the S9 site in SW 9-2-3W;
    c) Buffalo Drain: 0.09 m^3/s below the S14 site in SE 2-2-3W;
    d) Buffalo Creek: 0.40 m^3/s below the S11f site in SE 29-1-2W.

    These criteria apply during spring filling of the reservoir of the Development, and may be reviewed and revised by the Director upon request from the Licencee and/or upon new information obtained through monitoring of the Development.

20. The Licencee shall, on a daily basis while diverting water into the reservoirs of the Development, record volumes and rates of water pumped, durations of pumping, and instream flows at the monitoring points listed in Clause 19 of this Licence.

21. The Licencee shall, on a daily basis while irrigation from the reservoirs of the Development is occurring, record volumes and rates of water pumped, durations of pumping and fields irrigated.

22. The Licencee shall install backflow prevention devices and maintain them in operational condition at all times if fertilizer or crop protection products are applied through the irrigation systems of the Development.

23. The Licencee shall, if fertilizer or crop protection products are applied through the irrigation systems of the Development, not allow irrigation water containing these materials to be applied to or drain to surface water bodies.

24. The Licencee shall comply with the requirements of ***Manitoba Regulation 62/2008***, respecting ***Nutrient Management*** or any future amendment thereof.

25. The Licencee shall not apply nutrients within eight metres of Nutrient Buffer Zones, including roadside ditches and drains.

It is assumed similar conditions will apply to this Project. Additional assessment of conditions at the Project site follows.

4.3.1 DFO Classification Maps

The Project area is traversed by Rosenheim Drain (Map 1, Appendix A). Rosenheim Drain at this site is a constructed and maintained Provincial Drain; it is dyked to prevent flooding, presumably of the Blumengart Colony and downstream farms. Fishery is limited by the low habitat value and distance from the Red River, natural and man-made barriers to fish migration (e.g., drop structures, snow), and lack of overwinter flows (and ice).

The Government of Canada and the Province of Manitoba convened the Manitoba Drain Maintenance Committee to better understand the nature of agricultural drains as supporting fish communities. Subsequently, in January 2014, the Department of Fisheries and Oceans (Milani, D.W. 2013) released classifications of streams throughout Manitoba, including the area of interest along the Rosenheim Drain within the Project area. Appendix E provides a copy of relevant report figures and questions and answers with respect to the reference.

Milani (2013) summarizes five years of field surveys (2002-2006) and presents a first iteration of classified fish habitat maps. The classified fish habitat maps break the habitat of agricultural waterways into 5 habitat types, A, B, C, D or E, based on gross measurements of fish habitat complexity (complex, simple, indirect) and the fish species presence (captured or expected) and whether the habitat supports Commercial, Sport/Recreational, Domestic or Indigenous, or SARA listed Fish vs. Forage Fish vs. No Fish).

Generally, Type A and B habitat types support Commercial, Sport/Recreational, Domestic or Indigenous, or SARA species with Type A habitat being complex and Type B habitat being simple. Habitat Type C and D habitats support Forage Fish species with Type C habitat being complex and Type D habitat being simple. Habitat Type E drains can be simple or complex but provide indirect fish habitat.

The maps provide a risk assessment for the potential of impacts to fish and fish habitat in agri-Manitoba from a variety of works that occur in and near water, to be supplemented with local knowledge. According to Figure 8, Rosenheim Drain adjacent to the Project area is currently considered to be Class D habitat. In other words, the reach downstream of the Project is considered to provide simple habitat for Forage Fish.

Milani (2013) provides further detailed information on methodologies, techniques, channel photos and fishing results. This extensive report is clearly the best information currently readily available for making an initial determination of impact of the Project.

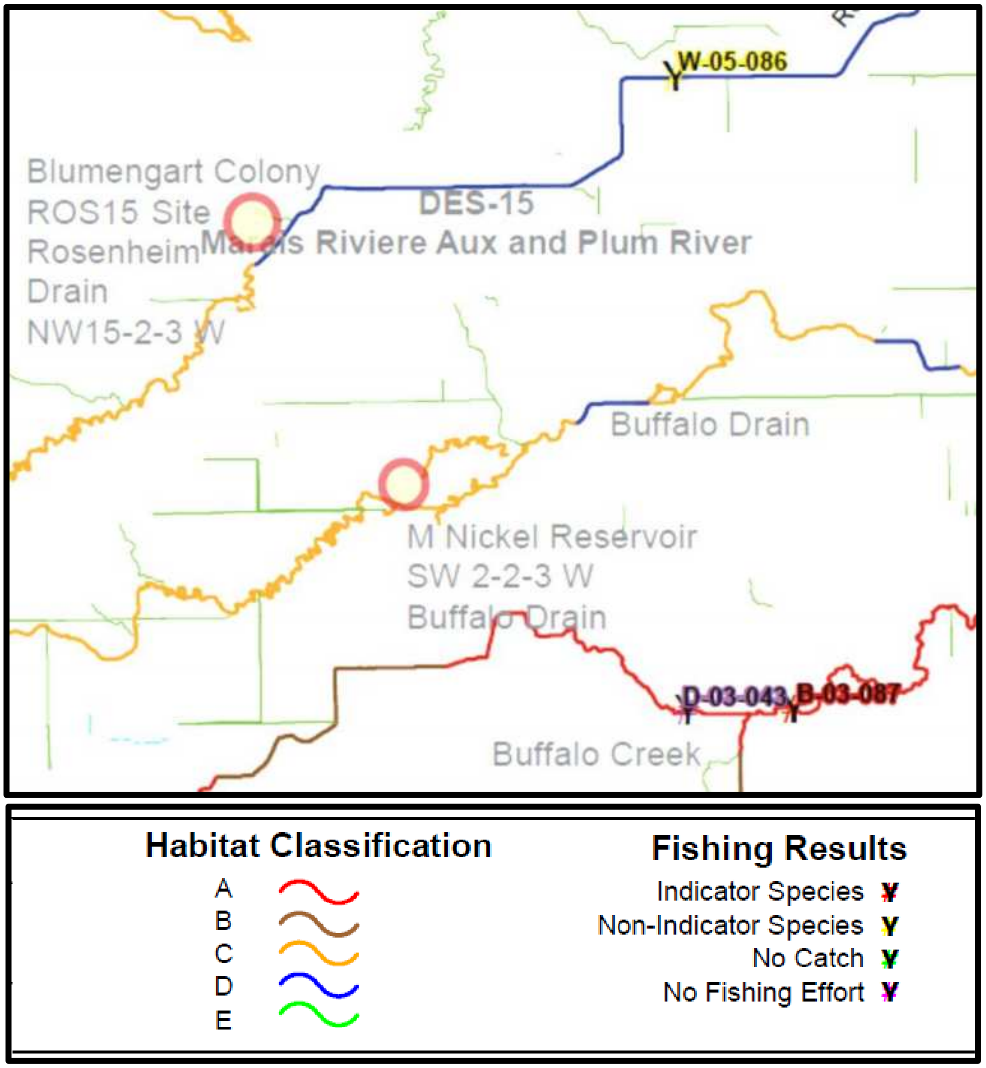


Figure 8 – DFO Habitat Classification of Streams and Constructed Drains in the Rosenheim Drain Project Area

4.4 Socio Economic Environment

The Project area in the RM of Rhineland is largely agricultural in nature. The Village of Gnadenthal is located to the south of the Project area and the larger town of Altona is located due east of the Project area.

The Project area is traversed by RM of Rhineland Road 9N and Road 15W which are connecting municipal roads that lead to PR201, PR 306 and PTH 32 which are regional arteries leading from the Project area to the PTH 14 and 3, which lead north to potato processing plants in Carberry and Portage La Prairie.

The Project will generate significant economic activity and will have total irrigation system expenditures in the order of $2.4 M (not including the potato shed and farm equipment). A significant portion of the expenditure (approaching 50%) will be spent on goods and services from outside the Project. Estimated expenditures are as follows.

Reservoirs	$0.9 M
On Farm	$0.5 M
Pipelines	$0.6 M
Power	$0.1 M
Pumps	$0.3 M

Currently there is three phase power in the Project area. The preferred power source based on environmental impact is Hydro-electric power; but capital costs will have to be evaluated to determine payback on investing in Hydro-electric power vs. Diesel engines. Currently, diesel prices are dropping and electric prices are increasing.

Blumengart Colony is a long-time agricultural producer operating in the RM of Rhineland. The Colony members work on all aspects of farm operations. The Project is geared to enhance the environmental and economic security of this farm operations, and to maintain and enhance their employment opportunities. Incremental employment due to the Project is associated with construction (short term) and operations (long term).

4.5 Public Safety and Human Health

Public safety is a primary concern for Blumengart Colony. This starts with on farm safety for their members but extends to off farm safety associated with truck traffic from the Project area to the potato storage sites. Blumengart Colony will have a direct haul contract for 2020 to potato processing plant(s). They have also rented an existing potato storage nearby (e.g. south of PR 201). As they expand operations they may need to construct their own potato storage facility. All truck drivers are provided with ongoing safety training, including defensive driving, follow standard operating procedures and are subject to scheduled performance reviews.

Producers in the the RM of Rhineland and adjacent RM of Stanley have been developing off stream reservoirs of this nature since the early 1990's and growing potatoes since the 1980's or before. The nearest reservoirs are directly upstream on the Rosenheim Creek (S9), to the south on Buffalo Drain (S14) and on the Hespler Drain (S15b) (Map 3; Appendix A). These reservoirs are included in EAL 2093R issued to Agassiz Resource Management (amended in 2015). There have been no reported issues with the operation of these reservoirs related to public safety and human health. The Blumengart Colony reservoir site (ROS15) would be designated with signage warning of dangers and prohibiting trespassing.

All irrigation pipelines are mapped with GPS and as-constructed plans can be filed with the RM of Rhineland as required. The majority of pipeline will be located on easement on private property. Where necessary, the RMs will be approached to allow the pipelines to be buried in their road allowances. Pipelines will be duly marked on each ½ mile (per their location).

Pipeline crossings are of special consideration for irrigation projects. All road crossings include a liner pipe, which is intended to contain pipeline water breaks to outside the travelled road and to prevent sink holes on the traffic area. All creek crossings will be marked on either site of the creek. All other crossings will adhere to appropriate regulations (e.g., Transport Canada, Manitoba Infrastructure), and will require approval by the appropriate authorizing agency.

Riser pipes are used to bring water to the edge of fields and to allow for venting of air and water. All riser pipes (turnouts, air valves, valves) are protected with wooden bollards which are painted white and include reflectors and signage. Special care needs to be taken where known off road activity is occurring (e.g., quads, snowmobiles).

Intake systems to the Creeks (Rosenheim Drain) are marked to maintain safety for users of the public waterways. There is no known navigation activity taking place on the Rosenheim Drain; it would be unsafe during flood conditions, and is generally dry in late spring and summer.

The raw water being pumped in the pipelines poses no risk to human health as it is not modified in any form. Backflow prevention devices will be provided on farm where fertigation systems are employed at the pivots, to prevent uncontrolled discharge of fertilizer in the event of pipeline breaks.

The irrigation systems are automated and are complete with safety shut offs to prevent them from moving off farm.

The remaining farming processes (e.g., planting, spraying, harvest) are carried out in accordance with Provincial farm safety regulations; and Blumengart Colony have ongoing safety programs for their members.

All contractors operating on the construction sites will be required to be COR certified or equivalent (Construction Safety Association of Manitoba, 2014). Currently the Blumengart Colony is planning to construct the reservoir (ROS15) with contracted forces.

4.6 Protected Areas

There are no parks or protected areas located with the Project area. There are two wildlife refuge within 10 km; the CJ Froese and CD Falk Wildlife Refuges are north of the Project area. The nearest provincial park is the Pembina Valley Provincial park which is approximately 47 km east of the Project area.

4.7 Indigenous Communities

The nearest Indigenous communities to the Project consist of First Nation communities of Dakota Tipi and Long Plain First Nation to the north, Swan Lake to the north west, Roseau River and Buffalo Point to the east. All First Nation communities are greater than 30 miles from the Project area and have no known interest in Project.

4.8 Heritage Resources

Contact was made with Manitoba Historic Resources Branch in to ascertain what existing heritage resources exist within the Project area. A copy of the correspondence is included in Appendix C (C.2). A response had not been received at time of printing this EAP. The Proponents will follow up after submitting this report.

There is published and marked Historical sites in the rural areas, mainly demarking school districts and other more recent cultural resources. To our knowledge there are none of these at the proposed reservoir site(s) and any pipelines will be routed to avoid these Historic sites.

More ancient sites associated with Indigenous activities are less well documented and past activities within the Project study area are possible. A book titled *Uncovering Early Aboriginal History in Southern Manitoba* (2011), provides a reference that could be consulted. It is a 128 page book with 74 illustrations comprising maps, artifact photos and drawings, and "people pictures" showing living scenes and imagery based on the findings at a recently excavated site near the Pipestone Creek in Southwest Manitoba and other sites in southern Manitoba and elsewhere. The volume describes the objectives of conducting excavation of archaeological sites in general. It relates what happened at a certain locale on the prairie landscape.

Under provisions of *The Heritage Resources Act* (1986), land developers may be called upon to provide for, at their own cost, the mitigation of impacts on Manitoba heritage resources. The Proponent is aware of this responsibility.

5.0 Environment Effects

Potential impacts of the development on the environment, are described in detail in this section, including recommendation of mitigation measures and subsequent significance of the impact on the environment of the Project area.

5.1 Impact and Mitigation on Physical Environment

5.1.1 Impact on Geology and Groundwater

There is currently no planned groundwater withdrawal.

The reservoirs will be designed to not leak into underlying deep glacial till or bedrock and are located to the east of the known Winkler Aquifer footprint. Test holes at site ROS15 are pending but will confirm adequate a minimum of 4 m silty clay below the surficial sandier and siltier soils. Additional investigation will occur in May 2020 to confirm extent and depth and uniformity of the near surface silty clays and to design positive reservoir seepage cut-off systems (e.g., clay liner and base).

The irrigated lands will follow Beneficial Management Practices regarding wind and water erosion and Provincial nutrient management guidelines based on individual field by field basis (see nutrient management zones Map 7; Appendix A). There are no direct groundwater users on the parcels planned for irrigation. The Blumengart Colony gets their domestic water supply from the Pembina Valley Water Cooperative.

Follow up by the Proponent could include one on one discussions any nearby well owners and baseline water sampling (e.g., to define pre-Project conditions) if any known or unknown groundwater users are identified.

The only unique geologic features near the Project area are the Winkler Aquifer and the Emarado Beach ridge. None of the proposed reservoir sites will negatively impact either of these features as they are not within or in close proximity to the planned Project footprint. Care will be taken with pipeline construction to identify any potential downslope groundwater movement in trenches (e.g., clay plugs).

There are no significant impacts anticipated on geology and / or groundwater because of the proposed construction or operation activities.

5.1.2 *Impact Surface Water Hydrology and Water Quality*

Surface water will be diverted and stored in the planned reservoir (ROS15). The reservoir will be engineered by qualified professional engineers registered with their Association of Professional Engineers and Geoscientists in Manitoba.

Water diversion rates will vary at a rate of up to a maximum of 520 liters per second (8000 US gpm) but could be increased to 750 litres per second (11,500 US gpm) per EAL 2093R approved rates. Diversions would last for about 5 - 10 days depending on the rate of diversion. The water to be diverted is largely spring freshet runoff from snowmelt and rainfall and is not expected to include any component of groundwater baseflow (see Appendix D). Allocation will be made by Manitoba Conservation and Climate from available water allocation budgets, based on careful consideration of economic and environmental uses of water. The Project has been issued a Development Authorization Permit for construction (Appendix C [C.1]). The Project will be issued a Water Rights Licence after construction. All Water Rights License conditions will be adhered to by the Proponent.

The Project will have little impact on the large channel forming flows and associated downstream flooding along the Rosenheim Drain or the Deadhorse Creek as it meanders to the Red River, with maximum diversion rates at less than 6% of observed peak daily flows (e.g., Upper Quartile peak flow at Deadhorse Creek at Morden (1.8 m^3/s) and at Rosenfeld (8.0 m^3/s); with peak flows another order of magnitude larger (e.g. 40 m^3/sec at Morden and > 200 m^3/s at Rosenfeld). Minimum in stream flows will be maintained in accordance with any EAL and Water Rights Licenses issued; it is anticipated the MIF will be 0.18 m^3/sec per EAL 2093R. Variable rate pumping can be utilized to maintain minimum required flows (e.g., based on water level). The minimum in- stream flow will help to maintain downstream flow during withdrawals and support the duration of the recessional limb of the hydrograph downstream of the Project area.

The impact of tile drainage and irrigation on runoff are described in Section 5.1.3 (Impact and Mitigation on Soil-Landscape Resources). This section also describes the impact of irrigation and drainage on nutrient management. Blumengart Colony will make some consideration of tile drainage water recycling going forward, with reference to recent BMPs issued by Manitoba Agriculture through PAMI (available at: http://pami.ca/beneficial-management-practices-for-agricultural-tile-drainage-in-manitoba/) (Appendix I).

Measures to prevent sediment runoff from Project construction sites is described under Section 5.2.3 (Impact on Fisheries) and Section 5.1.4 (Impact on Soil Erosion and Transport).

Backflow prevention will be included on all irrigation systems, and those employing fertigation systems; to prevent backflow of fertilizer into the distribution pipelines. Discharge from irrigation pipeline to waste (e.g., ditches) will be controlled and only undertaken during filling, commissioning, and draining of the pipelines.

There are no significant impacts anticipated on surface water hydrology or water quality because of proposed construction or operation activities.

5.1.3 Impact and Mitigation on Soil – Landscape Resources

Stantec (2011) established guidelines for assessing the suitability of soil-landscapes for irrigated crop production in Manitoba. In accordance with that guideline, individual field by field assessments were made for the 26 fields being considered for irrigation development. The land suitability assessment, certification of irrigation suitability and recommendation of Best Management Practices was completed by a Professional Agrologist (AgriEarth Consulting Ltd.).

Table 10 provides a summary of recommendations for irrigation suitability for each field. Generally, the fields proposed for irrigation are well-suited for irrigation and the production of potatoes, as discussed in Section 4.1.8 and summarized in tables 6 and 7, and no additional field investigations are recommended to confirm suitability at this time. However, some limitations to irrigated crop production, specifically potatoes, require special consideration prior to development and/or require special management consideration if developed for irrigation. Specifically, the occurrence of fine (clay) textured soils and associated ratings of Fair for general irrigation suitability and Class 5 for land suitability for irrigated potato production affect a significant portion of fields 3a, 5E, 6, 8, 9 and 15/16W. Class 5 soils are considered to have the least desirability for potato production (presumably due to harvestability concerns) and also have limited drainability and soil water movement (hydraulic conductivity). The agronomic limitations these soils pose for irrigated potato production are difficult to mitigate through improvement or other management practices. Hence, the fields affected by these limiting clay soils are considered to have a precautionary recommendation for irrigation development.

A combination of clay soils and poor drainage in the west half of field 5E warrants a additional investigation to confirm suitability prior to development for irrigation for potato production. The proponent currently cultivates this area and states its productive.

Assessment of irrigation suitability includes consideration of the impact of the addition of supplemental water through irrigation on soil drainage limitations. The Project study area is predominantly imperfectly drained (Map 5, Appendix A). A limited portion of the soils are considered well drained, primarily in the southern portion of the Project study area.

Due to the limitations of these imperfectly drained soils, the proponent has previously developed tile drainage in numerous fields and is planning for tile drainage improvements on the remaining fields in the future. A summary of tile drainage status on fields proposed for irrigation is provided in Table 10. The primary benefit of tile drainage would be relief of high water tables in early spring, and allowing for earlier planting, easier access for implementation of best production practices, and prevention of crop drown out (Sands, 2013). Secondary benefits to the environment would be reduced surface runoff (Sands, 2013) and associated sediment and phosphorus loading to the streams. Improved crop production uniformity and crop productivity resulting from tile drainage improvements are generally considered beneficial to environmental sustainability of the crop production system in this region, as previously discussed in Section 4.1.7.

There are no significant impacts anticipated on soil landscape resources resulting from proposed irrigation (and associated drainage) development. The guidelines through which BMPs were identified are described in more detail in Stantec (2011).

5.1.4 *Impact on Soil Erosion and Transport*

Wind and water-driven soil erosion is an important consideration in the soils of the Project study area. Traditionally, BMPs implemented in the Project study area include shelterbelts, cover crops and reduced tillage of crops in rotation with potatoes. The implementation of tile drainage is considered a relatively new measure to reduce the potential for soil erosion due to water, as it increases the available storage of infiltrated water and reduces surface ponding and runoff. In addition, saturation levels are reduced on tile drained land, conditions favourable for soil compaction are reduced, and water infiltration is increased, adding to crop water utilization and again reducing water erosion.

The land being proposed for irrigation is already under intensive annual crop production, the development of irrigation for potato production results in an incremental change to potential impact on soil erosion. The production of potatoes represents an intensification of the annual cropping system, including, typically, more intensive soil disturbance (seedbed preparation, hilling, harvesting, etc.). Therefore, BMPs are recommended to mitigate the potential for increases in soil erosion risk and potential for increased soil loss.

Specific BMPs that should be incorporated include, but are not limited to:

- Residue Management and Tillage
  - Reduced/conservation tillage practices will be adopted where feasible.
  - Anchoring of potato vines with light disking following harvest.
  - Crop rotation will include high residue crops, namely fall rye following potato crops.
  - Stubble and trash (e.g., corn stalks) will be managed to minimize fall tillage, promote incorporation and/or maintain stubble.
  - In extreme situations straw will be spread to increase trash on field after potato harvest (e.g., where cover crops not possible and erosion potential significant).

- Fall Cover Crops
  - Fall rye is planned in the crop rotation and will be planted following potato harvest (e.g., on early harvested fields), whenever timing permits.

- Shelterbelts and Permanent Cover
  - Shelterbelt planting will be maintained where feasible (e.g., edge of field, block plantings) depending on the nature of the irrigation system and field shape.
  - Permanent grass cover will be maintained along edges of waterways

- Irrigation and Drainage
  - Irrigation of dry soils in spring in extreme conditions to mitigate wind erosion risk.
  - Prevent over-irrigation (e.g., saturate soils) by monitoring soil moisture and following irrigation scheduling, to prevent irrigation from contributing to runoff events.
  - Irrigate at application rates below the infiltration rate of the field specific soil.
  - Incorporation of tile drainage in the future to improve soil potential for infiltration and improve water usage.
  - Use of dammer-diker system to create surface water storage in rows to improve soil capacity to infiltrate larger rainfalls and reduce runoff.

Construction activities must also account for the potential erosion of bare soil exposed or modified during construction of the proposed reservoirs and pipelines. Best construction practices to be followed to manage erosion and sedimentation related to reservoir development are documented in Appendix F and discussed further under the section on Impact on Fisheries. Contractors will be required through contract specifications to follow the prescribed measures for erosion and sediment control. Protection of soils exposed during excavation and installation of pipelines should also be considered. If pipelines are installed through areas of permanent cover (e.g., grassed areas), these areas should be re-seeded with an appropriate seed mix following the completion of pipeline installation.

Given the implementation of the Best Management Practices as outlined above and as summarized in Table 10, there are no significant incremental impacts anticipated on Soil Erosion and Transport anticipated because of the Project.

5.1.5 Soil Nutrients

Most of the soils in the Project area are rated as nutrient management zone N1 (98%) or N2 (2%) in accordance with the Nutrient Management Regulation (M.R. 62/2008). This legislation dictates the allowable residual soil nitrogen according to soil-landscape properties and allowable phosphorus application rates based on residual phosphorus concentrations. The regulation is intended to guide sustainable production systems that will minimize nutrient losses to surface water and groundwater.

Agronomic management influences the nutrient balance in the soil and potential risk of leaching and/or runoff losses. In recent years, a better understanding has developed of the benefits to potato yield and quality from tailoring fertilizer to crop demand (i.e., “spoon-feeding”). Fertigation systems have become a common element of irrigation systems designs for delivering supplemental nitrogen needs. Fertigation allows lower starter nitrogen applications and, combined with the timing of small, subsequent applications, minimizes the potential for leaching losses following early season rainfall events. Combined with advanced methods such as variable rate nutrient application systems there is now advanced capacity to better precision farm for optimized nutrient use efficiency. Generally, 4R nutrient stewardship should be followed for sound nutrient management for the cropping system on fields associated with the Project.

Some BMP guidelines for potato production and soils under tile drainage are available, as follows:

- University of Minnesota (2008) documents BMPs for Nutrient Management on Irrigated Potatoes (see Appendix G), available at:
  https://conservancy.umn.edu/bitstream/handle/11299/198232/n-bmps-irrigated-potatoes-2008.pdf?sequence=1&isAllowed=y
- BMPs for nutrient management under tile in Manitoba, including considerations for nitrogen, phosphorus and manure nutrient sources, are provided through the Prairie Agricultural Machinery Institute (PAMI), available at:
  http://pami.ca/beneficial-management-practices-for-agricultural-tile-drainage-in-manitoba/

The suite of BMPs available for producers include the following:

- Application rates for nitrogen fertilizer should be based on recommended rates for potato variety and yield anticipated and should be appropriate for the Manitoba climate.
- Account for spring soil nutrient status determined from soil sampling.
- Meet the requirements of the Nutrient Management Regulation (62/2008) including managing nitrogen to meet allowable nutrient residual concentrations, considering limiting nutrient management zone classifications, and following phosphorus application limits based on soil residual concentrations.
- Plan nitrogen application to achieve high efficiency of N use and minimal leaching to shallow groundwater and tile outflow.
    - Split application of N during planting and hilling
    - Fertigation of N during remainder of year where equipment is utilized
    - Petiole analysis of potato crop after emergence to track nutrient status of plant and indicate demand for split applications.
    - No nitrate in starter N
- Practice irrigation scheduling and tailor irrigation applications to soil water holding capacity to avoid over-irrigation to minimize the potential for creating leaching conditions and/or events.
- Track performance of nutrient management through water quality testing using groundwater monitoring and tile outflows, if applicable.
- Consider University of Minnesota Irrigation Water Management Considerations for Sandy Soils; AG-FO-3875 (see Section 5.1.6 below).
- Consider PAMI Nutrient Management BMPs for Tile Drainage (IF-01) (as introduced above and included in Appendix F).
- Keep comprehensive field by field record keeping.
- If manure is utilized:
    - Test manure for nutrient content
    - Calibrate manure application equipment
    - Apply manure uniformly through the field
    - Incorporation of manure
    - Follow Manitoba Nutrient Management Regulations related specifically to manure
- Establish fall cover crops to utilize residual nitrogen, maintain soil health, and increase moisture infiltration in spring (Kahimba et al. 2008). Kahimba et al. (2008) found that during the spring, the cover crop treatment warmed and thawed earlier enabling more snow melt infiltration. If cover crops are used, removal of vegetative material prior to freeze up should be considered to reduce the potential for surface phosphorus losses from decaying vegetative material.

Given the implementation of the Best Management Practices as outlined above and as summarized in Table 10, there are no significant incremental impacts anticipated on unintended loss of soil nutrients anticipated because of the Project.

5.1.6 Impact of Water Conservation Methods on Water Usage

Managing irrigation systems for optimal use of allocated water resources requires a detailed assessment of crop water demands, field soil and topographic variability, irrigation and monitoring equipment technologies, and advanced agronomic techniques.

Variable rate irrigation technology is still in the experimental stage (Evans et al., 2013), but none the less is being actively pursued by manufacturers and producers in many jurisdictions. To date the incremental investment has not proven its return to the producer. The future promise of this technology is for better utilization of available water resource, which is limited and increasingly expensive to develop. The Proponents are committed to using the latest irrigation technologies as it becomes feasible.

Irrigation scheduling relies on first understanding the soil-landscape and the available water holding capacity. The University of Minnesota Publication – Irrigation Water Management Considerations for Sandy Soils in Minnesota (AG-FO-3875) provides an excellent summary of the concepts and technologies for managing water in the types of soils within the Project area.

The concepts that must be understood are summarized here about the information contained in the individual field by field agronomic/irrigation suitability assessments.

5.1.6.1 Soil Texture and Infiltration

Soil texture is a major determining factor in the ability of a soil to hold water. Detailed soils survey information was available for all Project fields, resulting in suitable mapping of the soil polygons for the entire Project. As slopes are predominantly level to nearly-level, soil texture largely determines infiltration rates in this soil-landscape. The predominantly medium (loam, very fine sandy loam) textured soils would be expected to have infiltration rates in the range of 6 to 14 mm/hr (0.24 to 0.55 in/hr). The fine (clay) textured soils (approximately 15% of the Project study area) would be expected to have infiltration rates in the range of 3 to 5 mm/hr (0.12 to 0.20 in/hr). The moderately coarse (fine sandy loam) textured soils (approximately 7% of the Project study area) would be expected to have infiltration rates in the range of 11 to 18 mm/hr (0.43 to 0.71 in/hr).

The irrigation systems will be designed to ensure that application rates do not exceed infiltration rates to minimize the potential for surface ponding and runoff and ponding due to the application of irrigation water.

Future considerations could include variable rate irrigation specifically geared to zoned variation of irrigation amounts to better match water holding capacity, soil slopes, irrigation demand variation and risk of surface water runoff.

5.1.6.2 Internal Drainage Class and Water Table Contribution

Soils in the Project are rated as imperfectly drained (95% of the Project study area). The need for irrigation on imperfectly drained soils will be to some degree mitigated by the contribution of shallow groundwater to crop growth through capillary rise into the crop rooting zone (Cordiero, 2013). Typically, imperfectly drained soils require less water than well drained soils due to this effect. The impact for water conservation is that irrigation scheduling and applications should be adjusted to account for this contribution, when groundwater conditions are such that water is being supplied through capillary rise.

Estimated heights of capillary rise above the surface of the groundwater table for different soil texture classes are provided in Table 9. The predominantly medium to fine textured soils in the Project study area would be expected to experience capillary rise in the range of approximately 100 cm (40 in) or greater.

The elevation of the water table can be determined by a couple of methods. Tile drainage flow indicates water table within the depth of tile. For deeper measurements, test piezometers may be required. Typically, the shallow water table is regenerated each spring. However, situation may exist where the initial water table is significantly lower than the tile (e.g., preceding conditions). In this instance one could anticipate a higher irrigation demand.

Table 9 – Estimated Height of Capillary Rise in Different Soil Textures

Soil Texture	Capillary Rise
Very coarse sand (VCoS)	0.8" (2.0 cm)
Coarse sand (CoS)	1.6" (4.1 cm)
Medium sand (S)	3.2" (8.1 cm)
Fine sand (FS)	6.8" (17.3 cm)
Very fine sand (VFS)	16.0" (40.6 cm)
Silt (Si)	40.0" (101.6 cm)
Clay (C)	>40.0" (>101.6 cm)
Source: Handbook of Drainage Principles, OMAFRA, Publication 73 taken from https://www.gov.mb.ca/agriculture/environment/soil-management/soil-management-guide/soil-salinity.html	

5.1.6.3 Available Water Holding Capacity

The available water holding capacity (AWHC) provides a measure of the amount of water that a soil can hold and make available for crop use. It is a useful measure to support irrigation scheduling and application depths. This is usually reported in inches per foot or mm per meter. Available water holding capacity is determined as the difference between field capacity and permanent wilt point. This is the total amount available to the plant and, when multiplied by the effective plant rooting depth, provides an estimate of the allowable depletion factor, or the amount of soil water drawdown that should be allowed prior to an irrigation application. Irrigation applications should be tailored to replace the same amount of water that has been depleted to bring soil the soil water content back to field capacity.

The irrigation interval is simply the allowable water depletion divided by the rate of evapotranspiration less water supplied through rainfall and/or capillary rise. Irrigation systems must be designed to meet the peak water demands associated with maximum root depth, maximum evapotranspiration and minimum precipitation. Short-term water deficits drive this design (e.g., Table 4). Variable application rates (timing intervals and/or application depths) over time and between fields can be utilized to account for variable evapotranspiration rates, variable effective rooting depth, changes in soil texture and AWHC, and landscape position/drainage class (e.g., proximity to capillary fringe). For example:

- Applications of smaller amounts (reduced application depth) are favourable early in the growing season when effective rooting depths are relatively shallow and ET rates are relatively low.
- More frequent applications of smaller amounts (reduced application depth) are favourable on coarse textured soils with lower AWHC and allowable depletion.
- Less frequent and larger amounts (increased application depth) may be favourable on medium textured soils with high AWHC later in the growing season when effective rooting depths are relatively deep and ET rates are relatively high.

5.1.6.4 Irrigation Scheduling Approaches

University of Minnesota (2008) documents the basic irrigation scheduling approaches:

- Feel method
- Check book method
- Soil water measurement (e.g., tensiometers, TDR)

Currently the producers practice the feel method. The check book method (for example the Alberta Irrigation Management Model (Alberta Agriculture and Rural Development, 2014)) is not well suited to the Project area because it does not account for capillary rise (Ayers et al., 2006). The soil water measurement technology has recently taken on renewed interest due to the number of companies now offering real-time, telemetric monitoring solutions. This technology can improve the performance of the irrigation scheduler.

New technology is available to producers, to supplement and calibrate their field knowledge of soil water status. Real time irrigation sensors are being actively marketed by industry. These technologies not only provide real time instantaneous data but allow producers to see spatial and temporal trends as well as to document responses to rain and irrigation events, and the impacts of capillary rise.

The proponent will employ the use of professional agronomists (e.g., Certified Crop Advisor, Professional Agrologist) to help with evaluation of this technology in the context of the Project area soils. Producers in Manitoba have been actively involved with AAFC and University of Manitoba researchers, and local agro-meteorological companies and have experience in the application of this technology. While it is early in the process of technology adoption, there is no doubt that this type of data has led to an increased understanding of the water balance in these soils. An example of this approach is provided in Cordiero (2013), which is a Ph.D. thesis issued from the BioSystems Engineering department at the University of Manitoba, based on data from Hespler Enterprises Ltd. farm in the same region as the Project.

Given the implementation of the Best Management Practices as outlined above and as summarized in Table 10, there are no significant impacts anticipated on Conservation and Beneficial Use of Water Resources resulting from over-irrigation anticipated because of the Project.

Table 10 – Proposed Irrigated Fields, Irrigation Suitability Recommendation and Recommended BMPs for Major Considerations

			Recommended Beneficial Management Practices (BMPs)																						
			Nutrient Management				Soil Erosion				Soil Salinity				Drainage Management				Irrigation Management			Other			
Field ID	Legal Land Location	Irrigation Suitability Recommendation	Nutrient Management Planning	Fertigation	Split Application	Other: Enhanced Efficiency Nitrogen	Residue Management	Fall-seeded Cereal Cover Crops	Reduced/Conservation Tillage	Other:	Subsurface Drainage Improvements	Salinity Monitoring Program	Permanent Cover Crop	Other:	Subsurface Drainage Improvements	Surface Drainage Management	Drainage Assessment	Other:	Irrigation Scheduling	Soil Moisture Monitoring	Other:	Other: Clayey soils for potatoes	Other:	Existing Tile Drainage Yes/No
1/2E	SE-20-2-3-W1	Recommended	x				x	x	x						x				x					no, future planned
1/2W	SW-20-2-3-W1	Recommended	x				x	x	x						x				x					no, future planned
3a	S-21-2-3-W1	Recommended, precautionary[1]	x				x	x	x						x				x			x		no, future planned
3b	N-15-2-3-W1	Recommended	x												x									no, future planned
5E	NE-21-2-3-W1	Recommended, precautionary (E1/2 of field)[1,2] Phase II investigation required (W1/2 of field)[3]	x				x	x	x						x				x			x		no, future planned
5W	NW-21-2-3-W1	Recommended	x				x	x	x						x				x					no, future planned
6	SW-28-2-3-W1	Recommended, precautionary[1]	x				x	x	x						x				x			x		no, future planned
8	SE-28-2-3-W1	Recommended, precautionary[1]	x				x	x	x						x				x			x		no, future planned
9	SW-27-2-3-W1	Recommended, precautionary[1]	x				x	x	x						x				x			x		no, future planned
10	SW-26-2-3-W1	Recommended	x				x	x	x						x				x					yes
11	NE-22-2-3-W1	Recommended	x				x	x	x						x				x					no, future planned
12	NW-26-2-3-W1	Recommended	x												x									no, future planned
13	SE-26-2-3-W1	Recommended	x				x	x	x						x				x					no, future planned
15/16W	W-22-2-3-W1	Recommended, precautionary[1]	x				x	x	x						x				x			x		yes
17b	E-15-2-3-W1	Recommended	x				x	x	x						x				x					partial
18a	15-2-3-W1	Recommended	x				x	x	x						x				x					yes
18c	SW-15-2-3-W1	Recommended	x				x	x	x						x				x					yes
19a	S-16-2-3-W1	Recommended	x				x	x	x						x				x					yes
19c	S-16-2-3-W1	Recommended	x				x	x	x						x				x					yes
20/21b	N-16-2-3-W1	Recommended	x				x	x	x						x				x					yes
20/21c	N-16-2-3-W1	Recommended	x				x	x	x						x				x					yes
22	NE-17-2-3-W1	Recommended	x				x	x	x						x				x					no, future planned
23	SW-17-2-3-W1	Recommended	x				x	x	x						x				x					no, future planned
24	NW-17-2-3-W1	Recommended	x				x	x	x						x				x					no, future planned
25b	NW-10-2-3-W1	Recommended	x				x	x	x						x				x					no, future planned
26a	NW-10-2-3-W1	Recommended	x				x	x	x						x				x					no, future planned

Notes:
Refer to Stantec 2011 for more detailed information on the guidelines for irrigation suitability recommendations and determination of recommended beneficial management practices.

1. Recommended, precautionary due the occurrence of fine (clay) textured soils and associated ratings of Fair for general irrigation suitability and Class 5 for land suitability for irrigated potato production affect a significant portion of fields. The agronomic limitations these soils pose for irrigated potato production are difficult to mitigate through improvement or other management practices.
2. Recommended, precautionary due to the occurrence of a significant portion of the field being considered poorly drained (combined with fine textured [clay] soils, as indicated in note 1, above).
3. A Phase II field investigation is required to confirm suitability of soils in the west half of this for irrigation for potatoes (the east half of this field is considered to have a suitability of “recommended, precautionary” as it has better (imperfect) drainage.

5.2 *Impact and Mitigation on Terrestrial and Aquatic Environments*

5.2.1 *Impact on Terrestrial Habitat and Wildlife*

There is no planned alteration to habitat, other than the proposed reservoir site ROS15 located in the abandoned/remnant oxbow in NW 15-2-3 W. The existing habitat is considered marginal being surrounded by the Blumengart Colony base of farming operations, having a limited water supply (e.g. drying up in summer) and having no pristine bush/trees. The creation of a off stream reservoir at ROS15 would add to the wetland habitat, which is limited in the Project area. Shelterbelt plantings could add to the habitat value of this site. Map 4 (Appendix A) highlights the lack of wetland habitat and the significance of the proposed water body within the Project area.

There will little to no loss of trees, with efforts to maintain the existing field shelterbelts, and/or replace any disturbed by the irrigation systems installations. Creek crossings are proposed to take place by directional drilling and every attempt will be made to keep damage to limited existing riparian zones to a minimum. The habitat at these locations are already disturbed due to the maintenance of the Manitoba Infrastructure drainage ditch and dykes, including management of grassed areas along these features.

There are potential impacts anticipated on Terrestrial Habitat and Wildlife because of construction or operation activities. These impacts will be mitigated by limiting access for pipelines / intakes to what is absolutely necessary as a corridor; through additional tree plantings adjacent to the proposed reservoir sites (e.g., ROS15) and to replace any disturbed shelterbelts; through creation of wetland habitat and create new upland habitat at the proposed reservoir.

5.2.2 *Impact on Species at Risk*

The reaches of the Rosenheim Drain have been classified as NOT supporting species at risk (i.e. Class D) and have been significantly modified by human activities and development (e.g. channelized) to the point of being of limited habitat value. The remainder of the Project area is cultivated land with little habitat value, and is not expected to support species at risk. The Manitoba Conservation Data Center will be consulted regarding the potential for species at risk being reported in the Project area.

The potential for species at risk or of conservation concern will be confirmed through a CDC search. However, due to the nature of Project activities and the current land use in the Project area species at risk not currently anticipated to be significantly impacted by Project activities.

5.2.3 *Impact on Fisheries*

The Rosenheim Drain in the Project area is considered to be Class D and as such is not considered to support Commercial, Sport/Recreational, Domestic or Indigenous, or SARA fish species. The Rosenheim Drain in the Project area is channelized and migration to it is restricted by drop structures downstream towards the Red River.

Rosenheim Drain is not listed as a designated waterway. Furthermore, according to the DFO web site, a Project does not require DFO review if it meets the following criteria:

Water Extraction

Surface water extraction for commercial bottling, drinking and sanitary, industrial use, thermal/nuclear generation, agricultural irrigation and other uses.

There is no reduction in the width of nearby water bodies.

All the off-stream reservoirs will only extract water during spring freshet and will not impact the stream width on the Rosenheim Drain.

None the less DFO guidelines for minimizing impact of construction activities on Fisheries will be followed including but not limited to:

General activities around water

- Plan activities near water such that materials such as paint, primers, blasting abrasives, rust solvents, degreasers, grout, or other chemicals do not enter the watercourse.
- Develop a response plan that is to be implemented immediately in the event of a sediment release or spill of a deleterious substance and keep an emergency spill kit on site.
- Ensure that building material used in a watercourse has been handled and treated in a manner to prevent the release or leaching of substances into the water that may be deleterious to fish.

Construction of intakes

- Clearing of riparian vegetation should be kept to a minimum: use existing trails, roads or cut lines wherever possible to avoid disturbance to the riparian vegetation and prevent soil compaction. When practicable, prune or top the vegetation instead of grubbing/uprooting.
- Minimize the removal of natural woody debris, rocks, sand or other materials from the banks, the shoreline or the bed of the waterbody below the ordinary high-water mark. If material is removed from the waterbody, set it aside and return it to the original location once construction activities are completed.
- Immediately stabilize shoreline or banks disturbed by any activity associated with the Project to prevent erosion and/or sedimentation, preferably through re-vegetation with native species suitable for the site.
- Restore bed and banks of the waterbody to their original contour and gradient; if the original gradient cannot be restored due to instability, a stable gradient that does not obstruct fish passage should be restored.
- If replacement rock reinforcement/ armoring is required to stabilize eroding or exposed areas, then ensure that appropriately-sized, clean rock is used; and that rock is installed at a similar slope to maintain a uniform bank/shoreline and natural stream/shoreline alignment.
- Remove all construction materials from site upon Project completion

Using PTO Driven Tractors for Filling

- Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks, invasive species and noxious weeds.
- Whenever possible, operate machinery on land above the high-water mark, in a manner that minimizes disturbance to the banks and bed of the waterbody.
- Wash refuel and service machinery and store fuel and other materials for the machinery in such a way as to prevent any deleterious substances from entering the water

During Creek/Drain Crossings

- Limit machinery fording of the watercourse to a one-time event (i.e.,, over and back), and only if no alternative crossing method is available. If repeated crossings of the watercourse are required, construct a temporary crossing structure.
- Use temporary crossing structures or other practices to cross streams or waterbodies with steep and highly erodible (e.g.,, dominated by organic materials and silts) banks and beds. For fording equipment without a temporary crossing structure, use stream bank and bed protection methods (e.g.,, swamp mats, pads) if minor rutting is likely to occur during fording.
- Time work in water to respect timing windows to protect fish, including their eggs, juveniles, spawning adults and/or the organisms upon which they feed. Guidance on timing is provided by the Department of Fisheries and Oceans at: http://www.dfo-mpo.gc.ca/pnw-ppe/timing-periodes/mb-eng.html
- Minimize duration of in-water work.
- Conduct in-stream work during periods of low flow, or at low tide, to further reduce the risk to fish and their habitat or to allow work in water to be isolated from flows.
- Schedule work to avoid wet, windy and rainy periods that may increase erosion and sedimentation.
- Design and plan activities and works in waterbody such that loss or disturbance to aquatic habitat is minimized and sensitive spawning habitats are avoided.
- Design and construct approaches to the waterbody such that they are perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation.
- Avoid building structures on meander bends, braided streams, alluvial fans, active floodplains or any other area that is inherently unstable and may result in erosion and scouring of the stream bed or the built structures.
- Undertake all instream activities in isolation of open or flowing water to maintain the natural flow of water downstream and avoid introducing sediment into the watercourse

During Construction of Reservoirs and Pipeline Distribution Systems

- Develop and implement an Erosion and Sediment Control Plan for the site that minimizes risk of sedimentation of the waterbody during all phases of the Project. Erosion and sediment control measures should be maintained until all disturbed ground has been permanently stabilized, suspended sediment has resettled to the bed of the waterbody or settling basin and runoff water is clear. The plan should, where applicable, include:
    - Installation of effective erosion and sediment control measures before starting work to prevent sediment from entering the water body.
    - Measures for managing water flowing onto the site, as well as water being pumped/diverted from the site such that sediment is filtered out prior to the water entering a waterbody. For example, pumping/diversion of water to a vegetated area, construction of a settling basin or other filtration system.
    - Site isolation measures (e.g.,, silt boom or silt curtain) for containing suspended sediment where in-water work is required (e.g.,, dredging, underwater cable installation).
    - Measures for containing and stabilizing waste material (e.g.,, dredging spoils, construction waste and materials, commercial logging waste, uprooted or cut aquatic plants, accumulated debris) above the high-water mark of nearby waterbodies to prevent re-entry.
    - Regular inspection and maintenance of erosion and sediment control measures and structures during construction.
    - Repairs to erosion and sediment control measures and structures if damage occurs.
    - Removal of non-biodegradable erosion and sediment control materials once site is stabilized.

Design of Intake Systems

- Ensure that all in-water activities, or associated in-water structures, do not interfere with fish passage, constrict the channel width, or reduce flows below required in-stream levels.
- The upper Rosenheim Drain is not considered to be required to be screened, given the ephemeral nature of the stream, the position within the watershed, the downstream blockages during times of water withdrawal.

The potential for impacts on Fisheries due to construction or operation activities will be mitigated by employing best practices when constructing and operating in proximity to the Rosenheim Drain, and by limiting withdrawal rates to maintain the minimum instream flow rate (rate to be confirmed).

5.3 *Impact and Mitigation on Socio Economic Conditions*

5.3.1 *Impact and Mitigation on Heritage Resources*

There are no known impacts on Heritage Resources at this juncture of the planning studies. Final investigations are planned for each reservoir site and will follow recommendations of Historic Resources Branch regarding the assessment and potential significance.

5.3.2 *Economic Activity and Employment*

Blumengart Colony's members work full time within the RM of Rhineland. The Blumengart Colony is a taxpayer, an educator and an active member of the rural community within which it resides.

Construction activity will involve members of the Blumengart Colony, local construction companies, Provincial utilities (e.g. Manitoba Hydro), regional and local suppliers, international, national, regional and local manufacturers.

5.3.3 *Traffic*

The Project already generates traffic from the Project area to the nearby Provincial Roads and Highways (e.g. 201, 306, 32, 14, 3) in the vicinity of Gnadenthal, Winkler, Plum Coulee and Altona, Manitoba. The implication of construction of the Project will mean a short-term increase in traffic during construction within the Project area (Map 1, Appendix A). The current levels of traffic associated with seeding, crop protection and harvest will be maintained or increased slightly due to additional crop production. However, this increase should be manageable within the rural environment and with consultation with neighbours and the RM of Rhineland.

Every effort will be made to reroute truck traffic around points of congestion during high traffic periods. Blumengart Colony drivers will be given standards of operation for this purpose.

5.3.4 *Utilities*

Existing utilities will not be interrupted because of the construction of the Project. All utilities will be in the field prior to any / all site investigations, underground construction and boring. Any Highways or Provincial Drain crossings will be pre-approved by Manitoba Infrastructure and will be lined to prevent piping of the roadway or in the case of creeks pressure tested fused HDPE pipeline. RM road crossing will be pre-approved by the RM and will be lined to prevent piping of the roadway in the event of a pipeline failure. Crossings of rural water pipelines will be made above them at right angles. MTS and Manitoba Hydro underground cables will be avoided by pipeline routing where feasible or crossed below at right angles if pipelines must traverse these utilities. There are no planned railway or oil/gas pipeline crossings currently.

Manitoba Hydro will be approached regarding provision of three phase power to the intake site, reservoir ROS 15.

5.3.5 Recreation and Parks

There are no recreation facilities or parks impacted by the Project.

5.3.6 Impact on Human Health and Safety

The Project has some considerations regarding Human Health and Safety.

- Operators will be trained by the Proponents on the safe operation of pumps, reservoirs and irrigation systems, and on the proper transport, storage and use of fuel and chemical products, to ensure no waterways are contaminated.
- Fuel storage on sites will meet Manitoba regulations (e.g., double wall, anti-syphon). Spill response will be developed, around any potential to contaminate Rosenheim Drain .
- All on farm practices are subject to regular farm practices, regarding safe handling of fuel, chemicals and fertilizers.
- All irrigation systems utilizing fertigation will employ backflow prevention.
- All truck drivers are given stringent standard operating procedures and routing instructions, and their performance is monitored.
- All construction sites will be Cor certified or equivalent (Construction Safety Association of Manitoba, 2014) and in accordance with appropriate Manitoba Farm Safety regulations.
- All reservoirs will be designed and constructed to the approved engineering standards qualified engineers registered with the Association of Professional Engineers and Geoscientists of Manitoba.
- The Proponents will implement a dam safety program, including annual inspection and emergency response plans for the water storage structures.

There are no significant adverse impacts anticipated on Human Health and Safety as a result of construction or operation activities.

There are no significant impacts anticipated on Socio Economic issues as a result of construction or operation activities.

5.4 Pollutants, Hazardous Wastes and Fuel Products

The Project is not anticipated to release significant pollutants or hazardous wastes. Pollutants would be limited to exhaust emissions from diesel engines required to operate filling and distribution pumps. Active consideration is being given to electric pumps which would make use of clean renewable energy (hydro electricity). Smaller diesel generators are utilized to power the mobile center pivot and linear irrigation systems. Due to the need for this power unit to be mobile, electricity is not currently a viable option. Booster pumps may be required for the irrigation pipeline system and for certain on farm irrigation systems, including travelling guns and boom carts. The travelling reel is typically powered by gas engine.

Fuel for all pumping and power equipment will be transported, stored and utilized in accordance with all Provincial regulations. Tractors used to power PTO intake pumps will be refueled in a means to prevent contamination of the watercourse.

Standard operating procedures for fuel handling and safety will developed to ensure employees follow the requirements of the Environment Act License. Spill response procedures will be developed.

Sediment and erosion control measures were documented elsewhere (e.g., Section 5.1.4).

There are no significant releases of Pollutants or Hazardous Wastes anticipated as a result of construction or operation activities.

5.5 Climate Change Implications

Short term increase in greenhouse gas production will be associated with the construction project. The incremental ongoing emissions from this Project will be associated with operation of the reservoir filling, the irrigation pumping system and the on-farm irrigation systems power sources.

The system will be operated to typically apply 6 inches of water which will take an average of 500 hours per year. Re-filling will take place over an approximately 30-day period (30 x 6 acre feet = 180 acre feet per year).

The following are examples of the incremental energy consumption of the Project.

1. Filling 1 x 150 HP (electric) running for 5 – 7 days.
2. Pumping 500 hours x 2 x 100 hp.
3. Irrigation 500 hours x 4 x 10 hp.

IF all of these were diesel units they would certainly generate additional CO2. However, given the number of hours, the HP, and the number of units, this is insignificant within the Project area and the Region (e.g., in comparison to truck and car traffic alone).

None the less, the Proponents recognize the following strategies to reduce these emissions:

1. Switching to Hydro-electric power.
2. Water conservation to ensure optimal water application.
3. Planting trees in form of edge of field shelterbelts.

The construction activities will also generate additional CO_2. These emissions are unavoidable and can only be mitigated (reduced) by keeping all equipment in good working order.

The Proponent is committed to examining climate change implications of their operations and implementing affordable technology to reduce the impact of the Project on greenhouse gas emissions.

There is no significant long-term increase of greenhouse gas emissions anticipated because of construction or operation activities.

5.6 Impact on Indigenous Rights

There are no known implications arising from the implementation of Project activities with respect to Indigenous rights. There are no Indigenous communities in the Project area, with the closest community more than 30 miles away. There is no known Indigenous hunting, fishing or trapping in the Project area. There are no known cultural or traditional activities in the Project area. Manitoba Heritage Resources has been consulted regarding any further field work that may be required to assess the historical Indigenous use within the Project areas to be disturbed.

There are no significant adverse impacts anticipated on Indigenous rights as a result of Project construction or operation activities.

6.0 Environmental Risk Management, Mitigation Measures and Follow Up

The Proponent is committed to managing the environmental risk during all phases of design and construction, to implement mitigation measures and to follow up with regulatory agencies as indicated in the sections below.

In general, the Proponent is prepared to commit to all environmental protection measures and mitigations specified within the Environment Act License, the water Development Authorization Permit, Water Rights License, the Water Resource Administration Act, and the RM of Rhineland Permits, and those dictated by other regulatory bodies (e.g., DFO, Historic Resources Branch).

6.1 Design

6.1.1 Consultation with DFO on intakes and Transport Canada on navigation.

No consultation is deemed required for this Project.

6.1.2 Review of Minimum In-Stream Flows with Manitoba Conservation and Climate

Manitoba Conservation and Climate will provide guidance on Minimum In-Stream Flows (MIFs). A monitoring system will be devised to monitor Rosenheim Drain stream flows and adjust pumping rates accordingly to maintain downstream requirements. A MIF of 0.18 m3/sec is proposed by the Proponent, based on existing EAL requirements of existing irrigation projects on the Rosenheim Drain.

6.1.3 Investigation of Potential Heritage Resources on Construction Sites

Manitoba Historic Resources Branch is being consulted on the potential for historic or heritage resources at the proposed reservoir site locations. Recommendations will be incorporated into the Project design and/or construction phases, as appropriate.

6.1.4 Investigation of Potential Species at Risk on Construction Sites

Manitoba Conservation Data Center is being consulted on potential for Species at Risk at the proposed Project sites. Recommendations will be incorporated into Project design and/or construction phases, as appropriate.

6.1.5 Detail Sediment and Erosion Control Plans

Detailed sediment and erosion control plans will be included in all contracts and/or construction specifications.

6.1.6 Detail Specifications for Backflow Prevention

Detailed backflow prevention equipment will be specified for all fertigation systems.

6.1.7 Intakes and Creek Crossings

Develop riparian zone protection plans for intake(s) and pipeline crossings of the Rosenheim Drain.

6.2 Construction

6.2.1 Detailed Contract Specifications

All contracts will be governed by detailed contract specifications and inspected by the engineer of record.

6.2.2 Safety

All contracts will contain a workplace safety component meeting the intent of COR and Manitoba Farm Safety guidelines.

6.2.3 Erosion and Sediment Control

All methods proposed will be reviewed and approved by the engineer of record.

6.3 Operations

6.3.1 Soil and Water BMPs

The Proponent will employ BMPs for soil erosion, nutrient management and irrigation water management. The Proponent will report on all water use with accurate records of fields irrigated and amounts of water used, diverted and otherwise employed.

6.3.2 Fuel BMPs

The Proponent will employ fuel management BMPs in accordance with EAL requirements.

6.3.3 Traffic BMPs

Training of all truck driver staff will be completed as to company Standard Operating Procedures on truck routes, truck safety and public safety.

6.3.4 Dam Safety

The Proponent will establish a Dam Safety monitoring and evaluation plan, to be overseen by a Professional Geotechnical Engineer

6.4 Repair, Renewal, Decommissioning

6.4.1 Pipelines

The Proponent will replace worn underground PVC pipelines and abandon pipes in place.

6.4.2 Mechanical and Electrical Equipment

The Proponent will replace worn equipment and recycle parts as feasible or dispose in landfill.

6.4.3 Reservoirs

The Proponent will maintain reservoirs in good shape. This will include the following:

- Renew liner system to limit seepage and maintain safety.
- Remove silt as required and place on nearby agricultural fields.
- Breach dykes and fill in reservoirs IF no longer utilized.

7.0 Conclusions and Closure

PBS Water Engineering Ltd. has compiled the data and information presented in this Environmental Act Proposal report, in accordance with the requirements of Manitoba Conservation and Climate, using the best information available at the time of writing. The report will form an attachment to the Environment Act Proposal for the Blumengart Colony Farms Ltd. Irrigation Project.

Based on the studies undertaken to date and the commitment of the Proponent to employ beneficial management practices and technologies during construction and operation, the Project is not anticipated to result in significant or un-mitigable adverse impacts on the local environment. The development is expected to be consistent with the current land use, adding value and stability to the land base for agricultural production purposes. Economic activity, including securing long-term employment in the region will result. The Proponent is committed to long term sustainability of the soil landscape through employing management practices consistent with the suitability of the soil landscape resources and the recommended BMPs for erosion, nutrient management, and irrigation water management. The Proponent will use the latest and best available technologies to support management of the Project, as appropriate.

Based on the information gathered and presented, PBS Water Engineering Ltd. believes that the conditions and the guidelines for an Environment Act Proposal for this Class 2 Development have been met. The Proponent is committed to meeting all requirements of authorizations, licenses, permits and by-laws that will be granted to them as part of development of this Project or that are otherwise applicable to it.

This report is prepared for the use of Blumengart Colony Farms Ltd. and is intended to form part of their Environment Act Proposal for submission to and review by Manitoba Conservation and Climate. Any third-party use of this report and any reliance or decision made based on it, are the responsibilities of the third parties.

The information and conclusions of this report as presented are the opinion of PBS Water Engineering Ltd. based on the Project as described and an office-based assessment of the environment within which it is located.

8.0 References

Agassiz Irrigation Association, 1995; Environment Act Proposal; Irrigation Dugouts Plum River Phase III and IV, Winkler, Manitoba, May 1995.

Agassiz Irrigation Association, 1996; Environment Act Proposal; Irrigation Reservoirs – 1996 Projects, Plum River System – Phase V, Morris River System – Phase II

Alberta Agriculture and Rural Development, 2014; Alberta Irrigation Management Model; Accessed at: http://agriculture.alberta.ca/acis/imcin/aimm.jsp; accessed May 17, 2014.

Ayers, J., Christen, E., Soppe, R., Meyer, W.; The Resource Potential of in-Situ Shallow Ground Water Use in Irrigated Agriculture – A Review; Irrigation Science, 2006, Volume 24:147-160.

Community Led Emissions Reduction (CLER) Program (2010); MSTW Local Climate Change Action Plan (2008-2012); Morden, MB.

Construction Safety Association of Manitoba; What is Cor ™ ; Accessed at: http://www.constructionsafety.ca/cor/; accessed May 17, 2014.

Cordeiro, M.R.C., 2013. Agronomic and Environmental Impacts of Corn Production under Different Water Management Strategies in the Canadian Prairies. PhD Thesis. Department of Bio systems Engineering. University of Manitoba. Winnipeg, Manitoba.

Evans, R., La Rue, J., Stone, K., King, B.; Adoption of Site-Specific Variable Rate Sprinkler Irrigation Systems. Publications from USDA-ARS/UNL Faculty Paper 1245. Accessed at:: http://digitalcommons.unl.edu/usdaarsfacpub/1245

Kahimba, F.C., Sri Ranjan, R., Froese, J., Entz M., Nason, R., 2008. Cover Crop Effects on Infiltration, Soil Temperature, and Soil Moisture Distribution in the Canadian Prairies. Applied Engineering in Agriculture. 24(3): 321-333.

KGS Group, 2002; Manual of Best Management Practices for Irrigated Crop Production in Manitoba; 2nd Draft, Central Manitoba Irrigation Association, Association of Irrigators in Manitoba, AAFC-PFRA, KGS Group.

Manitoba Agriculture and Food, University of Manitoba, Environment Canada, 2001. Growing Season Precipitation to Maturity for Potatoes. November 2001. Accessed at:

http://www.gov.mb.ca/agriculture/weather/pubs/growing_season_precip_to_maturity_potatoes_25_percent_risk.pdf

http://www.gov.mb.ca/agriculture/weather/pubs/growing_season_precip_to_maturity_potatoes_10_percent_risk.pdf

Manitoba Agriculture. 1999. Suitability of Land for Irrigated Potato Production in Selected Areas of Southern Manitoba. Manitoba Agriculture, Soil Resource Section, in cooperation with Manitoba Land Resource Unit, Agriculture and Agri-Food Canada and Department of Soil Science, University of Manitoba.

Manitoba Agriculture and Food, University of Manitoba, Environment Canada, 2001. Climatic information to maturity for production of potatoes. Accessed at:

http://www.gov.mb.ca/agriculture/weather/pubs/crop_water_demand_maturity_potatoes_25_percent_risk.pdf

http://www.gov.mb.ca/agriculture/weather/pubs/crop_water_demand_maturity_potatoes_10_percent_risk.pdf

http://www.gov.mb.ca/agriculture/weather/pubs/water_deficit_maturity_potatoes_25_percent_risk.pdf

http://www.gov.mb.ca/agriculture/weather/pubs/water_deficit_maturity_potatoes_10_percent_risk.pdf

Manitoba Agriculture, Food and Rural Development. Commercial Potato Production and Management. Accessed at: http://www.gov.mb.ca/agriculture/crops/production/potatoes.html

Manitoba Groundwater Section, 1982; An Electromagnetic Survey of the Miami Aquifer System.

Manitoba Hydrogeology Section, 1987; Aquifer Capacity Investigations (1980 – 1986).

Michalyna W.; Podolsky, G.; St. Jacques; 1988. Soils of the Rural Municipalities of Grey, Dufferin, Roland, Thompson and Part of Stanley; Canada Manitoba Soil Survey; Soils Report No. D60.

Milani, D.W. 2013. Fish community and fish habitat inventory of streams and constructed drains throughout agricultural areas of Manitoba (2002-2006). Can. Data Rep. Fish. Aquat. Sci. 1247.

MSTW Planning District, 1979/1982. Groundwater Resources in the MSTW Planning District.

MSTW Planning District, 2007; Development Plan By-Law No. 4-05; Landmark Planning and Design Inc. Winnipeg, MB. Accessed at:- http://www.mstw.ca/PDF/MSTW_Development_Plan_ByLaw_4-05.pdf; accessed May 16, 2014.

Podolsky, I. G., 1991; Soils of the Rural Municipality of Rhineland; Manitoba Department of Agriculture; Soils Report No. 76.

Prairie Agricultural Machinery Institute, 2019. Beneficial Management Practices for Agricultural Tile Drainage in Manitoba (10 Fact Sheets). Accessed at: http://pami.ca/beneficial-management-practices-for-agricultural-tile-drainage-in-manitoba/.

Sands, 2013; Developing Optimum Drainage Design Guidelines for the Red River Basin; University of Minnesota.

Smith, R.E., Michalyna W., 1973. Soils of the Morden-Winkler Area; Manitoba Department of Agriculture; Soils Report No. 18

Smith, R.E.; Veldhuis, H.; Mills G.F.; Eilers R.G.; Fraser, W.R.; Lelyk, G.W.; 1998. Terrestrial Ecozones, Ecoregions and Ecodistricts of Manitoba; An Ecological Stratificatoin of Manitoba's Natural Landscapes; Land Resources Unit, Research Branch, Agriculture and Agri-Food Canada; Technical Bulletin 1998-9E.

Stantec Consulting Ltd. 2011. Guideline for Assessment of Land Suitability for Irrigated Crop Production in Manitoba. DRAFT Version 1. March 31, 2011. Winnipeg, MB.

University of Minnesota, 2008; Best Management Practices for Nitrogen Use: Irrigated Potatoes; Publication #08559; University of Minnesota Extension (copied with permission).

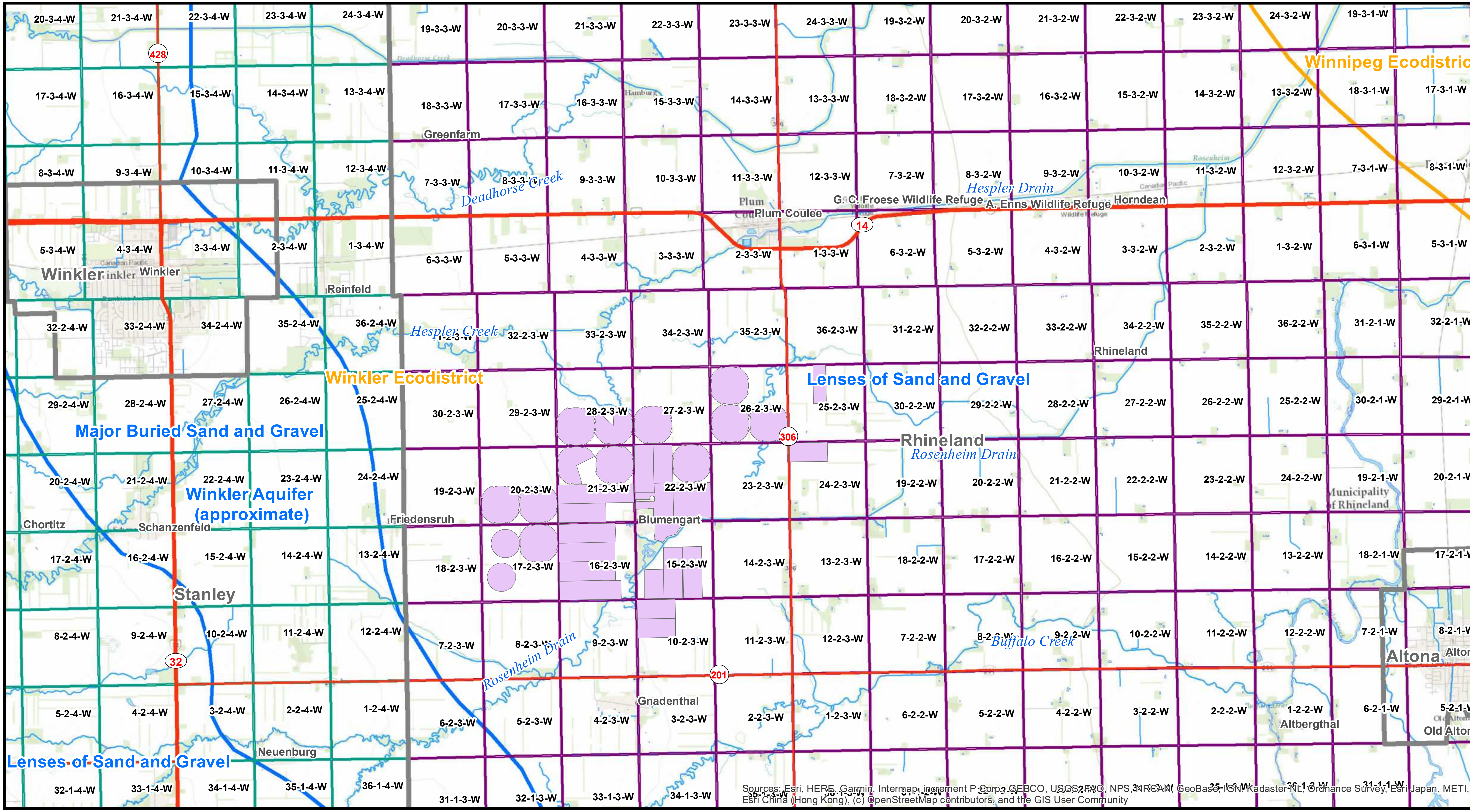
University of Minnesota, 2014; Irrigation Water Management Considerations for Sandy Soils in Minnesota; AG-FO-3875; University of Minnesota Extension.

Unilever, 2010; Sustainable Agriculture Code, Implementation Guideline. Accessed at: http://www.growingforthefuture.com/unileverimpguid/; accessed May 15, 2014.

Working Group on Irrigation Suitability Classification. 1987. An Irrigation Suitability Classification System for the Canadian Prairies. Land Resource Research Centre, Agriculture Canada, Ottawa. LRRC Contribution No. 87-83.

APPENDICES

APPENDIX A - Maps



Map Name

Project Regional Context

Map Number

1

Project Name

Blumengart Colony Farms

NORTH

3,000 1,500 0 3,000

Metres

Map scale - 1:75,000

Date - April 23, 2020
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

Acknowledgements:
Original drawing by AgriEarth Consulting Ltd.
Data accessed from Manitoba Land Initiative, Province of Manitoba.

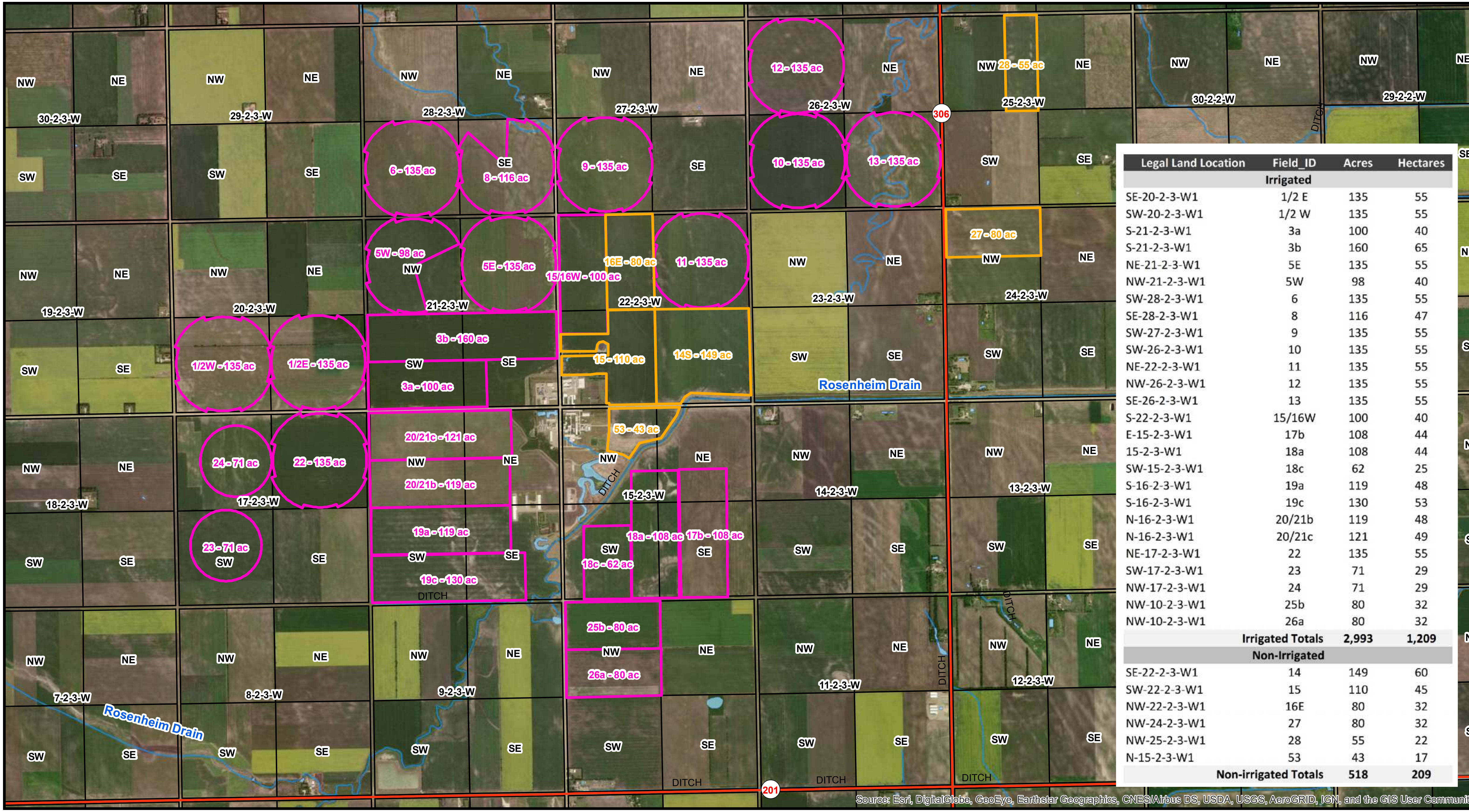
Legend

- Project fields
- Provincial roads
- Provincial highways
- Rural municipalities
- Water bodies
- Water courses
- Aquifers
- Ecodistricts

Prepared by

PBS Water Engineering

agriearth consulting ltd.



Legal Land Location	Field_ID	Acres	Hectares
Irrigated			
SE-20-2-3-W1	1/2 E	135	55
SW-20-2-3-W1	1/2 W	135	55
S-21-2-3-W1	3a	100	40
S-21-2-3-W1	3b	160	65
NE-21-2-3-W1	5E	135	55
NW-21-2-3-W1	5W	98	40
SW-28-2-3-W1	6	135	55
SE-28-2-3-W1	8	116	47
SW-27-2-3-W1	9	135	55
SW-26-2-3-W1	10	135	55
NE-22-2-3-W1	11	135	55
NW-26-2-3-W1	12	135	55
SE-26-2-3-W1	13	135	55
S-22-2-3-W1	15/16W	100	40
E-15-2-3-W1	17b	108	44
15-2-3-W1	18a	108	44
SW-15-2-3-W1	18c	62	25
S-16-2-3-W1	19a	119	48
S-16-2-3-W1	19c	130	53
N-16-2-3-W1	20/21b	119	48
N-16-2-3-W1	20/21c	121	49
NE-17-2-3-W1	22	135	55
SW-17-2-3-W1	23	71	29
NW-17-2-3-W1	24	71	29
NW-10-2-3-W1	25b	80	32
NW-10-2-3-W1	26a	80	32
	Irrigated Totals	**2,993**	**1,209**
Non-Irrigated			
SE-22-2-3-W1	14	149	60
SW-22-2-3-W1	15	110	45
NW-22-2-3-W1	16E	80	32
NW-24-2-3-W1	27	80	32
NW-25-2-3-W1	28	55	22
N-15-2-3-W1	53	43	17
	Non-irrigated Totals	**518**	**209**

Map Name

Project Overview

Map Number

2

Project Name

Blumengart Colony Farms

NORTH

1,000 500 0 1,000

Metres

Map scale - 1:30,000

Date - April 15, 2020
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

Acknowledgements:
Original drawing by AgriEarth Consulting Ltd.
Data accessed from Manitoba Land Initiative, Province of Manitoba.

Legend

- Provincial roads
- Water bodies
- Water courses

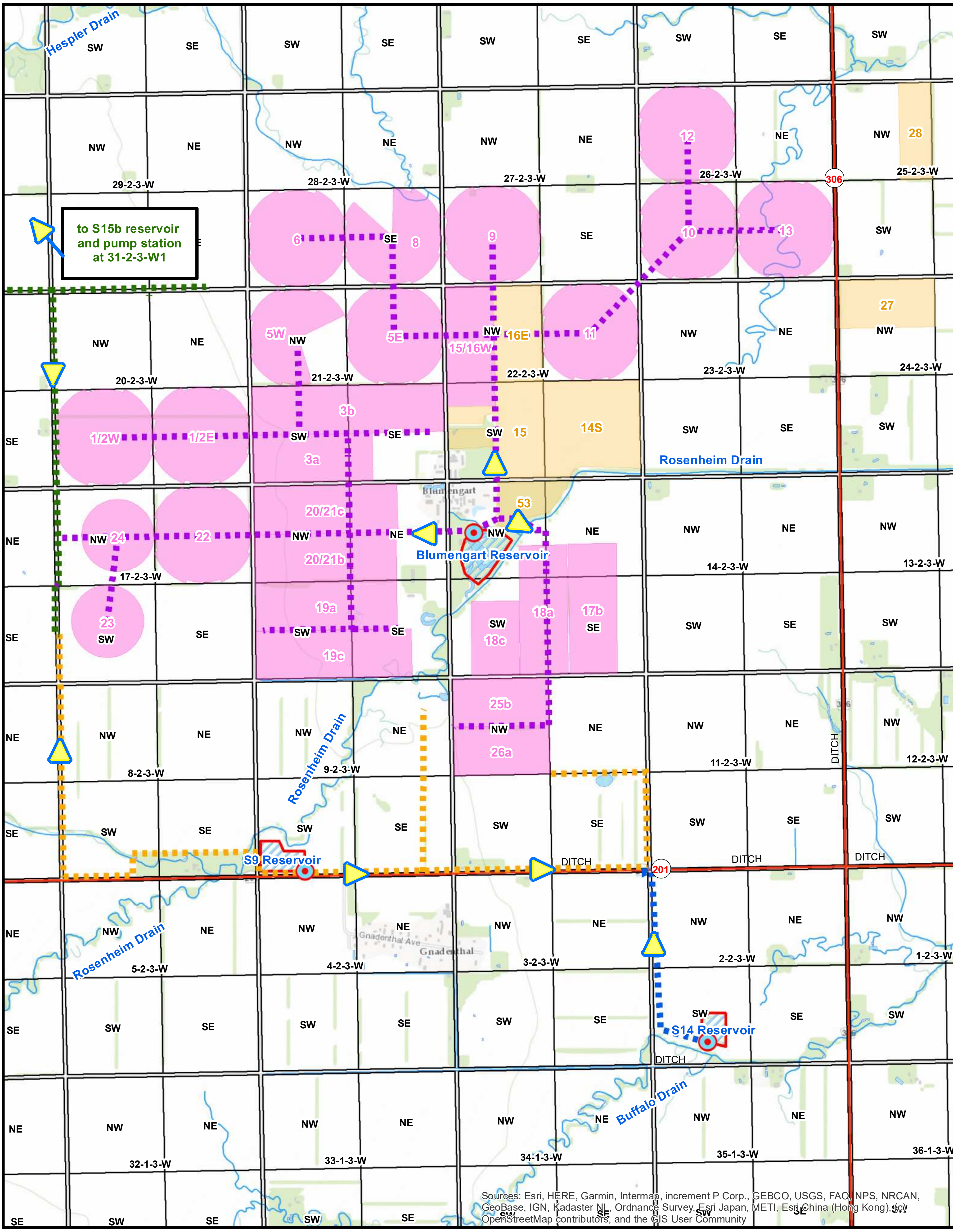
Proposed fields

- Irrigated
- Non-irrigated

Prepared by

PBS Water Engineering

agriearth consulting ltd.



Legend

Provincial roads	**Reservoir & Pump Stations**	**Proposed Fields**	**Pipelines**
Water bodies	Reservoir	Irrigated	ROS15 pipeline
Water courses	Pump station	Non-irrigated	S14 pipeline
			S15b pipeline
			S9 pipeline

Map Name

Project Infrastructure

Map Number

3

Project Name

Blumengart Colony Farms

NORTH

1,000 500 0 1,000

Metres

Map scale - 1:30,000

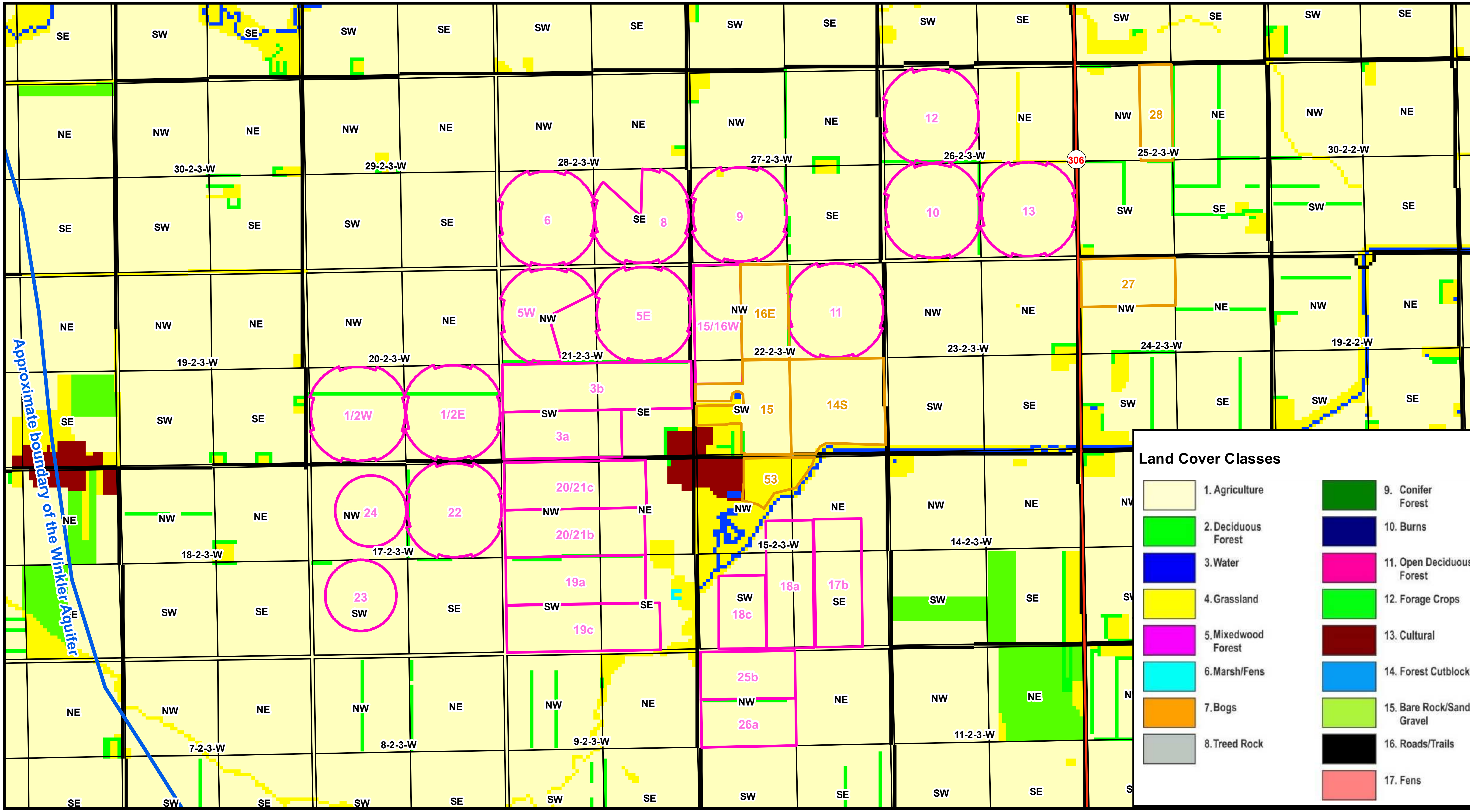
Date - April 15, 2020
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

Acknowgements:
Original drawing by AgriEarth Consulting Ltd.
Data accessed from Manitoba Land Initiative, Province of Manitoba.

Prepared by

PBS Water Engineering

agriearth consulting ltd.



Map Name

Land Cover Classes

Map Number

4

Project Name

Blumengart Colony Farms

NORTH

1,200 600 0 1,200

Metres

Map scale - 1:30,000

Date - April 15, 2020
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

Acknowledgements:
Original drawing by AgriEarth Consulting Ltd.
Data accessed from Manitoba Land Initiative, Province of Manitoba.

Legend

- Provincial roads
- Provincial highways
- Aquifers

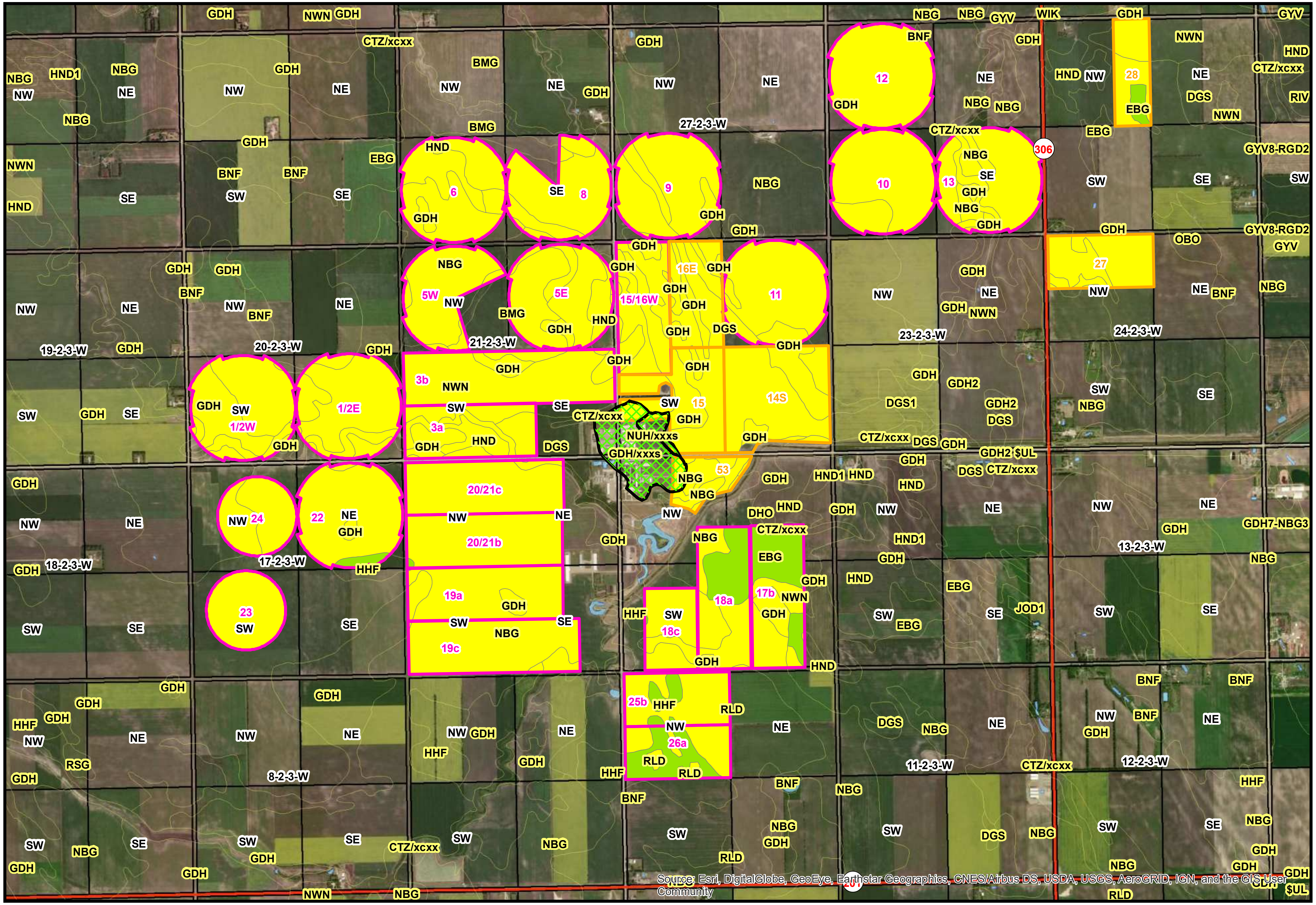
Proposed fields

- Irrigated
- Non-irrigated

Prepared by

PBS Water Engineering

agriearth consulting ltd.



Soil Map Units

Simple Map Units

ABC — Soil Series Symbol

xb1s — Degree of erosion; Slope Gradient Class; Degree of Salinity; Degree of Stoniness

DEF — Soil Series with no phases

Compound Map Units

ABC (7) / xc1x – DEF (3) / xbxx — Decile extent of soil series within the polygon; Units with different phases associated with each series

ABC(7) – DEF(3) / xbxx — Units with same phases associated with each series

Degree of Erosion

x	non-eroded or minimal
1	slightly eroded
2	moderately eroded
3	severely eroded
o	overblown

Degree of Stoniness

		Surface Covered
x	non-stony	<0.01%
1	slightly stony	0.01-.1%
2	moderately stony	0.1-3%
3	very stony	3-15%
4	exceedingly stony	15-50%
5	excessively stony	>50%

Topography (Slope Gradient Class)

Slope Gradient

x	0-0.5%	level to nearly level
b	0.5-2%	nearly level
c	2-5%	very gently sloping
d	5-9%	gently sloping
e	9-15%	moderately sloping
f	15-30%	strongly sloping
g	30-45%	very strongly sloping
h	45-70%	extremely sloping

Degree of Salinity

		Conductivity (mS/cm)
x	non-saline	0-4
s	weakly saline	4-8
t	moderately saline	8-15
u	strongly saline	15+

Map Name

Soils & Drainage Class

Map Number

5

Project Name

Blumengart Colony Farms

NORTH

1,000 500 0 1,000

Metres

Map scale - 1:30,000

Date - April 15, 2020
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

Acknowledgements:
Original drawing by AgriEarth Consulting Ltd.
Data accessed from Manitoba Land Initiative, Province of Manitoba.

Legend

Provincial roads — Soil polygons

Proposed fields
- Irrigated
- Non-irrigated

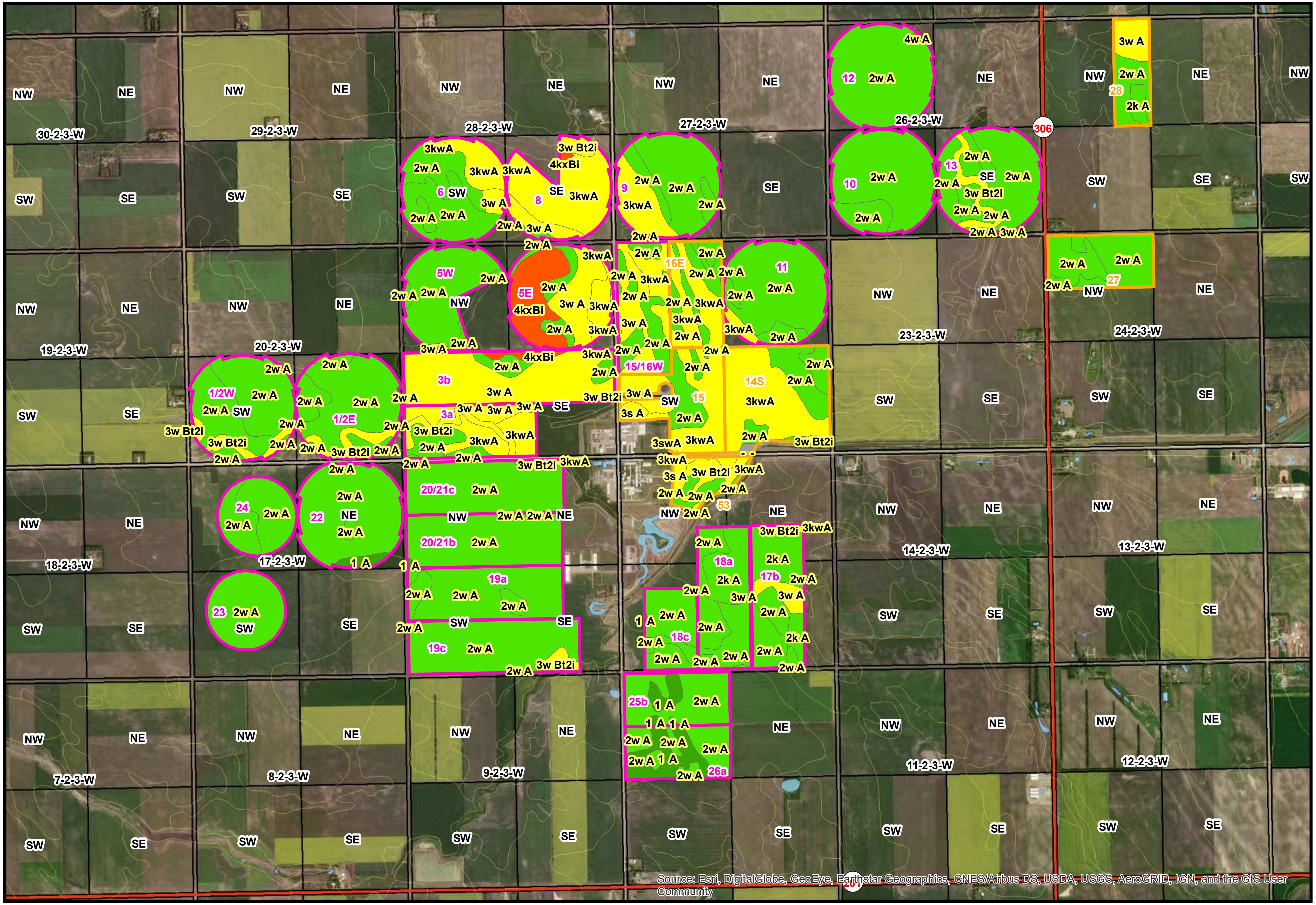
Salinity
- Slight

Drainage Class
- Rapid
- Well
- Imperfect
- Poor
- Very Poor

Prepared by

PBS Water Engineering

agriearth consulting ltd.



Irrigation Suitability Map Units

Irrigation Suitability Map Unit Notation

Soil Limitation Class

Extent of Suitability Class in Decile Format (i.e. 7 = 70% of polygon area)

2Akw(7)

Landscape Limitation Class

Specific Limitations (up to three characters)

Irrigation Suitability Rating

Rating	Description
Excellent	Lands in this class have no significant limitation(s) for irrigation. They are capable of producing a sustained and relatively high yield of a wide range of climatically adapted crops. The soils are medium textured, well drained, and hold adequate moisture. Harmful accumulations of soluble salts are absent from the soil and topography is level to nearly level.
Good	Lands in this class have a slight limitation(s) for irrigation due to unfavorable characteristics of soil and/or landscape properties. A narrower range of crops or slightly more input to development and management may be required. They can be maintained or possibly improved with proper management.
Fair	Lands in this class have moderate limitations for irrigation due to adverse characteristics of soil and/or landscape. Greater management input as well as more intensive soil conservation and improvement practices are required for these lands.
Poor	Lands in this class have severe limitations for irrigation due to adverse characteristics of soil and/or landscape. These lands may have some limited use under irrigation but generally their limitations are so severe that they do not form suitable, irrigation farm units. Special crops, irrigation system designs, and special soil and water management practices will be required to irrigate any lands in this class.

Irrigation Suitability Rating

- Excellent
- Good
- Fair
- Poor
- Organic
- Not rated

Map Name

General Irrigation Suitability

Map Number

6

Project Name

Blumengart Colony Farms

NORTH

1,000 500 0 1,000

Metres

Map scale - 1:30,000

Date - April 15, 2020
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

Acknowledgements:
Original drawing by AgriEarth Consulting Ltd.
Data accessed from Manitoba Land Initiative, Province of Manitoba.

Legend

- Provincial roads
- Soil polygons

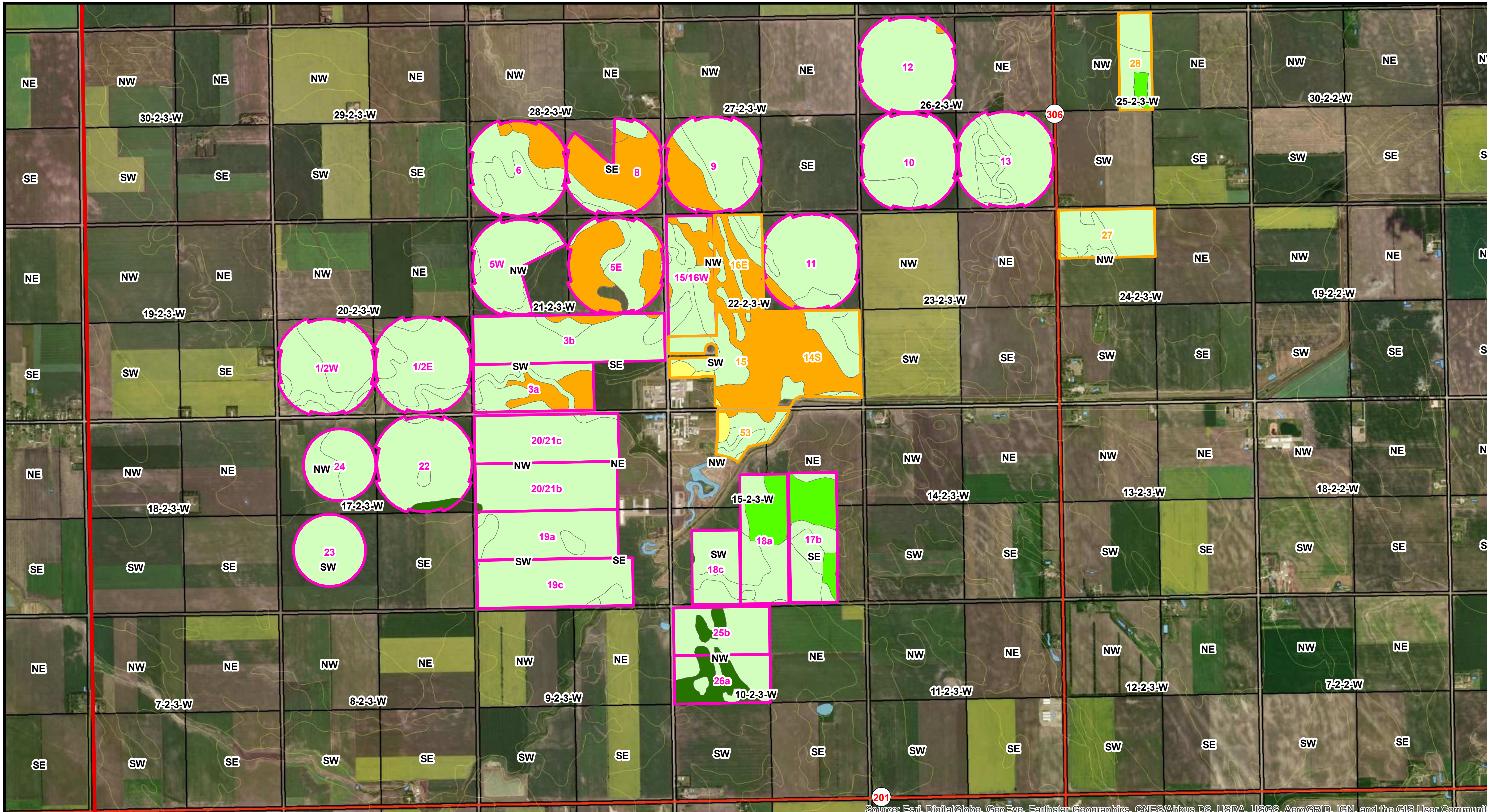
Proposed fields

- Irrigated
- Non-irrigated

Prepared by

PBS Water Engineering

agriearth consulting ltd.



Map Name

Land Suitability for Irrigated Potato Production

Map Number

7

Project Name

Blumengart Colony Farms

NORTH

1,000 500 0 1,000

Metres

Map scale - 1:30,000

Date - April 15, 2020
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

Acknowledgements:
Original drawing by AgriEarth Consulting Ltd.
Data accessed from Manitoba Land Initiative and AgriMaps, Province of Manitoba.

Legend

- Provincial roads
- Soil polygons

Proposed fields

- Irrigated
- Non-irrigated

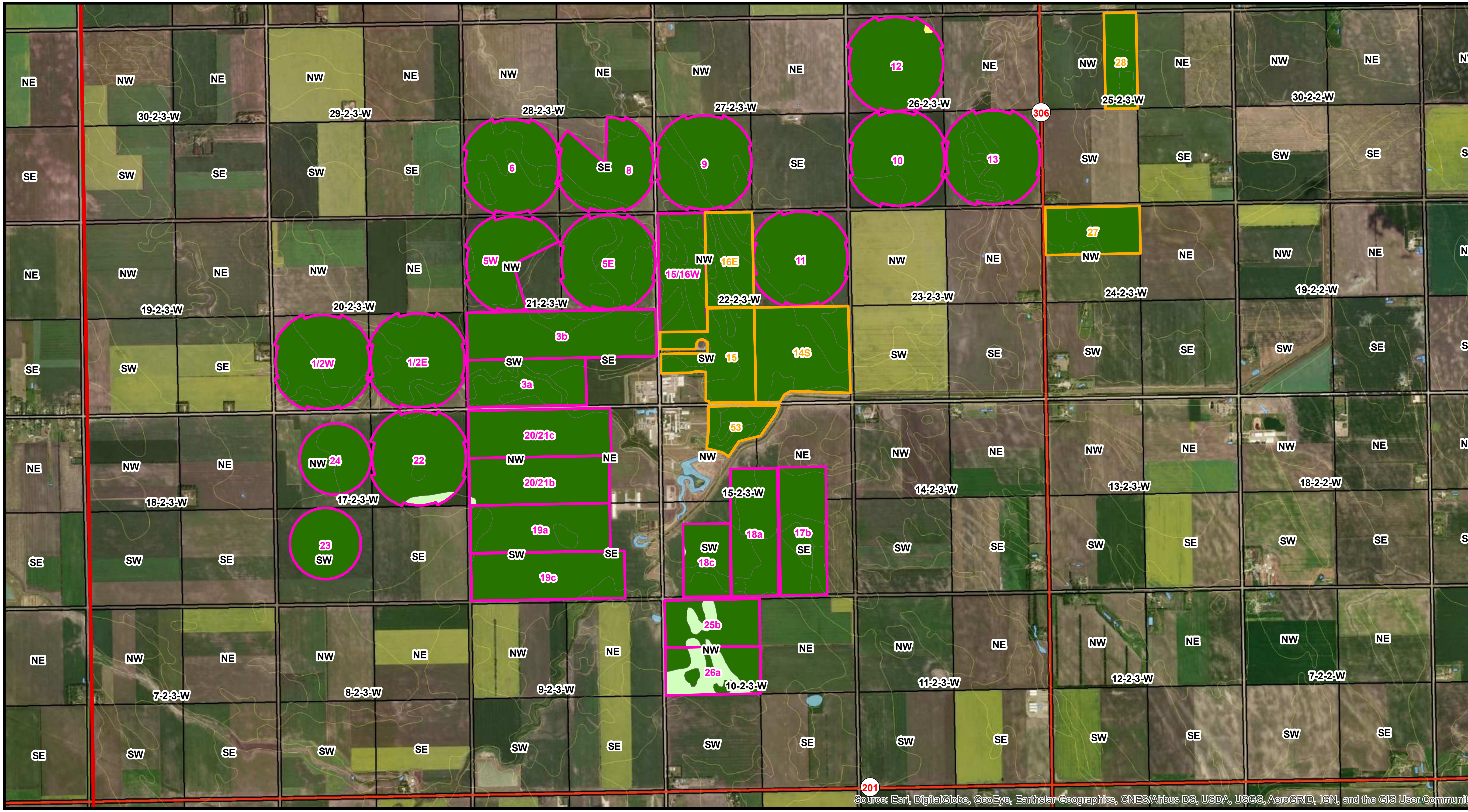
Suitability Ratings

- 1 (most desirable)
- 2
- 3
- 4
- 5 (least desirable)

Prepared by

PBS Water Engineering

agriearth consulting ltd.



Map Name

Nutrient Management Zones

Map Number

8

Project Name

Blumengart Colony Farms

NORTH

1,000 500 0 1,000

Metres

Map scale - 1:30,000

Date - April 15, 2020
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

Acknowledgements:
Original drawing by AgriEarth Consulting Ltd.
Data accessed from Manitoba Land Initiative and AgriMaps, Province of Manitoba.

Legend

Provincial roads
Soil polygons

Proposed fields

Irrigated
Non-irrigated

Nutrient Management Zone

N1
N2
N3
N4

Prepared by

PBS Water Engineering
agriearth consulting ltd.

APPENDIX B - RM Correspondence

From: Susan Stein
To: Michael Rempel; Bruce Shewfelt
Subject: RE: Blumengart Colony Irrigation Reservoir _-- Rosenheim Drain
Date: Monday, April 6, 2020 4:31:34 PM

Hi Bruce, the application would require a copy of the design plan, provincial approval, the fee of $300.00. The process takes approximatly 15-30 days. This may vary slightly due to the fact that we are possibly rescheduling council meetings in May/June/July due to covid 19 and are required to maintain social distancing for all meetings.

Susan Stein
Community Development Officer
Municipality of Rhineland
Susan.stein@rhinelandmb.ca
Office: 204-324-5357
Cell: 204-362-4854

Documents are available in alternate formats, upon request.

RHINELAND Municipality

From: Michael Rempel <michael.rempel@rhinelandmb.ca>
Sent: April-06-20 4:25 PM
To: Susan Stein <susan.stein@rhinelandmb.ca>
Subject: FW: Blumengart Colony Irrigation Reservoir _-- Rosenheim Drain

---

From: Bruce Shewfelt <shewfelt@mymts.net>
Sent: April-06-20 1:52 PM
To: 'Bittner, Matthew (MI)' <Matthew.Bittner@gov.mb.ca>; Michael Rempel <michael.rempel@rhinelandmb.ca>
Cc: 'Butterfield, Tamara (CC)' <Tamara.Butterfield@gov.mb.ca>; 'Webb, Bruce (CC)' <Bruce.Webb@gov.mb.ca>; mark@blumengart.ca; 'Marlon Kuhl' <marlon@southernpotato.com>
Subject: Blumengart Colony Irrigation Reservoir _-- Rosenheim Drain

Matthew and Michael (cc: Tamara and Bruce W):

Matthew. Hope the flood fighting is coming along. Seemed like a slow melt of the latest snow so hope that worked out. Realize between that and COVID you are busy, but thought I would share additional information on the Blumengart Colony situation.

Regarding the Blumengart Colony. We have completed a "conceptual" design layout of a possible 275 acre foot reservoir adjacent to the Rosenheim Drain in order that we can have a full discussion on options to build in this area. The attached layout achieves the storage needs but requires a dyke to come within 5 -10 m of the outside toe of the Rosenheim dyke. It occupies most of the area between the Colony, your dyke and the existing turkey barn.

Further design work would be pending your review of the concept and approval in principle. This would be followed by application to RM of Rhineland for Conditional Use Permit, along with Geotechnical and Civil Engineering design, layout, drawings and specifications. The latter would not occur until May 2020 all things considered.

PBS Water Engineering will be undertaking to complete an Environmental Act Proposal for this site starting this week. I have included a copy of the Development Authorization provided by Water Stewardship.

Michael. Can you advise what the application for Conditional Use Permit for this project would need to include, the timelines and the fees if any. As well if you can provide feedback at this point with any initial concerns you or local councillor may have then we can incorporate into the design as we go along.

Thanks for your help.

Best Regards

Bruce Shewfelt, P.Eng.

From: Bittner, Matthew (MI) <Matthew.Bittner@gov.mb.ca>
Sent: Tuesday, March 31, 2020 6:26 PM
To: 'Bruce Shewfelt' <shewfelt@mymts.net>
Subject: RE: Projects

I am a little busy with spring flood at the moment, this will need to wait.

From: Bruce Shewfelt <shewfelt@mymts.net>
Sent: March-31-20 12:27 PM
To: Bittner, Matthew (MI) <Matthew.Bittner@gov.mb.ca>; 'Graham Copithorn' <gcopithorn@accesscomm.ca>; 'dennis thiessen' <dennis@prairiegeospatial.ca>; 'Victor Klassen' <vrkconsulting@shaw.ca>; 'John' <oosterveenj@hotmail.com>
Cc: 'Michael Rempel' <michael.rempel@rhinelandmb.ca>; Webb, Bruce (CC) <Bruce.Webb@gov.mb.ca>; Butterfield, Tamara (CC) <Tamara.Butterfield@gov.mb.ca>
Subject: Projects

Hello Matthew (cc Michael Rempel RM of Rhineland). Hope all is well for MI (and RM) these days. Trying times.

PBS Water Engineering Ltd. clients continue to move forward and I have a couple of projects that I would like to discuss with you. This email is about Blumengart Colony near Gnadenthal MB in the RM of Rhineland. I will send a separate email on status of South Tobacco Creek project.

For the Blumengart Colony they have a Development Permit for storing up to 262.5 acre feet and diverting up to 175 acre feet. Their preferred site would be adjacent to the MI Rosenheim Drain in NW 15-2-3 W. PBS Water Engineering is working on a plan to develop storage in this abandon Oxbow area adjacent to your dykes.

The attached map is LiDAR of the area which they wish to develop.

Questions for you are as follows:

1. Land control. What land control does MI have at this location.
2. Any concerns regarding proximity of Blumengart dyke to your physical structure (e.g. drain dyke).
3. Any detail you could provide (e.g. map) of the drain design including contours, ROW, geotechnical, etc.
4. Existence and maintenance of any existing through dyke structures (e.g. existing culvert ?).
5. Existence of toe drains.
6. Pumping from the drain with PTO pumps.
7. Any issues with Rosenheim dykes spilling water during flood flows on that Creek (e.g. north or south dyke).

Currently thought is a lower height dyke, slightly above the elevation of your dyke (e.g. 1 m higher ?), c/w keyway to prevent seepage. The shape would be dictated by the existing physical structures (hog barn, etc.) and the Oxbow, as well as limits to the north (e.g. road, etc.). In order to complete final design we would need the following steps.

1. MI approval/conditions to build in this zone. Obviously this could be some back and forth.
2. Conditional use permit from RM. To be submitted AFTER MI discussions.
3. Geotechnical engineering. To be completed in May.
4. Civil engineering. To be completed in June.
5. Drawings and specs. To be completed in July.

We are currently writing up an Environment Act Proposal (to be submitted in April) and there is no doubt we will also need a Heritage Resource Survey. Goal is to design by July 2020 with Construction start in August 2020 with completion for October 2020.

Please feel free to call me at 204 362 5666. I am available for social distance field visit. Maybe that would be ideal. IF you have any plans that are digital and can share that would be great.

Regards

Bruce Shewfelt, P.Eng.

APPENDIX C – Provincial Correspondence

APPENDIX C.1 – Provincial Licensing Correspondence

DEVELOPMENT
AUTHORIZATION
PERMIT

Manitoba

Issued in accordance with the provisions
The Water Rights Act and regulations made thereunder.

Subject to the terms and conditions contained in this Development Authorization Permit, the Minister of Sustainable Development authorizes:

Blumengart Colony

In the **Municipality of Rhineland**, in the province of Manitoba, to establish, operate and maintain an intake, pump(s) and transmittal pipeline(s) (the "WORKS") for **Irrigation** purposes on the following land:

NW 15-2-3 WPM

and construct an off-channel reservoir to impound water diverted during the spring runoff period.

This Development Authorization Permit allows you to divert, store and use water for **Irrigation** purposes until the expiry date.

The WORKS shall be constructed and operated in accordance with the terms and conditions described as follows:

1. This Permit expires within twenty-four (24) months of the date of issuance. Failure to construct all of the necessary WORKS and use water for **Irrigation** purposes prior to the permit expiry date may result in cancellation of the application for a Water Rights Licence.
2. The maximum quantity of water available for your project from the **Rosenheim Drain** during the spring runoff period (primarily March 1 to May 31) is **215.87 cubic decametres (175.00 acre feet)**. The maximum area of land to be irrigated in any one year shall not exceed **350.00** acres.
3. Upon completion of reservoir construction, the Permittee shall submit a drawing indicating the full supply capacity of the off-channel reservoir.
4. The Permittee may construct the off-channel reservoir 50% larger than the allocation amount indicated above. In any one year you may only divert the maximum allocation volume water, unless written permission is granted. The purpose of this benefit is to allow you to mitigate, to some extent, the risk that in any single year you will not be able to fill the reservoirs. It is not meant to encourage you to expand your irrigated acres.
5. The design and construction of the proposed off-channel water reservoir shall be in accordance with local municipal and/or planning board requirements, where applicable.
6. This Permit is not transferable or assignable to any other party.
7. The Permittee must have legal access to all lands occupied by the project.
8. The Permittee must hold and maintain all regulatory approvals and requirements for the construction, operation or maintenance of the WORKS or to divert or use water as provided by this Permit.
9. The Permittee shall assume any liability that may result from the construction of the WORKS.
10. The Province of Manitoba shall hereby be released from any liability or claims for damages whatsoever that may result from the construction of the WORKS.
11. The Minister or Minister's agents have the right of unrestricted access for the purpose of inspection of any WORKS constructed under this Permit.
12. The Minister or Minister's agents, under certain conditions, may instruct the Permittee to reduce or terminate withdrawal of water from the **Rosenheim Drain** to accommodate existing senior licenced water users, domestic users and environmental needs.
13. The Permittee shall install and maintain, on the water diversion WORKS, a water measuring device acceptable to this Section that will accurately measure the instantaneous water flow and the accumulated volume of water diverted.
14. The Permittee must keep daily and annual water use records to be submitted to the Water Use Licensing Section prior to February 1st of the following year.

15. The issuance of this Permit does not imply that the Department will extend or renew the Permit in subsequent years.

FOR OFFICE USE ONLY	
Issued at the City of Winnipeg, in the Province of Manitoba, this 6th day of March A.D. 2020	
Perry Stonehouse	[signature]
Print Name	Signature
Signed by the Honourable Minister of Conservation and Climate (or her/his designate)	

Page 2 of 2

MG-14855 (English)

Licence to Impound and Use Water for Irrigation Purposes

Manitoba
Conservation and Water Stewardship
200 Saulteaux Cresc.
Winnipeg, Manitoba
R3J 3W3

Project: S14

Issued in accordance with the provisions of
The Water Rights Act and regulations made thereunder.

Licence No.: **2016-004**
(Previous Lic. No.: 2008-002)
U.T.M.: Zone 14 590041 E
5438131 N

Subject to the terms and conditions contained in this Licence, the Minister of Conservation and Water Stewardship authorizes:

Agassiz Resource Management Ltd.

of the **Rural Municipality of Rhineland** in the Province of Manitoba ("the LICENSEE") to:

(a) divert, primarily during the spring runoff period, water from **Buffalo Drain and Buffalo Creek** by means of a temporary pumping installation and pipeline located on:

SW 2-2-3 WPM and SE 27-1-3 WPM

(b) impound water by means of an off-channel reservoir located on:

SW 2-2-3 WPM

and

(c) use for **Irrigation** purposes the impounded water from the off-channel reservoir by means of a pumping installation and pipeline, the water to be used, and the pumping installation and pipeline to be placed, on lands held by the LICENSEE.

The above pumping installation, pipelines, and off-channel reservoir (the "WORKS") are more particularly shown on the attached Exhibit "A".

This licence is issued upon the express condition that it shall be subject to the provisions of The Water Rights Act and Regulation and all amendments thereto and, without limiting the generality of the aforesaid, to the following terms and conditions, namely:

1. The water shall be used solely for **irrigation** purposes.
2. The WORKS shall be operated in accordance with the terms herein contained.
3. The LICENSEE is authorized to withdraw water from **Buffalo Drain and Buffalo Creek** into the off-channel reservoir during the spring runoff period only, which is normally considered to be from March 1 to the following May 31, unless the LICENSEE obtains authorization to divert water at another time in accordance with Clause 4.
4. The LICENSEE shall obtain authorization from Manitoba Conservation and Water Stewardship, in writing, prior to:
   a) diversion of water from **Buffalo Drain and Buffalo Creek** at any other time than the spring runoff period specified in Clause 3; or
   b) diversion of a quantity of water from **Buffalo Drain and Buffalo Creek** in excess of the maximum quantity specified in Clause 5.
5. a) The rate at which water may be diverted into the off-channel reservoir pursuant hereto shall not exceed **0.758 cubic metres per second (26.8 cubic feet per second)** .
   b) The total quantity diverted in any one year shall not exceed **98.68 cubic decametres (80.00 acre feet)** .
6. Water shall not be diverted during any spring run-off period when the flow in **Buffalo Drain and Buffalo Creek** is at or below a specified flow rate.
7. The LICENSEE does hereby remise, release and forever discharge Her Majesty the Queen in Right of the Province of Manitoba, of and from all manner of action, causes of action, claims and demands whatsoever which against Her Majesty the LICENSEE ever had, now has or may hereafter have, resulting from the construction, operation, and maintenance of the WORKS and the diversion and use of water for **Irrigation** purposes.
8. In the event that the rights of others are infringed upon and/or damage to the property of others is sustained as a result of the operation or maintenance of the WORKS and the rights herein granted, the LICENSEE shall be solely responsible and shall save harmless and fully indemnify Her Majesty the Queen in Right of the Province of Manitoba, from and against any liability to which Her Majesty may become liable by virtue of the issue of this Licence and anything done pursuant hereto.
9. This Licence is not assignable or transferable by the LICENSEE and when no longer required by the LICENSEE this Licence shall be returned to Manitoba Conservation and Water Stewardship, for cancellation on behalf of the Minister.

10. Upon the execution of this Licence the LICENSEE hereby grants the Minister or the Minister's agents the right of ingress and egress to and from the lands on which the WORKS are located for the purpose of inspection of the WORKS and the LICENSEE shall at all times comply with such directions and/or orders that may be given by the Minister or the Minister's agents in writing from time to time with regard to the operation and maintenance of the WORKS.

11. This Licence may be amended, suspended or cancelled by the Minister in accordance with The Water Rights Act by letter addressed to the LICENSEE at Box 750, Winkler, MB, R6W 4A8, Canada and thereafter this Licence shall be determined to be at an end.

12. Notwithstanding anything preceding in this License, the LICENSEE must have legal control, by ownership or by rental, lease, or other agreement, of the lands on which the WORKS shall be placed and the water shall be used.

13. The LICENSEE shall keep the following records for each calendar year, and a copy of such records shall be furnished to Manitoba Conservation and Water Stewardship not later than February 1st of the following year:
a) daily and annual volumes of water diverted into the off-channel reservoir;
b) the rate that water was diverted into the off-channel reservoir;
c) weekly and annual volumes of water used for Irrigation purposes.

14. The LICENSEE shall install and maintain, on the pumping WORKS, a water measuring device acceptable to Manitoba Conservation and Water Stewardship that will accurately measure the instantaneous water flow and the accumulated annual volume of water diverted from the water source.

15. The LICENSEE shall hold and maintain all other regulatory approvals that may be required and shall comply with all other regulatory requirements for the construction, operation, or maintenance of the WORKS or to divert or use water as provided by this Licence.

16. The term of this Licence shall be ten (10) years and this Licence shall become effective only on the date of execution hereof by a person so authorized in Manitoba Conservation and Water Stewardship. The LICENSEE may apply for renewal of this Licence not more than 365 days and not less than 90 days prior to the expiry date.

17. This Licence expires automatically upon the loss of the legal control of any of the lands on which the WORKS are located or on which water is used, unless the Licence is transferred or amended by the Minister upon application for Licence transfer or amendment.

In witness whereof I the undersigned hereby agree to accept the aforesaid Licence on the terms and conditions set forth therein and hereby set my hand and seal this 21 day of April A.D. 20 16.

SIGNED, SEALED AND DELIVERED
in the presence of

Witness } Licensee (Seal)

Canada, PROVINCE OF MANITOBA To Wit:

I, ______ of the ______

of ______ in the Province of Manitoba, MAKE OATH AND SAY:

1. That I was personally present and did see ______, the within named party, execute the within Instrument.
2. That I know the said ______ and am satisfied that he/she is of the full age of eighteen years.
3. That the said Instrument was executed at ______ aforesaid and that I am subscribing witness thereto.

SWORN BEFORE me at the ______

in the Province of Manitoba this ______ day of ______ A.D. 20___.

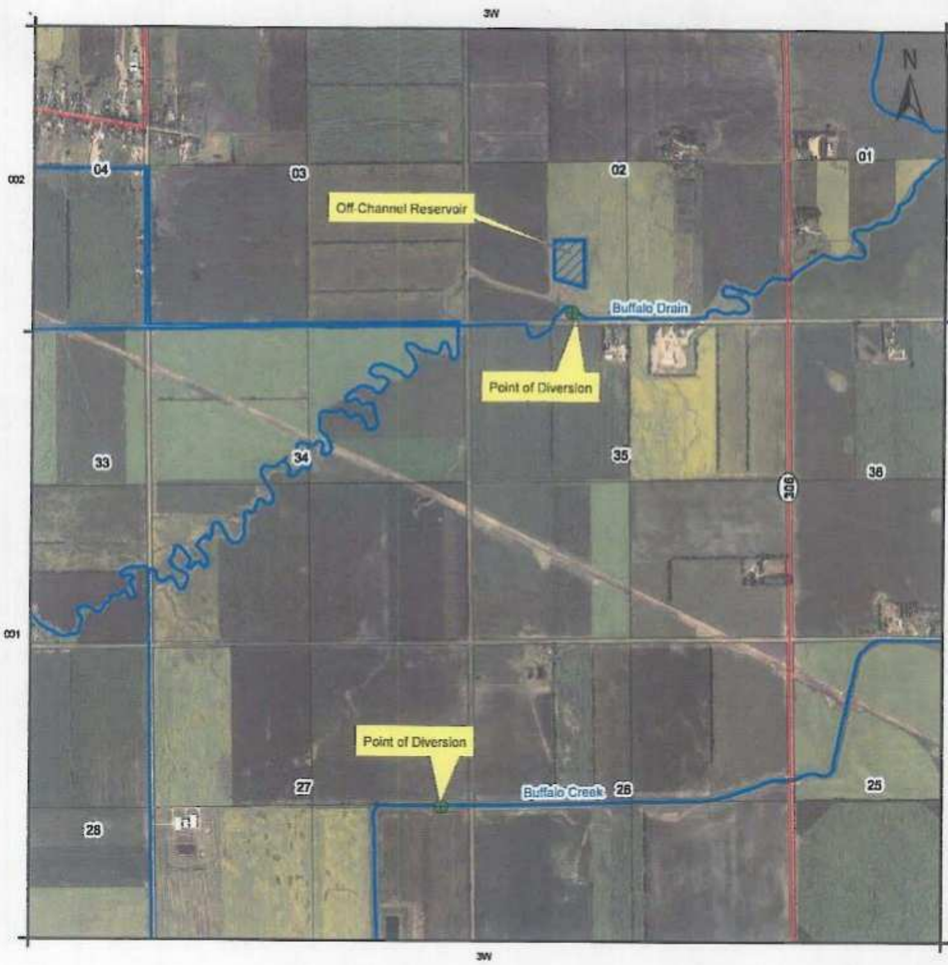
A COMMISSIONER FOR OATHS
in and for the Province of Manitoba } Witness

My Commission expires ______

FOR OFFICE USE ONLY

Issued at the City of Winnipeg, in the Province of Manitoba, this 2nd day of April A.D. 2016.

The Honourable the Minister of Conservation and Water Stewardship (or her/his designate)



LOCATION PLAN OF IRRIGATION PROJECT
FOR
AGASSIZ RESOURCE MANAGEMENT LTD
BUFFALO DRAIN & BUFFALO CREEK
SW 2-2-3 WPM & SE 27-1-3 WPM

0 460 920 Metres

EXHIBIT "A"
THIS PLAN IS AN INTERGRAL PART OF
LICENCE NO. 2016-004
ISSUED UNDER THE WATER RIGHTS ACT

APPENDIX C.2 – Correspondence with Historic Resources Branch

Bruce Shewfelt

To:	suyoko.tsukamoto@gov.mb.ca; 'mark@blumengart.ca'; Marlon Kuhl
Cc:	Webb, Bruce (CC); David Whetter; Butterfield, Tamara (CC)
Subject:	Blumengart Colony Irrigation Project - Historic Resources Impacts
Attachments:	Blumengart Colony - Preliminary Design Layout.pdf

Dear Suyoko (or to whom it may otherwise concern):

PBS Water Engineering Ltd. is working on a project for Blumengart Colony (north of Gnadenthal MB). The project will involve the construction an irrigation pond. Currently we are focused on one site for the reservoir, I have attached a map of the proposed location. Site BLU15 will dyke an old oxbow on the Rosenheim Drain which was previously dissected by the a Provincial Drain. Site BLU15 is an off stream reservoir which would store water pumped from the Rosenheim Drain.

The reservoir site (size) triggers the need for an Environment Act License. PBS Water Engineering Ltd. with consultation from AgriEarth Consulting Ltd. will be filing an Environment Act Proposal in April, 2020.

One requirement of the EAP will be is to do a search of Manitoba Sustainable Development and Heritage Resources data bases for occurrences of rare and endangered species and/or historic resources.

Site BLU15 requires further feasibility studies and a decision is pending on whether to proceed with it, depending on geotechnical engineering and Provincial and RM of Rhineland approvals of location relative to the Rosenheim Drain. IF this site is unfeasible, an open field about ½ mile north of this site would be considered. Additional information can be provided on these sites (e.g. additional site plans) on request.

The source of water for the project will be the Rosenheim Drain with access on the south side of the Blumengart Colony yard site. Interconnecting pipelines will allow filling of reservoirs and to deliver water from the reservoirs to the irrigated lands in the summer. Pipeline will be installed in future years, as will be documented in the EAP, almost exclusively on cultivated land. Routing is TBA.

Please consider this request to review your records and provide any concerns arising from the potential project/project site; especially that may impact the choice of optional locations.

Please fee free to call to discuss and questions or concerns.

Please acknowledge receipt of this request.

Regards

Bruce Shewfelt, P.Eng.
PBS Water Engineering Ltd.
Morden, MB
R6M 1R4

204 362 5666
shewfelt@mymts.net

cc: D Whetter (Agri Earth); D Thiessen (Prairie Geospatial); Bruce Webb, Tamara Butterfield; Mark Tschetter (Blumengart Colony), Marlon Kuhl (Southern Potato)

APPENDIX C.3 - Correspondence with Manitoba Conservation Data Center

From:	Bruce Shewfelt
To:	"chris.friesen@gov.mb.ca"; "Colin.Murray@gov.mb.ca"
Cc:	"David Whetter"; "dennis thiessen"; "Butterfield, Tamara (CC)"; "Webb, Bruce (CC)"; "mark@blumengart.ca"; "Marlon Kuhl"
Subject:	FW: Blumengart Colony Irrigation Project - Historic Resources Impacts
Date:	Friday, April 10, 2020 12:57:16 PM
Attachments:	Blumengart Colony - Preliminary Design Layout.pdf

Chris, Colin. Please see my request below regarding the upcoming project at Blumengart Colony near Gnadenthal Manitoba (plan attached).

Please consider this request to review your records for rare species and provide any concerns arising from the potential project/project sites; especially that may impact the choice of optional locations.

Please fee free to call to discuss and questions or concerns.

Please acknowledge receipt of this request.

Regards

Bruce Shewfelt, P.Eng.
PBS Water Engineering Ltd.
Morden, MB
R6M 1R4

204 362 5666
shewfelt@mymts.net

cc: D Whetter (Agri Earth); D Thiessen (Prairie Geospatial); Bruce Webb, Tamara Butterfield; Mark Tschetter (Blumengart Colony); Marlon Kuhl (Southern Potato)

From: Bruce Shewfelt <shewfelt@mymts.net>
Sent: Friday, April 10, 2020 10:16 AM
To: 'suyoko.tsukamoto@gov.mb.ca' <suyoko.tsukamoto@gov.mb.ca>; 'mark@blumengart.ca' <mark@blumengart.ca>; 'Marlon Kuhl' <marlon@southernpotato.com>
Cc: 'Webb, Bruce (CC)' <Bruce.Webb@gov.mb.ca>; 'David Whetter' <david.whetter@agriearth.ca>; 'Butterfield, Tamara (CC)' <Tamara.Butterfield@gov.mb.ca>
Subject: Blumengart Colony Irrigation Project - Historic Resources Impacts

Dear Suyoko (or to whom it may otherwise concern):

PBS Water Engineering Ltd. is working on a project for Blumengart Colony (north of Gnadenthal MB). The project will involve the construction an irrigation pond. Currently we are focused on one site for the reservoir, I have attached a map of the proposed location. Site BLU15 will dyke an old oxbow on the Rosenheim Drain which was previously dissected by the a Provincial Drain. Site BLU15 is an off stream reservoir which would store water pumped from the Rosenheim Drain.

The reservoir site (size) triggers the need for an Environment Act License. PBS Water Engineering Ltd. with consultation from AgriEarth Consulting Ltd. will be filing an Environment Act Proposal in April, 2020.

One requirement of the EAP will be is to do a search of Manitoba Sustainable Development and Heritage Resources data bases for occurrences of rare and endangered species and/or historic resources.

Site BLU15 requires further feasibility studies and a decision is pending on whether to proceed with it, depending on geotechnical engineering and Provincial and RM of Rhineland approvals of location relative to the Rosenheim Drain. IF this site is unfeasible, an open field about ½ mile north of this site would be considered. Additional information can be provided on these sites (e.g. additional site plans) on request.

The source of water for the project will be the Rosenheim Drain with access on the south side of the Blumengart Colony yard site. Interconnecting pipelines will allow filling of reservoirs and to deliver water from the reservoirs to the irrigated lands in the summer. Pipeline will be installed in future years, as will be documented in the EAP, almost exclusively on cultivated land. Routing is TBA.

Please consider this request to review your records and provide any concerns arising from the potential project/project site; especially that may impact the choice of optional locations.

Please fee free to call to discuss and questions or concerns.

Please acknowledge receipt of this request.

Regards

Bruce Shewfelt, P.Eng.
PBS Water Engineering Ltd.
Morden, MB
R6M 1R4

204 362 5666
shewfelt@mymts.net

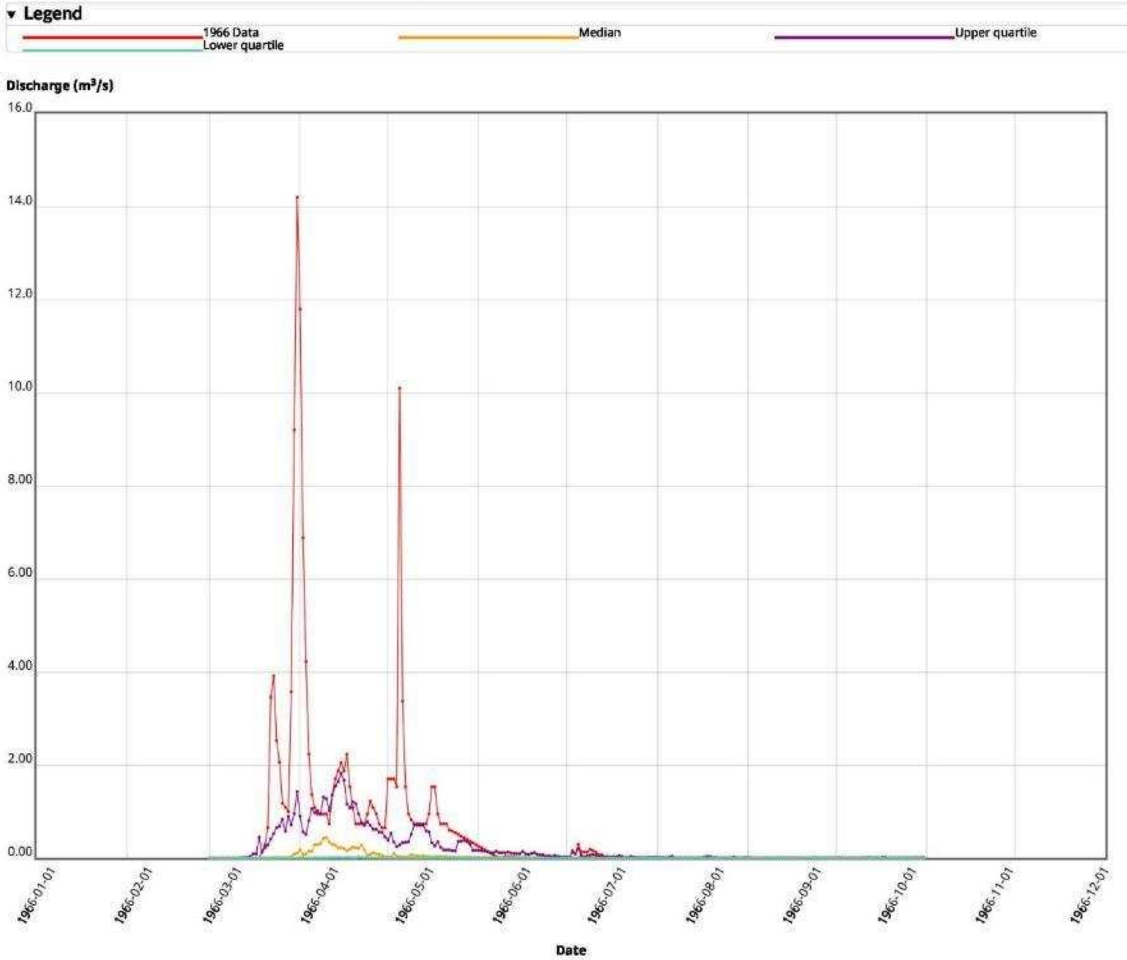
cc: D Whetter (Agri Earth); D Thiessen (Prairie Geospatial); Bruce Webb, Tamara Butterfield; Mark Tschetter (Blumengart Colony), Marlon Kuhl (Southern Potato)

APPENDIX D – Water Survey of Canada - Hydrometric Data

Government of Canada Gouvernement du Canada

Daily Discharge Graph for DEADHORSE CREEK AT MORDEN (05OC015) [MB]

All times are specified in Local Standard Time (LST). Add 1 hour to adjust for Daylight Saving Time where and when it is observed.



Statistics corresponding to 25 years of data recorded from 1966 and 1996.*

*Note: If n<10, percentiles are not calculated.

Station Information

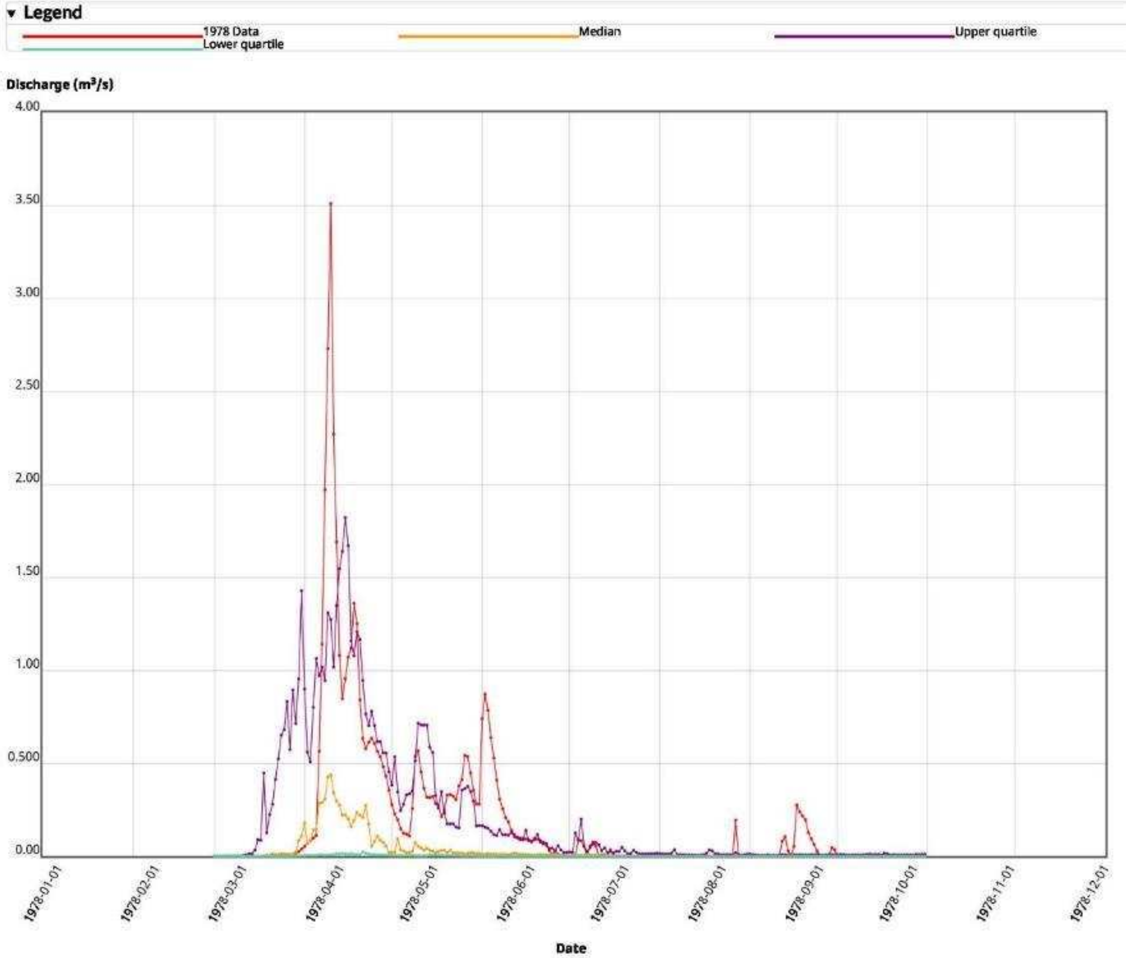
Active or discontinued:	Discontinued	**Province / Territory:**	Manitoba
Latitude:	49° 11' 47" N	**Longitude:**	98° 06' 38" W
Gross drainage area:	137 km^2	**Effective drainage area:**	N/A
Record length:	25 Years	**Period of record:**	1966 - 1996
Regulation type:	Regulated	**Regulation length:**	N/A
Real-time data available:	No	**Sediment data available:**	No
Type of water body:	River	**RHBN:**	No
EC Regional Office:	WINNIPEG	**Current Operation Schedule:**	N/A
Data contributed by:	N/A	**Operation Period:**	N/A
Datum of published data:	ASSUMED DATUM	**To convert to:**	GEODETIC SURVEY OF CANADA DATUM 1928 ADJUSTMENT,add 299.923 m

Government of Canada Gouvernement du Canada

Daily Discharge Graph for DEADHORSE CREEK AT MORDEN (05OC015) [MB]

All times are specified in Local Standard Time (LST). Add 1 hour to adjust for Daylight Saving Time where and when it is observed.

▾ Legend



Statistics corresponding to 25 years of data recorded from 1966 and 1996.*

*Note: If n<10, percentiles are not calculated.

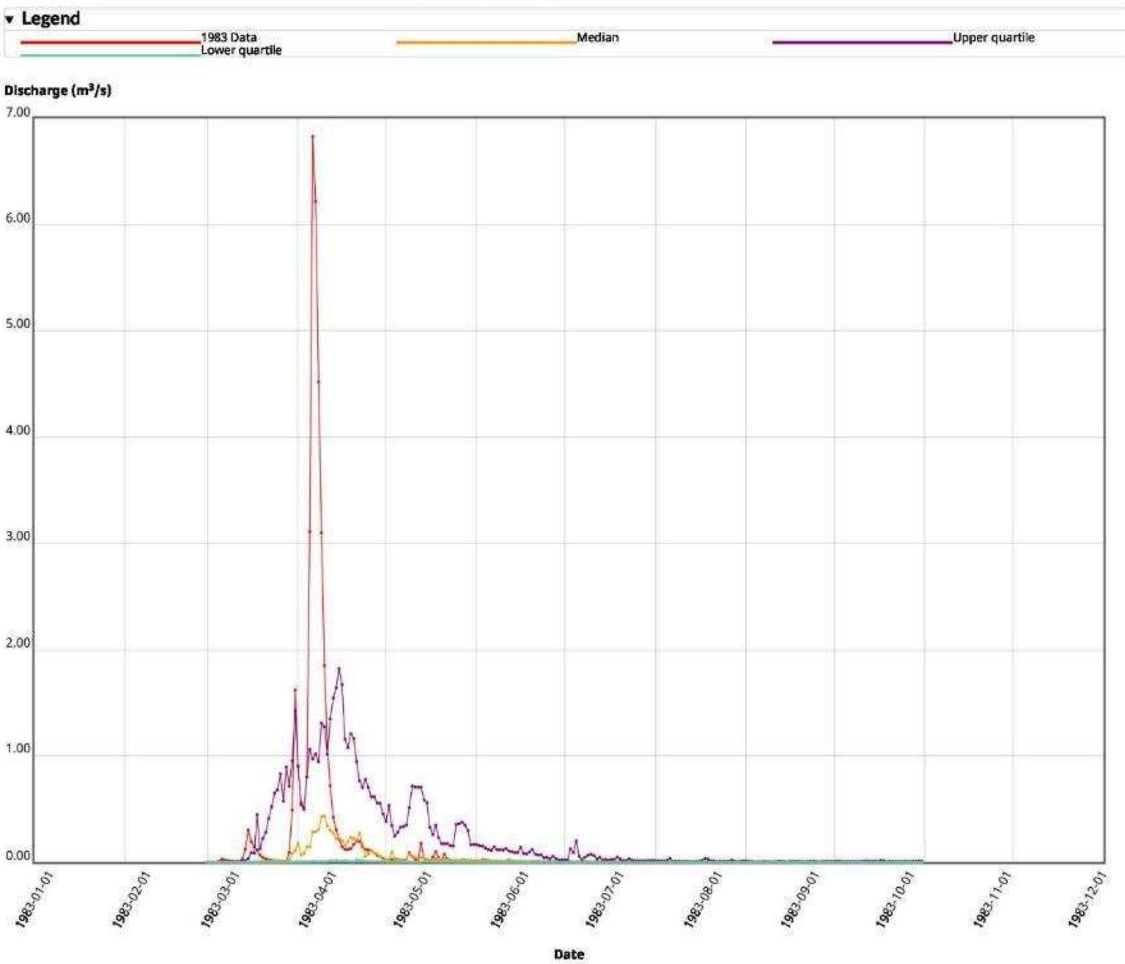
Station Information

Active or discontinued:	Discontinued	**Province / Territory:**	Manitoba
Latitude:	49° 11' 47" N	**Longitude:**	98° 06' 38" W
Gross drainage area:	137 km^2	**Effective drainage area:**	N/A
Record length:	25 Years	**Period of record:**	1966 - 1996
Regulation type:	Regulated	**Regulation length:**	N/A
Real-time data available:	No	**Sediment data available:**	No
Type of water body:	River	**RHBN:**	No
EC Regional Office:	WINNIPEG	**Current Operation Schedule:**	N/A
Data contributed by:	N/A	**Operation Period:**	N/A
Datum of published data:	ASSUMED DATUM	**To convert to:**	GEODETIC SURVEY OF CANADA DATUM 1928 ADJUSTMENT,add 299.923 m

Government of Canada Gouvernement du Canada

Daily Discharge Graph for DEADHORSE CREEK AT MORDEN (05OC015) [MB]

All times are specified in Local Standard Time (LST). Add 1 hour to adjust for Daylight Saving Time where and when it is observed.



Statistics corresponding to 25 years of data recorded from 1966 and 1996.*

*Note: If n<10, percentiles are not calculated.

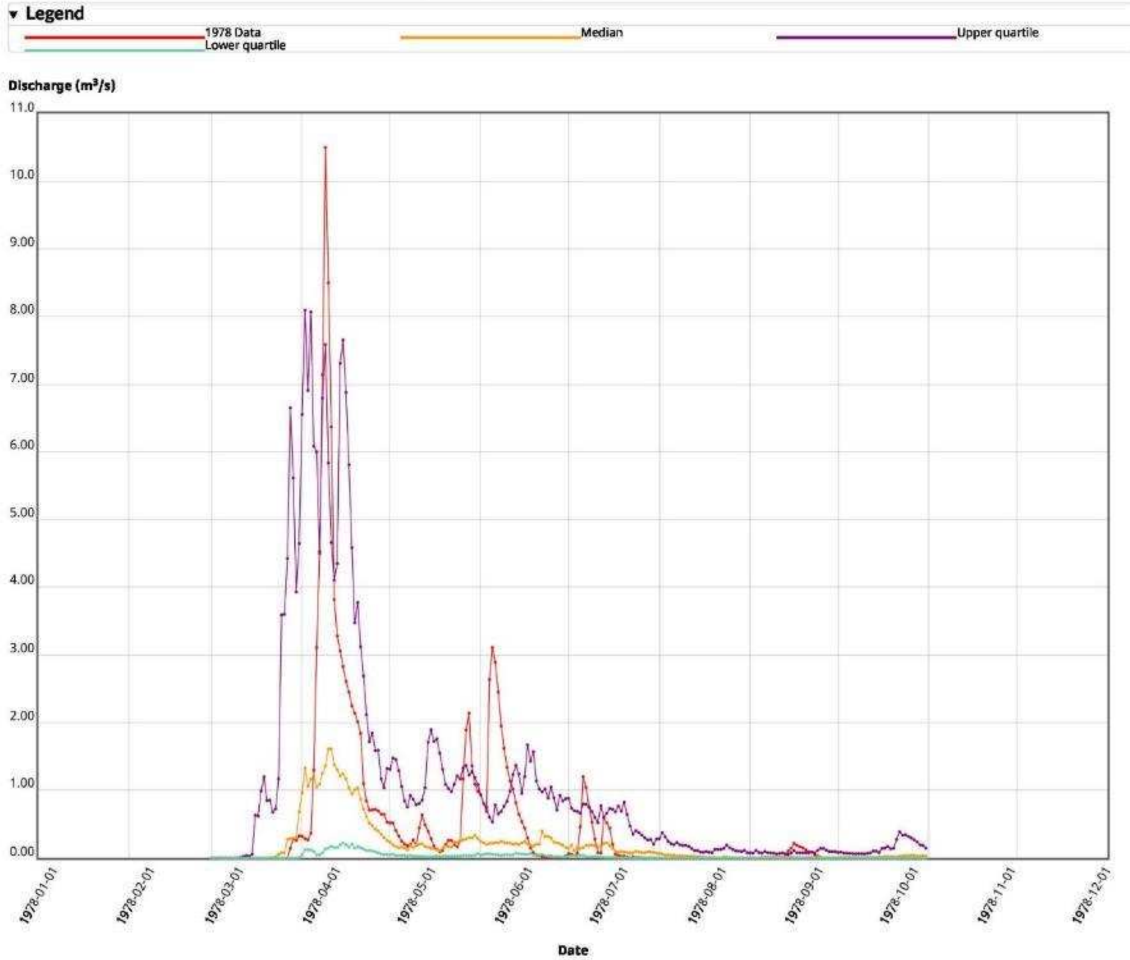
Station Information

Active or discontinued:	Discontinued	**Province / Territory:**	Manitoba
Latitude:	49° 11' 47" N	**Longitude:**	98° 06' 38" W
Gross drainage area:	137 km²	**Effective drainage area:**	N/A
Record length:	25 Years	**Period of record:**	1966 - 1996
Regulation type:	Regulated	**Regulation length:**	N/A
Real-time data available:	No	**Sediment data available:**	No
Type of water body:	River	**RHBN:**	No
EC Regional Office:	WINNIPEG	**Current Operation Schedule:**	N/A
Data contributed by:	N/A	**Operation Period:**	N/A
Datum of published data:	ASSUMED DATUM	**To convert to:**	GEODETIC SURVEY OF CANADA DATUM 1928 ADJUSTMENT,add 299.923 m

Government of Canada Gouvernement du Canada

Daily Discharge Graph for DEADHORSE CREEK NEAR ROSENFELD (05OC016) [MB]

All times are specified in Local Standard Time (LST). Add 1 hour to adjust for Daylight Saving Time where and when it is observed.



Statistics corresponding to 50 years of data recorded from 1968 and 2018.*

*Note: If n<10, percentiles are not calculated.

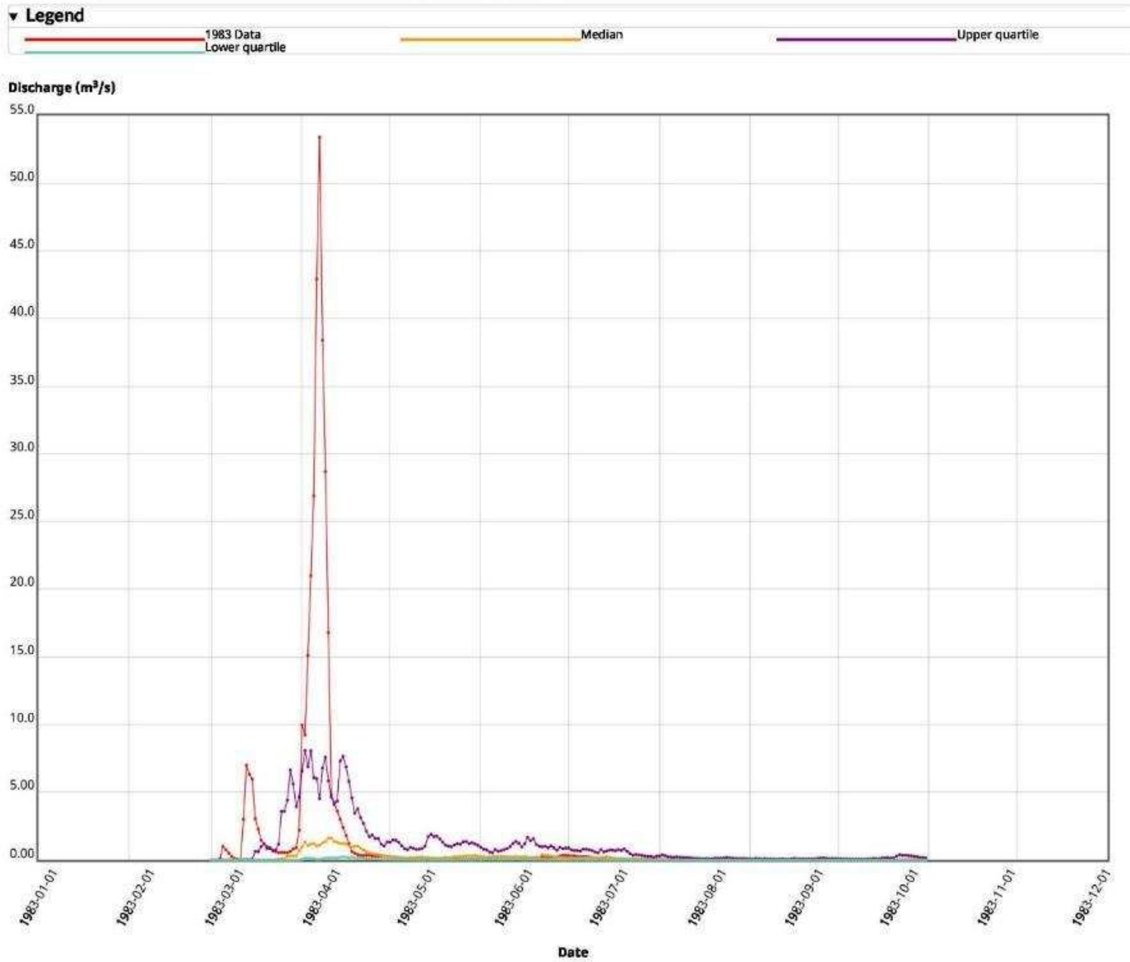
Station Information

Active or discontinued:	Active	**Province / Territory:**	Manitoba
Latitude:	49° 15' 02" N	**Longitude:**	97° 32' 59" W
Gross drainage area:	926 km^2	**Effective drainage area:**	N/A
Record length:	54 Years	**Period of record:**	1967 - 2020
Regulation type:	Natural	**Regulation length:**	N/A
Real-time data available:	Yes	**Sediment data available:**	No
Type of water body:	River	**RHBN:**	No
EC Regional Office:	WINNIPEG	**Current Operation Schedule:**	Seasonal
Data contributed by:	N/A	**Operation Period:**	MAR - OCT
Datum of published data:	ASSUMED DATUM		

Government of Canada Gouvernement du Canada

Daily Discharge Graph for DEADHORSE CREEK NEAR ROSENFELD (05OC016) [MB]

All times are specified in Local Standard Time (LST). Add 1 hour to adjust for Daylight Saving Time where and when it is observed.



Statistics corresponding to 50 years of data recorded from 1968 and 2018.*

*Note: If n<10, percentiles are not calculated.

Station Information

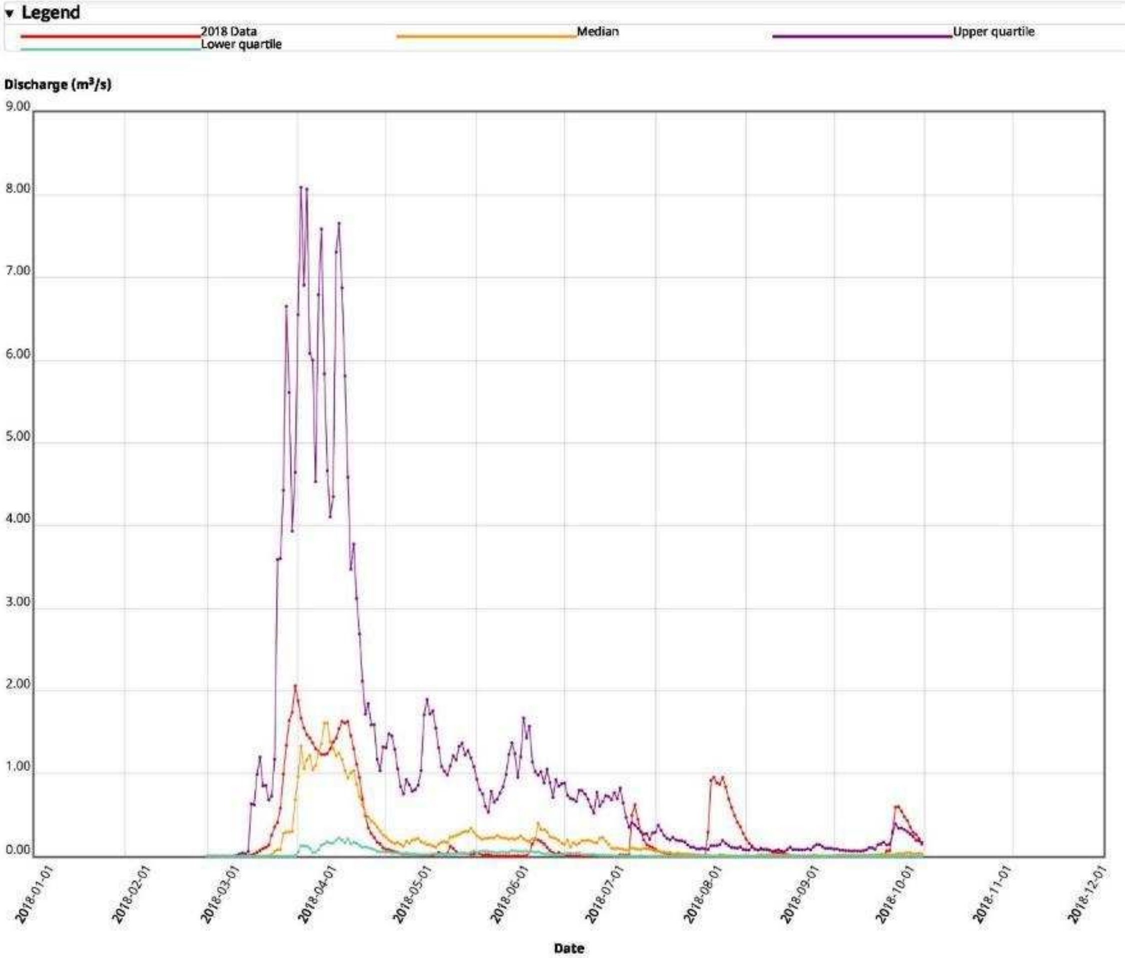
Active or discontinued:	Active	**Province / Territory:**	Manitoba
Latitude:	49° 15' 02" N	**Longitude:**	97° 32' 59" W
Gross drainage area:	926 km²	**Effective drainage area:**	N/A
Record length:	54 Years	**Period of record:**	1967 - 2020
Regulation type:	Natural	**Regulation length:**	N/A
Real-time data available:	Yes	**Sediment data available:**	No
Type of water body:	River	**RHBN:**	No
EC Regional Office:	WINNIPEG	**Current Operation Schedule:**	Seasonal
Data contributed by:	N/A	**Operation Period:**	MAR - OCT
Datum of published data:	ASSUMED DATUM		

Government of Canada Gouvernement du Canada

Daily Discharge Graph for DEADHORSE CREEK NEAR ROSENFELD (05OC016) [MB]

All times are specified in Local Standard Time (LST). Add 1 hour to adjust for Daylight Saving Time where and when it is observed.

▾ Legend



Statistics corresponding to 50 years of data recorded from 1968 and 2018.*

*Note: If n<10, percentiles are not calculated.

Station Information

Active or discontinued:	Active	**Province / Territory:**	Manitoba
Latitude:	49° 15' 02" N	**Longitude:**	97° 32' 59" W
Gross drainage area:	926 km²	**Effective drainage area:**	N/A
Record length:	54 Years	**Period of record:**	1967 - 2020
Regulation type:	Natural	**Regulation length:**	N/A
Real-time data available:	Yes	**Sediment data available:**	No
Type of water body:	River	**RHBN:**	No
EC Regional Office:	WINNIPEG	**Current Operation Schedule:**	Seasonal
Data contributed by:	N/A	**Operation Period:**	MAR - OCT
Datum of published data:	ASSUMED DATUM		

APPENDIX E – DFO Habitat Maps For Rosenheim Drain

BACKGROUND AND FREQUENTLY ASKED QUESTIONS
FOR FISHERIES AND OCEANS DATA REPORT

Milani, D.W. 2013. Fish community and fish habitat inventory of streams and constructed drains throughout agricultural areas of Manitoba (2002-2006). Can. Data Rep. Fish. Aquat. Sci. 1247: xvi + 6,153 p.

Background:

After the creation of the Province of Manitoba in 1870, networks of surface ditches were constructed in several areas of wetland and wet prairie in the south to increase arable lands, facilitate rapid spring runoff, and prevent flooding of crops during heavy summer downpours. The constructed channels often drained fish bearing wetlands used by many large bodied fish seasonally for spawning and rearing, and providing year round habitat for forage fish. The increased speed of runoff from draining these wetland areas often resulted in downstream flooding, and the continuation of drainage works to include channelizing and diking natural waterways to increase flow capacity. Many of these drains continue to be utilized seasonally by fish, and some perennial drains provide permanent habitat for forage fish, and often for large bodied fish species as well.

While the Governments of Canada and the Province of Manitoba recognize the important socio-economic benefits derived from well-drained agricultural land, both governments also share the mandate to conserve and protect water resources and fish habitat. In 2001, the Manitoba Drain Maintenance Committee (DFO, Manitoba Conservation and Water Stewardship) was convened to gain a better understanding of the role of drains as fish habitat and to document the mechanical processes required for effective drain maintenance.

This report documents the results of five years of field surveys (2002-2006) and summarizes the data and methods used to develop the first iteration of classified fish habitat maps for the study area. The classified fish habitat maps break the habitat of agricultural waterways into 5 habitat types, A,B,C,D or E, based on gross measurements of fish habitat complexity and the fish species presence (Commercial, Recreational, Aboriginal or SARA listed fish species captured or expected vs. Forage Fish species captured or expected vs. no fish captured or expected).

Generally A and B habitat types support Commercial, Recreational, Aboriginal or SARA species with Type A habitat being complex and Type B habitat being simplified. Habitat Type C and D drains support Forage Fish species with Type C habitat being complex and Type D habitat being simplified. Habitat Type E drains can be simple or complex but provide indirect fish habitat.

The maps provide information that can be used for a quick risk assessment for the potential of impacts to fish and fish habitat in Agro-Manitoba from a variety of works that occur in and near water, not just drain maintenance. While the maps can help to inform DFO and other regulators of potential risks, they cannot anticipate all situations. Site specific information should always be used in conjunction with the maps to make informed regulatory and management decisions.

Frequently Asked Questions:

Q: My project is on Type A habitat, does that mean I can't do it?

A: While Type A habitat is generally the highest quality fish habitat, projects will be considered based on the type of work proposed, the scale of the project, and site specific information. Generally if your work is not covered by a DFO Operational Statement or other standard or guideline then you should talk to DFO about site specific assessment and review on Type A habitats.

Q: What if I disagree with the assessed habitat type on a stream and feel that it should be a different habitat type?

A: The habitat classifications have been completed based on large scale assessments of habitats and fish presence/absence. Should site specific information and more detailed information on a watercourse or watershed lead to the conclusion that the habitat type should be different, then that information should be presented to DFO and other regulators in your environmental assessment when you are seeking approvals. DFO will make management decisions based on the information that is available. The maps have been labeled as "Draft Data subject to ongoing review" to highlight to users that the information on the maps could change.

Q: Are Type A habitats considered pristine?

A: Generally Type A habitats have the best combination of stream and riparian habitat characteristics to provide the highest quality fish habitat in Manitoba. Many streams with Type A habitat have been impacted and degraded by human activities, often with reduced water quality from nutrient and sediment runoff, and from dams, perched culverts and water management issues. If these issues are addressed however these habitats are often very resilient and will recover their productive capacity.

Q: Does DFO have any concerns about works in Type E habitats:

A: Generally Type E watercourses provide water and nutrients to downstream portions of the watercourse but fish don't live there directly. Pollution and sediment can run down a Type E watercourse and impact fish and habitat downstream and need to be properly considered and managed. Similarly projects that remove all water from a type E (e.g. dam and pump) or projects that greatly increase flows in a Type E (e.g. a water diversion) can greatly affect fish use in the watershed, and should be considered carefully. Generally projects such as a drain clean out, and culvert installation and maintenance can occur in Type E watercourses following best management practices. DFO is working on a Standard Advice document for drain cleanouts in Type D and E habitats.

Q: The watercourse I am interested in is not covered by any of these maps. How do I know the habitat?

A: This inventory program only covered the parts of Manitoba that are currently used for agriculture, approximately 20% of the province. Watercourses outside of these areas were not inventoried by this program. The methods used in this assessment program can be applied to areas outside of those assessed in Agro-Manitoba to determine habitat type. Caution should be used if you wish to apply this assessment methodology outside of Manitoba, as several other provinces have their own habitat classification and mapping methods and requirements (e.g. Alberta Codes of Practice maps).

Q: The drain that I am interested in is not drawn on the map which shows other drains around it. How do I get the habitat classification?
A: Since drain construction is a dynamic process in Manitoba, the base electronic maps are not always up to date. Certain drains can be missed on the maps (e.g. the floodway around the town of Rosenort on the Morris River) and have not been classified. To be cautious the unmapped waterway should be considered the same classification as the watercourse it flows into unless a qualified aquatic environment specialist (e.g. a fisheries consultant) has good information to decide otherwise or if you receive guidance on your project from DFO.

Q: Will the maps be updated with new information?
A: While it is the intention of DFO to update maps periodically there is no fixed schedule for this. The maps have been labeled as "Draft Data subject to ongoing review" to highlight to users that the information on the maps could change. If maps are updated they will likely be released in a new Data or Technical Report, or potentially through the provincial Manitoba Land Initiative (MLI) website. DFO is looking to partner with the Province of Manitoba to have maps placed on the MLI website.

Q: How will these maps be used with the amended Fisheries Act?
A: These maps are useful tools for making quick risk management decisions. They may be referred to in future guidelines, Operational Statements or Standards that are made for Manitoba. Regulatory decisions will be made based on several factors including the fish species, habitat sensitivity, and the type and scale of project being proposed. Site specific information and factors will always be used to inform DFO's regulatory decisions.

Q: How do I know where aquatic species at risk are on this map?
A: While fish species listed under the Species At Risk Act (SARA) as threatened or endangered were considered as indicator species during this inventory, the list of aquatic species at risk is under constant review. Please visit the SARA registry website for details and recovery plans for distribution maps. If an aquatic SARA species is known or suspected in a drain then the habitat of that drain should be considered Type A until site specific review can be completed and information provided by the DFO Fisheries Protection Program and/or Species at Risk Program.

Q: I wish to use the raw data in the Excel spreadsheet, and the GIS shape files for the habitat classifications. How should I cite this information?
A: All of the data tables and classified line segments are found in the data report. The original report should be cited if you use the shape files or Excel spreadsheet to make maps in your GIS, or to present that information in a report. You should indicate that it was adapted from Milani, D.W. 2013. Fish community and fish habitat inventory of streams and constructed drains throughout agricultural areas of Manitoba (2002-2006). Can. Data Rep. Fish. Aquat. Sci. 1247: xvi + 6,153 p.

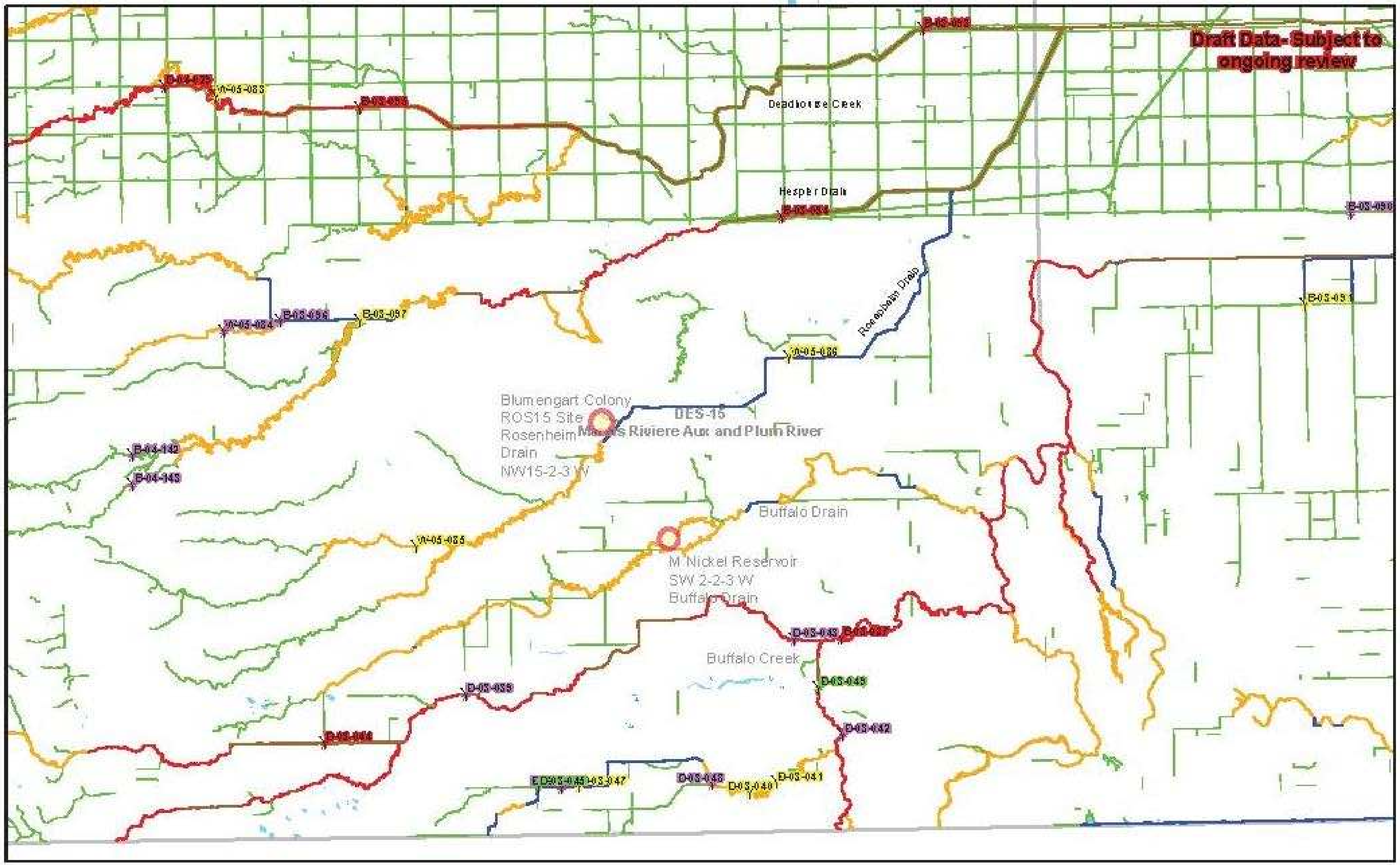
Q: I have downloaded some of the shape files but they are not displaying properly on my GIS. What could be the problem?
A: Be sure to download the “Project File” or .apr file, and all five of the files associated with each of the shape files. Each file (e.g. indicator_species, non_indicator_species, no_catch, des_lines etc.) has a series of similarly named files with different formats including .dbf, .sbn, .sbx, shx, and .shp. Place all the files into the same registry as all are needed to properly display the data. Then when you open the .apr file and point to all the included .shp files when prompted the map is built and displays properly.

The ESRI files that include “basemap” in their name do not need to be downloaded but do provide the study area as “clip” of the entire province. All of the “basemap” ESRI files are public but will not likely be required if inputting the shape files into an existing GIS.

Note: The files are geo-referenced in decimal degrees. If you are using UTM referencing you will need to convert the files from decimal degrees to UTM coordinates (NAD 83, Zone 14).

Q: Our GIS guy is going to add the DFO habitat map layers to Google Earth for us but he had a question about one of the data folders called DES_Line_Data which contains three categories called “Type”, “New Type”, and “Type 08”. He was assuming they refer to the new and old habitat classifications for the watercourses and was wondering which one should he use?
A: To properly display the Type A to Type E classifications have your GIS specialist input the DES lines, the NHN (NTS) lines and the NHN polygons. In each of these data sets the field to the far right side of the tables displays the most recent classification (A to E). Each of these unique values has to be assigned a colour; my colours used in the data report were A= Red, B= Brown, C= Orange, D= Blue, E= Green. Do that for each data set then stack the data so that it displays properly (i.e bottom layer = NHN polygons, next layer NHN lines, then top layer = DES lines).

Q: I have found some typo’s in the report, or want to suggest changes to stream classifications based on site specific assessments. Who should I report this to?
A: Please direct your comments in an email to Todd.Schwartz@DFO-MPO.GC.CA and I will record them. Should significant mistakes be brought to our attention we will add an errors/errata page to the report or otherwise update it on WAVES (the DFO library site).



062G08	062H05	062H06
062G01	062H04	062H03

Habitat Classification

A
B
C
D
E

Fishing Results

Indicator Species
Non-Indicator Species
No Catch
No Fishing Effort

Appendix 9

Sampling sites, fish captures and habitat classification of streams and constructed drains throughout agricultural areas of Manitoba (2002 – 2006)

062H04

Produced April 2012

APPENDIX F – Sediment and Erosion Control Measures

Sediment Control Plan for Construction of Pumped Storage Irrigation Reservoirs

The recommendations outlined herein are specific to pumped storage irrigation reservoirs and are based on the requirements defined in Manitoba Stream Crossing Guidelines for Protection of Fish and Fish Habitat (DFO and MNR, 1996).

The recommendations are provided to the contractors as part of the construction specifications, to provide them with specific measures that will reduce the amount of sediment that enters water bodies adjacent to construction sites to the lowest possible levels practical.

1. Prior to commencement of construction, the contractor will be prepared to control sediment from the construction site with a general plan based on an understanding of the site conditions and will have the materials on site that are needed to implement the plan.
2. The areal extent of the disturbance will be limited to the minimum needed for construction.
3. Existing vegetation; especially adjacent to waterways, shall be left intact wherever possible.
4. Grubbing will not commence until the latest possible time before the actual construction.
5. Materials to be wasted shall be removed from the construction site at the earliest convenience
6. Materials to be stockpiled shall be done in a pre approved location, with appropriate silt fencing perimeter to intercept runoff from the stockpile.
7. Area selected for the stockpiled materials shall be sufficiently removed from the natural stream channel to prevent direct runoff.
8. Grading of the site shall be away from the stream channel to a sump or field or, where possible, into grass or bush areas where sediment will be filtered through the natural vegetation and terrain.
9. Pumping of ponded water from the sump or any excavation where the water has been collected will be to a field or natural terrain and not directly into a stream channel; so that sediment will be filtered through the natural vegetation and terrain.
10. Site grading will be to the most stable inclination possible such that the velocity of runoff flow and associated erosion of exposed soils is minimized.
11. Runoff will be diverted away from exposed soils by the use of berms and appropriate grading.
12. The duration of soil exposure will be minimized through the application of appropriate construction scheduling including the re-establishment of vegetation at the earliest opportunity.
13. Construction scheduling will incorporate concepts to minimize erosion during construction of in stream works including temporary or permanent diversion channels, weirs or any other features which affects flow of water in the stream channel.

APPENDIX G – University of Minnesota – Nutrient Management BMPs for Irrigated Potatoes

UNIVERSITY OF MINNESOTA
EXTENSION

Best Management Practices for Nitrogen Use: IRRIGATED POTATOES

BEST MANAGEMENT PRACTICES FOR NITROGEN APPLICATION

Best Management Practices for Nitrogen Use: Irrigated Potatoes

Carl J. Rosen and Peter M. Bierman, Department of Soil, Water, and Climate, University of Minnesota

Summary

Nitrogen (N) is an essential plant nutrient that contributes greatly to the economic viability of irrigated potato production. Unfortunately, the nitrate form of N can leach into groundwater if N is not managed properly. Contamination of water resources by agricultural production systems will not be tolerated by the public and could lead to laws regulating the use of N fertilizers if this contamination is not minimized.

Research-based Best Management Practices (BMPs) have been developed specifically for irrigated potatoes and integrated into the BMPs that were developed previously for other agronomic crops on coarse-textured soils. Various strategies are provided that take into account N rate, timing of application, method of application, and N source. Optimum N management also depends on the variety grown and its harvest date, so basic principles are similar but specific recommendations differ for early, mid-season, and late-season varieties.

The main objectives of these BMPs are to maintain profitability and minimize nitrate leaching. By following these recommendations, the threat of fertilizer regulations can be avoided and a more profitable and better community can be attained.

Introduction

Nitrogen is an essential plant nutrient that is applied to Minnesota crops in greater quantity than any other fertilizer. In addition, vast quantities of N are contained in the ecosystem, including soil organic matter. Biological processes that convert N to its mobile form, nitrate (NO_3), occur continuously in the soil system. (For greater understanding see: ***Understanding Nitrogen in Soils* AG-FO-3770**). Unfortunately, nitrate can move (leach) below the rooting zone and into groundwater.

In response to the Comprehensive Groundwater Protection Act of 1989, a Nitrogen Fertilizer Management Plan was developed with the purpose of managing N inputs for crop production to prevent degradation of Minnesota water resources while maintaining farm profitability. The central tool for achievement of this goal is the adoption of Best Management Practices for Nitrogen. Best management practices for N are broadly defined as economically sound, voluntary practices that are capable of minimizing nutrient contamination of surface and groundwater. The primary focus of the BMPs is commercial N fertilizers; however, consideration of other N sources and their associated agronomic practices is necessary for effective total N management.

General BMPs for all Regions of the State

The use of BMPs is based on the concept that accurate determination of crop N needs is essential for profitable and environmentally sound N management decisions. General BMPs that apply to all cropping regions in the state are listed below:

- Adjust the N rate according to a realistic yield goal (for all crops except corn and sugar beets) and the previous crop
- Do not apply N above recommended rates
- Plan N application timing to achieve high efficiency of N use
- Develop and use a comprehensive record-keeping system for field specific information.
- If manure is used, adjust the N rate accordingly and follow proper manure management procedures to optimize the N credit:
    - Test manure for nutrient content
    - Calibrate manure application equipment
    - Apply manure uniformly throughout a field
    - Injection of manure is preferable, especially on steep sloping soils
    - Avoid manure application to sloping, frozen soils
    - Incorporate broadcast applications whenever possible

For more detailed information on making the most efficient use of manure nutrients and avoiding potential adverse effects on water quality, see the University of Minnesota Extension publications listed at the end of this bulletin.

The Need for Best Management Practices for Irrigated Potatoes

Most of the BMPs developed for crop production in Minnesota have been based on research with corn and small grains. Management strategies for coarse-textured soils can be found in: ***Best Management Practices for Nitrogen Use on Coarse Textured Soils* (08556, revised 2008)**. In contrast to most agronomic crops, potatoes are a relatively shallow rooted crop and require intensive management to promote growth and yield. In addition, adequate N needs to be available to maintain both yield and tuber quality. The shallow root system of potatoes, the need for adequate N, and the extensive production on sandy soils greatly increase the potential of nitrate contamination of shallow aquifers under irrigated potato production. Fortunately, University of Minnesota research strongly suggests that environmental impacts can be minimized by using nitrogen BMPs specifically designed for potatoes.

While the general BMPs developed for corn and small grains listed above will also apply to irrigated potato production, BMPs focused on irrigated potato production are described within this bulletin so that more precise management practices can be followed. The research-based nitrogen BMPs discussed here, therefore, have been tailored specifically for potato production on irrigated, coarse-textured soils. These BMPs are not only environmentally sound, they are also potentially more profitable. When N leaches below the potato root zone, where it can degrade water quality, it also becomes a purchased input that is lost from the crop production system. Efficient N management that minimizes losses provides both economic and environmental benefits.

Specific Nitrogen Best Management Practices for Irrigated Potatoes

Nitrogen management considerations for irrigated potatoes include decisions regarding: 1) N rate, 2) timing of N application, 3) use of diagnostic procedures to determine N needs during the growing season, 4) effective water management, 5) sources of N, and 6) establishment of a cover crop after harvest. Suggested N management approaches for different varieties and harvest dates of irrigated potatoes are presented following the discussion on BMPs.

Selecting a Realistic Nitrogen Rate

The rate of N to apply to irrigated potatoes primarily depends on the cultivar and date of harvest, expected yield goal, amount of soil organic matter, and the previous crop. Rates of N recommended for potatoes can be found in ***Nutrient Management for Commercial Fruit and Vegetable Crops in Minnesota*** (**AG-BU-5886-F**) and in Appendix A of this document. Response to N by potato is typical of other crops in that the first increment of fertilizer usually brings about the greatest response in yield, followed by a more gradual increase with succeeding increments of N (Table 1). As the N rate increases, however, the potential for losses also increases. In addition to environmental concerns due to excessive N applications, high rates of N can detrimentally affect potato production by promoting excessive vine growth, delaying tuber maturity, reducing yields, decreasing specific gravity, increasing brown center, and inducing knobby, malformed, and hollow tubers. Selecting a realistic N rate is therefore important from both a production and an environmental standpoint. Unfortunately, the effect of excess N on tuber quality is dependent on soil moisture and temperature as well as the cultivar grown. This means that the N rate at which detrimental effects will occur is difficult to predict.

Base N rate on variety, harvest date, and realistic yield goals

Different potato varieties and differences in harvest date will have a pronounced effect on yields and yield goals. Because of lower yield and earlier harvest, early maturing varieties like Red Norland (Table 2) generally require less N than later maturing varieties, such as Russet Burbank (Table 1). A definition of harvest date is as follows: Early - vines are killed or the crop is green dug before August 1; Mid-season - vines are killed or the crop is green dug before September 1; Late - vines are killed or the crop is green dug September 1 or later. Unlike corn and sugar beets, the yield goal concept is still being used to guide N recommendations for potatoes, in conjunction with variety and harvest date, until a more complete measure of the N supplying capacity of the soil is available. Currently N recommendations are also adjusted for the amount of soil organic matter, with higher rates for low organic matter soils than for medium to high organic matter soils which have a greater capacity to release plant-available N. Yield goal for potatoes is based on the total yield obtained rather than the marketable yield, but the two are generally well-correlated. An overestimation of the yield goal will result in excessive applications of N, which can potentially result in nitrate losses to groundwater.

Table 1. Response of Russet Burbank potatoes to nitrogen rate at Becker MN, 2004-2005.

N rate	Marketable*	Total
lb N/A	------------- cwt/A	-------------
0	299	377
30	326	485
80	423	550
120	547	651
160	531	629
180	583	667
240	611	690
320	594	663

*Marketable tubers are greater than 3 oz in size with no visible defects.

Table 2. Response of early harvested Red Norland potatoes to nitrogen rate at Becker MN, 1995-1997.

N rate	Total and Marketable
lb N/A	-- cwt/A --
125	336
165	325
205	324
245	317
285	303

Account for nitrogen from previous crops

Previous crop can also affect N needs. Legumes in a crop rotation can supply significant N to subsequent crops. Research in Wisconsin on sandy soils (Kelling, et al., 1991) found that maximum potato yields following sorghum sudangrass required 40 lb/A more N than following red clover and 80 lb/A more N than when following alfalfa. Similar results from a 20 year study in the Netherlands found that N requirements for optimum potato yield following oats were 60 lb N/A greater than following red clover and 90 lb N/A greater than following alfalfa (Neeteson, 1989). Failing to account for N supplied by legumes can lead to a buildup of soil N and increase the potential for nitrate leaching.

Test irrigation water for nitrogen content and adjust N fertilizer accordingly

The amount of N in the irrigation water should also be considered when adjusting N rates. Nitrate in irrigation water can supply a portion of the N required for crop production. In N calibration studies on potatoes at Becker MN, the nitrate-N concentration in irrigation water ranged from 7 to 10 ppm (parts per million). This concentration of N in the water should be considered as background, but amounts above 10 ppm should be credited as fertilizer N. Additionally, the time to credit N from irrigation water is when the plant is actively growing and taking up N. For late season potatoes this occurs from 20 to 60 days after emergence (Figure 1). Because nitrate-N levels in irrigation water can vary, samples of irrigation water need to be tested annually during the pumping season to determine approximate nitrate-N concentrations.

If nitrate-N in irrigation water is one ppm, then each inch of irrigation water applied is equal to 0.225 pounds of N applied per acre. As an example, if irrigation water is found to have 20 ppm nitrate-N and 9 inches of water are applied during the active part of the growing season, then about 40 lbs of N/A would be supplied with the water (0.225 * 9 * 20). After subtracting the background amount of 20 lb N/A, the remaining 20 lb N/A should be credited toward the total amount of N applied. In practice, you will not know how much N was applied in irrigation water until after the active growth period when all or most of the N fertilizer has already been applied, so for the current growing season you will have to estimate the N credit for irrigation water from records of previous years.

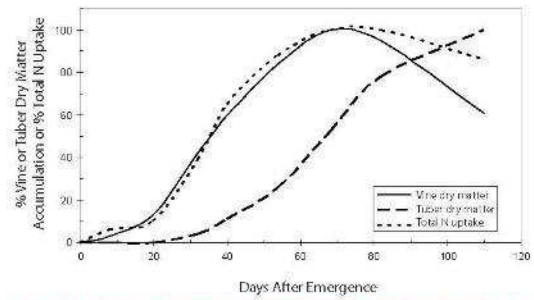


Figure 1. Relative tuber growth, vine growth and total nitrogen uptake by the potato crop. Based on data from the Russet Burbank variety.

Timing of Nitrogen Application: Match N Application with Demand by the Crop

One of the most effective methods of reducing nitrate leaching losses is to match N applications with N demand by the crop.

Do not fall apply N on sandy soils (sands, loamy sands, and sandy loams)

Do not use more than 40 lbs N/A in the starter for mid/late season varieties

Do not use more than 60 lbs N/A in the starter for early harvested varieties

Nitrogen applied through the hilling stage should be cultivated/incorporated into the hill

Plan the majority of soluble N inputs from 10 to 50 days after emergence

Nitrogen applications in the fall are very susceptible to leaching. Nitrogen applied early in the season when plants are not yet established is also susceptible to losses with late spring and early summer rains. Most nitrification inhibitors are not registered for potatoes and therefore cannot be recommended. Peak N demand and uptake for late season potatoes occurs between 20 and 60 days after emergence (Figure 1). Optimum potato production depends on having an adequate supply of N during this period. The recommendation is to apply some N at planting for early plant growth and to apply the majority of the N in split applications beginning slightly before (by 10 days) the optimum uptake period. This assures that adequate N is available at the time the plants need it and avoids excess N early in the season when plant growth is slow and N demand is low.

Research at the Sand Plain Research Farm at Becker, with full season varieties like Russet Burbank, demonstrates that nitrate movement below the root zone can be reduced by lowering the amount of N in the starter fertilizer without affecting yields (Table 4). Starter fertilizer should contain no more than 40 lb N/A for full season varieties. Uptake of N by the crop (vines plus tubers) increases when split N applications are used compared with large applications applied before emergence. Nitrogen applied through the hilling stage should be incorporated into the hill to maximize availability of the N to the potato root system.

Just as N fertilizer applied too early in the season can potentially lead to nitrate losses, so can N fertilizer applied too late in the season. Nitrogen applied beyond 10 weeks after emergence is rarely beneficial and can lead to nitrate accumulation in the soil at the end of the season. This residual nitrate is then subject to leaching.

For determinate early harvested varieties like Red Norland, higher rates of N in the starter may be beneficial (Table 5). These varieties tend to respond to higher rates of early N than indeterminate varieties, but the total amount of N required is generally lower because of lower yield potential and early harvest. In addition, late application of N to these varieties will tend to delay maturity and reduce yields, particularly if the goal is to sell for an early market. In many cases it is not possible to know when the exact harvest date will be as this will depend on market demands as well as weather conditions during the season. Because of these unknowns it is important to have some flexibility in both rate and timing of N application.

Table 4. Nitrogen starter effects on Russet Burbank potato yield and nitrate-N leaching to the 4½ ft depth. Means of 1991 and 1992.

Timing of N application			Yield		NO_3-N Leaching
Planting	Emergence	Hilling	Total	Marketable	
lb N/A			cwt/A		lb/A
0	0	0	359.9	292.3	18
0	120	120	602.7	532.8	76
40	100	100	594.0	518.5	114
80	80	80	612.9	519.7	134
120	60	60	589.4	493.5	158

Errebhi et al., 1998.

Table 5. Nitrogen starter effects on Red Norland potato yield, Becker - 1995-1997.

Timing of N application			Total Yield
Planting	Emergence	Hilling	
lb N/A			cwt/A
25	70	70	325
45	60	60	328
65	50	50	338
85	40	40	337

Use petiole analysis to aid in making post-hilling nitrogen applications

Increases in N use efficiency have been shown when some of the N is injected into the irrigation water after hilling (fertigation). Because the root system of the potato is largely confined to the row area during early growth, do not fertigate until plants are well established and potato roots have begun to explore the furrow area between rows. This is usually about three weeks after emergence. Nitrogen applications after this time are most beneficial in years when excessive rainfall occurs early in the growing season (Tables 6 and 7). In dry years with minimal leaching, N applications later than 16 days after emergence show little if any advantages from a production standpoint over applying all of the N by that stage (Tables 7 and 8). However, leaching losses can still be reduced.

Table 6. Effect of N applications later than 16 days after emergence on Russet Burbank yield, Becker – 1991 (high leaching year).

Timing of N application[1]				Tuber Distribution					
Plant.	Emerge.	Post Emerge.	Late PE	Culls	<3 oz	3-7oz	7-14oz	>14oz	Total
lb N/A				cwt/A					
40	40	40	0	23	51	240	158	5	477
80	80	80	0	28	47	224	179	8	486
40	40	40	80	36	42	221	200	13	512

[1]Planting, emergence, 16 days post-emergence, and two late post-emergence applications more than 16 days after emergence of 40 lb N/A per application.

Table 7. Effects of excessive irrigation and nitrogen rate, source, and timing on cumulative NO$_3$-N leaching to the 4 ft depth (Zvomuya et al., 2003).

N Rate	N Source	Irrigation: Standard	Irrigation: Excessive
		NO$_3$-N leaching	
lb N/A		lb N/A	
0	----	46	61
125	urea[1]	59	88
125	PCU[2]	55	84
250	urea[3]	75	204
250	PCU[2]	50	128
250	posthill[4]	80	121

[1]25 lb N/A at planting, 50 lb N/A at emergence, and 50 lb N/A at hilling.
[2]Polyolefin-coated urea in a single application at planting.
[3]25 lb N/A at planting, 112 lb N/A at emergence, and 112 lb N/A at hilling.
[4]25 lb N/A as urea at planting, 72 lb N/A as urea at emergence, 72 lb N/A as urea at hilling, and 40 lb N/A as equal amounts of N from urea and ammonium nitrate at 3 and 5 weeks after hilling.

Table 8. Effect of N applications later than 16 days after emergence on Russet Burbank yield, Becker – 1992 (low leaching year).

Timing of N application[1]				Tuber Distribution					
Plant.	Emerge.	Post Emerge.	Late PE	Culls	<3 oz	3-7oz	7-14oz	>14oz	Total
lb N/A				cwt/A					
40	40	40	0	32	58	267	158	3	518
80	80	80	0	31	53	281	223	12	601
40	40	40	80	29	58	246	195	14	541

[1]Planting, emergence, 16 days post-emergence, and two late post-emergence applications more than 16 days after emergence of 40 lb N/A per application.

If applications of N later than 16 days after emergence are used, then 2/3 to 3/4 of the recommended N fertilizer should be applied by that stage. Timing of the remainder of the N applications should be based on petiole nitrate-N levels determined on either a dry weight or sap basis. Table 9 shows suggested sufficiency ranges for Russet Burbank potatoes through the growing season. Other potato varieties may vary slightly in their sufficiency ranges. However, the ranges in Table 9 are still a suitable starting point to adjust post-emergence N applications for other varieties. Typically if N is needed, 20 to 40 lb N/A can be injected per application.

Another potential in-season monitoring tool is soil testing for plant-available inorganic N in the upper 12 to 18 inches of the soil. Samples should be collected from the hill area in sets of five soil cores and analyzed for nitrate-N and ammonium-N. One core should be from the top of the hill, one core from each side of the hill half-way up the side slope, and one core from each side at the base of the hill. Initial research on in-season soil testing suggests that sufficiency levels for total inorganic N (nitrate-N + ammonium N) in the 0-1 ft depth for Russet Burbank are about 140 lb N/A (35 ppm) during initial bulking (June) and 80 lb N/A (20 ppm) during early bulking (July). Additional research is necessary to calibrate in-season soil tests and determine how much N to apply at specific soil test levels. Soil testing should be viewed as a tool to help fine tune N management and used in conjunction with, not as a substitute for, petiole testing.

One danger of relying on N applications through the irrigation system occurs when rainfall patterns during the time for fertigation are adequate or excessive. Applying N through the system in this case may potentially lead to an increase in nitrate leaching if high amounts of irrigation water are also applied. In situations where there is a demand for N, but rainfall has been adequate or excessive, low amounts (less than 0.3 inch) of water should be applied with the N fertilizer. Another potential problem with delayed N application occurs when the potato crop dies back early due to insects or diseases. In this situation, N applied more than 16 days after emergence may not be used as efficiently and they may increase N leaching losses. It is essential therefore, that an integrated cropping approach be taken to minimize nitrate leaching losses.

Selecting Appropriate Nitrogen Sources

Do not use fertilizers containing nitrate in the starter

Each fertilizer N source used for potatoes has advantages and disadvantages, depending on how they are managed. However, because leaching often does occur in the spring, fertilizer sources containing nitrate (i.e. UAN-28 and ammonium nitrate) should be avoided at planting. Ammonium sulfate, diammonium phosphate, monoammonium phosphate, poly ammonium phosphate (10-34-0), or urea are the preferred N sources for starter fertilizer. Advantages of urea compared with ammonium nitrate are greater availability, lower cost, and delayed potential for leaching. Disadvantages of urea are that it is hygroscopic (attracts water), it must be incorporated after application or ammonia volatilization losses may occur, and its slow conversion to nitrate in cool seasons may reduce yields. Anhydrous ammonia may be beneficial in delaying the potential for leaching losses; however, positional availability of the N in relation to the hill may be a problem with sidedress applications. Further research needs to be conducted on the use of anhydrous ammonia for potato.

Table 9. Petiole nitrate-N sufficiency levels for Russet Burbank potatoes on a dry weight and sap basis.

Time of Season/ Stage of Growth	Sap NO_3-N	Dry wt. NO_3-N
	ppm	
Early Vegetative/tuberization (June 15 - June 30)	1200 – 1600	17,000 - 22,000
Mid Tuber growth/bulking (July 1 - July 15)	800 – 1100	11,000 - 15,000
Late Tuber bulking/maturation (July 15 - August 15)	400 – 700	6,000 - 9,000

Table 10. Effect of a controlled release N source on potato (Russet Burbank) yield, Becker – 2005.

N rate[1]	N source			
	Urea	ESN[2]	Urea	ESN[2]
	Total Yield		Marketable Yield	
---- lb N/A ----		cwt/A		
80	643	679	499	526
160	698	695	579	582
240	676	677	583	560
320	660	625	576	519
240 (ESN emergence)	-	737	-	631

1All treatments received 40 lb N/A from diammonium phosphate at planting.
2ESN was applied at planting, except for the second 240 lb N/A rate which was applied at emergence.

Substantial reductions in nitrate leaching can occur if controlled release sources of N are used (Table 7). Controlled release N sources include polymer coated urea that can be formulated to release N over various time intervals. These controlled release sources can also be applied earlier in the season without the fear of nitrate leaching losses. The main disadvantages of controlled release N fertilizer are delayed release to ammonium and nitrate when soil temperatures are cool and the higher cost of many of the products compared to conventional quick release N fertilizers. However, there are some newer slow release fertilizers on the market that are more economical and the cost savings of being able to make a single N fertilizer application rather than multiple applications is another factor to consider. Table 10 shows the yield response to ESN, a relatively low cost controlled release N fertilizer, compared to quick release urea applied using standard split application practices. When ESN was applied at planting there was a reduction in marketable yield at the higher N rates compared with urea, but ESN (240 lb N/A) applied at emergence produced the highest total and marketable yields in the study. Further research with low cost controlled release sources needs to be conducted to evaluate effects on tuber quality and nitrate leaching.

For mid to late season varieties, apply ESN no later than emergence.

ESN for early harvested potatoes (vines killed or green dug before August 1) is not recommended due to slow release of N.

Water Management Strategies

Follow proven water management strategies to provide effective irrigation and minimize leaching

Water management has a profound effect on N movement. While leaching of nitrate due to heavy rainfall cannot be completely prevented, following the N management strategies discussed above will minimize these losses. However over-irrigation, even with optimum N rate applied and proper timing of N application, can cause substantial leaching losses. Therefore, effective water scheduling techniques based on soil moisture content and demand by the crop should be followed to prevent such losses. For more information on irrigation scheduling, refer to: ***Irrigation Water Management Considerations for Sandy Soils in Minnesota*, AG-FO-3875**.

Cover Crops Following Potatoes

Establish a cover crop following potatoes whenever possible

For early harvested potatoes (July/August), any nitrate remaining in the soil is subject to leaching with rainfall. Establishing a cover crop such as winter rye will take up residual N to minimize this potential loss. An additional benefit of the cover crop is to reduce wind erosion. After the cover crop is killed or plowed under, N will be released from the vegetation the following spring. Cover crops can also be planted after potatoes harvested in September/October, although the purpose here is more for erosion control than to reduce N losses.

Specific Best Management Practices for Irrigated Potatoes on Coarse-Textured Soils

Best management strategies for irrigated potatoes need to be somewhat flexible because of differences due to soil type, unpredictable weather, and the numerous potato cultivars grown. However, some general guidelines should be followed with the understanding that modifications may be necessary to fit specific situations and that fine-tuning BMPs for N is an ongoing process. Based on the research conducted with potatoes on sandy soils, the following best management options for N are suggested (these suggestions are based on research with Russet Burbank, an indeterminate late season variety and Red Norland, a determinate early season variety; response may vary with other varieties):

Mid/late season varieties - Vines killed or green dug August 1 or later

Option 1 - when fertigation is available:

- Apply up to 40 lb N/A in the starter (this amount should be included in meeting the total recommended N rate)
- Apply one-third to one-half of the recommended N at or around emergence and cultivate/incorporate the fertilizer into the hill; if ESN is used, apply no later than emergence and incorporate in the hill
- If hilling at emergence is the final hilling operation, begin fertigation 14-21 days later and apply the remainder of the recommended N in increments not exceeding 40 lb N/A
- If a final hilling operation is done 10-14 days after emergence, apply one-third of the recommended N at that time and cultivate/incorporate the fertilizer into the hill. On

heavier textured soils during rainy periods, it may not be possible to time this application properly due to row closure; in this situation, the N can be applied using fertigation

- Base timing of subsequent N applications on petiole analysis; apply up to 40 lb N/A per application through the irrigation system
- Establish a cover crop after harvest whenever possible

Option 2 - for mid/late season varieties when fertigation is not available:

- Apply up to 40 lb N/A in the starter (this amount should be included in meeting the total recommended N rate)
- Apply one-third to one-half of the recommended N at or around emergence and cultivate/incorporate the fertilizer into the hill; if ESN is used, apply no later than emergence and incorporate in the hill
- Apply the remainder of the recommended N rate at final hilling and cultivate/incorporate the fertilizer into the hill
- Establish a cover crop after harvest whenever possible

Option 1 has generally shown better N use efficiency, particularly during years when excessive rainfall has occurred before hilling. Remember that best management practices are based on the most current research available. As more information becomes available through research efforts, some modification of BMPs may be necessary.

Early season varieties, with or without fertigation - Vines killed or green dug before August 1

- Apply up to 60 lb N/A in the starter (this amount should be included in meeting the total recommended N rate)
- Apply one-third to two-thirds of the recommended N at or around emergence and cultivate/incorporate the fertilizer into the hill
- Apply the remainder of the recommended N rate at final hilling and cultivate/incorporate the fertilizer into the hill
- If fertigation is available, base timing of subsequent N application on petiole analysis; if needed, apply up to 30 lb N/A per application through the irrigation system; avoid late applications of N, because that will delay maturity
- Establish a cover crop after harvest

References

Errebhi, M., C.J. Rosen, S.C. Gupta, and D.E. Birong. 1998. Potato yield response and nitrate leaching as influenced by nitrogen management. Agronomy Journal. 90:10-15.

Kelling, K.A., D. Hero, C.R. Grau, D.I. Rouse, and A.C. MacGuidwin. 1993. Potato responses to nitrogen following various legumes. Proceedings of the Wisconsin Annual Potato Meetings. pp. 93-103.

Neeteson, J.J.. 1989. Effect of legumes on soil mineral nitrogen and response of potatoes to nitrogen fertilizer. In: J. Vos, C.D. van Loon, and G.J. Bollen, eds. Effects of Crop Rotation on Potato Production in Temperate Zones, p. 89-93. Kluwer Academic Publishers.

Zvomuya, F., C.J. Rosen, M.P. Russelle, and S.C. Gupta. 2003. Nitrate leaching and nitrogen recovery following application of polyolefin-coated urea to potato. Journal of Environmental Quality. 32:480-489.

Publications on Manure Management

Manure Management in Minnesota, FO-3553

Fertilizing Cropland with Swine Manure, FO-5879

Fertilizing Cropland with Dairy Manure, FO-5580

Fertilizing Cropland with Poultry Manure, FO-5881

Fertilizing Cropland with Beef Manure, FO-5582

Self-assessment Worksheets for Manure Management Plans

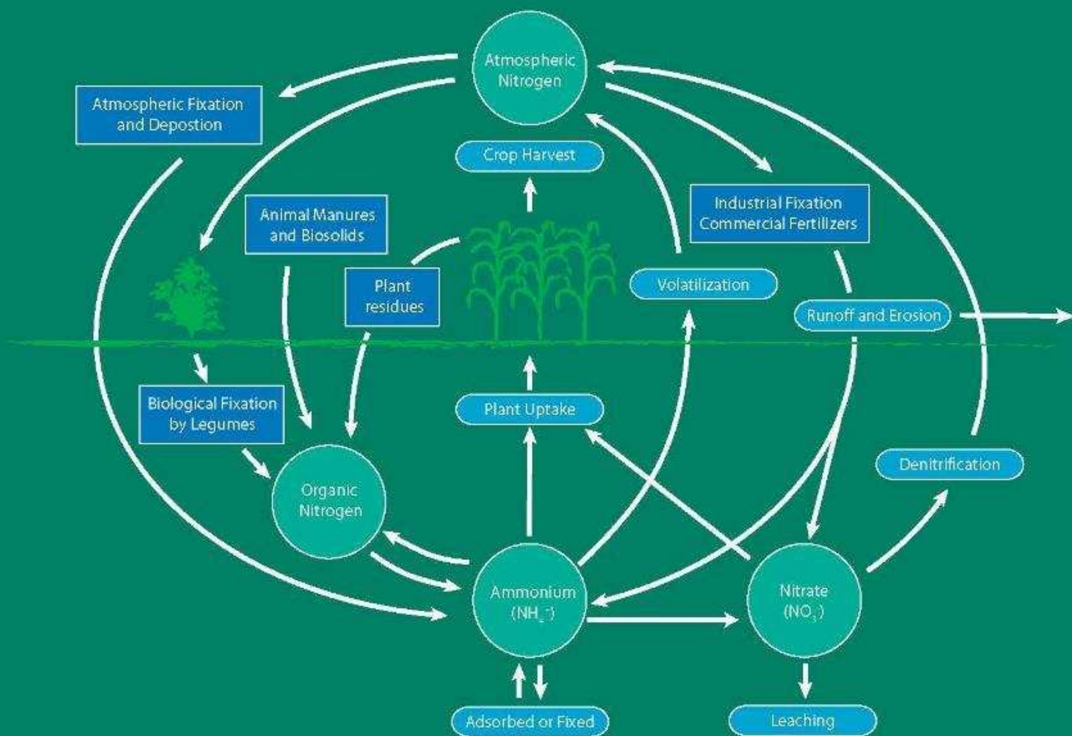
Appendix A

Nitrogen recommendations for irrigated potato production.

		Previous Crop and Organic Matter (O.M.) Level							
		alfalfa (good stand)[1] -O.M.[2]-		soybeans field peas -O.M.-		any crop in group 1 -O.M.-		any crop in group 2 -O.M.-	
Yield Goal[3]	Harvest Date[4]	low	medium to high	low	medium to high	low	medium to high	low	medium to high
cwt/A		N to apply (lb/A)							
<250	Early	0	0	80	60	60	40	100	80
250-299		25	0	105	85	85	65	125	105
300-349		50	30	130	110	110	90	150	130
350–399	Mid	75	55	155	135	135	115	175	155
400–449		100	80	180	160	160	140	200	180
450–499	Late	125	105	205	185	185	165	225	205
500+		150	130	230	210	210	190	250	230

Crops in Group 1	Crops in Group 2		
alfalfa (poor stand)[1]	barley	grass hay	sorghum-sudan
alsike clover	buckwheat	grass pasture	sugarbeets
birdsfoot trefoil	canola	millet	sunflowers
grass-legume hay	corn	mustard	sweet corn
grass-legume pasture	edible beans	oats	triticale
red clover	flax	potatoes	wheat
fallow		rye	vegetables

[1]Poor stand is less than 4 crowns per sq. ft.
[2]Low = less than 3.1% O.M., medium to high = 3.1-19% O.M.; greater than 19% O.M. would be an organic soil and not a coarse-textured soil.
[3]Yield in this table refers to total yield not marketable yield.
[4]Early = vines killed or green dug before August 1; Mid = vines killed or green dug August 1-August 31; late = vines killed or green dug after Sept 1.

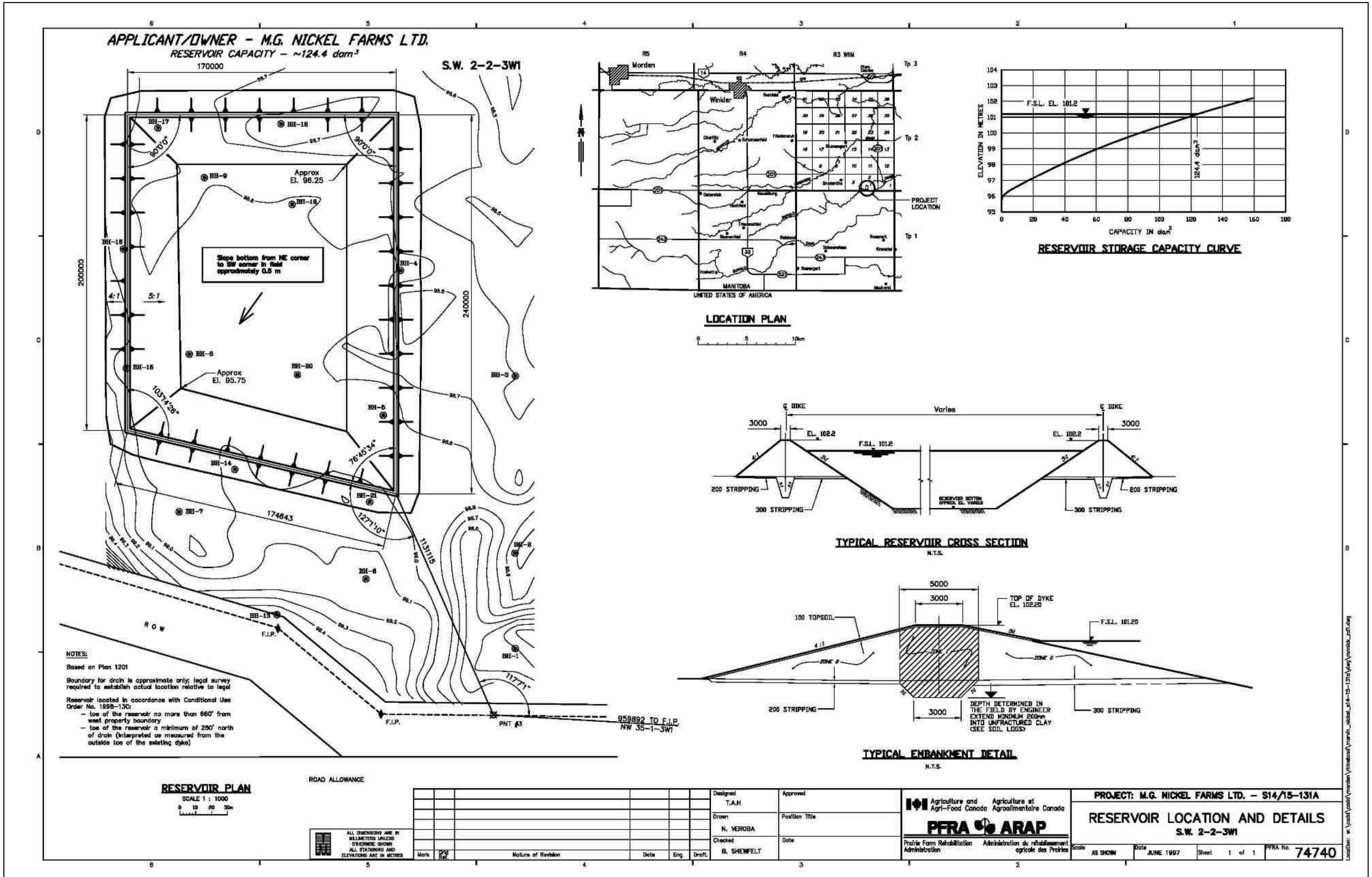


UNIVERSITY OF MINNESOTA EXTENSION

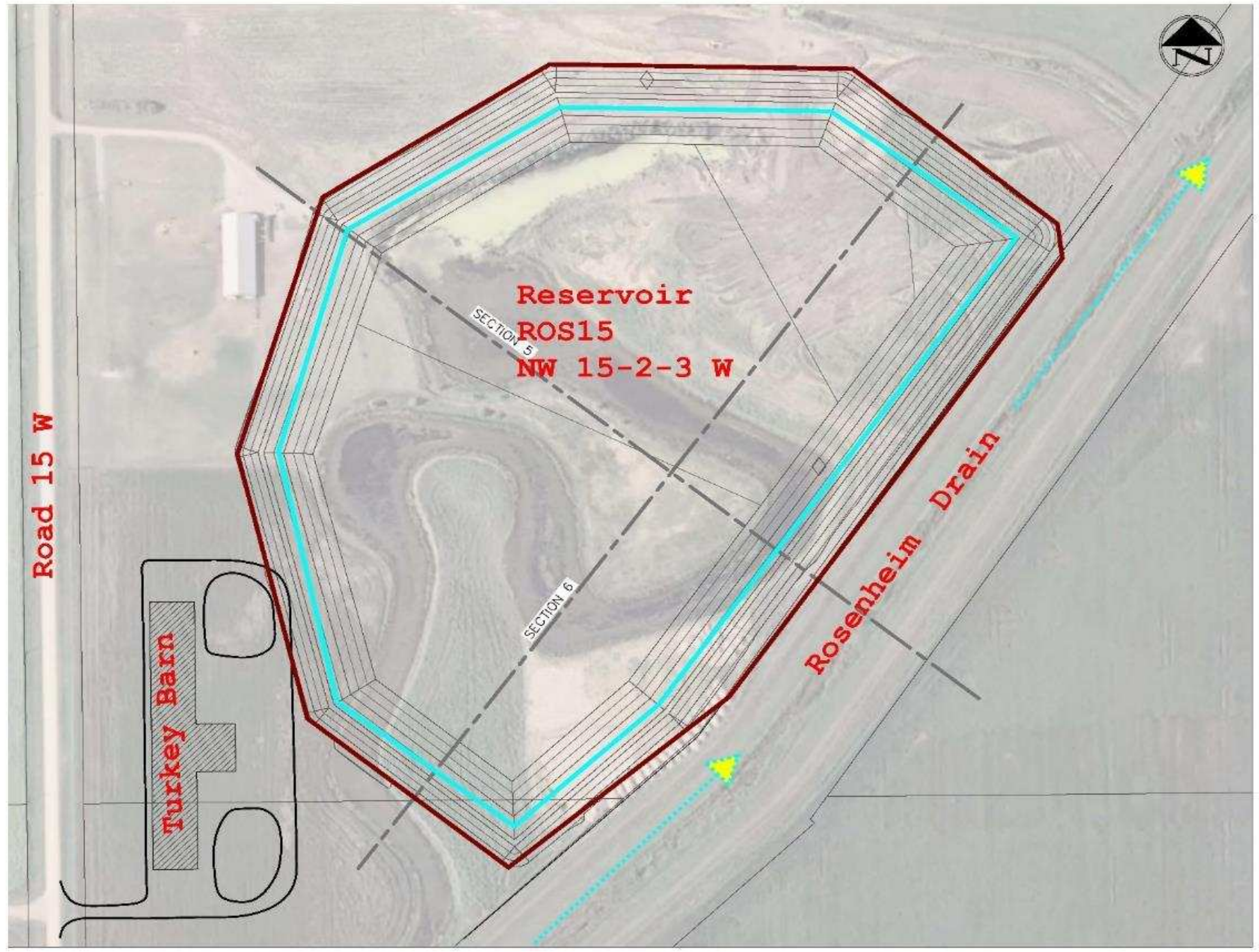
Best Management Practices for Nitrogen Use: Irrigated Potatoes

PUBLICATION # 08559

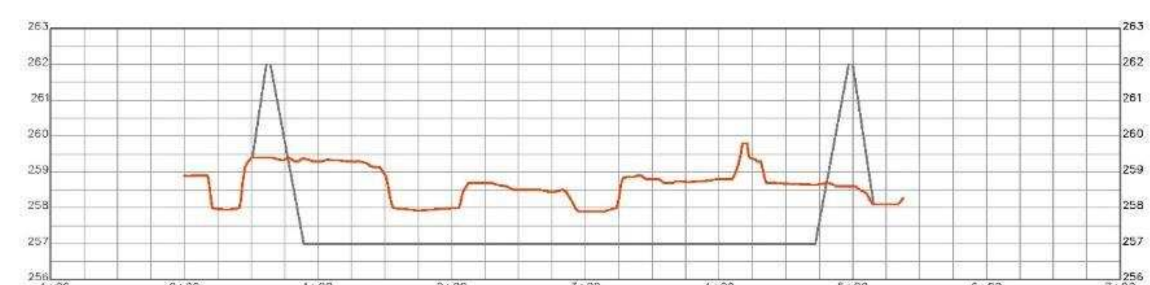
APPENDIX H – Engineering Drawings and Other Background Information



APPLICANT/OWNER – M.G. NICKEL FARMS LTD.
RESERVOIR CAPACITY – ~124.4 dam³
S.W. 2-2-3W1
Slope bottom from NE corner to SW corner in field approximately 0.5 m
Approx El. 96.25
Approx El. 95.75
959892 TO F.I.P. NW 35-1-3W1
ROAD ALLOWANCE
NOTES:
Based on Plan 1201
Boundary for drain is approximate only; legal survey required to establish actual location relative to legal
Reservoir located in accordance with Conditional Use Order No. 1998-13C:
– toe of the reservoir no more than 660' from west property boundary
– toe of the reservoir a minimum of 250' north of drain (interpreted as measured from the outside toe of the existing dyke)
RESERVOIR PLAN
SCALE 1 : 1000
LOCATION PLAN
PROJECT LOCATION
RESERVOIR STORAGE CAPACITY CURVE
F.S.L. EL. 101.2
ELEVATION IN METRES
CAPACITY IN dam³
TYPICAL RESERVOIR CROSS SECTION
N.T.S.
TYPICAL EMBANKMENT DETAIL
N.T.S.
TOP OF DYKE EL. 102.20
F.S.L. 101.20
100 TOPSOIL
200 STRIPPING
300 STRIPPING
DEPTH DETERMINED IN THE FIELD BY ENGINEER EXTEND MINIMUM 250mm INTO UNFRACTURED CLAY (SEE SOIL LOGS)
ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SHOWN ALL STATIONING AND ELEVATIONS ARE IN METRES
Mark
Grid Ref.
Nature of Revision
Date
Eng.
Draft.
Designed T.A.H
Approved
Drawn N. VEROBA
Position Title
Checked B. SHEWFELT
Date
Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
PFRA ARAP
Prairie Farm Rehabilitation Administration
Administration du rétablissement agricole des Prairies
PROJECT: M.G. NICKEL FARMS LTD. – S14/15-131A
RESERVOIR LOCATION AND DETAILS
S.W. 2-2-3W1
Scale AS SHOWN
Date JUNE 1997
Sheet 1 of 1
PFRA No. 74740



SECTION 5



SECTION 6

Cut/Fill Summary

Name	Cut Factor	Fill Factor	2d Area	Cut	Fill	Net
Volume - Earth	1.000	1.000	120423.36sq.m	117464.01 Cu. M.	61823.40 Cu. M.	55640.61 Cu. M.<Cut>
Volume - Water	1.000	1.000	103109.84sq.m	441352.04 Cu. M.	0.00 Cu. M.	441352.04 Cu. M.<Cut>
Totals			223533.19sq.m	558816.05 Cu. M.	61823.40 Cu. M.	496992.65 Cu. M.<Cut>

NORTH

BLUMENGART COLONY
RESERVOIR & PIPELINE STRATEGY
2020

PROJECT NUMBER 10375-1

NW-15-02-03W
PRELIMINARY DESIGN LAYOUT

SHEET
06

PRECISION LAND SOLUTIONS

Tile Drainage Plan

Client: Blumengart Colony

Location: Main Farm

Field Name: Various

Date: March 3, 2015

Contractor: Precision Land Solutions

Specifications

Project Acreage: ~4,160 acres

Lateral Spacing: ~50 ft

Tile Type: Non-perf. Mains; Filtered Laterals

Project Depth: 2.4-7.5 ft

Drainage Coefficient: 1/4"/day

Flow Rate: 19,600 gpm

Outlet Type: Pumps

Surveyor/Designer: D.S.-LiDAR/L.R.

Legend

18" Dual Wall:

15" Dual Wall:

12" Dual Wall:

12" Single Wall:

10" Single Wall:

8" Single Wall:

6" Single Wall:

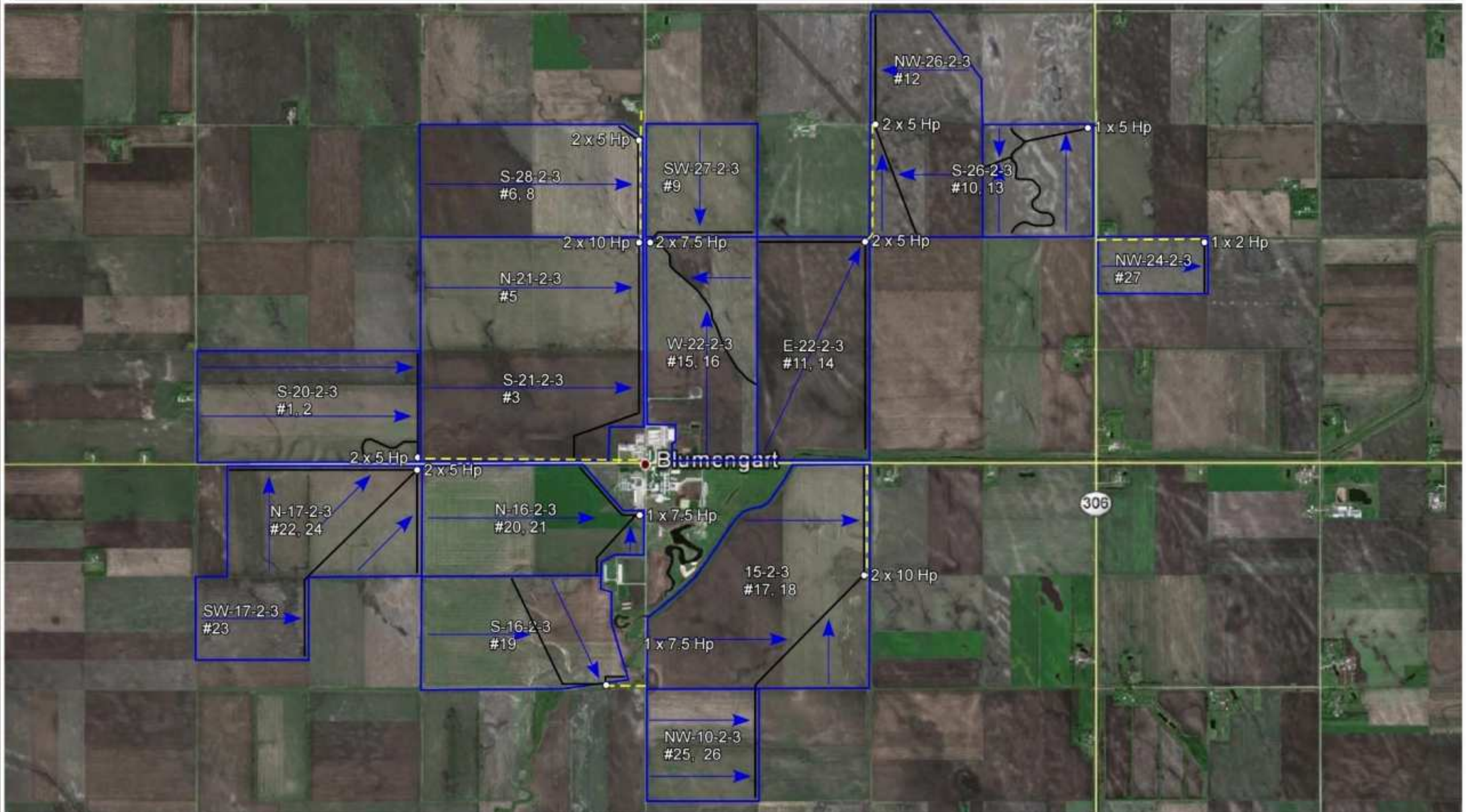
4" Single Wall:

Buried Electrical:

Grade Break:

Irrigation Pipeline:

Notes



APPENDIX I – Beneficial Management Practices for Agricultural Tile Drainage in Manitoba (PAMI)

Controlled Tile Drainage

IF-04

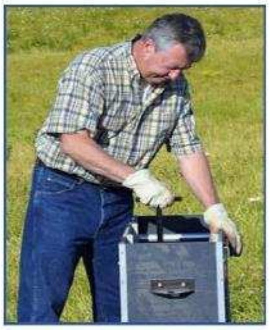


Figure 1. Operating a water control structure (USDA-NRCS).

What can controlled tile drainage accomplish?

The objectives of controlled tile drainage, also known as drainage water management, are ***Improving Water Quality*** and ***Conserving Water***. Controlled tile drainage systems make it possible to retain water in the soil profile, reducing the amount discharged from the tiles to downstream receiving waters. Crops benefit from the stored water and any nutrients contained in it during dry periods. At other times, such as seeding and harvest, excess water is allowed to flow freely from the tiles to achieve favourable field conditions.

Leading US researchers (e.g. Christianson et al., 2016) consider controlled drainage a cost-effective water management tool.

Overview of controlled tile drainage

Controlled drainage is the use of one or more flow restricting devices (such as stop logs, risers, gates, and valves) placed inline with the tile drainage pipes, allowing the water level in the field to be artificially set. Pump level controllers on lift stations located at the main outlet, can also be used to set the water level. Each control structure will influence a portion of the field called a water management zone.

Although an existing tile drainage network can be retrofitted to include controlled drainage, ideally this practice should be considered during the initial design phase. Field elevations must be mapped for the appropriate placement of the tiles, control structures and the establishment of the water management zones. Usually, one control structure is needed for every 30 to 45 cm (1 to 1.5 ft) elevation change along the main line.

The current industry standard is the inline stop log control structure (Figures 1 and 2). By manipulating the settings of the control structure, water is held back to raise the height of the water table within a water management zone. When all stop logs have been removed, the system reverts to free (conventional) tile drainage. Stop logs can be adjusted manually (Figure 1); however, automation and remote controls are also available. A controlled tile drainage system is expected to last as long as a conventional tile drainage system (>50 years).

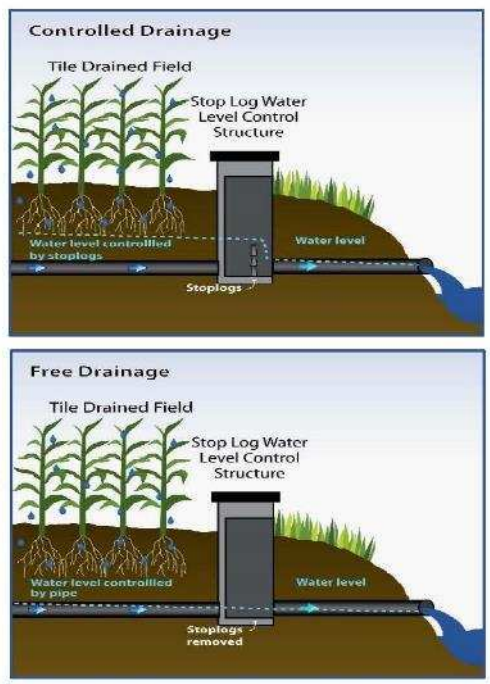


Figure 2. Controlled drainage using stop log control structures (top) and free drainage with stop logs removed (bottom).

Applicability of controlled tile drainage in Manitoba

Manitoba often has too much water when it is not needed, such as in the spring, and not enough water when it is dry. In most years, agri-Manitoba is subject to crop-water deficit during the growing season, meaning that soil moisture reserves and growing season precipitation are often inadequate to meet crop needs. Controlled drainage provides a means of storing water in the ground for crop use in dry periods.

Controlled drainage is best-suited to nearly-level land, ideally with an average slope of less than 0.5% (Christianson et al., 2016). A significant portion of agri-Manitoba meets this slope criterion; however, the suitability of this practice for any given field will depend on additional site-specific characteristics and economics.

Current research findings on controlled tile drainage

Controlled drainage has been studied extensively in the USA, especially in the upper Midwest. Crop yield and nitrate reduction benefits from various states are illustrated in Figure 3 (Christianson et al., 2016). The benefits of controlled drainage in Manitoba are expected to be different than in the upper Midwest due to differences in hydrology between the two regions. The overall drainage volume in Manitoba is lower and the overall water deficit in Manitoba is typically higher.

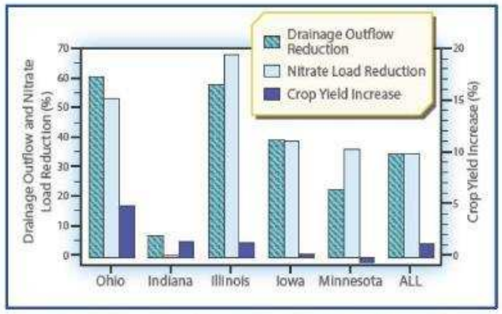


Figure 3. Drainage outflow and nitrate load reduction and crop yield increase resulting from controlled drainage vs. conventional drainage systems (Christianson et al., 2016).

Cordeiro (2013) confirmed that during short periods of water deficit, the shallow water table can meet a significant portion of crop water demand (Figure 4). Crop water demand is reflected in the measurements of hourly ETc (dashed line). Increases in hourly ETc correspond with observed drops in the water table (solid line), confirming shallow groundwater usage by the crop. As the shallow water table often contains elevated nitrate levels, holding back groundwater with controlled drainage can also supply nutrients to the crop.

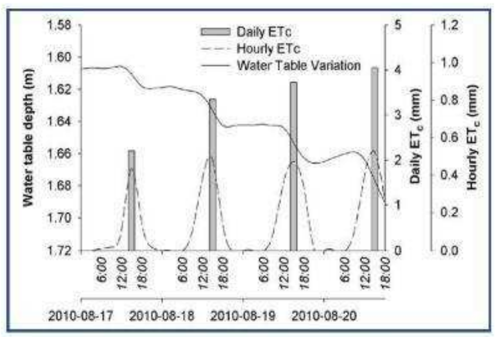


Figure 4. Contribution of shallow water table to meeting crop water demand (Daily ET_c) (Corderio, 2013).

Controlled drainage systems can be designed to include sub-irrigation, which involves feeding water back through the tile to supply the crop from below. Cordeiro (2013) and Satchithanantham (2013) studied sub-irrigation of corn and potatoes in Manitoba. While both studies confirmed the contribution of the shallow water table to crop production, they also revealed obstacles to adoption of sub-irrigation, such as lateral seepage. Several technical issues (e.g. water treatment) need to be addressed prior to adopting sub-irrigation as a BMP in Manitoba.

There is significant research in California showing shallow water tables within 1.8 m (6 ft) of the surface benefit crop yield (University of California, 2015; Ayers et al., 2006); supporting that controlled tile drainage in semi-arid regions such as Manitoba will also increase yields.

What are some design and operational considerations?

Controlled drainage can add significantly to the capital cost and operational complexity of a tile drainage system warranting *Professional Services* (see *BMP EA-01*).

Figure 5 shows the layout of a 300-acre controlled drainage system near Homewood, MB. Differences in design features of a control drainage system vs a conventional system include:

- Shorter lateral lines;
- Extra sub-mains to create water management zones;
- Multiple in-line stop log structures and buried control valves to establish and maintain water levels in each zone.

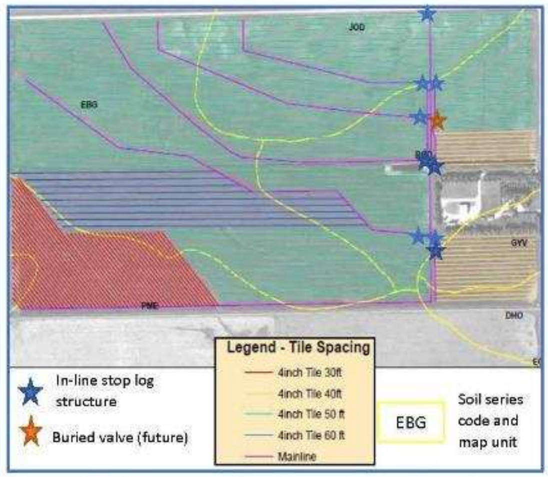


Figure 5. Typical controlled drainage design in Manitoba.

In addition to field elevations, engineering design should consider water table elevations, soil type and variability, locally-measured flow rates, drainage intensity (i.e depth/spacing tiles) and potential for lateral flow. Sub-irrigation adds further design complexity and requires a source of irrigation water.

Controlled drainage is best designed to capture a portion of the tile flow, after allowing tile water to flow freely early in the growing season. Based on a modelling exercise by Sands (2013) and the results of the Cordeiro (2013) and Satchithanantham (2013) studies, a reasonable target for Manitoba would be to save up to 25 mm (1 in) of tile drainage water for crop use, by holding back 300 mm (12 in) of water depth. Establishing a rough schedule for holding back and releasing tile water is an important component of controlled drainage. A properly managed controlled drainage system could have reduced the amount of irrigation that was otherwise required in the summer of 2011 (Figure 6).

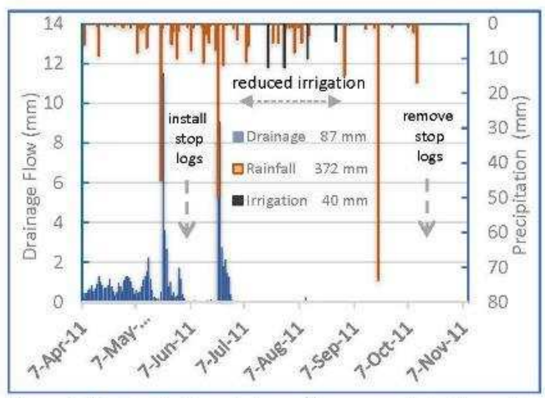


Figure 6. Illustrative free drainage flow vs. precipitation and irrigation (Cordeiro, 2013); showing potential to install stop logs at start of June to conserve water for July/August and removal of stop log in late October.

The performance of a controlled drainage system should be monitored. Crop response, soil moisture levels, and the use of piezometers to track changes in the water table can aid in optimizing performance. Guidance for the design and operation of a controlled drainage system is provided in the Drainage Water Management chapter of the Conservation Practice Standards series published by USDA–NRCS.

Outstanding questions and potential future improvements

Controlled drainage is a proven technology, with most experience gained in the Upper Midwest of the USA, Ontario and Quebec. Optimizing design and performance for Manitoba conditions requires additional research and development, including:

- Further information is required on timing of stop log adjustments relative to crop stage and/or growing season parameters (e.g. planting date, heat units), as well as water table response to evapotranspiration.
- The implications of controlled tile drainage for greenhouse gas emissions and adaptation to climate change should be studied.
- Site selection and design criteria based on soil texture and stratigraphy, hydraulic conductivity, and existing ground and groundwater gradients should be established.
- Field measurements at local research and demonstration sites, and modelling (Skaggs et al., 2012) are needed to assess:
  - the agronomic benefits of controlled drainage, particularly crop yield;
  - other potential benefits including water quality improvement;
  - performance monitoring and operation protocols.

Complementary practices

Controlled tile drainage is complementary with other BMPs that reduce nutrients in tile outflow or drainage volume:

- *IF-01 – Nutrient Management;*
- *IF-02 – Cover Crops.*

Controlled tile drainage can be supplemented by other BMPs as noted:

- *WS-01 – Tile Water Recycling; EF-01 – Bioreactors; EF-02 – Saturated Buffers; WS-02 – Constructed Wetlands).*

Design aids

USDA-NRCS Conservation Practice Standard Drainage Water Management Code 554. Access on USDA-NRCS website.

Additional BMP resources

ADMC and NRCS, 2013. Drainage water management; a tool that interacts with the 4Rs. Conservation Innovation Grant 68-3A75-6-116. Poster on 4R Tomorrow website.

Christianson, L.E., J. Frankenberger, C. Hay, M. J. Helmers and G. Sands, 2016. Ten ways to reduce nitrogen loads from drained cropland in the Midwest. Pub. C1400. University of Illinois Extension.

Frankenberger, J., E. Kladivko, G. Sands, D. Jaynes, N. Fausey, M. J. Helmers, R. Cooke, J. Strock, K. Nelson and L. Brown, 2006. Questions and answers about drainage water management for the Midwest. Pub. WQ-44. Purdue University Cooperative Extension Service

USDA-NRCS, 2013. Drainage water management benefits landowners (video). Access on USDA-NRCS website.

References

Ayers, J.E., E.W. Christen, R.W.O. Soppe and W.S Meyer, 2006. Resource potential of shallow groundwater for crop water use; a review. Irrigation Science: 24:147-160.

Cordeiro, M.R.C., 2013. Agronomic and environmental impacts of corn production under different water management strategies in the Canadian Prairies. Ph.D. Thesis, Dept. of Biosystems Engineering, University of Manitoba.

Sands, G., 2013. Developing optimum drainage design guidelines for the Red River Basin. University of Minnesota.

Satchithanantham, S., 2013. Water management effects on potato production and the environment. Ph.D. thesis, Dept. of Biosystems Engineering, University of Manitoba.

Skaggs, R.W., M.A. Youssef and G.M. Chescheir, 2012. DRAINMOD: Model use, calibration, and validation. Trans. of the American Society of Agricultural and Biological Engineers: 55(4): 1509-1522.

University of California, 2015. Use of shallow groundwater for crop production. Agriculture and Natural Resources Publication 8251.

Nutrient Management

IF-01

Figure 1. Soil sampling for lab analysis.

What does nutrient management accomplish?

Agricultural nutrients that enter surface and groundwater pose concerns for ecological and human health. The objective of nutrient management is to fertilize the crop in a manner that minimizes nutrient losses to the environment and ***Improving Water Quality***. Nutrient management strategies are used to retain nutrients within the root zone for crop use and reduce nutrient loss from the field via tile flow.

Keeping nutrients in the field and available for crop use also makes good agronomic and economic sense!

> ***Nutrient management requires the implementation of practices that optimize fertilizer use – matching supply with crop requirements to minimize nutrient losses from fields.***
>
> Source: modified from www.nutrientstewardship.com

Overview of nutrient management

Nutrient management principles should be followed when fertilizing any agricultural field. For tile drained lands, special consideration should be given to the change in hydrology that the practice achieves.

4R Nutrient Stewardship is an internationally recognized framework that includes all of the components of comprehensive nutrient management. Applying fertilizers according to the principles of Right Source, Right Rate, Right Time and Right Place (the 4Rs; Figure 2) minimizes greenhouse gas emissions and losses of nutrients to surface and ground waters. The installation of tile drainage may require adjustment of any or all of the 4Rs.

Figure 2. ***4R Nutrient Stewardship (Right Source @ Right Rate, Right Time, Right Place ®).***

Applicability

Nutrient management is key to sustainable agriculture and is an important complementary practice when adopting tile drainage. While nutrient management is broadly applicable in Manitoba, individual practices should be customized to fit each farm's unique combination of climate, soil and landscape features, crop rotation, equipment and overall management system.

Nitrogen issues and management

Nitrogen (N) is one of the most intensively-managed crop nutrients. Once applied to soil, some N is converted to nitrate (NO_3^-), which is highly soluble in water and very prone to leaching (downward movement through the soil profile) (Figure 3). Once below the root zone, nitrate can enter tile drains and discharge to surface water. Numerous studies in the U.S. and Canada link subsurface drainage and increased nitrate movement from fields to surface waters (Christianson et al., 2016). Each of the 4Rs is important to reduce N in tile outflow.

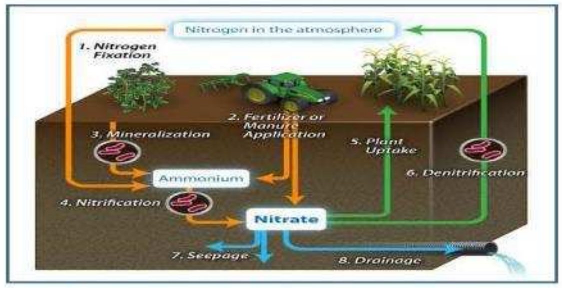


Figure 3. Nitrogen (N) cycle and tile drainage (Christianson et al., 2016).

Right Source. Sources include N fertilizers and animal manures. While there are many types of commercial N fertilizers, Enhanced Efficiency Fertilizers that contain controlled release or inhibitor technology have a particular fit in imperfectly and poorly drained soils. Their use should be reassessed when tile drainage is adopted.

Right Rate. Determining the correct application rate is an essential component of nutrient management. As tile drainage increases productive capacity of the field, a higher rate of N may be appropriate. Producers should soil test every field annually to determine appropriate fertilization rates that consider residual soil nutrients and crop requirements.

Variable rate application technology can be used to reduce application on areas requiring little or no additional N or on sensitive areas if in-field variability is adequately understood (Dinnes et al., 2002).

Right Time. The risk of nitrate leaching to the tiles is higher if soil nitrate levels are elevated when water is moving through the profile. This risk is minimized when N is applied as close as possible to when the crop needs it.

Fall application of ammonium fertilizers is a common practice in Manitoba. Late fall application reduces the risk of nitrate accumulation in the soil because the conversion of ammonium to nitrate slows in cold temperatures. Spring application presents less risk of nitrate leaching during spring snowmelt and early rainfall events, however, spring application is not always feasible.

Perennial forage crops and some annuals receive split applications of N rather than supplying the full N requirement of the crop in a single application. Split applications can also reduce the risk of nitrate leaching. Fertigation, the application of nutrients in irrigation water, is a recognized practice for high-input crops under irrigation management (e.g. potatoes). This practice meters out smaller amounts of N as the crop is growing and reduces the potential for high soil nitrate levels that could be at risk of nitrate leaching.

Within the chosen season, weather conditions and the forecast should be taken into account when timing N applications to avoid excess water moving through the root zone and taking nitrate with it.

Right Place. Applying N in concentrated bands beneath the surface of the soil is more efficient than broadcasting N onto the soil surface. This allows the producer to reduce the overall N application rate to achieve the same yield potential and also reduces the risk of elevated N levels in the soil that could be leached to the tiles.

Phosphorus issues and management

Phosphorus (P) is naturally deficient in Manitoba soils and must be supplied to sustain commercial crop production. In soil, P is less soluble than nitrate and is not particularly susceptible to leaching. It can, however, reach drainage tiles via preferential flow through macropores, such as soil cracks, earthworm holes and root channels (Figure 4).

The main concern associated with P loss from agricultural fields is the accelerated eutrophication of surface water. Phosphorus is primarily transported to surface water via runoff, especially during spring snowmelt. Tile drainage partially shifts the hydrology from surface to subsurface drainage and results in trade-offs between P losses in overland flow versus tile flow.

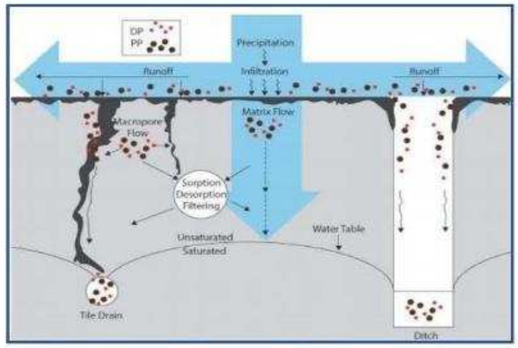


Figure 4. Representation of processes controlling P losses, DP, dissolved phosphorus; PP, particulate phosphorus (Kleinman et al., 2015).

4R Nutrient Stewardship should be followed for P management. The Right Source, Right Rate, Right Time and Right Place should be considered for P application to each field. In addition, incorporating P via tillage should reduce the risk of loss via surface runoff and disrupt macropore networks connecting the field surface to the tiles.

What about manure application on tile drained lands?

The water and nutrient content of manure varies greatly, making it more challenging and costly to manage than synthetic fertilizer. Nutrients from synthetic fertilizers and livestock manure are both susceptible to loss through tile drainage. The 4Rs of nutrient management should be followed when applying manure to tile drained land.

Right Source. Unlike synthetic fertilizer, manure is not a balanced nutrient source. As well, not all of the nutrients in manure are immediately available for crop uptake. Supplying the nutrient needs of the crop requires estimation of the fertilizer value of the manure. Due to its ability to flow, liquid manure is inherently more likely than solid manure to reach tile drains if macropores are present.

Right Rate. Manure is most often applied based on the N requirement of the crop. This often results in over application of P and buildup of soil test P, which increases the risk of P loss via leaching or runoff. At low soil test P levels, accumulation of P is beneficial, but must be well managed by establishing sustainable manure application rates based on soil testing and crop requirements.

Figure 5. Example of manure injection technology.

Right Time. In Manitoba, manure is most commonly applied in the fall to ensure sufficient over-winter manure storage capacity and because favourable conditions for application in the fall generally last longer than in the spring. Application timing should always consider soil moisture levels and the weather forecast. Manure cannot be applied in the winter when ground is frozen, and should not be applied when soil is saturated, tile water is running, or just prior to a rain event.

Right Place. Manure should be placed beneath the soil surface, as much as possible, to maximize nutrient use efficiency and minimize the risk of surface runoff losses. The optimal placement practice includes injection or immediate incorporation of manure that involves disturbance of macropore networks concurrent with application. This is of particular importance for application of liquid manures to reduce the potential for losses via preferential flow (Cooley et al., 2013).

Outstanding questions and potential future improvements

Tillage disrupts the macropore network and the hydrologic connectivity between the soil surface and tile drains. Tillage prior to manure application can reduce preferential flow of nutrients to tiles through cracks and other macropores. More research is required to determine the most effective tillage practices and quantify impacts on tile water quality.

Complementary practices

Nutrient management is complementary with other BMPs that can reduce the volume of tile outflow and drainage intensity, in turn reducing nutrient export from the field:

- *IF-04 – Controlled Tile Drainage;*
- *IF-05 – Site-Specific Tile Drainage Design.*

Similarly, reduction in nutrient loading using nutrient management will lead to improved performance of other nutrient reduction BMPs:

- *EF-01 – Bioreactors;*
- *EF-02 – Saturated Buffers;*
- *WS-01 – Tile Water Recycling;*
- *WS-02 – Constructed Wetlands.*

General nutrient management resources

Manitoba Agriculture, 2007, Manitoba Soil Fertility Guide

Additional BMP resources

Christinson, L.E., J. Frankenberger, C. Hay, M.J. Helmers, and G. Sands, 2016. Ten Ways to Reduce Nitrogen Loads from Drained Cropland in the Midwest. Pub. C1400, University of Illinois Extension.

Cooley, E.T., Ruark, M.D., and Panuska, J.C. 2013. Managing Tile-Drained Landscape to Prevent Nutrient Losses, University of Wisconsin Discovery Farms, Fact Sheet No. 3 GWQ064- Madison, Wisconsin.

Manure management on tile drained land

Manure management on tile drained lands in Manitoba – literature reviews by Stantec Consulting Ltd./PBS Water Engineering Ltd. and University of Manitoba.

References

Dinnes, D., D. Karlen, D. Jaynes, T. Kaspar and J. Hatfield, 2002. Nitrogen management strategies to reduce nitrate leaching in tile-drained midwestern soils. Agronomy Journal 94:153-171.

Harrigan, T. and B. Northcott, 2007. Keeping Land-Applied Manure in the Root Zone, Part 2: Tile-drained Land. Michigan State University Extension. Extension Bulletin WO-1037.

Kleinman, P., D. Smith, C. Bolster, and Z. Easton, 2015. Phosphorus Fate, Management, and Modeling in Artificially Drained Systems. Journal of Environmental Quality 44:460-466.

Beneficial Management Practices for Agricultural Tile Drainage in Manitoba

Tile Water Recycling

WS-01

Figure 1. Water storage reservoir near Gnadenthal, MB (JKW Construction).

What can tile water recycling accomplish?

The objectives of tile water recycling are ***Conserving Water*** and ***Improving Water Quality***. Tile drainage water is captured and stored in a retention structure (e.g. Figure 1), primarily for crop irrigation but may also reused for other purposes such as livestock watering.

Making use of tile drainage water to reduce crop water deficits can increase yields. Recycling tile water for crop irrigation allows the crop to reuse most of the nutrients present in the captured drainage water. Recycling tile water improves water quality by reducing the discharge of nutrients, as well as salts, to downstream water bodies.

Drainage water recycling captures excess water drained from fields, stores the water in a pond or reservoir, and uses the stored water to irrigate crops when there is a water deficit. Relative to conventional tile drainage, drainage water recycling can: (1) increase crop yield, and (2) improve downstream water quality.

Source: Adapted from TransformingDrainage.org

Overview of tile water recycling

Tile water recycling involves several components (Figure 2):

- A constructed water storage reservoir or pond;
- A pump to move the tile water from the tile outlet to the storage;
- A distribution system to use the water which could include irrigation of a crop, water for livestock or other farm needs;
- A water treatment system, if necessary, depending on the proposed use.

When used for irrigation, recycled tile water needs to be stored for several months, because soil moisture deficits generally occur in July and August while most tile flow tends to occur in the spring and late-fall. Similarly, if used to water livestock, storage is required to meet year-round livestock demands.

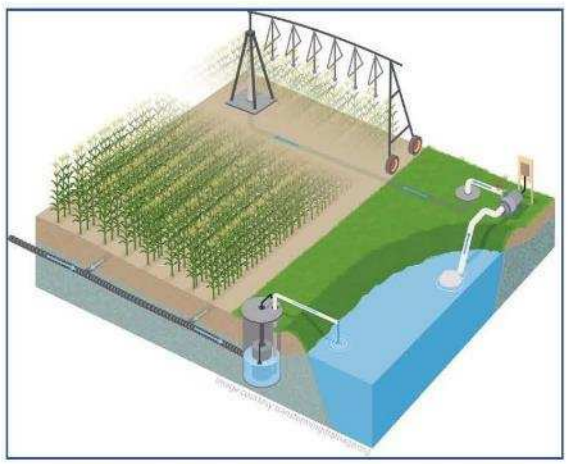


Figure 2. Capture and recycling of tile drainage water typically involves pumping, storage, and reuse (TransformingDrainage.org).

Applicability of tile water recycling in Manitoba

Tile drainage recycling is broadly applicable across agri-Manitoba. Site-specific consideration is required to determine its suitability to a given agricultural operation. For a successful recycling water project there must be: (1) existing water shortage (i.e. demand for recycled water), and (2) sufficient flow from the tiles to meet all or part of the shortage.

Manitoba crops often experience water deficit in the summer. The benefits of irrigating with recycled tile drainage water has been shown through research and practical experience. Research in Ontario showed that sub-irrigating with tile water conserves water and nutrients, and improves crop yields (Tan et al., 2007). Research in Ohio (Purdue Extension, 2017) also showed that recycling water can increase net corn and soybean yields between 12% and 29% (depending on the moisture deficit) versus conventional (free) tile drainage.

In some areas, dugout water is necessary to meet livestock water needs. In Manitoba, some producers use tile water for a portion of their farm water needs. To date there has been minimal data/analysis published for the Manitoba sites.

What are the design considerations?

Due to the complexity associated with tile water recycling, *Professional Services* (see *BMP EA-01*) are recommended for project planning and design, especially for the following aspects.

Sizing

Understanding the water balance is the first step in sizing a tile water recycling system. The size of the reservoir should be based on irrigation and/or another farm water demand. Generally, tile water alone can only be expected to meet a portion of the irrigation requirements in Manitoba. Other sources of water are likely necessary to fill the reservoir. Local or estimated tile flow data, mathematical modelling, land availability and economics should be considered in sizing the system.

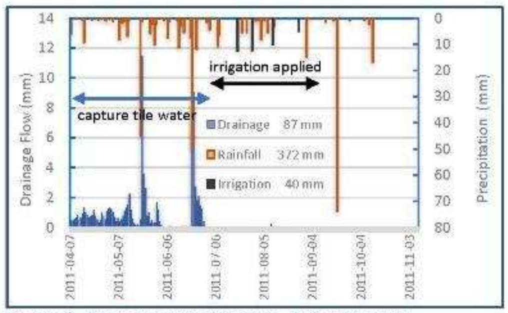


Figure 3. Drainage water flow vs. irrigation and precipitation – Hespler Farms (Cordeiro, 2013).

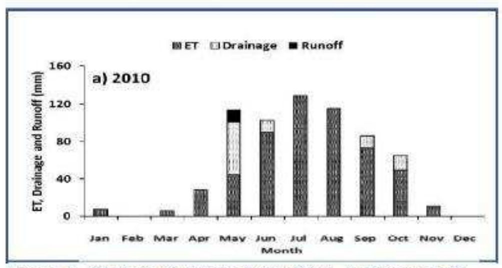


Figure 4. Monthly drainage water flow, surface runoff and evapotranspiration modelled with DRAINMOD for Hespler Farms (Satchithanantham, 2013).

Local data (Figure 3) showing tile drainage flow in relation to precipitation and irrigation provide insight into the water balance in Manitoba. Cordeiro (2013) measured a total tile drainage volume of 87 mm (3.4 in) in April, May and June 2011. The volume of tile drainage water could have replaced the irrigation water (40 mm or 1.6 in) applied that year in July and August.

Irrigation reservoirs in the Winkler area are typically sized to hold 6 inches (150 mm) a portion of irrigation water volume DRAINMOD (Skaggs et al., 2012) is a mathematical model that can simulate tile drainage flows using multi-year climate data. Based on results from DRAINMOD (Sands, 2013; Satchithanantham, 2013 – Figure 4) and Cordeiro (2013), a reasonable estimate for how much tile water could be captured in Manitoba is about 2.5 to 3.5 inches (64 to 89 mm). In some years (e.g. 2012), however, tile flows may be much less than this (Satchithanantham, 2013).

Drainage flow, irrigation demand and storage requirements will vary significantly across southern Manitoba, especially where shallow groundwater provides a significant portion of the crop water demand (University of California, 2015). As an example, irrigation reservoirs in the Winkler area are typically sized to hold 6 inches (150 mm) of water volume.

Engineering

The storage reservoir should be engineered using investigation, design and construction standards that provide assurance of embankment safety and seepage prevention (e.g. Figure 5). OMAFRA (2016) provides guidance in this area.

Figure 5. Construction of an engineered seepage cut-off trench on a water storage reservoir (PBS Water Engineering Ltd.).

Regulatory requirements

The construction of a reservoir or pond and the installation of a tile drainage system requires provincial and municipal approvals.

Water quality

Tile drainage water will likely contain dissolved nitrates and phosphorus. Recycling this water eliminates the direct discharge of these nutrients from tiles to receiving water bodies. The nutrients in the tile water will benefit crop production when the water is reused for irrigation.

Irrigation water must meet all irrigation water quality standards including the amount of salt. Fields with a history of salinity prior to tile drainage will produce tile drainage water with elevated salt levels. Tile drainage with excessively-high salt levels can be diluted with spring runoff water to reach salt levels acceptable for irrigating crops (Sask. Ministry of Agriculture, 2008).

Pesticides from the tile water could be a cause for concern when the water is recycled. More research is needed in Manitoba to assess the risk of pesticides in recycled water.

Sediments and organics are a concern for sub-irrigation due to the potential to clog the tile lines.

Irrigation design

Drip irrigation and overhead irrigation have significantly better uniformity of water application than sub-irrigation; and hence crop uniformity. Higher-value crops (tomatoes, potatoes, etc.) may warrant a more uniform irrigation system design. Higher-value crops may provide better economic return on a tile water recycling investment.

Treatment

If sub-irrigation is used, water filtration to remove sediment and organics is recommended. Additional treatment may be needed for other farm water uses, such as livestock water.

Wetlands

Where possible, it is desirable to design wetland benefits as part of the reservoir (Purdue Extension, 2017).

Outstanding questions and potential future improvements

A better understanding of tile water recycling in Manitoba could involve:

- Hydrologic modelling of the water balance between precipitation and evaporation, snowmelt and rainfall runoff, tile drainage flows and irrigation demand, using software like DRAINMOD. Use of multi-year data sets to determine hydrologic risk and to optimize storage of surface and tile drainage water.
- Research on tile water quality with respect to impact on recycling to crops, including pesticides and salt loads.

- A means to correlate tile water salt levels to pre and post- tiling salt levels present in project specific soils.
- Cost-benefit analysis for Manitoba, including geographic differences in soils, hydrology, water quality, climate and crops.

Complementary practices

Drainage water recycling BMPs are complementary to other BMPs that reduce nutrients in tile outflow or drainage volume:

- *IF-01 – Nutrient Management and IF-02 – Cover Crops,* considering recycled nutrients;
- *IF-03 – Controlled Tile Drainage,* especially if sub-irrigation is being considered;
- *WS-01 – Constructed Wetlands,* reservoir design could provide some wetland benefits (Purdue Extension, 2017).

BMPs which would not be implemented if water recycling was put into practice include *EF-01 – Bioreactors* and *EF-02 – Saturated Buffers*.

News article

Corn and Soybean Digest. Farmers use reservoirs to collect water, use in irrigation pivots.

Additional BMP resources

Ontario Ministry of Agriculture, Food and Rural Affairs, 2016. Design, construction and maintenance of irrigation reservoirs in Ontario. Factsheet 16-009. AGDEX 753/562. May 2016.

Purdue University Extension, 2017. Questions and answers about drainage water recycling for the Midwest. Purdue Paper ABE-156-W. March 2017.

Transforming Drainage (.org). Website hosted by leading drainage researchers and extension specialists across the Midwest, as well as modeling experts and social scientists.

Guidelines

Saskatchewan Ministry of Agriculture, 2008. Irrigation certification guideline.

References

Cordeiro, M.R.C., 2013. Agronomic and environmental impacts of corn production under different water management strategies in the Canadian Prairies. Ph.D. thesis, Dept. of Biosystems Engineering, University of Manitoba.

Sands, G., 2013. Developing optimum drainage design guidelines for the Red River Basin. University of Minnesota.

Satchithanantham, S., 2013. Water management effects on potato production and the environment. Ph.D. thesis, Dept. of Biosystems Engineering, University of Manitoba.

Skaggs, R.W., M.A. Youssef and G.M. Chescheir, 2012. DRAINMOD: Model use, calibration, and validation. Trans. of the American Society of Agricultural and Biological Engineers: 55(4): 1509-1522.

Tan, C.S., T.Q. Zhang, C.F. Drury, W.D. Reynolds, T. Oloya and J.D. Gaynor, 2007. Water quality and crop production improvement using a wetland-reservoir and drainage/subsurface irrigation system. Canadian Water Resources Journal: 32(2): 129-138.

University of California, 2015. Use of shallow groundwater for crop production. Agriculture and Natural Resources Publication 8251. 2008. Irrigation certification guideline.