FIGURE 11. Comparison of Lower Kananaskis Lake Annual Stage Range (PM 58) under the Base Case and the Alternate Scenarios

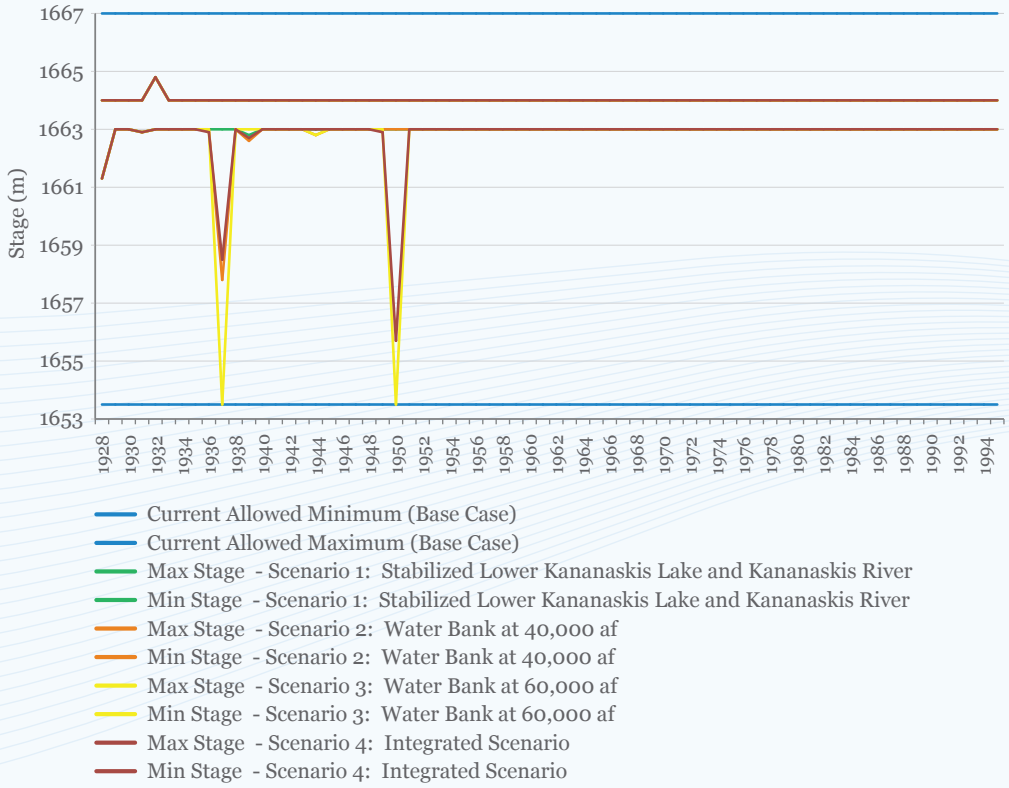
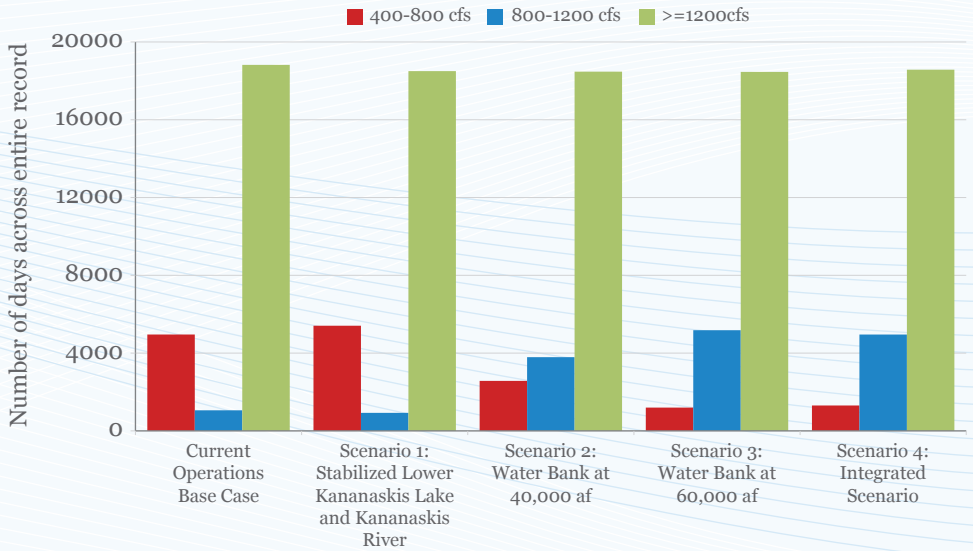


FIGURE 12. Comparison of Bassano Flows (PM 62) under the Base Case and the Alternate Scenarios



Although scenario 1 alone increases the number of lower-flow days (11.3-22.6 cms, or 400-800 cfs), the three scenarios that include a water bank dramatically reduce the number of these days. When the water bank is at 74,000 dam^3 (60,000 acre feet), as it is for scenarios 3 and 4, the number of low-flow days is 20-25% of the number for the base case and scenario 1. Thus, it is clear that some water bank water is needed to offset any possible

negative impacts of stabilizing Lower Kananaskis Lake and Kananaskis River. In addition to affecting Bassano flows, there could be negative effects in Calgary in some years with just this stabilization and no water bank.

Several other key performance measures, including PM 6 (flood events in Calgary), PM 18 (walleye spawning), and PMs 50-53 (reservoir recreation seasons), were essentially unchanged by any of the scenarios from the base case. Significantly, this was also the situation with PM 5 (apportionment) and PM 64 (percent of natural flow before the Bow/Oldman confluence). In other words, none of the alternate scenarios showed any significant impact on the natural flow that is passed on to Saskatchewan. The full set of performance measures is included in Appendix D.

The alternate scenarios are expected to have a substantial benefit for the aquatic ecosystem of the Kananaskis River above Barrier Dam. For the most part, improvement on the Kananaskis River does not come at a cost to the Bow River and alternate scenarios even show some benefit to the Bow at various times of the year. However, under the alternate scenarios, there may be lower flows in April in the Bow to enable storage of water to offset other environmental effects later in the year. Further work is needed to better understand any possible effects on instream flow needs.

3.4 SCENARIO STRESS TESTS

To assess how well select scenarios might respond to future challenges and stresses, five stress tests were performed on the base case and all of the alternate scenarios. The full results of all the stress tests can be viewed in the BROM and its attached charts.

Stress test 1: Calgary region demands increased by a factor of 2.4

This was identified as an important stress test to validate that the proposed alternate scenarios would address future population demands and support *Water for Life* goals. The stress test went beyond the forecast in the Calgary Metropolitan Plan of 1.6 times current municipal water use, and modelled the full use of the Calgary licence at 2.4 times current municipal water use. This increase in water use by municipalities of 2.4 times current use had little impact on overall water flow or on any of the performance measures, as seen in Figure 13.

In particular, this increase in municipal demand does not substantially increase shortages for the irrigation districts, as Figure 13 indicates. Although more water is being taken, the municipal return flow remains at about 85% and total water used is still small relative to irrigation diversions.

Irrigation Canal

Stress test 2: Irrigation District return flows at 10% of total diversion

This stress test was designed to assess the impact if the irrigation districts were to provide 10% return flow back to the river. Some increased shortages were apparent for EID and BRID over the historical record with the two alternate scenarios, as Figure 14 shows. Most return flows come in below Bassano or into the Red Deer or Oldman Rivers, which were not part of the BROM.

FIGURE 13. Effect of Stress Test 1 (Increased Calgary Region Demands) on Days with Shortage (PM 13) under the Base Case and Scenario 3: Water Bank at 60,000 acre feet

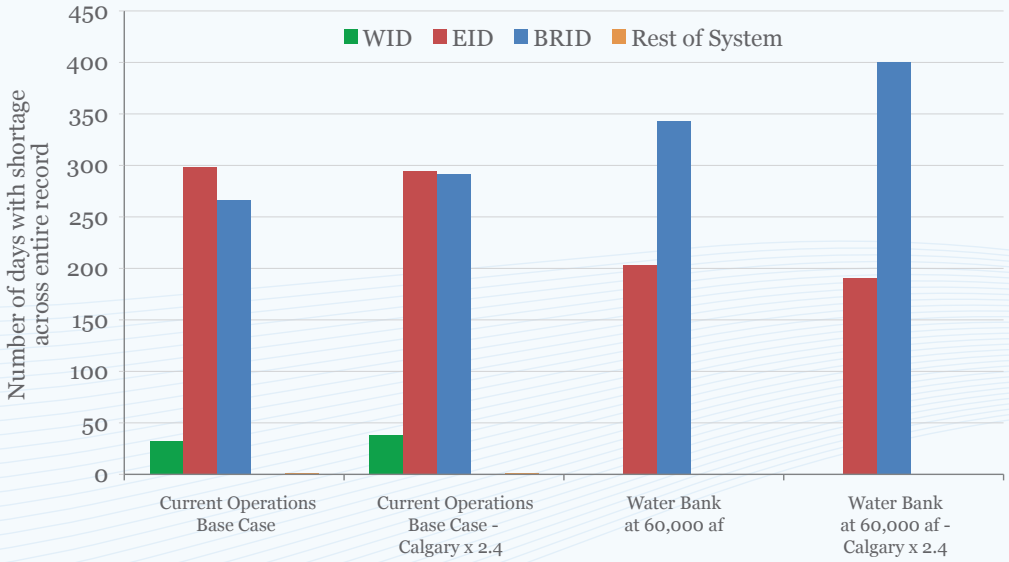
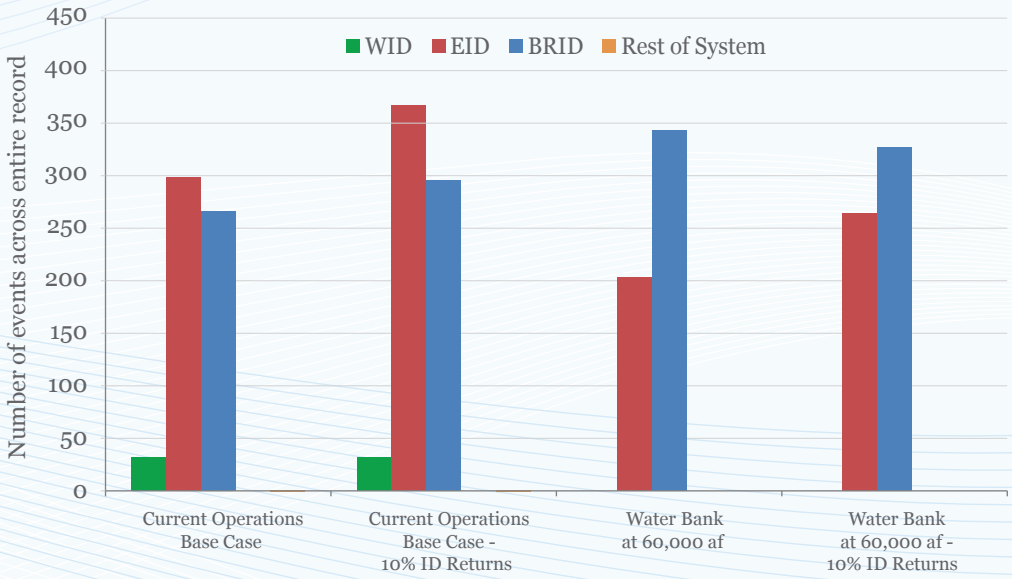


FIGURE 14. Effect of Stress Test 2 (Reduced Irrigation Return Flows) on Days with Shortage (PM 13) under the Base Case and Scenario 3: Water Bank at 60,000 acre feet



Stress test 3: Three consecutive wet years

This test looked at the impact on performance measures of three consecutive wet years; the years chosen were 1965-1967. In general, the results demonstrated that there was little impact from the alternate scenarios compared to the base case and the alternate scenarios outperformed the base case.

Stress test 4: Three consecutive dry years

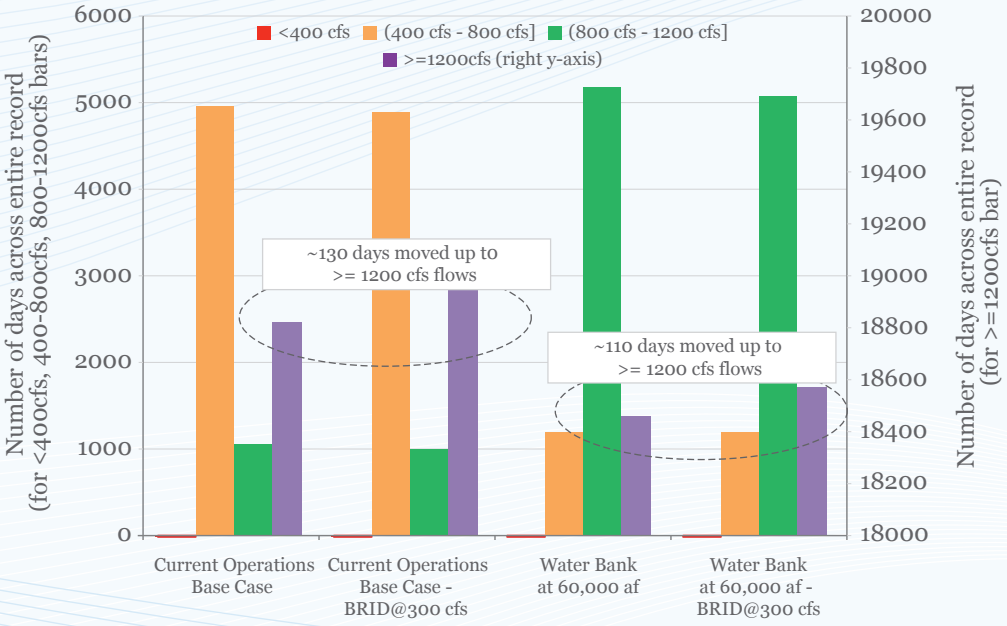
This stress test looked at the impact on performance measures of three consecutive dry years; the years chosen were 1983-1985. In general, the results demonstrated that there

was little impact from the alternate scenarios compared to the base case and the alternate scenarios outperformed the base case.

Stress test 5: BRID infrastructure at 300 cfs from 500 cfs

As described in the box below and referenced in other parts of this report, the BRID canal infrastructure requires a minimum flow of 14.1 cms (500 cfs) to enable off-take at the Carseland diversion. The stress test was designed to test the effect of reducing this minimum requirement from 14.1 cms to 8.5 cms (500 cfs to 300 cfs). Figure 15 illustrates that reducing the minimum flow required for BRID increases the number of days with substantially higher flows at Bassano. This chart likely understates the full benefits, as it does not show flow improvements within the bars; for example, moving flows from 450 cfs to 750 cfs. This infrastructure change would produce a substantial net benefit, particularly on the most critical low-flow days in late summer.

FIGURE 15. Effect of Stress Test 5 (BRID Infrastructure Change) on Bassano Flows (PM 62) under the Base Case and Scenario 3: Water Bank at 60,000 acre feet



3.5 WATER QUALITY IMPACTS OF THE INTEGRATED SCENARIO

Alberta Environment agreed to run the OASIS output through its Bow River Water Quality Model (BRWQM), which covers the reaches of the Bow from Bearspaw Dam to Bassano Dam. The BRWQM is an integrated system of selected surface water quality and quantity models that is used to assess and compare the water quality impacts of different scenarios and has been used as part of a number of computer model exercises to support the South Saskatchewan Regional Plan (Government of Alberta, 2010)

At the point in the project when the Consortium worked with Alberta Environment to run the BRWQM, it was decided to test the integrated scenario. At that time, the integrated scenario included stabilized Lower Kananaskis Lake and Kananaskis River, and restored Spray; a water bank and increased storage at Langdon reservoir were not part of the integrated scenario when the BRWQM was run.

Alberta Environment took output from the OASIS model for both the base case and the integrated scenario and ran it through the BRWQM. This analysis was done to represent three hydrologically different years, selected by the Consortium: 1988, 1990 and 1993. The assessment nodes, reflecting the three reaches of the river in the model (Bearspaw to Highwood, Highwood to Carseland, and Carseland to Bassano), were Stiers Ranch, Carseland and Bassano, and the parameters were water temperature, dissolved oxygen, and phosphorus. Due to the time constraints of the project, this model run was done using a semi-final version of the data. As the Bow River Operational Model is refined over time, there will be future opportunities to again run it through the BRWQM.

Bearspaw Water Treatment Plant, Calgary

The water quality simulation results for the base case and the integrated scenario show essentially no differences in water quality for any of the three parameters at any of the three sites, as noted in Table 3 and Figure 16.

TABLE 3. Summary of Bow River Water Quality Modelling Results

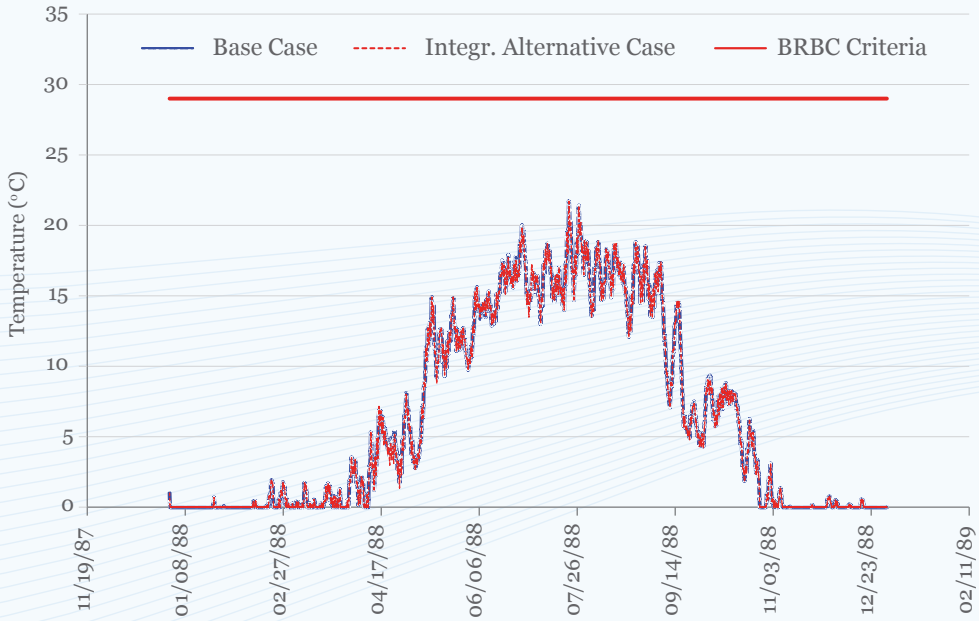
1. WATER TEMPERATURE									
	Evaluation Criteria	Averaging Period	Assessment Node	Water Temperature Exceedance (days)					
				Base Case			Integrated Scenario		
				1988	1990	1993	1988	1990	1993
Central Bow River	<=24° C	instantaneous	Stiers Ranch	0	0	0	0	0	0
			Carseland	0	0	0	0	0	0
Lower Bow River	<=29° C anytime	instantaneous	Bassano	0	0	0	0	0	0

2. DISSOLVED OXYGEN - ACUTE									
	Evaluation Criteria	Averaging Period	Assessment Node	Dissolved Oxygen Exceedance - acute (days)					
				Base Case			Integrated Scenario		
				1988	1990	1993	1988	1990	1993
Central Bow River	>=5.0 mg/L	instantaneous	Stiers Ranch	0	0	0	0	0	0
			Carseland	0	0	0	0	0	0
Lower Bow River			Bassano	0	0	0	0	0	0

3. DISSOLVED OXYGEN - CHRONIC									
	Evaluation Criteria	Averaging Period	Assessment Node	Dissolved Oxygen Exceedance - chronic (days)					
				Base Case			Integrated Scenario		
				1988	1990	1993	1988	1990	1993
Central Bow River	>=6.5 mg/L	7 day mean	Stiers Ranch	0	0	0	0	0	0
			Carseland	0	0	0	0	0	0
Lower Bow River			Bassano	0	0	0	0	0	0

4. TOTAL DISSOLVED PHOSPHORUS									
	Evaluation Criteria	Averaging Period	Assessment Node	Total Dissolved Phosphorus Exceedance					
				Base Case			Integrated Scenario		
				1988	1990	1993	1988	1990	1993
Central Bow River	<=0.015 mg/L	daily mean	Stiers Ranch	169	118	164	167	119	166
			Carseland	131	0	167	131	79	165
Lower Bow River			Bassano	62	63	133	58	65	134

FIGURE 16. BRWQM Predicted Temperature (Degrees C) at Bassano for Three Consecutive Drought Event Scenarios
{Source: Alberta Environment}



3.6 POTENTIAL BENEFITS FROM THE PREFERRED SCENARIO

The Consortium reviewed the modelling results and concluded that a water bank approach to managing the Bow River System was very desirable, producing a wide range of economic, environmental and social benefits. For the purpose of this section of the report, the focus is on the water bank scenario with 74,000 dam³ (60,000 acre feet) of available water (scenario 3 in the modelling outputs). This is referred to as the Preferred Scenario from this point forward. To recap, the Preferred Scenario features the following major changes from current operations:

- The capacity of Langdon reservoir is doubled from 8,340 dam³ to 16,700 dam³ (6,750 acre feet to 13,500 acre feet).
- Lower Kananaskis Lake is stabilized at 1663.5 metres—3.5 metres below the current 1667-metre full supply level (FSL)—with a fluctuation of ± 0.5 metre; this is a significant change from current annual fluctuation of up to 13.5 metres. This reservoir is not allowed to use its spillway unless elevation rises above 1667 metres. Stabilizing Lower Kananaskis Lake was modelled based on the operating parameters proposed by FREWG (2001).
- Discharge flows into the Kananaskis River from the Pocaterra power plant are held steadier, with the objective of ensuring that within-day instantaneous flows vary by no more than a factor of three, maximum day-to-day instantaneous flows vary by no more than a factor of two, while minimum day-to-day instantaneous flows vary by no more than a factor of 0.5.
- Access is provided to 74,000 dam³ (60,000 acre feet) using the “water bank” approach.

The Preferred Scenario could be enhanced to provide additional potential benefits by considering the option of restoring Spray, thus providing storage and managed access to another 75,200 dam³ (61,000 acre feet) of water. The Preferred Scenario with this option included was modelled as the integrated scenario (scenario 4).

Further work is required to assess how the integrated scenario might be implemented and the extent of additional benefits that would accrue. Although there was not time to reliably quantify all of the value that could be obtained through the Preferred Scenario, a number of benefits clearly emerge if this scenario were to be implemented. These benefits are described in the following sections. None of the proposed changes are expected to affect deliveries under Alberta's existing priority water allocation system.

3.6.1 MEETING THE NEEDS OF A GROWING POPULATION

A key desired outcome of the BRP is mitigating future risk for a growing population that will need access to water. There are limited opportunities for new reservoirs in or around Calgary and the only current option may be off-stream storage. Costs to construct an off-stream storage reservoir with capacity of 67,800 dam^3 (55,000 acre feet)—considered sufficient to serve 70,000 people outside the Calgary Regional Partnership—has been estimated at $115-million (WID, 2009). Thus the next best sources of available water are likely to be costlier for municipalities, compared to using existing and expanded upstream storage. There are some advantages to having off-stream storage near the licensed use, especially if the use is critical to the user, as this storage can offset periods when water cannot be taken directly from the river. Examples include municipal use, an industry that requires water continuously for its processes, and fire protection.

The Preferred Scenario may also improve opportunities to manage waste assimilation from higher base flow during certain times of year if total loading increases from population growth and municipal expansion. The focus of the BROM on water supply complements the work being done by municipalities to improve water conservation, efficient use and water treatment technologies.

Calgary Region Water Needs

The Calgary Regional Partnership has forecasted municipal use of water to 2076; their most likely scenario projects municipal water use to increase by approximately 1.6 times current use given technological changes and other conservation measures. To add in a 50% margin for error to the forecast, the BRP increased this forecast future use of water for municipalities to encompass the entire amount of all the City of Calgary water licences, which amounted to 2.4 times the amount of water presently used. This amount of water for municipal use was the basis for the stress test for each scenario.

Given the uncertainties related to where water diversions may be located and the timing of these diversions and return flows over the next 65 years, the BROM simply took this amount of water at Calgary and forecast return flows of 85% downstream of Calgary. This increase in water use by municipalities of 2.4 times current use had little impact on overall water flow or on any of the performance measures because return flows are high and the total water used is still small relative to irrigation diversions. Since the flow rate did not change significantly, and the assumption is that wastewater treatment technology over the next 65 years will at least match the small reduction in flow, water quality should not be affected. If water quality is affected, additional flow may be available under the larger water bank and the integrated scenarios. To further refine the analysis, future testing of the model should include specific parameters for water effluent from the system based on forecast water use, return flow and forecast technologies for wastewater treatment.

3.6.2 ENHANCED AND EXPANDED RECREATION OPPORTUNITIES

Information and data to determine recreation and tourism benefits across the entire basin are lacking. However, substantial positive impacts are expected to emerge from managing the Bow River in a different way, and the need for such opportunities has been noted in the terms of reference for the South Saskatchewan Regional Plan.

This project and the associated performance measures indicate that the Kananaskis area, which is already a globally recognized recreation destination, would benefit from the proposed changes in river management. A re-managed Bow system, including the Kananaskis, would enhance opportunities and expand the shoulder season for rafters, kayakers, canoeists and anglers as well as those who support the recreation and tourism industry (hotels, restaurants, retailers, fishing guides, travel operators and the nearby casino/hotel). For example, in 2001, it was noted that stabilizing Lower Kananaskis Lake could increase annual visitor-days by 35% through expansion of lakeshore recreation and some new facilities, dramatically improve productivity of the littoral zone, increase fish production by three times or more, improve wildlife habitat in the re-vegetated shoreline area and improve the aesthetics of the lake (FREWG, 2001). The river from Barrier Lake power plant down to the confluence with the Bow could also be managed during certain portions of the year to enhance the recreational and commercial use of the significant white-water run.

3.6.3 FLOOD MITIGATION

Integrated management of the Bow system could reduce the peak of moderate flood events, but would require an improved forecasting capability; e.g., if a flood or heavy rain in the headwaters was forecast, one or more reservoirs could be drawn down in advance. This could be a very important factor for population centres. For example, Ghost reservoir upstream of Calgary could be adjusted within the Preferred Scenario to increase the full supply level by three metres, but reserved for flood emergency purposes only. This would have enabled Ghost reservoir to have absorbed one full day of the ten days of flooding in 2005 in Calgary.

Bow Bridge, Calgary

Depending on the operating decisions, this amount of emergency storage may have been used to reduce the peak flow for a few hours on several of those days. Other potential flood mitigation opportunities are available, but only for helping to mitigate moderate flooding events. A more detailed assessment is needed to determine costs and benefits of potential flood mitigation than could be done by this project. Given the potentially catastrophic consequences of recorded historic (and indicated prehistoric) floods, it is only prudent to more carefully assess the potential for flood mitigation.

It is recognized that considering Ghost reservoir for potential emergency flood mitigation could affect local residences, so this possibility needs further assessment and analysis.

3.6.4 DROUGHT MITIGATION

There are opportunities for drought mitigation if management decisions were made for water storage to be carried over for emergency human supply under certain drought conditions. There are risks involved in carry-over storage in the event of an unexpected flood event. Improvements would be needed in snowpack monitoring, short- and longer-term weather forecasting, and modelling, but over the long term, significant opportunities could be available from coordinated management of the reservoirs. Part of the Preferred Scenario involves a stabilized Lower Kananaskis Lake to improve the aquatic ecosystem and fisheries. This reservoir could act as a water supply of last resort for human use in the event of an Australian-like drought emergency.

Stabilizing this reservoir for environmental protection and fish productivity may provide this important secondary purpose and would certainly be less damaging to the system than what currently happens with an annual draw down of up to 13.5 metres. Drought mitigation planning by all the users of the Bow System could also be valuable to irrigation districts by such methods as refilling off-stream reservoirs to their full supply level in the fall, thus providing carry-over water for municipal and agricultural purposes.

3.6.5 IRRIGATION

Value-added and yield contributions from irrigated agriculture is estimated at 2.66 times those of dryland farming (Anderson and Associates Ltd., 2002) and some particularly high-value crops can only be grown in southern Alberta under irrigation (e.g., peas, sweet corn, sugar beets, carrots, dry beans). Irrigation expansion has been driven primarily by improved efficiency and many irrigators believe they can live within their existing water allocations.

Irrigation pivot

Continued conservation efforts through water controls and on-farm technologies will create an opportunity to increase irrigated acreage and agricultural production with the same Bow River water diversions. The BROM can assist in setting the acreage limits that demonstrate that river sources are not negatively affected.

3.6.6 FISH HABITAT

Fish habitat is defined as “spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes” (Fisheries Act, sec. 34(l)). Any aspect of river management that improves the aquatic environment and riparian health is likely to also improve the fisheries in those reaches. A study done during the 1990s (FREWG, 2001) found that altering the operating criteria of the Pocaterra power plant could at least triple biological productivity, including fish productivity, in Lower Kananaskis Lake. The BRP modelled the hydrologic feasibility of this considerable improvement to the aquatic ecosystem in the Bow headwaters and found it to be doable without having a large impact on capital costs for hydro operations.