Re-Fresh: The Confluence of Ideas and Opportunities on Water Reuse

Symposium Proceedings

Alberta Water Council
June 25 & 26, 2014
Calgary, Alberta

About these Proceedings

These proceedings contain synopses of the 18 presentations and discussions that followed, as well as the two panel discussions and the opening and closing remarks. The synopses were prepared by the Alberta Water Council based on notes taken during the speakers' presentations and on their slides. Although speakers each reviewed and edited their draft synopsis for content and accuracy, readers should appreciate that the synopses may not reflect the individual writing styles of the various presenters. The MS Powerpoint™ slide presentations are available on the Alberta Water Council's Water Reuse Symposium website at http://awcreusesymposium.ca/Speakers/tabid/191/Default.aspx until summer 2015, after which time, they will be provided on request to the Council through the contact information below. A link to the slides for each presentation appears at the end of each synopsis.

About the Alberta Water Council

The Alberta Water Council is a multi-stakeholder partnership that provides leadership, expertise and sector knowledge to engage and empower industry, non-government organizations, and governments to achieve the outcomes of the *Water for Life* strategy. The Council also advises the Alberta Government, stakeholders and the public on effective water management practices and solutions to water issues, as well as on priorities for water research. Where there is consensus, the Council may advise on government policy and legislation. However, the Government of Alberta remains accountable for the implementation of the *Water for Life* strategy, and continues to administer water and watershed management activities throughout the province.

The Council operates by consensus and is guided by an executive committee. It submits reports and recommendations directly to the Minister of Environment and Sustainable Resource Development and to other stakeholders.

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Introduction to the Water Reuse Symposium

The concept for the water reuse symposium originated from a proposal presented to the Alberta Water Council by the Government of Alberta. The Council identified this initiative as priority work at its October 2012 board meeting and established a committee to further define and scope the project. In addition to all our sponsors and Conference Couch hosts, noted below, the Council is very grateful to the symposium committees that organized and delivered this event. Committee members and their affiliations are noted in Appendix A.

The purpose of this initiative was to organize and host a symposium that would bring water using sectors together to share global water reuse knowledge, challenges, and solutions to inform the potential development of responsive water reuse policy in Alberta. The symposium organizers aimed to connect knowledgeable and experienced experts with those working to solve water reuse questions in Alberta and elsewhere. In addition to the formal conference presentations and the discussion they stimulated, the organizing committee also implemented "the Confluence Couch" –an informal, relaxed setting for participants and speakers to interact for more in-depth discussions on water reuse. Each Confluence Couch host facilitated those discussions during breaks at the symposium and encouraged dialogue among delegates and speakers. The following organizations hosted a Confluence Couch session:

- Watershed Planning and Advisory Councils
- Alberta Association of Municipal Districts and Counties
- Western Canada Water Environment Association
- Ducks Unlimited Native Plant Solutions
- Alberta Urban Municipalities Association
- Alberta Low Impact Development Partnership
- Alberta WaterSMART

Over two days, nearly 200 water managers, decision makers and others with an interest in how water is used and reused explored opportunities for Alberta to adapt and build on innovative technologies and systems. The Alberta Water Council was very pleased to host this symposium. We hope the information provided will be thoughtfully and creatively incorporated into strategies that move our province towards a more integrated and adaptable water management system that includes water reuse.

Gordon K. Edwards
Executive Director
Alberta Water Council

Symposium Agenda

Re-Fresh: The Confluence of Ideas and Opportunities on Water Reuse
Symposium Schedule of Events

Wednesday June 25, Morning

Theme 1: Business and Environmental Sustainability - Perspectives of business and how to make water reuse sustainable and economical.

7:30 – 8:30 Ballroom/Foyer	**REGISTRATION & BREAKFAST** *Breakfast Sponsor: ConocoPhillips Canada*
8:30 – 8:35 Ballroom (Spectrum 4&5)	**Symposium Opening** (Gord Edwards, Executive Director, Alberta Water Council)
8:35 – 8:50 Ballroom (Spectrum 4&5)	**Welcome Remarks** (Jay Ingram, Science Writer and Broadcaster)
8:50 – 9:10 Ballroom (Spectrum 4&5)	**Welcome Remarks** (Shannon Flint, Assistant Deputy Minister, Alberta Environment and Sustainable Resource Development)
9:10 – 10:10 Ballroom (Spectrum 4&5)	**Keynote 1: Water Reuse: Business and Environmental Sustainability** (Speaker: Edwin Piñero, Senior Vice President for Sustainability and Public Affairs; Veolia North America)
10:10 – 10:35 Ballroom/Foyer	**NETWORKING BREAK & CONFLUENCE COUCH** *Break Sponsor: Canadian Association of Petroleum Producers*
10:35 – 11:20 Spectrum 3	**Concurrent 1** a) **The Business Case for Reuse: Encana's Experience So Far** (Speaker: Dave Lye, Vice-President Policy, Environment & Sustainability Investor Relations & Communications, Encana Corporation)
Spectrum 4&5	b) **Healthy Aquatic Environment – Improving Watershed Health through Water Reuse** (Speaker: Dr. Stephen Stanley, Senior Vice President, EPCOR Water Services)
Spectrum 1&2	c) **Matching Water Quality to Reuse: Rationale for performance-based targets and a systems approach to manage public health** (Speaker: Professor Nicholas Ashbolt, School of Public Health, University of Alberta)
11:30 – 12:15 Ballroom (Spectrum 4&5)	**Business Case Panel Discussion** (Speakers: Edwin Piñero, Dave Lye, Dr. Stephen Stanley, and Nicholas Ashbolt)

Wednesday June 25, Afternoon

Theme 2: Technology and Innovation - Exploring novel approaches or technologies from Alberta and other jurisdictions.

12:15 – 1:15 Ballroom/Foyer	**NETWORKING LUNCH & CONFLUENCE COUCH** *Lunch Sponsor: City of Calgary*
1:15 – 2:15 Ballroom (Spectrum 4&5)	**Keynote 2: Influencing Technology Development and Adoption – Market Pull vs. Technology Push** (Speaker: Brian Gregg, Manager Global Research, General Electric Canada)
2:25 – 3:10 Spectrum 3	**Concurrent 2** a) **Water Life Cycle in a SAGD Oil Sands Facility** (Speaker: Dr. Michael Scribner, ConocoPhillips Canada)
Spectrum 1&2	b) **The Interplay between Technology and Regulation as it Impacts Environmental Performance** (Speaker: Dr. Preston McEachern, CEO, PurLucid Consulting Ltd.) *Session Sponsor: Alberta Innovates Energy & Environmental Solutions*
Spectrum 4&5	c) **Stormwater Reuse Innovation Down Under: Are the challenges in Alberta really that different?** (Speaker: David Seeliger, Corporate Lead, MPE Engineering Limited) *Session Sponsor: Brownlee LLP*
3:10 – 3:35 Ballroom/Foyer	**NETWORKING BREAK & CONFLUENCE COUCH** *Break Sponsor: University of Lethbridge*
3:35 – 4:20 Ballroom (Spectrum 4&5)	**Water Reuse Best Practices Panel Discussion** (Speakers: Brian Gregg, Dr. Mike Scribner, Dr. Preston McEachern, and David Seeliger)

Wednesday June 25, Evening

5:45 – 6:30 Foyer	**RECEPTION & CONFLUENCE COUCH**
6:30 – 9:00 Ballroom/Foyer	**DINNER & ENTERTAINMENT** (Loose Moose Improv)

Thursday June 26

Theme 3: How to Apply Water Reuse in Alberta - Implementation of water reuse ideas within the Alberta context.

8:00 – 9:00 Ballroom/Foyer	**BREAKFAST & CONFLUENCE COUCH** *Breakfast Sponsor: Canadian Association of Petroleum Producers*
9:00 – 9:45 Spectrum 3	**Concurrent 3** a) **Barriers and Acceptability of Water Reuse** (Kim Fries, CH2M HILL)
Spectrum 4&5	b) **Water Reuse Policy Development (Part 1): Understanding opportunities and barriers** (Speaker: Susan Davis Schuetz, Consultant, Alberta WaterSMART)
Spectrum 1&2	c) **Regulatory and Practical Issues and Opportunities for Water Reuse in the Power Generation Sector** (Speaker: David Lawlor, Director, Environmental Affairs, ENMAX Corporation) *Session Sponsor: City of Edmonton*
9:45 – 10:15 Ballroom/Foyer	**NETWORKING BREAK & CONFLUENCE COUCH** *Break Sponsor: Devon Canada*
10:15 – 11:00 Spectrum 1&2	**Concurrent 4** a) **Understanding Greywater Reuse** (Speaker: Wayne Galliher, Water Conservation Project Manager, Water Services – Planning, Building, Engineering and Environment -City of Guelph)
Spectrum 4&5	b) **Alberta Water Reuse Policy Development (Part 2): Exploring policy development options to support stormwater use and wastewater reuse** (Speaker: Angela Alambets, Project Engineer, Alberta WaterSMART) *Session Sponsor: MLT Lawyers*
Spectrum 3	c) **How to Get Your Water Reuse Project Approved** (Speaker: Ryan Devlin, Vice President Sales and Operations, ZL EOR Chemicals Inc.)
11:15 – 12:00 Spectrum 3	**Concurrent 5** a) **Integrative Water Systems for Urban Developments** (Speaker: Susan Nelson, CEO, OpenGate)
Spectrum 4&5	b) **Removing Barriers to Implementation in the City of Calgary: Why and how would a municipality implement stormwater reuse?** (Speakers: Harpreet Sandhu, Team Lead - Water Resources Strategy and Bert van Duin, Senior Planning Engineer, City of Calgary)
Spectrum 1&2	c) **Flowback and Produced Water Reuse** (Speaker: Bill Berzins, President, K'nowbe)
12:00 – 1:00 Ballroom/Foyer	**NETWORKING LUNCH & CONFLUENCE COUCH**
1:00 – 2:00 Spectrum 4&5	**Keynote 3: The Economics of Well-being of Water Reuse** (Speaker: Mark Anielski, Economist and Author)
2:00 – 2:15 Spectrum 4&5	**Closing Remarks** (Jay Ingram, Science Writer and Broadcaster)

Opening Remarks

Jay Ingram,
Symposium Chair

Albertans understand water is a very important issue for the province and are anxious to see some progress on water reuse. The symposium organizing committee recognized 1) how important the topic of water reuse is, and 2) how important it will be to generate real momentum following this event. We need some action, not just talk, and want to tap into the many experienced and knowledgeable people in attendance.

Daniel Kahneman in his book, *Thinking Fast and Slow*, describes two ways of thinking. System 1 is the one we use most – it's intuitive, fast, impetuous, impressionistic, gullible, based on gut instinct, and relies on stereotypes. That isn't a very flattering list of descriptions, but System 1 is a useful way of thinking; it depends on information it already has in store, and has proven to be useful. System 2 is different; it's more reflective, slower, deliberate, analytical, deep, explorative, and provides sober second thought. When we face new ideas, it is worth reflecting on the fact that our immediate reaction may not be the best one.

Dan Kahan is an expert in the field of cultural cognition. He notes that we all live with people who share our values and attitudes, and when those values and attitudes are challenged we tend to reject that input. The most important thing cultural cognition says is that when there is a scientific controversy, the resolution might look like science but most of the time these things are not decided by science. Rather they are based on social or cultural attitudes that people already have onboard. This is hard to overcome – and indeed no convincing remedies have been offered as far as I can see – but it is something we need to keep in the back of our minds.

Alex Pentland has written about social physics and says the best ideas come from careful and continuous exploration. Crowd wisdom works as long as there is no social interaction – that is, only when each piece of data is independent. But if the best ideas come from exploration, there has to be some social interaction. At one end of the spectrum some people are preoccupied only with their own thoughts, while the other end is an echo chamber where nothing is new. We have to find the space in the middle where you take your ideas and some of the crowd's best ideas and move them forward. Ideas only take hold with susceptible people if the ideas are useful, consistent with your ideals, and come from a trusted source. So how do we create the situation to get these ideas? Unsuccessful groups have people holding forth for a long time. A better approach is to get ideas out quickly and succinctly followed immediately by comments, and the most important thing is to have a diverse group.

With that context, we will launch into this symposium. Be skeptical of yourself. Hold firm to your ideas but not too firmly and be willing to listen to new ones that might challenge yours.

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Theme 1:
Business and Environmental Sustainability

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Water Reuse: Business and Environmental Sustainability

Edwin Piñero,
Veolia North America

Adopting approaches to preserve and protect our water resources is inherently good, but in reality such approaches can be derailed by many things including the need to make the business case for water stewardship. In particular, the discrepancy between the price of water and its actual value has often prevented the adoption of many innovative approaches. Water reuse is one area where the technology and know-how exist, but the business case, policy conditions, and societal views can hinder development and implementation of new ideas.

First, implementing water reuse requires additional investment in technology and processes compared with traditional "collect, treat, and discharge" systems. Then getting society to accept reuse of treated water, regardless of how clean it is, is often a challenge and has resulted in relatively low levels of reuse compared to what the technology can support.

The key point is that water reuse has to be seen as the logical and prudent path forward. Once organizations recognize the true value of water, which is invariably greater than what they pay for it, they will use and manage water much more proactively and sustainably. Several enabling factors will help us get to this point, including technology, infrastructure, education and awareness, policy and incentives, public acceptance, and private sector drivers. The corresponding policy framework must also be in place if we are to make any progress.

But the catalyst for making a sound business case for reuse is recognizing the role and value of water in society, ecosystems, and the economy, as well as its cultural and historical significance and its value in terms of security and resilience. The value of water includes all of these aspects plus recognizing the risks and impacts of its absence. This does not mean trying to determine a monetary value of water in the ecosystem, or to price its social and cultural value. That value is, for all intents and purposes, priceless, especially in the eyes of many stakeholders. Instead this is a working value for planning purposes.

In the business community, a key element of recognizing the true value of water, beyond the known direct and indirect costs, is being able to assign a dollar value and understanding the associated risks. When such a more comprehensive business case is made, innovation and creative decisions result. This includes considering return on investment and payback timeframe, risk management, regulatory issues, social licence to operate, and brand management. Challenges in making a business case for water reuse include:

- Water is too cheap, which makes for long paybacks compared to other projects.
- It is difficult to compete for investment dollars, compared to energy and climate investments.
- The risks are not well understood, they are rarely monetized, and they focus on water quality impacts, not availability especially if the risks are not natural and predicted.
- Until recently, water-related risks (e.g., operating in a water-scarce area) did not figure into the cost of capital, insurance rating, or investment risk rating, but this is changing.

The World Economic Forum looks at global risks and in 2013, ranked water supply as the second major risk. Others have also highlighted the potentially serious financial impacts to companies if water was priced to reflect its true value. Most water risks (operational, financial, regulatory, and reputational) are known, but they need to be monetized in order to be incorporated into long-term decision making.

Once the risks to an organization associated with water, such as loss of access or adverse quality impact, are truly evaluated, reuse becomes a much more attractive and economic option. Reuse simultaneously reduces the treated wastewater discharge and increases available supply. This solves two major risks that are faced by nearly every type of water-using entity, whether private or public. Other opportunities related to good water management also become apparent:

- Improved competitiveness,
- Co-creation of shared value for the organization and for other stakeholders,
- Licence to grow,
- Optimization of insurance fees,
- Improvement of cost of capital, and
- Better rating from agencies.

Innovative water reuse strategies have been developed in the oil sands operations in Alberta; the Fulton County, Georgia wastewater treatment plant; and Singapore.

Water reuse is already occurring in Alberta oil sands operations and is one of the most advanced applications to date. However, several risks are all coming to a head at the same time, including potential water scarcity, increasing regulatory pressure, changing public perception, cost of operations and the fact that logistical limitations of other options are being reached. This experience demonstrates that investing in reducing risk and supportive business approaches makes sense, and water reuse is one of these approaches. The objective of this work, undertaken by Canada's Oil Sands Innovation Alliance (COSIA) as well as other companies and stakeholders, was to make a business case for water stewardship based on water valuation in the oil sands. When very specific risks and issues were considered and translated into economic terms so their impacts on an organization could be assessed, the hidden costs became apparent. When all of these costs were included, it was obvious that the company had much more exposure per cubic metre than previously thought; monetizing the water risks enabled them to better justify their investments, recognizing that water reuse reduces risks.

Fulton County, Georgia has developed a wastewater reclamation facility with six miles (10 km) of distribution pipes. This water is used for irrigation at various community facilities, including churches, golf courses and others. The water is not used for drinking nor is it for use by private residents. The community built an education centre at the facility to raise understanding and awareness.

The establishment of water reuse initiatives in Singapore was driven by necessity, as there was not enough water to support the country's growth. Supplies from Malaysia only meet 30% of current needs. Using existing technology, Singapore developed a national strategy and has become a world leader in reuse technology. Reuse supplies one-third of the total water demand and 5% of tap water, and is proudly accepted by the public.

With a better understanding of the business case and risks, we are seeing a notable increase in water reuse. However, policy development and public awareness are equally important. The policy and regulatory structure has to recognize the value of reusing water and facilitate the effort. Efforts to raise awareness of why reuse is important and necessary, and providing a comfort level that it is safe, must occur in parallel with policy development.

Discussion

Q: What factors could turn the Fulton County example into something that more closely resembles Singapore? Also, what obstacles did Fulton County encounter; for example, irrigating golf courses with reused water is one thing, but what about uses such as firefighting?

Edwin Piñero (EP): Fulton County started its work by acknowledging the growing demand on its water resources and the need to reduce pressure on its current potable water supplies. In the US, federal, state, and municipal laws vary; there are also specific and variable regulations and rules for utilities. At the same time, the public's perception may differ from what the regulatory scenario says is possible – the "ick" factor, which means that people simply do not want reused water used for some things. Until we get over that psychological barrier, there is little appetite on the part of regulators to address the issue. This means local authorities have to work with utilities to make a case for a specific use. Because the water is used only on municipal sites and not for human consumption, Fulton County's treatment does not get it to a potable level, although that is technically possible. Raising the level of public acceptance of water reuse will eventually lead into a regulatory process.

Q: You talked a lot about large facilities. What about micro-systems for places that can't put in large infrastructure?

EP: Small scale reuse is actually much more common than people realize. You can have in-house treatment plants to treat water from a facility and use it internally as a loop within the organization. On a very small scale, people may use rainwater or discharge from their dehumidifier to wash clothes. Usually this is because they want to do a good thing on their own, but most people do not see the need.

Q: Have you seen many municipalities look at valuing water for reuse?

EP: The methodology and tools are relatively new although the World Business Council for Sustainable Development (WBCSD) has published a concept paper on water valuation. On the public sector side, there is an artificial business driver; even if the math doesn't work, they may have to do something because of responsibility to the community. The Value of Water Coalition (http://thevalueofwater.org/) in the US is addressing this aspect with education and a framework to enable the implementation of innovative technology. Then a business case can be developed to determine what actions might be warranted (e.g., a rate increase). It is something of a reverse approach, but the idea has to be sold to ratepayers and permission is needed from utility commissions, so it is complicated.

Comment: We are building a micro-system plant for a 19-acre site to serve between 340 and 1200 people. We had to get a variance to allow greywater use, which can be done as long as certain standards are met. But the challenge in Alberta is that there is no such thing as greywater – it's either potable or non-potable. This project will realize big savings and will take demand off potable water.

EP: This shows the need for the right enabling framework. Public sector responsibilities mean that changes in policy and regulatory require a comfort level in the public that no harm will result.

Q: Would you agree, given the need to clearly define terms like "potable water" to citizens, that education is a key challenge?

EP: Yes. People know clean water comes from one pipe and wastewater goes out somewhere else. It is very important to raise awareness of the water reuse concept in a practical way.

Slides for this presentation can be viewed here.

The Business Case for Reuse: Encana's experience so far

Dave Lye,
Encana Corporation

Encana Corporation is a leading North American energy producer with operations in both Canada and the US. The company's portfolio includes natural gas, oil and natural gas liquids. Encana utilizes significant volumes of water during the completion of oil and gas wells during hydraulic fracturing operations. Decisions around water reuse are made in the larger context of the life cycle of an oil and gas "play"; that is, an oil and gas development area. Hydraulic fracturing involves injecting through the well a combination of water, sand, and a small amount of chemical additives into the target rock formation, which is located deep underground, at high pressures. The injected fluid creates small cracks in the targeted rock formation, allowing gas and oil to flow up to ground surface. Both flowback water (the water returned to the surface after the well has been hydraulically fractured) and produced water (formation water) are returned.

Encana's approach to water sourcing is to minimize the use of fresh surface water as much as practical in its operations. The company has being working to reuse flowback water as one way to avoid surface water use; reusing flowback water presents a number of challenges and opportunities.

Water is a critical input and is what enables hydraulic fracturing to be done. Encana understands that water is valuable and that the company has a responsibility to be a strong steward of that water. This stewardship includes water reuse as well as the use of non-potable water when possible and practical in hydraulic fracturing operations. Encana also ensures industry best practices are followed and the company is transparent about the water volumes and chemicals it uses. Also, water plans are developed for all plays.

In identifying the most appropriate water source for each play and creating the business case for water reuse, Encana's analysis considers:

- Community and stakeholder concerns, including how we use and treat water when it comes to neighbouring communities
- The geology and terrain
- Environmental factors
- Technical and economic feasibility
- Regulatory and permitting components
- Opportunities for industry collaboration
- Play maturity. To develop a resource play can take 30 or more years. Steps include exploration to validate the presence of the resource, pilot wells which allow for appraisal work that can determine whether an oil and gas play is viable, and finally commercial development. At this stage, we can explore reuse schemes and potential partnerships and collaborations.

Long-term exploration and testing of plays has enabled us to make the case for reuse. As the sustainability lens is applied to the economic lens, reuse becomes a priority. Technical feasibility is also important so we can determine how dirty the water can be and still be reused. Minimizing the amount of treatment required improves the viability of our business.

Policy drivers also affect water reuse and these vary with the jurisdiction. In Alberta, these drivers are water conservation policy and the Alberta Energy Regulator's (AER) play-based regulation. Water conservation policy requires industry to show increased use of alternate sources and to preferentially maximize water reuse and recycling. The AER water management objective is focused on enabling saline and recycled water use. In BC, the drivers are largely the *Water Sustainability Act*, which requires operators to prove they are using water efficiently, and the Infrastructure Royalty Credit Program, which supports water infrastructure that enables recycling and reuse.

General challenges to water reuse include:

- Economies of scale
- Volume of the available water stream
- Quality of the available water stream, which affects how much treatment is needed
- The availability and practicality of infrastructure (as infrastructure is built out, there are more opportunities to implement a reuse scheme)
- The availability and practicality of water storage capacity.

Three case studies illustrate examples of water reuse in the US and Canada.

Case 1: Piceance Three Phase Gathering and Treatment Facility

This facility is located near Denver, Colorado. The play has been active for 20-25 years with thousands of wells and mature infrastructure. Since 2003, Encana has used an extensive water treatment and distribution system to support drilling and well completion operations in Colorado's Piceance Basin. The play has now moved to a closed-loop water management system and the project treats approximately 1000 m^3 per day. The natural gas and water come to a central treatment facility where gas is processed for market and the water is treated and stored in the lined pond for reuse. For this approach to work, a mature field along with a significant amount of infrastructure and water are required.

Case 2: Neptune Water Treatment Facility

This facility is located in Wyoming and will be in operation shortly. To get a permit to proceed with this development, the potential for water reuse had to be explored. Encana has a lot of information about the geology and operation of the wells which will determine whether reuse is possible. Several hundred wells are planned for the next 60 years in the region, and this will be the third largest water treatment facility in the US (the other two deal with heavy oil water in California). The plant will treat 3800 m^3 of water per day to be used in hydraulic fracturing operations. By treating it to drinking water standards, the extra water can be used for other purposes. The process uses an opti-pore treatment, which deals with the organic compounds and there is a reverse osmosis system that deals with the hydrocarbons.

Case 3: Dawson Water Resource Hub

This mature operation is in BC and the initial source water is from deep saline wells. This facility recycles water from our operations and combines it with otherwise unusable saline water from deep aquifers, providing Encana with source water for hydraulic fracturing and greatly reducing our need for fresh water. The facility functions as a recycle and reuse loop by blending water returned from hydraulic fracturing with saline water. This project requires significant storage capacity, as between 1200 and 6000 m^3 per day are used.

In summary, the case studies have revealed several things that are essential for water reuse to succeed:

- Approaching water sourcing from a sustainability perspective preferentially positions reuse as the preferred option.
- Water sourcing and reuse solutions are complex; identifying the right solution requires thorough analysis by an interdisciplinary team.
- Play maturity is the critical driver to enable reuse opportunities. The capital investment is large and certainty in the play development is needed.
- Government policy and stakeholder expectations preferentially maximize reuse and recycling.
- There is no "one size fits all" solution to water reuse. Each play is different and there is often variability across the plan. We need to understand all the technical aspects (environment, geology, terrain, etc.).
- Collaboration and innovation are key.

Discussion

Q: We have a lot of wells in our area and there have been issues with hydraulic fracturing and water contamination. Only about 150 feet of pipe are put into the ground and this affects our drinking water. We have never had accurate answers to our questions. Water is being brought in to do the fracturing; why isn't the produced water being reused?

Dave Lye (DL): Casing is paramount. Drilling is done below the base of groundwater to ensure that potable water is not being affected. The play in that area is very mature so the challenge is to figure out how the infrastructure can be adapted for water reuse. It would be a big challenge to retrofit as this would require more disturbance and cost.

Q: Are you seeing any interest from investors and insurance with respect to water issues?

DL: Interest has increased in the last several years, as water more often comes up as a risk. Then they ask how it is being managed and we describe our plans. On the financial side, if you see our regulated disclosure, water risk is there.

Q: Collaboration leads to action. What are the important factors?

DL: Maturity of play is important; our competitors must understand the development of the play and they need to be on the same side. Proximity is important as we need to be positioned correctly together. Joint ventures are common to share the risk and existing business relationships facilitate collaboration. Scarcity of available water will enable collaboration. We also looked at selling our excess water to suppliers, although that is not exactly collaboration.

Q: Regulations in Alberta mean that water cannot be used between facilities here. Have you encountered this?

DL: I'm not sure about that.

Q: Is there a difference between BC and Alberta in terms of water storage standards?

DL: Standards are generally the same.

Q: What was the biggest risk to making these decisions happen, and did public pressures in the area play any role in the decision?

DL: Supply issues would be the biggest risk. When engaging with the public, it's a bit of an organic conversation and there is no easy way to get there. Links to community expectations, regulatory aspects, development timelines, and all the other factors have to come together to make everything work. Our way is to get the people together.

Q: Does play-based regulation enable water reuse opportunities?

DL: Yes; since there is no “one size fits all” solution, play-based regulation helps to create opportunities for each area.

Q: How is disposal managed when dealing with a surplus of water?

DL: It falls out of the water rights licences and regulation. Generally speaking, historically regulation has required us to dispose of produced and flow back water back into the formation. It is difficult for us to provide it to other operators because of water rights licensing laws.

Slides for this presentation can be viewed here.

Healthy Aquatic Environment – Improving Watershed Health through Water Reuse

Dr. Stephen Stanley,
EPCOR Water Services

EPCOR serves about 80 communities and industrial sites in Alberta and BC, as well as communities in the southwest US (Arizona and New Mexico), and also operates in the oil sands region. Various facilities in the southwest US have well-developed water reuse programs in place, as do the Edmonton Wastewater Treatment Plant and some companies in the oil sands. The main driver for water reuse is water scarcity, which in turn is driven by a number of factors. About 80% of the world's population lives in dry or drought-prone areas. Historically water scarcity has not been a big issue in Canada, but it is an emerging issue and will result in increased costs to obtain water supplies.

Water reuse is becoming a significant source of water in many locations, such as Australia and California. Traditionally wastewater is treated and goes into the river, so reuse is occurring indirectly. Types of more direct water reuse include:

- Augmentation of supply sources, such as groundwater recharge
- Urban reuse; e.g., irrigation of parks and golf courses, toilet flushing
- Environmental and recreational reuse; e.g., creation or restoration of wetlands
- Agricultural use and reuse
- Industrial reuse and recycling; e.g., cooling water, fire protection.

About 70% of water reuse projects are for agricultural irrigation (32%), landscape irrigation (20%) and industrial use (19%). Potential benefits include conservation of freshwater supplies, better nutrient management, improved protection of sensitive aquatic environments by reducing effluent discharges, and provision of economic advantages (e.g., reducing the need for supplemental water sources, associated infrastructure and energy use). Advantages of water reuse are its good proximity in urban areas and its dependability as a reliable source. The reality is that even though we continue to improve our treatment of wastewater, we still rely on dilution to achieve the desired water quality objectives.

Three major factors need to be considered in any water reuse project:

- Economics,
- Matching supply and demand, and
- Return flows. Instream flow needs often require return flows, which are also important for consumptive use. Return flows can also substitute for freshwater use.

Globally, water reuse has focused on irrigation, which accounts for over 50% of all projects. In Canada, this use is limited due to the relatively short irrigation season, which requires large storage capacity. Urban irrigation comprises only a small portion of overall water use. Here, we need to find reuse opportunities that have year round demands, and industrial requirements meet this need.

I would like to share two examples of water reuse solutions that EPCOR has been part of. The first is the EPCOR-Suncor Solution at Gold Bar Wastewater Treatment Plant in Edmonton, and the second is a surface water treatment plant in Anthem, Arizona that uses Colorado River water.

The Gold Bar facility treats the City of Edmonton's municipal wastewater and delivers a portion of it to Suncor's Edmonton refinery for use as cooling water and the production of hydrogen and steam. Cost was a significant driver for the project, given the costs associated with new river intakes and treating raw river water, and there were also issues with respect to new river intakes. This project has reduced Suncor's freshwater use from the North Saskatchewan River by 40%.

The Anthem project has both a water treatment plant and a wastewater treatment facility on a common site. It has three different systems that deliver potable water, wastewater collection and treatment, and reclaimed water. In essence, water is used three times: as potable water, wastewater, and effluent/recycle. One hundred percent of the wastewater is reclaimed, reused, or recharged. The main driver for this project was water scarcity and the cost of source water and Arizona has a well-developed regulatory framework for water reuse.

EPCOR conducted sustainable return on investment (SROI) analysis on a residential irrigation reuse project in Edmonton at the former municipal airport site, and concluded that the overall SROI was negative due to the relatively low reduction in water use as a result of reuse. For this project, rainwater capture made more sense. It is important to note that this largely results from the low use of water for residential irrigation given the climate in Edmonton.

In conclusion, water reuse is an important tool to address water scarcity challenges and can improve watershed health. In Canada, we need to look for opportunities where demand matches supply. Finally, Alberta needs to develop regulatory frameworks for water reuse, as has been done in many other jurisdictions.

Discussion

Q: As we start to look for water reuse opportunities, including groundwater, are there issues with respect to water softeners, for example, and residuals management more generally?

Stephen Stanley (SS): This has to be factored into the overall costs. At Gold Bar this is not a significant issue but in Arizona and when you are dealing with brackish water, it does become significant. As long as you factor it in, the analysis can still be done.

Q: Did you see a net decrease in loading with the Gold Bar project?

SS: There were average flows out of the plant, so not a huge reduction now – about 10% per day.

Q: Do you see standards playing into the Canadian situation?

SS: We need to think about this in Alberta. Phosphorus levels could be reduced. This is an important issue. If we need to get to the next level of phosphorus removal, we may need to revisit the analysis. In Edmonton, the Gold Bar facility is in the middle of the city so infrastructure costs are low.

Q: Wouldn't SROI change depending on the residential uses?

SS: It was still not positive and the cost was significant. For that project, we did not see a large potential amount of water reuse.

Q: Would other refineries near Gold Bar be involved?

SS: This comes down to a decision as to when more money needs to be spent on infrastructure. The driver right now is when they have to spend a lot to upgrade or expand. Then a company can consider which approach is more effective.

Q: Did you do any calculations on the cumulative effects of taking water from non-consumptive municipal use for consumptive use such as irrigation; what would the impacts be on downstream users or junior licences, for example? At some point, return flows could become very low. If return flows are licensed for other users, the water is taken out of the life cycle of water use. What would the net difference be, given growth in Edmonton 50-100 years from now?

SS: The North Saskatchewan River is only about 25% allocated. So taking water out of the return flow is small and would not have the same impact as in a closed basin.

Q: Were there any issues in the Anthem project with respect to fluoride and water softeners?

SS: There is high chloride in the whole region and in the intake. We are not removing chloride but some efforts are underway to try and deal with this issue.

Q: What would you suggest as key elements in a potential framework for water reuse in Alberta?

SS: The biggest thing is the need for clear policies and guidelines. On the water quality side, what are the standards? Other jurisdictions have very specific standards with respect to public health, for example. Alberta would need to look at a number of projects and the risk of contact. Overall water management is more difficult to work out, including allocations. In Arizona the high cost of water is a big reuse driver.

Q: In calculating SROI, did you consider rebuilding infrastructure vs. new community development where nodal solutions could be built?

SS: This is much better and easier to do on greenfield sites, but you need to find the best solutions for each development. In our analysis, traditional water and wastewater infrastructure were close. In greenfield developments, you still have to built a wastewater treatment plant. There will be challenges in any Alberta market because the use of reuse water is pretty limited in a residential area. A whole new distribution system would be needed for relatively small water use.

Q: Does EPCOR do purposeful recharge of groundwater in Arizona and do you get credit for it? If so, is there any room for this approach in Alberta?

SS: Yes we do and yes we get credit. In the Phoenix area, groundwater is under a lot of stress with a lot of urban irrigation. In Alberta, the challenge is that groundwater is not yet a significant source.

Q: Seventy percent of water from a wastewater treatment plant goes back to water bodies. Do you see issues around pharmaceuticals, for example, in water reuse?

SS: This is probably an issue, and more studies are looking at impacts on people. The water that goes to Suncor is not going to the river. If water is reused for irrigation or other such uses, that could help address any potential impacts, and this is likely to become more important in the long term.

Q: Is there treatment for pharmaceuticals?

SS: Technology exists to meet the present water quality standards.

Q: A lot of water comes out of households. Could this be reused for irrigation?

SS: It would be costly to connect every household to a separate system. It's probably better to have a central facility and look for opportunities for reuse such as large industry or irrigation.

Slides for this presentation can be viewed here.

Matching Water Quality to Reuse: Rationale for performance-based targets and a systems approach to manage public health

Dr. Nicholas Ashbolt,
School of Public Health, University of Alberta

Looking back at the history of water quality and public health, we see that it was very difficult to identify the root problem for diseases like cholera. Drinking water was first described in a conclusive way as a pathway by John Snow in 1854, but the actual cause of the disease was local faecal contamination. With the development of centralized sewerage systems it was assumed that "local" nightsoil/cesspit pollution would no longer be an issue. Hence the focus turned to drinking water treatment, which continues today, to control what are now termed "waterborne pathogens," ones from the faecal-oral route of disease transmission that involves water. A second major point was to keep faecal wastes (sewage/wastewater) well separated from drinking water. Therefore, with our growing interest for wastewater reuse, it is going against conventional wisdom built up over the last 150 years.

In wastewater reuse it is important to understand various hazard (pathogen) pathways and hazardous events so both can be managed. This management is considered best when using a water safety plan that focuses on control points in the production of water fit-for-purpose. For example, if we want to reuse greywater, we must first consider the key hazards (pathogens and chemicals) present and likely exposure pathways, say in using it for toilet flushing, to understand what levels of treatment may be necessary to control risks. Australia uses this framework to underpin water regulations, which aim at a single annual risk-based target, the same as suggested in Canada for drinking water (< 1 disability adjusted life year [DALY]/ million people).

Given the traditionally profligate use of water in both Canada and Alberta, but increasing awareness of reduced productivity due to water scarcity in some regions or problems from wastewater discharges, we need to change how we view, use and manage water. Australia developed the concept of treating water to be fit-for-purpose with performance-based targets identified in the site-specific water safety plan.

Urban water systems are complex, and plumbing principles (e.g., dual distribution systems) have led to some of the challenges we have today, which include:

- Water services use about three to seven percent of a nation's electricity.
- Limited nutrient and energy recovery and emissions of greenhouse gases (GHGs); the embedded energy in organic matter in urban waste systems is about the same as the amount of energy needed to dispose of the organic matter and to pump water and wastewater. Hence viewing sewage as a waste has led us to develop the wrong physical system and financial model for water services.
- Aging water and wastewater infrastructure are costing trillions of dollars to maintain and still causing environmental health concerns, such as eutrophication.

If we were to recycle treated greywater for flushing toilets, washing clothes, and other such uses, it does not need to be of potable quality. By adopting this fit-for-purpose concept, we can reduce GHGs and nutrient emissions and develop infrastructure that is resilient to both climate and demographic changes. The challenge is to move from one system to the other, recognizing that there are human and ecological hazards in "wastewaters." Hazards include faecal pathogens such as viruses, bacteria and parasitic protozoa, as well as respiratory pathogens that grow post treatment in pipes (so-called water-based pathogens), such as *Legionella,* in addition to various chemicals (heavy metals, pesticides, pharmaceuticals, etc.). Very little is known about water-based pathogen behaviour, which makes developing a safety plan more problematic. What we do know, however, is that *Legionella* from drinking water can cause Legionnaires' disease, which leads to tens of thousands of hospitalizations annually in North America. Further, it is not always possible to identify the disease-causing agent when a drinking water outbreak occurs, and even more difficult to identify endemic (background) diseases via water.

Advances in public health have enabled us to better understand the important roles microbes play in our bodies and in protecting our well-being. We know that a healthy gut microbiome will displace pathogens and toxins. However, as with the widespread use of antibiotics in livestock to encourage weight gain, the same impacts on our gut microbes, which is thought to be contributing to higher fat accumulation/obesity in humans. This is of particular concern with antibiotic treatments in early childhood. In addition, there is potential impact from waterborne antibiotics from industry and hospital wastewaters and from animal production and manure. Yet of greater concern is the release of antibiotic-resistant genes that may come back to us within pathogens via water use and reduce the efficacy of clinical antibiotic use.

So what standards to treat reclaimed waters to? California Title 22 (1978, and updated in 2007) specified treatment steps with respect to coliforms and viruses, but this approach may highly underestimate pathogen risks, particularly from *Norovirus* and *Adenovirus* that are far more numerous than the enterovirus data used to develop Title 22. By 1995, some jurisdictions in addition to California, did have microbial criteria for non-potable water reuse, among them Arizona (US), New South Wales (Australia), and Israel. While these criteria specified the number of control barriers and what measures they should meet, pathogens remain an acute hazard – meaning that short-duration events of suboptimal treatment performance are critical to health outcomes. Others have pointed out that trying to manage drinking water risks by end-point testing is not only statistically too infrequent to provide safety, but also misses markers of actual pathogen presence. Hence, the preferred method today includes a systems approach based on identifying and controlling short-duration hazardous events throughout the system via pathogen treatment surrogates using target action levels at control points.

To address pathogens, these target levels require the use of quantitative microbial risk assessment (QMRA), which has previously been used for regulatory development. The World Health Organization and the US Environmental Protection Agency set water criteria and treatment requirements based on QMRA and epidemiological studies. QMRA can be used to develop a safety plan for reclaimed water, based on four key steps:

1. System description for reclaimed water: What hazards and hazardous events could occur?
2. Exposure assessment: What is the likely range in source, treatment removal and exposure of each hazard and for each type of event? In Australia, for example, a problem has been dual systems and cross connections, providing at least a perceived risk with customers.
3. Health effects: What are the identified health effects and by level of dose?
4. Risk characterization: Simulate for each pathogen baseline and event conditions, and determine infection risks with variability and uncertainty separately identified.

In addition to aiding in prioritizing hazards and pathways, QMRA can aid in the setting of performance-based targets in a water safety plan. We need to select appropriate control point targets, based on a QMRA-derived safe level for overall risks. For example, our traditional faecal indicator *E. coli* is actually a diverse group of different types present in drinking water, recreational water, wastewater or reused wastewater; even though they are the same species, they do not reflect the same level of risk, so we need to be more careful when selecting surrogates of treatment performance. Key questions include:

- What is the health target?
- What are the priority hazards and hazardous events, and which surrogates are representative?
- What are the tolerance limits and how often is monitoring needed?
- What level of corrective action is required?

An example to demonstrate the use of QMRA to identify critical densities of health concern is *Legionella* in piped water. *Legionella* is an environmental pathogen that grows in water systems within various protozoa that feed on biofilm bacteria. We can use reverse QMRA to determine what levels of *Legionella* densities we need to identify in, for example, piped water going to a morning shower. Starting from the infectious dose required deep in our lungs, we can work back to how many need to be in aerosols generated at the shower head, and therefore how many per litre of drinking water. This work has been most informative, such as identifying that a very high density is needed in piped water (millions per litre), which can only really be generated under some limited conditions (such as long periods of stagnation in warm-hot water). A related study in Australia suggested that it is not the initial water type (drinking vs. reclaimed water), but rather either would lead to *Legionella pneumophila* of concern if left with periodic stagnation in a typical household garden hose.

A case study in Cape Cod looked at various options for water reuse to address septic system eutrophication issues, including 1) a conventional centralized sewer (business as usual), 2) composting toilets, 3) urine-diverting toilets, 4) blackwater sewer with greywater treatment and reuse, and 5) option 4 plus rainwater harvesting and reuse. Options were compared for their energy consumption, global warming potential and human health risks over each system's life cycle. Option1, business as usual, showed the worst results, with a blackwater sewer for energy and nutrient recovery being the preferred.

When we think about water reuse, we need to take a systems-based approach to all municipal water services to aid in decision making. From a health point of view, performance-based targets derived through QMRA can be identified along the source-to-customer treatment train, which requires identified surrogates for pathogen management that are dependent on the intended uses. This approach allows for innovation in treatment options and system designs rather than specifying limited allowed components, but we need to be careful how we verify and validate treatment options.

Discussion

Q: Is turbidity a true option for determining water quality?

Nicholas Ashbolt (NA): Turbidity is a crude proxy. If you have a sand filter or micro filter, a sudden increase in turbidity may likely indicate filter breakthrough, so possible pathogen presence. Particle sizing may also be a better predictor of barrier breakthrough or presence. Hence, turbidity changes should be used as a warning. Conversely, people who want to use a certain level of NTU[1] need to be very careful in not getting a false sense of protection; as a low turbidity source water impacted by pathogens needs little treatment to meet, say, a 1 NTU criterion, but may give less than a log-reduction in pathogens. Hence, overall, turbidity can be used as an indicator of change and performance for particle removal.

[1] NTU, or Nephelometric Turbidity Units, are standard units of turbidity measured using a calibrated nephelometer.

Q: Are there health and liability issues for construction workers who may be working on automation and diversion of water for water reuse? For example, has there been any research on showerheads vs. hand-held ones in terms of practicality, liability for disease, or issues of water quantity?

NA: Large drops or flows are probably safer from an aerosol perspective. Finer drops or flows create more aerosols of respiratory size and so likely increased respiratory risk, but this is very poorly understood and more research is planned in this area. Generally, showerheads that generate more aerosols are more risky due to risk of inhalation. But more important than showerhead design would be the hot water system in the building. There is a big difference in *Legionella* risk between electric and gas hot water heaters. An electric system allows for temperature stratification within the water heater tank, providing an environment for a continuous culture growth at the colder lower zone in the tank. So liability relates more to hot water management. Hospitals, for example, circulate water above 50^{o} C to the point of use, then have thermostatic mixers to take care of this concern.

Q: What about house builders who may be concerned with liability for water reuse from shower to toilet?

NA: The main issue with greywater reuse has focused on faecal (enteric) pathogens and effectively they are removed by treatment. Most faecal-borne pathogens are spread person-to-person in a house, not through water exposure. Nonetheless, greywater must still be treated to an acceptable level, and there is growing awareness of the need also to remove skin-based pathogens (e.g., *Staphylococcus aureus*) present in greywater. The question is also about how well the system is maintained, not just how it was constructed. A third party such as a plumber should be required for annual maintenance and on-call, but this is not now in place in Calgary or in the US, as it is in some parts of Australia.

Slides for this presentation can be viewed here.

Business Case Panel Discussion

Participants: Edwin Piñero, Dave Lye, Stephen Stanley and Nicholas Ashbolt

Q: If you had one minute to make a business case for water reuse, what would you say?

Edwin Piñero (EP): The price of water is infinitely rising.

Dave Lye (DL): Effective water management is effective risk management. Reuse is at the top of the risk mitigation hierarchy.

Stephen Stanley (SS): With respect to municipal wastewater reuse, as we derive stricter criteria for water quality, this water is often as good as or better than source water. It may be cost competitive to develop water infrastructure for reuse. It is a valuable resource that we need to look at.

Nicholas Ashbolt (NA): We need to think of wastewater reuse from its embedded energy, which makes it more valuable. When we also look at managing resources in an integrated manner – nutrients, energy/heat, and water to be reclaimed and reused – the business case becomes compelling. For example, we would not build traditional sewers with such an approach.

Q: How do you evaluate the softer issues in terms of their risks?

EP: One challenge is trying to put a dollar value on a cubic metre of water. We are not trying to value water in the ecosystem or to society; instead we are trying to value the impact of that cubic metre to the organization in question. Many feel that the value of water to society and the ecosystem is priceless, and any dollar amount assigned would be too low. So it is not prudent to try to assign such a value. However, an organization can calculate the cost impact of not having access to water, in some cases this restriction results from others thinking it is priceless and should not be used.

Q: Are we doing this well?

EP: What is not going so well is engaging stakeholders in this valuation process, at least enough to know what their concerns and priorities are. These factors will influence availability and use conditions, and need to be recognized and acknowledged in order to make informed decisions.

Q: Are we at a critical stage where we need to talk about social licence and open up discussions about the value of water that may not have seemed important before?

DL: Absolutely, and we have tried to engage in these conversations before. Social licence is very difficult to measure but you know when you have it or not. Then diagnosing input and impact and responding is key. Water is more and more a central point in these discussions. Trying to find sustainable solutions with stakeholders is a challenge. This information must be fed into the value proposition and business plan.

NA: It is a community dialogue – a bit of "chicken and egg." We can assess things like willingness to pay for ecosystem services and other aspects, but we need to have an awareness of the range of other options; e.g., we don't need to use as much water as we currently do in homes – we can use different showers, toilets, etc. We need some economic and iconic demonstrations to help us understand the range of options, otherwise we (institutions, managers, citizens) are constrained by current thinking. We need to move outside our current comfort zone in the water sector to really move towards more sustainable systems.

Q: There has been less emphasis on reuse in areas of low water flow. How will this affect stream flows in these areas?

EP: This is an example of unintended consequences. If water reuse takes hold on a large scale and is successful, you could have closed loops up and down a river. If reuse is done properly, it has to address water balance issues. When is reuse logical over time and place? What do we mean by reuse in terms of how much gets returned to the ecosystem and when? Maybe the total discharge is the same, but coming from different places and at different times as compared to pre-reuse conditions. The net balance may be the same, but there are different users. These are all part of the same discussion and we are still early in that discussion.

SS: This is an important point. A driver in water-scarce areas is return flows. If we stop water from going back, that is a good driver and can reduce the amount of nutrients going into a river. In the South Saskatchewan River, there are opportunities to replace fresh water with reused water since many uses are not potable-related. In the overall watershed, there would probably be a net benefit.

NA: Pricing water to environmental needs, then community needs, then industrial needs is a sobering task. You can renegotiate water rights although this is tricky. On the municipal side, there is nothing to prevent having zero discharge, but socially we aren't there yet. We can put in place economic incentives to renegotiate water rights. For example, in Sydney, Australia all new buildings must be 50% energy and water conserving, which has prompted innovation. Incentives can be implemented in various ways.

Q: Is there a different case to be made for municipalities and to get economies of scale for them? Can they look at more partners to realize this or can they do it internally?

NA: Hamburg has blackwater-only sewers in new developments (www.hamburgwatercycle.de/index.php/blackwater.html), such as Jenfelder Au with about 1000 households connected; not only is the ecological footprint smaller, it is less expensive than the usual gravity sewer system. For the remaining greywater, local wetland collection and treatment is used. At this scale, it becomes economic to harvest energy (methane) and thermal energy to heat buildings. Smaller communities could construct a business case to explore feasibility. In Hamburg, the impetus was economics and sustainability.

Q: We do need to take a "whole system" approach, not just for water. Some years ago, Alberta had the Environment Council of Alberta, an advisory body that listened to input from industry, academics, municipalities, and non-government organizations and collaborated to find solutions. It was a very integrated and holistic approach to many of these same issues. Would collaboration by such groups on certain themes related to water be timely in terms of achieving focused results?

EP: The challenge is that so many players are touched in so many different ways that it is difficult to bring them all together. Who is the right convenor who can reach out to all the players? There is already much activity and collective engagement within sectors. It is also important to stay focused and get productive output. Risk evaluation, assessment of options, and mitigation is effective for an organization, but with others involved there may be a need for trade-offs and sharing.

NA: I support a collaborative approach but we may need to reengineer approaches for the longer term. We need different financial models to facilitate these activities and a different governance structure. Water systems also need to be adaptable and flexible going into the future.

Q: If you had to choose one iconic project or next steps to raise awareness and move water reuse forward, what would you choose?

DL: We need to identify ways to spur and enable innovation that allows us to think and approach problems differently. How to do this in a clear and tangible next step – I don't have a good answer. But we need regulatory, technological and financial innovation.

SS: I would focus on overall water management, of which reuse is part; xeriscaping is a good example. Reuse is an important component, but we also need to take a closer and more integrated look at water management overall.

NA: It's not just a single development somewhere, but we need to bring everything together, including a regulatory framework and due diligence on these developments – not just on the water or reuse side, but on urban transformation. Many people see these issues as too complex for one demonstration. Stockholm is an example of how incorporating water reuse helped to transform urban redevelopment.

EP: An early project is one undertaken by the Alliance for Water Stewardship,[2] which issued a standard that an organization could follow that would lead to watershed-scale stewardship improvement. It has a watershed approach to water stewardship but with roles for each player. Another element involves compliance with the standard, which means not only addressing water quality, quantity and other aspects but also participating in watershed governance with other stakeholders. This approach is voluntary and will bring many groups together and hopefully result in tangible, verifiable performance.

Q: Do any of you see ways for new technology or new technology companies to get exposure to groups that require some of these things? Getting beyond bench testing is tough. How can we accelerate this process beyond what we are doing now?

DL: I don't have a good answer. Often it's not about funding technology, but finding conditions to enable technology so it can be applied. I think we are missing spots to plug the technology in.

NA: There is a lot of institutional inertia to any change. We need to stand back and think about what the basic regulations and principles are trying to achieve. We might be able to relax the details and open up innovation. We need to learn to give a little freedom to industry, as long as they meet the original intent of regulations. We need more flexibility to innovate.

[2] See http://www.allianceforwaterstewardship.org/.

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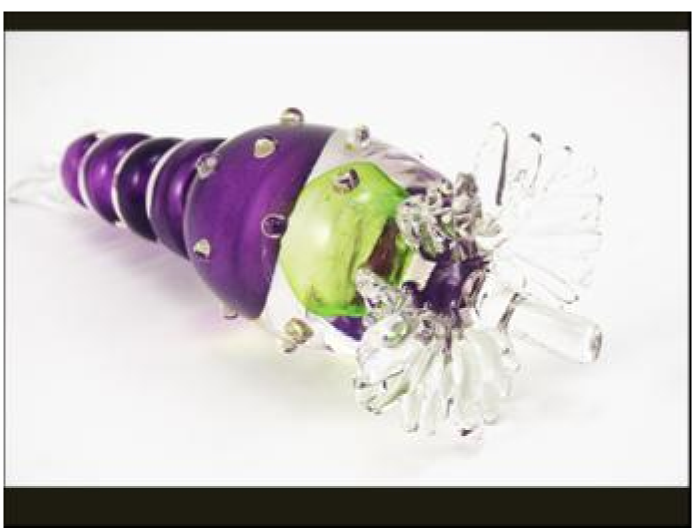
Lunch Presentation:
Through the Bees Lens: Water Microbes in Glass

During lunch, delegates were treated to an extensive slide show by the glass artists collective Bee Kingdom and Dr. Norma Ruecker, Leader of Biology with The City's Water Resources. Bee Kingdom has been working for the last six months with lab technicians in Calgary's water treatment facilities to interpret some of the micro-organisms they work with as models in hot sculpted glass. The residency period and the resulting work bring to light the often unthought-of hard work happening behind the scenes in water treatments, and the fascinating world of microbiology present in the system.

This collaboration between Bee Kingdom and the City's lab staff is part of Watershed+, a unique public art initiative hosted by City of Calgary's department of Utilities and Environmental Protection as part of the Calgary Public Art Program.

Examples of the glass work are shown below.



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Theme 2:
Technology and Innovation

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Influencing Technology Development and Adoption: Market Pull vs. Technology Push

Brian Gregg,
General Electric Canada

The importance of ongoing investment in research and development has been core to GE throughout its 135-year history. GE's Global Research organization works to de-risk and eventually commercialize promising new technologies that push the limits of science and technology for our customers. The uncertain struggle between making investments in technology and realizing the gains that come from effective adoption in viable application markets is something GE routinely wrestles with across the many industries we participate in. Technology development for various water reuse application markets presents some unique characteristics. My presentation focuses on what it takes to get technology into the market.

GE has a wide range of water and process technologies, including chemical and monitoring solutions as well as engineered systems. At its core, GE is a technology-driven business; we identify a need then develop the technology, as we want markets to pull technology to them. GE Global Research is the cornerstone of the company's commitment to technology, and our internal industrial research capability is market-focused as we seek to work more closely with end users. We have six technology domains, in seven international technology centres, employing about 3,300 researchers (scientists and engineers) and over 40,000 technology and product development personnel. Development is about de-risking technology, and we often introduce new technologies that are not yet necessarily solutions.

GE invests about 6% of its revenue in technology development annually. It is essential to understand market application segments and technology is only one element in a broader marketplace. Developing technology for a specialized application without market pull is like pushing a rope – you can do it, but you risk developing technologies that will just sit on the shelf and never be used. Sometimes solutions are developed but not commercialized, and in those cases, we won't focus there until the barriers to adoption and commercialization have been overcome. To avoid this, GE adheres to a few simple concepts.

First, we develop a deep understanding of the market – hunting for technology gaps and opportunities then finding the people and the way to fill those gaps. Then within the GE technology development ecosystem, we start to think about the technology performance design space. When it comes to technology development and how get it to market, we need to look at creative options, which may require design input and collaboration with end users. Research and development are the next step, followed by commercialization. It's not just a question of technology but we also need to work to get it adopted and accepted.

Developing a deep market understanding requires the construction of a market ecosystem map, which includes understanding stakeholders and relationships, and who or what needs to change to make the partnership or innovation succeed. Each water reuse market represents a unique technology performance "design space." Stakeholder context is needed to understand all the risks, and other factors include aspects of water quantity and quality, value trade-offs and time horizon. If scarcity is a problem, for example, there are many more opportunities.

Technology commercialization efforts also require collaboration with end users to develop solutions. The intent is to have a secure market at the end of the process, which can take a number of years. Matching up with the appropriate business partner(s) is crucial to ensure they have a plan for technology development, a budget, and people managing the portfolio, as well as confidence that the company will be around long enough to commercialize. If these aspects are missing, technology development efforts can be at risk. In some cases, technologies should never get to the tech transfer stage because they cannot be de-risked. At present, in addition to internal technology development, GE is exploring crowd-sourced ideas and experimenting with open innovation.

In the end, both technology development and adoption need to be de-risked. A good idea is the starting point and money is invested as technology development proceeds through R&D to commercialization, identifying a manufacturer and developing a supply chain, and eventually to market adoption. Where possible, GE aims to be the first to market with differentiating technology and works directly with customers to extend the number of early adopters, while also securing a fair price for the solutions it develops.

GE Water and Process Technologies has developed a number of unique water reuse solutions, including:

- Brightwater Plant in Seattle, Washington treats wastewater for reuse and safe disposal.
- BP Luggage Point, Australia is overcoming water scarcity challenges through reuse, which enabled the plant to expand.
- Pennant Hills Golf Club is Australia's first commercial sewer mining water reuse plant, providing irrigation water for a golf course.
- Bedok NEWater Factory in Singapore is transforming wastewater into high quality industrial feedwater and potable water.

Internally, GE has committed to reducing its own water use through its Ecomagination program. Ecomagination is reducing GE's environmental footprint and producing technologies that are third-party certified. Part of the intent is also to show shareholders that a successful business can be built on sustainable products. Among other things, water use has been reduced and reuse improved. Between 2006 and 2012, a 46% reduction was achieved in target sites consuming more than 15 million gallons of water per year; further reductions of 25% are targeted by 2015.

Discussion

Q: If we look at technology gaps in the water industry and assume pipes for drinking water supplies are based on capacity to fight fires, how could we fight fires without using water? Has GE looked into this gap, which is fundamental to how we manage water?

Brian Gregg (BG): I'm not aware that we've looked at this with respect to municipal uses.

Q: GE has a large number of employees and presumably a lot of diversity. Does the company have special mechanisms to ensure staff are as creative as possible?

BG: We experiment constantly. We were challenged in terms of how to develop technology in the region for a region. We had a lot of centralized labs and businesses, but decided that to develop products for specific markets, like India and China for example, that we needed to locate within these regions and conduct the research there. Like all experiments we conduct we aim to determine quickly whether they are working or not, and if things aren't working, we move on. One approach was that GE decided that everyone in India on a particular day would work on problems specific to India. We set up a research centre in Bangalore and soon some interesting ideas emerged. One example was ultrasound technology that could give good quality results at a low price without relying on highly trained technicians to operate it. The product was a device that could be plugged into a laptop. The next step was to figure out how to get it into the Indian market. It turned out that this technology has similar applications in remote areas of OECD countries. We've also done some internal crowd sourcing and are trying as many new and different approaches as we can.

Q: Can you comment on your relationship with universities and government organizations?

BG: GE does work with these groups, but it tends to be riskier technology, especially with universities. In these cases, it's often too early for the market so we have to do some technology de-risking. Probably 20% of incoming funding is external funding from governments or customers. Then there are organizations like Alberta Innovates that we work with to get to the field at the pilot demonstration stage. At this pilot stage it is expensive and challenging to get enough products into the field to test for long enough and get the data needed to assess and understand how they operate in real world conditions. We engage in those places too. The end user represents the market and the rest of us are trying to get to the market, so these agencies can and do make a valuable contribution.

Slides for this presentation can be viewed here.

Water Life Cycle in a SAGD Oil Sands Facility

Dr. Mike Scribner,
ConocoPhillips Canada

ConocoPhillips Canada has a strong portfolio in Canada's oil sands, focused primarily on SAGD – steam-assisted gravity drainage. We have a 50% ownership interest in Foster Creek and Christina Lake, which are operated by Cenovus. Our own operated facility, Surmont, is a 50/50 joint venture between ConocoPhillips Canada and Total. Surmont is currently undergoing the largest single-phase expansion in the history of the oil sands. Water treatment is very important to a SAGD project because, in oil sands, if you're good at water treatment it not only helps the business it also helps reduce our environmental impacts. This presentation describes how SAGD water management fits into the broader picture of the Canadian oil sands.

Although the overall water intensity of oil sands and conventional crude extraction is fairly comparable, conventional production does not have to recycle water. The major difference is the source of the water. The big challenge with many SAGD operations is that the source water we're using is saline – salty, mucky stuff that's not useful for other kinds of human activity like drinking or agriculture. Still, we have to clean it up a lot before we can use it in our facility.

With the SAGD process, steam that is generated is sent down into the reservoir to reduce the viscosity of the bitumen so that it can flow. Water is condensed from the steam and combines with the bitumen in the reservoir to form an emulsion. Bitumen is brought up to the surface along with the water, where the oil and water are separated. The oil is blended with a lighter oil product called diluent. The blended product is called Synbit; it then travels by pipeline to the Enbridge Cheechum terminal where it is sold.

The rest of the process is all water recycling. After we separate the water from the oil, we need to treat it. The first step is de-oiling where we remove all the oil that's left in the water using a series of vessels – a skim tank, flotation vessels and de-oiling filters. After the water is de-oiled, it is treated to get it ready for steam generation. Once the water is treated, it is turned into steam through the steam generators and then sent back down into the reservoir. We burn natural gas in our steam generators.

We strive for a water recycle rate of 80-90%; we are now at 80% and are looking for ways to increase the rate in this and future phases. The relationship between water recycle rate and disposal rate (how much can be disposed) is important. We need to have a balance between how many times to process the water to recycle versus the point where we need to dispose of it. Ultimately, the water treatment process at a SAGD facility comes back to the Steam-Oil Ratio (SOR). The SOR measures the volume of steam used to produce one unit volume of oil. The simple arithmetic of SOR is this: How much water plus how much natural gas equals how much oil coming out of the ground? Obviously it's in our best interests to get those first two things – water and gas – as low as possible, while getting the oil output as high as possible. The less water we use, the less natural gas we burn to heat it, and the less money it costs so we aim to optimize the use of saline and non-saline water sources. Recycling more water is better for our company and the environment, and ConocoPhillips has a few different projects underway to help us do this.

Some of the developing technologies that may help lower our SOR include:

- Flow control devices allow for a more optimal steam injection pattern, which reduces the amount of time it takes for a reservoir to fully mature. This reduces the overall lifespan of the reservoir, allowing us to produce the same amount of oil with less water, and therefore less natural gas up-front and fewer greenhouse gas (GHG) emissions.

- E-SAGD injects a mixture of lighter hydrocarbons along with the steam, which softens the bitumen more efficiently than steam alone. This allows us to produce more oil for the same amount of steam.
- Novel well architecture establishes the steam chamber a little more rapidly so the production phase is shorter.

By making a number of smaller, cumulative improvements to the operating efficiency of our plants, we can help reduce the SOR as well.

Ultimately, we'd like to have a 100% water recycle rate – a perfect closed loop. But even today, the make-up water we actually need is minimal. We produce around 30,000 barrels of bitumen per day at our Surmont facility. In 2013, Surmont 1 used an average of 1056 m^3/d make-up water from groundwater wells to produce 4300 m^3/d of bitumen – an intensity of 0.25 bbl/bbl. The industry average for SAGD is about 0.5 bbl/bbl. We only use about 24% of our daily approved maximum diversion limit (4450 m^3/d) for Surmont 1. For a point of comparison, the City of Calgary uses about 233,000 m^3/d of water (about 233 L/person). An 18-hole municipal golf course uses about six times the amount of water that we use in Surmont.

Surmont produces about 10 million barrels of bitumen per year. One barrel of bitumen has about 6.1 gigajoules of energy in it. So 10 million barrels have about 61 million gigajoules. That amount of energy could power roughly 100,000 Canadian homes for a year, or charge an iPhone about 34 trillion times (based on an average usage of about 5 kwH per charge).

Water use in SAGD processes is heavily regulated. The quality of the water we use is very low, requiring extensive treatment before we can use it. If we used pristine potable water we could recycle the water more times and there would be less clean-up needed. When it comes time to dispose of the contaminated water, there is a trade-off. We currently inject it deep below the aquifer and a certain amount of processing is needed to ensure the water is treated to a degree that is sufficient. If we took a different approach to wastewater disposal, we could remove all of the remaining water to leave only solids. However, processing and disposing of this solid waste takes more energy (more GHGs) and has more long-term risk which is why we are disposing of it in deep wells.

There are a number of benefits for us and for the environment if we can use less water and reuse more of it. But it's not that simple. Increasing our water reuse rate or reducing our water usage can sometimes have unintended effects in other environmental areas. Water treatment facilities have a land footprint. Sometimes treating water more thoroughly requires more heating, which requires burning natural gas which increases GHG emissions. This same principle applies to using the very salty brackish water sources that we've been regulated to use. Switching from a non-saline to a saline water source could also increase the required pipeline infrastructure – depending on the physical location of the facility—which would increase the overall land footprint. Additional facilities such as evaporators would also be required, increasing it further. For all these reasons, it's impossible to have less freshwater use and fewer GHG emissions at the same time. By using more saline water, we're also creating more disposal waste, more GHG emissions and creating a larger land footprint. There are freshwater sources that are non-potable –and therefore not useful for human consumption or agriculture – but the way that water sources have been defined in the past by the regulators has prevented us from using these. We hope this won't be the case in the future. That's why we always try to look at our environmental footprint from a net effects perspective. By taking this holistic view and using different water sources, we believe the industry could build SAGD facilities that have a smaller land footprint and produce fewer GHGs. For more information, you can visit our sustainability portal at www.cpcsustainability.com.

Discussion

Q: How long has deep well disposal been going on?

Michael Scribner (MS): I do not know the history of deep well disposal in Alberta. This activity is monitored and highly regulated. We always know what exactly is going down the well and what is happening to it. The important thing to think about is to get the right solution; if it is too diluted, we are not using our water efficiently.

Q: How deep are the wells and how do you choose the location?

MS: I don't know how deep they are. Location has to do with the groundwater zones.

Q: With respect to Directive 81, you spoke briefly about the government's decision on prioritizing water vs. GHG production. Can you elaborate?

MS: We first looked at recycled water only, then focused on disposal amounts. The more processes we implement to use less water and the more energy we require, the more GHGs are produced. That is the trade-off between water and GHG emissions.

Q: Have you thought of using treated wastewater as well?

MS: No we haven't, and I can't recall any studies that investigated wastewater use. One general issue is that we need to have a consistent large-volume supply. We do not have that in municipal or camp wastewater supplies.

Q: Do you have enough experience to determine what happens with SAGD over time?

MS: In Surmont, we have not been there long enough. We have strict monitoring that deals with any issues around subsidence, ground heave, etc.

Q: Do you have protection around some anticipated issues?

MS: It is reflected in operational plans and forecasts, monitoring and correction actions are covered in those plans. We do research related to the seismic techniques that are used by Operations.

Slides for this presentation can be viewed here.

The Interplay between Technology and Regulation as it Impacts Environmental Performance

Dr. Preston McEachern,
PurLucid Consulting Ltd.

There are two distinct pathways to regulation: technology-based approaches and outcomes-based approaches. Those based on technology (e.g., Best Available Technology Economically Achievable) use some selected industry standard to set a base performance, while outcome-based approaches are typically driven by public expectations and are usually not prescriptive.

Outcomes-based pathways typically allow flexibility in implementation, facilitate integrated planning for complex projects (such as reclamation), and advance the concept of public accountability for environmental exploitation. This approach can be risky because outcomes or expectations have higher priority than feasibility and the ability to implement can often fall short. This uncertainty creates a challenge for innovators, reducing enthusiasm for its adoption.

The typical structure for implementing outcomes-based pathways is hierarchical and has the greatest potential for game-changing innovation and development of new technology. However, people who are involved in setting up an approval are influenced by criteria that already exist (e.g., the Alberta *Environmental Protection and Enhancement Act*, or EPEA), and automatically start thinking about existing technology. This approach becomes strategic in nature with many criteria, indicators, measurements and thresholds that are not always compatible under multiple objectives, which means this approach can become quite complex and complicated to implement. One example is the Conservation and Reclamation Regulation under EPEA. This is a good approach because it allows flexibility, which promotes research and innovation. But is this flexibility responsible for slow reclamation progress or expectations that exceed feasibility?

Technology-based pathways are often risky because they drive to endpoints specific to the technology performance. This means they can be dissociated from social and environmental needs and drive maintenance or cause diminishment of the status quo (similar efforts can justify using cheaper methods that don't give the best performance). Benefits are that these pathways are typically based on proven technologies and have a high probability of success, the business case is easily made, and implementation and compliance are easy – we know how much effort will be required and what the performance will be. A technology-based example is Directive 074 issued by the former Energy Resources Conservation Board to address tailings performance criteria in the oil sands. It originally focused on outcomes that could be delivered, and promising outcomes were achieved as initial drafts were being developed. Within months these were put into a revised Directive 074 which contained specific criteria that appear to be directed to these technologies. This specificity limited the ability to promote other technologies that could have been closer to commercial success. The challenge is that if we have regulations, how do we create a new technology around different criteria that haven't been developed yet?

So how do we stay ahead? Implicitly, regulation on either path must be based on much broader knowledge. We need to know the full range of possible technologies and their performance as well as the full range of acceptable outcomes, have access to a wide range of data, and be able to communicate between those who support both approaches. It is challenging to clearly communicate between technology adopter and regulator as well as with a public looking for reassurance. Emotional factors can come into play as well as the advantages and disadvantages of the two approaches.

There are several barriers to successfully applying an outcomes-based approach:

- Expectations: We want to be good stewards of the land and so we set our expectations very high.
- Communications: In an effort to simplify do we misconstrue? Because we have these high goals, we tend to come out with statements that we can't meet; e.g., "tailings ponds will be eliminated." At the start, this goal was never on the table. Or comments such as "Contamination in the Athabasca River is 'mostly' from natural sources"; what does 'mostly' mean – 99%? 51%? Such comments can be taken incorrectly and misconstrued. In the end, regulation reflects the expectation, and this can happen very quickly.
- Technology innovation: Issues exist around ownership of intellectual property and benefits to innovators vs. contractors.
- Regulation: Once an approval is issued, it may restrict innovation and opportunities to try new approaches.

Many questions remain:

- How do we do more to advance technology and therefore performance?
- How do we reward innovators?
- How do we commercialize game-changing technology?
- How do we work more closely with regulators and collaborate in the regulatory environment?

Discussion

Comment: One person's prescription is another's outcome; e.g., Directive 074 was very prescriptive with respect to tailings ponds. What if we looked at the system in its native form - does reclamation reach this; e.g., making something similar by year 5?

Preston McEachern (PM): This outcomes approach is inherent in the Alberta regulatory perspective but it is very difficult to operationalize, particularly in oil sands where the scales are so large and the communities so divided about acceptable outcomes.

Q: Almost everything that was brought up in the presentation has happened to my company. Regulators are asking why some technologies are not being used. It's our choice not to give up the rights to the technology. Why are we importing technologies from other countries?

PM: Innovation – bringing in new technology and keeping ownership of it – is one challenge. If a technology works, innovators get to keep all their own intellectual property. We will likely see more and more technology funds, but whether they work is up for debate. If they don't work, innovators will have to put in their own money.

Comment: In my experience, the best approach is a bit of a hybrid. When setting an outcome, we want it to be realistic.

PM: Yes, it has to be achievable. This is why broader knowledge is important because in the tendency to simplify the message we also make it seem like environmental problems should be easy to fix. For example, in tailings the dialogue is often simplified to the cost per barrel to treat the problem. The number always looks small compared to $100 oil but there is no context on profitability and this simplification completely misses the perspective of outcome, e.g., for that cost per barrel did you get a functioning landscape or another liability. Corporations are in the business of making money and we get lured into simple economic discussions when really it’s as complex as predicting the weather. Sometimes the only way to make action happen in this uncertainty is through government and regulation; the trick is providing incentive through regulatory pressure on the accelerator without blowing up the engine.

Slides for this presentation can be viewed here.

Stormwater Reuse Innovation Down Under: Are the challenges in Alberta really that different?

David Seeliger,
MPE Engineering Limited

Stormwater and rainwater reuse practices provide substantial economic, environmental and social benefits in the urban context. They are seen as being indispensable in meeting evolving regulations in the Calgary region, to realize both water quality and environmental protection objectives. As reuse is an emerging practice in Alberta, drawing ideas and experiences from other countries like Australia can help advance best practices here. The very dry state of South Australia is an acknowledged leader and innovator in harvesting and reusing stormwater. Rainwater has been a key potable water source since early settlement, and this continues to be the case in many regions. Adelaide, South Australia and Calgary have both similarities and differences. The populations and average precipitation are similar, but water prices are typically higher in Australia, which also has much more evaporation.

Stormwater harvesting for reuse has evolved over the last 30 years to become a major resource for metropolitan Adelaide and smaller regional communities. A seven-year drought that started in the early 2000s provided a renewed focus on the value of stormwater as an alternative urban water source. This resulted in significant infrastructure investment over the past decade to improve the resiliency of the water supply system. The ultimate plan is to provide stormwater reuse systems in the metropolitan area with a capacity to harvest 60GL per annum, the equivalent of around 30% of Adelaide's current potable water demand.

The early adopters were a few progressive municipalities. They used natural advantages, combined with necessity, to develop stormwater reuse schemes that now meet the needs of the community. These visionaries considered stormwater as a resource. They adopted terminology like "fitness for purpose" and advanced the development of aquifer storage and recovery technologies. They foresaw the multiple benefits of constructed wetlands: flood protection, water quality treatment and protection of the receiving environment, ecological and aesthetic value, and ultimately an economic opportunity for stormwater harvesting and reuse. Today, these early adopters continue to push the boundaries by advancing the knowledge, development and application of stormwater reuse technologies.

The City of Salisbury was one of the early adopters. The first stormwater wetland in Adelaide was constructed in the 1970s. The largest wetland complex in the southern hemisphere was constructed in land used to store urban runoff, in order to protect development in low-lying areas from flooding, in response to combined flooding and high tide events. Today the City has over 70 wetland systems; many have been created to treat stormwater for reuse. By 1998, a dual reticulation system (Mawson Lakes) was in place, and by 2002 stormwater was being harvested for irrigation and industrial use. This was followed by research trials in the mid- to late-2000s to look at aquifer storage and recovery (ASR) in mainly sedimentary aquifers. Other early adopters in the region also built wetlands and developed water reuse infrastructure for particular industries and activities (e.g., sports fields, racecourses, golf courses).

During the drought in the early 2000s, the worst in Australia's history, the most reliable source of water (the River Murray) dried up. Many parks and other recreational facilities ceased irrigation, severe water restrictions were put in place, and the price of potable water increased by more than three times. The drought also led to unprecedented cooperation among all levels of government, academia and industry, enabling a broad range of policies, strategies and approaches to be applied in managing stormwater. Regional waterproofing plans were prepared to identify the most favourable opportunities for both stormwater and rainwater reuse. A rainwater reuse policy was developed and, as of 2006, all new homes must have a rainwater tank plumbed in. Supporting business cases were developed and funding was secured to implement numerous schemes, with a goal of attaining a stormwater reuse capacity of 20GL per annum by 2013, which has been achieved.

Various strategies were implemented in stages to waterproof the Adelaide region and provide water security. The level of water treatment depends on the use and other factors such as the time of irrigation (e.g., no disinfection is needed if public spaces irrigation is done between 9pm and 6am). Treatment processes typically include continuous monitoring of conductivity, pH and turbidity.

An aquifer storage, transfer and recovery trial has been underway for more than four years to determine if aquifers can be used to treat stormwater to meet drinking water quality standards. This process may be useful to augment potable supplies as long as we understand the risks. The ASR stormwater use options study showed that five options of the 16 examined were more economic than using potable mains water alone. Other findings of the study concluded that ASR enables a doubling of harvestable volume at 50% lower cost than surface storage. Also, low impact development in the catchment area is important in managing water quality and provides attenuation benefits.

In summary:

- Stormwater and rainwater is a valuable and economically viable resource.
- Developing a networked distribution system provides flexibility and is not reliant on specific users.
- ASR increases stormwater capture efficiency and reduces capital costs.
- Bioretention treatment of stormwater for reuse is an important emerging technology.
- Technologies and approaches are applicable to Alberta provided cold climate issues are addressed.

Discussion

Q: Are you aware of any groundwater recharge work underway in the Calgary area due to soil characteristics? The soil is largely clay so it would likely be difficult.

David Seeliger (DS): I'm not aware of any but it probably should be looked at.

Q: We hear that water reuse in Alberta is uneconomical except for industrial applications. Is it the same in Australia?

DS: City parks have been working on this in Calgary and they demonstrate that the irrigation of park and sports fields has significant cost advantages over using potable water. In Alberta, it's not necessarily about the value of water, but other factors, such as protecting the downstream aquatic and riparian environment, will also be driving water reuse here. The Alberta Low Impact Development Partnership has good information.

Q: If ground conditions are not suitable for storage, is it possible to do the same thing using offstream storage, in a wetland, for example?

DS: This could be an alternative from a water reuse perspective, although the value of land and, to a lesser extent, evaporation might be an issue. Can we dedicate land to these systems and make them usable for multiple purposes and therefore multiple benefits?

Slides for this presentation can be viewed here.

Best Practices Panel Discussion

Participants: Brian Gregg, Michael Scribner, Preston McEachern and David Seeliger

Q: In your experience what is the single best management practice (BMP) that should be implemented when reusing water?

David Seeliger (DS): Incorporating upstream source control measures to ensure water quality at the storage/reuse site. If catchment runoff is highly contaminated it overloads the downstream treatment system. Providing a bypass around the reuse system is also a good strategy to avoid poor treatment performance during specific runoff periods; e.g., salt-laden snowmelt events.

Preston McEachern (PM): Open the door to a broad range of considerations, especially integrated planning. In the past, we have had limited understanding about integrated water use at mine sites. So my answer would be to implement integrated water management systems that clearly track consumptive needs versus non-consumptive needs and current recycling, including limitations to recycling (e.g., ion concentrations). This accounting should include the longer-term perspective such as water return from tailings.

Michael Scribner (MS): In terms of SAGD operations, in any operation, safety will be paramount. Second would be to take a holistic view between economics that drive the reason for doing business and the sustainable development factors that allow us to have the social licence to operate. The balances have to do with cumulative effects; they are not focused totally on water, but also include greenhouse gases, and the land footprint. From the business perspective it's often a trade-off between capital costs and operating costs.

Brian Gregg (BG): Have all stakeholders involved and understanding the value trade-offs for each of them. We always miss some.

Q: Regarding application of best practices and how useful they are from a regulatory perspective, we could look at BMPs as a suite of options to use to undertake certain activities. Could you explain how BMPs can be used in a prescriptive or outcomes-based system?

PM: BMPs are really tools in the toolbox – standard fare to accompany innovation and new technology. They are the proven tools that allow you to meet an outcome no matter how you get to it; e.g., standard BMPs exist that can be used to minimize the amount of sediment moving to surface waters. These are only optional if something else is available to achieve the outcome, which you would only use if you could get a better result.

DS: I think the biggest issue is that we often bring BMPs from other areas that may not have been proven for the desired application. We have to prove them up and find out how they will perform, then we can be more confident of the result. Then a more prescriptive or outcomes-based system can be applied.

Q: Do you integrate natural structures in stormwater management and how do you address the trade-offs?

DS: We want to apply source control to reduce runoff and also improve water quality. Most of these practices are natural systems that can also provide other environmental and social benefits. Provided we understand how these systems best work for the local conditions and do them well so the public sees them as a benefit, then there shouldn't be many trade-offs against the old way of doing things.

PM: Decisions can be dominated by a single thought process in the absence of a larger knowledge set. The trade-off between efficient, controlled water treatment versus the less reliable or certain use of landscape features makes this a problematic decision. In Alberta, there is a strong case for using natural features like wetlands; the amount of runoff is directly related to the amount of wetlands you have in the watershed: more wetlands = more retained soil moisture = more runoff over a longer period of time. In our geography, the boreal forest requires and indeed therefore has extensive wetlands and it seems wise to try to mimic this in water management here.

Q: With respect to a higher level policy outcome for surface water quality, how would you see BMPs driving innovation? There are so many layers and so much knowledge to bring in. Some layers are regulated and some are not. Do you see outcome-based regulation being feasible in that regard? If we have outcomes for surface water quality, how can you drive innovation? You can implement certain BMPs but others could put you over the threshold.

PM: How can you be a good performer in a group of poorer ones? The approach has to go down to the individual approval holder and their corporate culture. We need to have regional outcomes; but if we just say we want a certain water quality in the Athabasca River and we don't care how a group of companies achieves it, there could be problems. However, if you don't have that, there will be problems. In the end, the plan depends on how well individuals perform and what counts for good behaviour, which may mean setting individual limits and requirements for improvement. This has been traditionally adopted in regulatory processes in Alberta for individual approval holders in water but it has been problematic to apply at the regional scale.

DS: In Calgary, BMPs for water quality are not well understood. Volume control is better understood. If we can monitor results we can push the boundaries.

Q: If you were to look ahead to where you'd like to be, what would you say is the biggest challenge to getting there?

DS: The City of Calgary is setting volume control targets to meet water quality objectives. One of the key practices is stormwater reuse; however the biggest barrier to stormwater reuse is provincial regulations within Alberta Environment and Sustainable Resource Development (ESRD). Urban systems develop a lot more runoff than natural systems and therefore it is important that this water is managed responsibly in order to protect the environment.

MS: For SAGD, the impediment is an economic one. We were more competitive a few years ago, prior to the unconventional plays in North America. The challenge now is that we need to find more technological solutions to get back to that point of being economically attractive. We need to ensure that companies look at operating practices, sustainability, capital efficiency, and technological advancement within their industry and how to continually improve them. Environmental net effects are also key and represent a big opportunity.

BG: I think the next playing field is non-water based bitumen extraction assuming there is a strong motivation to stop using water to get bitumen out. There is still a lot of uncertainty in those techniques, though, and they need to be proved out. We will start to see a reluctance to put more money in infrastructure while this remains an option, which will introduce other challenges. To make these industries more water efficient will likely take more money than to look at waterless extraction. Another big challenge is how to improve infrastructure in cities where costs are already sunk.

Q: From a political point of view, we can have different kinds of policies depending on which basin you're in and whether it is closed to new licences. Can you comment on this?

DS: Adelaide has been in a closed basin for a long time. How do we manage stormwater in that context? We need water for the environment, for urban uses and for agriculture so we can reprioritize water use. ESRD has policy for stormwater in a closed basin; if you can use extra water from urban development in your project, the water is not lost to the system if it is often returned back into the river, if you consider rainwater or stormwater for toilet flushing for example. We need to protect the Bow River and we can do this by allowing reuse and thus reducing the amount of water that would be otherwise used. There should not be restrictions on stormwater reuse by type of basin provided that appropriate level predevelopment flows continue to enter the river. Placing a disincentive on stormwater reuse results in downstream water quality and riparian degradation. Is this likely to have higher ecological impacts than any benefit of increased flow?

Q: Current technology is almost all endpoint treatment. What are your thoughts on this vs. source protection or earlier treatment?

PM: I see water as a universal solvent and as a tool to do work – to keep us alive, for use in industrial processes, etc. The terminology in the *Water Act* is "best use," so what is the best use? We need to figure out where water will go and what it will be used for then set up treatment accordingly. Large portions of it will come back into the hydrologic cycle eventually. Water stored in a mine site has to go back to the river. We are dealing with the hydrologic cycle, what is in the water, what are the costs to get it out and return the water to the hydrologic cycle, and where is the best point to do it?

Q: We have to get the solids out – the more we clean the water the more we can use it. But so many processes occur at the very last point, should we start treatment earlier?

DS: From the point of stormwater management and the catchment, water collects impurities along the way. The application of Low Impact Development provides a whole set of tools to manage water quality by providing a treatment train approach so it is easier to reuse at the end.

Theme 3:
How to Apply Water Reuse in Alberta

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Barriers and Acceptability of Water Reuse

M. Kim Fries,
CH2M HILL

Reused water has negative connotations for many potential consumers. Most people picture reused water coming directly from the toilet to the tap. This perception is incorrect, but is a key issue the industry has had to deal with: changing perceptions. Everyone would rather draw their water from pristine streams, but two questions arise. First, are there any pristine streams remaining and second, is the cost of extraction from those sources prohibitive within an economic, social and environmental context?

Water reuse is often misunderstood. We think of the water cycle as linear in that clean water comes in at one end and wastewater is taken away at the other. But in reality almost all water used for residential, agricultural, commercial and industrial consumption contains some fraction of reused water. Regardless, there are many constraints to increasing water reuse and these constraints arise due to economic concerns, public acceptance concerns and regulatory concerns. There is no technical constraint to producing reused water. Technology is available to treat wastewater to a degree that its quality would be better than potable water in most municipalities. We have the technology to accelerate water treatment so that it can be reused more quickly, but technology uptake is slow due largely to public perceptions.

Technology examples include the following:

- Gippsland Water Factory generates reused water from domestic wastewater and supplies it to a pulp and paper mill in Australia. Drought conditions meant no more water was available. Raw wastewater from the mill and surrounding communities was collected and treated for use in the mill rather than draining it to the ocean. Using reverse osmosis following ultra-filtration membrane tanks, water was treated to acceptable standards of reuse to gain public acceptance.
- Western Corridor Recycled Water Project in southeast Queensland, Australia was subjected to serious water restrictions during the severe drought of 2001-08. A $2.5-billion program extended the treatment of wastewater effluent and supplied this flow to reservoirs for use as potable water. The target water consumption during extreme drought was only 140 litres/capita/day. The Luggage Point plant was a key part of this project and was sized to provide 70 megalitres/day and meets all Australian drinking water guidelines.
- Singapore-Changi Water Recovery Centre/NEWater. Due to shortages of new supplies of potable water, Singapore decided to aggressively pursue water reuse to meet many of its demands. Changi WRC has the largest of four NEWater plants, co-located with a major wastewater treatment plant with a capacity of 145 megalitres/day. After conventional wastewater treatment, the effluent is further treated by ultra-filtration and reverse osmosis. Most of the water is for industrial use and treated water that is not used by industry discharges into the city’s drinking water reservoirs.
- The Advanced Water Purification Facility in Oxnard, California adapted a reclaimed water facility attached to a wastewater treatment plant. Seawater intrusion into an aquifer was progressively contaminating the municipal drinking water supply as well as extracted groundwater used for agricultural irrigation. The facility employs reverse osmosis and advanced oxidation and will have an eventual capacity of 95 megalitres/day

Such projects are expensive, and when the average cost of water is very low, building the business case for reuse is a challenge. Retail water rates in Calgary are about $1.70/m^3 and wastewater treatment costs are similar at about $1.50/m^3, which are near the average for larger Canadian communities. The cost for producing reused water is significantly higher. This differential suggests that water reuse does not appear economically justifiable in Calgary, at least in the short term.

Denver, Colorado is facing a number of water issues as new sources are very limited. The region is thus aggressively pursuing strategies for water reuse. The first step has been to separate demands that don't require potable water and meet those needs through a "purple pipe" system. The next step is to develop full water reuse systems. In Denver, this approach is less costly than trying to find and develop new potable water sources.

Even when water reuse projects are economically viable, there can be a high risk of adverse public reaction. The public is concerned about health (pathogens, substances of emerging concern, heavy metals), aesthetics (colour, odour) and, worst of all, the unknowns. Because of public concerns, the first step in any water reuse program is to replace potable water use in non-potable uses such as landscape watering, industrial cooling and agricultural irrigation. However, there are many municipalities where the shortage of secure water extraction sites has necessitated a move toward broader reuse, including indirect and direct potable reuse. In these cases, public education has proven a necessary and invaluable tool in gaining acceptance. Studies have shown that public education, gained through tools such as visitor centres, enhances understanding of the water cycle and lends support to reused water initiatives, but water education is often ignored or receives little attention.

Regulatory constraints reflect public concerns. Regulations are put in place to protect the public to a level at which the risks are appropriate. Scientifically-based regulations that the community sees as reliable and enforceable improve the acceptance of reused water. However, in many areas of the world, regulations are overly prescriptive, increasing the cost of reused water. In other areas, the regulatory approach has not kept up with advances in technology or possible reuse strategies, unnecessarily encumbering the implementation of reasonable schemes. California's Title 22 Regulations Related to Recycled Water were originally published in 1986 and have been updated and modified many times since. They establish water quality standards for every type of use and look at processes proven to be able to meet the quality requirements. Alberta is not as far along. The Alberta Wastewater and Storm Drainage Regulation provides for site-specific approvals for water reuse for irrigation on agricultural lands or other large facilities such as golf courses. Alberta Health knows there are risks involved with water reuse in other applications but research is lacking to support wider use at this time. Alberta's Reclaimed Water Working Group is looking at potential regulations as they pertain to different types of water reuse.

Discussion

Q: There is no economic driver in Calgary for water reuse. We are downstream from Calgary. Where is the tipping point to implement reuse to ensure we have the necessary water?

Kim Fries (KF): When you get to the point, as in Denver, when you simply can't get any more water. That is when there is willingness to pay the cost for more water and the infrastructure that goes with it. This is the marginal cost and it is very site-specific. At present, the marginal cost in Calgary is not that high, so although there may be some political will, the economic case isn't there.

Q: Does Calgary consider its rural surroundings and drought years when making water use decisions?

KF: We are always doing triple bottom line analysis to look at the social impacts and environmental impacts, as well as the economic impacts. Calgary's treatment facility capacity does take the greater area into account. One of the factors we considered was technology associated with future reclamation needs.

Q: What can individual homeowners do on their specific site?

KF: Small systems don't get the attention they should. I am a little leery of greywater systems, but if they are done right, they're fine.

Q: How do we get beyond the perception of drinking where you pee?

KF: We have to convince the consumers there is no risk.

Slides for this presentation can be viewed here.

Water Reuse Policy Development: Understanding opportunities and barriers

Susan Davis Schuetz,
Alberta WaterSMART

The Alberta Innovates-Energy and Environment Solutions Water Reuse project described in this presentation aims to develop definitions related to water management in the context of reuse, assess linkages between water reuse and return flow, investigate three case studies, develop policy recommendations and, in the end, improve management of reused water and stormwater. This presentation examines the opportunities and barriers, and my colleague, Angela Alambets, will discuss policy development options in part 2 of WaterSMART's two-part water reuse presentation.

In terms of current water reuse, Alberta is unique with different regions having distinctive water needs and contexts; water quantity and quality challenges vary throughout the province. Some basins in the water-stressed southern regions are closed, while northern Alberta experiences water quantity challenges during low-flow periods and water quality concerns. Across the province, there is tremendous interest in water reuse and stormwater use but gaps in the water policy framework have resulted in barriers to implementing water reuse and stormwater use initiatives. Barriers include a lack of, or inconsistent use and interpretation of, existing water terminology, creating a lack of shared understanding about what is meant by a given term. Too, there is the absence of a water reuse policy that can provide the necessary guidance to regulators.

Significant volumes of return flow in Alberta are potentially available for use. The 1969 Master Agreement on Apportionment provides some guidance as to volumes of return flow potentially available for use. The Agreement specifies that a minimum of 50% of all natural flow in any Alberta watercourse must flow into Saskatchewan, although there can be exceptions based on daily volumes.

As part of this project, modelling was undertaken using the OASIS model.[3] The modelling showed there is some room for lower return flows in the South Saskatchewan River Basin without violating the apportionment requirement, and less potential in the Oldman River Basin. The Red Deer River Basin still needs to be assessed. The interconnected nature of these basins before entering Saskatchewan requires an integrated assessment if the use of expected return flows is further considered. In all cases, specific Water Conservation Objectives (WCOs), Water Management Plan requirements and other site-specific requirements need to be respected.

In addition, significant volumes of treated wastewater are currently not returned to the river system or are only returned on a seasonal basis and associated with concerns of decreasing water quality during those releases. However, the consequences of its use must be evaluated to ensure there is no impact to river requirements, including downstream users, apportionment agreements, and the environment.

The potential impact of reuse on water quantity was assessed for a typical municipal situation where water is diverted for use and discharged as wastewater. The analysis showed that two scenarios will

[3] OASIS (Operational Analysis and Simulation of Integrated Systems) is sophisticated simulation software developed by HydroLogics, Inc. (www.hydrologics.net) for modelling water systems throughout the US and internationally. The model is flexible, transparent, completely data-driven, and effectively simulates water facility operations.

have a positive impact on water supply including: exchanging water type for current use (i.e., using effluent rather than fresh water for consumptive or non-consumptive use); or identifying new consumptive uses or effluent and offsetting the reduction in return flows with conservation.

Opportunities also exist for stormwater use. Fifty percent of stormwater that would naturally flow into watercourses could be used without violating the Apportionment Agreement, but downstream users and environmental health must be considered. As well, 50% of groundwater that connects to surface water must also be returned. On this basis, stormwater can be used for beneficial purposes in catchments that are not hydro-geologically connected to rivers flowing into Saskatchewan. Relevant restrictions will exist for any other apportionment agreements in the province.

Gaps in legislation regarding the right to use water, policy gaps on the impact of water reuse and stormwater use on river requirements, and regulation gaps related to the implementation of water reuse projects are the main barriers impeding opportunities for water reuse and stormwater use. These gaps have arisen for various reasons. Previous priorities on water management did not include water reuse due to a general lack of interest and general availability of water, which created barriers for consistent licensing and approval opportunities. With a growing interest, Alberta Environment and Sustainable Resource Development (ESRD) has sought to support selected projects, which have been implemented based on interim practices and guidelines.

The following are barriers identified through this project's work:

- There are policy gaps around the right to use surface and groundwater more than once.
- The right to use stormwater and rainwater is unclear. An interim policy indicates that stormwater can only be used for irrigation, and the volume available is the difference in evapotranspiration for pre- and post-development.
- Current policy does not support the right to use tailings water.
- River requirements include apportionment agreements, aquatic health and downstream users. Current policy does not identify the impact of changing inputs to the river systems due to various uses of surface water, stormwater, rainwater and groundwater.
- Aquatic health objectives like WCOs and Instream Flow Needs have not always been established based on science, are not reach specific, and do not exist for all stretches of Alberta's rivers and tributaries.
- There are a number of terminology and policy gaps related to stormwater collection and use.
- There are regulation gaps on the implementation of water reuse projects.

In conclusion, previous priorities on water management have not included water reuse due to the degree of interest and availability of water. However, water reuse and stormwater use interest has risen considerably over the past several years. This has resulted in numerous gaps and policy barriers limiting the effective use of these important resources. ESRD has endeavoured to support innovative and non-impactful water reuse and stormwater use projects and as such, projects have been implemented based on various interim accepted practices and guidelines. Yet, this approach has created a new set of challenges pertaining to consistent licensing and approval opportunities.

Discussion

Note: Both Susan Davis Schuetz and Angela Alambets, the speaker looking at policy development options in the second presentation, responded to questions.

Q: You identified a number of different potential challenges. If you had to pick one, what would it be?

Susan Davis Schuetz (SDS): I would say issues related to stormwater use.

Angela Alambets (AA): I would say definitions and the need for common understanding and interpretation. Without a shared understanding of the system and its needs, the discussion of opportunities is challenging.

Comment: We need some good working examples. There are barriers in closed basins and we need to work through them. The Water Act *has been applied to allow for water reuse and there could be further applications where basins are not closed. There are examples we can learn from.*

SDS: A number of reuse projects are underway and more are coming. We do need a provincial system under which this can be done, but we also need public education and outreach. There are too many different interpretations of the same information.

AA: *Water Act* mechanisms do allow for water reuse, and this is often not clear to water users, which is why a reuse policy is necessary. Also, reuse proponents are getting different answers and interpretations of legislation from different Government of Alberta (GoA) representatives, and a clear message is needed.

Q: With respect to stormwater and apportionment, you said that 50% of the water that falls must go to Saskatchewan, but I understood that 50% of the water in rivers must be passed along.

AA: Apportionment refers to all the water in the river plus any water that is in the watershed that could reach the river. We currently don't have many specific measurements of how much water is being used throughout the system. It is currently just measured at the border. The GoA has indicated that they may start looking at implementing additional monitoring stations, not just at the border but elsewhere. The use of all natural flow must be considered.

Q: What happens to water if it is not returned to the system?

SDS: It evaporates.

Comment: My municipality has continuous discharge to the Sheep River and returns 80-85% of the water with seasonal fluctuations. They've been working with the GoA for two decades on the notion of return flow credits and have tried to get water licences up and downstream. The GoA refuses to recognize credits for return flows while municipalities think they should get credit for cleaning and returning water. Alberta needs to deal with this.

SDS: Our project did not determine if there is interest on the part of GoA to consider this issue.

AA: We looked at how different areas around the world handle return flows and credits, and where return flow credits are in place; but application differs in Canada and Alberta where we are landlocked. We need to understand the functionality of rivers and the types of reuse proposed; we would like to see seasonality and the type of return flow taken into consideration. I would say this is not off the table and is still evolving.

Comment: In oil sands region, there is no policy regarding water reuse, but some companies are doing it, so the situation varies.

SDS: The GoA recognizes that the context differs across the province and that flexibility is needed to adjust within a given context. As noted earlier, in an effort to respond to the growing interest in reuse, there are now challenges with consistent licensing and approvals. [Note: The Water Conservation Policy for Upstream Oil and Gas Operations will be released by the GoA in the near future, and will address the option for reuse at a high level.]

Slides for this presentation can be viewed here.

Regulatory and Practical Issues and Opportunities for Water Reuse in the Power Generation Sector

David Lawlor,
ENMAX Corporation

ENMAX is a wholly owned subsidiary of the City of Calgary. ENMAX supplies 15% of Alberta's electrical generation capacity, 83% of which comes from coal, 11% from natural gas, and 6% from renewables. The water used in power generation is primarily for cooling, and volumes vary with the energy source; nuclear cooling towers use the most water, followed by coal cooling towers, nuclear once-through (in which the water is heated and goes back into a cooling pond where it is lost through evaporation), and coal once-through.

The company has two natural gas facilities where water is reused; this presentation focuses mostly on the Shepard Energy Centre, which is a $1.4-billion, 800MW combined cycle project that will meet a large part of Calgary's current electrical needs when it is completed in 2015. Combined cycle power plants produce high grade steam in addition to electricity and thus use more water than a simple cycle facility. A cooling tower is needed to condense the water and get it back into the system.

Water can be sourced in several ways, but no new water licences are available in southern Alberta, so companies must be innovative and use water in different ways to meet their needs. Three options are available for cooling water at Shepard: evaporative water cooling, air cooling (which takes a lot of energy), and once-through water cooling (which takes a lot of water). The Shepard plant will use reclaimed water from Bonnybrook Wastewater Treatment Plant. This water will pass through an on-site treatment facility before being used at Shepard and will also go through cooling towers and steam make-up. Whatever water is not evaporated in the cooling ponds goes back to Fish Creek Wastewater Treatment Plant as blow down and eventually makes it back to the river. All the water except for what employees drink comes from reclaimed water.

Water reuse for an industrial complex has a number of environmental, economic, social and efficiency benefits. These include reduced direct withdrawals from the river, better plant operating efficiency with more power output and less fuel consumption, and less cost to reclaim water than to treat to potable standards. At Shepard, 96% of incoming water will be used for evaporative cooling; of this, 80% will be evaporated and 20% returned. Four percent of incoming water will be used for other purposes. In Alberta, this project was the first reuse of municipal wastewater for evaporative cooling purposes and is a good example of matching water quality to its use.

This is not to say there were no permitting or regulatory obstacles to this project. This was a new and different project and Alberta had no specific policy to deal with it. The province permits municipal wastewater reuse for crop irrigation only, under the Stormwater Drainage regulation. All other applications must receive approval from the Director, and no government staff were assigned to this specific application process. Other regulations and codes (e.g., plumbing and building codes) do not contemplate water reuse. Also water licences are not clear on the use of water after treatment – every licence is a bit different, and the City of Calgary did not want to have to adjust its licence approval.

Further, ENMAX is regulated by the Alberta Utilities Commission (AUC), which looks to Alberta Environment and Sustainable Resource Development (ESRD) to approve environmental components of projects; however, ESRD is mandated to issue its approval after the AUC ruling. There are no known environmental policies on the topic, which leads to more time, more studies and more explanations. ESRD does regulate cooling towers and requires operators to report real-time disinfection levels. This can be quite cumbersome and requires extra work compared with monitoring of raw water which might be worse quality than the effluent being reused. More clarity around all of these issues is needed to anticipate and alleviate questions about water reuse.

ENMAX is proposing another project to reuse water – the Bonnybrook Energy Centre, which would be a 165MW natural gas-fired cogeneration facility located on the Canada Malting site in southeast Calgary. This facility would generate electricity and capture and use otherwise wasted heat energy as a by-product. The host – Canada Malting – uses large amounts of heat and water and has existing water licences but high costs of water treatment. A membrane bioreactor will be installed to improve water quality for reuse, and the cogeneration plant will provide heat to the district energy system and power to the grid.

The Government of Alberta needs to decide if water reuse is a priority and if so, develop a policy and standard specifications for reclaimed water. Other jurisdictions have done this and offer good examples. Standard terms for approvals will be needed, including treatment levels that must be reached.

ENMAX successfully launched two projects using reclaimed water, but it took much more effort than it would have to use potable water. Practical and regulatory barriers do exist but with some policy and regulatory changes, water reuse and use of reclaimed water can be encouraged with an awareness of the environmental impacts.

Discussion

Q: Should we have concerns about Legionella *when using wastewater that may be less than potable?*

David Lawlor (DL): The same issues exist despite the water source. We have to get the water in the cooling towers right in terms of chemistry and other parameters. Since the first episodes of *Legionella*, industry has been very careful and there has never been a case in Alberta.

Q: From a regulatory perspective, the City of Calgary doesn't want to amend licences but is this project reducing return flows or are there specific restrictions on the licence? From a public perspective, did the City have to notify the public about possible reductions and are the reporting requirements similar to those for fresh water?

DL: ENMAX does not have a water licence, but rather a commercial arrangement with the City of Calgary which does have a water licence. Depending on how a licence is written, there can be an expectation that 95% is returned. Even though the project is using a lot of water, the overall requirements for discharge were not changed. The City didn't amend the water licence, but added a small clause saying they are using the water in a different way but are still meeting the percentage requirement for return flows. So this was not a full amendment but an administrative adjustment saying water reuse would occur but this would not impact the amount of water going back to the river. There was no need for public engagement but we did have to get a letter from the City and from the Water Commission. In a lot of cases the approval doesn't say what you have to monitor, but it may require tertiary treatment, treatment of other parameters, etc. We need to take samples before and after water goes through the cooling towers.

Q: How did you get approval without a water licence?

DL: We did not need a water licence for the project. We have a permit through a commercial arrangement to divert from the City of Calgary. ENMAX has approval to operate the facility that uses the water.

Q: Do you expect any impact on downstream users related to changes in return flow?

DL: The City of Calgary is able to meet its return flow requirements so no impacts are expected. This is one reason why industry likes to operate where a licence is already held, which is one of the attractions of cities for industry. In terms of how we can change from non-consumptive use to consumptive use, it relates to the nature of the licence and whether it requires return flow to the river. When we get down to maybe 75% return, everyone downstream would be short. The original licences were like this and ESRD would not approve such licences now. So there is limited opportunity in terms of how long we can use water in this way, before ESRD would change water licensing.

Q: Does the operating approval have limits on what is sent to Fish Creek Treatment Plant?

DL: No. Fish Creek has the discharge approval. They can accommodate maximum flow from the site.

Comment: You need to get the water from some place so it is better to use recycled water than fresh water and it doesn't need to be potable. This is a good example of the "fit for use" approach.

Slides for this presentation can be viewed here.

Understanding Greywater Reuse

Wayne Galliher,
City of Guelph – Water Services

The City of Guelph is one of Canada's largest communities relying solely on groundwater, with 123,000 residents and 55,000 more expected by 2031. The City has a local growth management strategy in which water management has a central role. Alternatives to groundwater supplies (e.g., water from the Great Lakes) have been considered but these have significant environmental and economic implications and were not supported through current water supply master planning as a result. Wastewater treatment and water reclamation are other challenges.

A Water Supply Master Plan was developed in 2006 and will be in place for 50 years. Water sustainability is a priority for the City, with a target of 20% reduction in 2006 daily water use by 2025 through conservation and other similar efforts. This is expected to provide significant benefits in terms of avoided infrastructure costs, approximately $85-million in avoided community investment over the planning period. The City's ten-year Water Conservation and Efficiency Strategy aims to reduce water use by 8.7 megalitres/day by 2019, which will also reduce greenhouse gas emissions and provide operational savings of $141,000/year. This strategy is being implemented through a multi-sector community approach, targeting residential, industrial, commercial, institutional and municipal uses. The emphasis is on raising awareness and engaging the public and youth, with support for innovation and building capacity.

The City offers incentive programs to encourage residents to implement strategies in their homes for seasonal (e.g., rain barrels) and all-season use (e.g., reuse with flushing, clothes washing); these approaches can reduce household demand by up to 50%. Challenges with greywater use include matching water quality to source, addressing potential health risks, technology affordability and performance (Guelph had to set its own performance criteria), public awareness and attitudes, willingness of end users to do the work required, future reliability of servicing capacity and available of support networks.

Between May 2009 and September 2011, Guelph initiated a pilot through which 26 greywater reuse systems were installed in new and existing homes to assess technology performance and acceptance and clarify the municipality's role and responsibilities. A number of core considerations were central to the field test, including ability to achieve current health and water quality standards, systems operations and performance, water use reductions, and municipal responsibilities of such servicing approaches. The final report from the pilot is available at www.guelph.ca/greywater.

Five elements are essential to understanding and adopting greywater use:

- Legislation, standards and certification
- Public health
- Policy drivers and economics
- Public awareness and acceptance
- Management frameworks.

With respect to legislation, standards and certification, plumbing codes are needed to protect public health and safety and to identify and manage risks. Plumbing codes are a provincial responsibility. Ontario allows non-potable water use to flush toilets and urinals and for sub-surface irrigation.

Greywater use has been permitted since 2006 with dedicated piping and no cross connections stipulated through the Ontario Building Code. Alberta does not permit closed-loop greywater use in buildings. Legislation dealing with effluent categorization is the key and appropriate legislation is needed for source and needs. Relevant standards include CSA B64.10 (maintain the quality of municipal systems), and CSA B128.1/B128.2 (best practices in design and installation of non-potable systems, maintenance and field testing). Health Canada Guidelines for Domestic Water Reuse define exposure limits and water quality guidelines for treating greywater to limit potential health impacts. Finally, technology certification standards address performance of non-potable water reuse systems, the ability of the technology to achieve the reduction targets, and ability to meet minimum standards for public health.

Municipal policy drivers include demand management, scarcity and risk to existing supply, infrastructure costs and limitations, regulations, and community ecological needs and sensitivities.

Financially, implementing greywater use can be a challenge. New supply costs $3 to $8 per litre capacity per day, while incentives for homes to install greywater systems are $22 to $30 per litre capacity per day (based on a per-home incentive of $1500), based on the limited end use of greywater in residential environments. Payback duration varies with the system, and operations and maintenance can be a challenge due to equipment failures, general product availability and the maturity of support networks for such technologies.

Public awareness and acceptance are key to success. Focus groups held with the general public found that awareness of greywater use was minimal and that people may not want to invest if the payback period is more than ten years. There was ideological support for the practice but education needs to be accessible. A technology users' focus group found that the system lacked self-sufficiency and that efforts are needed to initially and continuously engage people. This group felt that conservation ideals, not payback, were driving uptake, and that health concerns were generally not an issue.

Several management frameworks are available to provide guidance, such as the USEPA *Handbook for Managing Onsite and Clustered (Decentralized) Wastewater Treatment Systems.* This handbook recommends looking at design options, site conditions, operating and maintenance requirements, periodic inspections, repair schedules, fines for non-compliance, and other aspects. It is important to identify risks and benefits as this is a dynamic exercise. As greywater use expands, a long-term view is needed to anticipate emerging issues; e.g., will having a greywater system affect the sale of a house? When Guelph was assessing municipal risks, the City set up an internal group with expertise from various sectors to identify risks, impacts and mitigation strategies.

As Alberta moves ahead with greywater use, clear regulations with delineation of source waters will be necessary, along with certification and market confidence. As a business case is developed, it will need to appeal to different sectors based on their perspective, bearing in mind that there is a level of risk with servicing approaches and sustainability. To improve risk management and get widespread support for the program as a whole, we will need to have alignment and engagement across municipalities.

Discussion

Q: Did you negotiate the option for water reuse for clothes washing?

Wayne Galliher (WG): No. This was not supported through the building code and preliminary water quality results did not support the extension of end use outside of toilet and urinal flushing.

Q: With respect to Legionella*, were temperatures measured in pipes and homes?*

WG: We didn't directly measure *Legionella* but some temperature measurements were taken at a subset of homes, with results being comparable to expected ranges through literature.

Q: Through the master plan you mentioned evaluation of a communal treated wastewater effluent system and that the maximum treated wastewater flows which could be diverted away from the local speed river as only 3 MLD. Beyond this limitation are there challenges through the regulatory process in Ontario? I'm not seeing standards to take to other parts of the community.

WG: This system has been discussed but currently the Province has no design or performance standard for such systems. These would have to be formed to support the project and eliminate risk in the interim.

Q: Would there be a quicker return on investment using rainwater systems alone rather than blending them with greywater systems?

WG: With extended usage, such as clothes washing, there could be a greater return on investment. However, this would have to be weighed against the overall implementation cost of a rainwater harvesting system (which is generally greater than that of the technologies assessed through our field test).

Q: Do you have private wells within your community?

WG: Within the urban boundary, 99.9% of properties are on the City's municipal water and wastewater system. Of those on remaining on private wells, the City monitors wastewater entering the system and bills accordingly for such services.

Q: If an individual installed softeners, they would be responsible. Isn't this an obstacle?

WG: This is the easiest way the City of Guelph found to do this. Managing a decentralized system doesn't come with the same barriers so we need to evaluate the risk.

Q: If the system is in the basement, pumping costs could be high. We need to be careful of cisterns and the location of storage systems in homes.

WG: Yes, this is true. Depending on the built form, energy output could be 1 - 2 KWh. There is a water benefit, but in the process we are adding an energy investment into the system.

Q: Did insurance companies look at these homes as a risk?

WG: Not to my knowledge. The inclusion of the system may mean that the assessed value and taxes for the home may increase. Perhaps if the concentration of systems would increase it could receive more attention from the insurance industry.

Slides for this presentation can be viewed here.

Alberta Water Reuse Policy Development: Exploring policy development options to support stormwater use and wastewater reuse

Angela Alambets,
Alberta WaterSMART

The first presentation on this project by my colleague Susan Davis Schuetz looked at some of the policy barriers and challenges to water reuse in support of increased economic development. My presentation explores policy and regulatory changes that the Government of Alberta (GoA) might consider to overcome some of these barriers. Policy options first address system-wide barriers, then focus on more specific areas such as clarifying the right to use water and the impact of reuse on river requirements. Regulatory options focus on efficient implementation of a transparent licensing and approval process with integrated resource management.

To address system-wide barriers, the following policy options are proposed:

- Establish scientifically determined aquatic health objectives related to seasonality and impacts to timing and location of diversions and discharges. These do exist in some places but need to be in place more broadly across the province.
- Establish clear definitions for source, purpose, use and type, end fate, consumptive and non-consumptive uses, stormwater, rainwater and greywater. Different organizations have different definitions for terms like return flow and it is critical to have a shared understanding across the entire water reuse system.
- Establish and communicate the concept of environmental net effects and consider all environmental impacts on air, land and water; for example, water reuse requires energy inputs which can have impacts such as increased greenhouse gas emissions.

To address the "right to use" barriers as noted in Susan Davis Schuetz's presentation, our project proposes the following general "right to use" policy options:

- Implement a policy that formally recognizes water reuse as a management option.
- Standardize licences with respect to return flow, end fate and water source, as not all licences have return flow requirements.
- Review existing licences only during a renewal period.
- Establish a clear definition for return flow; the project proposes to use the definition from the GoA's 2006 Water Conservation and Allocation Policy for Oilfield Injection; that is, water that has been diverted under the terms of the *Water Act* licence for a specific purpose but does not get consumed in the process and is returned to the environment.
- Adopt the concept that location or timing of right to use water remains with the licence holder until the licensed purpose has been spent or when it reaches the final "end fate" receiving environment (the river).
- Adopt a definition for end fate; the project proposes the following definition: The final discharge receiving water body or water cycle component where the right to use the licence is returned to the Crown (this could refer to the atmosphere, a lake, river or tributary).
- Establish a clear Cabinet-approved policy definition for "source water" or "water source." Is a water source only a natural water body? Or a manufactured body? Is runoff or stormwater a source? Natural sources are noted for existing licences but there is an option to have a manufactured source in a new licence.

- Consider adopting a definition for all purposes that are identified on licences, such that water users are clear on when they will require amendments to their licences for different types of reuse projects; e.g., municipal water use would refer to purposes usually served by water within a city, town or village, including but not limited to household and sanitary purposes, watering of lawns and gardens, and fire protection.
- Consider reuse of return flow from an existing licence as part of the original diversion for which the licence holder was granted the licence; e.g., where a municipality applies for a licence, or amends the licence, such that part of its return flow may be used by an industrial sector.

"Right to use" policy options that take into account river requirements, including apportionment agreements, downstream user rights, and Water Conservation Objectives and/or Instream Flow Needs include:

- Adopt the concept that licence holders are entitled to use a portion of water that would, under natural or licensed conditions, flow into a river for an initial, second or multiple use if it can be shown there is no negative impact to river requirements.
- Consider projects on a case-by-case basis. Benefits should be weighed against reductions and changes in timing of return flow and resulting impacts on river requirements.
- Matters and factors to evaluate net environmental impact should include original source, original end fate, volume consumed, quality returned, timing of return, and impact on river water quality.

In order to reduce municipal and Alberta Environment and Sustainable Resource Development (ESRD) resource requirements for multiple municipal wastewater or stormwater use projects, another proposed policy option includes allowing the management and tracking of water and wastewater within a licence holder's boundaries by the licence holder. This could be done through a Director-approved Water Management Plan (see http://environment.gov.ab.ca/info/library/6367.pdf).

The project also looked at policy options to overcome barriers related specifically to the right to use stormwater, with the intent of allowing its use where there is no impact on downstream users. "Right to use" policy options for stormwater include developing a definition for stormwater within Director-approved policies that may be implemented at a local scale. A stormwater definition should clearly communicate different water types embedded within stormwater that is naturally flowing as well as water created through impervious surfaces and available without a licence. There are currently multiple uses and interpretations of this word and it does not exist in current policy. When creating policy around its use, and identifying legislative requirements pertaining to its use, the definition of the term is critical to understand. A number of conditions that would allow for stormwater use where downstream users are not impacted, as exceptions to current policy, were proposed.

The use of stormwater and water sourced as groundwater may impact how much returns to the river, with the potential to impact river requirements. Therefore, clarification on how and when stormwater and return flows from groundwater sources are required to meet aquatic health objectives will allow for decisions on use to be made.

The impact on river requirements of using water sourced as groundwater is not clear, and may present an opportunity. Policy options regarding groundwater use include:

- Clarify if water sourced from groundwater is required to meet river requirements and what impact this has on licensing and approvals.

- Determine how aquifer recharge may benefit regional aquifer systems, and consider aquifer recharge as a water reuse activity in a water reuse policy.
- Support the use and development of tools to more effectively identify water reuse risks and opportunities.

A new licensing and approval process for stormwater use and water reuse projects is required and proposed. Specifically, a policy and regulatory tool for approving different uses of stormwater must be identified, which can apply to both closed basins such as the Bow River and Oldman River basins, and basins without licence restrictions. Other implementation policy options include requiring water reuse feasibility assessments for new diversion approvals to determine the net environmental impact of reuse vs. typical river diversion. In addition, requiring significant licence holders to identify potential reuse opportunities, especially those that use a lot of water and are non-consumptive activities, may identify significant reuse opportunities. This approach is used in Florida.

Discussion

Q: In your assessment, you mentioned the Oldman, Bow, and lower Athabasca River systems. Some of the recommended policy options look at controversial issues, so how do we ensure policy options are balanced for other systems?

Angela Alambets (AA): We need to know the context for the different regions when identifying policy options and we hope to address these issues in a way that is clear. However, some things that apply in the south may not apply in the north. With more dynamic systems, we have to figure out the decision processes that work for all regions.

Q: If you have base flow, instream flow or WCO requirements and then initiate uses of stormwater to find we are below base flow, how would you deal with this in terms of return flow after the fact? One of your principles was to do no harm, but the WCO is not being met. Once the water has been repurposed, should you also repurpose the use for industry?

AA: We would like to first ensure all river requirements are met including for downstream users and aquatic health, and that is the intention of the proposed policy options. We don't want to see decisions made without those considerations.

Comment: Those uses could be modelled in the Bow project that was referred to.

Comment: Whether it's called water use or reuse, you may not know where water has been before you decide to use it. When it gets to a pond and is taken out for irrigation is splitting hairs. My second point is that if we think about active recycling of beverage containers, we don't ask if the container has been recycled before. We don't care. This is reuse. I would be happy if we could get away from this terminology.

AA: The most critical definitions are those that affect how decisions are being made. Many definitions need to be outlined and clarified so we are all using the same terms.

Q: We also need to consider rainwater as a source where it falls. In the long term, we should be tracking rainwater too. We could look for opportunities to ensure ways to use rainwater, maybe as a threshold amount. Also, what are the next steps to take this work through to help ESRD make changes?

AA: In Alberta's current policy and regulatory framework, stormwater is considered as anything more than rainwater that is collected on a single residential property. There may be opportunities to better understand how much is available and what the impact of use might be. We don't monitor quantities going into river systems so we don't know how much is being contributed. In terms of next steps, in the next few months we will be developing an implementation plan that looks at these recommendations and those from our case studies. The final report will be made public at some point.

Slides for this presentation can be viewed here.

How to Get Your Water Reuse Project Approved

Ryan Devlin,
ZL EOR Chemicals Ltd., SLS Chemicals Inc.

There are several challenges presented to water users who intend on reusing water for additional purposes beyond that for which it was originally intended. Public perception, technology, design and construction challenges can impede one's plans for water reuse, however if the regulatory approval process is clearly defined and all requirements are satisfied, approval for the project should be forthcoming. Unfortunately in Alberta, the regulatory approval process is not clearly defined. There is, however, a way to navigate the complexity. The Government of Alberta does not want to discourage innovation; therefore there is a way to get them approved (no guarantees of course). Risk mitigation is a major part of getting a project approved, and if you can demonstrate that you have limited risk, you can get noticed.

As other speakers have noted, definitions and common terminology are very important. Alberta defines some terms in the water reuse vocabulary, but generally "wastewater" is a very broad catch-all category, and greywater is not defined or recognized by the Province. Alberta has four general categories of water reuse: irrigation of public and residential areas, commercial uses (e.g., car washes, nurseries), industrial uses and residential (flushing of toilets and urinals).

Relevant Acts, Regulations, Standards and Codes include Alberta's *Water Act*, the *Environmental Protection and Enhancement Act* (EPEA), Activity Designations Regulations, the *Safety Codes Act,* the 2005 National Plumbing Code, the 2006 National Building Code, and various other provincial and national guidelines, including a 2010 Health Canada policy document (*Canadian Guidelines for Household Reclaimed Water for Use in Toilet and Urinal Flushing*). However, Alberta does not have regulations or a Code of Practice for the use of reclaimed water. Some policy documents exist on water reuse such as rainwater harvesting, but they are not legally binding.

The *Water Act* addresses the diversion of water. When we are asking to do reuse projects, the question of whether we are diverting water must be considered. If your project plans to use water for purposes that are not listed in the *Act*, approval is at the discretion of the Director who may require a study of the use itself and the receiving environment. The Director is obliged to hear the applicant's request/application and must provide you with information on how to proceed. The Director will consider many factors, the most important of which will be the identification and mitigation of risk factors to people and the environment. The *Water Act* also references conservation planning, and includes efficiency, conservation recycling, and reuse, and there provides the foundation for making a case to the Director for different approaches to water reuse.

Under EPEA, the Activities Designation Regulation provides guidance for industries, which have specific codes of practice for use. As an example, Alberta Environment and Sustainable Resource Development (ESRD) may issue approvals for reuse under EPEA's Wastewater and Storm Drainage Regulation.

The Alberta *Safety Codes Act* includes Plumbing Code and Building Code Regulations. The 2010 Plumbing Code has now been adopted in Alberta and references the CSA standards that address water reuse in a building. It discusses non-potable water reuse standards and long-term performance. The Code asks proponents to provide proof of 'equal to or greater levels of safety to the public or the environment,' and this is very important. The consideration for a reuse project is this: If the appliance or fixture is attached to a drain that is connected to a sewer system, you will have to apply for an alternate solution. The *Safety Codes Act* allows local approving governments (municipalities) to entertain innovative solutions to water resources challenges by applying for an alternate solution. These applications are made to the approving municipality, which forwards it to Alberta Municipal Affairs (AMA). If the application provides 'equal to or greater levels of safety to the public or environment,' a variance order may be issued. The 2009 Alberta Private Sewage Standard of Practice allows for the reuse of treated wastewater under certain conditions and the approval process is clearly defined.

Every Alberta municipality has storm sewer and wastewater sewer bylaws that regulate servicing connections and the release of matter and water to the sewage system and watercourses. The cities of Edmonton and Calgary also state that permission from the City Manager is required for a person to use stormwater, and the approval process is clearly defined.

Other examples of water reuse are guided by various approaches. Guidelines are in place for rainwater harvesting, and the Alberta Building, Plumbing and Electrical Codes apply to this activity. Once rainwater has contacted the ground, it becomes stormwater and its reuse gets more complicated. Both ESRD and AMA govern activities related to stormwater reuse. Water collected from a green roof is viewed as stormwater but the approval process is not clearly defined and a variance order may be required. Stormwater approvals can range from simple ponds and conveyance systems to larger multi-pond facilities and the approval process may require a variance order depending on the reuse activity. Various factors are considered in an approval, including whether the water is available, if the system is scientifically viable, and if it will provide 'equal to or greater levels of safety to the public and environment' in the post-storm period (after rain).

Processes that use water and generate wastewater are governed by the *Water Act* and EPEA. Industrial wastewater processes are governed by the industry's standards and approvals processes, which are clearly defined by each industry and ESRD.

Other examples of potential water reuse include:

- Swimming pools. Water reuse is currently prohibited because a pool is a fixture and has a drain, thus drained water must go to the sewer system. To reuse this water would require an application for an alternate solution and a variance order.
- Spray parks. Reuse is prohibited for the same reason as a swimming pool, so a variance order would be needed to enable water reuse.
- Car washes. Reuse is prohibited for the same reason as a swimming pool, so a variance order would be needed to enable water reuse.
- Municipal wastewater can be reused. Approval is through ESRD, depending on the reuse activity. AMA may be involved if the reuse is a residential one.

In summary, water reuse in Alberta is still in its infancy and technology has far surpassed the regulations. Legislation does not necessarily prohibit water reuse, but you have to get approval to do it.

Discussion

Q: How do you handle reuse and snow melt, such as ice rink snow?

Ryan Devlin: I'm not sure about this. We must consider that the water came from a fixture and remained in a building for use. The skating rink is the appliance and therefore must have a drain or exit point. In this case, the ice shavings are the exit point (drain). To place them outside the building into the environment, may require an approval under the EPEA. The volume of ice and location of the ice (and melted water) will become important. I recommend calling ESRD for an opinion. The same thought process must be applied to reusing the ice shavings.

Slides for this presentation can be viewed here.

Integrative Water Systems for Urban Developments

Susan Nelson,
OpenGate and its TwinHillsCalgary.ca project

TwinHills has utilized a collaborative connection and conversation system, which brought together academics, government representatives, non-profits, and companies for their expertise and input on various vital issues to be accumulatively considered and compiled into an improved integrated urban development. The overall approach is based on a "**Five Bottom Line**" whole system model that considers environmental, social, economic and technological implications, and wellness (physical, emotional, mental health and education). The model has been shown to work well for both municipalities and corporations.

Collaboration among all these different organizations, representatives and the project developer as well as with companies situating within the project, end users, community and academic groups, focused on policy and practice change to result in better standards. Appropriate location and site requirements have to be considered along with different approaches to water reuse, and water management opportunities have to be identified.

Coordination and collaboration are essential when it comes to creating change. To do this, we need to look at the whole relationship and how it all fits and works together. Inclusion is a key part of public participation and engagement but doing it well takes time. However, with time delays and other things (such as governments, economics, demographics) changing, risk analysis is vital. There are many variables in risk analysis to consider related to integrated urban development sustainability involving political, environmental, cost, time and people risks related to water management and water reuse.

Traditionally, urban growth has occurred near a river. In choosing appropriate location and site characteristics for any development, the proximity to water and how surface and underground water moves must be taken into account. We also need to look at appropriate water management location criteria; these include:

- Land elevations, soil composition and geotechnical characteristics,
- Adjacent land composition and uses; barriers to overland and groundwater movement, and
- Seasonal and weather incident impacts.

An integrative water management approach involves connecting natural spaces within the urban environment to result in water management and special places. With this approach, water management planning deals with freeze and thaw, spring thaw and flooding. Water reuse results in better water quality and better management of water quantity.

Overall, water reuse related to low impact development (LID) has many positive benefits and cumulative effects on such a system approach to urban development.

- Water reuse focuses on reuse for ponds and for horticulture and other uses; rainwater can be captured for watering plants.
- Offsite process management: The TwinHills Prairie Preserve is a place for a variety of community activities through the seasons; they have created their own compliance management process so the City of Calgary does not need to spend valuable resources on day-to-day management but rather as a compliance auditor.

- Creating more green spaces using channels of water allows us to think about how to deal with those that are operationally and cost-efficient; e.g., use of drain pipes and gathering water off house roofs into rain gardens.
- Pervious surfaces can be used for parking and boulevards.
- Channel diversion variations preserve natural watercourses and create vibrant waterways.
- The focus is on safe storage, beautification, and recreation.
- Multi-purpose infiltration, bioswales and use of creative landscape architecture can take advantage of different types of vegetation to absorb different amounts of water and improve water quality as a filter and purifier. Rocks can also be used to control weeds and add beauty, and mulch adds humus and enriches the soil, with additional weed control benefits.
- Green roofs function as absorbent infiltration spaces. They are still somewhat experimental in Alberta's climate but some materials, plants and container approaches have been identified that are more suitable.
- LID can use water features to create gathering spaces for both parks and residential purposes. LID can also be a feature of retail and corporate gathering spaces.
- Water LID can become a feature art piece or an urban plaza feature.
- LID can provide irrigation water for urban agriculture, market gardens and parks.

There are also opportunities to use a micro-grid to control water movement, ensure compliance and manage water quality and quantity compliance issues. In addition to providing a wide range of "Five Bottom Line" benefits, integrative planning involving water management and water reuse can save a lot of money for municipalities and promote more sustainable regional planning.

Discussion

Q: Have you looked at greywater use?

Susan Nelson (SN): We only dealt with showers and toilets and had to deal with the plumbing code, health and municipal codes, which all required changes federally; all have successfully been passed and are applicable in Alberta.

Comment: The codes have been approved and will be implemented, and the project will proceed to get a variance based on these changes.

Q: When will this development happen?

SN: The Area Structure Plan has been approved but discussion has been more about whether there will be City resources for any suburban growth. The TwinHills Calgary WORK-LIVE Town location is about eight miles from downtown so its operating costs and capital costs are less. This municipal costs dilemma is occurring all over North America. As we look at industrial rural growth, suburban or inner city residential growth, associated contaminants and water quality in increased populated areas must be carefully considered in an integrated urbanization approach within the whole water basin. A smart grid facilitates compliance, monitoring, and management even down to allowing sections where water treatment can be put in. TwinHills utilizes a smart micro-grid approach and is at the approvals stage where the project is moving to the Priorities and Strategies Committee (Calgary) for final approval.

Q: Did you look at other technologies for water reuse?

SN: We considered using aquifers for water storage but were told that could not be done. Water can be managed on-site at this location as it has high lands and plateaus with existing ditches so not is prone to flooding; Water Modelling for Low Impact Development was completed first on the site prior to land use planning and design.

Slides for this presentation can be viewed here.

Removing Barriers to Implementation in the City of Calgary: Why and how would a municipality implement stormwater reuse in Alberta?

Harpreet Sandhu and Bert van Duin,
City of Calgary

The City of Calgary's Sustainability Direction is based on a systems thinking approach, which addresses both water quality and water quantity. From a sustainability perspective, Calgary is working on water management issues such as:

- not enough water to balance supply and demand,
- too much water due to excess stormwater, and
- "dirty" water related to stormwater quality.

As a Utility, The City has three business lines: potable water, wastewater and stormwater. Calgary is developing different programs for each area, recognizing that developing a Water Reuse program will benefit all three business lines.

To further define sustainability from an urban water management perspective, the speakers have identified six principles:

1. Sustain our community with an appropriate supply of potable water of good quality.
If one reviews the water management cycle from an urban perspective, most of the water diverted from the Bow and Elbow Rivers is eventually returned to both rivers. The City has reduced demand and minimized leakage losses and is working to improve efficiency by working on both supply and demand management. The intent is to accommodate future population growth with the same amount of water removed from the rivers as in 2003, which means lowering demand from 500 to 350 litres/person/day. One tool has been the shift from a flat rate to a rate structure based on household water metering – 95% of households in Calgary now have water meters.

2. Sustain our community with appropriate stormwater management.
The City aims to provide an appropriate level of service to protect its citizens and minimize damage to infrastructure and private property.

3. Sustain the Bow and Elbow Rivers.
This principle requires satisfying instream flow needs in the Bow and Elbow Rivers to meet the Apportionment Agreement with Saskatchewan and fish habitat requirements, as well as controlling the contaminant loadings by reducing both concentrations and runoff volumes. Treating stormwater is more difficult than treating wastewater due to the variable amount, temperature, and other factors, which create greater fluctuations in contaminant loadings. Better stormwater treatment upland lowers downstream potable water treatment costs; this can be done in part by reducing runoff volumes.

4. Sustain our creeks.
Our creeks suffer the consequences from exponential increases in runoff volume associated with development, as seen by the associated impacts of creek bed and bank scouring. Runoff volume control targets have been introduced in various Water Management Plans in Calgary.

5. **Sustain our wetlands.**
   When land is developed, catchment areas can be cut off so that wetlands are no longer supplied with water. An appropriate amount of stormwater of suitable quality is needed to provide adequate moisture to maintain wetland habitat, so some supply of runoff is needed to sustain such wetlands.

6. **Sustain our landscapes.**
   Landscapes need moisture to survive, but this does not need to be potable water. Landscapes provide many benefits to humans and we need to ensure they are protected.

In short, the key question is whether stormwater is a curse or blessing. On the negative side, it may cause flood damage, change the structure of creeks and discharge contaminants to receiving waters. Its benefits are that it sustains the Bow and Elbow Rivers with runoff, and sustains wetlands and our landscapes. An appropriate regime of stormwater management is clearly needed and, fortunately, a comprehensive Low Impact Development (LID) toolbox is available to develop such a regime. Tools include absorbent landscaping, bioretention, green roofs, permeable pavement, rainwater harvesting and reuse, and stormwater capture and reuse.

With runoff management, the question has been raised as to whether we may not be able to sustain the Bow River. In the Calgary area, prior to development, actually only about 3% of precipitation became surface runoff, with most of it returning to the atmosphere through evapotranspiration (95%). Even with the City's most stringent water management plans to control runoff volume, there will be an increase over natural conditions.

In water reuse systems, the moisture is not being lost to the river and the hydrologic cycle. For instance, runoff that is reused for toilet flushing is returned to the Bow River via Calgary's Wastewater Treatment Plants.

Various municipal concerns have also been raised with respect to reuse systems. While we need to look honestly at a whole range of issues, the reality is that these many reuse activities are occurring now without provincial or municipal authorizations, which results in a lack of monitoring and enforcement mechanisms in place to protect public health.

The City of Calgary Water Resources Business Unit reviews over 700 development applications per year. The interim stormwater targets for runoff rate, runoff volume and water quality control necessitate the application of LID to meet these targets, so all of these applications may have a future water reuse need. The City's view is that municipalities should be allowed to authorize water reuse systems, as long as water management plans and provincial regulatory requirements are being adhered to; public health is protected; and appropriate inspection, monitoring and data management systems are in place. Municipal authorization would result in a simpler, one-window approach that would promote the concept of regulatory efficiency in Alberta.

One concern that may impact the granting of a municipal approval relates to what happens when a user stops utilizing the water, goes bankrupt or forgets to turn on the irrigation system in spring. We need to examine possible failure scenarios in the design stage, and have in place proper operating and maintenance procedures and checklists, as well as inspection and monitoring programs.

To protect the public, we need to specify appropriate pre- and post-treatment provisions as a function of the type of source water and application, ensure that relevant codes are met, eliminate potential for cross connections, use CSA-approved materials, ensure installers are certified, and have in place proper operating and maintenance procedures, checklists as well as inspection and monitoring programs.

Inspections and monitoring are required to demonstrate that the system is operating properly. Such inspections are a function of the type of system being installed. The designer needs to sign off on the installation, and third-party inspections by certified professionals may be appropriate.

The City of Calgary has already undertaken a number of initiatives to implement water reuse and further actions are underway. LID technical guidance documents have been prepared, and the City is now preparing a Water Reuse Strategy, which will identify the various components of a long-term water reuse program in the city.

An important aspect of stormwater reuse is determining what level of risk there actually is and what level we are willing to accept. We cannot eliminate all risk and water reuse systems will never be entirely risk-free. Stormwater reuse is not new and has been occurring in Alberta for decades. For instance, Calgary Parks has been a leader in stormwater reuse for over 10 years.

Discussion

Q: Thinking about the cost of potable water, what happens when we use less and less municipal water because of stormwater reuse? At what point does the cost go down or up for users?

Bert van Duin (BvD): We are still dealing with growth right now in Alberta, which puts a lot of strain on our supply infrastructure. But this is a tough question, as it depends on what the local conditions are. If water is not being used in one place, it could be used somewhere else. With stormwater, we have issues where we have way too much in certain areas where the quality is poor. We need some way to manage that.

Harpreet Sandhu (HS): This is also a water supply issue. Southern Alberta is prone to drought so we need to be preparing as we approach limits on water supply.

Comment: Risks to human health, such as dog faeces, are unpredictable, but from a human health point of view there is a relatively low level of risk. We need to be concerned about faeces to get to the real risk, which is pathogens in the water.

BvD: Agreed; dog faeces was used as a simple example to make a point. Some people tend to over-react, and as soon as a citizen is sick we get phone calls. The automatic reaction is that water is responsible for every health problem. Many other factors do come into play as per the example, but public and health professional perceptions can be a challenge.

Q: Can you speak further regarding your comments on streamlining the regulatory process?

HS: Part of the issue we need to resolve is terminology, not only for the types of reuse applications, but also which provincial requirement are we addressing: are we talking about a water management plan requirement for a river basin or a regulatory requirement for Alberta Health, for example. We need to understand what types of applications could potentially be streamlined, because having each and every application going through multiple approval steps at the provincial and municipal level is a clear barrier to establishing water reuse in Alberta. We need to enter into discussions with the Province to clarify these matters, as long as we ensure the public is protected and we meet regulatory requirements. One approach is to look at the Water Use Reporting System for all water licensees and adopt a similar approach for water reuse reporting to the Government of Alberta.

Also, many regulations are full of “may” language rather than “shall.” There will need to be a different kind of discussion here in southern Alberta since this basin is closed to new water licence applications.

Slides for this presentation can be viewed here.

Flowback and Produced Water Reuse

Bill Berzins,
K'nowbe

The life cycle of management of frack water supply, flowback and produced water creates many opportunities for minimizing environmental impact, maximizing use and reducing costs. There are many precedents that show the benefits of water that is reused from oil and gas operations for other uses. If industry has wastewater that could be used for another purpose such as agricultural irrigation, we should consider the barriers and risks that need to be addressed to allow this to happen.

"Flowback" is defined as a water-based solution that flows back to the surface during and after the completion of hydraulic fracturing (fracking). Flowback is distinct from "produced water" that is generated during long-term production. The oil and gas sector has developed a Flowback and Produced Water Reuse Strategy that includes frack water specifications, and accommodates the use of lower quality saline water. The increasing use of lower quality water is accommodated by a suite of treatment processes including filtration, adding certain chemicals to the injection water, electrocoagulation, ozonation, and other processes that condition the water to ensure successful fracking activities. These additives are similar to the water in the heating pipes in a commercial building; they inhibit scale and corrosion, control bacteria, reduce friction, stimulate flow and play other roles that help protect and conserve the equipment.

Scale is the formation of inorganic soluble salts and minerals that build up during fracking and inhibit flowback and scaling – scale formation has a number of implications. Scale inhibitors are especially important when water is high in sulphates, which can cause scaling and block pipes; high sulphate source water should be avoided. As chemicals are added to the saline fracking water, they can accumulate in the reused water; this residual must be considered and managed as it affects dosing estimates for subsequent reuse. High levels of barium, strontium, radium226 and iron can also be associated with scaling. After the water is injected and starts to flow back, the first bit of water that appears is what was most recently injected; the longer-term flowback has higher salinity. The water will change significantly over the life cycle of the system, so we must plan for and design the water reuse process in alignment with the average characteristics of the flowback water, asking questions such as, What is the chemical content of the return flow? How much chemical should be added? How are chlorine concentrations managed effectively? In short, we have to know the chemicals and plan in advance to ensure proper disposal.

Bacteria accumulation can also have implications and we need to monitor and balance bacterial levels present in flowback. For example, microbes can affect corrosion, generate toxic hydrogen sulphide, and create iron sulphides that can line tank bottoms and cause plugging. Microbial activity can also contaminate downstream equipment and pipelines. Bacteria must be controlled for aquatic and terrestrial toxicity.

No one technology can address water quality and reuse issues so we need to assess what will happen at the various stages of reuse and how to ensure the system is flexible, given that flowback characteristics change over time. To optimize reuse of flowback and produced water, we need fit-for-purpose modular systems for online analysis, blending, and conditioning of frack fluid. Optimizing the water management system involves minimizing freshwater requirements, removing solids to protect the hydrocarbon reservoir, removing precipitates to prevent fouling and scaling, and minimizing additives. If deep well disposal is not available, advanced treatment will be required to achieve surface water discharge requirements. Strategies to dispose of produced water must consider the changing characteristics of the produced water, the specific geography, and changing technology.

One example is a well-to-well cascading strategy, which covers management of the entire life cycle of the fracking operation. For a solution to succeed, all components of the life cycle must be included. My philosophy is that if the oil and gas sector can find solutions to make the system of oil extraction work as efficiently and effectively as possible, then the cost is lowered which means that extra money and time are made available to protecting the environment because the sector understands that the health of the industry is connected to the health of the environment.

We are also examining what can be done to minimize water use in the drilling process and maximize reuse of the mud by focusing on improving overall process efficiency and minimizing the energy and carbon footprints. To do this, we need to understand the complete cycle and where the fit for improved technologies is, and water scarcity is the driver.

Keys to technology selection include being able to adapt to changes in flow and composition, and that ability is found in a modular approach. Other keys are the application of a cascading strategy, managing risks of upsets (which may have higher levels of bacteria or chemicals at various points) and a QA/QC sentry at the point of generation.

Simple strategies can be developed by, among other things, maximizing reuse, controlling residuals throughout the life cycle, optimizing the water management system, using integrated and flexible modular or mobile systems, and having a proactive stakeholder strategy. In summary, the key considerations for success are having:

- A life cycle approach,
- A cascading system and understanding what's happening at each process,
- Modular systems to allow customization of process, and
- Good risk management.

Discussion

Q: What are the impacts of deep well disposal?

Bill Berzins (BB): Deep well disposal is typically done in an abandoned oil and gas well that was used for exploration. A decision may be made to use it for injection wells. There are differing views about using fresh water for injection (maintaining it for other uses that require fresh water vs. efficient need to extract oil). The key is to ensure there is a benefit socially, economically and environmentally in the decisions.

Q: What is the water loss intensity in a fracking operation?

BB: What is the definition of loss? Flowback can return 100-120% of the water used which can be available for reuse. By using saline, non-potable source water, the impact on freshwater supply can be reduced.

Slides for this presentation can be viewed here.

Closing Keynote:
The Economics of Well-being of Water Reuse

Mark Anielski,
Genuine Wealth Inc.

What economists measure is not connected to what makes us happy or what really matters. We all have a relationship with natural assets, so we need to think about how we act and make decisions that will enhance the well-being of our children and grandchildren. Genuine Wealth is about measuring what matters to well-being.

For this symposium, what is the problem we are trying to solve? To use or reuse? Is water reuse in the best interest of the well-being of current and future generations? Is that the right question? Are we taking responsibility for the way we use resources? And how do we know we are not impairing the well-being of nature?

Wealth can be defined as "the conditions of well-being." Five types of capital are encompassed by genuine wealth:

- Human capital refers to the life capabilities or capacities of people, including their education, experience, motivation, health, happiness, available time and spiritual well-being.
- Social capital is about relationships and networks among family, friends and colleagues that facilitate collective action.
- Natural capital refers to the environmental stocks and systems that provide us with the many natural materials and services upon which we rely to sustain economic activity.
- Built capital is the produced goods that provide benefits or services to their owners over time by helping to produce other goods and services (equipment, machinery, buildings, roads, patents and other infrastructure).
- Financial capital is the monetary assets of an organization.

Most of us are familiar with balance sheets, but when it comes to the environment, we do not know the natural capital balance of Alberta. It's time that governments put natural assets on their balance sheets. This would include land, water resources, energy, minerals, timber, and a range of ecological goods and services.

Genuine Wealth Assessment is tied to the science of happiness and well-being and determining what really matters to the well-being of communities. Basic questions are: What is the highest and best use of our natural assets? What contributes to or impairs our well-being? A study in the US looked at the value of New York City's watershed. The City decided in 1997 to invest US$1.5 billion to protect the Catskill watershed instead of building another water filtration plant – a plant that would have cost $6-8 billion to build and additional millions to maintain.

Other studies have looked at the health of Canada's natural capital and found substantial variation across the country. These studies include mapping the water quality index of Canada's watersheds, the carbon absorption capacity of Canada's forests and wetlands, soil organic carbon by watershed, and toxic substances released by watershed. The challenge is determining how loss of ecological integrity translates into economic impacts and affects overall well-being.

Many questions remain to be answered:

- Do we believe that what we do in terms of human development will have a net positive or net negative benefit on our watersheds or will it be neutral?
- Are we realizing the highest and best use of these resources?
- What is the state of well-being of Canada's watersheds in 2014?

Optimistically, I see a future where economic growth, GDP and profit maximization will be replaced by well-being optimization.

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At this point, Judy Stewart, one of the symposium organizers, joined Mark onstage and asked him a number of questions:

Judy Stewart (JS): Should we make a distinction in how we treat reused water and do it better? How can we use well-being to change our perspective about how we use or reuse water?

Mark Anielski (MA): Do you mean would we do things differently if we knew that a level of 70% tree cover in the Upper Bow would save money for Calgary? We need to consider what is the highest and best use of the watershed. When we use water we don't want to create future liability.

JS: This seems to me like a marriage between managing risk and moving forward.

MA: It's like risk management for an insurance company – can we create the right signals to modify behaviour? We need to be honest and transparent about the risks.

JS: Is lack of trust a barrier to water reuse?

MA: My question is why isn't the Government of Alberta doing more on this issue? What are we afraid of? Let's be prudent and use common sense.

JS: We heard about fracking and its impacts on water, with growing concern and fear. How can discussion about water reuse create a sense of happiness instead of similar concern and fear?

MA: We need to be conscious of how we use water. We have the sense that water is sacred but we can't be separate from it. We need to think about it as a relationship. Also, we tend to think too short term. We are caught in the systems we've developed and they prevent us from doing well by doing good.

JS: You talked about the history of contractual relationships in Alberta; maybe we need to focus on social relationships rather than contracts.

MA: Lots of places with a high happiness index have long life spans and are also among the most densely populated areas. We are social creatures and relationships matter to our well-being.

JS: I also wonder about the language we use – currency, banks – these could be water terms as well as economic terms!

MA: We are always being told we need to save for the future and are afraid we won't have enough money. We could create credit that is reflective of our natural assets.

JS: I have a friend who wants to design a home that recycles water several times before it goes down the drain but is facing many challenges in trying to do a good thing. Do we need water reuse to be regulated to avoid these challenges? Could we treat water reuse as a basic human right?

MA: Water is a basic human right, but we can't control requirements for reuse. We have a responsibility as stewards and are entrusted to manage. We should not control private ownership.

Discussion

Q: You used the term "highest and best use." I've seen this term in water management in other contexts. Some places have tried to tackle it but how do you establish what "highest and best use" is? It seems pretty subjective.

MA: You do it based on the value it creates. I think we can go far enough along that path to ensure that natural assets are delivering a sustainable future. How many of the issues around fracking are hype and how many are real? Who are the leaders in the field? We need to remove the emotion from it and be as objective as possible. We can do it, but we don't, although there will always be emotion, opinion and perception.

Comment: If everyone had perfect knowledge and trusted each other, we wouldn't need lawyers.

MA: A lot of prudent and wise companies are looking at shared responsibility. With First Nations, we share the benefits of healthy watershed.

Q: When talking about comparing dog waste and rainwater, you can use common sense and maybe we are overly careful. We could say the same thing about many building codes – use common sense, such as stucco vs. vinyl siding. But I think the key is how to balance fear and other emotions.

MA: When you experience disasters like last year's flood, people did things differently by getting together and responding well. You do things for different reasons. The solar panel on my house will not be worth it until the price of natural gas triples. How do we know when we are getting a good return on well-being? How do we design a neighbourhood that maximizes relationships? We need to figure out what attributes contribute to a happy life and then invest in those things. But the reality is that sometimes we are precluded from making the best choices for various reasons.

Q: From the perspective of the Genuine Progress Indicator, what metrics and indices might be useful for water reuse?

MA : For every sub-basin in Alberta, I would hire some biologists to develop an account – what is the natural recharge, what is the flow rate of the watershed, what are the characteristics of the watershed that deliver a flow rate that gets used? Which are the most constrained watersheds in Alberta and why? Scarcity signals innovation and then the price rises. I think water is too cheap because the signal is not there to make the best choice. I would ask ESRD to produce these accounts and to value the ecological goods and services. We need to maintain upper watershed integrity. Accounts provide signals to all users and to government about where we are. We ultimately want to get to a "no regrets" situation. But I wonder if maybe the economics aren't really good enough yet to focus on reuse.

Q: If allocations in basin are underutilized, could they be reassigned?

MA: Perhaps, based on each watershed and knowing what the best use for humans should be. Grandfathering these rights forever doesn't make sense. Water users have to be accountable for achieving the highest and best use and the ability to redistribute water rights should be open to discussion. Is irrigation the highest and best use, for example?

Slides for this presentation can be viewed here.

Closing Remarks

Jay Ingram,
Symposium Chair

We are left with many ideas to contemplate as this conference wraps up. How important is the business case when we want to develop water reuse projects? How do we protect watershed health? How do regulatory issues get addressed? I encourage each of you to concentrate on the ideas that are most pertinent to what you do and to think of the symposium as a perpetual gift! I'm sure you heard many approaches and got new insights in the last two days, and I urge everyone to use System 2 thinking as you process, reflect and act on what you've heard.

Appendix A: Symposium Committees

Organizing and Program Committee

Angela Alambets, Alberta WaterSMART
Ken Brown, Watershed Planning and Advisory Councils
Al Kemmere, Alberta Association of Municipal Districts and Counties
Scott Millar, Alberta Energy Regulator (committee co-chair)
Tara Payment, Canadian Association of Petroleum Producers
Edith Phillips, City of Calgary
Judy Stewart, Alberta Lake Management Society (committee co-chair)
Zoe Thomas, Canadian Association of Petroleum Producers
Fayi Zhou, City of Edmonton
Alesha Hill, Alberta Water Council
Meredith Walker, Alberta Water Council
Andre Asselin, Alberta Water Council

Sponsorship Sub-Committee

Brenda Casella, City of Calgary
Al Kemmere, Alberta Association of Municipal Districts and Counties
Kelly Rowsell, City of Calgary
Judy Stewart, Alberta Lake Management Society (committee co-chair)
Fayi Zhou, City of Edmonton

Communications and Promotion Sub-Committee

Tasha Blumenthal, Alberta Association of Municipal Districts and Counties
Joey Hurley, Alberta Environment and Sustainable Resource Development
Sharon McKinnon, Crop Sector Working Group
Jay White, Alberta Lake Management Society

Appendix B: Speaker Biographies

Note: The biographies appear in the same order as the presentations.

Edwin Pinero is Senior Vice President for Sustainability for Veolia North America (VNA), and liaison to Veolia's worldwide Corporate Social Responsibility and Public Affairs departments. Mr. Pinero oversees all efforts related to sustainability, in regard to outreach, client issues, and internal practices, including the water, energy, and waste business lines. VNA provides leading edge water, energy and environmental service and technology activities, and has approximately 10,000 employees and generates approximately $2 billion in annual revenue.

Mr. Pinero is heavily involved in water management and stewardship initiatives around the world, including the UN CEO Water Mandate, the Alliance for Water Stewardship International Standards Development Committee; and ISO's Integrated Water Task Force, among others.

Pinero began his career in the oil and gas industry. He has Bachelors of Science degree in Geology from the State University of New York and Masters of Science degree in Geology from Texas A&M University.

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Dave Lye is Vice-President, Policy, Environment & Sustainability, working with Encana's Investor Relations & Communications team. His responsibilities include Encana's sustainability strategy and programs, corporate responsibility governance and internal policy development.

Dave holds a Bachelor of Science (Physical Geography) degree from Simon Fraser University and a Master of Science (Environment and Management) from Royal Roads University. Dave joined one of Encana's predecessor companies as a Senior Environmental Specialist in 1998 after 10 years working as an environmental consultant and provincial regulator focused on environmental issues and environmental emergency response.

Since the formation of Encana in 2002, Dave has held various Environment, Health & Safety and Corporate Responsibility leadership roles within Encana's operating divisions and corporate groups. In this capacity, he has been significantly involved with the formulation and implementation of Encana's internal EH&S and sustainability strategies and policies and Encana's approach to corporate responsibility and governance.

Dave's current responsibilities include the development and implementation of Encana's environmental programs including the ongoing development and implementation of Encana's comprehensive water sourcing and use strategy.

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Dr. Stephen Stanley holds a B.Sc. in Civil Engineering, a M.Sc. in Water Resources Engineering and a PhD in Environmental Engineering, all from the University of Alberta. He is also a graduate of the Executive Program at Queen's University.

Dr. Stanley is currently the Senior Vice President for EPCOR Utilities Inc. where he is the executive in charge of EPCOR Water Services in Canada. EPCOR Water Services provides water and wastewater services to more than 75 communities in Western Canada including over 1 million people in the Edmonton region. EPCOR has also recently expanded to the United States and is now the largest private water utility in both Arizona and New Mexico. EPCOR also provides water and wastewater services to industrial clients like Suncor and Albian Sands Oil Sands in Fort McMurray. Prior to joining EPCOR, Steve was a professor at the University of Alberta in the Department of Civil and Environmental Engineering.

Dr. Stanley is currently on the Board of Directors of the Alberta Chamber of Resources, the External Advisory Council for the School of Public Health, University of Alberta, and the External Advisory Board for the University of Alberta Water Initiative and served on the Management Advisory Council for the Alberta Water Research Institute.

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Prof. Nicholas Ashbolt is a world-renowned leader with 30 years' experience in the field of environmental pathogen fate and transport, and specializes in the application of quantitative microbial risk assessment (QMRA) to aid in the management of community water systems. Dr. Ashbolt was invited to join the U.S. EPA as Title 42-Senior Research Microbiologist 2007-2013, and was previously a professor and Head of the School of Civil and Environmental Engineering, University of New South Wales, Sydney, Australia.

From 1998-2005 he led the microbial risk assessment aspects of the Swedish (MISTRA) Urban Water Program, investigating risks from household urine-diversion, composting toilets, greywater treatment systems and energy-recovery blackwater sewer systems, and from 2001-2005 led the stochastic design and analyses of microbial risks for the MicroRisk Project investigating drinking water management systems in Europe.

His research and interpretation with the World Health Organization (WHO) was fundamental to the risk-based approach adopted in the most recent WHO recreational, drinking and water reuse guidelines, as well as risk-based innovations in Australian and US water regulations. As Alberta Innovates Health Solutions Translational Health Chair he is helping led the application of water safety plans for recreational, drinking and reuse waters in the province and more broadly.

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Brian Gregg is the Manager of Global Research-Canada for General Electric and is responsible for identifying new, adjacent market growth opportunities in Canada enabled by advanced technology. Brian acted as the program manager for a multi-year, multi-technology field trial of next generation SAGD produced water de-oiling and pre-concentration technologies that GE Water & Process Technologies is conducting in partnership with Alberta Innovates – Energy & Environment Solutions and Suncor Energy. Brian previously led GE's Customer Innovation Centre in Calgary through its first year hosting over 235 customer/partner sessions. Customer sessions ranged from broad, market development collaborations to specific commercial or technology development initiatives sponsored by GE Businesses experimenting with "in-market" collaboration/co-creation.

Prior to joining GE Brian worked for a venture capital company focused on oil and gas reservoir management technology and also with Halliburton for 10 years in market development and management roles. Brian has over 20 years of management consulting experience with specific experience in: strategic marketing, partner relationship management, and business process re-engineering and technology commercialization. Brian is a Calgary native and graduated from the University of Alberta with a MSc. in Geography – Water Resource Management.

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Dr. Mike Scribner is currently the manager of the Technology and Optimization organization for Oil Sands, ConocoPhillips Canada (CPC). The organization is involved in the technology development process for improving economic return on CPC assets and future developments via proving of technology in the field. He manages a team that covers subsurface and facilities technology development.
During his 29 years with ConocoPhillips, Mike has led organizations in Research and Development, Technology Development, and Technical Services for ConocoPhillips. Prior to joining ConocoPhillips, he received his PhD in Organic Chemistry from Iowa State University doing thesis research on the flash vacuum pyrolysis of coal-modeling compounds. He also holds a BA in Chemistry from Simpson College.

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Dr. Preston McEachern started PurLucid Energy & Environment to bring innovative technologies in solids control and water treatment to the oil and gas sector. PurLucid is developing several product lines and implementing pilot projects with producers in such areas as tailings management, bitumen recovery and produced water and EBD treatment. Prior to PurLucid, Dr. McEachern worked in both technology development and regulatory roles. He was the Vice President of Tervita's Research and Development Department where his team implemented a disciplined enterprise and innovation management system to address the challenges of meeting increasingly stringent environmental regulations at low cost. For over a decade with Alberta Environment he led the science research and innovation section providing input to EPEA approvals, Water Act licenses and authoring policy documents for Alberta's oil sands.

****

David Seeliger is a Professional Engineer with 25 years of Australian and Canadian consulting experience specializing in stormwater management including policy, guideline development, planning and analysis, plus design and construction in the urban environment. A key focus of David's work over the past 10 years has been the integration of stormwater management practices to achieve multiple benefits when dealing with flooding, water quality, reuse, environmental protection and asset management. This often involves combining emerging Low Impact Development (LID) and Best Management Practices (BMP) with traditional engineering methods to provide cost effective solutions to problems in new and existing urban communities.

David earned a Bachelor's degree in Civil Engineering from the University of South Australia where he developed a keen interest in stormwater management under the inspiration of Professor John Argue, a pioneer of LID in Australia. David is in the process of attaining his Master's degree in Water Resource Management, leads the stormwater management team at MPE Engineering and is Vice President of the Alberta Low Impact Development Partnership.

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Kim Fries has focused the majority of his more than 30-year career on municipal and industrial wastewater treatment and has worked extensively on projects for the City of Calgary since the 1990s. Kim specializes in providing environmentally sensitive wastewater treatment plant process design, evaluating and making recommendations for treatment process selection, and optimizing treatment process operations. He has led or participated in wastewater treatment plant design for more than 150 communities in Canada, Australia, the Caribbean, and the Far East. His major areas of interest include nitrification, denitrification, biological nutrient removal, wastewater reclamation, advanced digestion, and odour control. A specialist in applying innovation within the context of large plant design, Kim is recognized for his ability to think 'out of the box' and develop solutions that optimize wastewater treatment process operations.

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Susan Davis Schuetz has a Master of Arts Degree in Conflict Analysis and Management from Royal Roads University where she was the recipient of the Royal Roads Chancellors Award for highest academic achievement. She also has a Bachelor of Arts Degree (Honours) in Political Science from Queen's University and holds a Conflict Resolution Certificate from Mount Royal University. Susan has over ten years of facilitation and mediation experience in a variety of environments.

She specializes in the analysis and management of multi-party/multi-issue conflicts, which often involves the creation and implementation of co-operative multi-party processes for the purpose of unearthing solutions to accommodate various interests. Susan also has considerable experience in the area of public policy development and reform. She has led a number of significant policy and regulatory reform projects involving the regulation and management of natural resource industries at the federal, provincial and municipal levels of government. Inspired by the passion of Alberta WaterSMART's integrative thinking to improve the status of water in the Province, Susan became a member of the team in the summer of 2011. She has been, or is currently involved with the Co-operative Stormwater Management Initiative, the South Saskatchewan River Basin Adaptation Project, several Oil Sands Leadership Initiative projects, the Athabasca River Basin Project, the Government of Alberta Water Conversation, and both the Alberta Economic Development Authority and the Alberta Innovates – Energy and Environment Solutions' Water Reuse projects.

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David Lawlor joined ENMAX Corporation in September 2002 and since that time has worked in various capacities in the environmental and sustainability management for the Corporation. His current responsibilities include: environmental and safety policy advocacy and obtain environmental approvals for ENMAX Corporation and its subsidiaries.

Mr. Lawlor has permitted the use of reclaimed water in two Natural Gas Combined Cycle facilities; the 800 MW Shepard Energy Centre and the 176 MW Bonnybrook Energy Centre. Mr. Lawlor holds a Bachelor's degree from the University of Saskatchewan and Masters of Environmental Studies (MES) from Dalhousie University.

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Wayne Galliher has worked within the Ontario Municipal Water Sector since 2003 holding positions in Water Treatment Operations, Infrastructure Planning, Water/Wastewater Education and Outreach and Water Demand Management. Wayne is currently Project Manager of the City of Guelph's Water Conservation Program, an award winning multi-sector community water sustainability initiative aiming to reduce the City's 2006 average daily water production by 20 per cent (10,600 m^3/day) by 2025.

In addition to his work with the City, Mr. Galliher also serves as part of the Council of the Federation's Water Partner Advisory Committee, Canadian Municipal Water Efficiency Network and is past Chair of the of Ontario Water Works Association's (OWWA) Water Efficiency Committee.

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Angela Alambets is a project Engineer at Alberta WaterSMART in Calgary. Angela has a Bachelor of Environmental Engineering degree from Dalhousie University. She has experience in the oil and gas industry as a process engineer with CH2M Hill undertaking design for a SAGD water treatment process, and in municipal consulting as a design engineer for MPE Engineering Ltd., developing stormwater, water and wastewater treatment, collection and distribution infrastructure solutions.

Angela joined Alberta WaterSMART in 2012, and has been involved in a number of projects. She provides engineering support for facilitation of a municipal collaborative, such as the Co-operative Stormwater Management Initiative that is leading the water reuse policy development project for Alberta Innovates - Energy and Environment Solutions as well as a previous phase for the Alberta Economic Development Authority, also the collaborative project on best practices for magnesium oxide dosing systems in SAGD facilities, and consultation on collaborative and integrative water and wastewater management solutions in northern Alberta. Angela's passion for contributing to collaborative, improved water management has her volunteering as a Co-Chair of the Bow River Basin Council, Bow Basin Water Management Plan Implementation Committee.

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Ryan Devlin has worked in the Consulting Engineering and Specialty Chemical industries for over 18 years. He graduated from the University of Alberta with a Bachelor of Science in Organic Chemistry & Molecular Biology. Ryan has provided senior leadership to some of the largest chemical and consulting engineering companies in Canada and currently serves on the Board of Directors of the PLWA, an NGO charity whose goal is to protect, persevere and enhance Alberta's watersheds.

Ryan has published several articles regarding water and wastewater treatment and reuse strategies for industrial and residential communities. Ryan has worked closely with all levels of regulatory governance to ensure proper regulatory approvals are obtained as they apply to water resource infrastructure and reuse strategies in Alberta.

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Susan Nelson has her BA and MA in Environmental Management Certification. She has also been involved with visioning and implementing Sustainable Land Development with Transit Oriented Development (TOD), Low Impact Development (LID) in Storm Water Management, Water Efficiency through Design, Technology and Recycling, and LEED-ND & Alternative -District Energy Focus.

Susan's experience looks at regulatory and government advisory expertise in land use transportation, surface water, low impact development; environment management, parks and recreation at the federal and provincial levels. She has also facilitated public participation and team building activities and is a past regulatory board Member of the Natural Resources Conservation Board (NRCB) in Alberta, Canada. Presently, Susan is the CEO of OpenGate and takes part in the Sustainable town within Calgary-TwinHills-registered LEED-ND involving different sectors: CYBER CENTRO, Town Mixed Use CENTRO, Residential Centers, Green Open Spaces & Civic Plazas located on SE 17 Avenue Corridor Calgary.

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Harpreet Sandhu is the Team Lead of the Water Resource Strategy team at the City of Calgary. Her responsibilities include leading the development of strategic plans and policies for The City in the areas of riparian protection, watershed management, regional drainage and water supply availability.

Her previous positions include working with the Southern Region *Water Act* Approvals team at AESRD and Director of Planning and Community Development for Skamania County, Washington, where she was responsible for regulatory decision making, watershed planning and salmon recovery efforts along the lower Columbia River. While in the United States, she also participated and testified in various policy, budget and regulatory reform hearings at the Congressional and Washington State legislative committee level. She is also a member of the American Institute of Certified Planners.

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Bert van Duin is a Senior Planning Engineer and was recently appointed as the Drainage Technical Lead at the Infrastructure Planning Division of the City of Calgary's Water Resources department. His responsibilities concern the evolution of Calgary's stormwater design practice including updates to Calgary's Stormwater Management & Design Manual, coaching and mentoring of staff, and internal / external training.

He also oversees the generation of Calgary's upcoming Low Impact Development Manual and acts as liaison with the development industry for the practical implementation of "sustainable" drainage practices.

Prior to joining the City of Calgary in 2009, he worked for more than 20 years in consulting engineering. He is also a founding member and past President of the Alberta Low Impact Development Partnership.

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Bill Berzins, M.A.Sc., P.Eng has more than 30 years of experience in design-build-operate infrastructure including water, wastewater, flowback, produced water, slop oil, hazardous waste and solid waste. Over the past 10 years, Bill has an extensive background in Alberta's *Water For Life* implementation including serving as Chair of the Bow River Council, director of the AWC, director of the Alberta Water Research Institute and co-founder of the Alberta Water Portal.

Bill was heavily involved in the AWC and AWRI during their inception and chaired the Bow River Basin Council from 2000 through 2009. Having volunteered the equivalent of more than a year towards water policy development in Alberta, he resigned from his volunteer posts several years ago to focus on the application of water management principles to industrial and municipal applications – in addition to spending more time with a young family.

K'nowbe have invested several million $ in technology to accelerate the time-to-market for new technology and avoid the cost/schedule creep associated with traditional engineering-procurement-construction (EPC) execution that plagues technology innovation in water reuse and creates a practical barrier to new development.

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Mark Anielski is a rare economist specializing in the economics of well-being and happiness. He is also one of the world's leading experts in the field of natural capital accounting and sustainability measurement.

He is the author of the best-selling book *The Economics of Happiness: Building Genuine Wealth,* published in May of 2007. His book was published in China in 2010. Mark's mentor economist Herman Daly referred to Mark as 'God's auditor' in the forward to Mark's book. In 2008 his book won the gold medal in the Los Angeles Nautilus Book Awards in the category of Conscious Business and Leadership and won a bronze medal at the Axiom Book Awards in New York in the category of economics.

Mark is co-founder and Partner of Genuine Wealth Inc. whose mission is to build new economies of well-being based on his Genuine Wealth model. In 2008 *Alberta Venture* magazine named him one of Alberta's 50 most influential people. Mark has advised governments and business in Canada, US, China, the Netherlands, Austria, and Tahiti on how to measure and optimize their well-being. Mark lives in Edmonton, Alberta, Canada with his wife, Jennifer and their two daughters.

Appendix C: Delegates

First Name	Last Name	Organization
Gopal	Achari	University of Calgary
Angela	Alambets	Alberta WaterSMART
Arshad	Ali	Alberta Environment and Sustainable Resource Development
Mark	Anielski	Economist and Author
Nicholas	Ashbolt	University of Alberta
Andre	Asselin	Alberta Water Council
Darcy	Austin	Cenovus Energy
Sarah	Barbosa	ISL Engineering and Land Services
Keith	Beilman	Aqueous Teknologies
Bill	Berzins	K'nowbe
Berniece	Bland	Wheatland County
Tasha	Blumenthal	Alberta Association of Municipal Districts & Counties
Alice	Booth	Wheatland County
Andrea	Brack	NOVA Chemicals
Erwin	Braun	Western Irrigation District
Ken	Brown	Milk River Watershed Council Canada
Steve	Brubacher	Urban Systems
Fanni	Bu	Encana Corporation
Ken	Bullis	Alberta Energy Regulator
Terry	Burton	City of Lloydminster
Andrea	Buzinski	Devon Canada Corporation
Lara	Cameron	Cenovus Energy Inc.
Brenda	Casella	City of Calgary
Martin J.	Chamberlain	Department of Energy, Government of Alberta
Michael	Chau	City of Calgary
James	Clark	Shell Canada
J Robert	Cote	Town Of Bruderheim
Sherry	Cote	
Deanna	Cottrell	Shell Canada
Kim	Cousineau	Royal Roads University
David	Crowe	Alberta Health Services
Susan	Davis Schuetz	Alberta WaterSMART
Laura	De Carolis	Alberta Urban Municipalities Association
Rick	Deans	Town of Cochrane
Ryan	Delvin	ZL EOR Chemicals LTD
Denise	Di Santo	The City of Calgary
Simon	Doiron	MD Greenview
Clayton	Drewlo	Urban Systems
Daniel	du Toit	Associated Engineering
Pamela	Duncan	City of Calgary

First Name	Last Name	Organization
Lauren	Eden	WaterSMART Solutions Ltd.
Gord	Edwards	Alberta Water Council
Rick	Evans	Brazeau County
Curtis	Ferguson	ConocoPhillips Canada
Darren	Finney	City of Calgary
Carrie	Fischer	Town of Okotoks
Shannon	Flint	Alberta Environment and Sustainable Resource Development
Lisa	Fox	Sustainability Resources
Kim	Fries	CH2M HILL
Erin	Furlong	Shell
Larry	Gabruch	Native Plant Solutions
Wayne	Galliher	City of Guelph
Indira	Gonela	ERD
Sue	Gordon	Alberta Environment
Caroline	Gort	Kerr Wood Leidal Assoc.
Brian	Gregg	General Electric
Marc	Gressler	Brazeau County
Mohammad	Habib	Alberta Environment and Sustainable Resource Development
James	Hackett	ATCO Power
Jerry	Hanna	Clearflow Enviro Systems Group
Anthony	Heinrich	Brazeau County
Brian	Hicks	
Alesha	Hill	Alberta Water Council
Jeremy	Hogg	White Water Management
Roger	Hohm	Alberta Agriculture
Kris	Holthe	TAQA North Ltd.
Joey	Hurley	Alberta Environment and Sustainable Resource Development
Jay	Ingram	Science Writer and Broadcaster
Zahidul	Islam	Alberta Environment and Sustainable Resource Development
Michel	Jackson	Town of Black Diamond
Claire	Jackson	WaterSMART Solutions Ltd
Lawrence	Jeff	Lac La Biche County
Wallis	Johnson	Alberta Department of Energy
Tim	Keizer	Nalco Champion
Al	Kemmere	Alberta Association of Municipal Districts & Counties
Bruce	Kendall	Rocky View County
Cary	Kienitz	Qualico Communities
Derek	King	Brownlee LLP
Brittney	Klein	Athabasca Watershed Council
Brenda	Knight	Wheatland County
Jason	Kopan	ISL Engineering and Land Services
Jen	Landry	Athabasca Watershed Council
David	Lawlor	ENMAX Corporation

First Name	Last Name	Organization
Kelly	Learned	Calgary Regional Partnership
René	Letourneau	The City of Calgary
Lisa	Li	Clearbakk Energy Services
Dave	Lye	Encana Corporation
Fern	Maas	Enerplus
Kari	MacDonald	City of Calgary
Ray	MacIntosh	CUI
Patrick	Marriott	Alberta Energy Regulator
Shawn	Marshall	White Water Management
Grayson	Mauch	City of Medicine Hat
Truper	McBride	Stantec
Heather	McDougall	ATCO Energy Solutions
Dr. Preston	McEachern	PurLucid Consulting Ltd.
Scott	McKenna	Urban Systems Ltd.
Jorie	McKenzie	Rocky View County
Mike	McLean	Syncrude Canada Ltd.
Ron	McMullin	Alberta Irrigation Projects Association
Rene	Michalak	Canadian Association for Rainwater Management
Peer	Mikkelsen	Alberta Health Services
Scott	Millar	Alberta Energy Regulator
Debra	Mooney	Alberta Health
Valerie	Moore	City of Calgary
Kirk	Morrison	City of Lloydminster
Mike	Murray	Bow River Basin Council
Jackie	Mykytiuk	Associated Engineering
Susan	Nelson	OpenGate
Kayla	O'Farrell	White Water Management
Larry	Ottewell	AEDA - Alberta Economic Development Authority
Cajun	Paradis	Lacombe County
Jesse	Parker	Town of Strathmore
Sarah	Pearce	ESRD
Brian	Peters	Secure Energy Services
Hugh	Pettigrew	MD of Foothills
Edith	Phillips	City of Calgary
Edwin	Pinero	Veolia North America
Oleg	Podporin	Alberta Environment and Sustainable Resource Development
Brett	Purdy	Alberta Innovates - Energy and Environment Solutions
Tom	Pye	Athabasca Oil Corporation
Rick	Quail	Town of Okotoks
Les	Quinton	Town of Black Diamond
Anuja	Ramgoolam	Alberta Water Council
Donald	Reid	Alberta Environment and Sustainable Resource Development
Brier	Reid	Urban Systems

First Name	Last Name	Organization
Byron	Reimann, RET	Rocky View County
Karen	Ritchie	Government of Alberta
Francois	Roberge	GCM Consultants
Bill	Robertson	Town of Okotoks
George	Roman	The City of Calgary
Maggie	Romuld	SEAWA
Tammy	Rosner	Independent Consultant
Lisette	Ross	Native Plant Solutions
Kelly	Rowsell	The City of Calgary
Susan	Ryan	University of Calgary
Kim	Sanderson	Alberta Water Council
Harpreet	Sandhu	City of Calgary Water Resources
Michel	Savard	Aquatera Utilities
Michael	Scribner	Oil Sands Development, ConocoPhillips Canada
Christa	Seaman	Shell Canada
David	Seeliger	MPE Engineering
Michael	Seneka	Alberta Environment and Sustainable Resource Development
Apoorva	Sharma	Devon Canada Corporation
Jason	Sinclair	City of Calgary
Stacia	Skappak	Shell
Sarah	Skinner	Battle River Watershed Alliance
Jon	Skjersven	Lac La Biche County
John	Skowronski	Canadian Fuels Association
Dawn	Smith	Town of Okotoks
Stephen	Stanley	EPCOR
Barry	Station	ATCO Energy Solutions
Carly	Steiger	Government of Alberta, ESRD
Judy	Stewart	Alberta Water Council
Bruce	Stewart	
Kim	Sturgess	Alberta WaterSMART
Nicole	Symington	ATCO Energy Solutions
Sheryll	Tavener	Athabasca Oil Corporation
Lorne	Taylor	WaterSMART Solutions Ltd.
Murray	Tenove	Alberta Agriculture and Rural Development
Zoe	Thomas	CAPP
Breanna	Thompson	Alberta Environment and Sustainable Resource Development
Rodd	Thorkelsson	Brownlee LLP
Jason	Unger	Environmental Law Centre
Leta	van Duin	Alberta Low Impact Development Partnership
Bert	van Duin	City of Calgary Water Resources
Carlos	Vargas	City of Calgary
Stephanie	Vehnon	City of Lethbridge
JoAnne	Volk	Talisman Energy Inc.

First Name	Last Name	Organization
Krista	Vopicka	City of Calgary
Patricia	Vos	Brazeau County
Perry	Wager	Alberta Municipal Affairs
Ryan	Waldie	H2O Innovation
Meredith	Walker	Alberta Water Council
Jason	Weimer	TAQA NORTH Ltd.
Dale	Wells	Cenovus Energy
Dean	Wigmore	Town of Blackfalds
Emma	Wilkins	University of Alberta
Dusty	Williams	Town of Black Diamond
Dianne	Wyntjes	The City of Red Deer
Xindi	Yu	ClearBakk Energy Services
Jasmin	Zenchyson	Connacher Oil and Gas
John	Zhou	Alberta Innovates-Energy and Environment Solutions