SPEAKING FOR THE SALMON

GROUNDWATER AND SALMON

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PROCEEDINGS

Edited by
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Speaking for the Salmon

www.sfu.ca/cstudies/science/salmon.htm

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Background material is available by visiting www.sfu.ca/cstudies/science.salmon.htm or www.watershed-watch.org

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Meeting Purpose and Structure

Water is essential to salmon. Yet water is also undervalued and generally threatened by weak or non-existent legislation and a myriad of human activities (including climate change). While BC's "Water Use Planning" process is a step in the right direction in recognizing and affirming water's value to fish, BC's *Water Act* is antiquated in its recognition and protection of fisheries values. Nor does the *Water Act* adequately protect BC groundwater resources, the value of which can only increase.

This omission is a serious oversight. Groundwater is increasingly under threat from development and climate change. Groundwater is also increasingly recognized for its vital role in the ecology of salmon—and in the proper functioning of ecosystems in general.

Since 1998, many salmon conservation issues have been addressed through Simon Fraser University's *Speaking for the Salmon* seminar series. It seemed a natural fit for the *Speaking for the Salmon* venue to again host an enclave of interested and knowledgeable participants, whose one-day task was to discuss our collective understanding of the issues, assess our progress in protecting critical groundwater and fisheries resources, and provide suggestions on what must be improved.

Specifically, the main objectives of the meeting were to:

- Discuss critical issues and geographic areas relative to groundwater and salmon in BC;
- Provide an update on the state of groundwater legislation in BC;
- Agree on steps needed to improve consultation around water and salmon, and on better ways to protect groundwater resources important to salmon.

The meeting was structured thusly. A panel of experts opened the discussion on the above points. Their presentations are included as part of the day's record. Two case studies were then presented, and a representative of the provincial government's Water Stewardship Branch updated the audience on the ministry's progress on revising the *Water Act*. The participants then engaged in a wide-ranging discussion on issues raised in the meeting, and made recommendations on water protection and stewardship.

Panel Presentations

Sustainable Groundwater Governance

Linda Nowlan, *Faculty Research Associate, Institute of Resources, Environment and Sustainability, University of British Columbia, Vancouver, BC*

Governance is the the process by which stakeholders articulate their interests, their input is absorbed, decisions are taken and implemented, and decision-makers are held accountable. Governance can also be described as the overall structure and management processes by which resources are used. Two key elements that define resource governance structures include who is at the table, or who the decision makers are (i.e., government, public, scientists or a combination), and the process for how decisions are made. Each element contains a mix of factors which ultimately make the governance process increasingly complex.

Many principles of good governance exist and the prioritization of each principle varies between and among jurisdictions and the organizations involved. Principles of good governance include: the protection of public health and safety, and the environment; accountability for stewardship and performance; transparency of information among all people involved; equity, efficiency and effectiveness; and active participation.

In BC, several water governance models exist. The Columbia Basin Trust was mandated by legislation. As a result the area comptroller of water rights has to consider the effect of the Columbia Basin Water Management Plan when making decisions on water licences. The Langley water management plan was the first municipal water management plan established in the province. The plan was prompted by the need to resolve water use issues and was produced through a partnership between the township and the Ministry of Environment and Ministry of Agriculture and Lands. BC Hydro's water use plans were not formally mandated by the government or the *Water Act*, though are governance models none-the-less. The government requested that BC Hydro formally lead the development of these plans. The plans are developed from a consultative committee comprised of a wide variety of stakeholders. BC Hydro's water and energy needs had to be balanced with other stakeholder concerns and the needs of fish and ecosystems.

Two other models in BC include the Okanagan Water Board, which obtains expert input from the Water Sustainability Committee, which arose from the water shortage concerns in the area; and the Abbotsford-Sumas Aquifer Task Force, which is unique in that it is transboundary in nature.

In comparison to surface water, established groundwater use plans are much less common in Canada. This may be due to the fact that groundwater is not as visible as surface water, even though it is likely a larger source than all surface water combined. Groundwater has not received as much public attention as surface water in streams, lakes and oceans. Hence, the extent to which people depend upon groundwater may not be completely realized by the general public.

The regulation of groundwater is much more recent than that for surface water. When groundwater is regulated it is often treated very differently than surface water, regardless of the physical interconnectedness between the two. However, there is growing awareness surrounding groundwater problems in Canada, and initiatives exist that attempt to treat both types of water in a more integrated fashion. Evidence of this exists in BC, in areas where water shortages are of concern, such as the Township of Langley, Gulf Islands, Nicola Valley, and Okanagan. In addition, there is growing awareness of the links between groundwater and freshwater ecosystems and some jurisdictions are beginning to realize these important relationships.

Currently, groundwater data are scarce and are not compiled in an easily accessible form. Natural Resources Canada and the Geological Survey of Canada are consolidating information, conducting more aquifer mapping, and bringing more public attention to this important water resource. It is apparent that a lot is still unknown.

The nature, extent, sustainability, and vulnerability of groundwater resources on a national scale are virtually unknown. Groundwater is estimated to supply 82% of the country's rural population with drinking water, 43% of agricultural needs, and 14% of industry needs.

Much variability exists in provincial groundwater legislation. Ontario has extensive legislation compared to BC. Licensing of groundwater extraction in Ontario began in 1961 and there are currently about 2,800 licences. At present, groundwater is still not licenced in BC. British Columbia has approximately 1.1 million people (29% of BC's population) reliant on groundwater; 3.2 million depend on it in Ontario. Groundwater use in BC represents 10% of total water use (greater than 100,000 wells), compared to only 2.5% of the total in Ontario, which has approximately 500,000 wells. In Ontario, a permit is required for extractions greater than 50,000 litres/day. In contrast, the BC Environmental Assessment Act is triggered at a much higher rate of 75 litres per second (6,480,000 litres/day). Groundwater use reporting is currently discretionary in Ontario but will soon be mandatory. In BC, its use is only reported when Environmental Assessment procedures apply.

Groundwater-Surface Water Interactions and Groundwater Contributions to Low Flows

Diana Allen, *Associate Professor, Earth Sciences, Simon Fraser University, Burnaby, BC*

Dr. Allen's research team at SFU and other research colleagues (at UBC Okanagan, UBC and Environment Canada) are interested in groundwater-surface water interactions, specifically during times of low surface-water flow.

One of the research topics associated with this work involves investigation of the geologic and hydrologic controls on the interaction of groundwater and surface water. This is a very difficult question to answer because different streams interact with groundwater in many different ways. It is not always possible to generalize learning from one system to other areas. Information is needed for each stream on the amount of surface water that seeps into the groundwater system, and the amount of groundwater that seeps into the stream.

Another important topic under investigation involves the process behind the mediation of low surface flows by groundwater, particularly in view of the potential impacts of climate change. It is generally known that summer season groundwater provides a flow of water into streams and sustains base flows. These interactions can be expected to change if the hydrology of the river is altered. If groundwater levels fluctuate because of climate change, there may be a reduction in its ability to sustain base flows. Due to climate change, peak flows in some areas are predicted to occur earlier in the year. In this scenario, flow magnitude will not likely change; however, a prolonged period of lower base flow is predicted, thereby enhancing the interactions with groundwater. Presently, these interactions under current and future climate conditions are being modeled.

Groundwater-Surface Water Interactions

Gaining streams are surface water channels that gain water from groundwater systems. Groundwater temperatures and upwelling water tend to have constant temperatures. In southern Canada, groundwater temperatures are usually in the range of 10 to 12°C, and water is usually relatively high in dissolved nutrients and low in dissolved oxygen. In contrast, losing streams contribute to groundwater systems. This downwelling water varies in temperature and tends to be high in dissolved oxygen. Streams may be gaining in certain areas and losing in others; therefore, it may be difficult to categorize a stream into one of these categories. These attributes also can vary seasonally depending on water levels.

Given the important relationships between groundwater and surface water, extraction can have indirect but serious impacts on water reserves. Groundwater extraction can create what is termed a 'cone of depression' which refers to the impact shape imparted on the underground water reserve. As a result, wells located near streams can have impacts on stream levels. In gaining streams, this extraction can reverse the direction of water movement and produce a losing stream. In losing streams this effect enhances water loss. These are significant problems currently affecting surface and groundwater systems in BC.

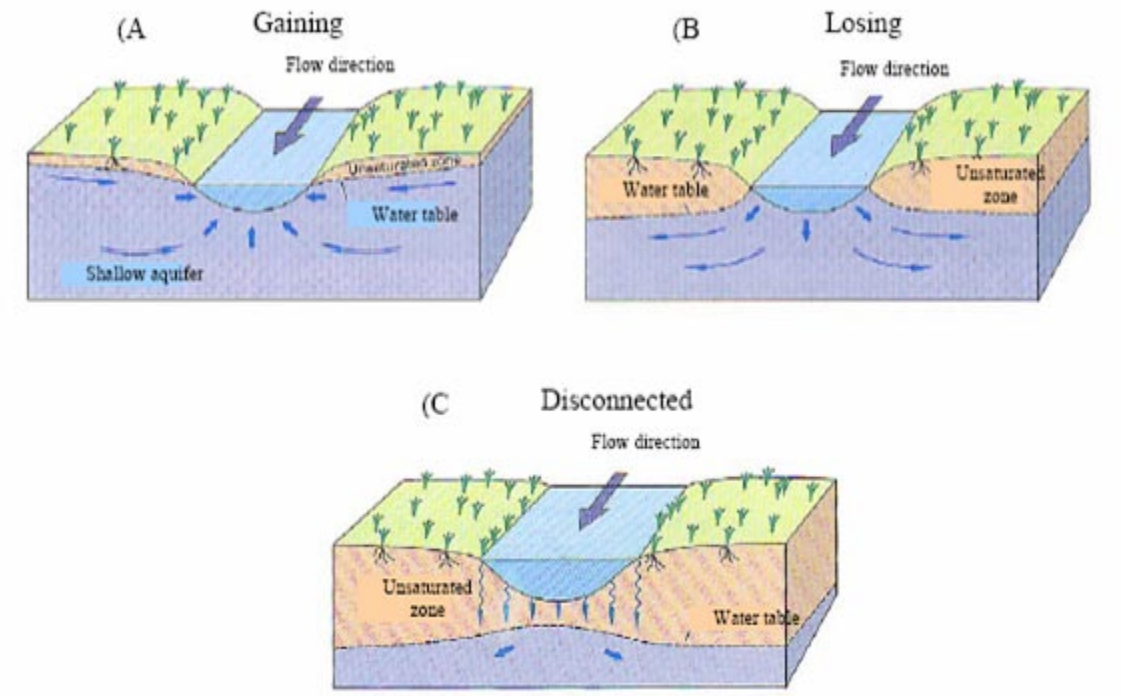

Figure 1. Generalized depiction of stream and groundwater interchange with gaining, losing, and disconnected stream reaches (Winter et al. 1998)[1].

Groundwater-Surface Water Interactions in the Okanagan Region

The purpose of this research, sponsored by the Canadian Water Network from 2005-2007, was to understand groundwater recharge in the Okanagan area through a series of targeted sub-projects. The objective of one study was to quantify the contribution of surface water from upper stream catchments to groundwater by investigating three streams. Preliminary results indicate that Shorts Creek tends to be a losing stream with about 20 to 85% of low flow going to groundwater. Upper Vernon Creek is gaining in the upper reaches and losing in the lower reaches. Other results indicate seasonal differences, and it has been observed that kokanee spawn in the lower reaches. Lastly, Vaseux Creek is predominantly a losing stream and functions to recharge the local aquifer; 24 to 100% of flow goes to groundwater, which amounts to about 14 million litres/day.

Physical and Chemical Interactions Between Groundwater-fed Streams and the Cheakamus River

The purpose of this study, conducted in 2000-2001, was to determine whether the Cheakamus River contributes to stream discharge or whether discharge is due to the upwelling of deep groundwater at the North Vancouver Outdoors School, where extensive stream rehabilitation has been undertaken. Seventy-five piezometers were installed in 1999 throughout the study area within the floodplain and in the streams. Geophysical and chemical sampling was also conducted. Strong positive correlations between floodplain water levels and river stage were observed. Hence, when the Cheakamus River is at a high stage, the surrounding groundwater is also high. A component of deep upwelling groundwater was also observed to contribute to stream flow. It was also documented that groundwater upwelling and downwelling varies seasonally; and in July, considerably more upwelling occurs than in other months.

Provincial Assessment of Trends in Groundwater Levels and Streamflow

The purpose of this study, sponsored by the Climate Change Action Fund (2005-2007), was to evaluate relationships between groundwater fluctuations and past climatic variations using available climate, hydrometric, and recording

[1] Winter, T.C., J.W. LaBaugh, and D.O. Rosenberry. 1998. The design and use of a hydraulic potentiometer for direct measurement of differences in hydraulic head between groundwater and surface water. Limnology and Oceanography 33:1209-1214.

well network data in order to gain insight on the mediating ability of groundwater to regulate summer low flows. The September data from 1976 to 1996 indicates a negative trend in surface water levels in southwestern BC (Figure 2), which corresponds to a similar trend in groundwater levels (Figure 3). The objective of this study is to draw conclusions concerning climate change and its effects on low stream flows and the resulting mitigating ability of groundwater.

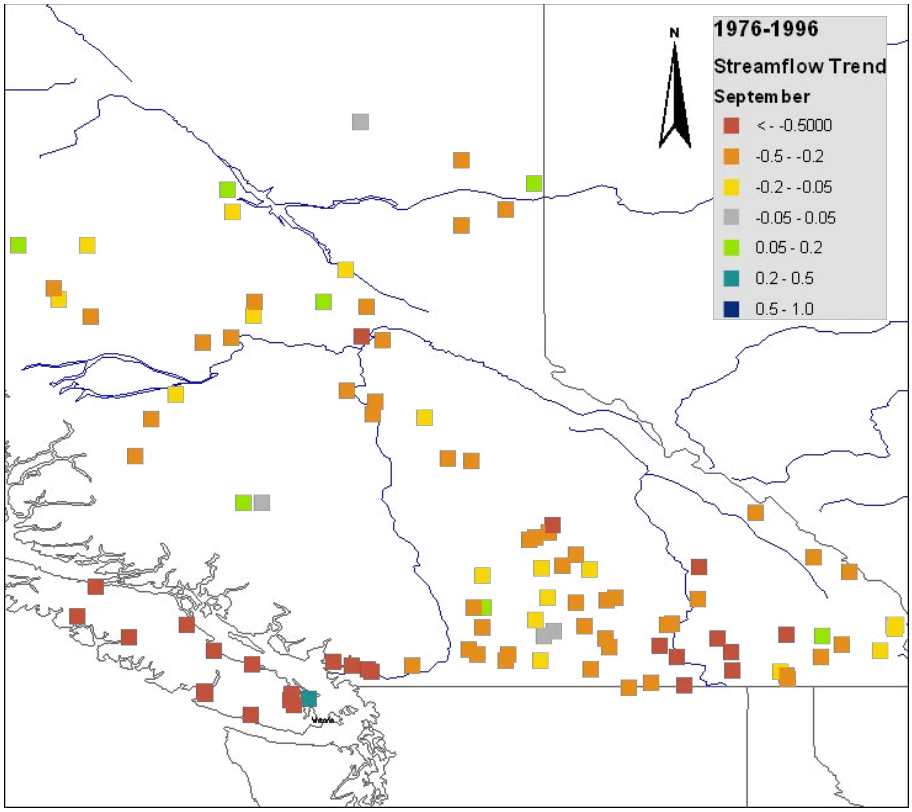

Figure 2. Trends in September streamflow, 1976-1996.

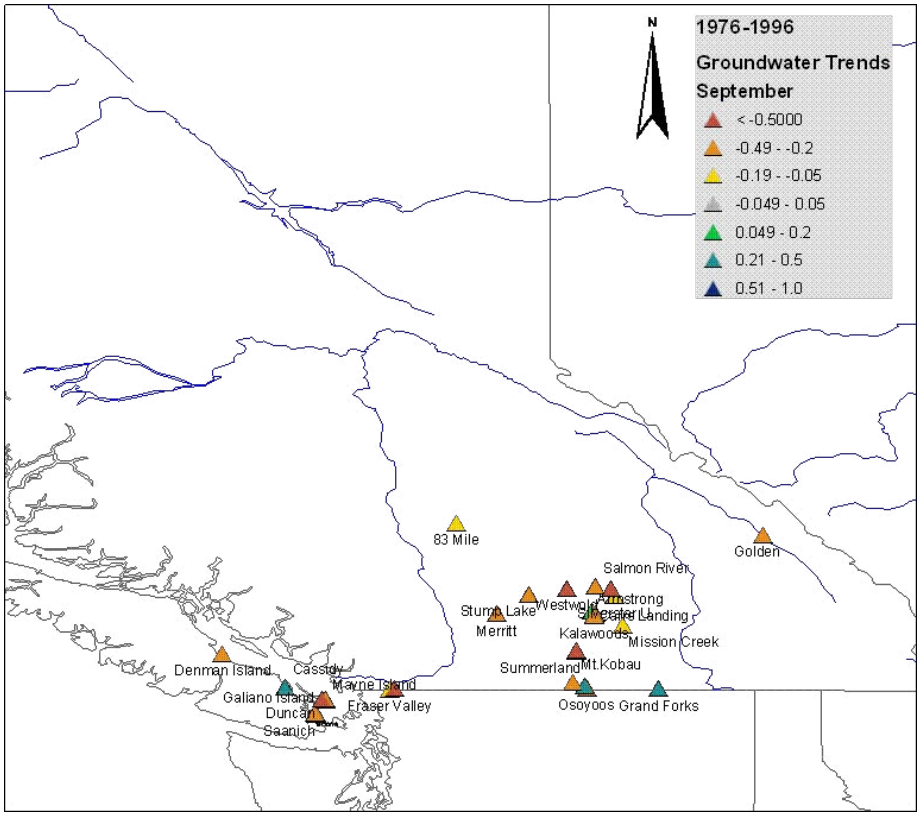

Figure 3. Trends in September groundwater levels, 1976-1996.

BC Groundwater Regulation

Randy Christensen, *Sierra Legal Defence Fund*

The Sierra Legal Defence Fund conducted a review sponsored by Watershed Watch Salmon Society on the jurisdiction of BC and its regulation of groundwater (www.watershed-watch.org/publications/files/Groundwater_Regulation_Review_SLDF.pdf). In this review we examined current groundwater regulation, the regulatory structure in place to protect fish and fish habitat, surface water regulation, and other regulatory options and examples in other jurisdictions.

Prior to 2004, virtually no regulation of groundwater occurred in BC. Hence, the processes of siting, development, usage and abandonment of wells could be done without any interaction with the government in most cases. In 2004, the *Groundwater Protection Regulation* was established. The main objectives of this regulation were to establish qualifications for well drillers and to create a public registry so that contractors could be found. The regulation also details a code of practices for well drilling and deactivation. Water supply wells need to have construction reports sent to the province.

There are several important aspects that are currently unregulated in BC. The siting of wells and extraction rates and extraction limits are unregulated. No monitoring of extraction or usage reporting exists. Prior to well development, no assessment of impacts on the environment or existing water users is conducted. Therefore the vast majority of groundwater use is not assessed in BC. The only case where wells are regulated is if their installation triggers the BC *Environmental Assessment Act*. This only occurs for a few cases each year. The number of environmental assessments that occur regarding wells in the province on a yearly basis is approximately 50. In contrast, it is estimated that approximately 1000 new wells are being installed yearly.

Groundwater use is not assessed, monitored or regulated with regards to implications for fish. A regulatory vacuum exists in BC because some legislation applies to surface water but not to groundwater. For example, the *Fish Protection Act* allows for streams to be designated and for assessments to be done, but it does not apply to groundwater. The Federal *Fisheries Act* in theory could be used to address problems regarding groundwater use including dewatering of streams, but this route is very problematic. One problem is that it is a prosecution and typically the environmental harm has already been perpetrated. Another problem is that the current scientific understanding of groundwater-surface water interactions is complex; hence, the information needed to exercise the *Fisheries Act* in this regard would be difficult.

Surface Water and Groundwater Regulation Options

For those who want to use surface water other than for limited domestic uses, they should have to apply for a governmental licence. This gives the opportunity for the government to do an assessment of the water extraction, though this is a reactive approach. In terms of some of the regulatory options available to the province, licensing above a certain extraction threshold should be established. This is a common regulation found throughout North America. In addition, the proponent should be required to do an environmental assessment as part of the licensing process. Certain objectives or conditions can be attached to licences that need to be followed by the user which may include constraints on pumping rates. Minimum set back distances from surface water sources or other groundwater wells can be enforced. This can minimize negative effects on surface and groundwater and reduce conflicts between users.

Models in Other Jurisdictions

One regulatory initiative that is quite progressive is the European Union (EU) Water Framework Directive. Some details regarding this initiative are not readily available because it is currently being implemented. The EU has identified the water basin as the appropriate water management unit of area regardless of political boundaries. This management initiative is impressive because it is occurring on an international scale. In the next few years, each major group of basins will have plans in place for the protection of water quality, quantity and the integration of surface water and groundwater management. The preferable option for BC is to begin more detailed regulation of groundwater before a serious water crisis situation develops.

Pacific Northwest Groundwater and Diversity

Jenny Brown, *Conservation Ecologist, The Nature Conservancy, USA*

The Nature Conservancy initiated freshwater and marine ecosystem conservation within the last 10 to 15 years. However, these initiatives have focused on surface water. Approximately three years ago in Oregon, the Nature Conservancy recognized the importance of groundwater to conservation. In Oregon, surface water is generally over appropriated and users are likely to extract more and more groundwater which will lead to further over-appropriation. We have begun to focus on the relationships between local ecology and groundwater and to identify ways in which the Nature Conservancy needs to get involved in order to achieve its mission: the conservation of all biodiversity. A major goal was to discover how groundwater dependent ecosystems are being threatened. It was discovered that little information exists on groundwater resources and its importance to biodiversity in Oregon.

Part of our work is focused on determining where in Oregon and Washington groundwater is important for ecosystems and species. A GIS analysis will examine how the quantity and quality of groundwater are threatened and will highlight priority conservation areas and the threatening factors. This will allow us to develop appropriate conservation strategies in high priority areas.

We are exploring whether improvements in groundwater regulations need to be addressed to improve the conservation of this resource; hence, our involvement in state policy decisions may become more significant. This summer we will be conducting a legal review of the relevant legislation regarding groundwater regulation and associated roadblocks that impede its sustainable management. The planned completion date is June 2007.

A methods guide has been developed for planners and site managers to assist them in understanding groundwater flow patterns, connectivity between surface and groundwater and hydrologic conditions required to sustain and enhance the quality of aquatic habitats. It describes approaches and tools to help non-experts understand groundwater processes within a watershed. In addition, it identifies important ecosystems and species dependant on groundwater and describes the groundwater requirements of ecosystems and species. Use of the guide also facilitates their decision making by non-experts and helps them identify where further information or studies are needed to allow for the appropriate conservation steps to be taken.

The Nature Conservancy is also involved in evaluating the success of different groundwater conservation strategies in California, Oregon and Washington, in an effort to determine the best management practices conducted by our organization and others.

These initiatives will provide information that will be integrated into environmental planning and management to ensure groundwater is managed in a way that is compatible with species and ecosystems, while meeting the needs of humans.

Groundwater and Salmon Interactions: Groundwater Moderation of Thermally Challenging Environments in the Southern Interior of BC

Richard Bailey, *Program Head, Chinook and Coho Stock Assessment, BC Interior, Fisheries and Oceans Canada, Kamloops, BC*

The Thompson Basin and Southern Chilcotin and Cariboo drainages support significant populations of spring and summer Chinook and COSEWIC listed Interior Fraser coho. Throughout much of this region (southern interior of the Fraser River Basin), stream flows are driven by winter snowfall and subsequent melt. Peak flows occur in the spring and early summer, and low flows occur in late summer and often continue throughout winter. These areas are thermally challenging for fish because it is not unusual to get summer day water temperatures that exceed 25°C which is lethal to salmon. Some systems have extended night time water temperatures remaining as warm as 20°C. Low summer flows exacerbate this situation for fish.

Given these extreme conditions, groundwater upwelling likely serves a critical function by recharging some of these streams and producing cool water thermal refugia from warmer conditions in the surrounding area. This groundwater function may be more important in this area relative to other parts of the province.

Figure 4 describes when groundwater is important for salmon in the Southern Interior of BC. There are nine months of the year where groundwater is particularly important in moderating the thermal environment for salmon. During the period of ice break up which usually begins in March through the runoff period which ends in June, groundwater likely does not have a major effect in moderating the thermal environment for salmon survival. However, as the freshet period recedes in July continuing to mid-September, groundwater upwelling is critical for providing thermal refuge habitat for juvenile salmon. In streams where groundwater upwelling occurs, Chinook and coho salmon have been observed to burrow into the interstitial spaces of the substrate where temperatures are approximately between 16 and 17°C, significantly lower than surrounding ambient stream temperature which can be 25°C.

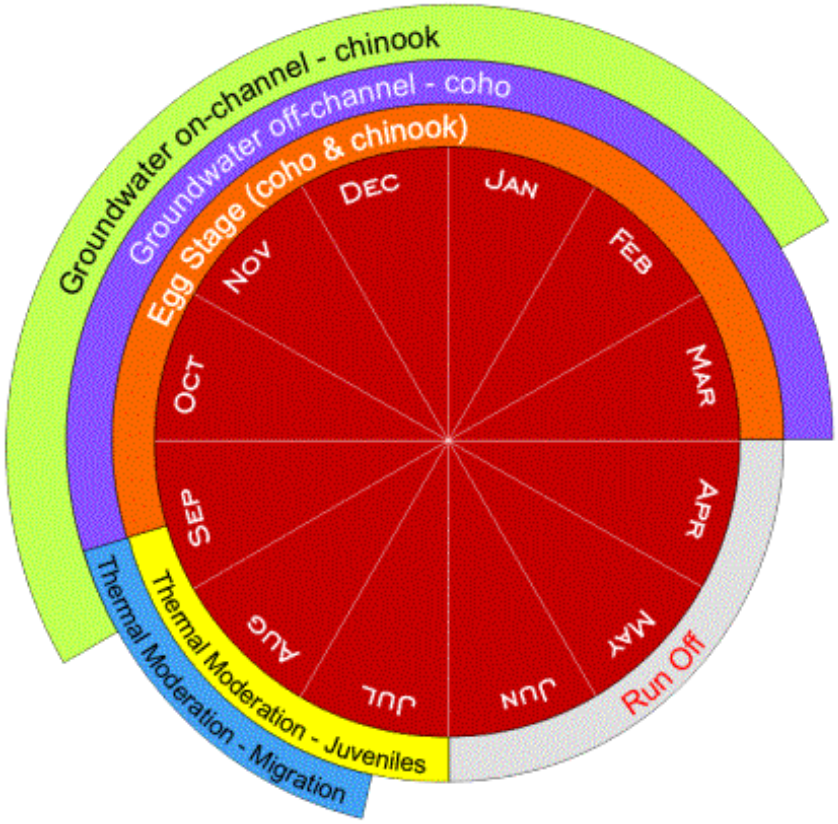

Figure 4. Summary of the importance of groundwater upwelling to salmon in the southern interior of BC. Yellow represents the summer low flow period when upwelling is important to salmon rearing by providing localized cooling and thermal refugia from day and night temperature extremes. Blue represents the summer low flow period when upwelling is important for adult migration by providing localized cooling. Orange indicates the winter low flow period when upwelling is important to redd site selection and egg incubation by inhibiting the formation of anchor ice and maintaining stable surrounding water temperatures. Purple represents the winter low flow period when upwelling provides stable over-wintering rearing temperatures and inhibits the production of ice cover. Light green represents the winter low flow period which minimizes the production of anchor ice and provides warmer temperatures throughout interstitial spaces where fish reside.

Similarly, in the Nicola and other streams in the area, groundwater upwelling likely benefits fish by thermally moderating temperature along the migration route. In these areas, large portions of the returning spring Chinook runs may hunker down in short river sections that are about 21°C and thermally moderated by groundwater, while surrounding stream reaches during mid-day are 25°C. In these areas, salmon frequently migrate during cooler night-time temperatures.

With regard to spring-run Chinook, we observed that redd site selection is almost entirely dependant on the presence of influent groundwater. A theory is that their redd site selection favours areas near groundwater upwelling because

this allows them to acquire the appropriate thermal units for proper egg development and it inhibits anchor ice formation near the redd in cold periods of winter which would otherwise kill eggs.

Chinook and coho salmon parr also have wintering strategies to survive the -20°C temperature periods that involve groundwater upwelling. Coho parr predominantly spend this time in groundwater fed off-channel habitat that is between 7 and 9°C as opposed to 0°C main channel habitat. Contrastingly, Chinook parr tend to bury themselves in the interstitial spaces of the substrate that are fed by groundwater upwelling to evade anchor ice and colder water.

Some streams in the Horsefly and Quesnel drainages are on the cusp of being considered temperature sensitive; therefore, the effects of climate change and the mountain pine beetle infestations on these areas and consequently on sockeye spawning are of great concern. In addition, we have little understanding of the effects of groundwater extraction on its ability to thermally moderate these aquatic habitats. We will begin examining the effects of extraction in temperature sensitive areas such as the Nicola drainage system using forward looking infrared technology by thermally mapping groundwater sources. In addition, we need to find out how much water we can extract from these aquifers before we degrade their thermal moderating capabilities. In summary, groundwater is likely an essential thermal moderator for salmonids in these temperature-sensitive areas.

Case Studies: Groundwater and Fish in British Columbia

Tanis Douglas, *Watershed Watch Salmon Society, Coquitlam BC*

Groundwater directly affects surface water by sustaining base flow, moderating temperature, and supplying nutrients and inorganic ions. This connectedness has implications for surface and groundwater water quantity and quality, and fish habitat.

The temperature moderating effect of groundwater is important to fish in coastal climates and more important in hotter climates or areas subject to winter ice formation. Extensive studies demonstrate fish reliance on groundwater, including use of groundwater upwelling areas for rearing, holding and spawning[2].

Extraction of groundwater will usually reduce surface flows. Extraction can have significant short-term and reversible effects on surface water flows, but also can have long-term water table depletion that affects (and even eliminates) surface flows. Shallow aquifers may be recharged if extraction ceases; deeper, ancient aquifers can take millennia to recharge.

Whether a stream reach is gaining or losing will depend on local geology and topography. This attribute can also vary seasonally.

Although a significant amount of information exists in the literature concerning the importance of groundwater to fish and habitat, there is a paucity regarding management of groundwater.

Two progressive examples of groundwater management in BC are currently being implemented in the Township of Langley in the lower mainland, and in the Nicola Watershed located in the provincial interior. (For the full case studies, please visit: www.watershed-watch.org/publications/index.html.)

Water Management Plan, Langley, BC

Many Langley stream reaches are gaining, due to the types of aquifers present in the area. Langley contains 18 major aquifers and most are shallow and unconfined (meaning they are not overlaid by a protective cap, and are vulnerable to contamination from surface activities). Langley's streams are typically groundwater-fed and originate in low lying areas. Their protection is challenging because they are often located in prime land suitable for agriculture or development. The most accessible and economic sources of groundwater that currently supply Langley with water are the Hopington, Fort Langley, Brookswood, Aldergrove and Abbotsford aquifers.

[12] Douglas, T. November 2006. Review of groundwater-salmon interactions in British Columbia. Watershed Watch Salmon Society 19p.

Groundwater modeling indicates well pumping rates (both township and private) generally result in aquifer water level declines and that water is drawn indirectly from nearby streams. A comparison between current and pre-development conditions suggests that stream baseflows within the boundaries of four heavily used aquifers have decreased between 12 and 70%. At the current rate of groundwater depletion, it is estimated that by 2018 the direction of water flow in Bertrand Creek will reverse into Aldergrove Aquifer, causing it to be a losing stream. Withdrawals from Hopington Aquifer could reduce flows in the Nicomekl and Salmon Rivers by 36%. Continued extraction from Aldergrove and Brookswood aquifers will also compromise baseflow in local watercourses.

Salish suckers and nooksack dace have limited distributions in Canada, and both are classified as endangered species and are in rapid decline due to habitat degradation and loss. Their habitat requirements include small streams with instream structure and overhanging vegetation. In Langley, these streams usually rely on groundwater upwelling. Sublethal temperatures may occur in these thermally-moderated streams if groundwater extraction alters base flows. Coho, Chinook and steelhead are also present in Langley streams and are species that are very reliant on groundwater because they remain in freshwater for considerable lengths of time during their lifecycle.

In 2006, Langley was confirmed as the first municipality to develop a Water Management Plan under new (2004) provisions of the BC *Water Act* and will focus specifically on groundwater. Water permitting is one of a number of options that may be implemented in Langley as part of this plan. If approved by the provincial government, a supporting regulation making the plan legally binding will be designed. An important reason Langley became involved in this process was that under current provincial law, municipalities do not have legal authority to regulate the development of private wells or the extraction of groundwater. Some of the township's aquifers are being depleted; hence, a new form of management and regulation is needed to prevent water conflicts and risks, including risks to fish.

Nicola Water Use Management Plan (WUMP)

The Nicola Watershed—which encompasses Merritt BC—has experienced longstanding conflicts over scarce water resources (Figure 5). There is uncertainty in whether the water supply is sufficient for population and economic growth, fish, and agricultural users. Certain waterways have had reduced flows and certain fish populations are in jeopardy.

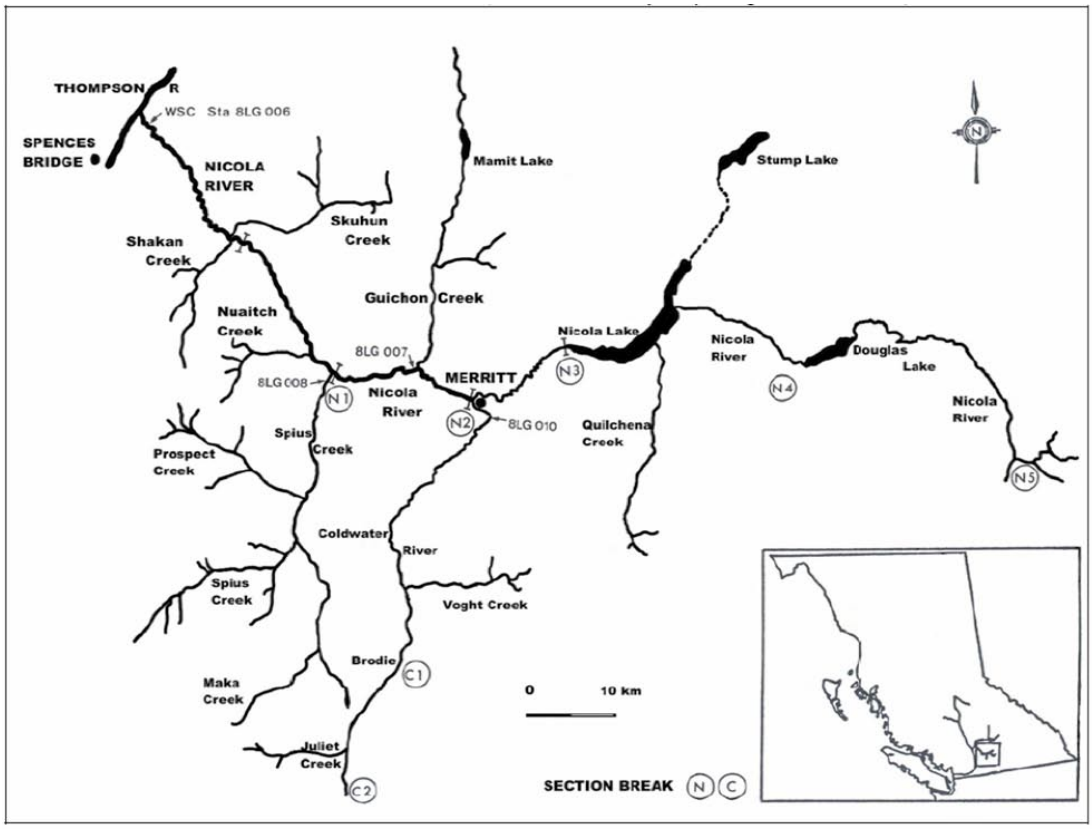

Figure 5. Nicola Watershed.

Fish populations of concern include the endangered interior Fraser coho, upper Fraser spring and summer run Chinook, and Thompson River steelhead and pink salmon. These populations are highly sensitive to changes in water quality, quantity and temperature. Stream temperatures have been affected by water extraction, riparian vegetation removal and loss of groundwater inputs. Local experts believe cool groundwater inputs create thermal refugia and are important to juvenile fish survival during short-term high temperature periods. Water temperatures can reach 25°C or higher. In addition, cool groundwater refugia are also important to adult survival during migration.

A successful community-led process in the Nicola Valley is addressing these water concerns in order to inform sustainable choices for the use and conservation of groundwater and surface water. The Nicola WUMP (2004) is a consensus-based community driven process designed by the community and gathers needed information through technical studies. The projected total cost for the entire WUMP is $1.3 million.

Some groundwater management issues that are of concern in BC include a lack of regulation, lack of scientific knowledge, lack of public awareness, the exacerbating effects of climate change, and groundwater contamination. Some of these concerns may be addressed by increased information gathering activities such as groundwater inventories, mapping, monitoring, metering and modeling. Best management practices such as improved land use, flow protection, and groundwater permitting will likely have significant positive implications on the protection of this resource. Improved regulation and planning is required beyond what currently exists in BC. The creation of the Langley and Nicola initiatives signify a need for improved groundwater management in our province.

Lynn Kriwoken, *Innovation and Planning, Water Stewardship, BC Ministry of Environment*

A concerted effort was made two years ago by the Premier to shift the provincial approach from water management to water stewardship. Water stewardship embodies governance and many levels of government and stakeholders. One of British Columbia's goals is to lead the world in environmental management, with the best air and water quality, and fisheries management. We recognize that water quality includes values such as quantity and ecosystem functioning. It is difficult to rate or compare BC's water management with other regions because appropriate comparison indicators or performance measures are not available. British Columbia's immediate goal is to create a new provincial water strategy, integrating various ministries and their interests in water. The significant components of BC's Water Strategy are governance and *Water Act* renewal. We look forward to consultations from stakeholders and other organizations for direction and input.

With reference to governance, the province is looking at ways to become more inclusive in decision making. We are looking at alternative governance models ranging from traditional command-and-control of water rights/comptroller to delegated or collaborative decision-making. We are examining opportunities to enhance water governance and water stewardship in BC and increase community and local involvement.

The province is embarking in a partnership program on water governance—the Fraser Salmon and Watersheds Program and the UBC Program on Water governance—to map out a spectrum of water governance approaches for BC, and detail case examples in the province. This will help us determine useful methods and strategies based on successful examples from the province and elsewhere. These activities are a major component of our current work, and will contribute to *Water Act* renewal.

Phase 1 of the groundwater protection regulation was enacted and we are currently working on the next incremental step: Phase 2. The groundwater advisory board is made up of experts who inform the province on this regulation. The Phase 1 regulation focuses on certification requirements for well drilling, pump installation, well identification, construction, maintenance and operation. For Phase 2, the board has considered integration of well siting, reporting requirements for users, and mandatory submission of construction reports into the regulation. The province is currently drafting the regulation and we expect to have the first stage completed by Fall 2007. There are provisions in phases 1 and 2 that will have province-wide application. Phase 3 will be piloted through the Township of Langley Water Management Plan. This phase will designate water management areas and allow for focus on critical areas that need special attention. Provisions could be included for these areas that allow for permitting and licensing of groundwater. Province-wide groundwater management plans take significant resources and provincial and local

capacity. The *Water Act* provisions that enable water management plans are being implemented incrementally at this point in time.

Although it has taken significant work to implement groundwater regulation in BC and many gaps still exist, the groundwater program on the non-regulatory side has been quite successful. This includes an increase in the number of employees focusing on this issue, characterization and classification of groundwater resources in BC and outreach.

Summary of Question and Answer Period for Lynn Kriwoken, Ministry of Environment

Comment from participant
How does the provincial government take into consideration the cumulative effects of the increased number of independent power projects (IPP) on groundwater, fish populations and ecosystem integrity when it grants permits to the proponents? Why is BC not more prescriptive such as Ontario with regards to its water licensing and permitting? Why does the province not require the proponent to address questions regarding effects on downstream users, fish populations and habitat?

Response
We will likely see more applications for IPP projects in the future because of the new energy plan. Regional staff review these applications and an increased onus is being placed on proponents to ensure the impacts of their projects are described and regulatory requirements are met.

However, the province is struggling with capacity and resource issues to process the increased number of these applications. A possible solution to this problem may be to increase the onus placed on applicants for IPP projects and water licences.

Comment from participant
Problems facing groundwater and other resources in BC are rooted in an expanding human population and a need for more resources, yet this issue is not reported on by the government. Within any basin there is a finite water budget which is recruited seasonally and there is a minimum amount for the maintenance of healthy fish populations and ecological integrity. As long as socioeconomic drivers regulate water extraction, and we foster the philosophy of economic and population growth, the outcome will be: the depletion of fish populations and ecological health. When managing water we need to consider fish as legitimate users of water.

Comment from participant
A broader approach to permitting and licensing approvals would likely be useful and be facilitated by tools such as GIS databases, Landsat, temperature-sensitive stream modeling, and groundwater mapping. These should be integrated to produce planning tools to guide wise development that protects groundwater-sensitive areas. In addition, the environmental assessment threshold for project evaluations should be lowered in areas sensitive to changes in groundwater.

Response
The Water Stewardship Division currently lacks the capacity for planning and outreach; however, at minimum all available information and databases should be available to all interested agencies and organizations.

Comment from participant
Regarding the chapter on water in First Nations treaties, it is set out in reserve; however, it is not specifically set aside for the protection of fish and fish habitat. How does the provincial government weigh First Nations interests in contrast to socioeconomic drivers when managing water requirements for fish?

Response
Regarding individual water licence applications, the comptroller or decision maker includes all First Nations' concerns in their deliberations. The decision maker is required to consider the impacts that their decision will have on First Nations' interests, including their interests in fish.

Summary of Question and Answer Period for Panel, Final Discussion and Conclusions

Independent Power Producers (IPPs)

Comment from participant
Are researchers looking at cumulative effects of IPP (run-of-river) projects and their impacts on groundwater and fish habitat?

Panel response
Modeling the effects of this type of water removal on groundwater is a small but growing field of study. The repercussions of IPPs on groundwater systems can be quite significant, though effects are dependant on site characteristics and the amount of water diverted from the river.

Comment from participant
What legal recourse exists regarding the cumulative effects of IPP projects; specifically, the removal of river water and its transfer to penstocks and the resultant effect on groundwater?

Panel response
There are two legal avenues to approach cumulative effects. The first is to object to the water licence itself through the BC Environmental Appeals Board. This may only be done by someone such as a property owner who may be affected by the project in question. Unfortunately, the current *Water Act* does not include a provision that allows other interested parties to take up such an appeal. In provinces with this type of provision, the appeal board often limits who interested parties can be. A good recommendation for the new *Water Act* is to allow for appeals by a much broader scope of interested people. The other avenue of legal recourse entails an attempt to prosecute after the project has had its negative impacts on the environment. If an IPP project harmfully alters, destroys, or degrades (HADD) fish habitat, the federal *Fisheries Act* could be used as a prosecution tool. However, the burden of proof required for an after the fact prosecution regarding effects on groundwater or the resulting effects on fish and fish habitat would likely be difficult to prove. The *Fisheries Act* in its current form is not able to deal with groundwater HADDs. In addition, it should be noted that input from the public or other interested parties has never stopped an IPP project from being undertaken in BC, though some projects have been stalled or altered, and degraded habitat has been compensated or replaced.

The state of groundwater in other areas

Comment from participant
Groundwater in the Walla Walla Basin, Washington, is over-allocated and instream flows are being reduced and are insufficient to support some native aquatic species. Upwelling springs are drying up. This situation in the Walla Walla Basin could foreshadow the future of certain basins in BC if appropriate measures are not put in place to protect provincial groundwater. Experiences in Washington have demonstrated that groundwater and surface water should not be managed at the reach scale, but at the watershed scale. Much of our groundwater is reserved in alluvial aquifers which are connected to streams and are therefore important to salmon populations. We learned that changing the hydrologic regime by using a portion of the peak flows for power production in the summer had reduction effects in base flows later in the year. In many of our systems, peak flows are a major recharge mechanism for the aquifer, which in turn, maintains stream base flows later in the season. In addition, we found an integrated approach that includes groundwater and fisheries scientists is most effective in sustaining groundwater resources appropriate for fish.

Panel response
A similar recharge mechanism occurs in BC basins that are lined with alluvial aquifers. This recharge mechanism is derived from the freshet which produces a pulse of water that moves out into the aquifer. After about 30 to 60 days, this water begins to move back towards the stream and functions to sustain base flow throughout the summer.

Groundwater science and resource regulation

Comment from participant
Given that a finite amount of water accumulates on an annual basis in each basin, is it possible for water management agencies to determine the maximum annual yield that could be extracted without significant impacts imparted upon fish and fish habitat?

Panel response
Accurately estimating the amount of water available is very difficult because of the complicated network of water inputs and outputs in each basin. All these sinks and sources vary spatially and seasonally which complicate things further. In a typical basin, inputs to surface water include groundwater, precipitation, and snow melt. Outputs of surface water include groundwater, wells, irrigation, and evaporation. There is uncertainty in our quantitative estimates of these inputs and outputs. The cumulative uncertainty is quite high; therefore, it is difficult to come up with reliable estimates of the available water in a basin. Our information needs regarding basin-wide water availability and groundwater are on a much finer scale than our current level of knowledge.

Comment from participant
The precautionary principle in fisheries management implies that when enough is not known about the functioning of a system, then conservative management measures should be applied for the protection of fish and fish habitat.

Panel response
In theory this is true; however, in practice, humans have large water needs that usually conflict with the needs of fish. As a result, decisions are made based primarily on societal and economic needs. In addition, a provincial regulatory regime will likely not make the best decisions across the board for all individual basins and communities. Regional management boards may be the most appropriate decision making body. However, at this time, many communities by and large are prevented from even participating in decision making regarding groundwater.

Actions

BC is in a good position to tailor future legislation on groundwater licensing that can lead the world. If the creation of legislation is rushed, a flawed model (e.g., first-in rights grandfathered) may be put into place instead.

Currently there are few monetary incentives for people to protect water in BC. A common mentality in the Okanagan is that "you need to use it or lose it". A financial incentive to protect water and other associated resources needs to be established in order to facilitate the protection of structure and function in BC's aquatic ecosystems. An initial step may be to identify which areas are most important and in need of conservation, then apply financial incentives in these areas since a limited amount of money will likely be available. Initiatives exist in Oregon and Washington as leasing programs. Both federal and provincial legislation would likely have to be modified to incorporate these incentives in BC. Such incentives could include: rebates, tax benefits, incentives for the conversion of water extraction licences to conservation licences, and conservation easements on water rights. Presently in BC, water flows are quantified, priced and appropriated to industry, residential users, and agriculture, but they are not conserved for fish or managed to maintain ecosystem integrity.

Currently the responsibility of demonstrating that a water extraction or development will cause harmful alteration, degradation, or destruction rests upon the federal government. However, a more precautionary strategy would be to shift the burden of proof onto the developer or water user to demonstrate the project will not have harmful effects on fish and fish habitat. As long as the burden of proof relies upon the agency (or public) and not the developer, we are fighting a losing battle.

Ecosystem-based water regulatory requirements need to be integrated into informed decision making and policy. It has been done in Washington and Oregon. These concepts need to be communicated to the public and decision makers. Instream flow requirements for ecological needs is not a new idea in BC though it is to some decision makers and needs to be integrated into the planning process.

A new coordinated initiative needs to be organized to elicit change in current groundwater policies. The Ministry of Environment, in cooperation with Fisheries and Oceans Canada, has developed coarse filter streamflow guidelines for use with IPP developments. These could be used for agriculture or other uses by the Water Stewardship Division to assess water needs. This may inform their decision making on whether to allocate or not and to develop conservation flows, fish passage flows, etc.

The *Water Act* needs to be updated and should be changed from a "first in time, first in right approach" to a hierarchical rating scheme that promotes wise use of water and deters wasteful uses.

In the development of the *Fish Protection Act*, a draft version allowed community groups to acquire water licences for conservation if they so desired; however, this component was removed from the final act version.

Other possible actions include: all communities should have mandatory regulations requiring low flush toilet installation in new developments; water requirements of river ecosystems need to be explained to stakeholders and the public; the importance of climate change and its effects on surface and groundwater need to be explained to the public and government; salmon need to be considered as legitimate and legal users of water of the appropriate quantity, temperature, chemistry and quality.

Generally we must recognize that water is important for many parts of ecosystems: waterfowl, amphibians, riparian zones, etc. We need to search out other groups with similar concerns about water resources and conservation in order to maximize our influence. These may include naturalist clubs or organizations like Ducks Unlimited. We can also present our groundwater knowledge and messaging to UBCM (Union of British Columbia Municipalities), CWRA (Canadian Water Resources Association), the Engineers Association, and the Irrigation Association, to increase the base of support for change.

The *Species at Risk Act* should be used as an influential piece of legislation to protect water and ecosystems in some areas, if all else fails. Some listed fish species are present in BC's Interior.

A delegation should also go to the Premier and/or the environment minister to press for action on groundwater conservation and protection. Politicians must be reminded of promises that have not been met. This group should be as diverse as possible, and include First Nations and non-governmental organizations.

Point Summary of Meeting Items (from participants):

- Money is a viable incentive for decreasing water use by
    - developers
    - public
    - ranchers
- Identify sensitive or important areas first
- Look at Oregon and Washington State models
- Recognize that the resource is finite
    - stream flow is result of an aquifer
- Recognize "water for fish and wildlife"
    - maybe tough to quantify at fine scale
    - precautionary management actions in the meantime (temperature, flow, chemistry)
- Educate public on aquatic systems and their degradation– refer to Langley WMP as a solution model
- Burden of proof should be on proponent (accountability)
- Revisit water regulations and value of different water uses and fish money
- Examples of instream flow requirements for fish and wildlife exist in N.A.
- Provincial government licensing- get it started
- Enforce surface water regulations
- Appropriation– don't use "First time, first in right," method because it is a broken model
- Link climate change and water
- Link pine beetle and Fraser flows
- Link concerned groups (amphibians, SARA listed fishes, waterfowl)
- Price resource at true value
- Instream flow requirements should be based on ecosystem values– need to develop appropriate regulations
- Don't rush implementation of poor regulations
- Rally community to get behind groundwater issues-education
- Influence government and provincial will– surplus of money exists
- Experts should comment on the situation and visit the provincial and federal government
- Bring message to UBCM, CWRA, Irrigation Association
- Litigation (or threat of it) can move things forward
- Strong message to the Premier or Minister of Environment to promote best water management strategies in the permitting process within an area's growth management strategy
- Support Wild Salmon Policy and use of water as habitat indicator

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