Lake Diefenbaker
Reservoir Operations

Context and Objectives

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Hydrology And
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1.0 Introduction and Background

This document presents the physical constraints and current objectives that determine the operations of Lake Diefenbaker. The document is a reference for Saskatchewan Watershed Authority (Authority) staff who plan operations and a resource to inform a broader audience on the operations of Lake Diefenbaker.

The South Saskatchewan River was recognized as an important water source in southern Saskatchewan as early as the start of the 20^{th} century. In the early 1900's, studies were commissioned to examine constructing a dam on the South Saskatchewan River for domestic and agricultural water supplies. In 1944, a test drilling program was initiated to determine foundation characteristics at ten sites along the river; one site was eventually selected.

The findings of The Royal Commission on the South Saskatchewan River Project in 1952 were not entirely favorable to develop the project. The Province of Saskatchewan, however, was convinced that development of a significant and reliable source of water for the southern portion of the province was desirable.

An opportunity to renew interest in the project came with a change in federal government after the 1957 election. The signing of a Federal-Provincial agreement in 1958 marked the official start of the South Saskatchewan River Project with the stated purpose:

> *"The project is to provide facilities for the irrigation of approximately 500,000 acres of land in Central Saskatchewan and in the Qu'Appelle Valley and to provide other benefits to the area including a source of hydroelectric power, a source of rural and urban water supply, flood control, and recreation facilities."*

The federal government, through Prairie Farm Rehabilitation Administration (PFRA), was to build the Gardiner and Qu'Appelle River dams to impound water in the valley. Saskatchewan was to pay 25 percent of the cost to a maximum of $25 million. The project ultimately cost approximately $120 million with the federal portion being $95 million. Saskatchewan Power Corporation (SaskPower) paid for the construction of the Coteau Creek hydroelectric plant ($40 million).

Gardiner Dam (Figures 1 through 3, Table 1) on the South Saskatchewan River, complete with a concrete spillway, five diversion tunnels and a hydroelectric plant, was the largest earth filled dam by volume in the world at the time. Water in the new lake behind the dam would have flowed away down the Qu'Appelle River without a companion dam. A smaller earth fill dam known as The Qu'Appelle River Dam (Figures 4, 5) was constructed to contain the lake and allows for controlled releases from Lake Diefenbaker to the Qu'Appelle River via a gated diversion conduit. Both dams and the Gardiner spillway were largely complete by 1966, and reservoir filling began in 1967. SaskPower began producing electricity in the fall of 1968, and by 1970, the reservoir, known as Lake Diefenbaker, had filled.

Figure 1: Gardiner Dam - Opening Ceremony July 21, 1967

Ownership of the project, including operational responsibility, was transferred to the Province of Saskatchewan on April 1, 1969. Although the Province of Saskatchewan made water management decisions from the outset, PFRA staff continued to perform on-site duties until April 1, 1997. Thereafter, provincial personnel undertook all operation and maintenance activities. The Watershed Authority currently operates and maintains the South Saskatchewan River Project on behalf of the Province.

2.0 Physical Parameters

Gardiner Dam is a zoned earthen embankment with a central impervious clay core, granular and random fills for outer zones and a downstream filter blanket. The river section of the main embankment incorporates an upstream impervious blanket for seepage control. The embankment has a riprap face upstream and grassed slope downstream. There are various seepage collection facilities including granular drains, pipe drains, relief wells, conduits and observation wells. The main embankment forms the east portion of the overall dam, crosses the original river channel.

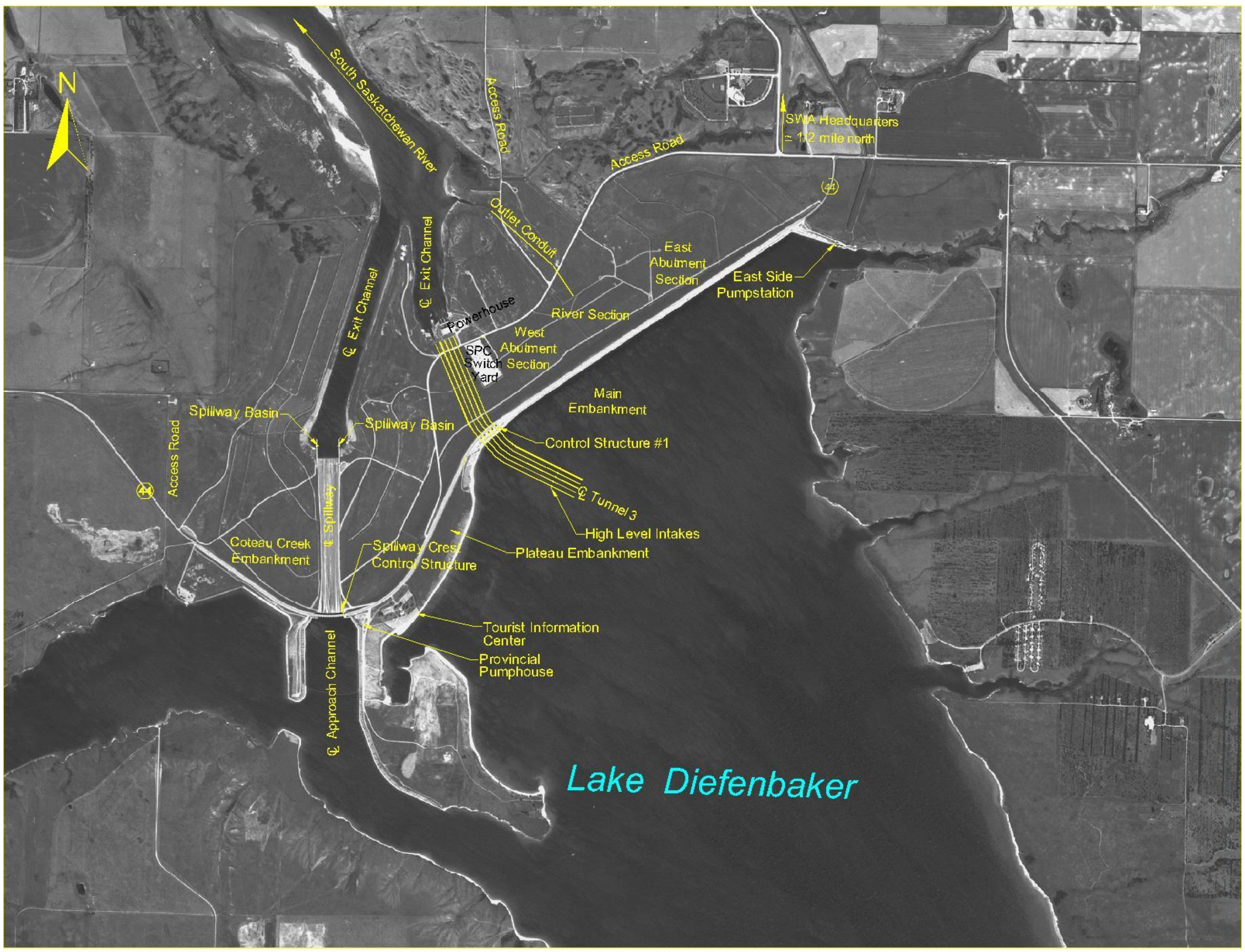

Figure 2 – Gardiner Dam Structures

Figure 3 - Downstream View of Gardiner Dam SaskPower Coteau Structure

Figure 4 - Qu’Appelle Dam

Figure 5 - South View Overlooking Qu’Appelle Dam

Table 1 – Physical Dam Characteristics

	Gardiner Dam	Qu'Appelle Dam
Top of Dam (TOD):	562.36 m	562.36 m
Maximum height	64 m	27.4 m
Full Supply (FSL)	556.87 m	556.87 m
Crest Width	18.3 m	13.7 m
Total Crest Length	4970 m	3080 m
Minimum Release Level	522.73 m	541.78 m
Volume of Earth Fill	64,910,000 m^3	10,390,000 m^3
Embankments Main Embankment Plateau Embankment Coteau Creek Embankment	 Height 64 m, Length 2440 m Height 2 m, Length 1525 m Height 45 m, Length 915 m	 Height 27.4 m, length 3100 m

2.1 Reservoir

Lake Diefenbaker is a long narrow water body confined to the original river valley and coulees. It is generally 2 to 3 km wide by 225 km in length. At its Full Supply (FSL) of 556.87 m elevation, the mean depth is 22 m; the maximum depth is 58 meters and the surface area is 43,000 ha. It is the largest body of water in Southern Saskatchewan. Table 2 shows key elevation/area/capacity values, while Figure 6 shows the area-capacity curve.

Table 2 – Key Elevation Area Capacity Points

	Storage (dam^3)	Area (ha)
Total at FSL (556.87 m)	9,400,000	43,000
Total at DSL (522.73 m)	1,100,000	10,200
Live Storage (34.14 m)	8,300,000	32,800

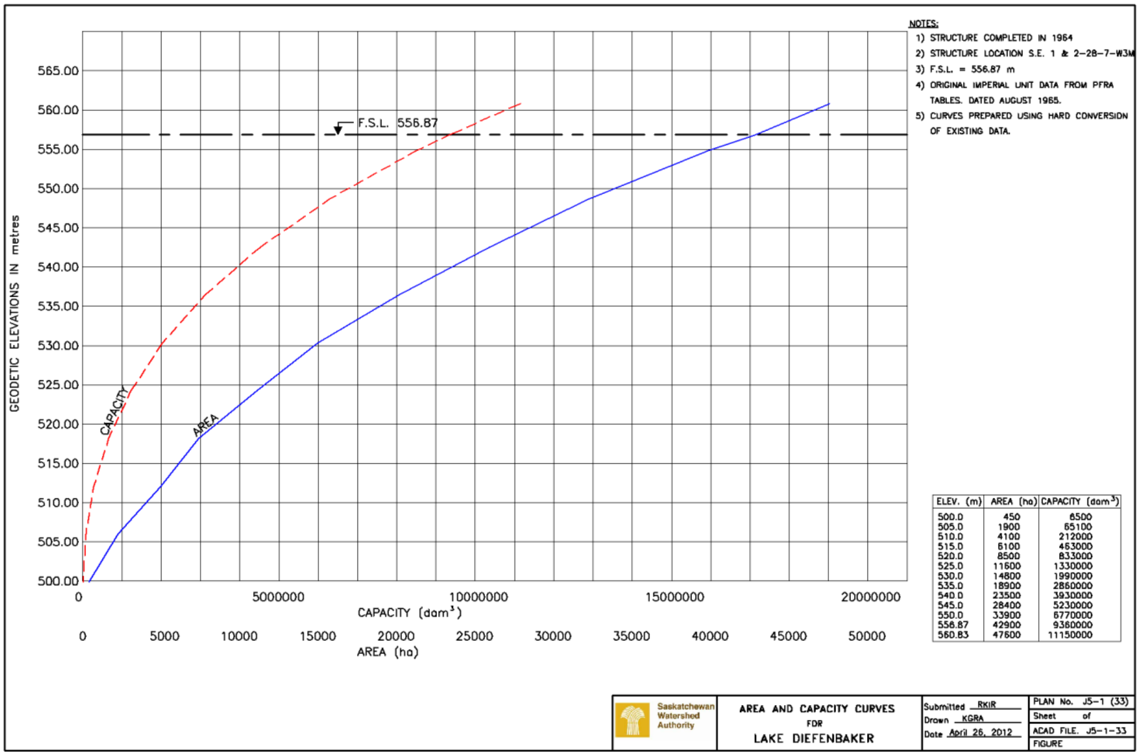

Figure 6 – Area / Capacity Curve

2.2 Outflow Facilities and Capacities

Gardiner Dam

The discharge facilities for Gardiner Dam include five tunnels along the east edge of the plateau embankment and the main spillway is located along the west edge of the plateau embankment. The various discharge rating curves for the spillway and Tunnel 5 are provided in Figures 7 and 8 respectively, and are summarized in Table 3.

The Coteau Creek Hydroelectric Station utilizes three of the tunnels for hydropower production, the fourth tunnel is available for future power generation, and the fifth tunnel is used as a low-level outlet for the reservoir. All five tunnels had their low-level intakes sealed off and flows are now via the high-level intakes. The tunnels are 6.1 m in diameter, 1160 m in length, and incorporate a 68 m deep shaft and a superstructure housing the equipment for two vertical lift gates for flow control at the embankment crest. The invert of the high-level intakes is 522.73 m elevation and the invert of the control structure is at 490.27 m.

The spillway consists of 11 gated bays and a spillway chute is 1160 m in length. Flow is controlled via eleven 12.2 m wide radial gates seated on an ogee crest (548.64 m elevation). The discharge through the eleven spillway bays when they are fully opened is estimated to be 12,200 m^3/s (assuming a peak reservoir elevation of 561.4 m). This is the maximum discharge associated with the Probable Maximum Flood. The spillway will pass approximately 6400 m^3/s, with Lake Diefenbaker at its FSL elevation of 556.87 m. The maximum recorded outflow below Gardiner Dam since construction is less than 2000 m^3/s.

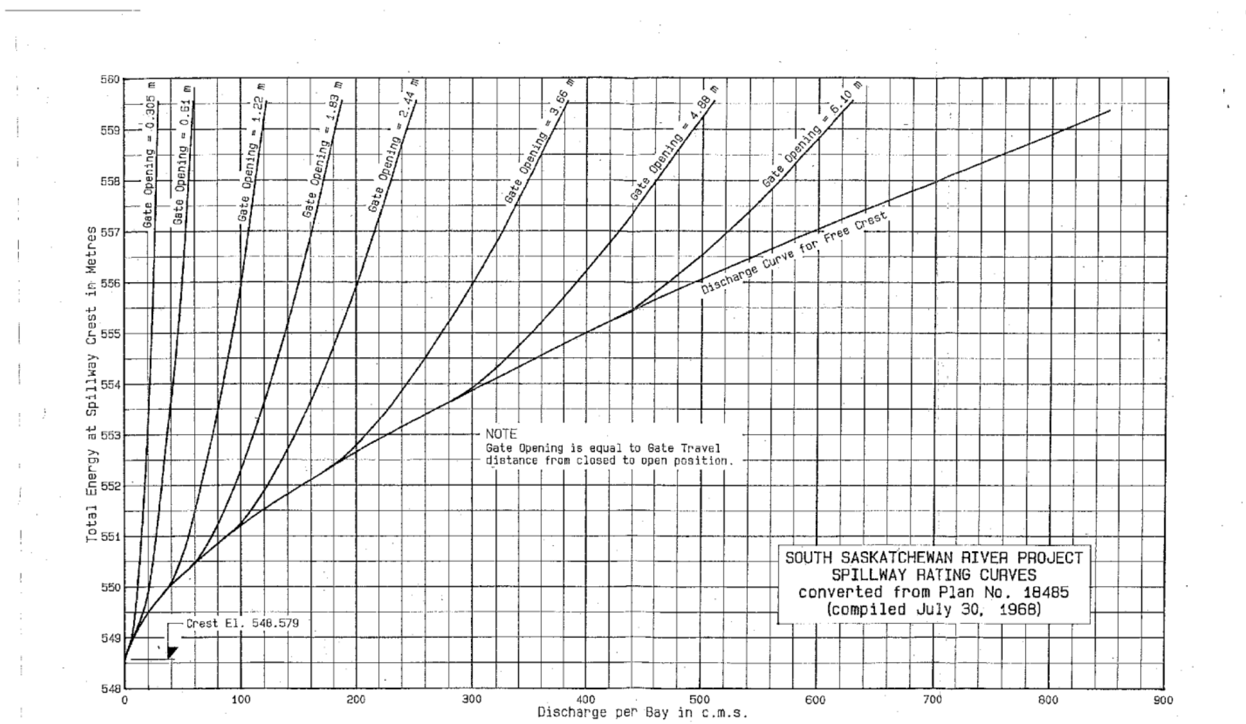

Figure 7 – Spillway Rating Curve

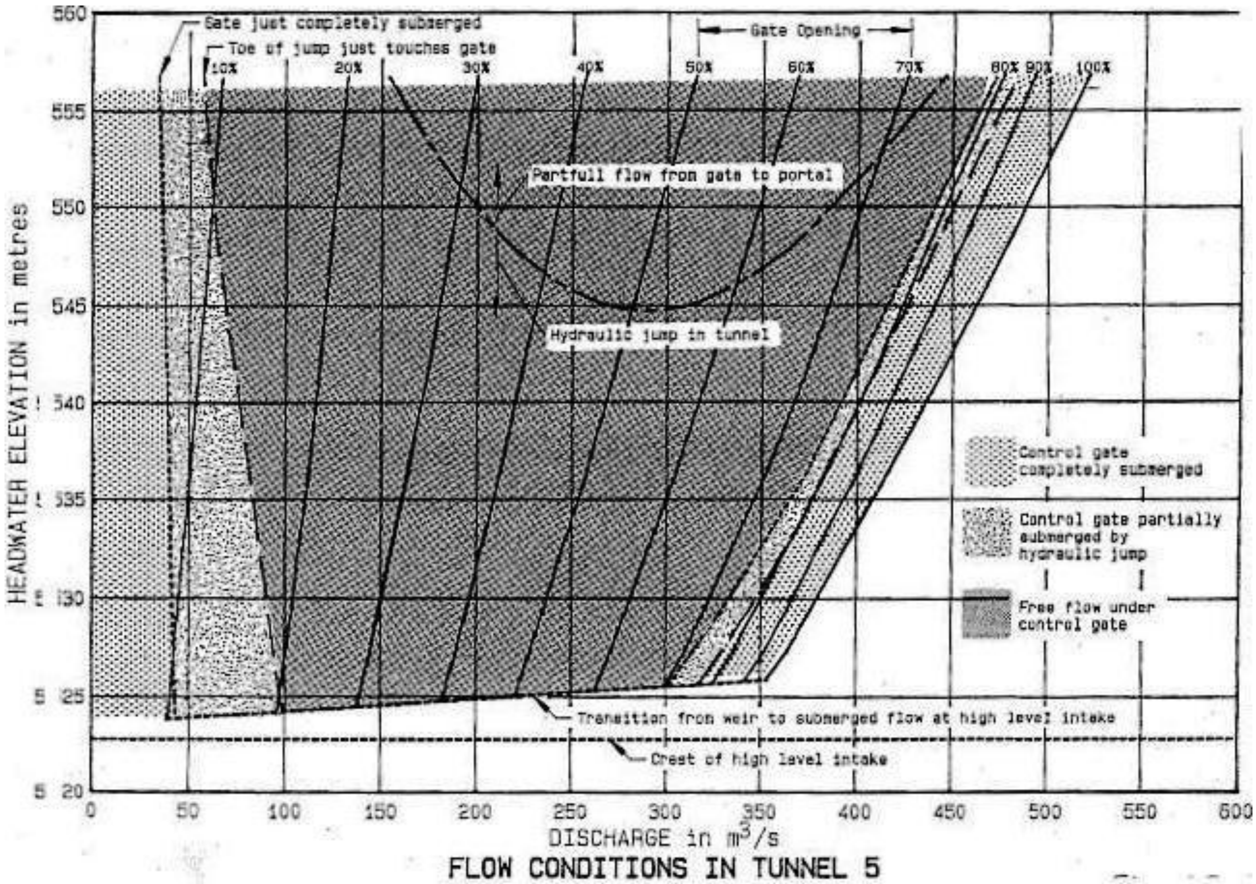

Figure 8 – Tunnel Five Rating Curve

Figure 9 – Gardiner Dam Spillway

Qu’Appelle Dam

Flow releases from the Qu’Appelle Dam are made via the dam’s gated riparian outlet structure located near the south end of the dam. The riparian outlet works consist of a drop inlet, a horseshoe shaped conduit, gated at mid length with a control structure, and a downstream chute and energy dissipating outlet basin.

The inlet structure consists of seven bays of the octagonal shaped drop inlet. Each bay is 3.5 m wide with a weir crest elevation of 541.78 m (1777.5 ft.). The horseshoe shaped inlet and outlet conduit is 3.2 m wide, 3.1 m high and 457 m long. Conduit sections downstream of the control gate were designed to operate under free flow conditions only (i.e. partial depth), and not under conditions of pressure flow. The gated control structure contains four 1.5 m by 1.5 m high pressure dry well sluice gates. The gates are aligned into two lines, with two gates in tandem. The gates are designed to open and close under fully unbalanced head conditions and to operate at partial gate openings.

Table 3 – Summary of Discharge Capacities

Facility	Invert Elevation (m)	Capacity at FSL (m^3/s)	Capacity at 561.4 * (m^3/s)
Gardiner Dam			
Spillway bays (11) fully open	548.64	6,410	12,200
Coteau Creek Power Station (3 tunnels)	522.73	425	425
Low level outlet fully open	522.73	520	540
Qu'Appelle Dam			
Outlet Structure	536.25	68	-

Notes: * Top of Dam (TOD) equals 562.36 m but the Probable Maximum Flood elevation is approximately 561.4 m.

2.3 Site Access

Gardiner Dam is located approximately 29 km upstream (southeast) of the Town of Outlook or 95 km south of the City of Saskatoon, or 175 km North West of the city of Regina (Figure 10).

The Qu'Appelle River Dam site is located approximately 145 km upstream (southeast) of the City of Saskatoon. The site is approximately 19 km southeast of the Town of Elbow (Figure 11).

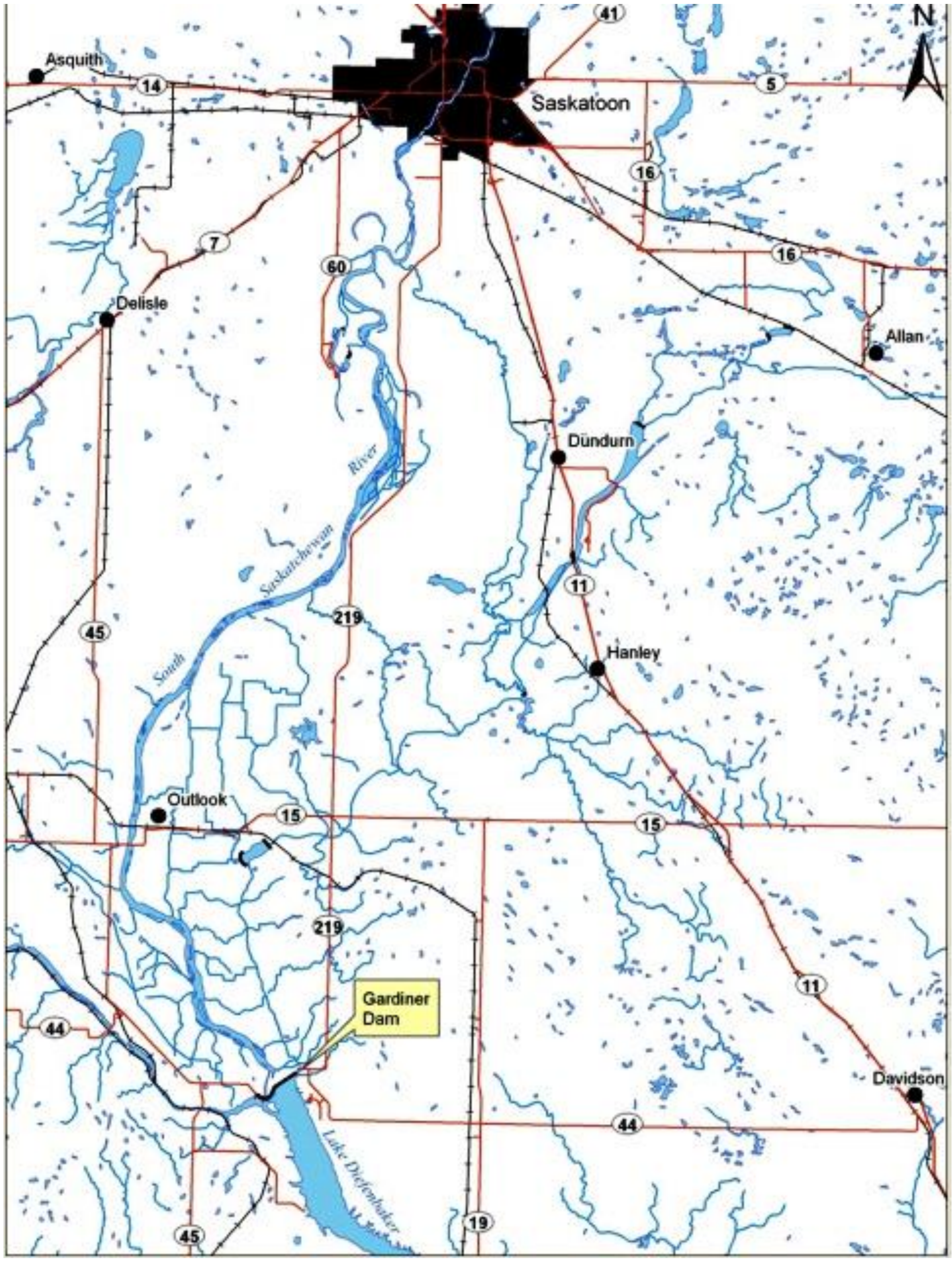

Figure 10 – Gardiner Dam Location Plan

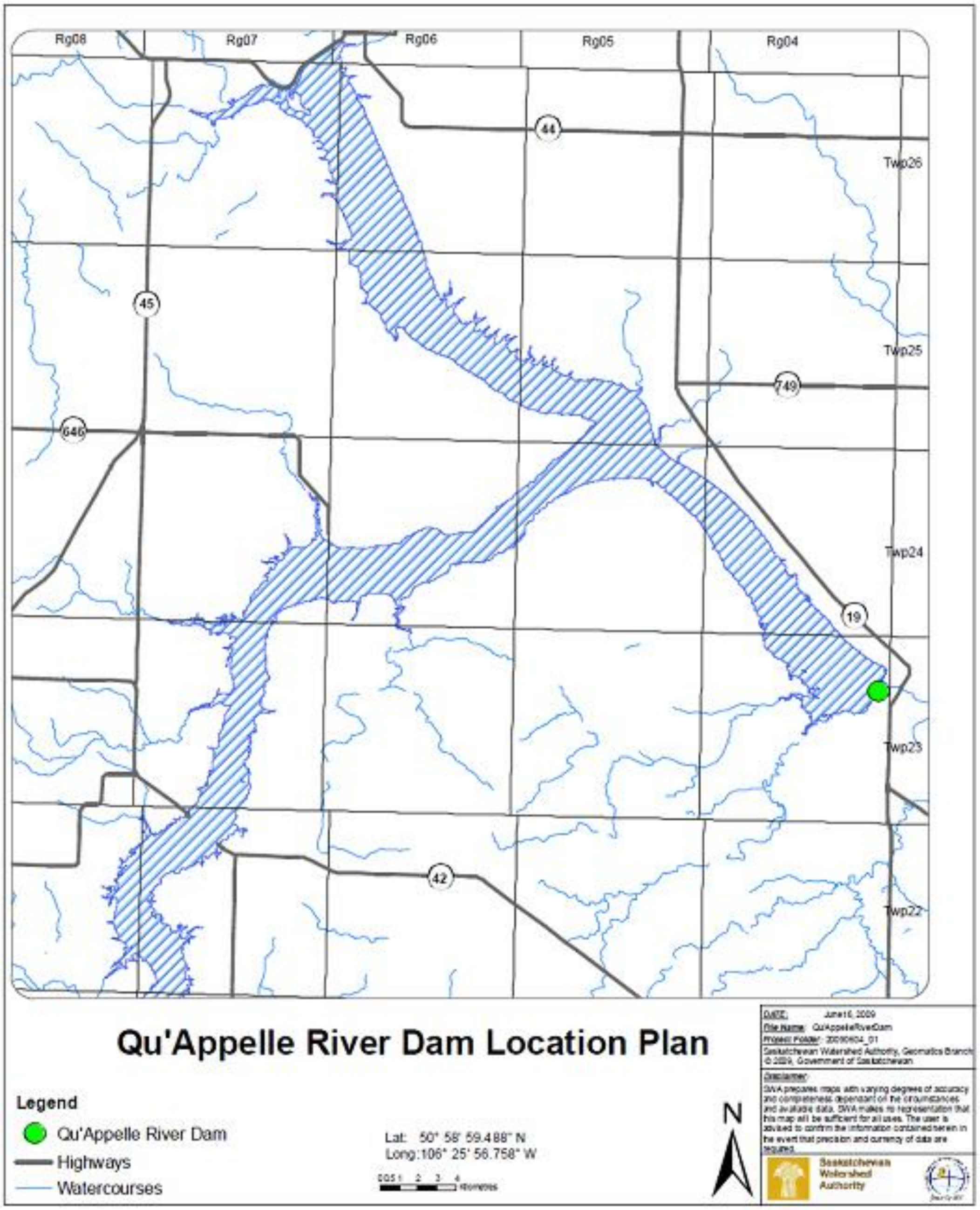

Figure 11 – Qu'Appelle Dam Location Plan

3.0 Land and Regulatory Considerations

3.1 Take Line

Lake Diefenbaker is a long, narrow constructed reservoir created by partially inundating the original river valley and coulees of the South Saskatchewan and Qu'Appelle River valleys. Geologically, the valleys are young and continually changing as erosion continues and banks stabilize. Superimposed over the natural change are complications arising from the standing water, wind and wave action because of the man-made reservoir. Recognizing that reservoir would affect a larger area than what was inundated at FSL and that a new shoreline would establish over the coming decades, a "Take Line" was acquired around the reservoir rim. Land within the take line is expected to erode, or be at risk of eroding, as the lake establishes its shoreline through water level changes, wind and waves.

3.2 Reservoir Development Area

Land use around Lake Diefenbaker is regulated pursuant to "The Reservoir Development Area Regulations". As a recognized Reservoir Development Area (RDA) (Figure 12), the regulations ensure controlled development occurs within the RDA and a restricted building area has been delineated. Land within this zone may, at some time, be impacted by erosion or land sliding. Owing to this potential, development is precluded within the restricted building area.

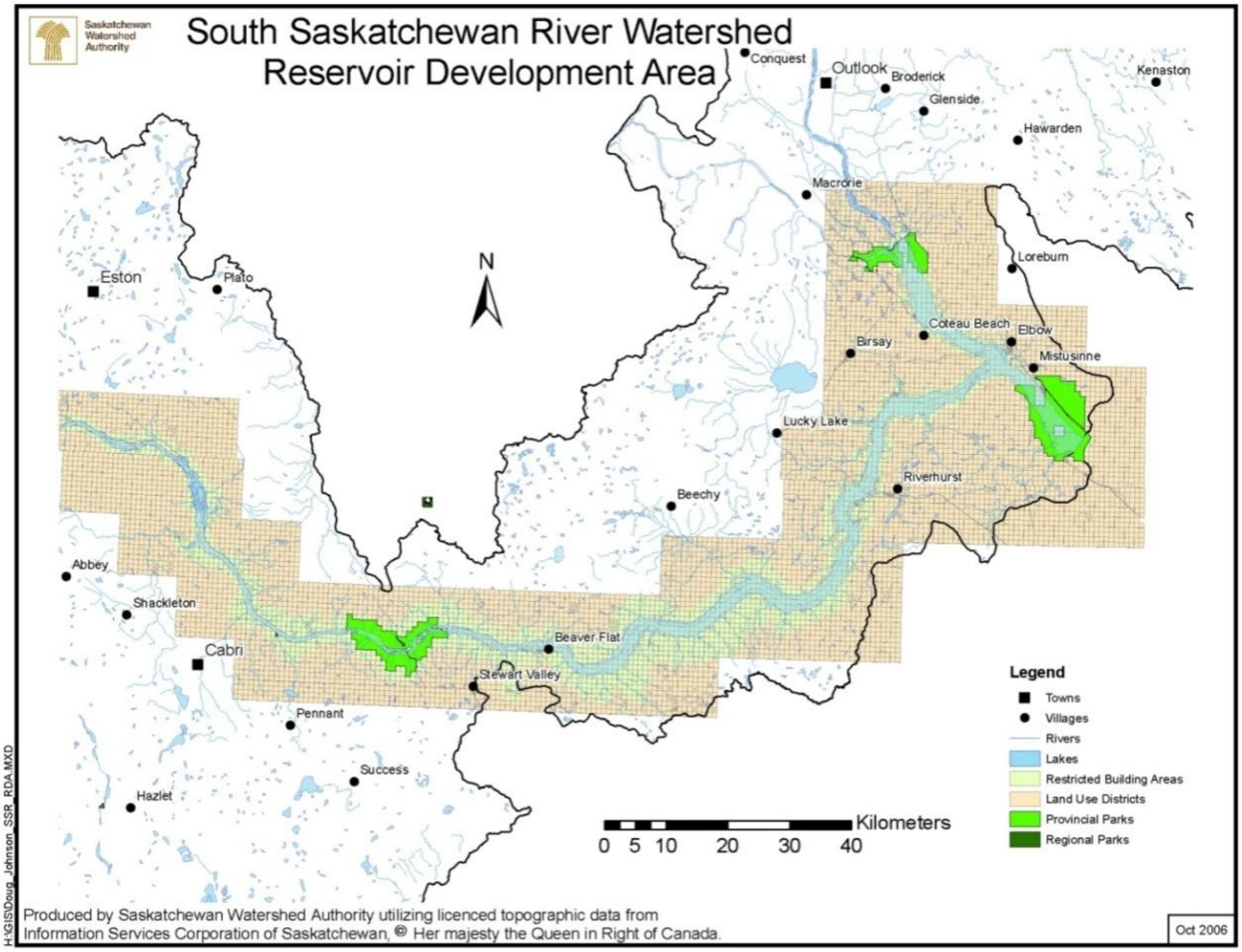

Figure 12 – Lake Diefenbaker Reservoir Development Area

4.0 Hydrology and Water Supply

4.1 Watershed and Inflows

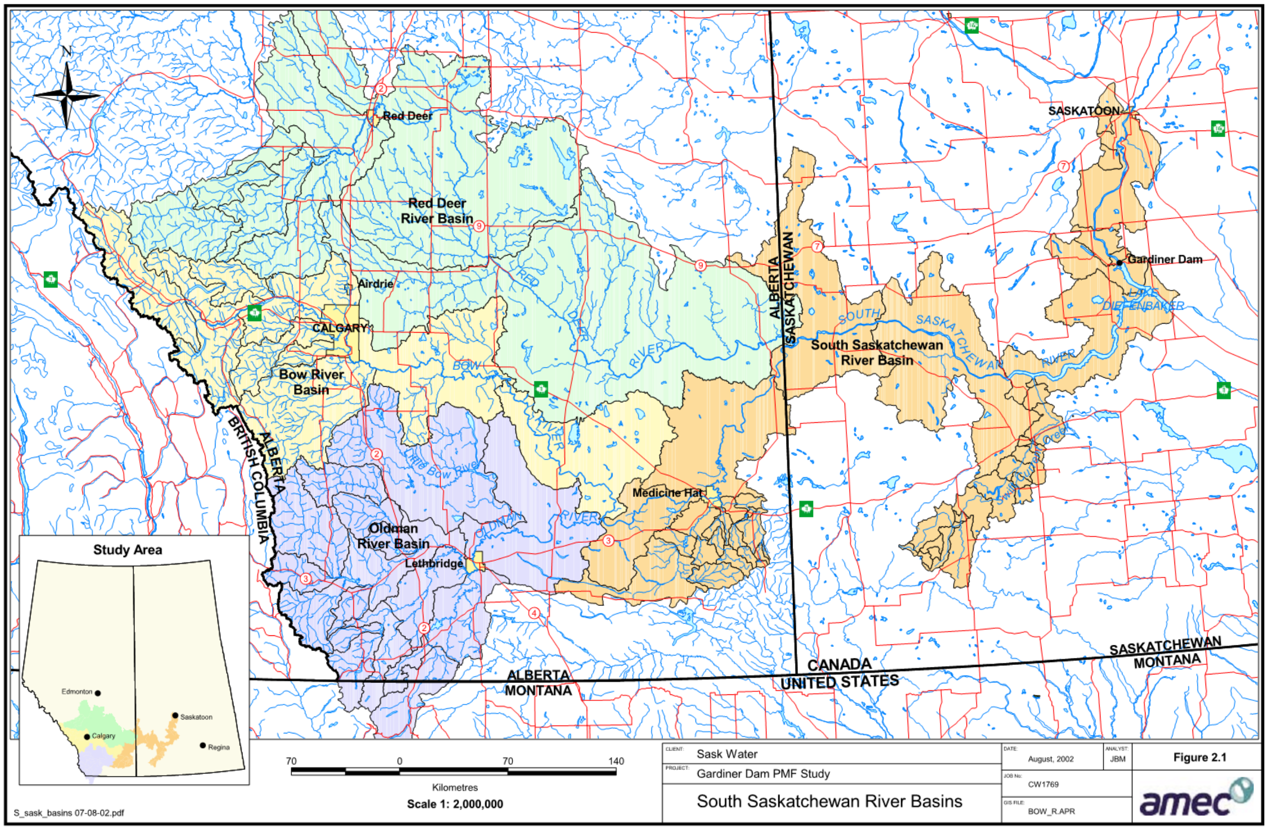

Figure 13 – South Saskatchewan River Basin Watersheds

The drainage basin of the South Saskatchewan River to Gardiner Dam (Figure 13) extends from Saskatchewan to Alberta and northwestern Montana, encompassing prairie, foothill, and alpine environments. The main tributaries are the Red Deer, Bow and Oldman Rivers with their headwaters on the eastern slopes and foothills of the Rocky Mountains. The effective and gross drainage areas are 82,300 km^2 and152,700 km^2 respectively.

The size and geographic complexity of the basin are reflected hydrologically in the complexity of inflows to Lake Diefenbaker. Geographically, inflow originates from mountain and prairie regions. The majority of inflow volumes occur in two periods:

1) A lesser inflow volume from late March through April with the prairie snowmelt, varying widely from near nil to significant,
2) The majority of inflow volume arrives from late May through June as a combination of alpine snowmelt and late spring/early summer rain event runoff from the mountains and/or the prairies.

Median annual unit runoff for the basin is shown in Figure 14. The mountain region consistently produces a significantly higher runoff per unit area even though the relative runoff contribution from each of these regions may differ in individual years. Geographically, 80% of inflow volumes originate from the mountain and foothill areas from snow and rain with a small contribution from glacier wastage. The remaining 20% of inflow is from prairie snowmelt and rainfall runoff. Overall roughly half of runoff is the result of snowmelt and half from rain, however on any given year this proportion can vary widely. When planning reservoir operations it is assumed that observed snowfall accumulations in the mountain headwaters account for roughly 50 percent of the historical normal spring/summer inflow while rainfall runoff accounts for the balance.

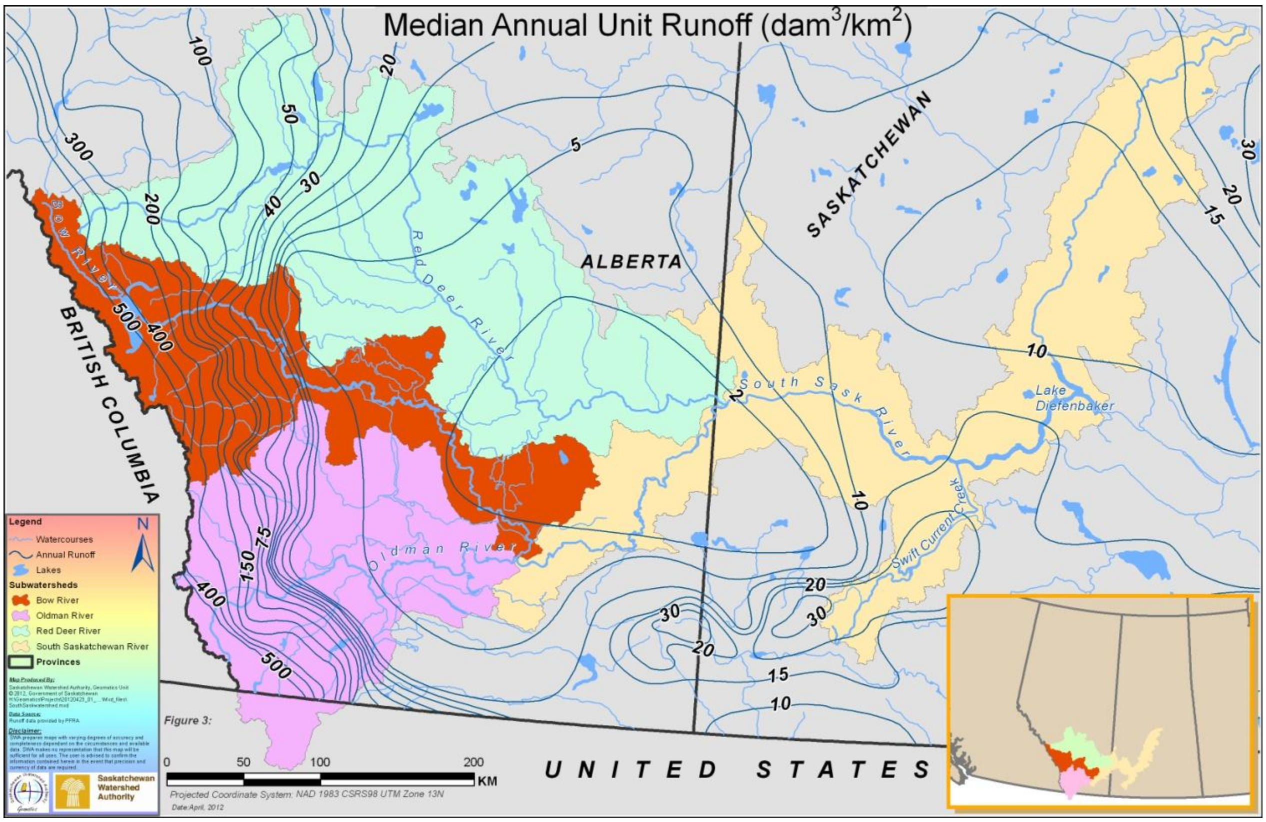

Figure 14 – Median Annual Runoff

Peak inflow rates are the product of combined rainfall and snowmelt. Snowmelt in the alpine regions and upper elevations does not occur until late spring, roughly the same annual period that meteorological patterns often bring widespread rain events to central North America. Rain events centered in the foothills or widespread events on the prairies can result in significant flows that when combined with the ongoing alpine runoff produces the peaks. Travel time from the foothills to Lake Diefenbaker is roughly one week, although at high flows it can be as little as 3 days.

The basin climate is classified as semi-arid to sub-humid with the southern and southwestern areas being mainly semi-arid. Annual precipitation varies from 770 mm in the mountains (Lake

Louise), to 540 mm in the foothills (Pincher Creek) to 350 mm on the plains (Medicine Hat and Saskatoon). Some of the precipitation statistics for these centres based on Environment Canada data are shown in Table 4. It should be noted that the ratio of snow to rain may be changing as climate change progresses in Western Canada.

Table 4 – Precipitation Statistics for Three Centres in the South Saskatchewan River Basin

Centre	Total Annual Precipitation (mm)	Snowfall as a % of the Annual Precipitation	Rainfall in April, May and June as a % of the Annual Precipitation
Lake Louise	570	46	17
Medicine Hat	335	25	36
Saskatoon	350	24	38

(Source: Environment Canada Climate Norms, 1971-2000)

Figure 15 shows the estimated actual and computed natural flows for the South Saskatchewan River below the Red Deer River. The average flow crossing from Alberta into Saskatchewan from 1928 to 2004 was 208 m^3/s or an average annual volume of approximately 6,600,000 dam^3 (based on Water Survey of Canada recorded flow data). The mean annual net evaporation is approximately 600 mm per year based on climatic records for the period from 1977-2006.

A water supply analysis was conducted by the Authority for Lake Diefenbaker in 2006 and included a simulation for the years 1928 to 2004 but assuming that Alberta was at its maximum level of development and using its full apportionment. The median annual inflow to Lake Diefenbaker in that scenario was calculated to be 5,500,000 dam^3. The annual average evaporative losses from Lake Diefenbaker were calculated to be 270,000 dam^3.

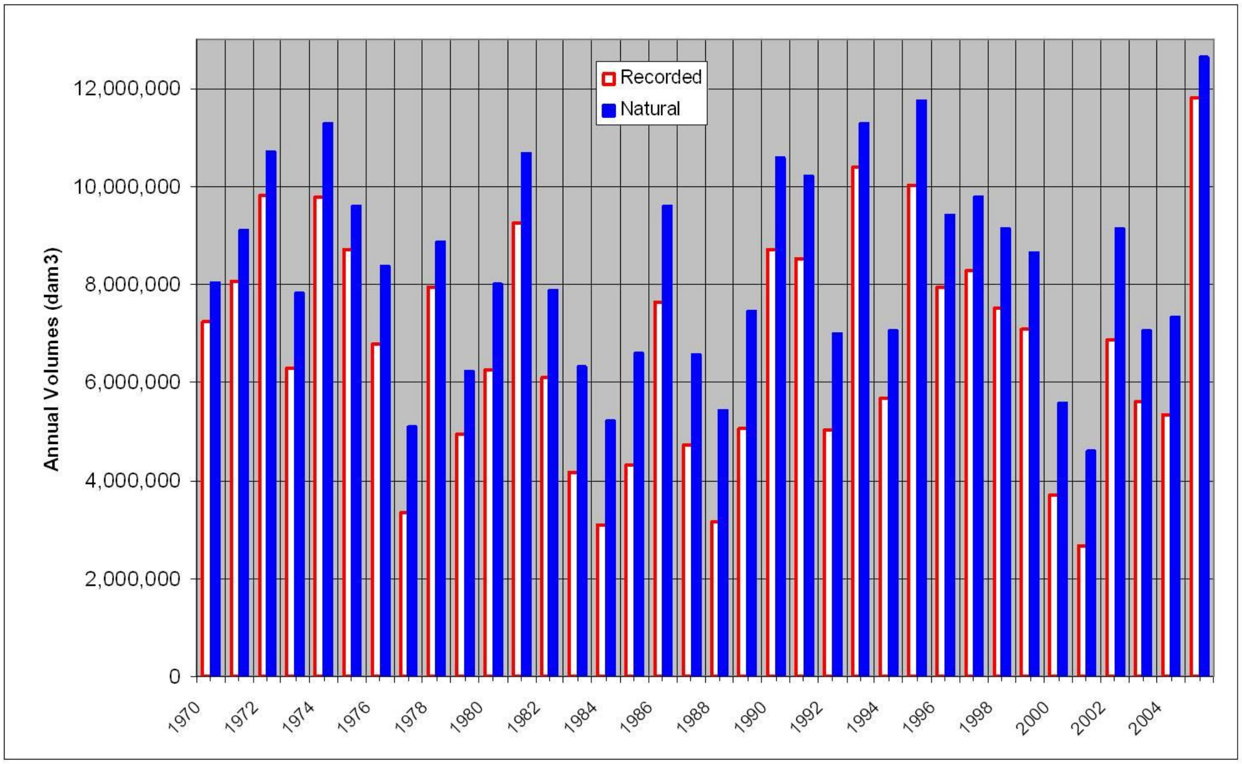

Figure 15 – Natural and Recorded Inflow Volumes (Prairie Provinces Water Board)

4.2 Apportionment Obligations

Under the 1969 Master Agreement on Apportionment Saskatchewan is obligated to pass on to Manitoba one-half of the waters it receives from Alberta, plus one-half of the natural flow arising in Saskatchewan within the Saskatchewan River basin.

This constraint has not been approached in the operating history of Lake Diefenbaker and the Master Agreement, and is not expected to at the current level of water use in the Saskatchewan portion. There is little use on the North Saskatchewan River and, as a result, Saskatchewan provides well in excess of its obligation on the main stem of the Saskatchewan River into Manitoba.

5.0 Reservoir Uses

The term “use” in water management is broad. For example, use may mean consumptive use, such as irrigation. It may mean use of water flow without actually withdrawing the water, such as cooling water. It may just mean its presence, such as for recreation or simply the aesthetics of seeing water. Some uses are easily quantifiable, but others are more value-based and difficult to compare with numbers. All uses have specific needs or desires and specific times they wish them to be met.

From the perspective of a reservoir, any use which removes water from reservoir storage can be considered a consumptive use. Therefore irrigation, hydropower production and supplementing downstream flows are all reservoir uses.

Lake Diefenbaker is a multiuse reservoir, important for:

- hydropower production;
- water supply, including municipal, irrigation, and industrial water uses;
- habitat;
- recreation; and
- flood control and downstream flow regulation.

Hydroelectric Generation

Hydropower is less costly to generate than most other sources of electrical generation so maximizing generation from the available water benefits Saskatchewan power consumers. Hydropower is maximized by minimizing the amount of water that is passed downstream over spillways rather than through turbines, and by maximizing reservoir head levels along with the timing of generation.

Most power generated in Saskatchewan is produced by SaskPower. The Authority works closely with SaskPower providing operational constraints and guidelines to balance SaskPower’s need for water with the needs of other users both on Lake Diefenbaker and downstream.

SaskPower has three generators with a total installed capacity of 186 MW at Coteau Creek Generating Station. Water from Lake Diefenbaker, flows downstream through two more hydro stations on the Saskatchewan River, Nipawin and E. B. Campbell, with a combined installed capacity of 543 MW. Lake Diefenbaker is the largest storage reservoir in the Saskatchewan River basin upstream of the Manitoba border and plays an important role in storing water for hydroelectric generation in Saskatchewan. The ten year annual average electricity produced at the three stations, Coteau Creek, Nipawin and E. B. Campbell, is 2,600,000 MW-hrs.

The value of hydroelectric generation varies throughout the year and even on a daily and hourly basis. Hydroelectric generation is the least expensive form of electrical generation available to SaskPower, followed by wind power, coal fired and gas fired electrical generation. Wind power and coal fired generation are used for base load electrical generation. The amount of hydropower generated is limited, therefore it is generally used for to meet peak electrical demands when power demands are correspondingly higher during the morning and evening hours.

Water Supply

Lake Diefenbaker is the most reliable source of water in southern Saskatchewan and accordingly many users rely on it as a water supply source. The reliance is both direct, as in drawn directly from the reservoir, or indirect as in benefitting from regulated flow downstream. Licensed allocations from the reservoir are summarized in Table 5.

Table 5 – Licensed Allocations from Lake Diefenbaker

Type of Use	Details	Licensed Annual Allocation (dam^3)
Irrigation	172 irrigation users	196,410
Multiple Uses	Through the SSEWS System	72,775
Municipal	9 users	770
Industrial	One user	127
Domestic	Four users	4
Total Annual Licensed Allocation		270,086

Municipal

Approximately 45 percent of the provincial population relies on Lake Diefenbaker as a source for their drinking water supply, through withdrawals directly from the reservoir such as the Saskatoon South East Water Supply System (SSEWSS), diversion to the Qu’Appelle River or directly from the river downstream of Gardiner Dam. The total municipal water supply from the South Saskatchewan and Saskatchewan Rivers including Saskatoon is about 79,000 dam^3. Regina and Moose Jaw use about 35,000 dam^3 per year.

Industrial

Similarly, Lake Diefenbaker is the source water for several industries including six potash mines, and fertilizer and ethanol plants at the Belle Plaine industrial complex. Water is delivered via the SSEWS system, the Qu’Appelle River, as well as directly from the South Saskatchewan River downstream of Lake Diefenbaker. The lake also supplies cooling water for Queen Elizabeth Power Station at Saskatoon.

Irrigation

The total current irrigated acreage in the Lake Diefenbaker Development Area (LDDA) is approximately 101,300 acres (41,000 ha) as shown in Table 6. District irrigators account for the majority of irrigation water use. The larger irrigation districts include the South Saskatchewan River, Luck Lake, Riverhurst, Macrorie and Grainland Irrigation Districts. Irrigation allocations from Lake Diefenbaker are based on an "18 inch duty", that is, each acre is entitled to use 18 inches (460 mm) inches of water. Thus, the irrigation allocation is about 187,400 dam^3 per year. However, actual water use averages about 12 inches (300 mm) yielding an average annual irrigation water use of about 125,000 dam^3.

Table 6 – Current Lake Diefenbaker Area Irrigation Projects

Project	Irrigated Area (acres)	Licensed Annual Water Allocation (dam^3)	Average Annual Water Use (dam^3)
Irrigation Districts	62,900	116,400	77,600
Private Irrigators	38,400	71,000	47,400
TOTAL	101,300	187,400	125,000

Potential exists for further irrigation development around or upstream of Lake Diefenbaker. Potential future projects are listed in Table 7, which also indicates how much water is being held in reserve for these projects by Regulation. There has been interest in two other additional large projects. These are the Qu'Appelle South Irrigation District, with a potential development using about 200,000 dam^3 and the Westside Irrigation Development, with a potential development using up to 650,000 dam^3. The latter project is the same project as the West Side Pump Project included in Table 6 values but with a larger potential development.

Table 7 – Water Reservations for Future Irrigation Development

Irrigation Project	Acreage (acres)	Annual Water Reserved (acre-feet)	Annual Water Reserved (converted to dam^3)
West Side Pump Project	30,000	86,000	106,100
Sage Creek	5,000	11,500	14,200
Elbow East	8,000	18,500	22,800
Valley Park	1,500	3,500	4,300
French Flats	2,500	6,000	7,400
TOTAL	47,000	125,500	154,800

(From the *Withdrawal from Allocation Regulations*)

Qu'Appelle River Diversion

While diversions made to the Qu'Appelle system are used, in part, for municipal and industrial supplies, diversions are also made for irrigation, wildlife projects, in-stream flow needs, and to mitigate the effects of evaporation on the eight recreational lakes along the Qu'Appelle River. Over the last 30 years (1981-2000), releases to the Qu'Appelle River have averaged 108,000 dam^3 annually. The minimum and maximum annual releases are 38,200 dam^3 in 1982 and 196,000 dam^3 in 1989 respectively. These releases have been adequate to meet all current uses except replacement of lake evaporation losses in dry years.

Habitat and Fisheries

As expected, the development of Lake Diefenbaker altered and continues to alter the landscape of the Saskatchewan River Basin. Owing to shoreline erosion around the main body of the lake, wide expanses of sand and gravel beaches exist when the reservoir elevation is below FSL. The controlled releases from Gardiner Dam have also altered sandbars and islands located downstream. The sand and gravel areas provide nesting habitat for Piping Plovers, a bird species recognized by law as a threatened. A legal duty exists to mitigate the impacts of reservoir operations on these birds.

Lake Diefenbaker has frequently supported one of the largest single-site populations of Piping Plovers in North America with upwards of 5% of the breeding population, and has been identified as both a globally significant Important Bird Area and a potential Western Hemisphere Shorebird Reserve Network site.

A considerable threat to breeding Piping Plovers is the rapid rise in water levels during their critical nesting and brood-rearing periods in the late spring and early summer. These periods coincide with the time that the larger alpine runoff inflows occur. Water levels that rise too fast can flood nests along the shore or remove significant brood-rearing habitat. The areas where Piping Plover are known to nest are shown in Figure 16. The Watershed Authority, in partnership with SaskPower, leads the Lake Diefenbaker Piping Plover Conservation Plan to assist with bird survival. When feasible, operations on Lake Diefenbaker have been optimized to assist in the recovery plan for the Piping Plover. Operations may be altered to control the rate of rise or the overall water level (and hence the amount of beach available) where and when other uses will not be severely affected. Figure 17 shows the risk categories for the Piping Plover based on reservoir water level and rate of rise during filling used in the Conservation Plan. Modeling and past operating experience indicate that the July 1st range can be met in about 70 % of years.

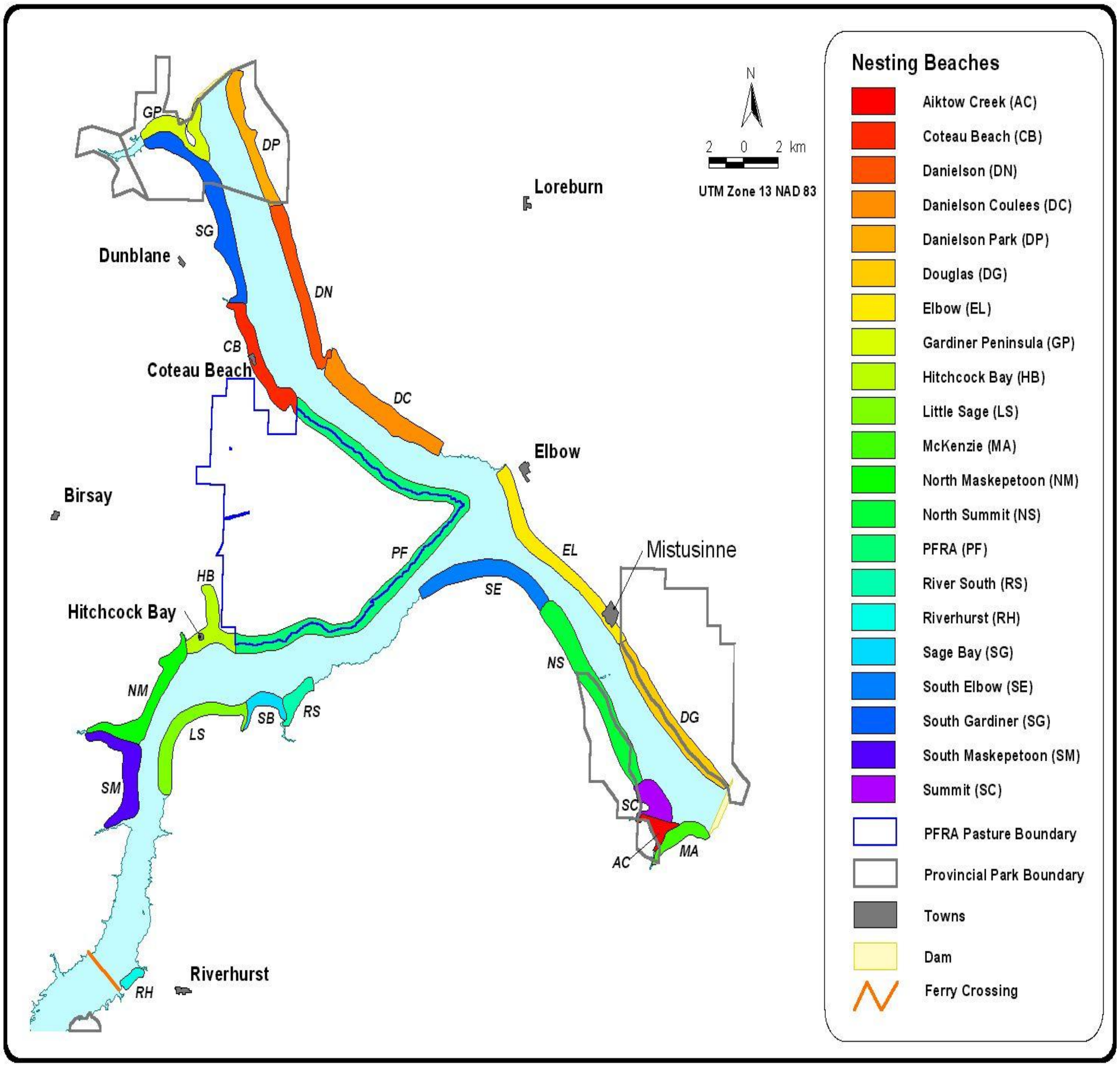

Figure 16 – Piping Plover Nesting Beaches

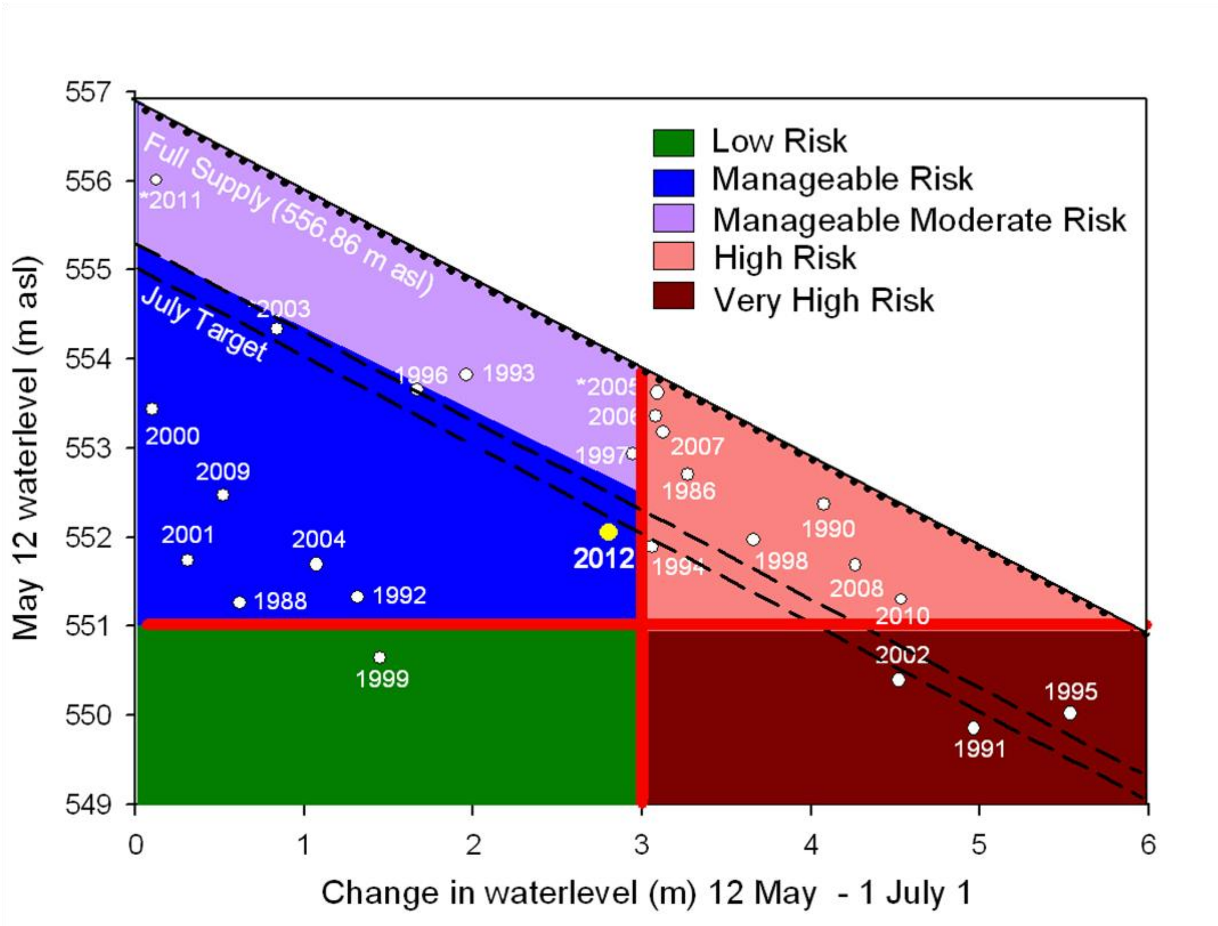

Figure 17 – Piping Plover Risk Categories

The initial fisheries assessment on Lake Diefenbaker was carried out from 1967 to 1969 to document physical, chemical and biological characteristics of the newly formed reservoir, and to provide baseline information in order to develop a preliminary fish management plan. Numerous additional investigations and sport fish management investigations have occurred since.

Anglers relayed many comments during interviews at Lake Diefenbaker in 2004. Comments varied from a great fishing experience, caught walleye limit, catches 50-70 walleye on a good day to statements such as fishing was poor and the walleye were small, no pike in the lake, and walleye numbers down. A common statement was that ice fishing was too dangerous due to variable ice conditions. The majority of anglers who were asked what species they preferred to catch indicated walleye, followed by rainbow trout.

Most species of fish show some preference to water temperature and require suitable oxygen conditions. Both these factors can restrict the water depths that are suitable for the survival of a particular species. Additionally, reservoirs generally differ from natural lakes in several important ways. Water levels fluctuate frequently and to greater extremes, which can lead to:

- Limited habitat of submerged or emergent aquatic vegetation;
- Exposure and desiccation of fish eggs during incubation, particularly over-winter;
- Shorelines subject to erosion and thus increasing turbidity and sedimentation.
- The wide variation in water level, with minimum levels occurring in winter and spring, can have an impact to spring spawning species because potential spawning grounds may be high and dry, and likely has a substantial impact on the reproductive success of fall spawning fish.

Results from a 2004 study suggested that the spawning walleye population in the lower reaches of Lake Diefenbaker in the Coteau Bay area was in a healthy state.

Annual water fluctuations appears to have affected lake trout in particular, which spawn on rocks and shoals usually mid-September to October in larger lakes. However, some successful reproduction must be occurring, as lake trout are still captured by both gillnets and anglers. Lake trout have not been stocked since 1975.

Whitefish and cisco are also fall-spawning species, and both have become successfully established in Lake Diefenbaker. Lake Whitefish generally spawn late November to mid-December and able to reproduce in areas other than rock shoals. In past years, a commercial fishery for whitefish operated in the fall (from 1976 until 1985) and targeted the spawning fish. It appears that the reservoir provides ample whitefish habitat with suitable water temperatures, adequate oxygen and appropriate spawning and rearing areas.

Pike numbers have shown a decline in abundance since reservoir formation, when it was the most frequent fish taken by angling. Limiting spawning habit is likely the contributing factor to the low levels of abundance. Northern pike require flooded vegetated areas in which to lay their eggs. Drawdown in early spring tends to leave coulees dry, and areas suitable for this species to reproduce appear to be limited. Water levels do not rise until late June or July to flood terrestrial sites so these areas remain unusable in most years. Eroding shorelines do not allow rooted vegetation to become established. There are several tributaries flowing in to Lake Diefenbaker which may provide some suitable habitat. The amount and suitability of spawning and nursery habitat for northern pike has declined in Lake Diefenbaker since its creation. However, although the numbers appear sparse, this population appears to have reached a stable level.

Recreation

Recreational activities including swimming, boating, fishing and camping exist on and around Lake Diefenbaker. Three Provincial Parks; Danielson, Douglas and Saskatchewan Landing, are all located on the reservoir. There are also two Resort Villages, five Regional Parks and four marinas located on Lake Diefenbaker. While there are at present only a few cottage subdivisions; it is expected that there will be more in the future.

The design of marina facilities at Lake Diefenbaker need to accommodate the wide range in water levels experienced over the course of the year. A consideration that has emerged is that the Elbow Harbour marina requires a minimum reservoir level of at least 552.0 m by the beginning of the open water season (taken to be the Victoria Day Weekend in May) in order for larger boats to be launched.

Flood Control and Flow Regulation

The relatively large storage capacity of Lake Diefenbaker allows for significant control of downstream flows, reducing the natural fluctuations from the variable inflows while maintaining minimum or desirable target flows downstream.

Although Lake Diefenbaker was primarily designed as a water supply reservoir, downstream flood control is another important function of the reservoir. The definition of "flooding" used here is any flow that causes inundation outside of the present main river channel, regardless of the reasons for the overbank flow. In most cases, the operation of Lake Diefenbaker is able to reduce peak flows, often substantially. The general objective is to operate Lake Diefenbaker to provide as much flood mitigation as possible with the available storage while allowing for the possibility of subsequent flood events. In managing Lake Diefenbaker, flows on the North Saskatchewan River and the available storage in Tobin Lake must also be considered to minimize flood risk at Cumberland House and other developments along the Saskatchewan River.

Depending on how much flows exceed the river channel capacity, some or all of the natural flood plain will be inundated. Flood plain areas most susceptible to flooding include agricultural land in the RM of Corman Park upstream of Saskatoon as well as lands between Saskatoon and the confluence of the North Saskatchewan River. Other areas susceptible to flooding are parcels within the City of Saskatoon, the Muskoday and WhiteCap Reserves, and along the Saskatchewan River near Highway #123 downstream of Tobin Lake as well as the community of Cumberland House.

The river below Gardiner Dam is a dynamic system with changing hydraulics. At this time the best estimates for flooding are:

- Flows will first come out of the main channel and inundate land on the river flood plain used for agriculture in the RM of Corman Park when flows exceed approximately 1100 m^3/s.
- Flooding of the Muskoday First Nation Reserve begins with flows of approximately 2500 m^3/s.
- Flooding in the City of Saskatoon starts impacting residential areas at flows greater than 5400 m^3/s; however flows in excess of 900 m^3/s appear to create intake sediment issues at the City water treatment plant.
- Highway #123 overtops when flows in the Saskatchewan River below Tobin Lake exceed approximately 2700 m^3/s. This results in loss of road access to Cumberland House.
- Cumberland House is threatened with flooding when sustained flows in excess of 2500 m^3/s occur on the Saskatchewan River.

Instream Flows

One of the most significant factors affecting Lake Diefenbaker operations is the need to maintain minimum flows downstream of Gardiner Dam. A 1963 study reviewed flow requirements for sewage effluent dilution at Saskatoon and for operation of water intakes at Outlook, Saskatoon, St. Louis, the Queen Elizabeth power station, and irrigation systems along the river. The same study also reviewed flow requirements for the operation of ferries, recreational uses, fisheries and the operation of the Coteau Creek power station. Based upon this study, the minimum flow at Saskatoon was established to be 42.5 m^3/s.

Experience with the system has since shown that impacts during summer months are significantly reduced if the average daily flow is no less than 60 m^3/s. An average daily flow in the range of 100 to 120 m^3/s is desired by most users. The "preferred flow range" identified in the South Saskatchewan River Basin Study (1991) was between 60 and 150 m^3/s during the summer months and recreation season.

5.1 Current State of Supply and Use

The median annual inflow to Lake Diefenbaker is approximately 6,887,000 dam^3. Over the past 30 years (1981-2010), annual flows of the South Saskatchewan River through Saskatoon have averaged 5,590,000 dam^3. The minimum annual volume over the same period was 1,700,000 dam^3 in 1988. Although these inflows have been more than adequate to meet the volumetric requirements of all users, pumping issues exist with many intakes when reservoir and river levels are low.

Figures 18 through 20 shows representative reservoir water balances for years of low, median, and high inflow. In years of median inflow, the diversions and consumptive uses sourced from Lake Diefenbaker constitute only 3.5 % of the reservoir inflow, this volume amounting to about 240,000 dam^3. In dry years, water use increases for irrigation, municipal consumption and higher evaporation from lakes and water supply reservoirs along the Qu'Appelle and SSEWS systems and can total over 400,000 dam^3. During a low flow year, such as 2001, this level of use represents approximately 15% of total inflow (Figure 18). Thus, even in low flow years, Lake Diefenbaker is able to satisfy existing consumptive demands. The only water supply shortages experienced to date occurred when lake levels were not high enough for some intake structures and when intake issues occurred downstream due to low river levels and moving sandbars.

Water that is not consumed or diverted from the lake is available for hydropower production because of the storage provided by Lake Diefenbaker. In low and normal inflow scenarios the remaining water is used for hydropower production and release for downstream flow needs. In the high inflow year scenario from 2005 shown in Figure 20, over 20% of the annual flow passed as surplus over the spillway at Gardiner Dam.

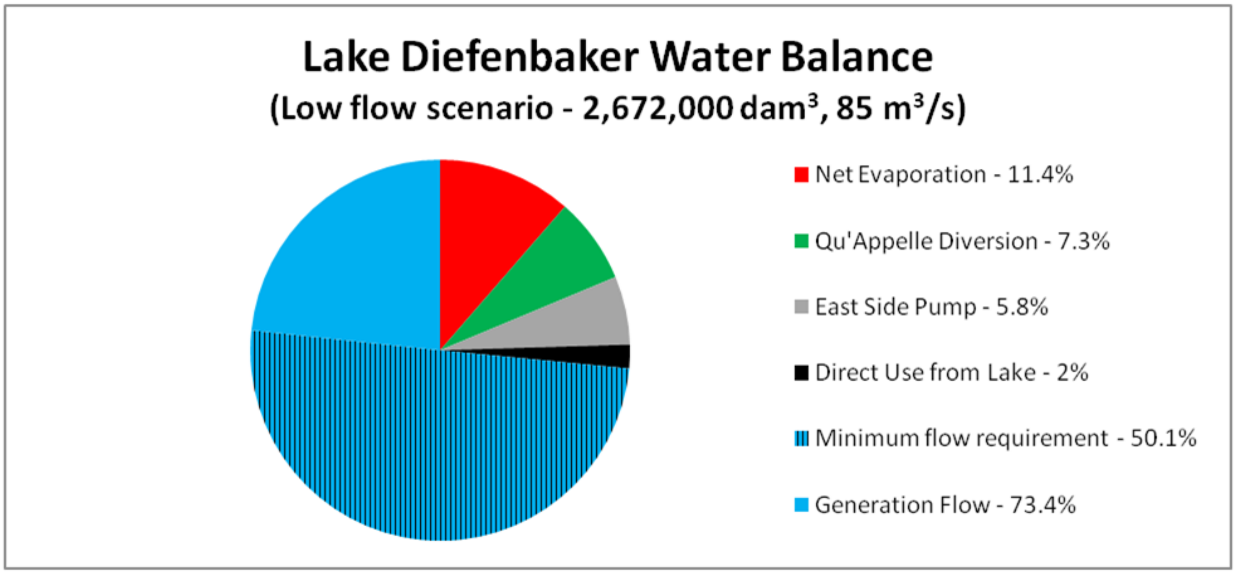

Figure 18 – Representative Water Balance – Low Flow Scenario

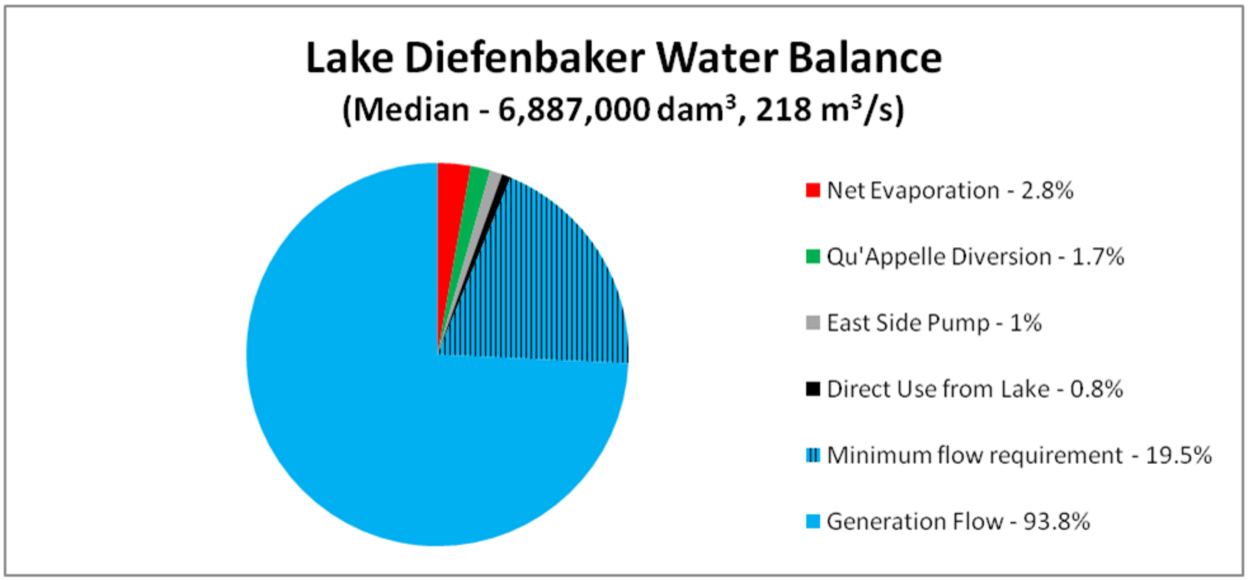

Figure 19 – Representative Water Balance – Median Flow Scenario

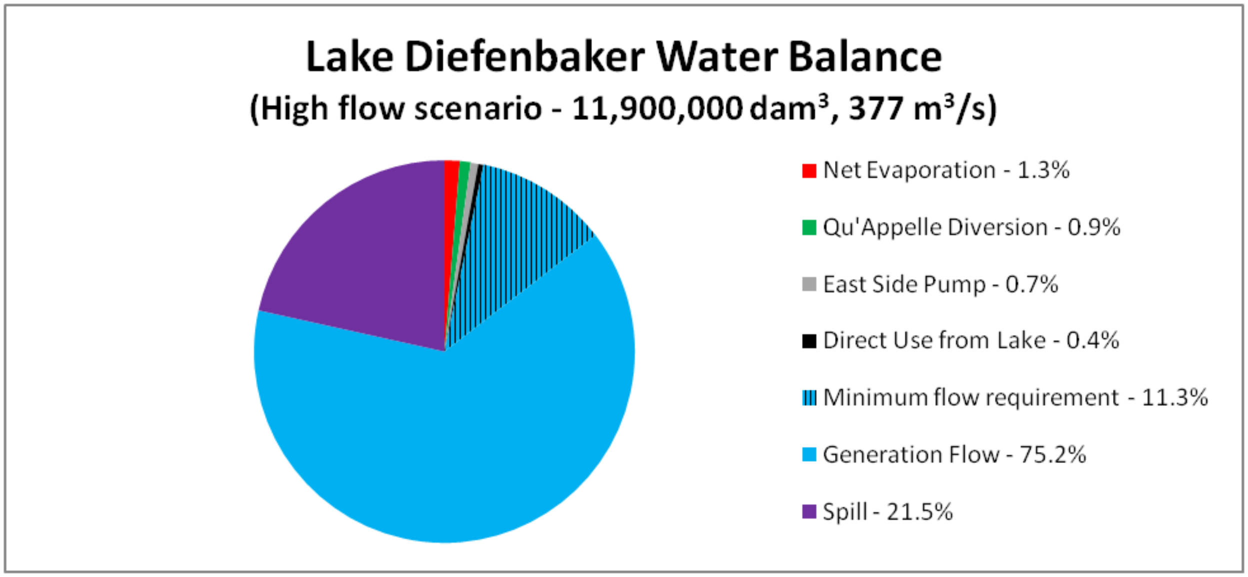

Figure 20 – Representative Water Balance – High Flow Scenario

6.0 Historical Water Levels and Downstream Flow Regulation

Lake Diefenbaker filled over a three year period from 1967-1969. There are now over 40 years of water level data for the reservoir.

Figure 21 is a trace of mean daily water levels from 1968 through 2005. The figure demonstrates annual level fluctuations and shows that the reservoir often reaches its FSL. However, during low runoff years such as 1984, 1988 or 2001, the reservoir barely reached 552.0 m, three metres below the minimum desired July 1 level and almost 5 metres below the FSL.

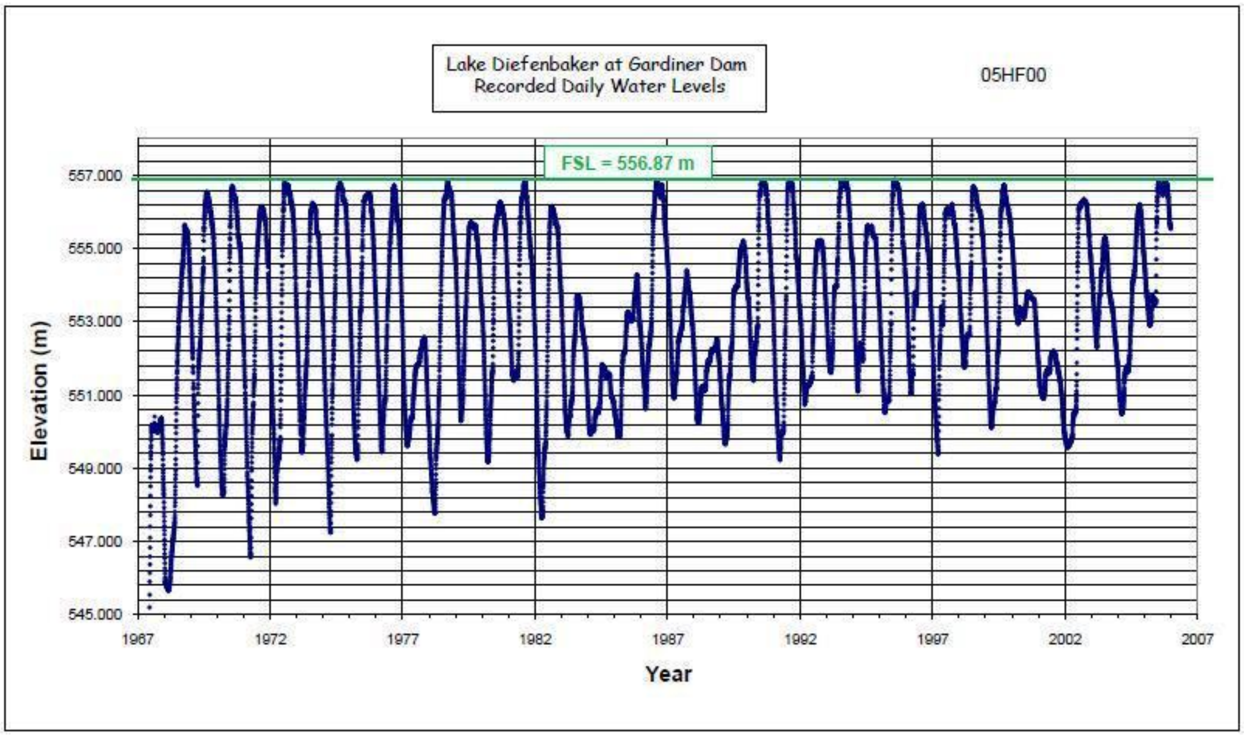

Figure 21 – Lake Diefenbaker Daily Recorded Water Levels

Figure 22 depicts the recorded mean daily water levels for the 1969 to 2005 period. The pattern of the lake levels is quite consistent, with the lowest levels from mid-March to early April, a rise in early April from snowmelt on the prairies and maximum water levels occurring in early July as a result of runoff from the Rockies. However, there can be a variance between years by as much as 5 meters at any particular time. For the period 1968 to 2009, based on the recording station 05HF003 (Lake Diefenbaker at Gardiner Dam) the reservoir level has exceeded 556.0 m elevation 27 times out of 42 years. The lowest July 1 level recorded during the same period was 551.48 m in 1984.

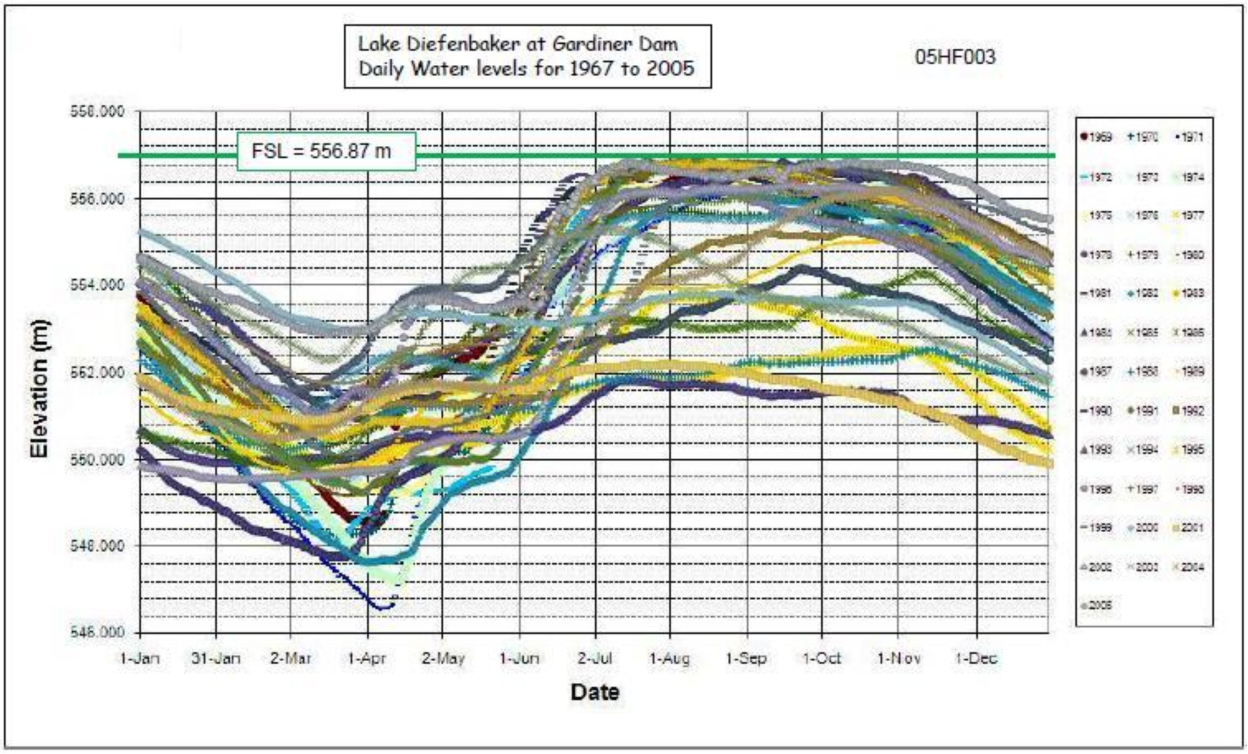

Figure 22 – Lake Diefenbaker Daily Levels, 1969-2005

Downstream Flow Regulation

The existence and operation of the reservoir has significantly changed the flow environment downstream of Gardiner Dam. In general, the high inflows in late spring/early summer that would otherwise simply pass downstream are instead captured and released more or less continuously throughout the remainder of the year. The result is a relatively predictable and stable downstream flow environment and a less active natural river system.

The effect of the flow regulation is illustrated in Figure 23, showing gauged flows through Saskatoon. Visually it is readily apparent that the peak flows at Saskatoon are considerably lower following reservoir development.

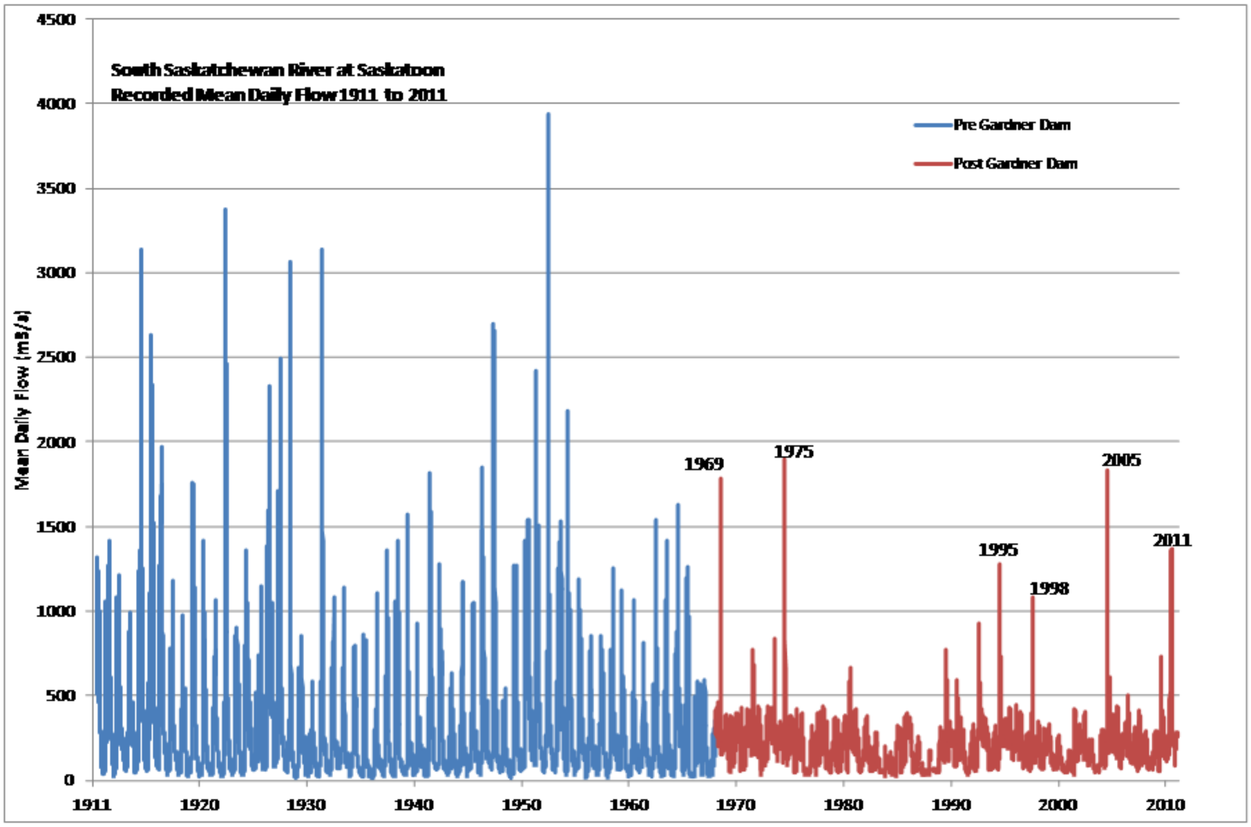

Figure 23 – Gauged Flows on South Saskatchewan River at Saskatoon

Table 8 lists selected frequencies for river flows at Saskatoon to estimate the effect of the reservoir as currently operated on flows.

The table shows that prior to the reservoir development, the median peak annual flow through Saskatoon was approximately 1100 m^3/s, meaning that, on average, every second year flows could potentially go out of channel and onto the river flood plain. The net result of the flow regulation on the downstream river environment is a drastic reduction of low flow conditions because of the artificial subsidization of flows during normal low flow periods. From an ecological perspective the maintenance of minimum flows may have some benefit, however that is countered by a reduction in frequency of flood plain inundation that occurs with reservoir operation.

Table 8 – Select Estimated Downstream Flow Frequencies
(To Demonstrate the Effect of Lake Diefenbaker)
(Based on Constructed Inflow 1969-2011)

Return Period	Without Lake Diefenbaker (m^3/s)	With Lake Diefenbaker (m^3/s)
1:1.4	700	370
1:2	1100	420
1:5	1800	750
1:10	2000	1250
1:20	3000	1800
1:50	3800	1900
1:100	4100	2000
1:500	7700	4200

7.0 Operating Philosophy

Lake Diefenbaker is operated within the context of the larger Saskatchewan River Basin and as a water supply source for uses in the Qu'Appelle River Basin. Considerations extend beyond the South Saskatchewan River to include the North Saskatchewan River, Tobin Lake, Cumberland Lake and the Qu'Appelle River System.

The operating philosophy of Lake Diefenbaker is to manage the reservoir to maximize benefits for the people of Saskatchewan for the multiple uses listed in Section 5 while respecting dam safety requirements and operations prescribed by regulatory approvals for minimum flows below Tobin Lake. Within this context, the basic strategy for the management of Lake Diefenbaker is to fill the reservoir during the high flow window corresponding to the runoff from the prairie and mountain regions. Uses then deplete the stored water throughout autumn and winter until the following spring, when the opportunity to refill the reservoir returns. This annual cycle does not, however, provide water supply capacity over a multi-year drought. Given the many water uses dependent on the reservoir for supply, an emphasis is placed on filling the reservoir each year to provide as much drought resilience as possible, as should a drought period ensue any storage deficits are carried forward into the low flow years.

Following the basic operating strategy, it is recognized that flow and water level conditions will often arise such that hard 'targets' and/or 'absolute ranges' are often only achievable with considerable sacrifice. However, three primary target elevations on Lake Diefenbaker have been established for reservoir filling to help meet the needs of the users:

- A May 1 minimum elevation target of 551.0 m, to enable operation of irrigation and other seasonal pump stations around the lake.
- A May 15 elevation target of 552.0 m to facilitate boating and other recreational activities.
- A July 1 target elevation within the range of 555.0 to 555.3 m, unless it would require spilling water to achieve. The range is sufficient for summer recreational use but also preventing the flooding of significant portions of the Piping Plover nesting habitat and improving the rearing success rate for these shoreline birds.

Figure 24 shows the general operating zones defined by physical factors and other operational objectives. Although there is no formal established flood control zone, flood mitigation is provided by the storage created through water use, i.e. water use over the entire year creates storage that can also be utilized for flood control.

Figure 25 is an illustration of the co-benefit relationship between water use and flood control as reservoir operating zones through a typical year. In years with normal inflows and water use over the fall and winter, storage is created in the reservoir that is also available for flood control during the high inflow period from April to July, the critical window to refill the reservoir. As the reservoir is filled over this period, the flood control storage available correspondingly is reduced. Historically large rainfall inflow events have not occurred in late summer. Even though the reservoir may be filled to near FSL during this period, thereby maximizing water supply/use benefits, the likelihood of attendant downstream flooding is relatively low.

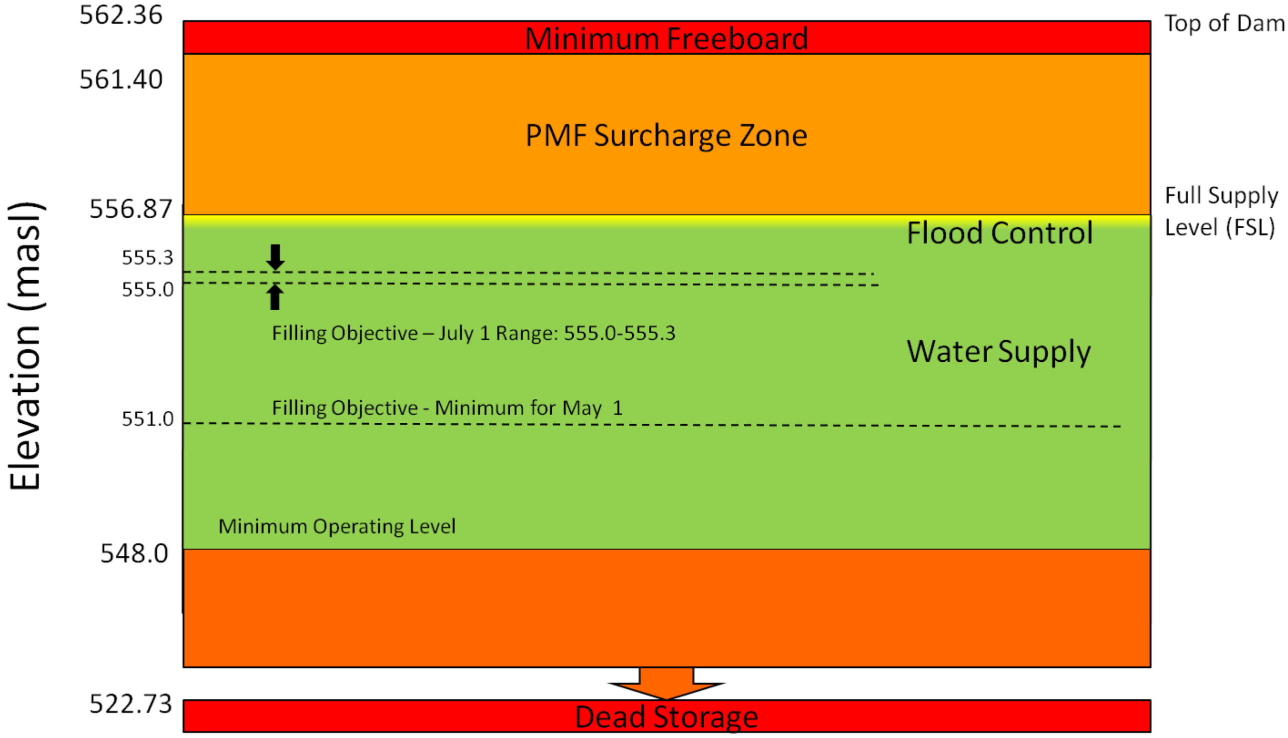

Figure 24 – Reservoir Zones and Filling Objectives

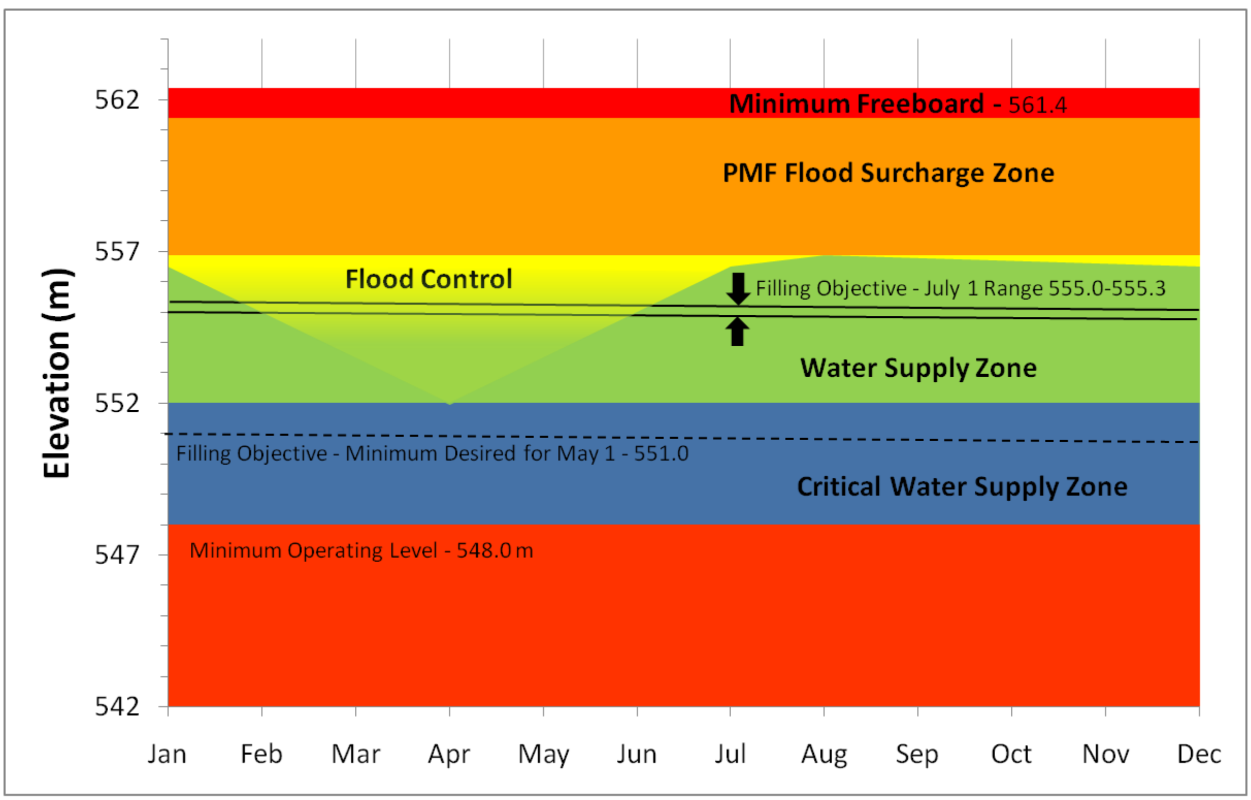

Figure 25 – Illustration of Water Use and Flood Control Zones in a Typical Year

Figure 26 shows the filling objectives relative to the annual water level profile. Miry Creek Irrigation District, which operates a group irrigation project at the upper end of Lake Diefenbaker, requires a minimum water level of 551.41 m. In recent years though, this elevation has been too low, because of siltation near their pump site. When the lake is above 551.5 m Miry Creek Irrigation District is able to operate their pumps more easily. Elbow Marina desires a lake level of at least 552.0 m by May 15 to facilitate boat movement.

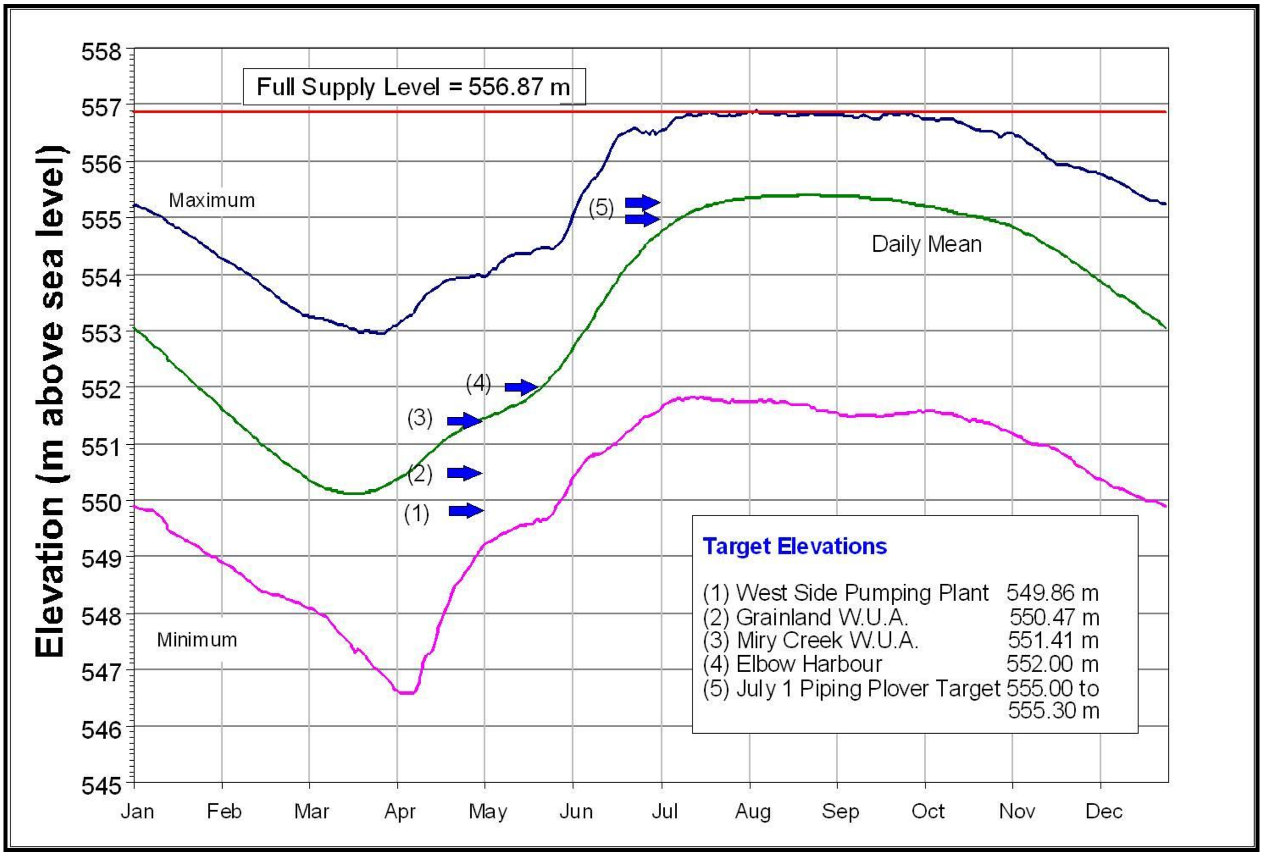

Figure 26 – Lake Diefenbaker Filling Objectives and Annual Reservoir Level Profile

Outflows from Gardiner Dam are generally managed to fill the reservoir during the high flow window while considering the following objectives:

- Ensure adequate safety of the dam, primarily endeavour to keep the Lake level at or below FSL in order that the Project Inflow Design Flood (Probable Maximum Flood) can be safely passed through Lake Diefenbaker;
- Maintain a minimum instream flow of at least 42.5 m^3/s (but preferably 60 m^3/s) for water intakes at Outlook, Saskatoon, and St. Louis; irrigation intakes along the river; ferry operation; recreational use and fisheries;
- Facilitate power production at the SaskPower’s Coteau Creek, Nipawin and E. B. Campbell Generating Stations;
- Avoid and/or minimize spill from Gardiner Dam to maximize hydropower generation and reduce risk of downstream overbank flooding;

- Provide sufficient releases to maintain the licensed minimum daily average outflow from E. B. Campbell Dam of 150 m^3/s;
- Attempt to maintain flows through Saskatoon between 60-120 m^3/s during the open water season;
- Provide cooling water for SaskPower's Queen Elizabeth Thermal Station;
- For ferry operation, provide a relatively constant flow to avoid switching ramps, and maintain a desirable minimum flow of at least 60 m^3/s to avoid imposition of load restrictions;
- Maintain steady downstream flows during the irrigation season to avoid the need to reposition pumps and intakes;
- Maintain flows during the winter as steady as possible to avoid issues with river ice;
- During flood events on the South Saskatchewan River, provide as much flood control as possible with available storage while allowing for the possibility of subsequent flood events;
- During flood events on the North Saskatchewan River, provide as much flood control as possible with available storage in Lake Diefenbaker to minimize spill at Nipawin and E. B. Campbell generating stations, and to avoid/minimize flooding at Cumberland House, while allowing for the possibility of subsequent flood events on either the North or South Saskatchewan rivers;
- Recognizing the approximate flood thresholds shown in Table 9;
- Although yet to occur in the operational history, in extreme drought years satisfy apportionment requirements to Manitoba.

Table 9 – Summary of Currently Estimated Flood Thresholds

Threshold	System	Approximate Flow (m^3/s)
Inundation of agricultural land in river flood plain, RM of Corman Park	South Saskatchewan River below Gardiner Dam	1,100
Muskoday First Nation Reserve	South Saskatchewan River below Gardiner Dam	2,500
City of Saskatoon starts impacting residential areas	South Saskatchewan River below Gardiner Dam	5,400
Highway #123 to Cumberland House	Saskatchewan River below Tobin Lake	2,700
Cumberland House	Saskatchewan River	sustained flows in excess of 2,500

8.0 Operating Objectives

Although the many complementary and competing uses create operational challenges, the most difficult aspect of operating is managing the uncertainties in hydrology, considering the lead times necessary to affect the reservoir. The ability to manage reservoir levels and reservoir outflows is constrained by the following:

- Operational decisions must be made on forecasted inflows, which are difficult to predict and change greatly with changes in climate and weather conditions;
- Since only outflows can be controlled, reservoir levels will largely depend on the realized inflows relative to forecasted inflows.

Forecasting inflows for the South Saskatchewan River basin is difficult because of the sparseness of data, unpredictability of continental hydrology and the inaccuracy of long range weather forecasts. More specific challenges are:

- Roughly half of inflows result from snowmelt, however the majority of the snowfall does not occur until after the beginning of March;
- Although snowpack conditions in part determine inflow volumes, the correlation of future runoff volumes from measured snowpack conditions is weak at best;
- The travel time from alpine and foothills areas to Lake Diefenbaker is roughly four days to one week (depending on low flow or high flow conditions), so the reaction time to measured inflows is short from an operational perspective;
- Rainfall events in May and June are generally responsible for roughly half of reservoir inflows, thus the lead time to react is the travel time, which is often less than one week.
- The net result is there is great uncertainty in inflows estimates more than a week into the future. Because of the uncertainty involved, the current practice is to trend inflow; forecasts into the future toward means, i.e. future inflows are forecast to trend back to the mean, but the rate at which it is forecast to go back to mean is based on basin conditions, measured flow, and precipitation on the basin.

Lake Diefenbaker operations are optimized to provide optimum water management benefits for the Province of Saskatchewan. Operational approaches are described below in three categories based on the likely future inflows - Normal operations, High Flow/Flood Operations, and Low Flow/Drought Operations.

8.1 Safety and Regulatory Constraints

Passage of the Probable Maximum Flood

The spillway at Gardiner dam is adequately sized to pass the PMF. However, to do so when the starting reservoir elevation is at FSL, all spillway gates must be fully opened three days prior to the arrival of peak inflows. During this three day period, the reservoir is drawn down to 555.2 m. This imposes a dam safety operating constraint that the reservoir level must be held at or below the FSL regardless of inflow until the inflow exceeds the spillway capacity at FSL of 6,400 m^3/s. In practice this would be a very difficult operation to execute, as the PMF is a theoretical flood and would be difficult to discern in real time during an extremely large event.

Minimum Safe Operating Level

The earth embankment of the Gardiner Dam is protected from erosion by a system of layers of sand, gravel, and increasingly large rock known as riprap. The bottom of the riprap is at elevation 544.1 m. This imposes a dam safety minimum water elevation of 548.0 m which allows for wave action below the minimum level to bear on the protective riprap rather than eroding the unprotected portion the dam face.

E.B. Campbell Dam Minimum Flow

A condition of the SaskPower's Water Power Act licence for E.B. Campbell Dam is that a minimum average daily flow of 150 m^3/s in the Saskatchewan River below Tobin Lake must be maintained. There is no consideration for flow entering the province and originating within Saskatchewan. In the fall of 2001, combined flows entering the province in the North and South Saskatchewan rivers, and the Battle River was less than 150 m^3/s and there were virtually no local inflows in the Saskatchewan portion of the basin. Storage in Lake Diefenbaker was used for a number of weeks to augment streamflow in the Saskatchewan River to meet the 150 m^3/s constraint.

8.2 Primary Purposes and Co-Benefit Uses

Common Operations

Fall: Regardless of the end-of-summer elevation, flows in the fall are generally managed to have Diefenbaker elevations track the median historic elevation curve going into the freeze-up period. Thus, if reservoir levels and/or inflows are above normal in the fall, outflows will be above normal, up to plant capacity. If reservoir elevations and/or inflows are low, reservoir outflows will be reduced as well. Minimum outflow requirements of 42.5 m^3/s from Lake Diefenbaker and 150 m^3/s below Tobin Lake are respected.

Late Fall: During the late fall period, as winter approaches, temperature and ice conditions are monitored and aerial surveys are sometimes made to check on the ice formation. Operating restrictions may be imposed on SaskPower to allow a stable ice cover to form, which occurs typically by December. During this period, water levels in the Moon Lake area are monitored and used as a guide to establish release patterns and restrictions from Gardiner Dam. Once the ice cover is established, the operating restrictions may be relaxed, but generally the flow at freeze-up is near the maximum projected winter flow.

Winter: The additional friction from the ice cover slows river velocities and causes levels to rise. In some years, the river ice forms a very rough cover or even a partial ice jam, which further restricts flows. Thus, the amount of water which can be released may be reduced by as much as 33 percent of the total plant capacity from the Coteau Creek Generating Station. Winter operations are carefully managed to avoid issues with ice jams or rough ice cover on the river which might result in overbank flooding. Attempts to increase discharges could result in overbank flooding, particularly in the Moon Lake area

If ice roughness is not an issue, over-winter flows are set to achieve a spring drawdown objective, typically by mid-March. The spring drawn down objective is determined based on forecasts using measured snowpack accumulations in the Rocky Mountains and on long-term precipitation means for the balance of the winter and into spring.

Normal Flow Conditions

Early Spring: In years in which a normal mountain snowpack exists, the reservoir is operated in the central portion of the operating envelope by maintaining normal outflows. The operating strategy during early spring is to be at or above the May 1 target level of 551.5 m.

Late Spring/Early Summer: From late May and through July snowmelt occurs at the higher alpine elevations, while these months typically have the highest rainfall accumulations of the year. Rainfall runoff during this period is relied on to complete the filling of Lake Diefenbaker. Outflows during this period are managed to try to raise the reservoir level to the July 1 target range of 555.0 m to 555.3 m. If normal inflows are realized, this target can usually be reached assuming the May 1 target was achieved.

Summer: As summer progresses, the risk of significant rainfall runoff diminishes and outflows are managed to try to continue filling the reservoir while maintaining downstream flows within the target open water range of 60 to 120 m^3/s

High Flow / Flood Operations

Early Spring: In years in which there is an above normal mountain snowpack, the reservoir can be operated in the lower portion of the operating envelope by maintaining normal to above normal outflows, without initiating spill. The operating strategy during early spring remains to be at or above the May 1 target level, depending on observed alpine snowpack accumulations.

Late Spring/Early Summer: From late May through July, snowmelt continues at the higher alpine elevations while these months typically have the highest rainfall accumulations of the year. If rainfall runoff during these months is above normal, filling of the reservoir is during the summer is more certain. Outflows during this period are managed to try to raise the reservoir level to the July 1 target range of 555.0 m to 555.3 m, and later to not exceed FSL. Spills are not initiated solely to keep the reservoir level at or below the July 1 target, meaning the target will be exceeded if May-June inflows are greater than the available storage and generating station capacity. During flood events on the North Saskatchewan River, available storage in Lake Diefenbaker may be used to minimize spill at the Nipawin and E. B. Campbell generating stations.

Lake Diefenbaker has a relatively large storage capacity compared to the inflows of the South Saskatchewan River. The 1:100 and 1:500 flood events can be passed to match the 556.87 m elevation criteria (given upstream data is available and an aggressive, near perfect operation response). The gates will be operated to keep the maximum water level on Lake Diefenbaker at approximately the FSL of 556.87 m with the 1:500 peak outflow calculated to be 4,200 m^3/s.

During extreme inflow events (greater than 1:500) the spillway will be operated to try to maintain the reservoir at FSL. At FSL, the spillway can pass up to 6,400 m^3/s. If inflows exceed this value, the reservoir will rise. During the Probable Maximum Flood, reservoir levels will reach approximately 561.4 m and spillway flows will approach 12,000 m^3/s.

Summer: As summer progresses, the risk of significant rainfall runoff diminishes and outflows are managed to ensure filling of the reservoir and to reduce or eliminate spill. As reservoir inflows decline, outflows are reduced to fall within the target open water range of 60 to 120 m^3/s.

Low Flow / Drought Operations

Early Spring: In years in which there is a below normal mountain snowpack, the reservoir is operated in the higher portion of the operating envelope by maintaining below normal outflows. The operating strategy during early spring is to have the reservoir as high as possible and to be at or above the May 1 target level. Minimum outflow requirements of 42.5 m^3/s from Diefenbaker and 150 m^3/s from E. B. Campbell would be respected.

Late Spring/Early Summer: If rainfall runoff during the May through July period is below normal, filling of Lake Diefenbaker will not be achieved. Outflows during this period would be managed to try to raise the reservoir level as high as possible while not exceeding the July 1 target range of 555.0 m to 555.3 m. Minimum outflow requirements of 42.5 m^3/s from Diefenbaker and 150 m^3/s from E. B. Campbell would be respected.

Summer: As summer progresses, the risk of significant rainfall runoff diminishes and outflows are managed to try to continue filling the reservoir while maintaining downstream flows between the minimum of 42.5 m^3/s and the lower end of the target open water range of 60 m^3/s. Minimum outflow requirements of 42.5 m^3/s from Diefenbaker and 150 m^3/s from E. B. Campbell would be respected. Experience with the system has shown that the preferred minimum average daily flow during the summer months is 60 m^3/s and that an average daily flow, in the range of 100 to 120 m^3/s is desirable by most users. In low flow years, outflows are first reduced to 60 m^3/s and are lowered further as drought conditions intensify but to not less than 42.5 m^3/s.

9.0 Information and Decision Flow

Reservoir and Watershed Monitoring

Water levels on Lake Diefenbaker near Gardiner Dam are recorded at Hydrometric Station 05HF003 in real time. Flow in the South Saskatchewan River downstream of Gardiner Dam is recorded at Hydrometric Station 05HG001 located in Saskatoon. Outflow from the Qu'Appelle Dam to the Qu'Appelle River is recorded at Hydrometric Station 05JG006 approximately 1.5 km downstream of the dam. Data are available in real time for all three sites both sites on the Authority website as well as Water Survey of Canada's website.

A number of other hydrometric stations are located throughout the South Saskatchewan River watershed within Alberta, which the Authority monitors regularly. Data from these stations are displayed on Water Survey of Canada and Alberta Environment websites. Alberta Environment also maintains a network of snow pillows and snow courses in the Rocky Mountain headwaters and makes snowpack data public.

Flow Forecasting

Forecasts for flows and water levels for Lake Diefenbaker and the South Saskatchewan River are made by the Forecast Centre of the Authority's Hydrology and Ground Water Services Branch. Monthly forecasts are made looking six months ahead throughout the year.

More detailed forecasts for 7 to 10 days into the future are also issued when flow and level conditions warrant. During normal periods, the operations are reviewed on a weekly basis with day-to-day plans established. During extreme events, the operations plans are reviewed as new information becomes available and revised forecasts issued as necessary.

Decision Chain

Hydrology Service staff recommend all operations for Lake Diefenbaker. These recommendations may be for daily, weekly or monthly average flow releases from Coteau Creek Generating Station and for spill rates from the Gardiner spillway. The Executive Director of Engineering and Geoscience Division approves non-routine operations before implementation.

Flow alteration decisions for the Coteau Creek Generating Station are passed to SaskPower for implementation. Achieving the required average flows and deviations of instantaneous outflow from Coteau Creek Generating Station from the average are the responsibility of SaskPower. Operation of the Authority's outlet works at Gardiner and Qu'Appelle River Dams are undertaken by the Authority's Dam Safety and Major Structures Branch staff headquartered at Gardiner Dam.

Hydrology Service staff direct releases from the Qu’Appelle River Dam into the Qu’Appelle River. The Qu’Appelle outlet structure is also operated by the Authority’s Dam Safety and Major Structures Branch staff headquartered at Gardiner Dam.

The Watershed Authority often receives requests to modify operations by third parties that are undertaking activities below the dam which are flow critical. Where possible these requests are accommodated within the context of the current and forecast flows and water levels and achievement of operational objectives. Also factored in is the merit and value of the request. Decision and communication chains remain the same.

External Communications

Inquiries from the local residents, water users, and communities are handled by Watershed Authority regional offices. For the reach of the South Saskatchewan River from the Saskatchewan-Alberta border to the south boundary of the RM of Corman Park inquiries are handled by the Authority’s Regional office in Swift Current. Inquiries pertinent to the river reach through the RM of Corman Park and downstream are handled by the Authority’s Regional office in North Battleford.

Contact numbers:

Swift Current office: (306) 778-8257.
North Battleford office: (306) 446-7450.

If large changes in inflows or outflows from Lake Diefenbaker are anticipated, Authority regional offices endeavour to contact property-owners who may be impacted.

Flow forecasts and Advisories are posted on the Authority website: www.swa.ca

10.0 Additional Operational Considerations and Challenges

In addition to all the challenges and items detailed in the previous sections, the following items have been identified from files and references at the Authority, or provided based on operator experience and knowledge. There is no associated order of importance.

- Significant operations decisions must be based on forecasts or before precipitation occurs, as most runoff volume occurs in May and June:
    - From snowfall that occurs March and beyond;
    - From rain that falls at the time.
- The window to fill Lake Diefenbaker is reasonably small, coinciding with the late spring/early summer higher inflows.
- Maximizing drought resilience requires filling the reservoir each year, if possible.
- The Watershed Authority receives frequent ad hoc requests for specific downstream conditions for in-river activities.
- Shoreline evolution around Lake Diefenbaker is expected to continue for decades and perhaps centuries as the reservoir establishes itself. Shoreline erosion has been extensive, as predicted prior to dam construction.
- Ferries operate downstream and are affected by high flow and low flow scenarios, and by large changes in Gardiner Dam outflow.
- Power is generated at SaskPower's Coteau Creek Generating Station and two other stations downstream. It is desirable to avoid spill at Gardiner Dam so all releases can be used for power generation. For median inflow years, approximately 90 percent of the reservoir inflow is passed through the Coteau Creek turbines.
- There is a vibrant fish population within Lake Diefenbaker. Fishing on the lake is a provincial interest and an important recreational activity.
- Lake Sturgeon inhabit the Saskatchewan River system and may be affected by operations. This species is currently under review by the Federal Government of Canada to determine whether it should be listed under the Endangered Species legislation.
- If a major failure were to occur at either Gardiner or Qu'Appelle Dams there would be catastrophic consequences. An Emergency Preparedness Plan has been developed for Gardiner Dam, and a plan is under development for the Qu'Appelle River Dam.
- There is some scientific and anecdotal evidence that hydrology is changing, such as the ratio of snow to rain and the amounts of precipitation totals.
- Some consequences of operations can affect federally regulated subjects, most notably fisheries and species at risk e.g. Piping Plovers.

11.0 Related Documents

Document Type	Title	Date	Location/File
River Basin Study	South Saskatchewan River Basin Study	September 1991	Moose Jaw Library
Dam Safety Reports	Report on Dam Inspection	Nov 1990	Moose Jaw, H: Directory
	2003 Condition Assessment	Dec 2003	Moose Jaw, H: Directory
	2008 Condition Assessment	Apr 2009	Moose Jaw, H: Directory
O M & S Manuals	Gardiner Dam OM&S Manual		Moose Jaw
	Qu'Appelle Dam OM&S Manual		Moose Jaw
Structural Drawings	Various structure details, dam information.		Moose Jaw, H: Directory
Emergency Preparedness Plan	Gardiner Dam EPP	April 2002	Moose Jaw
	Qu'Appelle Dam EPP	In progress	Library
Upstream ROP(s)	N/A		
Downstream ROP(s)	N/A		
Watershed Plans	South Saskatchewan River Watershed Source Water Protection Plan	September 2007	Moose Jaw
	Upper Qu'Appelle River and Wascana Creek Source Water Protection Plan		Moose Jaw Regional Office
	Lower Qu'Appelle planning process initiated 2009	March 2008	Website
Technical Document	Qu'Appelle River System & Operation	1997	Moose Jaw Library

12.0 Document History

Version 1.0: May 2012

This document was prepared based on 'in-house' information.
No public input obtained specific to this operating plan.

- No external agency input obtained.