2021

Southern Potato – Kroeker Farms Deadhorse Irrigation Project Environment Act Proposal

Southern Potato Co.

Kroeker Farms Limited

PBS Water Engineering Ltd.

5/10/2021

PBS Water Engineering

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Submission Sheet

The Southern Potato - Kroeker Farms Deadhorse Irrigation Project -- Environmental Act Proposal, was prepared by PBS Water Engineering Ltd. for the Proponents; Southern Potato Co. and Kroeker Farms Limited. 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.

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Executive Summary

Southern Potato Co. and Kroeker Farms Limited (the Proponent) are proposing to construct an irrigation project in the Rural Municipality (RM) of Stanley which will consist of irrigated fields, an off-stream water storage reservoir, a buried 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 portions of up to 28 quarter sections, which are currently under annual, dryland agricultural production. These fields encompass some 1,387 hectares (3,427 acres). The Project proposes to store spring snowmelt and rainfall runoff water from the Deadhorse Creek watershed in an off-stream reservoir to be constructed central to the Proponent's land base. Kroeker Farms and Southern Potato (the Proponent) have filed independent water rights applications in 2014, which will be amalgamated in 2021 for purpose of the Development Authorization Permit for the off-stream reservoir in SE 18-3-4 W, also known as Site DC18. The joint water right application is to divert up to 465 cubic decameters (377 acre-feet) of water from the Deadhorse Creek and the local watershed to Site DC18 and to store up to 697.5 cubic decameters (565 acre-feet). This will allow for the irrigation of approximately 405 hectares (1000 acres), annually, in 3 to 4-year rotation. 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 may support additional water resource development should the Proponents decide to expand their irrigated acres and other water initiatives become technically and economically feasible in the future (e.g., Pembina River Diversion).

The Deadhorse Creek is a tributary to the Plum River and then the Red River at St. Jean. The Hespler and Rosenheim Drains join the Deadhorse above the Water Survey of Canada station at Rosenfeld. Water will be pumped from the Deadhorse Creek (NW20-3-4 W) and from local runoff (E ½ 18-3-4W) to fill reservoir DC18 using high volume pump(s), which will be PTO driven off existing farm tractors and/or via electric motors. Spring runoff on the Deadhorse Creek is flashy and can include high volume volumes over short periods of time. Withdrawal periods will be during spring runoff, with emphasis on the rising limb of the hydrograph and will typically last for 5 – 10 days. Withdrawal rates at the Deadhorse Creek (NW20-3-4W) are proposed to be in the up to a maximum of 0.95 m^3/sec (15,000 US gpm). This will be supplemented with withdrawal from the local watershed (SE 18-3-4 W) during average runoff years, at a rate of up to 1.2 m^3/sec (20,000 US gpm).

Water will be pumped from the reservoir(s) and distributed to the irrigated areas using pressurized 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., encasement pipe, backfill, etc.). Provincial Road crossings will be directionally bored and cased. All other crossings (oil, gas, rail) will follow utility specific requirements and Provincial or Federal regulations with respect to same.

The Project will be developed over a 2 to 4-year construction period. Engineering is ongoing and continuing this spring (2021), with initial design of Site DC18. The RM of Stanley (conditional use permit) and Manitoba Infrastructure (i.e., authorization for intake construction) have been contacted regarding approvals for the reservoir and intake/conveyance to Deadhorse Creek. Neighbours to the Project site are currently being consulted individually and can request additional information and review this report online when it is posted to the Public Registry. The City of Winkler has been previously consulted as the project took shape and will be directly consulted during the EAP review period. The City of Morden and the Pembina Valley Watershed District have been contacted directly for comment.

Construction of the storage reservoir (Site DC18) would begin in mid July 2021, 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 and 2022. Irrigation is planned to start in 2022, with full development to occur over a 2 to 3-year period after that. Irrigation of most northerly or southerly Southern Potato fields may be from Site A (Shannon Creek) and S15 (Hespler Drain) reservoirs pending water sharing agreements between Southern Potato and Kroeker Farms.

Land use within the Project area is largely 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 to 150 mm (5”-6”) range; with maximum demand projected at 200 mm (8”).

The landscape and near surface geology are largely reflections of the glacial Lake Agassiz. The lacustrine sediments include extensive layers of relatively impervious 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 28 quarter sections comprising the Project study area is predominantly considered Excellent and Good (95.7%) 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 98.5% 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 1.4% of the soils are rated as Class 5 due to the occurrence of fine textures and/or poor drainage. These Class 5 soils are considered to have low desirability for irrigated potato production and are naturally excluded from production (e.g., planted to cereal or permanent crop).

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 Proponents plans to tile drain most of the irrigated land base, pending future permits and necessary approvals.

Given the distance of the proposed reservoir site (DC18) to the Deadhorse Creek and lack of undisturbed natural habitat associated with the parcel (SE 18-3-4W) or at the proposed Deadhorse Creek pump site (NW 20-3-4W) the reservoir and intake are 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 habitat or historic resources field reconnaissance indicated by these reviews.

The habitat value for fish of the natural Deadhorse Creek in NW 20-3-4W is mapped as Type A – supporting commercial, recreational, aboriginal, or SARA species. The proposed withdrawals from Deadhorse Creek 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 Deadhorse Creek 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 for the Deadhorse Creek downstream of the DC18 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 downstream of withdrawal site. 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 nearby Rosenheim Drain of 0.18 m^3/sec. It is anticipated required minimum flow downstream of the DC18 withdrawal point will be in the order of 0.15 m^3/sec. Given the timing of the withdrawals and the position of the proposed intake in the watershed, it is not proposed to screen the intake on the Deadhorse Creek. The local drainage ditches providing surface runoff directly to the DC18 site, do not support fish habitat, are largely dry except for a limited time during spring runoff or large rains. No instream flow requirements are foreseen for the pumps at the reservoir site. Hydrologic computations suggest local runoff may be adequate to fill the reservoir in some 50% of the years (e.g., runoff to SE 18-3-4W).

Navigation along the Deadhorse Creek 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. In any case it is proposed that the filling pump intakes will be located off channel on an improved Municipal ditch, so there will be no impediment to navigation of any type.

The Project is partially located over the major, buried valley Winkler Aquifer. No water is to be withdrawn from this or other aquifers, and there appears to be geologic aquitards immediately underlaying the majority of the Project that limits vertical percolation (i.e., the known recharge area to the Winkler Aquifer is north of the project). The Project soils are considered imperfectly drained due to near-surface aquitards (i.e., lacustrine clay deposits) and the Proponent has plans to tile drain the Project fields because of this fact. The Project activities, including water use, irrigation and other crop production activities are not expected to impact groundwater. Southern Potato and Kroeker Farms have adopted Beneficial Management Practices aimed at protecting surface water resources. These will include nutrient management (e.g., fertigation, organic production) and potentially drainage water management.

The DC18 reservoir has been subject of extensive test drilling to confirm that there will be a minimum of 5 m of lacustrine clay separating the reservoir bottom and the Winkler Aquifer as defined by the top of the encountered glacial till. Geotechnical engineering reports are available on request and major conclusions summarized herein.

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 Southern Potato and Kroeker Farms. 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 Stanley. Traffic routes include Road 10, 11, 12, 14N, Road 23, 25, 26, 27W, PTH 3, PTH32 and PTH 14. Both Kroeker Farms and Southern Potato have crop storage facilities within City of Winkler limits.

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 (e.g., late spring).
- 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 greenhouse gas emissions.

Southern Potato and Kroeker Farms are 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 or activity 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.

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1.0 Introduction and Background

1.1 Proponents

Southern Potato Co. and Kroeker Farms Limited are planning to expand irrigation of their existing potato production systems within the RM of Stanley. Southern Potato Co. and Kroeker Farms Limited have grown potatoes for over half a century with a significant farming history preceding that. They have an ethos of working closely with their neighbours and landowners within the Project area. Southern Potato Co. and Kroeker Farms Limited will be referred to as "Southern Potato - Kroeker Farms" or "the Proponent" herein.

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1.2 Project Overview

The Project area is shown in Map 1 (Appendix A). The Project area is north and south of the Morden – Winkler corridor as defined by PTH Hwy 3 and 14. The project includes land within the watersheds of the Deadhorse Creek, the Shannon Creek and the Hespler 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 their existing potato production operations. The proposed water source for the Project is the Deadhorse Creek and adjacent local watershed(s) which are 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 land base may be provided with water from neighbouring projects storing water on the Hespler Drain and the Shannon Creek.

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 405 ha (1000 acres) of land each year in rotation (i.e., 3- or 4-year rotation). The total current water availability for this site based on Provincial estimates is 465 cubic decameters (i.e., 377 acre-feet). Ultimate irrigation of the entire land base is dependent on securing additional water sources. Options going forward could include working with others to develop additional water sources (e.g., Pembina River) and/or capturing and recycling of tile drainage waters from the Proponents land base; the City of Winkler is also currently considering Aquifer Storage and Recovery as an option to capture additional escarpment runoff in "wet" years using the Winkler Aquifer as storage.

Current application to Water Stewardship for site referred to as DC18, in SE 18-3-4 W on the Deadhorse Creek, is for diversion of 465 cubic decameters (377 acre-feet). Studies have been initiated to secure additional water to mitigate hydrologic droughts as is being experienced in the winter of 2020-21. To that end the storage reservoir will contain an additional reserve amount for higher demand (i.e., drought) years; with current allowance of 50% or approximately 237.5 cubic decameters.

The Project will involve withdrawal of water from the Deadhorse Creek during spring runoff and from the local watershed which drains to the reservoir site, during spring snowmelt and runoff from spring, summer, fall rainfalls, and storing the water in reservoir site DC18. A preferred location for site DC18 has been established (SE 18-3-4 W). Water will be distributed to up to a 1,387 ha (3,427 ac) irrigable land base (see Map 2, Appendix A; including future land locations which cannot 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 Proponents currently own and operate irrigation projects in the immediate area, and they currently grow dryland potatoes on a significant portion of the proposed project land base. The nearest projects involving the Proponent are Site A on Shannon Creek (EAL 3116 – Kroeker Hespler, issued 2014) and S15b on Hespler Drain (EAL 2093R – Agassiz Irrigation Inc., issued 2015). These projects and others operated by Kroeker Farms and Southern Potato service similar land types and production systems and in instances have been successfully operated more than 25 years (e.g., Site S5a – Agassiz Resource Management). Kroeker Farms Ltd. and Southern Potato Co. are experienced farming operators.

The Proponents 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 Previous Studies and Licenses

The Proponent has existing water rights and environmental act licenses, within the general area related to irrigation.

Manitoba Conservation and Climate has provided a review of the Deadhorse Creek water availability and the Proponent has requested a Development Authorization Permit for up to 465 cubic decameters (377 acre-feet) of water to be withdrawn from the Deadhorse Creek (NW 20-3-4 W) and the local watershed (SE 18-3-4 W) during the period March – June. The permit allows for storage of up to 50% above the amount of the approved withdrawal (i.e., additional 232.5 cubic decameters or 188 acre-feet).

Appendix C.1 contains a copy of the Water Rights applications for the Deadhorse Creek by the proponents (circa 2014); and a consolidated application dated 2021; which is for a withdrawal of 465 cubic decameters (377 acre-feet).

1.4 Project Alternatives

The selected water source for the Project is Deadhorse Creek watershed. Other available water sources in the area include groundwater, such as the Winkler Aquifer, other local creeks such as the Shannon Creek (to north) and the Hespler Drain (to south) and local runoff such as comes from the surface runoff, and lastly discharge from tile drainage systems installed on the Project land base. The Winkler Aquifer is currently fully allocated for municipal water use, although the City of Winkler has more recently been considering methods to enhance recharge, including improving infiltration rates and using Aquifer Storage and Recovery. Tile drainage outflows are limited and dispersed due to the individual nature of these projects and are insufficient to support the proposed level of irrigation without a supplemental water supply. The same can be said for the local drainage area runoff to the site in SE 18-3-4W1. Both those sources could be significant in wet years but are less reliable in dry years. The most readily actionable option was determined to be capture of spring snowmelt and rainfall runoff from Deadhorse Creek in an off-stream reservoir. Figure 1 shows the chosen location for the proposed reservoir and Figure 2 shows the chosen intake location to Deadhorse Creek located 1 mile north of the reservoir site. The preferred reservoir location and a preliminary pipeline route to the fields to be irrigated are shown in Maps 3.a & 3.b (Appendix A). Currently the Proponent has insufficient water to match the potential future demand and this Project is limited to approximately 8 center pivots (or equivalents) for a total of 1000 acres of irrigated production. The land base would support close to 1000 acres of irrigated potato production on a 1:3-year rotation.

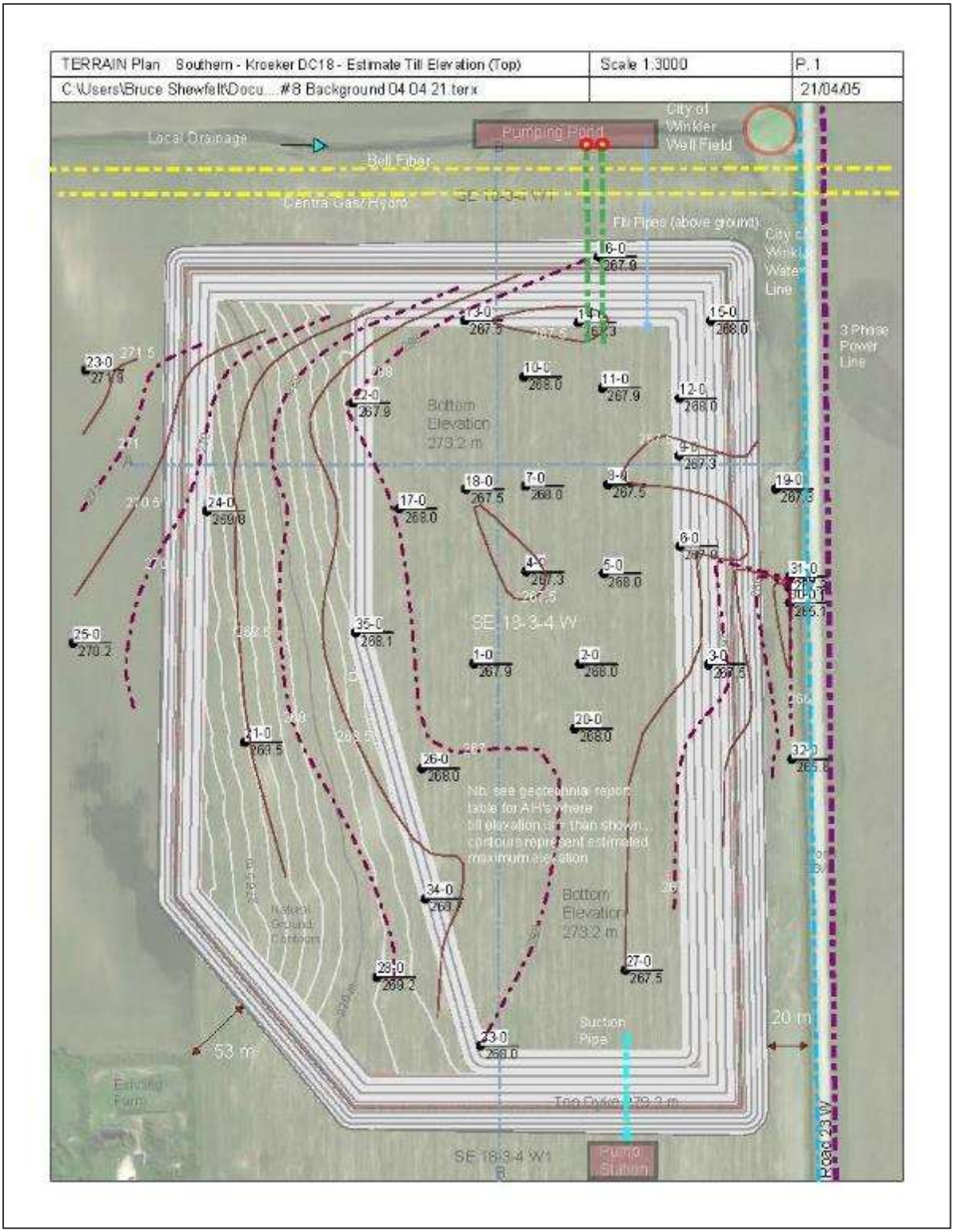

Figure 1 - Proposed DC 18 Reservoir Footprint - SE 18-3-4 W1 (Estimated Till Elevation)

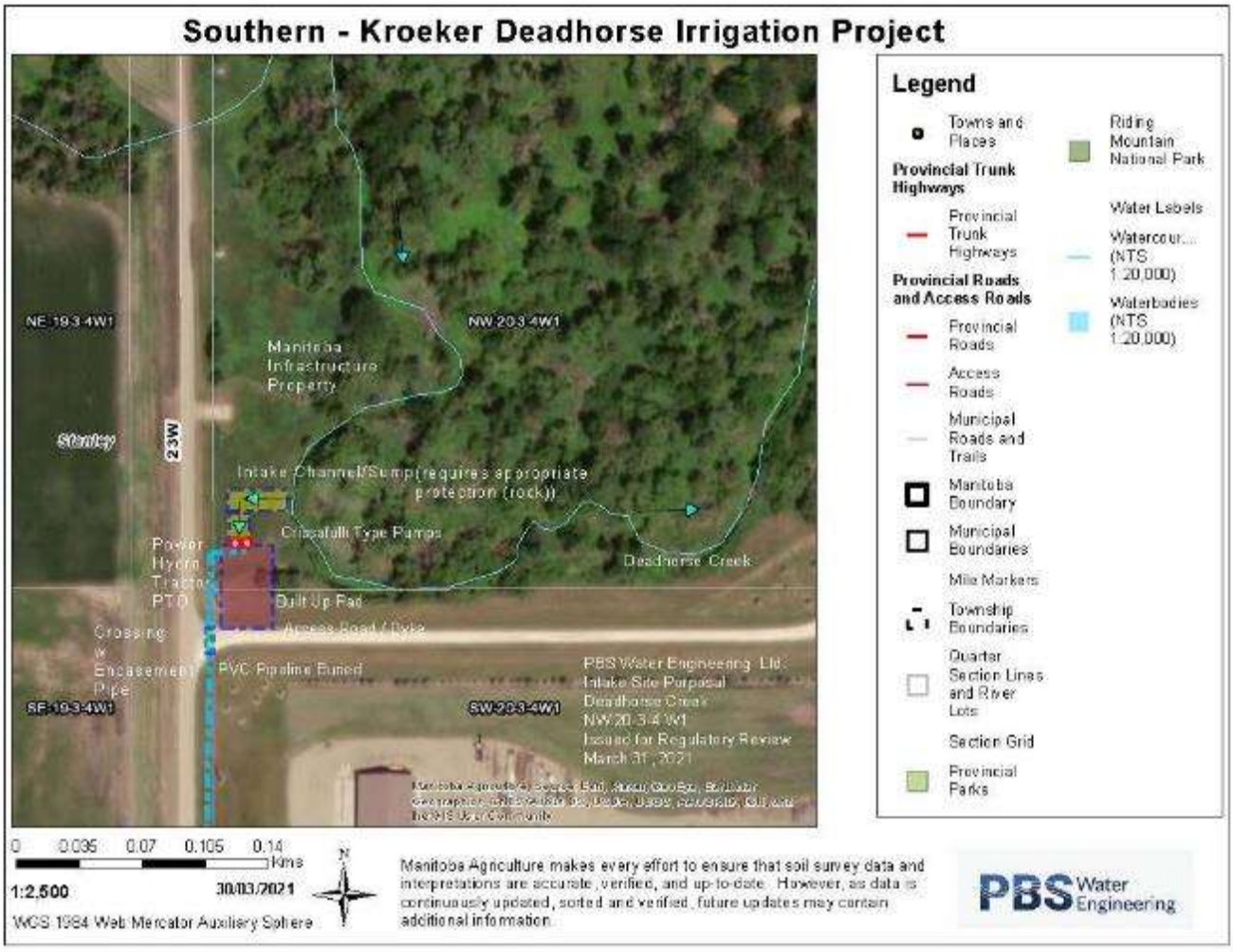

Figure 2 - Proposed Intake on Deadhorse Creek in NW 20-3-4 W (Manitoba Infrastructure ROW [Request submitted, permission pending])

2.0 Regulatory Submissions and Approval Status

2.1 Local Permits

2.1.1 RM of Stanley

The Proponent has notified the RM of Stanley of their intentions to build off-stream reservoir to capture spring runoff on the Deadhorse Creek as well as from the RM drainage network in E ½ 18-3-4- W. The Proponent is in the process of filing an application to obtain a Conditional Use Permit (see Appendix B). The RM of Stanley request will include access to install filling pipe and ditching (including culverts) within the ROW along W 17-3-4 W and SW 20-3-4 W to allow for filling from the Deadhorse Creek pump site. The RM of Stanley request will also include construction of filling (re-pumping) pond in E 18-3-4 W subject to adjacent landowner approval, and subject to avoiding existing utilities (City of Winkler wells, Fiber Cable, Centra Gas line) (see Appendix H).

Additional submissions to the RM will be required for approval of road crossings and location of pipeline or fittings in the Road Allowances, which require resolutions or legal agreements. To date pipeline routes and sizes are preliminary.

2.1.2 Building Permits (MSTW)

Building permits will be sought as required by Municipal bylaws for any permanent buildings (e.g., pumphouses). It is proposed that the permanent pump station will be constructed in SE 18-3-4 W with connection to Hydro 575 V power to operate pumps and vacuum syphon system.

2.2 Provincial Permits and Regulatory Considerations

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 465 cubic decameters (377 acre-feet). The Province maintains records of all Water Rights applications (Appendix C (C.1)). The Proponent currently awaiting a Development Authorization Permit.

No plans have been made for requesting for additional allocation for future expansion to irrigated acres. Expansion beyond 1000 acres would require additional water source identification and licensing.

2.2.2 Manitoba Infrastructure Permits

A request will be made to Manitoba Infrastructure with respect to location of the proposed filling pump station in NW 20-3-4 W relative to the Manitoba Infrastructure Deadhorse Creek dykes/channel (See Figure 2). The current plan is to utilize two Crisafulli type pumps at this location, one tractor powered, and one electric motor powered.

The pipeline distribution system may include crossings of the Provincial Drains (e.g., Hespler). Individual applications will be made for all crossings and for location of pipeline delivery systems in Manitoba Infrastructure rights of way, if / as 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. Nitrogen and phosphorus limits are provided in Table 1.

Table 1 – Residual Nitrogen Limits per The Nutrient Management Regulation (M.R. 62/2008)

Nitrogen Limits		
Nutrient Management Zone	**Residual NO_3-N within 0.6 m**	
	kg/ha	lb/ac
N1	157	140
N2	101	90
N3	33	30
N4	0	0
Phosphorus Limits (within N1 to N3)		
Soil Test Phosphorus (Olsen)	**P Application Rate**	
< 120 ppm	2x crop removal	
120-<180 ppm	1x crop removal	

Notes:

Agricultural Capability Classes for each nutrient management zone:

- N1 - 1, 2 or 3, other than 3M, 3ME, 3MI, 3MN, 3MP, 3MT, 3MW
- N2 - 3M, 3ME, 3MI, 3MN, 3MP, 3MT, 3MW or any other subclass of soil class 3 having an "M" subclass designation, 4, 5M if irrigated
- N3 - 5 (except 5M if irrigated)
- N4 - 6, 7, unimproved organic soils

No nitrogen application is permitted in nutrient management zone N4, unless these substances were being applied prior to the Nutrient Management Regulation (62/2008) coming into force on November 8, 2006, in which case these applications can continue but only in accordance with a registered plan.

No phosphorus application is permitted in nutrient management zone N4, unless these substances were being applied prior to the Nutrient Management Regulation (62/2008) coming into force on November 8, 2006, in which case these applications can continue but only in accordance with a registered plan.

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 reservoir 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 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 Deadhorse Creek 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 Deadhorse Creek 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 Deadhorse Creek 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).

Figure 2 details that water withdrawals will be from an improved channel that is off the main Deadhorse Creek and avoids any interference with navigation.

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 DC18 in SE 18-3-4 W1. 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 Hydro/Centra gas main that crosses the northern edge of SE 18-3-4 W1 (Figure 1), that has been avoided for reservoir construction. Additional crossings of Centra, TCE and Enbridge gas and oil pipelines are a function of the final pipeline network, which is still under planning.

There are water pipeline networks within the Project area including the Pembina Valley Water Cooperative and RM of Stanley pipeline network. These pipes are generally deeper than the proposed irrigation pipeline, but none-the-less must be carefully considered.

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 Stanley and the Pembina Valley Water Coop.

Maps 3 a, b shows the proposed reservoir and pipeline network in relation to other pipeline networks within the project area. These maps are provision only and not for construction.

2.4.2 Local Conservation Groups

The Pembina Valley Watershed District is planning to do an Integrated Water Management Plan in 2021 for the Plum River Watershed. The Proponent has met with the Watershed District to share details of the proposed project for their comment.

2.5 Public Consultations and Submissions

Information and informal presentations on the Southern Kroeker Deadhorse Irrigation Project have been offered to the RM of Stanley, the City of Morden and the City of Winkler for consideration and comments. The RM of Stanley was provided an application for a Conditional Use Permit for the reservoir and have set public meeting for May 20, 2021 (Appendix B).

A copy of the pertinent information (this report) will be made available at the RM and City of Winkler and Morden offices 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 are being directly consulted by the Proponent; to allay concerns and/or address potential impacts and mitigative measures, and secure pipeline easement. A two-page information sheet was developed to local neighbours to the project. Negotiations are ongoing to determine feasible and possible pipeline routes.

PBS Water Engineering Ltd. is responsible for filing this EAP, along with all permit applications on behalf of the Proponent. AgriEarth Consulting Ltd. has been given responsibility for assessing and recommending the land suitability for irrigation. PFRA Ltd. and VRK Consulting Inc have been consulted on hydrogeology and geotechnical aspects of design and construction, especially as they relate to reservoir and intake design. KGS Group was engaged to perform specialized geotechnical computations with respect to safety of the project dykes and base.

Any licenses will be issued in the name of Southern Potato Co. and Kroeker Farms Limited 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 697.5 cubic decameters (i.e., 565 acre- feet) of water in the proposed reservoir, referred to as Site DC18. Water will be pumped to the reservoir from local drainage at the north end of the site and from the nearby Deadhorse Creek. Water from the reservoir DC18 will be piped in a common underground pipeline to the irrigation fields (Maps 3.a & 3.b, Appendix A).

There are 47 individual fields proposed for irrigation, encompassing portions of 28 quarter sections of land, for a total of 1,387 ha (3,427 ac). The project is divided into two blocks, with the North portion (fields north of provincial Highway 3) comprising 16 fields for a total of 588 ha (1,452 ac) and the South portion (fields south of highway 14) comprising 31 fields for a total of 799 ha (1,975 ac) (Table 1). Kroeker Farms is the proponent of 11 fields (299 ha, 738 ac) in the North portion and 23 fields (398 ha, 983 ac) in the South portion, while Southern Potato is the proponent of 5 fields (289 ha, 714 ac) in the North portion and 8 fields (401 ha, 992 ac) in the South portion.

The initial reservoir storage capacity (i.e., DC 18) will provide sufficient water to irrigate up to 405 ha (1,000 acres) annually. Maps 3.a & 3.b (Appendix A) shows the currently proposed land base, DC 18 reservoir location and currently proposed pipeline infrastructure.

Ultimately, irrigated acreage could exceed 1,000 acres annually, if additional water sources can be developed. Current plans are for operation of up to 8 modern sprinkler irrigation systems (e.g., pivots, linear systems). 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 irrigation system will be co-managed by the Proponents, Southern Potato and Kroeker Farms.

3.2 Project Area

The Project area is highlighted in Map 1 (Appendix A), located between Morden and Winkler, Manitoba within the Rural Municipality of Stanley. It is located between the Deadhorse Creek to the north and the Hespler Creek to the south and is within the Plum River watershed within the Red River Valley. 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 summarized in Table 2 and shown in Map 2 (Appendix A).

The Project irrigation system infrastructure components are illustrated in relation to the land base in Maps 3.a & 3.b (Appendix A). Those components include, irrigated land base, water delivery system, water storage, water diversion, and power supply.

Table 2: Project Field Number, Land Parcel Description and Acres (Irrigated)

Project Block	Producer	Field ID	hectares	acres
South portion	Kroeker Farms	405	21	52
		406	21	51
		407	20	49
		411	11	28
		412	12	29
		413	12	30
		414	11	28
		415	17	41
		419	33	82
		420	18	44
		421	15	36
		422	15	37
		423	19	46
		424	19	46
		425	19	46
		426	18	45
		427	15	37
		433	30	73
		441	24	60
		443	3	8
		444	13	32
		445	15	38
		446	18	44
		Kroeker Farms - South portion subtotal	**398**	**983**
	Southern Potato	10	57	141
		13	64	157
		14	64	158
		39	63	157
		91	48	120
		92	16	40
		96	24	60
		97	64	159
		Southern Potato - South portion subtotal	**401**	**992**
	South portion subtotal		**799**	**1,975**
North portion	Kroeker Farms	450	30	73
		451	31	78
		454	24	59
		455	13	32
		456	17	41
		457	26	63
		458	22	55
		459	9	22
		470	30	75
		471	43	107
		475	54	133
		Kroeker Farms - North portion subtotal	**299**	**738**
	Southern Potato	11	66	164
		12	63	156
		40	38	93
		48	59	145
		49	63	156
		Southern Potato - North portion subtotal	**289**	**714**
	North portion subtotal		**588**	**1,452**
Total			**1,387**	**3,427**

The following sections describe the proposed development components and reference the additional development information as required in the Environmental Act Proposal Guidelines.

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 47 irrigation fields (Table 2; Map 2, Appendix A) encompassing 1,386 ha (3,427 acres).

The maximum current farm irrigation will be 405 ha (1000 acres) per year, at an average duty of 115 mm (4.5 inches) and a maximum duty of 165 mm (6.6 inches), for a total average demand of 465 cubic decameters (377 acre-feet) and a peak demand (including water from storage) of 697.5 decameters (565 acre-feet).

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 Maps 3.a & 3.b (Appendix A); subject to change associated with final 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 if required. Dry waterway crossings and non gravelled RM roads will be open cut where feasible and acceptable. All road, highway and rail crossings will be provided with encasement 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 as may be authorized by Manitoba Infrastructure.

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 DC18 in SE 18-3-4 W. This site is located relative to the land base per Maps 3.a & 3.b (Appendix A).

Feasibility studies and consultations (i.e., RM, MI) are ongoing for this site. Final geotechnical engineering and design are required to confirm final feasibility, storage capacity and engineering details. The reservoir site will be engineered with the following elements:

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

KGS Group has just completed a final geotechnical assessment of protection of the reservoir elements from uplift pressure from Winkler Aquifer which lies beneath the site. PBS Water Engineering Ltd. and VRK Consulting Ltd. will complete final reservoir engineering. Total planned storage is 697 dam3 (565 acre-feet).

3.3.4 Water Diversion

Water will be transferred to reservoir DC18 from Deadhorse intake site (Figure 2, 3) with a combination of pumping and constructed ditch along Road 23 W. Local runoff that naturally accrues along the ditch which traverses the northern boundary of SE 18-3-4 W (Figure 1) will also be captured by direct pumping to the reservoir DC18.

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 950 l/s (15,000 US gpm). Depending on flow variability a smaller (e.g., 60 - 240 l/s; 1,000 - 4,000 US gpm) low volume low head electric transfer pump will be included. 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).

Figure 3 – Photo of Proposed Intake Site on Deadhorse Creek in NW 20-3-4 W1 (see plan view Figure 1)

3.4 Land Use and Access

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***. Southern Potato and Kroeker Farms have ownership of many of the fields identified in Table 1 and Map 2 (Appendix A) for irrigation or water storage. Non-owned fields have or will be secured by lease agreements. Mineral rights will be reported on ***if required***, as they are not impacted by the Project.

3.4.2 Existing Land Use

The land proposed for DC18 reservoir development, is currently 100% cultivated land (Figure 1; Maps 3 & 4, Appendix A).

Water delivery system (pipelines) will cross natural features such as creeks. Potential creek crossings are evident on Maps 3.a & 3.b (Appendix A). The intake will be located on a grassed area, next to a constructed ditch on the south side of an access road in NW 20-3-4 W (per Figure 3).

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 sub-surface tile drainage. Additional fields are planned for tile drainage improvements in the future.

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 (e.g., circular pivot), and to convert some cultivated land to the constructed irrigation reservoir. There is no planned increase to cultivated acres. Any riparian zones associated with the intake or creek crossings will be modified to the minimum required to locate the proposed infrastructure. The creation of the irrigation reservoir and associated tree plantings and revegetation has potential to increase the habitat value of the reservoir in SE 18-3-4 W, especially as it relates to waterfowl.

The Project would add wetland habitat in the form of the reservoir, 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

It is anticipated that a 1:3 or 1:4 rotation will require development of pipeline systems to over 3000 acres of land for this development. It is anticipated that the irrigation network will be fully developed by 2025. Planned development for the project is anticipated to be 8 Center Pivot or Linear irrigation systems.

3.5.2 Water Delivery Systems

The pipeline delivery systems will be scheduled to start construction in the fall or 2021 or spring of 2022. Additional pipe will be installed to service more land for approximately 3 years after initial installation, depending on the timing and number of irrigation systems purchased.

3.5.3 Water Storage Systems

Site DC18 is proposed to start construction in summer 2021, with first filling in spring 2022 or 2023.

3.5.4 Water Diversion

Water diversion facilities (e.g., Deadhorse, local drainage) access, intake, pump site will be developed in fall 2021 for site DC18. This would include proposed access channel improvements, pumping facility, delivery pipeline, ditching and culverts required to move water from NW20-3-4 W to SE 18-3-4 W.

Ditch improvements along the north boundary of SE 18-3-4 W will be undertaken in Fall, 2021.

The schedule is subject to approval of the RM of Stanley and affected landowners.

3.5.5 Engineering

PBS Water Engineering Ltd. is currently undertaking final design and engineering with assistance from VRK Consulting Ltd. (Geotechnical) and ProFessional Resources Assessment (PFRA) Ltd. (Hydrogeology) and KGS Group (Geotechnical).

The final geotechnical feasibility report is scheduled for completion in May, 2021 (KGS Group, VRK Consulting), no further test holes are envisioned at this point.

Additional investigations and engineering studies required for the various pipeline installations (e.g., crossing CPR, PTH 3, Oil and Gas), will be arranged for summer, 2021 as pipeline route is finalized. Pipeline surveys will be carried out by Barnes and Duncan.

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

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 2021 or 2022, depending on first filling of site DC18 reservoir. 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) - 40 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 Southern Potato Co. and Kroeker Farms Ltd.

4.0 Environmental Settings

4.1 Physical Environment

The Project area is located between Morden and Winkler, Manitoba, below the Manitoba Escarpment in the southern portion of the Red River Valley.

Map 1 (Appendix A) shows the proposed irrigation fields within the Winkler Ecodistrict and in relation to Deadhorse Creek to the north and the Hespeler Creek to the south. The Deadhorse Creek and Hespeler Creek carry surface water (snowmelt, rainfall runoff) from uplands associated with, and from the Red River Valley flatlands within the local Project area below the escarpment.

The Project area falls in the Deadhorse Creek and Hespeler Creek watershed budget areas (Figure 4). Reservoir site DC18 location at SE 18-3-4-W is shown in Figure 4 in relation to existing reservoirs S15b and S5a on the Hespeler Drain, and Site A on the Shannon Creek. Figure 4 also shows the location of the Water Survey of Canada 05OC016 on the Deadhorse Creek near Rosenfeld downstream of the Project.

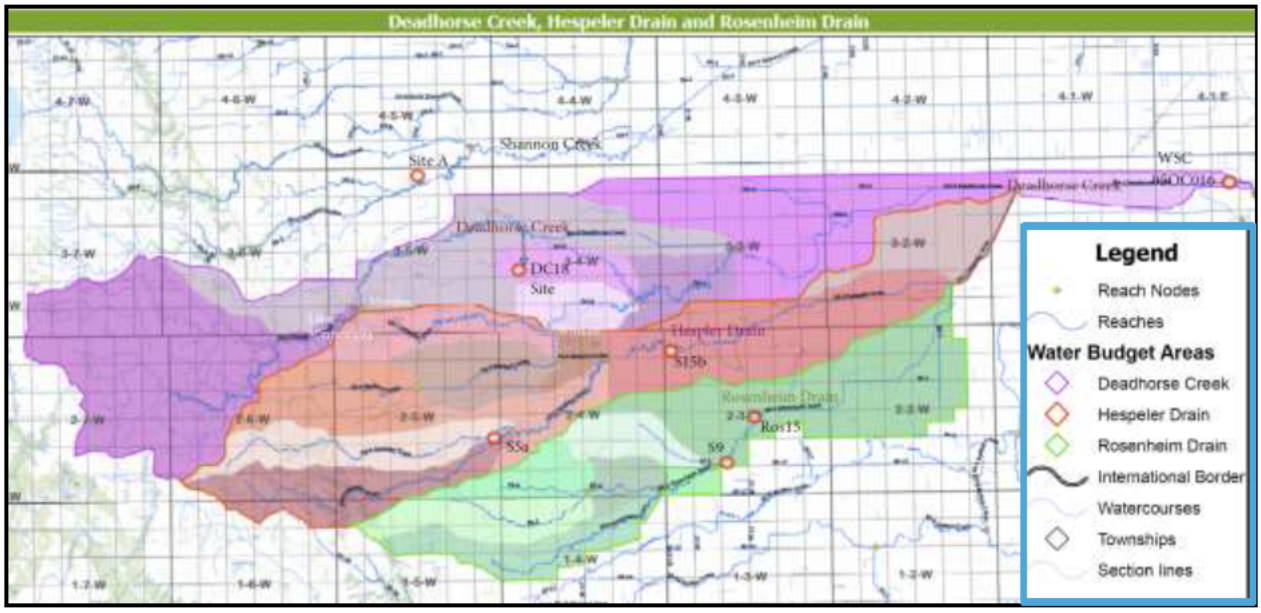

Figure 4 – Deadhorse Creek Watershed Budget Areas, DC 18 and Nearby Reservoir Sites (Manitoba Conservation and Climate 2020)

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 and 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 5 depicts the physiographic map units in relation to the Pembina Escarpment to the west.

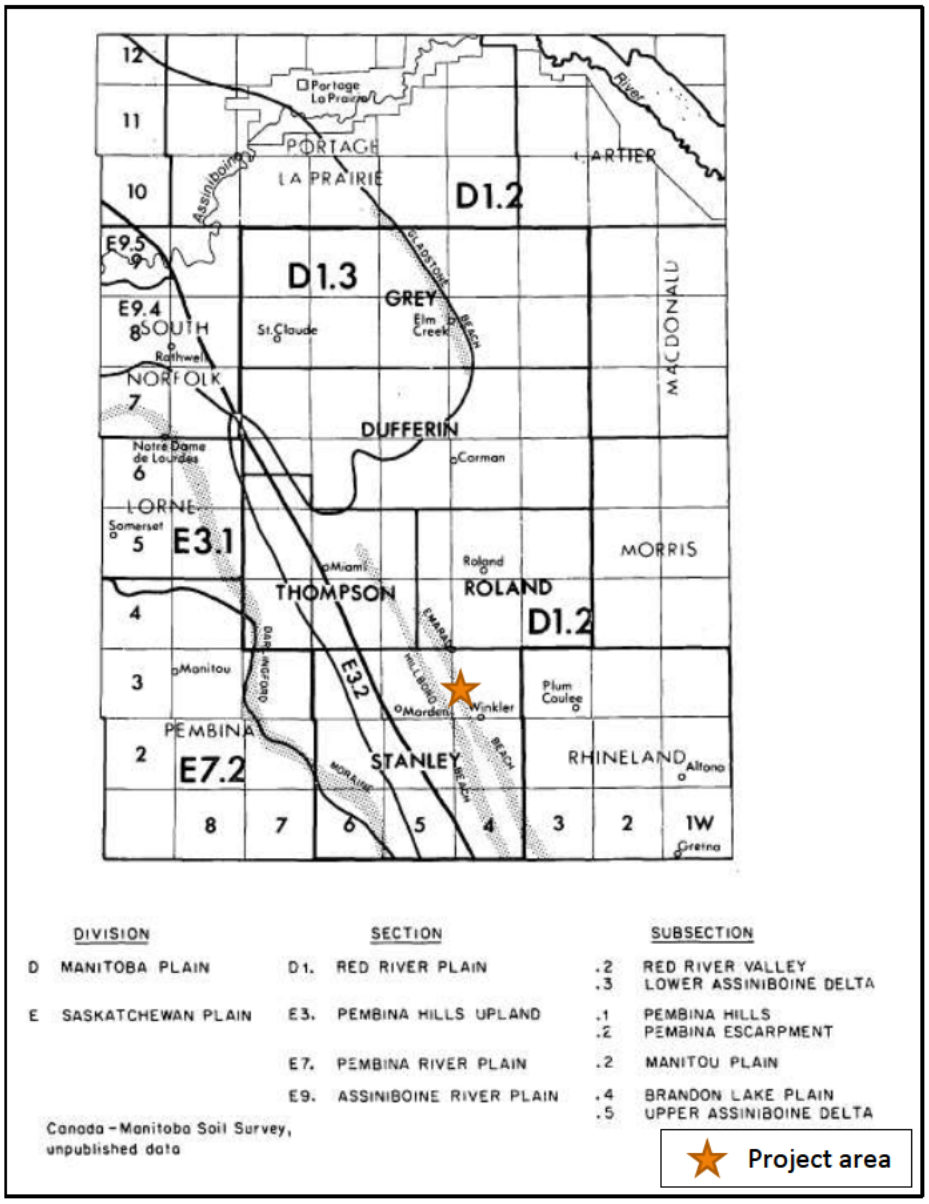

Figure 5 - Physiographic Map of the Project Area (Smith et al. 1988)

Within the study area the significant surface features are the naturally meandering creeks (e.g., Deadhorse Creek, Hespler Creek) which are alternatively channelized and/or dyked to prevent breakout flooding of adjacent cultivated fields (Map 1; Appendix A). Surface drainage in the region has been significantly altered by roads, drainage ditches and channels, which supplement the discharge into the natural (and altered) stream network (Podolsky, 1991).

Smith and 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). The Project Area is dissected by sandy deposits of the Emerado and Hillsboro Beaches and soils are generally silty deposits of approximately 2 m (Michalyna et al., 1988) underlain by lacustrine clays. Soils within the study area are predominantly a mix of imperfectly drained and well drained.

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 and Michalyna, 1971) with excellent yields of grains, oilseeds and horticultural crops (e.g., potatoes). Major challenges to crop production are maintaining adequate surface and subsurface drainage and prevention of wind and water erosion. Generally, the soils in the study area are considered suitable for irrigation (Smith and Michalyna, 1971; Michalyna et al., 1988); with the main limitations 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 has led to the predominance of annual cropping, including high value production, such as beans, corn, and potatoes, 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 on Map 1 (Appendix A), and the aquifer is further described in the following sections.

4.1.2 Geology of the Project Area

Michalyna et al. (1988) describe the bedrock geology of the region as follows.

> *The bedrock formations underlying the study area belong to the Upper and Lower Cretaceous Periods of the Mesosoic Era. High elevations in the western portion of the study area are underlain by the hard siliceous shales of the Riding Mountain Formation (Odanah and Millwood members). At lower elevations along the steeply sloping Manitoba Escarpment older shale bedrock of the Vermillion River Formation (Morden and Boyne members) are exposed at/or near the surface. Low lying and level terrain to the east of the Escarpment is underlain by Cretaceous shale of the Favel and Ashville formation, and sandstone of the Swan River formation. Depth of overburden ranges from 30 m near the Escarpment to more than 100 m in the eastern portion of the study area.*

A geologic cross section is presented in Figure 6.

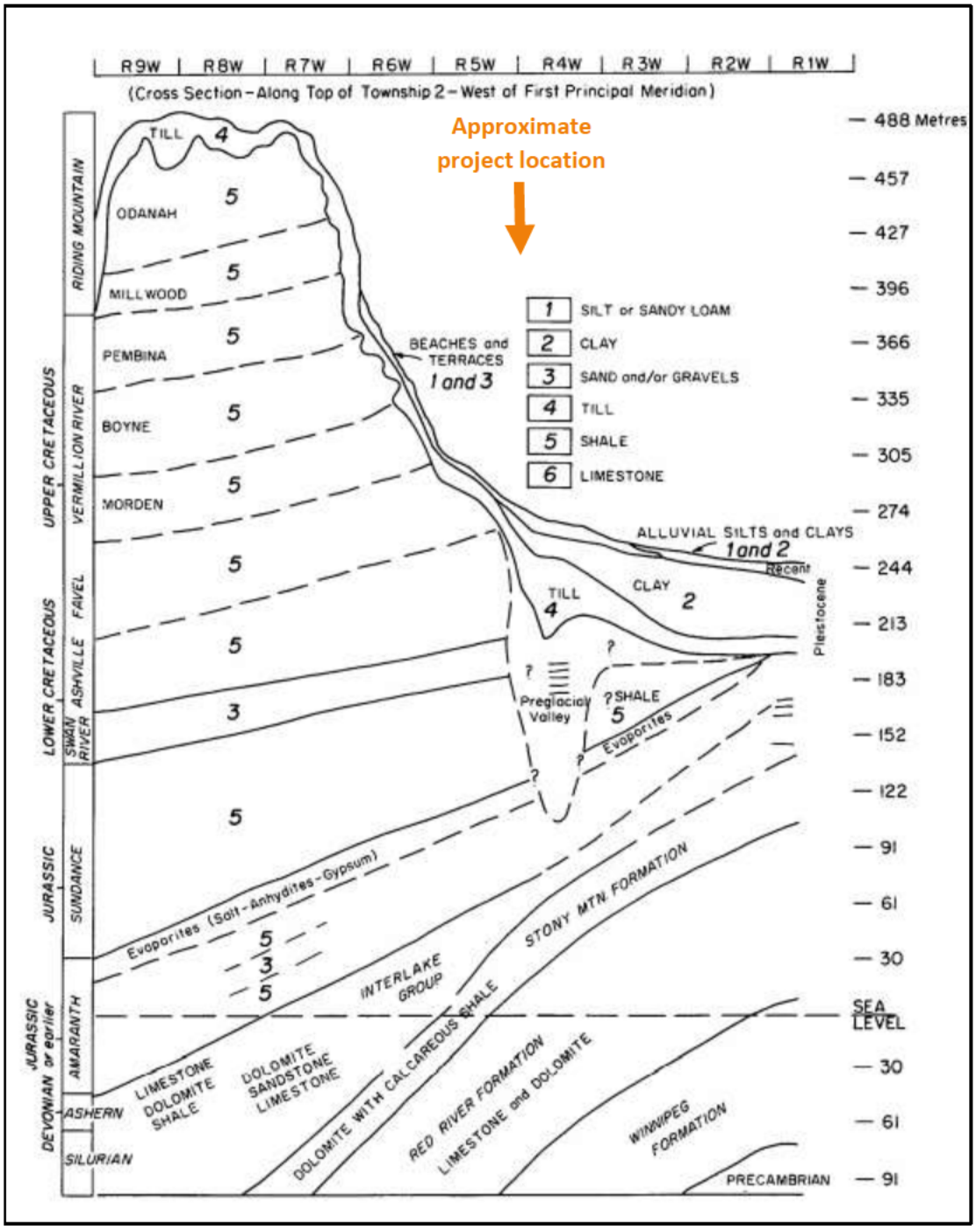

Figure 6 – Geologic Cross Section of Region (Michalyna et al., 1988)

The reservoir location in SE 18-3-4 W is directly underlain by the Winkler Aquifer. The City of Winkler has two production wells located in the NE corner of the SE quarter section. Extensive test drilling revealed the depth of the lacustrine (CH) clays at this location (Figure 1, Appendix H). Figure 7 shows that project area is characterized by a thin layer (e.g., 1.5 m) of silty soils (ML) underlain by heavy lake clay (CH) (e.g., 8.3 m) underlain by silty sand which is assumed to be associated with the glacial till or represents the top of the aquifer sands/gravels at this location. The till appear to be very thin at the project site.

The Winkler Aquifer at this location is confined by the surficial lake clays, and is typically under pressure at the interface between the silty sand and the lake clay (e.g. ~ 9.8 m on Figure 7). Figure 8 presents a geologic representation of the Winkler Aquifer stategraphy.

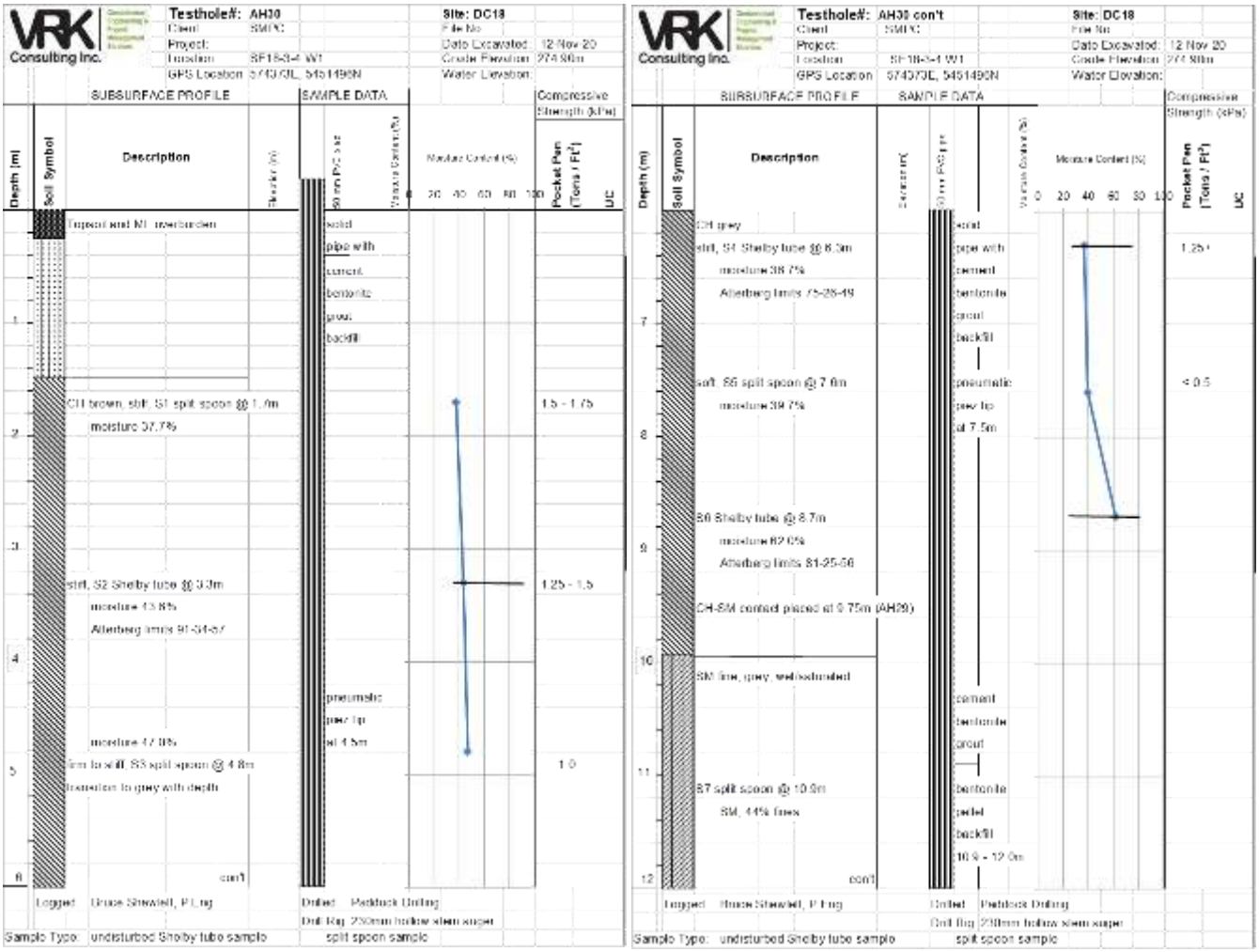

Figure 7 - Testhole # AH30 Log (VRK Consulting; see Figure 1 for location)

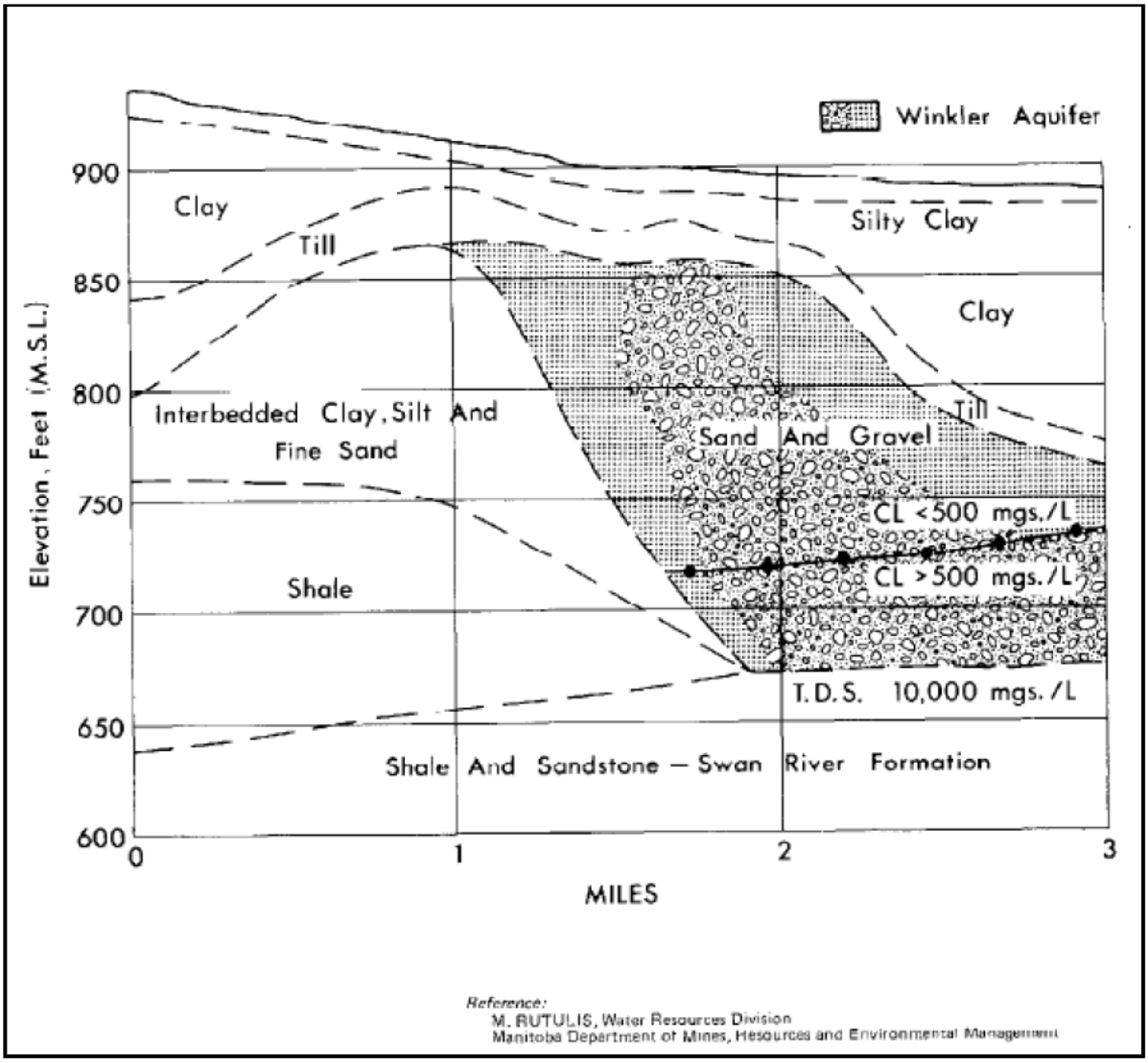

Figure 8 - Cross Section of Winkler Aquifer (Smith and Michalyna, 1973)

4.1.3 Groundwater

The groundwater in the Project area can be characterized as follows. Deep wells into the shale bedrock are typically saline (Smith and Michalyna, 1973) 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 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 to the east of the Project area as follows.

> *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.*

The RM of Stanley has developed rural water pipelines to service the farms in the Project area (see Maps 3.a & 3.b, Appendix A), due to the lack of potable groundwater and or the Provincial commitment of the Winkler Aquifer to the City of Winkler water supply. The Winkler Aquifer is utilized only by those farms, rural acreages, and small businesses directly over its footprint and remains a major water source for nearby City of Winkler (for both fresh and brackish water). The primary recharge to the Winkler Aquifer is outside the Project area to the north, adjacent to and south east of the Paterson Pit located in SW 11-4-5W. Figure 8 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. This is the case in SE 18-3-4 W, the site of DC18.

Hence, although the reservoir site DC18 is located over the Winkler Aquifer (Map 4, Appendix A), it will not contribute substantially to aquifer recharge.

The City of Winkler is currently studying ways and means to enhance the natural recharge of the Winkler Aquifer. A current initiative involves diversion of water from the Deadhorse Creek into the abandon creek channel adjacent to the Burwalde Woods per Figure 9. The City is hoping to enhance natural recharge to the aquifer from the surface waters of the Deadhorse Creek.

(http://www.landmarkplanning.ca/perch/resources/winklerpresentationboardssep2020-dead-horse.pdf)

The proposed diversion site for DC18 is downstream of the reach of the Creek that the City has studied for enhanced infiltration. The City has reviewed the Proponent's proposed intake on the Deadhorse Creek in NW 20-3-4 W. Initial review of GW Drill and other stratigraphic information by PFRA Ltd. suggests that this Creek in NW 20-3-4 W is underlain by a significant aquitard. At this point in time, the proposed DC18 withdrawal is not expected to interfere with the City of Winkler enhanced recharge project.

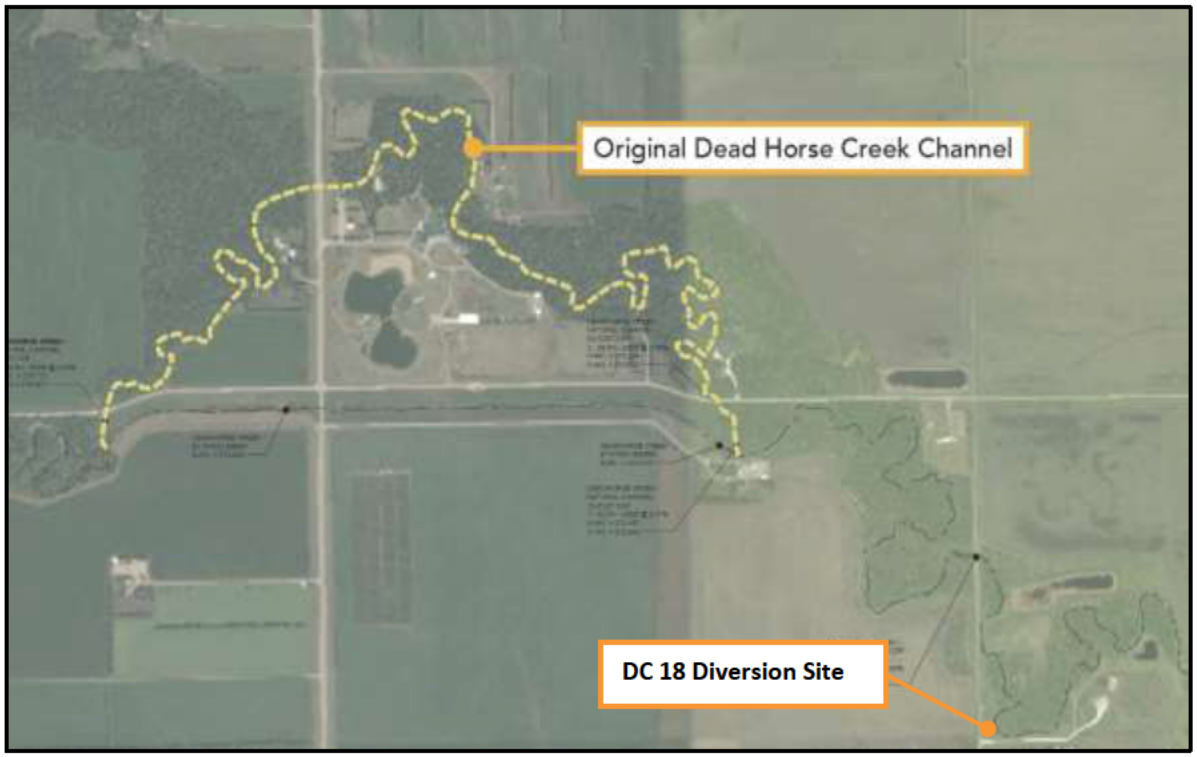

Figure 9 - City of Winkler - Aquifer Recharge Enhancement Project Area (Landmark Planning, October2020)

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 (Smith and Michalyna, 1973) 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 3); 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 3 – 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 4 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 4 – 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 sources to the Project area are the Deadhorse Creek and the Hespler Drain. The Deadhorse Creek is generally on the northern edge of the project area, whereas the Hespler Drain flows south of PTH 3, and is currently fully allocated. Deadhorse Creek water availability is estimated by the Province of Manitoba Drainage and Water Rights Licencing Branch, making use of Water Survey of Canada gauging station data. The nearest measured flow data are from Water Survey of Canada gauging stations 05OC015 (near Morden) and 05OC016 (near Rosenfeld). Historic average daily flow records are available for Station 05OC015, located in Morden downstream of Lake Minnewasta, from 1966 to 1971 and from 1978 to 1996. The gross drainage area for this station is listed as 137 km^2. Station 05OC023 was located a couple of miles downstream of Station 05OC015 and was operational from 1972 to 1976. The gross drainage area for this station is listed as 159 km^2. Station 05OC016 is located a further downstream on the Deadhorse Creek near Rosenfeld. It has been in operation since 1968. The gross drainage area for this station is listed as 926 km^2. The flow at Station 05OC015 is directly regulated by Lake Minnewasta. The City of Morden and the City of Winkler discharge lagoon water into the Deadhorse downstream of Station 05OC015 and upstream of Station 05OC016.

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

The diversion site on Deadhorse Creek in NW 20-3-4 W1 is approximately 5 miles downstream of Station 05OC023, with an additional gross drainage area of approximately 24 km^2, for a total gross ***drainage area of 183 km^2***.

In addition to flow in Deadhorse Creek, a gross drainage area of 19.5 km^2 supplies local drainage which flows past the reservoir site in SE 18-3-4 W1. That local drainage area is depicted in Figure 10. At the reservoir site the local runoff bifurcates with a portion travelling north along Road 23 W to the Deadhorse Creek and a portion travelling south along Road 23 W and the joining east flowing drainage ditches to the Deadhorse Creek (see Appendix H).

From the Project diversion location in NW 20-3-4W, water flows easterly towards the confluence with the Hespler Drain (as measured at Deadhorse Creek near Rosenfeld) and thereafter joins the Plum River and then the Red River near St. Jean (see Figure 4).

Past the point where the Deadhorse Creek and Hespler Drain join near Rosenfeld Station, the total drainage area, including the Rosenheim, Hespler and Deadhorse is 926 square kilometers (WSC 05OC016) (see Figure 4); a factor of 5 times larger than at the DC18 site.

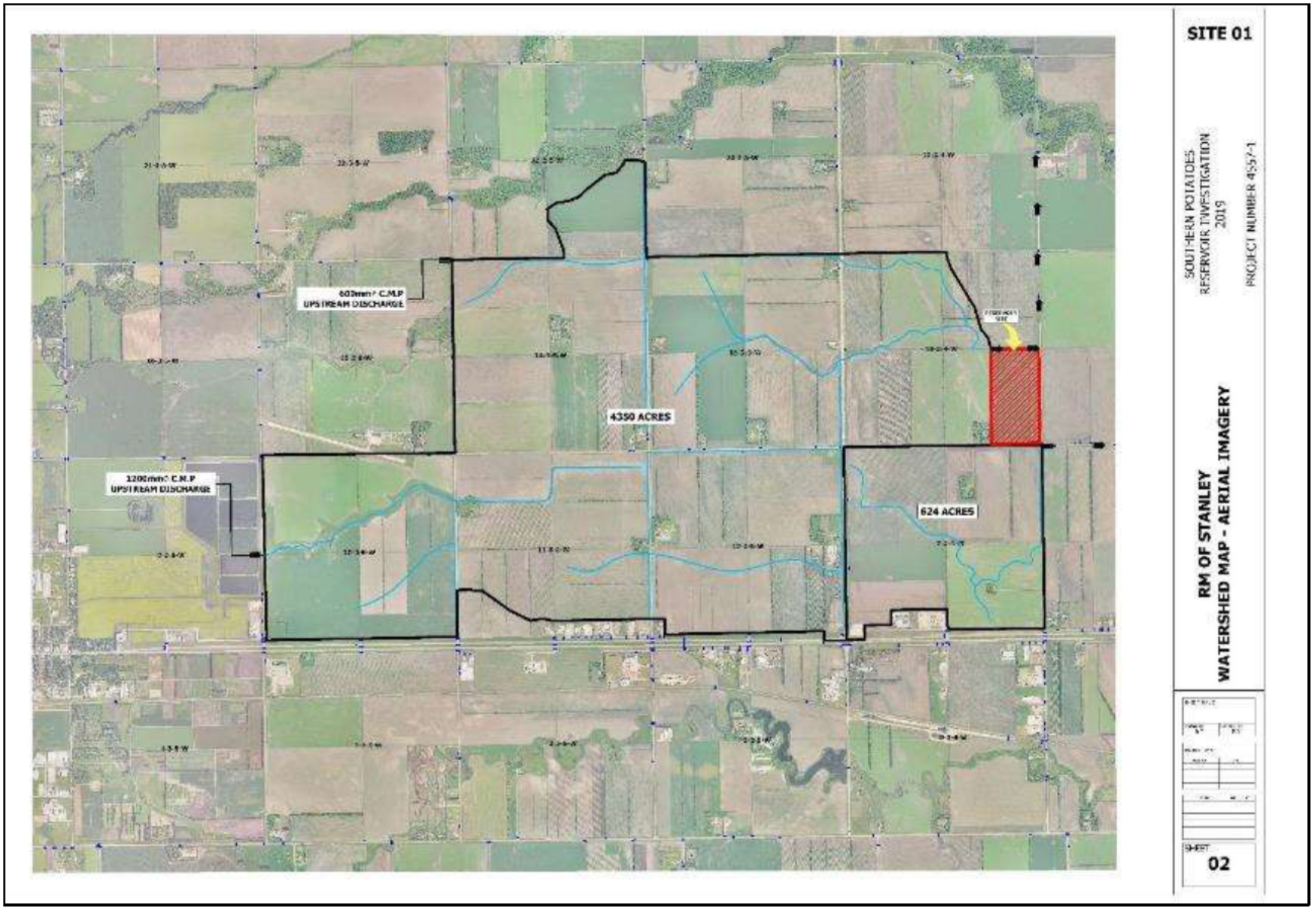

Figure 10 - Local Watershed Delineation for Site DC 18

The Deadhorse Creek is ephemeral 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 some 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. 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 peak flow at Morden (median/upper quartile) appears to be about 0.4 to 1.8 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 low flow or drought years such as 2021.

The Provincial Government is responsible for allocation of water during spring and summer flows along the Deadhorse Creek. Representatives of the Province of Manitoba Drainage and Water Rights Licencing Branch have indicated an initial allocation of 377 acre-feet (465 cubic decameters) to the Southern-Kroeker DC18 site, reflecting an availability factor of about 70% (e.g., water volume available in 7 of 10 years). Significantly, the Southern-Kroeker project is the last major water user expected to be licensed on the Deadhorse prior to joining the Hespler Drain. As the 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 0.95 m^3/s (950 l/s; 15,000 US gpm) be considered. This would allow pumping of 377 acre-feet (465 cubic decameters) in approximately 5 – 6 days. Examining the Deadhorse Creek at Morden and Rosenfeld hydrographs (Appendix D) and estimated flow records, this rate does not appear to be unreasonable. In fact, estimation of local runoff (Figure 10; to site SE 18-3-4 W) suggests that the water diversion rate of 377 acre-feet could be largely met in 50% of the years through pumping only runoff from this local drainage area.

Special consideration (e.g., year by year exemption) could be applied for to extend the pumping period and volume diverted, should the carry over storage be depleted due to drought. As currently planned, there is no desire to capture City of Morden waste-water releases which typically happen late spring and fall, unless water quality issues can be mitigated for irrigation use (e.g., salt, dissolved constituents). The waste-water releases are reflected in water flows at Deadhorse Creek near Rosenfeld (late – May, early June, fall).

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. That site has a similar drainage area to the Deadhorse at DC18; it is proposed that an instream flow of 0.15 m3/s be considered for DC18. Much of that should be a function of releases from Lake Minnewasta, during filling periods.

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). Forage crops are indicated in a couple fields and are sometimes grown in rotation with annual crops. 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 areas are often grazed grassland, due to their typically wetter soils, or have deciduous forest cover in conjunction with grassland (e.g., Deadhorse Creek). Very few occurrences of wetland land cover occur in the Project area; however, a small marsh/fen type wetland is indicated in SW-19-2-4W1 (Field 39) (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 proposed irrigation fields comprising the Project land base using existing soil resource information (Smith, Michalyna, 1971).

A general discussion of soil-landscape conditions within the Project study area is presented below and provides the basis for the subsequent effect's assessment and beneficial management practices recommendations certified by a qualified Professional Agrologist (AgriEarth Consulting Ltd., 2021).

4.1.7.1 Soil Surficial Deposits, Texture, Drainage, Salinity and Stoniness

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 medium (loam) to moderately fine (clay loam). The lacustrine surface deposits overlie glacial till of variable depths in the area between Morden in Winkler, due to the presence of a till-filled, pre-glacial valley running through the vicinity of Winkler. See section 4.1.2 for more on the local geologic setting.

Slow surface runoff and low permeability of soils have resulted in the predominance of imperfectly drained soils (72.8 %) throughout the Project footprint, while a significant portion of the footprint is characterized as well drained (26.9 %) (Table 5; Map 5, Appendix A). Poorly drained soils occur over 0.4% of the Project footprint, in Filed 420 (SE-34-2-5-W1) and Field 39 (SW-19-2-4-W1).

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

There is no stoniness mapped in the Project area.

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 5 – Drainage Classes of Project Soils

Drainage Class	Areal Extent		Proportion of Project Footprint (%)
	hectares (ha)	acres (ac)	
Very Rapid			
Rapid			
Well	372	920	26.9
Moderately Well			
Imperfect	1,010	2,495	72.8
Poor	5	12	0.4
Very Poor			
Totals:	**1,387**	**3,427**	**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, because of surficial soil textures and slope factors, as well as through management practices, namely tillage.

The dominantly medium (74% of Project footprint; very fine sandy loam) and moderately fine (4% of Project footprint; clay loam) textures are generally well protected from wind erosion losses, particularly if surface soils are well structured. However, the moderately coarse (22% of Project footprint; 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 soils within the Project footprint have a moderate (63.3%) to low (36.2%) water erosion risk. (Table 6).

Manitoba producers have long recognized the inherent erosion risk in these soils and implement agronomic practices (shelterbelts, reduced tillage) to reduce the potential for soil loss by erosion. The agronomic assessment includes a recommendation for consideration of erosion BMPs for those soils most susceptible (see Table 11).

Table 6 – Water Erosion Risk Classes of Project Soils

Water Erosion Risk Class	Areal Extent		Proportion of Project Footprint (%)
	hectares (ha)	acres (ac)	
None	7	17	0.4
Low	502	1,242	36.2
Moderate	877	2,168	63.3
High			
Totals:	**1,387**	**3,427**	**100.0**

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 Excellent and Good ratings (Map 6, Appendix A). Table 7 reveals that 26.0% of the soils in the Project footprint are rated as Excellent and 69.6% are rated as Good for irrigation suitability and are considered to have no limitations to slight limitations, respectively, for general irrigation suitability.

A minor portion of the landbase is rated as Fair (4.0%), due to limitations from wetness ("w" limitation), restricted soil water movement ("k" limitation; low hydraulic conductivity), or cumulative factors ("x" limitation). Soils with these limitations generally occupy minor portions of numerous fields through the Project landbase (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 presence of finer textured soils or variability in texture throughout the soil profile. Careful soil and irrigation management will reduce the potential for surface runoff and soil water erosion losses in these areas.

Approximately 0.4% of the Project soils are considered Poor for irrigation due to wetness ("w" limitation) associated with poorly drained soils. None of the fields are considered limited for irrigation, with only a small portion having significant concerns (e.g., 4.0%).

Table 7 - Irrigation Suitability Class of Project Soils

Irrigation Suitability Class	Areal Extent		Proportion of Project Footprint (%)
	hectares (ha)	acres (ac)	
Excellent	361	892	26.0
Good	966	2,387	69.6
Fair	55	136	4.0
Poor	5	12	0.4
Totals:	**1,387**	**3,427**	**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 98.5% of the Project soils in these classes (Table 8).

Approximately 1.4% of the Project soils are rated as Class 5 due to the poor drainage and drain ability limitations. The fields affected by an appreciable amount of Class 5 (i.e., > 5%) ratings include fields 39 (SW-19-2-4-W1), 48 (NE-35-53-5-W1) and 475 (NW-15-3-5-W1). 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 production (soil wetness) and harvestability of the potatoes (i.e., separation of soil and potatoes).

Table 8 – 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	355	878	25.6
2	8	19	0.6
3	1,003	2,479	72.3
4	1	2	0.1
5	20	49	1.4
Totals:	**1,387**	**3,427**	**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 area are almost completely considered to be nutrient management zone N1 and N2 (99.6% of Project footprint; Table 9; Map 8, Appendix A) owing to the soil and topographic factors favourable for annual cropping and nutrient management. A very minor portion of the Project footprint (0.4%) is considered nutrient management zone N3 soil wetness/poor drainage limitations. However, much of these N3 soils occur in Field 39 (SW-

19-2-4-W1), so nutrient management in this field needs to consider the relative sensitive nature of these soils and the allowable soil nitrogen residual concentrations (see Table 1, Section 2.2.4). There are no soils rated as N4 within the Project footprint.

Table 9 – Nutrient Management Zones of Project Soils

Nutrient Management Zone	Areal Extent		Proportion of Project Footprint (%)
	hectares (ha)	acres (ac)	
N1	1,056	2,610	76.2
N2	326	805	23.5
N3	5	12	0.4
N4			
Totals:	**1,387**	**3,427**	**100.0**

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 is 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

The Winkler Ecodistrict is characterized as predominantly cropland (Maps 1 & 4, Appendix A). The natural habitat within this Ecodistrict has been impacted by historic agricultural and associated development, with natural habitat remnants dispersed in nature with a lack of continuity or connectedness, even along the existing creek systems (e.g., Deadhorse Creek, Hespler Creek) (Map 4, Appendix A). The Project footprint is almost completely under annual crop production land use (Map 4, Appendix A), including some treed shelterbelts (e.g., fields 470 [SE-14-3-5-W1] and 475 [NW-15-3-5-W1]. A minor portion of Field 39 (SW-19-2-4-W1) is characterized as a marsh/fen type of wetland. Most of the planned pipelines will be located along road allowances and/or in easement or traverse cropped lands (Maps 3 & 4, 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. The intake will not impact the Deadhorse Creek other than to armor the existing connected Municipal drainage ditch, which will be lowered to allow for water withdrawals (see Figure 2 for intake layout and Figure 3 for photo of that site).

4.2.1 Vegetation

Michalyna and Smith (1971) 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 Deadhorse Creek.

At the proposed reservoir location DC18, the existing land use is agriculture (annual cropping; Map 4, Appendix A).

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.*

The transition from the Escarpment to the Red River Valley corresponds to an increase in agricultural land and a decrease in remnants of natural habitat, and consequently a decrease in wildlife occurrence.

Within the Project footprint, natural habitat is extremely limited as land use is agricultural with the minor inclusion of planted shelterbelts. No clearing of trees is planned for the development of the irrigation project. Shelterbelts are under active consideration for the area to the west and north of the irrigation reservoir DC18 as a means of wind break and snow capture to protect Road 23 W from snow drifting.

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]). An updated response was received April 8, 2021, also included in Appendix C. The main species of concern identified by Manitoba Conservation Data Center within the project area are:

Barn Swallow (Vertebrate Animal)

Yellow Banded Bumble Bee (Invertebrate Animal)

American Pellitory (Vascular Plant)

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 impact: (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, and it is anticipated similar clauses would be issued for site DC18 on the Deadhorse Creek.

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.

Additional assessment of conditions at the Project site follows.

4.3.1 DFO Classification Maps

The Project area is traversed by Deadhorse Creek (Map 1, Appendix A). Deadhorse Creek at this site is a natural channel maintained as a Provincial Drain; it is dyked to prevent break-out flooding, presumably of adjacent farms. Fishery is limited by the 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 Deadhorse Creek 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, Deadhorse Creek adjacent to the Project area is currently considered to be Class A habitat. In other words, the reach downstream of the Project is considered to provide complex habitat for Commercial, Sport, and Domestic 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.

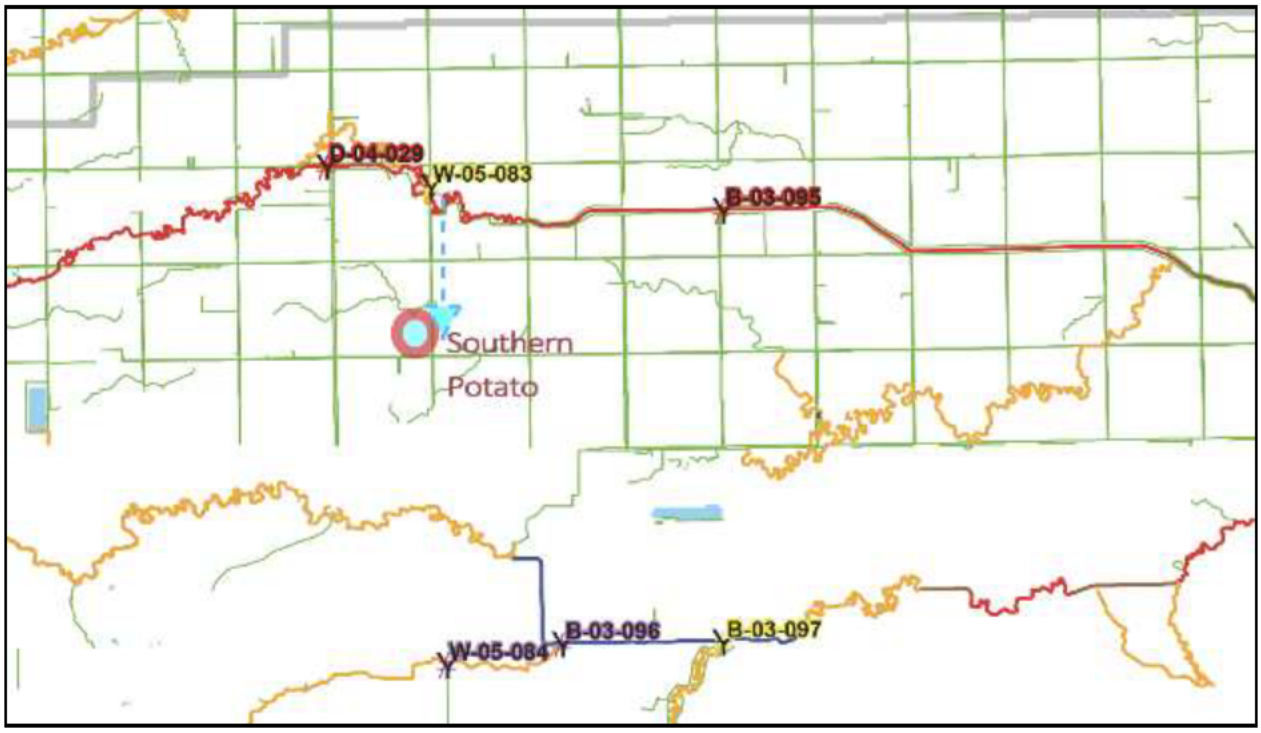

Figure 11 – DFO Habitat Classification of Streams and Constructed Drains in the Project Area

4.4 Socio Economic Environment

The Project area in the RM of Stanley is largely agricultural in nature. The project area takes place along the corridor between the Cities of Morden and Winkler adjacent to PTH #3 and 14.

The Project area is traversed by RM of Stanley Roads 11, 12, 14N and Road 23, 25, 26W which are connecting municipal roads that lead to PTH # 3 and 14 leading from the Project area to potato storages in Winkler and 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 $4.0M (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	$1.5 M
On Farm	$0.9 M
Pipelines	$1.5 M
Power	$0.1 M
Pumps	$0.6 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.

Southern Potato Co. and Kroeker Farms Ltd. are long-time agricultural producer operating in the RM of Stanley. Much of the current land base has dryland potatoes in rotation. The Proponent has a significant work force, both permanent and seasonal, for their farm's operations. The addition of irrigation will require additional labour, inputs and management associated with operations and increased productivity. 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 Southern Potato and Kroeker Farms. This starts with on farm safety for their employees but extends to off farm safety associated with truck traffic from the Project area to the potato storage sites. Southern Potato and Kroeker Farms have existing potato storage nearby in the City of Winkler. As they expand their operations they may need to construct additional 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 RM of Stanley and nearby RM of Rhineland have been developing off stream reservoirs of this nature since the early 1990's and growing potatoes since the 1980's or before. In the case of Southern Potato Co and Kroeker Farms Ltd., they have been growing potatoes since at least the 1960's. The nearest water reservoirs are north on the Shannon Creek (e.g., Site A) and south on the Hespler (S5a, S15) (Maps 3.a & 3.b, Appendix A). These reservoirs are partially or wholly owned by Kroeker Farms or Southern Potato. An instream reservoir located on the Walkof Coulee portion of the Hespler Drain (Road 24 W) was design by PFRA in the 1980's and is owned and operated by Garden Valley Vegetable Growers. There have been no reported issues with the operation of the Southern Potato or Kroeker irrigation reservoirs related to public safety and human health. The Southern-Kroeker reservoir site (DC18) 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 Stanley 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 or encasement 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 (Centra, Enbridge, TCE, CPR).

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 (Deadhorse Creek) are marked to maintain safety for users of the public waterways. There is no known navigation activity taking place on the Deadhorse Creek; it would be unsafe during flood conditions and the Creek 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 Southern Potato Co. and Kroeker Farms Ltd. 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 Southern Potato and Kroeker Farms is planning to construct the reservoir (DC18) with a combination of internal and contracted forces.

4.6 Protected Areas

There are no parks or protected areas located with the Project area. The closest protected areas to the Project are the Wellington Wildlife Management Area (WMA) 17 km to the northwest and the Pembina Valley WMA 30 km to the southwest. The nearest provincial park is the Pembina Valley Provincial park which is approximately 30 km southwest of the Project.

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 associated with the irrigation project or reservoir.

The reservoir is designed to not leak into underlying till or sand/gravel Winkler Aquifer which it lies directly over. Test holes at site DC18 have confirmed a minimum of 5.5 m of lake clay (CH) below the proposed bottom of the reservoir and the top of the Winkler Aquifer (see Appendix H). KGS Group has issued a final geotechnical report on the impacts of upward pressure from the aquifer on the reservoir bottom elevation and dyke slope design, which confirms stability under elevated Aquifer water levels. VRK Consulting and PFRA Ltd. have confirmed the extent and depth and uniformity of the near surface silty clays and the designed positive reservoir seepage cut-off systems (e.g., clay keyway, clay core and clay 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.

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, given the extensive Geotechnical Engineering investigations and design.

The City of Winkler enhanced infiltration project is upstream on the Deadhorse Creek and there is little infiltration into the aquifer downstream of the proposed withdrawal point for reservoir DC18 in NW 20-3-4 W1.

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 (DC18). The reservoir will be engineered by qualified professional engineers registered with their Association of Professional Engineers and Geoscientists in Manitoba.

Water diversion rates from Deadhorse Creek in NW 20-3-4 W1 will be to a maximum of 950 liters per second (15,000 US gpm), as may be required to supplement water diversion in SE 18-3-4 W1 from the smaller local drainage area runoff (19.5 km2). Local runoff will be diverted at up to 1250 liters per second (20,000 US gpm) from the ditch on the north side of SE 18-3-4W.

Diversions would last for about 5 - 10 days depending on the rates of diversion and the volume to be pumped. 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. 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 is anticipating a Development Authorization Permit for construction (Appendix C [C.1]). The Project will be issued a Water Rights Licence after construction pending submission of as-constructed plans. 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 Deadhorse Creek as it meanders to the Red River. Maximum diversion rates are less than 12% of observed ***upper quartile daily*** Deadhorse Creek flows (e.g., at Rosenfeld (8.0 m^3/s)); and less 2% of observed ***peak daily*** Deadhorse Creek flows (i.e., channel forming) which are order of magnitude larger again (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 in the order of 0.15 m^3/s. 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.

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. The Proponents will make some consideration of tile drainage water recycling and nutrient management 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 50 fields being considered for irrigation development. The land suitability assessment, certification of irrigation suitability and recommendation of Best Management Practices was completed by a qualified Professional Agrologist (AgriEarth Consulting Ltd.).

Table 11 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 7 and 8, and no additional field investigations are recommended to confirm suitability at this time. However, it is recommended that zone-based nutrient application be conducted in field 39 (SW-19-2-4-W1) due to the presence of nutrient management zone N3 soils within a significant portion of this field.

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 with a significant portion of well drained (Map 5, Appendix A).

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 many of the remaining fields in the future. A summary of tile drainage status on fields proposed for irrigation is provided in Table 11. The primary benefit of tile drainage is relief of high-water tables in early spring, 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.

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 and nutrient 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 when growing this row crop 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 including high residue crops, namely fall rye following potato crops.
    - Stubble and trash (e.g., corn stalks) managed to minimize fall tillage, promote incorporation and/or maintain stubble.
    - In extreme situations straw spreading 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 and/or the Proponent will be required 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 or N2 (99.7%) 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 (see Table 1, Section 2.2.4). 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 generally 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 Proponent is 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 (74%) medium (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 moderately coarse (fine sandy loam) textured soils (approximately 22% of the Project footprint) 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 largely rated as imperfectly drained (74.4% of the Project footprint). 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 10. The predominantly medium (very fine sandy loam) textured soils in the Project study area would be expected to experience capillary rise in the range of approximately 100 cm (40 in). The moderately coarse (fine sandy loam) textured soils would be expected to experience capillary rise in the range of approximately 40 to 100 cm (16 to 40 in).

The elevation of the water table can be determined by a couple of methods. For fields with tile drainage implemented, drainage flow indicates water table within the depth of tile. In the

absence of tile drainage or for more precise measurements, test monitoring wells may be used. Typically, the shallow water table is regenerated each spring and is drawn down over the course of the growing season. However, in drier years, the initial water table may be deeper than where crop roots can access water in which cases a higher irrigation demand can be anticipated.

Table 10 – 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 usually reported in volumetric %, inches per foot or mm per meter, and provides a useful measure to support irrigation scheduling and irrigation application depths. AWHC is determined as the difference between field capacity (the upper level of how much water a soil can hold against the forces of gravity) and permanent wilt point (the lower level of soil water that can be available to the plant). The AWHC of a given soil provides an estimate of 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 medium to moderately coarse textured soils which predominate the Project footprint can be expected to have an AWHC of 13 to 20% (Haluschak et al. 2004). In other words, these soils would be expected to hold approximately 1.6 to 2.4 in of plant available water per foot.

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 the 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 11 – Proposed Irrigated Fields, Irrigation Suitability Recommendation and Recommended BMPs for Major Considerations

Field ID	Legal Land Location	Proponent	Irrigation Suitability Recommendation	Recommended Beneficial Management Practices (BMPs)																Tile Drainage Status
				Nutrient Management					Soil Erosion				Drainage Management				Irrigation Management			
				4R Nutrient Management (planning, soil testing, application)	Split application and/or fertigation	Enhanced Efficiency Nitrogen	Zone-Based Variable Rate Application	Other:	Residue Management	Fall-seeded Cereal Cover Crops	Reduced/Conservation Tillage	Other:	Subsurface Drainage Improvements	Surface Drainage Management	Drainage Assessment	Other:	Irrigation Scheduling	Soil Moisture Monitoring	Other:	T = existing tile F = future, planned N = no tile planned
South portion																				
10	NE&NW-18-2-4-W1	Southern Potato	Recommended	x	x	x			x	x	x						x	x		T
39	SW-19-2-4-W1	Southern Potato	Recommended	x	x	x	x[1]		x	x	x						x	x		T
405,406,407	SE-24-2-5-W1	Kroeker Farms	Recommended	x	x	x			x	x	x		x		x		x	x		T (405), F (406, 407)
433	NW-24-2-5-W1	Kroeker Farms	Recommended	x	x	x			x	x	x						x	x		N
411,412,413,414,415	SW-25-2-5-W1	Kroeker Farms	Recommended	x	x	x			x	x	x						x	x		T
91	SW-26-2-5-W1	Southern Potato	Recommended	x	x	x			x	x	x		x		x		x	x		F
14	NW-26-2-5-W1	Southern Potato	Recommended	x	x	x			x	x	x						x	x		T
419	NE-27-2-5-W1	Kroeker Farms	Recommended	x	x	x			x	x	x		x		x		x	x		F
97	SE-36-2-5-W1	Southern Potato	Recommended	x	x	x			x	x	x		x		x		x	x		F
92,96	SW-36-2-5-W1	Southern Potato	Recommended	x	x	x			x	x	x		x		x		x	x		F
427	SW-35-2-5-W1	Kroeker Farms	Recommended	x	x	x			x	x	x		x		x		x	x		F
13	NW-35-2-5-W1	Southern Potato	Recommended	x	x	x			x	x	x						x	x		T
420,421,422,423	SE-34-2-5-W1	Kroeker Farms	Recommended	x	x	x			x	x	x						x	x		T
424,425,426	NE-34-2-5-W1	Kroeker Farms	Recommended	x	x	x			x	x	x		x		x		x	x		F
445,446	SE-2-3-5-W1	Kroeker Farms	Recommended	x	x	x			x	x	x		x		x		x	x		F
441,443,444,445	SW-2-3-5-W1	Kroeker Farms	Recommended	x	x	x			x	x	x		x		x		x	x		F
North portion																				
11	NW-7-3-4-W1	Southern Potato	Recommended	x	x	x			x	x	x						x	x		T
40	SE-18-3-4-W1	Southern Potato	Recommended	x	x	x			x	x	x		x		x		x	x		N
12	SW-18-3-4-W1	Southern Potato	Recommended	x	x	x			x	x	x						x	x		T
454,455,456	SE-11-3-5-W1	Kroeker Farms	Recommended	x	x	x			x	x	x						x	x		T
457,458,459	NE-11-3-5-W1	Kroeker Farms	Recommended	x	x	x			x	x	x						x	x		T
450,451	NW-11-3-5-W1	Kroeker Farms	Recommended	x	x	x			x	x	x						x	x		T
470	SE-14-3-5-W1	Kroeker Farms	Recommended	x	x	x			x	x	x		x		x		x	x		F
471	NE-14-3-5-W1	Kroeker Farms	Recommended	x	x	x			x	x	x						x	x		T
475	NW-15-3-5-W1	Kroeker Farms	Recommended	x	x	x			x	x	x		x		x		x	x		F
49	SE-35-3-5-W1	Southern Potato	Recommended	x	x	x			x	x	x		x		x		x	x		F
48	NE-35-3-5-W1	Southern Potato	Recommended	x	x	x			x	x	x						x	x		N

Notes:
Refer to Stantec 2011 for more detailed information on the guidelines for irrigation suitability recommendations and determination of recommended beneficial management practices.
1. Zone-based variable nutrient application is recommended due to the occurrence of a signficant portion of nutrient management zone N3 soils in this field.

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 potential tree plantings alongside the proposed DC18 reservoir site. The existing habitat is considered marginal being surrounded by the 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 DC18 would add to the wetland habitat, which is limited in the Project area. Shelterbelt plantings could add to the habitat value of the reservoir 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 is typically 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., DC18) and to replace any disturbed shelterbelts; through creation of wetland habitat and create new terrestrial habitat at the proposed reservoir site.

5.2.2 Impact on Species at Risk

The reaches of the Deadhorse Creek adjacent to the proposed intake have been classified as supporting species at risk (i.e., Class A) and are largely in the natural state. The proposed intake for the project is along a disturbed municipal ditch, which is maintained but mowing on a regular basis. No Creek habitat will be affected by the proposed intake system.

The remainder of the Project area is cultivated land with little habitat value and is not expected to support species at risk. None-the-less, the Manitoba Conservation Data Center was consulted regarding the potential for species at risk being reported in the Project area.

The Conservation Data Center provided the following input:

1. Within the footprint or primary location(s):

   Within SE-18-003-04W1 and NW-20-003-04W1:

   No listed or tracked species occurrences found at this time.

2. Within 2km of the footprint boundary:

   Within 2km of SE-18-003-04W1 and NW-20-003-04W1:

TAXGROUP	SCINAME	COMNAME	SRANK	ESEA	SARA	COSEWIC
Vertebrate Animal	Hirundo rustica	(Barn Swallow)	S4B	NA	Threatened	Threatened

3. General area records low locational accuracy:

   SE-18-003-04W1 and NW-20-003-04W1:

TAXGROUP	SCINAME	COMNAME	SRANK	ESEA	SARA	COSEWIC
Invertebrate Animal	Bombus terricola	(Yellow-banded Bumble Bee)	S4S5	NA	NA	Special Concern
Vascular Plant	Parietaria pensylvanica	(American Pellitory)	S3S4	NA	NA	NA

4. Found in broader area and similar habitat:

   No listed or tracked species occurrences found at this time.

The Proponent will engage the services of a Species at Risk specialist to advise the project of best means to avoid impact of any of the known species at risk as they relate to specific project construction and operational methods.

The potential for species at risk or of conservation concern has been confirmed through a CDC search. 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. None-the-less the Proponents intend to engage specialist advise relative to species identified above.

5.2.3 Impact on Fisheries

The Deadhorse Creek in the Project area is Class A habitat and as such is considered to support Commercial, Sport/Recreational, Domestic or Indigenous, or SARA fish species. The Deadhorse Creek in the Project area is not channelized, but migration to it is somewhat restricted by drop structures downstream towards the Red River and of course snow during spring freshet.

Deadhorse Creek 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.*

The DC18 off-stream reservoirs will only extract water during spring freshet and will not impact the stream width on the Deadhorse Creek, as the intake is off stream.

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.

Use of 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 re-fuel 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.
- Consider electric motors as alternative to diesel tractors to power pumps.

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 water course

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 Deadhorse Creek 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 Deadhorse Creek, constructing the intake off-stream on municipal ditch that enters the Deadhorse Creek (perpendicular) 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 the reservoir site and will follow recommendations of Historic Resources Branch regarding the assessment and potential significance.

5.3.2 Economic Activity and Employment

Kroeker Farms Ltd. and Southern Potato Co. employees work full time within the RM's of Dufferin, Thompson, Stanley, and Rhineland. The Proponents are employers, taxpayers, community supporters and are active members of their rural communities.

Construction activity will involve members of Kroeker Farms Ltd. and Southern Potato Co., 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 Highways (e.g., 3, 14, 32) in the vicinity of Morden and Winkler, Manitoba, as well as local municipal roads adjacent to the project fields in question. 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 Stanley.

Every effort will be made to reroute truck traffic around points of congestion during high traffic periods. Kroeker Farms / Southern Potato drivers will have standards of operation.

5.3.4 Utilities

Existing utilities will not be interrupted because of the construction of the Project. All utilities locations will be identified in the field prior to any 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 of Stanley 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, as feasible. Bell-MTS, Valley Fiber 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. Railway crossing will be pre-approved by Canadian Pacific Railway, will be made at right angles, and be lined in accordance with CPR and Federal standards with appropriate thickness of steel pipe. Oil and Gas crossings will be pre-approved by Enbridge, Trans Canada Energy and Centra/Hydro. Details of those crossings are pending nature and depth of Oil and Gas line and individual and Federal requirements for such crossings, and further utility consultations.

Manitoba Hydro will be approached regarding provision of three phase power to the pump sites at the reservoir in SE 18-3-4 W1 and the intake site in NW 20-3-4 W.

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 the Deadhorse Creek or the local drainage channel.
- 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 10-day period (10 x 38 acre-feet per day = 380 acre-feet per year).

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

1. Filling 2 x 150 HP (electric) running for 5 – 7 days.
2. Pumping 500 hours x 3 x 150 hp.
3. Irrigation 500 hours x 8 x 10 hp.

IF all of these power units were diesel, 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 or adjacent to the reservoir project.

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 as a result 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.

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 Stanley Permits, and those dictated by other regulatory bodies (e.g., Federal Agencies (e.g., Transportation Canada, DFO, Nav Can), Provincial Agencies (Agriculture, 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 Deadhorse Creek stream flows and adjust pumping rates accordingly to maintain downstream requirements. A MIF of 0.15 m3/sec is proposed by the Proponent, based on existing EAL requirements of existing irrigation projects on nearby drains.

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 location. 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 has been consulted on potential for Species at Risk at the proposed Project sites. Specialist consulting will be engaged to advise the owner on avoidance of identified species at risk. 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 Deadhorse Cr, Shannon Cr. and Hespler 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 containment 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 Southern Potato Co. and Kroeker Farms Limited Deadhorse 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 Southern Potato Co. and Kroeker Farms Limited 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 a combination of office and field based assessments of the environment within which it is located.

8.0 References

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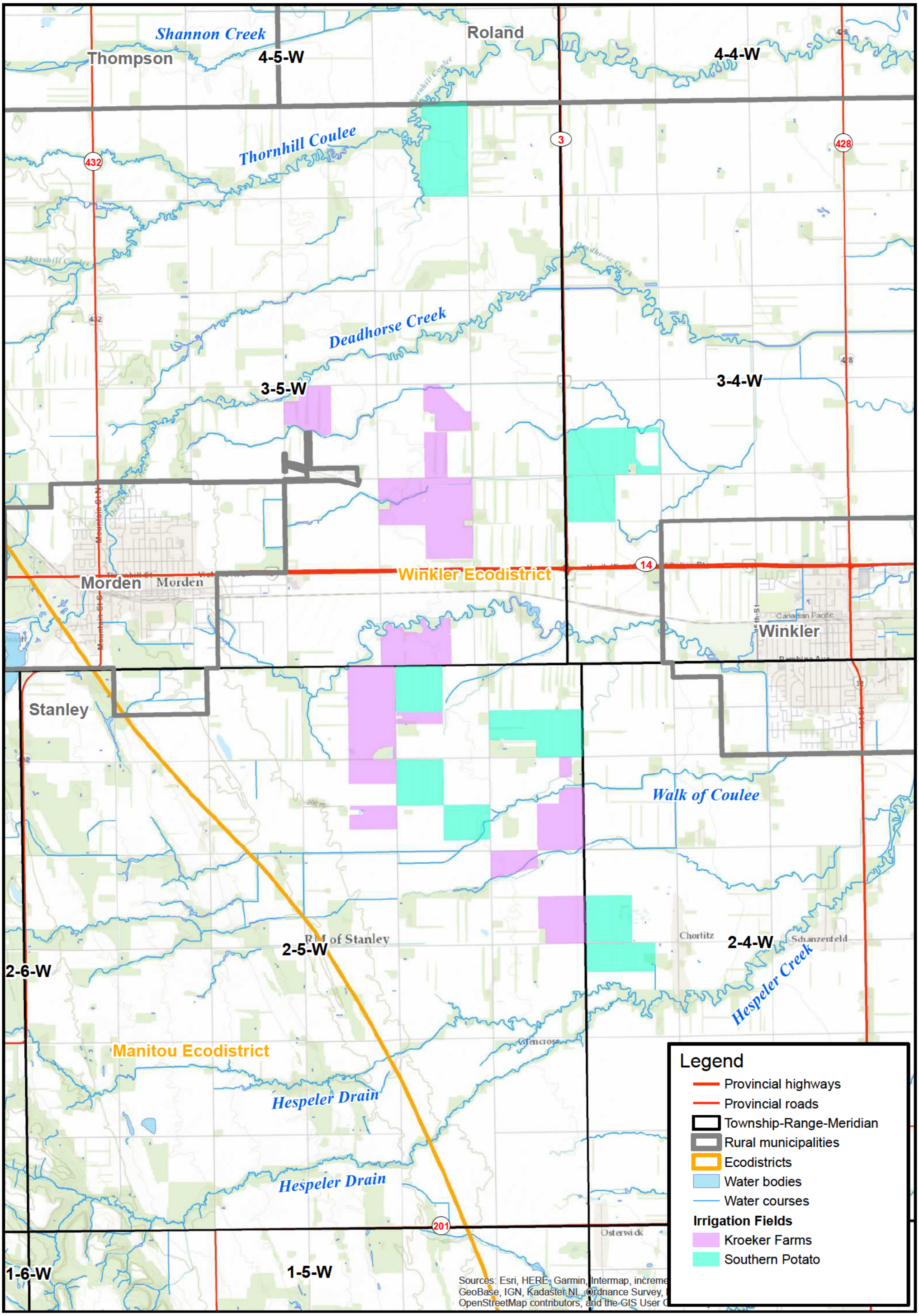
APPENDICES

APPENDIX A - Maps



Map Name

Project Regional Context

Map Number

1

Project Name

Southern Potato - Kroeker Farms

NORTH

1,900 950 0 1,900

Metres

1:60,000

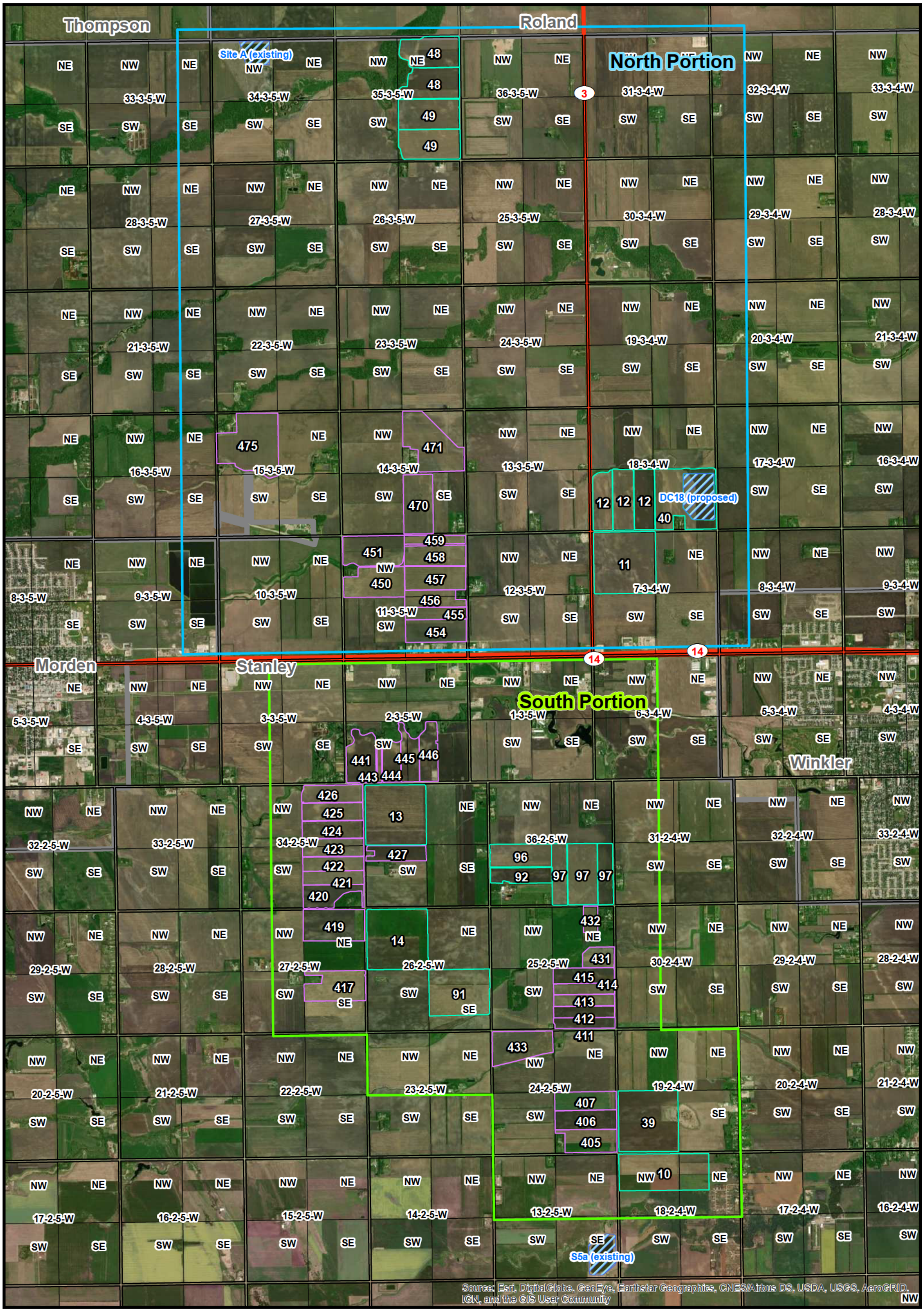
Date: 2021-05-10
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

Acknowledgements:
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

Project Overview

Map Number

2

Project Name

Southern Potato - Kroeker Farms

NORTH

1,400 700 0 1,400

Metres

1:45,000

Date: 2021-05-10
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

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

Prepared by

PBS Water Engineering

agriearth consulting ltd.

Shannon Creek

Site A (existing)

Deadhorse Creek

DC18 (proposed)

Option 1 (21" pipe)

Option 2 (21" pipe)

Option 1 (18" pipe)

Option 2 (18" pipe)

Legend

Irrigation infrastructure
- Distribution pump
- Fill pump
- Reservoir

Distribution pipeline - size (in)
- 8
- 10
- 12
- 18
- 21

Fill network
- Fill pipeline (30")
- Open channel

Irrigation Fields
- Kroeker Farms
- Southern Potato

Transportation
- Provincial highways
- Provincial roads
- Rail

Utilities (approximate)
- Manitoba Hydro (gas)
- TC Energy (oil)
- Enbridge (oil)

Note:
Locations of utilities in this map are to be considered approximations only.
Presentation of utilities is for preliminary project planning purposes only andthis information is not to be relied upon for construction or engineering purposes.

Map Name

Project Infrastructure - North Portion

Map Number

3.a

Project Name

Southern Potato - Kroeker Farms

NORTH

850 425 0 850

Metres

1:25,000

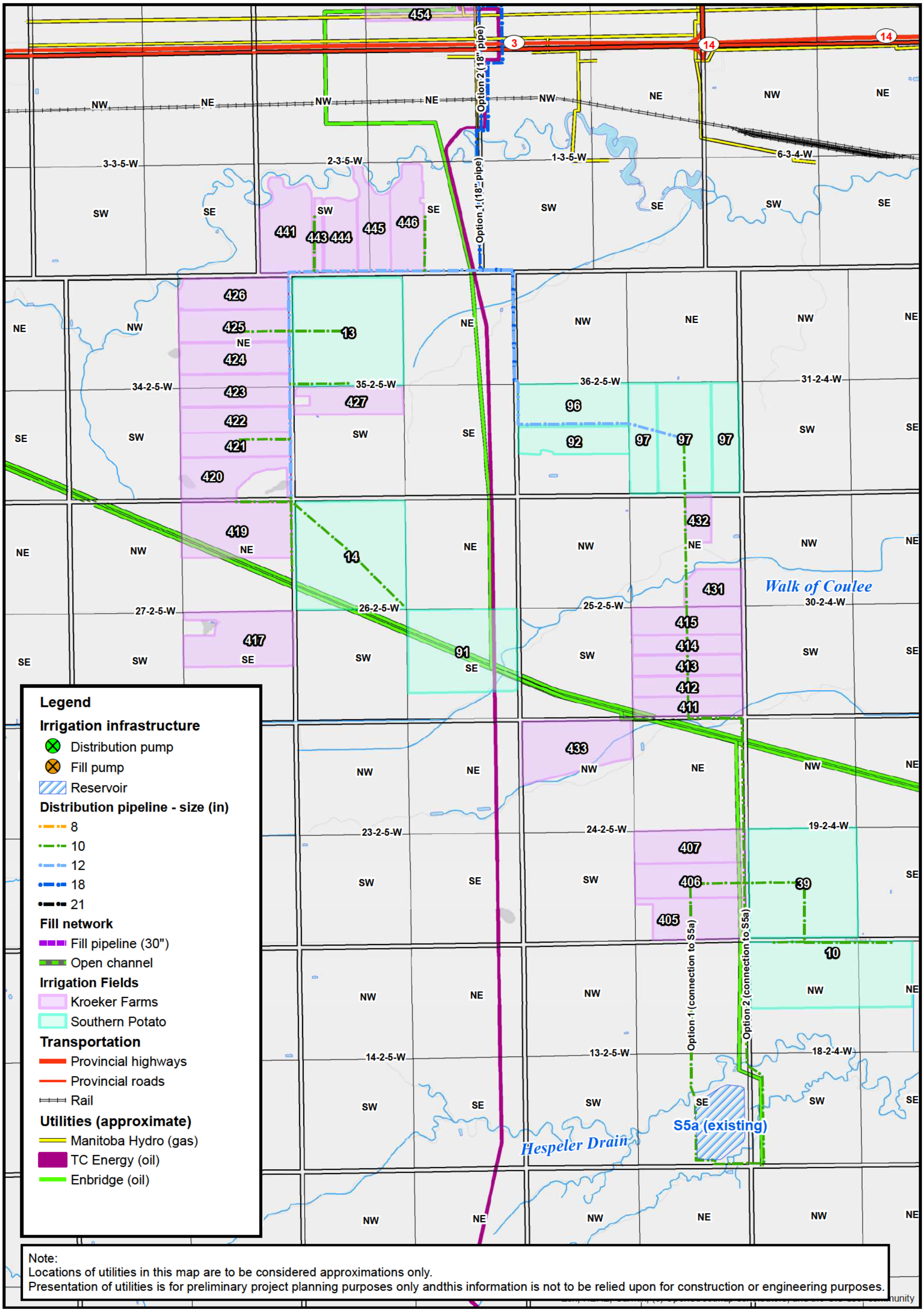
Date: 2021-05-10
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

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

Prepared by

PBS Water Engineering

agriearth consulting ltd.



Note:
Locations of utilities in this map are to be considered approximations only.
Presentation of utilities is for preliminary project planning purposes only andthis information is not to be relied upon for construction or engineering purposes.

Map Name
Project Infrastructure - South Portion

Map Number
3.b

Project Name
Southern Potato - Kroeker Farms

NORTH

850 425 0 850
Metres
1:25,000

Date: 2021-05-10
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

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

Prepared by
PBS Water Engineering
agriearth consulting ltd.

Legend

- Provincial roads
- Provincial highways
- Reservoir
- Aquifers

Irrigation Fields

- Kroeker Farms
- Southern Potato

Major Buried Sand and Gravel

Winkler Aquifer

Lenses of Sand and Gravel

Thin Unconfined Sand

Land Cover Classes

1. Agriculture
2. Deciduous Forest
3. Water
4. Grassland
5. Mixedwood Forest
6. Marsh/Fens
7. Bogs
8. Treed Rock
9. Conifer Forest
10. Burns
11. Open Deciduous Forest
12. Forage Crops
13. Cultural
14. Forest Cutblocks
15. Bare Rock/Sand/ Gravel
16. Roads/Trails
17. Fens

Map Name

Land Cover Classes and Aquifers

Map Number

4

Project Name

Southern Potato - Kroeker Farms

NORTH

1,250 625 0 1,250

Metres

1:40,000

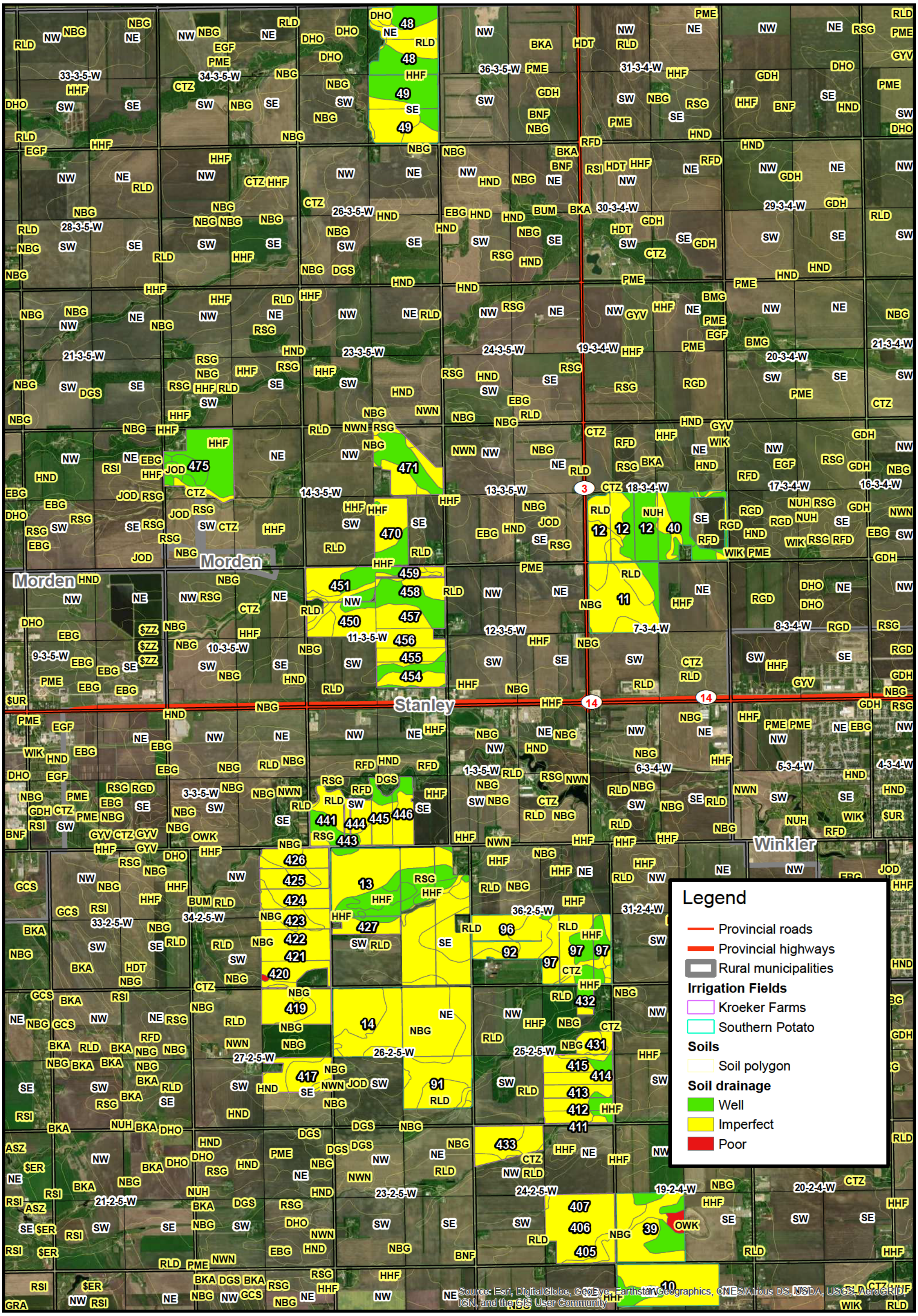
Date: 2021-05-03
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

Acknowledgements:
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

Soils & Drainage Class

Map Number

5

Project Name

Southern Potato - Kroeker Farms

NORTH

1,250 625 0 1,250

Metres

1:40,000

Date: 2021-05-10
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

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

Prepared by

PBS Water Engineering

agriearth consulting ltd.

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.

Thompson
Morden
Morden
Stanley

Legend

- Provincial roads
- Provincial highways
- Rural municipalities

Irrigation Fields

- Kroeker Farms
- Southern Potato

Irrigation Suitability

- Excellent
- Good
- Fair
- Poor

Soils

- Soil polygon

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Name

General Irrigation Suitability

Map Number

6

Project Name

Southern Potato - Kroeker Farms

NORTH

1,250 625 0 1,250

Metres

1:40,000

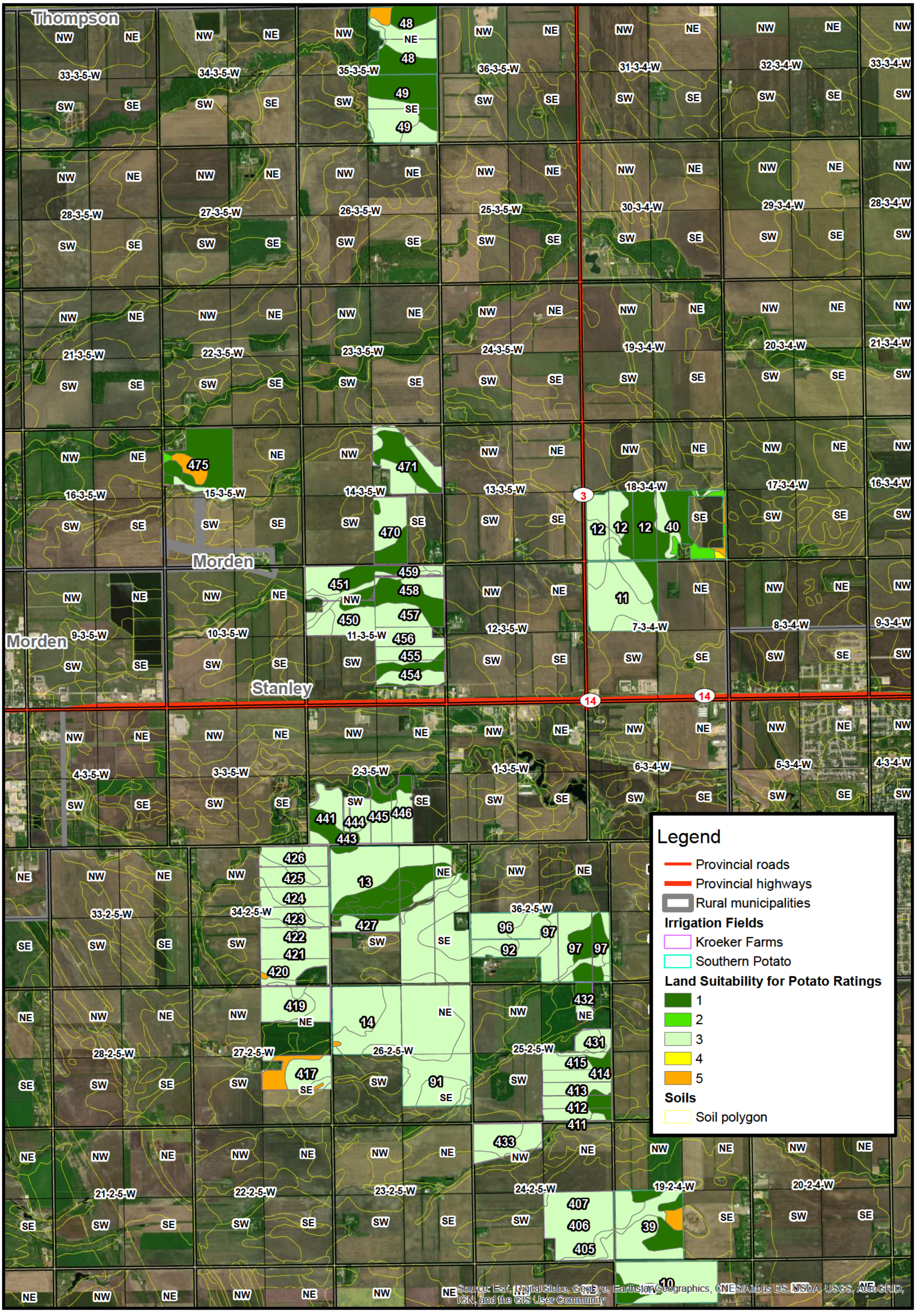
Date: 2021-05-03
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

Acknowledgements:
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 Suitability for Irrigated Potato Production

Map Number

7

Project Name

Southern Potato - Kroeker Farms

NORTH

1,250 625 0 1,250

Metres

1:40,000

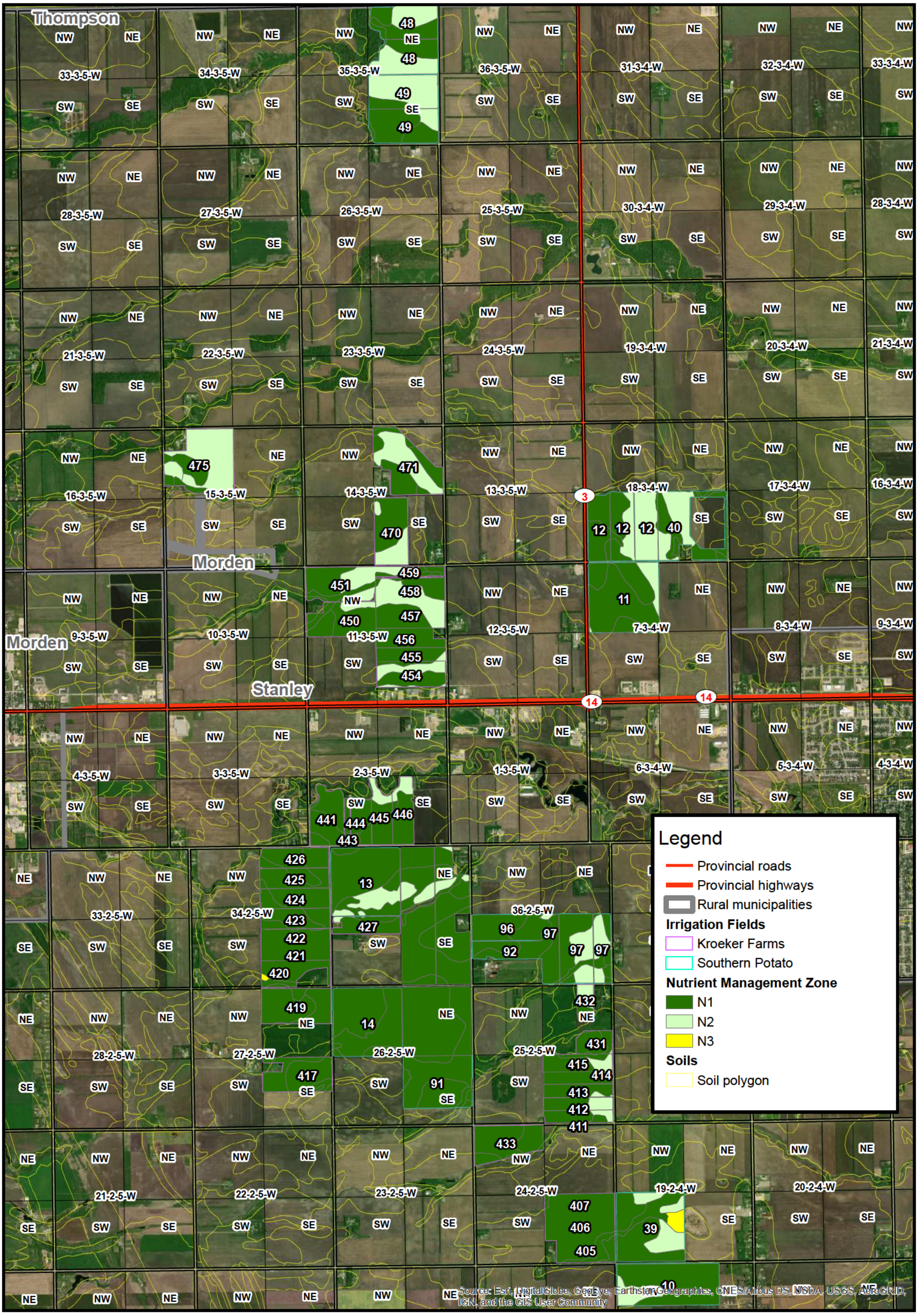
Date: 2021-05-03
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

Acknowledgements:
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

Nutrient Management Zones

Map Number

8

Project Name

Southern Potato - Kroeker Farms

NORTH

1,250 625 0 1,250

Metres

1:40,000

Date: 2021-05-03
Drawn by - D. Whetter
Reviewed by - B. Shewfelt

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

Prepared by

PBS Water Engineering

agriearth consulting ltd.

APPENDIX B - RM Correspondence

Hearing Date: _____

Time: _____

RM of Stanley
Planning Application

23111 7TH 14W
Box 1600 Winkler, Manitoba
R6W 4B5
Email: info@rmofstanley.ca
www.rmofstanley.ca

File No: _____ Roll No: 215200 CT: 2681543 / MORDEN

Applicant Name(s): Southern Potato Co and Kroeker Farms Ltd. Phone: 362 2107

Mailing Address: 375 North Railway

Town/City: Winkler Province: MB Postal Code: R6W 1J 4

Registered Property Owner Name(s): same Phone: _____

Mailing Address: _____

Town/City: _____ Province: _____ Postal Code: _____

OFFICE USE

Lot: _____ Block: _____ Plan: _____ Zone: _____

Quarter: _____ Section: _____ Township: _____ Range: _____

Civic Address (If known): _____

By-law Provision: EXISTING

Part: _____

Section: _____

Table: _____

Planning Act Section: PROPOSED

Comments: _____

OWNER'S SIGNATURE

I/We hereby certify that the information provided on this form and attachments hereto, to the best of my knowledge is a true statement of facts concerning this application.

Signature: _____ Date: May 2, 2021

TYPE OF APPLICATION

- [ ] Variation
- [x] Conditional Use
- [ ] Zoning By-law Amendment
- [ ] Road Creation
- [ ] Road Closing By-law

Attachments:

- [ ] Letter of Intent
- [x] Site Plan
- [ ] Building Plans

Date Application Received: _____ Receipt No: _____

RURAL MUNICIPALITY OF STANLEY
UNDER THE PLANNING ACT
NOTICE OF HEARING OF APPLICATION
FOR A CONDITIONAL USE ORDER

The Council of the Rural Municipality of Stanley under the authority of *The Planning Act* will hold a HEARING at:
RM of Stanley Administration Office
Council Chambers
1-23111 PTH 14, SW¼ 7-3-4W

Thursday, May 20, 2021
9:30 a.m.

at which time and place the Council will receive representations from the applicant and any persons who wish to make them in respect of the following application for a Conditional Use under the R.M. of Stanley Zoning By-Law No. 8-18.

File Number:	CU818-72
Roll Number:	215200
Applicant/Owner(s):	Southern Manitoba Potato Company Limited
Subject:	The purpose of this application is to permit an "Irrigation Reservoir" in the "AG" Zone. Approximate area shown on reverse.
Legal Description:	Part of SE 18-3-4W
Zoning:	"AG" Agriculture General Zone

[redacted]

Melissa Groening
Planning and Development Officer
Rural Municipality of Stanley

****Please note: If you wish to provide comments regarding the application we ask that you consider submitting your comments in writing to our office by email or mail (drop off box located at the office). If you wish to be present at the hearing we will require you to contact our office a minimum of 2 business days prior to the scheduled hearing as seating is limited and we need to ensure we can meet the physical distancing requirements. Anyone attending the office will be required to wear a face mask. If you wish to participate in the hearing electronically, please contact mgroening@rmofstanley.ca or call 204-325-4101. Thank you for your understanding and patience.**

See reverse

APPENDIX C – Provincial Correspondence

APPENDIX C.1 – Provincial Licensing Correspondence

FORM C

Application for Licence to Divert and Use Surface Water

Environmental Stewardship Division
Drainage and Water Rights Licensing Branch
200 Saulteaux Crescent
Winnipeg MB R3J 3W3
Email: wateruse@gov.mb.ca

Manitoba
Conservation and Climate

Pursuant *to The Water Rights Act*

APPLICANT'S NAME: Southern Potato and Kroeker Farms Ltd.	CONTACT NAME: Marlon Kuhl	PHONE: (204) 325-4316	
BOX # or STREET ADDRESS: 875 North Railway Ave		MOBILE:	
CITY or TOWN: Winkler	PROV: MB	POSTAL CODE: R6W 1J4	E-MAIL ADDRESS: Marlon@southernpotato.com

Hereby applies for authority to divert: **Spring Flow** [X] -OR- **Firm Flow** [ ] water from /

Deadhorse Creek and local Deadhorse Creek Watershed runoff
(name of river, creek, channel, etc)

by means of a pump located on the following described land:

	QUARTER	SECTION	TOWNSHIP	RANGE	E OR W
Pump Site 1	NW 20	3	4	W
Pump Site 2	SE 18	3	4	W

or otherwise described as See attached

for Irrigation use purposes,
(specify: municipal, agricultural, industrial, irrigation, other uses)

on the following described land:

QUARTER	SECTION	TOWNSHIP	RANGE	E OR W

or otherwise described as: See attached land map

at the following rates: cubic metres per second (pumping rate)

(propose to store 700 dam3) 465 cubic decametres per year (annual usage)

Total number of acres to be irrigated: 1000 (if applicable)

NB. Replaces:
1. Kroeker April 1, 2014 app
2. Southern Dec. 12, 2014 app
3. Southern Dec. 12, 2014 app
See attached copies
Precendence maintained

The above described lands are held as follows (check applicable box):

[X] as registered owner [ ] purchased under agreement for sale [X] lessee [X] to be determined

Copy(s) of the certificate(s) of title must be attached: (except for renewal and amendment) [ ] Title(s) attached Title Number(s): TBDX

Is this application for the renewal of an existing licence? [ ] YES [X] NO Existing Licence No.

Is this application for the transfer of an existing licence? [X] YES [ ] NO Existing Licence No. Applications dated

Is this application to amend an existing licence? [ ] YES [X] NO Existing Licence No.

What is your preferred method of communication? [X] email [ ] Postal mail

Date: March 29 20 21

Southern Potato Kroeker Farms

x [redacted]
(Signature of applicant)

**** IMPORTANT ****

FEE OF $100.00 MUST ACCOMPANY THIS APPLICATION. CHEQUE, TITLE, AND APPLICATION MUST BE MAILED TO:

MANITOBA CONSERVATION AND CLIMATE
BOX 16, 200 SAULTEAUX CRESCENT
WINNIPEG MB R3J 3W3

CHEQUES TO BE MADE PAYABLE TO MINISTER OF FINANCE

FOR OFFICE USE ONLY:

MG-14841 REV. CODE 6-15 2019-12

FORM C

Application for Licence to Divert and Use Surface Water

Water Stewardship Division
Water Use Licensing Section
200 Saulteaux Crescent
Winnipeg MB R3J 3W3

Manitoba
Conservation and Water Stewardship

Pursuant to The Water Rights Act

APPLICANT'S NAME: Krocker Farms	CONTACT NAME: Eric Klassen		PHONE: 325 4333
POST OFFICE ADDRESS: 230 Rothlin Blvd E			MOBILE: 362 7067
CITY or TOWN: Winkler	PROV: MB	POSTAL CODE: R6W 4B4	E-MAIL ADDRESS: dirtmover@krockers.ca

Hereby applies for authority to divert **Spring Flow** ☑ -OR- **Firm Flow** ☐ water from /

Dead Horse Creek
(name of river, creek, channel, etc)

by means of a pump located on the following described land:

QUARTER	SECTION	TOWNSHIP	RANGE	E OR W
	23	3	5	

or otherwise described as _____

for irrigation use purposes,
(municipal, agricultural, industrial, irrigation, other uses)

on the following described land:

QUARTER	SECTION	TOWNSHIP	RANGE	E OR W
	14	3	5	

or otherwise described as: _____

at the following rates: 180 acre Feet ~~cubic metres per second (pumping rate)~~
_____ cubic decametres per day (daily usage)
_____ cubic decametres per year (annual usage)

Total number of acres to be irrigated: _____ (if applicable)

The above described lands are held as follows: (check applicable box)

☑ as registered owner ☐ purchased under agreement for sale ☐ lessee ☐ to be determined

Attach copy(s) of the certificate(s) of title or title number(s).

Is this application for the renewal of an existing licence? ☐ YES ☐ NO **Existing Licence No.** _____
Is this application for the transfer of an existing licence? ☐ YES ☐ NO **Existing Licence No.** _____
Is this application to amend an existing licence? ☐ YES ☐ NO **Existing Licence No.** _____

Date: April 1 20 14 [redacted]
(Signature of applicant)

**** IMPORTANT ****

FEE OF $100.00 MUST ACCOMPANY THIS APPLICATION, CHEQUE AND APPLICATION MUST BE MAILED TO:

MANITOBA CONSERVATION
CASHIER'S OFFICE
BOX 42, 200 SAULTEAUX CRESCENT
WINNIPEG MB R3J 3W3

CHEQUES TO BE MADE PAYABLE TO MINISTER OF FINANCE

FOR OFFICE USE ONLY: 27

MG-14841 APR 3 3 2014 2013-11-30

FORM C

Application for Licence to Divert and Use Surface Water

Water Stewardship Division
Water Use Licensing Section
200 Saulteaux Crescent
Winnipeg MB R3J 3W3

Manitoba
Conservation and Water Stewardship

Pursuant to The Water Rights Act

APPLICANT'S NAME: Southern Manitoba Potato Growers	CONTACT NAME: Marlon Kuhl	PHONE: 204-325-4318	
POST OFFICE ADDRESS: Box 1420		MOBILE: 204-362-2107	
CITY or TOWN: Winkler	PROV: MB	POSTAL CODE: R6W 4B4	E-MAIL ADDRESS: Marlon@southernpotato.com

Hereby applies for authority to divert **Spring Flow** ☒ -OR- **Firm Flow** ☐ water from /

Dead Horse
(name of river, creek, channel, etc)

by means of a pump located on the following described land:

QUARTER	SECTION	TOWNSHIP	RANGE	E OR W
	11	3	3	W

or otherwise described as _____

for _____ use purposes,
(municipal, agricultural, industrial, irrigation, other uses)

on the following described land:

QUARTER	SECTION	TOWNSHIP	RANGE	E OR W
NW SE	29	2	3	W

or otherwise described as: _____

at the following rates: _____ cubic metres per second (pumping rate)
_____ cubic decametres per day (daily usage)
180 cubic decametres per year (annual usage)

Total number of acres to be irrigated: _____ (if applicable)

The above described lands are held as follows: (check applicable box)

☐ as registered owner ☐ purchased under agreement for sale ☐ lessee ☒ to be determined

Attach copy(s) of the certificate(s) of title or title number(s).

Is this application for the renewal of an existing licence? ☐ YES ☒ NO Existing Licence No. _____
Is this application for the transfer of an existing licence? ☐ YES ☒ NO Existing Licence No. _____
Is this application to amend an existing licence? ☐ YES ☒ NO Existing Licence No. _____

Date: December 12 2014

[redacted]
(Signature of applicant)

**** IMPORTANT ****

FEE OF $100.00 MUST ACCOMPANY THIS APPLICATION, CHEQUE AND APPLICATION MUST BE MAILED TO:

MANITOBA CONSERVATION
CASHIER'S OFFICE
BOX 42, 200 SAULTEAUX CRESCENT
WINNIPEG MB R3J 3W3

CHEQUES TO BE MADE PAYABLE TO MINISTER OF FINANCE

FOR OFFICE USE ONLY: File: -4

MG-1484]

2013-11-30

Validation over →

Transaction #: 41362
6-15: APPL & WATER USE FEES
(Name SOUTHERN MANITOBA POTATO)
1 @ $100.00
2014-12-12 12:17:22 PM
Cashier / Caisser: 211
Visa (V)

FORM C

Application for Licence to Divert and Use Surface Water

Water Stewardship Division
Water Use Licensing Section
200 Saulteaux Crescent
Winnipeg MB R3J 3W3

Manitoba
Conservation and Water Stewardship

Pursuant to *The Water Rights Act*

APPLICANT'S NAME: Southern Manitoba Potato Co. Ltd.	CONTACT NAME: Marlon Kehl	PHONE: 204-325-4324	
POST OFFICE ADDRESS: Box 1420		MOBILE: 204-362-2107	
CITY or TOWN: Winkler	PROV: MB	POSTAL CODE: R6W 4B4	E-MAIL ADDRESS: Marlon@southernpotato.com

Hereby applies for authority to divert **Spring Flow** ☒ -OR- **Firm Flow** ☐ water from /

Dead Horse
(name of river, creek, channel, etc)

by means of a pump located on the following described land:

	6	3	3	W
QUARTER	SECTION	TOWNSHIP	RANGE	E OR W

or otherwise described as _____

for Irrigation use purposes,
(municipal, agricultural, industrial, irrigation, other uses)

on the following described land:

SW	6	3	3	W
QUARTER	SECTION	TOWNSHIP	RANGE	E OR W

or otherwise described as: _____

at the following rates: _____ cubic metres per second (pumping rate)
_____ cubic decametres per day (daily usage)
59 cubic decametres per year (annual usage)

Total number of acres to be irrigated: _____ (if applicable)

The above described lands are held as follows: (check applicable box)

☐ as registered owner ☐ purchased under agreement for sale ☒ lessee ☒ to be determined

Attach copy(s) of the certificate(s) of title or title number(s).

Is this application for the **renewal** of an existing licence? ☐ YES ☒ NO Existing Licence No. _____
Is this application for the **transfer** of an existing licence? ☐ YES ☒ NO Existing Licence No. _____
Is this application to **amend** an existing licence? ☐ YES ☒ NO Existing Licence No. _____

Date: December 12 2014

[redacted]
(Signature of applicant)

**** IMPORTANT ****

FEE OF $100.00 MUST ACCOMPANY THIS APPLICATION, CHEQUE AND APPLICATION MUST BE MAILED TO:

MANITOBA CONSERVATION
CASHIER'S OFFICE
BOX 42, 200 SAULTEAUX CRESCENT
WINNIPEG MB R3J 3W3

CHEQUES TO BE MADE PAYABLE TO MINISTER OF FINANCE

FOR OFFICE USE ONLY: File: -5

MG-14841 2013-11-30

Validation once —)

Transaction #: 91362
6-15: APPL & WATER USE FEES
(Name SOUTHERN MANITOBA POTATO)
1 @ $100.00
2014-12-12 12:17:33 PM
Cashier / Caissier: 211
Visa (V)

APPENDIX C.2 – Correspondence with Historic Resources Branch

To: Tsukamoto, Suyoko (SCH)
Cc: Butterfield, Tamara (CC); Webb, Bruce (CC)
Subject: RE: Southern Kroeker Irrigation Project - Historic Resources Impacts
Date: Thursday, April 29, 2021 3:37:26 PM

Good afternoon Suyoko.

Just checking if a previous email regarding the above project has reached you.

The email was sent April 10th. We are planning to submit ***Environment Act Proposal to government next week,*** and in position to do HRIA IF required this spring in advance of EAP being drafted.

> Dear Suyoko (or to whom it may otherwise concern):
>
> PBS Water Engineering Ltd. is working on a project for Southern Potato Co. (north of Winkler MB) and Kroeker Farms Ltd. (north of Morden, MB). The project(s) will involve the construct on one or two irrigation ponds. Currently we are focused on one site for the reservoir, I have attached a map of the proposed location. Site DC18 will be a cut fill off stream reservoir located 1 mile south of the Deadhorse Creek, 100% on cultivated land in SE 18-3-4 W. Water to fill the reservoir will be pumped from the Deadhorse Creek
>
> 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 May, 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 DC18 is considered feasible for construction and decision to proceed with it is pending Environmental approvals and from RM of Stanley. A second site DC16 (Section 16-3-5) may be looked at as part of this project, located closer to Morden along the Deadhorse Creek; feasibility of that site is still under consideration. 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 Deadhorse Creek. 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 for DC18. Additional information may be provided as it becomes available and/or as part of the EAP to be filed.

Please feel 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: [redacted]
To: [redacted]
Subject: [redacted]
Date: [redacted]
Attachments: [redacted]

Hi Bryan

Thank you for your information request. I completed a search of the Manitoba Conservation Data Centre's (MBCDC) rare species database for your area of interest. The results for the primary location:
SE-19-009-04W1 and NW-20-009-04W1, and a two kilometer radius buffer from the edge of the location boundary.

The search resulted in the following occurrences:

1. Within the footprint or primary location:
Within SE-19-009-04W1 and NW-20-009-04W1:
No listed or tracked species occurrences found at this time.

2. Within 2km of the footprint boundary:
Within 2 km of SE-19-009-04W1 and NW-20-009-04W1:

TAXONCLF	SCINAME	COMNAME	SRANK	FSEA	SARA	COSEWIC
Vertebrate Animal	Hirundo rustica	Barn Swallow	S4B	NA	Threatened	Threatened

3. Occurrences recorded over historical timescale:
SE-19-009-04W1 and NW-20-009-04W1:

TAXONCLF	SCINAME	COMNAME	SRANK	FSEA	SARA	COSEWIC
Invertebrate Animal	Papilio cresphontes	Giant Swallowtail or Giant Eastern Swallowtail	S1S3	NA	NA	Special Concern
Vascular Plant	Panax trifolius	Dwarf Ginseng	S2S3	NA	NA	NA

4. Occurrences in broader area and similar habitat:
No listed or tracked species occurrences found at this time.

Further information on this ranking system can be found on our website at http://www.gov.mb.ca/conservation/cdc/publications/ranking.html.

Species designations can be found at:
http://web2.gov.mb.ca/laws/statutes/ccsm/e111e.php
https://www.canada.ca/en/environment-climate-change/services/committee-status-endangered-wildlife.html and
http://www.registrelep-sararegistry.gc.ca/default_e.cfm

Manitoba's recommended setback distances can be found at: https://www.gov.mb.ca/sd/pubs/conservation_data_centre/protection_setbacks.pdf.
The information provided in this letter is based on existing data in the Manitoba CDC at the time of the request. These data are dependent on the research and observations of CDC staff and others who have shared data, and reflect our current state of knowledge. **An absence of data does not confirm the absence of any rare or endangered species.** Many areas of the province have never been thoroughly surveyed. However, and the absence of data in any particular geographic area does not necessarily mean that species or ecological communities of concern are not present. This information should, therefore, not be regarded as a final statement on the occurrence of any species of concern or other value. It is essential for on-site surveys for species or environmental communities. Also, because our Biotics database is continually updated and because information requests are evaluated by type of action, any given response is only appropriate for its respective request.

Please contact the Manitoba CDC for an update of this natural heritage information if more than six months passes before it is utilized.

Third party inclusion of provincial rare species data in a format by Biotics database must be approved by the Manitoba CDC before information is released. Once approved, the primary source (identify the Manitoba CDC as one contributor) only may be included using data from our database, as the Manitoba Conservation Data Centre, Wildlife and Fisheries Branch, Manitoba Sustainable Development.

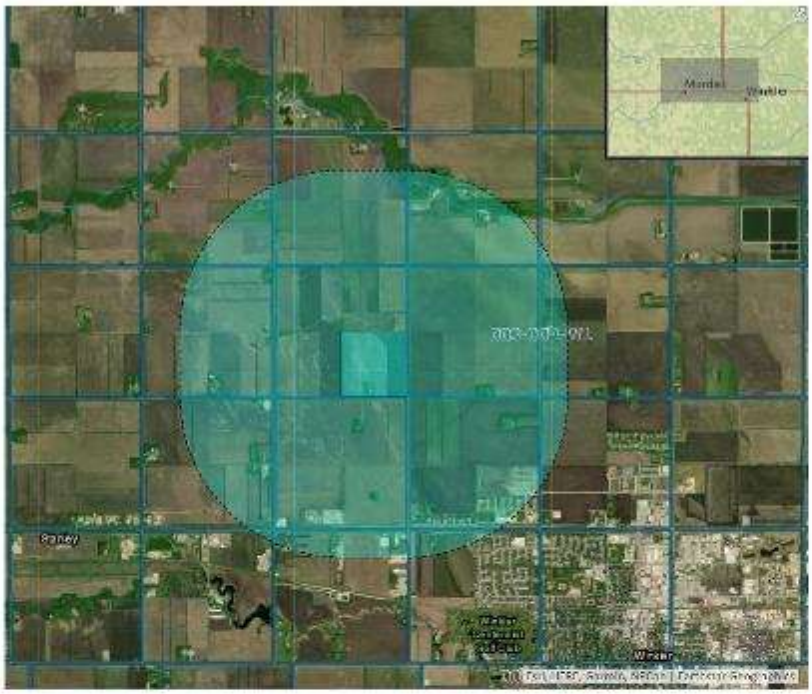
This letter is for information purposes only - it does not constitute consent or approval of the proposed project or activity, nor does it negate the need for any permits or approvals required by the Province of Manitoba.

We would be interested in receiving a copy of the results of any rare species survey that you carry out in order to update our database with the most current knowledge of the area.

If you have any questions or require further information, please contact me by email or (204) 945-7990.

Sincerely,

Reference # [redacted]
SE-19-009-04W1 and NW-20-009-04W1


Manitou
Virden
Rapid View
Rapid View Cemetery
Rapid View Hall
Rapid View Community Hall
Rapid View Elevator
Rapid View Grain Elevator
Rapid View Grain Elevator
Rapid View Grain

Colin Murray
Information Manager
Manitoba Conservation Data Centre
Wildlife and Fisheries Branch
Agriculture and Resource Development

200 Saulteaux Crescent
Winnipeg, Manitoba, R3J3W3
204-945-7780
colin.murray@gov.mb.ca
http://www.gov.mb.ca/conservation/index.html

[redacted]

From: Bruce Shewfelt <bshewfelt@mymts.net>
Sent: March 25, 2021 3:21 PM
To: Murray, Colin (AFD) <Colin.Murray@gov.mb.ca>; Friesen, Chris (AFD) <Chris.Friesen@gov.mb.ca>
Cc: 'David Whetter' <davidwhetter@agriearth.ca>; Webb, Bruce (LI) <Bruce.Webb@gov.mb.ca>; Butterfield, Tamara (LI) <Tamara.Butterfield@gov.mb.ca>; 'Marcel K.' <marcelk@southernpotato.com>; 'Frank Lies' <frank@klmresort.com>
Subject: RE: Southern Potato Reservoir - Krocker Farms Ltd. Reservoir - Deadhorse Creek - Heritage Resource Assessment

CAUTION: This email originated from an External Sender. Please do not click links or open attachments unless you recognize the source.
ATTENTION: Ce courriel provient d'un expéditeur externe. Ne cliquez sur aucun lien et n'ouvrez pas de pièce jointe, excepté si vous connaissez l'expéditeur.

Chris, Colin. This project is now moving into Environmental Act Proposal. We are currently working on irrigation water supply for the reservoir, intake and pipelines.

The reservoir has now been consolidated and there will be only one in SE 18-3-1 W, per the attached plan.

We are also developing a site plan and pumping concept involving an "off channel" pump attached to the Deadhorse Creek in NW 20-3-1 W.

Please consider this updated request and provide a review of previous responses and your data base as they may impact the project site (100% cultivated) or the pump intake site (in corner of pasture adjacent to Deadhorse) (more information available on request).

Please acknowledge receipt of this request.

Regards

Bruce Shewfelt, P.Eng.
PBS Water Engineering Ltd.
Morden, MB
R6M 1B4

From: Bruce Shewfelt <[redacted]>
Sent: Friday, April 10, 2020 2:05 PM
To: [redacted]
Cc: [redacted]
Subject: FW: Southern Potato Reservoir - Kreutzer Farms Ltd. Reservoir - Deadhorse Creek - Heritage Resource Assessment

Chris Cocks - Please see my request below regarding the upcoming project on Deadhorse Creek near Winkler Manitoba (plan attached).

Please consider this request to review your records for any sites and provide any concerns arising from the potential project/project sites, especially their way in the vicinity of archaeological sites.

Please feel 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 1Y5

204 361 5566
[redacted]

From: Bruce Shewfelt <[redacted]>
Sent: Friday, April 10, 2020 12:27 PM
To: [redacted]
Subject: Southern Potato Reservoir - Kreutzer Farms Ltd. Reservoir - Deadhorse Creek - Heritage Resource Assessment

Dear Sir/Madam (or to whom it may otherwise concern):

PBS Water Engineering Ltd. is working on a project for Southern Potato Co. (north of Winkler MB) and Kreutzer Farms Ltd. (north of Morden, MB). The project (s) will involve the construction of water storage reservoirs. Currently we are focusing on one reservoir. I have attached a map of the proposed location. The 70 ha (for a total of all storage reservoirs) reservoir will be located south of the Deadhorse Creek, 100s m south and east of SE 7-6-5 E. Water to fill the reservoir will be pumped from the Deadhorse Creek.

The reservoirs (s) will trigger the need for an Environment Act Proposal. PBS Water Engineering Ltd. with consultation from AgriEarth Consulting Ltd. will be filing an Environment Act Proposal in May, 2020.

The preparation of the EAP will be in the form of a Sustainable Development and Heritage Resources will be a basis for consideration of rare or endangered species and/or historic resources.

The EAP is to consider feasible alternatives to the project. It is proposing that one alternative is from Valley Stanley. A review of site DC16 (section 10-4-5) may be looked at as part of this project, quarter closer to Morden along the Deadhorse Creek. Possibly of that site is / will be considered. Additional information can be provided on these sites (e.g. aerial photos) on request.

The source of water for the project will be the Deadhorse Creek. Inter-connecting 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/sites for DC16. Additional information may be provided as it becomes available and/or as part of the EAP to be filed.

Please feel 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 1Y5

204 361 5566

Show all 8 lines

To: D Whetter (Agri Earth); D Thiessen (Prairie Geospatial); Bruce Webb; Tamara Butterfield; Mark Tschetter (Blumengarten Colony); Marlon Kuhl (Southern Peaks)

APPENDIX D – Water Survey of Canada - Hydrometric Data

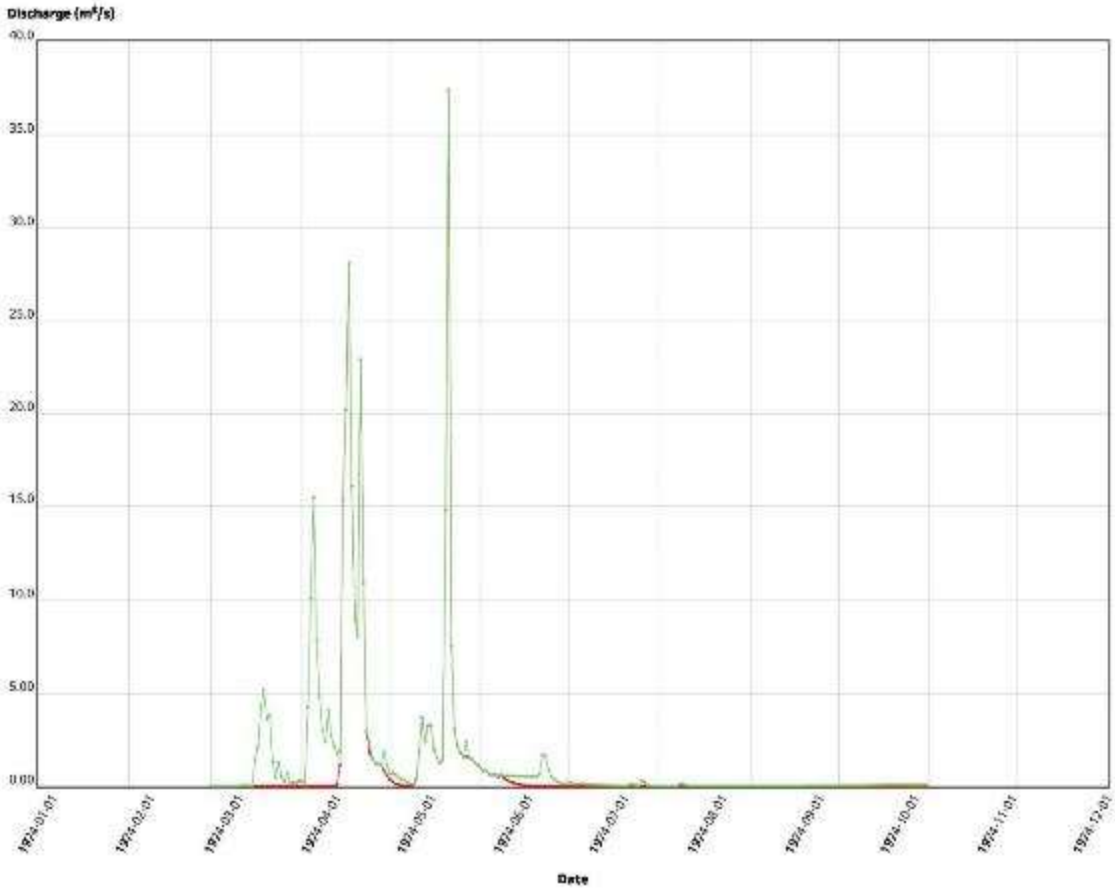
Government of Canada / Gouvernement du Canada

Daily Discharge Graph for DEADHORSE CREEK NEAR MORDEN (05OC023) [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

1974 Data — Maximum



Statistics corresponding to 4 years of data recorded from 1972 and 1976.*

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

Station Information

Active or discontinued:	Discontinued
Province / Territory:	Manitoba
Latitude:	49° 13' 02" N
Longitude:	98° 05' 30" W
Gross drainage area:	159 km²
Effective drainage area:	N/A
Record length:	5 Years
Period of record:	1972 - 1976
Regulation type:	Regulated
Regulation length:	N/A
Real-time data available:	No
Sediment data available:	No
Type of water body:	River

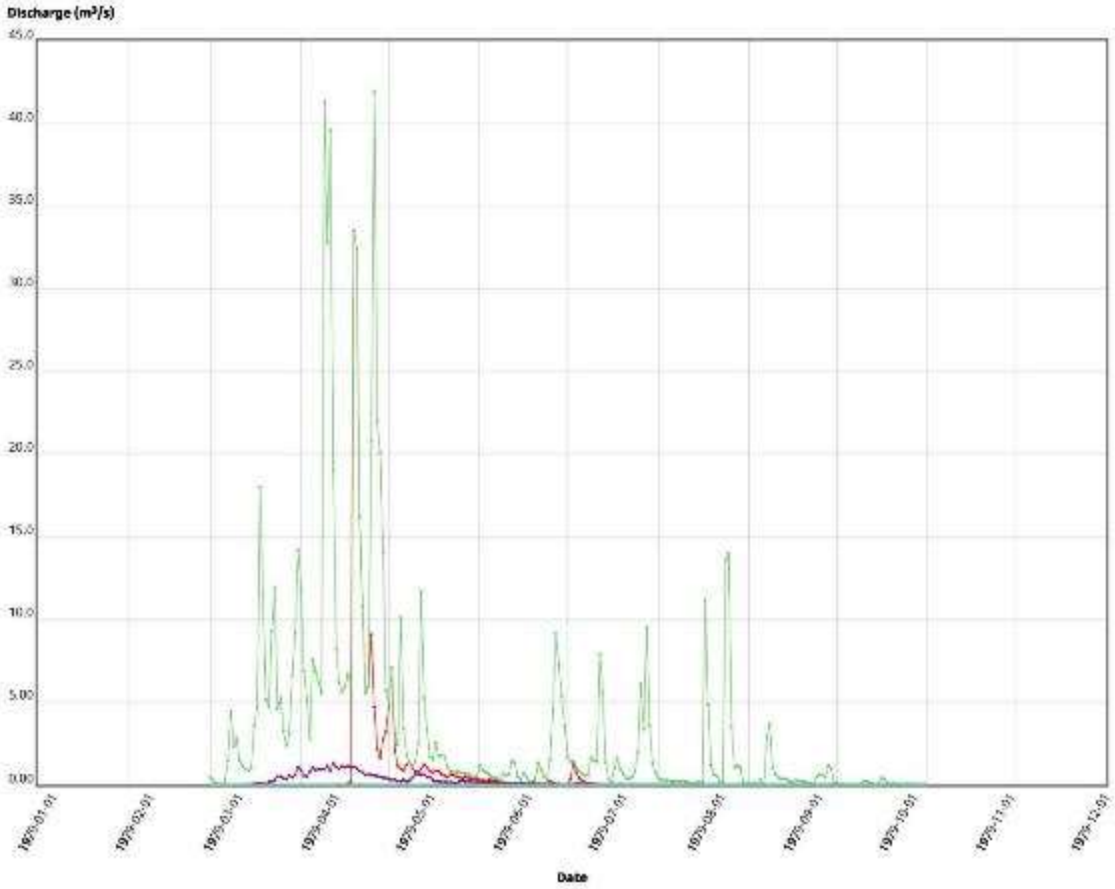
Government of Canada / Gouvernement du Canada

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

1979 Data — Maximum — Upper quartile — Lower quartile



Statistics corresponding to 30 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

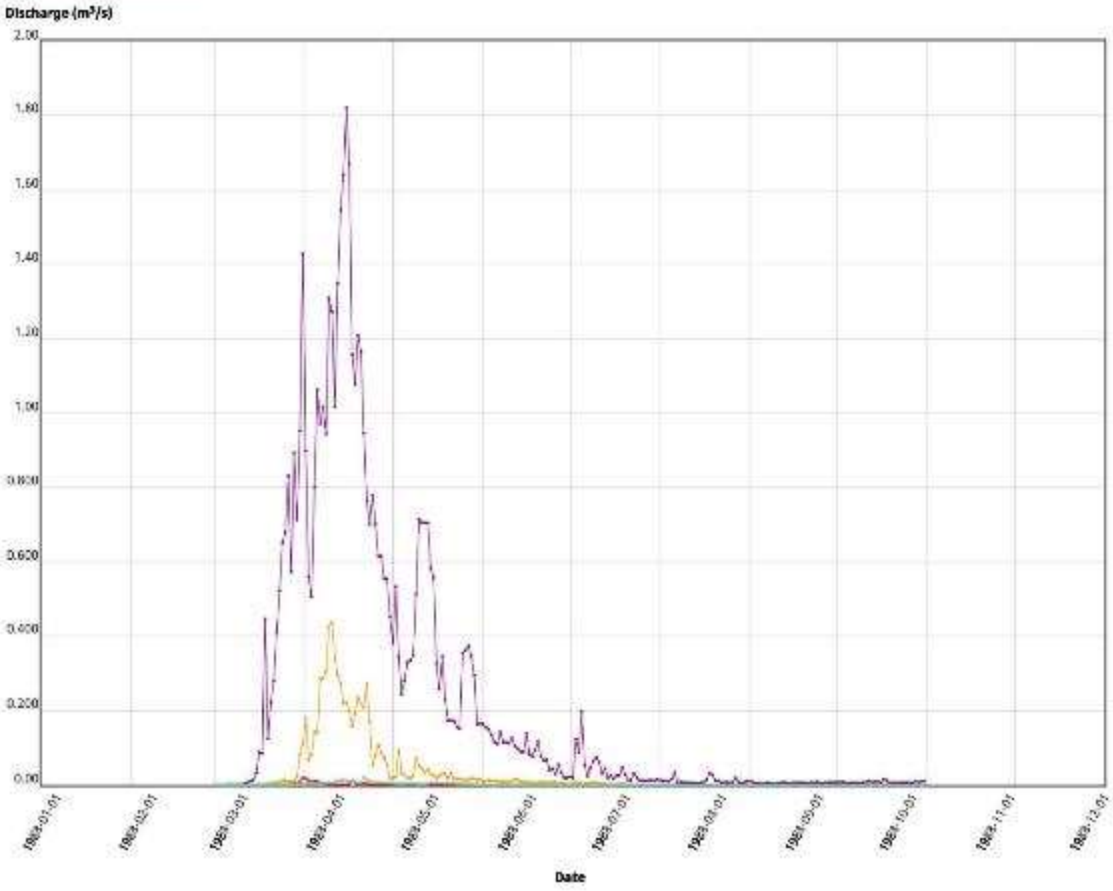
Government of Canada / Gouvernement du Canada

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

1988 Data | Median | Upper quartile | Lower quartile



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' 42" N	**Longitude:**	98° 05' 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

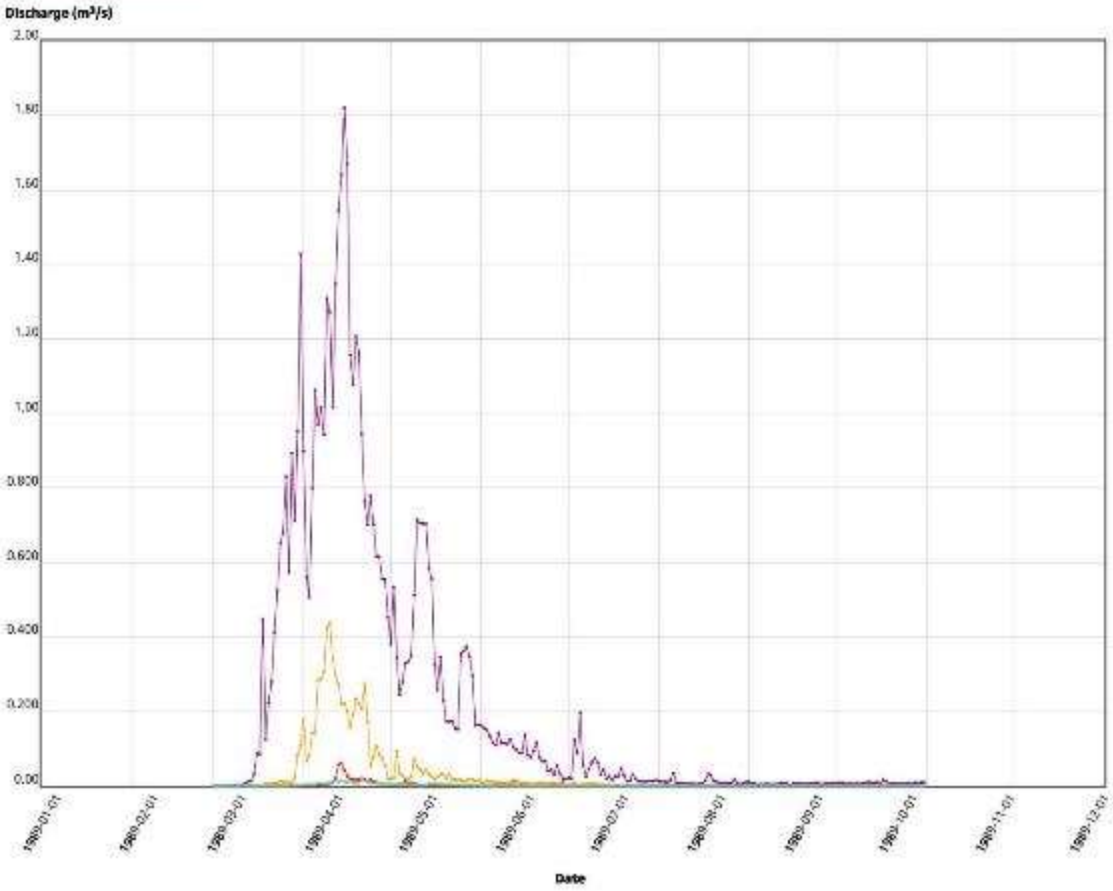
Government of Canada / Gouvernement du Canada

Daily Discharge Graph for DEADHORSE CREEK 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

1989 Data | Median | Upper quartile | Lower quartile



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° 05' 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 299.925 m

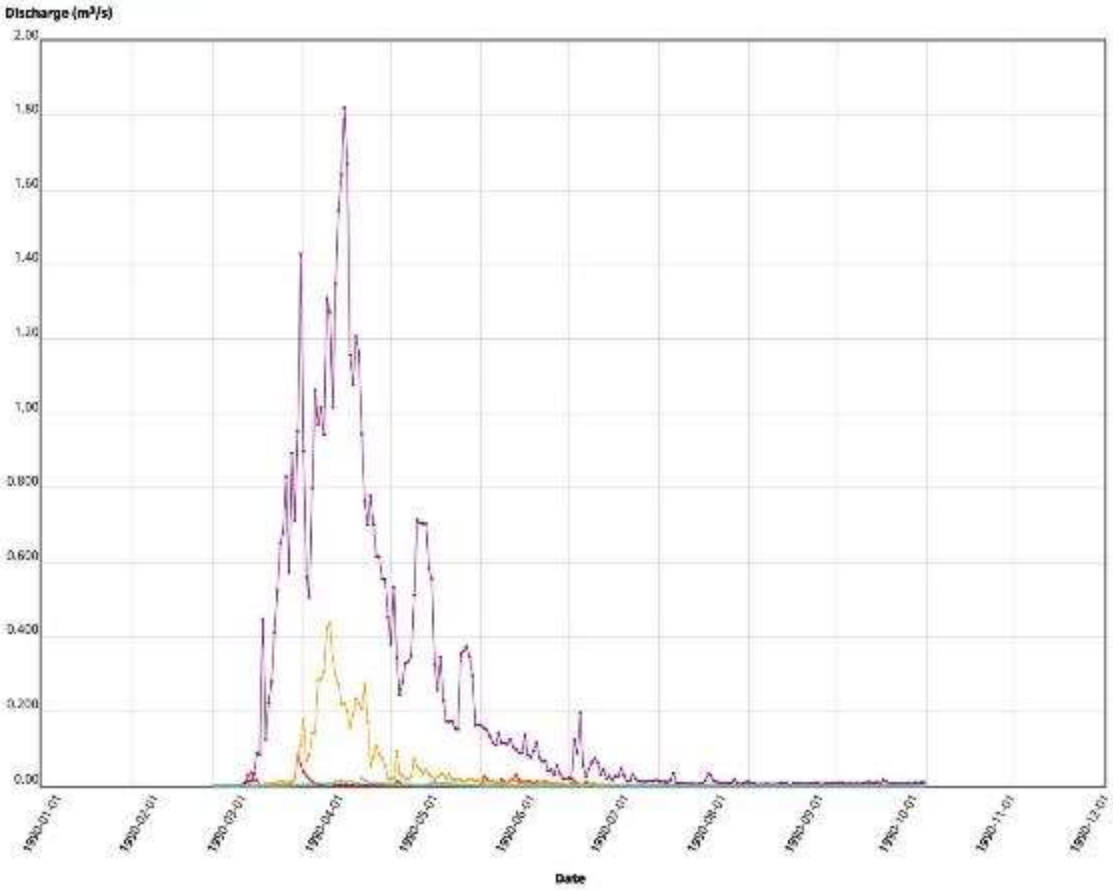
Government of Canada / Gouvernement du Canada

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

1990 Data | Median | Upper quartile | Lower quartile



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° 05' 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

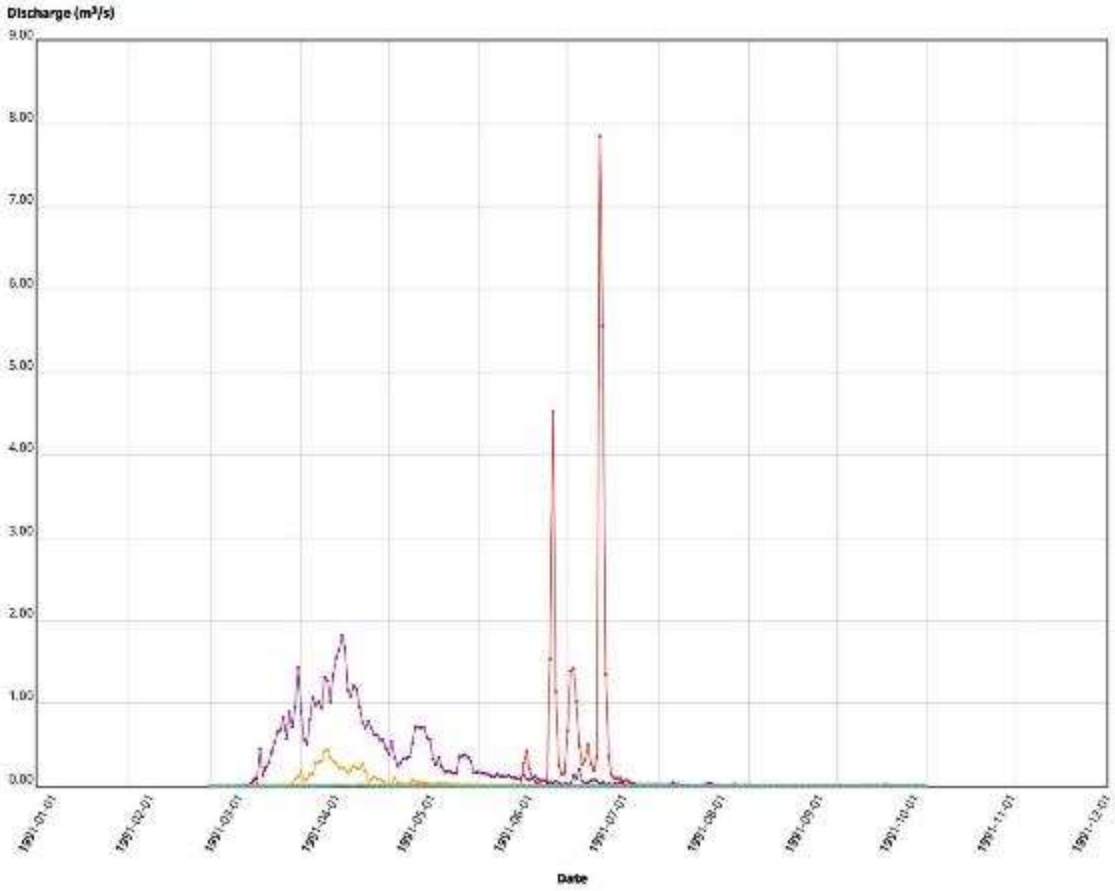
Government of Canada / Gouvernement du Canada

Daily Discharge Graph for DEADHORSE CREEK 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

1991 Data | Median | Upper quartile | Lower quartile



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° 05' 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

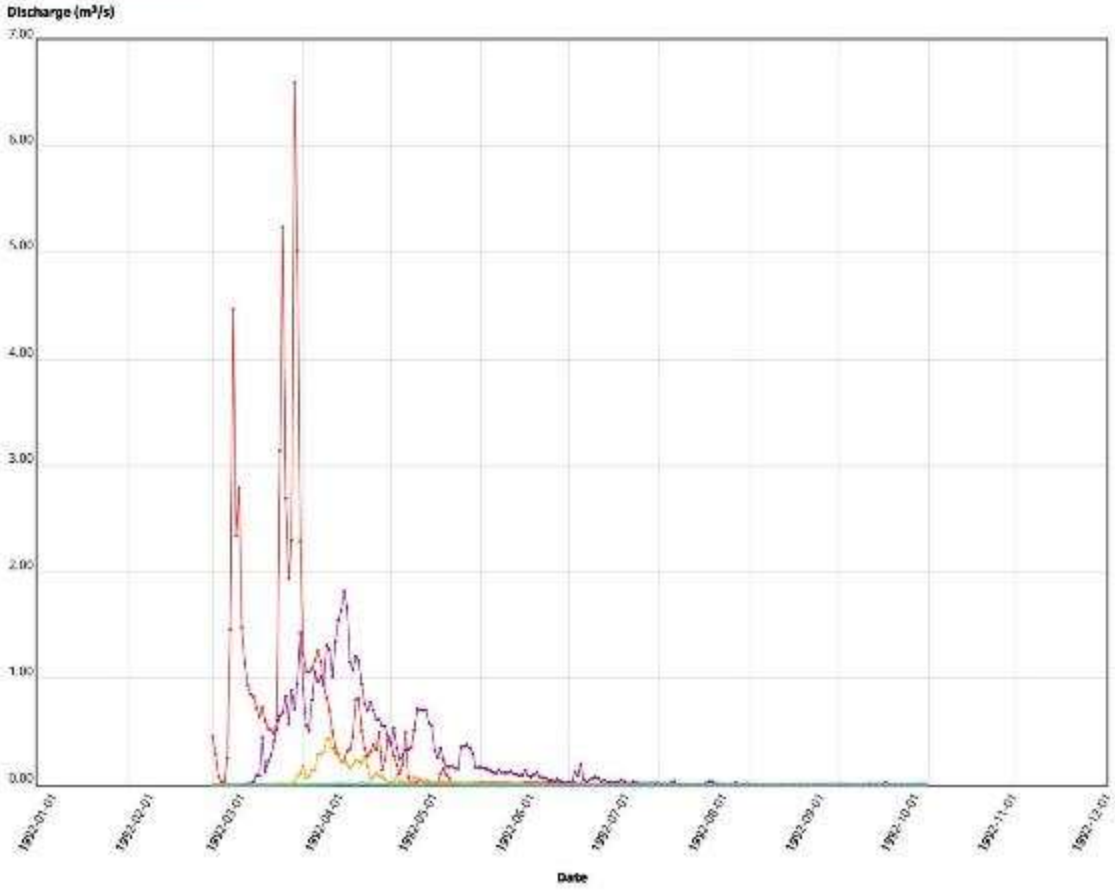
Government of Canada / Gouvernement du Canada

Daily Discharge Graph for DEADHORSE CREEK 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

1992 Data | Median | Upper quartile | Lower quartile



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

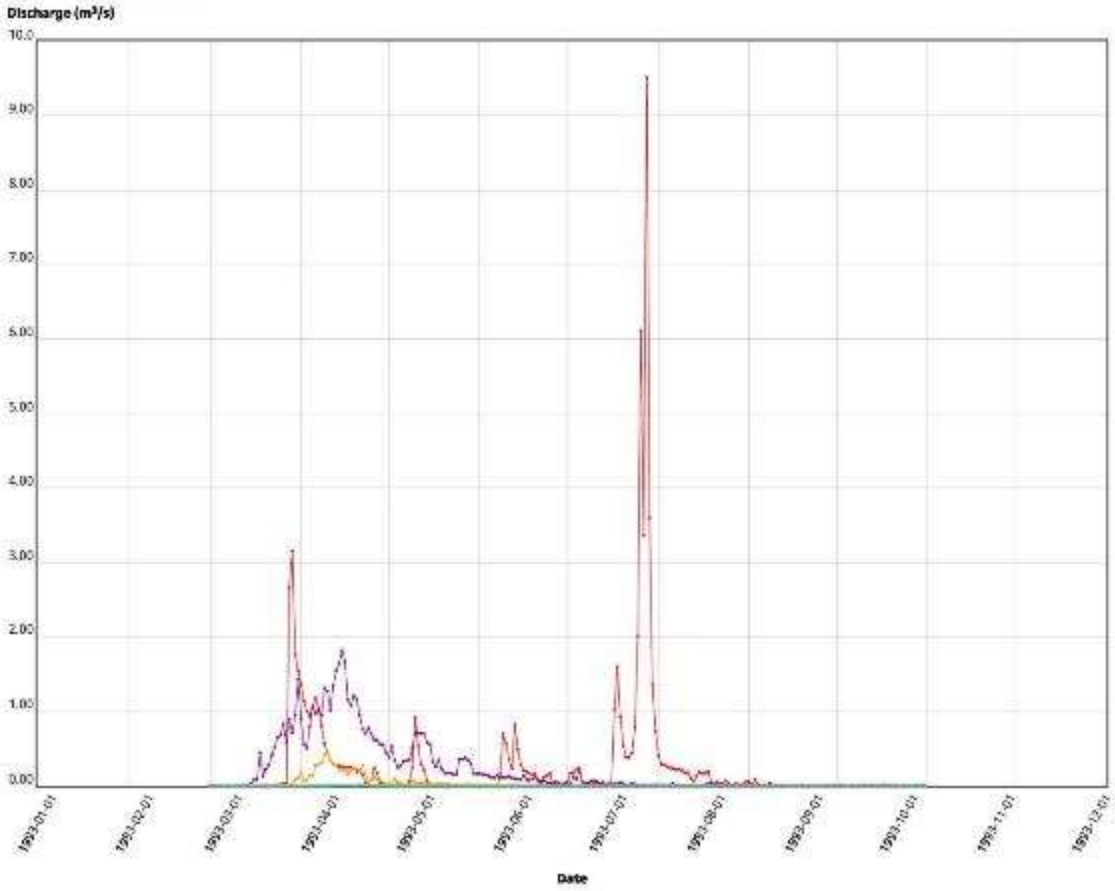
Government of Canada / Gouvernement du Canada

Daily Discharge Graph for DEADHORSE CREEK 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

1993 Data | Median | Upper quartile | Lower quartile



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° 05' 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

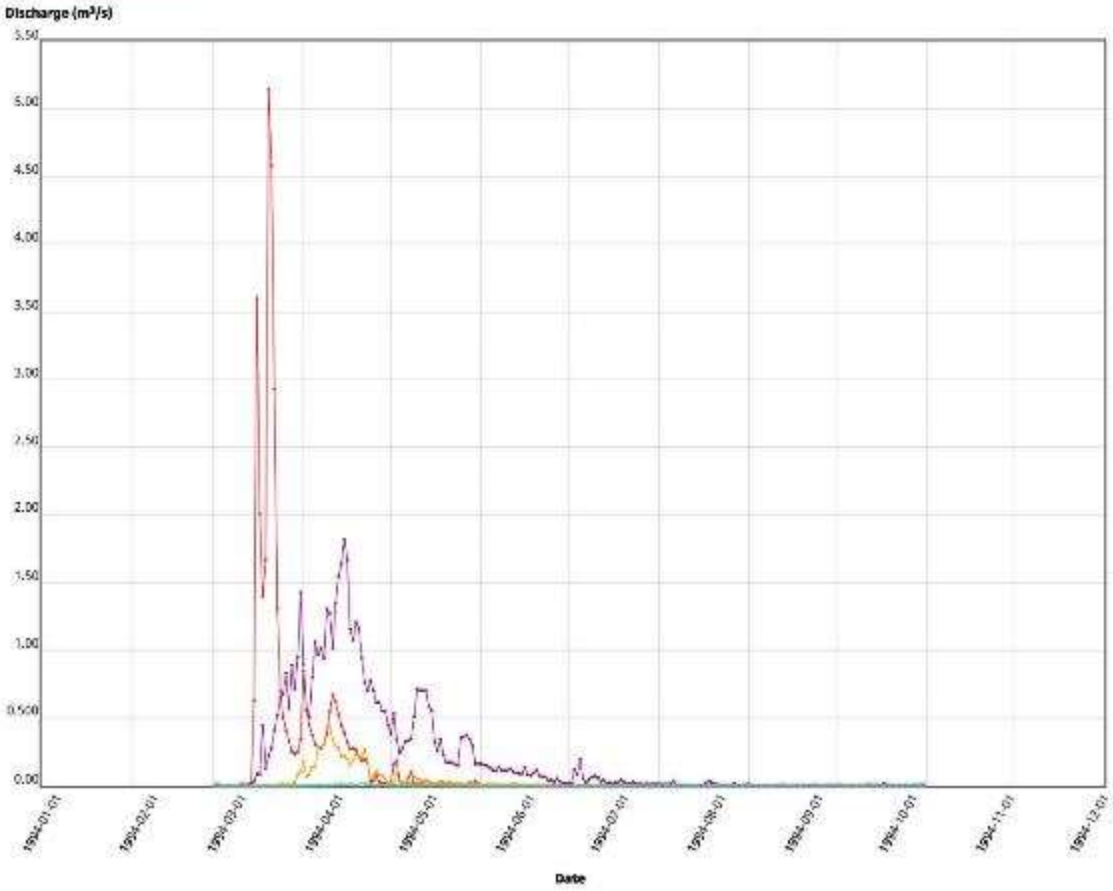
Government of Canada / Gouvernement du Canada

Daily Discharge Graph for DEADHORSE CREEK 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

1994 Data | Median | Upper quartile | Lower quartile



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° 05' 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 299.925 m

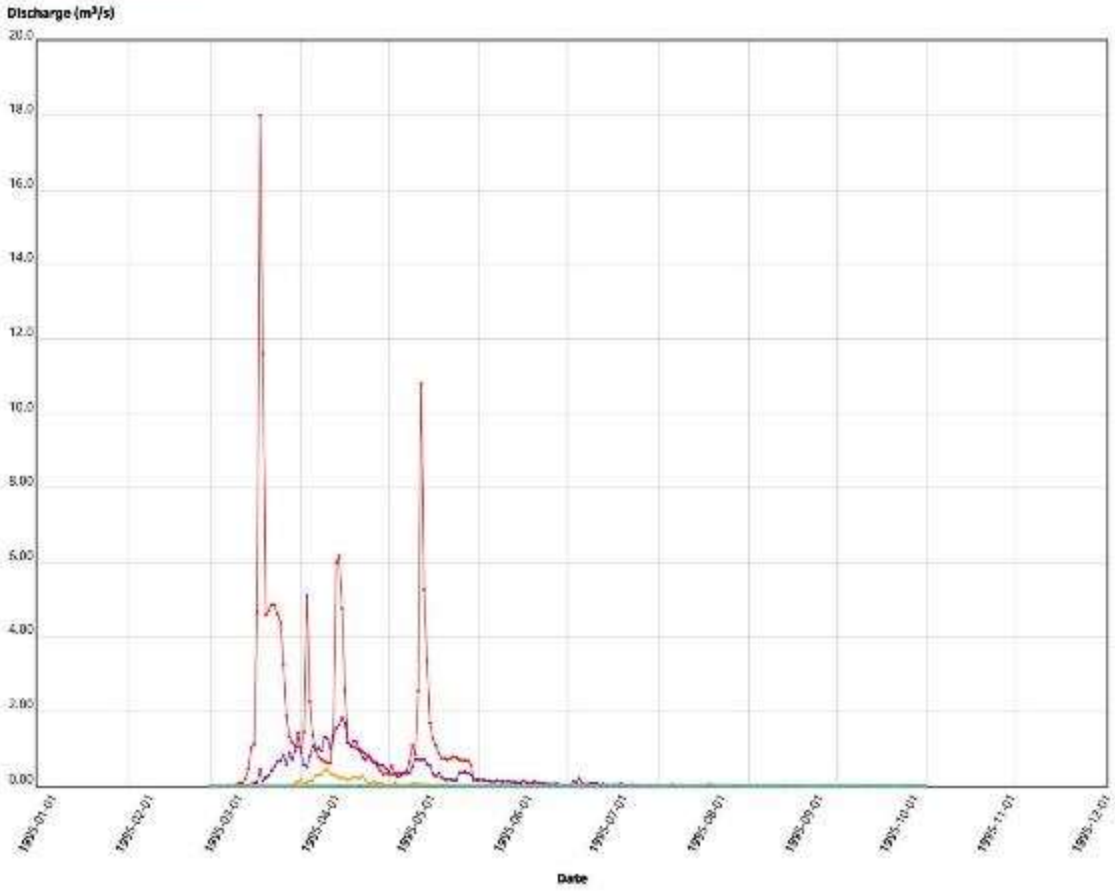
Government of Canada / Gouvernement du Canada

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

1995 Data | Median | Upper quartile | Lower quartile



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° 05' 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

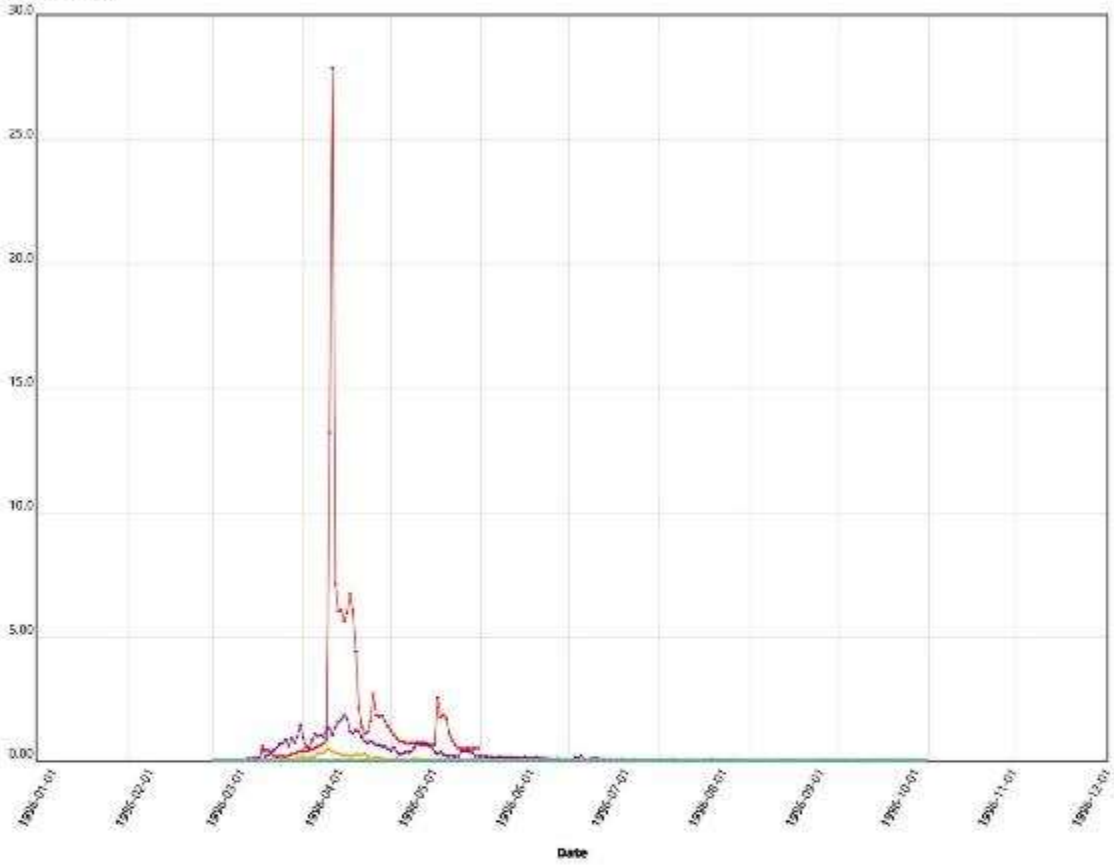
Daily Discharge Graph for DEADHORSE CREEK AT MORDEN (05OC015) [MB]

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

1996 Data
Lower quartile
Median
Upper quartile

Discharge (m^3/s)



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° 05' 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 299.925 m

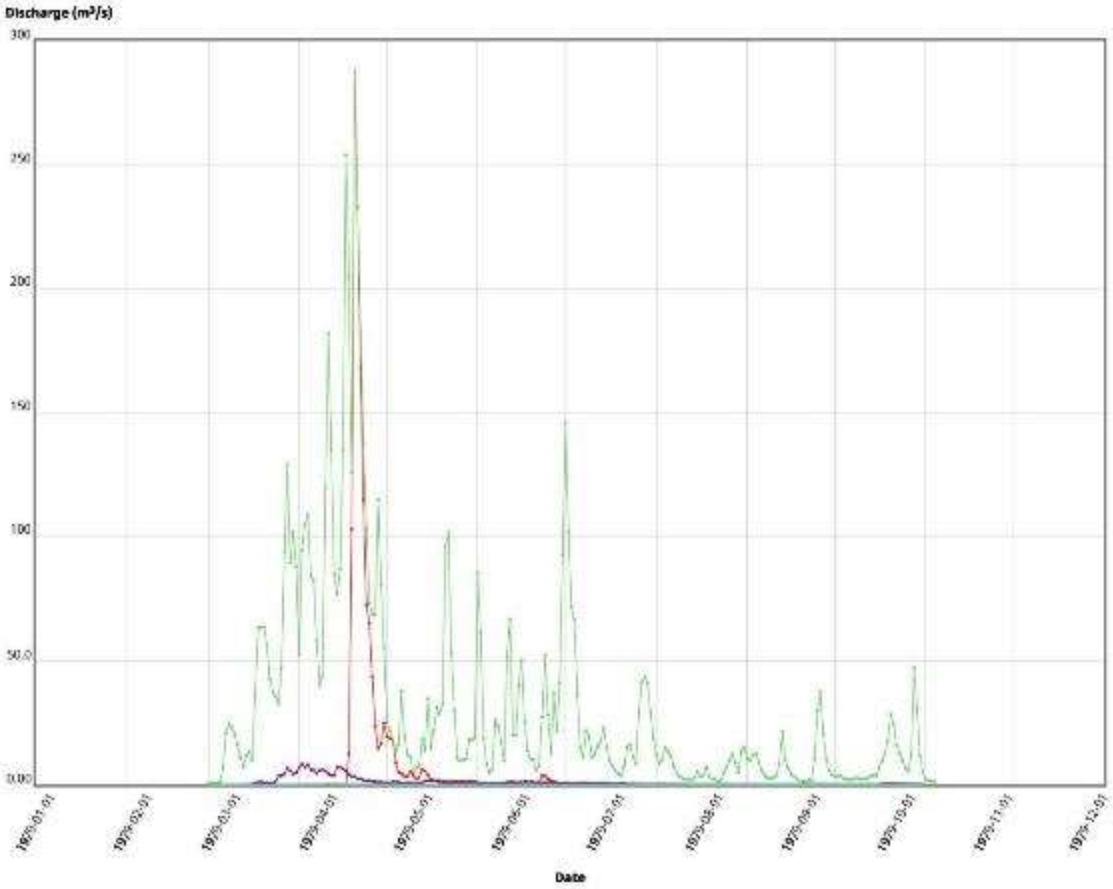
Government of Canada / Gouvernement du Canada

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.

▾ Legend

1979 Data | Maximum | Upper quartile | Lower quartile



Statistics corresponding to 51 years of data recorded from 1968 and 2019.*

*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:	55 Years
Period of record:	1967 - 2021
Regulation type:	Natural
Regulation length:	N/A
Real-time data available:	Yes

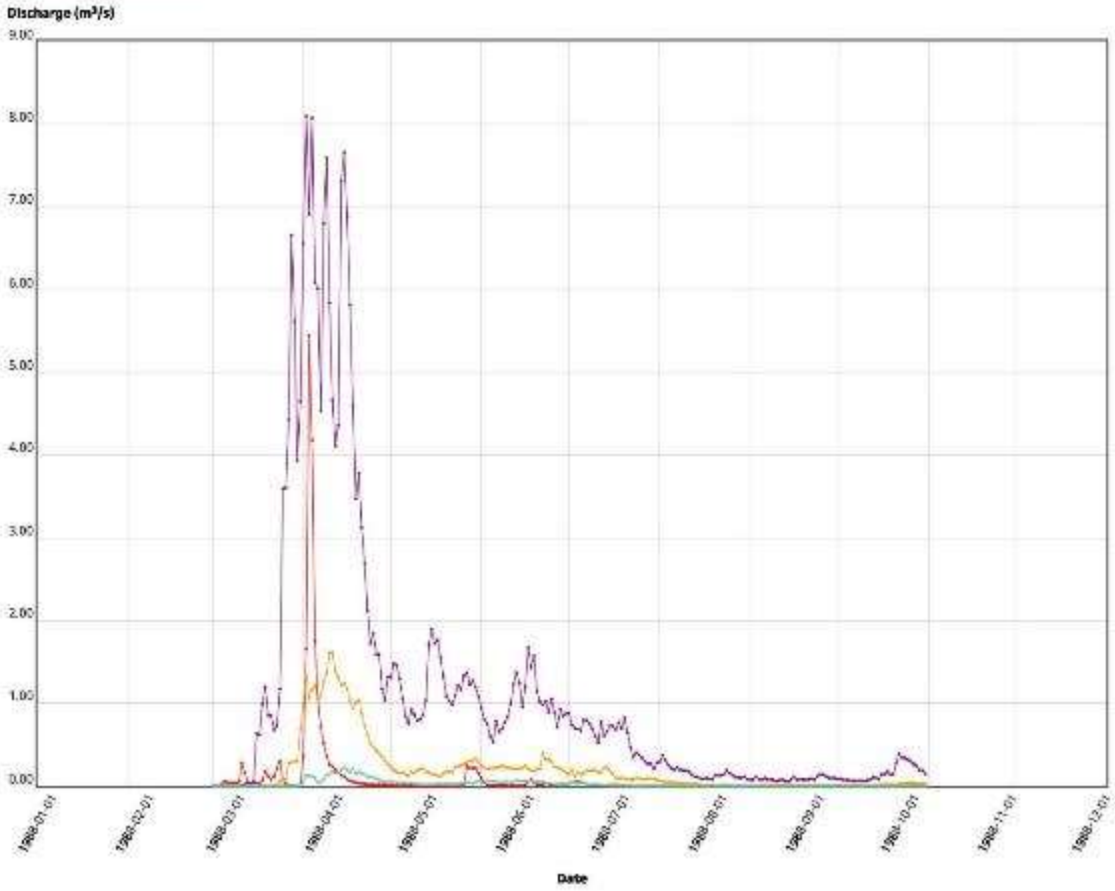
Government of Canada / Gouvernement du Canada

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

1968 Data | Median | Upper quartile | Lower quartile



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		

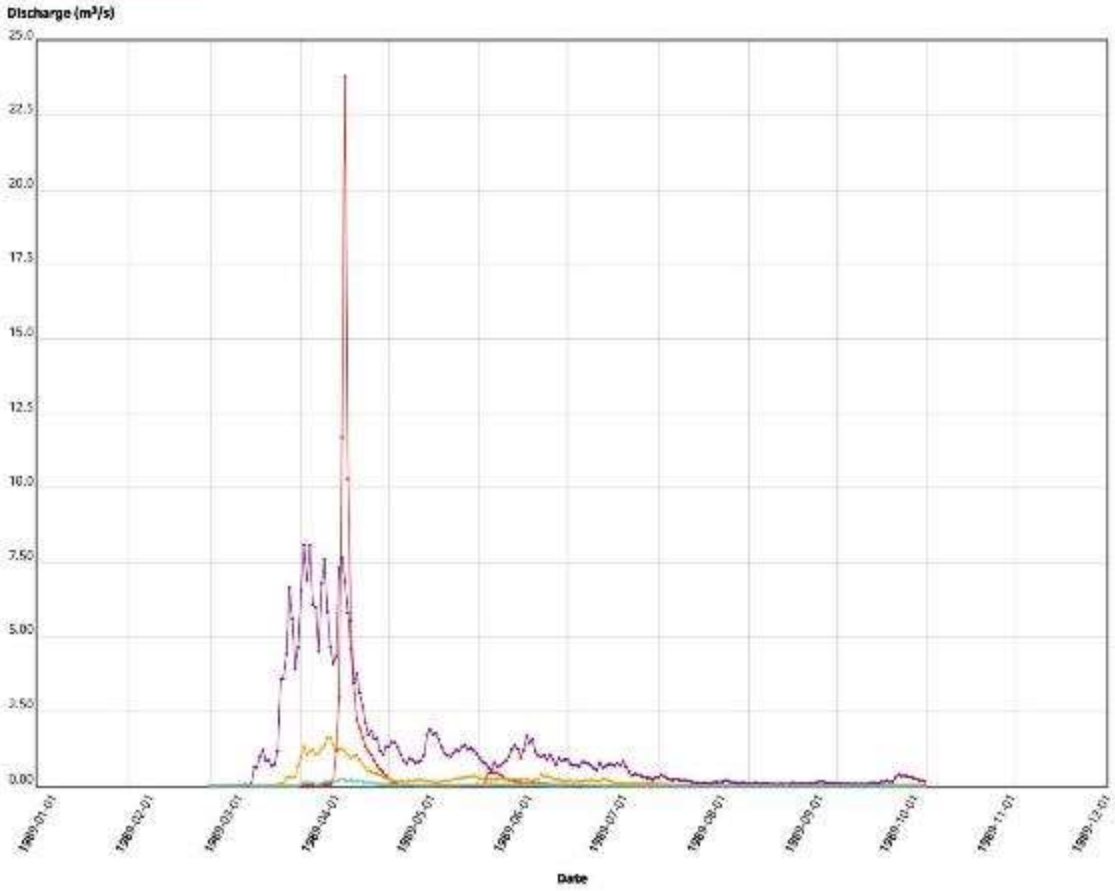
Government of Canada / Gouvernement du Canada

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

1989 Data | Median | Upper quartile | Lower quartile



Statistics corresponding to 50 years of data recorded from 1958 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		

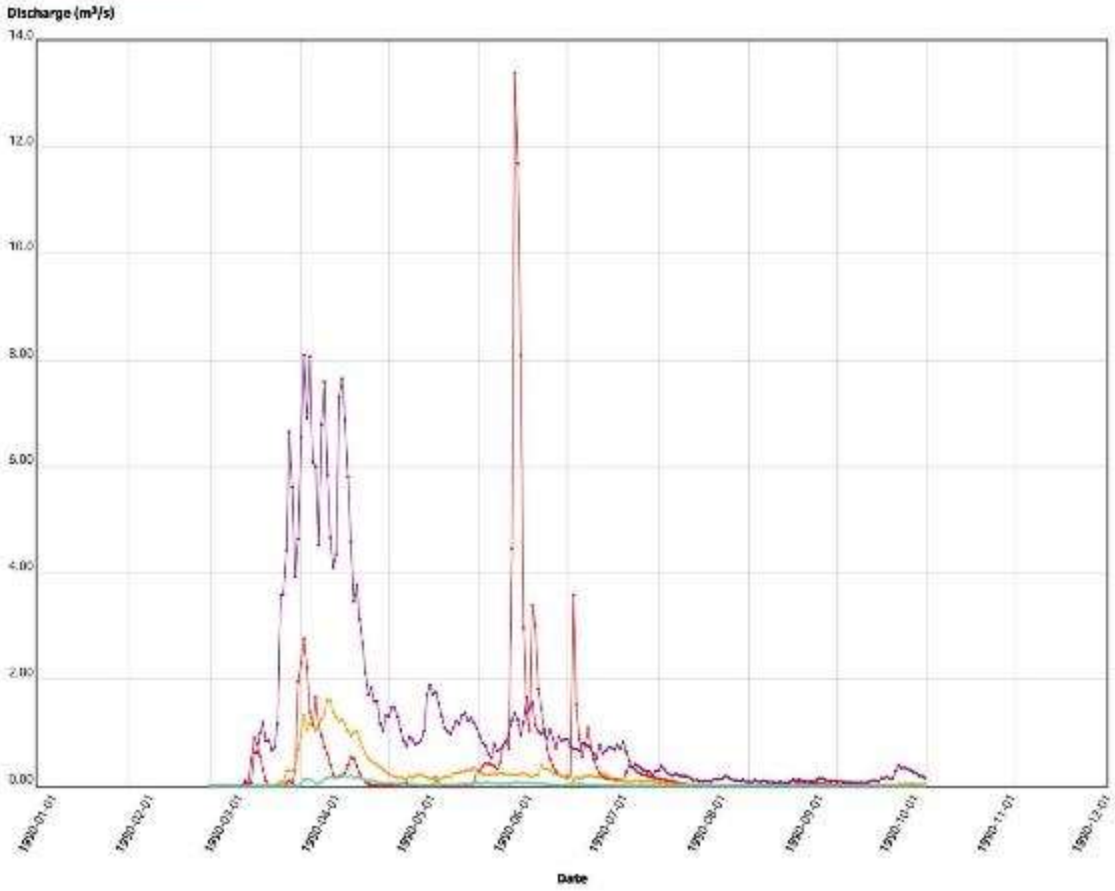
Government of Canada / Gouvernement du Canada

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

1990 Data
Median
Upper quartile
Lower quartile



Statistics corresponding to 50 years of data recorded from 1958 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		

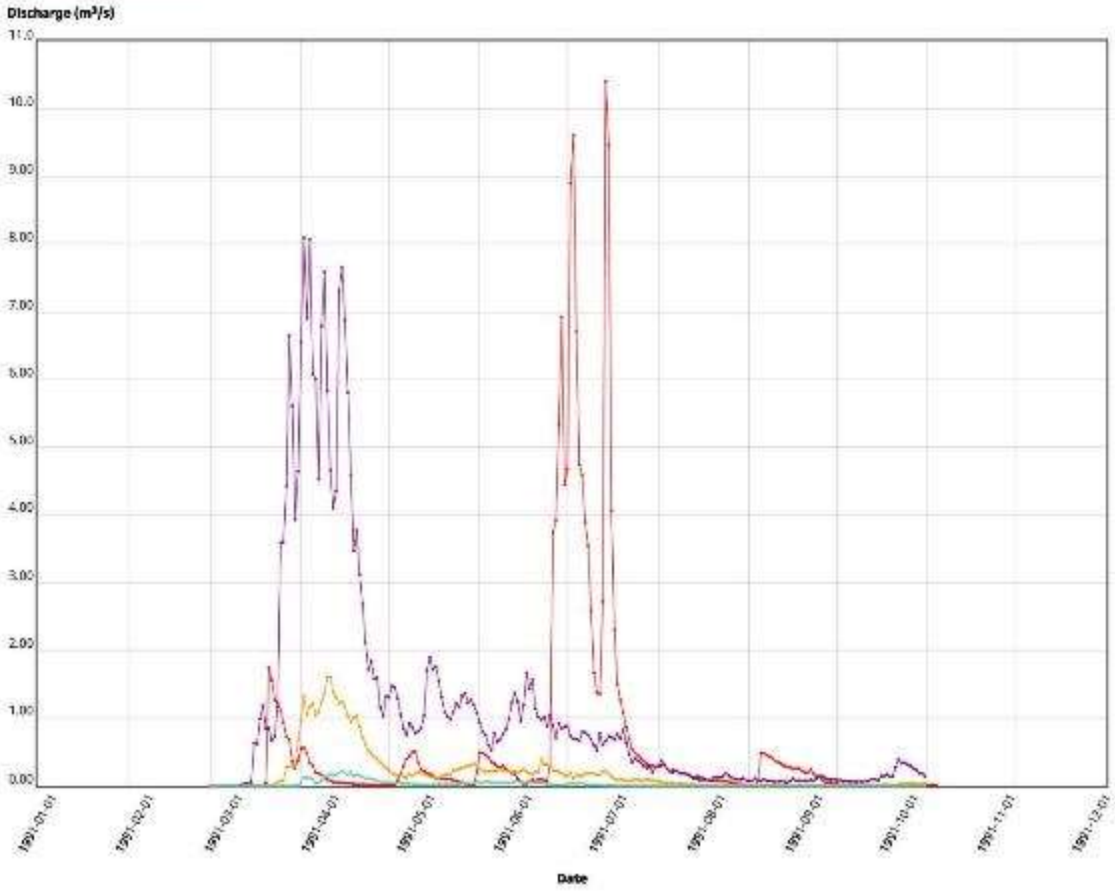
Government of Canada / Gouvernement du Canada

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

1991 Data | Median | Upper quartile | Lower quartile



Statistics corresponding to 50 years of data recorded from 1958 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		

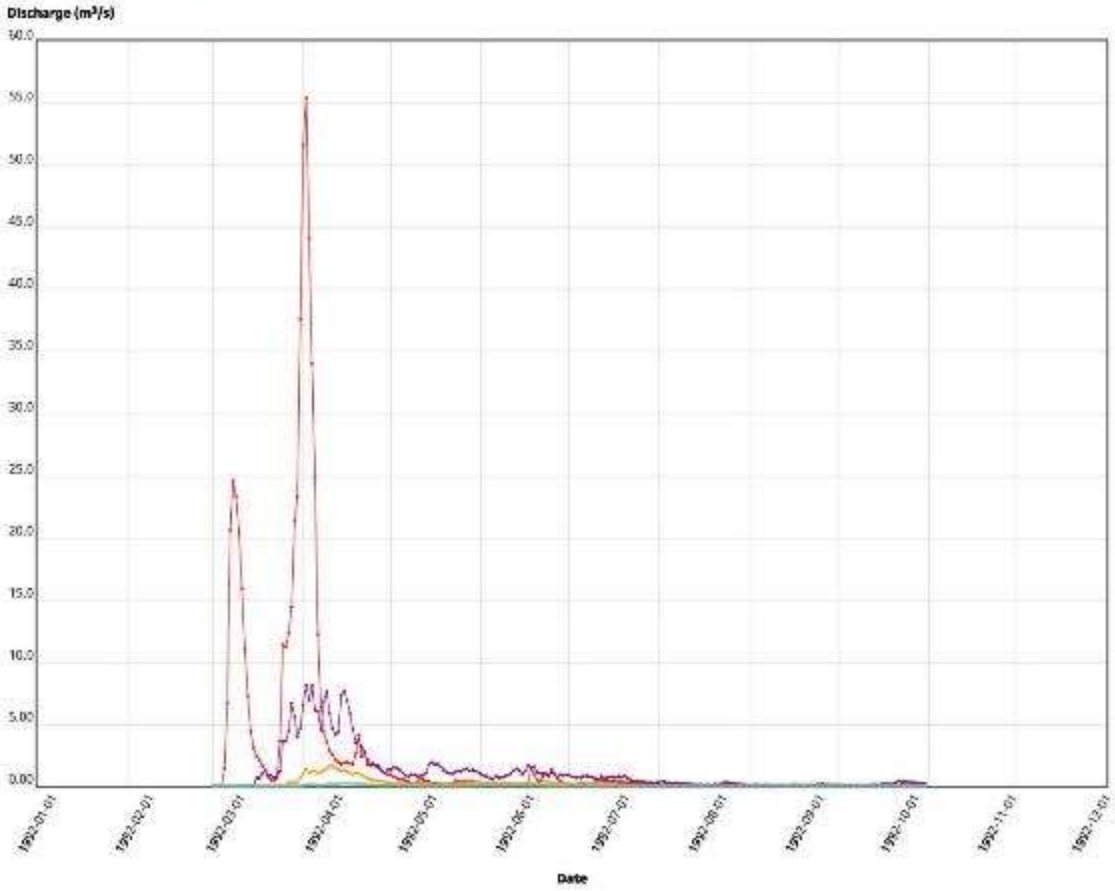
Government of Canada / Gouvernement du Canada

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

1992 Data | Median | Upper quartile | Lower quartile



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

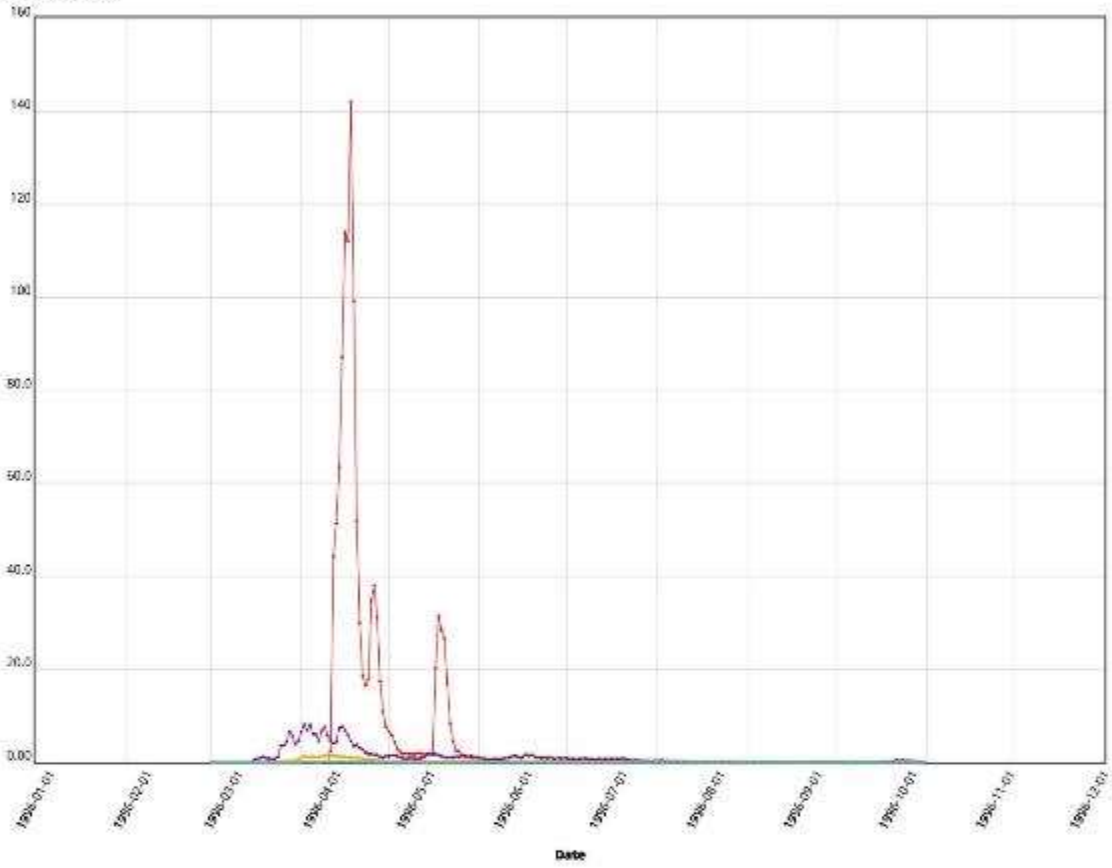
Daily Discharge Graph for DEADHORSE CREEK NEAR ROSENFELD (05OC016) [MB]

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

1996 Data | Median | Upper quartile | Lower quartile

Discharge (m^3/s)



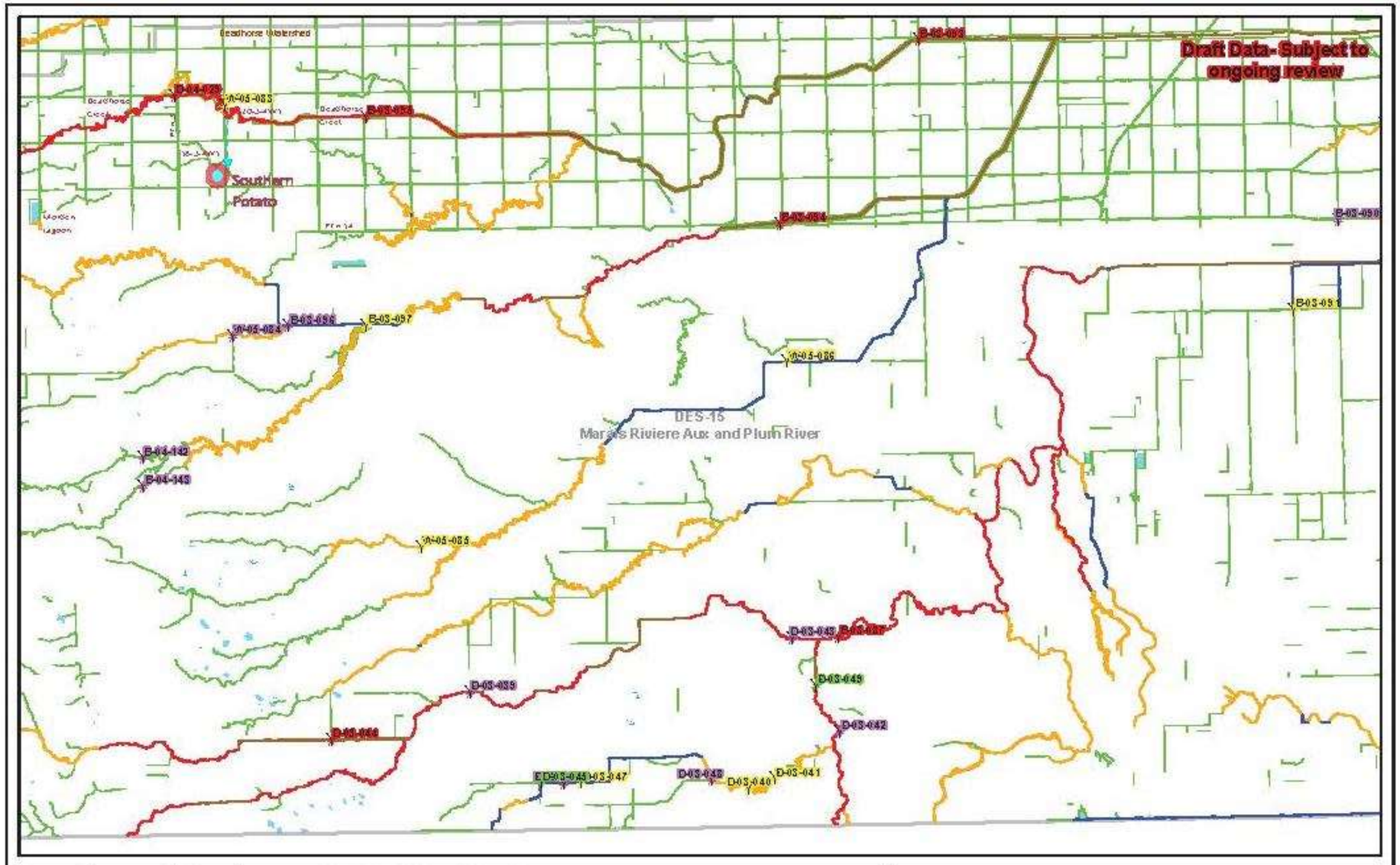
Statistics corresponding to 50 years of data recorded from 1968 and 2018.*

*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		

APPENDIX E – DFO Habitat Maps For Deadhorse Creek


Deadhorse Watershed
Draft Data- Subject to ongoing review
Deadhorse Creek
Southern Potato
DES-15
Marais Riviere Aux and Plum River
B-03-056
B-03-057
B-03-058
B-03-059
B-03-060
B-03-061
B-03-062
B-03-063
B-03-064
B-04-142
B-04-143
D-03-039
D-03-040
D-03-041
D-03-042
D-03-043
D-03-044
D-03-045
D-03-046
D-03-047
062G08
062H05
062H06
062G01
062H04
062H03
Habitat Classification
A
B
C
D
E
Fishing Results
Indicator Species ¥
Non-Indicator Species Y
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).

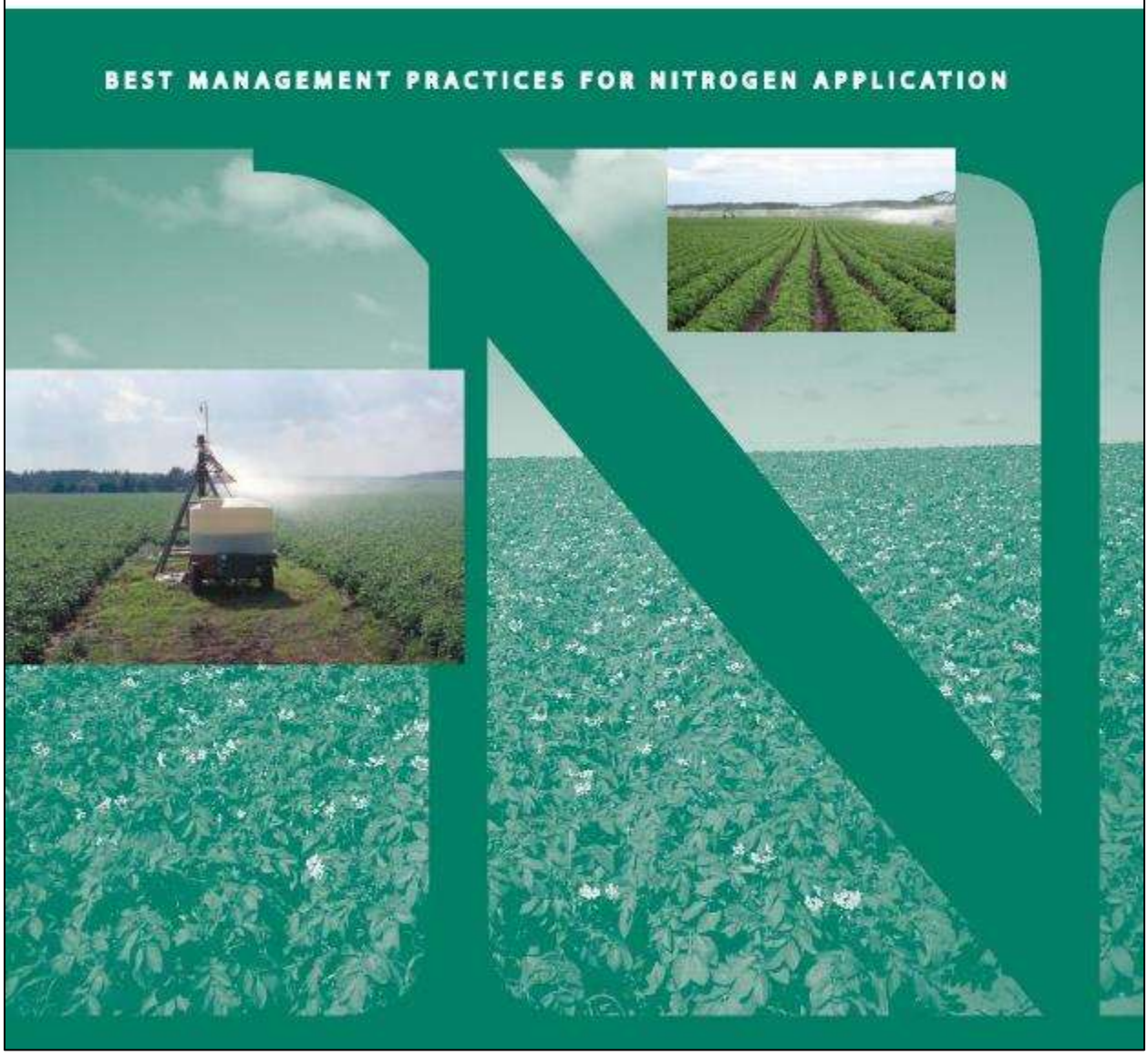
The recommendations are provided to the contractors as part of the construction specifications, to provide them with specific measures that will reduce the amount of sediment that enters water bodies adjacent to construction sites to the lowest possible levels practical.

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 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.

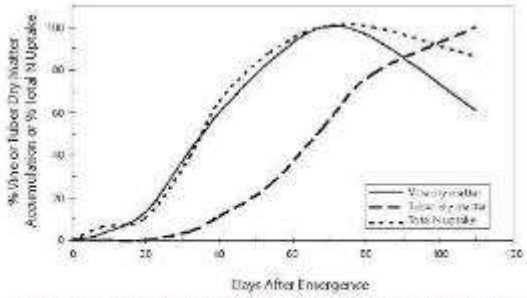


Figure 1. Relative tuber growth, vine growth and total nitrogen uptake by the potato crop. Based on data from the Russet Burbank variety.

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	156

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	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

[1] All treatments received 40 lb N/A from diammonium phosphate at planting.
[2] ESN 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

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Fertilizing Cropland with Swine Manure. FO-5879

Fertilizing Cropland with Dairy Manure. FO-6580

Fertilizing Cropland with Poultry Manure. FO-3081

Fertilizing Cropland with Beef Manure. FO-6582

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)/ -O.M.-		soybeans field peas -O.M.-		any crop in group 1 -O.M.-		any crop in group 2 -O.M.-	
Yield Goal[1]	Harvest Date[2]	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

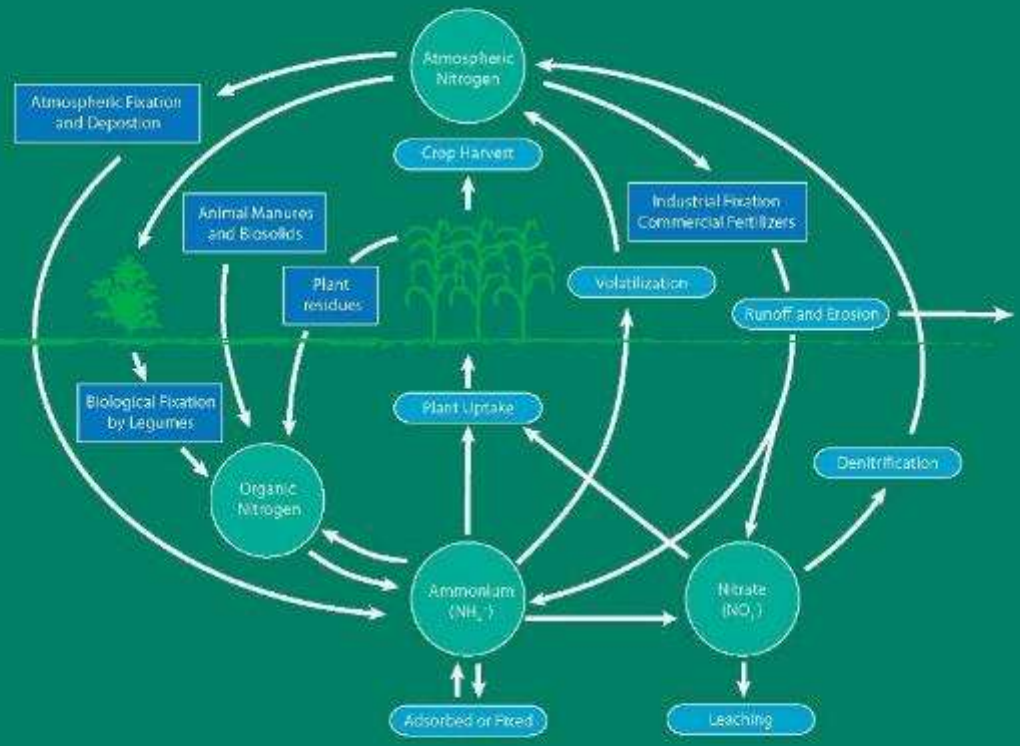
Crops in Group 1		Crops in Group 2	
alfalfa (poor stand)[1]	barley	grass hay	sorghum-sudan
alsike clover	buckwheat	grass pasture	sugarbeets
birdsfoot trefoil	canola	millet	sunflowers
grass-legume hay	corn	mustard	sweet corn
grass-legume pasture	edible beans	oats	triticale
red clover	flax	potatoes	wheat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

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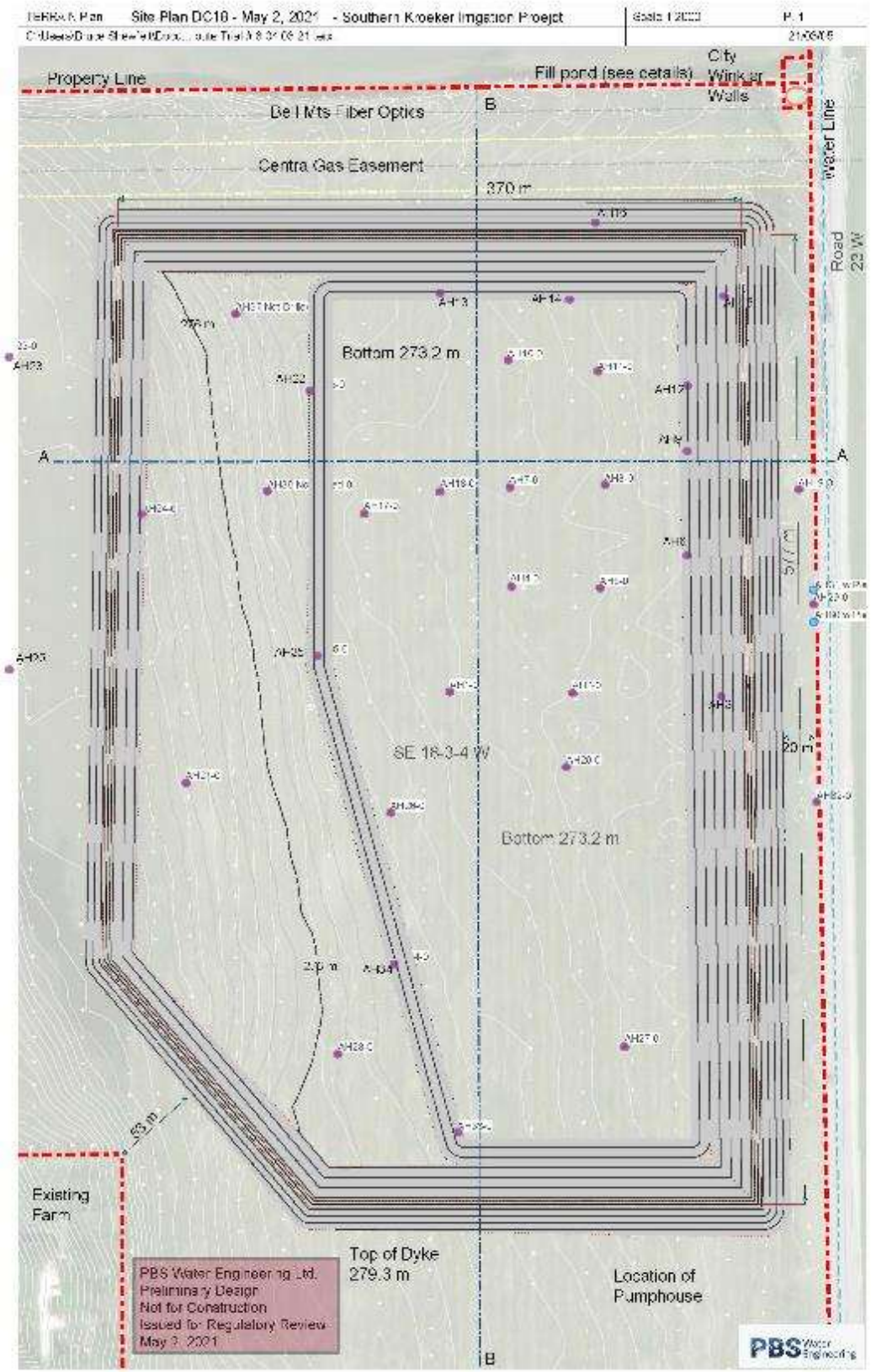
APPENDIX H – Engineering Drawings and Other Background Information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Bell Mts Fiber Optics
Centra Gas Easement
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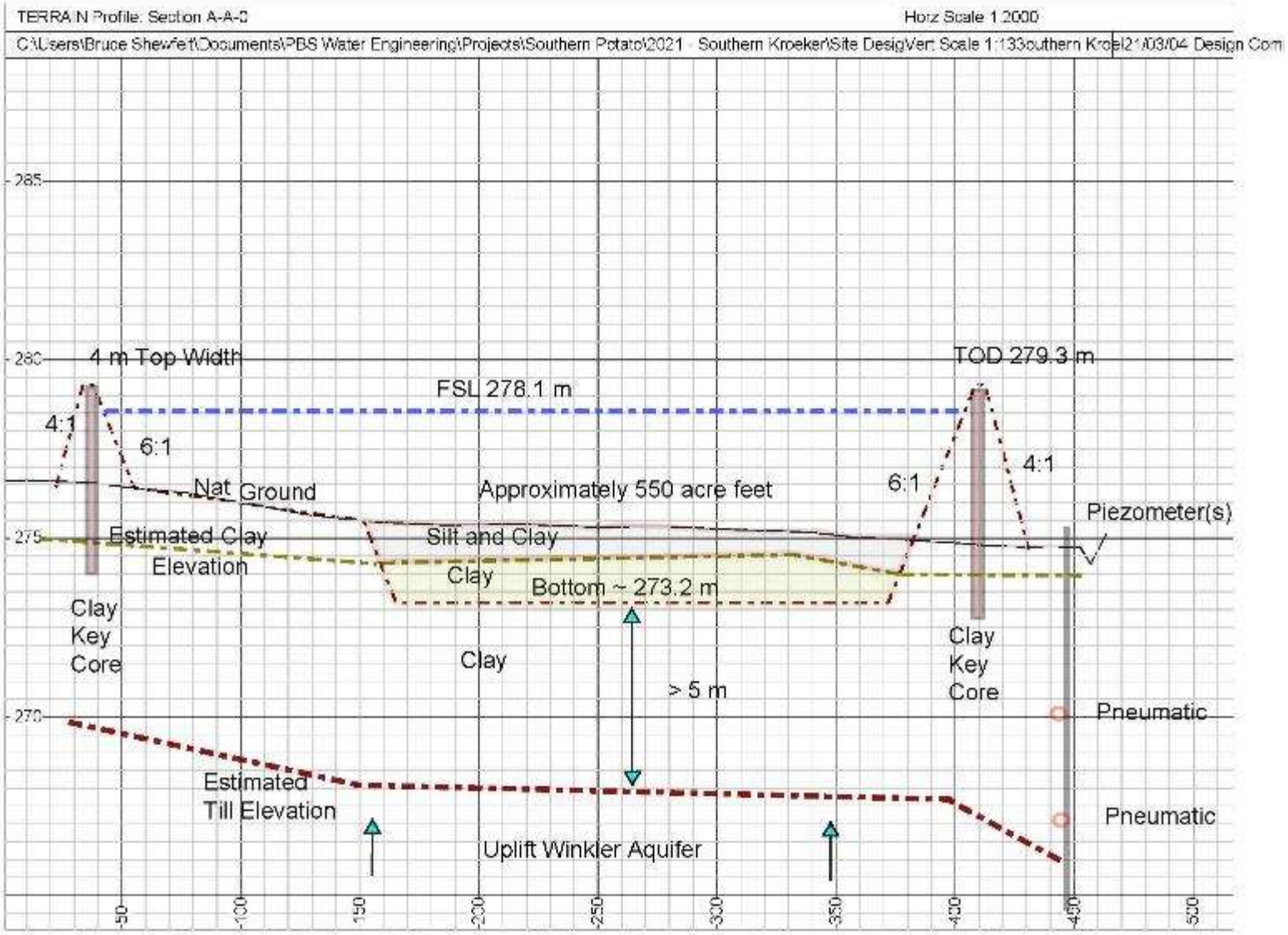
Water Line
Road 29 W
Bottom 273.2 m
A
B
577 m
SE 18-3-4 W
20 m
Bottom 273.2 m
Existing Farm
Top of Dyke 279.3 m
Location of Pumphouse
PBS Water Engineering Ltd.
Preliminary Design
Not for Construction
Issued for Regulatory Review
May 3, 2021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285
280
275
270
4 m Top Width
FSL 278.1 m
TOD 279.3 m
4:1
6:1
6:1
4:1
Nat Ground
Approximately 550 acre feet
Piezometer(s)
Estimated Clay
Elevation
Silt and Clay
Clay
Bottom ~ 273.2 m
Clay
Key
Core
Clay
> 5 m
Clay
Key
Core
Pneumatic
Estimated
Till Elevation
Pneumatic
Uplift Winkler Aquifer
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-150
-200
-250
-300
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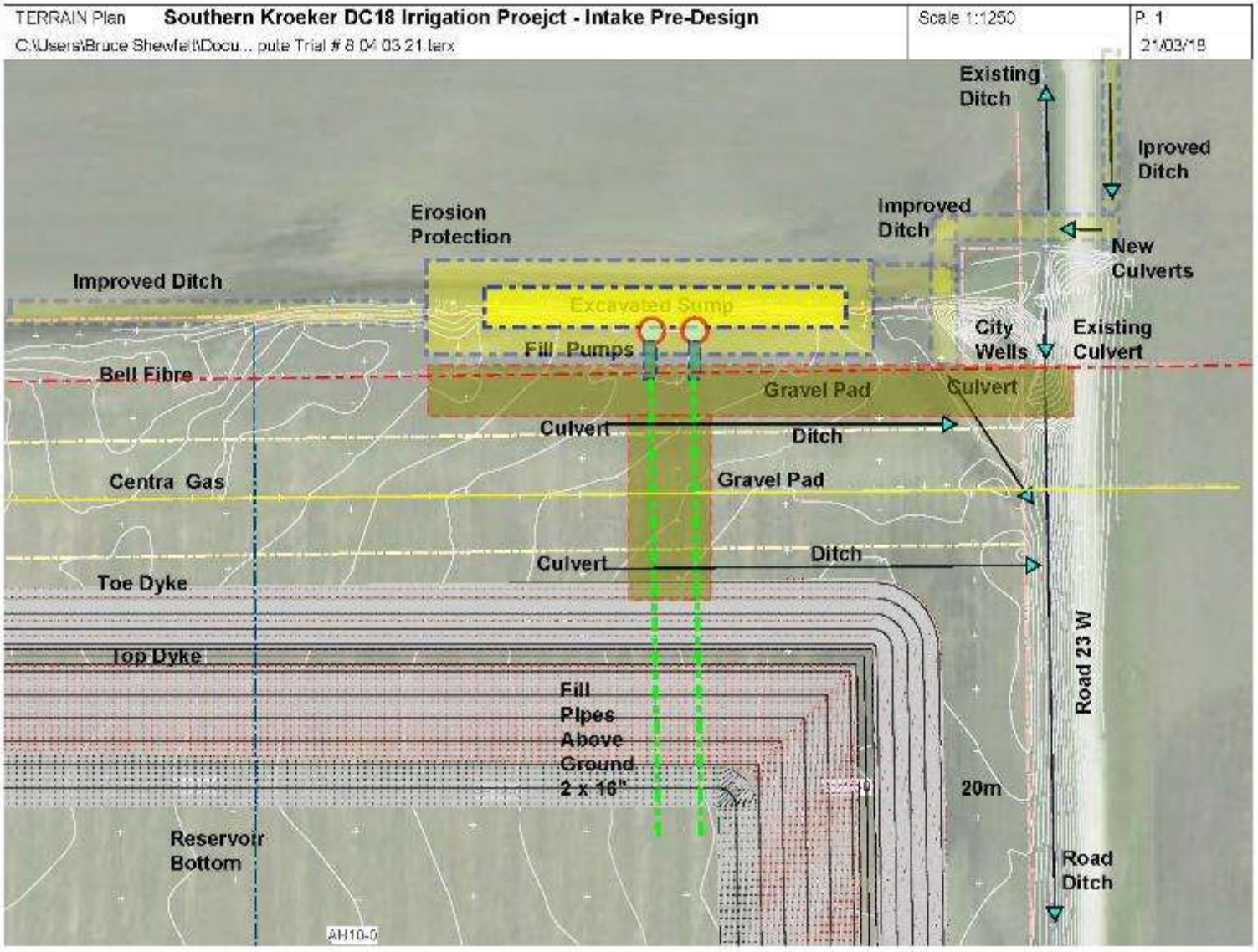
TERRAIN Plan
Southern Kroeker DC18 Irrigation Proejct - Intake Pre-Design
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21/03/18
Existing Ditch
Iproved Ditch
Improved Ditch
Erosion Protection
New Culverts
Improved Ditch
Excavated Sump
Fill Pumps
City Wells
Existing Culvert
Bell Fibre
Gravel Pad
Culvert
Culvert
Ditch
Centra Gas
Gravel Pad
Culvert
Ditch
Toe Dyke
Top Dyke
Fill Pipes Above Ground 2 x 16"
Road 23 W
20m
Reservoir Bottom
Road Ditch
AH10-0

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).

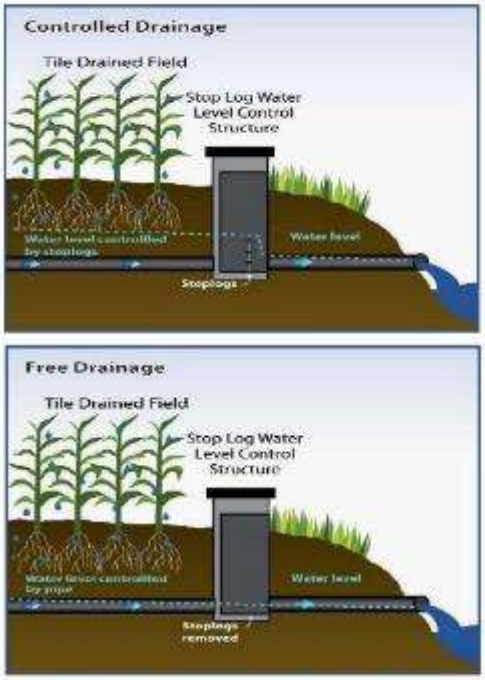

Figure 2. Controlled drainage using stop log control structures (top) and free drainage with stop logs removed (bottom).

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.

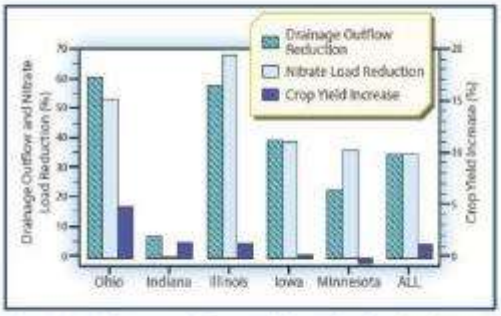

Figure 3. Drainage outflow and nitrate load reduction and crop yield increase resulting from controlled drainage vs. conventional drainage systems (Christianson et al., 2016).

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.

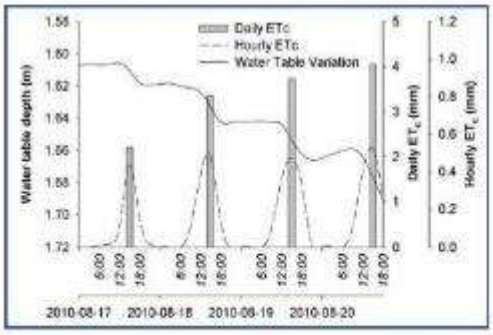

Figure 4. Contribution of shallow water table to meeting crop water demand (Daily ET_c) (Corderio, 2013).

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.

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).

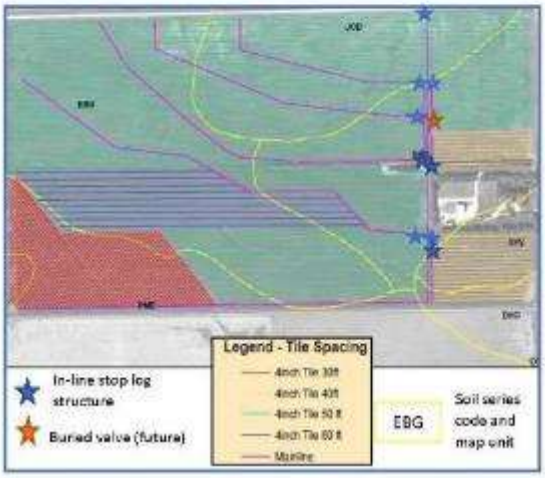

Figure 5. Typical controlled drainage design in Manitoba.

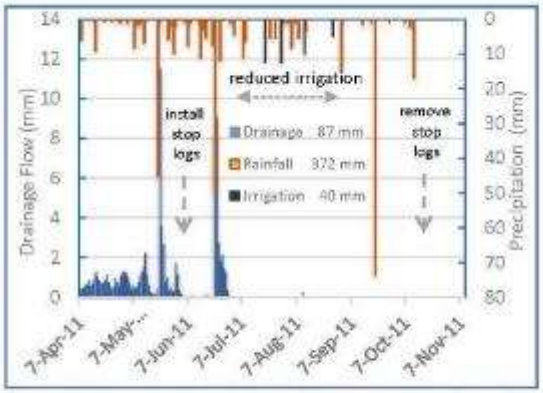

Figure 6. Illustrative free drainage flow vs. precipitation and irrigation (Cordeiro, 2013); showing potential to install stop logs at start of June to conserve water for July/August and removal of stop log in late October.

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.

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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.

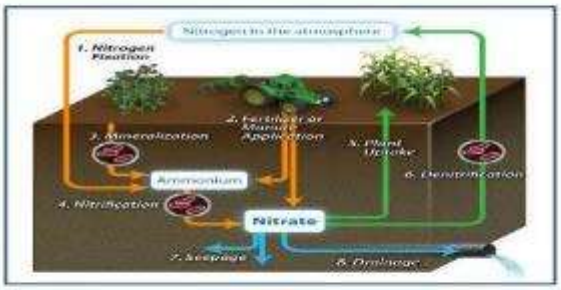

Figure 3. Nitrogen (N) cycle and tile drainage (Christianson et al., 2016).

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.

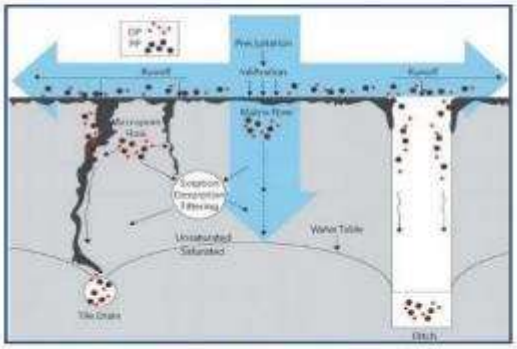

Figure 4. Representation of processes controlling P losses, DP, dissolved phosphorus; PP, particulate phosphorus (Kleinman et al., 2015).

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.

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.

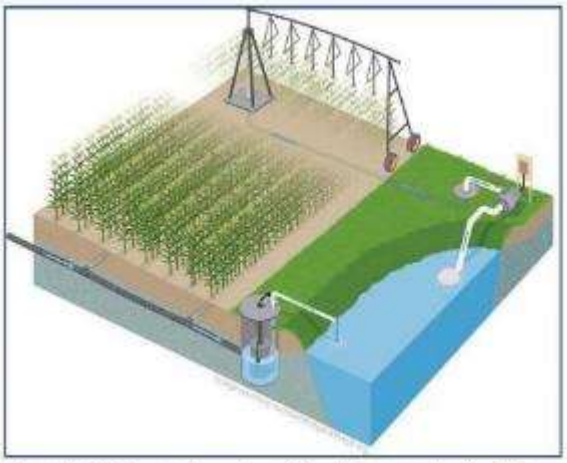

Figure 2. Capture and recycling of tile drainage water typically involves pumping, storage, and reuse (TransformingDrainage.org).

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.

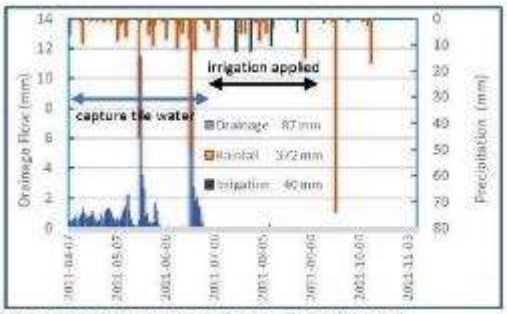

Figure 3. Drainage water flow vs. irrigation and precipitation – Hespler Farms (Cordeiro, 2013).

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.

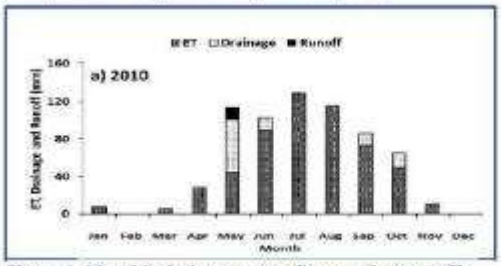

Figure 4. Monthly drainage water flow, surface runoff and evapotranspiration modelled with DRAINMOD for Hespler Farms (Satchithanantham, 2013).

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.

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