Snow Removal

SNOW REMOVAL WORKLOADS IN LARGE METROPOLITAN AREAS

by Walter F. Zeltmann (1)
International Weather Corporation
719 Bay Ridge Avenue
Brooklyn, NY 11220

ABSTRACT

A method of using water equivalents to estimate snow loads, by weight, over the streets of large metropolitan areas is described. Two examples of large snow storms in New York City are described. Several observations of water equivalent from a number of sites within the metropolitan area give a more realistic picture of the situation than just one site, allowing for timely and foresighted planning of the redeployment of snow clearance resources to those areas which receive the heaviest snow.

1. INTRODUCTION

The efficient removal of snow from metropolitan area streets is of vital importance for both economic and public safety reasons. Emergency vehicles are in constant use in cities and they must be able to proceed to the scene of emergencies without delay. Elderly and handicapped people who cannot leave their homes may suffer real, and sometimes life threatening, hardships. Transportation tie-ups result in major losses for businesses who can neither ship nor receive goods. Especially-hard hit are retail establishments which depend on customers coming to their shops. Workers who cannot get to their jobs lose pay. Failure to clear the streets in a timely manner can have adverse political effects for the responsible authorities.

2. THE USE OF WATER EQUIVALENTS

In the past, snow removal work loads have been estimated primarily from forecasts and observations of snow depth. These estimates have not been too successful because the depth of snow gives no indication of the snow weight to be removed. Snow depth may have a ratio to water equivalent of anywhere from 3 to 1 for wet snow mixed with rain to 30 to 1 for very dry powdery snow. Water equivalent is the key factor in planning the deployment of snow removal resources since the water equivalent of the snow can be used to estimate the weight of the snow that needs to be moved, and this in turn determines the work load.

A simple formula can be used to find the weight of snow on any given area:

$$W \times C = S_t$$

where:

W = Water equivalent of the snowfall in inches.

S_t = Weight of snow in tons.

C = .002605 X A, a constant which will differ from area to area.

A = Area to be cleared of snow in ft^2.

.002605 = Weight in tons, of one inch of water covering a flat surface one ft^2

3. PROCEDURE

A weather service should provide the given municipality with Quantitative Precipitation Forecasts (QPF) as soon as the first snow forecast is delivered, and these should be updated frequently as the storm unfolds. They can be used for planning purposes in place of W. These W's should be obtained as soon as possible from all nearby reliable observing stations during the storm and after the storm ends.

A cross check is desirable using additional stations. If the urban area is extensive, a large number of stations is needed, since snowfall can vary considerably over short distances. For maximum efficiency, redeployment of resources from one part of the city to another may be necessary.

4. EXAMPLES

Two examples from New York City will illustrate the method. The first is the storm of December 26-27, 1947 which had the highest snow depth reading in the city since record-keeping began. The second is the more recent storm of February 11-12, 1983, which has been referred to as the "Blizzard of eighty-three". Table 1 shows the snow depths and water equivalents (W) reported by stations within the New York metropolitan area for each storm. Two things are immediately evident. No common ratio of snow depth of W exists in either of these storms. Also, both the snow depth and W varied considerably over short distances. Some of the deviation can probably be explained by inaccuracies in the observations (snow blowing out of recording gages, etc.). No attempt was made to assess the accuracy of the individual reports in these examples; but even allowing for such deviations, there was considerable variation in W's from place to place across the metropolitan area.

Table 2 shows the street mileage in New York City. No average width of city streets is available, but this study assumes an average width of 30 ft. from curb to curb for local streets. Main avenues

STATION	DECEMBER 26-27, 1947 SNOW DEPTH INCHES	DECEMBER 26-27, 1947 W INCHES	FEBRUARY 11-12, 1983 SNOW DEPTH INCHES	FEBRUARY 11-12, 1983 W INCHES
Eastchester, NY	27.0	1.85		
Fort Schuyler, NY	20.5-22.0	2.01		
Larchmont, NY		2.30		
Mineola, NY	24.0	2.40	19.5	1.61
Ave. V, B'klyn, NY		0.93	20.3	1.96
Battery, NY, NY	25.8	2.67		
Central Park, NY, NY		2.40	17.6	1.49
J. F. Kennedy, Queens, NY			21.7	1.71
Laguardia, Queens, NY	22.8	2.66	22.0	1.66
Laurel Hill, Queens, NY			18.0	1.73
NYU, Bronx, NY		1.67		
Westerleigh, S. I., NY		1.41	18.0	1.27
Scarsdale, NY	28.2	2.92	19.0-22.0	1.52
Elizabeth, NJ	26.0	2.91		
Elizabethport, NJ		0.89		
Jersey City, NJ	26.2	1.95		
New Brunswick, NJ	19.5	2.00	17.9	1.31
Rahway, NJ	26.0	1.30	21.0	.79
Ridgefield, NJ	27.0	2.77		

Table 1. Snow depths and water equivalents for selected New York City recording stations.

BOROUGH	STREET MILEAGE (2)	C
BRONX	803.2	331426
BROOKLYN	1599.0	659799
MANHATTAN	504.3	208090
QUEENS	2443.4	1008225
STATEN ISLAND	1025.0	422948
TONS PER MILE OF STREET		413

Table 2. Street mileage by boroughs (2).

	W 1947 STORM	W 1983 STORM
BRONX		
Eastchester	1.85	
Ft. Schuyler	2.01	
Larchmont	2.30	
Central Park	2.40	1.49
Laguardia Arpt.	2.66	1.66
NYU	1.67	
Scarsdale	2.92	1.52
Ridgefield, NJ	2.77	
Average W_b	2.32	1.56
S_t	769,737	517,025
BROOKLYN		
Ave. V	0.93	1.96
Battery	2.67	
J. F. Kennedy Arpt.		1.71
Laurel Hill		1.73
Westerleigh	1.41	1.27
Average W_b	1.67	1.67
S_t	1,101,864	1,101,864
MANHATTAN		
Battery	2.67	
Central Park	2.40	1.49
Laurel Hill		1.73
NYU	1.67	
Jersey City	1.95	
Ridgefield	2.77	
Average W_b	2.29	1.61
S_t	476,526	335,025
QUEENS		
Ft. Scuyler	2.01	
Mineola	2.40	1.61
Central Park	2.40	1.49
J. F. Kennedy Arpt.		1.71
Laurel Hill		1.73
Laguardia Arpt.	2.66	1.66
Average W_b	2.37	1.64
S_t	2,389,493	1,653,489
STATEN ISLAND		
Ave. V	0.93	1.96
Westerleigh	1.41	1.27
Elizabeth	2.91	
Elizabethport	.89	
New Brunswick	2.00	1.31
Rahway	1.30	.79
Average W_b	1.57	1.33
S_t	664,028	562,521

Table 3. Station water equivalent W values and the computed average borough value W_b for the December 26-27, 1947 and the February 11-12, 1983 show storms. It is the weight of the snow in tons.

BOROUGH	1947 STORM	1983 STORM
BRONX	958	644
BROOKLYN	690	690
MANHATTAN	946	665
QUEENS	979	677
STATEN ISLAND	648	549

Table 4. Tons of snow per mile of street.

and thoroughfares are much wider. Compounding the problem, much of the snow shoveled from sidewalks and driveways ends up on the streets. If anything, the 30 ft. estimated width should yield a conservative (low) figure for the snow tonnage. Using a standard 30 ft. width when computing snow tonnage for each storm provides an estimate of the distribution of snow tonnage from one place to another, and provides a comparison of distributions from storm to storm. C was computed for each of the boroughs in the city using this 30 ft. width estimate and the street milagae. C was also computed for tons of snow per mile of street.

Table 3 shows the computed average W for each of the five boroughs at the end of these storms using the indicated stations which are either in the borough or adjacent to it. Then, using W and C from Table 2, the snow tonnage on city streets for each borough was computed.

Certain stations were used more than once for adjacent boroughs. Further, all stations were not available for both storms. The more stations that are available and the more accurate the observations, the better the estimate will be.

Table 4 is useful for operational estimates. It breaks down the tonnage per mile of street by borough. In the 1947 storm, Brooklyn and Staten Island had lower snow loads per mile than the other three boroughs. Planning could have begun to transfer snow clearance resources from these boroughs as soon as their own streets were cleared assuming that equal resources per mile of street were initially available in each borough. On the other hand, in 1983, Brooklyn had the heavier snow load per mile of street, closely followed by three other boroughs. The only borough which might have been cleared early was Staten Island, at which point its resources could have been made available to the other boroughs. Although the 1947 storm is rightly renowned for its record breadking snowfall over the city as a whole, in Brooklyn it was matched in weight by the storm of 1983.

5. MIXED PRECIPITATION

So far, we have considered cases where all the precipitation is snow. The system will work as well with any form of frozen precipitation, but where there are mixtures of both frozen and liquid precipitation, special problems arise. If the precipitation starts as rain or drizzle, it is important to obtain the W's as close as possible to the time of change-over to snow, so that these may be subtracted from the final W's for the storm.

On the other hand if the storm starts as snow and changes over to rain, the problem is much more complex. The snow will undergo some partial melting but, at the same time, it will be soaking up rain like a sponge and its W will be increased by some unknown amount. Factors involved are the ratio of frozen W to liquid W, temperatures of the air, ground and snow, and drainage. All but drainage will vary from place to place and from time to time.

In either case, a final W can be determined from the remaining snow and ice cover at the end of the storm.

6. CONCLUSION

The use of water equivalents provides a more accurate estimate of snow removal work loads because this measurement can be converted directly into an estimate of the amount of tons of snow to be removed. This is a far more useful figure than snow depth because the snow depth only measures the volume of snow and does not reflect the density of snow which can vary over short distances. This, in turn, inevitably produces inaccuracies that will inhibit the responsible authorities from redistributing their snow removal resources with maximum efficiency. Maximum efficiency can only be achieved with the most accurate estimates of the amount of snow to be removed from each location.

NOTES AND REFERENCES

1. Walter F. Zeltmann is the president of International Weather Corporation in Brooklyn, NY. He is currently working primarily in the fields of Forensic Meteorology and Applied Climatology. He is a graduate of the USAAF Weather Observers School at Key Field, MS in 1942; of the USAAF Weather Forecasting School at Chanute Field, IL in 1943; and of the USAF Special High Altitude Forecasting Training course at Chanute AFB, IL in 1950. He has been with International Weather Corporation since 1958.

2. Green Book 1985-86 Official Directory of the City of New York, Dept. of General Services of New York City.