though it is only a small part of the whole problem. We feel that so far the surface has barely been scratched with respect to exhausting the potentialities of solving precipitation problems. The science of cloud physics seems to be developed to the point where it would be profitable to start developing the solution to rain fall rate problems. The solutions to these problems would put the theory of cloud seeding on a quantitative engineering basis; the cloud seeder would be provided with charts on which he can intelligently base his operations plans, and predict his chance for success. If the theory of cloud seeding could be put on a quantitative basis, then it would be possible to decide in which areas cloud seeding could contribute enough to be economically valuable, and in which areas it would not be justifiable. It would be possible to decide whether some cloud seeding should be done from a few ground generators to blanket an area, or whether the concentration of nuclei is highly critical and the utmost control, using radar and radar aircraft, might be necessary to achieve the full economical benefits from seeding. Any developments in the engineering of cloud seeding for precipitation increases will doubtlessly also be of value in understanding hail and lightning prevention.

Reference: MacCready, P. B.; Smith, T. B.; Todd, C. J.; Beesmer, K. M., "Physical Evaluation of Cloud Seeding Effects", report to President's Advisory Committee on Weather Control by Meteorology Research, Inc., Pasadena, Dec. 21, 1956

SNOW REMOVAL PROBLEMS IN THE PROVINCE OF BRITISH COLUMBIA

By

F. E. Dembiske[1]/

The problems of removing snow from the roads and highways in British Columbia are great in extent and variety.

The provinces' highways maintenance work is relegated to the various maintenance districts set up throughout the province. There are 48 electoral districts in the province and each district has its own Department of Highways administration, maintenance and repair depot set up under the direction of a District Engineer or a District Superintendent. For better administration, several districts are now combined into a region headed by a Regional Engineer, but though these districts are combined for administration purposes, each district maintains its own establishment of maintenance crews and is responsible for all maintenance, including snow removal, of all roads in the district, whether these roads are main provincial highways, arterial highways, secondary highways, main feeder roads, side roads, farm roads and trails.

A District Engineer or Maintenance Engineer begins his preparation for snow removal about the middle of July. All roads in his district are listed on a priority-service basis, determined by either traffic count; public service - such as school bus service, mail routes, milk runs, daily commuters runs, etc. Main highways and arterial highways are, of course, given highest priority for snow removal service, but the engineer must not and cannot neglect these service routes for therein lies the source of the most of his public relations problems locally. It is surprising sometimes how little snow it takes to create a fuss with certain pressure groups such as Boards of Trade, Women's Institutes, Farmer's Institutes, P.T.A. Groups, Community Association Groups, etc.

After carefully studying the anticipated requirements of snow removal service in his district, the Engineer then considers his equipment requirements to handle his snow removal program. Invariably he comes to the conclusion that he is short from four to eight snow plowing units, but, being an optimistic type, he requisitions same from Headquarters through the Equipment Engineer. Now, snow removal costs for the districts are handled through an open account on General Revenues and are disbursed to the various districts at the end of each month when total costs have been submitted to the Departmental Comptroller. The Engineer is under strict orders to practice rigid economy in snow removal work without curtailing any necessary service. But the purchasing of equipment is handled through a vote and invariably the vote is far too small to handle all winter equipmer

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requirements submitted by the District Engineer and the districts usually end up with a new snow blade for a truck or an extra power sander instead of the heavy equipment the Engineer asked for originally.

The most common types of snowplowing equipment in use on British Columbia's highways today are truck plows, motor grader patrols mounted with either straight blades or V blade plows in front and a wing blade on the right-hand side of the machine, crawler tractors equipped with light snow blades and ice or snow tracks, two or three types of rotary snow plow units, the better known of which is the Sicard Rotary fan and the Richardson Rotary shovel types.

Each district has a large supply of five-ton dump trucks and some of these are mounted with snow blades and frames. These trucks provide the fastest plowing service and usually operate in two's and three's on main and arterial highways until snow is piled up on the sides of the road to such an extent that further truck plowing is inefficient.

The engineer then reverts to the use of his graders with wings to move back this snow. In heavy snowfall areas rotary equipment works in conjunction with trucks and graders and as the truck blades and grader blades move snow from one side of the road to another, leaving the snow in a windrow, the rotary plow picks up the windrow and blows it off the road completely. Thus avoiding a build-up of snow on the sides of the road.

One of the most difficult problems encountered by the Engineer in snow removal work is handling the different kinds of snow that will fall during a winter. You are aware that one snowfall will be fine, wind-driven, powdery snow and the next day it might be a very heavy, wet snow. Then again a snowfall might start with a rain, gradually progressing to sleet, then heavy snow, then light powdery snow. With this light snow, he knows his truck equipment will handle most snow problems but with heavy snows he is forced sometimes to use heavy equipment. Of course, this usually happens when his heavy equipment is on side roads and farm roads and often a few days travel away from the highways on which he needs to use them at the time.

An example of this kind of problem led up to one of the worst traffic tie-ups ever encountered in the provinces winter maintenance work. This example occurred on the Trans Canada Highway through the Fraser Canyon on November 11th of last year. On November 10th it had been raining all day in the Canyon, which is 100 miles long. During that night the temperature began to fall, the rain turned to a very heavy snow and by 8:00 a.m. on the 11th there was 14 inches of snow on the road through most of the Canyon and the temperature was around the zero mark.

The District Engineer for that area was aware that a high volume of traffic was expected through the Canyon because of the long holiday weekend. Many Interior motorists were heading for the Coast for the long weekend and many hunters headed into the Interior from the Coast cities for a spot of weekend hunting. All left their initial points in summery weather. All hit the Canyon on the 11th. All were equipped only for summer travelling.

Snowplows were rushed out as soon as the snow on the road reached from four to six inches in depth. But as soon as the snow was removed from the road, the exposed wet surface froze and in the matter of a few hours the whole of the Canyon route was a sheet of ice. Now, since nearly all the vehicles on the road that day were not prepared for winter, a horrible snarl of traffic occurred on all grades. So bad were the tie-ups that it was impossible for a long while to get through to the worst spots with sanding equipment. It took three days to finally move the last of the vehicles through. In the meantime, the Canyon was closed to further incoming traffic from each end. The only thing that saved the situation was the return of warm weather and the snow had stopped.

Reference has already been made to sanding. Now this term is used rather loosely. Sanding to the Maintenance or District Engineer means the controlling of icing conditions on road and highways and has become a major problem in connection with snow removal work.

When a road is plowed, especially the paved roads, the snow is removed as close as possible from the pavement but it is impossible to remove all the snow without brooming. Brooming is economically out of the question. So that on all plowed roads a certain amount of snow remains which traffic quickly packs into ice. This means that after every plow job invariably it is necessary to follow up with a sanding job. But this doesn't stop at just one application of sand or other abrasive material. If the weather is extremely cold the ice is too hard for sand to penetrate and the sand is usually blown off by truck and car tires in a short time. If the weather milds during the day enough to melt a little, the sand particles usually sink into the ice, are covered up with water and by evening the road is again a sheet of ice. This condition can be repeated many times and is, of course, a real headache to the Engineer.

During cold weather the Engineer must add retractors to his sanding material - such as calcium chloride or coarse common salt to help embed the sand particles so that an abrasive surface can be provided for vehicle tires - especially on graders.

The stockpiling of suitable sanding material in the most convenient locations along the highways is another major problem with the Engineer. Sand supplies close at hand to highways are rapidly becoming depleted at an alarming rate and the material in some instances now has to be hauled a considerable mileage to stockpile access. This, of course, adds to the cost. If the material out of the supply pile is too coarse it requires screening or crushing and this also adds further to the cost. Now, since only this material is on the road and winter is at an end, the material becomes a dead loss as far as further useability is concerned. It generally has to be swept or broomed off the highway because of the dust hazard and cannot be reclaimed for further use.

With reference to costs of these snow removal functions, last year it cost the Department of Highways over $3,000,000.00 to remove snow and control icing on the provinces 14,494 miles of highways. Considering the difficulty in securing larger appropriations for maintenance work generally, this cost is a very serious matter and yet public demand today is such that there is no way to cut these costs and still provide the demanded service.

A serious problem which has arisen in recent years is the skilled labour supply problem. With the great demands made upon the Highways Department for increase in service, the Engineer has been forced to commit the equipment at his disposal to a double shift basis or round-the-clock basis in some areas in snow removal and sanding. It used to be that, when operating only three or four pieces of heavy plowing equipment in a district, there was no trouble in organizing a second or third shift on short notice; but today, this is not the case. Most districts operate a large number of truck and heavy equipment units. The Engineer finds it difficult enough to keep a supply of skilled operators on strength for routine summer maintenance. When winter rolls around he must determine where he can locate sufficient numbers of skilled operators on very short notice to establish more than his regular shifts.

Some winter snowfalls are unpredictable. It is economically unwise to begin the winter season with a double or round-the-clock shift system because there have been winters when a regular crew could handle all the work to be done and a certain amount of overtime for the regular crews could be countenanced. However, if the Engineer's luck runs out, then he is plagued with the skilled labour shortage.

Skilled operators are reticent to hang around unless they are on a steady payroll. They are not interested in part time winter employment unless they have that cheque coming in every month. The day is fast approaching when the Engineer will be forced to set up a double shift system from winter's beginning in order to hold a crew just for the sake of having them on hand when the need arises.

Another serious problem facing the Engineer at all times is one of protecting the public on the road during winter. The Engineer has to consider carefully disposition of the snow when it is moved off the road. Side entrances to hospitals, schools, etc. must be individually handled. Snow must not be dumped on private property nor can it be piled high in someone's private entrance, especially if that person happens to be a personal friend of the MLA Member for that district. Snow windrows cannot be left in the middle of the road for any length of time. The public must be made well aware of snowplowing equipment on the road at all times. Warning signs and flasher lights on equipment must be functional at all times. Signs especially are a problem because with equipment moving distances at a time, these signs must be brought forward with them.

In some sections of the province snow slides are problems that give an Engineer nightmares. There are several types of slides, none of which are easy to handle, but the early winter slides of heavy wet snow and the spring break-up slides are the worst. The early slide brings with it trees, mud and rocks. Rotary type equipment is generally useless in clearing this type of snow and the Engineer is forced to bring out crawler equipment which will chew up pavements in the course of removing the slide.

Midwinter slides are usually pure snow free of all debris. By mid-winter the side hills are frozen and except for relatively few trees, nothing but snow will move. This type of slide is easily handled with rotary equipment and there is no pavement repair as an aftermath.

Winter communication service between districts and headquarters has also become a problem now. With a great volume of traffic moving from one part of the province to another during the winter months, the public demands to be kept informed with up-to-the-minute information on road conditions

in all parts of the province. Since most districts are scattered, communication facilities are very limited, consequently the Engineer is hard pressed to provide road condition information accurately - especially about some road in his district that he himself rarely sees in winter. However, most districts have radio or telephone communication with all foremen and major snowplowing units on the road and the district office can at least supply a general report - if not a detailed one.

There are, of course, many other problems confronting the District Engineer in his snow removal work. Problems dealing with pressure groups; with isolated settlers; with mining concerns and the logging industry; with municipality bodies and community associations. But perhaps one more problem should be mentioned before closing and that is one dealing with personal snowplowing requests. To cite an example - one of our district men received a request to plow five miles of road beyond the district's customary terminal point on that road. A plow was already heading to the terminal point but the operator was almost dead beat, having bucked several slides on route which kept him busy for 18 hours. On reaching the terminal point, he made for his bed after servicing his machine, thinking only of the four hours sleep he could get before he had to be on the road for the return journey.

The party who had requested the additional plowing arrived shortly after the operator had retired, barged into his bedroom and demanded that he arise and get to it. The operator refused, explaining that his instructions were to plow only to this particular point and to start his return trip in approximately five hours. Whereupon the party jumped onto his bed and began undressing and stating that she would start screaming if he wouldn't agree to plowing the five miles to her home.

Problems such as these are not too frequent but they do occur.

Incidentally the extra five miles were plowed out.

GRAPHICAL FORECAST ERRORS

By

Joseph I. Burns and Fred A. Strauss[1/]

At the Portland meeting of the Western Snow Conference in April 1955, a paper presented to the group by Francis Blanchard entitled "Operational Economy Through Applied Hydrology" very adequately set forth the need for accurate water supply forecasting and showed how statistical levels of forecast variance were required if the water manager was to get the "most" out of his operational program. A mathematically devised forecast scheme was used in that paper to illustrate the method of solution to certain problems of a water system operator. The California Division of Water Resources uses a graphical forecast scheme, which necessitates special steps in order to determine statistical levels of forecast departure which are necessary for the making of operational decisions. Many forecasters have avoided use of the graphical method only because of inability to accurately define statistical levels of departure of forecast. However, there is good authority that a graphical forecast method may well be as valuable as a mathematically derived scheme. For instance, Mordecai Ezekiel had this to say on the relative value of a mathematical or graphical solution to a problem:

> "When there is some logical basis for the selection of a particular equation, the equation and the corresponding curve may provide a definite logical measurement of the nature of the relationship. When no such logical basis can be developed, a curve fitted by a definite equation yields only an empirical statement of the relationship and may fail to show the true relation. In such cases a curve fitted freehand by graphic methods, and conforming to logical limitations on its shape, may be even more valuable as a description of the facts of the relationship than a definite equation and corresponding curve selected empirically."

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