FLOOD ROUTING PROCESS ON THE CONNECTICUT RIVER FROM SNOW MELT

By

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The Eastern Snow Conference has met now for a number of years in the interests of snow, ice and frost. Techniques have been studied and developed to measure the winter storage of water on the ground within the drainage areas of our rivers and lakes. We have had papers delivered which discussed the snowflake and the snow drift - the ice crystal and the ice lens. The percolation of the rain drop through the snow bank has been studied. Formulas have been presented to evaluate the expected run-off into a river system. It all has been a most fascinating study and has kept this group of engineers, scientists and teachers banded together in a never-ending research of problems that seem never to be quite solved. However, there is another phase that comes with the snow melt of the spring which certainly is of interest to the men on river control. They know how much water is locked up in the snow on the ground and have a fair idea how much run-off to expect when the spring rains come. They watch the day temperatures rise above freezing, the frost coming out of the ground and the freeze-up during the nights and the snow ripening for the run-off. Then comes the spring rains and rivers rise and flood stages fill the flood plain of our valleys.

It is probable that many people outside the hydro-electric industry simply conclude that the power companies open up the flood gates when the time has arrived and "let her go". That appears to be the way it is handled from a casual observation by those who drive past our dams and are fascinated by the thunderous flow of water through the flood gates.

The newspapers cover the dramatic angle of the floods. Turbulant rivers on a rampage, overflowing banks, ice jams, highways under water, bridges washed away, lives lost and the loss of property in the millions of dollars. Previous to this annual event, it seems that the power company men and the flood control men are the only ones alert to the potentialities of damage to property and lives that can be lost if the weather pattern develops unfavorably.

The Army Engineers have been flood control conscious for some time. They have planned and are constructing a pattern of flood control dams to prevent the loss of lives during major floods and the damage or destruction of property along the flood plain of our rivers. They have advised the people of the

valley of the ever-present threat that with the passing of each normal year we are one year nearer to our next flood.

How about the Power Company man who has to take each high water and flood as it comes along? Not much is printed about what he plans and the action he has to take. In the middle of the night when streams should have peaked but are still rising, the orders of the day are ineffective and useless in an hour. So let us review a spring run-off of the Connecticut River drainage area, particularly the upper reaches that go into the snow country.

The Connecticut River is the largest river system in New England. At its mouth at Saybrook it drains more than 10,500 square miles of New England's surface. It rises in the northernmost mountain passes of New Hampshire at a 2,000 feet elevation against the Province of Quebec and it forms a series of lakes in a mountainous terrain. Fed by many feeder streams, it soon becomes a river of sufficient importance to form the boundary between Vermont and New Hampshire. It flows in a southerly direction to Long Island Sound, a distance of 400 miles. Its fall to the ocean becomes gradual below the lakes and it meanders back and forth through many intervales and criss-crosses the flood plains. Intermittent natural controls are scattered throughout the run of its course to choke the rush of the flood water causing spill over the banks and inundation of the cultivated low lands, rich and productive, enjoyed by the farms of many generations. This phenomenon known as valley storage is a natural flood control, lessening the peak and slowing the run-off to some extent.

The Connecticut River is said to be one of the hardest worked rivers in the country. Many horsepower of work is performed by each cubic foot of water through the turbines of mills and electrical generating stations at the several dams.

There are many concerned with what the Connecticut River is doing in the spring. The Weather Bureau recognizes this and has in operation a river forecasting office at Windsor Locks, Connecticut to aid those living and working in the valley.

The flood waters do not generate any electricity once a reservoir is filled to overflowing. A reservoir that is being filled is impounding water, thereby lessening the run-off in the river system below. But once this reservoir is filled, the water surface elevation is held and stream flow conditions are established. No more water can be stored. The volume of discharge can neither be more or less than the volume of inflow water into the upper end of the reservoir. Flood control has come to an end under these conditions.

In anticipation of the spring snow melt, there are certain preparations necessary. Even before the snow surveys of the spring are started, the usable contents of our storage reservoirs are used for generation throughout the winter. The freeze-up and the snow blanket of the winter pinches off the flow into the river from springs and streams. Storage water in these reservoirs is utilized during this deep freeze period and so by the time spring weather arrives our reservoirs are depleted and in readiness to accept the snow melt of the spring.

From the northern border of New Hampshire to the northern border of Massachusetts there can be impounded on the main Connecticut River, over 380,000 acre feet of water which is available for power purposes at the several reservoirs and dams through the area.

This does not include the many small reservoirs and dams in the feeder streams and rivers where there are mill ponds, storage lakes and flood control dams.

The run-off from the mountainous valleys of the Connecticut River tributaries of the upper valley is of a flashy nature. Indian Stream, the Mohawk from Dixville Notch, the Passumpsic from Vermont, the Ammonoosuc off the slope of Mount Washington, the White River and the West River all roar into the Connecticut. The banks of the main river are soon filled to spilling over onto the flood plains of the valley floor. The routing of this water is complex. With the storage dams at the headwaters and the power dams below, it is like filling three vessels - a bathtub being filled from a farm spring line, a wash tub filled from a garden hose and a bucket from a fire hose - all at the same time. The overflow of the bucket has to be taken care of while watching the bathtub slowly rise.

The upper reservoirs at the start of the run-off have been emptied during the freeze-up of the winter. To fill them requires over 8,163,800,000 cu.ft., an inflow of over 1500 cfs for 50 days from snow melt and spring rains.

Two months after the snow melt, when we expect the upper reservoirs at the higher elevations to be filled and spilling, we find the main river below, well past the high flows of the spring. Thus we have effectively exercised flood control by storing this run-off.

The power dams below the storage reservoirs vary in their capacity to store waters in their ponds according to the intended use when built. Stored water is routed during average or normal flows from one power development to the next and so on down river for the most economic use by the system. When the flow of the river at a dam reaches the value of maximum ability of the turbines to utilize the volume of water through it, then the pond must rise until it is filled, and spilling takes place.

Following the river downstream, the first power dam in the New England Electric System is the S. C. Moore Station at Littleton, N.H. Here, in readiness for the spring run-off, the reservoir has been pulled by generation to some 40' below full pond, with over 114,000 acre feet or 57,000 cfs days to be put into storage This means that 11,400 cfs in five days will fill the reservoir. During this period of filling, the hydro turbines are wide open and passing down river 9,000 to 15,000 cfs as the head increases with the filling.

Here again we have exercised flood control to benefit ourselves by putting water into storage for future use, and also to benefit the installations

down river by impounding appreciable quantities of flood water.

This is duplicated at all of our stations on the Connecticut River. Some are filled at the tail end of the run-off. At the older and lower head dams, the removal of flashboards in the early stages of the run-off increases the capacity of the spillways. The replacement of such boards must, of necessity, come after a decrease in the flow permits work on the crests.

The spilling of flood waters through our dams is accomplished several ways. At the modern installations such as Moore Dam in Littleton and Wilder Dam near White River Junction, spilled water is handled through tainter gates and stanchion type flashboards. The tainter gate, an electrically operated gate on a depressed crest of the spillway, can be raised quickly and to selected openings. They are designed to pass river flows in excess of those recorded in history. The stanchion flashboards used in this combination are of a manual release type for the 100 year flood of future date. They are expendable for the infrequency of anticipated use.

At our Comerford Station built in 1930, the spillway carries low pressure, hydraulically operated lift gates in combination with pin type flashboards and stanchion flashboards. The low pressure gates handle the usual flood stage while the stanchion flashboards are used for the higher flows.

Our McIndoes Station, built in 1931 has a combination of tainter gates, pin type flashboards and stanchion flashboards.

Bellows Falls, built in 1928 uses the roller type of cylinder gate and the stanchion flashboards.

Vernon Station, built in 1909, uses the hydraulically operated lift gate and a long crest carrying pin type flashboards.

This hydro-electric development extending over 148.5 miles of the Connecticut River between the States of Vermont and New Hampshire has been built over a period of fifty years. The first dam for electrical generation was built and placed into operation in 1909. The most recent was in Littleton, N.H. During this fifty year period we have seen changes take place in methods and use of machinery. The pipe pin type of flashboard replaced or have been augmented by the stanchion flashboard. The tainter gate has replaced the roller gate and the hydraulic lift gate.

Over this period we have experienced record breaking floods to cause us to increase with each new installation the margin to spill flood water above the normal flows of the river.

This problem of handling flood waters is complex and requires quick decisions, for time and a rising river stage waits for no man.

What can we say as a conclusion to what has been learned in the past fifty years in handling the flood stages of our Connecticut River during the Spring run-

off of the snow melt?

We have improved our ability to pass flood waters using more efficiently operated gates and a better control of the spill. Less manpower is required to do the job.

We have developed more storage and with more water and higher heads available we avail ourselves of the KW peak loading of the larger stations.

We still lack the knowledge to evaluate each spring run-off with what we find in our snow cover. For many years now we have run snow surveys and have many records. We know what is on the ground, but we do not know what is up in the air.

So, at best, we are only a few hours or a day ahead of the river flows when the snow is ripe for the run-off and the weather makes up for spring.

Perhaps some day the weather modification people can exact the run-off by precipitating a quantitative amount acceptable to the valley under adjustable temperatures so that we are not so wasteful with our natural resources.