CLIMATE CHANGE
ADAPTATION PROGRAM

Evaluation of Irrigation Potential in the BC Peace Region

Project Summary

Funding for this project has been provided by the Governments of Canada and British Columbia through Growing Forward 2, a federal-provincial-territorial initiative. The program is delivered by the Investment Agriculture Foundation of BC.

DELIVERED BY

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Growing Forward 2

British Columbia

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Evaluation of Irrigation Potential in the BC Peace Region

Executive Summary
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Prepared for:

B.C. Grain Producers Association

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- Peace Forage Seed Association
- Peace River Regional Cattlemen's Association
- BC Ministry of Agriculture
- Peace River Regional District: Bruce Simard
- Peace River Forage Association
- BC Seed Growers' Association
- BC Agriculture & Food Climate Action Initiative

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Agriculture and Agri-Food Canada (AAFC) and the BC Ministry of Agriculture are committed to working with industry partners. Opinions expressed in this document are those of the authors and not necessarily those of AAFC, the Ministry of Agriculture, the Investment Agriculture Foundation, or the Agricultural Research and Development Corporation.

Executive Summary

Kerr Wood Leidal Associates Ltd. (KWL) was retained in January 2015 by the BC Grain Producers Association to conduct an Evaluation of Irrigation Potential in the BC Peace Region. Funding for the project was provided by Agriculture and Agri-Food Canada and the BC Ministry of Agriculture through the Investment Agriculture Foundation of BC under Growing Forward 2, a federal-provincial-territorial initiative. The program is delivered by the BC Agriculture & Food Climate Action Initiative. This report presents the project methodology, findings and recommendations regarding agricultural irrigation in the region.

Background

During the winter of 2012 and early 2013, the BC Agriculture & Food Climate Action Initiative brought Peace region agricultural groups, producers and government specialists together to develop a plan for supporting the agriculture sector with adapting to climate change. Completed in the spring of 2013, the *Peace Adaptation Strategies* plan identifies priority climate change impacts and strategies for adaptation for the region's agriculture sector.

One of the changes of greatest concern for participating producers is more frequent, and intensifying, dry and drought conditions during the summer. Water shortages and substantial moisture deficits for crop production have been experienced in recent years. Greater water demand from competing uses, and water use restrictions prompted questions about whether the current and future water demand for agriculture has been adequately considered in planning scenarios. While currently there is very little irrigation of crops in the region, the potential for irrigation needs to be established to adequately assess future agricultural water demand.

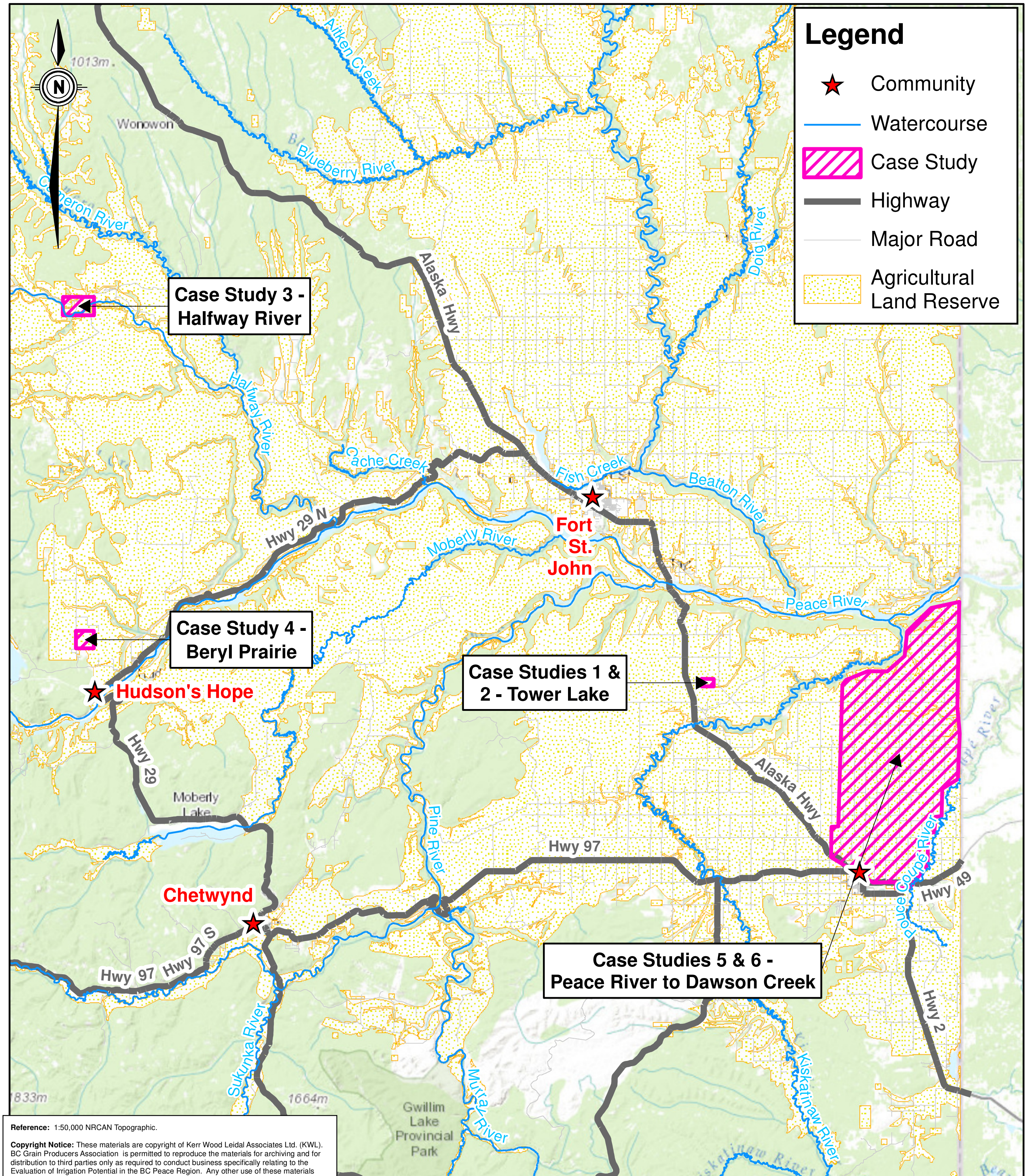
To explore this issue further, an irrigation feasibility study for the Peace region was identified as a logical first step. Input and guidance on the study was provided by the Peace Adaptation working group. The working group was initially formed to support the *Peace Adaptation Strategies* planning process, and continues in their role (providing sector and local expertise) as the plan is implemented.

Purpose

The objectives of the evaluation of Irrigation Potential in the BC Peace Region project are to:

1. produce a thorough cost-benefit analysis, assess the future feasibilities of various irrigation and cropping scenarios for agricultural land in the BC Peace region; and
2. identify suitable scales and structures of irrigation systems, and physical and institutional constraints, for current and future cropping scenarios.

The study area is the Peace River Regional District in northeastern British Columbia. The western portion of the region is mountainous and is generally unsuitable for agriculture. The focus of this study is the agricultural land in the eastern part of the region, as shown in Figure E-1.



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consulting engineers

Evaluation of Irrigation Potential in the BC Peace Region

Project No.	Date
3444-001	February 2016

30 0 30 Kilometers

1:1,375,000

Study Area

Figure 1-1

Path: R:\3400-3499\3444-001\430-GIS\MXD-RP\3444001_StudyArea.mxd Date Saved: 26/02/2016 9:56:55 AM
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Key Terms and Acronyms

Agriculture Water Demand Model (AWDM) is a GIS-based software system developed by the BC Ministry of Agriculture, initially for estimating agricultural water demands in the Okanagan Basin. It has since been deployed for several other areas of the province. The AWDM uses downscaled global climate modelling data from the Pacific Climate Impacts Consortium (PCIC) to estimate current and potential future irrigation demands for reference crops on a 500 m grid.

Benefit Cost Ratio (BCR) is the sum of the present values (PV) of incoming cash flows from an investment divided by the sum of the present values of the outgoing cash flows. A BCR greater than 1 indicates a profit and a value less than 1 indicates a loss.

Discount Rate is the rate at which the value of a capital investment grows over time. Discount rates reflect market and project conditions, consisting of a risk-free rate that an investor would expect from a very safe investment (e.g., Bank of Canada or US Treasury bonds) plus a risk premium that reflects the probability of no return on the investment. A real discount rate of 5% per year (net of inflation) is assumed for this study, and the impact of varying the discount rate between 2% and 10% is evaluated in the sensitivity analysis.

Geographic Information System (GIS) is a software system used to develop, store, process and display spatial or geographical data.

Net Present Value (NPV) is the sum of the present values of incoming and outgoing cash flows over a period of time. In calculating NPV, the values of all future cash flows in the period are adjusted to present value by an assumed discount rate. A positive NPV indicates a profit, while a negative NPV indicates a loss. An investment typically needs to yield a NPV significantly greater than zero (and a BCR significantly greater than 1) to cover investment risks and opportunity cost. For the purpose of this study, the life cycle NPV of an investment in irrigation would also need to be greater than the NPV of unirrigated agriculture (status quo) over the same period in order for the investment to be financially favourable to the producer.

Methodology

The overall approach used for the analysis consisted of three general steps:

1. Estimation of available water supply and potential water demands using GIS-based tools;
2. Development of typical scenarios and example case studies for financial and economic feasibility analysis; and
3. Development of conclusions regarding feasibility of irrigation under a range of typical local conditions throughout the region, and recommendations for further work.

The feasibility of irrigation the BC Peace region was developed with reference to several previous studies, particularly in southern Alberta and Saskatchewan, and published methodologies for feasibility assessment of agricultural projects. Reports, maps and data were provided by the Ministry of Agriculture, particularly for estimation of water demands, unit costs and prices for financial feasibility analysis. Between March 24 and March 26, 2015, members of the project team conducted a field review of agricultural areas in the Peace Region, and visited farms and interviewed producers.

Climate, Water Supply and Demand Forecasts

The climate of the BC Peace region is forecast to become significantly warmer by the 2050s. Forecasts of mean annual temperature change between 1970 and 2050 range from +1.2 to +2.5 °C. On average, summer precipitation may increase by 3% by the 2050s. Climate change is also a major risk factor for future agricultural production in the region. In addition to uncertainty in future average conditions, both the magnitude and frequency of extreme weather events are forecast to increase.

Water supply availability estimates used in this study are based on federal and provincial government data, including Water Survey of Canada streamflow data and the BC Ministry of Environment's *Inventory of Streamflow in the Omineca and Northeast Regions*. The average and 1:10-year drought condition flows were used to simulate typical and drought flows during the growing season of May to August using GIS. There is insufficient data available to forecast the impacts of climate change on stream flows. For the purpose of this study it is assumed that the 1:10-year drought may occur more frequently in the 2050s (two to three years in ten). Water availability for irrigation was limited to 15% of the average monthly streamflow for consistency with provincial water licensing practice.

Water demands for two reference crops (mixed grasses grown for hay, and cereals) are calculated using the Agriculture Water Demand Model (AWDM), which utilizes downscaled climate data from the Pacific Climate Impacts Consortium (PCIC) for both recent historical conditions, and future (2050s) conditions that account for the anticipated warming in the region. Although other crops, particularly canola and pulses, are currently grown in crop rotations in the BC Peace Region, cereals and grasses grown for hay were selected as reference crops for water demand modelling as they represent high and low extreme crop water demands. A canola scenario is included in detailed feasibility case studies, based on interpolation between the water demands for cereals and forage. The future scenario is used for the feasibility assessment. The AWDM utilizes a series of variables to determine irrigation water demand such as crop rooting depth, soil properties, rainfall, temperatures and irrigation efficiency to calculate the amounts of water required throughout the growing season to maximize crop yield.

The forecast maximum irrigation water demands for the 2050s that are used in the feasibility analysis are 13% to 45% greater than estimated demands based on historical conditions, depending on crop type. The feasibility analysis is therefore based on reasonably conservative assumptions for future water supply and demand conditions: Water sources must be able to reliably supply 13% to 45% more than the estimated current maximum water demand under a 1:10 year drought condition. This conservative basis for assessment of water source capacity assures that irrigation water supplies would be reliable when most needed.

Case Study Financial Analysis

A set of typical irrigation scenarios was developed, and a case study was identified for each scenario to evaluate the economic feasibility of irrigation under conditions typically available in the region. Scenarios were developed based on irrigation water demand, proximity to a water supply, and the elevation difference between the water supply and point of irrigation. The scenarios, along with a description and case study, are summarized in Table E-1.

Table E-1: Feasibility Scenarios and Case Studies

Scenario	Description	Case Study	Lift	Distance
1	Single Farm	Tower Lake	< 65 ft	< 0.6 mi
2	Single Farm with Constructed Storage			
3	Small Community System	Halfway River	< 165 ft	< 3 mi
4	Small Community System with Constructed Storage	Beryl Prairie		
5	Large System	Peace River to Dawson Creek	> 700 ft	> 3 mi
6	Large System with Constructed Storage			

The feasibility of irrigation under each scenario was evaluated using an Excel-based financial model developed based on typical agricultural project evaluation practices. The general sequence of analysis is as follows:

1. Define the parameters for evaluating each scenario based on a representative case study;
2. Apply a standard set of assumptions for three reference crops: cereals, canola and forage;
3. Estimate average, maximum and minimum revenues and costs using standard assumptions for each reference crop;
4. Calculate financial feasibility (average, maximum and minimum BCR and NPV) for status quo and irrigated production of each reference crop;
5. Identify water supply capacity limitations for each scenario;
6. Assess the sensitivity of the feasibility results to variations in project life cycle, and discount rate;
7. Consider the overall economic impacts on the region of widespread irrigation based on previous economic assessments of major irrigation projects in Alberta and Saskatchewan;
8. Consider a range of environmental and social implications of widespread irrigation; and
9. Consider potential alternative water supply scenarios and their potential impacts on the feasibility of irrigation in the Peace region.

Case Study Results

Based on average assumptions used for the analysis, estimates of the financial performance of dryland agriculture in the BC Peace Region (status quo) are shown in Table E-2. The results indicate that over 20 years, dryland forage production is expected to return roughly $100/acre, cereals $400/acre, and canola $500/acre. Annual returns are one-twentieth of these values (roughly $5 to $25/acre). The return on inputs of labour, machinery and materials (land and facilities excluded) is estimated to fall between 8% and 14%.

Table E-2: Unirrigated Crop Financial Parameters – Scenario 3, Halfway River

Crop	Average Revenue ($/acre)	Average Operating Expense ($/acre)	20-Year NPV ($/acre)	Benefit-Cost Ratio
Dryland Forage	101	-94	96	1.08
Dryland Cereal	241	-208	415	1.16
Dryland Canola	326	-285	502	1.14

The financial feasibility of irrigation is dependent on capital and operating costs of water supply and irrigation infrastructure, and crop type. Halfway River (Scenario 3) is shown in Table E-3 as an example of varying costs and revenue based on crop under irrigation. Unfavourable results are indicated in red text.

Table E-3: Irrigated Crop Financial Parameters – Scenario 3, Halfway River

Crop	Average Revenue ($/acre)	Average Operating Expense ($/acre)	Irrigation Capital Cost ($/acre)	20-Year NPV ($/acre)	Benefit-Cost Ratio
Irrigated Forage	234	-237	-784	-825	0.78
Irrigated Cereal	368	-285	-784	256	1.06
Irrigated Canola	498	-393	-784	518	1.09

Note: all data is based on the assumption of using a ¼ Section Centre Pivot that irrigates 125 acres, the remaining area is assumed dryland where irrigation does not reach (35 acres).

The results indicate that irrigating forage is not financially feasible in this scenario. Irrigating cereals and canola in this scenario both yield a small net revenue; however, both yield lower net revenue per acre than without irrigation and would therefore not be considered a worthwhile investment based on financial analysis alone.

Capital and operating expenses are relatively low in Scenario 3 as it is located in close proximity to a reliable and plentiful source of water, requiring minimal pumping lift and no water storage. The capital and maintenance costs vary widely between scenarios. Table E-4 shows the case study results for each scenario using canola under average conditions.

Table E-4: Irrigated Crop Financial Parameters – All Scenarios, Canola

Scenario	Average Revenue ($/acre)[a]	Average Operating Expense ($/acre)	Irrigation Capital Cost ($/acre)	20-Year NPV ($/acre)	Benefit-Cost Ratio
1 – Tower Lake	$427[b]	-$389	-$742	-$271	0.95
2 – Tower Lake with Storage	$498	-$415	-$2073	-$1740	0.74
3 – Halfway River	$498	-$393	-$784	$520	1.09
4 – Beryl Prairie with Storage	$498	-$393	-$2015	-$1000	0.86
5 – Peace to Dawson Creek	$498	-$471	-$2906	-$2579	0.71
6 – Peace to Dawson Creek with Storage	$498	-$430	-$2107	-$1654	0.78

[a] All data is based on the assumption of using a quarter Section Centre Pivot that irrigates 125 acres, the remaining area is assumed dryland where irrigation does not reach (35 acres).
[2]. Tower Lake irrigated canola yield is assumed to be limited by the capacity of the source, resulting in reduced revenue per acre than other irrigated canola scenarios.

Where limitations of the water source necessitate constructed storage such as a dugout, irrigation is not financially feasible due to the high capital cost of storage (Scenarios 2 and 4 most notably). Constructing storage in the Peace to Dawson (Scenarios 5 and 6) reduces overall costs as a smaller pump and smaller diameter distribution mains are required; however, irrigation is not financially feasible under either scenario.

Sensitivity Analysis

The financial analysis is based on estimates of average capital costs, annual input costs, market prices, yields and financial analysis parameters, each of which has varying ranges of uncertainty. Probable maximum and minimum values for these parameters were used to develop estimated ranges of uncertainty in the results. Estimates of the range of uncertainty in the financial feasibility results were developed for the following three primary sources of error:

1. Capital cost estimates used in this analysis are considered to have a margin of error of -50% to +100%;
2. Annual revenues and expenses, including market prices, yields and energy prices were varied based on estimated ranges developed by the project team based on recent historical data and market forecasts; and
3. Financial analysis parameters, project life cycle and discount rate, were varied from 20 years at 10% to 50 years at 3% annual discount rate.

The margins of error estimated for the three primary sources are combined using a standard method based on the assumption that the three sources are mutually independent. The combined percent uncertainty is calculated as the square root of the sum of the squares of the relative maximum errors. The results of the financial feasibility analysis and margins of uncertainty for the most favourable scenario evaluated (Scenario 3 – Halfway River) are shown in Figure E-2.

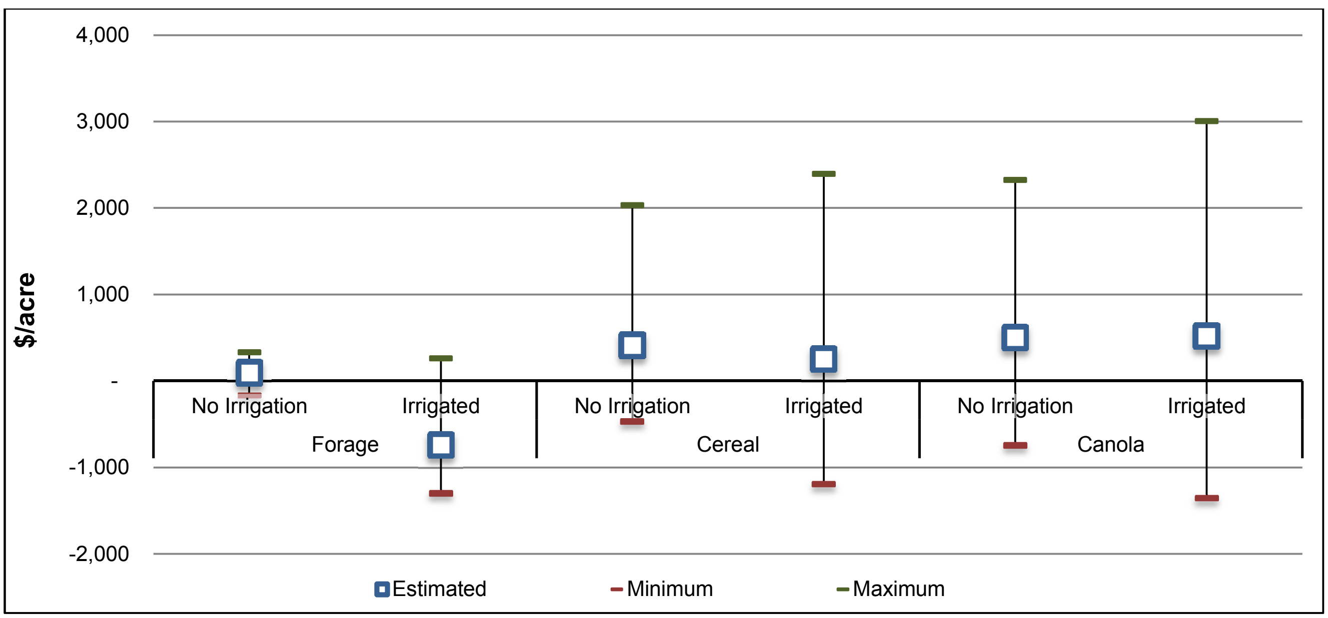

Figure E-2: 20-Year Net Present Value per Acre – Scenario 3, Halfway River

Review of Other Irrigation Scenarios

The case study scenarios are expected to represent favourable scenarios for irrigating the current primary crop types in the BC Peace Region at a range of scales. Although the following additional scenarios were not evaluated in detail, they were compared with the case study scenarios through identification of factors that may increase or decrease their feasibility relative to the case studies.

Site C Reservoir

Utilizing the Site C reservoir as a water source for irrigation is a variant of Scenarios 5 and 6. Using the reservoir as the source for a system that ultimately connects to Dawson Creek would reduce or eliminate intake costs and would reduce the required lift by 215 ft (65 m), reducing the capital and operating costs of pumping. However, the pipeline route would be considerably longer, including at least 9 mi through difficult terrain including crossing the Pine River to reach the northwestern extent of the farmland south of the Peace River. This scenario would certainly be more costly than the case study scenarios, and the shortest route to Dawson Creek (approximately following Highway 97) would not access farmland as efficiently as the case study scenarios.

An alternate scenario that may offer similar benefits to the case studies would be a pipeline from the Site C dam location north to the region between Montney, North Pine and Rose Prairie. This scenario may benefit from the Site C reservoir elevation and water quality while accessing farmland efficiently. As with the Peace to Dawson case study, the feasibility of a Site C to Rose Prairie project would rely on senior government investment to cover most or all of the capital cost of the shared infrastructure. This scenario is unlikely to significantly improve the feasibility of a major irrigation project in the BC Peace region.

In-Stream Storage

Water storage may be developed at a significantly lower construction cost than the $1,200 to 3,700/ac-ft ($1 to $3 per m^3) of live storage assumed for this analysis, by constructing dams to create reservoirs in river valleys or other natural depressions in the landscape. Examples of potential in-stream storage scenarios in the BC Peace Region include:

1. increase Charlie Lake weir height by 6 to 12 inches (0.15 to 0.3 m);
2. Dam Doe Creek or Saskatoon Creek (tributaries to Pouce Coupé River) at 620 m contour;
3. Dam Upper Goleta Creek at 620 m contour; or
4. Dam Alces River at 600 m or Kiskatinaw River at 620 m contour – potentially combine with hydropower project.

Efficiency of the catchment must be considered in each case, and elevation relative to farmland also significantly impacts overall project feasibility.

In the most ideal conditions, storage costs as low as $300/acre-ft ($0.25/m^3) may be achievable with large dams; however, only the largest projects in the most ideally suited locations are likely to achieve unit costs lower than $1200/acre-ft. The most cost-efficient new dam storage scenarios would also involve major changes to regionally significant creeks or rivers, and would require a high level of effort for planning, engineering, environmental assessment, land acquisition and regulatory approvals, with a high initial risk that the project will not proceed. It is therefore very unlikely that developing new in-stream storage would significantly improve the feasibility of irrigation in the BC Peace Region.

If the environmental and shoreline property impacts are acceptable, raising the existing Charlie Lake weir or similar projects to regulate levels of other lakes or wetlands within a level range of up to 1 ft (0.3 m) would likely represent the lowest-cost storage improvement in the region based on unit cost. Irrigating suitable farmland near a regulated lake or wetland may approach the financial feasibility of Scenario 3 (Halfway River). This approach would require coordination with the holders of existing wildlife conservation licenses on these watercourses, to ensure water levels will be managed to prevent harm to nesting waterfowl.

Municipal Wastewater Effluent

The Town of Dawson Creek has partnered with Shell Canada to improve its wastewater treatment system to supply up to 3.2 ac-ft/day (4,000 m^3/day) of reclaimed water to Shell for its operations in the South Peace Region. Shell has constructed a 30 mi (48 km) pipeline to deliver the reclaimed water from Dawson Creek to its Groundbirch area operations. The total cost of the treatment improvements was approximately $13 million.

If the need for fresh water related to gas development activity (primarily for hydraulic fracturing of wells) declines within the next 20 to 30 years as forecast, there may be a longer-term opportunity to purchase or lease the Shell infrastructure for irrigation uses. As the pipeline runs primarily through farmland, the cost of additional conveyance infrastructure would be minimal for farms near the pipeline. However, local storage and pumping would be required to fully utilize the available 1,200 ac-ft/year (1.5 million m^3/year, suitable for roughly 4.5 sections of canola).

A similar reclaimed water project could be developed at Fort St. John for irrigation use. The population and municipal water demand of Fort St. John are roughly 50% greater than that of Dawson Creek, indicating that a wastewater effluent flow of approximately 1,800 ac-ft/year may be available (suitable for roughly seven sections of canola). Requirements for treatment, storage and conveyance under this scenario would likely result in a higher unit cost of irrigation water supply than that of the Beryl Prairie with storage scenario, and a similar or lower financial feasibility.

Groundwater

Groundwater sources in the agricultural areas of the BC Peace Region generally have low to moderate productivity and poor quality. Total dissolved solids (TDS) and hardness of bedrock well water is typically greater than 1,000 ppm. Softer groundwater may have high fluoride and barium concentrations associated with sodium bicarbonate. The most productive bedrock wells in the region are in the range of 250 USgpm (16 L/s) (Dunvegan Formation), and most have much lower yields. Surficial aquifers that produce higher yields and may have better water quality generally follow the major river valleys, and are likely to interact with surface water. Confined aquifers recharge slowly (in the order of centuries or millennia), and are therefore highly vulnerable to over-pumping at the flow rates that would be required for irrigation.

Although groundwater may prove suitable for irrigating on a local scale (1/4 to one section) in some locations, conditions favourable for irrigating on a larger scale using groundwater are unlikely to exist in the BC Peace Region (with the exception of riverbank wells near major rivers). Unconfined aquifers may be unproductive in drought conditions, and the use of confined aquifers for irrigation is likely unsustainable. Storage would likely be required to supply the flow rates required for center pivot irrigation, resulting in a similar or lower financial feasibility to the Tower Lake with storage case study (Scenario 2). Groundwater is therefore unlikely to be a significant source of water for irrigation in the BC Peace Region.

Shared Infrastructure

In recent years, there has been substantial investment in water supply infrastructure in the BC Peace Region, including pump stations, pipelines and storage ponds to supply oil and gas development needs. Although oil and gas companies have developed most of the infrastructure, agricultural producers have developed some. A more deliberate and coordinated effort to develop infrastructure that meets combined agricultural, oil and gas, municipal and other industrial needs may enable a significant area of farmland to be brought under irrigation. The best opportunities currently appear to be in the South Peace region, where concentrated gas development activity coincides with widespread agricultural production.

A major water supply project that brings water from a major surface water source (e.g., Peace, Pine or Beatton River) to an area that shares agricultural opportunities with gas development and possibly municipal needs may be feasible. Based on the Peace to Dawson case studies, it is unlikely that such a project would be cost-effective for a primarily agricultural purpose. Such a project may only be feasible if the scale of irrigation is kept small enough that the majority of the project cost will be paid by the oil and gas development or municipal participants, both of which can justify a much higher unit cost of water than irrigation.

To date, oil and gas companies have been reluctant to share water supply infrastructure with other users. It is likely that agricultural producers would need to play a lead role in developing the shared infrastructure, potentially including ownership. The risks associated with developing infrastructure without a firm revenue stream from other users must be considered carefully. Water licensing for multiple uses may also be significantly more complex than for irrigation alone.

Other Crops and Larger Herds

The climate in the BC Peace region is suitable for production of a wider range of crops under irrigation than are currently grown in significant quantities in the region. In particular, a mix of vegetables is estimated to generate gross revenues ranging from $5,000 to 8,000/acre at a variable production cost of approximately $1,700/acre (2011 dollars). Sugar beets also generally yield higher returns per acre than cereals or oilseeds. However, realizing higher returns would require investment in new harvesting equipment and may greatly increase labour requirements. Transitioning to new crops and production methods typically requires several years, and a commitment by producers to make the required investments in equipment and capacity building on top of major investments in irrigation. New crops that are more dependent on irrigation may also increase risks of a shortfall in water supply in a drought year.

A 2012 study of the potato, fruit and vegetable market in Alberta identified the following eight competitive issues for these crops:

- Low cost of import competition;
- Local food trends;
- Climatic conditions;
- Labour;
- Temperature and humidity controlled storage capacity;
- Technology and innovation support;
- Industry organizational structure; and
- Branding.

The same study estimated net returns per acre of several crops as shown in the Table E-5.

Table E-5: Estimated Profitability per Acre of Vegetable Crops in Alberta

Crop	Gross Revenue	Irrigation	Other Costs	Total Cost	Net Revenue
Sweet corn	$3,500	- $73	- $3,031	- $3,104	$396
Cucumbers	$6,000	- $73	- $5,923	- $5,996	$4
Fresh potatoes	$2,400	- $79	- $2,436	- $2,515	-$115
Dryland carrots	$1,800		- $1,770	- $1,770	$30
Irrigated carrots	$2,520	- $79	- $2,127	- $2,206	$314

For comparison, the estimated annual cost of irrigation based on the most favourable conditions (Tower Lake and Halfway Case studies) ranges from $115/acre without storage to $250/acre with storage, including capital costs amortized at 5% over 20 years. This indicates potential for transitioning to certain higher-value crops such as sweet corn or carrots to increase the feasibility of irrigation in the BC Peace Region. However, market volatility and uncertainty in yields translate to a high degree of risk in investments in irrigation and production equipment for vegetables. In addition, yields are likely to be significantly lower in the cooler climate of the BC Peace Region than in southern Alberta.

By reducing risks of feed shortages, irrigation may also support safe increases in herd sizes, potentially allowing large increases in revenues per hectare for beef and other livestock operations. New cow-calf operations, feedlots and processing facilities may locate in the region if substantial areas of the BC Peace region have access to irrigation. However, careful management of feed supplies to hedge against drought risk is likely a more cost-effective strategy for safely increasing herd sizes than irrigating forage.

Further study including small-scale piloting to prove out yields and production costs would be required to quantitatively assess the potential impact of higher-value crops and increasing herd sizes on the feasibility of irrigation in the BC Peace Region.

Economic Analysis

A rigorous analysis of the impacts of irrigation on the regional economy of the BC Peace Region is beyond the scope of this study. However, similar analyses of the major irrigation projects in southern Alberta and Saskatchewan provide an indication of the potential magnitude of impacts of widespread irrigation in the BC Peace Region. For this study, economic analysis includes consideration of social and environmental costs, benefits and risks. The following elements were considered in a subjective review of economic factors:

Scale of Impacts

Irrigation of a small proportion of farmland (most likely scenario) will have minor impact on the economy of the BC Peace region, and is expected to have no material economic impact on a larger scale. While irrigation of more than a few percent of the area of farmland in the region is unlikely in the foreseeable future, more widespread irrigation may significantly impact the regional economy and have minor impact on a larger scale.

For the purpose of this analysis, a single local irrigation system is considered to have negligible impact regionally. This analysis is focused primarily on regional impacts (i.e., Peace River Regional District and local communities), and possible provincial impacts, of at least 5 to 10% of the field crop area in the BC Peace region (15,000 to 30,000 ha) coming under irrigation.

Baseline Economic Activity

Although agriculture is the dominant land use in the BC Peace Region, its economic impacts are currently relatively small and declining. However, in contrast to oil and gas development, agriculture in the region is stable and sustainable, and currently relies heavily on local labour, supply and distribution networks.

Of the roughly 3.7 million acres (1.5 million ha) of land in the Agricultural Land Reserve in the BC Peace region, approximately 1.5 million acres are improved and farmed. Roughly 0.74 million acres are in unmanaged pasture, and 0.74 million acres are in field crops primarily including alfalfa and other forages, canola and cereals. A very small proportion of the farmland is used for nursery products, fruits, berries, nuts, vegetables, silage corn and other field crops (roughly 2,470 acres total). The region supports a herd of roughly 100,000 cattle and calves almost exclusively for beef production, and smaller numbers of other animals. Beef production represents approximately one quarter of the BC total.

Agriculture in the BC Peace Region is primarily oriented toward export of crops and livestock. Gross farm receipts in the BC Peace region are roughly $150 million, or approximately $101/acre ($250 per hectare) of improved farmland, representing 0.6% of provincial GDP. Contribution margins are roughly half the provincial average, at 5.4% of farm cash receipts. Total farm capital in the region is approximately $1.8 billion, including $1.6 billion in land and buildings, and $230 million in machinery and equipment.

Dawson Creek and Fort St. John were each estimated to be 3% income-dependent on the agriculture and food sector in 2006, having declined from 6 and 7% respectively in 1991 (BC Stats). The labour force in “agriculture and other resource-based industries” was approximately 7,200 in 2006 (Statistics Canada). Of the 45,000 population of the Peace River Regional District (PRRD) aged 15 or older, 990 (2%) have post-secondary education in agriculture, natural resources and conservation.

Backward Linkages

Developing and operating irrigation will increase the need for equipment, supplies and services in the BC Peace region. The economic impacts of inputs to irrigated agriculture in the region may include:

1. investment and employment in irrigation system construction, operation and maintenance;
2. increased sales of seed, fertilizer and equipment, and new business opportunities related to training and supply chain; and
3. if large reservoirs are developed, potential for hydropower or recreational uses.

Forward Linkages

Increased and more reliable productivity of farmland, the capacity to produce a wider range of crops, and new water infrastructure will have a range of impacts on the BC Peace region. The economic impacts of outputs from irrigated agriculture in the region would include, including:

1. increased farmland value, as land becomes more productive and yields become more stable;
2. if irrigation is developed on a sufficient scale, investment and employment in processing and distribution; and
3. if irrigation is developed on a sufficient scale, growth in local communities as businesses are established to provide services to support more intensive, more diverse and more technically sophisticated agriculture.

Market Access and Competition

The BC Peace region is at a significant competitive disadvantage relative to the southern Alberta and Saskatchewan growing regions, where large areas of farmland are already under irrigation and the growing regions are near major population centres and have high distribution capacity. In particular, the Diefenbaker Lake system in Saskatchewan has unused capacity to irrigate at least 500,000 additional acres (200,000 ha), increasing the land area in Saskatchewan under irrigation by a factor of six. With the major reservoir infrastructure already in place and at higher elevation than the land to be irrigated, the cost of developing irrigation in Saskatchewan is substantially less than in the BC Peace Region.

Saskatchewan is closer to major markets and sources of supply, and its provincial economy would realize several additional benefits of expanding water supply systems for irrigation. These include increased potash production within the province, and addressing urban and industrial water needs with the same infrastructure used to supply irrigation.

Risks

Bringing farmland under irrigation can provide high value to producers and local communities by reducing risks, primarily the risk of crop loss and feed shortages due to drought. However, irrigation also introduces new risks and increases others. The following risks were assessed:

Drought

Drought is currently a primary risk to agriculture in the BC Peace Region, which is expected to become more prevalent with climate change. Currently, producers generally manage drought risk by managing herd sizes and areas of land in forage to ensure a modest surplus of hay each year, which can be sold into local and regional markets in most years. Drought risk to cereal and oilseed crops is typically covered through insurance.

The value of irrigation as a means of mitigating drought risk was assessed using the Tower Lake financial model as follows:

Net Cost of Irrigation as a Risk Mitigation Measure

Although irrigation is estimated to be less cost-effective in an average year than dryland production for each of the case studies analyzed, some producers may be willing to accept a reduction in annual average revenue to mitigate the risk of a large loss in the event of a severe drought. Over a 20-year life cycle, irrigated canola production without constructed water storage at Tower Lake (Scenario 1) is estimated to produce $180/acre/year less net revenue than unirrigated canola. This reduction in average revenue may be an acceptable cost to reduce drought-related financial risk. If constructed storage were required, the reduction in annual average net revenue would be an estimated $480/acre, which cannot be justified.

Increased Frequency of Historical 1:10 Year Drought

The greatest risk to unirrigated agriculture is a severe multi-year drought, a scenario which is predicted to become more likely by the 2050s. An increase in drought risk was modeled as an increase in the frequency of the current one in ten-year drought to two or more years in ten by the 2050s, and a correspondingly greater risk of a severe multi-year drought. As drought frequency increases and unirrigated yields decrease, irrigation becomes financially more favourable. The effect of more frequent drought on the financial feasibility of irrigating canola without constructed storage at Tower Lake (Scenario 1) was evaluated using the financial feasibility model. In order for irrigated canola at Tower Lake to generate equivalent life cycle net revenue to unirrigated canola, the frequency of the historical 1:10 year drought would need to increase to 1:2 years or more. This scenario is outside the range of likely impacts of climate change within the next 40 years, indicating that irrigation is unlikely to become financially favourable for canola at Tower Lake by the 2050s.

Solonetzic Soils

Solonetzic soils (also known as gumbo) are prevalent in the BC Peace Region, and are highly sensitive to the accumulation of salts. Land with up to 30% Solonetzic soils can be irrigated successfully; however, careful management is necessary to prevent loss of yield. Yields are generally lower and production costs may be significantly greater in these soils than in other types, reducing the cost-effectiveness of irrigation. Farmland with more than 30% Solonetzic soils is classified as non-irrigable in Alberta.

Soil Acidification

Irrigation necessitates higher fertilizer application rates. As fertilizers reduce soil pH, liming may be necessary to maintain pH within an acceptable range. Liming adds to the cost of production, and may diminish the cost-effectiveness of irrigation.

Water Availability and Quality

Most rivers, streams with very low summer and autumn flows, and lakes and aquifers in the main agricultural areas of the BC Peace region, are vulnerable to excessive use at the flow rates that are required for centre pivot irrigation. Groundwater resources in the BC Peace region can be extremely hard, and surface water sources fed from groundwater may also have relatively high hardness at times of minimum flow. There is a significant risk that water will be unavailable or of unacceptable quality in severe drought conditions, negating the benefit of irrigation as a drought management strategy. Climate change is likely to increase these risks.

Introduction of Pests and Disease with Irrigation

Pests that would normally die in the heat and dry weather will be able to flourish under irrigation. Certain plant diseases may also be promoted by irrigation. There is a risk that irrigation could contribute to reduced yields or crop losses in years that may otherwise produce good dryland yields. Pest and disease risks under irrigation will require new management techniques, adding to the cost of irrigated production and weakening the business case for irrigation development.

Safety

Irrigation will introduce new hazards to agricultural workers and the public, including:

- **Storage impoundments** – Larger dikes and dams are subject to the BC Dam Safety Regulation and must be classified, monitored and maintained in accordance with the regulation;
- **Major pipelines** – A break or accidental release of water from a high-capacity water pipeline could cause flooding, damage to nearby property or serious injury to anyone in the immediate area; and
- **New occupational hazards** – The construction and operation of water supply and irrigation systems will introduce several new occupational hazards to the local agricultural industry, including water under pressure, unfamiliar mechanical and electrical systems and controls, and new types of automated mobile equipment.

The cost of effectively managing all related risks must be considered in the business case to develop an irrigation system.

Summary of Findings

The central finding of this study is that in current market conditions, irrigated agriculture in the BC Peace Region is economically feasible only in very specific circumstances, generally at a small to medium scale where water of acceptable quality is locally available in sufficient quantity throughout the growing season. Combined with relatively low financial returns to land limited by the climate and soils of the BC Peace Region, the lack of local availability of water in most of the agricultural areas of the region generally limits the scale of feasible irrigation water supply systems to a few sections (hundreds of hectares).

Climate change will increase the feasibility of irrigation. However, the increase in drought frequency that would result in net returns from irrigated agriculture equivalent to those of unirrigated agriculture is outside the range of probable 2050s forecast scenarios. Substantial changes in economic conditions would also be necessary to develop a business case for irrigation on a larger scale.

The overall findings of the feasibility analysis are summarized in the Table E-6. Financial feasibility based on assumed average conditions is assessed for each scenario based on the case study analysis is shown as the 20-year NPV per acre for canola at a 5% annual discount rate, the BCR, and the difference in BCR from the status quo. These parameters indicate the expected life cycle impacts of irrigation on a producer's net returns to land investments. The influence of other factors on overall economic feasibility is indicated using '+', '-' or '0', reflecting the subjectivity of the analysis.

A scenario that is financially marginal but is positively influenced by most other factors may be economically feasible. The overall impact of these factors is summarized in the right column of the table.

The following findings are drawn from the case study analysis:

1. In all cases, dryland agriculture is estimated to be more profitable than irrigated agriculture when the life cycle capital, operation and maintenance costs of the irrigation system are taken into account. Investing in irrigation at any scale in the BC Peace Region is unlikely to increase net revenue to a producer growing traditional crops (cereals, oilseeds or forage grasses);
2. Irrigating forage grass in the BC Peace Region is not cost-effective under current or foreseeable future economic conditions. Maximizing forage production would require substantially more irrigation than cereals or oilseeds, and the increased net revenue per unit area of forage under irrigation is insufficient to cover the costs of irrigation;
3. Where an adequate water source is available near suitable farmland, irrigation of cereals or oilseeds may provide sufficient benefits to justify investment in water supply and irrigation infrastructure. The benefits to producers of revenue stabilization, reduction in drought risk and increased land value justify the net cost of irrigation in circumstances where irrigation is marginally feasible based on direct life cycle revenues and expenses. The business case must be considered for each individual project based on conditions available at the site;
4. Sufficient data are not available to assess the feasibility of irrigating forage seed crops as well as vegetables, sweet corn or other non-traditional crops in the BC Peace region. If similar net annual revenues to those in southern Alberta could be achieved in the BC Peace region for sweet corn and carrots, irrigation of those crops may be financially feasible. However, market volatility and uncertainty in yields translate to a high investment risks, and yields are likely to be significantly lower in the cooler climate of the BC Peace Region than in southern Alberta;

5. The value of irrigation to reduce drought risk may be sufficient to justify the cost of irrigation only in the most favourable scenarios. Under the most favourable scenarios evaluated, a producer would need to accept a reduction in average annual net revenue in the order of $200/acre to achieve the risk reduction benefit of irrigating canola. Although weather will become warmer and drought frequency may increase, a drought equivalent to the worst in the last 15 years would need to occur at least five of every ten years to reduce the benefit-cost ratio of dryland canola production to equal the life cycle benefit-cost ratio of irrigated production;
6. The distance of the BC Peace Region to major North American markets is a significant competitive disadvantage relative to irrigation districts in Alberta and Saskatchewan. Proposed projects such as the Upper Qu'Appelle in Saskatchewan, already well serviced with supply and distribution infrastructure, are likely to present a substantially stronger business case for investment than a similar project in the BC Peace Region;
7. Existing infrastructure needed for other purposes may provide important future opportunities for irrigation on a small to medium scale. Some agricultural producers have constructed water storage ponds for purposes mostly unrelated to irrigation, which may include livestock watering and sale of bulk water to the oil and gas industry. Oil and gas companies have cooperated with BC Hydro and the City of Dawson Creek to procure water, and have developed pipelines and storage facilities to meet their current needs. If the recent boom in oil and gas well completions declines within 20 to 30 years as predicted, water infrastructure may become available for irrigation; and

Coordinated planning may help to ensure that water infrastructure developed for other purposes will also be well suited to irrigation needs. The capacity of such infrastructure will be limited to relatively small irrigation projects, due to the relatively high volumes and peak flow rates required for irrigation. Although oil and gas companies are generally reluctant to share capacity in their infrastructure while they have potential needs for it, they are often willing to purchase water at favourable prices, potentially improving the business case for developing water supply infrastructure for irrigation. Licensing arrangements specific to this purpose need to be developed to ensure water sources are protected and usage is accurately reported while enabling sufficient flexibility for producers to recover their infrastructure costs.

Table E-6: Feasibility Analysis Summary

Scenario	NPV per acre (Canola)	BCR	Net BCR[1]	Backward Linkages	Forward Linkages	Drought Risk	Solonetzic Soils	Soil Acidification	Water Quantity	Pests and Disease	Safety	Summary
1 – Tower Lake	-$271	0.95	-0.19	0	+	0	-	-	-	-	-	Insufficient water supply to irrigate half section of canola without constructed storage. Near break-even for canola, but still not financially feasible. Increase in land value may justify irrigation development.
2 – Tower Lake w/ storage	-$1,865	0.74	-0.40	0	+	+	-	-	0	-	-	Constructed storage is not financially feasible and economic and risk reduction benefits do not justify the cost.
3 – Halfway River	$518	1.09	-0.05	+	+	++	0	-	++	-	-	Irrigation is slightly less cost-effective than dryland canola production; however land value and drought risk reduction benefits justify the cost.
4 – Beryl Prairie	-$1,000	0.86	-0.28	+	+	++	0	-	+	-	-	Constructed storage is not financially feasible and economic and risk reduction benefits do not justify the cost.
5 – Peace to Dawson	-$2,579	0.71	-0.43	++	++	+	-	-	+	-	--	Direct and indirect economic benefits combined do not justify the cost of a major irrigation project in the BC Peace region.
6 – Peace to Dawson with Storage	-$1,654	0.78	-0.36	++	++	+	-	-	+	-	--	
Site C to Rose Prairie[2]	-$1,417	0.85	-0.29	++	++	+	-	-	+	-	--	
Dam on Creek[3]	-$729	0.97	-0.17	++	++	+	0	-	+	-	--	These scenarios involve higher unit costs and risks than Scenarios 1 and 3, and no significant relative advantages. Benefits to producers and the community do not justify the costs and risks.
Sewage Effluent[d]	-$1,215	0.80	-0.34	+	+	+	-	-	0	-	--	
Groundwater[5]	-$2,105	0.70	-0.44	0	0	0	--	-	--	-	-	
Shared Infrastructure[6]	-$1,619	0.85	-0.29	++	+	+	0	-	0	-	--	
New Crop[7]	$-	1.00	-0.14	+	+	+	0	-	-	--	-	New irrigated crops including sweet corn and vegetables have the potential to improve the financial feasibility of marginal scenarios, including Scenarios 1 and 3.

1. BCR with irrigation minus BCR without irrigation
2. Site C dam to Rose Prairie - assume slightly more cost-effective than Peace to Dawson Creek due to reservoir elevation advantage
3. Assume slightly more cost-effective than Scenario 4 due to lower unit cost of storage
4. Assume Fort St. John lagoon effluent treatment and local distribution - less cost-effective than Scenario 4 due to added treatment requirement
5. Assume slightly less cost-effective than Scenario 2 due to cost of well construction
6. Assume substantially more cost-effective than Scenario 5 due to cost sharing with other users
7. Assume slightly more cost-effective than Scenario 1 due to higher net revenue per hectare

-- = major negative impact
- = minor negative impact
0 = negligible impact
+ = minor positive impact
++ = major positive impact

Recommendations and Next Steps

The following actions are recommended, which are consistent with the previous recommendations of the *Regional Adaptation Strategies series: Peace Region* report as noted:

1. Using the case studies described in this report as benchmarks, consider conducting site-specific feasibility assessments and pilot irrigation projects where most or all of the following conditions are met:
   a. The soils, climate and topography are suitable for production of grains and oilseeds;
   b. Soils are relatively well drained and less than 30% Solonetzic;
   c. A source of water supply is available throughout the growing season, with at least 1,174 m^3/acre of irrigated area (11.4 inches) per year in a dry year;
   d. The water source can reliably deliver a peak flow of 5 USgpm/acre (47 L/min/ha) for a single center pivot, or 1.7 USgpm/acre (16 L/min/ha) for every three center pivots, in a dry year;
   e. The water source is less than 0.6 miles (1 km) away and 65 feet (20 m) lower in elevation than the nearest centre pivot for projects to irrigate a quarter section (160 acres) or less; or less than 3 mi (5 km) away and 165 feet (50 m) lower in elevation for projects to irrigate more than one section;
   f. Hardness of the source water is low to moderate in mid to late summer;
   g. Three-phase power with adequate capacity is available within 0.6 miles (1 km) for projects to irrigate up to one section, and within 3 mi (5 km) for larger projects;
   h. Primary crops are cereals, canola, or other crops generating a similar or greater net revenue per unit area; and
   i. The producer has access to low-cost capital and will significantly benefit from increased revenue stability, reduced drought risk and improved land value.

   Pilot studies should include opportunities to evaluate inputs of capital, materials and labour, water demands, yields, costs, revenues and net returns to land for existing and potential future Peace region crop types including cereals, oilseeds, pulses, sweet corn, carrots, and forage seed crops. This recommendation supports Action 1.2B and Strategy 1.4 of the *Regional Adaptation Strategies series: Peace Region* report.
2. Further develop and formalize drought risk management strategies already in use for dryland forage production, including modest overproduction of hay, facilities and techniques for hay storage, and careful management of herd sizes within drought-resilient forage production limits. These strategies should be compared with the costs and risk-reduction benefits of irrigated feed production where irrigation is developed. This recommendation supports Strategies 1.5 and 3.2 of the *Regional Adaptation Strategies series: Peace Region* report.
3. Encourage collaboration between producers, governments, universities and industry organizations to fund and conduct pilot testing of irrigated agriculture in the BC Peace Region, including selection and optimization of a range of plant varieties, pest and disease management strategies, irrigation rates for a range of soil and climate conditions, and irrigation methods. Develop and maintain economic data to guide further development of irrigation where it yields the most benefit. This recommendation supports Strategies 1.4, 3.2, 4.2 and 4.3 of the *Regional Adaptation Strategies series: Peace Region* report.