CITY OF VANCOUVER

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ADMINISTRATIVE REPORT

Report Date:	March 1, 2013
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Meeting Date:	April 9, 2013

TO: Vancouver City Council

FROM: General Manager of Engineering Services

SUBJECT: Snow Removal Plan

RECOMMENDATION

THAT Council receive this report for information.

REPORT SUMMARY

This report responds to Council's motion of January 15th, 2013, requesting that staff report back on the City's Snow Removal Plan, identifying priority routes, the City's response to the weather event on December 19th, 2012, and make any needed recommendations for improvement on our management of future snow and ice events.

Snowfall in Vancouver is variable and it is unusual for the City to be required to manage snowfall and its impacts for more than several days at a time. In this context, the City has a snow plan which depends on the flexibility of equipment and manpower used for other purposes to be deployed to manage significant snow fall when it occurs. The city has a clear plan for responding to snowfall which involves multiple partners (Translink, Ministry of Transportation, VSB, VCH, BCAS, ICBC, and key agencies in the City – VPD and VFRS) and identifies clear priorities for snow clearance aligned with public safety and the need to maintain key transportation corridors across the city. The City also has a plan which is used throughout the winter months to manage ice on key routes: bicycle routes and bridges when the ambient temperature drops into an ice warning zone.

From mid-November to mid-March of each year, staff monitor weather forecasts 24 hours a day 7 days a week, to identify when snow and ice events are likely. In responding to these events, crews typically start by applying brine, an anti-icing treatment, to roadways prior to any snow or ice, followed by salt, a de-icing

treatment, if snowfall occurs, and plough only when there is 5cm or more of snow accumulating on roads.

The City's first priority is to service bus routes, arterials, collector roads, bridges, hot spots, access routes to emergency and critical health facilities, and priority bicycle routes. Appendix "C" includes details of all routes and locations that are treated and Appendix "D" includes maps of all priority routes. This strategy may change based on factors such as snow depth, temperature or a forecast indicating a longer term event. Complete details of the strategy, including the response level, forecast, actions and resources, is included as Appendix "E".

The lower mainland experienced a snow and ice event on December 19th, 2012. Staff received forecasts on December 18th, indicating a mix of rain and snow showers for the early evening hours of December 18th and potential for snow accumulations from 2 to 6cm between 4am and noon on December 19th. Accordingly, crews began salting operations on all major, secondary and priority bicycle routes that day. While crews continued operations into the next day, on December 19th, staff received a special notification at 8am that indicated a rain-snow mix at YVR had turned to heavy snow. Warmer air that was expected to move into Vancouver was later than anticipated by forecasters and, as a result, a warming-cooling cycle occurred with resulting snow, freezing rain, back to snow, and so on. The city received an additional 2 cm of a snow-ice mix over the 5cm of snow that fell. Although the city deployed resources according to the snow plan, the unexpected warming-cooling cycle during the early morning hours resulted in snow melting and subsequently freezing to the pavement on arterials and this was made worse with the subsequent freezing rain that fell mid-morning. The combination significantly reduced the effectiveness of the City's efforts.

Based on the routine review of the December 19th snow and ice event, staff identified a number of options available to the City to increase the effectiveness of its response under such conditions.

- Enhanced de-icing: Bus movement was significantly impaired during this snow/freezing rain event. In consultation with Coast Mountain Bus Company, staff have reviewed available options and the evolving plan is to expand on the use of anti-icing and abrasive treatments. Use of sand in the management of snow has historically been an underutilized treatment in the city because of the added maintenance costs associated with its removal from catch basins after winter events. However, sand does have a strategic use, particularly in the setting of the snow, melt, freezing rain cycles seen during the December 19th event, something that with global warming will likely become more frequent. Staff have concluded that on December 19th, the use of sand could have improved vehicle traction on icy stretches of road, and therefore will now be included in the City's snow and ice strategy. The recent event also highlighted additional hills throughout the City, included as Appendix "H", which posed problems for buses during this event. Staff have deemed these locations as "Hot Spots" and moving forward will treat these locations more aggressively during winter events.
- Improved deployment of staff and vehicle resources: A number of cities across North America have equipped their snow fleets with passive and active GPS technologies to help track vehicle progress, allocate fleet resources more effectively, and

maintain a direct record of work achieved. Staff are currently reviewing options for undertaking a comprehensive review of GPS solutions across multiple groups within the City.

- Parking Restrictions: Many cities issue seasonal parking restrictions during the winter season. The City does face its challenges for the few days of snowfall during the year, however given the overall impact on businesses and residents from seasonal parking restrictions or restrictions during individual snowfall events, staff have concluded that these would not be a viable option.
- Enhanced Mobilization of the City's Office of Emergency Management, Corporate Communications and other City Business Units: Engineering has traditionally taken full responsibility for management of a snow event and these events were seen as strictly a transportation issue. However, it is increasingly clear that the City could enhance its response by treating snow events like any other emergency event in the city. Our emergency management plan is comprehensive and multi-pronged, designed to deal with the root cause as well as the impact of any emergency on the public and business community. Use of this approach will broaden our approach, improve our communications, and allow us to enable the use of our team of volunteers currently being trained as part of the Vancouver Volunteer Corps.

In responding to Council's motion on January 15th, 2013, staff recommend that Council receive this report for information regarding the City's current snow removal plan, priority routes and details regarding the City's snow and ice response on December 19th, 2012.

COUNCIL AUTHORITY/PREVIOUS DECISIONS

On November 25TH, 2009, Council received the "Snow and Ice Treatment Review" report that provided a review of the current snow and ice treatment procedures on City streets and sidewalks.

On January 15TH, 2013, Council adopted a motion regarding the "Snow Removal Plan". Council directed staff report back on the existing snow removal plan for the City of Vancouver, identifying priority routes, allocation of existing snow removal resources and deployment on December 19TH, 2012. Council also requested that staff recommend options to further increase the priority on snow clearing, sanding and salting on bus routes.

CITY MANAGER'S/GENERAL MANAGER'S COMMENTS

The General Manager of Engineering Services RECOMMENDS that Council receive this report for information.

REPORT

SNOW AND ICE CONTROL BACKGROUND

Vancouver's Climate Trends

Forecasting precipitation in Vancouver is particularly complex and snow is problematic for Meteorologists due to variations in elevation and the moderating effects of the coast. The Pacific Climate Impacts Consortium, a regional climate service centre at the University of Victoria, predicts that mean temperatures for the Greater Vancouver area, in the next twenty years, will see an average temperature increase of 1°C, with snowfall percentages dropping by 22%. From analysis of historical data from Environment Canada over the past decade, Greater Vancouver generally receives some degree of snowfall 18 days a year, with total accumulations over the course of the winter of 35cm. While the number of days of snow and accumulations vary from year to year, with no predictable trend, Vancouver has been historically seeing less snowfall.

Forecasting Snow and Ice Events

Prior to the start of each winter season, staff consult with Meteorologists, who provide insight into the upcoming season so staff can plan accordingly. From mid-November to mid-March of each year, staff monitor winter forecasts 24 hours a day 7 days a week and receive information, via email, from two primary sources; NorthWest Weathernet Inc. and Environment Canada. Staff also phone both sources directly for updates during problematic situations. This information, paired with real-time observations of City streets, allows staff to make decisions regarding actions.

Snow and Ice Control Context

Considering that Vancouver does not routinely see significant snowfall, the City has opted to minimize the quantity of equipment solely dedicated for the purposes of treating snow, thereby reducing seasonal costs. As much as possible, the City has used existing equipment and scheduled night shift staff to deal with snow and ice events. Fundamentally, this has meant that arterials and other priority routes are treated during snow and ice events and residential streets are not, except in a limited manner during prolonged snow fights.

In comparing the City's snow and ice approach to that of other Canadian cities, it is clear that significantly expanding the scope of the City's current snow fight efforts would be costly. On average, over the last ten years, Vancouver has spent $2M per season towards its snow fight, with access to about 50 vehicles and 800 employees. Conversely, the City of Toronto (with approximately 4 times the length of streets as compared to Vancouver) has a mandate to salt, plough and remove snow from arterials, collectors, lanes and sidewalks, must maintain over 1,100 fleet vehicles (600 snowploughs, 200 salt trucks and 300 sidewalk ploughs) and 2,200 employees, two thirds of which are contracted services. Maintaining this level of service, has meant that $34M of their $87M annual snow budget, are for standby charges that compensate contractors reserving equipment for the City 24 hours a day 7 days a week, regardless of whether or not the equipment is used.

While local municipalities do not issue seasonal parking restrictions, cities such as Toronto, Ottawa, Montreal and Winnipeg all have winter parking restrictions, which are in place to ensure that snowploughs and salters can effectively carry out

operations. A few of these cities plough residential streets during the course of the year, and residents are notified through the city's website or can obtain a schedule by calling their 311 service. As no no-parking signs are installed along streets, they often absorb the costs of providing friendly-tows for vehicles parked on residential streets during clearing activities. Other cities install no parking signs along residential streets and designated snow routes, to facilitate snow clearing and the efficient movement of emergency vehicles, respectively. The measures make sense where snow is frequent and deep, but would have a significant impact on businesses and residents in Vancouver given the very few snow days.

Snow and Ice Equipment

The City uses existing staff involved in sanitation operations to carry out snow and ice activities during the night. Fleet vehicles are outfitted with equipment necessary to respond to winter weather events and include:

- 22 Tandem Dump Trucks equipped with ploughs and salt spreaders;
- 19 Single-Axle 5 Yarders, equipped with ploughs and salt spreaders;
- 6 Single-Axle 3 Yarders, Crew Cabs equipped with salt spreaders;
- 4 F450 1 Yarder Crew Cabs equipped with ploughs and salt spreaders;
- 4 Brine Trucks units with ambient and surface temperature gauges (brine is road salt that is dissolved in water, to form a liquid anti-icing agent); and
- A variety of small plough units, snow blowers, graders, Kubota's and backhoes.

Appendix "A" includes pictures of these vehicles as reference. At any given time during the winter season, eight trucks are kept immediately available to respond to salting operations. Four are stocked with salt and stored in a heated garage, while another four only require salt loading. An additional four brine trucks are always on standby, for brining operations.

Snow and Ice Treatments

The City's current snow and ice treatments fall into one of three categories below:

Anti-icing Treatments	Preventative treatments that involve the application of chemicals to roadways, before snow or ice have had an opportunity to settle and bond with the pavement. The City's preferred anti-icing treatment is the use of salt brine.
De-icing Treatments	Reactive treatments that remove snow and ice from the road surface after it has bonded to the pavement. The most effective and inexpensive de-icing practice employed by the City involves the use of road salt.
Abrasive Treatments	Abrasives are used in a limited way when temperatures fall below -6°C, when anti-icing and de-icing treatments are not as effective. Abrasives do not melt snow or ice, but are used to improve traction at any temperature, with the most common abrasive in use today being sand.

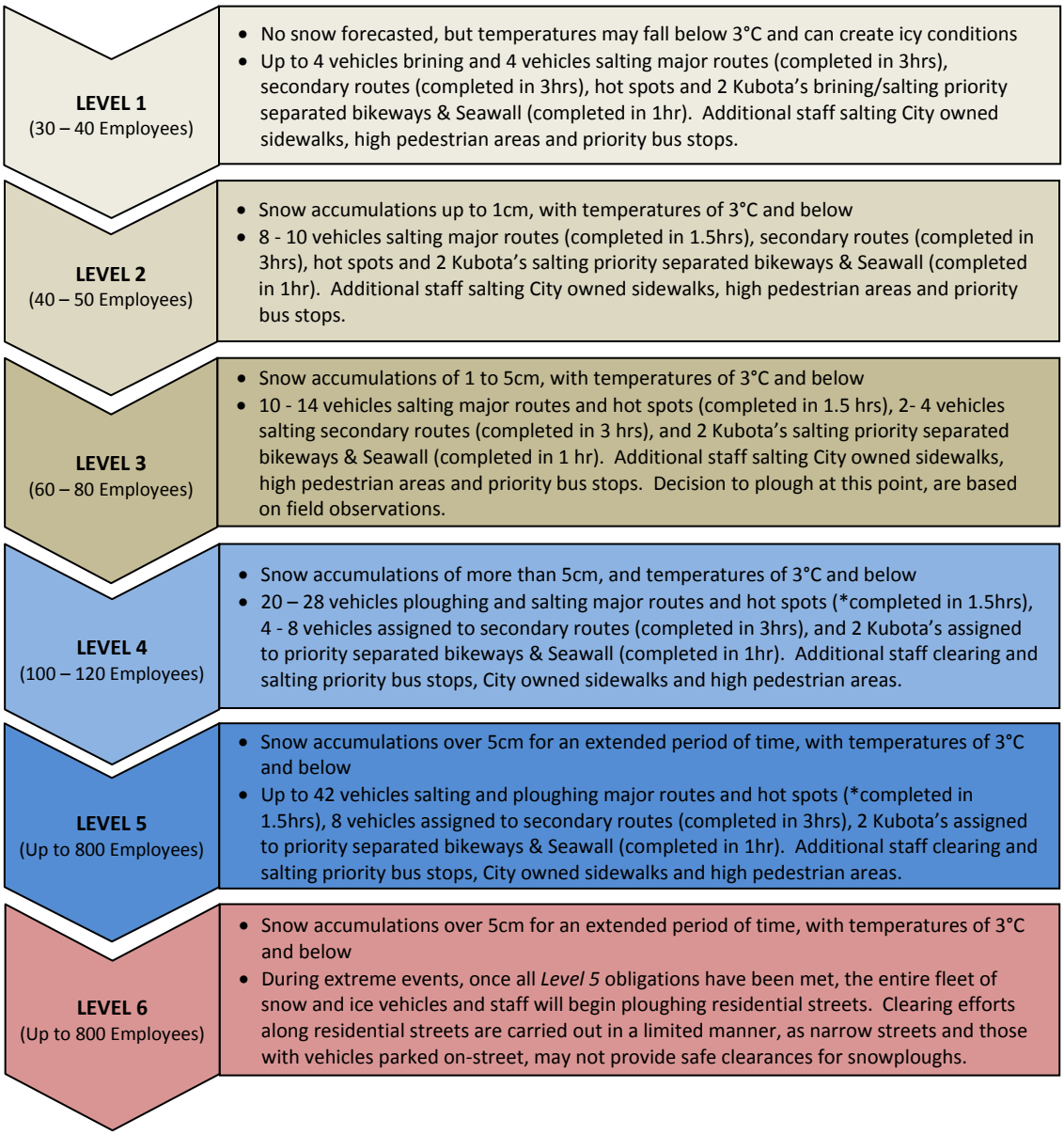
A complete overview of treatments, including the City's current stores of materials, is attached as Appendix "B".

SNOW AND ICE STRATEGY

The City's snow and ice strategy has staff monitoring forecasts to predict when conditions for snow and ice events are likely. Typically, crews start by applying an anti-icing treatment to the pavement surface prior to any snow or ice, followed by a de-icing treatment once snowfall has begun, and plough when there is 5cm of snow accumulations on roads, as at these depths snowplough blades are most effective at clearing snow. This strategy may change depending on factors such as snow accumulations, temperatures and the longer term forecast. The decision to plough is a serious one, especially in the absence of snow-blowing capacity in the city, because of the creation of windrows which can obstruct pedestrian access, can make parked cars difficult to access and may cause secondary issues such as flooding.

Snow and Ice Response Levels

In responding to snow and ice events, the City has developed a series of response levels, below, based on the forecast and the reported winter conditions of roadways throughout the City. Appendix "E" provides complete details for each response level, including forecast, actions and resources.



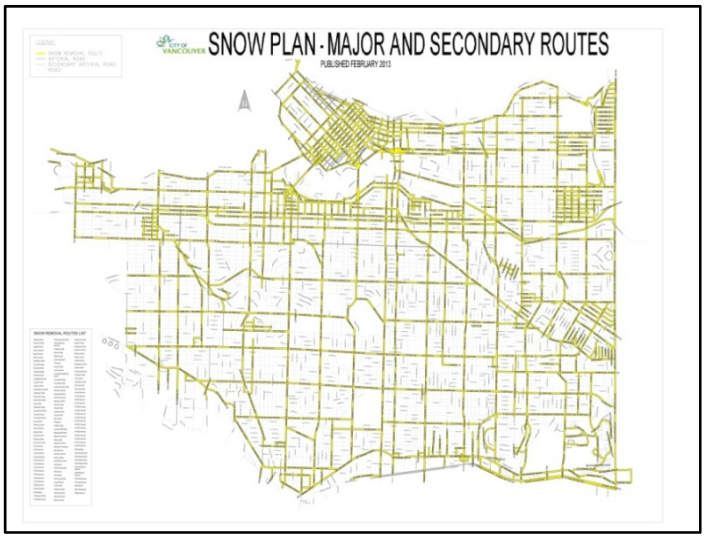
NOTES:

- Priority on-street bikeways are completed in conjunction with the major and secondary routes.
- Depending on the conditions, each route may be re-treated continuously.
- *Although the number of vehicles for these routes are doubled and tripled, the time to complete each route remains the same, as these vehicles travel in staggered form (commonly referred to as "echelon ploughing") along multi-lane roads. This means each vehicle spends the same amount of time covering route.

Snow and Ice Response Routes

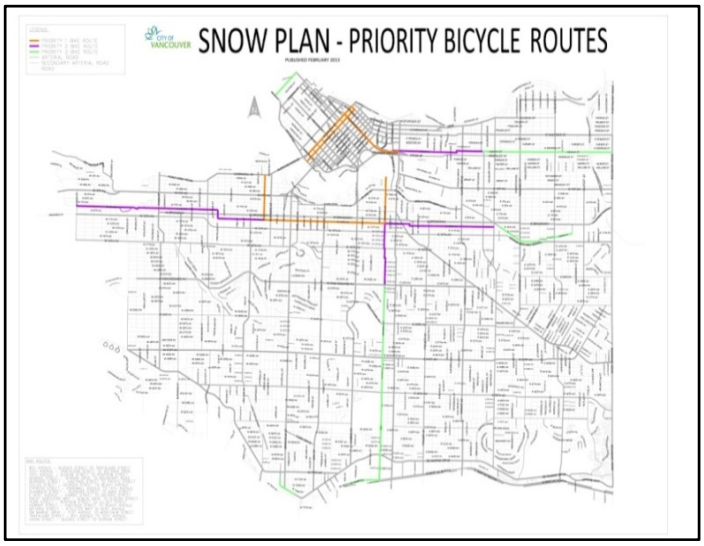
During snow and ice events, the City's first priority is to service:

- Major Routes (355 km) which include bus routes, primary and secondary arterials, collector roads and bridges. 14 trucks are normally assigned to the major routes;



- Secondary Routes (70 km) which include roads that may pose a safety risk to users during snow and ice events, such as steep hills (4 trucks), or have a clear public benefit, such as access to fire and ambulance stations (1 truck), hospitals and other primary health care facilities (2 trucks); and

- Priority Bicycle Routes (32 km) which include on-street bikeways (treated in conjunction with the major routes and secondary routes) and separated bikeways (2 dedicated special purpose vehicles) for the top 15 most used bicycle routes.



In all, these routes account for approximately 460 km of the 1,400 km of roadways throughout the City. Appendix "C" includes a detailed overview of all routes and locations that are treated and untreated, based on the City's snow and ice response level, and Appendix "D" includes maps of all priority routes.

Coordination with Partners

The city has a clear plan for responding to snow and ice events which involves multiple partners including Translink, Ministry of Transportation, VSB, VCH, BCAS, ICBC, and key agencies within the City (e.g., VPD and VFRS), and identifies clear priorities for snow clearance that is aligned with public safety and the need to maintain key transportation corridors across the city. During snow and ice events, communication channels between all partners have served to lessen the overall disruption to the public.

SNOW AND ICE EVENT ON DECEMBER 19TH, 2012

The lower mainland experienced a snow and ice event on December 19th, 2012. A summary of the event including the forecast, City's response and challenges, has been provided below. A detailed account of the forecast, actual weather as reported by Environment Canada and the City's response, is attached as Appendix "G".

Weather Event Details and City's Response

Tuesday December 18th, 2012

Weather sources forecast a mix of rain and snow showers for the early evening hours, with temperatures remaining above freezing. As a result, on the evening of December 17th, 2012, a Level 2 response was issued and 8 trucks were deployed to begin salting the City's major routes, secondary routes and priority bicycle routes along vehicle travel lanes. An updated forecast received at midday on December 18th, 2012, called for the potential of snow accumulations from 2 to 6cm between 4am and noon on December 19th, 2012. Accordingly, a Level 3 response was issued, and a total of 10 trucks continued salting all major routes, secondary routes, priority bicycle routes along vehicle travel lanes, and 2 Kubota's were assigned to salt priority separated bikeways and the Seawall. At a shift change at 7pm, a total of 14 trucks were salting all major routes, completing one full cycle every 1.5 hours, and ploughing as required.

Wednesday December 19th, 2012

While crews continued salting activities from the previous day, staff received a special notification at 8am that indicated a rain-snow mix at YVR turned to heavy snow. Warmer air that was forecast to move into Vancouver was later than anticipated by forecasters and, as a result, a warming-cooling cycle occurred with resulting snow, freezing rain, back to snow, and so on. The City received an additional 2 cm of a snow-ice mix that was not expected. The City's response level was upgrade to a Level 4 following the advisory and 24 trucks were deployed to plough and salt all major and secondary routes, with 4 additional trucks assigned to priority bike routes along vehicle travel lanes. One Kubota was deployed to plough and salt downtown priority 1 separated bicycle routes, and another was deployed to clear and salt the Seawall. Although it would normally take 1.5 hours to complete all major routes, staff report that during the event it was taking crews 3 hours to complete the major routes because of icy roads and traffic. Secondary routes and priority bicycle routes were completed within the normal timeframes. In addition, approximately 50 employees were clearing and salting priority bus stops and high pedestrian areas. During the late afternoon and evening, temperatures climbed to 5°C, which accelerated the snow melt process. The snow and ice response was subsequently downgraded to a Level 3 during the 7pm shift change, at which time 20 trucks were salting the major and secondary routes.

Thursday December 20th, 2012
With the warmer early morning temperatures and roads returning to normal condition, the City downgraded its response to a Level 2 at midnight, at which time 14 trucks remained on the roads, salting the major routes.

Challenges of December 19th, 2012
Unexpected Change in Weather
Forecasts received by staff in advance of the approaching storm before the City upgraded its response level, indicated warmer temperatures and snow arriving earlier and lighter than what actually occurred. Prior to upgrading the response level, sufficient resources were deployed according to the snow plan. On receiving the notification of changes, the City promptly responded by upgrading its response level and deploying additional resources. In spite of this, two unexpected issues, the cyclical warming and cooling trend during the early morning hours that saw snow melt and freeze to the pavement beneath and freezing rain that fell mid-morning, ultimately impaired the effectiveness of the City's efforts, as there were limited options available to deal with the combination of both issues.

Other Challenges
Although the primary challenge was the unexpected change in weather, other issues during that day posed additional challenges, including traffic, parking, and resourcing.

While the City's snow and ice fleet was extensively deployed on the day of the event, traffic along the major routes during the morning commute impacted the City's efforts, mainly due to private vehicles which were unprepared for winter conditions. This is not a new issue faced by City crews during these types of events, but the timing of the heavy snowfall and freezing rain paired with the commute, had many snowploughs along with other vehicles, in queues. As a result, it generally took twice as long to complete treatment of major routes. Similarly, crews also reported that vehicles parked along priority routes during snow and ice events, created additional challenges for ploughing operations, adding to the overall congestion.

It has also been found that when weather related events (e.g., snow, ice and wind events) take place, there were other demands on City resources due to impacts of the weather event. On December 19th, a series of issues across the City led to a dispersion of available crews. In one situation, a City tree had fallen over from the weight of snow and ice on its branches, at Granville St. at Belfour Ave., bringing down power lines. Vancouver Fire and Rescue Services responded and blocked off a section of Granville St., and maintained their presence waiting for BC Hydro to arrive. Around 2pm, a downed power pole ignited a fire in a residence in the 5200 block of Granville St., and with the fire crew having to attend, resources from the City's Streets Operations Branch were called in. City crews responded and waited for BC Hydro to attend.

RECOMMENDATIONS
Based on the routine review of the December 19th, 2012 snow and ice event, staff identified a number of options available to the City to increase the effectiveness of its snow and ice response under such conditions. These options are a culmination of lessons learned based on our own experiences, as well as practice reviews of other municipalities.

Keeping Buses Moving

Maintaining bus routes as clear as possible during snow and ice events is one of the City's top priorities. With transit functioning well during such events, many find leaving vehicles at home much easier. Unfortunately, buses are not immune to the effects of snow and ice, and on December 19th, buses on certain routes, particularly those with hills, had difficulty gaining traction and as a result became immobilized. Following a review, staff identified the options below.

- *Use Winter Tires*
  While this could provide buses with needed traction on icy roads, staff have had discussion with CMBC, who have indicated that this is not a financially feasible option.
- *Wider use of Anti-Icing and Abrasive Treatments*
  - Brine can be applied very early to form a bond with the pavement surface and can be effective for days, in the right conditions. After brine is applied to the surface, it dries into a fine powdery residue that immediately reverts back to brine during precipitation, and thereby slows the formation of ice on pavements. With growing support as the primary treatment of choice for cities worldwide, staff will expand on its use as part of the City's snow and ice control strategy.
  - Abrasives have historically been underutilized by the City due to maintenance concerns. Sand creates debris in catch basins and on roadways, which result in additional maintenance costs when it needs removal. Those costs further increase when sand is contaminated with road debris such as oil and grease, at which time it must be treated as hazardous waste. However, strategic use is appropriate and on December 19th, following the freezing rain, it could have improved vehicle traction on icy stretches of road. Moving forward, staff will increase the use of sand in the snow and ice strategy, as well as monitor its use.
- *Hot Spots*
  The recent snow and ice event highlighted specific hills throughout the City that posed problems for buses in these particular conditions. Staff have now deemed these locations as additional "Hot Spots" (included as Appendix "H") and moving forward will treat these locations more aggressively during snow and ice events. In addition, at the end of 2012, the City has added the Insurance Corporation of British Columbia ("ICBC") as one of its partners. ICBC has agreed to provide the City with locations where high accident volumes are occurring during snow and ice events. Currently, ICBC has not identified any such locations that could be considered "Hot Spots", but will monitor future events in attempts to record such metrics and make them available to us.

GPS Technology to Enhance Deployment of Staff and Equipment

A number of cities across North America have equipped their snow fleets with GPS technologies to help manage fleet vehicles. GPS technologies include passive GPS trackers which store information that that can be readily downloaded and analysed, and active GPS trackers which provide real-time location-based information. Benefits noted by other municipalities include the ability for fleet and operational managers to track vehicle progress, allocate fleet resources more effectively, and maintain a direct record of work achieved. Staff are currently reviewing options for undertaking a comprehensive review of GPS solutions across multiple groups within the City, of which the snow fleet is a small component.

Traffic Congestion and Parking
The City is proactively encouraging the public to be prepared for winter weather through key messages. Equipping vehicles with appropriate tires and leaving earlier than normal can help to ease traffic congestion, but the responsibility rests on vehicle owners. With regards to parking, a number of cities issue seasonal parking restrictions during the winter months. While the City does face its challenges for the few days it snows, the disruption which would be caused by issuing parking restrictions throughout the winter season would create an ongoing challenge for business and residents for the very few days of benefit.

Treating Snow and Ice Events as Emergency Events
Engineering has traditionally taken full responsibility for management of a snow event and these events were seen as strictly a transportation issue. However, it is increasingly clear that the City could enhance its response by treating snow events like any other emergency event in the city. Our emergency management plan is comprehensive and multi-pronged, designed to deal with the root cause as well as the impact of any emergency on the public and business community. Use of this approach will broaden our approach, improve our communications, and allow us to enable the use of our team of volunteers (Vancouver Volunteer Corps) who are our primary volunteer resource during emergency events.

Communication
Over the past several years, the City has assumed a proactive role in communicating key messages to the public during weather related events. Currently, key messages provided to the public include:

- Be on alert for extreme weather forecasts, particularly snow and ice;
- Have snow shovels and de-icing materials available;
- If transit is not your usual mode of transportation, take time to look up schedules and plan your route ahead of time; and
- If you must drive, be prepared with snow tires, leave earlier, allow more time for travel and take care.

In addition to key messages, providing the public with information regarding priority routes is another tool to ensure that the public can make informed decisions when planning trips. To that end, staff recommend the priority snow route maps included in this report, be added to the City's Streets and Transportation "Snow removal from City streets and sidewalks" webpage.

Implications/Related Issues/Risk (if applicable)

Financial
Currently major snow events are funded from the annual contingency budget in the operating budget. There is no plan to change this practice. Staff will assess costs associated with a wider deployment of a GPS solution for the City's snow fleet vehicles, and any incremental capital and/or operating funding requirements from current practices will be considered and prioritized as part of setting the contingency budget during the regular budget process.

CONCLUSION

In responding to Council's motion on January 15th, 2013, staff recommend that Council receive this report for information regarding the City's current snow removal plan, priority routes and details regarding the City's response to the snow and ice event of December 19th, 2012.

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CITY OF VANCOUVER'S SNOW AND ICE FLEET

Tandem dump truck with plough and spreader

Single-axle 5 yarder with plough and spreader

Single-axle 3 yarder with spreaders

F450 1 yarder crew cab plough and spreader

Brine truck

Grader

Kubota with sweeper

Brine Facility

SNOW AND ICE TREATMENTS

This appendix provides an overview of the City's current snow and ice treatments. Treatments can be used by themselves or in combination with each other.

Anti-Icing Treatments

Brine is an effective and inexpensive anti-icing treatment. It serves as a barrier between the pavement surface and snow, reducing the likelihood of icy roads and making ploughing activities much easier. The application of brine is most effective on dry pavements, as wet pavements may dilute the concentration. Research has also shown that anti-icing treatments have been found to:

- Return pavement surfaces to normal conditions faster, resulting in fewer accidents;
- Quicken the melting process, as de-icers such as salt, require moisture to be effective;
- Remain on the pavement surfaces longer, as they do not bounce off the pavement surface as salt does; and
- Lessen the use of salt.

De-Icing Treatments

Salt is an effective and efficient de-icing treatment applied after snow and ice has bonded to the pavement. Salt, in its solid form, has proven most effective when it is applied after snow starts to accumulate on roads and when surface temperatures are above -6°C. The application of salt on snow reduces the amount of salt that would otherwise be lost if it was applied onto dry pavements, and vehicles driving on salt assist in breaking down low volumes of snow and ice. Salt has also been found effective for snowfalls of up to 15cm, provided that temperatures are between 0°C and -6°C, and traffic is heavy enough to keep the snow-salt mixture agitated.

Abrasive Treatments

Abrasives are snow and ice treatments that are used in colder temperatures when anti-icing and de-icing treatments are not effective. Abrasives do not melt snow or ice, but are used to improve traction, with the most common abrasive in use today being sand. The City uses a sand-salt mix for spot treating icy stretches of pavements, especially on hills and bridge decks, and is most effective when surface temperatures are below -6°C.

City's Salt, Brine and Sand Stores

The City generally stocks 3000 tonnes of salt for the winter season, based on the average consumption during past seasons, with a healthy reserve available from suppliers, when needed. The City also manufactures its own brine at its National Yards facility. A reserve of brine is stored in storage tanks on site, and can be manufactured in short order. It is estimated that 75,000 litres of brine have been used in previous winter seasons, and this year, with brine vehicles equipped with flow meters, staff will be able to accurately measure quantities of brine used. In addition to salt and brine, a supply of sand is available at a number of City Yards.

SNOW AND ICE RESPONSE ROUTES

This appendix includes an overview of all routes and locations that are treated and untreated, based on the City's snow and ice response level.

Major Routes

The major routes are comprised of bus routes, primary arterials, secondary arterials, collector roads and bridges, and account for approximately 355 km of the City's roadways. These routes form the basic road network for transit, goods movement and movement of the public. Operationally, major routes are divided into 14 zones, which cover the entire City. Generally, one vehicle is assigned to each zone, at it normally takes 1.5 hours to complete one full treatment. Priority bicycle

Secondary Routes

In addition to the major routes above, City crews treat snow and ice on another 70 km of other roads throughout the City. These roads either pose a substantial safety risk (e.g., steep hills) to users during snow and ice events, or have a clear public benefit, such as access to fire and ambulance stations, hospitals and other primary health care facilities. Operationally, two vehicles are assigned to treating the 20 km of roadways surrounding the five major hospitals and primary health care facilities, and it generally takes 3 hours to complete. One vehicle is assigned to treating the 10 km of roadways surrounding fire halls and ambulance stations, and it generally takes 1 hour to complete. The remaining secondary routes are priority hills and are divided into 4 zones (Northeast, Northwest, Southeast and Southwest), with one truck dedicated to each zone. It generally takes 1.5 - 2 hours to complete a zone.

Priority Bicycle Routes (Including Seawall)

The City has 200 km of bicycle routes. Under the current procedures, the City provides snow and ice treatment for 32km of the top 15 bicycle routes (includes on-street and separated bikeways). The primary concern for bicycle routes is ice, particularly black ice. While ice treatment cannot completely remove ice, the treatment provides safer conditions for cyclists than untreated routes. Salt is less effective on bicycle routes, and therefore staff apply salt brine to improve the effectiveness of ice treatment on these routes. Operationally, these routes are treated in conjunction with major routes and secondary routes. However, separated bikeways and the Seawall, because of their design, have special purposed vehicles (Kubota's) assigned to them.

Walkways and Stairs

City crews provide snow and ice treatments to walkways, pedestrian underpasses and overpasses, sidewalks on bridges, stairs within the street right-of-way, and sidewalks where there is no abutting property owner.

Priority Bus Stops

The City has approximately 1,650 bus stops. During snow and ice events, ploughing activities can develop windrows (banks of snow formed from snowploughs clearing streets) that obstruct the safe egress of passengers using buses. As needed, City crews will shovel, salt and/or sand at the priority bus stops listed in the table below.

ON	AT
Broadway/Granville St	Granville St/Broadway
Granville St	5th Ave
Alma St	10th Ave
Main St/Hasting St	Hasting St/Main St
Howe St	Robson St
Davie St	Denman St
Burrard St/Dunsmuir St	Dunsmuir St/Burrard St
Main St	Terminal Ave
Richards St	Cordova St
Cordova St	Seymour St
Georgia St	Seymour St
Georgia St	Granville St
Davie St/Burrard St	Burrard St/Davie St
Broadway/Kingsway	Kingsway/Broadway
Broadway	Victoria St
Main St/2nd Ave	2nd Ave/Main St
Cambie St/Broadway	Broadway/Cambie St
Davie St	Mainland St
Davie St/Pacific Blvd	Pacific Blvd/Davie St
2nd Ave	Cambie St
2nd Ave	Ash St
Cambie St/King Ed Ave	King Ed Ave/Cambie St
Cambie St/41st Ave	41st Ave/Cambie St
Cambie St/49th Ave	49th Ave/Cambie St
SW Marine Dr	Cambie St
Nanaimo St/24th Ave	24th Ave/Nanaimo St
Renfrew St - Atlin St	29th Ave
Joyce St/Vanness Ave	Vanness Ave/Joyce St
Renfrew St	Grandview
Broadway/Rupert St	Rupert St/Broadway
Great Northern Way	Keith Dr
Broadway/Commercial Dr	Commercial Dr/Broadway

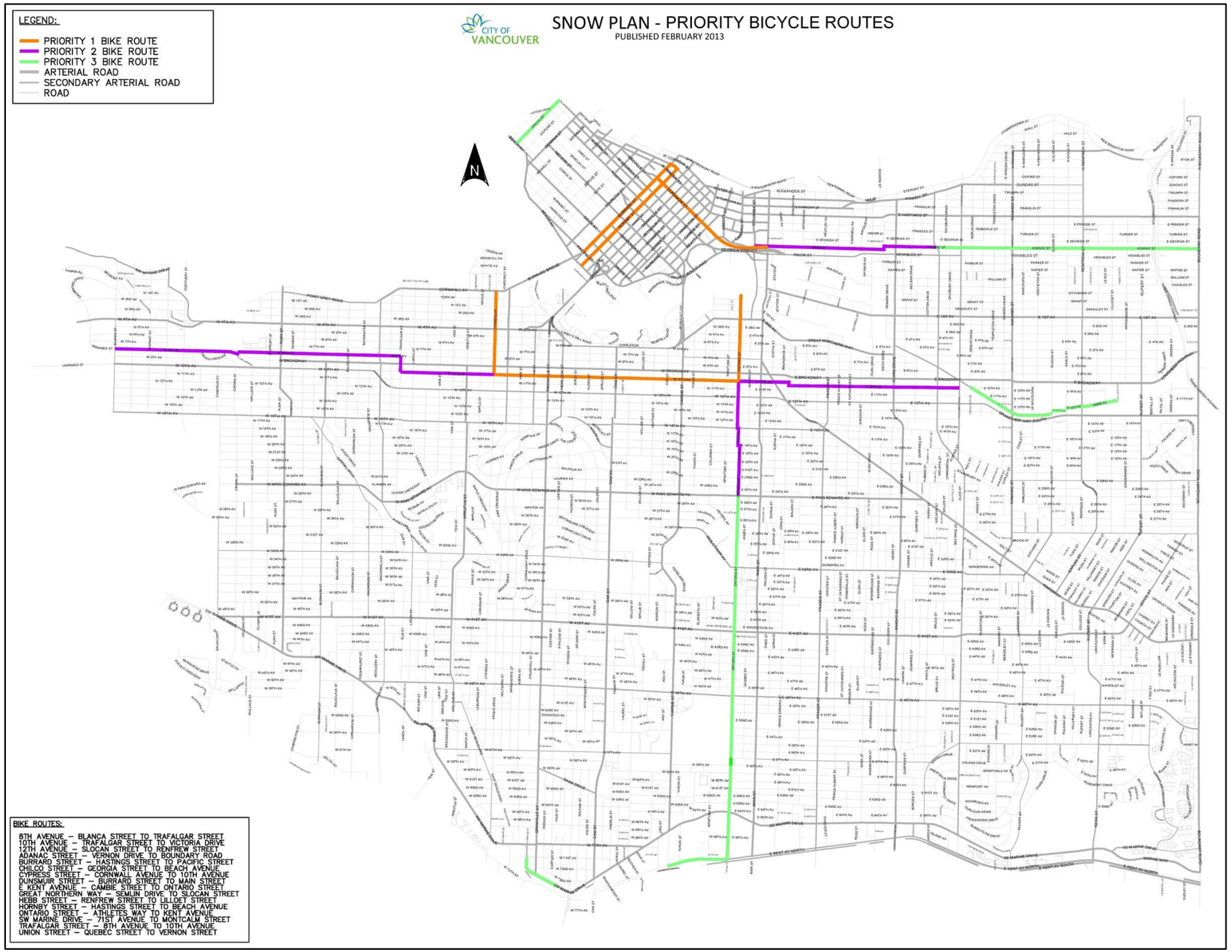
ON	AT
Broadway/Clark Dr	Clark Dr/Broadway
Broadway/Fraser St	Fraser St/Broadway
Broadway/Main St	Main St/Broadway
Broadway/Willow Ave	Willow Ave/Broadway
Broadway/Arbutus St	Arbutus St/Broadway
Broadway/Macdonald St	Macdonald St/Broadway
Broadway/Nanaimo St	Nanaimo St/Broadway
Broadway/Renfrew St	Renfrew St/Broadway
Hastings St	Granville St
Hastings St/Seymour St	Seymour St/Hastings St
Hastings St/Richards St	Richards St/Hastings St
Hastings St/Cambie St	Cambie St/Hastings St
Cordova St	Granville St
Pender St	Granville St
Robson St	Granville St
Davie St/Granville St	Granville St/Davie St
Pender St/Burrard St	Burrard St/Pender St
Pender St/Howe St	Howe St/Pender St
Pender St	Seymour St
Cordova St	Main St
Pender St	Main St
Georgia St/Burrard St	Burrard St/Georgia St
Howe St	Georgia St
Richards St	Georgia St
Cambie St	Georgia St
Denman St	Robson St
Robson St/Burrard St	Burrard St/Robson St
Hornby St/Beach Ave	Beach Ave/Hornby St
Pacific Blvd	Cambie St
Expo Blvd/Nelson St	Nelson St/Expo Blvd
Smithe St	Expo Blvd

Local Roads and Lanes

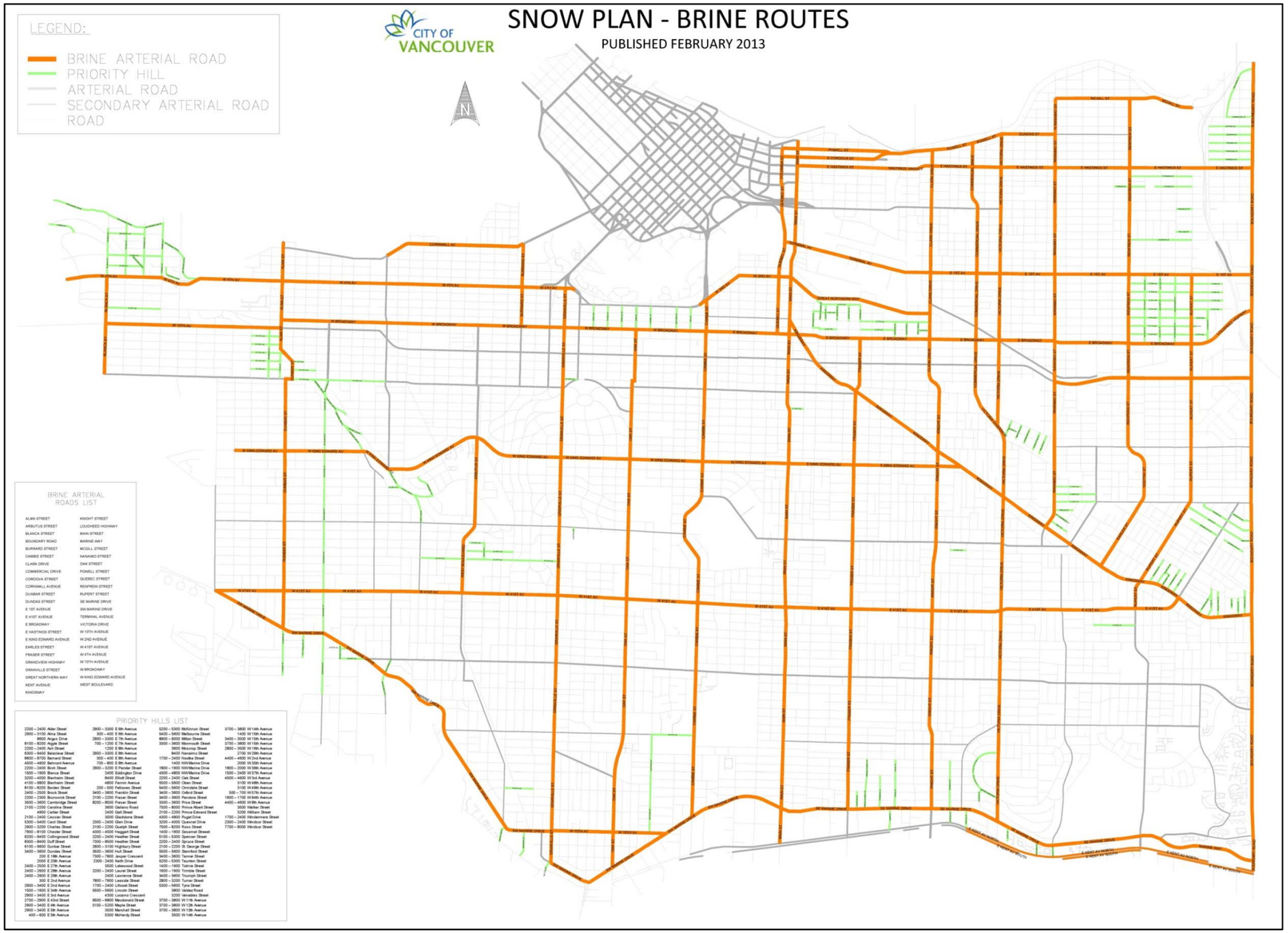
The City does not treat 1,060 km of local roads. Under normal winter conditions, the local roads generally remain passable or become passable shortly after a snow event and virtually all properties are within 3 blocks of a treated street. As well, the City does not treat snow or ice on the approximately 650 km of lanes. Due to low speeds and traffic volumes, snow and ice on the City's lanes do not pose a substantial safety risk. The exception for snow and ice treatment on side streets and lanes is when emergency or medical service vehicles require access to a street or lane. As necessary, City crews will salt or clear a street or lane to provide access for emergency vehicles. City crew support is generally only needed for secondary support or when vehicle access is required to support the first response. During extreme events, when all priority routes have been treated and can be maintained, the City will carry out treatment of local roads, but in a limited manner as resources become available.

SNOW AND ICE RESPONSE – MAJOR AND SECONDARY ROUTES

SNOW AND ICE RESPONSE – PRIORITY BICYCLE ROUTES



SNOW AND ICE RESPONSE – BRINE ROUTES



SNOW AND ICE RESPONSE LEVELS

LEVEL 1	***Forecast***	No snow forecasted, but colder temperatures (below 3°C) that can create icy conditions
	Actions	Salting units are deployed and patrol known freezing locations, as well as respond to complaints. The City's brine units are also deployed to priority routes including major routes, secondary routes, priority bicycle routes and hot spots. Staff also salt/sand City owned sidewalks, high pedestrian areas and priority bus stops.
	Resources	Up to 4 vehicles brining and 4 vehicles salting major routes (completed in 3hrs), secondary routes (completed in 3hrs) and hot spots. 2 Kubota's assigned to priority separated bikeways & Seawall. Total workforce of 30 – 40 employees.
LEVEL 2	***Forecast***	Snow accumulations of up to 1cm, with temperatures of 3°C and below
	Actions	Salting units (no brine units) are deployed to major routes, secondary routes, priority bicycle routes and hot spots, applying salt where needed. We do not plough at this point, as ploughing can create windrows which pose a challenge for commuters and pedestrians. Staff also salt/sand City owned sidewalks, high pedestrian areas and priority bus stops.
	Resources	8 - 10 vehicles assigned to salt major routes and hot spots (completed in 1.5hrs), 2 - 4 vehicles assigned to secondary routes (completed in 3hrs), and 2 Kubota's assigned to priority separated bikeways & Seawall (completed in 1hr). Total workforce of 40 – 50 employees.
LEVEL 3	***Forecast***	Snow accumulations of 1 to 5cm, with temperatures of 3°C and below
	Actions	Salting units are deployed to major routes, secondary routes, priority bicycle routes and hot spots, applying salt where needed. We do not plough all routes at this point, and decisions to do so are made in the field based on observations. Staff also salt/sand/clear City owned sidewalks, high pedestrian areas and priority bus stops.
	Resources	10 - 14 vehicles assigned to major routes and hot spots (completed in 1.5hrs), 4 vehicle assigned to secondary routes (completed in 3 hrs), and 2 Kubota's assigned to priority separated bikeways & Seawall (completed in 1hr). Total workforce of 60 – 80 employees.
LEVEL 4	***Forecast***	Snow accumulations of more than 5cm, and temperatures of 3°C and below
	Actions	The snow and ice fleet will start ploughing and salting major routes, secondary routes, priority bicycle routes and hot spots. With the potential of ploughing activities creating windrows, priority bus stops are cleared and salted, along with City owned sidewalks and high pedestrian areas.
	Resources	20 - 28 vehicles assigned to major routes and hot spots (*completed in 1.5hrs), 4 - 8 vehicles assigned to secondary routes (completed in 3hrs), and 2 Kubota's assigned to priority separated bikeways & Seawall (completed in 1hr). Total workforce of 100 – 120 employees.
LEVEL 5	***Forecast***	Snow accumulations of more than 5cm and expected over an extended period of time, with temperatures of 3°C and below
	Actions	The entire snow and ice fleet is deployed to major routes, secondary routes, priority bicycle routes and hot spots. Priority bus stops, City owned sidewalks and high pedestrian areas are cleared and salted. Ploughing and salting operations can continue for 24 hour cycles, when necessary. Conditions are regularly monitored and adjustments are made accordingly.
	Resources	Up to 42 vehicles assigned to major routes and hot spots (*completed in 1.5hrs), 8 vehicles assigned to secondary routes (completed in 3hrs), 2 Kubota's assigned to priority separated bikeways & Seawall (completed in 1hr). Total workforce of up to 800 employees.
LEVEL 6	***Forecast***	Snow accumulations of more than 5cm and expected over an extended period of time, with temperatures of 3°C and below
	Actions	During extreme events, once all *Level 5* obligations have been met, the entire fleet of snow and ice vehicles and staff will be deployed to plough and salt impassable residential streets. These activities can continue for 24 hour cycles, but may only be carried out in limited manner, as narrow streets and those with vehicles parked on-street, may not provide safe clearances for ploughs.
	Resources	All available snow and ice fleet vehicles, equipment and staff.

NOTES:

- Priority on-street bikeways are completed in conjunction with the major and secondary routes.
- Depending on the conditions, each route may be re-treated continuously.
- *Although the number of vehicles for these routes are doubled and tripled, the time to complete each route remains the same, as these vehicles travel in staggered form (commonly referred to as "echelon ploughing") along multi-lane roads. This means each vehicle spends the same amount of time covering route.

COORDINATION WITH EXTERNAL PARTNERS

Vancouver School Board ("VSB")

The Vancouver School Board identified a number of schools that are not part of the major road network, but because of the number of special needs children that attend the school, they have reported having difficulty accessing the school during snow and ice events, with buses not being able to access school drop-off zones. These locations have been provided to the City, and are now included in our priority response. The VSB also checks with the City regarding road conditions, during early morning hours, to make informed decision on whether or not schools should be closed.

British Columbia Ambulance Service ("BCAS")

The British Columbia Ambulance Service identified their 3 main concerns during snow and ice events. They include the inability to:

- Access some of the residential streets due to heavy snow or icy conditions;
- Enter and exit the roads that lead to the emergency departments at the major hospitals; and
- Gain access to some of the major senior care facilities.

From these concerns, the BCAS identified five major hospitals and a number of primary health care facilities that are now a part of the City's first response. The City has also provided two key contacts, available 24 hours a day, 7 days a week, if the need for the City's assistance arises.

Vancouver Coastal Health ("VCH")

The concerns of Vancouver Coastal Health during any given snow or ice event, is that roads to the five major hospitals be treated and maintained. As a result, the City has dedicated a vehicle to treating these routes, and has been included in the City's priority response. VCH will treat and maintain the sidewalks around hospitals with their maintenance staff.

Translink/Coast Mountain Bus Company ("CMBC")

The Coast Mountain Bus Company is one of our major partners and we interact with them a number of times throughout the winter season, and certainly during snow and ice events. The City's major snow and ice routes include the entire bus system in Vancouver and are part of the City's priority response when notification from the weather office indicates that a snow or ice event is in the forecast. Two concerns identified by CMBC included:

- Locations where the slightest amount of snow is problematic for buses; and
- A number of bus stops throughout the City which are extremely busy during snow and ice events, where windrows from ploughs create safety issues for passengers boarding and leaving buses.

City crews will treat those locations where traction is an issue for buses, with a mix of sand and salt. In addition, crews will clear and treat those locations where windrows become an issue (e.g., bus stops).

British Columbia Coroners Service ("BCCS")

The City has offered assistance to British Columbia Coroners Service during snow and ice events, at times when navigating local streets could pose a problem.

SNOW AND ICE WEATHER DETAILS AND CITY'S RESPONSE ON DECEMBER 19TH, 2012

This appendix provides a detailed account of the events of December 19th, 2012.

Snow and Ice Event – Forecasted Weather Details - Tuesday December 18th, 2012 to Thursday December 20th, 2012

Issued Tuesday December 18th, 2012 at 7:30am

- 4am to noon (Tuesday): Partly to mostly cloudy. High of 3°C.
- Noon to 8pm (Tuesday): Winds decreasing this afternoon with rain showers. Snow showers possibly starting around 6pm, with some areas receiving no accumulations and other up to 5cm. High of 2°C.
- 8pm (Tuesday) to 4am (Wednesday): Break overnight, with snow showers developing around 6am Wednesday morning.

Issued Tuesday December 18th, 2012 at 11:51am

- Noon to 8pm (Tuesday): Mostly cloudy. A wet snow shower or two after 3pm. High of 4°C. No snow expected.
- 8pm (Tuesday) to 4am (Wednesday): Increasing clouds. Light snow to develop around 1am, with snow mostly at higher elevations. High of 2°C. Trace - 1cm of snow.
- 4am to Noon (Wednesday): Cloudy. Snow increasing around 6am, turning to rain around 11am. High of 2°C. Accumulations of 2 – 6 cm of snow.

Issued Tuesday December 18th, 2012 at 7:16pm

- 8pm (Tuesday) to 4am (Wednesday): Increasing clouds. Light snow develops around 3 to 4am, with snow concerns down to sea level. High of 1°C. Trace - 1cm of snow.
- 4am to noon (Wednesday): Cloudy. Snow increasing around 6am, turning to rain around 11am. High of 2°C. Accumulations of 2 – 6 cm of snow.
- Noon to 8pm (Wednesday): Cloudy. Periods of rain. High of 3°C.

Issued Wednesday December 19th, 2012 at 4:28am

- 4am to Noon (Wednesday): Cloudy. Increasing snow and then turning into rain around 11am. High of 2°C. Accumulations of 2 – 6 cm of snow.
- Noon to 8pm (Wednesday): Cloudy. Rain. High of 3°C.
- 8pm (Wednesday) to 4am (Thursday): Cloudy. Periods of rain. High of 4°C.

Special Statement issued Wednesday December 19th, 2012 at 8:03am

- While warmer air aloft is moving into the area, ever so slowly, the intensity of the precipitation is keeping snow levels down to sea-level (I just had a report that rain-snow mix turned to heavy snow at YVR). Normally what warms you up and turns the snow to rain in these events is a south wind. You're not going to get it, except maybe in the extreme west ends of Vancouver, Richmond and Delta, and even those places I'm not confident that's going to happen. Still, enough warming should develop for North Vancouver, Vancouver, Richmond, Burnaby, Delta to see a switch over to rain sometime today below 300m. It won't be a clean warm up as when the snow lightens up it turns to rain, when the rain increases, it turns back to snow. It'll eventually stop doing that.

Issued Wednesday December 19th, 2012 at 11:20am

- Noon to 8pm (Wednesday): Cloudy. Wet snow and rain, turning to all rain later this afternoon. Could be all rain west half of the city by 1pm. High of 3°C and low of 0°C. Accumulations of 2 – 6cm of snow.
- 8pm (Wednesday) to 4am (Thursday): Cloudy. Rain decreasing in the evening. High of 4°C and low of 3°C.
- 4am to Noon (Thursday): Cloudy. Periods of light rain. High of 4°C and low of 3°C.

Issued Wednesday December 19th, 2012 at 7:31pm

- 8pm (Wednesday) to 4am (Thursday) – Cloudy. Periods of rain decreasing late. High of 4°C and low of 3°C.
- 4am to noon (Thursday) – Cloudy. Periods of rain increasing late. High of 4°C and low of 3°C.
- Noon to 8pm (Thursday) – Cloudy with a bit of clearing late. Rain tapering off after 5-6pm. High of 5°C and low of 2°C.

Issued Thursday December 20th, 2012 at 4:54am

- 4am to Noon (Thursday): Cloudy. Periods of light rain. High of 4°C and low of 3°C.
- Noon to 8pm (Thursday): Cloudy. Increasing rain. High of 5°C and low of 4°C.
- 8pm (Thursday) to 4am (Friday): Partial clearing after midnight. Rain breaks up in the evening. High of 4°C and low of 0°C.

Snow and Ice Event – Actual Weather Details Reported by Environment Canada - Tuesday December 18th, 2012 to Thursday December 20th, 2012

Tuesday December 18th, 2012

- 12am to Noon: Mostly cloudy with rain and snow showers. Trace amount of snow. High of 4.8°C and low of 0.1°C.
- Noon to 6pm: Mostly cloudy. High of 4.8°C and low of 1.1°C.
- 6pm to Midnight: Mostly cloudy with evening warming. High of 3.5°C and low of 1.1°C.

Wednesday December 19th, 2012

- 12am to Noon: Cloudy with snow and rain. 5cm of snow. High of 3.6°C and low of 0.3°C.
- Noon to 6pm: Cloudy with rain and snow showers. 2cm of snow. High of 4.8°C and low of 0.4°C.
- 8pm to Midnight: Cloudy with rain. High of 5.3°C and low of 4.6°C.

Thursday December 20th, 2012

- 12am to Noon: Cloudy with rain. High of 5.3°C and low of 1.7°C.
- Noon to 6pm: Cloudy with rain. High of 5.7°C and low of 5°C.
- 6pm to Midnight. Cloudy. High of 5°C and low of 3°C.

Snow and Ice Event – City's Response - Tuesday December 18th, 2012 to Thursday December 20th, 2012

From 9pm Monday December 17th, 2012 to 7am Tuesday December 18th, 2012
- Snow and ice response level 2
- 8 trucks (Sanitation crews) were deployed to salt all major routes, including bridges and priority hills.

From 7am Tuesday December 18th, 2012 to 7pm Tuesday December 18th, 2012
- Snow and ice response level 2 upgrade to a snow and ice response level 3 at noon.
- 10 trucks (Streets crews) were deployed to salt all major and secondary routes. In addition, 2 Kubota's were deployed to salt priority bicycle routes and the Seawall.

From 7pm Tuesday December 18th, 2012 to 7am Wednesday December 19th, 2012
- Snow and ice response level 3
- 14 trucks (Sanitation crews) were deployed to salt all major routes and plough as needed.

From 7am Wednesday December 19th, 2012 to 7pm Wednesday December 19th, 2012
- Snow and ice response level 3 upgraded to a response level 4 at shift change.
- 28 trucks (Streets crews) were deployed to salt and plough all major and secondary routes. 1 Kubota was deployed to salt and plough downtown priority 1 bicycle routes, and another was deployed to salt and plough the Seawall. In addition, approximately 50 CUPE 1004 employees were shoveling and salting priority bus stops and high pedestrian areas.

From 7pm Wednesday December 19th, 2012 to 7am Thursday December 20th, 2012
- Snow and ice response downgraded to a level 3 during 7pm shift change, and then further downgraded to a response level 2 at midnight.
- 20 trucks (Sanitation crews) were deployed to salt major and secondary routes. Most snow accumulations were gone by midnight, at which time 14 trucks remained to salt major routes.

SNOW AND ICE RESPONSE – HOT SPOTS

This appendix provides a summary of "Hot Spots" throughout the city, which moving forward, will receive added attention during the City's snow and ice response. They include:

- 41st Avenue from Main Street to Fraser Street;
- Granville Street from the south end of the Granville Bridge to King Edward Avenue;
- Knight Street from 33rd Avenue to 41st Avenue;
- The hills north of West 4th Avenue, including NW Marine Drive, Blanca Street, Tolmie Street, Sasamat Street, Belmont Avenue., West 2nd Avenue, West 3rd Avenue, Trimble Street, Bellevue Drive and Locarno Crescent;
- Canuck Place on Matthews Avenue;
- Oak Street from 6th Avenue to Broadway;
- Spruce Street from 6th Avenue to Broadway;
- Alder Street from 6th Avenue to Broadway; and
- Victoria Street from 57th Avenue to SE Marine Drive.