Winter Weather Operations: Adapting to Changing Times and Roles

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ABSTRACT

Snow and ice control is a primary function of local Public Works and State/Provincial Departments of Transportation agencies in most of the US and Canada. Regardless of size of agency or amount and frequency of snow events, it is essential to have a sound operations plan and comprehensive manual that: explains the mission, goals and objectives; states the policies, protocols, priorities and level of service; details specific duties, roles and responsibilities; defines the operational strategies and tactics; improves training; outlines the communication and control structures; enhances public information and relations and reduces liability exposure.

Though many managers realize the value of such a manual, developing and maintaining one is difficult because of time and effort involved and a general dearth of good examples. Public Works agencies have incurred substantial reductions in staff and budgets in recent years, a trend that will likely continue for some time. Therefore, management will have to find ways to provide critical snow and ice control with limited resources and ensure transfer of knowledge to newer staff. This paper will discuss the general components of a plan and recommended subjects to be included in a manual.

1. OVERVIEW

Keeping streets, roads and highways clear of snow and ice is a fundamental responsibility of local Public Works (PW) departments and State and Provincial Departments of Transportation (DOT). While Canada and much of the United States (U.S.) routinely experience winter storms, the 2010- 2011 season was significantly harsh. Even the southern states were hit with major snow and ice events and the mid-Atlantic and northeast regions suffered massive blizzards that overwhelmed capabilities of the affected. It is increasingly obvious that these agencies must be better prepared to deal with snow and ice.

For decades winter operations were built upon a simple premise; keep plowing and apply a lot of salt and sand. Truck operators would routinely deviate from set routes and application rates and act based on their observations and preferences. Levels of Service (LOS) were usually ill-defined. The accepted or expected norm was “bare pavement” on all streets and roads. Weather forecasting was adequate but imprecise, equipment was rudimentary, training was minimal (at best) and environmental concerns non-existent.

For most agencies, snow removal was considered secondary to other routine operations except in those locales that historically had long, snowy winters. However, in most regions of the US the number of storms and total snow each season was quite variable. A series of mild winters would lead to complacency. Therefore, when budgets needed to be reduced a common target

was funding for snow removal. Because officials placed more emphasis on construction and maintenance of infrastructure, less attention was given to keeping snow equipment in good condition, material stockpiles replenished and personnel trained and available. Inevitably, a "bad" winter came and these agencies lacked the proper resources to adequately respond. Levels of service were then curtailed generating much criticism from the public. For example, Denver, Colorado decided one year not to plow residential streets after a very heavy snowfall. In Seattle, Washington the city was inadequately prepared when a snowstorm struck in 2009. Atlanta, Georgia had only four plow trucks for the entire city to deal with a snowstorm in the 2010-11season.

In the 1990s, winter operations became more science-based with the development of alternative chemicals, improvements in equipment, application of new technologies such as Geographic Information Systems (GIS) and Automatic Vehicle Location (AVL), the evolution of wireless two-way communication, and advancements in weather forecasting and pavement condition monitoring. Also, the public's expectations increased as the Internet provided better access to local governments; for example, residents in some jurisdictions can view snow plowing progress on-line and submit complaints or comments via e-mails, websites, texts, social media sites or even call from cell phones while driving. This immediacy of contact places additional demands on an agency.

The growing complexity of winter operations, the need to ensure continuity as staffs change over time, more emphasis on transparency of governance, and the concern over increased claims and litigation from accidents caused by snow storms underlines the need for clear and comprehensive plans. It is not necessary to have extensive, detailed strategies for every conceivable scenario; instead, there should be guidelines established for the general types of events that are likely occur. "All agencies responsible for snow and ice control should have written policies and guidelines that document the intent, capabilities, and procedures…Guidelines provide the managers and operators with a basis for conducting specific operations under certain conditions." [1]

Though winter storms can be categorized by precipitation type, severity and duration, a number of other variables such as temperature range, wind direction and speed, humidity, pavement moisture, existing snow/ice accumulations, projected traffic activity, topography, etc. are considered when determining the course of action. Additional factors such as availability of staff, materials and equipment also bear upon these decisions. A sound plan will account for the different items that must be included in developing the strategy for each storm.

2. VALUE OF A WRITTEN PLAN AND OPERATIONS MANUAL

A plan includes the mission, goals, objectives and the strategies, tactics and resources. For winter operations the mission should be to keep the public streets, roads and highways safely passable employing the most efficient and environmentally safe use of resources. A related goal would be to provide clear streets and roads within a reasonable time after end of typical snowfall. An objective connected with that would be to achieve bare pavement on all travel lanes of arterial streets and roads within specified hours after cessation of snowfall in normal conditions.

Any entity that encounters snow and ice should have its plan, even if very rudimentary, documented in a manual. There is no universal template as to size, scope or style. Such plans may range from a simple resolution assigning responsibility and authority for snow and ice control to a multi-volume manual that covers all facets in great detail. Based on informal surveys of attendees at the author's presentations on this subject, the anecdotal conclusion is that many local PW departments either do not have a manual or believe that their existing ones need improvement. Though they have written policies, procedures and practices, they are usually not compiled into a single-source document. Additionally, many agencies lack a formal, regular and frequent review process to ensure that the plan and related documents are kept current. "One of the most important things a political entity can do is to have a reasonable, written snow and ice control policy and adhere to [it]…The policy should also be a 'living' document that is reviewed and updated annually." [2]

This "living document" is a comprehensive manual that:

1. Explains the legal and statutory reasons, responsibility and authority ,
2. compiles all pertinent information into a single, accessible format,
3. eliminates redundant, obsolete or contradictory documents,
4. promotes maximum feasible efficiency and effectiveness with available resources,
5. provides consistency and continuity of operations,
6. states the policies, protocols and level of service,
7. communicates goals, service levels, and priorities to staff, officials and the public,
8. defines what materials are used and application processes,
9. specifies the number and types of vehicles and equipment used and capabilities,
10. identifies supplemental staffing from other departments or contractors,
11. details roles and responsibilities, particularly command and control,
12. describes formal relationships with other departments, agencies and jurisdictions,
13. improves training,
14. aids in justifying budget requests and expenditures,
15. reduces liability exposure by risk management.

It is highly recommended that the plan and manual also conform to requirements of the U.S. National Incident Management System (NIMS) for several reasons:

1. NIMS is a scalable, flexible system for all levels of government to use in all-hazards incidents and planned events. As most are handled at the local level, basing winter operations on NIMS helps an agency to prepare plans for other emergencies and events.
2. In all situations where the size, scope and severity of an incident exceeds a jurisdiction's financial capabilities, a firm requirement for reimbursement from the Federal Emergency Management Administration (FEMA) is verification that the agency was NIMS compliant. Some winter storms have been extensive enough to qualify for federal assistance.

3. THE PLANNING PROCESS

Planning involves reviewing what has occurred, how it was handled, what did or did not work well, and envisioning what may happen in the future and what would be the response. Good planning begins soon after the conclusion of the preceding season. It can be difficult to stay focused on snow removal during spring and summer, especially as other programs and functions take precedence during these seasons. Still, it is important to bear in mind that in only a few months preparations for the next winter begin. Steps to take in planning include:

1. establish time frames, schedules and due dates,
2. identify successful practices as well as determining where improvements needed,
3. evaluate available resources including personnel, vehicles, contractors, materials,
4. assign distinct tasks for follow-through; delegate responsibility,
5. assess value of each item recommended based on need, priority, and feasibility,
6. develop, revise or modify policies, protocols, procedures and practices,
7. devise new or change existing LOS to conform with those capabilities,
8. present draft changes for review to stakeholders for comment and approvals,
9. incorporate changes into the overall plan,
10. ensure that staff, elected officials and the public are kept informed.

Because of the complexity of winter operations, planning should be continuous. Program managers should be constantly assessing the strengths and weaknesses and conduct an After-Action Review (AAR) shortly after each episode.

Once the current season has officially ended the planning for the next begins. It is recommended that a cross-section of employee groups (supervisors, operators, mechanics, dispatchers, administrative) and representatives from other departments or divisions that support Public Works be involved. Other stakeholders such as police, fire, medical providers, public transit, school districts and adjacent jurisdictions may also be included as some point.

4. DEVELOPING A MANUAL

4.1. Objectives

Writing a manual may seem like a very time-consuming task and one that is often deferred because of other issues needing immediate attention. However, it should receive priority due to its value to the agency and focus on achieving the following:

- comprehensive --- includes all essential information,
- cohesive --- organized in a logical sequence,
- clear --- plain language that avoids excessively technical terms,
- concise --- succinct, keeps to the essentials,
- correct --- grammatically and factually accurate,
- current --- information included is up-to-date.

4.2. Format and Content

There is no standard format for winter operations manuals; a large agency might have a voluminous bound document whereas a smaller agency's manual may be only several stapled pages. Regardless of the presentation style or length, it is recommended that a manual contain the following general categories:

- Policies – statutes, ordinances and resolutions that obligate an agency,
- Protocols --- prescribes the type of activity for certain conditions,
- Procedures --- steps for specific tasks, functions or activities,
- Processes ---systems for communication, documentation, procurement, etc.,
- Positions and People --- outlines organizational structure and responsibilities.

It is not necessary to include every relevant document. For example, the ordinances authorizing snow removal can be summarized and cited instead of fully printed in the manual. Another option is to include important documents and other information as attachments; this allows for customizing different versions of the manual for particular groups. For instance, elected officials may only receive an "executive summary" and the program managers and key staff have the full compendium.

4.3. Scope of Responsibility and Authority

The agency must establish what it is legally mandated to do and cite the statutes, ordinances and resolutions that assign authority to execute snow removal. Certain powers may be granted such as for declaring a snow emergency and the enforcement of other related regulations governing on-street parking and use of snow tires and chains.

A municipality may have major highways within its boundaries that are the responsibility of the state or county to maintain or streets that are shared with bordering communities. Agreements between entities to transfer or share snow and ice control must be properly documented and approved. Color-coded maps are quite useful to delineate the jurisdictional responsibilities. Snow control on private streets is often handled by property owners; any exceptions need to be stated. It is also important to explicitly state what the agency is not responsible for. The following is a sample Policy Statement:

> The Public Works Department is responsible for snow and ice control on municipal streets within the city limits. Responsibility for streets and roads that are on the borders with adjacent jurisdictions are determined by mutual agreements.
>
> - The Interstate freeway and state routes within the city limits are maintained by the state Department of Transportation,
> - Airports roads are maintained by the Airport Authority,
> - The County maintains certain designated routes within the city limits,
> - The transit stops are the responsibility of the Metro System,
> - Roads, paths and lots in the parks are maintained by the Park District,
> - The City does not treat private streets, parking lots or driveways,
> - The City is not responsible for snow and ice control on sidewalks.

4.4. Level of Service

At the core of an agency's plan is what level of service it intends to provide. There are no standard definitions of LOS for winter maintenance. Some agencies use charts with different brackets or classifications while others use a simple text description. Several agencies, Missouri DOT for one, use photographs of actual road conditions to illustrate as standards to be achieved.

An agency's LOS should be structured on what could reasonably be accomplished for a routine snow event as determined by a number of factors. This should be based on historical winter weather patterns including average snowfall, usual number of storms, normal temperature ranges of each month of the season, typical percentage of sunny days, prevailing wind direction and speeds, etc. Also, local topographical features (mountains, hills, large lakes, major rivers) that have significant impact on conditions should be considered. Each region is unique.

> Levels of service may be defined in a number of ways. The most common is to define the level of effort and/or sequence, priority, and type of treatment for various locations for particular storm types. Another common technique is to define level of service in terms of results by evaluating the surface condition of a particular road…at specified times during and after the storms. [3]

Also, an agency must assess its resources including personnel (regular and supplemental), vehicles and special equipment, materials, storage locations and capacities, main operational facilities, communications systems, contractor support, and funds for re-supply and repair. It is more than an inventory; this should be an evaluation of the availability, capability and condition of each factor. Thus, each agency should devise its LOS on the characteristics of its locale and current capabilities. "The primary operational considerations relating to LOS are cycle time, available material treatments, weather conditions, site conditions and traffic." [4]

A key factor in determining cycle time is lane-miles (LM) per route. Dividing total lane-miles by available trucks (excluding reserve and non-functional) gives a "quick ratio" or current LM average. To illustrate; a city has 15 trucks and 1,000 lane-miles which equates to nearly 67 LM per truck. However, to find out how many trucks would be needed for a specific target or ideal, simply divide the total lane-miles by a desired LM per truck. Using the above example, a city has 1,000 lane-miles and wants a target of 50 LM per truck; this works out to needing 20 trucks. In this scenario the "quick ratio" indicates a shortfall of 5 trucks. Options are:

1. acquire more trucks by purchasing, borrowing from other departments, renting or employing contractors;
2. assign trucks from reserve status, if any, into the ready-line;
3. stay with this ratio and adjust LOS.

In the first option, the agency may not be able to afford to buy or rent trucks. Contracting can be expensive plus there are additional considerations of finding qualified contractors. Borrowing from others is limited as the vehicles may not be suitable or available.

In the second option, most agencies have only a small reserve fleet, if any. They are usually older vehicles that require higher maintenance or do not have full capabilities. Regardless, reassigning from reserve to ready–line depletes the number available as substitutes.

The third option, adjust LOS, is the least costly but also the least effective. Lane-miles per truck equates to cycle-time, the interval needed by each truck to complete one pass over its assigned route. Trucks that are in plow-mode are limited as to speed, especially in denser urban areas, to minimize "cast" or the distance and velocity of snow plowed to the side. The ideal speed for urban areas is 15-20 MPH. The same principle applies when spreading material; the higher the speed the wider the dispersal pattern and lesser density, particularly with dry granular material. Thus, increasing lane-miles per truck cannot be easily offset by increasing the speed of the trucks.

As a general rule, the longer the route cycle-time the greater the interval when the truck passes a certain point. This becomes a critical matter on streets and roads with high traffic volumes. The fundamental purpose of plowing and material application is to achieve and maintain surface friction. The longer the cycle time the more difficult it is to sustain surface friction. The result is slower traffic and increased accidents. Agencies must carefully evaluate the consequences of fleet size and composition in establishing reasonable and feasible LOS.

LOS can also be described in broader terms as in the following example:

- The best level of service is reached when the major thoroughfare streets are down to "bare pavement" clear of snow and ice from curb-to-curb. Reaching that objective takes time which is affected by the variables of meteorological conditions, traffic activity and type and amount of materials applied. The width of certain streets and number of turn lanes also are factors.
- The minimum level of service for thoroughfares is to clear the through lanes and left-turn lanes at intersections and median breaks down to a packed snow cover. Exclusive right-turn lanes and joint center turn lanes may be left unplowed during main operations.
- For residential and other low-volume streets and cul-de-sacs the acceptable level of service is to provide a navigable surface; the street may still have snow or packed ice on it but plowing and material application allow a vehicle to travel the street safely on at least one center lane.

4.5. Priority Classification of the Street and Roadway System

LOS is also directly tied to the priority ranking of streets, roads and highways. Typically this is based on the classification by traffic volumes. In urban areas the classifications are commonly termed major and minor arterials, collectors, residential and other lightly used streets. County and state agencies use similar ranking systems.

Other factors in determining priority rankings are the location of important community facilities such as hospitals, schools, transit stations and routes, fire and police stations, major industrial, commercial or transportation hubs and terminals and large convention and entertainment venues. Though most would likely be on or near arterials, their presence nonetheless should be noted as that may help determine size and configuration of routes. Major revisions should be discussed with affected stakeholders before adoption.

Aside from the businesses, police, fire and public transit should be consulted. In certain situations, political influences may override facts. For instance, an old neighborhood may have gotten “preferential treatment” in the past because of a prominent official. Thus changing the LOS could incite strong opposition. Program managers should present their recommendations in objective, neutral terms but anticipate that “subjectivity” may prevail.

As mentioned, LOS will vary according to the priority classification. Basic cost-benefit analysis will indicate that the greater good is achieved by using identical resources on a major arterial versus a residential street. A truck plowing and spreading material on one lane- mile of arterial with heavy traffic is more efficacious than the same truck on one lane-mile of a residential street. Because of the higher traffic volume and speeds on an arterial, a LOS of bare pavement at all times is justifiable. On the other hand, the residential street may need plowing only after the snow has accumulated over 3 inches. Therefore, the arterial requires a much shorter cycle-time than the residential street.

> There are several ways by which highway agencies characterize the LOS they provide…level of effort category includes assigning more people and equipment to higher priority routes, providing more or less effort during certain time frames [and] varying the number of people and equipment providing treatment on relationship to the predicted severity of the event…The priority of treatment includes giving first and/or more frequent treatment to higher traffic routes, high accident /problem locations, …Some highway agencies [provide] treatment on a priority basis whereby the next lower category of highway is not treated until higher category roads are in “satisfactory “ condition. [5]

It is important that the LOS and the priority classifications of streets and roads be based on objective criteria and clearly stated. A general explanation, such as the following, is advisable:

> Snow and ice control measures are directed to achieving and maintaining relatively safe traffic movement on public streets within a reasonable time period by following the above priority ranking of streets. Therefore, efforts are first concentrated on the main thoroughfares and collectors that carry most of the traffic before residential and other low-volume streets and cul-de-sacs are handled.
>
> Special attention will be given whenever practicable to grades, curves, bridges or other locations known to be more difficult or hazardous to negotiate by vehicle. Streets that provide access for certain institutional, academic, cultural/social or commercial areas may also receive additional treatment as time, traffic and conditions warrant.

4.6. Resource Allocation and Management

As noted, there is a strong correlation between roadway system priority classifications and LOS. These two elements of the overall plan also have a direct bearing on resource allocation, the distribution of various assets for maximum efficiency and utility. For example, an arterial road with the highest priority LOS for bare pavement will require anti-icing measures prior to the storm, short cycle-times of plowing and re-application of materials (if needed) during the storm, and “push-back” of piled snow along curbs, shoulders and bridges.

Basic resources needed include the best trucks, most proficient operators and ample materials. In this scenario, if there is a shortage of operable trucks, materials, repair parts or even overtime for operators, the priority would be given to the routes with the highest LOS. This is a logical, rational approach; but program managers need to carefully balance the allocation of resources so that all areas receive a fair share even at reduced level, except in extreme situations.

4.7. Material Selection and Application

The most commonly used material for snow and ice control is rock salt. It is readily available, inexpensive and easily stored, handled and dispersed. Salt can be used in its natural solid form or diluted in water to form brine. However, it loses usefulness at lower temperatures. Calcium chloride, is effective at a very low temperature range and is often mixed with salt or applied directly to pavement. Both salt and calcium chloride are very corrosive and their use has raised environmental concerns.

Newer products include other magnesium chloride, potassium acetate and organics such as beet juice and corn by-products. Each has benefits and limitations. For example, one product works well at low temperatures but makes pavements slippery near the freezing mark. Cost per lane –mile is another consideration as these products tend to be more expensive than salt or calcium chloride.

Use of abrasives, mostly sand, is a common practice but agencies and the public need to understand that they do not melt snow or ice. They should only be used in limited locations such as hills, curves and intersections where traction enhancement is necessary. As snow and ice later melt away sand creates problems like air-borne particulates, sedimentation build-up in storm sewer systems and drainage channels, and loss of traction on bare pavement if deposits are excessive.

There is extensive information on the various materials and much research is still underway. It is beyond the scope of this paper to thoroughly describe the various products and their characteristics. Each agency needs to determine what will constitute its material “arsenal” and annually review. However, it should be noted that the materials selected will have an impact on accomplishing LOS. As part of the overall manual, detailed material storage, handling and usage plans are needed.

4.8. Vehicles and Equipment

No plan will work without sufficient vehicles and equipment. As discussed earlier, the ratio of operable trucks to lane-miles is a prime determinant of LOS. A snow fleet may consist of the following:

1. full-duty trucks (single or multiple axle) equipped with front and wing plows and spreader bodies. One-ton trucks can also be so equipped. Special function trucks, such as solid-waste trucks, can be equipped with just a front plow. Supplemental vehicles or equipment for special situations include road graders, front-end loaders with “V” plow attachments, backhoes, and skid-steers and “snow cats” for clearing bridge decks, parking stalls and sidewalks.

2. material –handling equipment used for storing and loading bulk materials; this includes portable or fixed belt conveyors, front-end loaders and track loaders.

Each agency's fleet is unique and based on various factors, primarily what is needed for year-round routine operations. Other factors include the organization's size, climate, availability of shared equipment, procurement policies and budgets. Just as important as the number and type of vehicles is their condition. A full-service truck with an inoperable spreader is no more useful than a limited –duty truck. A winter operations plan can be advantageous in justifying funding for acquisition, maintenance and upgrading to achieve maximum reliability and capability of a snow fleet.

4.9. Personnel

Staffing is another critical component of the winter operations plan. In recent years many positions have been eliminated in state and local governments, particularly in the maintenance workforces. These reductions are likely to be permanent and more positions may be eliminated as the "Baby Boomer" generation retires. Younger workers in maintenance operations are expected to leave for better jobs in the private sector as the economy improves. Overall, it is becoming more difficult to attract and retain good employees.

With these changes comes a substantial loss of experience and institutional knowledge thus emphasizing the need for a comprehensive winter operations plan and manual. There is increased awareness by snow program managers that training needs to be a recurring event and include veteran as well as new operators. Auxiliary help from other departments or agencies, seasonal workers and contractors need this training as well. Winter operations are, obviously, a deviation from normal work schedules and assignments. The unpredictability and fluidity of each situation may complicate the application of routine rules and policies, especially when it comes to pay. Covering these issues in advance can preclude unnecessary administrative problems later. At a minimum, the manual should:

- detail the number and type of positions and respective duties,
- list each individual involved and assignment by billet, shift, location, vehicle,
- describe the procedure for informing employees of pending activity,
- state employee responsibility to report for work in adverse conditions and also the maximum allowed hours of continuous duty,
- summarize applicable regulations regarding operator's licenses and permits,
- describe how and when employees can be excused from duty ,
- specify the proper clothing and equipment ,
- reference the organization's policies and rules regarding overtime, shift differential, holiday pay, compensatory and "flex" time, and "stand-by", "call-in" pay and out-of-class pay (if allowed),
- explain applicable rules regarding meal and rest breaks,
- describe transportation and lodging for employees during severe situations,
- include any other topic that program managers regard as pertinent.

Note that the information must conform with the official rules, regulations and policies of the organization, including agreements with a recognized union, and state and federal laws unless specifically exempted. Any informal practices that do not violate these should be acknowledged but with a stipulation that they could be suspended or eliminated at any time.

4.10. Route Design and Optimization

Configuration of routes is directly related to LOS. In simplest terms, the less lane–miles for a plow truck, the less time to complete one circuit or cycle along the assigned route. The less time for each circuit then the more efficient the snow removal operation. Many variables affect how a route is designed:

- number of trucks and other equipment, both agency and contract-operated,
- total lane miles that the agency is responsible for,
- priority classifications of the system,
- topography,
- traffic volumes by TOD (Time of Day) or DOW (Day of Week),
- important employment, education, medical, transportation and commercial nodes,
- distance from agency material stockpiles and fuel sources.

Other factors may be specific to a certain locale and politics. Nonetheless, routes should be based upon providing service according to well-defined, measurable and rational criteria.

Route Optimization refers to enhancing the efficiency of a plow truck by plotting a travel pattern that eliminates as much as reasonably possible “dead-heading” and doubling-over. For example, it is fairly easy to plan a route for a truck that works only on an expressway; go down this lane from Point A to Point B; turn around and back to Point A. It’s far more difficult in an urban area with varying street classifications (priorities), one-way streets, dead-ends and cul-de-sacs; winding and short-segment streets; T-intersections, etc. Furthermore, when dealing with residential streets, every resident wants his block plowed first!

Snow routes have traditionally been determined by calculating how far a plow truck could go spreading material at a certain rate before it ran empty. Natural (topographic) features and political (jurisdictional) boundaries also influence the shape of some routes as does the classification and pattern of streets. A typical approach is to select tentative start- end points for highways or major urban thoroughfares, calculate travel-mileage and then do a “dry run” to determine average cycle-time under various situations. Then adjustments are made for extra lanes, ramps, wide intersections, traffic congestion, traffic signal timing, etc.

For neighborhood or residential routes, the boundaries of the area are identified and then a particular sequence or travel pattern covering all the streets within that area is devised. Several “dry runs” are conducted to determine what seems to be the best way to run the route. It is not uncommon that during snow storms the assigned operator will deviate from the prescribed pattern and use his/ her own judgment as to how to run the route.

GPS and AVL (Automated Vehicle Location) systems can provide agencies with data useful for route optimization. However, such systems are still expensive for many agencies to acquire. Meanwhile, it is a good idea to review each route annually for needed changes. Consulting each route operator for suggestions at the end of a season is recommended. Also, annual adjustments may be needed due new lane-miles added, closures of road segments, changes in street classifications and traffic control, increased development or decrease of housing, commercial, industrial or educational institutions along a route, etc. These can substantially affect route configuration. At the very least, a "windshield tour" of each route can reveal possible opportunities for change.

4.11. Operations

The Operations portion of the plan details the strategies, tactics and methods including:

- determination of when to commence pre-storm activities,
- process to notify staff to report,
- communications between field and dispatch,
- initial strategies (pre-treatment, application rates at beginning of storm),
- decisions as to when plowing begins,
- plowing and spreading patterns and techniques,
- mid-storm changes, special situations,
- post-storm completion and spot complaints,
- safety practices and incident investigations.

Monitoring developing winter storms is an important duty of the program managers and the manual should indicate the sources of weather information that they rely upon. As with materials and equipment, there is a large body of knowledge…theoretical and practical…on operations available through numerous sources.

4.12. Communications and Public Relations

Another important component of the plan is communications. This describes what, how and by whom information is produced, conveyed and documented.

The internal communication system includes wired and wireless phones, pagers, two-way radio, fax, e-mail, text, electronic data and printed and written messages, reports and memoranda. The manual should contain a listing of phone numbers (office, cell, home) and pager numbers, if applicable, for all key employees and support staff. Lists of the home addresses, personal e-mail addresses and emergency contacts for staff involved in snow operations should be restricted and not openly disseminated.

Other listings include work key contact names, titles, e-mail addresses, fax numbers and mailing addresses for other entities that should receive specific information about the winter operations. For example, police, fire, school districts, mass transit and other departments.

List the two-way radio frequencies or channels and individual call numbers that will be used and to whom they are specifically assigned. A brief instruction on radio protocol is advisable. Note the phone numbers published for the public to use for questions or complaints and compliments.

Also indicate if the agency has a website or e-mail address that allows citizens to post concerns or requests. Specify who (by position) is responsible for answering phones and monitoring incoming electronic messages and the process for handling responses. Identify where the dispatch activity will be located; most agencies use the maintenance facilities but in some jurisdictions dispatch may be handled in an Emergency Operations Center (EOC) or Traffic Management Center.

The public relations piece includes pre-season activities such as community outreach to keep the citizens informed about the snow program. Methods include “open-house” activities at the maintenance facilities, equipment displays at events such as fairs and neighborhood gatherings, mailing or distributing brochures, notices in community publications, news releases, announcements on television and radio, etc. As an agency prepares to activate for a coming storm it is vital to use the media to remind the public of the levels of service, the priority ranking of roads and streets and designated emergency snow routes, required tires and/or chains, parking restrictions, and tips for driving on snow or ice.

The local media are always looking for news and are keenly interested in snow and ice operations. For consistency of message, the agency should designate a spokesperson to handle media interviews and inquiries or be the contact person if the spokesperson will be someone outside of public works. All staff be informed of how to deal with the media and to whom they should refer reporters to for details. Throughout the storm, periodic updates help manage the flow of information. The messages should be succinct and factual. At the conclusion of the storm there should be a statement as to when the main snow removal operations will cease and what will be the provisions for final clean-up and handling reports of trouble spots

4.13.Risk Management

Having a cogent winter operations plan and manual is a good defense against claims and litigation, as long as an agency adheres to what is stated. The manual is a legal document and public record; therefore, it should be reviewed by an organization’s attorney or law department before official adoption. A major pitfall to avoid is describing levels of service that the agency does not have sufficient resources to deliver.

> The most important policy issue pertaining to the application of snow and ice control treatments is the level of service (LOS). Policy makers have to balance cost, environmental impact, the safety of the highway users and the safety of the people performing snow and ice control operations. If that policy is reasonable, and the agency follows that policy to the extent possible, there will be very little successful litigation. [6]

Disclaimers that specifically state what the agency is not responsible for (private streets, sidewalks, bus stops, plowed snow pushed onto driveway approaches for example) are recommended. Also, limitations imposed by extraordinary situations should be mentioned. For instance, extreme temperatures and heavy snow will severely hinder even the best prepared agency’s ability to meet standard LOS.

Accurate and complete records of vehicle and equipment maintenance, material specifications and storage, plowing and treatment start and finish times, weather forecasts and periodic conditions, accidents and reports of problems and responses are vital.

Operator training reduces liability exposure as well but the agency must be able to prove that the operators were properly trained and qualified. Also, if operators are required to have certain licenses or permits the agency must have verification that these are current.

Conduct pre-season and mid-season inspection of each route to identify deficiencies and hazards such as fixtures and vegetation protruding into the roadway, pavement defects, clogged storm-water inlets or ditches, traffic calming devices and abandoned vehicles. These potential problems should be recorded and corrective action taken. Disclaimers that explicitly state that the agency is not responsible for damage to private property in the right-of-way (for example; portable basketball goals or non-permitted landscaping) are advisable.

4.14. Other Elements

Due to limitations on length, this paper cannot cover all the information that could possibly be part of a winter operations manual. It is advisable to include material specification sheets, charts of application rates for different conditions, vehicle and equipment checklists, cold weather medical hazards and precautions, lists of all mobile equipment, contractors, and all-hour contact information for critical service, commodity and supply vendors. Much of this can be as appendices or attachments.

5. BODY OF KNOWLEDGE

A literature search discovered considerable information on the technical and scientific aspects of winter operations but relatively few references from the legal, administrative and managerial perspective. In addition to the cited references, the following publications from various sources are recommended for developing or revising winter operations plans:

Snow and Ice Control, Amsler, Duane, Cornell Local Roads Program, CLRP No. 06-7, August, 2006.

Basic Concepts of Snow and Ice Control. Amsler, Duane, presentation at American Public Works Association North American Snow Conference, April, 2005.

Legal Issues and Risk Management Associated with Municipal Snow and Ice Control Operations, Amsler, Duane, Salt and Highway De-Icing, Salt Institute, Vol.44, No.4, 2007.

Levels of Service, Amsler, Duane, Salt and Highway De-Icing, Salt Institute, Vol.45, No.1, 2008.

Written Snow and Ice Control Plan and Policy Documents Absolutely Essential for Winter Maintenance Agencies, Amsler, Duane, Salt and Highway De-icing, Salt Institute; Part I, Vol.43, No. 3,; Part II, Vol.43, No. 4, 2006; Part III, Vol.44, No.1, 2007

Crafting a Written Snow and Ice Plan, October 18, 2007 webinar CD, PB.E270, American Public Works Association.

Developing an Effective Snow and Ice Program, CD, PB.E404, American Public Works Association.

Keys to Preparing a Winter Operations Manual, Bergner, Dave, APWA Reporter, October, 2007.

Optimizing Snow Routes: Factors to Consider, Bergner, Dave, APWA Reporter, October, 2009.

Adapting Levels of Service for Winter Maintenance, Bergner, Dave, APWA Reporter, October, 2011.

Winter Highway Operations, NCHRP Synthesis 344, Transportation Research Board, 2005.

Urban Snow and Ice Control, Florquist, Bruce, American Public Works Association, 2005.

Category: 133 Snow and Ice Control, Missouri Department of Transportation Engineering Policy Guide, 2011.

Chapter 2; Clear Roads, Minnesota Department Transportation Maintenance Manual, 2005.

Statewide Snow and Ice Plan, *2010-11*, Washington State Department of Transportation.

Highway Maintenance Guidelines, Snow and Ice Control, New York State Department of Transportation, 2006.

5. CONCLUSION

Nearly all Public Works agencies have some form of plan for snow and ice control; however, many of these same agencies have not updated plans or consolidated the documents into a single, cohesive document. A comprehensive and current manual is essential for ensuring efficiency and effectiveness of winter maintenance operations. As new concepts, methods and technologies relevant to snow and ice control are introduced, public works agencies must have a framework that is adaptable to assess and adopt these advancements. The forthcoming wave of retirements coupled with recent workforce reductions will result in smaller, inexperienced and less knowledgeable staffs. Written policies and manuals provide consistency and continuity of operations and promote better communication with the public and officials. Good plans and manuals mitigate liability exposure by clearly stating scope of responsibility and authority, disclaimers and exceptions, reasonable levels of service, rational priorities, weather and topographic factors, material selection and application decisions, workforce composition and training, and equipment capabilities. Though much information is available on the technical aspects of snow and ice control, more guidance on the legal, political and administrative perspectives is needed.

6. References

1. "Guide for Snow and Ice Control," American Association of State Highway and Transportation Officials, Washington, D.C., 1999. p.3
2. "Guide for Snow and Ice Control," p.15.
3. "Guide for Snow and Ice Control," p.16
4. Blackburn, Robert, Karin Bauer, Duane Amsler, S. Edward Boselly and A. Dean McElroy *NCHRP Report 526: Snow and Ice Control: Guidelines for Materials and Method*. Transportation Research Board of the National Academies, Washington, D.C., 2004, p.4
5. *Snow and Ice Control; Guidelines for Materials and Methods*, p.3
6. "Guide for Snow and Ice Control," p.16