Municipal and Regional Water Systems Concept of Operations –Emergency Response Plan

Prepared for: Regional Engineers Advisory Council (REAC) Water Sub-Committee

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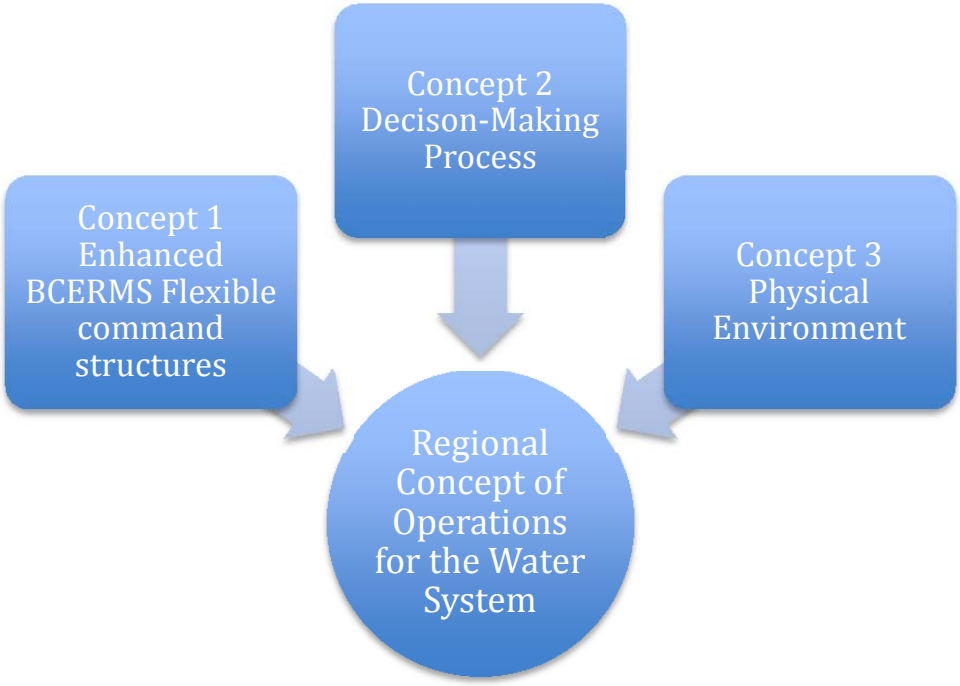
EXECUTIVE SUMMARY

The purpose of this report is to design a strategy aimed at improving regional communication and resource coordination in the event a major earthquake disrupts the supply of water to the 2.2 million residents in greater Vancouver, British Columbia. The deliverable of the report is a set of concepts that if implemented, will improve the communication level between water system managers and regulators and facilitate more effective decision-making during the recovery effort. This is a complex task, given the governance structure in the region. The regional body (Metro Vancouver) provides bulk water to 22 autonomous municipalities, one electoral district and one treaty first nation member. Each municipal organization is distinct from one another and each of them makes decisions largely in support of the citizens whom they represent.

The report is based on a literature review and interviews with various stakeholders who manage the regional and municipal water utilities, as well as their provincial regulators. A framework composed of three concepts creates a foundational piece that will facilitate efficient communication by key decision makers across the region. The framework is built on 3 principle constructs:



When all three concepts are combined, they form a regional concept of operations that will be offered to all the water systems. The concepts provide the following function:

- Concept 1 – Proposes enhancements to the British Columbia Emergency Response Management System (BCERMS), the hierarchical command

structure used in emergency situations, to facilitate better information sharing and more flexible decision-making.

- Concept 2 – Designs a decision-making process with response and restoration principles that support collaboration amongst the stakeholders.
- Concept 3 - Creates a physical environment with a central meeting location and standard communication protocol

Implementing the three components of the framework will require leadership by the client, the REAC water sub-committee. The REAC water sub-committee is made up of water managers from Metro Vancouver and the various municipalities that buy their bulk water from Metro Vancouver. There will be political challenges and considerable change management needed for successful implementation. Nine action items are recommended to support implementation of the concept of operations framework. They are:

- Action 1 – Develop mutual aid networks to improve the speed at which critical resources can be shared in the case of emergencies.
- Action 2 – Enhance command structures at the municipal level and at the regional level to provide liaison resources to improve information sharing and collaborative decision-making
- Action 3 – Develop a communication platform strategy that will ensure sufficient redundancy of communication mediums is available post disaster.
- Action 4 – Create a requirement for annual simulations to exercise the concepts of the framework
- Action 5 – Develop a training program for water professionals that provides basic managerial and leadership competencies needed during crisis situations.
- Action 6 – Commission a study to identify all critical facilities and create GIS maps to support the decision-making process.
- Action 7 – Commission a provision of water strategy to ensure critical water utility staff is not burdened with furnishing temporary water during the initial response phase.
- Action 8 - Identify senior government champions both at the municipal and regional levels that will drive the recommendations of this report forward.
- Action 9 – Determine a Backup EOC Location in case the primary EOC location is damaged beyond use.

Once the framework is politically accepted, and a plan to tackle the nine action items is established, ongoing maintenance needs can be addressed. Key contacts and system information and will need to be gathered and kept current. Agreements

with vendors and other agencies will also need to be established and maintained. The limited work capacity of the REAC water sub-committee members will restrict how much can be done without additional dedicated resources. Hiring an emergency planner at approximately $150,000 per year is recommended to advance this work.

One final note, if these recommendations are acted upon, there is the potential that this concept of operations could be used as a model and "scaled up" to integrate more essential lifelines like electricity, natural gas, sewage disposal and debris management. The contents of the report could serve as a launching point for a truly coordinated all-encompassing disaster response plan that provides an even larger benefit to the region. That will take far more work, but the framework developed for the water system may be the blueprint needed to make a full concept of operations a reality.

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ACKNOWLEDGEMENTS

Project Client: Regional Engineers Advisory Committee (REAC) Water Sub-Committee

The client for this project is the Regional Engineers Advisory Committee (REAC) Water Sub-Committee, which is comprised of water utility managers from around the region. The Water Sub-Committee reports to the parent REAC committee comprised of the City Engineers in the region. Policy actions proposed by the Water Sub-Committee are typically advanced as recommendations through the REAC committee for further consideration. The Water Sub-Committee is led by one of the members of REAC. Currently, Andrew Wood, City Engineer of Port Coquitlam chairs the Water Sub-Committee.

The recommendations contained in the report have been accepted for information the REAC Water Sub-Committee. The researcher wishes to thank all of the committee members for their assistance on this project. Their input has greatly shaped the conclusions and recommendations.

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INTRODUCTION

Recent events around the world have highlighted the vulnerability of cities to man-made and natural disasters. Earthquakes in Japan, New Zealand and Chile have shown how vulnerable modern cities are to the devastating effects of earthquakes. The recovery effort from the earthquake in Christchurch, New Zealand is expected to cost over $34US Billion once completed, representing what Prime Minister John Keys called the "largest and most complex, single economic project in New Zealand's history". (Scott, 2013) Hurricane Katrina and super storm Sandy further highlighted the interdependency of critical lifelines like water, sewer, and electricity and transportation networks during large disaster events.

In the lower mainland of British Columbia, current planning for a significant earthquake is insufficient. A Regional Initiative by the Joint Emergency Liaison Committee (JELC) completed in 1997 (Harding et al, 1997) identified a number of initiatives to improve preparedness, which included documenting vulnerabilities in the regional and municipal water systems. Following the report, a number of recommendations were acted upon, but others, key to improving communication in the region have still not been addressed. Recommendations to develop "communication protocols" and identify the "restoration of services priorities" are still outstanding.

The purpose of this report is to design a strategy aimed at improving regional communication and resource coordination in the event a major earthquake disrupts the supply of water to the 2.2 million residents in greater Vancouver, British Columbia. The paper addresses the specific recommendations of the JELC report that called for improvements to regional communication and coordination in the case of a major earthquake. The product is a set of concepts that if implemented, will improve the communication level between stakeholders and facilitate more effective decision-making during the recovery effort. This task is complex, given the governance structure in the region. There is a regional body (Metro Vancouver) that provides bulk water to 22 autonomous municipalities, one electoral district and one treaty First Nation member. Each municipal organization is distinct from one another and each of them makes decisions largely in support of the citizens whom they represent.

The report assesses the usefulness of enhancing the widely adopted BCERMS hierarchical command structure to support better cross-organizational response and recovery. A mutually agreeable decision-making process specific to the regional/municipal water systems is also proposed to improve information exchange and facilitate joint decision-making between the regional entity Metro

Vancouver and its 24 member organizations. Strengthening these systems will better prepare everyone if their capacities are overwhelmed during a significant event.

The client for this project is the REAC Water Sub Committee, a group comprised of the regional and municipal water managers. They have a vested interest in identifying who will be responsible to restore the water system post disaster. Developing an emergency preparedness plan, that considers a disaster extending beyond the boarder of any one municipality, has the potential to improve the overall regional response and facilitate recovery much faster than the current municipality-based approach.

The report concludes by proposing a framework for a concept of operations comprised of three components – enhancements to the BCERMS flexible command structure, a decision making process and a physical environment for a regional emergency operations center (EOC). A total of nine discreet projects are proposed and scoped as part of the implementation strategy.

BACKGROUND

The background section of the report sets the context for seismic risk in the region, and then reviews the governance model that exists in the region. The considerable seismic risk combined with the vast number of autonomous political systems creates a scenario that may overwhelm the individual capacities of the various jurisdictions. Calls for help may not be answered in an efficient manner because each organization is largely insulated from each other.

The last important background detail highlights the work currently being done by others on this issue. The Integrated Partnership for Regional Emergency Management (IPREM) is working on a broader preparedness exercise within the region. Unlike this paper that focuses solely on the water system, their work looks at all of the emergency lifelines such as transportation, social services, critical infrastructure and others. For the future applicability of this paper, it is important that the findings adhere to the principles already developed by IPREM.

Seismic Activity in the South Coast of British Columbia

In the lower mainland of British Columbia, the probability of an earthquake is far higher given the proximity of a number of tectonic plates and their corresponding fault lines. The Juan de Fuca plate (shown in the diagram below) is being forced east due to pressure from the Pacific plate. This pressure is forcing the dense Juan de Fuca plate under (subduction) the less dense North American plate at a rate of 45 mm/year. (Potter, 2013) As the Juan de Fuca plate subducts the North American plate, the incidence of volcanic activity and earthquakes increases on the surface directly over the subduction activity. In the Pacific North West, this action will eventually lead to increasingly significant seismic events. The region has not had a significant event in over 200 years and seismologists have suggested that a substantial earthquake could hit the region within our lifetime. (Potter, 2013)

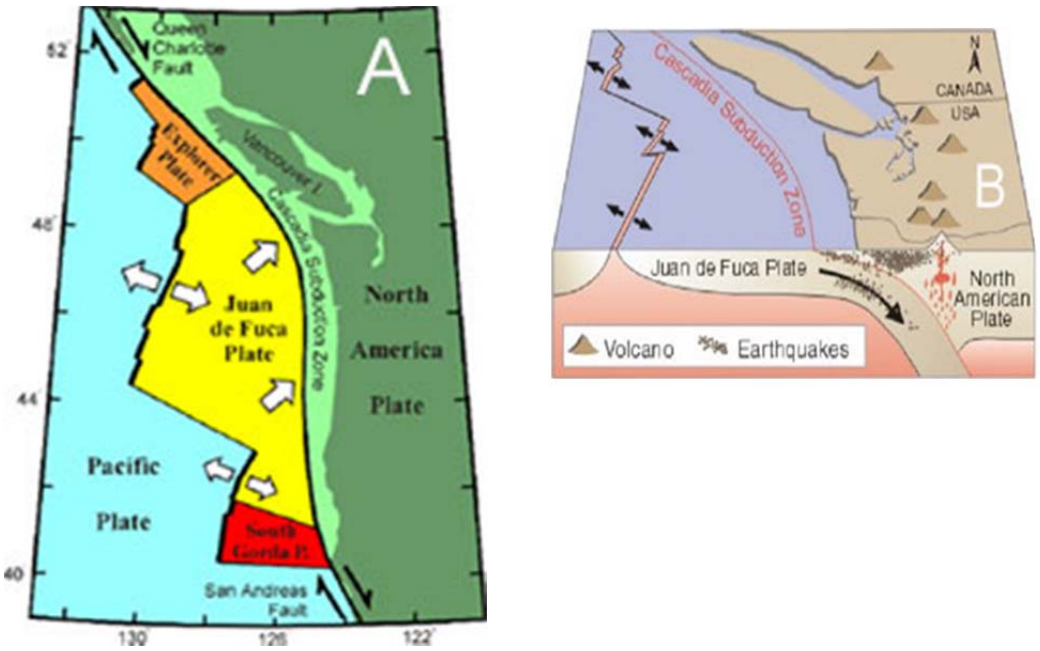

Figure 1 – Tectonic Plates in South Coast of British Columbia (Potter, 2013)

Metro Vancouver – Regional Entity and Municipalities Working Together

The region of the lower mainland of British Columbia shown in figure 2 contains 22 distinct municipalities, one electoral district and one First Nation member. (Metro Vancouver, 2013) The regional governing body, Metro Vancouver, provides a number of cross municipal services such as water supply, sewage collection and treatment, and solid waste management. These services are delivered more efficiently by the regional body rather than having individual municipalities construct their own facilities. This model is not unique; San Francisco for instance has a regional entity that serves as the wholesale provider of water, while the individual municipalities distribute water to the end customer.

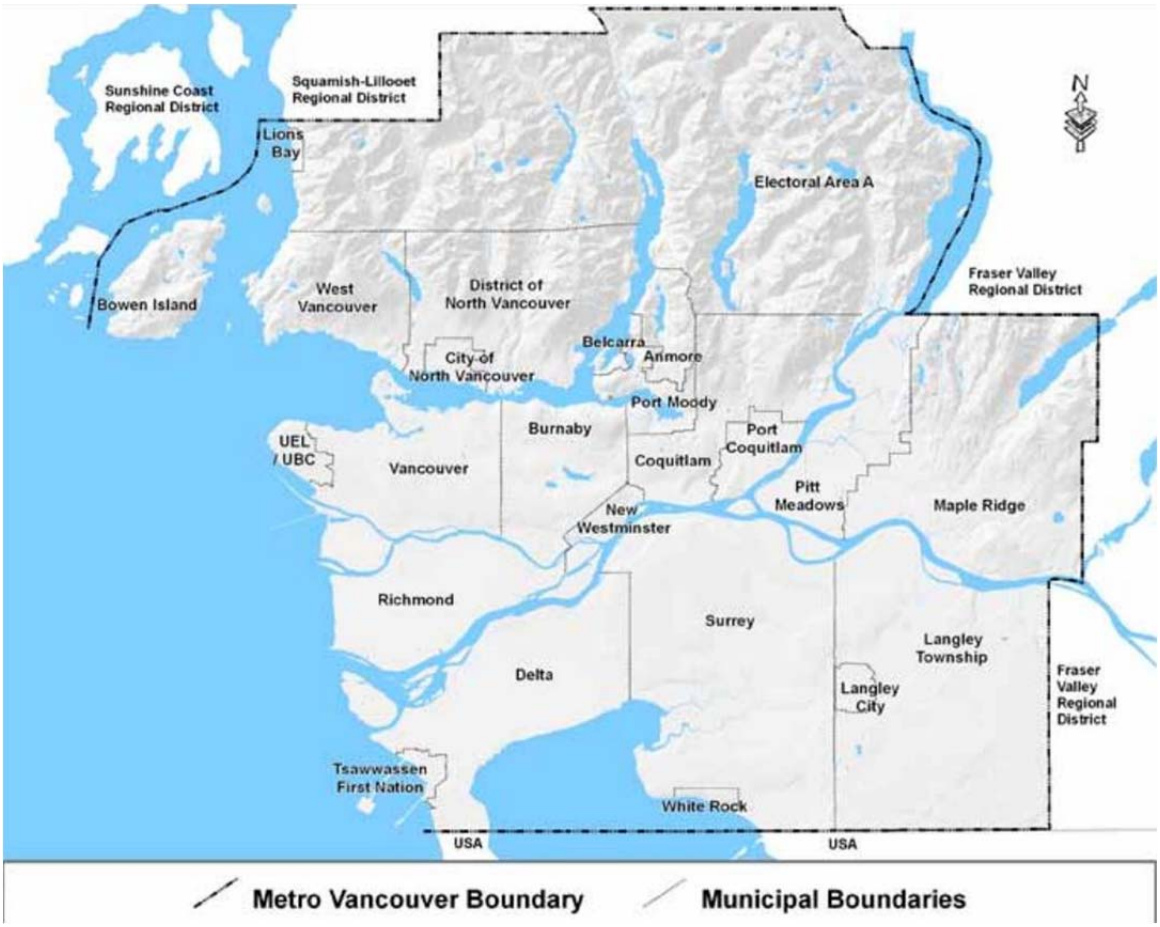

Figure 2 –Metro Vancouver Member Municipalities (VannStruth, 2012)

The regional water system, owned and operated by Metro Vancouver, consists of three alpine lakes located in protected watersheds. These lakes provide the majority of the water delivered to the region. An extensive transmission network supplies water to each municipality. All water entering a municipal system is metered, and each municipality pays volumetrically for what they consume. Once delivered into the municipal systems, distribution responsibility shifts to the local jurisdiction, which owns and operates their own distribution systems.

IPREM - Similar Planning Work Currently Underway

The Integrated Partnership for Regional Emergency Management (IPREM) initiative, spearheaded by the Province and Metro Vancouver, was formed to provide a focused look at a number of regional preparedness activities including the development of a 'concept of operations'. (IPREM, 2012) Their mandate is to analyze all of the critical lifelines that society relies upon for daily life. Prior to considering how the various lifelines like water, sewer, fuel, electricity etc., would be managed during a disaster, the IPREM team spent considerable effort consulting the regional stakeholders on basic underlying principles that need to be upheld for any plan to succeed. In the fall of 2012, these principles were finalized and

endorsed by the IPREM Steering Council made up of municipal, regional and provincial officials. The full text of the agreed principles are contained in appendix 1 and summarized below:

1. Local authorities maintain autonomy
2. Utilize existing structures to achieve regional coordination
3. Utilize existing resources
4. Pro-active leadership
5. Scalable, flexible and layered approach
6. Model(s) focus on process (es) to determine outcomes
7. Local authorities commitment
8. Collaborative decision making
9. Preparedness, training and exercises (IPREM, 2012)

To minimize conflict and create the best possible chance for success, the recommendations contained in this paper align closely with the principles adopted by IPREM in 2012. By ensuring alignment, the recommendations are more likely to be endorsed by the broader emergency management community, thus more likely to be implemented. There is potential that the work in this report can serve as a scalable blueprint for the broader concept of operations contemplated by IPREM.

LITERATURE REVIEW

This literature review section sets the initial context by defining an emergency in the water system, and is followed by a brief explanation of the four stages of an emergency. With this basic context set, the research narrows to focus on the strengths and weaknesses of hierarchical emergency command structures. Decision-making models and best practices are discussed as well. The final component of research examined the type and formation of command structures used in Emergency Operation Centers, and how decision-making frameworks are employed within those command structures. The information summarized in this section creates the basis for the three ideas that become the proposed concept of operations.

Definition of a Water System Emergency

A water system emergency exists "when a populated service area is expected to be without water for three days or more, or when water users with critical needs, lose service for a prolonged period". (Hussein & Grigg, 2000 p. 233) Critical users in an urban environment are hospitals, schools, emergency relief centres and sites with many employees. (Hussein & Grigg, 2000)

Therefore, when a water outage is expected to exceed three days then the regional emergency systems (emergency operation centers and related emergency management plans) are expected to activate. Therefore, the recommendations proposed in the report are based on an event that meets the requirements of this definition.

The Four Stages of Emergency Management

According to Dr. John Twigg, emergency management is a cycle comprising of four stages; mitigation, preparedness, response and recovery. (Twigg, 2004) This cycle is an established model applied as a best practice to all emergency planning.

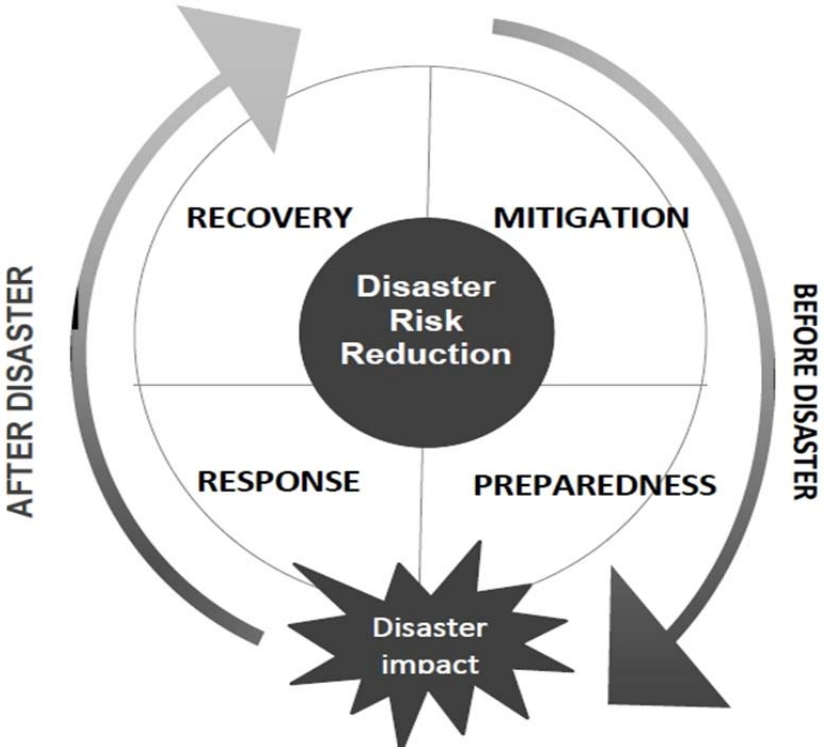

Figure 3 – Disaster Cycle (*Twigg, 2004)*

Mitigation works are activities that prevent an emergency or reduce the chance of an emergency from happening. Mitigation activities take place before and after the emergency happen. (Twigg, 2004) For water systems, mitigation activities often refer to resiliency improvements to the physical system. A simple example is the replacement of early 20th century brittle cast iron water pipe with modern ductile iron water pipe. Earthquake resistance depends on the ability of the pipe to move with the ground. (Ballantyne, 2008)

Preparedness includes plans or preparations done in advance of an event. The objective of the planning process is to save lives and improve response and recovery operations. (Twigg, 2004) For a water system, a number of activities require preplanning like the temporary provision of water, creating a network for mutual aid support and ensuring adequate supply of materials needed to repair damage in the system.

Response refers to the actions taken during an emergency. Actions include saving lives and preventing property damage. For a water system, the most critical response activity is ensuring water is available for fighting fires. Broken mains need to be isolated to maintain pressure in the system and prevent damage to property.

Recovery takes place after the initial response concludes. During this stage, systems are restored and often improved to defend against similar future events. This is often the most expensive and time intensive stage of the disaster as property and

infrastructure is rebuilt. (Twigg, 2004) For a water system, damage can occur in pipelines, reservoirs, dams and treatment facilities.

The recommendations in this paper focus on the preparation stage of the emergency cycle. And in particular, the concepts create a framework to help Metro Vancouver and the 24 jurisdictions work together better. Ongoing annual investments from the local governments into the water system are gradually improving the resiliency of the system. However, little work has been done to develop a robust communication network that facilitates rapid information exchange and resource deployment. Exploring the hierarchical command structures currently in use is a key area of interest, as any desired improvements to communication will need to consider how local governments make decisions.

Maintaining Control during an Emergency Situation - Incident Management Systems and the British Columbia Emergency Response Management System (BCERMS)

In British Columbia every government jurisdiction is expected to employ the British Columbia Emergency Response Management System (BCERMS) in their emergency operations environments. BCERMS is a command structure based on the Incident Management System (IMS) developed in the 1980's to address routine wildfire events in Southern California. (Perry, 2003) Since the 1980's, the structure proved effective in organizing resources needed to address discreet emergency events. For events like building collapses, forest fires and flooding events proved, the hierarchical structure has become the standard for command structures across North America including British Columbia. For illustration purposes, an example of the BCERMS structure is shown in figure 4.

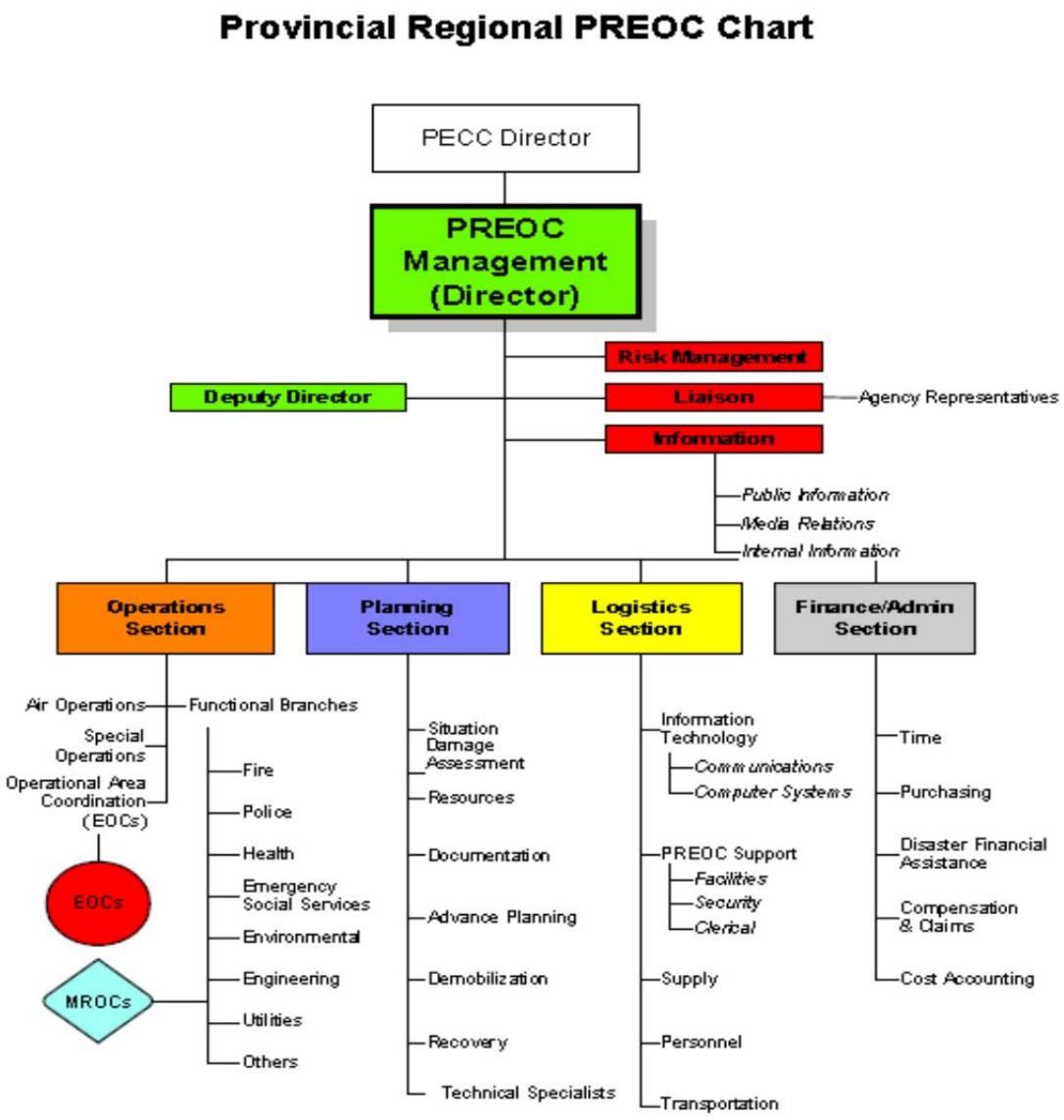

Figure 4 – Province of BC Emergency Response Management System

The key functional components of BCERMS are Management, Operations, Planning, Logistics and Administration. The roles of each functional component are described below:

Management (shown in green & red) – Management sets policy, priorities, manages deployment of resources and is responsible to communicate with the public and other agencies. In addition to a Director and Deputy Director that command the operation, there are three other key roles of the management team. Risk Management considers where the greatest risks lie in the response and recovery. Their primary role is to provide information to the Director that minimizes the loss of life and property damage. The Liaison role is tasked with

communicating with other agencies and reporting their activities to the Director. Finally, the Information team provides a linkage to the public and media with information generated internally. (Province of British Columbia, 2000)

Operations (orange) – Operations lead the fieldwork and carry out incident objectives by coordinating resources based on their needs. All of the agencies that have staff in the field, such as Fire, Police, Ambulance, Engineering and Social Services are represented at the Operations table and report to the Operations Chief. (Province of British Columbia, 2000)

Planning (blue) – Planning gathers the information necessary to guide operations and optimize resource allocation. The Planning team gathers information and looks ahead at what activities are required in the future. Regular situational reports prepared for the Director is a common requirement for the Planning team. (Province of British Columbia, 2000)

Logistics (yellow) – Logistics is the team responsible for obtaining materials, equipment, fuel, food, medical services and communications. The Logistics team works closely with Operations to ensure they have the resources needed to be effective in the field. Effective management of logistics ensures others are able to be effective in their roles. (Province of British Columbia, 2000)

Administration/Finance (grey) – Admin and Finance provide accounting, cost tracking, and procurement functions. The administrators organize information needed as records. They work closely with the Logistics team assisting with the costing and payroll for all resources. They also provide a vital link to senior levels of government in the event that financial support is made available. (Province of British Columbia, 2000)

BCERMS has proved to be an effective tool when a single director can control the entire response. Sometimes a single point of control cannot be established and this can occur during larger disasters. Recent events like the Indian Ocean tsunami, Hurricane Katrina and super storm Sandy, have generated questions on the overall effectiveness of the rigid hierarchical structure. Dr. John Harrald of George Washington University suggests there is a trade-off between rigid command and control, and the need to react to unforeseen conditions that often require improvisation from a host of actors not directly referenced in the closed IMS system. (Harrald, 2006)

Events from Hurricane Katrina highlighted this weakness when emergency officials were quickly overwhelmed and unable to effectively respond to failed levees and extensive flooding. The initial need for help from outside organizations and the subsequent need to manage the thousands of arriving volunteers were hampered by the rigid control system in place. (Harrald, 2006)

Harrald summarizes the failings of the Incident Management System by stating:

> "Diverse organizations must achieve technical and organizational interoperability requiring common structure and process while absorbing and interacting with thousands of spontaneous volunteers and emergent organizations." (Harrald, 2006 p. 257)

This theory presents a significant learning point for this project given the high number of autonomous organizations. Ensuring both discipline (structure) and agility (creativity and adaptability) is complicated requiring a stronger emphasis on the liaison role within BCERMS.

Enhancing the liaising activities needs to be done in two ways. First, the municipalities need to bolster their structure to include resources dedicated to regional information gathering. By doing this, it creates an "outward looking" team able to reach out to others who are also looking to share information. Secondly, there needs to be a host organization that can bring together the autonomous agencies for the purpose of information sharing. Therefore a collaborative command structure is needed to facilitate a regional response. Unified command theory may hold the key to solving the information exchange issue.

Unified Command Theory

In the years following Hurricane Katrina in New Orleans, many studies and reports deemed the local, state and federal response a failure. (Wise, 2006) Katrina was the first major disaster to hit the U.S. since the 9/11 terrorist attacks and served as the first significant test for the Department of Homeland Security, formed shortly after 9/11.

The primary failure during initial response and the subsequent recovery effort was the lack of co-ordination between the various levels of government and even lack of communication between departments within the same level of government. Unclear legislative authority, unprepared and insufficiently trained local responders also hampered the effort. (Wise, 2006) A report commissioned by Congress noted that "three operational commands were established during Katrina, but there was no unified command that took charge of the entire operation". (Moynihan, 2009 p. 902)

Understanding "who was in charge" proved to be contentious during Katrina, and was an underlying theme around the lack of integration. The same potential exists for the Lower Mainland. Because the Lower Mainland has never been overwhelmed by a disaster, there has not been the need to contemplate a large-scale operation. Developing a unified command model prior to a disaster should serve as the most important lesson from Katrina. At the conclusion of the House Committee Investigation, Secretary Chertoff stated to FEMA chairman Michael Brown: "You guys need to be connected together. That means unified command. What that

means is everybody who has command responsibility has to be in one place". (Wise, 2006 p. 305) Since Katrina, the Department of Homeland security has contemplated many organizational changes to improve response. (Monyinhan, 2009)

A unified command model creates a mechanism that allows two or more entities, which have their own individual authorities, to meet, set goals and collaborate on ways to contribute to the shared goals of the response plan. (Carwile, 2005) Locally, a unified command model will be crucial given the political autonomy of each municipality and stakeholder organizations.

Decision-Making Theory

Making decisions during an emergency often requires working with the best information available. Traditional decision-making is a result of modeled alternatives incorporating uncertainty. (Aven & Korte, 2003) From these alternatives, a decision is made. Traditional decision-making may also consider cost/benefit analysis, using money as the primary factor in which a decision is made. (Watson, 1981)

New theory is pointing researchers towards decision analysis tools that are designed to aid a decision-maker rather than using a mathematical proxy as the deciding factor. The concept of decision analysis proposed by Steven Watson in 1981, acknowledges the complexity of decision-making when decision makers are faced with conflicting goals. (Watson, 1981) A preferred method of decision-making during emergency events integrates a formal risk analysis. (Aven & Korte, 2003) Risk analysis requires an assessment of attributes so that consequences can be weighed against each other. Because numerous attributes are considered, each with their own performance metric, informal managerial judgment is required to finalize the decision. (Aven & Korte, 2003)

A case study relating to a rail disaster in the UK concluded that a shared mental model is also needed in advance. A shared mental model consists of a set of goals and outcomes desired during the emergency event. (Smith & Dowell, 2000) The shared mental model is best designed by the responding agencies that will come together and work collaboratively during the event. The agreed upon goals enables team members to generate similar expectations about a dynamic situation.

For purpose of this project, a shared mental model consisting of response principles should be designed and discussed with the key actors prior to the event. Another important point of consideration is the conflict that inevitably occurs when distributed decision-making is used instead of individual decision-making. Given that a unified command model will involve distributed decision-making, the process should also anticipate difficulties in obtaining consensus. (Aven & Korte, 2003)

Unified Command Emergency Operations Center

The final element is the composition of emergency operation centers. The research looked at examples of Emergency Operation Centers (EOC) that operate under a unified command model where decision-making is done collaboratively rather than through a 'command and control' hierarchy. If substantial changes are made to BCERMS and a collaborative decision-making process is created, then a physical environment that encourages collaboration is needed as part of the project.

An EOC is a physical place as well as a social system. It centralizes into a single location the personnel and equipment needed to manage under diverse types of emergencies. (Kendra & Walchendorf, 2003) Ultimately it serves as headquarters for decision-making during a disaster event and it supports the operational response occurring in the field.

For Metro Vancouver and their member municipalities, the environment should be built on a goal of coordinating the interaction of various agencies at different levels of government. Each municipality and agency will have its own established command hierarchy. However, when they are participating in regional response activities, the autonomous nature of each organization will dictate consensus decision-making, as no one is likely to delegate authority to another group. In order to meet this goal of creating a collaborative environment, a number of basic questions need to be answered:

- Where will the EOC be located?
- Who is invited to participate in discussions?
- What type of communication protocols will best support collaboration?

Discussion is required with the stakeholders to understand their expectations and constraints around proximity and travel to a central location. Designing an acceptable environment becomes the foundation for information exchange and collaborative decision-making. Once combined, these three elements create the framework for a regional concept of operations.

FRAMEWORK FOR A REGIONAL CONCEPT OF OPERATIONS

Three components are proposed as the foundational requirements for a regional water system concept of operations. The three components; enhancements to the BCERMS command structure to increase flexibility and introduce more rapid information sharing, a decision-making process that supports a regional response and establishing a physical/virtual environment for information sharing and decision-making activities. The conceptual framework is graphically illustrated the following way:

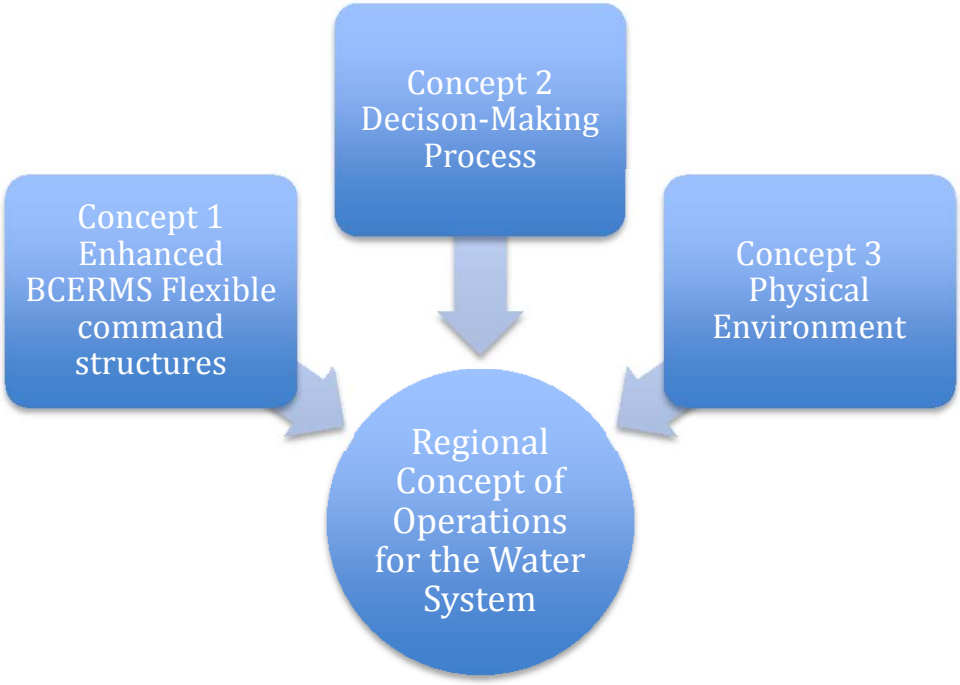

Figure 5 – Regional Concept of Operations for the Water System

The three components cannot exist in isolation, each depend on the other. This approach differs from the current state of emergency preparedness. Currently, each municipality and Metro Vancouver have individual command structures that activate during an event. As well, each have a decision making process that is led by one commander in chief and each has established an EOC. Each municipality will continue to operate their own structures complete with their own EOC. This proposal creates a point of connection to tie the EOC's together.

By integrating these concepts regionally, it forces each of the organizations to expand their view and consider what impacts are being felt outside of their jurisdiction. The benefits are vast, from increasing access to mutual aid to coordinating communications between the media and the public. The reason this has never been done is because it requires everyone to recognize that no one leader will direct the operation. Without a commander in chief, this proposal requires

collaboration rather than direction. From a political standpoint, that has been challenging. The work IPREM is conducting is taking on that challenge by engaging local politicians in their initial activities.

Failing to act on this issue will result in slower response and recovery times leading to higher amounts of property damage and increased risk to life safety. If an event occurs and the disparate nature of 24 separate jurisdictions provides a slow and awkward response, there will be mounting pressure to amalgamate many of the jurisdictions into larger organizations. Potentially all 24 municipalities could become one jurisdiction. So far, there has been no political appetite to amalgamate, but a poorly managed disaster may force senior levels of government to impose amalgamation requirements.

The concepts presented in the next sections were developed from the literature review, as well as through feedback gathered from initial interviews held with REAC Water Sub-Committee members.

Concept 1: Enhancing the roles in BCERMS

In order to build the flexibility and innovation identified by Harrald and others, (Harrald 2006, Smith, 2004) increasing information sharing capacity is critical. In order to accomplish this, three new roles are proposed for inclusion in the member municipality command structures under the broad title of Inter-organizational Communications – Regional Liaison, Situational Awareness, and Integrated Planning.

As discussed earlier in the report, BCERMS currently does have an identified role for liaison work. During typical activations, the Liaison is tasked with creating communication links to outside agencies to the internal groups such as Operations, Planning and Logistics. Once those connections are made, their efforts shift to external communications with the public via the media.

The proposed addition of the Inter-organizational Communication roles creates a sustained emphasis on liaison and information sharing activities. Rather than passively waiting for information to arrive, they continue to actively seek information from stakeholders outside of their jurisdiction for the duration of the event. Their sole focus is about understanding what is happening outside of their municipality. When asked about the need for this role, one emergency manager stated, “We expect all of the other stakeholders will come to us and keep us briefed all the way through the event”. This proposal flips that assumption around and creates the responsibility and the resource for the organization to actively pursue that information, instead of waiting for it to come to them.

Prior to going into detail on the duties of each role, an illustration of the enhanced structure is presented in figure 6. The location of the Inter-organizational

Communication layer is strategically placed to report directly to the EOC director. This is suggested to ensure that regional information is fed to the Director unfiltered. The information needs to be unfiltered so that the Director can weigh potential outside needs against internal needs in an unbiased way. Each of the roles contained in the Inter-organizational Communications team is explained in more detail.

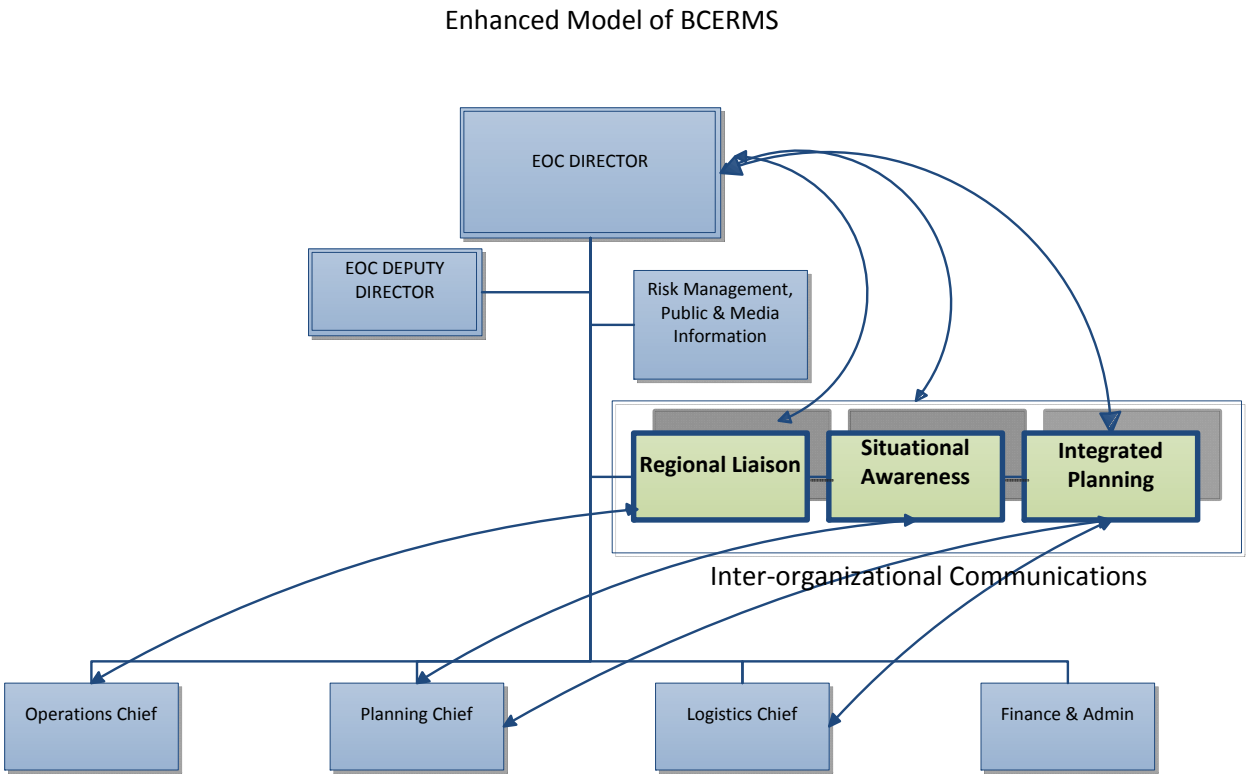

Figure 6 – Proposed "Inter-organizational Communications" layer within BCERMS

Regional Liaison – This position will be tasked to actively solicit information from agencies outside of the direct control of their EOC. In the case of this project, interaction with the Regional Water EOC will enable information sharing on incidents and activities occurring to the water systems outside of their jurisdiction. This role will filled by the representative attending the regional discussions and responsible to represent their organization in the decision-making process. Depending on the size of the organization, the role may be expanded further to include related utilities like sewers, electricity and gas distribution. The information they gather will be delivered directly to the EOC director and the appropriate table leads via the Situational Awareness lead.

Situational Awareness – This role is responsible for gathering all of the information gathered through the liaison role. In many cases, data scarcity or information

overload plague the EOC. (Smith & Dowell, 2004) This role is required to mine the information into a succinct report for the director. The report broadens the awareness of the EOC by creating context for the resource demands others may be facing. For instance, a neighbouring municipality may be dealing with extensive damage that limits service to critical sites. That knowledge may trigger a reprioritization of internal resources to assist the neighbouring municipality. That situational awareness may uncover a potential impact to them. For instance – water in the region flows from the north to the south. If damaged infrastructure in the northern region of the system restricts flow to southern municipalities, it is in the best interest of the southern municipalities to lend assistance to the northern communities.

Integrated Planning - Not to be confused with the Planning role ingrained in the existing BCERMS structure, Integrated Planning seeks to synthesize the regional situational information into the home municipality's recovery plan. The existing vertical planning (incident driven) team will maintain their task of focusing on incident planning under the control of the EOC, while the Integrated Planning role will take a broader regional look, presenting broader deployment options to the Director. For example, they may deem that the regional damage to the water utility is a greater priority than the damage to their own system. A recommendation by the Integrated Planner to reallocate internal resources outside of their organization may be met with resistance by the Planning lead, especially if that slows progress on active incidents in their organization. As a result, one should anticipate and even encourage a push-pull relationship between the Planning chief and the Integrated Planning lead.

METRO Vancouver – Unified Command - The previous section proposed an enhancement to a municipality's command structure. Inserting the Inter-organizational Communication layer in Metro Vancouver's structure requires a slightly different approach. Because of their status as the wholesale water provider for the entire region, Metro Vancouver is the natural linkage to the other organizations and is best positioned to facilitate information sharing between their members.

Metro Vancouver is also empowered under their Act to decide who will receive water during an emergency. (Harding et al, 1997) Even though they have the legislated authority, Metro staff has repeatedly expressed reluctance to exercise this power in determining where and when water is restored. Creating a way to share that decision-making authority in an efficient way is their preferred solution. Therefore, with Metro Vancouver expressing the desire to share the decision-making process with the member municipalities, they become the natural organization to lead the unified command structure. They deliver bulk water to all of the municipalities and have built strong networks with the local Health boards and Province. However, if Metro Vancouver takes the role of information host for 24 jurisdictions as well as dealing with their own incidents, the logistical challenge

may overwhelm their response structure. They too, will need to carefully consider how to suitably resource their Inter-organizational Communication layer.

Their Inter-organizational layer would have slightly different roles than their member agencies. If they host the environment, they will need to provide a number of roles that facilitate information transfer – liaison to members, meeting facilitation, information management, public relations and collaborative decision-making. Rather than calling it an Inter-organizational Communication layer, a more appropriate term would be Inter-organizational Network since their goal is to bring together others from around the region. These roles are elaborated below.

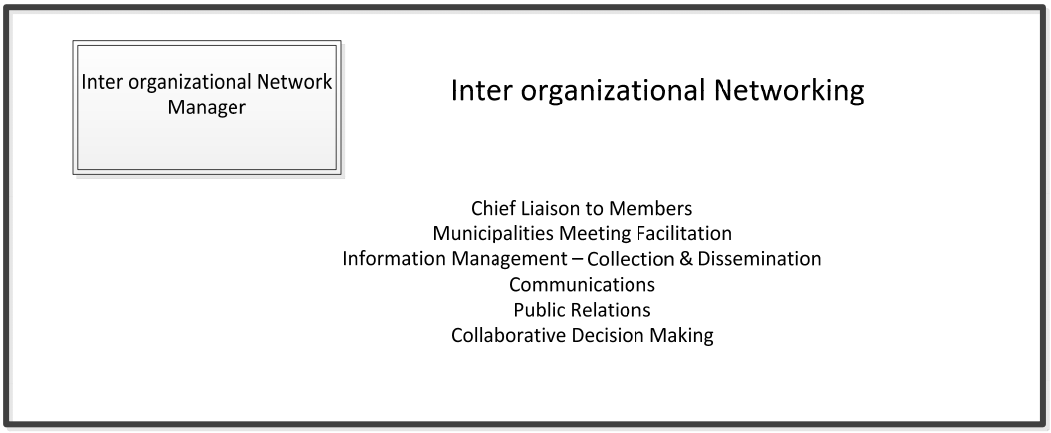

Figure 7 – Inter-organizational Networking Roles

Meeting Facilitation – It is anticipated that daily meetings will be an integral piece of the physical environment. The Metro official in charge of the meeting will manage the dialogue and record any relevant information for dispersion back into the network

Information Management – *Collection & Dissemination* - In addition to meeting minutes from the daily meetings, Metro Vancouver will also collect and share regional situational awareness information from the other member municipalities. Metro will encourage Municipalities to share their status reports and make them available to the rest of the region.

Communication platform maintenance – It is anticipated that any form of structured daily meetings will need to be made available to in-person and remote participants. A priority list of communication platforms along with redundancy options are required to ensure participants with compromised communications can be included in the meeting. Communication platforms are discussed later in the paper and are identified as an action item for the client's attention.

Public Relations – In a widespread event, media outlets will look for a reliable source of information regarding the state of the water system. Given the

information collected through the networking, they would be best to provide a system update and also provide consistent information on behalf of the member municipalities and the public health officers.

Collaborative Decision Making – The true strength of the daily meeting will be the opportunity to mutually set priorities based on the decision making process. The details on the process are highlighted in the next section.

Concept 2 – Decision Making Process

A significant factor needed to create a balanced and adaptive environment where collaborative decision-making can take place starts with well-defined processes and procedures. (Harrald, 2006) Agreeing on those procedures ahead of time and creating a structure stocked with technically competent people enables creativity and improves mobilization response time. By having principled logic for decision-making, the likelihood of cooperation among the various stakeholders is more likely to be achieved. (Harrald, 2006)

Building decision-making procedures involves establishing criteria, applying weight to those criteria, generating alternatives, and finally applying a compromise ranking method. (Opricovic & Tzeng, 2002) Creating the principles and criterion that supports a model and having the various parties agree on those principles ahead of time, greatly improves coordination. (Opricovic & Tzeng, 2002) In order to establish those principles, general consensus among the water managers will be important. Initial response principles (criteria to consider in the first 2-24 hours of the event) address the immediate need for water, while restoration (Day 2-4 and thereafter) addresses resource allocation post event.

The compelling reason for all municipalities to participate in the decision-making process will come from their need to:

- Understand the state of the regional water system
- Influence the prioritization of response and recovery
- Give and receive mutual aid assistance

Presently, no organized decision making process exists. During events like the 2010 Winter Games held in Vancouver, a communication dialogue was established and was deemed successful. But the planning for the Games fell short of actually mapping out a decision-making process to deal with a potential significant event requiring the cooperation of multiple agencies.

To remedy the current situation, a decision flow chart, presented in Figure 8, maps out the steps required to achieve a final decision. Each element of the flow chart is discussed in further detail.

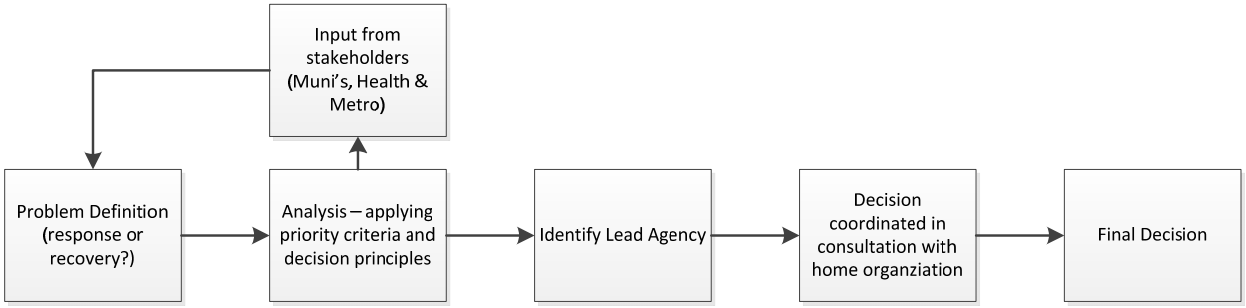

Figure 8 - Decision Making Flow Chart

Problem Definition - Based on the four-stage emergency management cycle, two of the phases pertain to the actual emergency – initial response and long-term restoration. When examining an incident requiring action, the first decision is whether the situation requires immediate response (life and property safety) or whether it is a restoration issue (provision of water). These conditions are defined further.

Response - provide water for firefighting: The provision of fire suppression is necessary for both life safety and property protection. During major disasters fire-fighting abilities need to be maintained or made available in as short a time period as possible.

The primary need for water in the first 2-24 hours will be fire suppression to minimize loss of life and property. During this reactive state, the municipal and regional water utility resources will be consumed reacting to the needs of their local fire departments isolating damage to minimize loss of pressure. Once the initial response has been met, restoration will begin and the decisions will become more complex as restoration activity commences.

*Restoration - Provide an adequate supply of potable water focusing on high priority facilities***:** Water is essential to life and health. Some needs are more immediate than others. Therefore, creating a generally accepted priority list is required.

Restoration Priority Criteria - Restoration priority depends on two sets of criteria – the technical details of the service interruption and the type of facility affected by the loss of water. Both sets of data are required for analysis purposes. With that data, the water managers and stakeholders can merge the information and determine best fit for resource allocation.

Technical criteria will be based on the:

- Number of people affected – requiring an estimate of populations downstream of damaged infrastructure.
- Distance of critical facility from intact system – This piece of criteria examines the distance from the critical facility and the nearest reliable water transmission source in service. An inventory of critical facility locations is critical for this analysis and each municipality needs to prepare the list of critical facility locations. This list should also include the population served. (Hospital capacity, number of shelter beds etc.)
- Level of damage, ease of restoration – In some cases, lower priority critical facilities might be able to have their water restored quickly and these sites should be considered for elevated priority.
- Ability to mobilize resources – Can equipment, materials and personnel be efficiently dispatched to the incident or are those resources locked in different parts of the region? Decision needs to consider deployment limitations.

The second set of decision criteria considers the *criticality of the facility that has lost water service*. The following priority list was derived during stakeholder interviews and represents general consensus from the key sectors. These priority rankings are intended to be guidelines as certain cases may facilitate a different response.

1. Hospitals + other Critical care (including kidney dialysis clinics)
2. Emergency Shelters (community centers)
3. Emergency Operations Centers
4. Bulk Water Fill Stations
5. Institutional Buildings (Municipal Hall, Sewage Treatment, Prisons)
6. Schools
7. Long Term Care Facilities – Seniors homes
8. Residential
9. Commercial
10. Industrial
11. Waste Disposal
12. Farming

The final response priority is the improvement of water quality being delivered into the system. There is an expectation that "region wide" boil water advisories will be issued by the health boards if service interruptions are widespread. As restoration of service continues and properly disinfected water is made available, the medical health officers will be able to lift the boil water advisories area by area.

Decision Analysis Cycle – As discussion takes place, a cycle will form as the problem is challenged, analyzed and reanalyzed. New information is expected to arrive rapidly. Once general consensus if arrived, the lead agency needs to be identified.

Isolating the Lead Agency - Once the analysis has been made to restore service and perform work at a specified location, the final decision needs to consider which authority will take the lead on the operation. Therefore, two more considerations are required:

Who is the owner of that asset?

Either the region or the local municipality will be the most affected by the damage at the incident location and therefore is required to take the role of lead water agency for the incident. Those parties also affected at the incident location will take a subservient role to the lead agency provided they have agreed to participate in the recovery activity.

Who relies on the asset for service?

The final question in the framework is who relies on the asset. The answer to this question provides guidance on who could be enlisted to assist via the mutual aid agreement. For example: If a Metro transmission main is damaged in North Vancouver, service for Vancouver and Richmond may be affected thereby creating a multi-agency desire for restoration.

The Final Decision - With the analysis complete, and the lead agency determined, the final decision can almost be made. Because of the autonomy of each organization, an opportunity for stakeholders to interact with their home organization is required. Time is of the essence and participants will be encouraged to conduct as close to "real time" interaction with their home EOC as possible. The responsibility will lie with the stakeholders to rapidly confirm direction from their end if they are unauthorized to make the decision.

Concept 3 – Physical Environment

The physical environment is the location and procedures that allow for unified command and the application of the decision-making process. The physical environment needs to contain all of the support systems that allow interaction between the various stakeholders to occur.

Presently, Metro Vancouver and each municipality operate their own distinct EOC. These locations will be the primary command centers for response for each jurisdiction. Each site will have its own command structure. Given Metro Vancouver's role as facilitator, their current EOC, located in Burnaby, would be a suitable location to host the regional interactions.

Location - Water Utility Emergency Meetings held at Metro Vancouver Lake City Control room (2775 Production Way, Burnaby, B.C.). In person attendance is encouraged, as is virtual participation. Invited stakeholders are:

- Metro Vancouver
- Municipal Water Utility Managers or designates – from 22 municipalities, Electoral District A and Tsawwassen First Nation
- Vancouver Coastal Health, Fraser Valley Health and Providence Health Officials

Time of Day - Formal meetings are held at 9:00am and 4:00pm daily until deemed unnecessary by the group.

Communication Protocol – If in-person attendance is not an option, communication to virtual participants will be offered in the following order depending on system operability:

1. Land line telephone – conference call
2. Cellular voice transmission
3. Satellite phone
4. Skype
5. Email
6. Text Message
7. Ham Radio

Facilitation and Agenda - Metro Vancouver staff, through the role of Inter-organizational Networking team lead, will facilitate the meetings. Meeting agendas shall include:

- Incident updates
- Response and restoration decisions (See Decision Making Process)
- Round table reporting of general situational awareness

This concept of operations framework was brought to the client for review and comment. In the methods section, the steps taken to gather feedback on the framework are discussed.

METHODS

Overview of Data Collection Process

A number of steps were followed to build this report and arrive at the final conclusions and recommendations. The first step was problem definition. Once the problem was defined, the literature search was conducted to assess theory specific to supporting better communication and decision-making. In parallel, the researcher was conducting initial interviews with participants to understand the current state of their organizations preparedness plans. Following those activities, the framework for the concept of operations was developed and offered to the client as an initial finding. The final data collection event was a focus group with all of the participants designed to gather comments about the framework and potential action items needed to support successful implementation. In this section, the methodology of the data collection phase is fully described, starting with identifying the participants and detailing how the participants were engaged.

Water Industry Participants

Interview participants were generated from four groups of water industry professionals. These stakeholders are the key individuals who will be responsible for recovery of the water system post disaster. Several key tasks, such as providing temporary water while infrastructure is repaired, monitoring water quality and communicating to the public will fall to these groups. Adequately preparing for the disaster, in advance, will be their primary responsibility. The participants came from four different groups within the industry:

Group 1 – Municipal and regional water managers, 21 in total

Group 2 – Municipal and regional emergency preparedness managers, three

Group 3 – Medical Health Officers – four (three from Vancouver Coastal Health Board and one from Fraser Health Board)

Group 4 – Representative from the Integrated Partnership for Regional Emergency Management (IPREM) – two

Design of Instruments

Initial Interviews – Jan to May 2013 - In total 14 organizations were interviewed by the researcher. The interview assessed the current preparation levels of the organization related to emergency planning, decision-making processes, and

communication protocols. The interview also measured the interest of a coordinated mutual aid program. A copy of the interview questions is attached in appendix 2.

All of the interviews were conducted over the phone. Each participant was asked to sign a participant release form. (Appendix 3) In most cases, the interview was conducted with only the Water Manager. However in two cases, the Water Manager invited their Emergency manager into the conversation as well.

The interviews offered an opportunity for participants to share experiences and case studies from past events. Their stories revealed successful activations and highlighted areas needing improvement. Probing the less successful events began to uncover what the organization would expect from a collaborative decision-making environment. An important component of the interview was learning how the organization would prioritize response and recovery of the water system post disaster. For instance, in the event the water supply was disrupted, would it be more important to use the remaining water to fight fires, or should that water be preserved for consumption? The answers to these questions helped form the basis for the decision-making principles.

Preliminary Findings Report out May 8, 2013 - The findings of the initial interviews were combined with the results of the literature search. The resulting product was an initial set of findings. Those findings were presented to a majority of the participants on May 8, 2013 at the REAC Water Sub-Committee meeting. The preliminary findings consisted of the interview feedback and the conceptual framework, which contained the proposals for the enhanced command structures, the decision-making process and the physical environment. The preliminary findings presentation was brief and participants had more questions than time allotted. To solicit further comment, a focus group was scheduled to take a deeper look at all of the components of the findings.

Final Focus Groups - June 19, 2013 - After the interviews had been completed and a draft framework developed, a broad gathering of the participants (13 municipal reps, 4 regional reps and 3 external stakeholders) was held on June 19, 2013 to solicit comments on the draft concept of operations. The participants of the focus group received a presentation that revealed the draft framework. They were then split into three groups and asked to rotate to a different station where they discussed each of the three concepts in the framework. After 10 minutes, the team moved to another station and discussed a second framework principle and then moved to the final station.

In providing comments at each module, participants employed a force field analysis technique. Force field analysis is a tool, first introduced by Kurt Lewin in 1946 (Schwering, 2003), and is an aid for change management projects. Participants were asked to consider the change objective then imagine the forces that will drive the change forward and the forces that will resist the change. The use of the force field brings to light the most critical issues that may hamper progress and encourages a discussion on ways to minimize those resisting forces.

All of the information gathered through the force field analysis was posted in the room. Each participant was then asked to review all of the comments and vote on the driving and restraining forces they felt were most critical to success. They were provided three sticky dots to use for voting. Their votes identified the strongest driving forces as well as the strongest forces opposing the change.

A copy of the focus group agenda and the raw data from the focus group are provided in appendices 13 and 14 respectively. The results of the data collection offer a series of findings that begin to crystallize a series of recommendations going forward. The next sections present those finding and discuss how the framework could be implemented successfully.

RESEARCH FINDINGS

Findings of Initial Interviews in developing the concepts

During the initial interviews, it was clear that very few of the municipal professionals had considered a multi-jurisdictional approach within their plans. Their scope of planning was limited to their own municipal boundaries. In contrast, the participants from Metro Vancouver and the Health Boards expressed a desire for a coordinated response. Not surprisingly, the regional and health officials found it difficult to achieve any momentum in creating multi-agency preparation plans without the effort of the municipalities.

A number of comments from the municipal participants reinforced their current municipal based approach and also alluded to potential challenges if their municipal resources were overwhelmed during a disaster. The following table links the participant comments with the most applicable framework principle.

Enhancing BCERMS	
Municipality comment	"We always take care of our own issues – we have never needed the help of another organization"
Municipality comment	"Our EOC structure could break down when it gets into too much detail. It will take more resources to indicate priorities and assist operations in getting them out there"
Municipality comment	"The BCERMS layout generally works, but the organization needs to remember that business lines play a role. In our exercise, the head of planning was a staff person from Parks with little experience. We needed to have the right people in the planning role"
Health Board comment	"If we have a situation that requires us to issue a boil water advisory, we will make that call, but we need Metro and the others to implement the order"
Decision Making Process	
Municipality comment	"We need some kind of allocation for resources to meet regional needs"
Municipality comment	"We don't have anything without Metro. If Metro isn't getting water to us we are done"

Municipality comment	"During a turbidity crisis, the whole focus was on the downtown eastside ensuring they got bottled water. It became a political response and little priority was given to the rest of the population. There were many other vulnerable populations like seniors with just as much difficulty getting bottled water due to limited mobility"
Municipality comment	"We never want to give up control to Metro", "They don't know how our system works"
Municipality comment	"If we get in real trouble, we assume the Province will set up PREOC and bring in all the other utilities but I am not sure how they will make decisions"
Municipality comment	"We have not had discussions with private contractors about post disaster response. There is a cost to getting exclusive commitment from those people and so far, it would not have been worth the investment"
Municipality comment	"We realize that there isn't enough equipment to go around the region. Who decides where it goes and who trumps who?"
Metro comment	" At Metro, we have at least six emergency plans written by different internal operations all specific to their individual needs. How do we bring all of that planning together internally before we try and tackle a regional response? Resources had been an issue"
Metro comment	"The key to working with all of the people in this region is unified command. We need to develop a unified command model that works."
Physical Environment	
Municipality comment	"During an event last year, we had too many people at the EOC, and there was confusion around who was in charge"
Municipality comment	"Maybe the Feds will show up and take over"
Metro comment	"Events like the 1st Narrows failure in the mid 80's

	showed how important communication is. Vancouver had restricted flow to its downtown and they needed information from us more rapidly than we could provide"
Health Board comment	"During a turbidity event in 2007, we took direction from the medical health officer. After we received direction, we fanned out the communication to senior environmental health officers and then out to the field. Information was generally good other than one piece of miscommunication. An established control room would have helped."
Health Board comment	"During a water quality event at a Vancouver hospital, we struggled to get in touch with key staff in Vancouver. The 311-call center was overwhelmed and we were unable to reach staff directly. How can we filter calls to ensure to ensure we are responding to the most pressing issues first?"

Table 1 – Coding of Interview Comments against Framework Concepts

A consistent theme developed around the need to share information and potentially resources. As a regulator, the health boards need the assistance of the municipalities and the region to implement their orders. Metro Vancouver's desire for a unified command structure highlights their need for more active engagement by the member municipalities. The municipalities also identified a potential shortage of equipment and people, creating support for mutual aid initiatives. All of these activities identified by the interviewees create issues for resolution, and these issues require mutually agreeable decisions. If no one organization is in charge, then a collaborative decision-making process is required.

During interviews, study participants were asked if they would be willing to give up decision-making control to Metro Vancouver. All but two stated they would not be willing to give up control given their Council's expectation that response would be maintained at the local level. However, they all agreed that rapid decision-making would be required and that restoring service to Metro facilities would be the highest priority.

Focus Group Findings - Results of the Force Field Analysis for Modified BCERMS

The idea of creating an "Inter-organizational Communications" layer into the BCERMS command structure was tested using force field analysis with stakeholders. The participants generated a number of driving forces in support of this layer as

well as a number of restraining forces. Table 2, 3 and 4 capture the comments that were received for each concept. The numbers in parenthesis denote the relative strength of the force, based on participant voting. The strongest driving forces and resisting forces are elaborated in the findings section and discussed in further detail in the discussion.

Driving Forces:	Resisting Forces:

• Mutual aid (in region or out of region) (4)
• Broaden/more effective use of resources (2)
• Assists in decision making framework prior to events (2)
• Establishes improved linkages (1)
  o Communication and for municipal planning
• Advance discussions on BCERMS and how IPREM fits/roles (1)
• Understanding Priorities better managed
• Enhances current model for regional "reality"
• Proactive modification
	• Need to identify roles/decision making (6)
	  o Effort and discussion
	• Reliability of common communication links (4)
	  o Radio?
	  o Cell?
	  o Internet?
	  o Texting?
	  o Lack of call lists
	  o Lack of interconnectivity between local systems
	• Legal certainty? (1)
	• Budget
	• Politics
	• Effort to change municipal plans and protocols
	  o Consistency
	• Effort required

Table 2 – Force field analysis for Concept 1 – Enhancing the roles of BCERMS

Driving Force 1 – Mutual Aid - In terms of support, the force field analysis reveals one significant driving force, which is the potential for mutual aid. Participants expressed concern that resource shortages, such as specially trained personnel, construction equipment and materials, could impair their ability to respond. Having quick access to others who may be able to help was seen as a major benefit. Improving communication between all of the organizations is regarded as a way to address mutual aid issues early and efficiently.

Resisting Force 1 – Capable Staff – There was concern that the new inter-organizational roles may be staffed with participants who lack the necessary decision making authority. This resisting force has the potential to lengthen the time needed to make a decision and potentially weaken engagement. One participant stated: "without the right people, this will not work". Ways to address this concern might include identifying champions in each municipality who can

lobby decision makers to assign suitable staff into the roles. Another mitigation activity could be the implementation of annual simulations. Participating in a simulation will help prove what skill sets are needed.

Resisting Force 2 – Communication Links - Another significant resisting force is the concern over the reliability of communication links. Several participants recalled instances where cell networks became overloaded and failed due to high call volume. The group did not feel like they had sufficient reliability and redundancy of communication mediums. The physical environment concept proposes a sequencing of communication mediums. Ensuring reliable communications are available is integral to the success of the physical environment. Mitigating this concern needs to look at the reliability of each communication medium and develop ways to improve reliability. Acquiring satellite phone technology may be part of the solution. Perhaps gaining access to amateur radio operators may be another remedy. This point is considered further in the discussion section.

Focus Group Findings – Decision Making Process

During the force field analysis for the Decision Making Process concept, a number of driving and resisting forces were noted although no specific force emerged as being most critical. Instead there were driving themes related to the efficient use of scarce resources allocated to critical priorities, while resisting themes noted concern about access to information and local autonomy issues.

Driving Forces:	Resisting Forces:
• More efficient use of resources (2) • Access to resources for regional priorities (2) • Strategic rationing of limited resources (water) (2) • Empower team to make decisions based on issues at the time (2) • Coordination to avoid working at cross purposes (1) • Need for resolution process (1) • Access to expertise • Metro up first • Sharing of resources that might not be able to get to their "home" (municipal) location • Helps achieve/consider health objectives with respect to water	• Getting access to sufficient information to make decision on the principles (2) • Conflicting local emergency plans (2) • Loss of control (local autonomy) (1) • Lack of resources • Geography movement of resources across natural barriers (downed bridges) • Lack of understanding of each other's systems • Potential legal liability issues (White Rock) • Misinformation of situation • Slow down/interfere with established municipal procedures • Metro up first

• Articulates the principles and enshrining the prioritization	

Table 3 – Force field analysis for Concept 2 – Decision Making Process

Driving Force 1 – Managing scarce resources – Several of the comments related to a notion that a decision-making process will improve the allocation of resources. Resources are not only restricted to people and equipment, but also to the restricted quantities of water in the system. Annual simulations where the decision-making process is tested could be a helpful way to further strengthen this benefit.

Driving Force 2 – Empowered Decision Making – The group generally agreed that delegating decision-making authority to the water managers would result in better decisions being made on the long-term recovery of the system. Creating a training program for participating water managers would build confidence when disaster strikes.

Resisting Force 1 – Access to Information - In order to make a decision, a reasonable amount of information is need. Prior to an event, a great deal of information can be assembled in advance. For instance, identifying where all of the critical locations like hospitals and care homes are located is one example of easily preassembled information. Technical information about the water system, including flow paths, valve schematics and flow demands could also be prepared in advance.

Resisting Force 2 – Conflicting Emergency Plans - An issue that was raised many times and still remains unanswered relates to the provision of temporary water. Much of the conflicting messaging between plans traces back to a lack of clarity around who will provide temporary water in the hours and days after the event. Water utility leaders are concerned that they will be tasked with the work and fear it will divert essential resources away from rapidly restoration of the buried water system. A comprehensive strategy for temporary provision of water is required to lower this resisting force.

Resisting Force 3 – Loss of Local Autonomy – This resisting force may be the most threatening as it speaks to political forces beyond the Water Managers role. There needs to be concerted effort to ensure the decision making process is transparent and not dictated by one organization. Finding champions at senior levels of the organization (City Engineer, Chief Administrative Officer and Chief Medical Officer) will be crucial for support. Proving the worth of the process through simulations is another way to build trust in the process.

Focus Group Findings – Physical Environment

During the focus group discussion on the physical environment, a number of forces were identified. The most critical driving force identified was the benefit of transparency in decision-making and priority setting. Another significant driving force was the ability to present a consolidated message to the public.

In terms of resisting forces, there is fear that communication systems will fail and undermine the environment as an information hub. Further discussion highlighted the need to explore redundancy options for the communication systems. Some questioned the vulnerability of the physical environment and whether an alternate location should be considered for backup purposes. These resisting forces were also mentioned in the force field discussions about enhancing BCERMS and the decision-making process.

Driving Forces:	Resisting Forces:

• Transparency of decision making/priority setting (7)
• Clearer communication among key stakeholders (3)
  o Public
• Allows dialogue between municipalities (1)
• Allows for dialogue (1)
• Receiving information from MV (status of transmission system)
• Provides for scheduling
• Sharing analysis and development of alternatives
• Has broad systems (IPREM) at table for broader understanding
  o Priorities and support
• Unified voice to external support agencies
• Allocation of outside resources
• Need to communicate reliably
• Need for each representative to clearly act as spokesperson for third agency
	• Communication system reliability/availability (3)
	• Decision making protocols? (2)
	  o Who makes final decisions?
	  o Vote?
	  o Commissioner?
	• Limitation of fixed location (2)
	  o Alternate locations available?
	  o Mobile command?
	• Competing municipal priorities for representative (1)
	• Resources/ability to "get there"
	• Staff availability
	  o Who?
	  o Politicians
	  o Too many
	• Moderating discussion
	• Potential for perception of municipal conflict
	• Can municipal data be accessed
	• How are protocols changed?
	• Increase complexity of decision making vis a vis IPREM
	• Need resources to create system for reliable communications
	• Lack of empowerment may be a concern under emergencies

Table 4 – Force field analysis for Concept 3– Physical Environment

Driving Force 1 – Transparency of Decisions – The physical environment creates a place where everyone can participate if they choose, either in-person or virtually. When a problem is being considered, everyone is welcome to offer informed input. Decisions become more transparent if everyone has had the opportunity to voice their opinion.

Driving Force 2 – Clearer Communication – Another benefit offered in the physical environment is consistent information. Information is delivered to everyone from the same source. As a result, reporting out to the public and media can be more accurate. Ensuring communication mediums can support this benefit is critical. The design of the physical environment should consider a media briefing space, to facilitate efficient access to the media.

Resisting Force 1 – Limitation of Fixed Location – The physical environment is proposed to be located at Metro Vancouver's Lake City facility in Burnaby B.C. In the event that Lake City is badly damaged and deemed unfit for use, a backup location should be identified. Further discussion is necessary by the client to find an agreeable backup location.

The focus group revealed a number of critical driving forces and resisting forces. The next section of the report delves deeper on the resisting forces in particular, looking for ways to mitigate the resistance. Many things can be done to weaken resistance and the next section develops the actions that should be taken during implementation.

DISCUSSION

This section focuses on ways to strengthen the driving forces and mitigate the resisting forces identified in the force field analysis. The product of the discussion is a set of action items proposed to support implementation of the concept of operations framework. Following the format in the findings section, each concept is individually examined.

Concept 1 – Action Items to Enhance BCERMS

Action 1 – Develop Mutual Aid Networks - A strong driving force identified during the focus group was the potential of creating a regional mutual aid network. Having a network prepared in advance would allow jurisdictions hardest hit in a disaster with the opportunity to ask for help immediately. This network is not formally established yet. Therefore, starting a mutual aid network based on the American Water Works – Water and Wastewater Agency Response Network (WARN) is an excellent way to create this benefit.

The WARN model has been extensively adopted in the United States as a way for water and wastewater organizations to administer mutual aid. The specialized nature of utility operations, create a relatively high need for self-sufficiency. Response plans that overly rely on the private sector for assistance may be flawed if private sector resources are mobilized to support other critical lifelines in the disaster. The WARN model allows municipalities, regions, all the way up to the provincial and state level to share personnel, equipment and resources. (AWWA, 2006)

Appendix 4 presents the WARN model in more detail. Responsibilities of the requesting agency and the responding agency are outlined. Next steps for implementation are also laid out in appendix 4.

Action 2 –Enhance Command Structures – There was concern expressed that stakeholder organizations would not be able to resource the Inter-organizational layer with the right people for the role. To mitigate this concern, an example from the City of Vancouver demonstrates how the layer could be resourced.

The structure shown in figure 9, presents a proposed hierarchy for the City of Vancouver Water Utility building in the new roles. The proposal for Vancouver identifies not only the new Inter-organizational Communication layer, but also the actual positions that would fill the roles. Because Vancouver is large, a separate individual is assigned to each role. In smaller jurisdictions all three roles might be assigned to the same person. Whether it is three separate individuals or one, the

benefit lies in developing the communication capacity so that regional engagement occurs. In order to address some of the concerns brought up through the force field analysis, the positions selected by Vancouver are senior staff capable and empowered to make decisions on behalf of the organization.

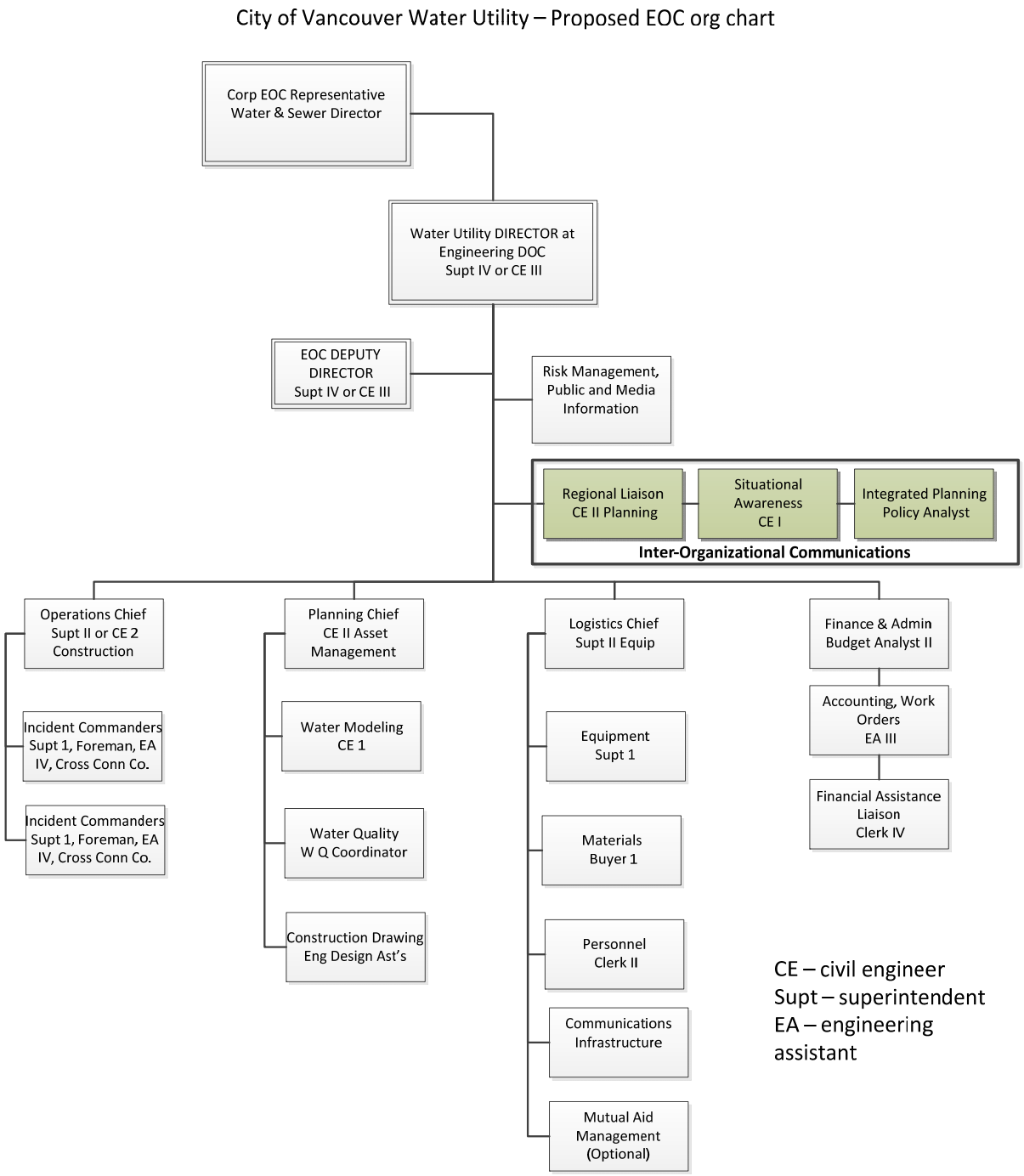

Figure 9 – Balanced Command Structure (Closed and Open Systems) for City of Vancouver Water Utility (Proposed)

The example from the City of Vancouver proves how the Inter-organizational Layer could be implemented at a municipal level. For Metro Vancouver, implementing the Inter-organizational Networking layer would be slightly different given their facilitation role. Initial feedback from Metro Vancouver staff expressed caution on creating this layer now. They are currently undergoing an extensive transformative re-organization process and proposing how the Inter-organizational Networking function might be integrated into their EOC may be too premature at this stage, at least until the new organizational structure is complete. During the force field exercise, staff raised a concern regarding potential resistance by senior staff if the proposal was mistakenly interpreted as resistance to the reorganization exercise.

Given there may be some apprehension from the organization, there are two ways in which the networking layer could be implemented. Option 1 (shown in figure 10) proposes a structure that adds an Intergovernmental Networking team for each area of control within Metro Vancouver. The benefit of this approach would come from assigning experienced water system leaders who also know the other actors in the region. Essentially the water team would oversee the networking of all water utility activities.

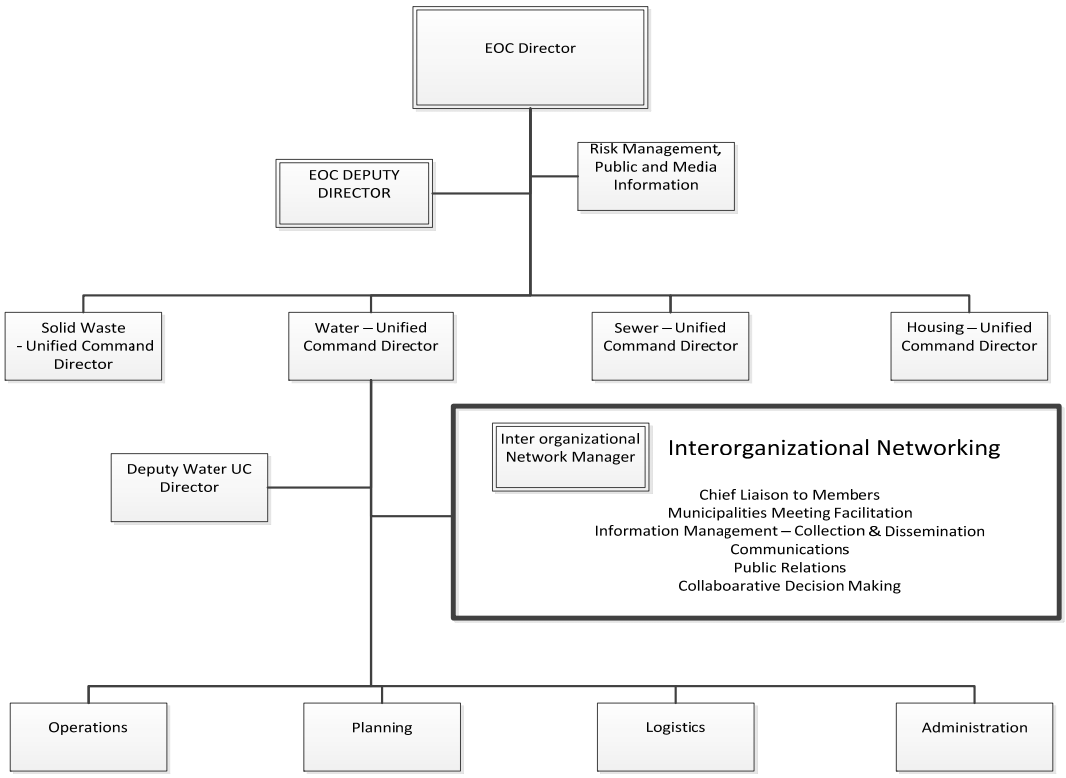

Figure 10 – Option 1 Inter-organizational Networking Command Structure Enhancement

Conversely, the team could be integrated at a higher level within the Metro Vancouver EOC structure. Option 2 assumes that there would be one Inter-organizational Networking team for all areas of control within Metro Vancouver. This team would report to the Director of the EOC rather than the unified commander for the specific business (water in the previous option). Within the Inter-organizational Networking Team, there would be separate team leads for each of the major functional areas like Water, Sewer and Solid Waste. The configuration of this option (presented in figure 11) may provide better inter-functional communication opportunities, while still ensuring the right people are assigned to the task.

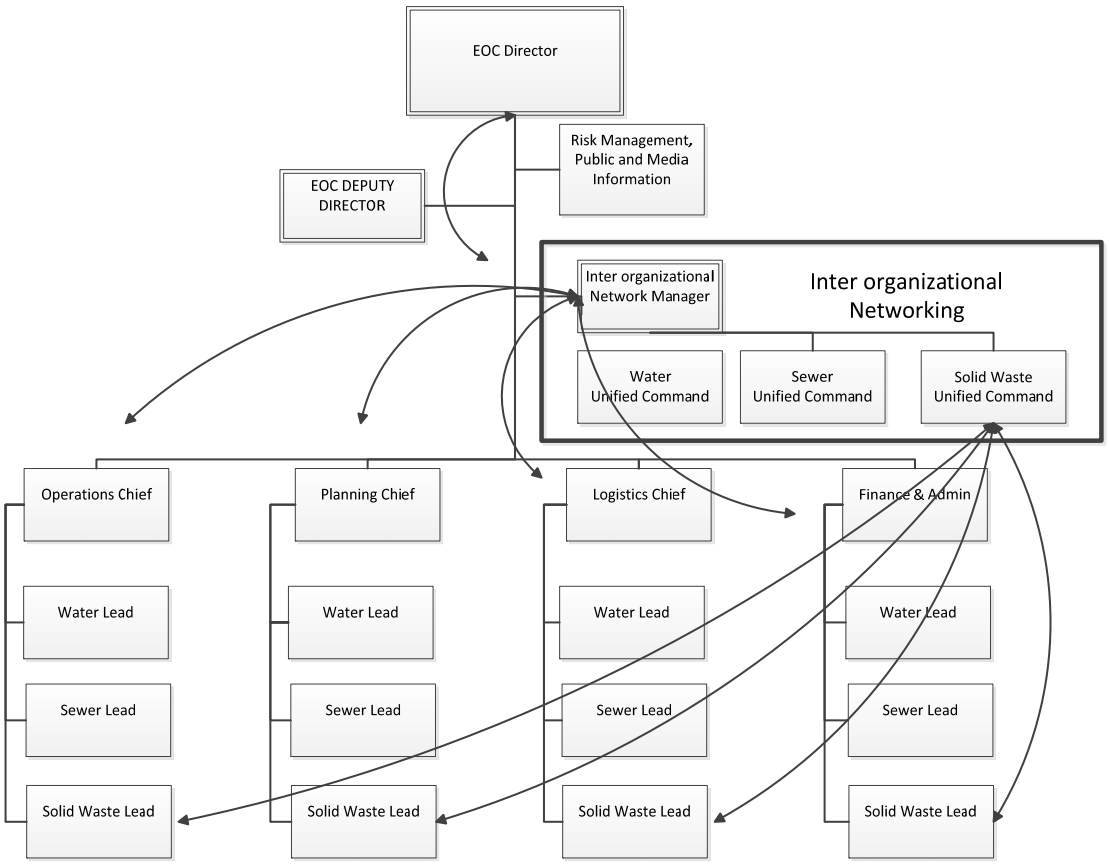

Figure 11 – Option 2 Inter-organizational Networking Command Structure Enhancements

Adopting a unified command structure under either option would create better coordination among agencies through real-time, accurate information regarding the status of human and physical resources. The ability to optimize deployment and accurately engage mutual aid where needed the most can be achieved under either

option. (Smith & Dowell, 2004) Metro Vancouver needs to figure out which model works best for their operation.

Action 3 – Develop a Communication Platform Strategy – Another resisting force discussed frequently during the focus group, was a concern about the robustness of communication links. The proposal for the physical environment lays out priority sequencing of communication mediums if in person attendance is not feasible. They are:

1. Land line telephone – conference call
2. Cellular voice transmission
3. Satellite phone for those equipped
4. Skype
5. Email
6. Text Message
7. Ham Radio

A strong communications network consisting of several redundant options would provide faster, accurate, more precise alerts to key decision makers providing an overall improved response during an emergency event. (Perry & Lindell, 1997) Cellular phone networks can be overwhelmed with traffic and fail as witnessed during the recent Boston Marathon bombings. (Farrell, 2013) Many of the interviewed participants did not have access to satellite phones. Some organizations forbid the use of Skype and few had access to Ham Radio operators.

Therefore, an important action item will be the development of a communication platform strategy. The strategy would need to identify what upgrades would be required to ensure each stakeholder had access to each communication protocol. A committee of information technologists may be most appropriate to lead this action item. Appendix 6 provides further elaboration on this action item.

Concept 2 – Action items for developing the Decision-Making Process

Action 4 – Create Requirement for Annual Simulations – The decision-making process is seen as a way to effectively manage and optimize the limited resources available for response and recovery. A way to strengthen this benefit is by practicing the decision-making process on a regular basis. Every single participant interviewed, stated that their organization needed to do more simulation training. Most admitted that simulations were held once per year or less.

Implementing a requirement for the REAC Water Sub-Committee to do an annual simulation will ensure that participants make full use of the environment when the situation is real. To do this, additional resources will be required – likely an individual to coordinate the simulations. There would be work required to identify

the right type of individual for the role, where funding for the position would come from and figuring out where they would report.

Appendix 7 proposes a scope of work for developing annual simulations.

Action 5 – Develop a Training Program for Water Professionals – Establishing empowered decision-making is seen as a potential benefit in the concept of operations. Ensuring staff feel confident in their abilities may require training. Many managers were unsure exactly how the BCERMS model worked. Others were unsure exactly what their role would be and what would be expected of them. The Justice Institute of British Columbia (www.jibc.ca) offers a wide range of courses and seminars that prepare students for emergency situations. Developing a curriculum of courses that provide a mixture of leadership training and management training is recommended.
Appendix 8 proposes a curriculum for consideration. Course descriptions, costs and time commitments are also identified.

Action 6 – Commission Study to identify all Critical Facilities - Access to information is considered a risk to the decision-making process. Analyzing the issues as they occur will need basic input about the water system and the customers that are served. Most organizations have done work in this regard and can readily identify where their critical facilities are located. Some have also identified key civic infrastructure that will be used as shelter or bases of operations. However, this inventory has not ever been gathered into one common database. It is recommended that a study be commissioned to map the key facilities that will take priority during restoration. In addition, critical areas of weakness in the regional and municipal water systems should also be identified. Both data sets would greatly aid the decision making process during the crisis.

Action 7 – Commission a Provision of Water Strategy – After the initial event takes place, there will be an immediate need to provide access to water for basic human needs. Rightly or wrongly, the water utilities are expected to fill this need. If critical utility resources are allocated to this activity, then the restoration of the underground system will be delayed further prolonging the recovery process. A strategy for the provision of water is needed. This strategy will identify the steps required to provide water, the suppliers, bottlers and haulers who can meet this need. Most importantly, the strategy needs to identify the resources within each jurisdiction that will be assigned to this activity.

Action 8 - Identify Senior Government Champions - To mitigate concerns that smaller municipalities will lose their local autonomy, a sustained effort is required to promote the benefits of the concept of operations and in particular the decision-making process. The REAC Water Sub-Committee will need to create a strategy to promote the recommendations of this report. The strategy may include, reports to the senior officials in the stakeholder organizations, information meetings with

senior levels of government and taking part in speaking engagements to promote the framework.

Concept 3 – Action items for the Physical Environment

Action 9 – Determine a Backup EOC Location - In the event that the Lake City location is damaged and cannot serve as the regional unified command EOC, an alternate location should be identified. The Lake City location in Burnaby is considered central for most and a backup location needs to offer similar access. In addition to having a favorable location, the backup EOC needs to have identical access to the communication mediums identified in the physical environment concept. The REAC Water Sub-Committee should lead this action item.

That concludes the discussion of this report. The nine identified actions represent enhancements and mitigation work necessary for successful implementation of the concept of operations framework. The final section of the report presents a consolidated set of recommendations for the client.

CONCLUSION AND RECOMMENDATIONS

This paper took on a challenging assignment of building a preparedness plan for the regional water systems. A framework detailing three concepts creates a foundational piece that if followed, will allow efficient communication by key decision makers across the region. The framework is built on 3 principle constructs:

- Enhancing BCERMS by introducing refinements to the existing command structure that facilitate better information sharing
- Designing a decision-making process with response and restoration prioritization principles that support collaboration
- Creating a physical environment with a central meeting location and standard communication protocol

Implementing the three components of the framework will require leadership by the REAC water sub-committee. There will likely be political challenges and considerable change management needed for successful implementation. Nine action items are recommended to support implementation of the concept of operations framework. They are:

- Action 1 – Develop Mutual Aid Networks
- Action 2 – Enhance Command Structures
- Action 3 – Develop a Communication Platform Strategy
- Action 4 – Create Requirement for Annual Simulations
- Action 5 – Develop a Training Program for Water Professionals
- Action 6 – Commission Study to Identify all Critical Facilities
- Action 7 – Commission a Provision of Water Strategy
- Action 8 - Identify Senior Government Champions
- Action 9 – Determine a Backup EOC Location

Once Municipal Councils and the Metro Vancouver board endorse the framework, a strategic plan can be developed to tackle the nine action items. Post implementation, key contacts and system information and will need to be kept current. Agreements with vendors and other agencies will also need to be maintained. The limited work capacity of the REAC Water Sub-Committee members, as well as their lack of any actual budget will restrict how much can be done without additional dedicated resources. During the focus group, there was unanimous consensus that an emergency planner was necessary to advance this work.

If an Emergency Planner is brought on to manage the implementation process, the client will need to decide where the position reports, how the position is funded, and the primary duties. Given the fact that REAC itself is made up of volunteers

from Metro Vancouver and the member municipalities, a funding mechanism that distributes costs is required. Other questions like the term of the assignment, priority of action items, program budget etc., need to be considered as well. For discussion purposes, the researcher suggests that a budget of $150,000 per year ($100k per year annual salary plus a $50k per year program budget for communication improvements, information systems, practice simulations, training tuitions etc.) be used when planning this new resource.

One final note, if these recommendations are acted upon, there is the potential that this concept of operations could be used as a model and "scaled up" to integrate more essential lifelines like electricity, natural gas, sewage collection and debris management. The contents of the report could serve as a launching point for a truly coordinated all-encompassing disaster response plan providing an even larger benefit to the region. That will take far more work, but the framework developed for the water system may be the blueprint needed to make a full concept of operations a reality.

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APPENDIX

Appendix 1 – IPREM principles

Principles:

1. Local Authorities maintain autonomy
    - Local Authorities will remain the lead authority and maintain their autonomy with regards to emergencies within their jurisdictions

2. Utilize existing structures to achieve regional coordination
    - The All Hazard Integrated Regional Concept of Operations (Concept) is based on the integration of existing agencies and authorities who play a role in planning, responding, and recovering from regional emergencies (Note: the Concept does not include the creation of a new regional emergency response function, organization, or facility)

3. Utilize existing resources
    - The Concept utilizes existing resources and facilities to the greatest extent possible and recognizes that in regional emergencies additional resources may be required

4. Pro-active leadership
    - The Concept is built on pro-active leadership aimed at identifying regional issues and clarifying roles, responsibilities and protocols prior to any regional emergency

5. Scalable, flexible and layered approach
    - The Concept is scalable, flexible, and involves layers of authority and responsibility that reflect current structure (Note: the Concept does not create new layers of authority)

6. Model(s) focus on process(es) to determine outcomes
    - The model is based on continual improvement and uses a practical approach focused on functions and decisions required to successfully manage regional emergencies

7. Local Authorities commitment
    - Local Authorities will continue to commit available resources to save lives and minimize injury and damage to property and infrastructure within their jurisdiction, with a commitment to assisting other jurisdictions to the best of their ability

8. Collaborative decision making
    - The Concept uses collaborative decision making and is consensus based

9. Preparedness, training and exercises
    - The Concept promotes and facilitates ongoing preparedness, training and exercises for regional emergencies

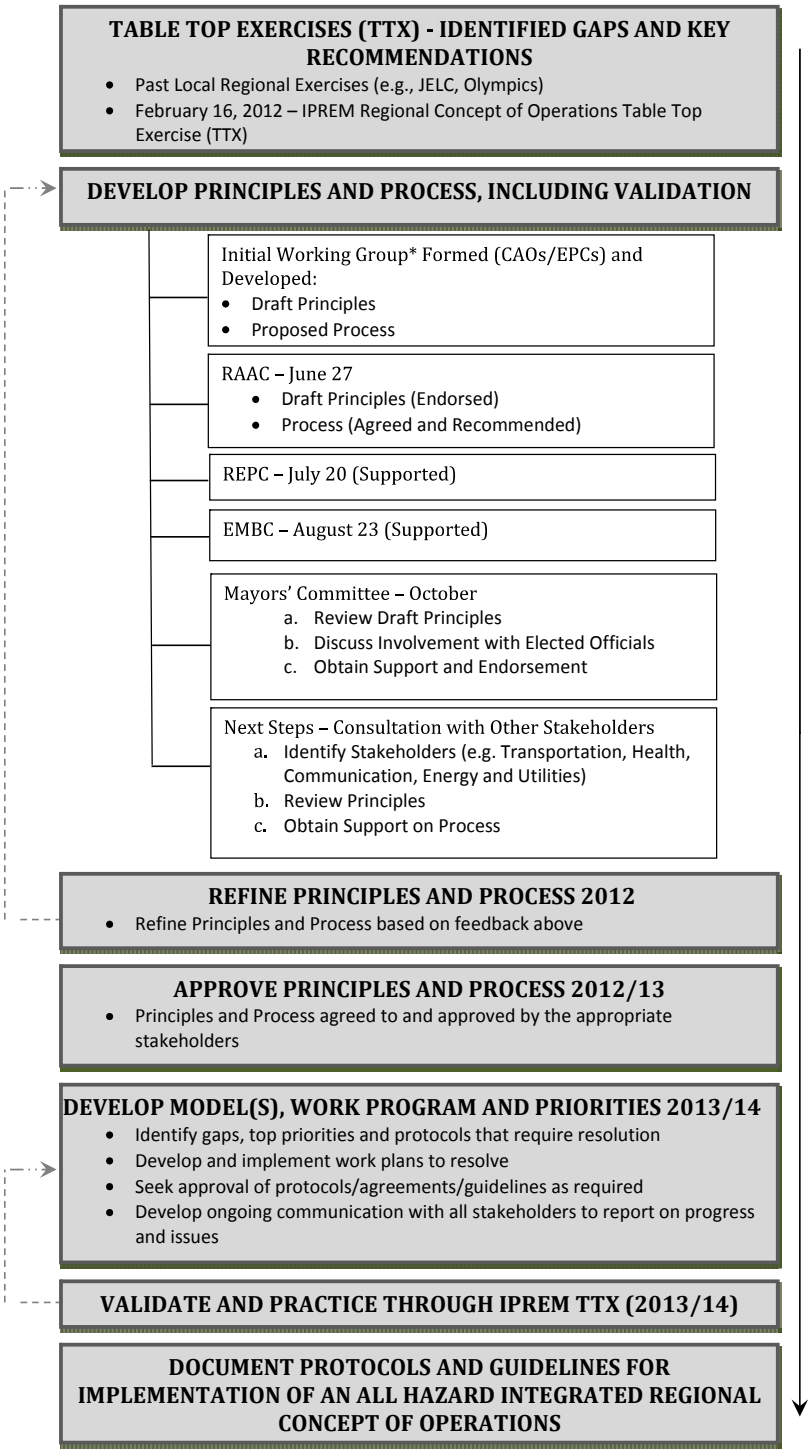
Proposed Consultation and Approval Process for an All Hazard Integrated Regional Concept of Operations (See Chart 1):

*Initial Working Group Members

(Chief Administrative Officers-CAOs, Emergency Program Coordinators-EPCs)

Jake Rudolph (CAO, Pitt Meadows), Paul Daminato (CAO, New Westminster), Ken Tollstam (CAO, City of North Vancouver), Delia Laglagaron (Deputy CAO, Metro Vancouver), Francis Cheung (CAO, Langley City), Tony Chong (former CAO, Port Coquitlam), Dorit Mason (NSEMO), Deborah Procter (Richmond), Dave Jones (New Westminster), Rob Nicholls (Metro Vancouver), John Oakley (EMBC), Andrew Morrison (EMBC, formerly IPREM), Heather Lyle (EMBC/IPREM), Doug Allan (IPREM), and Clarence Lai (IPREM)

Chart 1: Proposed Consultation and Approval Process for an All Hazard Integrated Regional Concept of Operations



Appendix 2 – Initial interview questions

Pre-amble

Thank you for agreeing to participate in this interview. The focus of this project surrounds our existing concept of operations for water utility response plans. The objective of the project is to ensure that we have sufficiently planned our response to a significant emergency as best as possible. In the event of a large-scale emergency, such as a large earthquake affecting multiple municipalities and Metro Vancouver, the desire to cooperate and prioritize a regional response regionally will likely be more effective.

Planning beyond the boundaries of our jurisdiction is difficult, both at staff levels and political levels as well. This project will propose several new concepts designed to improve the collaborative capacity within our existing emergency plans. I need your help to understand what changes could be made to the BCERMS model to facilitate a broader response.

During this interview, I will ask you about your experiences with emergency planning and look for ideas on how we could improve command structures and decision-making protocols for better response capacity.

<u>Command Structure - BC Emergency Response Management System and the Incident Command System</u>

Tell me about your experience with BC Emergency Response Management System and the Incident Command System

a) Can you tell me about a time that the BCERMS organizational structure worked well? What worked and why. (If no experience, show them the BCERMS suggested command structure)
b) Can you think of a time where the organizational structure did not work so well (or may be problematic if applied to your utility)? What happened (or what might happen)?
c) What would you suggest could be done to improve the structure and make it more workable for your water utility and corporation?

<u>Response Principles</u>

Post disaster, do you agree that the various water utilities should prioritize water under the following priorities?

1. Water for firefighting to protect life and property
2. Prioritized restoration of water to:
    a. Hospitals
    b. Emergency Shelters
    c. Schools
    d. Kidney dialysis locations
    e. Commercial Business
    f. Industry
    g. Residential
    h. Personal hygiene, waste disposal
3. Improve water quality to avoid boil water advisory

What is missing from the list?

What changes in priority would you recommend?

<u>Decision Making Protocols</u>

a) Can you tell me about a time where you were part of a departmental or corporate prioritization exercise where resourcing was limited?
    a. How were decisions made?
    b. What was your role?
    c. How did you do in the exercise?
    d. In the event of an emergency, do you expect your organization to prioritize in the same manner?
b) Was it successful and in particular, what worked well? (Probe on use of standard processes, logic based decision making, good communication,
c) What didn't work so well? (Probe on issues of communication, authority, lack of information transfer, transparency, end running and game playing by others)
d) In the event that the region and municipalities agree to work collaboratively during a disaster event, how would you like to be engaged?
    a. As a voting member – based on populations
    b. As a lead agency/support agency depending on severity and location of disaster
    c. Equal partner – each water manager gets a say, consensus rules. Tie break by Water REAC sub committee chair.
    d. Subservient to Metro Vancouver
e) Are you willing to offer resource support to other jurisdictions if operationally feasible? (This information measure the level of support for mutual aid agreements)

<u>Resource Boundaries/Mutual Aid</u>

Imagine a scenario where a massive earthquake has just occurred, the regional water supply is out of service and you have suffered enough damage in your own municipality to overwhelm your internal resources.

a) Can you think of a time that your organization needed the help of another similar organization to complete a piece of work? (Ideas may be – joint planning initiatives, construction support, integrated parks and rec, law enforcement, fire services).
    i. Probe questions – what resourcing plans have been made to access non water-utility internal resourcing?
    ii. What resourcing plans have been made to access private sector resources? What if they are committed elsewhere or will only work for the highest bidder
b) What worked well in that situation?
c) What didn't work so well?
d) What suggestions would you offer that might have may have improved the experience for everyone involved?

<u>Communication Mediums</u>

Tell me about how you communicate with field personnel. (In this case, I am referring to technology platforms)

a) What works for you and why?

Think of a time when you had difficulty communicating with field personnel. A case where you were unable to share information like normal.

a) What standard medium (radio, cell phones) normally worked well but had failed for some reason? Why did it fail?
b) What could have been done to improve communication redundancy? Probe on what backup systems are in place.

Appendix 3 – Sample waiver form

REAC Water Sub Committee

Participant Consent Form

Joint Regional/Municipal Water System Emergency Preparedness Plan for the Metro Vancouver region of British Columbia

You are invited to participate in a study entitled **Joint Regional/Municipal Water System Emergency Preparedness Plan for the Metro Vancouver region of British Columbia**

Peter Navratil, P.Eng, is conducting that.

Peter Navratil is a Graduate Student in the department of Public Administration at the University of Victoria and you may contact him if you have further questions. He can be reached by phone at 604-671-1954 or 604-873-7368 or by email at pnav@uvic.ca.

As a graduate student, I am required to conduct research as part of the requirements for a degree in Public Administration. It is being conducted under the supervision of Dr. Barton Cunningham. You may contact my supervisor at 250-598-9878.

Purpose and Objectives
The purpose of this research project is to prepare an emergency preparedness plan for the regional water system that considers a "source to tap" response. There are 22 municipalities that distribute water to customers. Metro Vancouver own and operate the source (watersheds and reservoirs) and transmit water to 22 municipalities in the region, who in turn, distribute drinking water to their citizens. The plan will propose a decision-making framework that will enable efficient response across municipal boundaries in the event of a major disaster.

Importance of this Research
Research of this type is important because a coordinated regional plan has never been contemplated. Individual municipalities and Metro Vancouver all have done stand-alone plans, and it is important to consider how a regional response will be managed when a disaster crosses municipal boarders. The work has the potential to be a model for other "concept of operations" such as sewer, road clearing, power, telecommunications and gas.

Participants Selection
You are being asked to participate in this study because you are directly involved with the provision of water or are a regulator overseeing the quality and quantity of water delivered in the community.

What is involved?
If you consent to voluntarily participate in this research, your participation will include up to two hours of interviews and a request to provide current emergency planning documents that describe standard operating procedures and command structures proposed by your organization.

Voluntary Participation
Your participation in this research must be completely voluntary. If you do decide to participate, you may withdraw at any time without any consequences or any explanation. If you do withdraw from the study your data will be compiled and presented as part of the findings of the project. The data will inform potential decision making frameworks taking into the account the unique needs of your organization.

Anonymity
In terms of protecting your anonymity, you can request that your name be omitted in the final document. Any information provided by you will be coded against the name of your organization.

Confidentiality
Your confidentiality and the confidentiality of the data will be protected by the researcher and will only be released if acceptable to you.

Dissemination of Results
It is anticipated that the results of this study will be shared with others in the following ways – through presentations to the Regional Engineers Advisory Committee, the Regional Administrators Committee, and the Medical Health Officers Annual General Assembly and via the written report made available to all water managers and emergency management officials.

Disposal of Data
Data from this study will be disposed of 6 months after the completion of the project. All electronic data will be erased and all written documentation will be shredded. Only the final copy of the report will remain available upon request.

Contacts
Individuals that may be contacted regarding this study include Water Manager, Medical Health Officers and Emergency Planning staff.

In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca).

Your signature below indicates that you understand the above conditions of participation in this study, that you have had the opportunity to have your questions answered by the researchers, and that you consent to participate in this research project.

Name of Participant	*Signature*	*Date*

I consent to be identified by name / credited in the results of the study: _____
(Participant to provide initials)

I consent to have my responses attributed to me by name in the results: _____
(Participant to provide initials)

Future Use of Data *PLEASE SELECT STATEMENT:*

I consent to the use of my data in future research: _____ (Participant to provide initials)

I **do not** consent to the use of my data in future research: _____ (Participant to provide initials)

I consent to be contacted in the event my data is requested for future research: _____
(Participant to provide initials)

A copy of this consent will be left with you, and the researcher will take a copy.

Appendix 4 - action #1 – Develop mutual aid agreements

Water/Wastewater Agency Response Network (WARN) - The WARN model has been extensively adopted in the United States as a way for water and wastewater organizations to create and easily administer mutual aid agreements. The specialized nature of utility operations create a relatively high need for self-sufficiency. Response plans that overly rely on the private sector for assistance may be flawed if private sector resources are mobilized to support other critical lifelines in the disaster. The WARN model allows municipalities and regions, to share specialized personnel equipment and resources with other jurisdictions up to and including the provincial and state level. (AWWA, 2006)

The strength of the program lies in the relative simplicity of the legal framework. If a requesting member asks for help, a responding member has the option to accept or decline. If the responding member agrees, then the requesting member is obligated to:

- Supply reasonable food and shelter for the responding members personnel
- Provide radio equipment if available, or at minimum, radio frequency information to facilitate communications
- Arrange for all permits required for response activities
- Reimburse the responding members personnel according to the terms provided in the responding members employment contracts
- Reimburse the responding member for the use of their equipment at rates agreed upon with the local WARN participants
- Reimburse the responding member for the actual replacement cost of all materials and supplies consumed during the assistance
- Fully indemnify and hold harmless the responding member from all claims arising from the responding members work during the period of assistance.
- Allow the requesting member the right to withdraw resources at any time.

The responding member is obligated to:

- Provide proof that worker's compensation benefits are in place for responding member personnel; however, costs associated with the insurance shall be reimbursed by the requesting member

The process to request help within the WARN network expands, based on geographical proximity. Initial calls for help are sent to neighbouring jurisdictions. If they cannot help, then jurisdictions outside of region are asked and so on.

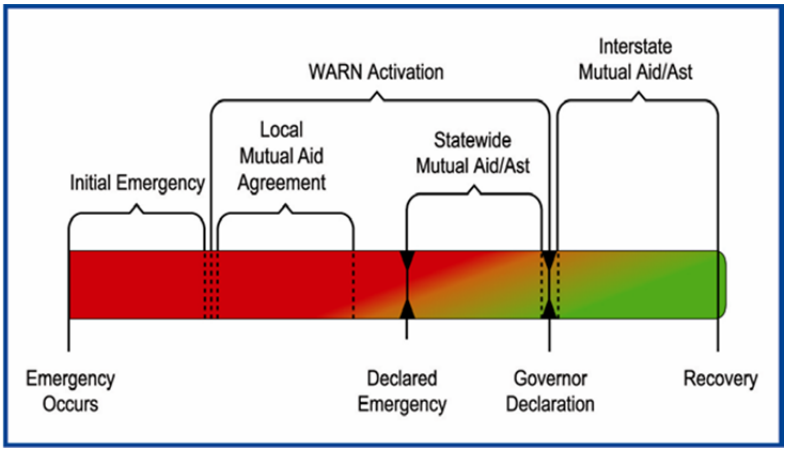


Figure A1 - WARN Activation Timeline – (AWWA, 2006)

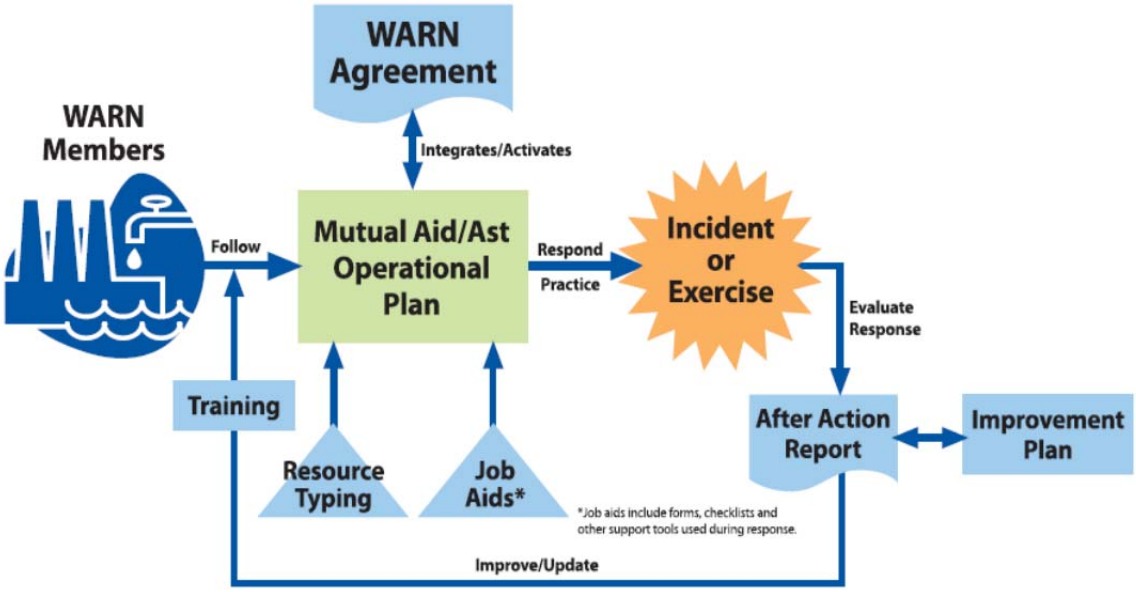


Figure A2: WARN Operational Plan Process Flow Chart

The City of Calgary has expressed interest in the formation of a BC/Alberta WARN group.

Setting up a WARN - Creating a WARN network requires an upfront investment of resources and an ongoing commitment to maintain the network, particularly contact information and equipment rates. The WARN Action plan available free from the AWWA (www.awwa.org), suggests that a steering committee should be developed to sustain the program. If the client acts upon the recommendation, a suitable first step is the formation of a steering committee to commence the organization process.

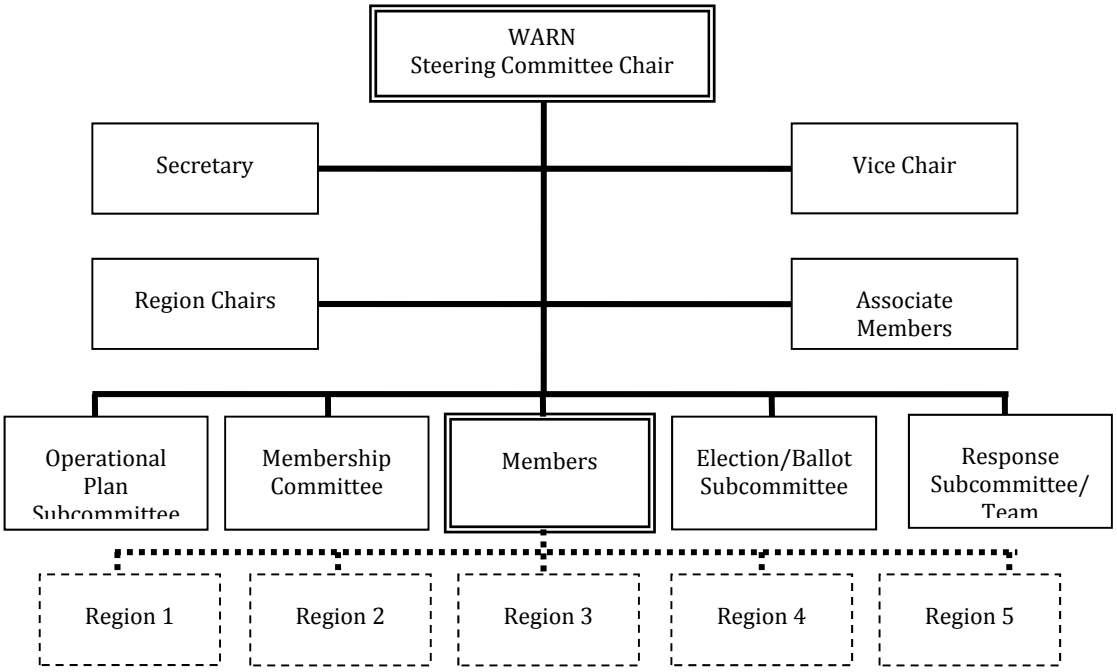


Figure A3 – WARN Steering Committee Org Chart

Action recommendation: That Metro Vancouver and the Member Municipalities undertake the formation of a local WARN and invite the Province to help develop a province wide WARN perhaps between BC and Alberta

Appendix 5 – action #2 – Enhance command structures

This action was discussed extensively in the report. An example from the City of Vancouver Water Utility demonstrated how the inter-organizational layer could be added to and existing command structure.

The larger challenge for the client will be ensuring these changes have been implemented. A champion from the REAC Water-subcommittee will need to emerge and lead the change. Annual simulations identified in Action #4 will support this activity and hopefully be the catalyst to operationalize the change going forward.

Action recommendation: Identify client champion to drive change in consultation with all relevant stakeholders

Appendix 6 – action #3 - Develop a communication platform strategy

One of the conclusions surrounding the failures of Hurricane Katrina was that in order to reap the benefits of improving situational awareness using a unified command model more reliable communications that are survivable and flexible are required. These communications platforms must be mobile, secure and both voice and data capable. (Wise, 2006) A strong communications network consisting of several redundant options would provide faster, accurate, more precise alerts to key decision makers providing an overall improved response during an emergency event. (Perry & Lindell, 1997)

It is recommended that a study be commissioned to ensure each communication medium is available in the physical environment. Also, a survey of each stakeholder's current capacity is needed as well. Each stakeholder will need to commit to upgrading or adding missing communication mediums on their end in order for concept of operations to be effective. The client will need to identify a governance team, develop a scope of work and identify a funding source for the project. Most jurisdiction have well established communication mediums, but many have abandoned tried and true UHF radio and lack access to satellite technology and amateur radio operators.

The following sections examine each communication medium in more detail. Case studies are discussed and provide description of actual observed failures. This information is intended to show local officials what they might have to contend with during an event.

Phones (land line) Recent Earthquakes in Haiti and Chile reinforce the potential for damage to traditional phone lines. In both cases, telephone communications were disrupted for several days. (Kovacs, 2010) Emergency response plans should be prepared with the expectation that telephone networks will be out of service for 3-5 days. Internet restoration via the cellular network will likely be disrupted as well, but should be restored faster that telephone as evidenced in Christchurch, New Zealand after a series of devastating earthquakes in 2010 and 2011. (Waterhouse, 2013)

Cellular phone Cellular service has steadily increased since the 1980's; however, system upgrades have not kept up with demand, especially during heavy call volume always experienced in disasters. The Boston Marathon bombing event in 2013 demonstrated the limits on the US wireless network, as the nation's major carriers were unable to manage the heavy loads. (Farrell, 2013)

Wireless towers are designed to block calls when loads exceed capacity rendering the network useless during extreme demands. (Farrell, 2013) A substantial earthquake will certainly generate higher call volumes and data transmission needs.

The earthquake may also damage the cellular towers, which create the physical backbone for the systems.

Satellite Phones - Satellite phones provide global coverage allowing one to communicate from any part of the world. (Narayanan & Ibe, 2012) Due to limited adoption (1 million satellite phones worldwide versus 3 billion 3G/4G phones (Narayanan & Ibe, 2012)), and extensive infrastructure requirements; user costs are high compared to cellular technology. The phones are difficult to operate as well, making their use one of the last resorts.

However, satellite phones may provide reliability, particularly early after an event, when other systems fail. Securing at least one phone per EOC will ensure that in the worst case, basic communication can occur. As of April 2013, per minute rates range from $1.0 - $2.0 per minute in addition to at $60 per month subscription fee. (Roadpost satcom, 2013)

In Chile, the water companies had transitioned to using cell phones as their primary method for voice communication. Primarily because of the failure of the widespread cell phone system, restoration efforts were delayed by a few days. (Eidinger & Davis, 2012) After a 5.9 Magnitude earthquake struck Virginia in August 2011, a flood of calls into the region effectively shut down voice traffic, forcing network carrier T-Mobile to "advise customers to use SMS or email". (Bilton, 2011)

Skype and Email – Skype and email service depends on fibre optic networks and telecommunication cable within buried conduit and overhead lines. Little is known about the true vulnerability of the fibre optic systems and whether they will hold up in the event of a massive earthquake. More engagement with the local telecommunication providers: Shaw, Bell, Rogers and Telus are needed to better understand the potential extent of service interruptions.

Short Message Service (Text) - Short messages service is a transfer to data through the cellular network. Text based transmissions are relatively small packets of information that have a higher probability of reaching the intended recipient. During heavy call volumes, cellular providers often encourage users to switch to texting rather than voice based communication. In the event of an emergency, AT&T is officially recommending that customers make only urgent calls and instead use text messaging to keep lines open for emergency personnel. (Buchanan, 2008)

The interviews with regional water managers revealed limited use of SMS, although the capability exists. The proliferation of smart phones with email capability (blackberry and IPhone) has penetrated deeper into most organizations. Many organizations confirmed that staff at the working foreman level (lowest level of field supervision) are now equipped with smartphone technology. Enhancing the use of texting will be and important means of creating communication medium redundancy.

Amateur radio - Better known as "HAM radio", it is one of the oldest point-to-point technologies utilizing a separate airwave frequency band. (Narayanan & Ibe, 2012) HAM radio is composed of a transmitter, receiver and antennae providing mostly voice and Morse code communication. Recent advances in technology have enabled connection between HAM radio and voice of Internet Protocols. As a result limited data transmissions such as text and simple databases are feasible.

The number of ham radio operators has steeply declined since the peak in the late 70's when over 10 million licenses were issued to operators in the US. Now, there is only an estimated 160,000 active operators in the US. Identifying active operators and securing their services will be a challenge for stakeholders.

Action recommendation: Commission study to confirm all communication mediums are available in the case of emergency

Appendix 7 – action #4 - Create requirement for annual simulations

Every single participant interviewed, stated that their organization needed to do more simulation training – at least on an annual basis. Most admitted that simulations were held once per year and often less. During the final focus group discussions further stressed the need for more scheduled simulations – annually at a minimum.

A program is required for the preparation and facilitation of annual simulations. The client will need to determine whether there is existing capacity with the various emergency manager positions that each organization employ. Perhaps a team could be built from existing staff. If no capacity exists, then resources will be required either from internal hires or consultants.

Scenario based simulations can be conducted in two ways – tabletop involving people and plans, or field simulations involving a more fulsome deployment of people and resources. Tabletops exercises involve a simulated response to a hypothetical disaster designed to serve a means of testing established plans. Tabletop exercises target several objectives:

- Validation of response plans
- Introduces personal and builds relationships for staff who may not work together day to day.
- Develops interagency cooperation, teamwork and confidence
- Improves understanding of Incident Management and Incident Command systems
- Most importantly – identifies gaps in planning. (Moyer, 2005)

Designing a tabletop or field simulation should include the following:

- A predefined starting and finishing time, which provides participants with a defined commitment of their time.
- A trigger action that initiates the exercise – an earthquake for instance
- An accelerated time rate to introduce many events that require a deployment decision.
- Sequenced delivery of information, also known as “injects”, that may trigger prioritization of other response activities already underway in the exercise.

Sample Simulation for annual MHO/Water Sub Committee Meeting

1:00 pm - Inject 1 – A 7.5 M scale earthquake occurred in Georgia Straight. Extent of damage unknown.

1:15 pm – Inject 2 – Flow from Coquitlam Lake has stopped according to SCADA monitoring locations. 911 has received a call of massive flooding on pipeline road in Coquitlam

1:45 pm – Inject 3 – Areas of Richmond, New Westminster, Burnaby and Coquitlam receiving reports of extensive structural damage, and flooding.

2:15 pm – Inject 4 – Coquitlam requests assistance from neighbouring municipalities.

2:30 pm – Inject 5 – Initial first responders in Richmond, Burnaby, New West and Coquitlam estimate 250 main breaks leading to widespread loss of systems within each municipality.

3:00 pm – Simulation Concludes

Several data sets will be required to support decision-making during the simulations and after a live event. These sets of information will inform the regional managers about available equipment, human resources, critical facilities and level of preparedness. These data sets should be updated annually as part of the annual simulation program. As a result, the act of running an annual simulation has a number of supporting roles listed below:

Simulation and Drill Development

- Co-ordination and facilitation of critical exercises designed to improve response time and mitigate risk during actual response – Annual tabletop exercise recommended.
- Build and maintain a library of simulations
- Provide post drill reports back to participants

Personnel and Equipment Inventory

- Collect and maintain human and physical resource inventory lists and contact information
- Contact Information for various emergency operation center locations – water utilities and related stakeholders
- Templates for incident information gathering

Communications

- Confirm communication mediums are robust and current

- Annual testing of primary and backup systems recommended

Critical Infrastructure Mapping

- Maintain asset vulnerability database – known weaknesses in regional and municipal water systems
- Maintain inventory of critical locations that will require water in support of the larger response – eg. Hospitals care facilities, rec centers, and emergency operations centers.

Action recommendation: Integrate an annual tabletop discussion into the annual REAC Water Sub-Committee work plan.

Appendix 8 - action #5 - Develop a training program for water professionals

On-going training for water utility managers is necessary to maintain a consistent regional response. During initial interviews, it was noted that a few of the water manager were unsure how the BCERMS model worked. Others did not know what their role would be and what would be expected of them during an activation of their EOC.

While training is important, demanding too much training may backfire given the limited time the busy managers have to invest. A blend of managerial skills related to commanding an operation along with leadership training is suggested. This action item recommends a suite of training designed to meet the minimum needs of the individuals who will find themselves in leadership roles during a crisis.

Leadership skills - During a command and control event, certain leadership traits have shown to deliver superior results. (Crichton et al, 2005) Leadership styles that command respect, minimize conflict between teams, provide clear direction and demonstrate confidence under pressure are important as decisions are made quickly, often times with limited information. For some, these skills are inherent, for others more accustomed to 'consensus based' decision-making; this style will be somewhat foreign. Good leadership is characterized by disciplined focus on key activities, and minimizing long discussion sessions that divert attention from the needs of others. (Chrichton et al, 2005)

Management skills - Separate from leadership skills, managing staff during a crisis often requires working longer hours than normal, often under stressful conditions. Having the ability to understand when certain individuals have exceeded their capacity is important in maintaining the recovery efforts over the longer term. A review of an incident in 2005 involving an oil drilling accident in the Gulf of Mexico concluded that a 12-hour work rotation led to high levels of fatigue and stress. A 3-shift system was recommended afterwards. (Chrichton et al, 2005)

Training Curriculum for Water Utility Managers - Interviews with the region's water managers in 2013 indicated a varying degree of training. Most were familiar with the principles of incident command, and many had participated in simulations where their corporate EOC facilities were activated. However, others stated the desire for additional training and more frequent simulations to build competency. The following curriculum of training is readily available within the region, all of which is offered by the Justice Institute of British Columbia in New Westminster. Many of the courses are offered online to lower time commitment barriers.

The proposed curriculum listed in table A1, targets hard and soft competencies – Emergency Response Fundamentals and Leadership & Management Skills. Full descriptions of each course can be found at the Justice Institute website http://www.jibc.ca.

Emergency Response Fundamentals
Incident Command
Level 100 – Couse # CMD 100 7 hours, online ($32, 2013 rate)
Level 200 – Course # CMD 200 14 hours online or classroom ($318)
Level 300 – Course # CMD 300 14 hours online or classroom ($318)

Managing and Leading during Emergency Response

Critical Incident Stress Management
CISM 100 - Introduction to Critical Incident Stress Management
7 hours, face-to-face (approx. $100)
CISM 200 - Post-Critical Incident Stress Reactions (Pre-req. CISM 100)
7 hours, face-to-face (approx. $100)
CISM 203 - Effective Team Participation (Pre-req. CISM 100)
7 hours, face-to-face (approx. $100)

Emergency Management
EM 110 - Introduction to Emergency Management in Canada
7 hours, online ($47.94)
EM 141 – Disasters and Trauma (Pre-req. EM110)
7 hours, face-to-face ($211.14)

Total # of Days required to complete curriculum = 10 days
Total Cost = approx. $1250

Table A1- Proposed Water Utility Manager Emergency Response Training Curriculum

Action recommendation: Ensure water managers have sufficient training prior to a live event.

Appendix 9 - action #6 – Commission study to identify all critical facilities

Work needs to be done to map and identify all critical infrastructure facilities within the region. Critical facilities can be separated into two categories:

- Critical facilities such as hospitals, temporary shelters and essential government facilities that require water as part of the broader disaster response
- Water system infrastructure that is liable to be damaged during a disaster

The scope of work for this project would include; defining the criteria for a critical facility, assembling a GIS base map of critical facility locations, and ensuring that the map is readily available at the Lake City EOC. The client will need to determine the resource needs and assemble a support committee comprised of each stakeholder to contribute to the project.

Action recommendation: Develop a critical facility map.

Appendix 10 - action #7- Commission a provision of water strategy

For the period between the disaster and the substantial recovery of the regional water system there will be an expectation that a temporary provision of water will be facilitated. The regional health departments have been clear that they expect a sufficient plan will be in place prior to a disaster.

Thus far, isolating who will take ownership for the provision of water has not been solved and this presents an enormous risk to the recovery operation if municipal water utilities are directed to oversee the temporary provision of water. This would divert the attention of the municipal or regional water agency away from the recovery of the underground pipe networking, sub-optimizing the manpower outside their normal scope of expertise, getting them away from what they do best: fixing the water pipes. (Smith & Dowell, 2000)

Trained water utility staff will be best utilized repairing the pressurized system so that normal supply conditions can be established as soon as possible. The temporary requirement still exists however, and will be an important response factor for each municipal government. The requirement to temporarily supply water falls to the municipalities, not the Province.

This requirement was clarified by the Ministry of Agriculture on February 28, 2013:

"I can confirm that the Ministry of Agriculture will not be responsible for the delivery of water to residents of Metro Vancouver in the event of an emergency such as an earthquake." Ted Van Der Gulik, P.Eng – Senior Engineer BC Ministry of Agriculture.

It is imperative that the region and municipalities develop a plan that identifies the various options for the temporary provision of water and who will lead the deployment mission.

Human Requirements - Basic personal needs suggest 2.5 – 4.5 litres of water is the minimum daily quantity for basic survival. (Glieck, 2009) This range is based on research by a number of organizations including the World Health Organization and the US Environmental Protection Agency.

For bottled water provision, 2L and 4L quantity denominations are standard for the bottling industry. Every effort should be made to provide 4L per person per day as the ideal, with 2L per person per day as the bare minimum.

Hospital and Care Facility Requirements - Hospitals and care facilities require more water per capita because of sanitation and hygiene needs. Therefore, delivering bottled water to hospital locations may not meet their basic needs. Part

of the strategy for the provision of temporary water must include planning with the hospital administrators to better understand the needs of the institutions and the ability of the local government to provide water.

The solution may include the provision of bottled water in addition to hauled bulk water that is stored (and disinfected if necessary) on site for use in the sanitization process.

Strategy Components - Developing this strategy is well beyond the scope of this report. If a consultant were to be engaged by the Client, the following elements would be critical criteria for the strategy:

1. The need to quantify the capacity and locations of bulk water providers
2. The need to identify alternate water supplies (wells) that could be connected into the underground system
3. The need to quantify the bottling capacity and bottling company locations within the region
4. The need to quantify the inventory and delivery capacity for bulk and bottled water (water tankers and bottled water trucks)
5. The need to quantify the potential demand for bottled water based on 2-4L per person per day
6. The need to quantify the demand for bulk water required at each critical infrastructure locations (linkage to critical sites Action #5)

Action recommendation: Develop a provision of water strategy that municipal members can implement within their organization.

Appendix 11 - action #8- Identify senior government champions

To mitigate concerns that smaller municipalities will lose their local autonomy, a sustained effort is required to promote the benefits of the concept of operations and in particular the decision-making process. The REAC Water Sub-Committee will need to create a strategy to promote the recommendations of this report. The strategy may include, reports to the senior officials in the stakeholder organizations, information meetings with senior levels of government and taking part in speaking engagements to promote the framework. This action will likely be the first action addressed since senior level buy-in will be critical in securing resources to move forward with implementation.

Action recommendation: Identify senior government champions that will support the implementation of the concept of operations.

Appendix 12 - action #9 Determine a backup EOC location

In the event that the Lake City location is damaged and cannot serve as the regional unified command EOC, an alternate location should be identified. The Lake City location in Burnaby is considered central for most and a backup location needs to offer similar access. In addition to having a favorable location, the backup EOC needs to have identical access to the communication mediums identified in the physical environment concept.

Needs assessment will be required to identify the functionality required from a backup location. Further to that, discussions will be required with the facility owner to lock up access agreements in advance. Some locations that could serve as a backup location might be:

- The Seymour Capilano Filtration plant located in North Vancouver
- The City of Vancouver ECOMM center located in Vancouver near Hastings and Boundary
- Burnaby City Hall

Appendix 13 – Focus group meeting agenda

REGIONAL WATER CONCEPT OF OPERATIONS - FOCUS GROUP MEETING PLAN

Date: June 16, 2013
Location: Seymour Capilano Filtration Plant
Time: 11am to 1 pm

Attendees:

Facilitator - Peter Navratil
REAC Water Sub-Committee members (10-13)
Metro Vancouver Staff (3)
Stakeholders (4)

AGENDA

Introductions – 5 mins

- State your organization and the role you perform

Recap of Initial Findings – context setting15 mins (Peter to present powerpoint)

- State the objective for the report and session
- Review the proposed concept of operations as well as the action items
- Map out the format for the rest of the session

Force Field Analysis 30 mins (13, 9, 7 minutes on each concept)

- Role Clarity in BCERMS (scribe - Andrew W)
- Decision Making Principles (scribe - Peter N)
- Con Ops – Physical Environment plan (scribe - Dan D)

Catered Lunch 15 mins –

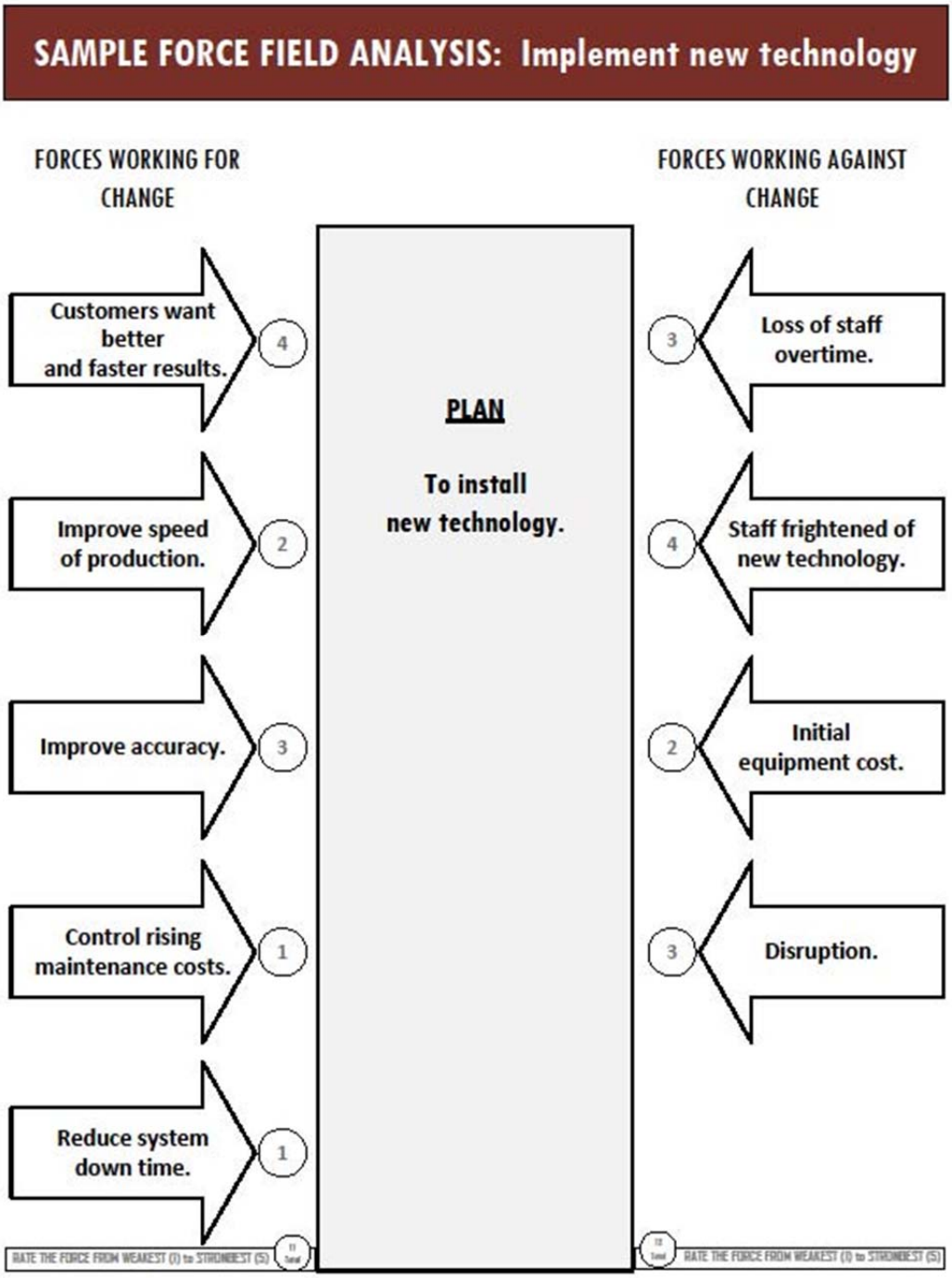
- Time for Peter to present the foundation for the next session – Decision Making Framework – process charting.

Process Flow Charting Exercise 20 mins

- Peter will break the group into three teams (same scribes from FF analysis) tasking each group with trying to develop a flow chart for decision-making that takes into account critical sites and restoration criteria

Wrap Up (5 mins)

Force Field Analysis Template:



http://www1.umn.edu/ohr/prod/groups/ohr/@pub/@ohr/documents/asset/ohr_asset_310480.pdf

Appendix 14 – Transcript from force field analysis and voting results

The following is a transcript of the flipchart notes captured during the force field analysis with the voting results from the issues ranking exercise indicated in brackets. Voting results are provided only for those issues that received votes.

Question 1 – Enhanced BCERMS Structures

Problem Definition: The current implementation of BCERMS does not adequately create communication linkages to the regional purveyor or neighbouring municipalities.

Change Objective: To enhance BCERMS to create communication linkages and operationalize these changes in our home organizations.

Driving Forces:

- Broaden/more effective use of resources (2)
- Priorities better managed
- Mutual aid (in region or out of region) (4)
- Enhances current model for regional "reality"
- Proactive modification
- Assists in decision making framework prior to events (2)
  - Understanding
- Establishes improved linkages (1)
  - Communication and for municipal planning
- Advance discussions on BCERMS and how IPREM fits/roles (1)

Restraining Forces:

- Legal certainty? (1)
- Budget
- Politics
- Effort to change municipal plans and protocols
  - Consistency
- Need to identify roles/decision making (6)
  - Effort and discussion
- Effort required
- Reliability of common communication links (4)
  - Radio?
  - Cell?
  - Internet?
  - Texting?
  - Lack of call lists
  - Lack of interconnectivity between local systems

Additional Comments

- What other linkages are required?

Question 2 – Decision Making Principles

Problem Definition: In the event that municipal and regional forces are overwhelmed, waters system recovery may need to be prioritized. A set of principles to guide that decision-making exercise will speed recovery.

Change Objective: Develop and agree on a set of principles and potentially a framework (decision matrix) or process flow.

Driving Forces:
- More efficient use of resources (2)
- Access to resources for regional priorities (2)
- Access to expertise
- Coordination to avoid working at cross purposes (1)
- Strategic rationing of limited resources (water) (2)
- Metro up first
- Empower team to make decisions based on issues at the time (2)
- Need for resolution process (1)
- Sharing of resources that might not be able to get to their "home" (municipal) location
- Helps achieve/consider health objectives with respect to water
- Articulates the principles and enshrining the prioritization

Resisting Forces:
- Loss of control (local autonomy) (1)
- Lack of resources
- Geography movement of resources across natural barriers (downed bridges)
- Conflicting local emergency plans (2)
- Lack of understanding of each other's systems
- Potential legal liability issues (White Rock)
- Misinformation of situation
- Slow down/interfere with established municipal procedures
- Getting access to sufficient information to make decision on the principles (2)
- Metro up first

Question 3 –Concept of Operations – Unified Command Posts

Problem Definition: The need to create the physical environment to support the concept of operations.
- Response
- Recovery

Change Objective: To create a protocol around an environment that supports information transfer and decision-making.

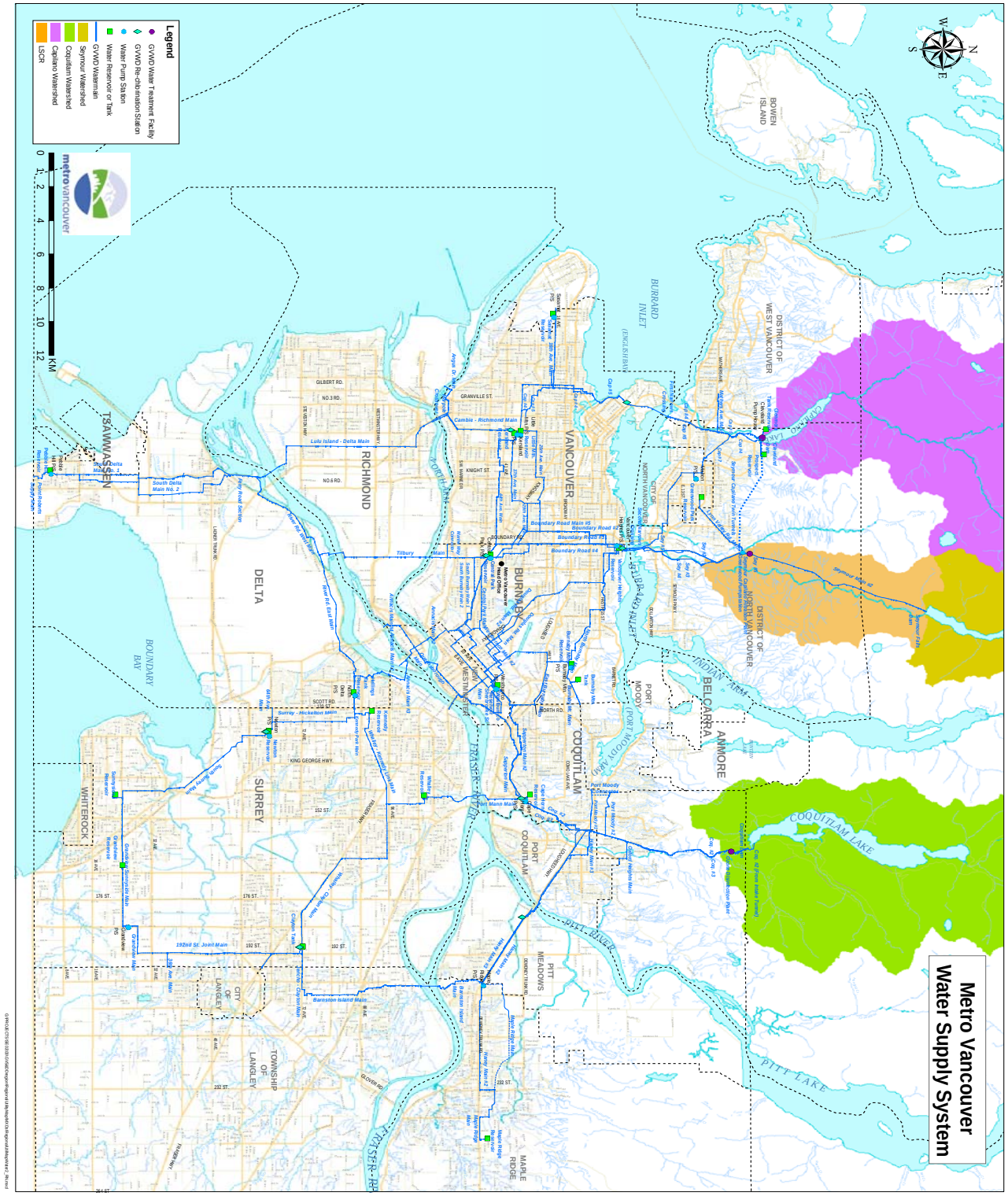
Driving Forces:

- Receiving information from MV (status of transmission system)
- Allows dialogue between municipalities (1)
- Allows for dialogue (1)
- Provides for scheduling
- Sharing analysis and development of alternatives
- Transparency of decision making/priority setting (7)
- Clearer communication among key stakeholders (3)
    - Public
- Has broad systems (IPREM) at table for broader understanding
    - Priorities and support
- Unified voice to external support agencies
- Allocation of outside resources
- Need to communicate reliably
- Need for each representative to clearly act as spokesperson for third agency

Resisting Forces:

- Resources/ability to "get there"
- Communication system reliability/availability (3)
- Staff availability
    - Who?
    - Politicians
    - Too many
- Competing municipal priorities for representative (1)
- Decision making protocols? (2)
    - Who makes final decisions?
    - Vote?
    - Commissioner?
- Moderating discussion
- Potential for perception of municipal conflict
- Can municipal data be accessed
- How are protocols changed?
- Increase complexity of decision making vis a vis IPREM
- Limitation of fixed location (2)
    - Alternate locations available?
    - Mobile command?
- Need resources to create system for reliable communications
- Lack of empowerment may be a concern under emergencies

Appendix 15 - Metro Vancouver water supply map



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