OPERATING THE ANDROSCOGGIN RIVER/RESERVOIR SYSTEM

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ABSTRACT

The seasonal effect of rainfall and snow cover on river flow can be greatly enhanced by use of a reservoir system. The natural formation of the Rangeley Lakes at the headwaters of the Androscoggin River provides an ideal reservoir/river combination that has been operated for river regulation and flood control for over 100 years. The accumulation of long term records and studies provides an interesting insight to the 3500 square miles of the Androscoggin River in Maine and New Hampshire. The Union Water-Power Company is a water storage and industrial water sales company with the prime responsibility of regulating the flow of the Androscoggin River as measured at Berlin, New Hampshire. This system culminates the solar process of annually recycling water.

GEOGRAPHICAL

Located in northwestern Maine, the storage drainage reaches to the Maine/Canadian border, works its way west to Errol, New Hampshire, south through Berlin, New Hampshire, from where it turns east across the New Hampshire/Maine border, then northeast through Rumford, Maine, south through Jay/Livermore to Lewiston/Auburn and on through Brunswick to Merrymeeting Bay and the ocean. Hydro electric development is at each falls along the river which coincides with the mentioned cities and towns.

The geological makeup is the northern mountain range of the Appalachian chain which runs diagonally northeast across the northern half of the drainage area. Elevations extend from 1000 (305m) to 3500 (1067m) feet. The southeastern half of the area is a transition from mountains to coastal lowlands, with elevations from sea level to 1000 feet (305m).

HISTORICAL

To familiarize you with what this is all about, some historical background should be helpful. In Lewiston, Maine, a natural ledge outcrop forms a drop in the river of about 40 feet (12m). Although many wooden structures were built to increase the head, it was not until 1862 that permanent granite dams were built. Together with flashboards, the dams now create a gross head of 56 feet (17m). These dams divert water into a canal system, built in the early 1850's, that delivers water to the mills for the generation of power. This was originally done mechanically with shafting and belts but was converted to electrical energy around the turn of the century.

Concurrently, but unrelated, log driving dams were being built at the headwaters of the Androscoggin River. When each season's log drive was over, the gates were fully opened thus returning the rivers to natural flow conditions.

The problem was that the mills in Lewiston had to schedule their production to a river that was subject to summer droughts and winter freeze ups.

The solution was the purchase of four headwaters storage dams with flowage rights in

1878, thus consolidating a vast drainage and reservoir system that would allow mill production to be scheduled in a more orderly fashion.

The storage system was completed in 1911 when the fifth and final dam was built at Aziscohos Falls on the Magalloway River. This construction was prompted by a severe drought in 1903.

MAINTENANCE

The four timber crib structures require annual maintenance of major and minor magnitude. Major repairs are scheduled for the weakest part of the system's structures so that no major "surprises" occur that would distort an already large budget. Present operating and maintenance costs are $400M/year. Maintenance takes about one-third of this amount.

MULTIPLE USE

The remote location and accessibility of this area has kept the recreation traffic down; however, the last ten years have seen a significant increase in the number of people using the area. The Rapid River is a class IV kayak run, and open canoes are virtually impossible. Many camps canoe the lakes but portage such rapids.

Summer camps have become more prevalent wherever roads have been built. The advent of snow travelers has increased winter use of this area. Fly fishing only is the name of the game; but with increased fishing and boating pressures, a decline in size and number of land-locked salmon, square tail trout, and smelt has become evident.

Many forms of wildlife are present to alert eyes.

WHY/HOW THE SYSTEM IS OPERATED

The system was built for two distinct purposes; namely, manufacturing by use of water power and as transportation for log driving. When the river failed to supply sufficient water to the mills in Lewiston, they soon looked upriver to the headwaters for storage that would give them a more uniform flow year round.

Through the early stages of operating the company, log driving was accomplished as a first priority of business. This produced tolls and helped support the system. After the drive was over, the remaining water was apportioned much the same as the system is operated today. Long term records and operating procedures have been developed over a continuous period of 70 years. While these records do not constitute an absolute rule for operating a system of this size, they do act as a guide and may be termed invaluable.

The exact procedure may well be described as starting on June First which is the average date for the system being full. At this time one must look ahead about six months and do some real crystal ball gazing to determine the best uniform flow that can be maintained through this period. Once having determined what flow will be run for June, the same procedure is used on July 1, August 1, etc.. As precipitation patterns change, so will the operator's determination of flow for the upcoming months. Each month's decision must be tempered with long term weather events so that necessary river flow changes are done gradually. This is no job for a "Nervous Nellie", but one where hard decisions must be made and then adhered to.

With the fall season at hand, a partial recharge of the system may be expected and then another six month prognostication must be made for the winter months. As each month goes by, some fine tuning may be necessary. As the snow pack arrives and continues to build, planning can be done for the spring runoff season. The graph shows the relationship between the amount of water on hand and the amount of water that can be released based upon a 75% yield from the storage drainage (Chart #1). Normally from April through June there is sufficient natural run-in to preclude regulation.

After each monthly flow determination, the operator at Errol Dam must perform somewhat of juggling act with thirty miles (48km) of river. His job is to regulate the flow from Errol Dam that reaches Berlin 12 to 16 hours later. When storm patterns render changing flows, the Errol operator must compensate by making changes at his dam. He must save as much water as possible and yet not let the flow at Berlin drop below the prescribed amount. This procedure can entail some real head scratching especially when flows from Berlin are not reported accurately.

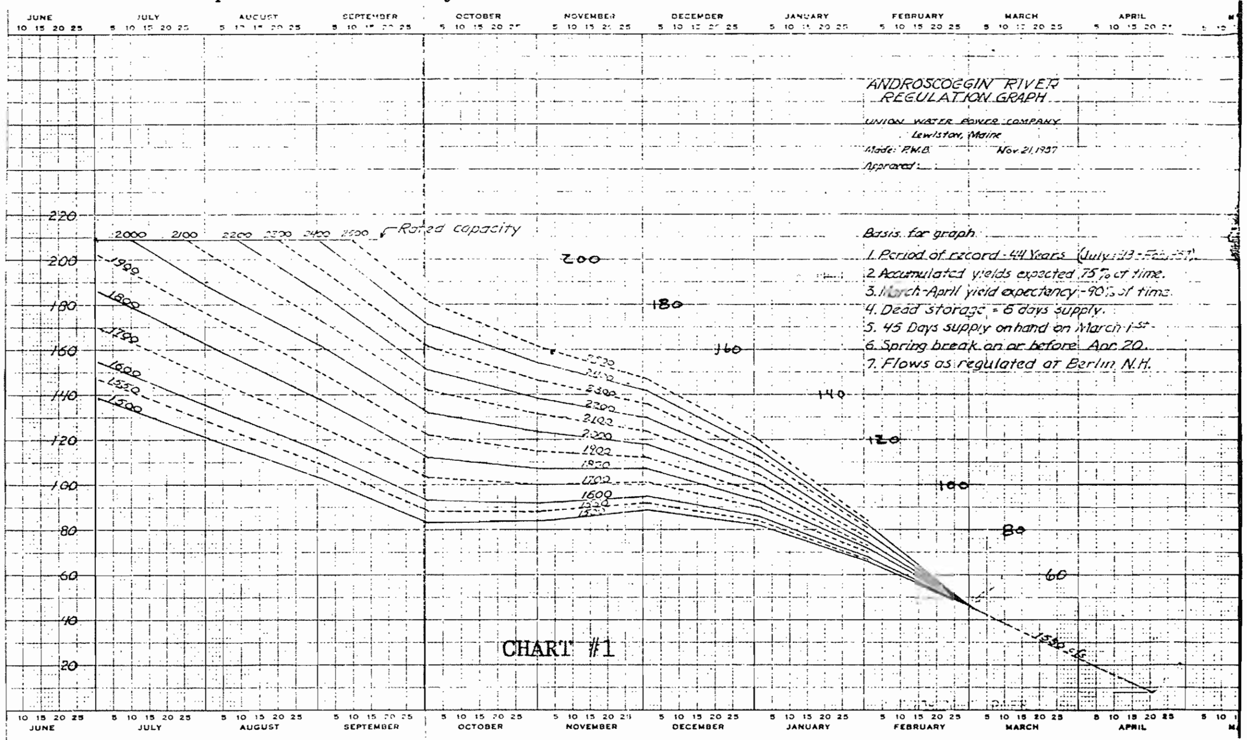


CHART #1

STORM PATTERNS

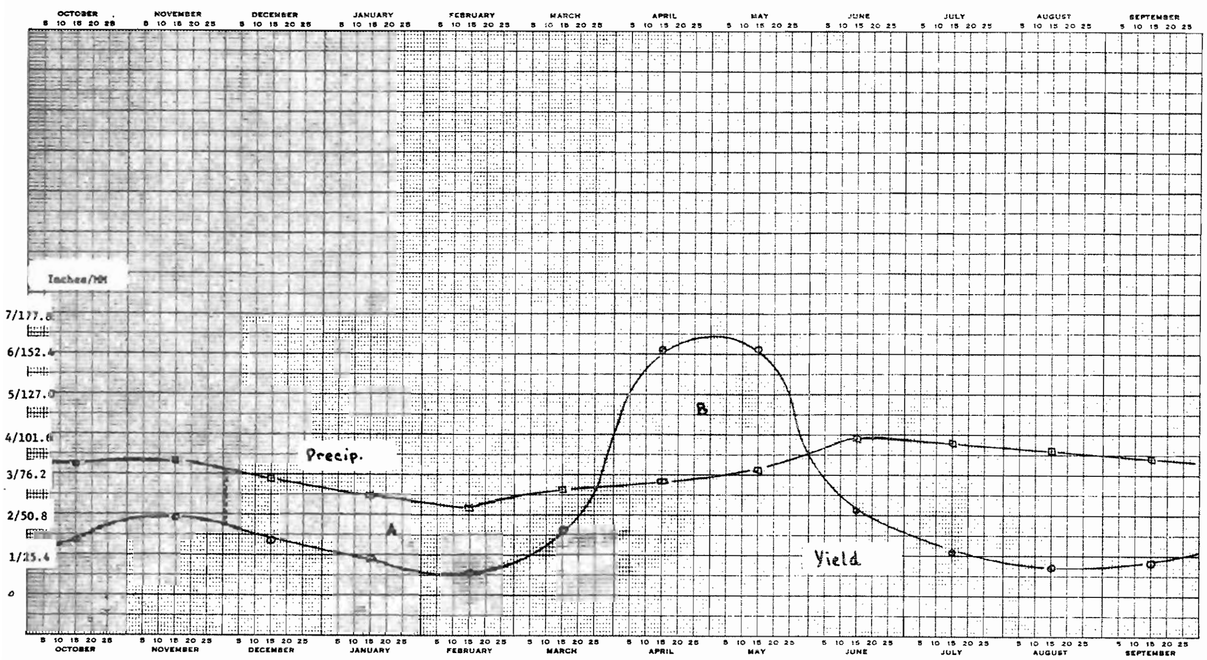
While it would be presumptuous of me to suggest that a mountain range with an average elevation of less than 2000 feet (610m) and a maximum peak of 4000 feet (1220m) is sufficient to steer a storm at 20,000'+ (6100m), there is sufficient data to suggest that the Appalachian Mountains are a dividing line of some sort. Coastal storms seldom produce the same amount of rain that a storm from the north or Great Lakes area produces. These northern storms do not produce as much precipitation along the coast. An example of this phenomenon is the flood year of 1936, when all time peak flows were reached everywhere along the river, while the four northern most lakes were well below full.

YIELD vs PRECIPITATION

One noteworthy observation is the relationship of long term precipitation to yield (Chart #2). The yield is the amount of water received into the storage system and is the "real world". With yield, all losses, real and hypothetical, are eliminated. Starting with June the long term average precipitation is 3.86 inches (98mm). This declines steadily through October to 3.22 inches (82mm). November shows a slight increase to 3.33 inches (84.6mm), but then the precipitation again declines steadily through to February, to a yearly low of 2.16 inches (54.9mm). This trend then reverses itself steadily upwards back to June.

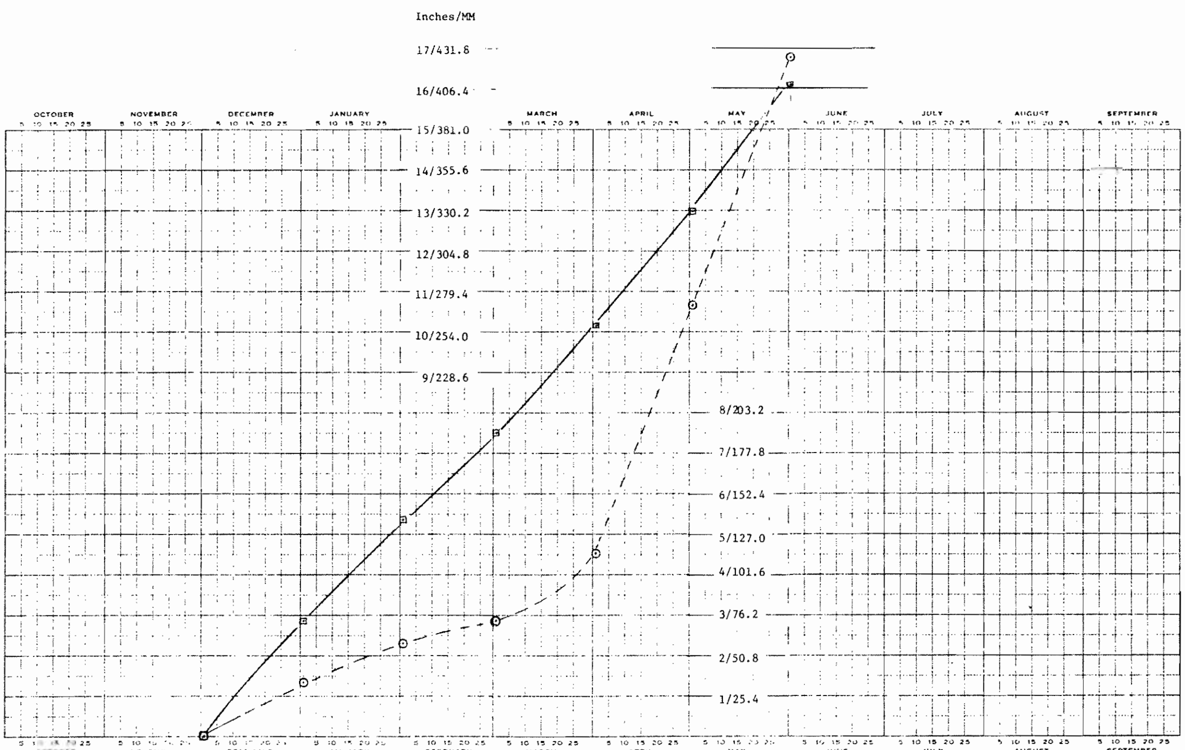
The yield through the summer, or foliage months, is less than one inch (25.4mm) of precipitation or about 19 percent of what is supplied through rainfall. Mother Nature is retaining 81 percent leaving the water company and the tourists to quibble over the remaining 19 percent.

Another particularly useful chart that was discovered after much experimentation is the relationship of accumulated precipitation to yield from December 1 through June 1 (Chart #3). Long term records show that the total yield for these six months will at least equal the precipitation received during that same period. It is particularly helpful at the start of the spring snow melt. By examining the chart, one may know in advance how much run-in is forthcoming. Thus far this relationship has been 100 percent accurate.



Monthly Precipitation
vs. Yield 68 yr. Ave.

CHART #2



Relationship of
Precipitation to Yield
6 Months Accumulation

CHART #3

This relationship can be verified by referring to the monthly precipitation vs. yield chart. Area A equals B, or the deficiency represented by area A is made up later by the excess represented by area B. The difference between precipitation and yield from June 1 to December 1 shows net precipitation losses occurring on this watershed.

SNOW SURVEYS

Chart #4 shows the snow stations that are measured on March first. The storage drainage has thirteen stations with a long term record of twenty-five years. On the drainage area between Errol and Berlin (318 square miles), there are five stations; Berlin to Rumford (704 square miles), fourteen stations; and Rumford to Lewiston (796 square miles), six stations. In addition, we take readings at the four principal lake stations (dams) on the 1st and 15th of each month that there is snow on the ground. These readings have a seventy year record. Reference has been made to readings being taken at Upper Dam in the 1880's. An Adirondack tube of fiberglass with stainless steel cutting edge is used. Comparative tests were made by Union Water-Power Company using the federal snow sampler tube of 1.485 inch (37.7mm) inside diameter. The Adirondack tube was found to be more accurate for a wider variety of snow consistencies and was adopted for our purposes. The Maine U.S.G.S. also uses this tube.

From these snow readings, water in the snow, and hence, flows may be estimated. As a practical matter, periodic interpretation must be made. Snow measurements are but a very small hole in the snow from which projections to a 1045 square mile area are made. This cannot be termed a very valid projection but can be used as an index when compared to the long term average. Even this index must be viewed with caution and updated with changes in weather conditions. Such factors as temperature, ground water conditions, cloudy or sunny days, rain, rain intensity, as well as the temperature of the rain, all contribute to the collection of water into the storage system.

The maximum water content at the four principal lake stations occurs on March 15 and the eighty year average is 7.7 inches (195.6mm). The average maximum reading occurred on April 1, 1969 and was 14.8 inches (376mm).

CONCLUSION

The operation of such a storage and river regulation system is reasonably complex, it varies with each and every storm and season, and it is intriguing because of its weather inspired variety. While the foregoing has been a very general overview, time does not permit a detailed analysis of the operation.

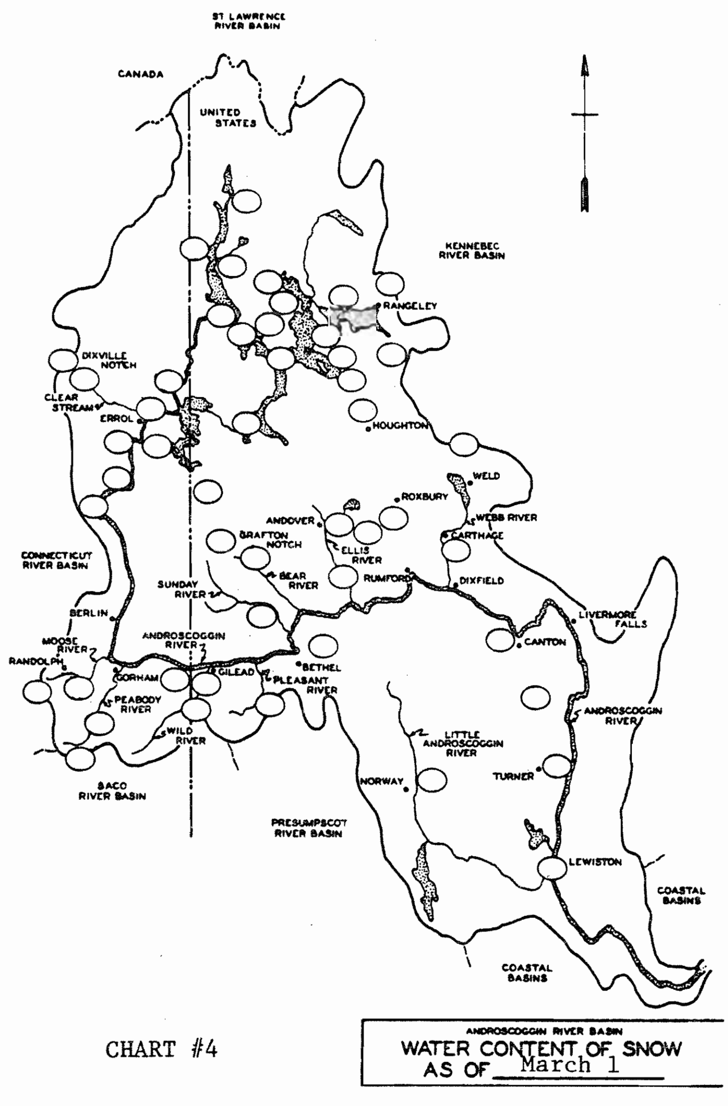


CHART #4