Partnership Committee on Agriculture and Environment

Minutes of meeting number 34 held on March 4th, 2008 in Victoria

Attendees	**Affiliation**
Jim Mattison	Ministry of Environment
Harvey Sasaki	Ministry of Agriculture and Lands
Steve Thomson	BC Agriculture Council
Jennifer Dyson	BC Agriculture Council
Denise MacDonald	BC Fruit Growers Association
Glen Lucas	BC Fruit Growers Association
George Hamilton	BC Agriculture Council
Linda Allison	BC Agriculture Council
Brian Baehr	BC Agriculture Council
Greg Norton	BC Agriculture Council
Christine Koch	BC Agriculture Council
Angela McKee	BC Agriculture Council
Henry Wiens	BC Agriculture Council
Allen James	BC Poultry Association
Andrew Flokstra	BC Landscape and Nursery Association
Bert Miles	IAF
Rae Fawcett	Horse Council of BC
Bob France	BC Cattleman's Association
David Borth	Ministry of Forests and Range
Lorne Hunter	BC Dairy Producers
Alisa Williams	Ministry of Environment
Margaret Crowley	Ministry of Environment
Al Martin	Ministry of Environment
Ben Kangasniemi	Ministry of Environment
Sylvia von Schuckmann	Ministry of Environment
Randy Cairns	Ministry of Environment
Lynn Bailey	Ministry of Environment
David Ranson	Ministry of Environment
Kirk Stinchcombe	Ministry of Environment
Laura MacLean	Environment Canada
John Patterson	Department of Fisheries and Oceans
Janet Demarcke	Union of BC Municipalities
Lloyd McKimmon	Union of BC Municipalities
John Berry	Agriculture and Agri-Food Canada
Philip Bergen	Agriculture and Agri-Food Canada
Terry Dash	Agriculture and Agri-Food Canada
Ken Nickel	Ministry of Agriculture and Lands
Geoff Hughes-Games	Ministry of Agriculture and Lands
Sean Darling	Ministry of Agriculture and Lands
Ted van der Gulik	Ministry of Agriculture and Lands

Chair – Jim Mattison am, Al Martin pm
Recording Secretary – Ted van der Gulik

1. **Minutes**
   The following changes were suggested to the minutes of meeting 33 – add an item regarding the concern from the agriculture community on the use of good arable land for the siting of facilities used for energy production. There is also a wording change to "Langley Water Management Plan" under the Water Strategy.

2. **Climate Change Focus Session**
   Ben Kangasniemi - MOE
   Ben provided a primer on climate change and the issues that face British Columbia. The human activities that warm and cool the earth were outlined. The northern part of the province is warming quicker than the southern area. Also the winter increase in temperature is higher than summer increases. The winter increases may be 2 to 3 times what has been seen in the past 100 years.

   An example of an impact of climate change is the pine beetle kill in the Fraser Basin (78% will be killed by 2015). The pine beetle kill will severely impact the hydrology of the Fraser River Basin. Spring snow levels in the province are also on the decline which may impact storage reservoirs around the province. The timing of snow melt will also change with the peak coming earlier. In regions like the Okanagan the total water supply may be exceeded by total demand by 2050.

   Extreme precipitation events will likely become more frequent. Globally there are 5 – 35 million people at risk of flooding by 2100 due to sea level rise. In British Columbia there are 126 km of dykes that protect 220,000 people that live at or below sea level. The sea level is rising about 3 mm per year and many of the low lying lands are also sinking about 1 -3 mm /yr. The highest recorded sea level was recorded in 1982.

   The cost of climate change could be up to 20% of world GDP. Work currently underway in British Columbia include hydrologic studies, a BC sea level study, $10 million in funding over 3 years to improve the hydrometric and meteorological monitoring network and a $90 million endowment to UVIC for climate action.

   Global Impacts to agriculture are:
   - Crop productivity will increase in mid to high latitudes
   - Crop productivity will decrease in tropical areas
   - Overall global food production will increase
   - Altered cultivars will improve cereal production

   Negative Impacts in British Columbia
   - Summer water shortages in snowmelt rivers
   - Sever rainstorms and erosion
   - Greater flooding and salinity problems in the Fraser Valley
   - More pest and disease outbreak due to winter warming
   - Heat stress affecting livestock

   Positive impacts in British Columbia
   - Increased growing degree days
   - Longer frost free season
   - CO_2 fertilization

- Displacement of forests may increase supply of agricultural land
- Selling to offsets market (carbon trading)
- Increased demand for local food due to the cost of shipping

Environmental benefits

- Converting farm waste to energy
- Conserving water will reduce energy use
- Reducing tillage will sequester carbon and minimize soil erosion
- Tree planting to sequester carbon could benefit stream-side habitat quality

Web sites and further information:

- Pacific Climate Impacts Consortium (PCIC), UVic
  pacificclimate.org
- Canadian Centre for Climate Modelling and Analysis (CCCma), UVic
  cccma.ec.gc.ca
- Adaptation and Impacts Research Division (AIRD), UBC
  ires.ubc.ca/aird
- Climate Impacts Group (CIG), University of Washington
  cses.washington.edu/cig
- Climate Action Secretariat
  climateactionsecretariat.gov.bc.ca
- WorkSmartBC
  https://www.worksmartbc.gov.bc.ca
- BC Bioenergy Strategy
  energyplan.gov.bc.ca/bioenergy/

Sean Darling – CLAD
Sean provided an outline of BC Government initiatives on climate change.

The province has committed to a carbon neutral public sector by 2010. This initiative targets mainly facilities and staff travel. For every tonne of GHG from government travel the province will invest $25 into a Pacific Carbon Trust. These projects may include energy efficiency, production of new clean energy or to support carbon sequestration.

Greenhouse Gas Reduction Targets Act requires levels to be 33% below 2007 by 2020. The act will legislate mandatory caps on major BC emitters. There will also be sectoral actions to help achieve provincial targets. Legislation will help communities encourage green development. The plan is also to partner with other jurisdictions. Coordination will be through the Climate Action team.

The agriculture sector contributes about 4% of the greenhouse gas emissions in British Columbia while transportation is about 40%.

Steve Thomson - BCAC
Steve provided a short overview of the initiatives currently underway by the agriculture sector with respect to climate change. A climate action initiative committee is also being established with funding from the Investment Agriculture Foundation to fund a policy coordinator to help liaise and partner with other agencies on climate change initiatives.

Agriculture Byproducts Strategy

George Hamilton raised the issue of an Agriculture Byproducts strategy that is being developed by Resource Management Branch. A draft of this plan may be completed later this spring. This plan will tie in with the climate action initiatives mentioned earlier.

Action: Follow up session on climate change mitigation to be held at the next Partnership Committee meeting in June. Ben Kangasniemi, Sean Darling and Resource Management Branch staff to facilitate and coordinate session. Adaptation initiatives will be covered at the PC session in the fall.

3. Water Management

Water Act Modernization – Randy Cairns MOE

The province has started a process to update the water act. The water act modernization process is within the scope of the water action plan. The act was developed in the late 1800's with a first in time first in right principle. Current and future considerations include:

- Population growth and economic development
- Ecosystem protection and sustainability
- First Nation Treaties and a new relationship
- Adapting to climate change
- Integrating water management
- Governance and participation

The objectives of the water act modernization are:

- Enable and encourage water stewardship in British Columbia
- Integrated, adaptive and results based management approach
- Streamline processes
- Clarify existing provisions
- Flexibility to adapt to changes
- Effective and efficient decision making

The project principles will include:

- Inclusive approach that brings different views to the table
- Early engagement of First Nations
- Ongoing stakeholder involvement
- Transparent and open process
- Robust policy outcome

The outcomes from the Water Act Modernization Workshop held in the fall include the first in time, first in right vs highest and best use; groundwater issues; valuing water; ecosystem protection; water planning and land use planning; and compliance and enforcement.

Issues that pertain to agriculture include water security, drought strategies, fair and equitable conservation and regulation and integration of agriculture needs in water policy development.

The next steps are to engage the agriculture industry and have representation on the policy development working groups.

Phases 2& 3 of the Groundwater Protection Regulation – Kirk Stinchcombe
Phase 2 includes the development of standards or requirements for well siting; cross connection of aquifers; controlling artesian flow; well construction; well pump installation; flow testing; water analysis; reporting; and storage of substances near the wellhead.

Phase 3 which is currently in the planning stage includes standards for well operation, regulations that implement water management plans in designated areas and requirements relating to aquifer protection, groundwater quality, quantity and use.

Action: Implement the PC Agriculture and Water Working Group to initiate discussions on a strategy for the agriculture sector. Ted van der Gulik contact Steve Thomson at BCAC to determine industry representation on the committee and attendees at Water Connections IV.

4. **Lunch**
Ministry of Agriculture and Land Minister Pat Bell provided the committee with the five key initiatives on the Agriculture Plan.

Ministry of Environment Minister Barry Penner provided the committee with an update on climate change initiatives being undertaken by the province of British Columbia. Minister Penner encouraged the agriculture community to pursue anaerobic digestion and other green energy initiatives.

5. **Habitat and Farmland Committee Report**
Ted van der Gulik provided a verbal update on the Habitat and Farmland Committee meeting held on February 28th.

Building Setbacks – MOE and DFO have verbally provided their support to the draft setback standards. A letter from the agencies is pending. The next step is to engage the BCAC council and obtain their support.

Tree Removal in the ALR – **Kathleen Zimmerman**
Kathleen updated the committee on a tree removal issue in Surrey, that has provincial implications for the ALR. A farmer in the ALR was denied the ability to clear land for agricultural production because of an eagle nest in one tree. Surrey has unofficially adopted the MoE guidelines of a 100 m buffer zone around the eagle nest where trees may not be removed, even though Surrey's tree protection bylaw does not explicitly reference the guideline.

The Ministry of environment has established best management practices for habitat protection, which have influenced how Surrey's bylaw is administered. How the current bylaw is administered appears to have an impact on agricultural development. Habitat issues similar to this may occur in other local governments.

Action: A small working group under the Habitat and Farmland Committee be established to work on a solution that takes into account both the habitat values and agriculture's needs. The working group will investigate how possible conflicts created by BMP's can be resolved; may work with legal counsel from the Attorney General's office to clarify scope of the existing legislation; and may consider other options in the future such as holding a workshop with industry and local government to clarify the legislation and BMP's.

Nooksack Dace – John Patterson
John provided an update on the Nooksack Dace issue in the Langley, Abbotsford, and Burnaby areas. As the Nooksack Dace is an endangered fish species under the *Species at Risk Act* DFO, the responsible federal department for aquatic species, has completed the consultative process regarding the recovery strategy and inclusion of critical habitat for Nooksack Dace. DFO has conducted Public Meetings (Langley, Abbotsford, Burnaby), consultations with local governments and BC Ministries (MAL, MOE, MEMPR), and the First Nations. The Recovery strategy will be revised, based on comments received during the consultations, and posted on the SARA website. Following posting, the Act allows for a 60 day review and comment period.

Biodiversity Guide – Sylvia von Schuckmann
Sylvia provided an update on the status of the biodiversity guide. The guide will be printed by the end of the fiscal year.

6. **Wildlife Committee Report**
Wray MacDonnell provided an update on the wildlife committee. A report is attached to the minutes. Progress has been made on escaped Bison in the Peace River area.
Brian Baehr provided an update on wildlife mitigation initiatives.

7. **Nutrient Management Committee Report**
Geoff Hughes-Games provided an update on the Nutrient Management Committee activities including the Okanagan Agricultural Soil Study (soil analysis to be completed by March 31) and the Poultry Nutrient Movement Study (contractor in place). He also provided some background and the status of the Manure Storage Capacity Survey.

8. **Federal Provincial Programming**
Phil Bergen provided an update on the Federal Provincial bridge programming for 2008/09. Environmental Farm Planning and the BMP programs will be continued for another year. The CBCNWSEP is also expected to be extended for one more year.

9. **Greenhouse Industry Wood Fired Boilers – David Ranson. MOE**
David provided an update on the emission limits for wood fired boilers across the province. Under the *Environmental Management Act*, Metro Vancouver has been given authority to set up their own emission limits through their bylaws, which they were doing using a permitting process. The Environmental Appeal Board struck down Metro Vancouver's process of setting emission limits by permit, but left the door open for a revised bylaw to be developed. Metro Vancouver required a much lower standard than the provincial limit in their permits.

MOE has had discussions with the Greenhouse Industry on what standards are achievable, and a new provincial standard is being developed. Metro Vancouver has also proposed a new standard. The industry is proposing that one standard be developed and enforced for the entire province.

10. **Written Updates attached to the Minutes**.
    - Specified Risk Materials

- AEI Committee
- EFP/NFSP Greencover
- CBCNWSEP
- NAESI
- Abbotsford Aquifer Science Forum report was distributed at the meeting.

11. Items for Future Meetings

Climate Change Focus Session on mitigation
Waterbucket – TvdG
Metro Vancouver Air Emissions Issue
Alien Species – Laura Darling

12. **Next Meeting** – Courtenay June 19th and 20th 2008

Agriculture Environment Initiatives
UPDATE

Operations Highlights:

- Wildlife agriculture conflict issues and initiatives have been a strategic priority for the AEI since its inception in 2001. On February 15th the provincial government announced a significant boost in support for the compensation component for this initiative as part of the "BC Agriculture Plan". Through the release of the provincial budget, MOE has confirmed a proportionately similar boost in its level of support towards the management of wildlife in the agricultural areas of the province. With the renewed emphasis on wildlife issues, the AEI Management Committee will need to reassess its priorities related to the overall initiative and in particular the prevention and mitigation component.

- BCAC and the Investment Agriculture Foundation of BC continue to work on details of a proposal that would see the establishment of an Agriculture Environment and Wildlife Fund. Related to that is a request by BCAC to extend the termination date for the current AEPI and AESI funds until June 2009 with a priority given to wrapping up all of the outstanding approved projects prior to that date.

- At the October 2007 Partnership Committee there was general consensus is that the PC wants to pursue anaerobic digestion as an opportunity for the agriculture sector. The AEI Management Committee was asked to facilitate discussion around the approach to seeing adoption and implementation of this technology in BC. The major limitations appear to be the lack of an attractive price for the end products of either electricity or biogas. A recently approved IAF project into upgrading of biogas to a suitable standard to be sold to a natural gas utility will provide relevant information. The BC Utilities Commission plays a key role in this going forward. There is still the major obstacle of significant capital investment without a solid expectation of a revenue stream with profit potential. Other constraints to be overcome include concurrence by the ALC for this type of activity in the ALR.

Financial Update:

- To date 143 applications have been fully or partly approved of the 198 submitted and 84 projects completed.

- Financial status to date
    - $11.2 million of $12 million in AEPI funds have been committed by MC decisions to date. Included in that is the commitment related to the $1,000,000 allocated for new and supplemental BMP's.
    - $873,362 of $990,000 AESI funds have been committed
    - A further $303,000 has been received by BCAC for contributions towards AESI/AEPI projects and operations.

Brian Baehr, AEI Coordinator **February 22, 2008**

Canada-British Columbia Water Supply Expansion Program

Update for Partnership Committee on Agriculture and the Environment
February 21, 2008

Program Activity Highlights:

The current focus is on wrapping up the current program by March 31, 2008. All program funds were committed and the Program Working Group is meeting as needed to manage the wind down of the program. The following are some program statistics as of mid-February.

- Program figures since inception (May 2004):
  - Tier 1 - 759 applications reviewed, 608 approved (297 completed and 255 cancelled). Total funding expended $1,039,000. Total funding expended and committed to Tier 1 projects: $1,223,000.
  - Tier 2 – 36 applications reviewed, 26 approved, 11 completed, 5 cancelled and 11 near completion. Total funding expended $1,399,000. Total funding expended and committed to Tier 2 projects: $2,399,000.
  - Tier 3 – 61 applications reviewed, 38 approved, 27 completed, 1 cancelled and 10 in-progress. Total funding expended $1,490,000. Total funding expended and committed to Tier 3 projects: $1,834,000.

Program Summary:

- The objective of the Program is to provide financial and technical support for the planning and development of sustainable water supplies for agriculture.
- The Program has three components:
  - Tier 1 – On-farm water infrastructure projects such as wells, dugouts and small dams. Irrigation equipment is not eligible. The Program contributes up to one-third of the eligible costs to maximum of $5,000 per project.
  - Tier 2 – Multi-user infrastructure projects that are larger and will provide water for agricultural purposes. The Program contributes up to one-third of the eligible costs.
  - Tier 3 – Strategic work projects that will serve to increase opportunity for strategic partnerships and enhance understanding of the operational and developmental limitations to the water resources for agriculture in their community or region.
- Total Program funding available: $5,600,000. The last application date was June 1, 2007. **The Program ends March 31, 2008**.
- The Program is managed by a Program Working Group that includes federal, provincial and industry members. The application contact point for Tier 1 is the BC Agriculture Council, (604) 854-4483 and for Tiers 2 & 3, Agriculture and Agri-Food Canada, (250) 782-3116.

Future Program?

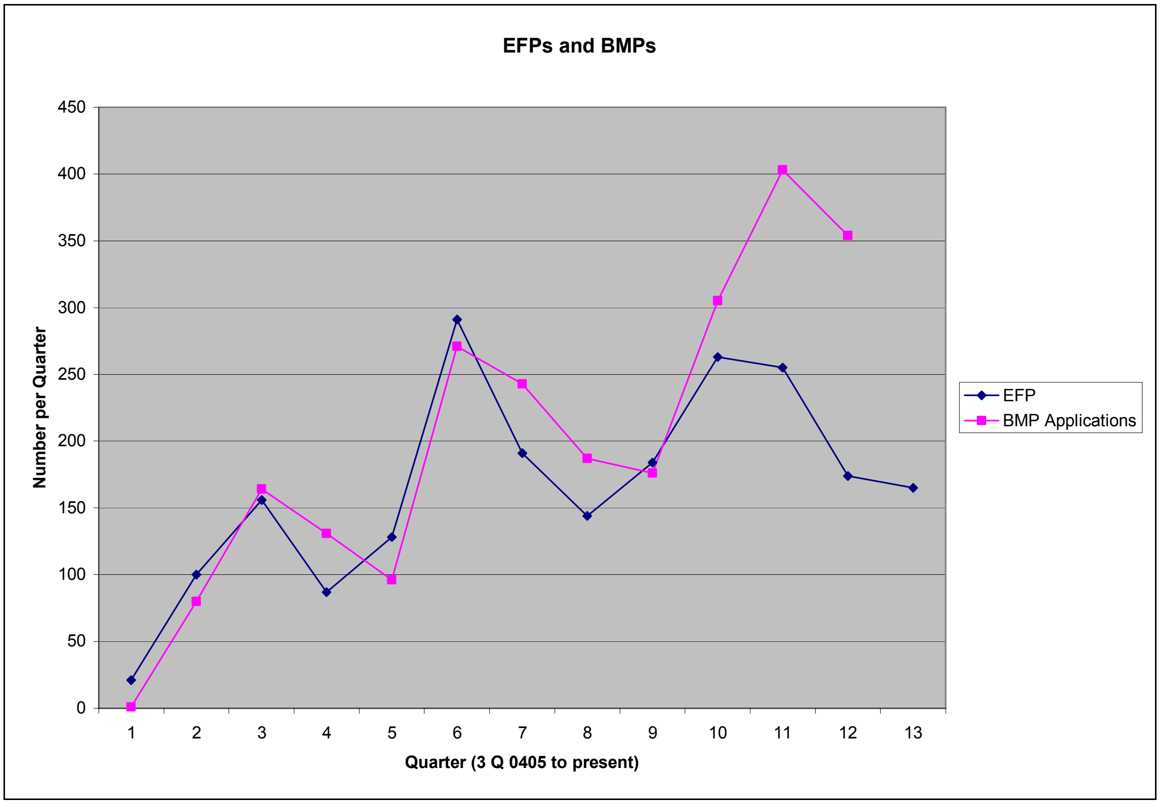
Agriculture and Agri-Food Canada is seeking the necessary authorities to continue the current program for an additional year to provide a transition year to Growing Forward programs.

Prepared by: Philip Bergen
Agriculture and Agri-Food Canada
February 21, 2008

Update Report to February 24, 2008 for Canada-British Columbia Environmental Farm Plan Program

The Environmental Farm Plan program funded under the Agriculture Policy Framework concludes on March 31, 2008. A one year transition program will commence on April 1, 2008 and conclude on March 31, 2009.

The following table shows trends over time for the numbers of EFPs completed and the number of applications for BMP funding.



Environmental Farm Planning

The following statistics are totals from throughout the province since the inception of the program:

- Communication events 593
- Workshops 1740
- Producer participants 4684
- Statements of Completion 2159

Beneficial Management Practices

This table lists the top 10 BMPs with expenditures to December 31, 2007.

BMP #	Category	Cumulative to Date	
		# of Projects	Expenditures
18	Irrigation Management	314	1,480,387
1	Improved Manure Storage and Handling	55	950,760
10	Riparian Area Management	96	456,825
23	Preventing Wildlife Damage	129	443,705
8	Product and Waste Management	180	349,767
14	Improved Cropping Systems	50	225,606
11	Erosion Control Structures (Riparian)	29	202,610
6	Relocation of Livestock Confinement and Horticultural Facilities	22	201,282
16	Improved Pest Management	67	108,118
19	Shelterbelt Establishment	29	94,755
	All others	94	475,456
Total		**1065**	**4,989,271**

Program Coordination

The current program coordinators, Niels Holbek, PAg and Ron Bertrand, PAg will be concluding their involvement at the termination of the current program. They would like to thank BCAC, AAFC, MAL and all other members of the Partnership Committee for their support of the program during the last 5 years.

Angela McKee is now leading the program delivery role on behalf of BCAC

Update on Environment Canada's
National Agri-Environmental Standards Initiative (NAESI)
February, 2008

Prepared by L. Maclean
Environment Canada
Laura.Maclean@ec.gc.ca

BACKGROUND

The National Agri-Environmental Standards Initiative (NAESI) is a four-year (2004-2008) project between Environment Canada (EC) and Agriculture and Agri-Food Canada (AAFC), and forms part of the Environment Chapter of the Agriculture Policy Framework (APF). The objective of the NAESI program is to establish a suite of national, non-regulatory national environmental performance standards for the agriculture sector in four key theme areas: air, water, pesticides and biodiversity. Through the development of science-based standards, EC and AAFC will define common goals for environmental quality in agricultural landscapes in Canada.

CURRENT STATUS

NAESI is currently in its fourth and final year. As such, the focus of this year was on completion of standards in the four theme areas (air, water, pesticides and biodiversity), initiation of a peer review of the standards, production of annual technical reports, and production of synthesis reports to summarize the research from the past four years.

A total of 89 draft standards have been developed: 1 air standard for ammonia as a precursor to airborne particulate matter; 15 habitat-based standards for biodiversity in riparian, forest, grassland and wetland ecosystems; 56 pesticide standards (for single compounds, pesticide mixtures and meteorological conditions); and 17 water standards (for eutrophication and nitrogen toxicity for streams and coastal areas, for sediments, pathogens, and instream flow needs for streams, and a series of water availability indicators).

Synthesis reports detailing the science methods used and recommendations regarding draft standards were distributed to select academic peer reviewers (three reviewers per report for a total of 45 reviewers) on January 28, 2008 for a 4-week review period. On February 5-6, 2008, as part of this wider peer review process, the draft standards were presented to AAFC representatives at a technical meeting. AAFC has committed to provide EC with technical feedback on the synthesis reports by the end of February.

Provincial agencies, agriculture sector representatives and environmental organizations will have an opportunity to review and comment on the results of the NAESI program at a stakeholder consultation event to take place in the summer of 2008.

Abbotsford-Sumas Aquifer Science Forum

April 26, 2007 (UCFV, Abbotsford, BC)

Executive Summary

"The rates of change of urbanization and agricultural intensification are now unprecedented. Complex patterns of production and consumption occur atop a set of vulnerable aquifers whose roles as physical and economic buffers are largely unrecognized." - UN Food and Agriculture Organization, 2003 publication on Groundwater Management

This document summarizes the key elements of the Abbotsford-Sumas Aquifer Science Forum held on April 26th, 2007 and captures the current understanding of issues specific to the aquifer, particularly with respect to widespread nitrate contamination. It provides a summary of both the current state of knowledge as well as knowledge gaps in the interrelated fields of hydrogeology, agronomy, nutrient management and human health. The one-day Science Forum was successful in bringing together researchers and science-based professionals from a range of disciplines and sectors to provide presentations and engage in discussion on the topic of nitrate contamination of groundwater in the Abbotsford-Sumas aquifer from agricultural sources. Government agencies involved in aquifer issues were represented at federal (Canada and US), provincial (BC), state (Washington), regional (Fraser Valley), county (Whatcom County) and municipal levels.

Nitrate contamination in the Abbotsford-Sumas aquifer resulting largely from agricultural land use has been reported for over the last 30 years and has likely been occurring over a longer time frame. The results of long-term groundwater monitoring across an area of intensive agricultural production indicates that on average, the nitrate concentration is about 1.5 times the maximum acceptable concentration for nitrate in drinking water (10 mg/L as Nitrate-Nitrogen or 45 mg/L as Nitrate), with some locations showing concentrations 4-5 times this benchmark level. Nitrate distribution is not uniform however, with some aquifer zones showing highly elevated nitrate concentrations, while other zones have very low concentrations. The Abbotsford-Sumas aquifer is transboundary, straddling the Canada/US border between British Columbia and Washington State and provides water to an estimated 100,000 inhabitants, with growing water supply demands.

The aquifer is composed primarily of sand and gravel sediment deposited by retreating glaciers at the end of the last ice-age. This highly permeable material is largely saturated with groundwater which flows slowly in a southerly direction (with components of flow in easterly and westerly directions towards corresponding aquifer boundaries). Groundwater in the aquifer is continually recharged through the high levels of seasonal precipitation that predominate in this region. The highly permeable nature of this aquifer also makes it highly vulnerable to contamination from overlying land use activities.

It is generally understood that fertilizer application (both synthetic and manure) to berry fields (primarily raspberry) is the primary source of nitrate in the aquifer. Efforts have been made over the past decade by the agricultural sector to improve nutrient management practices, however nitrate concentrations in underlying groundwater have not showed a coincident decreasing trend (and also no significant increasing trend either). The question remains "*Why* *are nitrate concentrations not decreasing below drinking water guideline levels in the Abbotsford-Sumas aquifer and what can be done to improve the current situation*?" Through scientific presentations and subsequent discussion groups, the Science Forum was successful in identifying a number of knowledge gaps and scientific issues that may hinder progress towards reducing nitrate levels in the aquifer. These fall into one or more of the following topics:

- Groundwater Monitoring
- Nutrient Management
- Beneficial Management Practices (BMPs)
- Soil Science
- General Environmental Management
- Communication
- Regulatory
- Health
- Research Needs

Some key items from the Science Forum discussion groups and presentations are summarized below.

Key Discussion Topics from the Abbotsford-Sumas Aquifer Science Forum (April 26, 2007).

Groundwater Monitoring

- Incorporate monitoring techniques that minimize the time lag between change in land use practice and detection of water quality change

- Link groundwater monitoring of shallow (young) groundwater with soil zone monitoring and directly to specific land uses

- Computer simulations based on available soil and groundwater data suggest potential for pre-harvest leaching of fertilizer nitrate; detailed field-scale studies will be important in verifying/refining these model results

Nutrient Management

- Post-harvest nitrate test is currently the only soil measurement tool that is relied upon to guide soil-nitrate amendment but it has limitations and requires considerable refinement

- There is a need to develop alternate measurement tools such as plant tissue tests and soil mineralizable-Nitrogen tests

- Need to refine knowledge about Nitrogen dynamics in raspberry plantings, including simulation modeling (e.g. NLOS)

- Given proximity of poultry operations to berry fields, over-application of manure may still be a convenient yet problematic waste-management practice

- No standard test (pre-harvest) that guides berry producers on how much fertilizer needs to be applied at the beginning of the growing season

BMPs

- Anecdotal evidence of improvement in BMPs but insufficient definition or quantification for verification purposes

- Need for improved manure spreading technology to enable reliable application at specific rates

- Concept that farmers should not apply more nutrient than crop need should be fundamental to Environmental Farm Plan but this is complicated by knowledge gaps re. crop requirements and nutrient availability (esp. manure)

- Useful to know what BMPs farmers are adopting and a system to record fertilizer, pesticide and manure application, storage and shipment information.

- Explore new and innovative BMP options in addition to the evaluation of existing BMPs

Soil Science

- Mineralization of soil organic nitrogen is a complex process that may be contributing leachable nitrate at different times of the year. There is currently no good soil test for assessment

- Manure application for raspberry needs could be very small amount. Excess application for soil amendment purposes may be unnecessary

- Berry crops are already known to be “leaky” with respect to nitrate and there is uncertainty regarding the use of carbon sources to mitigate excess nitrate in the soil zone

- Lack of knowledge regarding annual nitrate uptake by plants and influences of variability of crop type, crop cycle, and other agronomic factors.

General Environmental Management

- Anecdotally, 80-90% of shipped poultry manure moves off the Abbotsford aquifer but stays within the Fraser Valley (Sustainable Poultry Farming Group estimates about 31% of total annual manure nitrogen is moved off the aquifer). This may not be enough for significant changes in groundwater quality and raises questions over incentives/methodologies for more drastic manure removal from aquifer. In general, the location of intensive livestock operations over sensitive aquifers is questioned, particularly in the absence of effective waste management strategies. Manure transport studies are currently underway to refine estimates but it is not clear if these studies are subject to government agency review.

- Lack of quantitative understanding of decadal change in regional agricultural management practices.

- Soil surveys suggest that fields with manure application have much higher post-harvest soil nitrogen concentrations

Communication

- Better communication of existing state of knowledge of Abbotsford-Sumas aquifer issues to improve prioritization/evaluation of research needs and to better inform practices and policies

- Improve access to environmental, agricultural and BMP-related data and information. Improve transparency and online (web) access

- Need to integrate different specialties/disciplines involved in aquifer issues (e.g. soil science, public health, agronomy, hydrogeology, etc.)

Regulatory

- Nutrient management plans are not currently a requirement for producers (currently more of a voluntary focus supported by incentives)

- BC Environmental Management Act doesn't appear to effectively address the issue of fertilizers (manure or synthetic) as potential sources of contamination

- Currently, manure spreading advisories place burden of responsibility to avoid pollution on the producer. Given all the uncertainties around nutrient availability in manure, plant requirements and soil processes, it seems impossible for the producer to effectively determine what constitutes "excess" manure application. Producers can't determine correct compliance levels

- BC agricultural code of practice is weak on manure and fertilizer application guidelines re. environmental protection

Health

- Nitrate contamination may not be seen as having convincing negative impact (e.g. health risks/effects), which may challenge the willingness and ability of decision makers to take action. Greater consultation with health experts (and researchers) on nitrate toxicity issues should be pursued to avoid misinformation

- Apparent lack of health studies to better understand what type of health impacts could occur over the Abbotsford aquifer (re. use of groundwater for drinking water) or might actually be occurring due to elevated nitrate levels in groundwater

Research Needs

- Groundwater research should ideally be conducted in tandem with agronomic and unsaturated zone research at field-scale (min. 3 representative sites)

- Research into deposition of air-ammonium (known to be elevated in Abbotsford area) and potential contribution to soil nitrate (note: data may be available but not yet reported in this context)

- Undertake field studies to facilitate prediction of nitrogen mineralization in soils over the Abbotsford aquifer

- In addition to poultry and raspberry production, there should be consideration of newer activities such as blueberry, greenhouse and rural-residential (septic) issues.

- Need for improved data collection (particularly with respect to nutrient management) and computer simulations (e.g. NLOS)

- Develop overall conceptual model of the relationship between agricultural practices, soil/geology and groundwater. Identify/Prioritize main areas of uncertainty to further guide research, policy and practice

Abbotsford-Sumas Aquifer Science Forum

April 26, 2007 (UCFV, Abbotsford, BC)

Summary of Discussion and Presentations

Prepared by Gwyn Graham, Environment Canada.

The Abbotsford-Sumas aquifer Science Forum was organized following discussion at meetings of the Partnership Committee on Agriculture and the Environment. It was the third of similar aquifer science forums held over the past 15 years. This summary document has been prepared to capture pertinent information from presentations and discussion group sessions on the state of knowledge regarding groundwater, soil, health and agricultural science issues related to the aquifer. It is intended to provide information useful to the preparation of a subsequent forum that will focus primarily on policy, economic, legal, and regulatory issues. The primary goal of the science forum was to determine what is needed to *understand why groundwater nitrate is not declining to a level below the drinking water standard* by providing a venue for exchange of scientific understanding, panel discussions on data gaps and outlining recommendations for future work. It is expected that this document will provide a synthesis of scientific information useful for a subsequent forum on policy issues related to groundwater quality in the Abbotsford-Sumas aquifer and a discussion of potential policy approaches that will help to mitigate non-point source pollution of groundwater.

The science forum was hosted by the University College of the Fraser Valley (Abbotsford) and was open to all interested individuals, although a specific invitation list of science participants with knowledge of Abbotsford-Sumas aquifer issues was also used to assemble a core group for discussion purposes. Support for the Science Forum was also provided by the Canadian Water Network (CWN) and the BC Ministry of Agriculture and Lands.

The April 26th (2007) Science Forum Agenda is shown below:

Moderator: Dr. David Rudolph (Professor, Dept. Earth Sciences, University of Waterloo)

Part 1: Overview and long term trends		
8:30	Dave Rudolph, University of Waterloo	Welcome and Introduction
8:40	Al Kohut, Hy-Geo Consulting	Overview and history of issue
9:00	Prabjit Barn (for Ray Copes, BC Centre for Disease Control	Groundwater nitrate health concerns
9:20	Gwyn Graham, Env. Canada	Long term groundwater monitoring, and 2004-5 sampling
9:40	Melanie Redding, Ecology, Wash. State	Nitrate trends in the Central Sumas-Blaine surficial aquifer
10:00	Len Wassenaar, Environment Canada	Decadal trends in groundwater nitrate contamination
10:20	Coffee break and discussion	
Part 2: Soil zone (1.5 hours)		

10:50	Grant Kowalenko, AAFC	Plant and soil N considerations, berry fertilizer management
11:10	Orlando Schmidt BC MAL	Recent soil nutrient survey results
11:30	Romain Chesnaux, SFU	Vadose Zone Modelling
11:50	Mark Sweeney, BC MAL	Berry Industry Update
12:10	LUNCH – in the UCFV cafeteria at individual expense (50 mins)	
Part 3: Groundwater zone		
1:00	Robert Mitchell, Western Wash Univ.	Groundwater nitrate studies in the Sumas aquifer, US work
1:20	Cathy Ryan, University of Calgary	Field scale study on nitrate leaching under raspberries
1:40	Diana Allen, SFU	Groundwater flow and nitrate transport modeling
2:00	Barb Carey, Ecology, Wash. State	Nitrate in soil and groundwater beneath a manured field
2:20	Steve Cox, USGS	Hydrogeologic features and the distribution of nitrate concentrations along a flow path
2:40	Coffee break	
Part 4: Panel Breakout Discussions on "Where we should go from here"		
3:00	Group 1	Group 2
3:30	Reports from Breakout Groups on their discussions	
4:00	Panel discussion with invited speakers on "Where we should go from here"	

Organizing committee:
Peter Andzans, City of Abbotsford
Edith Camm, University College of the Fraser Valley
Geoff Hughes-Games, BC Ministry of Agriculture and Lands
Gwyn Graham, Environment Canada
Gevan Mattu, Environment Canada
Cathy Ryan, University of Calgary
Kim Sutherland, BC Ministry of Agriculture and Lands
Mark Zubel, Fraser Health

Some common abbreviations used with reference to presentations and discussion topics:

ASA (Abbotsford-Sumas Aquifer)
ASAITF (Abbotsford-Sumas Aquifer International Task Force)
BMP (Beneficial/Best Management Practice)
IARC (International Agency for Research on Cancer)
MAC (Maximum Acceptable Concentration)

Note: Nitrate can be expressed as mg/L nitrate or mg/L nitrate-N.
45 mg/L nitrate is equal to 10 mg/L nitrate-N (also the MAC for nitrate in drinking water).

Part 1 – Discussion

The discussion information in based on notes taken during the panel breakout discussion sessions held after the science presentations (Part 2) during the Science Forum. Discussion topics and comments have been organized into categories based on the themes that were indentified following review of the discussion reports. The following topics include a variety of comments, opinions, questions and recommendations and do not necessarily represent a consensus amongst participants.

Groundwater Monitoring

- Closing the loop – there is a need for monitoring of groundwater conditions in a manner that allows faster observation of potential changes to groundwater quality in response to potential changes in nutrient management and other land use practices. This includes more focus on monitoring of shallow (younger) groundwater conditions and the capability of distinguishing effects from individual fields with known practices from upgradient area source effects.

- Monitoring above the water table - Developing methods to monitor soil-zone nitrate concentrations in addition to shallow groundwater is recommended, although it is acknowledge that accurate and effective monitoring of soil-water conditions is complicated due to heterogeneity and macro-pore effects (i.e. unpredictable pattern of possible preferential flow paths).

- Relevance – Groundwater monitoring should be conducted in a way that is relevant to the timescales between land use changes and changes in aquifer quality, with improved linkage to land use practices.

Nutrient Management

- The post-harvest nitrate test is currently the only soil measurement tool that is being relied upon to guide N amendments but it has limitations and requires considerable refinement.

- There is a need to develop alternate measurement tools such as a plant tissue test and a soil mineralizable N test, as well as examining the potential implications of nitrate adsorption,

- Need to determine long term requirement by raspberries for N (i.e., residual effects) and examine “life-cycle” implications of raspberry plantings (i.e., planting to maturity)

- Need to refine knowledge about N dynamics in raspberry plantings including the development of simulation modelling (e.g., NLOS).

- Fertilizer efficiency – manure can be a good fertilizer. Is the concern of over-application (historical) clouding a potentially problematic increase in the use of commercial inorganic fertilizer? Nutrient management plans should address both organic (manure) and inorganic fertilizers.

- In terms of organic vs. inorganic fertilizers, we don't know which is more beneficial or problematic at this point in terms of agronomic requirements and groundwater impacts.

- Given proximity of manure production (poultry) to berry fields, it may be all too easy to over-apply manure to fields, since it may still be more convenient waste disposal that shipping excess manure off the aquifer.

- There is indication that some berry producers consistently have low post-harvest residual soil nitrate levels with vigorous crops and high-input, non-manure, fertilizer. Does this signify high rates of nitrate leaching or high rates of plant uptake? Studies have not adequately addressed this issue to date.

- Currently there is no standard soil test (e.g. pre-harvest) that will tell berry producers how much fertilizer needs to be applied. This is particularly complicated for organic (manure) fertilizer but also relates to gaps in soil and plant test methods and studies. Despite this, farmers manage to get advice from independent nutrient management specialists as to how much nitrogen, phosphorous and other nutrients they should apply to optimize crop yield. It is unclear if there is sound scientific basis for these recommendations.

- Incorporate socio-economic factors into evaluations of nutrient management practices and BMP compliance (e.g. what really governs the way producers operate?).

- Nutrient management plan guidelines/requirements should be more complete that is currently the case.

Beneficial Management Practices (BMPs)

- Anecdotally, there has been an improvement in BMP application over time with respect to manure storage and fall/winter field application but the actual level of improvement has not been adequately defined or quantified.

- Not clear if inorganic fertilizer is better than organic.

- Need for better manure spreading technology that enables reliable application at specific rates.

- Current manure spreading advisories issued by the Provincial agriculture agency warns producers not to apply manure in excess of berry plant requirements. The questions are: how are these nutrient requirements determined and how much nutrient is readily available in the manure?

- Overall concept that famer should not apply more nutrient than crop need should be elemental aspect of Environmental Farm Plan, but there are complications in determining crop requirements and nutrient availability (particularly for manure sources).

- Agriculture agency experts indicate that currently there is no test that farmers can employ to determine how much fertilizer to apply at beginning of season.

- It would be useful to know what BMPs producers are actually adopting and a system to record fertilizer, agrichemical applications manure storage and shipment information and other related land use activities. Record keeping on farms in the Fraser Valley is currently minimal.

- Manure fate should be reported (e.g. field applications, off-site shipment, etc).

- BMPs should ensure the capture of all management practices, not just on-field, but also barn and near-barn practices, etc. that may have potential for nutrient or chemical leaching.

- There is uncertainty over the ability/appropriateness of current nutrient management BMPs to make a difference to aquifer quality and whether or not they are even expected to meaningfully address the groundwater nitrate problem.

- Key soil science information is missing and thus not reflected in BMPs (e.g. nitrate flux to soil and aquifer).

- BMPs should reflect an acceptable target for reasonable groundwater impact which would balance economic, environmental and health expectations.

- Explore new and innovative BMP options instead of simply focusing on an evaluation of existing BMPs (e.g. soil amendment with carbon).

- We need to improve compliance with BMPs amongst producers and ensure that BMPs are actually effective in minimizing excess nutrient application and nitrate impacts to groundwater.

- The experience in Whatcom County (WA State) is that while some farmers are doing all they can, others are not interested in changing practices or helping. There is a cost share program that offers up to $100K for producers (to adopt BMPs, including nutrient management plans, etc.) but there isn't much evidence to indicate that these commitments are being honored.

- Low market prices for raspberries mean that the aquifer land use is shifting (e.g. increase in blueberry production). Research and management activities should reflect these changes.

Soil Science

- Mineralization of soil organic nitrogen is a complex process that may be contributing leachable nitrate at different times of the year. There is currently no good soil test to assess this process.

- Manure application for raspberry nutrient needs could be a very small ("salt and pepper") amount. Application in excess of this is for soil amendment purposes but it is unlikely that this is needed by the soil.

- There is a possibility that field renovation (preparing and re-planting new crop) affects how much soil nitrate is available for leaching. In addition to tearing up all of the root zone material and soil organic matter, some growers add significant amounts of manure on the field prior to tilling. This could contribute a significant amount of leachable N to the field on an irregular basis (crop cycle).

- Berry crops are already known to be "leaky" with respect to Nitrogen, but can Carbon sources be used to minimize excess N?

- Soil mineralization is the big question, with some forage fields not even able to meet acceptable Fall Nitrate Test levels.

- Need to predict soil zone nitrogen mineralization and hence the magnitude and timing of nitrate leaching below the base of the root zone or reaching the water table.

- Lack of knowledge regarding annual Nitrogen uptake by plants. It varies a lot between years, crops, etc. and in some areas, the root zone may be very close to the water table, depending on the type of plant and seasonal peak water table conditions.

- There is currently no pre-growing season test that farmers can use as an indicator of how much (if any) fertilizer they should apply.

- The potential role of mineralization needs to be better addressed, with a need to potentially identify some areas where nitrogen mineralization effects might be greatest (e.g. replanting areas?).

General Environmental Management

- Currently, we don't have a good quantitative understanding of how much management practices have changed in the past decade. Current estimates of poultry manure export off the aquifer may not be significant in the context of seeing changes in groundwater nitrate concentrations. Survey data suggests that fields with manure application have much higher fall soil N concentrations.

- 80-90% of shipped poultry manure goes off the aquifer but stays within the Fraser Valley. Up to a third of broiler (poultry) manure was shipped to mushroom compost facilities and about 31% of total annual manure N is shipped to near (e.g. within Fraser Valley) and distant markets. A study of poultry manure transport is currently underway to improve estimates.

- The poultry industry moved onto the aquifer within close proximity to berry growers but perhaps it's time to investigate further incentives and innovative methods for more drastic reduction of poultry manure applied to nearby fields.

- Research into the potential effects of conversion of land used for berry horticulture and poultry production over the aquifer to other uses (e.g. urbanization) is needed to understand alternative impacts with reference to long-term expectations for aquifer conditions.

Communication

- There is a need to address the challenge of integration of the various research efforts being undertaken on the Abbotsford-Sumas aquifer with improved cross-validation (some form of peer review).

- There is a need to generate compilation reports or state of knowledge summaries.

- Better translation (communication) of the existing state of knowledge of the aquifer issues to more effectively prioritize/evaluate research needs and inform critical decisions on land use practices and/or policies.

- Researchers and policy makers require better access to environmental, agricultural and BMP-related data and information than is currently available. More effort required in transparency and online access.

- There is a need to integrate the different specialties/disciplines involved in Abbotsford-Sumas aquifer issues (e.g. soil science, ag practices, public health, hydrogeology, hydrology, etc.)

Regulatory

- BC Agricultural Code of Practice is weak on manure application guidelines (e.g. fertilizer and soil conditioner issues) re. environmental protection.

- Very little attention in Environmental Management Act (and related legislation) on the role of fertilizers (organic and inorganic) and soil conditioner substances in groundwater pollution.

- Nutrient management plans are not currently a requirement for producers, with focus more on voluntary compliance with BMPs encouraged through economic incentives.

- Enforcement of BC's Agricultural Code of Practice is minimal.

- Example cited from Ontario indicated that 85% of nitrate loading occurred in 10 distinct areas. Highlight a need for area-specific or focused approach to assessment studies and compliance efforts.

- 10 years ago the Abbotsford-Sumas aquifer International Task Force recommended a $6M action plan but, due to a number of factors, this plan did not proceed.

- BC Environmental Management Act has focused on manure storage and effluent control but doesn't appear to effectively address the issue of fertilizers (manure or synthetic) as potential sources of contamination.

- Current BC Provincial manure spreading advisories indicate that the responsibility is on the producer to apply manure in a manner that does not cause pollution. Given all of the uncertainties around nutrient availability in manure, soil bio-chemical processes and plant (e.g. berry) requirements; it seems impossible for producers to effectively determine what constitutes “excess” manure application. This situation, combined with the real need to apply manure to the land (manure storage constraints), makes it difficult for producers to know if they are in compliance or not and may lead to unwillingness to share information on land use practices.

Health

- There appears to be a lack of information on the study of health risks related to nitrate in groundwater (and drinking water in general) and an apparent lack of epidemiological research and related health studies to know what type of health impacts could occur over the aquifer or might actually be occurring due to elevated nitrate levels in groundwater.

- There may be a link between nitrate (NO_3) and nitrite (NO_2) health risks for ingested nitrate (e.g. from nitrate (NO_3) in drinking water). This is a concern given the potential health risks associated with nitrite (NO_2).

- Some stakeholders are concerned that the current Canadian Guideline for Drinking Water Quality level of 10 mg/L Nitrate-Nitrogen (equivalent to 45 mg/L Nitrate) may be unnecessarily conservative. How sensitive are the potential health impacts to this nitrate concentration? Is more research required to support the current guideline level? A greater degree of consultation with health experts would be of benefit here.

- Nitrate contamination may not be seen as having convincing negative impact (e.g. health risks/effects) which may challenge the willingness and ability of decision makers to take action (e.g. proactive vs. reactive stance and linkage to health information). Greater consultation with health experts (and researchers) with respect to nitrate and nitrite toxicity and nitrate levels in the aquifer should be pursued to avoid misinformation.

Research Needs

- Conduct detailed and coordinated soil, vadose zone (unsaturated zone) and groundwater monitoring to link groundwater nitrate to land use issues.

- Research into deposition of air-NH_3 emissions (ammonium) which are known to be elevated in the Abbotsford area. The magnitude of this potential source of Nitrogen to soil in the agricultural area of Abbotsford is currently not known and thus the potential contribution to soil nitrate cannot be accounted for (note: this data may be available but not yet reported).

- Study nitrate hot-spots in the aquifer, particularly what specific types of land use activities, as well as soil and groundwater conditions, may be responsible for these areas of highly elevated nitrate in groundwater. The concentrations in these areas are significantly higher than the drinking water guideline level.

- Need to undertake field studies to facilitate prediction of soil zone nitrogen mineralization in soils over the Abbotsford aquifer.

- Undertake studies to evaluate the potential impacts of other contaminants on the aquifer (e.g. veterinary pharmaceuticals, pesticides, pathogens, etc.). Assess the extent to which nitrate contamination may be an indicator of other forms of contamination.

- The transboundary aquifer flow system may not be well understood with respect to nitrate transport. Nitrate transport directions and rates should not be inferred from groundwater quality samples alone in the absence of studies of groundwater hydraulic gradients. Recent modelling work should be supported with more field data.

- In additional to poultry and raspberry production, there should be consideration of newer activities such as blueberry, greenhouses and rural residential (septic). Data collection should be conducted with computer modelling using NLOS.

- Need to look at bigger picture and not just evaluate raspberry production issues but develop a means of tracking of manure production and shipment in the Fraser Valley.

- Need to develop a means of determining the available nitrogen content of manure so that we can better estimate how much is too much for given crop types.

- Develop an overall conceptual model of the relationship between agricultural practices, timing, soil/geological conditions and groundwater, identifying main areas of uncertainty. This would assist development of research priorities, policy and practice.

- Investigate potential mitigation/remediation technology re. nitrate contamination.

- Determine reasonable time scale for evaluating environmental effects that may result from changes to BMPs (note: influenced by potential changes to soil and groundwater monitoring approaches).

- Groundwater research should ideally be conducted in tandem with agronomic, soil, and vadose zone research at a minimum of three representative sites.

Part 2 – Conclusions

The Abbotsford-Sumas aquifer Science Forum was successful in capturing key elements on the topics of nitrate contamination of groundwater, soil science and agricultural nutrient management through interdisciplinary presentations and subsequent discussion. While it is generally understood that fertilizer application (both inorganic and manure) to berry fields (primarily raspberry) is the primary source of elevated nitrate levels in the aquifer, many knowledge gaps have been identified that represent potential roadblocks towards mitigation of nitrate contamination. Given the importance of transboundary groundwater flow as a key issue in the discussion on groundwater quality concerns, the Science Forum was also successful in combining presentations and discussion topics from scientists on both sides of the international border. Some of the primary conclusions of presentations and discussion topics are identified below.

Our ability to link potential changes in land use practices over the aquifer to changes in groundwater quality may benefit from a shift towards techniques that monitor the quality of younger/shallower groundwater recharged under fields whose land use is known (ideally, integrated with soil zone and vadose zone), rather than 10-20 yr. old groundwater. Two of the groundwater researchers indicated that the potential source areas for nitrate observed in monitoring wells is likely in the range of several kilometers up-gradient from the monitoring locations based on computer simulation of groundwater flow (tracing backwards along the groundwater flow direction). From discussion on this topic, there was clear interest in investigating the application of groundwater monitoring techniques to provide information on water quality at or very close to the water table. This would complement the existing regional groundwater monitoring network and should be done through integration with soil and vadose zone (unsaturated zone) monitoring.

Effective nutrient management may be hampered by a number of soil science and berry horticulture knowledge gaps. There is uncertainty over the significance of post-harvest residual soil nitrate tests as an indicator of efficient fertilizer application. There is a paucity of test methods needed to provide the necessary information on what kind of fertilizer to apply, how much fertilizer to apply and when to apply it. There is also a lack of information on natural attenuation processes in the soil zone. BMPs and nutrient management planning appear to be currently operating within wide margins of uncertainty with respect to crop nitrogen demands (e.g. we don’t know how much nitrate the plants need), nitrogen availability and leaching of soil-zone nitrate to the water table. This current situation could easily lead to excess fertilizer application over an aquifer that is intrinsically vulnerable to contamination from the land surface. There is a general impression that current agricultural BMPs may not be stringent enough for highly vulnerable aquifers such as the Abbotsford-Sumas aquifer.

In addition to improvements in nutrient management, BMPs and groundwater monitoring techniques, the performance assessment of individual producers in following BMPs could be improved. The current distribution of elevated nitrate in the aquifer indicates “hotspots” where nitrate concentrations greatly exceed the drinking water MAC compared to the general background levels (which are still above “natural” background levels for nitrate). Further study is needed on the causative factors behind the occurrence of these hotspot zones, assuming localized zone of influence. More detailed field-scale studies currently in progress may provide more information on the transport processes of nitrate in the aquifer and potentially result in refinement of current computer simulation results.

While the current drinking water limit of 10 mg/L nitrate-N (or 45 mg/L nitrate) is the benchmark for contamination in the aquifer (national health standard for both in the US and Canada), the relevance of this MAC is being questioned by agricultural stakeholders with respect to the economic effort that may be required in order to meet it. It is not clear if the concerns over blue-baby syndrome (methaemoglobinaemia), cancer and other health issues are adequately reflected by the current drinking water MAC or if an unrealistic factor of safety is being applied. This represents an area for greater involvement and clarification by qualified health experts and researchers.

The current reliance on post-harvest residual soil nitrate tests as a benchmark of potential environmental impact (re. leaching of nitrate to the water table) may be unreliable given the potential for leaching of applied fertilizer nitrate in early spring. The recent studies that point to potential for springtime leaching of nitrate conflict somewhat with the conventional view that nitrate leaching only occurs in the fall. Field studies to confirm the modeling results would be beneficial but given this new information, the timing of nitrogen fertilizer application relative to peak crop nutrient uptake and precipitation statistics should be considered in nutrient management planning. Further studies are required to determine berry crop nutrient uptake dynamics.

There has been significant (yet largely anecdotal and unmeasured) effort to transport poultry manure off the aquifer in an effort to reduce excess application to the land (and subsequent leaching of excess nitrate to groundwater). Given that there is an intensive manure-producing industry over an intrinsically vulnerable aquifer together with predominant crop types that have low nutrient demands, more attention should be directed towards monitoring and tracking manure disposal/use. A standardized practice for determining the available nitrogen content of this manure is also required.

Improved communication and coordination between key stakeholder agencies has also been identified as an area for improvement. More emphasis should be placed on joint studies between Agriculture, Environment and Health officials and scientists at federal, provincial and municipal levels (as well as academic research). The dissemination of research findings could also be improved through more effective communication planning and identification of stakeholder information needs and interests. The research needs identified in this document should provide a basis for planning future collaborative studies.

In addition to groundwater quality, nutrient management and soil science issues, greater communication of health-related issues and the possibility of specific area-based health/epidemiological studies were also indentified as a gap amongst stakeholders and government agency representatives alike.

Appendix - Summary of Presentations

Presentation summaries are provided below in order of presentation.

Overview and History of Issue
A.P. Kohut, P.Eng

- The aquifer is susceptible to water quality degradation by nitrates due to sandy-gravelly soils, shallow water table, unconfined conditions, wet winters and dry summers when irrigation is practiced with application of agricultural and domestic sources of nitrogen to land;

- Nitrate in ground water has been monitored since the early 1970's with major studies starting in the mid 1980's by the Ministry of Environment, Environment Canada and the US Geological Survey;

- The behaviour of nitrate in the ground water regime appears to be very complex;

- Major initiatives undertaken in 1992 included establishment of the Federal-Provincial Groundwater Coordinating Committee and International Task Force on Abbotsford-Sumas Aquifer International Task Force (ASAITF);

- Significant efforts have been made with regard to public education, preparation of an ASAITF action plan, enforcement of agricultural waste regulations, establishment of stakeholder groups and transport of poultry manure litter off the aquifer;

- The issue has been an opportunity for inter-agency collaboration.

Health Effects of Nitrate in Drinking Water
Prabjit Barn (for Dr. Ray Copes), BC Centre for Disease Control

- Health effects of nitrates include:
    - Methaemoglobinaemia (blue baby syndrome),
    - cancer,
    - reproductive issues (further research needed on human effects), and
    - developmental issues (e.g. motor reflexes, perceptual vigilance and neurobehavioural changes).

- The maximum acceptable concentration (MAC) for nitrate in drinking water is 10 mg of nitrate nitrogen per Liter (equivalent to 45 mg nitrate per Liter).

- In areas where drinking water concentrations are less than 50 mg/L nitrate (or < 11 mg/L nitrate-Nitrogen), food is the largest source of nitrate intake.

- Infants less than 6 months and adults with reduced gastric acidity and/or lack of enzymes are at highest risk of acquiring blue-baby syndrome (reduced capability of blood to deliver oxygen to cells of body). It generally occurs at levels >90 mg/L nitrate (or >20 mg/L nitrate-N) but some studies show impacts at <50 mg/L (<11 mg/L nitrate-N).

- Nitrate is an IARC Group 2A carcinogen (Probable Human Carcinogen or cancer causing substance).

Groundwater Monitoring in the Abbotsford Aquifer
Gwyn Graham, P.Geo (Environment Canada)

- Extensive network of piezometers (narrow groundwater sampling wells) in southern (agricultural) areas of aquifer (covering a range of depths). Initiated in mid-80's and now totaling 63 piezometers. 26 of these sampled monthly and 35 sampled annually.

- Average nitrate concentration (as Nitrate-Nitrogen) is around 15 mg/L (greater than MAC) and maximum concentrations are 3 to 4 times higher.

- Long-term nitrate variability appears to be in-synch with precipitation cycles (e.g. El Niño, etc.).

- General decrease in nitrate concentration with depth, suggesting that older groundwater from more distant recharge locations had lower nitrate load than more local younger (shallower) groundwater.

- Spatial distribution shows "hotspots" of elevated nitrate concentrations, while temporal data shows shifts in locations of hotspots over 10 yr period (1992-2002).

- 2004 survey of private wells (~150 wells) showed high nitrate levels in south-central to eastern portions of the aquifer with 40% of all wells >10 mg/L MAC. 4-7% of wells were positive for fecal coliform (shallow wells & poor construction/location) but no apparent correlation to high nitrate concentrations.

Nitrate Trends in the Central Sumas-Blaine Surficial Aquifer
Melanie Redding (WA Dept. of Ecology)

- Sumas-Blaine aquifer identified as one of most severely contaminated aquifers in WA state.

- Est. Nitrate loading from manure is greatest source (66%), followed by fertilizer (21%) and atmospheric deposition (8%).

- Elevated nitrate concentrations in aquifer shows hotspot distribution (2 yr. study; bi-monthly sampling).

- Mean nitrate concentration = 11.2 mg/L to max of 43.1 mg/L (nitrate-N).

- 20% of wells consistently over 10 mg/L N and 71% of wells show at least one occurrence of >10 mg/L N. 30% show increasing nitrate trend, 6% show decreasing trend and 54% show no trend (over 2 yr. study period).

- Overall, there is a long-term increasing nitrate trend attributed to excess soil nitrogen from past practices, continued nitrogen loading and migration of nitrate in groundwater from sources in Canada.

Efficacy of BMPs to Reduce Nitrate Contamination in Abbotsford Aquifer: Decadal Scale Geochemical and Isotopic Patterns
Len Wassenaar, Ph.D. (Environment Canada)

- Abbotsford aquifer characterized as unconfined aquifer, coarse sediment, thin soil cover, high rainfall and intrinsically vulnerable setting.

- Generally southerly groundwater flow with 20-30 yr groundwater residence time.

- Land use dominated by raspberries, poultry (16 Million birds producing about 600,000 m^3 manure/yr)

- Early 1990's – recognition of widespread groundwater contamination, poor agricultural practices, transboundary concerns and recognition of need to rectify problems (sources). 1995 Nitrogen isotope study indicated that nitrate was predominantly from poultry manure (no significant intrinsic denitrification in aquifer -aquifer can't clean itself up).

- 1996 BC Code of Agricultural Practice for Waste Management (BMP) resulted in extensive industry and local action to improve practices over aquifer.

- After 10 years, expectation was that young (shallow) groundwater would show improvement (groundwater age is a function of depth below the water table), but instead, we see a significant increase in nitrate for groundwater less than 5 yrs old for data constrained to last 5 years (2000-2005).

- New sampling and N-isotope analysis shows significant shift from manure to inorganic fertilizer sources over past 10 yr period of BMP initiative. Majority of sites with groundwater age of less than 5 yrs show shift towards inorganic fertilizer Nitrogen isotope signature.

- Decreasing manure-source nitrate despite 50% increase in poultry – highlights positive impact of BMPs, but question over whether BMPs are leading to increased used of inorganic fertilizer to meet perceived crop requirements.

- Apparent poor linkage between BMPs and soil/groundwater conditions and need for improved vigilance in application of BMPs given the high intrinsic vulnerability of the aquifer to contamination.

- Results parallel decadal trends for groundwater nitrate in agricultural settings across the US (stable or increasing nitrate trends).

Soil and Plant Research for Raspberry Nitrogen Management in Coastal British Columbia
Grant Kowalenko, Ph.D. (AAFC, Agassiz)

The objective of the presentation was to outline research on the nitrogen (N) nutrition of raspberries as it relates to concerns about elevated nitrate concentrations in the Abbotsford-Sumas Aquifer. Raspberries have been the predominant crop grown over this unconfined aquifer and a primary focus as a major contributor of the nitrate. There are two main “streams” of research that have helped develop nitrogen management for raspberry production:

- the general behaviour of nitrogen in coastal B.C. soils, and
- nitrogen management for raspberries.

1. General behaviour of N in coastal B.C. soils

The dynamics of N in soil-plant systems are a very complex mix of biological, chemical and physical processes competing for nitrogen in response to constantly changing environmental conditions (weather) and management practices.

30 yrs ago, there had been limited examination of N behaviour in coastal soils. Fertilizer recommendations were based on crop response studies, with minimal soil N measurements. No soil N tests were available or used (recommendations were general and not site specific).

1.1. Losses from the root zone
1.1.1. Leaching
Leaching of inorganic N is minimal during the growing season in coastal British Columbia due to high evaporation and transpiration (by plants) of the water during the summer, despite the abundant yearly precipitation that occurs. Most of the precipitation occurs during seasons when evaporation and transpiration are minimal, thus any nitrate in the soil after crop growth ceases is subject to essentially complete leaching from the root zone. This has contributed to the proposal for the use of post-harvest soil nitrate measurements as a soil N test.

1.1.2. Denitrification
Limited work has been done directly on this soil N process (biochemical transformation of nitrate to inert Nitrogen gas). The studies that have been done show that amounts vary with relatively large potential for denitrification during the autumn.

1.1.3. Volatilization of ammonium
Limited work has been done where direct measurements were made, with focus on liquid dairy manure.

1.1.4. Runoff/erosion
Limited work has been done where direct measurements were made, with focus on liquid dairy manure.

1.2. Nitrate adsorption
The assumption that nitrate moves freely with water in the soil (surface and sub-surface) needs to be re-evaluated, and can have profound implications. A study has shown that

adsorption of nitrate occurs in coastal soils, and the amount varies with a variety of factors. Measurement of the process is complex, which makes it difficult to determine practical implications.

1.3. Clay fixation of ammonium

Clay fixation of ammonium is usually ignored in soil N studies, but has been measured in coastal British Columbia soils. The amount varies with soil and other factors, and its availability to plants is poorly understood. Its measurement is difficult. The influence of this inorganic N fraction in the soil on the development of a soil test needs attention.

1.4. Mineralization

A variety of studies have shown that, since organic N accounts for most of the N in the soil, mineralization plays a crucial role for supplying N to crops. However, the process is closely associated with many other transformation processes especially immobilization, making measurements of mineralization and development of a mineralizable soil N test very complex. This is further complicated by clay-fixed ammonium, which is an inorganic form of N in the soil.

2. Studies on nitrogen management for raspberries

2.1. Leaf tissue for nutrient recommendations

A 1981 report concluded that nitrogen concentrations in raspberry leaves are too dynamic and inconsistent over time and year to year for nitrogen recommendation purposes.

2.2. Plant N dynamics/quantities

Whole plant above-ground destructive sampling through the growing season has provided fundamental knowledge about the amount of N taken up by the plant over the season and the distribution in different plant components. These studies showed that, contrary to earlier assumptions, the amount of N in biomass of commercial fields of raspberries is modest due to the distance between rows of plant, and thus N application rates need to reduced accordingly.

2.3. Relationship to land use

Conclusions from a budget calculations using Census data are that “nitrogen additions exceeded N removals by 134, 185, and 245 kg N ha^{-1} in 1971, 1981 and 1991, respectively, indicating a high potential for leaching to occur” in the Abbotsford Aquifer. This was due to the large area of raspberry fields often associated with poultry operations.

2.4. Responses to N applications in B.C. and Oregon research trials.

Of a limited number of research trials conducted in the Pacific Northwest, few have shown increased yield responses from the nitrogen applications. This is assumed to be related to the relatively small amount of nitrogen present in plant biomass on a field basis where rows are planted wide enough to allow the use of conventional farm machinery. With the relatively low plant density, the N requirement by the crop can be satisfied by the N stored in the soil.

2.5. Development and promotion of post-harvest/residual soil N test

The first attempt at using the post-harvest soil nitrate test for raspberries was during the Canada – British Columbia Soil Conservation program in the early 1990’s. The post-harvest test was proposed from initial fundamental research on nitrogen and on raspberries. The soil test was promoted by an Industry Raspberry Development Council project (2000-2003).

Although the theoretical basis for the test is sound, there are many practical problems. A variety of research projects have subsequently been conducted to develop the practical use of the soil test. The practical problems include:

- time of sampling,
- location of sampling (banding applications is a significant issue),
- depth of sampling,
- type of amendment (organic vs inorganic), and
- management practices (such as cover crop, placement of amendment, etc.).

The test is limited to identifying only those fields where there was a large excess of nitrogen in relation to crop requirement and utilization; cannot define cases of sufficiency from deficiency nor what the agronomic rate of application should be.

2.6. Other direct and indirect factors/issues
A variety of other factors could influence responses of raspberries to N, and will need consideration for their influence on management recommendations. Some of these have been examined and include:

- tissue other than leaves for plant-based N management recommendations,
- the influence of yield and plant growth of different cultivars,
- residual effects of amendments
- the influence of other nutrients on N including the implications of deficiency or imbalance,
- inter-row management,
- mineralizable N soil test.

Fraser Valley Soil Nutrient Study 2005:Key Findings Pertaining to Soil Nitrates over the Abbotsford Aquifer
Orlando Schmidt (BC MAL)

- Study of 5 census zones in Lower Fraser Valley, including South Matsqui (Abbotsford Aquifer area) – focus area for presentation.

- Marble Hill and Abbotsford Soils present with only 20-30 cm topsoil cover.

- Core-sampling at end of growing season in 2005 (Sept-Oct) at depths of 0-15 cm; 15-30 cm; and 30-60 cm

- South Matsqui study area showed highest residual soil-nitrate (149 kg NO_3-N/ha over 0-60 cm or 43% of sites in the high to very high risk category with respect to nitrate leaching).

- Site distribution for residual soil-nitrate:
  - Raspberry (12 sites) ranged from 40% medium to 40% very high.
  - Blueberry (6 sites) ranged from 30% medium to 15% very high
  - Grass (12 sites) ranged from 30% medium to 8% very high.

- Fields with fertilizer-only showed ~12% high residual soil-nitrate vs. combined manure & fertilizer fields, which showed 55% high residual soil-nitrate.

- Removing "outlier" sites changed average residual soil nitrate from 149 to 97 kg NO_3-N/ha (indicating that some sites are extremely high).

- Need for standardized interpretation of post-harvest soil tests for both agronomic and environmental purposes.

- It is possible to maintain optimal yields while maintaining post-harvest soil-nitrate in medium to low category.

- Need to target BMPs for fields with very high post-harvest residual soil-nitrate levels for fastest overall performance improvements in reducing nitrate leaching over the aquifer.

- Nutrient management practices need to be customized to better suit berry horticulture and use of poultry manure.

- Poultry manure should be applied at lower rates with appropriate application equipment (recommended BMP).

- Recommend renewed efforts at cover cropping and explore the use of permanent grass covers between rows.

- Recommend enhanced extension efforts and appropriate incentives for adoption of BMPs.

Vadose Zone Modelling For Nitrate Transport, Abbotsford-Sumas Aquifer, BC and WA
Romain Chesnaux, Ph.D and Diana Allen, Ph.D (Simon Fraser University)

The presentation summarized work with the objective of quantifying nitrate loading to the water table (nitrate loading function) so that we could undertake saturated zone (groundwater) transport modeling of nitrate. Following the presentation, there was a discussion about the nitrogen loading estimates for the raspberry fields. Two errors were subsequently discovered (one unit conversion error and one related to not including soil mineralization), the effects of which cancelled each other out, providing reasonable results. Model input parameters have since been modified.

Nitrate concentrations are observed to fluctuate with time, in accordance with the water levels measured in piezometers. The original working hypothesis (supported by previous researchers) was that winter rains were responsible for nitrate loading to the aquifer. This would imply that the source of nitrate to the aquifer was residual soil nitrate, which is flushed through the soil zone during the fall when the heavy rains begin. The residual soil nitrate data was analysed as a first step to see if there are any differences between manured (both manure and synthetic fertilizer) and non-manured fields.

Based on a four-year post-harvest survey of residual nitrate (late September), soil residual nitrate ranged from 20 to 70 mg/kg N-NO_3, with an average of 40 mg/kg. These soil concentrations correspond to dissolved NO_3-N concentrations of 67 to 233 mg-N/L (nitrate-N), with an average of 133 mg-N/L, for the 4 surveyed years (assuming a gravimetric water content of 0.3 for saturated conditions).

Overall, the residual concentrations measured in manured fields are higher than those measured in non-manured (synthetically fertilized) for the same amount of applied nitrogen. For the case of synthetic fertilizers, the higher the amount of applied nitrogen, the higher the post-harvest concentration recovered. This behavior is not observed in manured fields where the residual concentrations appear not to be dependant solely on the initial amount of nitrogen applied. Given that the same application amounts of fertilizer are considered for both manured and non-manured fields, the low residual soil nitrate in non-manured soils suggests that potentially more nitrate was leaching during the early spring at a time when synthetic fertilizers are applied to berry fields, and when there is generally high precipitation and the raspberry crops have not yet reached a high nutrient demand stage. These three factors, in combination with the coarse nature of the soil and aquifer media, can potentially lead to ideal conditions for rapid nitrate leaching at this time of the year, thereby increasing the risk that nitrates are quickly mobilized to depths below the root zone.

Following early spring application, nitrogen undergoes nitrification in the soil to produce nitrate, nitrate then dissolves in water and infiltrates downward with infiltrated water. Part of the nitrate can be attenuated in the soil zone (e.g. denitrification) and by raspberry plant uptake in the root zone. The nitrate eventually reaches the water table and then is transported in the saturated zone of the aquifer.

A conceptual model was developed for the period 2000-2003 in a raspberry production area using representative climate, soil properties and fertilizer application rates. Using estimated nitrogen application, and subtracting estimated losses from plant losses and denitrification, so as not to require simulation of these losses, a numerical simulation was conducted to model nitrate leaching through the vadose zone.

Climate data for the model period were obtained from Farmwest. Net monthly infiltration (precipitation-evapotranspiration, no runoff considered) was used. Nitrate leaching in the Abbotsford-Sumas aquifer can occur naturally in the spring and in the fall when evaporation/transpiration and plant uptake are minimal. During the growing season (summer months), there is a net moisture deficit and, thus, nitrate leaching would not normally occur. Irrigation, however, influences soil moisture in the summer months. So, we considered irrigation in the summer months (June to September) and estimated this to be 450 mm (total) or 112 mm/month over this period.

A specified mass of nitrogen (as synthetic fertilizer) was applied at the surface of the soil on April 15 as an initial model condition. This is an average date for the onset of fertilizer application; however, it actually can fluctuate depending on the farmers' practices. Application amounts were estimated at 216 kg-N/ha following consultation with soil science experts and modification allow for a more representative accounting of the net amount of nitrogen available for leaching. This equates to a concentration of 1200 mg N/L (used as the loading concentration). The computer codes used for this study are SEEP/W (water seepage) and CTRAN/W (contaminant transport), which are versatile and well-suited for nitrate leaching simulations.

Nitrate concentrations were shown as a function of depth and time through the vadose zone. The applied nitrate is dissolved during the first rainfall but as infiltration progresses, nitrate is diluted both in water previously contained in the porous medium (pore water), and also in water coming from rainfall (infiltrated water). Nitrate is quickly leached through the soil by the spring precipitation. After 1.5 months (June 1), the maximum concentration is found at about

25 cm below the ground surface, which corresponds to the lower zone reached by the raspberry roots. At this time, nitrate has begun to reach the interface between the soil and vadose zone located at an elevation of 4 m above the water table (located at 5 m depth). After this period, irrigation starts but typically provides only limited infiltration beyond the root zone, explaining why during the irrigation period, the contamination front makes limited downward progress.

Leached nitrate is first observed at the water table in August. At the end of September, the infiltration front begins entering in the capillary fringe (situated at 40 cm above the water table) where the pore water content is higher because the material has a higher capacity for water retention. From the end of September, there is a higher rate of dilution of nitrate in this zone and a corresponding decrease in concentration. At the beginning of October, when precipitation is re-established, the nitrate front tends to be flushed more quickly. Henceforth, higher concentrations are loaded at the water table. The maximum nitrate concentration at the water table is obtained on October 20 and corresponds to 132 mg N/L (or 29 mg/L nitrate-N). Finally, by November 15, all nitrate has been transported to the saturated zone of the aquifer. Modeling results for this example show that it takes 7 months for the available nitrate (i.e., that amount not denitrified and not up taken by the crops) to get completely flushed to the water table. Nitrate leaching is therefore very fast in the vadose zone according to the coarse nature of the material and its low capacity for pore water retention.

Similar simulations were undertaken for different depths of the water table, and for different thicknesses of the vadose zone. The results indicate that water table position has little effect on the nitrate concentrations loaded at the water table. However, the time required for the contamination front to reach the water table is different depending on the distance of travel from the soil. For the case where the water table is 10 m deep. the maximum nitrate concentration reaching the water table was observed only a week after the case of a water table located at a depth of 5 m.

The average simulated residual soil nitrate concentration shows a good fit between modeling and observed results. Furthermore, a comparison of modeled and observed concentrations was made for different cases of synthetic fertilization ranging from 40 kg-N/ha to 120 kg-N/ha. The linear fit of the five points is good (R2 = 0.89) and the extrapolated line (slope = 1.05) passes through the origin. The constructed model, therefore, can be considered to be reasonably calibrated. Furthermore, the comparison has been made over a long term period of 4 years, which provides a good calibration period. The good fit between field data and modeling results also indicates that the assumptions pertaining to the losses of nitrogen are realistic.

Seasonal fluctuations in nitrate loading to the water table have been simulated for different fertilizer application amounts. In all cases, the peak in nitrate concentration occurs in October, and concentrations at the water table increase as the amount of applied fertilizer increases (as might be expected). The range of concentrations, however, is also consistent with concentrations currently measured across the aquifer, and indicates that nitrate concentrations are largely the result of current nutrient management practices for raspberry crops (i.e., favoring the use of synthetic fertilizers).

Sustainable Nitrogen Management - Berry Industry Perspective
Mark Sweeney (BC MAL)

- 2000-2004 Raspberry Management Project included Post Harvest Nitrate Study (4 yrs of survey data; 44-72 fields/yr; 33-37 growers involved).

- Trends in fertilizer Nitrogen:
    - Overall applications: 50-90 kg/ha (lower rates = lower residual soil nitrate)
    - Vigorous fields = moderate nitrates
    - Weak fields = higher nitrates
    - Manure use = highest nitrates

- Programs developed for Awareness and Education
- Program developed for improved manure practices:
    - Less manure application (<24% of acreage)
    - Improved manure storage
    - Timing of applications
    - Increased use of cover crops.

- Message to raspberry growers: aquifer nitrate levels are not declining – "it's not good enough!" -demoralizing effect.
- Questions over organic vs. inorganic sources
- Questions over other information gaps
- Grower fatigue
- Need for incentives
- Other challenges facing raspberry industry as a whole.
- Land use dynamics – Blueberries and other uses (conversion of raspberry fields)

Groundwater Nitrate Distributions South of Judson Lake, Whatcom County, WA
Robert Mitchell, Ph.D. (Western Washington University).

- Elevated nitrate concentrations in the aquifer (Whatcom county near Judson Lake) are due to nitrate source on both sides of the BC/WA border.

- Nutrient management effects in Whatcom County are considered difficult to assess due to Canadian inputs.

- WA Dept. of Ecology funded groundwater studies from 1997-99 and 2002-04 to:
    - Quantify nitrate concentrations and distribution in a study site adjacent to the border,
    - Attempt to distinguish between BC sources of nitrate and WA sources, and
    - Assess BMPs

- Sampling was conducted using existing domestic wells.

- 14 of 26 wells showed nitrate-N concentrations greater than 10 mg/L and 21 of 26 wells showed nitrate-N concentrations greater than 3 mg/L.

- Shallow wells had higher nitrate levels than deeper wells.

- Nitrate concentrations were higher in wells to the north of Pangborn Lake and Creek than to the south and further studies identified a zone of denitrification in the vicinity of Pangborn bog attributed to organic-rich peat deposits.

- Nitrate concentrations measured in BC are similar in magnitude to bordering WA wells, with shallow wells showing the highest concentrations of nitrate.

- One well was observed to show apparent fluctuations of nitrate in-synch with seasonal fluctuations in water table elevation.

- Nitrogen isotopes indicate animal (manure) sources and mixed manure/commercial inorganic fertilizer sources. Only a few sites showed only inorganic nitrate sources.

- Nitrate concentrations were high in both groundwater and surface water in the study area.

- Nitrate concentrations inferred to be transported across BC border range from 10 to 25 mg N/L and reflect a mix of organic and inorganic sources.

- Nitrate concentrations in shallow wells in WA range from 15-35 mg N/L and correlate to both BC and WA source types (N-isotope signature).

Field scale study on nitrate leaching under raspberries
Cathy Ryan, Ph.D. (University of Calgary).

To date, virtually all of the groundwater samples (and interpretation of the problem) have been based on water sampled from monitoring wells yielding groundwater that is about 10 years old on average, and probably containing groundwater that migrated from several kilometers up-gradient (or more) reflecting the influence of changing management by a number of producers. Even the most detailed work conducted (Wassenaar et al., 2006) relies on samples from a handful of monitoring wells (six out of eight sampled with an average groundwater age less than 5 years) without specific information about which farm the groundwater was recharged on, or how the management practices of said farms had changed to conclude the groundwater situation is management practices did not improve the groundwater situation.

This study concluded that there is a need to more clearly link management practices to groundwater monitoring. There is also a need for more detailed and frequent sampling from the most shallow groundwater zone. We have begun doing this (P. Kuipers, MSc research, University of Calgary) and have found that shallow groundwater nitrate (and chloride) concentrations have decreased as the water table rose during the winter rainy season. This type of groundwater research ideally needs to be linked to soil zone nitrogen monitoring.

Objectives of field study:

- estimate actual rate of N leaching from raspberry production
- characterize fate of groundwater nitrate
- in the longer term, evaluate alternative management practices

Nitrate Transport in the Abbotsford-Sumas Aquifer: Heterogeneity and Model Scale
Diana Allen, Ph.D. (Simon Fraser University)

A numerical groundwater flow model was developed for the trans-national Abbotsford-Sumas in southwestern British Columbia, Canada and northwestern Washington State. The model was used for a number of purposes, including:

- Simulation of groundwater flow on the Canadian side of the aquifer,
- Determination of potential source areas of high nitrate concentrations measured in piezometers
- Determined the potential impacts of future climate change on groundwater in this region

The aquifer system area is 160 km^2, and is comprised of heterogeneous glaciofluvial sediments, bounded by glaciomarine sediments that infill steep and variable bedrock topography of buried paleovalleys, bedrock outcrops and mountain ranges. Bedrock outcrops of Tertiary sedimentary and volcanic rocks outcrop in the eastern portions of the study area (e.g., Sumas Mountain in BC).

The Sumas Drift and Fort Langley Formation are the most extensive geologic units in this study area. Generally, Fort Langley Formation is present in the west and northwest part of the study area, and also underlies the Sumas Drift at depth. Sumas Drift consists of many sandy and gravelly sediments, which locally include large lenses of flow tills. The surficial aquifers roughly follow the extent of Sumas Drift. In the Abbotsford area, the Sumas Drift is known as Abbotsford outwash which is most coarse grained and forms major aquifer in that area.

The hydrostratigraphic units were modeled in three-dimensions from standardized, reclassified, and interpreted well borehole litho-logs. A series of slides in the presentation showed successive layers in the aquifer from the bottom up. Hydraulic properties used in the model were from available well test data, mostly on US side, but supplemented by Canadian data where available.

A new methodology was developed for generating spatially-distributed (and temporally-varying) recharge for the surficial aquifer. The recharge model is driven by physically-based daily weather inputs generated by a stochastic weather generator that is calibrated to local observed climate.

A three dimensional groundwater flow model of variable spatial resolution (constrained by borehole spacing) was implemented in Visual MODFLOW, and calibrated to historic static water elevations in several thousand wells. The recharge values determined previously were used as a recharge boundary condition in the groundwater flow model (all streams, ditches, etc. were included in the model as boundary conditions). From a trans-national perspective, a large proportion of the aquifer drains toward the south, as was illustrated in the water table surface map. However, the results suggest that the groundwater flow patterns are much more complex than originally thought.

A series of GPR (ground-penetrating radar) surveys and borehole geophysical logs were collected at a site on the aquifer. The borehole logs suggest that there are dominantly fining-upward sequences (within coarse sediments) on the scale of 3 to 10 m. Representing this vertical heterogeneity is important in vadose zone transport modeling as there will be an impact on transport times and concentrations due to variably saturated conditions. The GPR profiles show that these sequences extend laterally a few meters between nested monitoring wells; a few extend several 100s of meters. Lateral continuities of coarser grained materials may contribute to permeable pathways for nitrate migration. Generally, the GPR reflections showed an undulating to chaotic stratigraphy, suggesting that depositional variability extends across the site and likely throughout the Abbotsford outwash deposit (based on geological information). Large scale heterogeneity can be captured in a regional model, but small scale heterogeneity, as evidenced by the geophysics, can only be incorporated in small scale models.

A particle tracking study was undertaken with the objective of verifying the groundwater flow model so that it could be more reliably used for nitrate transport. The work was carried out in association with a nitrate Hotspot study conducted for the Fraser Health Authority. The study involved undertaking a particle tracking (back tracking) analysis to estimate the approximate origin (at surface) of nitrate contamination measured at monitoring piezometers within the aquifer. Model groundwater ages were estimated from the particle tracking results and compared with ages determined by Environment Canada using isotopic techniques (Wassenaar et al., 2006). Land use directly above the point of origin was identified based on the most recent land use map for the region (BC Ministry of Agriculture and Lands).

Model travel times compare reasonably well to isotopic ages. However, model ages tend to be underestimated by a factor of 1.4 (revised estimate), suggesting that transport is occurring at a more rapid rate in the model than would be expected based on field data. There are two main reasons that explain this occurrence. First, particle tracking represents advective transport only and does not consider dispersion. Second, the model can lead to oversimplification of the small scale heterogeneities that can strongly influence transport locally. Notwithstanding the discrepancy in ages, the point of origin of the particles is likely representative. The land use directly above the point of origin of the particles is identified using the most recent land use information.

Nitrate-N in Soil and Groundwater at a Field Where Manure is Applied 2004-2008
Barb Carey (WA Dept. of Ecology)

Objective to track nitrate changes in a typical grass field over the Abbotsford-Sumas Aquifer in soil, groundwater, dairy manure, and removed grass crop. Also, to observed relationships of these components to seasonal changes, manure application rates and replanting of crop.

- Site consisted of 22 acre grass field with silty loam to sand with silt and clay soil. Manure was applied 3-5 times per year.

- Depth to water table varied from 0.5 to 11 ft (peak in Nov-Dec and low in September). Aquifer K~$6x10^{-4}$ ft/sec and v=0.34 ft/day.

- Fall (mean weekly) soil nitrate levels did not appear to fluctuate directly with variations in applied manure-N loading.

- General Findings:

    - Replanting the grass crop was followed by high fall soil nitrate followed by elevated shallow groundwater nitrate-N.

- Nitrate-N gradually decreased over the next three years following grass replanting and modest manure application.
- Some wells indicate occurrence of denitrification especially in the fall, based on dissolved oxygen and chloride concentrations.
- Timing of manure application to promote uptake helps prevent high winter nitrate spikes in groundwater.

Variability in hydrologic features of the Abbotsford-Sumas Aquifer and the distribution of water quality along a ground water flow path
Steve Cox, Ph.D. (USGS)

- LENS (Lynden-Everson-Nooksack-Sumas) study provides transboundary map of aquifer area and geological variations.

- NEWQA study shows groundwater flow pattern in the vicinity of the Abbotsford airport and indicates a flow divide to the south of the airport, with groundwater being directed to Fishtrap Creek to the west and towards the East/South-East.

- Along a south/south-westerly flowpath from the airport to Fishtrap Creek, the shallow groundwater zone immediately downgradient of the airport appears to show nitrate-N concentrations lower than 10 mg/L-N, but these increase further downgradient through the agricultural area. Deep groundwater is below 10 mg/L-N all along the flowpath. All depth zones are non-detectable for nitrate in proximity to Fishtrap Creek.

- Denitrification in the vicinity of Fishtrap Creek is indicated by dissolved gasses (Ar and N2) and various redox-active geochemical constituents.

- Report is available: Report no.98-4195 & Water Resources Research Vol. 39, p. 1545-1559 (http://wa.water.usgs.gov)

Agriculture Wildlife Advisory Committee Meeting Minutes

February 21, 2008
Ramada Inn, Penticton

Attendees: Chris Vos, Alex McLean, Phil Hallinan, Mike Badry, John Wilson, Mike Rose, Brian Baehr, Karen Goodings, Wray McDonnell (Chair) , Dennis St John, Jeff Morgan, Carl Withler, Larry Plett

The meeting was called to order at 9:05 am. Introductions were made and the agenda was reviewed.

1. <u>Business Arising from the Minutes:</u>

Item # 10 from the previous minutes was amended to replace the words "cull proposal" with "proposed control measures". The issue of how concerns of high deer numbers are brought forward to regional MoE staff. It was recommended that re-forming regional conflict committees (as in the Peace) would help move these issues forward. MoE regional staff currently consult with local stock associations and concerns with conflict can be raised there as well. It will be important to coordinate increased seasons with access to private lands (PAZWP) and the BCAWAC continues to support Jeff's PAZWP to address ungulate conflicts on private lands. There is concern with the livestock industry that this process progresses quickly.
Action: MOE to provide deer harvest stats and deer-vehicle collision stats for next meeting.

It was confirmed that the BCAWAC has not been forwarding minutes to the Partnership Committee but will be from now on. Previous reports to the PC have been delivered by the BCAWAC chairs. Wray distributed the summary that was presented at the October 2007 PC meeting. The process is working well and the BCAWAC will continue to be advisory to the PC.

Progress has been made regarding escaped bison in the Peace. Wray distributed a handout of the MAL protocol to deal with "bison at large" and recent activities to remove 22 feral bison. Karen indicated that the response to escaped bison is still not quick enough. Communication process needs to be improved – timing is essential.

Wray distributed response from Dr. Merv Wetzstein regarding management of CWD in zoos. CWD is a reportable disease and in the case of an outbreak the federal government is the lead agency and would immediately take over.

2. <u>Wildlife Act Review and Amendments:</u>

Mike Badry provided an update. The Wildlife Act Review has resulted in a scaled down package of amendments, not the major review as originally proposed. Changes that will be going forward include:

- Fines and penalties
- First Nations Relationships
- Definition of an officer
- Control of Dangerous Exotics

3. Compensation Projects:

Chris Vos reported that:

- Wrapping up 2007-08 business
- $10 million in new funding has been announced for 08-09
- All current projects being continued in 08-09
- Potential wild ungulate foraging program in development. Todd Bondaroff has been contracted to examine a program for losses to forage crops by wild ungulates and other wildlife, as well as an excreta cleaning program.

Karen asked about compensation for damage to infrastructure such as vehicles and buildings from wildlife. Chris indicated that this would not be consistent with the federal agreement and the province needs to be consistent in their delivery to access shared funding.

4. AEI Projects:

Brian Baehr provided an update on status of Agriculture Wildlife Issues and Initiatives:

- Proposed Agriculture Environment Wildlife Program not signed off yet. Likely to have $2.5 million over the next year to address broad environmental issues.
- This money cannot be used to support current programs, must be new proposals.
- Do have the ability to fund the Wild Predator Control Loss and Compensation Program to March 09.

5. Predator Loss Program:

John Wilson circulated a handout on the Predator Loss Program.

- Number of incidents continues to rise, likely due to increased wolf numbers and increased uptake of the program by producers.
- Incidents of harassment have increased substantially.

Discussion took place regarding compensation vs. mitigation.

6. EFP Prevention Activities:

BCAC is continuing to collect list of items that should be included in Environmental Farm Planning. There is no new agreement in place yet and the old list of BMPs is being used in the interim. Items discussed included:

- bear fencing, snake fencing, agriculture land fill fencing for bears, hunting cabins, wetland fencing for amphibians, netting for common bird species.

Also need to review caps on funding (i.e. larger operations have greater requirements such as numerous haystacks).

Action: All BCAWAC members should forward items to include under EFP to Brian Baehr.

7. Enfranchisement/Incentives Project:

Jeff Morgan discussed the PAZWP and its objectives:

In making a contribution to the PAZWP, MoE will augment (not replace) the existing resources that are dedicated toward agriculture/wildlife conflict in the province. In doing so, MoE will help to create a provincial team, or focal point, that will develop consistent management approaches and coordinate intra and inter-ministry resources.

Once established, the Provincial Agricultural Zone Wildlife Program (PAZWP) will allow MoE to establish firm targets for wildlife populations in agricultural zones, to increase hunting opportunities, and to use hunting as a tool to mitigate agricultural impacts. The PAZWP will provide practitioners with the resources required to effectively manage wildlife and to maintain public, stakeholder and First Nations confidence. The PAZWP will: 1) establish and work cooperatively toward economic, ecological and social objectives within the Agricultural Land Reserve; 2) leverage federal funding (Federal-Provincial-Territorial Framework Agreement on Agriculture); and, 3) effectively coordinate resources with other organizations in order to optimize societal returns.

Ministry of Environment's authority to manage wildlife will be coordinated and balanced with Ministry of Agricultural and Lands' (Business Risk Management Branch) authority and ability to assess crop damage and provide compensation to producers.

At the provincial level, coordination will be achieved through existing committees and through a technical working group that are mandated to promote stewardship and integrate all prevention, mitigation and compensation strategies (see Figure 1) for agriculture/wildlife conflict. At the regional level, agriculture/wildlife conflict resolution committees will be established and maintained (see Figure 2).

In addition, government will coordinate resources and develop partnerships with other organizations such as the BC Agriculture Council (BCAC) which delivers the Environmental Farm Plan and the Agriculture Environment and Wildlife Fund.

With increased population assessment information, Ministry of Environment wildlife managers will establish population targets and develop harvest strategies for agricultural settings based on the objectives of all sectors. The Agricultural Land Reserve will be recognized as a special zone with specific objectives and opportunities and MoE will increase its focus on proactive wildlife management solutions.

Specifically Ministry of Environment PAZWP will:

- fund incremental regional MoE positions and/or direct existing positions to act as 'point people' to coordinate and contribute toward the management of wildlife populations and crop damage mitigation in agricultural settings;
- collaborate in the development of provincial and regional agriculture zone harvest strategies;
- collaborate in regular wildlife population assessments;
- assimilate and respond to crop loss assessment information provided by MAL;
- develop and manage private land hunting coordination programs;
- develop an agriculture zone hunting license system to promote agriculture zone hunting and increase revenues;

- develop provincial policies and MOUs for issues such as the issuance of wildlife kill permits, escaped buffalo etc.;
- collaborate with the Conservation Officer Service (MoE) in the development of private land compliance and enforcement strategies;
- collaborate with MAL in the development of a public and local government education and awareness strategy designed to maintain the use of hunting as a wildlife management tool within the ALR;
- partner with other organizations and funding sources (e.g. Insurance Corporation of BC and the BCAC) to develop additional programs that promote public safety and environmental stewardship (involving biodiversity, water and recreation) on private land; and,
- establish, in cooperation with MAL, regional agriculture/wildlife conflict resolution committees.

Through the PAZWP, hunting would be promoted as an effective "win-win" wildlife management tool. An agricultural zone hunting license system would be developed to generate additional revenues that could be used to support the program (subject to Treasury Board approval).

8. New Issues Arising/Wildlife Reports:

Wray distributed handouts regarding conflicts between MOE BMPs and FPPA Normal Farm Practices. These BMPs are restricting landowners from agricultural opportunities. This issue will be discussed at the PC meeting on March 4 in Victoria.

The West Kootenays is experiencing a problem with elk in haystacks and displacing cattle from feed. The EFP may be a possibility to support fencing or other mitigation. The program is wrapping up for now but another will be forthcoming. Producers can be directed to the BCAC website for contacts.

Next Meeting: - June 18-19 along the Hwy 16 corridor or Kootenays.

The meeting adjourned at approximately 3:00 pm.

The Canada-British Columbia Agreement Establishing the Facilitation of The Disposal of Specified Risk Materials (SRM) Program was signed on April 11, 2007. The Canada-British Columbia Specified Risk Material Management Program (BCSRMMP) is funded through a 60:40 federal-provincial cost-sharing agreement between Agriculture and Agri-Food Canada and the BC Ministry of Agriculture and Lands. The program is designed to assist the province's beef processing sector in complying with the Canadian Food Inspection Agency's enhanced feed ban regulation. The purpose of the Agreement is to assist industry in adapting to new controls on animal feed by improving adequate disposal infrastructure; and, where applicable, investing in research to seek long-term, value-added uses for SRM.

There are six areas of support or subprograms under the Canada-British Columbia Specified Risk Material Management Program. These include:

A. On-Site Slaughter Plant SRM Separation and Storage;
B. On-Site Slaughter Plant SRM Destruction or Containment;
C. Regional/Community SRM Destruction or Containment;
D. Bovine Dead Stock Storage, Destruction or Containment;
E. Environmental Assessments required for SRM Projects; and
F. On-Site Slaughter Plant SRM Separation, Storage, Destruction or Containment

There have been 10 completed projects to date under the BCSRMMP, for a combined federal funding agreement amount of $ 519,302. Out of the 10 completed projects;
6 were completed under Subprogram A – On-Site Slaughter Plant SRM Separation and Storage;
1 was completed under Subprogram B – On-Site Slaughter Plant SRM Destruction Or Containment;
1 was completed under Subprogram C – Regional/Community SRM Destruction or Containment;
2 were completed under Miscellaneous funding.

There are 28 projects in progress to date under the BCSRMMP, for a combined federal funding amount of $895,623. Out of the 28 projects in progress;
13 have applied under Subprogram A – On-Site Slaughter Plant SRM Separation and Storage
4 have applied under Subprogram B – On-Site Slaughter Plant SRM Destruction Or Containment
4 have applied under Subprogram C – Regional/Community SRM Destruction or Containment;
3 have applied under Subprogram D – Bovine Dead Stock Storage, Destruction or Containment;
2 have applied under Subprogram F – On-Site Slaughter Plant SRM Separation, Storage, Destruction or Containment;
2 have applied under Miscellaneous funding.

The focus moving forward for the BCSRMMP is to implement Regional / Community Solutions to establish long term solutions in regions of the Province where they are currently inadequate or non-existent. The obstacles that the program must overcome arise from the negative public perception pertaining to environmental and social concerns associated with slaughterhouse and SRM waste disposal options.

Canada - British Columbia SRM Management Program

SRM Program Summary

SRM Program	SRM Program Applications Received	Incomplete Applications	Applications Approved by Adj. Committee	Agreements Offered	Agreements Accepted and Signed	Total Program Funds Offered	Total Program Funds Paid and Disbursed
Programs A & B: On-Site SRM Separation, Storage,	26 (-2 withdrawn)	6 of 24	18 of 18	18 of 18	16 of 18	$ 1,545,700	$ 410,401
Program C: Regional Containment & Destruction	5	2 of 5	2 of 2	2 of 2	2 of 2	$ 13,850	$ 6,055
Program D: Deadstock	2	2 of 2	-	-	-	-	-
Program E: Enviro. Assess.	-	-	-	-	-	-	-
Progarm F: On-Site	2	1 of 2	1 of 2	-	-	$ 100,000	-
Misc. Funding	3	-	3 of 3	-	-	$ 16,500	$ 8,862