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Water Management Solutions

Agrium

Water stewardship and incentives: report of programs and project options

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Contents

List of figures

1.0 Executive summary

Water is completely unique as a resource. Therefore it is impossible to provide one blanket solution to water management for agriculture across the globe. Water and agriculture create a broad and dynamic combination, with an unlimited number of scenarios, conditions, social values, and economic influences. No two growers are the same, no two farms are the same, and no two watersheds are the same.

For Alberta, North America, and the entire world, water demand management (due to scarcity and climate variability) and water quality are already areas of concern and focus related to economic prosperity, environmental sustainability, and social well-being. Implementing change proactively at a watershed health level is cheaper for communities (e.g. compared to building infrastructure) and enables growers with more effectively control the land they understand so well.

Many localized stewardship programs exist around the world and many are delivered in a one-way communication approach. The disadvantage of this is the lack of direct feedback for the grower and the reliance on government and other organizations to provide performance indicators as well as monitoring and data to measure impact. Gaps exist in grower awareness and understanding for holistic water management (opposed to just erosion, salinity, or nutrient control), which can have direct impacts on the local watershed, as well as communities downstream.

Globally there is also a prevalence of water quantity and water quality credits and trading pilots and programs, which creates an excellent springboard for the Agrium work. Government-led (and regulated) systems exist, as well as a growing area of NGO, industry, and government collaborative approaches, such as the Chesapeake Bay program and the Michigan / Veolia water quality credits pilot, both excellent examples for building a foundation for the Agrium program.

As part of the valuation of water stewardship, ecosystem services could be the missing link to bring stewardship and incentives together. The project scope has an exciting opportunity to bring land use and water management together, under one umbrella for growers, with consistent economic values to inform a trading system. However, one of the biggest gaps is the consistent application of baseline performance indicators and data to monitor performance against the goals. There appears to be many academic programs and broad programs sharing information, though no programs or initiatives investigated have fully leveraged technology and data to create an adaptable program that can be localized (on a global scale) and supports growers in a practical way.

The goal of this project is to provide water stewardship and incentives, in a way that is accommodating and relevant for each grower, contributes to the economic and social priorities of a rural community, and ultimately improves overall watershed health. In the initial conversations between Agrium and Alberta WaterSMART the project scope would follow a path to ultimately create a water program in a similar form to the successful 4R program and the Alberta NERP. Following further research and insights from this report, three project options are proposed, all of which can all contribute to the objective through different communication, technological, and collaborative methods. The options are:

A. 4R building block (estimated between $1 to $1.5m)
B. Building a knowledge hub through existing global work e.g. “best of the best in water and agriculture” (estimated between $2 to $2.5m)
C. Enabling growers through integrated technologies (recommended with incorporation of option B as the tool for water stewardship (include estimated cost when confirmed). This option is a cycle that builds in the incentives from the beginning with ecosystem services valuation, effective monitoring, and credits management within the same online system (estimated between $6m to $8m).

Option C provides the most advantages and opportunities; however it is also the most costly in terms of time and finance. It is estimated, to reach the end goal of a water credits program through piloting and policy evolution, will take anything from five (optimistic) years to ten (more realistic), based on similar watershed policy and regulation work.

Perhaps the biggest takeaway from scoping this project is that no brand new technology is required; the knowledge exists, the instrumentation exists, the communication methods are reliable, and the organizations willing to be involved are apparent.

Rather, the project can create a global leadership opportunity through inter-linking the most valuable information and approaches from around the world, in the best interests of both growers and watershed managers, and use technology to leap frog programs already in place.

The timing of this project means Agrium’s can strongly position itself as a world leader in water stewardship and incentives for growers that effectively, and measurably, contribute to watershed health across their existing markets and further abroad.

2.0 Project definitions: water language

Consistent language and definitions at the start of the project ensures clarity and understanding throughout the project phases by all stakeholders involved. Appendix A contains a full glossary of key water and watershed management terms suggested to provide consistency throughout the project and this report.

The glossary should be considered a working list. In most cases the definitions were reproduced verbatim from the original source, however in some cases modifications were needed to make the definition relevant to water stewardship. These adaptations are noted in the column titled Source. Where more than one definition was available from different sources, judgment was used to select the most appropriate for the purposes of this project.

3.0 Project context

During infancy in any project it is important to clarify and understand the 'who and the why'. This section of the report addresses core reasons for the project. In time these can be refined and developed as messaging to communicate with stakeholders and audiences involved and impacted.

Note: throughout this report, farmers, growers, and producers are referred to inclusively as growers to reflect language adopted in Agrium's 4R program. For this project the term agriculture does not include fisheries or forestry.

3.1 What area of agriculture does this project focus on?

Initially in this scoping exercise the approach was to analyze specific regions and crops only served by Agrium. However as the scoping progressed, to maintain an open approach to the potential of this project and potentially influence other regions and/or markets to engage with Agrium, the work accessed information from across agriculture as it relates to water. From a project management perspective it is more efficient to refine the focus in future than to attempt to expand it (increasing scope and budget) at a later date.

However, with the above broad and global scope in mind, there are areas that need to be defined as boundaries.

The first is dryland and irrigation. Water risks for these areas are different, e.g. dryland has supply risks e.g. rainfall to fill dugouts or small flowing creeks while irrigation has water delivery and water quality risks top of mind. With water trading as an end goal there are opportunities for both irrigators and dryland farmers to benefit, potentially through trading with each other as well as other industries.

No matter the farming approach or localized influences there are commonalities in the communications and measurement aspects (e.g. using similar tools, data, and technologies) e.g. it is possible to adapt stewardship recommendations created for an individual grower, depending on the inputs of that individual grower. This is similar to the 4R program, which creates recommendations based on inputs from the grower such as soil tests and farm priorities (economic, social, or environmental).

Further, the scope does not focus on one type of crop in relation to water management. Crop type would become an input of research in the selected project option (see Section 8.0 for project options). For broad context, Figure 1 shows the liters per kilogram required for a range of crops (with a comparison for livestock which is connected by other crops due to feed and land use choices).

Crop or livestock	Water required (liters per kilogram)
Crop	
Soybeans	2000
Rice	1600
Sorghum	1300
Alfalfa	1100
Wheat	900
Corn	650
Potatoes (dry)	630
Millet	272
Livestock	
Broiler chicken	3500
Pig	6000
Beef cattle	43,000
Sheep	51,000

Source: Pimentel and colleagues (2004).

Figure 1: Estimated amount of water required to produce crops and livestock

3.2 Why water is different to other resources

For analysis, monitoring, and improving conditions, water cannot be treated like other influences on the land. Water must be approached differently to other resources because:

- When it comes to water, everything is connected – it is completely unique in this respect. Water is a key element in erosion, salinity control, and non-point source pollution programs. It is the magnifying glass and in many cases, the natural vehicle, for the impact of these issues.
- Watershed impacts are highly localized – what happens for one grower may not happen for another grower who operates ten kilometres down the road.
- Water has a natural cycle – impacts can occur at any stage throughout the cycle.
- Water travels across political boundaries – at least 20 countries source more than half their water from rivers that cross international boundaries (Gleick, 1993) and 14 countries receive 70% or more of their surface water resources from rivers that are outside their borders (Alavian 2003, Cech 2003).

- There is no silver bullet technology – new technologies are being researched, launched, and built upon, however there is no one technology that can provide the answer in all situations. To succeed technology must be combined with regulatory changes and informed individuals to bring effective change.

This project identifies with these challenges, and seeks ways to include or navigate them while remaining true to the overall objective.

3.3 What is the knowledge gap?

From a water management and watershed planning perspective there is a knowledge gap for growers in water stewardship and, from an operational and technology perspective there is a knowledge gap for water experts in agriculture. The following diagram outlines assumptions on the gaps. Specific research is recommended to confirm or challenge these assumptions.

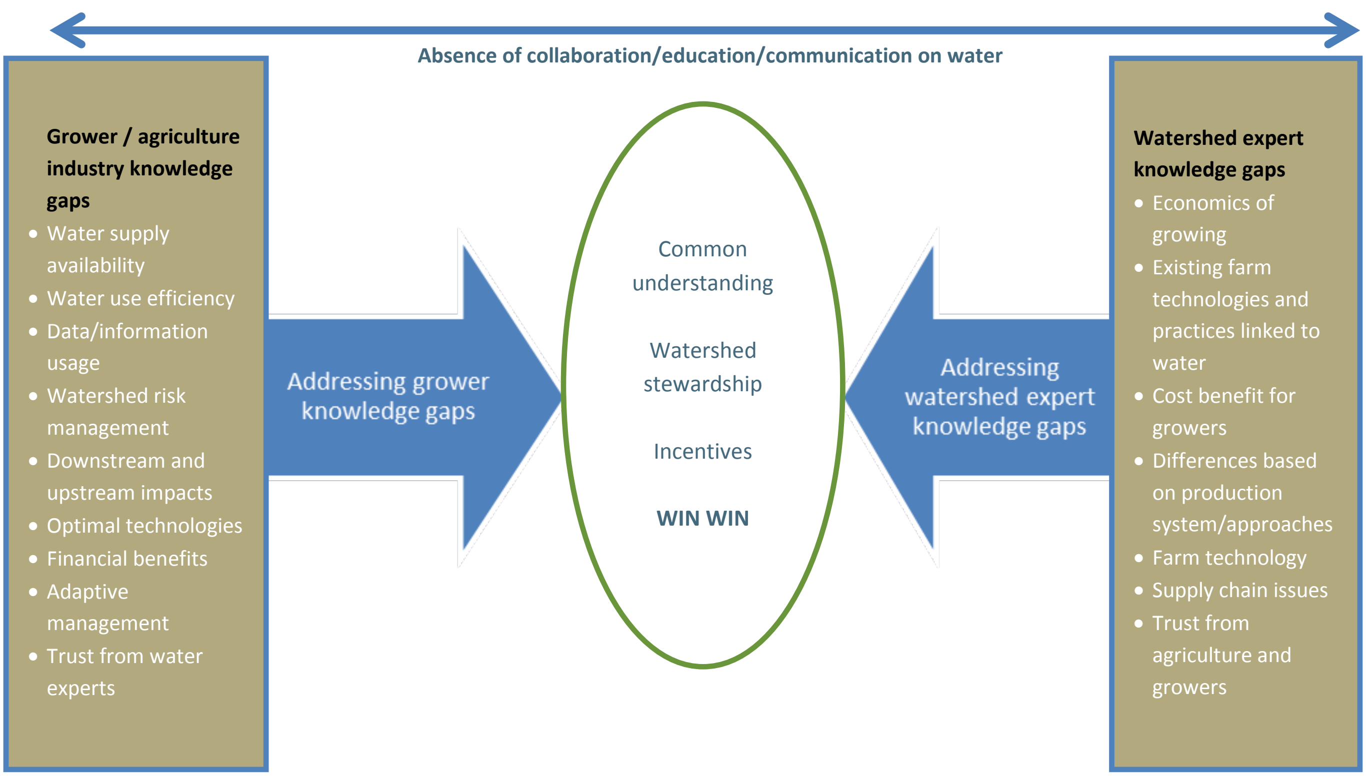


Figure 2: Addressing knowledge gaps for growers and watershed experts

For water stewardship and incentives the following are as critical as addressing the knowledge gaps:

- Recognition of the diverse and unpredictable combinations of social and economic factors influencing growers to make decisions and take actions
- Climatic, soil, and watershed differences in different jurisdictions and within jurisdictions e.g. Alberta has vastly different soil types, climate, and crops that can change in a short distance, and
- A practical, effective, accessible way for growers to understand, track, and improve how they can manage water, with potential for a system to trade water as an incentive in future.

Lastly, there are many existing programs and approaches for water management in agriculture. The issue is that benefits of water stewardship may exist but they may not be known across the industry—there are pockets of knowledge but they are not necessarily accessed by the industry as a whole. This is an excellent opportunity for Agrium to leverage its existing network and geographical reach to fill these knowledge gaps across entire regions.

3.4 Why growers need support to act

If we start with the obvious, water is an essential component in every agricultural product, its production, and entrained in the product itself.

However, how water arrives and leaves a farm is where things get more complicated, whether it is runoff, in the product or carrying waste, or showing up unwelcome such as major flooding. For instance, although water is considered a renewable resource because it is replenished by rainfall, its availability is finite in terms of the amount available per unit of time in any one region (Pimentel et. al, 2004).

> *Water is rarely available in the right place at the right time in the right quantity and quality for anyone. Growers are no exception to this.*

Good water stewardship practices ensure water availability through soil and other storage, aquifer retention and conservation in consumption, as well as routing unneeded water away from production points without making surrounding land (including neighboring farms) and downstream communities worse off. Through educated and efficient practices growers can maintain the natural holding capacity of the land, store water when it comes, avoid excess water passing by, and avoid contaminating water which gravity moves to neighbors.

From an economic perspective water is growing as a risk to be managed by all businesses. At the 2016 World Economic Forum, water crises were identified as the global risk of highest concern for the next ten years (see Figure 3).

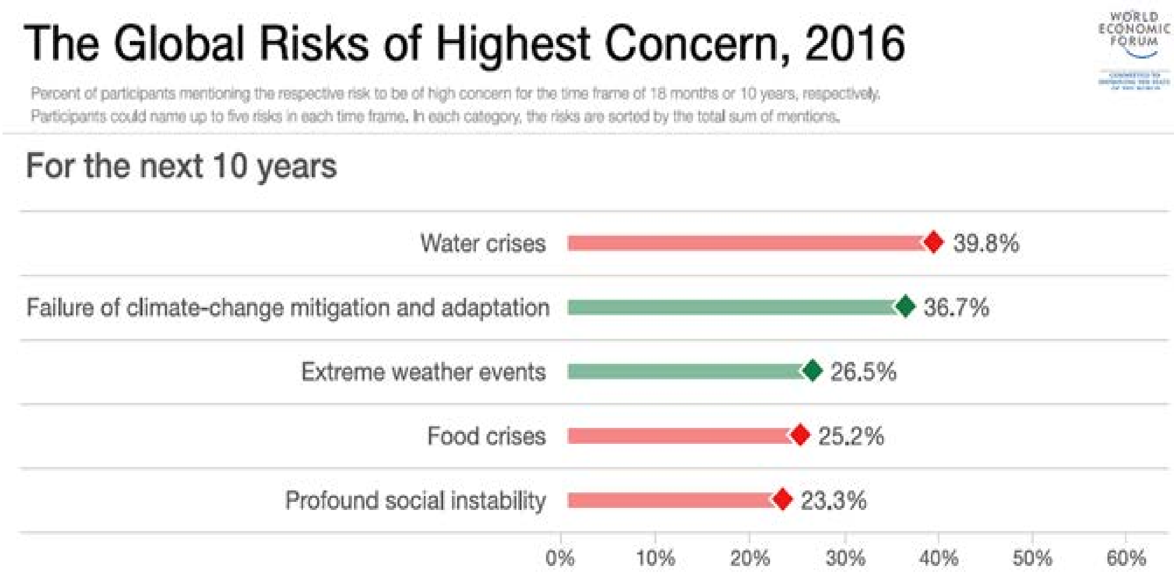


Figure 3: Global risks of highest concern

The above graph does not represent agriculture only. However it shows the potential for increasing pressure from industries and sectors outside agriculture as they recognize the risks of water to business and economies, and the link to the agricultural industry's access and availability to water.

If growers cannot act now to improve water management and efficiency, in a proactive way using genuine incentives, it is inevitable they will need to act later at a bigger cost—eventually more regulation, red tape, and consumer expectations will be placed upon the industry to manage water using ways that may not be as affordable, or effective, as a proactive and enabled approach.

Due to growing water scarcity in regions, water quality issues, and the increasing demand for global food production, water management—regardless of connected issues like non-point source pollution—will become a stand-alone focus with increasing attention and scrutiny. As the largest consumer of freshwater in the world, agriculture is both an industry seeking change and an industry pressured to change, based on the strong connections between water, energy, and greenhouse gas emissions.

3.4.1 Sustainable supply chain influences

In a Ceres research project two thirds of companies researched were still not evaluating water issues in their agricultural supply chains, where the majority of water risks lie (Roberts & Barton, 2015).

As more companies like General Mills, Molson Coors, and PepsiCo take action to improve water risk management and watershed protection plans, the pressure on growers to improve practices and measure performance for water management will increase. Key examples include Coca-Cola's Replenish program, General Mills' water policy, Molson-Coors' Grower's Group, Levi Strauss' Better Cotton initiative, and a host of other companies that have signed-on to the CEO Water Mandate, the Alliance for Water Stewardship and the Sustainable Agriculture Initiative Platform (Roberts and Barton 2015).

The move toward enhanced water stewardship in agriculture is driven in large-part by broader market demand and shareholders that are increasingly interested in corporate social responsibility and environmental stewardship (Roberts and Barton, 2015). As such, for Canadian agriculture to remain competitive, it is necessary for growers to demonstrate how their products align with these values.

It is estimated 50% of Canadian agri-food output is exported to global markets (Kerr 2016). As global agri-food markets become increasingly interlinked, stewardship of water resources will become a key element driving of Canada's agri-food competitiveness. Sustainable sourcing is also an element of the Alberta Environmental Farm Plan.

The future of sustainable supply chains may be summarized in this statement by Unilever:

> *Agriculture and forestry contribute more greenhouse gas emissions globally than any other industry, and are therefore significant contributors to climate change. We purchase significant volumes of agricultural crops and manufacture many products that rely on forestry for packaging. It's our responsibility to do so sustainably (Unilever Sustainable Sourcing Fact Sheet).*

In the future it is realistic to expect consumers, corporations, and governments to continue to increase standards and requirements around the delivery of more sustainable products and services—including supply chains that, in many cases, start with growers.

3.5 The grower asks, "What's in it for me?"

A critical piece of any change program is the relevance of action to create a benefit or other requisite impact for that individual. For growers to contribute to a healthy watershed there needs to be collective action, aligned with the understanding of a larger goal. This approach is based on the water cycle and downstream considerations that many growers may not consider (or even be aware of) in their day-to-day decisions.

Don McCabe, a long-time leader in Canadian agriculture and director with the Canadian Federation of Agriculture has indicated, "…Agriculture is ecosystem management for the production of food, fiber and fuel… and farmers are therefore ecosystem managers…" (Ontario Climate Consortium). With water a primary element in the environment, this statement speaks to the fact growers have a deep connection with their local water resources.

As both stewards of their land and business owners/operators, growers are typically inclined to conserve and optimize their resources, minimize their risks, and seek opportunities to produce marketable and quality products.

> *It is no secret growers manage their water supplies and exposure to a variety of water-related risks on a day-to-day basis in order to maintain productive operations and farmsteads. However, the effectiveness of the current approach from a watershed health and upstream/downstream impacts perspective shows there are gaps and opportunities for improvement.*

Watershed stewardship programs have been developed to support growers in optimizing their management of water resources to simultaneously increase productivity while achieving environmental objectives that protect the water resources over the long-term. However how clear these programs and best management practices are, and how widespread they are adopted, has not been openly evaluated.

Farmers and scientists have identified a wide range of land and water management practices that can address land degradation and increase long-term agricultural productivity. The benefits of these improved land and water management practices to farmers and rural economies include higher crop yields, increased supplies of other valuable goods such as firewood and fodder, increased income and employment opportunities, and increased resilience to climate change (World Resources Institute, 2013). Figure 4 demonstrates the dominance of water quantity in relation to crop losses in one jurisdiction over more than sixty years.

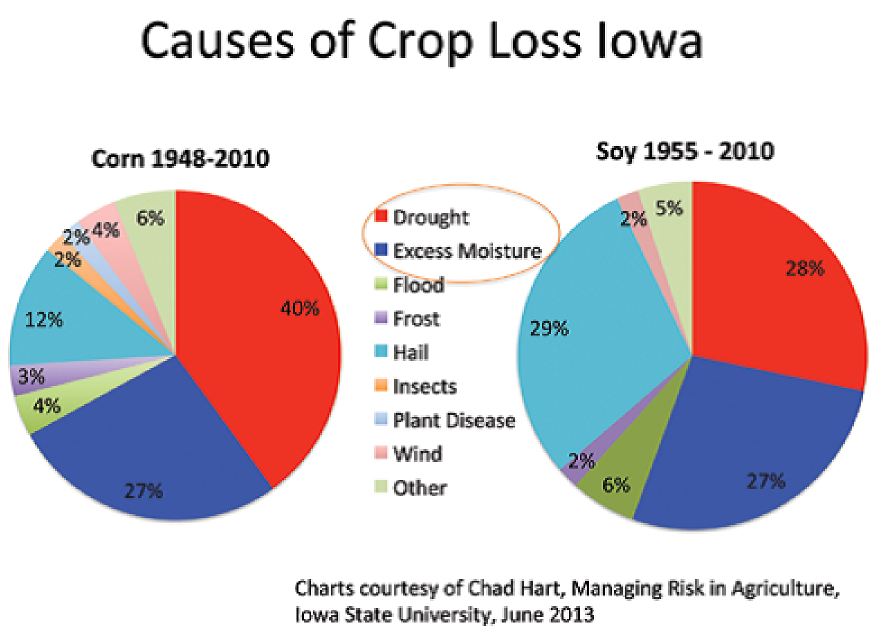


Figure 4: Causes of crop loss in Iowa

Further, if soil and water conservation measures are not implemented, the loss of water for crops through soil erosion may amount to as much as five million litres per hectare per year (Pimentel et al. 2004).

Some international groups are already recognizing the opportunity in a more holistic approach to water that can also benefit growers financially. For example, Green Water Credits focuses on rain-fed growers and has run pilots in Kenya, Morocco, China, and Algeria. See Figure 5 for the Green Water Credits model.

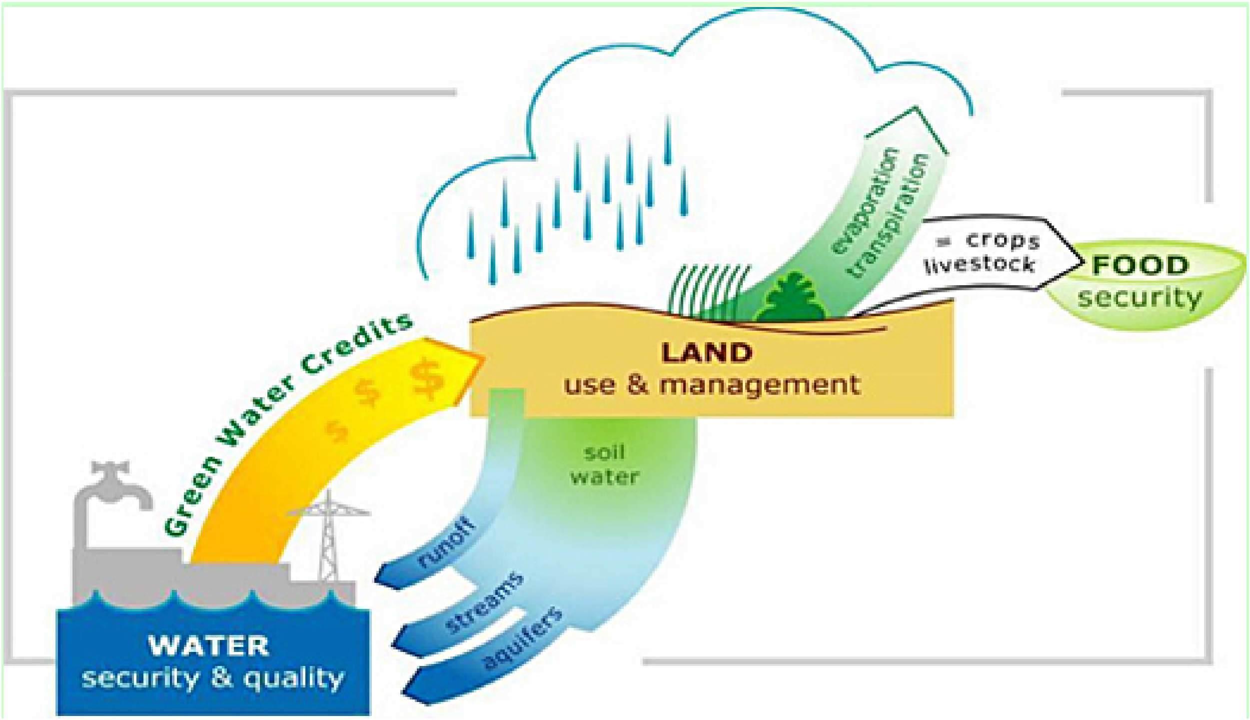


Figure 5: Green Water Credits model

When growers understand where water goes on their land, and how it can be managed and used more effectively and efficiently while contributing to overall watershed health, everyone can win.

3.6 What does a healthy watershed mean for communities?

Watersheds provide much more than a water supply. Healthy watersheds provide what has been termed as ecosystem services. Ecosystem services are the benefits that humans receive from nature. These benefits include provisioning services such as food and clean water; regulating services that affect climate, floods, and water quality; cultural services that provide recreational benefits; and supporting services such as soil formation (Millennium Ecosystem Assessment, 2005).

Figure 6 (Millennium Ecosystem Assessment, 2005) shows the links between ecosystem services and human well-being, including fresh water (provisioning) and primary production (supporting).

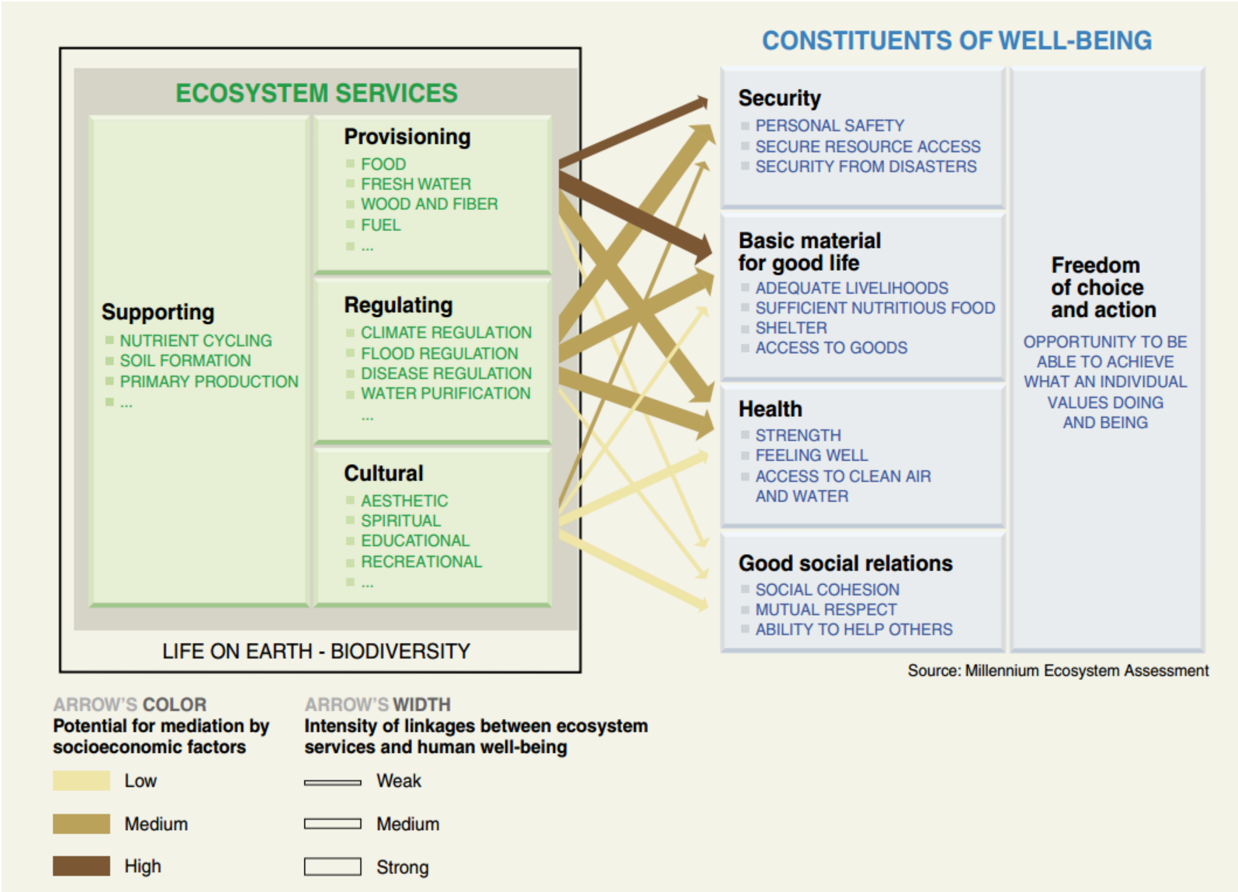


Figure 6: Influence of ecosystem services on human well-being

The Millennium Ecosystem Assessment (2005) also outlines a number of moving systems within the ecosystem services area, including drivers of change both indirect and direct. Figure 7 from the Assessment shows how strategies and interventions (both direct and indirect such as change programs in water stewardship) impact and interplay across the ecosystems and impact human well-being.

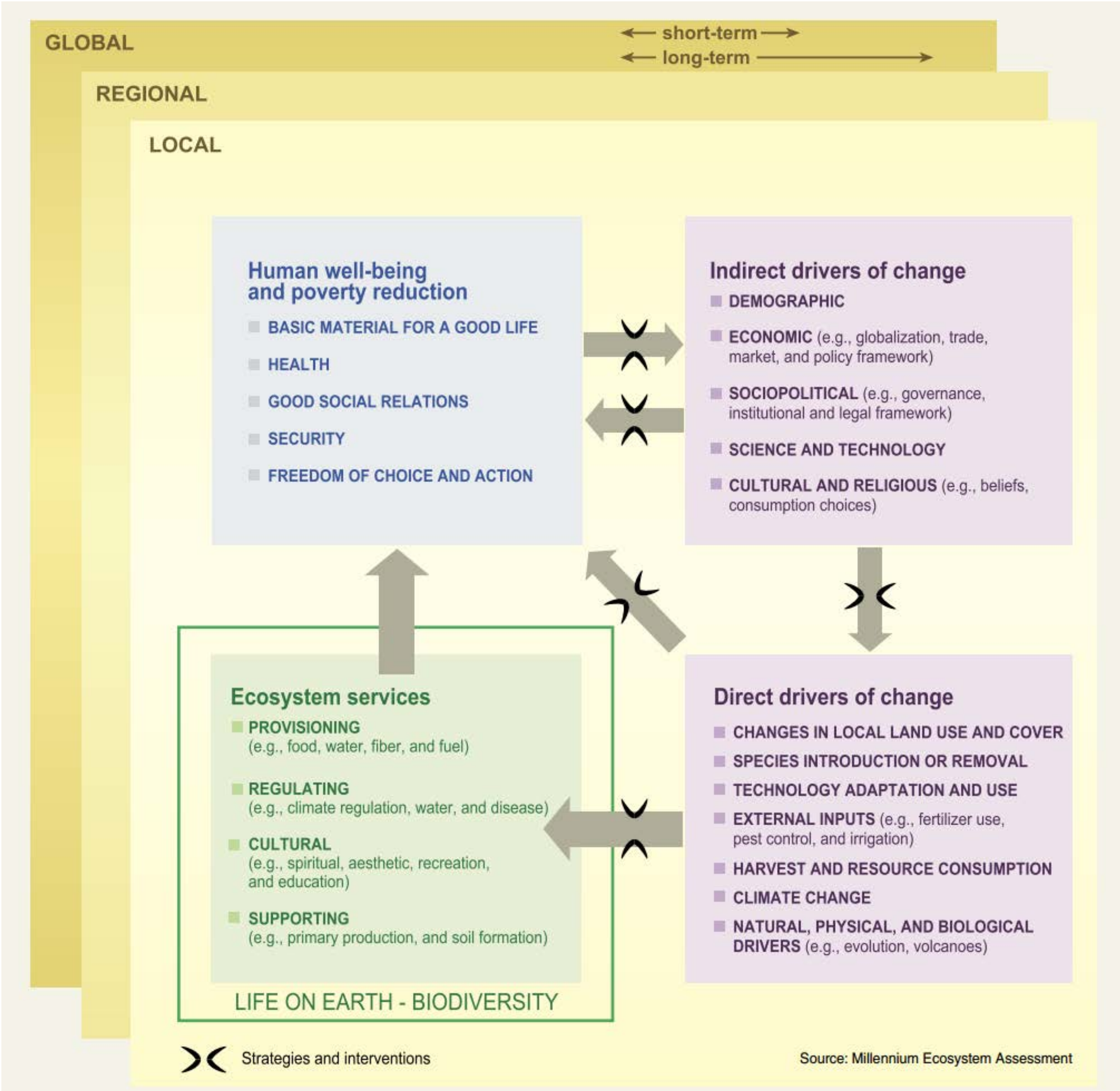


Figure 7: Conceptual framework of interactions between biodiversity, ecosystem services, human well-being, and drivers of change

While some of these areas are more challenging to measure quantifiably (e.g. cultural, religious, and inspirational values, and aesthetic enjoyment), other goods and services such as flood control and water purification are areas that can save communities, provinces, and countries, billions of dollars.

Figure 8 outlines examples of capital cost savings by opting for watershed health focus over traditional infrastructure approaches. Collectively, better water management in agriculture contributes to these cost savings. A percentage of such infrastructure savings could be allocated (e.g. by government) to fund grower water stewardship incentives.

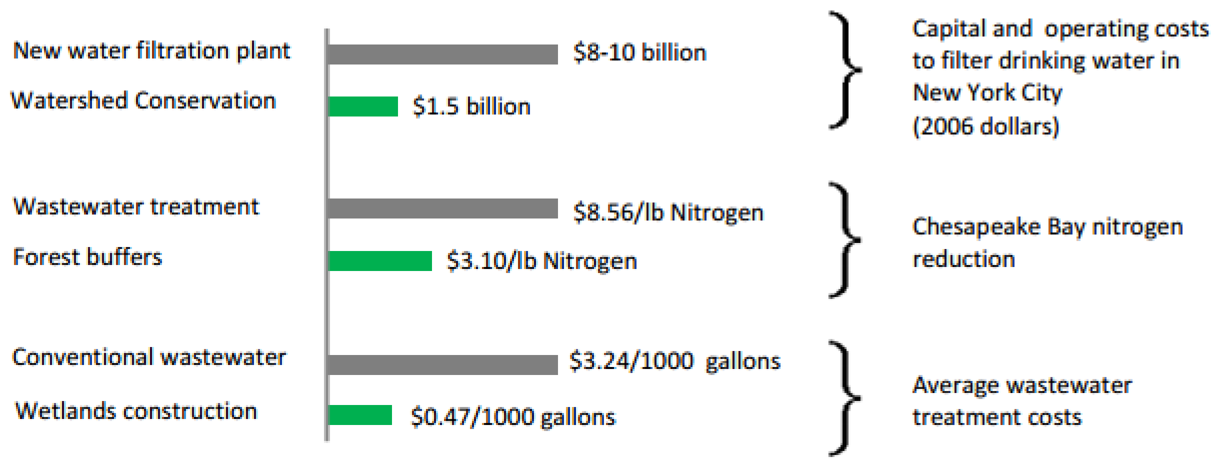


Figure 8: Watershed protection is less expensive than building new "grey" infrastructure

Healthier watersheds reduce drinking water treatment costs, sustain revenue-generating activity including agriculture, can minimize vulnerability and damage from natural disasters, and ensures we leave a foundation for a vibrant economy for generations to come (U.S. EPA, 2012).

> *By taking a watershed focus, while maintaining the importance of economic and social drivers for growers, an Agrium-led project can avoid the misguided conception that simple and localized efficiencies will solve all water issues.*

The default response has been to drive efficiency first without any real knowledge of the hydro-economic (see Appendix A definition) system from which they are drawing water. Most corporate targets and even certification schemes have this efficiency bias. Both standards and corporate targets need to shift to include contributions to watershed-wide outcomes. For businesses like farms, it is critical to understand how their responses actually affect risk – be it mitigation, transference of risk to someone/ somewhere else, or in fact increasing risk and reducing resilience (World Wildlife Fund and International Union for Conservation of Nature, 2015).

3.7 Risks for farm and watershed systems

Although water is a critical input to agricultural, it can also pose serious hazards to production systems when it is in excess, lacking, and its quality is degraded. At the individual farm scale, natural processes such as riverine flooding, inundation on the landscape and erosion can cause negative effects to plants, be detrimental to soil quality put livestock in harm's way, and damage farm equipment and structures (FAO 2013).

On the other end of the scale, droughts are among the greatest risk to farm productivity and soil quality. Droughts have had devastating effects on Canadian agriculture, with the 2001-2002 drought event in western Canada causing up to $3.6 billion lost in agricultural production, which translated to a loss of 41,000 jobs (AAFC 2015).

When scaled to larger watershed and sectors, water-driven risks can translate into declines in food supply, impose large costs for crop-insurance, contribute to loss of harvested/stored products, and affect the overall economics and socio-cultural character of agricultural areas.

> *Within Canada, southern Alberta and Saskatchewan have been rated as having "high" threats to water availability, with availability of supplies in basins such as the South Saskatchewan River Basin observed to be declining over time (Wheater et al. 2013).*

Globally, and in parts of Canada, there are also grave threats to the availability of good quality groundwater for irrigation and rural use (Famiglietti 2014; Bruce et al. 2009). In many of these areas, water quality threats from pollution sources including agricultural runoff and infiltration can cause risks to drinking water supplies (Bruce et al. 2009).

3.7.1 Regulatory risks for growers

Water resources are managed through various government policies and programs on the basis of a watershed, or drainage basin. These government policies and programs are designed to manage numerous objectives and issues related water supply, hazards (e.g., floods) and demand.

In Alberta, a key example is the water licensing and allocation system. The Alberta *Water For Life* strategy is a document that guides decisions related to water resource and watershed management. Together, these and other related regulations have numerous implications for the types of activities growers can engage in and the opportunities (e.g., incentives and support programs) available.

Ultimately however, they are designed primarily to ensure water quality and quantity is maintained while hazards are managed. The key for this project is to acknowledge regulatory risks and work with frameworks applied at a local level.

3.8 Climate change as a risk and opportunity

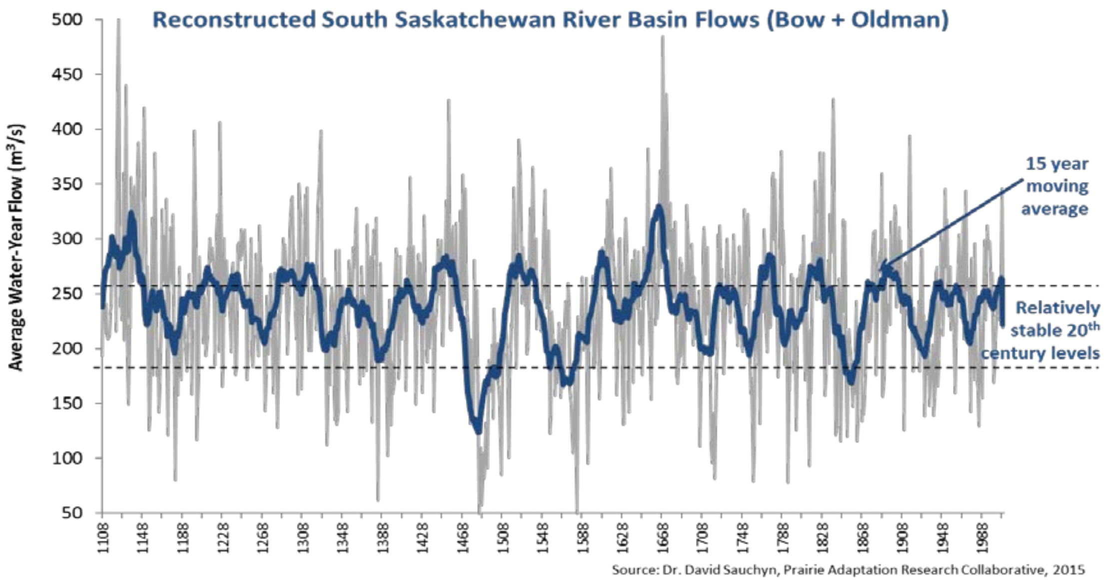
A watershed's climate is a key driver of water supply availability, agricultural demand (i.e., influenced by evapotranspiration) and the profile of water-related hazards (flood, droughts, extreme precipitation) (FAO 2013). As the climate changes, so too will these factors' influence on agriculture.

For example, it has been estimated that irrigation demand in Western Canada could increase by between 12 and 25% by the 2050-2060s, based on average changes in climate alone (Islam and Gan 2015; Kulshreshtha and Nagy 2015). This does not account for the fact that droughts are likely to increase in frequency, requiring even more water in those dry years.

The continued loss of forests and other vegetation and the accumulation of carbon dioxide, methane gas, and nitrous oxide in the atmosphere are leading to global climate change. Over time, these changes may alter precipitation and temperature patterns throughout the world (Downing and Parry 1994, IPCC 2002). This will have direct influences on the agriculture industry's approach to water management.

Historically, there has been variability in local climates, which farmers have become accustomed to managing, however recent increases in the frequency of droughts and excessive moisture have increased, meaning that a "good growing year" is harder to predict and manage for (IPCC 2014; FAO 2013).

In Alberta, the history of water and climate can be demonstrated in the following demonstration of the moving average. No matter one's view on climate change, the dips and peaks of climate variability are evident and unavoidable.



3.9 Summary of agricultural water risks from a water stewardship perspective

As a basic starting point Appendix B outlines agricultural risks to farm and watershed systems, along with potential on-farm mitigation strategies that could be incorporated into the Agrium water stewardship element of the project (adapted from: FAO, 2013; Santhi et al., 2013; Wheater et al., 2013).

The strength of the agricultural activities/assets for mitigating each risk is rated on a three-point scale based on professional judgment:

1. + provides indirect risk mitigation
2. ++ provides direct risk mitigation, and
3. +++ provides strong risk mitigation.

In the development of a water stewardship program and pilot, the risk matrix could be used as a foundation for further research (either new or to find existing research) to support the messages around benefits and "what's in it for me" via collective action by growers in the interests of watershed health.

3.10 Project relationship to 4R program

A water stewardship framework has strong water quality connections to the 4R and could be seen as an extension of that work. This was discussed as an option with Agrium in the beginning phases of the project scoping however, as more information comes to light around the challenges and unique circumstances created by water, it requires careful consideration. Refer to Section 8.0 for the advantages and disadvantages outlined in project option A (4R building block).

3.11 Project relationship to government programs

The typical “government model” is to provide a locally-based certification process (e.g., in Canada the Environmental Farm Plan) that enables growers to address key regulatory and other voluntary requirements. Technical support is provided to assist in farm assessment and planning of on-farm stewardship projects. Cost-sharing programs and incentives are put in-place to implement the best management practices. There is usually an element of project verification and farm signage.

The Alberta Environmental Farm plan provides a step-by-step process for growers to assess their environmental impacts and risks, and obtain funding through the federal-provincial Growing Forward 2 Initiative to implement many best-management practices, such as grazing and nutrient management, installation of shelter-belts, and other measures. It should be noted many of these practices have been proven to increase overall farm productivity and minimize production costs.

While these programs provide a solid base of support for agri-environmental initiatives, there are caps on the maximum level of government support a farm can receive for best management practices. Also, these programs generally support a pre-defined list of best management practices which may not match the complexity of circumstances for individual farms and local watershed impacts.

An opportunity exists to support more innovative approaches, building on the various official agri-environmental programs to fill gaps and create continuous improvement for the benefit of growers, rural communities, and watersheds. There is also a gap for technology to provide automated or real time feedback on actions taken on the farm, with a longer term feedback loop for watershed impacts.

Additionally, it is important to note the value of enabling growers to solve their own problems. “What has been missing all along are performance standards and the on-farm tools farmers can use to measure their own performance. Farmers are problem solvers. If they have a goal they will figure out how to get 'er done!” (Governor of Minnesota’s Water Summit, 2016).

A step toward this on-farm tool and information is Agriculture Victoria’s (Australia) Farm Water Calculator, which helps growers determine:

- How much water is used on the property (including domestic use)
- How much water can be stored on the property
- Potential supply from sheds, waterways, groundwater and catchment run off

- How long the water will last on the property, and
- How farm water supplies cope under different rainfall scenarios.

More detail on an enabling approach through latest technology and grower-centric tools can be found in Project Option B and C (Section 8.0).

3.12 Project relationship to CEO Water Mandate

The CEO Water Mandate is a program of the UN's Global Compact. While it is focused more on individual corporations / organizations creating their own water stewardship approach, the resources and tools may be applicable as inputs to a grower-focused tool.

The Alliance for Water Stewardship is a standard for water stewardship and reporting system used by the CEO Water Mandate and many other organizations, and the Sustainable Agriculture Initiative Platform is the primary global food industry initiative for sustainable agriculture. These resources are key strategic and unifying approaches to be considered and, where possible engaged, in the expansion of a broader agricultural water stewardship program around the world.

4.0 Water stewardship programs

4.1 Approach to analysis

The approach to analyzing water stewardship programs employed a watershed focus rather than an agricultural focus. This enabled a broader perspective on programs that could be adapted for use in a specific agricultural context. Further, the opportunities have been interpreted with the development of an industry (e.g. Agrium-driven) water stewardship program in mind, rather than a government or NGO driven program.

All the stewardship programs reported are voluntary. There were no regulated stewardship programs found in the scan. This may be due to the challenges around measuring performance against baselines and the complexity of water related problems, which requires several different, but complementary management mechanisms. For instance, in addition to voluntary adherence mechanisms for water management requires command and control, consensus building, and economic instruments—each requiring a different institutional arrangement (Porto & Lobato, 2004). Please refer to section 4.3 for more information on voluntary versus regulatory approaches.

Further, there are no corporate leaders who have designed and implemented a specific industry leading program (corporations are involved in some programs, but do not have their own water stewardship for customers). Agrium already recognizes the strong opportunity, as part of their corporate social responsibility program, to join or build a water stewardship program tailored to their customers / markets.

In addition to general research, the following databases of agricultural stewardship programs were used:

- AgPal
- UNDP's CAP-NET Program
- Agriculture Canada's List of Programs and Services
- The CEO Water Mandate's Water Action Hub – Sustainable Agriculture Projects

The programs in the following table are not listed in any priority and are presented by region of focus (Canada, global, United States, other).

Table 1: Global water stewardship scan summary

Region of focus, program, organization	Regulatory or voluntary, Target water issue(s), program	Interpreted successes [+] and challenges [-]	Agrium value and applicability [ ] higher [ ] lower
Alberta focus Alberta Environmental Farm Plan and On-Farm Stewardship Program (Agricultural Research and Extension Council of Alberta Government of Alberta)	• Source water protection • Water quality protection • Irrigation management • Process for assessing and managing environmental risks through certain BMPs • EFP = (1) Contact EFP rep and arrange farm visit; (2) Complete assessment process; (3) Acquire certification from EFP rep • Ongoing implementation of BMPs using government cost-sharing programs through the stewardship program	[+] Clear and simple process [+] Clear pathways for ongoing funding support to assure farmer benefit and successful implementation [+] Identifies range of interrelated environmental risks [+] Assists with regulatory compliance [-] Limitation on value of cost-sharing for specific set of BMPs may make innovative approaches challenging to fund	• Use of technical support materials • Leverage cost sharing programs already in-place • Cost-share funding has a cap/farm – New stewardship program could provide support above and beyond
Alberta focus Rural Water Quality Information Tool (Government of Alberta)	• Source protection • Water quality protection • On-line tool to assesses quality/suitability of raw water sources • Farmer inputs water quality test results • Tool provides interpretation and recommendations for crop/farm usage suitability	[+] Useful information for tailoring on-farm field management practices (e.g., altering water quality, crop selection, treatment of drinking/livestock supplies, etc.) [-] Requires a level of knowledge in water quality	• Information for producers is practical • Tool is simple and accessible
Alberta focus Alberta Irrigation Projects Association	• Irrigation management • Water quality • Range of activities focused on education and outreach, governance, innovative management, partnerships and research • Key projects: Every Drop Counts education initiative for youth; testing new irrigation technologies	[+] Focus is on a significant area of water use and water quality risk for Alberta	• Potential partner for Alberta water stewardship
British Columbia focus Environmental Farm Plan (British Columbia Agriculture Council)	• Irrigation management • Drainage management • 4-step process to assess and implement certain environmental BMPs • (1) Arrange appointment with EFP advisory; (2) Complete workbook; (3) Apply separately for implementation funding; (4) Display sign • Technical support and documentation provided throughout	Similar to Alberta Environmental Farm Plan (first row on this page)	• See Alberta Environmental Farm Plan

Region of focus, program, organization	Regulatory or voluntary, Target water issue(s), program	Interpreted successes [+] and challenges [-]	Agrium value and applicability [ ] higher [ ] lower
Saskatchewan focus Farm Stewardship Program (Government of Saskatchewan)	• Irrigation management • Runoff/erosion control • Water quality protection • Cost-sharing program to support implementation of certain BMPs • Requires completion of an environmental farm plan	Similar to Alberta Environmental Farm Plan (p23)	• See Alberta Environmental Farm Plan
Ontario focus Canada-Ontario Environmental Farm Plan Program (Ontario Soil and Crop Improvement Association)	• Water use efficiency • Water quality protection • Process wastewater management • 3-step process to assess and implement certain environmental BMPs • (1) Attend info workshop; (2) Develop EFP using worksheets and with technical support; (3) Implement BMPs using government cost-sharing programs • Technical support and documentation provided throughout	Similar to Alberta Environmental Farm Plan (p23)	• See Alberta Environmental Farm Plan
Ontario focus Rural Water Quality Programs (Region of Peel and Waitland Valley Watershed and South Nation Conservation)	• Water quality protection • Source water protection • Technical and financial resources to support environmental stewardship locally • Applications for on-farm projects submitted to local committee for approval and cost-sharing with applicant • Technical support provided by Conservation Authority staff	[+] Committee-based local decision-making puts program ownership/priorities in local farmers' hands [-] Limitation on value of cost-sharing for specific set of BMPs may make innovative approaches challenging to fund	• Locally-based partnerships can have benefits to program buy-in and success
Ontario focus Collective Infrastructure Projects (Partners in Project Green Water Stewardship program)	• Water infrastructure • Urban water management • Governance committee of business, government and NGO partners focused on collaborative water projects • Context for work is CEO water mandate • Current projects focus on joint-funding for urban water management, primarily on industrial properties	[+] Effective for addressing shared water risks and interests [-] Difficult to achieve consensus on collaborative projects and funding models	• Potential partner in GTA • Collaborative governance and resource-sharing model

Region of focus, program, organization	Regulatory or voluntary, Target water issue(s), program	Interpreted successes [+] and challenges [-]	Agrium value and applicability [ ] higher [ ] lower
New Brunswick focus Agri-environmental Clubs (New Brunswick Soil and Crop Improvement Association)	• Water quality protection • Network of local clubs focused on sharing of knowledge and experience to the advancement of a sustainable agricultural industry • Largely focused on BMP implementation • Leads a range of workshops/farm tours, and shared staff provide support services for water sampling, EFPs, etc.	[+] Flexible community-based structure that addresses multiple agri-environmental objectives [-] Specific focus on water stewardship is lacking	• Potential local partner
Global focus Sustainable Water Management Certificate (Earth Institute, Columbia University)	• Water supply and demand management • Hydro-climatic variability • Water quality • Professional development certification program • Focused on developing skills in integrated water management systems analysis	[+] Comprehensive coverage of water issues using integrated [-] Expensive and curriculum materials not readily available	• Holistic and integrated treatment of water quality, quantity and socio-economics
Global focus Water Stewardship for Sustainable Agriculture guidelines (Sustainable Agriculture Initiative Platform)	• Water quality • Water supply and demand management • Guidance manual for how food/drink manufacturers can work with the agricultural supply chain to address water challenges • Use of water foot-printing to identify opportunities in the supply chain, Alliance for Water Stewardship and EWP standards for stewardship program certification • Uses watershed-based and risk-based approaches	[+] Overall model for understanding and developing stewardship programs to address agricultural water issues [+] Oriented toward business strategies that reduce reputational and regulatory risk	• Model provides a helpful framework for engaging with downstream supply chain partners • Holistic step-by-step method for developing water stewardship
Global focus Barley Water Management Projects and SmartBarley® (InBev)	• Water quality protection • Water use efficiency • Conducted in-depth water assessments in barley-growing regions, with specific projects tailored to needs to stakeholders locally • Works directly with growers to implement BMPs and water conservation through training of local technicians • Demonstration/pilot projects to test innovative water efficiency technologies	[+] Local and global non-profit partners give credibility to the program [+] Multiple levels of engagement (watershed, individual growers) [+] Program fits within broader corporate water stewardship strategy and performance measures, but also has significant capital investment	• Includes programming in Agrium regions (SA, Europe) • Potential partner within supply chain

Region of focus, program, organization	Regulatory or voluntary, Target water issue(s), program	Interpreted successes [+] and challenges [-]	Agrium value and applicability [ ] higher [ ] lower
Global focus BetterCotton Initiative (Industry partnership)	• Water quality protection • Water use efficiency • Standard/criteria for environmentally sustainable cotton production • Individual producers sign-on to the program to implement BMPs that reduce cotton growing footprint • Supply-chain partners can also commit	[+] Significant consultation used to develop globally relevant criteria and accreditation process [-] Specifics of implementation are unclear	• Potential supply chain partner • Framing of water issues may be relevant
Global focus Farmer and Equity (C.A.F.E) Practices (Starbucks Coffee)	• Source water protection • Water efficiency • Wastewater management • Cultivating, growing and harvesting coffee using methods that avoid adverse impacts on water resources • Promotes and supports farmers with implementation of BMPs	[+] Local and global non-profit partners give credibility to the program [+] Program fits within broader corporate water stewardship strategy and performance measures, but also has significant capital investment	• Potential partner (member of UN Global Comact)
United States focus Fieldprint® Projects and Calculator (Field to Market® member organizations and growers, Alliance for Sustainable Agriculture)	• Irrigation Water Use • Water quality Protection • Demonstration projects of field-scale water stewardship projects and training with farmers • Online software to compare different stewardship practices and their impact on multiple categories of indicators (water, soil, farm economics, etc.) • Factsheets and other simple documentation to assist farmers	[+] Collaboratively implemented with supply chain partners [+] Software contains numerous conservation and stewardship option, is easy to use and based on science [+] Program results/ performance documented through indicators in annual report [-] No clear/direct incentive or funding for growers to use resources	• User-friendly software • Demonstration projects • Partnerships with supply chain groups • Holistic assessment of field-scale stewardship options
Manitoba focus Manitoba Environmental Farm Plan (Government of Manitoba)	• Protection of water quality and water supplies • Self-assessment to help farmers identify and manage agri-environmental risks and assets • (1) Completion of workbook and optional workshop; (2) Review of workbook by EFP staff; (3) indicate completion with farm sign • Implementation and cost-sharing support separate from EFP process	Similar to Alberta Environmental Farm Plan (p23)	Similar to Alberta Environmental Farm Plan Program

Region of focus, program, organization	Regulatory or voluntary, Target water issue(s), program	Interpreted successes [+] and challenges [-]	Agrium value and applicability [ ] higher [ ] lower
Michigan focus Farmstead, Cropping, Livestock and Forest, Wetlands and Habitats Verification System (Michigan Agriculture Environmental Assurance Program)	• Irrigation management • Water quality protection • Water use efficiency • Voluntary, collaborative process for addressing on-farm risks • 1) education; 2) farm-specific risk assessment and practice implementation; and 3) on-farm verification • Assessment uses risk-based worksheets	Similar to Alberta Environmental Farm Plan (p23)	Similar to Alberta Environmental Farm Plan Program
United States focus Ogallala Aquifer Initiative and other water-based initiatives (USDA Natural Resources Conservation Service)	• Water quality protection • Water demand reduction • Enhanced crop productivity • Part of a range of region/water-body specific projects to address need for agricultural stewardship funded through NRCS Agricultural Water Enhancement Program (AWEP) and Environmental Quality Incentives Program (EQIP) • Technical/financial assistance to help them implement conservation practices on farms • Program implemented through partnerships with local extension offices/universities	Similar to Alberta Environmental Farm Plan (p23)	Similar to Alberta Environmental Farm Plan Program
United States focus Great Lakes Agricultural Projects (The Nature Conservancy)	• Water quality protection • Collaborative projects with agricultural community, research universities and other environmental organizations on several test projects throughout the region • Focus is regional-scale and watershed-based initiatives (e.g., irrigation/drainage infrastructure rehabilitation, 4R Nutrient Certification, watershed strategies, etc.)	[+] Projects are high-profile and innovative [+] Collaboration-based model builds strong partnerships [-] Focus on pilot projects makes widespread impact difficult	• Focus on innovative practices • Use of partnerships to have strong public impact • Agrium could help mainstream innovations • TNC could be a partner • 4R Nutrient program featured as a project

Region of focus, program, organization	Regulatory or voluntary, Target water issue(s), program	Interpreted successes [+] and challenges [-]	Agrium value and applicability [ ] higher [ ] lower
California focus Agricultural Water Stewardship Initiative (Community Alliance with Family Farmers)	• Water demand management • Water quality protection • Aims to increase awareness of water stewardship techniques for the agricultural sector • Website and detailed project summaries • Workshops and training sessions on dryland farming and conservation techniques	[+] Community-based model can build strong local partnerships	• Technical resources on sustainable farmers may be directly applicable in program development
California focus California Water Stewardship Project (ECO Ecological Farming Association)	• Water supply and demand management • Resources and educational materials to help evaluate the best on-farm water efficiency and conservation techniques in dry land environments	[+] Emphasis on water-scare contexts	• Technical resources on sustainable farmers may be directly applicable in program development
Europe focus Collective Actions Promoting Water Stewards in Agriculture (European Water Partnership)	• Water efficiency • Water quality • EWP develops partnerships to improve water across Europe through partnerships • Program is a multi-stakeholder platform involves actors from industry, agriculture and civil society to develop and disseminate lessons learned and best practices from these partnerships • Shared on the Water Action Hub	[+] Focus on the broader conditions needed for effective stewardship provides the systematic supports [-] Not focused on stewardship actions, but the partnerships and funding needed, which may not be directly applicable for Agrium	• Represents a model of collaboration and a structure of a network for agricultural water stewardship in Europe • Focus on dissemination of best practices and knowledge around agricultural water stewardship • Key program elements are around communicating water stewardship, developing strong partnerships and collective funding for watershed programs

Region of focus, program, organization	Regulatory or voluntary, Target water issue(s), program	Interpreted successes [+] and challenges [-]	Agrium value and applicability [ ] higher [ ] lower
Chile focus Water and Energy Projects (Fundacion Chile)	• Water supply access • Water efficiency • Collaborative investments in large-scale projects to improve access and sustainability of Chile's water resources	[+] Strong local water stewardship implementation due to effective partnerships and stakeholder engagement	Potential partner (member of Alliance for Water Stewardship)
Egypt focus Improving Sustainability of Groundwater Resources (multiple NGOs and businesses)	• Water quality • Water supply and demand management • Reduce threats to water security and to develop sustainable water management strategies while ensuring socio-economic development and ecological health • Groundwater cooperative for local farmers with collaborative monitoring, data sharing and development of needed scientific information	[+] Development of a model designed to be scalable across Egypt [-] Requires a significant number of local and international partners for successful implementation	Potential partner project in Egypt (member of UN Global Compact)
Egypt focus Agricultural Extension (American University Cairo, Research Institute for a Sustainable Environment)	• Water quality protection • Water use efficiency • Water supply and demand management • Conducts research, education and agricultural extension services to improve sustainability of dry land agriculture in Egypt • Maintains large demonstration and innovation testing farms • Provides advisory services to local farmers	[+] Works with/supports a variety of local stakeholders and farmers [+] Large farming facilities provide opportunity to actively test and showcase innovations [-] Specific programs are not clearly defined	• Potential local partner • Could be an important resource on local agricultural water issues
United Kingdom LEAF's Water Management Tool (Linking Environment and Farming, Molson Coors, ASDA Stores Limited)	• Six steps for water management on your farm (simple factsheet) • Online tool designed to give growers a health check for water use on their farm. • Maps water use, assesses risks, and improves efficiency, suggests ways of saving money. • On-line tool looking at: - Better distribution and monitoring - Improved irrigation - More efficient washing systems - Protecting water quality - Recycling and reusing	[+] The six steps is one of the simplest frameworks to enable water supply and water-related hazards [+] Leverages technology to enable access from growers via the internet [-] Member only service [-] High level / basic guidelines without data / in depth technical information for support or decision making	• Could be used as the basis for creating a tool for farmers to input data specific to regions

4.2 Water stewardship program insights

4.2.1 Specific issues versus overall watershed focus

Most of the stewardship programs scanned in this scoping activity are broad, and intend to address different issues in different watersheds using the same water management guide and/or model. The programs with this approach are effective in terms of raising awareness and educating growers about the link between land use and watershed management, however it is arguable how effective these blanket programs would be across the diverse variables presented in agriculture.

> *Using a watershed-wide approach (rather than programs focusing on specific issues e.g. salinity) provides a more holistic solution rather than organizations and governments addressing disjointed silos of issues (of which the causes may impact other areas negatively) and duplication of efforts due to isolated management.*

An example of a watershed-scale approach is Agriculture and Agro-Food Canada's *Watershed Evaluation of Beneficial Management Practices* completed in 2013 (AAFC, 2016). Consistent with guidelines for agricultural water stewardship from the Sustainable Agriculture Initiative Platform and other similar programs, a key finding from the AAFC was that the practices of greatest benefit need to be determined based on the watershed and water resource conditions and issues locally, and that measureable impacts occur when implemented in conjunction with broader watershed planning.

Likewise, in Illinois water quality improvements from best management practices alone would be insufficient. Rather they needed to occur within a larger drainage water management program to be successful (Lemke et al., 2011).

No programs outlined performance measures at the outset and there was a clear absence of monitoring and evaluation to help participants identify performance or improvements. This is where transparency in the grower's collective action can inspire change and become a motivator for others to act and benefit. Also, a new program could specifically focus on baseline measures and how to monitor and measure performance and it could be considered a success as a practical tool for growers.

4.2.2 Value of aligning to established international standards

There are a number of important guidelines, standards and certification programs related to water stewardship at the corporate level that have guided the development and implementation of many well-recognized water stewardship programs. Fortunately, the agencies responsible for these programs tend to cooperate closely and there is little overlap in the tools, guidelines, and support given to participants. This creates the beginnings of a global approach to water stewardship that Agrium can carry forth through the development of a program for growers.

The materials and organizations highlighted in Figure 9 add significant credibility in various aspects of a stewardship program to (corporate strategies, program design, implementation, and certification). This credibility is essential in reducing regulatory and reputation risk to the partnering organizations involved.

There is no need to reinvent the wheel for the initial water stewardship methods for growers to help improve local watershed health. Using existing, established and scientifically valid frameworks and learning from the successes and failures of these different programs gives a higher chance of success for an Agrium-led initiative. There is also an opportunity to contact and collaborate with these organizations and integrate and/or build upon these existing standards to increase participation and trust in the work developed with Agrium.

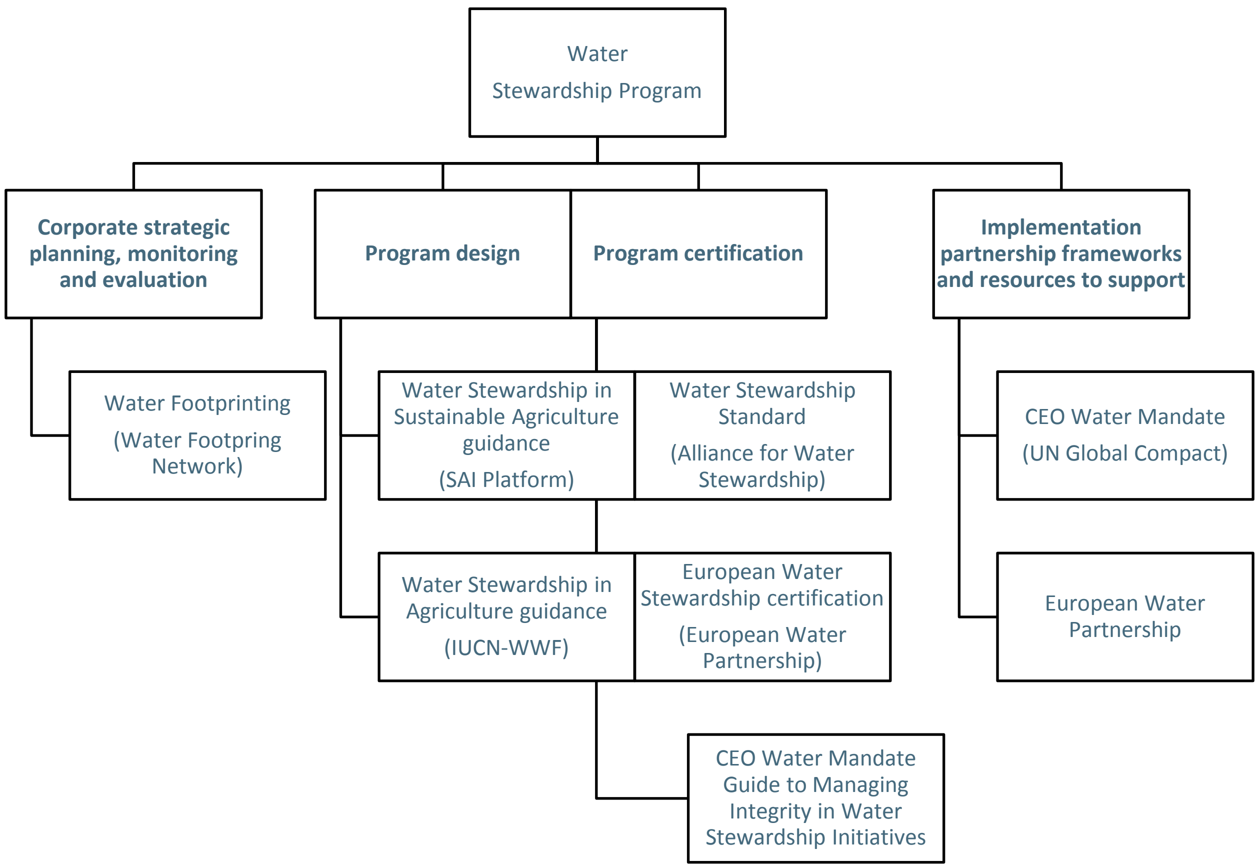


Figure 9: Global resources for water stewardship program development, certification, and implementation

4.2.3 Avoiding perceptions of "greenwashing"

To avoid the potential for water stewardship programs to be interpreted as "greenwashing", a rigorous monitoring and evaluation framework with pre-defined quantitative and qualitative indicators should be established and implemented. See Section 7.1 regarding data and monitoring opportunities.

4.3 Voluntary versus regulatory approaches

A key consideration in the adoption of an approach for growers to manage water is whether the program is voluntary or regulatory. When an industry is seen as responsible for an environmental problem, policy makers must choose if they require the industry to correct the problem, or if they create an incentive for the industry to voluntarily remedy the problem.

Recently there has been growth in the use of voluntary programs to address environmental problems. Generally these can be placed into three categories:

1. Unilateral commitments by industrial firms, sometimes referred to as business-led corporate environmental programs
2. Public voluntary schemes, in which participating firms agree to standards that have been developed by public bodies such as environmental agencies, and
3. Negotiated agreements created out of a dialogue between government authorities and industry, typically containing a target and a timetable for reaching that target. Negotiated agreements may take on the status of legally binding contracts if legislation empowers executive branches of government to sign them. (Lyon and Maxwell, 2001).

Voluntary programs can have strategic benefits in the political and regulatory arenas to influence the actions of regulators. Strategies identified include:

1) Preempting tougher government regulations
2) Weakening forthcoming regulations, in situations where full preemption is impossible
3) Reducing the extent of monitoring by regulatory agencies, and
4) Signaling regulators to persuade them to raise rivals' costs (Lyon and Maxwell, 2001).

The US Department of Agriculture has used voluntary programs, such as the Conservation Reserve Program, and more recently the Environmental Quality Incentives Program for growers to withdraw environmentally damaging land from production. These programs offer growers payments in exchange for voluntary land retirements. Similar incentive approaches could be applied for watershed stewardship however the overall benefits for the local watershed health would need to be linked.

The appeal of voluntary environmental improvement is its apparent low-cost pathway to achieving environmental goals. However, evidence to date suggests voluntary activity should complement a regulation (not substitute for it), as the threat of regulation is an important factor in motivating voluntary actions (ibid).

For the Agrium project it is recommended the voluntary versus regulatory approach per Figure 10 is applied in the development. This approach would be suitable in most regions with sound government process to form an effective credits / incentive regulatory policy.

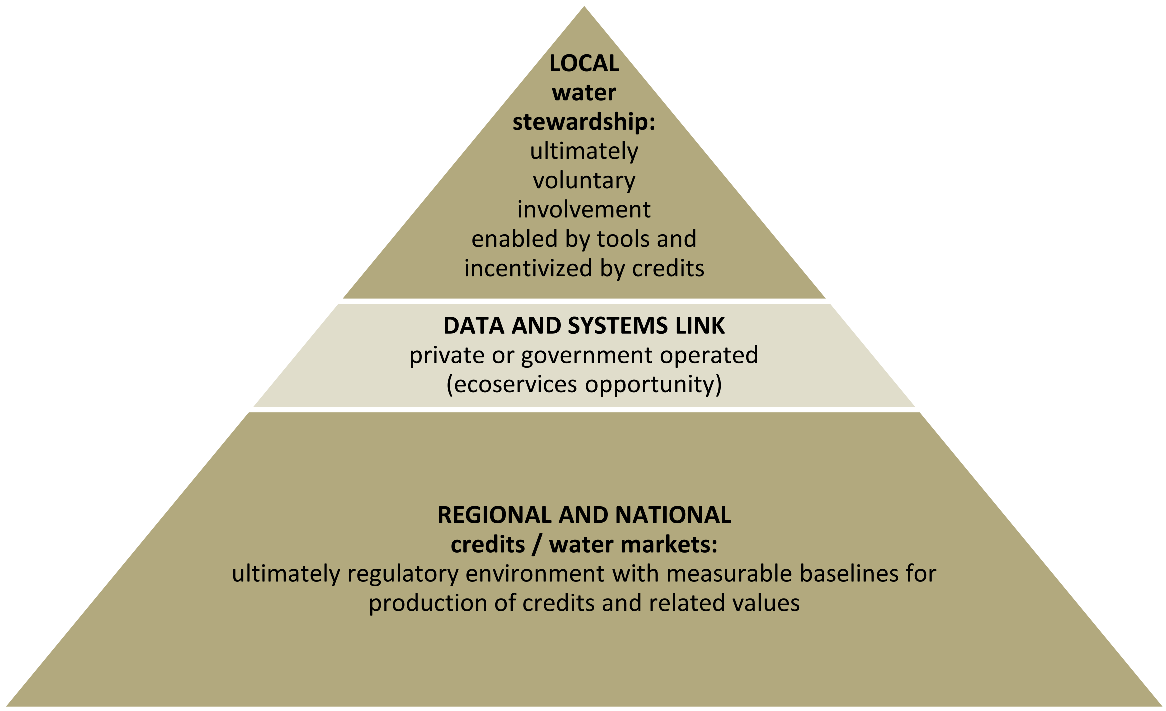


Figure 10: Project focus levels of voluntary and regulatory action

4.4 Recognize existing water stewardship

Throughout the water stewardship research it is obvious there are many growers doing the right thing environmentally.

An important consideration in the development of a water stewardship program for agriculture is to recognize the existing efforts of growers in the water area. This ensures growers who have been able, or chosen to act regarding water management either through individual knowledge or other programs, do not feel alienated or ignored with the development of an Agrium-led program.

Sharing success stories can be an effective way to inspire action through lessons, recognition of similar issues and problem solving, and that something is possible to be done / proven and how it was achieved. Examples include:

- The Pacific Institute's California Farm Water Success Stories
- Alberta example *A Producer's Perspective: Strategic Planning Process Helps Hone Legacy of Stewardship for Producers.*
- World Overview of Conservation Approaches and Technologies (WOCAT) Success Stories.

It is recommended part of the messaging around this project (no matter the selected option) refers to building on the great work already achieved by growers in water management and taking it to the next level.

5.0 Water credit programs / incentives

5.1 Introduction to water credits

Water credits, also known as water trading, are most simply described as the voluntary exchange or transfer of a quantifiable water allocation between a willing buyer and seller. In this section the focus is on regulated, government-involved programs with examples of pilots, technologies, and existing trading programs initiated through non-profit and industry groups.

As further context, basic considerations for water credits include:

- Water is limited and its use by one person affects its availability to others. This may result in competition and conflict, and creates the need for a coordinated, equitable and efficient system of allocation (National Water Commission, Australian Government).
- Water trading reflects a cap and trade system where consumptive uses of water must be identified within the need for water in the environment.
- After a cap on total consumptive water is established, water trading is a mechanism to ensure that limited water resources are put to their most productive uses.
- Economic advantages of water trading:
  - Seasonal water trading enables the water available in any given season to be reallocated across crops, locations, irrigators and other water users in response to seasonal conditions.
  - Water trading can facilitate investment and structural adjustment in response to changing conditions.
  - The price signal for water in the market provides an incentive for users to make efficient use of all inputs and invest in improving the efficiency of their on-farm water use.
- Elements required for water market design:
  - Balance between consumptive and environmental water use, clearly defined and tradeable property rights, regulation of the market, trading platforms, water accounting, compliance and enforcement arrangements, and institutional and governance arrangements.

5.2 Water trading case studies

5.2.1 Australia

In the 1980s it became clear many of Australia’s surface water and groundwater systems in the Southern Murray Darling Basin were fully developed, if not over developed. The agricultural sector became exposed to international competition in commodity markets and water trading began as a pragmatic and user-driven response to emerging circumstances.

The general approach in Australia is that access rights are specified to a proportion of the total pool of water available each year. This way the exact volume changes year to year depending on seasonal conditions. In the Australian system water users have either a *water access entitlement* or *water allocation* where they can:

- Use water allocated to their entitlements
- Buy additional water allocations
- Sell part of or all of their allocations
- Buy or sell entitlements, and/or
- Lease entitlements.

In the 2000s, when a severe and prolonged drought and rapid changes in market conditions for key agricultural commodities were experienced in Australia, there is strong evidence the trading system had an effective outcome. Precursors to water trading in Australia included introducing volume-based licences to replace area-based water rights, and embargoes on new water diversions to prevent further deterioration to the environment.

The current water trading system in Australia can be attributed to a concerted and ongoing effort across multiple levels of government, in collaboration with users and water service providers, for more than thirty years (National Water Commission, Australian Government).

5.2.1.1 Government transparency in water trading

In South Australia the water trading program is accessible and open for users via Water Connect (a State Government operated service). This publically accessible site reports every water trade, performance standards of the trading system, and trade history for previous years. This is an attractive approach due to the openness and communication of the system, and provides real time updates on water availability to inform options for buyers and sellers.

5.2.1.2 Waterfind – existing online water trading example

Waterfind is an Australian company enabling irrigators to trade water through a free, easy to use, online trading platform. They also offer a more traditional broker service.

This service offering is an excellent example of a working system that producers can access for efficient water sales and purchases. The site also offers SMS alerts for water availability, water licence reviews, active trades, and the ability to place a grower's own buy or sell order on the Waterfind system.

Option C could incorporate a tool like this for water credits, showing growers when they have an amount online from water stewardship practices and an easy way to offer the additional water created to various buyers (see Section 5.3.1 for example buyers).

5.2.2 Chile

Chile's free-market Water Code was passed in 1981. Since then the country has become a text-book example of water rights treated as a fully marketable commodity (Bauer, 2008).

When the Water Code was being drafted in the last 1970s and early 1980s, the government's primary concerns were irrigation and agriculture. Little attention was given to non-agricultural water issues, other than to assume that free markets would reallocate some agricultural water supplies to non-agricultural uses.

In 1981 traditional agricultural water rights were converted to water rights that are entirely separate from land and can be traded (Reuters Factbox). Essentially, free-market economic theory was simply applied to water management without much effort to adapt it to the specific characteristics of water resources.

Water rights in the Chile system are derived from a percentage of the water available, so the risk is a lack of water is borne by rights holders. Buyers and sellers can execute short-term sales of specific volumes, annual leases or permanent sales.

There have been some challenges with the approach with some experts criticizing the model for its weak regulation and unfairness (i.e. equity issues such as irrigators with more water shares possess greater decision-making rights). In 2005 authorities introduced reforms to discourage people from hoarding water, including a tax on unused water rights.

For growers, water trades improved economic activity especially in the fruit production sector during the 1996 to 1997 drought. It is also reported the water trading system has led to improved agricultural and industrial income and value for water.

5.2.3 United States

Water trading in the U.S. varies by state, according to each state's water code, system of water rights, and the authorities regulating water trading. Experts have attributed the country's trading successes to clearly and uniformly defined rights.

One of the most vibrant water markets in the U.S. is the Colorado-Big Thomson Project (CBT). The CBT transfers water east across the Rocky Mountains to supply 30 towns and cities and:

- Spreads over approximately 250 miles in Colorado and stores, regulates, and diverts water from the Colorado River on the western slope of the Continental Divide to the eastern slope of the Rocky Mountains.
- Provides supplemental water for irrigation of about 720,000 acres of land, municipal and industrial use, hydroelectric power, and water-oriented recreation opportunities.
- Water rights/ trading in the CBT are correlative; sharing fluctuations annually in response to water conditions, and all shareholders benefit or lose each year.
- Has the advantage of using water imported from another watershed, thus freeing it from the impacts of reduced or altered flows on downstream users of externalities that complicate water trades along natural rivers.
- The main purpose is for irrigation and power generation.

In the past 20 years, there have been more than 2,000 water transactions in Colorado.

5.2.3.1 American Farmland Trust water quality credit trading

The American Farmland Trust (AFT) is an excellent example of water quality credit trading. Since 2009, the Electric Power Research Institute (EPRI) and AFT, along with a strong collaboration of power companies, farmers, state and federal agencies, and environmental interests, have been developing an interstate water quality trading program in Ohio, Indiana and Kentucky.

The program connects buyers of nutrient credits (power plants, wastewater utilities and corporations) with sellers (farmers) to benefit the environment (AFT).

Currently the power companies and wastewater utilities involved do not yet need the credits created through the program as they meet water quality standards for the Ohio River. The credits created are voluntary and compliance grade (they would meet all requirements in the U.S. should a compliance market be necessary).

> *This voluntary approach is useful knowledge for the Agrium-led project, as it means a compliance market may not need to be in place to develop and test the concept in Alberta. Compliance and regulation around water markets can be developed in parallel with the pilot results and outcomes.*

Lastly, the American Farmland Trust has offered stewardship credits (retired for public benefit) to be available via public auction in later 2016. Further examples of water trading in action are provided in the case studies in Section 6.0.

5.2.4 South Africa

In South Africa agriculture drove the need for the national and international water trading program. National water markets improve water use efficiency by allocated water to high-value uses (i.e. permanent water trades helped farmers in the Lower Orange River grow high-value table and wine grapes for exportation) (Fleskens, & Tayaka, 2012).

Successes of the approach include:

- Government involvement – regulations that protect in-stream flows to rivers and international communities (i.e. Namibia), ecological water reserve management, policies on equitable distribution, Department of Water Affairs and Forestry supplied necessary information to potential buyers and sellers.
- Allocation of water rights according to volume of water available each year based on hydrological data obtained.

South Africa has excellent information transfer with a clearly defined water allocation process (human and livestock needs before irrigation), as well as available information on potential buyers and sellers. As a result South Africa experienced increased agricultural productivity and water-use efficiency. However a major challenge was the sale of dormant water rights that increased water stress in Crocodile Catchment area (ibid).

5.2.5 South Asia

Singapore and Malaysia's water trading is an interesting country to country example. Water transactions between Singapore and Malaysia date as far back as 1927. Since then, agreements have been signed in 1961, 1962, 1990, and 2001 between the two countries (Segal, 2004). Singapore depends on Malaysia for nearly 40% or more of its water supply (ibid).

Singapore buys untreated freshwater from Malaysia, which is transferred via pipe. Singapore then sells some water back to Malaysia as treated potable water. Disputes are ongoing between Singapore and Malaysia over the price of transactions. Malaysia wants to separate from Singapore for water trading however this would mean a loss of revenue Singapore may not be able to afford.

The operational side of the water transfer agreement has proven effective however there are political issues between the countries that jeopardize the agreement's success.

Other jurisdictions that use some form of water trading include Brazil, Chile, China, India, Indonesia, Mexico, Oman, Pakistan, and Tanzania.

5.3 A link between stewardship and credits: payments for ecosystem services (PES)

Today there is a growing focus on payments to provide incentives through a market-based mechanism, similar to subsidies and taxes, to encourage the conservation of natural resources. For growers this means payments for certain actions that manage their land in a way that provides an ecosystem service (International Institute for Environment and Development).

As the payments provide incentives to land owners and managers, PES is a market-based mechanism, similar to subsidies and taxes, to encourage the conservation of natural resources.

Payments for watershed services (PWS) are a subset of payments for ecosystem services (PES). PWS may include water quality protection or enhancement (including erosion, pollution, and sediment control), water quantity management (including flood control and in-stream flows), groundwater infiltration, and similar processes. For example, a common form of PWS is an upstream-downstream transaction in which a downstream user such as a water utility pays upstream landowners to institute water-friendly land management practices in order to improve or maintain downstream water quality (Majanen, Friedman & Milder, 2011).

Some forms of payment for PWS—such as Conservation Reserve Program payments under the *U.S. Farm Bill*—are relatively well known. However, new innovations have emerged in the past decade and are pointing the way toward watershed protection approaches that might effectively complement existing government conservation programs and incentives for rural landowners (ibid).

Despite ecosystem services being around for some time as a concept, and hundreds of pilots and research initiatives around the world, in Alberta PES and PWS are in the early stages. Collaboration and involvement with groups such as ALUS (Alternative Land Use Services) who work directly with growers to 'build a healthier environment by providing support to farmers and ranchers to enhance and maintain ecosystem services' could strengthen the Agrium project's work between voluntary water stewardship (via tools) and economic values.

5.3.1 Buyers and motivation in payments for watershed services (PWS)

Buyers in PWS are a good starting point to identify buyers for a credits pilot, as it is likely a water credits pilot would attract similar / the same buyers.

PWS buyers included a wide range of public and private actors, motivated by a desire to protect water resources for a variety of public and private purposes. Eighty-four percent of buyers sought to enhance environmental quality for public benefit, which includes human water consumption and wildlife habitat. Economic gains or cost savings drove 38% of buyers, while 16% of buyers identified experimentation and innovation as important motivations. The sum of these percentages exceeds 100% because some buyers have multiple motivations (ibid).

Buyers in PWS include:

- Public and quasi-public agencies such as water utilities and conservation districts, which seek to secure environmental benefits on behalf of their ratepayers, taxpayers, or society at large
- Private buyers, including those that seek to secure clean and reliable water supplies for commercial operations and those that seek to protect the environment to improve their corporate image
- Philanthropic buyers, which are typically non-profit conservation organizations or individual donors, and
- Consumers paying indirectly for watershed services by purchasing eco-certified products that include water-friendly criteria.

These buyers are similar to the partners involved in a Michigan and Veolia water quality credits pilot (see section 6.3).

5.3.2 Ecosystem services and land programs

A range of programs and organizations should be reviewed, and invited as relevant, as part of the research into ways to create an incentive program in the pilot:

Ecosystem services

Millennium Ecosystem Assessment (Global).

Ecosystem Services + Biodiversity Network (Canada).

Land focused groups and programs

University of Alberta - Alberta Land Institute (Alberta).

Land Stewardship Centre (Alberta).

Alternative Land Use Services (Canada, also works across ecosystem services).

There is an obvious link between good water stewardship and incentives; PWS is an existing term and approach that could be integrated into the overall program for Agrium as the "missing link" between the two programs – water stewardship and credits/incentives.

> *Further, with involvement from the land based programs and initiatives this project could break through silos and reduce duplicated work, as water experts work with land experts and vice versa, in the best interests of outcomes for both growers and watershed health.*

6.0 Specific case studies

As requested by Agrium, the following case studies have been analyzed from a water management perspective. The Michigan Veolia water quality credits pilot has also been included as a specific case study due to the potential for it to be used as a working example for developing an integrated pilot in Alberta.

6.1 Chesapeake Bay Program

Lead organization: Regional partnership among state, federal, academic and private/non-profit agencies in the Chesapeake Bay watershed.

Website: https://www.epa.gov/ms-htf

Description: The Chesapeake Bay Program (CBP) is a longstanding partnership to improve water quality and ecosystem health in the Chesapeake estuary and is the U.S. EPA's flagship model for its National Estuaries Program.

The program is currently working toward the implementation of over 100 short and longer-term goals and actions broken-down into the areas of species/habitat, clean water, climate change, land conservation, and community engagement. Each action in the work plan is assigned to a specific member(s) of the program. There is a unified monitoring program to evaluate progress against the key goals and indicators. Actions cover a wide array of watershed conservation measures, ranging from field/farm best management practice support, to watershed-scale and interjurisdictional policy/legislation.

Robust monitoring and evaluation of actions to identify and adaptively manage new and evolving risks support the program. All of this information is provided interactively on the Chesapeake Progress website. The CBP is underpinned by an agreement signed by all parties, which launched in 2014. The program operates by providing various kinds of grants and funding through federal agencies and the Chesapeake Bay Trust for watershed restoration, education and land conservation and management practice improvement projects.

To support coordinated implementation of the program across jurisdictions, there are watershed-based management plans produced by each state in the bay following a unified framework of targets.

Effectiveness and applicability for Agrium: In the early 1980s, the CBP implemented a framework of numeric goals and deadlines for reducing pollution to the bay, and since then, the bay has seen significant improvement in its ecological health, with several key indicator species being re-established such as the American shad (fish species). In additional key measures, such as phosphorus, nitrogen and sediment loading have all decreased by almost half from the period of 1985-2015.

The CPB is a collaborative model for supporting watershed restoration projects aimed at improving the overall health of the Chesapeake Bay. Resources across watershed stakeholder groups are pooled and tasks for restoration are assigned to those with the best capability to implement given actions.

Having a single entity coordinate activities across these stakeholders and leverage the resources and skills of each is a model that the Agrium program could follow if other organizations were involved (e.g., producer groups, watershed groups, livestock sector). The notion of having a unified framework of objectives and indicators on a watershed basis, along with an online platform and centralized tools/protocols for monitoring performance are also areas that could be beneficial in an Agrium-led program.

6.2 Mississippi River/Gulf of Mexico Hypoxia Task Force

Lead organization: U.S. Environmental Protection Agency (EPA).

Website: https://www.epa.gov/ms-htf

Description: The Mississippi River/Gulf of Mexico Hypoxia Task Force (MARB Task Force) was established in 1998 to understand the causes and effects of eutrophication in the Gulf of Mexico, to coordinate activities to reduce the size, severity and duration of this phenomenon, and to ameliorate its effects (MARB Task Force Charter, 1998). Since its initial formation, the MARB Task Force has evolved its approaches for managing nutrients to best align with advances in watershed, water quality, and ecological science, and performance metrics. The MARB Task Force is comprised of state, federal and scientific representatives, organized into various sub-committees and working groups.

In its most recent 2008 and revised 2013 strategies, the MARB Task Force assigned responsibility for nutrient management action plans to states and conservation organizations within local watershed to enable them to develop measures best suited to their watershed conditions and contexts. These state strategies were developed following a broad EPA framework and were developed in close consultation with local agricultural and conservation organizations.

> *At the federal scale, the MARB Task Force developed strategies for integration of nitrogen and phosphorus. These federal-scale elements are focused on water quality monitoring, decision support tools, identification of highest propriety areas at a national scale, regulatory tools, financial assistance and education/outreach.*

Under the MARB Task Force, there are a number local water quality improvement programs supported through funding and research support. The taskforce has also been active in developing, piloting and scaling field and farm scale best management practices. This effort is based on targeting financial and technical assistance to the highest-priority watersheds, based on monitoring information.

The MARB Task Force, namely through state members, has also been actively developing an assurance/certification program for the voluntary adoption of conservation measures by farmers. This provides farmers with assurance that their measures are in accordance with state's requirements for water quality protection. This certification also helps move the concept of ecosystem service markets forward. Members of the MARB Task Force are also actively exploring how to implement an economic market for ecosystem services. This effort is underpinned by the need to understand the performance applicability of different technologies and conservation measures in various operational contexts. The MARB Task Force is also involved in quantifying the effects of hypoxia on socioeconomic values, which is an essential aspect of developing a market for environmental services.

All of the MARB Task Force's work is supported by robust analysis of the environmental impacts it set out to tackle. This analysis is via rigorous monitoring programs, along with a research agenda designed to reduce scientific uncertainty in the causes/effects of hypoxia, and effectiveness of best management practices.

Effectiveness and applicability for Agrium: The broad structure of the program and emphasis on coordination among all stakeholders has been successful at increasing the uptake of conservation practices among farmers and conservation organizations. At a sub-watershed and state scale the MARB Task Force program has had numerous successes in reducing nutrient loading. For example, the Lake Pepin Watershed in Minnesota saw declines of 75% in annual phosphorus loading to the Mississippi River over the period of 2000-2013 (MARB Task Force Report to Congress, 2015).

The program has had challenges in overall loading on the Mississippi River and Gulf of Mexico due to extreme weather events. Many smaller-scale watershed have however, seen great benefits because of the program. The program has also raised the bar in the science related to hypoxia, nutrient management, and agricultural water stewardship.

The MARB Task Force is a complex program, with many elements and players that work together in a complementary manner. The complexity of the program can however, make it difficult to understand by the general public or external stakeholders. This is an area the Agrium program could learn from—to create, no matter the level of complication or layers in a program, an easy to understand and easy to follow program for all stakeholders involved e.g. a seamless, clear communication with growers, stakeholders, Government, etc. This can be achieved through the identification of target audiences with specific messaging and channels tailored for the target audiences including online user interface and user experience considerations.

The notion that actionable strategies for environmental management need to reflect local conditions and contexts has allowed the program to operate successfully at multiple scales. This element – providing an overall framework, but allowing for diversity in on the ground strategies and stewardship actions – could be integrated into an Agrium program via any of the project options presented in Section 8.0.

Also within the MARB Task Force's work, there are objectives and related performance measures at multiple scales (watershed, state and federal), which has been beneficial in developing targeted strategies to maximize the benefit of program resources. Research that the MARB Task Force has completed on markets for ecosystem services is another area the Agrium program could directly learn from.

6.3 Michigan and Veolia water quality credits pilot

Please note the following project information is not public. While recent leadership changes at Veolia North America mean their involvement may or may not change, the project is continuing and Ecosystem Services Exchange (ESE) can provide more detail as required.

The Veolia Michigan water quality credits pilot involves organizations including local government, soil/land organizations, ESE, and Veolia North America. Basically growers and industry can offset water quality by obtaining credits. Not all credits should be used otherwise it simply becomes a system of trading pollution. A percentage of credits are always retired to contribute to the overall improvement of watershed health. The farm land was used to grow food for disadvantaged families, leveraging the pilot to create a good social outcome while testing the approach to water quality credits.

The pilot is structured as:

- ESE invested in the technology to improve water management on the land.
- Veolia invested in the technology to provide monitoring for five years.
- The grower implements best practice to reduce water quality issues, measured by the monitoring equipment.
- As credits are created through better practices they can be traded / sold e.g. to a local utility to help them meet wastewater quality requirements for discharge.
- Along with the grower, the initial investors (ESE and Veolia) benefit through sharing a percent of the credit created.

Buyers in this project could be private industry, corporations (contributing to Corporate Social Responsibility by retiring credits), and/or individuals (for philanthropy or sustainability initiatives e.g.

donating credits to an NGO as part of their mission).

From Veolia's perspective the challenge was regulation agencies and verifiable ways to test non-point source pollution. The technology exists to measure non-point pollution so it was a matter of including that monitoring technology as part of the pilot. In the development of the pilot it was found that regulation agencies became more acceptable of tradable credits for compliance purposes.

> *Strengths of the pilot include a market-based approach with multiple outcomes and the use of technology for direct monitoring and feedback from the land. This pilot overcomes the initial investment hurdle for growers to purchase infrastructure or equipment to improve water management.*

By sharing the market with other players, the upfront cost of improving water management can bypass the grower (with the tradeoff being a split water quality credit benefit shared across the initial investors).

6.4 Green Water Credits

Lead organization: ISRIC - World Soil Information

Website: http://greenwatercredits.net/

Description: Green Water Credits is an investment mechanism which enables upstream growers to practice water management activities. The Green Water Credits team with ISRIC World Soil Information as the lead agency assists financiers that are establishing programs and funds for these farmers by performing scenario studies and cost-benefit analyses. The team is working in Kenya, China, Morocco and Algeria (Green Water Credits website).

Effectiveness and applicability for Agrium: The program, in operation since 2005, may provide valuable insights into the development of the Alberta pilot, especially for growers in regions that are rain-fed.

7.0 Project and research gaps

The challenge of this project is to cater for the enormous range of water scenarios across the agricultural sector. No two growers are the same, no two farms are the same, and no two watersheds are the same.

This scoping activity has highlighted key gaps to progress the project to its full potential. The primary gap regards baseline data, monitoring, and indicators.

7.1 The elephant in the room – baseline data and indicators for improved performance

There are two aspects to the absence of data and monitoring in this project:

1. *Global program focus:* the challenge of creating localized baseline performance targets and a way to monitor data so all stakeholders, including growers, are clear on the progress of a water stewardship program on local watershed health.
2. *Alberta/pilot focus:* a lack of consistent, available, water data and monitoring in Alberta, the proposed site for the pilot program.

Global program focus

In the water stewardship programs analyzed for this report (Section 4.0) there was little focus on the development of clear measures to indicate success on the farm scale or local watershed scale. Instead, it was more common for broad targets were developed as sweeping guides for growers to aim toward.

There is an important approach for the Agrium water stewardship program to consider: growers need the goals and the tools. Best practice should be an aspiration that comes to reality after the goals are achieved through the tools provided.

> *If we don't have goals and ways to measure progress, and simply continue to preach BMPs we are shooting on the dark. Measuring water quality in our precious lakes and rivers tells individual farmers nothing about their own performance (Governor of Minnesota's Water Summit, 2016).*

Data and monitoring is fundamentally tied to progress against any set targets. If data management is in the hands of the grower, it may be more effective and faster than governments to provide, however it comes at a cost. In the Michigan Veolia pilot data instruments were not at a cost to the grower, instead third parties provided the equipment and shared in a percentage of the incentive gained.

While precision farming is on the rise, it will be important for any program involving data and indicators to clearly show the benefits for growers. According to Friedman (2015) there are four major benefits for farmers who embrace the use of data tools for water management:

- Measurement data can help farmers better manage their operations – the more information they have, the more they can make decisions that are tailored to their farm's specific needs.
- The information obtained can help farmers identify efficiencies that lead to higher productivity and profitability, lower input costs, and optimized fertilizer use.
- The more a farmer knows about his or her farm, the better their opportunities to strengthen supply chain relationships. Data help farmers eliminate volatility and risk which is beneficial not just to the grower but also to the supplier – so the supplier is more apt to work with that farmer on a long-term basis. At the same time, the data allows the producer to work with the supply

chain to help companies and retailers increase the transparency of their ingredients.

- Data collection allows for farmers to approach conservation at a landscape-scale, versus at the farm or even the county level. The more information growers have, the better the opportunities to work together with others at a watershed-scale to make informed decisions about conservation priorities.

Mixed with local implementation through a pilot and success stories, data management and technology can be key to the success of the water stewardship approaches across Alberta and the world.

Alberta/pilot focus

A pilot in Alberta is recommended in the Bow River Basin, North Saskatchewan Basin, or the Oldman River Basin, as these are areas with data strong enough to provide a picture of change.

> *There is a leapfrog opportunity for the project to use best practice monitoring and data collection. As the whole of Alberta does not have an extensive water quality and quantity monitoring program with consistent regulation, there are strong opportunities to learn from other regions and incorporate lessons learned to create an even better approach as part of a pilot.*

Alberta Agriculture and Forestry provided a list of academic papers regarding nutrient run-off, sediment, and/or pesticides as background, however these require further analysis by an expert, in the context of the selected project option (see Appendix C for the list of papers provided).

Further, an integrated sampling program with adequate sampling frequencies and densities to detect significant spatial and temporal changes in water quality, rangeland quality, and aquatic and riparian ecosystem health has been discussed (Alberta Environment, 2008). The pilot could be a good driver for this work at a small scale.

Data is also held in a variety of other spatial databases held by the Alberta Energy Regulator, Alberta Infrastructure and Transportation, municipalities, academic researchers, and environmental non-governmental organizations. Statistics Canada's population and agriculture censuses, municipal censuses, and crop insurance data, and various pesticide sales databases can be used to monitor human population and dwelling unit density and amounts of agricultural and non-agricultural fertilizers and pesticides applied to the land (Alberta Environment, 2008). However this is an intensive research cycle that continues to change under a variety of influences including funding, communications/knowledge sharing, and transparency.

For the purpose of a pilot, further research and collaboration is recommended to form baseline measures of performance that align with existing or intended measures in watersheds in Alberta. Then it is a valuable experiment with ways to monitor the performance to create an open feedback loop that informs growers in the region of the pilot of the success of their collective action.

7.2 New technologies for water in agriculture

There are a growing number of monitoring technologies that can be considered in the development of the program for Agrium's water stewardship. It is recommended that any water-related data collection be integrated into one of the existing systems, rather than a stand-alone approach, primarily because many growers are overwhelmed with information and they may not know what to trust.

Technology examples include:

CropX

CropX's technology works by from various publicly available sources. After CropX's algorithms get a solid understanding of the land, it then mails the customer some soil sensors along with detailed instructions via a mobile app for where to place the sensors in the dirt. After the sensing system is running CropX can provide farmers detailed information about how much water their land needs and exactly what areas should be watered and when. The sensor and data system can help farmers save more than 10% of their water, along with the accompanying energy that the irrigation systems uses (Forbes, 2015).

Farmer's Business Network

This company aggregates and standardizes all of this data being collected from farms nationwide to create an analytics dashboard, which also integrates outside information like weather or regional soil conditions. By leveraging the results reported by all farms in the FBN network, farmers can make informed decisions about which agricultural products and practices will produce the highest output (Farmers Business Network website).

Agrium may also have access to and/or knowledge of the above technologies and others that could be relevant for testing or as partnerships in the pilot program. Additionally within Alberta Farming Smarter may provide more options and insights into the technology application for a watershed-focused program.

7.2.1 Echelon – Agrium's potential technology link

The project should also consider Agrium's existing precision farming arm, Echelon. With connections to the 4R program Echelon is a vehicle that could be used to incorporate water management for growers based on their location.

As precision farming practices increase with boosted crop yields and less waste, the data collected could be adapted and used to inform water impacts through overlapped watershed modeling. There is an opportunity for commercial companies like Agrium/Echelon to serve their customers from the data collected, helping growers develop good precision management strategies that also contribute to watershed health.

8.0 Project options

Originally this scope project was assumed to be an extension of the 4R program. Through the insights gained in this report research, to provide Agrium with a full picture of the potential in the water area and more clearly define the opportunities for consideration, three project outcomes are proposed.

All options are capable of fulfilling the objective to support growers to better manage water on their land and improve watershed health. Additionally each project option has a similar approach to initial engagement and, broadly, research and communications.

From a collaborative perspective the 4R approach was an excellent example and should be used as the foundation to formulate the pathway to partnerships for this project (even if the option pursued is tactically different to the outcomes of the 4R). Alberta WaterSMART also has existing, proven models for engaging diverse stakeholders on watershed issues, modelling, and planning.

Most important to note in reviewing these options is the number of tools and technologies available is overwhelming – this can be daunting for growers interested in measuring farm practices. Measurements can certainly add to productivity and efficiency, but growers need to think critically through which tools can help them achieve particular outcomes. Then, tools and measurements can be matched to help meet environmental and business outcomes (Friedman, 2015). This goes back to the project context and reasons for change.

Another key question to answer is the availability of the outcomes e.g. are these seen as open tools for anyone to use from anywhere, or a specific tool developed to enhance Agrium's service offering through retail / crop advisors, etc. For the following options is has been assumed the services/values offered as a result of the work will be available to all growers.

8.1 Option A – 4R building block

In this project approach the 4R implementation framework is used to add broad (e.g. guideline) water management techniques, using existing 4R communication and education channels. This is a static educational approach essentially piggybacking the existing 4R to attach further, more specific information on water stewardship. Government and/or other organizations would perform monitoring and collective performance without direct contact with the grower.

Figure 11: Project option A

Advantages

- Existing framework in place to add water specific considerations.
- Cost effective and pilot could be launched in two to three years due to the general nature of the information (still requires research / academic verification of the guidelines).

Disadvantages

- Lost opportunity to create and launch a water specific framework and position Agrium as a true leader in water management in agriculture.
- Water management messages may become lost in the 4R or may not gain traction if the delivery (e.g. via 4R channels) is the same.
- Partners / organizations already involved in the 4R may not want to attach further information / messages due to the risk of confusing / overwhelming growers with too much information in one area and diluting the 4R message.
- No direct feedback for growers on how individual actions create a collective action that has a real measured impact on the local watershed.
- Incentives to recognize and reward action in water stewardship (e.g. credits) would be developed separately to this program.

Example involvement from grower

In this option, growers familiar with the 4R program would also gain information about water stewardship approaches in the form of traditional and digital communications covering more general information on water stewardship innovations and/or success stories. Information would be dispersed via existing 4R channels of communication. Typical actions may include creating a water stewardship plan for the land and measuring success against individual farm targets.

As the credit program is developed separately / in parallel to this program the offsets created through implementation of a program would be the responsibility of the grower to measure and provide evidence for selling those credits/offsets. There is also an opportunity through this option for Agrium to provide offsets or purchase water quantity/quality credits as a closed program e.g. direct to customer.

8.2 Option B – building a hub through existing work

Option B would bring existing research, materials, and tools from around the world to create an online hub (the "best of the best about water in agriculture" in a clear and accessible way). In the beginning this is a one-way communication and education program with encouragement for inputs from growers (e.g. case studies, sharing knowledge, forums etc.) to create opportunities for two-way communications and ownership of the stewardship in an online community (aiming to replicate the conversations that occur face to face in rural communities).

This approach fills a gap; there is not a lack of existing water stewardship information and programs that can help (in terms of general guidelines to improve) but there is an absence of a "one stop shop", grower-friendly, global information portal or hub that uses scientifically robust information.

Water hubs exist however, e.g. HSBC-led example, they tend to focus on a range of issues across a range of regions, rather than focus on people 'on the ground' who can make differences and drive change upward.

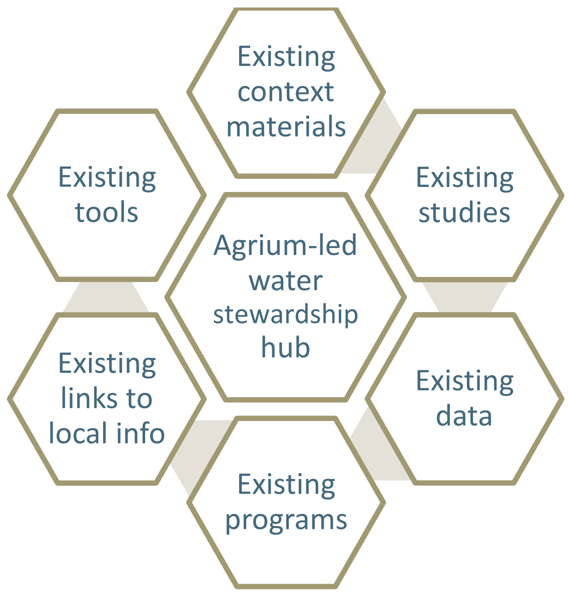


Figure 12: Project option B

Advantages

- Existing material could be vetted and peer reviewed to form part of the water stewardship hub, making it a reliable source of best practices for water management on farms around the world.
- Localized information / data can be inputted (if available) to tailor the experience for the grower/user of the hub.
- Cost effective and the hub could be launched in two to four years.
- Manageable pilot of this online approach could be undertaken in various regions, not just Alberta, due to the online nature of the information making it easier to scale globally.
- Technology exists and could be adapted easily for this use.
- Clearly positions Agrium as a leader in water stewardship around the world through an active resource that could be used as a value add by Agrium retail.

Disadvantages

- This option risks being too academic and aspirational, cluttering the amount of information for growers that is not a practical tool to implement.

- Feedback on how individual actions create a collective action that has a measured impact on the local watershed would need to come from grower participation on the hub - this may be too much to expect considering the usual time demands and priorities of growers.
- From a two-way communication perspective the hub would only be as strong as its inputs from users.
- The option would include data from existing research but does not leverage data collection on a scale to help growers improve water management practices.
- Incentives to recognize and reward action in water stewardship (e.g. credits) would be developed separately to this program.

Example involvement from grower

In this option, growers would be enabled with scientifically data and existing materials online with options to add / share / comment on various techniques etc. to create a grassroots / bottom up approach to water management and what works / doesn't work. Actions taken on the farm would be informed by the grower's individual appetite for risk / financial investment (potential to be tied in with existing/new government or other programs).

This option also holds the potential for growers with experience in water stewardship to become online mentors or subject experts based on their real experiences (rather than focusing on academic knowledge which may be less accessible). Incentives for this kind of activity would need to be reviewed in the development of the option.

Actions for growers for credits in Option B would be similar to Option A (developed separately / in parallel to this program) and, as the hub would be global, credits would need to be managed by region/jurisdiction.

8.3 Option C – enabling growers through integrated technologies

This more complicated option also holds the most opportunity. From the beginning of the cycle incentives are integrated and calculators and precision farming become inputs to build a personalized water management tool. This farm-centric data is married with local watershed data to create a picture of how individual decisions and actions impact downstream / neighboring land and the overall watershed.

Essentially the process starts by providing guidelines/tools for growers to manage water for local watershed health, which can be monitored on the farm and/or across the watershed. An economic value is assigned to the resulting impacts using ecosystem services.

The measurable impacts (assigned dollar values) are then used to create water credits which, using the same online system as the guidelines and inputs for monitoring, are managed by the grower via online trading. The cycle begins again and is continuous depending on the conditions of the watershed to start with, and weather patterns or other changing influences.

Similar to the Nitrous Oxide Emission Reduction Protocol (NERP) approach, aggregators could be used to pull together different credits created (water quality or quantity) and package them for trade to a buyer.

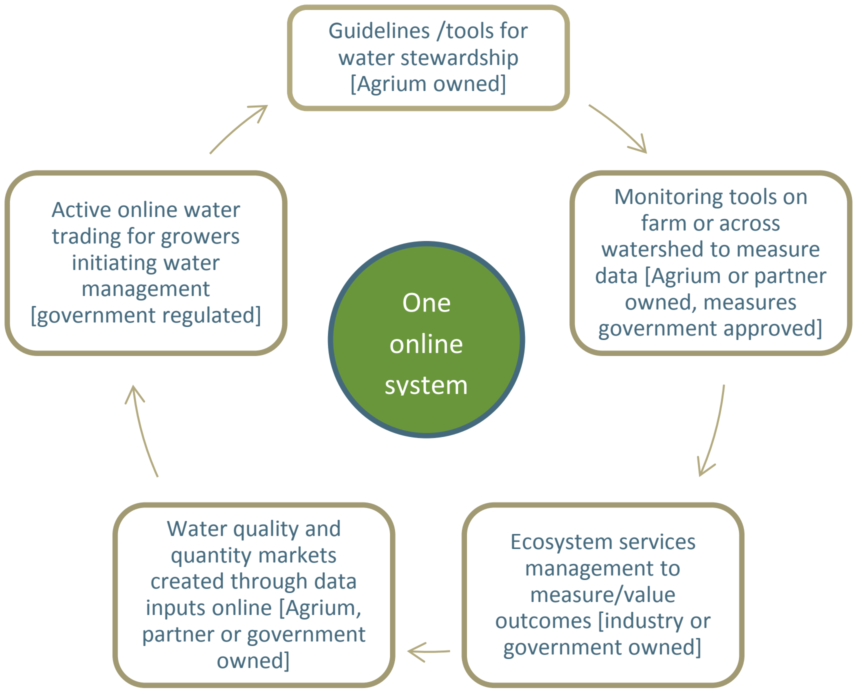


Figure 13: Project option C

Advantages

- A total system approach to the problem that can be adapted and leverages technology to provide more real time inputs to performance (both on the farm and the local watershed).
- A family of practical tools growers can use as part of a logical process to improve water stewardship with incentives inbuilt.
- An innovative and groundbreaking approach that would position Agrium not only as a water stewardship leader and a technology-based water credits leader.

Disadvantages

- More costly and complex to deliver with longer timelines (even if areas are developed in parallel and integrated as project paths in testing phases).
- Multiple owners across steps require long-term collaboration and potential contracts and agreements e.g. monitoring partner.
- Technology focus, which may alienate some more traditional growers and also contribute to the overwhelming amount of data and information available to all growers. The interface for this

would need to be carefully considered and developed (reducing duplication of data and information where possible through collaboration with land groups, precision farming tools etc.) for this to be avoided.

- From a scaling perspective, the challenge in this option is the variation of financial incentive based on jurisdiction regulation or policy. To address this, active online trading would need to be regulated or have involvement or oversight by the appropriate government level (e.g. local, provincial/state, federal and, in some cases, international agreements).

Example involvement from grower

In this option, actions from the grower for each step may include:

- Guidelines/tools: undertaking water stewardship activities (or having certification/similar through a program like the Alberta Farm Plan) to increase efficiency and improve water management on their property. Actions may include identifying erosion, tree planting, rainwater capacity, keyline design, farm ponds for irrigation, and other actions (see Appendix B for high level areas growers may need to address via scientifically robust tactics).
- Monitoring: Allow access for monitoring systems to be installed on the property and maintain upkeep e.g. notify system "owner" of any damage, replacement etc. Potential to keep informed / receive copies of raw data from monitoring for transparency.
- Ecosystem services: Have an awareness of the ecosystems principles and how values of their work are calculated to go to market.
- Water markets: Have an awareness of the policy and/or regulation surrounding water credits.
- Active trading: Action or membership of a collective with a representative using the system for water credits (e.g. similar approach to the WaterFind website).

8.4 Project management

For each option the project approach is the same, based loosely on a Project Management Body of Knowledge approach (initiating [current stage], planning [next stage], executing, monitoring, and closing).

8.4.1 Timelines

As there are a number of pathways to achieve the end goal of a water stewardship program with flexibility for incentives the project timelines are based on projects with similar research, planning, implementation, and refinement. Figure 12 shows the timelines for the project (these would be refined into a specific Gantt chart and work breakdown structure following the selection of the project option).

The project could also be partitioned into four-year blocks to align with electoral cycles in Alberta.

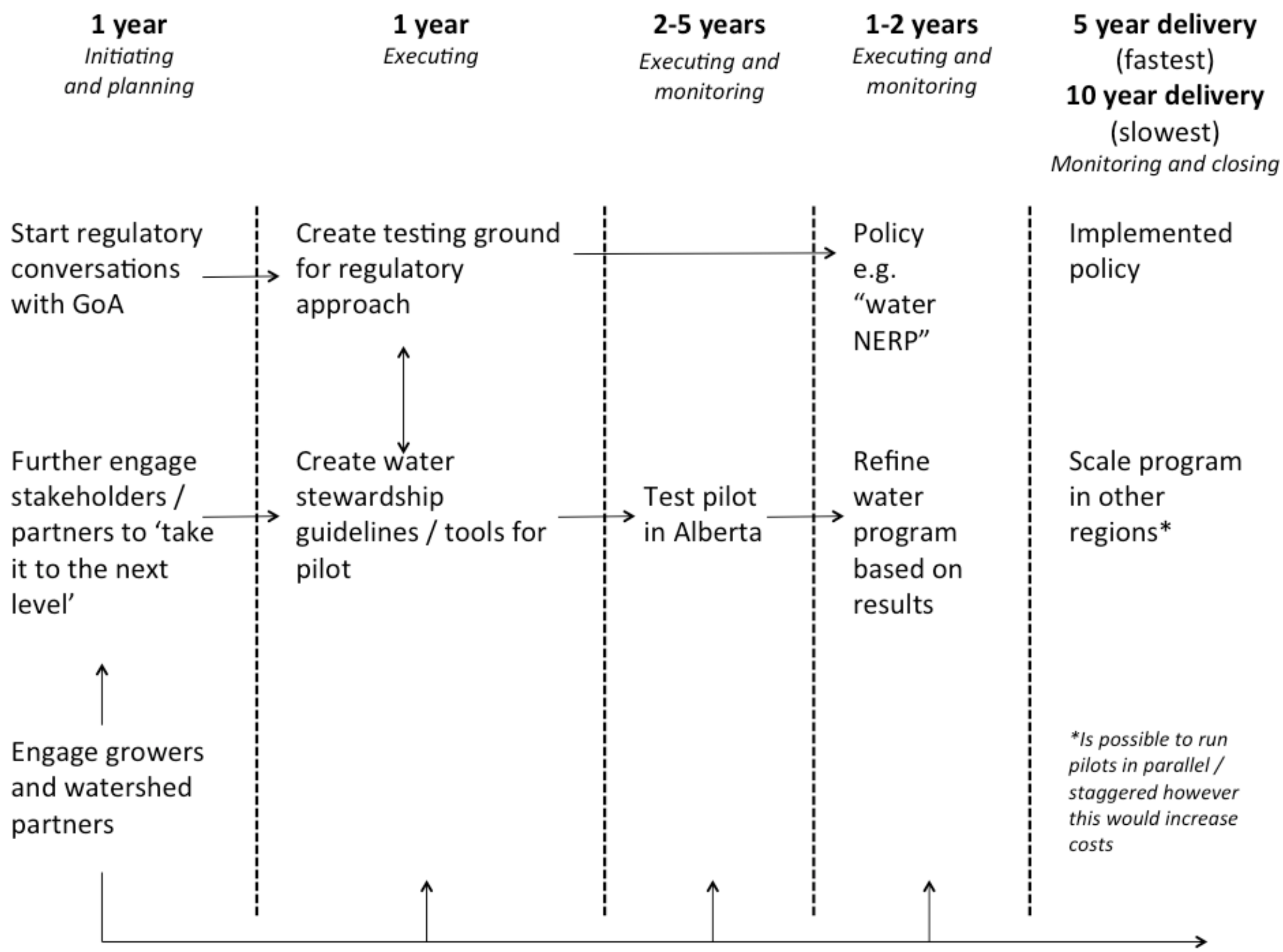


Figure 14: Long term project timelines

8.4.2 Project option costs

The following rough estimates are based on the creation of the project per each option including stakeholder involvement and collaboration, research and academic engagement, testing and refinement, and communications. They are also based on one pilot being operated within two watersheds in Alberta—not other regions and the ranges in cost are influenced by the end product’s quality, scientific input, and communication methods.

- Project A: $1 to $1.5m
- Project B: $2 to $2.5m
- Project C: $6m to $8m

Agrium would be the project champion and provide initial funding, as well as engaging a consortium of funders for the project. Buy in from other stakeholders, both from a funding and resource / in kind perspective, is critical to deliver the project.

8.5 Pilot project communications approach

This project communications section is based on an Alberta pilot. Further refinement of the approach and tactics including project key messages, channels (e.g. ways to communicate with audiences) and details such as a project name can be developed after the preferred project option is selected. Toward the end of the pilot communications for the global distribution of information would be developed accordingly.

One of the keys in communication for this pilot, and the entire project concept (no matter the option), is the complexity of the interactions between upstream and downstream communities and industries. Figure 14 is a causal loop diagram that maps the links between upstream grower actions and impacts on downstream communities, other growers, and industry. While this example (The Economics of Ecosystem Biodiversity, 2016) is focused on hydropower the format is relevant to this project, to help target audiences understand the links throughout watersheds, as part of the reasons why water stewardship is required. Mapping a causal loop for water and agriculture can also be a good stakeholder exercise for project organizations and participants. A final version could be adapted into an attractive design for grower and stakeholder reference.

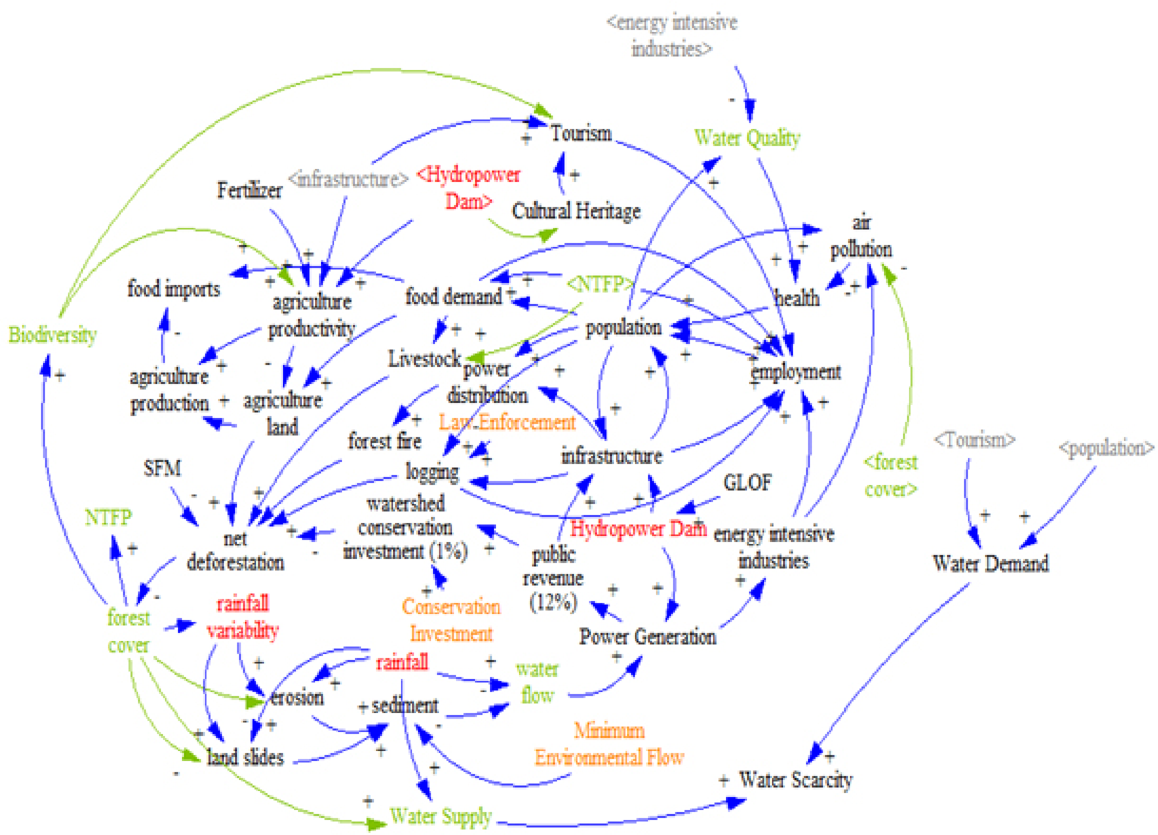


Figure 15: Causal loop diagram – communications format to show links and benefits

8.5.1 Benefits of Agrium as the core communications source

As a global company Agrium has an established, wide reaching, consistent platform of communication channels to inform, educate, and support growers to undertake their own water stewardship actions. As the project initiator, key messaging and materials can also be cascaded from Agrium through project stakeholders. Consistent communication from all project stakeholders adds credibility and builds trust from audiences with a clear understanding of the project objectives right from the beginning.

While communication from Agrium to growers about water stewardship and incentives may be interpreted as a sales pitch the advantages outweigh this challenge. Many of the existing groups involved in water stewardship, both corporate, government and NGO have had difficulties engaging with growers due to a variety of cultural and communication barriers e.g. city folk / academics telling growers what to do without understanding what growers do. As an agricultural inputs supplier, Agrium has a unique relationship with growers and the respect for Agrium and its crop system consultants could be leveraged to spread the word about the project.

Down the track, the water stewardship and incentives work by Agrium could be developed as a unique service offering, for instance, in Western Canada Crop Production Services provides services to growers including precision agriculture, crop protection, seed, soil and plant fertility; adding water management support creates an avenue to offer a new service differentiated from competitors.

Agrium also has a closer connection with growers compared to government regulators, corporations further down the supply chain (e.g., food/drink manufacturers), and environmental NGOs who are instigating change in the water and agriculture sphere, but may not have the understanding of agriculture issues to manage the nuances for the work to be a success.

8.5.2 Demographics

Any communications strategy and tactics needs to incorporate understanding of the demographic to more effectively target messages and channels. Using Alberta as a pilot it is important to understand the following:

> *The demographic composition of the Canadian agriculture industry is undergoing significant changes as many farm operators are approaching an age when they may retire. The 2011 Census of Agriculture found that farms where the oldest operator was 55 years or older represented more than half of all farms in 2011, compared to 37.7% in 1991. In addition, less than one out of 10 farms had the oldest operator under 40 years old in 2011, whereas two decades earlier it was about 1 in 4. These two trends were found in farms of different types and sizes in all provinces (Statistics Canada, 2011).*

The trends of fewer operators, fewer young operators, and fewer farms showed no signs of reversing and may indicate more consolidation and significant turnover in farm assets in the future (ibid).

This not only poses a challenge from a communications perspective, but also requires consideration in the pilot to determine if new ways of communication (e.g. digital base compared to face to face or print material) are appropriate, or if growers prefer a range of ways to access the same information (diverse communication channels which is more costly).

8.5.3 Pilot target audiences and objectives

The following table outlines the different audiences and basic questions / examples of measure for communicating information to inform change and action from growers, stakeholders, and others.

Table 2: Target audience summary

Audience	Key questions to answer	Example measures toward project success
Growers (involved in the pilot region)	• Project context / watershed and agriculture links? • What is the pilot and why is it necessary? • How to be involved? • What are the benefits? • Where to learn more? • How to give feedback? • Who is involved and why (organizations)?	• 85% of growers in the region of the pilot are aware it's happening • Communication channel use and visitation / contact for more information is effective and consistent • 75% of growers involved understand the benefits of a water stewardship program
Growers (involved in the pilot itself) Note: the total number of growers involved in the pilot will depend on the project option and the region selected	• In addition to the above grower points… • What should I expect to need to do (e.g. time, resource commitment)? • Who can help me answer questions / resolve issues? • How do I provide feedback and be an effective member of the pilot group?	• In addition to the above grower points… • 100% of pilot participants understand expectations and where to seek help for questions/issue resolution • 95% of pilot participants provide feedback and record results/data/etc. as required
Government (Alberta Agriculture, Environment Canada, AI-EES etc.) Municipalities (local, dependent on area of	• What is the pilot and why is it necessary? • How to be involved / benefits of involvement? • Connections / progression of existing, related government/municipality water quality and quantity programs	• All project stakeholders have key messages / pilot fact sheet • All project stakeholders have attended at least one information session on the pilot program and

pilot) Watershed Planning and Advisory Councils	that impact growers/local watersheds? • Details of the pilot e.g. timing, objectives, methods? • Outcomes of pilot and next steps for involvement (ongoing through pilot)?	opportunities • All project stakeholders have the ability to join the project at an appropriate stage / in line with the pilot objectives and terms of reference
NGOs in the region and/or relevant to watershed health and grower support	• What is the pilot and why is it necessary? • If involved, how to disseminate information and support pilot outcomes? • Connections / progression of existing NGO activities and/or programs? • Details of the pilot e.g. timing, objectives, methods?	• All identified NGOs operating in the region are aware of the pilot and understand how it fits and expands/improves upon existing work • All NGOs have a copy of pilot fact sheet
Alberta's general public (including other agriculture areas)	• What is the pilot and why is it necessary?	• Online information and phone number available for multiple project stakeholders to point enquiries toward

8.5.4 Communication channels for growers

A grassroots approach is more effective and contributes to trust from the growers and local communities. This suits the pilot (due to size and location) and can be done via a number of ways (European Commission Directorate D – Water, Chemicals & Biotechnology, 2011):

The information must be…	That means in practice…
User friendly	• Well presented to encourage action • Include many illustrative items (such as graphics, best practice examples) • Easy to read + short • Pictorial appeal • Provide clear guidance on issues like funding + implementation • Adaptation of the messages at local level
Consistent	• All routes providing same message, yet recognizing that the farmers and society also strive towards other objectives • Clear strategy
Up to date	• Accessible • Method used should be able to be kept up to date easily
Focused and practical	• Farming type • Addressing key pressures • Local relevance • Advice on what, who and why and where more detailed information can be found • Highlight economic benefit to the farm, when appropriate • Highlight public ecosystem services provided by farmers

Figure 16: Requirements for the preparation of information targeted at growers

Promotional activity such as print or radio advertising may not be as effective to share interest in the pilot. Word of mouth, established groups with rural connections and networks who can demonstrate the approach and benefits are a recommended approach for face to face communications, supported by a mixture of old and new (e.g. accessible digital information and basic printed handouts).

> *Note: while the communication channels can be flexible as a shorter term strategy (e.g. five years) the delivery of information e.g. in project Option C (all online) may need to be more long term and accommodate the increases in technology adoption for business productivity and social use, as well as the revolution of big data and the Internet of Things (in this context e.g. automated water monitoring to a grower's smartphone to a water credit system).*

Ultimately, similar to the 4R program, grower ambassadors could represent the program and continue to encourage uptake within their local community with opportunities to speak and present to communities in other provinces or countries depending on the ambassador program initiated. Lessons from the 4R program would be analyzed to increase the chance of success in communicating the project option selected. Lastly, it is imperative to share the findings of the pilot across project stakeholders, growers/participants, and the general public. Targeted communications (e.g. levels of detail tailored for each audience in the form of a final report / summary) are recommended as part of the pilot as an opportunity to share transparent information on the performance of the water stewardship activities and is critical to the scalability of the approach.

8.6 Potential project partners

Partners are defined as an organization or individual who can contribute to the progress of the project by either financial, expertise, sharing of existing resources, and/or in kind support. Further NGO groups can be identified following the selection of the project option

Potential partner	Initial reason/s	Relationship	Contact
Alberta Biodiversity Monitoring Institute	Potential for monitoring involvement	WaterSMART contact	Stephen Lougheed, Board Chair
Alberta Innovates	BioSolutions and Technology Futures have done work in Ecosystem Services	WaterSMART contact	Pam Valentine (acting CEO)
Alberta Land Institute (University of Alberta)	Partner for testing knowledge gaps and stakeholder feedback on project option	WaterSMART contact	Vic Adamowicz
Alberta Meat and Livestock Agency	Funding partner for testing knowledge gaps and stakeholder feedback on project option	Multiple conversations and submitting funding application in June	Clinton Dobson
Alliance for Water Stewardship	Existing international network focused on water stewardship best practice	WaterSMART contact	Matthew Howard
Alternative Land Use Services	Ecosystem services / valuation input	To be developed	To be developed
Decisive Farming	Potential for monitoring/technology involvement.	To be developed	To be developed or Agrium to confirm contact
Dow Chemical	Potential pilot involvement or support	WaterSMART contact	Shawna Bruce
Earth Institute / Columbia University	Dedicated research institute to find solutions for sustainable development (access to more than 30 research centers and over 850 scientists, staff, and students).	Agrium to confirm contact	Prof. Jeffrey Sachs (note Prof. Sachs is moving on from the position in June)
Ecosystem Services Alberta	Stakeholder for engagement early in project	To be developed	To be developed (potentially via Silvacom Group)

Potential partner	Initial reason/s	Relationship	Contact
Farmer's Edge	Potential for monitoring/technology involvement.	To be developed or Agrium to confirm contact	Dan Heaney Ph.D
Farming Smarter	Potential for monitoring/technology involvement and communications for southern Alberta.	To be developed	Ken Coles
International Plant Nutrition Institute	Science based institute with global reach.	Agrium to confirm contact	Terry L. Roberts
Natural Science and Engineering Research Council of Canada (NRSERC)	Potential funding partner for research based / academic work.	To be developed	To be developed
Silvacom Group	Ecosystem services involvement/ data management systems	WaterSMART contact	Tom Grabowski
The Nature Conservancy	NGO with broad reach and credibility	Agrium to confirm contact	To be developed
University of Alberta	Academic support and research insights	WaterSMART contact	David Percy
University of Lethbridge	Academic support and research insights	WaterSMART contact	David Hill
Veolia	Potential pilot involvement or support	WaterSMART contact	Johann Clere
World Overview of Conservation Approaches and Technologies (WOCAT)	Success story and research inputs	To be developed	To be developed
World Soil Information	Green Water Credits pilot research	To be developed	To be developed

9.0 Next steps

The next key steps to progress this work include:

1. Agrium to provide feedback on the project scope report and preference / feedback on a project option (via meeting arranged with WaterSMART in early July 2016).

2. WaterSMART to create a two-page summary of the selected project option and proposed pilot for funding conversations and pitching to government agencies and key project partners identified (summary to be approved/input from Agrium).

3. Address the knowledge gaps in detail (involves engagement with potential project partners and, if possible, growers in a potential pilot watershed).

4. In parallel to step three above, if necessary identify and engage a wider range of industry / NGO partners to work on the project through in kind or funding (wider than identified in this report).

5. Secure funding for project option resulting in a detailed budget and stakeholder/communications approach as well as implementation of the pilot.

6. Identify and engage technology partners for new ways that are also effective/warranted for growers to work, through traditional means (e.g. stakeholder networks) and using tools such as the UN Water Action Network.

7. Aim to start a pilot in Alberta in 2017.

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11.0 Appendices

Appendix A - Project definitions: water language

Term	Definition	Source
Adaptive Capacity	The ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.	IPCC (2014)
Adaptive Management	A dynamic system or process of task organization and execution that recognizes the future cannot be predicted perfectly. Planning and organizational strategies are reviewed and modified frequently as better information becomes available. Adaptive management applies scientific principles and methods to improve management activities incrementally as decision-makers learn from experience, collect new scientific findings, and adapt to changing social expectations and demands.	Alberta Environment (2008)
Allocation (of water)	Water that is available for a specified use and requires obtaining a withdrawal licence in many jurisdictions.	Adapted from: State of Victoria (2016)
Aquifer	A geological formation or structure that stores and/or transmits water, such as to wells and springs. Use of the term is usually restricted to those water-bearing formations capable of yielding water in sufficient quantity to constitute a usable supply for people's uses.	USGS (2015)
Baseflow	Sustained flow of a stream in the absence of direct runoff. It includes natural and human-induced streamflows. Natural base flow is sustained largely by groundwater discharges.	USGS (2015)
Basin	An area having a common outlet for its surface water runoff. The land area within a basin/watershed drains water to a particular stream, river, or lake. (See also Watershed – the term used throughout this report).	WMO and UNESCO (1998); USGS (2015)
Biodiversity	The variability among living organisms from terrestrial, marine, and other ecosystems. Biodiversity includes variability at the genetic, species, and ecosystem levels.	Based on International Union for Conservation of Nature definition
Climate Variability	Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events.	IPCC (2014)
Climate Change	Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.	IPCC (2014)
Conservation (of water)	Measures introduced to reduce the amount of water used for any purpose, and/or to protect it from pollution.	WMO and UNESCO (1998)
Conservation tillage	A tillage practice that leaves residues on the soil surface for erosion control and water conservation. It includes specific residue management practices, such as no-till,	USDA (2012)

Term	Definition	Source
	mulch-till, or ridge-till.	
Consumptive Use	Quantity of surface water and groundwater absorbed by crops and transpired or used directly in the building of plant tissue, together with that evaporated from the cropped area, expressed in units of volume per unit area, also including the degraded effluent which cannot be reused directly without appropriate treatment.	WMO and UNESCO (1998)
Credits	Credits are units of goods to be traded. They are generated for every unit of measured reduction beyond a baseline level. Specifically for the context of this project scope, water credits the voluntary exchange or transfer of a quantifiable water allocation between a willing buyer and seller.	Food and Resource Economics Department, UF/IFAS (2013)
Desertification	Process by which arid or semi-arid land is transformed progressively into desert due to a continuous lack of precipitation and/or land mismanagement.	WMO and UNESCO (1998)
Discharge	Volume of water flowing per unit of time, or the rate of flow. The use of this term is not restricted as to a water course, and it can be used to describe the flow of water from a pipe, drainage basin or of groundwater.	Adapted from: WMO and UNESCO (1998); Alberta Environment (2012)
Drip irrigation	A common irrigation method where pipes or tubes filled with water slowly drip onto crops. Drip irrigation is a low-pressure method of irrigation and less water is lost to evaporation	USGS (2015)
Drought	A period of abnormally dry weather long enough to cause a serious hydrological imbalance. Drought is a relative term; therefore any discussion in terms of precipitation deficit must refer to the particular precipitation-related activity that is under discussion.	IPCC (2014)
Ecosystem Services	Ecological processes or functions having monetary or non-monetary value to individuals or society at large. These are frequently classified as (i) supporting services such as productivity or biodiversity maintenance, (ii) provisioning services such as food, fiber, or fish, (iii) regulating services such as climate regulation or carbon sequestration, and (iv) cultural services such as tourism or spiritual and aesthetic appreciation.	IPCC (2014)
Evaporation	The process of liquid water becoming water vapor, including vaporization from water surfaces, land surfaces, and snow fields, but not from leaf surfaces	USGS (2015)
Evapotranspira tion	Water withdrawn from soil by evaporation and plant transpiration.	USDA (2012)
Flood	The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods.	IPCC (2014)
Frequency	The number of occasions that the same numerical measure of a particular quantity has occurred between definite time periods. Often stated in terms such as return	USDA (2012)

Term	Definition	Source
	interval, recurrence interval, or percent chance.	
Greywater	A term commonly used to describe household wastewater collected from sources like bathrooms (showers, baths, hand basins) laundries (washing machines and troughs) and kitchens (sinks and dishwashers).	Adapted from South Australian Water Corporation; Government of South Australia SA Health
Groundwater	Subsurface water, typically defined as being in the fully-saturated zone. It originates from rainfall or snowmelt that penetrates the layer of soil just below the surface. For groundwater to be a recoverable resource, it must exist in an aquifer.	Adapted from: Alberta Environment (2012); WMO ad UNESCO (1998)
Hydro-economic models	Hydro-economic models represent spatially distributed water resource systems, infrastructure, management options and economic values in an integrated manner. In these models water allocations and management are driven by the economic value of water or economically evaluated.	Adapted from Julien J. Haroua, Manuel Pulido-Velazquezb et.al (2009)
Irrigation	The controlled application of water for agricultural purposes through man-made systems to supply water requirements not satisfied by rainfall.	Alberta Environment (2012)
Mitigation (of risk)	The lessening of water-related risks through any number of human interventions. (See definition of risk)	Adapted from: IPCC (2014); CSA (2011)
Mitigation (of climate change)	A human intervention to reduce the sources or enhance the sinks of greenhouse gases.	IPCC (2014)
Precipitation	The total measurable supply of water of all forms of falling moisture, including dew, rain, mist, snow, hail, and sleet; usually expressed as a depth of liquid water on a horizontal surface in a day, month, or year, and designated as daily, monthly, or annual precipitation.	USDA (2012)
Recharge (of groundwater)	Natural or artificial introduction of water into the saturated zone of an aquifer. Recharge results from surface water infiltrating through the soil to the water table.	Adapted from: WMO and UNESCO (1998); IPCC (2014)
Reservoir	A pond, lake, tank, basin, or other space, either natural in its origin or created in whole or in part by the building of engineering structures. A reservoir stores, regulates, and controls water.	USDA (2012)
Resilience	The capacity of a social-ecological system to cope with a hazardous event or disturbance, responding or reorganizing in ways that maintain its essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation.	IPCC (2014)

Term	Definition	Source
Risk (as applied to water)	The potential for consequences where something of human value (including humans themselves) is at stake and where the outcome is uncertain. Usually expressed as probability of an event multiplied by its consequences. In the context of water stewardship, water can be the value at stake (e.g., loss of water quality is a risk), or water can pose a risk to other values (e.g., flooding can be a risk to communities).	Adapted from: IPCC (2014); CSA (2011)
River	A natural stream of water of considerable volume, larger than a brook or creek.	USGS (2015)
Runoff	That part of precipitation that does not evaporate and is not transpired, but flows through the ground or over the ground surface and returns to bodies of water.	IPCC (2014)
Soil moisture	Moisture contained in the portion of soil, which is above the water table, including water vapour present in the soil pores. Levels of soil moisture control the amount of water available for plant growth and also the potential for water infiltration and runoff.	Adapted from: WMO and UNESCO (1998)
Source Water	Raw/untreated water received for treatment to provide potable water to municipal, industrial or private users. Sources may include high quality groundwater, groundwater under the influence of surface water and surface water from lake, stream, river or watercourse.	Alberta Environment (2012)
Stewardship	The use of water that is socially equitable, environmentally sustainable and economically beneficial, achieved through a stakeholder-inclusive process that involves site and catchment-based actions.	Alliance for Water Stewardship
Sub-basin	Part of a river basin drained by a tributary or with significantly different characteristics than the other areas of the basin.	Alberta Environment (2012)
Surface water	Water that is present on the Earth's surface, such as in a stream, river, lake, or reservoir. Some definitions include groundwater with a direct and immediate hydrological connection to a surface water body.	Adapted from: USGS (2015); Alberta Environment (2012)
Stream (or water course)	A general term for a body of flowing water; natural water course containing water at least part of the year. In hydrology, it is generally applied to the water flowing in a natural channel as distinct from a canal.	USGS (2015)
Streamflow	General term for water flowing in a river or watercourse that is often quantified using discharge, or flow rate. (see Discharge).	Adapted from: WMO and UNESCO (1998)
Wastewater	Any combination of the following: domestic effluent consisting of blackwater (excreta, urine and faecal sludge) and greywater (kitchen and bathing wastewater); water from commercial establishments and institutions, including hospitals; industrial effluent, stormwater and other urban run-off; agricultural, horticultural and aquaculture effluent, either dissolved or as suspended matter.	UN-Water (2015)
Water table	Surface of the zone of saturation of groundwater in the subsurface, or the top surface of groundwater.	Adapted from: USGS (2015); WMO and

Term	Definition	Source
		UNESCO (1998)
Water quality	A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.	USGS (2015)
Watershed	An area having a common outlet for its surface water runoff. The land area within a basin/watershed drains water to a particular stream, river, or lake. (see also Basin).	WMO and UNESCO (1998); USGS (2015)
Weather	State of the atmosphere at a particular time, as defined by the various meteorological elements.	WMO and UNESCO (1998)
Well (water well; groundwater well)	An artificial excavation put down by any method for the purposes of withdrawing water from the underground aquifers. A bored, drilled, or driven shaft, or a dug hole whose depth is greater than the largest surface dimension and whose purpose is to reach underground water supplies.	USGS (2015)

Appendix B - Agricultural water risks matrix

The strength of the agricultural activities/assets for mitigating each risk is rated on a three-point scale based on professional judgment:

1. + provides indirect risk mitigation
2. ++ provides direct risk mitigation, and
3. +++ provides strong risk mitigation.

In the development of a water stewardship program and pilot, this risk matrix could be used as a foundation for further research (either new or to find existing research) to support the messages around benefits and "what's in it for me" via collective action by growers in the interests of watershed health.

Agricultural water risks			**Agricultural activities / assets as potential risk mitigation strategies**																						
			Infrastructure							**Land and soil management**									**Water management**						
Risk Cate-gory	**Risk Receptor**	**Specific Risk**	Install Irrigation Systems	Install Drainage Systems	Irrigation Efficiency Improvements (drip)	Waste / Drain water Treatment	Drainage System Modernization (controlled)	Water Storage Facilities	Riparian Buffers	Optimized Nutrient Management	Optimized Pesticide Management	Drought-resistant varieties	Cover Crops	Conservation Tillage	Enhanced crop rotation / diversification	Manure, chemical and waste storage	Windbreaks	Wetland restoration	Water allocation transfers	Aquifer Storage	Groundwater development	Water and climate monitoring & forecasting	Rainwater harvesting	Conjunctive Use (GW + SW)	Water Reuse

Agricultural water risks			Agricultural activities / assets as potential risk mitigation strategies																						
			Infrastructure							Land and soil management									Water management						
Risk Cate-gory	**Risk Receptor**	**Specific Risk**	Install Irrigation Systems	Install Drainage Systems	Irrigation Efficiency Improvements (drip)	Waste / Drain water Treatment	Drainage System Modernization (controlled)	Water Storage Facilities	Riparian Buffers	Optimized Nutrient Management	Optimized Pesticide Management	Drought-resistant varieties	Cover Crops	Conservation Tillage	Enhanced crop rotation / diversification	Manure, chemical and waste storage	Windbreaks	Wetland restoration	Water allocation transfers	Aquifer Storage	Groundwater development	Water and climate monitoring & forecasting	Rainwater harvesting	Conjunctive Use (GW + SW)	Water Reuse
Water supply and demand management	Farm	Loss of water availability for irrigation & livestock watering (due to restrictions or increased ET)	+++		+++			+++	++	+	+	+++	+++	+++	++		+	+++	+++	+++	+++	+++	+++	+++	+++

Agricultural water risks			**Agricultural activities / assets as potential risk mitigation strategies**																						
			Infrastructure							**Land and soil management**									**Water management**						
Risk Cate-gory	**Risk Receptor**	**Specific Risk**	Install Irrigation Systems	Install Drainage Systems	Irrigation Efficiency Improvements (drip)	Waste / Drain water Treatment	Drainage System Modernization (controlled)	Water Storage Facilities	Riparian Buffers	Optimized Nutrient Management	Optimized Pesticide Management	Drought-resistant varieties	Cover Crops	Conservation Tillage	Enhanced crop rotation / diversification	Manure, chemical and waste storage	Windbreaks	Wetland restoration	Water allocation transfers	Aquifer Storage	Groundwater development	Water and climate monitoring & forecasting	Rainwater harvesting	Conjunctive Use (GW + SW)	Water Reuse
		Seasonal shifts and variability in water availability (e.g., snowpack) and demands e.g., crop-water requirements	+++		+++			+++	++	+	+	+++	+++	+++	++		+	+++	+++	+++	+++	+++	+++	+++	+++
	Water-shed	Over-abstraction / pumping			+++		+++		++	+	+	+++	+++	+++	++		+	+++	+++	+++		+++	+++	++	+++

Agricultural water risks			Agricultural activities / assets as potential risk mitigation strategies																						
			Infrastructure							Land and soil management									Water management						
Risk Cate-gory	**Risk Receptor**	**Specific Risk**	Install Irrigation Systems	Install Drainage Systems	Irrigation Efficiency Improvements (drip)	Waste / Drain water Treatment	Drainage System Modernization (controlled)	Water Storage Facilities	Riparian Buffers	Optimized Nutrient Management	Optimized Pesticide Management	Drought-resistant varieties	Cover Crops	Conservation Tillage	Enhanced crop rotation / diversification	Manure, chemical and waste storage	Windbreaks	Wetland restoration	Water allocation transfers	Aquifer Storage	Groundwater development	Water and climate monitoring & forecasting	Rainwater harvesting	Conjunctive Use (GW + SW)	Water Reuse
		Seasonal shifts and variability in water availability (e.g., snowpack)			+++		+++		++	+	+	+++	+++	+++	++		+	+++	+++	+++		+++	+++	++	+++
Water Quality Management	Farm	Microbial contam-ination				+++	+++	+++	+++	+++			+++	+++		+++	+					+++			
		Chemical / pesticide contamination from current or historical activities		+++		+++	+++		+++	+++	+++	+	+++	+++	+++	+++	+					+++			

Agricultural water risks			Agricultural activities / assets as potential risk mitigation strategies																						
			Infrastructure							Land and soil management									Water management						
Risk Cate-gory	**Risk Receptor**	**Specific Risk**	Install Irrigation Systems	Install Drainage Systems	Irrigation Efficiency Improvements (drip)	Waste / Drain water Treatment	Drainage System Modernization (controlled)	Water Storage Facilities	Riparian Buffers	Optimized Nutrient Management	Optimized Pesticide Management	Drought-resistant varieties	Cover Crops	Conservation Tillage	Enhanced crop rotation / diversification	Manure, chemical and waste storage	Windbreaks	Wetland restoration	Water allocation transfers	Aquifer Storage	Groundwater development	Water and climate monitoring & forecasting	Rainwater harvesting	Conjunctive Use (GW + SW)	Water Reuse
	Watershed	Nutrient loading			+++	+++	+++		+++	+++	+++	+	+++	+++	+++	+++	++	+++				+++			
		Microbial contam-ination			+++	+++	+++		+++	+++	+++	+	+++	+++	+++	+++	++	+++				+++			
		Chemical/ pesticide contam-ination			+++	+++	+++		+++	+++	+++	+	+++	+++	+++	+++	++	+++				+++			
Hydrologic Hazard Protection	Farm	Flooding / excessive moisture		+++			+++	+++	+	++	+++		+++	+++	+		+	+++	++	++		+++	+++		
		Agricultural drought (lack of soil moisture)	+++		+++	+++		+++	+++	+++	+++	+++	+++	+++	++		++	+++	+++	+++	+++	+++	+++	+++	+++

Agricultural water risks			Agricultural activities / assets as potential risk mitigation strategies																						
			Infrastructure							Land and soil management									Water management						
Risk Cate-gory	**Risk Receptor**	**Specific Risk**	Install Irrigation Systems	Install Drainage Systems	Irrigation Efficiency Improvements (drip)	Waste / Drain water Treatment	Drainage System Modernization (controlled)	Water Storage Facilities	Riparian Buffers	Optimized Nutrient Management	Optimized Pesticide Management	Drought-resistant varieties	Cover Crops	Conservation Tillage	Enhanced crop rotation / diversification	Manure, chemical and waste storage	Windbreaks	Wetland restoration	Water allocation transfers	Aquifer Storage	Groundwater development	Water and climate monitoring & forecasting	Rainwater harvesting	Conjunctive Use (GW + SW)	Water Reuse
		Soil erosion / nutrient leaching	+++	+++	+++	+++	+++		+	+++	+++	+++	+++	+++	+++		+	+							
		Salinization of soils	+++	+++	+++	+++	+++		+	+++	+++	+++	+++	+++	+++		+	+							
	Water-shed	Drought (agricultural and hydrologic)				+++			+++	+++	+++	+++	+++	+++				+++				+++			+++

Appendix C - Alberta academic papers on monitoring

The following papers were p\Provided by Alberta Agriculture and Forestry in response to a request for any sources of data in Alberta (or regions in Alberta) on the following: nutrient run-off, sediment, and/or pesticides. These form a useful starting point for further analysis on the data, monitoring, and considerations for the pilot in Alberta.

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Bolseng, T.A. 1992b. Water Quality in Irrigation-distributions Systems in the Lethbridge Northern Irrigation District during 1990–1991. Lethbridge, Alberta, Canada. 20 pp.

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