Balancing Act

The Lakes of the Upper Androscoggin

FPL Energy
Maine Hydro

Operation of the Androscoggin River Storage System
And the Effect on Summer Lake Levels

The Rangeley Lakes region is blessed with extraordinary beauty and unique natural resources. It is widely acknowledged as one of Maine's most treasured assets. Public use is assured with certain restrictions, since much of the shoreline of the major lakes is owned either by the State of Maine or by local land trusts. There is also considerable acreage of sustainably managed forests in the region. In spring, summer and fall, popular activities include fishing for landlocked salmon and brook trout, hiking, hunting and boating. Snowmobiling on numerous trails throughout the area, cross country and downhill skiing and ice fishing are popular winter sports.

In 1999, FPL Energy purchased rights to operate the dams and manage the storage system of the headwaters of the Androscoggin River, which have been managed as a regulated water storage system since 1878. The system includes Aziscohos, Rangeley, Mooselookmeguntic, Upper and Lower Richardson and Umbagog Lakes. The management of this system affects not only water levels for the Rangeley area lakes but also the river flows of the Androscoggin River in both Maine and New Hampshire. FPL Energy owns and operates Errol, Upper, Middle and Rangeley dams, and is the operator and part owner of Aziscohos Dam.

FPL Energy, as the custodian of the water flows of the upper Androscoggin River watershed, is committed to the same water management program that has successfully balanced the diverse needs of a changing society for more than 100 years. The four most important goals of FPL Energy's management program are to:

- Maintain uniform water flows for downstream users.
- Strive to balance lake and river levels with recreational users, fisheries and wildlife.
- Protect the integrity of the dams.
- Minimize the danger of flooding.

This booklet is designed to provide an overview of the factors that affect lake water levels and river water flows. For those who are unfamiliar with hydrological terminology, a glossary is included at the back.

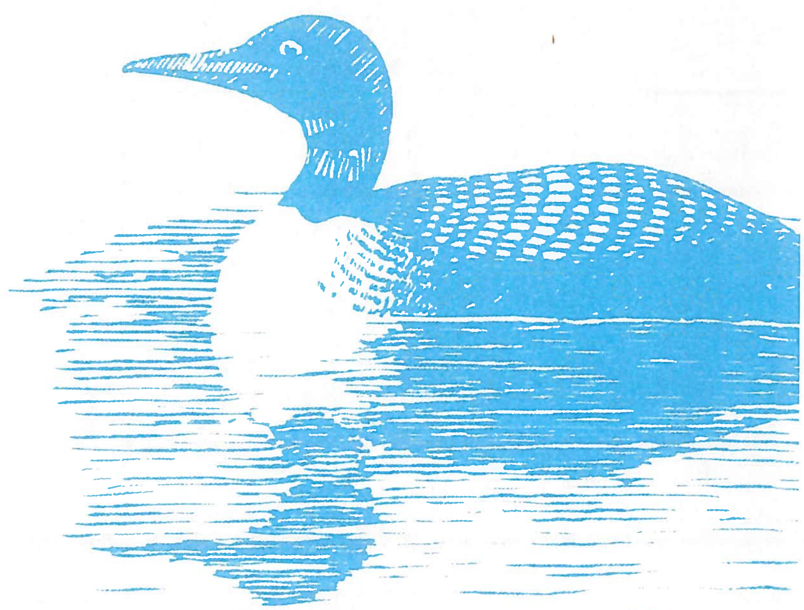


FIGURE 1 **STORAGE RESERVOIR AT HEADWATERS OF ANDROSCOGGIN RIVER**

Since colonial times, logging has been an important part of the region's economy. The lakes and rivers provided vital transportation to float logs to downstream sawmills. Prior to the mid-nineteenth century, logs transported from the Rangeley Lakes area traveled downstream without the benefit of dams to help control water levels in the streams connecting the lakes. Moving logs was only possible during periods of high water. Each spring flood, great numbers of logs moved downstream, and when the floodwaters receded, the residual logs would be left high and dry on the riverbank. As a result, floating logs from the Rangeley area to Lewiston sawmills usually took about four years. In addition, in the early 1900's the lakes were becoming more popular as vacation destinations. It was at this point that dams were first built and used to regulate water levels to improve the ability to transport logs and accommodate the emerging tourist industry.

Original Dams

Squire Rangeley Built The First Dam

Log driving dams were built in the Rangeley Lakes area as early as 1836 when the dam at the outlet of Rangeley Lake (reportedly built by Squire Rangeley) raised the natural level of the lake by about four feet. In the early 1850's, the Richardson Lake Dam Company acquired the water rights and erected dams at the present sites of Middle and Upper Dams. Middle Dam raised the natural elevation of the Richardson Lakes by about nine feet and Upper Dam raised Mooselookmeguntic Lake by about six feet. A small dam on the Rapid River was also constructed about this time to facilitate the movement of logs down the Rapid River into Umbagog. During the same period, the Androscoggin River Improvement Company obtained similar rights to erect a dam in the Androscoggin River at Errol, located a few hundred feet above the present Errol Dam. This dam provided better log driving conditions in the river both above and below Errol.

The log driving dams, which were used until about 1880, held back the spring runoff and created higher water levels in the lakes during the spring and early summer months. Large aggregations of logs, knows as rafts, were towed by boats across the lakes to the various dams for driving. The dam gates were opened briefly until these logs had passed down river to the next lake, where the process was repeated. Eventually, the logs arrived at sawmills along the banks of the Androscoggin River as far away as Brunswick. Primarily softwood logs were transported this way because they float more readily than hardwood species. By early July, the log drive was usually completed in the upper lakes. The gates in the dams were then opened completely, allowing the lakes to lower to their natural levels. This procedure was repeated each spring. As a result of this operation, many feet of lake shoreline were exposed throughout most of the year, including the majority of the summer.

Conversion To Storage And River Flow Management

Water Management Started More Than 100 Years Ago

Late in the second half of the 19th century, the power of flowing river water fueled the start of the Industrial Revolution. In 1878, the Union Water Power Company was incorporated for the purpose of raising and storing the waters of Rangeley, Mooselookmeguntic and Richardson Lakes, which in turn would augment the flow of water in the Androscoggin River for power and manufacturing purposes. The newly formed company purchased the dams and small parcels of land at Errol, Lower Dam, Middle Dam, Upper Dam, Rangeley and Kennebago. Land ownership generally did not exceed 500 acres surrounding the dams near the outlet of each lake. Flowage rights were acquired from owners of the shorelines of the Richardson Lakes and Mooselookmeguntic Lake to permit the reconstruction of Middle and Upper Dams, allowing for greater volumes of stored water. By 1885, these structures had been rebuilt to their current configurations and elevations.

Aziscohos Development

The severe drought of 1903-04, combined with increasing demands for power in industrial developments, fueled a demand for more water storage capability for the Androscoggin River. A detailed feasibility study identified the Magalloway River above Wilsons Mills as a site for a water storage dam. The dam was erected at the head of Aziscohos Falls, and created the Aziscohos Reservoir in 1911. The Reservoir now stores 9.6 billion cubic feet of water in what was a part of the Magalloway River and its nearby uplands.

The 1909 Operating Agreement

The Androscoggin Reservoir Company (ARCO) was formed in 1909 to own and operate the Aziscohos Dam. The founding companies, Berlin Mills Company (now owned by an affiliate of the Canadian firm Brascan Corporation), the Rumford Falls Power Company (now Mead Paper), the International Paper Company and the Union Water Power Company (whose interests in the storages are now owned by FPL Energy), signed an operating agreement that provides:

- The regulated flow at Berlin be maintained at not less than 1,550 cfs (cubic feet of water per second), whenever possible
- That the total seasonal draw from storage be in the ratio of one-third from the Aziscohos Reservoir and two-thirds from the combined volume impounded by Errol, Middle, Upper and Rangeley dams. This is approximately equal to the rated full capacity of the respective sub-systems; i.e. 72 days' supply at Aziscohos equals one-third of the total 209 days supply.
- The other three companies pay a proportional share of the cost of maintenance, repair, and operations of UWP dams (now owned by FPL Energy) on the Rangeley Lakes.

Although some of these companies have been bought by new owners and their names have changed, the basic agreement, signed in 1909 and modified in 1983, still exists and still governs the operation of the upper watershed.

The source of the Androscoggin River is at the outlet of Umbagog Lake and at the mouth of the Magalloway River in Errol, New Hampshire. The Androscoggin flows generally southeastward through the cities of Berlin, Rumford, Lewiston and Auburn and meets tidewater in the town of Brunswick. The tidal section then flows east from Brunswick and joins the Kennebec River in Merrymeeting Bay. From Errol to Brunswick, the river flows through 167 miles of the New Hampshire and Maine countryside and falls 1,247 feet to sea level. The drainage area of the river above Brunswick is 3,430 square miles, a little more than 10% of the area of the state of Maine. About 1,045 square miles of the drainage area is above the Errol Dam.

Topography

The area above Rumford is predominately forest and mountains, and contains some of Maine's higher elevations. Run-off from rain and snow is rapid. The ground here gives up its moisture in a shorter time than other areas which results in a rapid rise and drop in the natural river flow. Without the water control structures in the Rangeley area, flows in the river below Errol would fluctuate widely each season, from high spring run-off to a trickle in late summer. Below Rumford, the terrain flattens somewhat and a number of ponds and lakes flow into the river. There is more agricultural use of the land here and the soil types retain more ground water from precipitation. For this reason, the natural flow into the river is prolonged over a greater time.

Economic Development

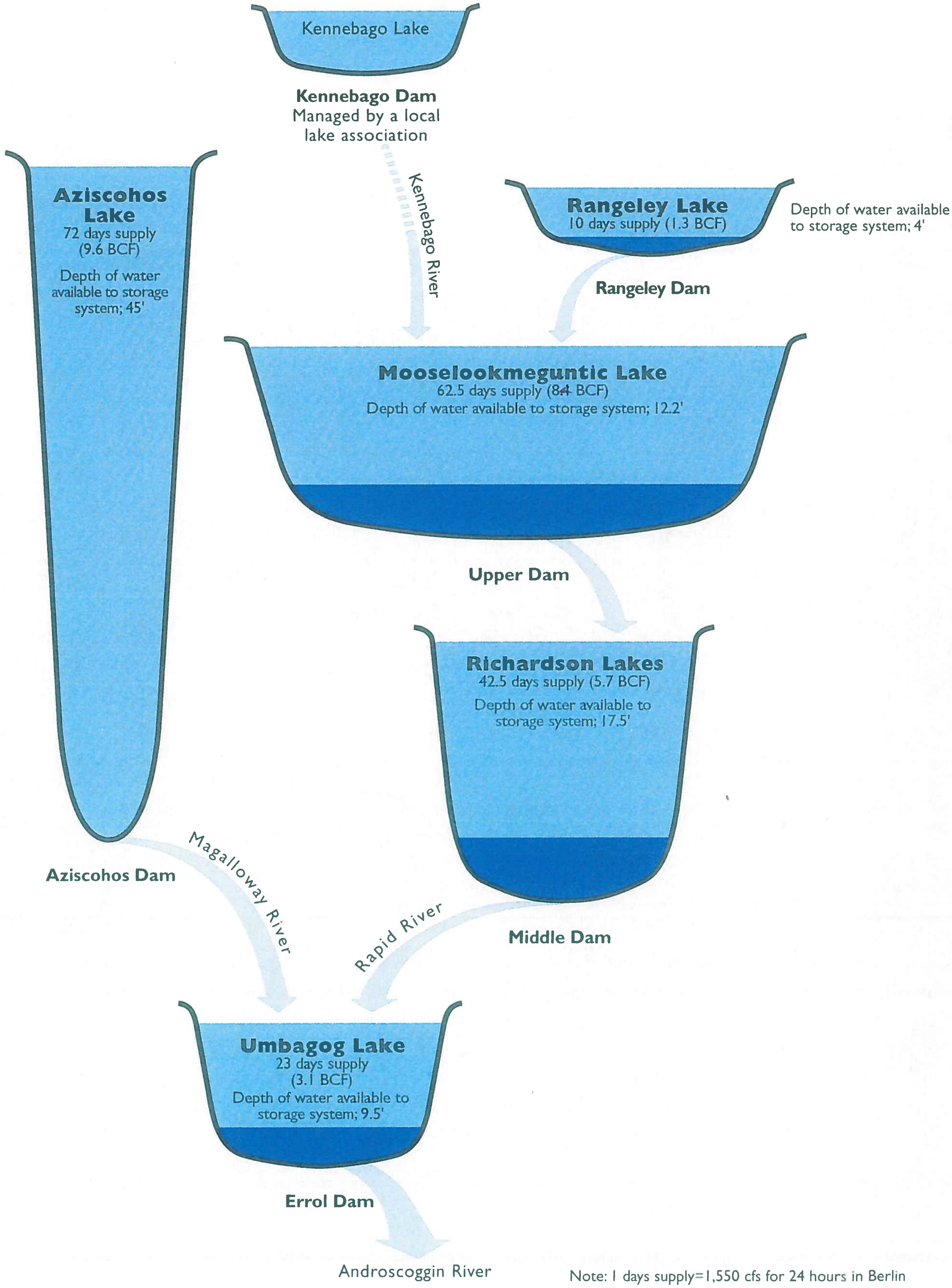
Many Towns Depend On A Managed River Flow

The well-being of the industries and towns along the river is closely tied to the maintenance of a consistent volume of good quality water flowing in the river. The availability of the upriver water storage system, which helps assure year-round flows, is essential to sustaining a healthy economy in the valley.

Several large water-consuming industries downstream from Errol are located on the banks of the river, including paper and paperboard mills at Berlin, Rumford, Jay, Livermore Falls and Lisbon Falls. These industries use the river's water to generate electricity and to process raw materials. Thousands of quality jobs are supported by these industries. In addition, hydro-facilities along the length of the river generate some of the State's lowest cost electricity. Management of the storage system is critical to the operation of municipal wastewater treatment facilities in Maine and New Hampshire. The operation of the upper storage reservoirs is also beneficial to downstream towns and property owners because of the system's ability to mitigate the impact of flooding. Most flooding potential in this area occurs in early spring when lakes are typically drawn down to their lowest level, thus providing greater storage capacity for upper basin rainfall and run-off.

The regulated flow of the river, particularly during summer months, is also important to outdoor recreation. Fishing and boating are just two activities that attract visitors and benefit from a higher summer water flow. Whitewater boating depends on releases from the storage system for the recreational use of the Rapid River and the Magalloway River.

FIGURE 11 **SCHEMATIC DIAGRAM OF ANDROSCOGGIN RIVER STORAGE SYSTEM**



Note: 1 days supply=1,550 cfs for 24 hours in Berlin
Elevations are USGS datum
BCF = Billion Cubic Feet
Shaded Area = natural lake volume

The Androscoggin Storage System is comprised of Aziscohos Lake, impounded by Aziscohos Dam, Rangeley Lake, impounded by Rangeley Dam, Mooselookmeguntic Lake impounded by Upper Dam, Upper and Lower Richardson Lakes impounded by Middle Dam and Umbagog Lake impounded by Errol Dam. All together, the storage comprises 28.1 billion cubic feet of water, not counting the smaller unregulated ponds and streams that flow into it. Kennebago Lake, impounded by the Kennebago Dam is also part of the storage system and is operated by an independent lake association. Although Kennebago Lake's water eventually contributes to the storage system, this volume is not used in the computation of stored water on hand.

Management Prolongs High Lake Levels

Before the dams were built, the lakes, rivers and streams fluctuated dramatically based on storm events and the seasons. The dams provided a method to retain water above the water's natural elevation and manage its release to smooth out the variability of the seasons and weather. Water from snow melt that would normally be completely gone from the storage area in a three-month period is now retained for release over six to nine months. Managing the river run-off this way allows FPL Energy to maintain higher and more stable water levels for everyone's benefit during drier months of the year.

Aziscohos Reservoir is the only man-made lake in the system. The dam, erected at the head of Aziscohos Falls, stores water in what was part of the Magalloway River and its nearby uplands. When all storage is drawn from this reservoir, the old course of the Magalloway is plainly visible. This part of the river contained some small ponds prior to flooding.

Mooselookmeguntic Is Twice As Wide As The Other Rangeley Lakes

Figure II is a schematic diagram of the entire Androscoggin River storage system. The widths of each reservoir, as shown on the diagram, give the relative size of the surface area of the lakes. For example, Mooselookmeguntic Lake is about twice as wide as any of the other reservoirs – the volume of water contained in a one foot layer of water on the lake is twice that in the same depth on any other lake. Similarly, the depth of water that can be drawn from each reservoir is shown vertically in each lake representation. The lake with the least available draw is Rangeley (four feet) and the lake with the greatest draw is Aziscohos (45 feet).

The area depicting the reservoir shows the proportion of stored water that can be contained in that reservoir in relation to any other reservoir. This relationship is further shown by the rated capacity indicated in "days supply." For example, Rangeley Lake has a rated capacity of 10 days supply, while Mooselookmeguntic Lake has 62.5 days supply. One "days supply" equals 24 hours of water flow of 1,550 cfs in the river at Berlin. With a glance at the diagram it is clear the largest reservoir is Aziscohos Lake, which contains about one third of the total storage system. The second largest reservoir is Mooselookmeguntic in the Rangeley chain, which contains nearly as much water as Aziscohos, with a maximum draw of 12.2 feet.

The storage system ends at Errol Dam, just below the outlet of Umbagog Lake.

At the outlet of each reservoir except Aziscohos, natural features restrict the drawing out of the bottom few feet of stored water at the rate desired. This stored water is accessible, but the time required to draw it from storage is much longer because the rate of discharge at the dam is very much reduced as the lake level drops. Because this point and other influencing conditions vary, the amount of uncontrolled storage fluctuates. This factor of uncontrolled storage has considerable bearing on operation of the storage system and will be further explained in Section VI.

The factors which determine the precise elevation of any given reservoir, the flow of the river or the status of storage as a whole, may be divided into two general classes – natural and managed. Natural factors are primarily determined by the weather and the seasons. Managed factors are based on many considerations including license commitments, operating agreements and natural resource and industrial demands.

NATURAL FACTORS

Spring Run-off

The most significant event for filling the reservoirs and determining summer lake elevations and river flows is the magnitude and timing of the spring run-off. Historically, the spring break begins sometime between March 8th and April 18th, signalled by increased runoff from snowmelt and rainfall as the daily temperatures grow warmer. April 1st is considered the date of the average break. This marks the beginning of the spring filling period for the storage system. These events and any precipitation that may occur during the following several weeks constitute the spring run-off. Snow melt alone will not fill a reservoir. It must be accompanied by timely precipitation. The volume of water reaching each reservoir depends on the water content of the snow cover, the air temperature and the amount and temperature of any new precipitation during the period. The losses due to ground absorption of water and evaporation also affect the volume and rate of spring run-off.

Runoff Was Insufficient To Fill Lakes In '65, '80, '95 ,'01

Historic records indicate that the system will "fill" approximately 73% of the time. In these "fill" years, water inflow will exceed the reservoir's capacity for storage and will be discharged as excess through the dams. In 27% of the time, the combined run-off and precipitation fails to bring the lakes to their normal full levels. The four most notable non-fill years were 1965, 1980, 1995 and 2001. The first three of those years saw a below normal snow cover and spring months of deficient rainfall. In 1965, the fill was less than 67%, and, in 1980, it was less than 65%. More recently in 1995, a year with both below normal snow cover and almost nine months of deficient rainfall, lake levels suffered proportionally. In 2001, considered the driest year on record, good snowpack was largely lost to evaporation and ground absorption as spring rains failed to materialize to accelerate and augment the break.

Melting snow and spring rains restore to the ground most or all of the water which has drained during the winter months. With the soil so wet that it is unable to absorb more water, any additional precipitation has a marked effect on lake elevations since there is an almost immediate run-off from the added rainfall. When the ground is again able to absorb water, the run-off from such rainfall is both delayed and reduced. The amount of water retained by the ground is largely dependent upon the intensity of the rainfall and physical characteristics of the soil. An inch of rain falling in two hours on the ground will have a high rate of run-off, while the same amount falling in 24 hours will result in far less run-off since much more of the falling water can be absorbed by the ground.

Rainfall distribution

Rainfall Is Very Localized

The distribution of rainfall over the surrounding area is another important factor in managing lake levels and river flows. Rain from a large general storm will fall over all or most of the storage area. However, records show the amount of rainfall from the same storm can vary greatly from place to place. It is not uncommon for one locality to receive twice the amount of rain that an adjacent area will receive from the same storm. As a result, one reservoir may rise sharply following a storm while another will show only a moderate rise. Similarly, thunderstorms with intense rain of short duration and covering relatively narrow strips of drainage area can be expected to have only a localized effect on the storage system.

Evaporation and Transpiration

Natural Factors take 12"-15" Off Lake Levels

Evaporation and transpiration (both natural processes wherein moisture is returned to the atmosphere) are closely related factors which have an effect on reservoir elevations and the rate of drop of the lake surfaces during the summer. During the course of a summer season, evaporation from any of these lake surfaces can amount to as much as two vertical feet of water. The average loss over the course of a summer is probably between 12 and 15 inches. A hot and dry summer is conducive to a high evaporation loss.

July and August of 1952 were very dry and the average temperature was well above normal. At no time during these months was more than the minimum water flow passed by Rangeley Dam to operate the Oquossoc Fish Hatchery and sustain fish life in Rangeley River. Despite this minimum flow passing from the dam, the water in Rangeley Lake dropped a total of 20 inches by September 1st largely due to evaporation. That is nearly half of the total usable storage in the lake.

Transpiration is the process whereby vegetation draws water from the ground and in turn passes the moisture into the air through branches and leafy growth. This process continues from the time the growth begins in the spring until it returns to an inactive state in the fall. The start of the leaf growing season is clear because run-in to the reservoir system terminates, as abruptly as turning off a faucet, when the leaves begin their initial summer growth. Transpiration reaches a maximum through the summer months of July and August and drops sharply when the foliage falls or is killed by frost.

Vegetation And Evaparation Soak Up 80% Of Rainfall During Mid-Summer

The amount of water lost through the combination of evaporation and transpiration changes throughout the year. In late spring, at least 50% of the measured precipitation is lost to these processes. During the summer months, nature consumes up to 81%. This is contrasted to a very minor loss during the balance of the year.

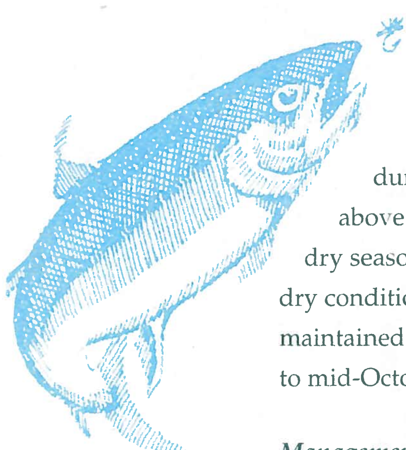
MANAGED FACTORS

Effective operation of the storages requires decisions based on years of accumulated historical data and decades of experience with actual operations. These decisions weigh many factors including local impacts, license commitments, operating agreements and natural resource and industry needs. Some water management decisions have a bearing on the relative water levels of the separate reservoirs and they are more fully described in Section VI.

Operating Agreements

Regulated Flow

The 1909 ARCO agreement among the major water users on the Androscoggin River provides that water be released from storage at a rate that maintains the river flow at Berlin at "as high a point above the minimum as shall be consistent with proper and economical use of the stored water." While the minimum flow of 1,550 cfs is attainable most of the time, the flow at Berlin has been less than this at times, even if only for a few days. The maximum usable flow in the several power stations at Berlin is about 2,600 cfs. Therefore, the flow at Berlin is maintained at a regulated level somewhere between the two limits (1,550-2,600), except during periods of excess run-in above Berlin, and for the few extremely dry seasons that occur. In 1995, extremely dry conditions dictated the flow at Berlin be maintained at 1,300 - 1,500 cfs from early June to mid-October.



Management Minimizes Natural Variations

Supporting this regulated flow represents the greatest demand on water at Umbagog, and in turn has a major effect on the elevations of the storages. The rate of draw depends on those natural factors which prevail at the time, varying from no draw in the spring or early summer to drawing whatever the regulated flow may be in the hot summer months. In other words, it may require no water from storage to hold the desired flow or, in very dry conditions, practically all of the water passing Berlin may be coming from storage. The difference between the regulated flow and the natural run-off into the storage basin represents the amount that must be drawn from the storage system to maintain the desired flow at Berlin. It is obvious that when the run-off is high, the lakes remain high or drop only very slowly, and, as the run-off reduces, the rate of draw on the reservoirs increases proportionately. As the natural run-off decreases, the regulated flow at Berlin also decreases to ensure the highest sustained flow that prevailing climactic conditions will permit.

FPL Energy strives to maintain as uniform a flow as possible in the Androscoggin River, and also keep the Berlin flow above 1,550 cfs, whenever possible. Berlin serves as the focal point of the regulated river to provide the maximum amount of predictability for the users downriver.

1998 Settlement Agreement

Collaborative Agreement Achieves Balance Among Users

As part of the FERC licensing process for a portion of the storage system, a collaborative agreement was reached in 1998 between FPL Energy, ARCO and approximately 20 other governmental and non-governmental organizations, including representatives of state and federal resource agencies, environmental groups, municipalities, industries, camp owners, and a land trust. The Agreement strikes a carefully considered balance between energy, flood protection, wastewater assimilative capacity, ecological, and recreational values derived from the Upper, Middle and Aziscohos dams.

The Agreement stipulates operational criteria and non-operational protection and enhancement measures. The goals include:

- Increase minimum flows to benefit fish species.
- Provide more stable reservoir levels in the

summer to enhance summer recreation and tourism and to protect important wildlife resources.
- Guarantee whitewater releases to provide predictability to boaters wishing to raft and kayak.
- Provide additional recreational amenities for the region.
- Maintain ability of FPL Energy to operate the reservoirs in a manner similar to historic operations, thus providing consistent flows for hydroelectric generation, industrial use, wastewater treatment and flood protection purposes in the future.

Natural Resources

FPL Energy is committed to environmental stewardship in the responsible operation of the storages. The needs of fish, wildlife and recreationists are important considerations in how water levels and flows are managed. FPL Energy's effective management is essential to ensure the ecosystem remains healthy. In its management of the fisheries resource, FPL Energy conducts tributary surveys each fall. Woody debris is cleared from the tributaries to improve access for spawning brook trout and salmon. Fishing surveys are conducted regularly on the lakes and rivers to monitor and evaluate the resource. FPL Energy has studied ospreys, otters, ducks, kingfishers, tree swallows, crayfish, bats, eagles, beaver, turtles, many varieties of fish, and macroinvertibrates as well as water, plants, wetlands, sediment, and mercury, to name a few. Its extensive yearly studies of loons have received very favorable peer reviews. In fact, more is known about the robust population of loons on Aziscohos Lake than loons practically anywhere else in North America.

Loon Nesting Rafts Aid Breeding Success

An example of how FPL Energy accommodates the needs of loons is the deployment of loon nesting rafts. Because they move awkwardly on land, loons typically build their nests at the water's edge. Fluctuating water levels can sometimes either flood a nest or leave it stranded many feet from the water's edge. FPL Energy biologists pioneered the development and use of floating nesting platforms designed specifically for loons, and have deployed about 50 rafts throughout the storage system. With these nests, a loon is never more than one step away from the water, no matter what the lake level. The loons have taken to the platforms, and exhibit great success with their use.

People can help protect loons in a number of ways:

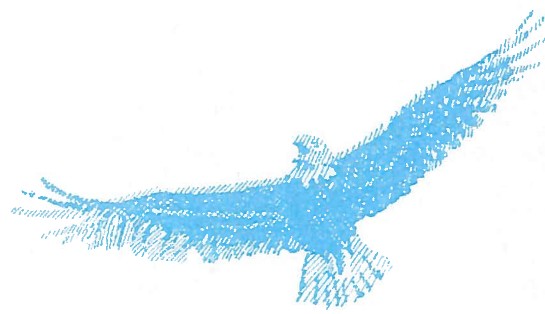
- Enjoy the birds from a distance; stay clear of loons and their nesting areas.
- Limit boat traffic and recreational activities that easily disturb nesting birds. Disturbed loons stay off the nest and the eggs die from exposure.

Flood Mitigation

Efficient water use and flood control are critical factors considered in operating the system. Intense summer weather events can sometimes quickly add water to a reservoir. FPL Energy monitors the weather closely and if time permits can draw down a reservoir in advance of anticipated rains. In the fall, reservoirs are kept somewhat lower in anticipation of usual fall rains. This accomplishes two things. First, it affords a measure of flood protection to the valley below Errol in New Hampshire and Maine and prevents water in the storage lakes from getting too high. Second, it allows efficient and timely use of the water deposited on the headwaters area by nature. An effort is made to draw approximately an equal volume of space (expressed in inches of run-off from the respective drainage areas) in Aziscohos and in all reservoirs above Middle Dam.

Maintenance and Repair

Any structure, regardless of the materials from which it is made, requires repair and maintenance work. While the dams holding back the Rangeley Lakes are old and largely of timber or concrete crib and steel construction, they are in good condition and are well maintained. It is sometimes necessary to rebuild gates, piers, braces and other portions of the structure which are below normal lake water levels. Such work requires lowering water levels. To minimize disruption of lakeside recreation activities and keep repair costs low, non-emergency work is scheduled when the water level is naturally low.



Storage Maximizes Lake Levels

It is the purpose of the storage system to provide a steady, uninterrupted flow of water in the river below the reservoirs. In this part of the country, an excess of run-off in the spring, and usually again in the fall, is expected. By storing water during periods of high run-off and releasing it during periods of low run-off, fluctuating natural precipitation is converted to a steady dependable flow in the river below.

The major considerations in operation of the storage system are:

- to establish relatively uniform flow of water in the Androscoggin River for economic and public use.
- to create the essential water supply for users along the river.
- to minimize impacts to recreational users and fish and wildlife populations in the headwaters area.
- to operate the system consistent with established agreements.

The table below shows the relationship between the drainage areas at each storage dam to the reservoir capacities of the respective lakes. The ratio of capacity to area (last column) indicates the amount of run-off required from each square mile of area to provide sufficient water to fill the storage capacity of the reservoir. Based on physical characteristics of the storage drainage area and knowledge of climactic conditions over time, the ideal ratio of capacity to drainage area at each dam should be between .300 and .350 days supply per square mile.

Aziscohos, Umbagog and Errol

Only at Aziscohos does the ratio fall within these ideal limits. While the ratio for Upper Dam alone appears to be within these limits, the entire area above the dam must be considered because of the very small volumes contained by Rangeley and Kennebago dams. Of particular note is the situation at Errol where a large drainage area feeds a reservoir of limited capacity. One other conclusion can be drawn from this table. If all gates in all dams were closed at the time the spring run-off starts, the lakes would fill in the order of Umbagog, Rangeley, Aziscohos, Mooselookmeguntic and Richardson Lakes, provided there was no overflow or waste from one reservoir to another. The Richardson Lakes take the longest to fill because they have the smallest drainage area relative to their storage capacity.

In practice, because of several factors, this order of filling is somewhat varied. At the earliest opportunity in

Relationship of Storage Capacity to Drainage Area

Storage Dam	Drainage Area In Sq. Miles	Storage Capacity In Days Supply	Ratio Of Capacity To Area In Days Supply Per Sq. Mile Of Drainage Area
Rangeley Dam (Rangeley Lake)	99	10	.101
Upper Dam (Mooselookmeguntic Lake)			
Alone	182	62.5	.343
Total Above	382	72.5*	.190
Middle Dam (Richardson Lakes)			
Alone	90	42.5	.472
Total Above	472	115*	.244
Aziscohos Dam (Aziscohos Lake)	214	72	.337
Errol Dam (Umbagog Lake)			
Alone	359	23	.064
Total Above	1,045	210*	.201

**Kennebago Lake not included for storage capacity. (Kennebago drainage area=101 sq. mi)* the spring, the gates at Aziscohos, Middle and Upper Dams are closed. At or about the same time, the flow through Errol is reduced by a partial closing of the gates. The elevation of Umbagog Lake is permitted to rise a few feet so that this added storage may be used to maintain the regulated flow at Berlin without use of any water from above Umbagog. By fluctuating the height of Umbagog, it is usually possible to maintain the desired river flow until June 1st without having to draw water from other reservoirs. In dry years, the draw from other lakes may start during the first part of May, and in wet years it may be as late as July 1st before water is required from above Umbagog Lake.

As soon as the natural run-off above Errol Dam drops to a point less than the discharge through Errol necessary to maintain the regulated flow at Berlin, the seasonal draw on the storage system starts. The initial draw creates space for refilling if the natural run-off increases again. When it becomes necessary to draw from other reservoirs, water is passed through Aziscohos and Middle Dams in about equal amounts at a rate sufficient to hold Umbagog Lake steady.

During the fill period, sufficient run-off is generally available to fill Aziscohos above the normal full lake elevation. The resulting flow (over the top of the free spillway) is passed downstream to Umbagog. If Umbagog is already full, the water will pass out of storage and into the Androscoggin River.

Richardson, Rangeley and Mooselookmeguntic

On the Rangeley side of the system, the Richardsons and Mooselookmeguntic are permitted to rise at a rate consistent with the natural run-off from the respective drainage areas with Mooselookmeguntic targeted to reach a level of 1,467 above sea level by June 1st. As Upper Dam reaches a higher water elevation, water is passed into the Richardsons to compensate for its smaller drainage area and higher capacity ratio. As the snow melt diminishes for the season, it is ideal for the water on the Upper Dam gauge to be about one foot higher than the Middle Dam gauge (20.50 feet is full pond on both local gauges).

Because of the small storage capacity of Rangeley Lake, the gates at this dam remain partially open to pass water into Mooselookmeguntic during the first part of the spring. Under these conditions the run-off into the lake exceeds the discharge at the dam, so that the lake rises to meet a target of being full and stable by June 1st. An effort is made to maintain this rate of rise until the lake is about a foot from being full. If the run-off remains high, the gates are opened further to stabilize the lake elevation just below full.

On the last of the spring run-off, provided sufficient volume comes into the lakes, each reservoir in the Rangeley chain is brought to within six inches of its normal full pond elevation, then gradually increased to full at all lakes. Gates are opened or closed to hold the lakes at or near their full pond elevations until regulation and draw from storage becomes necessary. Any unfilled space provides a small capacity available to be used in the event a heavy storm creates high run-off from the area.

Rangeley Lake

Numerous recreational and wildlife interests on all of the lakes, such as boating, fishing and loon nesting, are also significant factors in maintaining water levels. The physical characteristics of Rangeley Lake permit the retention of a higher lake level during summer months. As previously indicated, the volume of usable water in Rangeley is small and can be drawn in just a few weeks. If drawn to the lakes below, it would have little effect on the elevation of the lower lakes. It is customary to limit any draw on Rangeley Lake during the summer months to the needs of the fish hatchery and rearing station located just below the dam and maintain a reasonable minimum flow in Rangeley River. As a result, conditions permitting, Rangeley will generally be held full through Labor Day. Gates are opened in the fall at the request of the Department of Inland Fisheries and Wildlife to aid in its fish propagation program. The gates remain open and flow is managed to have Rangeley at its natural elevation sometime in the late winter or early spring.

Drawing The Reservoir System

As mentioned previously, the most significant event for filling the reservoirs is the magnitude and timing of the spring run-off. To provide capacity to control the spring run, the reservoirs are normally drawn down to about 32% above their natural elevation.

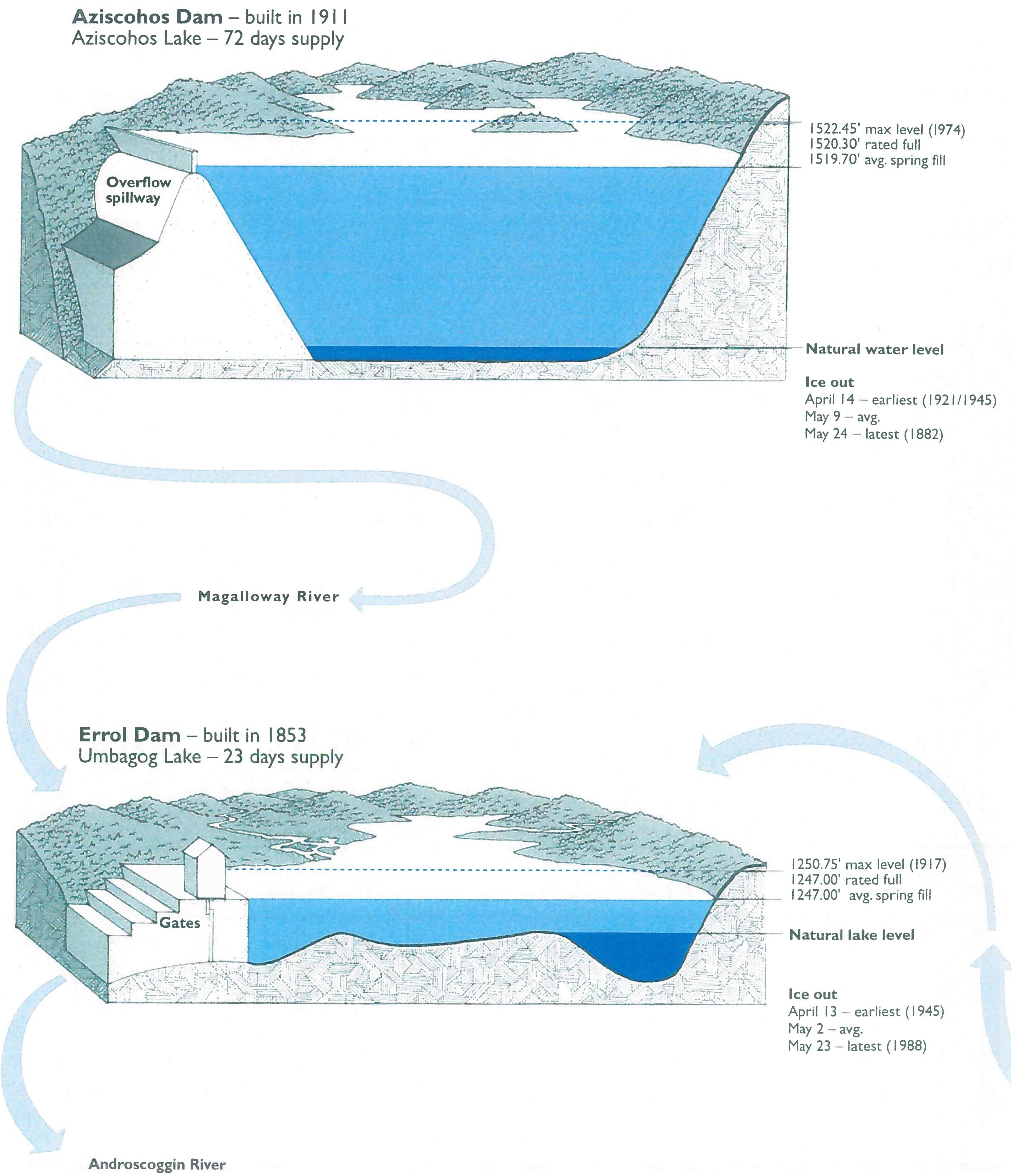
Late winter weather and climactic conditions will influence the amount of water drawn. A normal snowpack and a gradual spring thaw will release water moderately over time into the reservoirs. This water can be either held in storage or passed, depending on the total amount of water expected. A very late spring and/or an excessive amount of water content in the snow could result in a rapid release of water into the storages. In these situations it is prudent to "pull the ponds" below the normal 32% draw to minimize flooding and possible damage to the dams.

In unusually circumstances, conditions can be such that a complete drain of the system is in order. The entire draw takes time, so accurate weather forecasting and modeling is essential.

For a complete draw, water would generally first be taken from Rangeley Lake. Next in line at Mooselookmeguntic Lake the draw is controlled by Upper Dam until about two feet of the 12.2′ of stored water remains in the lake. The natural channel outlet (about half-way from the dam to Black Point) then governs the amount of water leaving the lake. As with Rangeley Lake, several weeks are required to draw Mooselookmeguntic down to its natural level.

Next, at Richardson Lakes, the bottom four or five feet of the 17.5′ stored by Middle Dam can be reached only over about seven weeks. Aziscohos is then the only sizable reservoir remaining to deliver a dependable supply of water. For regulating purposes it is essential to maintain sufficient supply in Aziscohos for the major part of this seven-week period. This supply amounts to about half of the rated capacity of the reservoir. This supply in turn is drawn, leaving Umbagog as the sole source of storage, which can continue the 1,550 cfs flow for about five more days.

FIGURE III **LAKE LEVEL RECORDS**

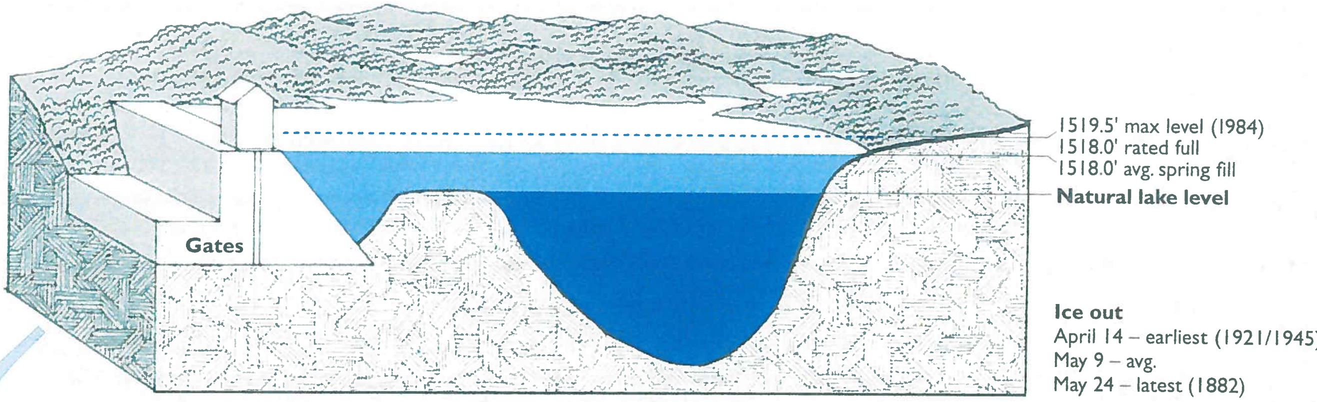


Elevations are United States Geologic Survey height above mean sea level.

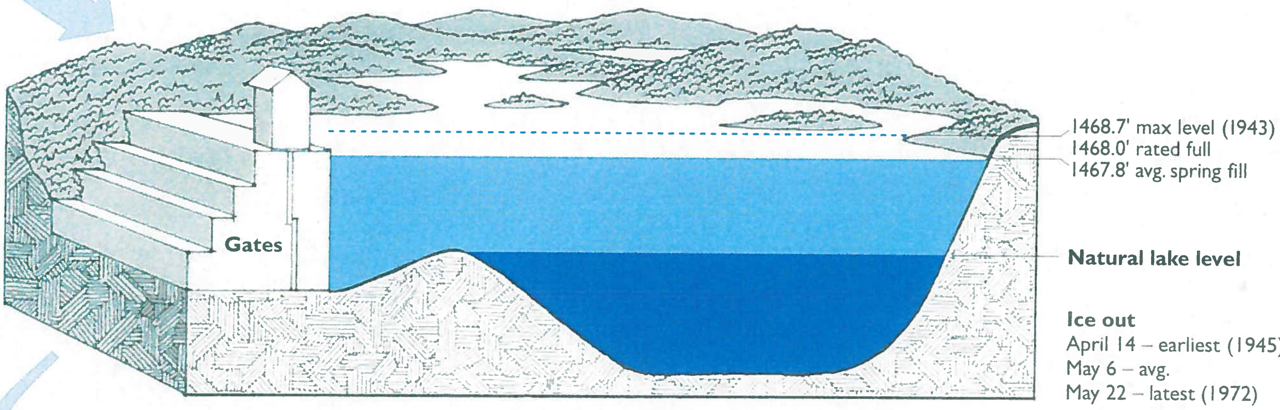
Figures in parenthesis are the year in which the record was established.

1 days supply = 1,550 cfs for 24 hours in Berlin.

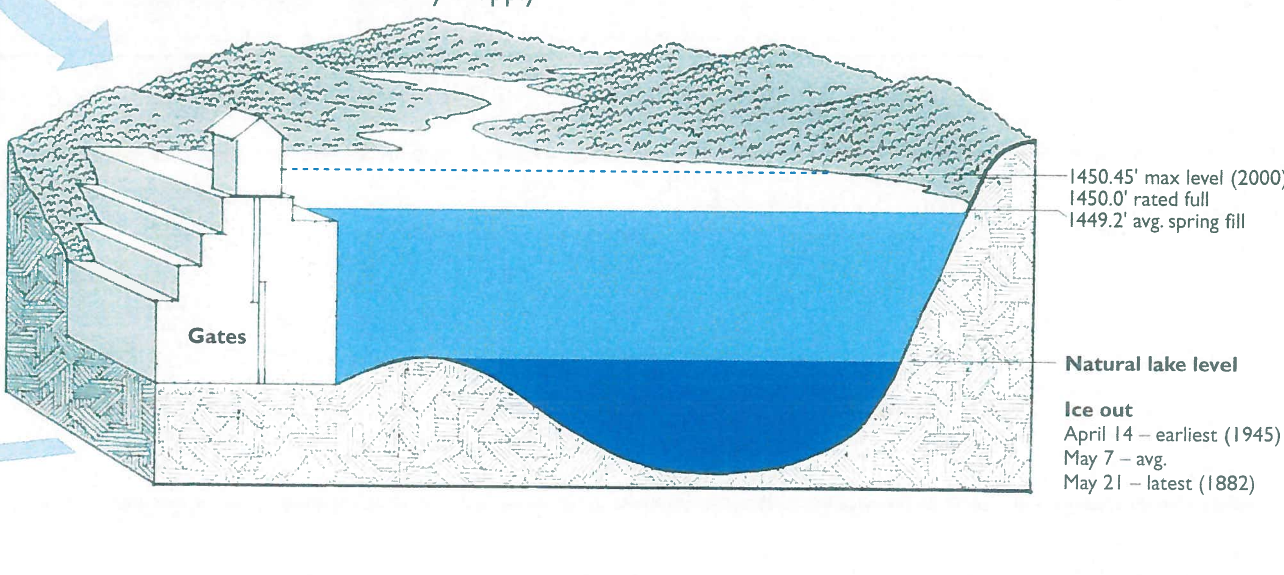
Rangeley Dam – built in 1836 (rebuilt in 1983)
Rangeley Lake – 10 days supply



Upper Dam – built in 1853
Mooselookmeguntic Lake – 62.5 days supply



Middle Dam – built in 1853
Richardson Lakes – 42.5 days supply

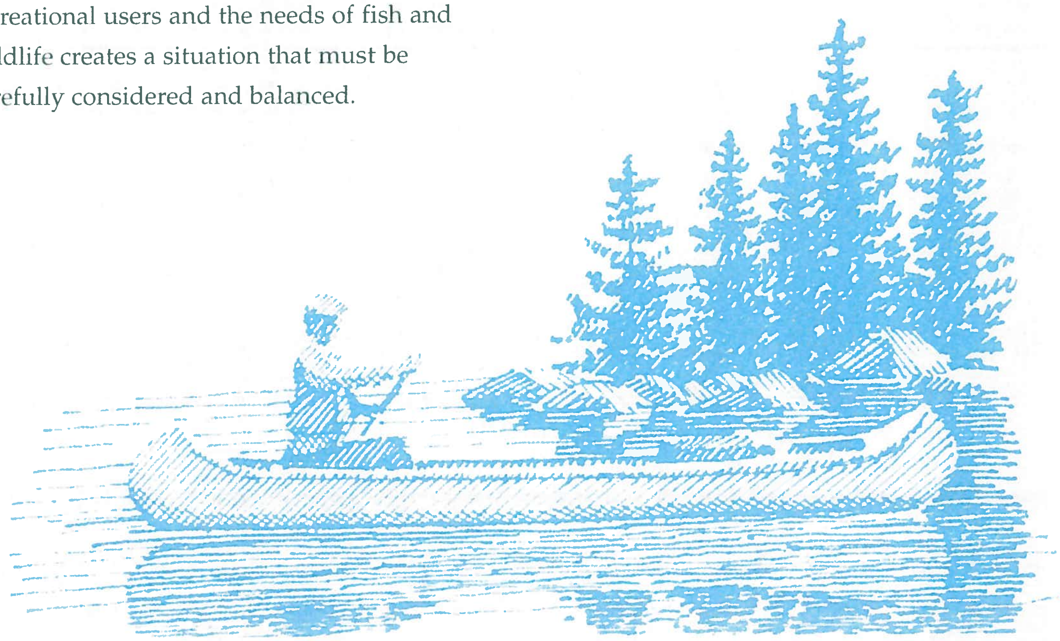


General

Historic Data Informs Today's Management

Since 1911, dam keepers at the four principal dams have kept complete daily records covering precipitation, temperatures, lake elevations and gate openings. This historical data, maintained by FPL Energy, provides a reference for daily and long term decisions made in operating the storage system. For example, the data shows that natural systems (evaporation and transpiration) use nearly 69% of the rainfall during the four months from June to September. This use peaks in August with natural systems retaining 81% of the measured precipitation. Of course no two years are exactly alike, and the historic data is reviewed in the context of the current unfolding weather forecast and the natural capacities and constraints of the system. Decisions on holding or releasing water at any given time must balance a great many factors, including current conditions, long term needs, weather forecasts, operational and settlement agreements, the terms of the federal operating license, natural resource, industrial, recreational, public and safety needs.

The combined demands of nature, the economic communities along the river, recreational users and the needs of fish and wildlife creates a situation that must be carefully considered and balanced.



Water Management Mitigates Effect of Weather

The elevation of any reservoir and the flow in their outfall rivers is dependent upon many factors, and the most influential of these is weather. The overall effect of the weather may be moderated to some degree by the ability to manage water flows at dam sites. Operating the dam system to achieve this moderation must balance many important factors, all of which are considered in setting the daily flows at the dams.

Property owners and visitors interested in the area from a recreational viewpoint may be assured that they have received and will continue to receive consideration in the operation of the storage system. Since such recreational interests exist on all the lakes an effort is made to distribute the storage draw to minimize impacts felt system-wide.

The water in the Androscoggin River below Errol is a key factor in the economic well being of thousands of families in the larger towns and cities. For many other thousands, it is an indirect and partial means of support. While the need for a regulated flow of water below Errol may sometimes be in contrast with the desire for water to be retained in the Rangeley Lakes, these interests have lived in reasonable harmony for more than 100 years. With good communication and water level management, the next 100 years should be even better.

Drainage Area

That area of the earth's surface that lies above or upriver of a specified location from which direct surface run-off of precipitation normally drains into the stream. Drainage area is synonymous with "drainage basin" and "watershed." The drainage area above or upriver of Errol, New Hampshire is 1,045 square miles.

Pull The Pond

Also called "pulling a hole", this is the practice of drawing water from a reservoir to increase storage capacity in anticipation of a rapid influx of water.

Regulated Flow

The rate of river flow as measured at Berlin, New Hampshire that is determined to be obtainable for each coming month. The precise determination depends on prior and current climactic conditions, over 90 years of historical data and the usable volume of water contained in the storage system. Uniform river flow may be accomplished only in connection with a storage system. The regulated flow is usually between 1,550 and 2,600 cfs.

Run-off

The accumulated amount of water flowing in the several streams and brooks within a drainage area at a given time. This may be from water running over the surface of the ground to the stream from recent precipitation and/or water reaching these streams from seepage through the ground.

Spring Break

The date in March or April when the run-off from the drainage area above Berlin, New Hampshire, increases to a point where there is no need for water to be drawn from storage to maintain a regulated flow. This condition can be created by warm temperatures causing the snow to melt, by rainfall or a combination of the two. Should the spring break occur prior to March 25th it is called an "early break" and, if after April 7th, a "late break".

Spring Run-off

Dramatically increased runoff from snowmelt and rainfall as daily temperatures grow warmer in the Spring.

Stored Water

Water that is retained above the natural lake level by a dam. It is not possible to withdraw any water below the natural outlet of these lakes.

Yield

This term is nearly synonymous with run-off. It refers to the natural flow from a drainage area over a given period of time and is usually measured in "days supply" or billions of cubic feet.