

KANANASKIS RIVER SYSTEM ASSESSMENT

**Lower Kananaskis Lake
and the Kananaskis River
from Lower Kananaskis Lake to Barrier Lake**

**Fisheries and Recreation Enhancement Working Group
(FREWG)**

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SUMMARY

The Fisheries and Recreation Enhancement Working Group (FREWG) was formed in 1992 to examine options for improving fish habitat and recreational opportunities for reservoirs and rivers affected by hydroelectric operations in Alberta.

To focus its efforts, FREWG ranked the water bodies affected by hydroelectric development. The top priority was the Kananaskis River system, specifically Lower Kananaskis Lake and the Kananaskis River downstream to Barrier Lake.

Considerable fishery and recreation information was available for the Kananaskis River system. However, a number of data gaps were identified. Commencing in 1994, a series of projects were initiated by FREWG to fill the most important data gaps.

FREWG evaluated a wide variety of scenarios for improving water management within the Kananaskis system. These scenarios included

- existing operation of the Pocaterra Power Plant and five alternatives
- existing management of Lower Kananaskis Lake and four alternatives.

The evaluation of scenarios examined the key factors that must be considered in managing water in the Kananaskis system. These factors include the costs associated with changes in the production of electricity, biological productivity of Lower Kananaskis Lake, fish habitat in the Kananaskis River, reservoir and river recreation, flood control and safety, impact on the Bow River, and the effect on winter ice jams.

FREWG concluded that there would be substantial benefits from changes in the management of Lower Kananaskis Lake and the Kananaskis River (Lower Kananaskis Lake to Barrier Lake). The greatest benefits would be provided by what is designated Scenario 4b which includes stabilization of Lower Kananaskis Lake and operation of the Pocaterra Plant to provide average weekly flow in the Kananaskis River. The benefits of Scenario 4b are:

- a tripling of the biological productivity of Lower Kananaskis Lake
- improved access to the lakeshore, better fishing opportunities, and improved aesthetics at Lower Kananaskis Lake
- a substantial increase in fish habitat in the Kananaskis River to a level comparable to natural conditions
- a positive effect on reducing winter ice jams.

However, Scenario 4b is only recommended if a satisfactory financial strategy can be developed for mitigating the costs of implementing improvements (\$9.8 million dollars over 13 years). As well, it is recommended that several issues be assessed in more detail and that no changes in water management should be made without consultation with the people who could be affected by a decision.

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1 INTRODUCTION

1.1 History of FREWG

In October of 1992, the Fisheries and Recreation Enhancement Working Group (FREWG) was formed to examine options for improving fish habitat and recreational opportunities for reservoirs and rivers affected by hydroelectric operations in Alberta. FREWG is a partnership among Trout Unlimited Canada, TransAlta Utilities, Parks Canada, Fisheries and Oceans Canada, and Alberta Environment. The group's mission statement is "To provide stewardship for improving fish habitat and enhanced recreational opportunities."

The objectives of FREWG are:

- to define management objectives for fish and recreational uses within waters affected by hydroelectric operations in Alberta,
- to identify and assess existing fish and recreational management issues and concerns,
- to evaluate options which address these issues and concerns,
- to determine strategies for the improvement of fish habitat and recreational opportunities, and
- to seek approval of recommended strategies and implement, monitor, and evaluate approved strategies.

As well, FREWG adopted the following principles (not in any order of priority) to guide its work:

- Work would be conducted in a spirit of partnership and shared responsibility.
- There would be no compromise in dam or public safety.
- The concepts of sustainability and biological diversity would be emphasized with the goal of establishing healthy, naturally sustaining populations of bull, cutthroat, rainbow and brown trout.
- There would be no compromise in TransAlta's corporate performance.

1.2 The Issue

TransAlta's hydroelectric operations have long provided reliable, relatively cheap power to help meet the needs for electricity in Alberta. As well, the reservoirs and some downstream sections of rivers provide recreational opportunities that did not exist before construction of the dams. However, there are negative impacts on the environment and on recreational opportunities associated with dam construction and operation.

An important characteristic of hydro plants is that the generators can respond rapidly to increase or decrease their rate of generation. Because of this, the TransAlta hydro facilities are primarily used within the Alberta electrical system for two purposes. The first is to cover peak daily demand periods, when electricity consumption increases rapidly but for relatively short periods of time. This mode of operation is referred to as "peaking" operation. The second is for load control, which is the minute-to-minute variation in electricity demand within the Alberta system.

Only about 3% of TransAlta's total annual generation is produced by the Bow River hydro system. However, because of the significant role this generation plays for peaking and load control, the Bow River hydro system provides a very important service to the Alberta electrical system.

One result of peaking and load control operations at hydro plants is that water levels in downstream river reaches may fluctuate substantially over the course of daily operations. This has impacts on fish and wildlife habitat, riparian vegetation, recreation, and aesthetics.

Another characteristic of hydro operations is the storage and release of water in reservoirs. The natural hydrologic cycle in Alberta is characterized by high flows during the spring and early summer, followed by low flows during the fall and winter. In order for hydro plants to provide a more reliable source of generation throughout the entire year, reservoirs are commonly constructed to store water during high flow periods for subsequent release during low flow periods.

The annual fill and drawdown cycle in the TransAlta hydro reservoirs has a range of impacts. In downstream river reaches, peak flows during runoff are reduced which provides a marginal reduction in the probability of flooding. More importantly, winter flows are substantially increased. This provides benefits for water supply, effluent dilution and fish habitat, but can also adversely affect the formation and stability of river ice cover. In the reservoirs themselves, the resulting variation in water level over the course of a year is large enough that it prohibits the formation of a biologically productive littoral zone around the perimeter of the lake, as would exist around a natural lake. This can directly impact fish and wildlife habitat. Reservoir level fluctuation also affects recreation and aesthetics.

1.3 Priorities

It was recognized from the beginning that FREWG's mandate was very broad, the potential projects were many, and the resources that participants could devote to the work were limited. To be effective, FREWG needed to focus on key projects and water bodies. At its third meeting in January 1993, FREWG established a set of priorities. These were established after considering mitigation and enhancement initiatives in other jurisdictions and documenting existing issues, data, legal requirements, and operational procedures.

To determine which water bodies should be the focus of its efforts, FREWG ranked the various water bodies affected by hydroelectric development. This ranking considered factors such as

safety, energy production, existing fish habitat and recreational use, and the potential for improving fish habitat and recreational opportunities. The priorities were:

Reservoirs

- 1 Lake Minnewanka
- 2 Upper and Lower Kananaskis Lakes

River Reaches

- 1 Bow River below Ghost Dam
- 2 Kananaskis River
- 3 North Saskatchewan River below Bighorn Dam

In 1996, following completion of TransAlta's study of Lake Minnewanka, FREWG re-examined its priorities. An extensive evaluation of factors ranging from ecological integrity to peaking capability resulted in the following priorities being established:

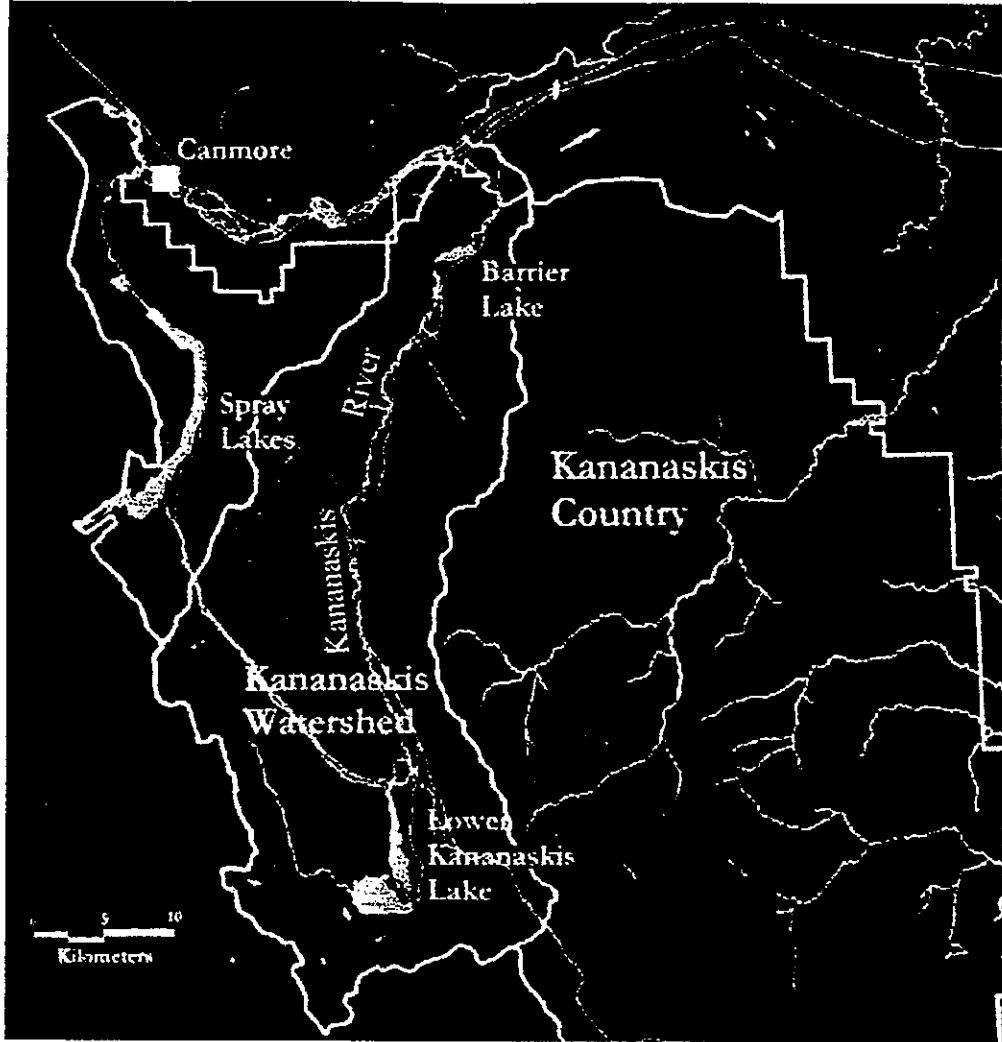
- 1 Kananaskis system (Lower Kananaskis Lake, Barrier Lake, and the Kananaskis River below Lower Kananaskis Lake)
- 2 Cascade River below Lake Minnewanka
- 3 Bow River from Ghost Dam to Bearspaw Reservoir

For more information on priority-setting, please see Section 5.1 and the reports *A Proposal for a Fisheries, Recreation and Water Management Plan for the Kananaskis River System* and *FREWG Priorities*.

2 PURPOSE OF THE ASSESSMENT

This report summarizes the results of FREWG's assessment of options for improving fisheries and recreational opportunities in the Kananaskis River system. (See Map 1.) The two key components of the system that were assessed are Lower Kananaskis Lake and the Kananaskis River from Lower Kananaskis Lake to Barrier Lake. This assessment considered existing data and the various studies and investigations done by FREWG and its member organizations. Reports used by FREWG in this assessment are included in the Bibliography (Appendix E). The purpose of this report is to provide decision-makers with the information, tools and recommendations to determine if changes should be made in the management of the Kananaskis River system.

This assessment was preceded by a desktop study to review management options for Lower Kananaskis Lake. That study scoped the effects, both positive and negative, of improving fish production and recreational opportunities.



Map 1
Kananaskis Watershed

3 EXISTING SITUATION

3.1 Hydro Operations

TransAlta operates three hydroelectric developments along the Kananaskis River. Moving downstream through the river basin, these are Interlakes Plant on Upper Kananaskis Lake, Pocaterra Plant on Lower Kananaskis Lake, and Barrier Plant on Barrier Lake.

Upper Kananaskis Lake was a natural lake but has been increased in size and depth by dam construction. Initial development took place in 1933 and involved building a small dam to increase depth and regulation of lake water levels to augment winter generation at downstream power plants on the mainstem of the Bow River. This was followed by an increase in dam height in 1942 and construction of the Interlakes Plant in 1955. Upper Kananaskis Lake has a total storage capacity of 101,000 acre-feet, making it the third largest reservoir in the Bow River hydro system. The Interlakes Plant has a capacity of 5 megawatts, with typical annual power production of 8,600 megawatt-hours.

Lower Kananaskis Lake was also a natural lake and has similarly been increased in size and depth by dam construction. The dam and power plant were both constructed in 1955. Lower Kananaskis Lake has a total storage capacity of 51,000 acre-feet. The Pocaterra Plant has a capacity of 15 megawatts, with typical annual power production of 29,500 megawatt-hours. The physical configuration of the Pocaterra development is unique and quite different from Interlakes or Barrier. At the latter two facilities, the power plant is located immediately at the toe of the dam. However, the Pocaterra plant is located approximately 1.3 km downstream of the dam and is connected to the reservoir by a penstock. This was done to maximize the vertical elevation difference between the reservoir and power plant, which correspondingly increases the generating potential of the hydro plant.

Barrier Lake was created by the Barrier hydro development. The dam and power plant were constructed in 1947. Barrier Lake has a total storage capacity of 20,000 acre-feet. The Barrier Plant has a capacity of 13 megawatts, with typical annual power production of 40,400 megawatt-hours.

The combined generating capacity of the three Kananaskis River hydro plants is 33 megawatts, which is roughly 10 percent of the generating capacity of TransAlta's Bow River hydro system. All three hydro plants are operated in a block peaking mode, meaning that the plants are either "on" or "off", with no intermediate operation, and that the timing of plant operations is geared to daily peak electrical demand periods.

The Interlakes Plant discharges directly into Lower Kananaskis Lake and as a result, peaking operations at this facility have limited downstream impacts. Peaking operations at the Pocaterra Plant result in fluctuating water levels along a 40 km reach of the Kananaskis River extending downstream to Barrier Lake. Numerous tributary streams join the Kananaskis River through this reach which results in some attenuation of water level fluctuations. Peaking operations at the Barrier Plant result in fluctuating water levels along a 10 km reach of the Kananaskis River to its

confluence with the Bow River. No tributary streams of consequence join the Kananaskis River through this reach.

The combined storage capacity of the three hydro reservoirs is 172,000 acre-feet, which accounts for 30 % of the total storage in the Bow hydro system. Of this amount, 58% is held in Upper Kananaskis Lake, 29% in Lower Kananaskis Lake and 13% in Barrier Lake. Reservoir operations at all three lakes result in substantial water level variation over the course of a year. Typical annual fluctuations are 11.5 m at Upper Kananaskis Lake, 10 m at Lower Kananaskis Lake and 6 m at Barrier Lake. (Based on TransAlta operating records)

3.2 Fisheries

3.2.1 Upper Kananaskis Lake

Upper Kananaskis Lake was originally barren of sport fish. It was first stocked with adult cutthroat trout in 1914. Rainbow trout were introduced in 1935 and were regularly stocked as fingerlings from 1968 to 1988. Poor survival of the stocked rainbow trout fingerlings resulted in very low catch rates and a very poor return to the angler; only 1% of the stocked fish were harvested at an estimated cost of \$116/kg of trout harvested (Stelfox 1985). Since 1992, the stocking program has been redesigned to involve placement of catchable-size (>20 cm) rainbow trout. This management program costs more for each fish stocked, but has improved the fishery by increasing the catch rate (Alberta Environment file data).

Fluctuation of the water level, which prevents the development of a productive littoral zone, is considered to be the major factor limiting the quality of the fishery in Upper Kananaskis Lake.

3.2.2 Lower Kananaskis Lake

Prior to development as a hydro reservoir, Lower Kananaskis Lake supported a self-sustaining fishery for native bull trout and westslope cutthroat trout. Cutthroat trout virtually disappeared from Lower Kananaskis Lake following impoundment because their two key spawning areas - in the inlet and outlet of the lake - were destroyed by damming and diversion. Bull trout have maintained a self-sustaining population in the lake by spawning in Smith-Dorrien Creek (Stelfox and Egan 1995; Stelfox 1997).

Efforts have been made to create a rainbow trout and, more recently, cutthroat trout fishery in Lower Kananaskis Lake through stocking fingerling fish. As was the case in Upper Kananaskis Lake, poor survival of the stocked fingerlings resulted in very low catch rates and a very poor return to the angler; only 1% of the stocked fish were harvested at an estimated cost of \$62/kg of trout harvested (Stelfox 1985). Fluctuation of the water level, which prevents the development of a productive littoral zone, is considered to be the major factor limiting the quality of the fishery in Lower Kananaskis Lake. Lack of suitable spawning habitat also prevents the establishment of a self-sustaining cutthroat trout fishery.

The bull trout population in Lower Kananaskis Lake uses Smith-Dorrien Creek as its spawning area. This portion of the system was relatively unaffected by hydro development. Juvenile bull trout remain in the creek for two to four years before entering the lake.

Over-harvest by angling has proven to have a major impact on the Lower Kananaskis Lake bull trout population. By 1992, the bull trout population in the lake had declined to such an extent that there were only 60 adult fish in the entire spawning run. At that time, fishing regulations for Lower Kananaskis Lake and Smith-Dorrien Creek were revised dramatically. Since 1992, bull trout have staged a remarkable recovery such that by 1998 the spawning run consisted of 1,278 adult fish - more than a 20-fold increase in six years (Mushens and Post 2001). It is not known whether the ultimate size of the bull trout population in the lake will be determined by the availability of spawning and rearing habitat in Smith-Dorrien Creek or by the extent to which fluctuating water levels in the reservoir affect the survival and growth of juvenile bull trout after they enter the lake.

3.2.3 Kananaskis River from Lower Kananaskis Lake to Barrier Lake

Prior to hydro development, the Kananaskis River below Lower Kananaskis Lake supported a self-sustaining fishery for native bull trout, westslope cutthroat trout and mountain whitefish. At present, bull and cutthroat trout are largely absent from this reach of river, but a self-sustaining population of mountain whitefish remains. Self-sustaining populations of brook trout and brown trout are now present in this reach of river as the result of earlier stocking efforts (Paul et al. 1997; Courtney et al. 1999).

The brown trout and mountain whitefish are primarily found in the lower half of the reach. These populations appear to spend part or all of the open-water season in the river, then over-winter in Barrier Lake. Brook trout and mountain whitefish are the primary species found in the upper half of this river reach (Boag 1997).

Fish populations are substantially lower in the Kananaskis River than in other east-slope Rocky Mountain streams that are unregulated or less significantly regulated. The quality of the fishery in this reach of the Kananaskis River is generally poor. The fluctuation of water level which results from peaking operations at the Pocaterra Plant is considered to be the major factor limiting the quality of the fishery in this reach of river (Courtney et al. 1999).

3.2.4 Barrier Lake

Barrier Lake did not exist prior to construction of the dam and power plant in 1947. As noted in the previous section, self-sustaining populations of brown trout and mountain whitefish alternately use Barrier Lake and the Kananaskis River upstream of the lake during different portions of the year. Natural reproduction is sufficient to maintain a medium quality fishery in the lake (Rasheed 1997).

Fluctuation of the water level, which prevents the development of a productive littoral zone, is considered to be a major factor limiting the quality of the fishery in Barrier Lake. Spawning and rearing success in the Kananaskis River upstream of the lake is also considered to be a factor. However, it is not as much of a limiting factor as the fluctuating water levels in the river and lake, given the poor growth rates of brown trout and mountain whitefish in Barrier Lake (Rasheed 1997).

3.2.5 Kananaskis River from Barrier Lake to the Bow River

The fishery in this reach of the Kananaskis River would have been similar to that in the reach upstream of Barrier Lake prior to hydro development. Little is known about fish populations or species currently present in this reach, but it is generally expected that fish are even less numerous than above Barrier Lake. This is due to impacts on habitat associated with the greater fluctuation in water level which results from peaking operations at the Barrier plant.

3.3 Recreation

3.3.1 Upper Kananaskis Lake

There are three day-use areas (230 units), a boat launch area, many kilometres of hiking trails and a backcountry campsite on or in close proximity to Upper Kananaskis Lake. Boating use is mainly comprised of small motorboats used for fishing purposes, though canoes are also commonly used.

The lake is extremely scenic, but the constructed dams and evidence of fluctuating water levels are quite visible until the water level rises in mid-summer. Upper Kananaskis Lake is a fishing destination for many visitors in both summer and winter and is also a sightseeing destination for visitors including tour bus companies (Hanna; pers. comm.).

Prior to and after the development of dams, the area around the lakes was used for outdoor recreation. Lands around the reservoirs were managed as part of the Bow Forest Reserve with limited camping facilities being provided. In the early 1960s, a 70-lot cottage subdivision was surveyed and lots leased for summer cottages. These have remained and recently some have been upgraded or expanded.

In 1977, the provincial government announced plans to develop Kananaskis Country as a provincially significant outdoor recreation area for Albertans. As part of this, Peter Lougheed Provincial Park was established in 1978 and Upper and Lower Kananaskis Lakes became focal points for significant campground, day-use and trail recreation developments.

3.3.2 Lower Kananaskis Lake

There are currently two campgrounds (152 units), five day-use sites (190 units) and a boat launch area on the shore of Lower Kananaskis Lake. As well, there are 70 cottages, a lodge for seniors and the disabled (100-person capacity), and 3 km of shoreline hiking trail. There are another five campgrounds (394 units), a major park visitor centre and several other day-use sites (380 units) near Lower Kananaskis Lake. In the immediate lake vicinity, this gives a total of 546 camping units, approximately 100 fixed-roof accommodation units, and 600 day-use sites. Some boating with small motorboats occurs and canoeing is quite common near the cottages.

The lake is scenic, although less so than Upper Kananaskis Lake, but the constructed dam and evidence of fluctuating water levels are quite visible until the water level rises in mid-summer. The significant recovery of the bull trout population has caused Lower Kananaskis Lake to become a destination for anglers seeking catch-and-release fishing opportunities for large bull trout, primarily during the open water season (Alberta Environment file data).

3.3.3 Kananaskis River from Lower Kananaskis Lake to Barrier Lake

There are three day-use sites and four campgrounds presently along this river reach. As well, the Kananaskis Golf Course is closely associated with the river. Other recreation-associated infrastructure along the river include the Kananaskis Village sewage treatment plant and domestic wells for the Nakiska Ski Area.

Presently, the seasonal and daily flow variations associated with the Pocaterra hydro development restrict paddling use in this river reach. Also, due to the poor quality fishery in this reach of river, there is limited angler usage.

3.3.4 Barrier Lake

Recreation facilities at or near Barrier Lake include two highly popular day-use sites, a boat launch area, and hiking / biking / horse trails across the dam and along the west side of the lake. There is a backcountry campsite (Jewel Bay) at the northwest corner of the lake and random camping occurs at a few other west shore locations.

The lake is moderately scenic, but the constructed dam and evidence of fluctuating water levels are quite visible. The extent of water level drawdown is less at Barrier Lake than at either Upper or Lower Kananaskis Lake, and water levels return to more aesthetic conditions earlier in the season. Some motorized boating does occur but due to the small size of the lake, cold water and winds the reservoir is not heavily used for boating. The lake also serves as a fishing destination for some visitors, primarily during the open-water season.

3.3.5 Kananaskis River from Barrier Lake to the Bow River

This reach of the river is used extensively by commercial, institutional, and private recreational paddling users and instructors involved in whitewater rafting, kayaking, tubing, and river rescue training. It is a destination for tens of thousands of visitors each year, making it one of the most heavily used river reaches in Alberta.

One of the reasons for the high usage of this river reach is that the release rate from the Barrier Plant provides good to optimum flow conditions for a full range of paddling activities. Under non-regulated conditions, similar flow rates would only occur for six to ten weeks each year. However, because the flow rate is now regulated, good paddling conditions exist from early spring until late fall. Nonetheless, use conflicts can occur if the timing of electricity demand (and therefore Barrier Plant operation) does not coincide with the timing of paddling demand.

Due to fluctuating river levels and access constraints (there are limited developed access points and some of this reach runs through private property or the Stoney Indian Reserve), angling use of this reach is virtually nil except in the immediate vicinity of the confluence with the Bow River.

3.4 Bow River Basin

As discussed in Section 1.2, the primary downstream river basin impact of hydro operations is related to reservoir operations. The reservoirs are progressively filled during the spring and summer, then progressively drawn down over the fall and winter, reaching minimum levels in approximately mid-May.

The storage available during spring runoff in hydro reservoirs in the upper Bow River Basin is sufficient to reduce peak flow rates, and thereby reduce potential flooding, for runoff events up to approximately a 1-in-10 year frequency. For larger floods, however, the reservoirs have relatively minor flood attenuation capability (Alberta Environment, 1983).

A much more important product of hydro reservoir operation is increased river flow during the fall and winter period. Minimum winter flows through Calgary now are more than double what would have occurred without the reservoirs in place. This has significant beneficial implications for security of municipal and industrial water supplies as well as the ability of municipalities and industries to meet effluent release guidelines.

It has been speculated that the increased winter flow resulting from hydro reservoir operation is one of the primary factors contributing to the world-class fishery in the Bow River downstream of Calgary. This reach of the river has become a major recreational destination.

Hydro reservoir operation also supplements water availability in the early spring (April through mid-May) for consumptive withdrawal. This can provide value to various users, but is often most beneficial for irrigation.

3.5. Provincial Energy Legislation

The *Alberta Electric Utilities Act* has mandated that as of January 1, 2001, TransAlta's hydroelectrical facilities will be operated under a Power Purchase Arrangement (PPA) between TransAlta and the Balancing Pool of Alberta. Under the PPA, TransAlta will have defined obligations for both energy and reserve (capacity) which must be supplied into the Alberta Electrical System. Failure to meet the specified obligations will result in financial penalties. The obligation quantities established in the PPA were determined based on review of historical performance of the hydro plants. Therefore, the obligation amounts implicitly reflect the effects of current reservoir operations and use of the plants for peaking purposes.

The Hydro PPA remains in place until the end of 2020. After that date, the hydro facilities become completely deregulated. There is one exception to this date which has implications to the FREWG assessment. Based on engineering evaluations, the reliable service life of the penstock connecting Lower Kananaskis Lake to the Pocaterra power plant (as described in Section 3.1) will end in 2013. TransAlta included costs for replacement of this penstock in its PPA submissions, however, the costs were ultimately not considered to be economically justifiable and were disallowed by the Province. As a result, the Pocaterra development will be released from the Hydro PPA at the end of 2013. At that time, it will be up to TransAlta to decide the future fate of the facility.

4 DATA COLLECTION AND METHODS

4.1 Data Needs

Considerable fishery and recreation information was available for portions of the Kananaskis River system. However, a number of data gaps were identified. Commencing in 1994, a series of projects were initiated by FREWG to fill the most important data gaps. The following sections provide a brief summary of these projects and the key results.

4.1.1 Biological Productivity of Water Bodies

Knowledge about the relative biological productivity of water bodies in the Kananaskis River system was generally missing. This information was necessary in order to confirm the enhancement priorities that had been placed on individual portions of the system. Productivity information can also help identify system-limiting factors. This is useful input when predicting the amount of benefit that might result from modifications to current water management practices.

Between 1994 and 1998, biological productivity investigations were carried out on Upper and Lower Kananaskis Lakes and the Kananaskis River between the Pocaterra Plant and Barrier Lake. In addition, a more detailed investigation on the impact of fluctuating water levels on the productivity of Lower Kananaskis Lake was done.

The purpose of these studies was to assess the potential benefits to sport fish populations of fertilizing these water bodies. Fertilization of lakes and reservoirs to increase sport fish productivity is becoming a common strategy for mitigating the impacts of reservoir operations, in particular in the Province of British Columbia. The results of the field studies indicated that Lower Kananaskis and Barrier Lakes were unproductive (oligotrophic), and supported sparse communities of the microscopic plants and animals that form the base of the food chain. The river between the lakes carries a slightly higher concentration of nutrients, indicating it would be expected to be slightly more productive. There was very little upstream/downstream variation in this section of the river.

A literature search was carried out regarding the effects of whole-lake fertilization. The conclusion was that such practices consistently resulted in increased productivity at the lower levels in the food chain and occasionally the productivity of the fish fauna was also enhanced (Kovats 1997).

4.1.2 Fish and Fish Habitat Inventories

Relatively complete and up-to-date information was available on fish species and populations in Upper and Lower Kananaskis Lakes (Stelfox 1985, 1987, 1995; Stelfox and Egan 1995; Mushens and Post 2001). However, information was either missing or outdated for the rest of

the system. As with productivity, this information was necessary in order to confirm the enhancement priorities previously determined and also to identify the species to target when developing a management plan.

In 1995, fish species and population investigations were carried out on Barrier Lake and the Kananaskis River downstream of the Pocaterra Plant. In addition, an initial habitat inventory was conducted on the Kananaskis River.

Gillnetting revealed that Barrier Lake's fish population is dominated by longnose suckers and mountain whitefish, with brown trout comprising only 3% of the gill net catch in 1995. Growth rates and condition factors for mountain whitefish and brown trout were lower in Barrier Lake than in the upper Bow River, Spray Lakes Reservoir, and Ghost Reservoir, thus indicating that food availability is the major limiting factor (Rasheed 1997).

Recent electrofishing studies were conducted on the Kananaskis River in 1995 (Boag 1996), 1996 (Paul 1997), and 1997-98 (Courtney, et. al. 1998a and 1999). The Kananaskis River investigations identified that there are very few fish resident in the upstream section of the river in the Fortress Bridge vicinity. The fish that are present in the Fortress Bridge section are primarily brook trout with some seasonal use by mountain whitefish. In the vicinity of the Nakiska Bridge, including the section of river upstream to the Mount Kidd RV Park, brown trout are the dominant sport fish species. Mountain whitefish are seasonally abundant in this reach with some brook trout present as well. The total fish biomass estimates for the Kananaskis River were found to be less than the biomass estimates for other nearby rivers that are unaffected or less significantly affected by hydropeaking.

Other findings from the river investigations included:

- The primary spawning habitat for brown trout appears to be from the Nakiska Bridge area downstream to Barrier Lake. This reach also provides rearing habitat for all species.
- The mountain whitefish appear to be migratory populations which winter in Barrier Lake and move into the Kananaskis River in summer. Brown trout in the river may also be migratory, but that has not been demonstrated.
- Habitat and food supply appear limited by flow fluctuations and depth of flow when the Pocaterra Plant is not generating.

4.1.3 Water Level and Water Temperature Monitoring

The degree of water level fluctuation at various points along the Kananaskis River downstream of the Pocaterra Plant was well understood from a qualitative standpoint but had never been specifically quantified. This is an important factor when assessing benefits that might result from modifications to current water management practices.

During 1996, water level recorders were installed on the Kananaskis River at the Fortress and Nakiska Bridges. The information collected was used extensively in various other analyses.

One potential impact of reservoir operations is to alter natural temperature regimes in a river. Similarly, any changes in operating characteristics of existing reservoirs may result in further alteration of river temperature regimes. Since temperature can be a limiting factor for a fishery, it is important to have an understanding of baseline conditions to be able to assess conditions that might result from modifications to current water management practices. Baseline data on the Kananaskis River system was generally missing.

Between 1995 and 1998, water temperature data was collected in Upper and Lower Kananaskis Lakes and at several points along the Kananaskis River downstream of the Pocaterra Plant. This information was then used in modeling analysis done during assessment of management scenarios.

4.1.4 Instream Flow Needs

Based on the results of the biological productivity and fishery inventory work, it was confirmed that the Kananaskis River downstream of the Pocaterra Plant was a good candidate for enhancement consideration. In order to conduct a thorough assessment, it was necessary to have instream flow needs (IFN) information for the target fish species in the Kananaskis River. This type of information was not available.

In 1996/97, detailed IFN studies were conducted on the Kananaskis River downstream of the Pocaterra Plant. A one-dimensional (1-D) PHABSIM study site was established near Fortress, and two-dimensional (2-D) River2D sites were established near Fortress and near Nakiska (Courtney et al. 1998b). The Fortress site provided an opportunity to compare results from a 1-D modelling approach with a 2-D modelling approach. From the standpoint of fish habitat, the two methods produced comparable results, but the general conclusion was that the 2-D approach provides a more realistic and accurate representation of the habitat conditions within the study site.

Habitat measurements were collected from the Kananaskis River to develop site-specific habitat suitability functions required in habitat modelling. Mountain whitefish and brown trout were identified as the target management species for developing habitat criteria. Although site-specific data were collected for most lifestages of mountain whitefish and brown trout, a workshop with fisheries experts was held on December 11, 1998 to review and, if considered appropriate, to modify the suitability curves (Courtney and Walder, 1999).

The final habitat suitability curves developed at the workshop were then used to recalculate the habitat-flow functions for both the 1-D and the 2-D sites. The modified results for the 1-D site are reported in Courtney and Walder (1999). These final habitat-flow functions were used for evaluating the different flow scenarios for the Kananaskis River between the Pocaterra Plant and Barrier Lake.

4.1.5 Recreational Use

A great deal of information was available on current recreational use in the Kananaskis River Valley. However, this information had not been collected with the intention of assessing potential recreation enhancement that might result from modifications to current water management practices. Additional information was necessary to conduct thorough assessments of management alternatives.

Between 1995 and 1998, additional site information was gathered at existing facilities and potential new recreation sites. Reconnaissance and controlled canoe and rafting tests were also conducted on the Kananaskis River (Alberta Environment 2000b).

4.1.6 Lower Kananaskis Lake Fishery Monitoring

A significant unknown was how the 1992 changes in fishing regulations would affect the Lower Kananaskis Lake bull trout population. This information is important in evaluating the potential benefits of different management alternatives.

With the exception of 1994, annual monitoring has been conducted on the bull trout spawning run since 1991. The monitoring has documented that the bull trout population has recovered rapidly in response to the catch-and-release regulations and bait ban, increasing more than 20-fold from a low of 60 spawners in 1992 to more than 1200 in 1998. Growth rates are still very good, indicating that food is not a major limiting factor for adult bull trout in Lower Kananaskis Lake under the current operating regime (Stelfox and Egan 1995; Mushens and Post 2001).

Creel data has also shown, as suspected, that survival of subcatchable cutthroat trout stocked in the lake in 1992 and 1994 was low. However, the growth of the cutthroat trout that did survive has been good, with some attaining a size of 50 cm (Alberta Environment file data).

4.2 Methodology

As basic data for the Kananaskis River system became available, numerous analyses were carried out to enable an eventual assessment of water management scenarios. The methodology used in each analysis is briefly summarized in the following paragraphs.

4.2.1 Defining Management Scenarios

Within the Kananaskis River hydro system, implications of reservoir operating policies and power plant operating policies can reasonably be separated and assessed individually. The process used by FREWG to develop alternative management scenarios involved two steps.

First, using the information described in the previous section, a preliminary assessment of all enhancement options was carried out. This assessment confirmed that the highest priorities for enhancement continued to be Lower Kananaskis Lake and the Kananaskis River between the Pocaterra Plant and Barrier. This assessment is discussed in more detail in Section 5.

Second, through a screening process, FREWG members then developed specific management scenarios involving a wide range of operating policies for Lower Kananaskis Lake and the Pocaterra Plant. These management scenarios are described in detail in Section 5.

4.2.2 Kananaskis Hydro System Simulation Modeling

Once the management scenarios were developed, it was necessary to conduct simulation modeling of both the Kananaskis River hydro system and the Bow River downstream of the confluence with the Kananaskis River. This was done to enable prediction of changes in water levels and flow rates resulting from different operating policies, which in turn could have implications on the environment and other water users.

4.2.2.1 Lower Kananaskis Lake Simulation

Simulation of Lower Kananaskis Lake operating policies was conducted using the Water Resources Management Model (WRMM) developed by Alberta Environment (Alberta Environmental Protection, 1996b). The WRMM is a steady-state, surface water allocation model which optimizes water allocation within a system based on ranked water use priorities defined by the model user. The model uses a linear programming optimizer routine as its driver and runs on a weekly time step simulation.

Initially, a WRMM was configured and calibrated for the entire Bow Hydro System for current conditions, taking into account all existing TransAlta operating policies. Then, the Kananaskis River sub-basin was separated out and simulations of the individual management scenarios were conducted using the sub-basin model. Finally, outputs from the Kananaskis River sub-basin model were used as point inputs into the Bow Hydro System WRMM in order to identify implications downstream of the Kananaskis River. This approach was taken to ensure that the specific implications of individual management scenarios could be clearly identified. A detailed discussion of the lake simulation modeling is contained in a separate report (TransAlta 1998).

The hydrometeorological data used in this analysis were developed by the Surface Water Assessment Branch, Alberta Environment (June 1994). These data include naturalized streamflow, precipitation and evaporation estimates, on a weekly time step, for the period 1928–1988. This natural flow data base is the generally accepted basis for assessment throughout the South Saskatchewan River Basin.

Results of the Lower Kananaskis Lake simulations were used in environmental and recreational assessments of the lake, recreational assessments for the river downstream of Barrier Lake, water

quality assessments downstream of Calgary, implications on downstream water rights, and determining hydro system generation.

4.2.2.2 Kananaskis River Simulation

The weekly time step output resulting from the WRMM simulation was sufficient for assessment of reservoir operations as well as flow conditions in the Bow River downstream of the Kananaskis River confluence. However, the weekly time step was inadequate for assessment of flow conditions in the Kananaskis River itself. This is because peaking operations at the Pocaterra Plant can result in significant flow variability through the course of each day.

The additional analysis required for the Kananaskis River involved two components: a sub-basin hydrology analysis and; development of a post processing model to generate daily maximum and minimum flows in the Kananaskis River based on the WRMM output. Detailed descriptions of these analyses and results are contained in separate reports (Golder 1998b, Golder 1998c, Golder 1999).

The naturalized streamflow data base from Alberta Environment provides local streamflow into the Kananaskis River for the entire reach between the Pocaterra Plant and Barrier Lake. The hydrological analysis involved further subdividing this local inflow into smaller components. Based on available streamflow data and sub-basin characteristics such as area and elevation, separate, naturalized local inflow files were developed for the Kananaskis River below Pocaterra Creek, at Fortress Bridge, and at Nakiska Bridge. The analysis also involved synthesizing daily flow data from the weekly naturalized data. This was done through a regional analysis of gauged streamflow data to develop correlations between daily and weekly flow rates.

The post-processing analysis involved synthesizing daily maximum and minimum releases from the Pocaterra Plant based on user-defined operating rules and the weekly time step, WRMM simulation results. The Pocaterra releases were then routed downstream and sequentially added to the naturalized local inflows to develop maximum and minimum daily flows for the Kananaskis River below Pocaterra Creek, at Fortress Bridge, and at Nakiska Bridge which reflected different operating policies at the Pocaterra Plant.

Results of the Kananaskis River simulations were used in environmental and recreational assessments of the river, river regime assessments, and determining hydro system generation.

4.2.3 Lower Kananaskis Lake Fishery Enhancement Assessment

A Delphi panel of experts was assembled to estimate the effects of various operating scenarios on fish production in Lower Kananaskis Lake, in terms of total yield of fish. The scenarios included reservoir stabilization at various elevations, partial stabilization, and the potential effects of fertilization. The advice of the Delphi panel on likely consequences for fish populations was used in the subsequent evaluation of scenarios (Fernet 1999).

4.2.4 Kananaskis River Temperature Assessment

Water temperatures were recorded in the Kananaskis River at the Nakiska Bridge by Alberta Environment in 1998. ASci Corporation (1999) was retained to model the estimated effects of five different operating scenarios (1b, 2a, 2b, 3a and 3b) on downstream river temperatures. Modelling results were then analyzed by Golder Associates (Baxter and Digel 2000), to determine the suitability of water temperatures with each of the scenarios for all life stages of brown trout and mountain whitefish. This analysis was carried out by initially comparing the baseline (i.e., recorded) temperature information to temperature preferences of the various life stages of the two species of interest, when they were present in the river. A comparable analysis was then carried out for each of the modelled scenarios. Finally, the results of each of the scenarios were compared to the baseline condition to determine if water temperatures were better or worse for the various life stages of interest for each of the scenarios.

The results of the analysis revealed that there was essentially no difference in the suitability of water temperatures with the various scenarios. As a result, the effect of reservoir operation on downstream water temperatures was eliminated as a criterion in scenario evaluation.

4.2.5 Kananaskis River Fishery Enhancement Assessment

To evaluate different flow scenarios for the Kananaskis River, the following steps were required:

- Collection of hydraulic and biological data
- Calibration of the hydraulic models
- Creation of habitat suitability functions
- Calculation of habitat-flow relationships for each target lifestage
- Creation of flow scenarios to be evaluated
- Development of a tool for calculating effective habitat and conducting effective habitat time series analysis

The first five steps are summarized in Section 4.1.4 and described in detail within other reports produced for FREWG (Courtney, et al. 1998b, Courtney and Walder 1999).

The final step that was required to evaluate flow scenarios for the Kananaskis River was to develop a tool that could analyze the effective habitat of a hydropeaking system. The original PHABSIM group of models contained a program to calculate effective habitat; however, this program contained some calculation errors. Utah State University developed PhabWin-98, which updated the original habitat modelling programs and corrected errors within the effective habitat program. A corresponding program, WinHabTime, was created to calculate the effective habitat for 2-D data. WinHabTime was also used to conduct and analyze effective habitat time series for the 1-D site at Fortress and the 2-D site at Nakiska. The new software was extensively tested by Utah State University and by members of FREWG (report in preparation).

4.2.5.1 Effective Habitat

Within a hydraulic model, habitat is evaluated on a cell-by-cell basis. A cell is a relatively small area within the study reach that is defined to have the same depth, velocity and substrate. For each modelled flow, a cell will have a corresponding depth, velocity, and substrate value. The habitat at each cell is determined for each lifestage based on the suitability criteria for depth, velocity, and substrate of that lifestage. Each lifestage will have different habitat values because each lifestage has different habitat suitability criteria. The habitat for a study reach is calculated by taking the sum of the habitat at each cell for each modelled flow.

Effective habitat is used to evaluate the habitat of two different flows that occur on the same day. In this case, the flows used are generation flow and base flow. Within the effective habitat evaluation process, two different habitat values are compared, one corresponding to the maximum flow of the day (generation flow) and one corresponding to the minimum flow of the day (base flow). The effective habitat for each cell in the model is then defined as the lowest of the two habitat values, and may be a result of either the high flow or the low flow. The overall effective habitat value for a study site is obtained by adding together the effective habitat area for all of the cells within the model study reach for each of the modelled flows.

As an example of how effective habitat is calculated, if a point in a stream is not submerged under the base flow conditions, it will not have any usable habitat for fish. Usable habitat could become available at that exact same point in the stream under generation flow. However, in this example, the effective habitat area at that point in the stream would be zero corresponding to the lowest habitat value, in this case the habitat at base flow. This habitat analysis assumes that fish do not move and is a conservative approach emphasizing the negative effects of hydropeaking.

Effective habitat is calculated for each day within each flow scenario for each lifestage. This will result in a chronological series of habitat values (a habitat time series) that can be difficult to interpret. To simplify the data for interpretation, the data can be sorted into habitat duration curves for each lifestage and each flow scenario within a Biologically Significant Period (BSP). BSPs are defined to separate the year into biologically defined seasons where key biological processes occur (e.g., the typical spawning period for a fish species). The four BSPs defined for the Kananaskis River are:

BSP1: Apr 2 – Sep 23 (BNTR fry, juvenile, adult – MNWH fry, juvenile, adult)¹

BSP2: Sep 24 – Oct 28 (BNTR fry, juvenile, adult – MNWH incubation, fry, juvenile)

BSP3: Oct 29 – Dec 2 (BNTR fry, juvenile, incubation – MNWH incubation)

BSP4: Dec 3 – Apr 1 (BNTR fry, juvenile, adult, incubation – MNWH incubation)

A duration curve defines habitat values from a time series in terms of how often that habitat value is equaled or exceeded over the period of record being evaluated. The habitat value at the

¹ BNTR = brown trout

MNWH = mountain whitefish

10% exceedence would correspond to a high habitat value and that amount of habitat or greater is rarely available at any single moment for that particular flow scenario. The habitat value at the 90% exceedence would correspond to a low habitat value and that amount of habitat or more is almost always available at any single moment.

An advantage of habitat duration curves is that several different habitat metrics can be extracted from the sorted data. One of the most common metrics, and the metric used for this analysis, is referred to as Index-A. Index-A is the average habitat value from 50%-90% on the habitat duration curve and represents most of the moderate to poor habitat conditions for the scenario being evaluated. It assumes that improvements in habitat during poor habitat conditions best define expected gains in productive capacity of the system. The Index-A results from all of the flow scenarios can then be compared to determine the relative ranking of which flow scenarios provide better habitat.

4.2.5.2 Flow Scenario Evaluation

The River Subcommittee of FREWG reviewed the detailed effective habitat results by lifestage and by season (BSP) for the Nakiska and Fortress sites. Several methods for developing an overall summary ranking for the scenarios were investigated, all of which produced very similar scenario rankings. The final summary rankings presented by the River Subcommittee are based on the Index-A habitat metric for the Nakiska Site on the Kananaskis River. The habitat for all species and lifestages present in a BSP were averaged for the final scenario evaluation. The River Subcommittee decided to use only the Nakiska Site for the final scenario rankings for several reasons:

- including the Fortress Site did not change the overall rankings of the plant operation scenarios
- the Nakiska Site was based on the 2-D hydraulic model, which was considered to better represent available habitat compared to the 1-D Fortress site, and
- the Nakiska Site was believed to provide better fish habitat compared to the Fortress Site.

The Index-A value for each flow scenario was shown as a percent change from existing conditions (denoted Scenario 1a). By definition, Scenario 1a was always a 0% change from existing conditions. Habitat losses were given a negative value and habitat gains were given a positive value scaled to the existing (Scenario 1a) habitat value using the following equation:

$$(\text{Index-A for Scenario "X"} - \text{Index-A for Scenario 1a}) / \text{Scenario 1a}$$

This calculation was done for each lifestage within each BSP. An overall percent change from existing conditions was first calculated for each BSP by averaging the results of the individual lifestages for each scenario. The results from each BSP were then averaged for each scenario to

derive the overall change in habitat from existing conditions. These values were then range standardized by dividing each scenario by the habitat value of the best scenario in order to show the best scenario as a 100% change from existing conditions. This approach provided a good coarse filter for evaluating the flow scenarios.

The members of FREWG decided that the scenarios should be examined in more detail to determine if the scenario evaluation could be refined. Individual lifestages and BSPs were examined in more detail. In particular, BSP3 and BSP4 had large habitat gains relative to the natural flow for some scenarios and were masking habitat losses during BSP1 and BSP2. Much of the habitat gains were from MNWH and BNTR incubation. In particular, MNWH-I showed very large habitat gains for BSP3 and BSP4. However, MNWH spawn in BSP2 when the available habitat is less for some of the scenarios. It was assumed that the habitat available in BSP 3 and 4 would not be realized since the eggs would already be distributed and could not move to take advantage of improved habitat availability. The incubation habitat values were changed to reflect the BSP with the lowest average habitat value as the limiting time of year. The limiting time of year for incubation varied depending on the flow scenario and varied between BNTR and MNWH incubation.

It was also decided to remove all fry lifestages from the analysis due to the nature of fry weighted usable area (WUA) curves. Fry prefer low depths and velocities and, in turn, the WUA curves are skewed to the left showing the greatest amount of habitat at very low discharges. At very low discharges, the shallow and slow habitat is located in the centre portion of the stream, which is also where larger fish would be located. Competition and predation by larger fish would make this habitat less preferential for fry than indicated by the model. This is a common result in virtually every IFN study. Higher discharges were not assumed to be limiting for fry since shallow and slow habitat at stream margins can be utilized. Brown trout juvenile and adult lifestages were also removed from BSP4 because the available habitat suitability curves were based on summer observations. Also, these lifestages might move down to Barrier Lake for the winter.

4.2.5.2.1 Changes Made to the Final Scenario Evaluation

- The habitat value for incubation lifestages was modified to reflect the BSP with the lowest habitat value as the limiting time of year. The lowest habitat value was then used for all BSPs where incubation was present.
- All fry lifestages were removed from the analysis due to the WUA curves being skewed to the left to reflect a preference for low flows. Habitat was not considered limiting at higher flows, and competition and predation may make low flows less preferential than indicated by the model.
- BNTR-A and BNTR-J were removed from BSP4 since habitat criteria were based on summer observations and the possibility that these lifestages move to Barrier Lake for the winter.

Once these changes were made, the scenarios were once again evaluated and ranked based on the averaged Index-A values using the same methods described above. The final scenario rankings

are presented in Appendix C. A FREWG technical report is currently in preparation, which will provide the detailed scenario habitat results and evaluation methodology.

4.2.6 Recreation Enhancement Assessment

A report entitled *The Impacts of Stabilizing Lower Kananaskis Lake on Recreation in the Kananaskis Watershed* was produced by Alberta Environment in June of 1997. It described the likely recreation benefits if stabilization or near stabilization of Lower Kananaskis Lake were to occur. It found that significant improvements to recreation values would result. A further evaluation which compared the relative recreation benefits of three possible stabilized water levels was reported in February 2000. Both these evaluations gave preliminary consideration to expected environmental effects of improvements and identified some concerns, limitations or areas for further study.

4.2.7 Kananaskis River Regime Assessment

The intent of this study (Winhold 2000) was to undertake a mainly qualitative assessment of the different Kananaskis River management scenarios, with respect to their potential impact on river regime. Specifically, this study examined how the various alternatives could potentially affect:

- Summer Flooding - Impact on open-water flood levels.
- Winter (Ice Jam) Flooding - Impact on ice formation and the potential for flooding due to ice blockage or ice jamming.
- Flushing Flows - Impact on the capacity of the river system to “flush” out accumulated fine sediments on an annual basis.
- Channel Morphology – Impact on lateral channel stability, deposition, scour and erosion.

The river regime assessment focused on the reach of the Kananaskis River in the vicinity of the Nakiska Bridge and Kananaskis Golf Course. This reach was selected due to its prominence as a major recreational focal point within Kananaskis Country and the belief that this particular section of the Kananaskis River provided a logical reference point, in terms of measuring the sensitivity of the entire river system to changes in flow regime. A considerable amount of information on both the hydrologic and hydraulic characteristics of the Kananaskis River was readily available for this location.

The simulated flows at the Nakiska Site (Golder 1999) were analyzed for several key hydrologic parameters (flood frequency, mean monthly flows, etc.) selected to characterize the flow regime for each of the management scenarios, including the current operating scenario (Base Case or Scenario ID: 1) and for natural conditions (pre-hydro operations). Each of the selected parameters was derived from a statistical analysis of the simulation data for a 61-year period of record (1928-1988). An existing HEC-2 Water Surface Profiles computer model of the Kananaskis River (Alberta Environmental Protection 1996a) was used to generate basic hydraulic conditions (flow depth and velocity) characteristic of the Nakiska reach.

The following hydrologic conditions were selected to be the performance measures in assessing the key river regime parameters.

- Summer floods: annual maximum daily discharge as a percentage of the Base Case
- Winter floods: diurnal fluctuation range
- Flushing flows: June maximum weekly flow as a percentage of Base Case
- Channel morphology: "regime discharge" as a percentage of the Base Case

4.2.8 Downstream Water Rights Assessment

Since stabilization options for Lower Kananaskis Lake would change the timing of releases from the reservoir, FREWG examined the potential impacts of changes in releases on downstream water users. (Alberta Environment 2000c) This analysis used output from the simulation model of TransAlta Utilities' hydroelectric system in the Bow River Basin (upstream of Bearspaw Dam). The results of two scenarios were used:

- current operations (Base Case or Scenario ID: a)
- full stabilization at elevation 1663 m (Scenario ID: b)

These two scenarios represent the range of options from existing flow conditions to the flow conditions that would be created if stabilization were implemented. The results from these two scenarios were added as input to Alberta Environment's simulation model of the Bow River downstream of Bearspaw Dam. This model simulates water supply, withdrawals, and instream objectives.

It was decided to examine the potential impact on irrigation withdrawals since irrigation is the largest consumptive water user in the basin. Considering irrigation also provides an indication of how licensees with different priorities might be affected since senior licensees (irrigation districts), junior licensees (private irrigators on the Highwood River), and possible future private licences (in the Highwood and Little Bow systems) are included.

Irrigation withdrawal was set at the maximum allowed under the *South Saskatchewan River Basin Water Allocation Regulation* (Alta. Reg. 307/91). Existing licences governed withdrawals for facilities that are already in place. It should be noted that the irrigation demand data used in this analysis was being revised at the time. It is expected that irrigation demand will be reduced as a result of the revisions, but the amount of change is not known.

4.2.9 Water Quality Downstream of Calgary Assessment

Two scenarios were evaluated in terms of potential effects on water quality downstream of the City of Calgary (Digel and Bechtold 2000). The first scenario was current operations (Base Case or Scenario ID: a), while the second was stabilization of Lower Kananaskis Lake (Scenario ID:

b) at elevation 1663 m.² A computer model was used to predict total phosphorous, total nitrogen and ammonia concentrations downstream of the City of Calgary's wastewater treatment plants, over a 20-year time frame. The modelling was done using current wastewater loadings to the Bow River. The results of the analysis indicated there would be a negligible effect on nutrients in the Bow River, with current wastewater loadings, as a result of lake stabilization.

4.2.10 Hydroelectric Considerations

Modifying the operating policies of Lower Kananaskis Lake, Pocaterra Plant, or both has the potential to affect the following:

- capacity of the Pocaterra Plant (maximum power rating in megawatts (MW));
- generation at the Pocaterra Plant (annual energy produced in megawatt hours (MWh));
- generation at downstream plants including Barrier, Kananaskis, Horseshoe, Ghost and Bearspaw (annual energy produced in MWh).

The direct cost related to impacts on capacity and generation can be estimated for each management scenario. In addition, some of the management scenarios being considered will require physical modifications to existing infrastructure or other direct capital investment in order to be implemented. These factors are briefly discussed in the following paragraphs.

4.2.10.1 Capacity

Capacity at the Pocaterra Plant is directly related to head (reservoir level) and flow rate through the generating unit. The ranges of head and flow rate for each management scenario were determined in the hydro system simulation modeling and this information was used to calculate plant capacity.

4.2.10.2 Generation

Generation can be affected by the management scenarios in two ways: lost generation and generation being shifted off-peak. Each of these is discussed below.

All of the management scenarios being evaluated result in lost generation compared to current operating policies. In other words, there will be less total electricity generated each year by the Bow hydro system. Lost generation in the scenarios being evaluated results from two causes.

1. Under lake stabilization scenarios, water that is currently stored in Lower Kananaskis Lake during the runoff season would be released instead. This results in increased spill at Pocaterra, Barrier, Kananaskis, Horseshoe, Ghost and Bearspaw which correspondingly reduces generation over the annual cycle.

² Lower Kananaskis Lake could be stabilized at several different elevations. However, differences in stabilization elevation have a negligible effect on flows through Calgary.

2. Under modified plant operation scenarios, the Pocaterra Plant is operated at release rates that are less efficient than the current operating regime. The result is that the same volume of water produces less total generation.

In addition, the Bow hydro system has been geared toward producing generation during on-peak, or high-demand, hours. Due to operational changes embodied in the management scenarios, a greater percentage of the annual generation from the Bow hydro system will be produced during off-peak, or low-demand, hours than is currently the case. Generation being shifted off-peak in the scenarios being evaluated also results from two causes:

1. Under lake stabilization scenarios, the Pocaterra Plant is often required to run 18 to 24 hours per day during the runoff season in order to maintain the reservoir level. Under current operations, this would hardly ever occur. Similarly, the hours of plant operation at the Barrier and Ghost plants are also increased during non-spill periods.
2. Under modified plant operation scenarios, reduced release rates from the Pocaterra Plant result in significantly increasing the number of hours of plant operation per day during periods of the year other than runoff.

Quantities of lost generation and generation shifted off-peak for each management scenario were determined from the results of the hydro system simulation modeling. A summary of impact on generation is presented in Section 6 of this report.

4.2.10.3 Lost Opportunity Costs

Lost opportunity results from both lost generation and generation being shifted off-peak. In the former case, the generation is simply not being produced and therefore is not available to market. In the latter case, the relative value of off-peak generation is less than the value of on-peak generation. Given the structure of the Hydro Power Purchase Arrangement (PPA - see Section 3.5), these lost opportunity costs do not just represent forgone potential earnings, they represent actual penalties that TransAlta will be assessed for failure to meet the PPA obligations.

Lost opportunity costs were estimated for the management scenarios being evaluated based on actual 1999 power pool price data. The results are presented in Section 6 of this report.

Lost opportunity may also result from changes in capacity of the Pocaterra Plant. However, due to uncertainty about how capacity will be valued after January 1, 2001, no attempt to quantify this cost has been made at this time.

4.2.10.4 Capital Expenditures Required

Direct capital expenditures would be required for several of the scenarios as follows.

1. Lake stabilization scenarios (Scenario ID: 1b, 2b, 3b, 4b) would require shoreline reclamation work to be carried out. Costs for this were estimated from the reclamation work done at Spray Lakes Reservoir in the mid 1990s plus anticipation that more work would be required at Lower Kananaskis Lake due to its higher degree of use and visibility.
2. Some revised peaking scenarios (Scenario ID: 2a-1 and 3a-1), which involve a minimum release of 2 cubic metres per second (70 cubic feet per second), would require construction of an automated flow bypass structure, since the existing infrastructure cannot pass this much water when the plant is off. Costs for this were estimated based on the cost of the smaller bypass structure built in 1999 at the toe of the Pocaterra Dam on Lower Kananaskis Lake.
3. The average weekly flow scenarios (Scenario ID: 4a, 4b, 4c) will require complete replacement of both the turbine and generator unit at the Pocaterra Plant. This involves not only the mechanical and electrical equipment, but also civil modifications to the building. Costs for this were estimated from 1998 engineering estimates for replacement of the Ghost Unit #1 turbine and generator with a higher capacity unit. The cost estimates take into account that the potential Ghost replacement unit was slightly smaller than the Pocaterra replacement unit, and also involved less civil modification.

4.2.10.5 Economic Analysis

Lost opportunity costs occur every year throughout the life of a management scenario. Capital expenditures, on the other hand, are one-time costs that occur at a specific time in the life of a management scenario. In order to get a representative, or composite, value of the cost of the management scenarios, the net present value (NPV) of each scenario was determined. NPV is the discounted value in today's dollars of a series of annual values extending into the future. Capital costs, if any, were assumed to occur in 2002 along with annual lost opportunity costs in all years.

As discussed in Section 3.5, the Pocaterra hydro development will be released from the Hydro Power Purchase Arrangement at the end of 2013. At that time, an evaluation of the future of the Pocaterra development will be made based on the economic viability of penstock replacement. Accordingly, the period used in the economic analysis for this study extended from 2002 through 2013. If a longer period had been appropriate, the percentage difference in costs among scenarios would have been different, but the ranking of scenarios would have remained the same.

The results of the economic analysis are presented in Section 6 of this report.

5 SCENARIOS

5.1 Preliminary Assessment

This section describes the rationale for focusing on Lower Kananaskis Lake and the Kananaskis River from Lower Kananaskis Lake to Barrier Lake. For further information on FREWG's rationale, please see the reports *A Proposal for a Fisheries, Recreation and Water Management Plan for the Kananaskis River System* and *FREWG Priorities*.

In determining which water bodies to focus on, FREWG's objective was to find the best candidates for enhancement and those that would also serve as a pilot project for how to evaluate other water bodies. A wide variety of factors were considered including the benefits to fish habitat and recreation, the impact on TransAlta's production of electricity, and the importance of re-introducing native fish species or increasing their populations.

5.1.1 Upper Kananaskis Lake

Upper Kananaskis Lake was considered a less suitable candidate for stabilization than Lower Kananaskis Lake because of the volume of storage that would be sacrificed, and also because the steep, rocky shoreline would greatly limit the amount of productive littoral zone that could be developed through stabilization.

Stocking of bull trout was identified as a viable means of improving the fishery in Upper Kananaskis Lake (Fisheries and Recreation Enhancement Working Group 1995).³

The potential for enhancement or expansion of existing recreation facilities, or creating new ones, is limited by access and topography. While there may be some room for parking lot expansion at Upper Lake Day-Use Area, the present level of development is close to maximum, even without considering the desirability of added facilities or use.

5.1.2 Lower Kananaskis Lake

Lower Kananaskis Lake was considered the best candidate for stabilization because there are large areas of mildly sloping shoreline for development of a littoral zone. Other contributing factors include:

- the lake previously supported a quality fishery for native cutthroat and bull trout; therefore, re-introduction of cutthroat trout might be more likely to succeed
- the lake does not contain substantial numbers of trout species that might hybridize with cutthroat trout
- the potential exists to create (for some scenarios) suitable cutthroat trout spawning habitat

³ Consideration is also being given to stocking catchable-size cutthroat trout in Upper Kananaskis Lake rather than the current practice of stocking catchable-size rainbow trout.

- re-establishment of a native species complements fisheries managers' preferred plans.

The amount of storage sacrificed through stabilization would be moderate.

Bull trout exhibit good survival (for adults) and growth under the current operating regime. Although stabilizing the water level is likely to improve cutthroat trout survival and growth the most, it is anticipated that it will also benefit bull trout to some extent.

The potential has been identified to enhance or expand several of the current recreation facilities at Lower Kananaskis Lake, as well as developing up to three new facilities. These initiatives would have implications for use at Upper Kananaskis Lake due to the proximity of the two lakes.

5.1.3 Kananaskis River from Lower Kananaskis Lake to Barrier Lake

This reach of river was considered a good candidate for fishery enhancement, primarily because of: the length of the reach; a better fishery existed prior to hydro development, and existing self-sustaining fish populations are present and would probably re-establish a higher quality fishery if better habitat were available.

Human impact concerns along the river within Peter Lougheed Provincial Park upstream of Fortress Bridge and downstream of Ribbon Creek would restrict paddling potential there, but scenic Grade I or II paddling could become available downstream from Fortress Bridge, Opal Day-Use Area, or Eau Claire Campground under different flow conditions.

5.1.4 Barrier Lake

Stabilization of Barrier Lake would result in the smallest sacrifice in storage of any reservoirs in the Kananaskis River system. The lake does have areas of mildly sloping shoreline for littoral zone development. However, Barrier Lake was considered a less desirable candidate for stabilization than Lower Kananaskis Lake for a number of reasons. The small size of the lake limits the fish production and recreational enhancement that could be achieved. In addition, there is a high degree of interaction between Barrier Lake and the Kananaskis River upstream in the life cycle of the resident fish species. As a result, stabilization would primarily benefit non-native brook and brown trout, as opposed to native bull and cutthroat trout. Stabilization of the lake might only provide a substantial fisheries benefit to the river if it were directly associated with changes in operation of the Pocaterra Plant.

Similarly, due to the smaller size of the reservoir and topographic and access constraints, the enhancement or expansion potential for recreation facilities at Barrier Lake is less than the potential at Lower Kananaskis Lake. Due to its proximity to Calgary and high scenic quality, some additional paddling and sailing activity is anticipated even if no operational changes are made.

5.1.5 Kananaskis River from Barrier Lake to the Bow River

Due to the short length of this reach, access limitations, and its intense use for paddling recreation, fishery enhancement in this section of the Kananaskis River was given very low priority.

Moratoriums and limits have already been placed on issuing new use permits for this reach of river by Kananaskis Country. In view of this, the potential to expand recreational usage is considered to be limited, although marginal enhancement may be possible under some scenarios. This reach was not considered to be as good a candidate for fisheries enhancement as the reach above Barrier Lake due to the shorter length of river and the higher cost of changing hydro operations.

5.2 Plant operating scenarios

Six different modes of plant operation were modeled in the assessment of Pocaterra operations. The six scenarios represent the range of options and include two different minimum flows. The six plant operating scenarios are as follows:

- Current Operations (Scenario ID: Base Case or 1)
- Revised Peaking #1 (Scenario ID: 2)
- Revised Peaking #2 (Scenario ID: 2-1)
- Flat Loading #1 (Scenario ID: 3)
- Flat Loading #2 (Scenario ID: 3-1)
- Average Weekly (Scenario ID: 4)

In order to explain the six scenarios, some background information on the Pocaterra Plant's operation characteristics is first provided. The Pocaterra Plant consists of a single turbine/generator unit. At its maximum operating head of 56.4 m (185 ft), the maximum flow and generating capacities of the unit are 27.8 cms (980 cfs) and 13.7 MW, respectively. The Pocaterra Plant cannot be operated for sustained periods between 11.3 and 19.8 cms (400-700 cfs) and below 7.1 cms (250 cfs) as these are "rough zones". Rough zones are defined as ranges in flow in which excessive machine vibration and cavitation occur. Operating in these zones for sustained periods can damage the machinery.

The rate of flow that is released through the Pocaterra Plant is controlled by the gate opening. The gate opening refers to the size of the physical opening that restricts the flow of water from the penstock into the turbine. The gate opening is controlled by a series of "wicket gates" that surround the turbine entrance. The greater the gate opening, the greater the rate of flow through the turbine. In its current peaking mode of operation, the Pocaterra Plant is operated at two gate settings: 70% in the summer and 90% in the winter (100% represents completely open).

The six modeled plant operations scenarios are described below. The six scenarios are summarized in Table 1.

Current Operations (Scenario ID: Base Case or 1). Current Operations involves running the Pocaterra Plant at full or near full capacity for a limited period of the day, then turning the plant

Table 1
Plant Operating Scenarios

Plant scenario	ID	Generating flow ranges cms (cfs)	Maximum flow cms (cfs)	Minimum flow cms (cfs)	Plant modifications required?
Current Operations	1	Winter: 25.5 to 27.8 (900-980) Summer: 19.8 to 21.8 (700-770)	Winter = 27.8 (980) Summer = 21.8 (770)	0.1 (5)	No
Revised Peaking #1	2	Year round: 19.8 to 21.8 (700-770)	21.8 (770)	1.0 (35)	No
Revised Peaking #2	2-1	Year round: 19.8 to 21.8 (700-770)	21.8 (770)	2.0 (70)	Yes (2.0 cms (70 cfs) bypass required)
Flat Loading #1	3	7.1 to 11.3 (250-400) 19.8 to 27.8 (700-980)	27.8 (980)	1.0 (35)	No
Flat Loading #2	3-1	7.1 to 11.3 (250-400) 19.8 to 27.8 (700-980)	27.8 (980)	2.0 (70)	Yes (2.0 cms (70 cfs) bypass required)
Average Weekly	4	0.1 to 27.8 (5-980)	27.8 (980)	0.1 (5)	Yes (major modifications required)

off for the remainder of the day. The rationale for this approach is to generate energy during peak demand periods (generally during daytime) and conserve water when demand is lower. In this mode of operation, the plant operates in an on/off fashion. No minimum flow is provided in this mode.

Revised Peaking #1 (Scenario ID: 2). Revised Peaking is similar to peaking since the plant operates in an on/off fashion. However, the extreme flow variability is decreased by reducing the maximum flow and increasing the minimum flow. The Revised Peaking #1 scenario entails limiting the gate opening to 70% for the entire year and ensuring that a minimum flow of 1.0 cms (35 cfs) is passed to the downstream river channel via a bypass. The Revised Peaking options are designed to maintain as much peaking capability as possible while providing a minimum release to the river.

Revised Peaking #2 (Scenario ID: 2-1). The Revised Peaking #2 scenario is identical to the Revised Peaking #1 scenario, except the minimum flow is increased from 1.0 to 2.0 cms (35-70 cfs). Revised Peaking #2 was only evaluated with Current Operations of Lower Kananaskis Lake.

Flat Loading #1 (Scenario ID: 3). The goal of "Flat Loading" the plant is to minimize the variability in plant flow release without violating the operating constraints of the plant. This is accomplished by operating the plant in one of the acceptable flow ranges: 19.8 to 27.8 cms (700-980 cfs) or 7.1 to 11.3 cms (250-400 cfs). Depending on the total volume of water being passed through the plant each week, the plant release may be constant or may alternate between the acceptable operating zones. Under the Flat Loading #1 scenario, if there is insufficient flow to allow continuous operation of the plant in the acceptable zones, a minimum flow of 1.0 cms (35 cfs) is passed to the river via a bypass. Peaking would still occur, although the frequency and magnitude of peaking would be less than with either Current Operations or Revised Peaking scenarios.

Flat Loading #2 (Scenario ID: 3-1). The Flat Loading #2 scenario is identical to the Flat Loading #1 scenario, except the minimum flow is increased from 1.0 to 2.0 cms (35 cfs-70 cfs). Flat Loading #2 was only evaluated with Current Operations of Lower Kananaskis Lake.

Average Weekly (Scenario ID: 4). The Average Weekly mode of plant operation ignores the plant operating constraints and rough zones and operates the plant at a steady flow rate equal to the weekly flow rate provided by the reservoir model. This mode of operation is currently not possible with the existing machinery at the Pocaterra Plant.

5.3 Lake management scenarios

Five different scenarios for management of Lower Kananaskis Lake were evaluated as part of the assessment. Fertilization of the lake was also considered.

The full range of options was considered in selecting scenarios for management of the reservoir. Stabilization above 1665 m would not allow for safe operation of the spillway for the dam. Stabilization at 1661 m was selected as the lowest level to evaluate because it is the operating

target that provides benefits in terms of increased biological productivity and full utilization of a spawning channel.

The five scenarios included:

- Current Operations (Scenario ID: Base Case or a);
- Stabilization at 1661 m (Scenario ID: b⁴);
- Stabilization at 1663 m (Scenario ID: b⁴);
- Stabilization at 1665 m (Scenario ID: b⁴); and
- Partial stabilization at 1661 m (Scenario ID: c).

Each of the five lake management scenarios is described in detail below and summarized in Table 2.

Current Operations (Scenario ID: Base Case or a). The Current Operations scenario represents the current operating objectives and constraints that are utilized to manage Lower Kananaskis Lake and the Pocaterra Plant. Under this scenario, the reservoir is managed using guide curves that draw the reservoir down prior to spring-runoff and raise its level from late spring through to late fall. This enables the maximum volume of run-off to be stored for energy production. Under this scenario, the reservoir elevation varies annually by about 13 m (from 1653.5 m to 1667 m).

Stabilization at 1661 m (Scenario ID: b). Stabilization at 1661.1 m represents the lowest reservoir stabilization level modeled. The allowable range for this scenario was 1660.6 m to 1661.6 m (1661.1 m +/- 0.5). This scenario was devised, in part, to accommodate the development of a cutthroat trout spawning channel at the inlet to Lower Kananaskis Lake in the former Kananaskis River channel at the south end of the reservoir. No modification to the existing spillway would be required to accommodate this scenario.

Stabilization at 1663 m (Scenario ID: b). Stabilization at 1663.0 m represents the intermediate reservoir stabilization level modeled. The target range for this scenario was 1662.5 m to 1663.5 m (1663.0 m +/- 0.5). This scenario would reduce the length of a cutthroat trout spawning channel compared to stabilization at 1661 m, but does not eliminate that option. No modification to the existing spillway would be required to accommodate this scenario.

Stabilization at 1665 m (Scenario ID: b). Stabilization at 1665.0 m represents the highest reservoir stabilization level modeled. The target range for this scenario was 1664.5 m to 1665.5

⁴ In terms of effects on Lower Kananaskis Lake, each stabilization scenario was analyzed separately. However, in assessing the combined plant operating and lake management scenarios (See Section 5.4), only stabilization at 1663 m was considered. This is because, for combined scenarios, the effects on the Kananaskis River of the stabilization scenarios are considered to be so similar that further analysis of downstream effects was not required. As a result, the letter "b" is used to identify the three stabilization scenarios.

Table 2
Lake Management Scenarios

Lake scenario	ID	Target elevation	Target stabilization period	Target elevation range	WRMM scenario name
Current Operations	a	Rule curve (variable)	None	None	TAU 42M
Stabilization at 1661 m	b	1661 m	Year round	±0.5 m	KANSCEN 12M
Stabilization at 1663 m	b	1663 m	Year round	±0.5 m	KANSCEN 13M
Stabilization at 1665 m	b	1665 m	Year round	±0.5 m	KANSCEN 14M
Partial stabilization	c	1661 m	May 1 to July 27	±0.5 m (May 1 to July 27)	KANSCEN 17M

m (1665.0 m +/- 0.5). This scenario negates the possibility of using the former Kananaskis River channel as a cutthroat trout spawning channel. No modification to the existing spillway would be required to accommodate this scenario, but the reservoir level must be drawn down 1.5 m each year for two to four weeks during the summer for dam safety considerations.

Partial stabilization (Scenario ID: c). This scenario represents partial stabilization of the reservoir at elevation 1661 m between May 1 and July 27 each year and allowing the reservoir to fill to Full Supply Level (FSL) later in the season. The target stabilization range from May 1 to July 27 is 1660.5 m to 1661.5 m (1661.0 m +/- 0.5). This scenario was created to promote multiple use of the reservoir, including developing a cutthroat trout spawning channel in the former Kananaskis River channel, utilizing available reservoir storage, and maintaining a minimum flow of 1.0 cms (35 cfs) in the Kananaskis River. No modification to the existing spillway would be required to accommodate this scenario.

5.4 Combined plant operating and lake management scenarios

Of the combinations possible between the six plant and five lake operations, a total of twelve combined scenarios were examined in detail. Natural river flow conditions were also examined for comparison purposes.

The twelve scenarios are identified in Table 3. The scenarios are identified using the numeric ID of the plant operating scenario with the letter ID of the lake management scenario. For example, the scenario that consists of the Revised Peaking #1 (Scenario ID: 2) and Stabilization at 1663 m (Scenario ID: b) is assigned an ID of 2b.

Table 3
Combined Scenarios

		Plant operating scenario						
	Current Operations	Revised Peaking #1	Revised Peaking #2	Flat Loading #1	Flat Loading #2	Average Weekly		
ID	1	2	2-1	3	3-1	4		
Current Operations	1a Base Case	2a	2a-1	3a	3a-1	4a		
Stabilization at 1661 m	b	The results for the Kananaskis River will be similar to the results with stabilization at 1663 m.						
Stabilization at 1663 m	b	2b		3b		4b		
Stabilization at 1665 m	b	The results for the Kananaskis River will be similar to the results with stabilization at 1663 m.						
Partial stabilization at 1661 m	c	2c		3c		4c		

6 RESULTS

In assessing the management alternatives for the Kananaskis system, FREWG considered a variety of factors. These factors are:

- **Reservoir productivity (fish and invertebrates):** The amount and diversity of biological activity and habitat in Lower Kananaskis Lake.
- **Fish habitat (river flow):** The amount of flow and how it affects conditions for fish in the Kananaskis River (Lower Kananaskis Lake to Barrier Lake).
- **Fish habitat (river water temperature):** The change in water temperature in the Kananaskis River (Lower Kananaskis Lake to Barrier Lake).
- **Wildlife and vegetation:** A preliminary qualitative assessment of how changes could affect wildlife and vegetation adjacent to Lower Kananaskis Lake and the Kananaskis River (Lower Kananaskis Lake to Barrier Lake).
- **Reservoir recreation:** The impact of changes on recreational use, recreational facilities, and the environmental factors that influence recreation at Lower Kananaskis Lake.
- **River recreation:** Changes in flow and how it affects recreational use in the Kananaskis River (Lower Kananaskis Lake to Barrier Lake).
- **Capital and lost opportunity costs:** The costs associated with changes in the production of electricity and capital investment for reclamation and modification of facilities. The capital and annual lost opportunity costs are summarized in Table 4, along with the net present value (NPV) of the costs for each scenario for the period 2002 through 2013.⁵ *13 year*
- **Flood control and safety:** The ability to control high flows and the level of Lower Kananaskis Lake.
- **EUB criteria:** Regulatory approvals that could be required.
- **Downstream impacts:** The effects of changes in flow in the Bow River on water quality and irrigation withdrawals.
- **River regime:** The effects on
 - winter ice jams
 - summer flood damage
 - flushing flows and changes in the river channel that help sustain a healthy ecosystem.

A series of tables were prepared that summarize the impacts of changing water management. These tables are included in Appendix C. Based on the information in Appendix C, FREWG considered the pros and cons of the scenarios.

The assessment showed the substantial benefits, costs, and trade-offs that are involved in changing water management in the Kananaskis system.

⁵ The economic analysis is described in Section 4.2.10.5.

Table 4
Summary of Capital and Lost Opportunity Costs

SMP Basis Year 1999
 Average On-Peak Price \$52.89
 Average Off-Peak Price \$22.44

13 years

Lake Management Scenario	Plant Operating Scenario	Scenario ID	Lost Generation On-Peak (MWh)*	Lost Generation Off-Peak (MWh)*	Generation Shifted Off Peak (MWh)*	Annual Lost Opportunity Cost	Initial Capital Expenditure**	Net Present Value of Capital & Lost Opportunity Costs
Current Operations	Current Operations	1a	0	0	0	\$0	\$0	\$0
	Revised Peaking #1	2a	3,690	0	0	\$195,164	\$0	\$1,396,000
	Revised Peaking #2	2a-1	5,610	0	0	\$296,713	\$750,000	\$2,770,000
	Flat Loading #1	3a	6,970	0	4,400	\$502,623	\$0	\$3,594,000
	Flat Loading #2	3a-1	8,250	0	4,290	\$566,973	\$750,000	\$4,702,000
	Average Weekly	4a	2,610	0	7,760	\$374,335	\$5,250,000	\$7,062,000
Stabilization @ 1661 m	Current Operations	1b	4,090	2,250	3,650	\$377,953	\$500,000	\$2,915,000
	Revised Peaking #1	2b	7,780	2,250	3,650	\$573,117	\$500,000	\$4,311,000
	Flat Loading #1	3b	11,880	2,250	7,360	\$902,935	\$500,000	\$6,771,000
	Average Weekly	4b	6,640	2,250	11,210	\$743,024	\$5,750,000	\$9,785,000
Stabilization @ 1663 m	Current Operations	1b	3,510	2,250	3,650	\$347,276	\$500,000	\$2,915,000
	Revised Peaking #1	2b	7,200	2,250	3,650	\$542,441	\$500,000	\$4,311,000
	Flat Loading #1	3b	11,500	2,250	7,480	\$886,491	\$500,000	\$6,771,000
	Average Weekly	4b	6,130	2,250	11,440	\$723,054	\$5,750,000	\$9,785,000
Stabilization @ 1665 m	Current Operations	1b	3,940	2,250	3,650	\$370,019	\$500,000	\$2,915,000
	Revised Peaking #1	2b	7,630	2,250	3,650	\$565,183	\$500,000	\$4,311,000
	Flat Loading #1	3b	12,140	2,250	7,550	\$922,472	\$500,000	\$6,771,000
	Average Weekly	4b	6,640	2,250	11,590	\$754,595	\$5,750,000	\$9,785,000
Partial Stabilization	Current Operations	1c	2,600	1,750	3,640	\$287,622	\$0	\$2,057,000
	Revised Peaking #1	2c	6,290	1,750	3,640	\$482,786	\$0	\$3,453,000
	Flat Loading #1	3c	10,310	1,750	7,770	\$821,162	\$0	\$5,872,000
	Average Weekly	4c	5,250	1,750	11,500	\$667,118	\$5,250,000	\$8,986,000

* Refers to combined generation from Pocaterra and all downstream plants.
 ** See Section 4.

SMP = system marginal price
 MWh = megawatt hours

6.1 Lower Kananaskis Lake

Stabilization of Lower Kananaskis Lake would triple the reservoir's biological productivity compared to current conditions. The potential yield of sportfish (kg/ha) would be similar to natural conditions.

Partial stabilization of Lower Kananaskis Lake would only increase potential sportfish yield by 6%. It is not an efficient way to improve productivity.

Fertilization of Lower Kananaskis Lake was evaluated as a way to improve productivity in the reservoir. Fertilization would not be effective without stabilization. There was not consensus among the Delphi panel members that stabilization without fertilization would restore the productivity of Lower Kananaskis Lake.

Stabilization would also benefit recreation at Lower Kananaskis Lake. Improved access to the lakeshore, better fishing opportunities, and improved aesthetics would enhance the quality of visitors' recreational experiences on and near the reservoir. Quantitative benefits are expected to include an increase of up to 35% (165,000) in annual visitor days through expansion or enhancement of existing lakeshore recreation facilities and development of several new facilities. As well, the improved shoreline and wildlife habitat that would result from stabilization would increase wildlife use of the area. This would increase the likelihood for viewing wildlife in a more natural setting. The impacts of increased human use on wildlife have been considered in these estimates. Partial stabilization would improve recreation at Lower Kananaskis Lake, but the benefits would be reduced compared to stabilization.

The total cost of stabilization would be in the order of \$3 million (NPV) over the next thirteen years due to increased capital and lost opportunity costs. Partial stabilization would be less expensive with a total cost of around \$2 million (NPV). (See Table 4.)

Compared to current conditions, stabilization or partial stabilization would generally decrease flow in the Bow River during the winter and spring and increase flow during the summer and fall. The greatest decrease in flow occurs in March and April. These changes would not affect existing irrigation or other withdrawals nor would they result in reduced water quality in the winter with existing wastewater discharges.

Stabilization or partial stabilization would not change existing water temperature in the Kananaskis River and would create a marginally positive increase in flushing flows. As well, stabilization would not affect ice jams, summer flooding, or changes in the river channel relative to existing conditions.

6.2 Kananaskis River

In terms of fish habitat in the Kananaskis River, scenarios with Average Weekly plant operations would provide the greatest improvements compared to current conditions and the amount of habitat would be comparable to natural conditions. The Flat Loading scenarios provide less of

an improvement for fish habitat compared to current conditions and provide much less habitat than both the Average Weekly scenarios and natural conditions. The Revised Peaking scenarios do not provide much improvement over current conditions.

In those scenarios where fish habitat would improve in the Kananaskis River, it is expected that angling success would also improve. In terms of other types of recreation, paddling sports would see substantial benefits from a combination of a fully stabilized reservoir plus either Current Plant Operations or Revised Peaking. These benefits to recreation would occur in the reach from Fortress Bridge to Ribbon Creek Bridge. Since recreational use of the upstream and downstream reaches would have negative impacts on wildlife and safety, recreation should be discouraged in those areas. The impacts of the different river scenarios on recreation opportunities below Barrier Dam were assessed and found to be negligible or somewhat beneficial in terms of increased hours of daily flow.

The total cost of implementing Average Weekly operations would be in the order of \$7 million (NPV) over the next thirteen years due to increased capital and lost opportunity costs. Implementing Flat Loading alternatives would be less expensive with a total cost of \$3.6 to 3.9 million (NPV). (See Table 4.)

In terms of river regime, the Flat Loading and Average Weekly options would have

- a positive effect on reducing winter ice jams, particularly in the vicinity of the Kananaskis Golf Course
- a marginally positive effect on maintaining a healthy river channel
- a marginally negative effect on summer flooding.

The Average Weekly option would marginally increase the risk for TransAlta in terms of flood control and safety. As well, the Average Weekly option requires a new turbine and generator unit which, in turn, could require approval from the Alberta Energy and Utilities Board.

Plant operating scenarios would not affect existing irrigation or other withdrawals nor would they result in reduced water quality in the Kananaskis and Bow Rivers with existing wastewater discharges.

6.3 Combined plant operating and lake management scenarios

No single scenario would provide a mutually satisfactory result for all interests. Scenario 4b is the scenario that would provide superior results in terms of improving fisheries and recreation. It is a combination of stabilization⁶ of Lower Kananaskis Lake and Average Weekly plant

⁶ In terms of fisheries and recreation improvements, all the potential stabilization levels (1661m, 1663 m, 1665m) are acceptable in combination with Average Weekly plant operations. A level of 1663 m is the preferred stabilization level.

operations. Reservoir productivity and fish habitat in the Kananaskis River would be comparable to or better than natural conditions.

The NPV for Scenario 4b would be \$9.8 million dollars over the next thirteen years due to capital and lost opportunity costs.

7 CONCLUSIONS AND RECOMMENDATIONS

1. The information that has been compiled is sufficient to decide whether changes to the management of Lower Kananaskis Lake and the Kananaskis River should be considered.
2. There would be substantial benefits to fisheries and recreation with changes in the management of Lower Kananaskis Lake and the Kananaskis River (Lower Kananaskis Lake to Barrier Lake). Scenario 4b would provide the greatest benefits including:
 - a tripling of the biological productivity of Lower Kananaskis Lake
 - improved access to the lakeshore, better fishing opportunities, and improved aesthetics at Lower Kananaskis Lake
 - a substantial increase in fish habitat in the Kananaskis River (Lower Kananaskis Lake to Barrier Lake) to a level that would be comparable to natural conditions
 - a positive effect on reducing winter ice jams, particularly in the vicinity of the Kananaskis Golf Course.
3. Scenario 4b is recommended if a satisfactory financial strategy can be developed for mitigating the costs of implementing improvements. The financial strategy should be developed as soon as possible, preferably before January, 2002, to maximize benefits and reduce uncertainty.
4. The scenarios that do not provide much improvement over current conditions and are not, therefore, recommended are Partial Stabilization (Scenario ID: c) and Revised Peaking (Scenario ID: 2 and 2-1).
5. No changes should be made to the management of Lower Kananaskis Lake and/or the Kananaskis River (Lower Kananaskis Lake to Barrier Lake) without consultation with those people who could be affected by a decision (Table 5).
6. In addition to preparing the financial strategy, it is recommended that, during the next year, the partners in FREWG:
 - review this report and its recommendations with those people who could be affected by a decision
 - clarify the following issues:
 - a. the ability to reduce the impact of changes
 - b. the impact of stabilization on water quality in the Bow River downstream of Calgary's wastewater treatment plants at future levels of wastewater loading
 - c. impacts on wildlife and riparian vegetation
 - d. fisheries management objectives
 - e. detailed recreation assessment of recreation facility improvements around Lower Kananaskis Lake, environmental impacts of increased recreational activities, boating hazard reduction, and "naturalization" of a stabilized lakeshore

- f. options for post-2013 operations
- g. feasibility of a spawning channel for cutthroat trout
- h. effectiveness of fertilization as a method of improving the productivity of Lower Kananaskis Lake
- i. the design of a post-implementation monitoring program to determine the effectiveness of decisions
- j. identify how different scenarios affect the development of frazil ice in relation to winter fish habitat in the Kananaskis River.

Table 5

**Who Could Be Affected
By a Change in Water Management
Kananaskis River System**

FREWG Partners

- Alberta Environment
- Fisheries and Oceans Canada
- Parks Canada
- TransAlta Utilities Corporation
- Trout Unlimited Canada

Others

- Alberta Balancing Pool
- Alberta Energy and Utilities Board
- Businesses providing services within Kananaskis Country
- Consumers of electricity
- Downstream water users
- First Nations
 - Siksika
 - Stoney/Nakoda
- Fisheries, recreation, and environmental groups
- Municipalities
 - City of Calgary
 - Kananaskis Improvement District
 - Municipal District of Bighorn
 - Municipal District of Rocky View
 - Town of Cochrane
- University of Calgary – Kananaskis Research Centre
- Visitors to Kananaskis Country
 - Anglers
 - Campers
 - Canoeists, kayakers, and other paddlers
 - Cottage owners on Lower Kananaskis Lake
 - Hikers

Appendix A

**Members
of the
Fisheries and Recreation
Enhancement Working Group**

**Members
of the
Fisheries and Recreation
Enhancement Working Group**

Dave Ardell	Manager, Water Power	Alberta Environment
Kerry Brewin	Alberta Council Manager and Biologist	Trout Unlimited Canada
Kasey Clipperton	Instream Flow Biologist	Alberta Environment
Don Cockerton	Protected Areas Planner	Alberta Environment
Rick Courtney	Impact Assessment Biologist	Fisheries and Oceans Canada
Roger Drury	Water Management Planner	TransAlta Utilities
Dave Fernet	Principal	Golder Associates
Chris Katopodis	Regional Habitat Engineer	Fisheries and Oceans Canada
Brian Lajeunesse	Fisheries Biologist	Alberta Environment
Allan Locke	Instream Flow Needs Specialist	Alberta Environment
Bob Morrison	Water Planner	Alberta Environment
Charlie Pacas	Aquatics Specialist	Parks Canada
Jim Stelfox	Fisheries Biologist	Alberta Environment

Appendix B

Licence Summary

Water Power Licences

The Bow River upstream from Calgary is subject to a number of water power licences. The rights to water held under these licences are the most complex on the river system. Many of these licences were first granted by the federal government to Calgary Power. The administration of most licences, including those for the developments on the Kananaskis River System, has since been transferred to the province. All licences themselves have been assigned to TransAlta Utilities Corporation, the successor to Calgary Power. The licences have also been subject to specific statutes and to agreements between the province and the licensee.

The Alberta Government has completed the consolidation of all of TransAlta's water power licences. The consolidation incorporates previous statutes and agreements. The purpose of the consolidation was to simplify administration and ensure that the water rights are clearly documented. The consolidation received the approval of the Lieutenant Governor-in-Council in 1998.

Interlakes Licence

This licence was issued in 1947 and dates back to an authorization granted in 1931. The licence entitles the licensee to store and use the waters of Upper Kananaskis Lake and the streams flowing into it and the waters of the Kananaskis River up to a maximum capacity of 101,000 acre feet at an FSL of 5,583 feet. The Interlakes Licence has been assigned a priority date of September 12, 1930.

Pocaterra Licence

This licence was issued in 1961 and dates back to an interim licence that was granted in 1954. It entitles the licensee to impound and store at the Pocaterra site, for power and storage purposes, all the waters of Kent Creek and Pocaterra Creek that are feasible to divert, and of the Kananaskis River and their tributaries up to a capacity of not less than 51,100 acre feet. The licensee may store such water in the Reservoir (Lower Kananaskis Lake) up to a full supply level of 5,469 feet above sea level, or such other elevation as the licensee may determine to be the economic maximum. The Pocaterra Licence has been assigned a priority date of December 31, 1931.

Barrier Licence

The Barrier Licence was granted in 1949 and dates back to an interim licence granted in 1947. It entitles the licensee to store and use the waters of the Kananaskis River at the Barrier site up to a maximum capacity of 20,100 acre feet at an FSL of 4,515 feet. The summer operating level of the reservoir must be no greater than 4,513 feet. The Barrier Licence has been assigned a priority date of August 6, 1945.

Appendix C

Results of Scenario Assessment

Component	Issue	Performance Measure	Natural	Base Case (LMS a)	Stabilization (LMS b - 1661)	Stabilization (LMS b - 1663)	Stabilization (LMS b - 1665)	Partial Stabilization (LMS c)	Fertilization
F & W	Fish Habitat (water temp.)	Impact on Fish	NR	<ul style="list-style-type: none"> No significant water temperature problems were identified. Spawning and incubation are successful for all scenarios. 					
F & W	Wildlife & Vegetation		NR	<ul style="list-style-type: none"> Ice build-up and/or flooding may negatively affect riparian vegetation compared to natural conditions A spawning channel and/or Interlakes boat launch will raise concerns about further interference with wildlife movement in that area. It is expected that in the Kananaskis River upstream of the Fortress Bridge and downstream of the Ribbon Creek Bridge the negative impacts on safety and wildlife habitat would outweigh any recreational benefits. Recreation should be discouraged in those areas. 					NR

F & W = Fisheries and Wildlife
 NC = no appreciable change from Base Case
 POS = plant operating scenario
 f = frequency
 si = significant improvement
 -- = marginally negative effect
 LMS = lake management scenario
 NR = not rated
 ++ = positive effect +
 Ns = non sufficient
 = marginally positive effect

Component	Issue	Performance Measure	Natural	Base Case (LMS a)	Stabilization (LMS b – 1661)	Stabilization (LMS b – 1663)	Stabilization (LMS b – 1665)	Partial Stabilization (LMS c)	Fertilization
Recreation	Reservoir Recreation	Ranking			3*	1*	2*	4*	
* Ranking based on significant improvements for recreation from stabilizing at all three levels. Differences between 1, 2, 3 and 4 based on recreation development potential and environmental factors including risk of drawdown/surcharge. Differences between 1, 2 and 3 are relatively small.									

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Component	Issue	Performance Measure	Natural	Base Case (LMS a)								Stabilization (LMS b - 1661)				Stabilization (LMS b - 1663)				Stabilization (LMS b - 1665)				Partial Stabilization (LMS c)				Fertilization						
				Base Case (POS 1)	Revised Peaking #1 (POS 2)	Revised Peaking #2 (POS 2-1)	Flat Loading #1 (POS 3)	Flat Loading #2 (POS 3-1)	Average Weekly (POS 4)	Stabilization (LMS b - 1661)	Base Case (POS 1)	Revised Peaking #1 (POS 2)	Flat Loading #1 (POS 2)	Revised Peaking #1 (POS 3)	Flat Loading #1 (POS 3)	Average Weekly (POS 4)	Stabilization (LMS b - 1663)	Base Case (POS 1)	Revised Peaking #1 (POS 2)	Flat Loading #1 (POS 2)	Revised Peaking #1 (POS 3)	Flat Loading #1 (POS 3)	Average Weekly (POS 4)	Stabilization (LMS b - 1665)	Base Case (POS 1)	Revised Peaking #1 (POS 2)	Flat Loading #1 (POS 2)	Revised Peaking #1 (POS 3)	Flat Loading #1 (POS 3)	Average Weekly (POS 4)	Fertilization			
Hydro	Capital & Lost Opportunity Costs	20 Year NPV (2002 - 2013) (\$)		0	1,396,000	2,770,000	3,594,000	4,702,000	7,062,000		2,915,000	4,311,000	4,311,000	6,771,000	9,785,000		2,915,000	4,311,000	4,311,000	6,771,000	9,785,000		2,915,000	4,311,000	4,311,000	6,771,000	9,785,000		2,915,000	4,311,000	4,311,000	6,771,000	9,785,000	NA
Hydro	Flood Control & Safety	Ranking		1	1	1	1	1	2	1	1	1	1	1	2		1	1	1	1	1	2	3	1	1	1	1	1	1	2	NA			
Hydro	EUB Criteria	Ranking		1	1	1	1	1	2		1	1	1	1	2		1	1	1	1	1	2		1	1	1	1	1	2	1				
		Total replacement of a generating unit could require EUB approval.																																

Ranked based on ability to control flood inflows and reservoir levels without using spillway.
 1 = NC, 2 = marginal increase in risk, 3 = somewhat greater risk

F & W = Fisheries and Wildlife
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Component	Issue	Performance Measure	Natural	Base Case (LMS a)								Stabilization (LMS b - 1661)				Stabilization (LMS b - 1663)				Stabilization (LMS b - 1665)				Partial Stabilization (LMS c)				Fertilization
				Base Case (POS 1)	Revised Peaking #1 (POS 2)	Revised Peaking #2 (POS 2-1)	Flat Loading #1 (POS 3)	Flat Loading #2 (POS 3-1)	Average Weekly (POS 4)	Base Case (POS 1)	Revised Peaking #1 (POS 2)	Flat Loading #1 (POS 3)	Average Weekly (POS 4)	Base Case (POS 1)	Revised Peaking #1 (POS 2)	Flat Loading #1 (POS 3)	Average Weekly (POS 4)	Base Case (POS 1)	Revised Peaking #1 (POS 2)	Flat Loading #1 (POS 3)	Average Weekly (POS 4)							
Downstream Impacts	Withdrawals	Irrigation	NR									<ul style="list-style-type: none"> Stabilization (LMS b - 1661) 				<ul style="list-style-type: none"> Stabilization (LMS b - 1663) 				<ul style="list-style-type: none"> Stabilization (LMS b - 1665) 				<ul style="list-style-type: none"> Partial Stabilization (LMS c) 				NR
	Water Quality		NR									<ul style="list-style-type: none"> Stabilization (LMS b - 1661) 				<ul style="list-style-type: none"> Stabilization (LMS b - 1663) 				<ul style="list-style-type: none"> Stabilization (LMS b - 1665) 				<ul style="list-style-type: none"> Partial Stabilization (LMS c) 				NR

No impact on irrigation districts' water supply from Base Case.
 No significant change from Base Case in water supply for Highwood and Little Bow irrigation.

With existing wastewater loadings, predicted ammonia concentrations in the mixing zone downstream of Calgary for lake stabilization are generally higher than for the Base Case. Instream water quality guidelines for ammonia are met for both scenarios.
 With existing wastewater loadings, total phosphorus concentrations in the Bow River with the lake stabilization scenario will be no more than 15% higher than with the Base Case and 70% of the time the difference will be less than 5%. The increase in nutrient concentrations with stabilization is very small and unlikely to result in a measurable increase in the amount of aquatic plants or algae in the Bow River.

F & W = Fisheries and Wildlife
 NC = no appreciable change from Base Case
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Appendix D

Factors Not Covered in This Report

Factors Not Covered in This Report

- Funding alternatives
- Corporate benefits of modified operations (e.g., goodwill, public relations)
- Frazil ice and its effects on winter fish habitat use
- Potential to lessen icing problems associated with the Kananaskis Golf Course
- More detailed assessment of wildlife issues
- Stratified withdrawal from the reservoir
- Re-regulation weir
- Future wastewater loadings
- More detailed assessment of environmental impacts and conflicts associated with increased recreational activities or new facilities around Lower Kananaskis Lake and along the Kananaskis River between Opal Day Use and Ribbon Creek (if river recreation is expected to increase).
- More detailed assessment of habitat enhancement or "naturalization" of the stabilized lakeshore including risk of increased human-wildlife conflict.
- Detailed feasibility studies of upgraded, expanded or new recreation sites around Lower Kananaskis Lake and along the river.
- Detailed assessment of boating hazard reduction and erosion protection requirements at Lower Kananaskis Lake.
- Public and stakeholder consultation regarding the scenarios.

Appendix E

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(including projects completed for FREWG)**

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