

**SUSTAINABLE GROUNDWATER REGULATION
FOR AGRICULTURE IN B.C.**

by

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Abstract

As the effects of climate change and population growth are felt in B.C.'s agricultural regions, regional groundwater resources are being depleted. As a result, the current lack of provincial groundwater withdrawal regulation can threaten regional economic well-being and ecosystem viability. This study develops and evaluates policy alternatives to regulate agricultural groundwater use in B.C. The water resource governance policies of three jurisdictions and B.C. stakeholder views are examined to guide the formulation of relevant policy alternatives. My policy recommendations include the establishment of groundwater regulations in pilot "high priority" areas where: representative regional Watershed Agencies develop water allocation plans based on studies of groundwater demand and hydro-geological characteristics, groundwater withdrawals are licensed, agricultural groundwater use is monitored and reported, priority use during droughts is given to environmental and domestic needs, and water rights are bought back by the province to reduce users' rights for environmental health.

Keywords: Groundwater; Agriculture; Sustainability; Watershed; Climate change; Ecosystem viability

Executive Summary

Water resources in British Columbia are managed by provincial authorities on behalf of the Crown and its citizens, yet B.C. is the only Canadian province that does not regulate groundwater withdrawals in its jurisdiction. The agricultural sector currently represents about 20 percent of provincial groundwater demand. However, in some agricultural regions, groundwater resources are affected by climate change related droughts, population growth and the historical over-allocation of regional surface water resources.

As a result, this study will focus on developing policy levers to regulate groundwater withdrawals in agricultural regions of B.C. through the analysis of three case studies, interviews with key informants and content analysis of B.C. stakeholder views during the B.C. *Water Act* modernization process. Three case studies of water resource governance - Australia, Manitoba, and the South East Kelowna Irrigation District - provide indications as to which water resource policy elements have been successful in international and domestic jurisdictions. Expert interviews and B.C. *Water Act* modernization consultation reports provided provincial context and stakeholder input to developing policy options for agricultural groundwater regulation in B.C.

Based on my analysis of the three case studies and B.C. stakeholder views, four policy alternatives are developed and evaluated through a set of groundwater policy relevant criteria – effectiveness, administrative capacity, equity and acceptability. The resulting preferred policy option for provincial groundwater policy in the short-term is to establish pilot governance framework in “high priority” areas where groundwater resources are declining. In such “high priority” areas, representative regional Watershed Agencies would develop water allocation plans based on studies of groundwater demand and hydro-geological characteristics. Additionally,

agricultural groundwater withdrawals are licensed, monitored and reported. In cases of drought priority use of groundwater is assigned to environmental and domestic needs. Minimum environmental standards are set by provincial authorities who can buy back water rights when users need to reduce their long-term allocations to the benefit of environmental health.

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Glossary

Term	Description
Aquifer	The storage area that is completely filled or “saturated” with water and can yield a usable supply of water for pumping and surface water flows.
Catchment	A large area of land that catches and collects water for a river, stream, creek or lake.
Consolidated Bedrock Aquifer	Water in these aquifers is located in the spaces between the rock grains or in the fractures within the more solid rock. Bedrock aquifers are fairly well defined and do not yield as much as unconsolidated aquifers.
Instream Flows	The stream flows needed to protect and preserve instream resources and values, such as fish, wildlife, and recreation.
Out-of-stream Use	Stream flow: 1) not returned to point-of-diversion - while a portion of the flow withdrawn is returned to the basin, it is usually at a location considerably downstream of the point-of-diversion and/or after some period after withdrawal; 2) returned to point-of-diversion – this refers to water that is withdrawn for purposes that result in complete or nearly complete return flow near the point-of-diversion
Recharge	A hydrologic process where water moves downward from surface water to groundwater. Groundwater is recharged naturally by rain and snow melt and to a smaller extent by surface water (rivers and lakes) and anthropologically (i.e., "artificial groundwater recharge"), where rainwater and/or reclaimed water is routed underground.
Recharge Area	The surface area through which water can infiltrate into the ground.
Surface Water Runoff	The water flow that occurs when soil is saturated to full capacity and excess water from rain, meltwater, or other sources flows over the land.
Unconsolidated Aquifer	A wet underground layer of water-bearing permeable rock or unconsolidated materials from which groundwater can be usefully extracted.
Watershed	A watershed is a unit of land, which encompasses the surface drainage area of one or more of the smaller tributaries of a larger river basin.
Water “use” or “withdrawals”	Refers to water taken from a source and used by humans. In the case of agriculture, these withdrawals include either groundwater or surface water taken from local sources or water transported via infrastructure projects.

INTRODUCTION

British Columbia's agricultural sector satisfies about 50 percent of the province's food needs and is expected to continue to increase production as population grows (B.C. Ministry of Agriculture and Lands, 2006). Access to sufficient water resources is intimately linked with the ability to cultivate agricultural land through the B.C. Agricultural Land Reserve. Currently, the agricultural and municipal sectors are each estimated to account for about 20 percent of overall groundwater use in British Columbia, with industry (e.g., oil and gas) representing most of the remaining demand. Municipal demand is expected to follow population growth, while agricultural groundwater demand will increase in times of drought, with more demanding water crops or if additional productive land is brought into cultivation.

Although the allocation and management of provincial water resources is the responsibility of the provincial government, groundwater withdrawals are not currently regulated in B.C. Given the expectations of regional lower precipitation to replenish groundwater sources due to climate change, groundwater will become more valuable to farmers and ecosystems. As a consequence, localized conflicts and declining groundwater levels, which threaten aquifer sustainability and stream flow ecosystems in some areas, are arising and will be exacerbated if a lack of effective groundwater governance persists.

Groundwater demand will be especially acute in areas where surface water licenses are already fully allocated and where surface water is unavailable, of low quality, or hard to reach. In the Okanagan in particular, one of B.C.'s main agricultural production centres, rapid population growth, climate change related droughts, and overall increased demand for water suggest the possibility of a crisis as regional surface water resources are expected to be fully allocated in the

next 25 years (Nowlan, 2005). Therefore, this study will focus on “high priority” agricultural regions, such as the Okanagan, as pilot cases for sustainable agricultural groundwater regulation and resulting long-term province-wide initiatives.

Of critical relevance to evaluating the regulatory potential for sustainable groundwater use is the relationship among governance structures, groundwater demand management tools, and incentives for efficiency and conservation of groundwater. My research proceeds through three case studies of different jurisdictions’ agricultural water governance policies, interviews with Okanagan agriculture and groundwater stakeholders as well as provincial government agency officials, and content analysis of government *Water Act* Modernization consultation reports. With that information base, I explore alternative policy frameworks for regulating agricultural groundwater demand in B.C., assessed through four criteria of comparative evaluation.

1: GROUNDWATER RESOURCES AND GOVERNANCE IN BRITISH COLUMBIA

The following section provides an overview of the context and main factors driving the need for regulation of agricultural groundwater use in “high priority” regions of B.C., such as the Okanagan. My discussion covers the localized nature of groundwater declines, the connection between ground and surface water, and the lack of integrated regulation of water resources by the B.C. *Water Act*. Based on that material, I propose a framework to define sustainability for groundwater resources.

1.1 Regional Declines in Groundwater Levels

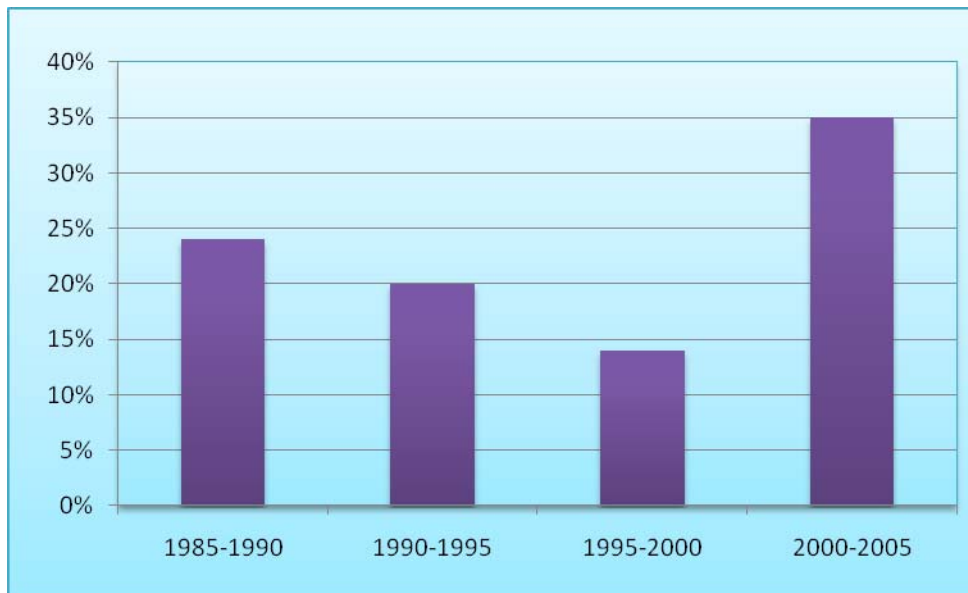
The Okanagan region is part of the agricultural heart of B.C. Rapid population growth, climate change related droughts, and inefficient allocation of surface water licenses are expected to fully distribute the region’s water resources in the next 25 years. These factors have driven the Canadian Water Resources Association to project a pending water crisis in the Okanagan (Nowlan, 2005).

Observed mean annual temperature, averaged across the Okanagan basin, showed a gradual increase between 1961 and 2006. Climate change scenarios developed by University of British Columbia researchers and the Pacific Agri-Food Research Centre in Summerland predict that winter snow packs will decrease as the climate warms. Annual melting snow packs provide fresh stream flow to rivers in the summer, helping fish spawn, as well as recharging groundwater aquifers. The upward trend in temperatures is also paralleled by increasing irrigation demand for water. General climate models project an average 33 percent increase in irrigation water demand by 2100 (van der Gulik et al., 2010).

Starting in 1961, the B.C. Ministry of Environment (B.C. MoE) established the Observation Well Network, comprised of unused groundwater wells of various developed aquifers, to monitor and collect groundwater quantity and quality data close to areas of human impact. The B.C. MoE uses the information gathered to report the percentage of observation wells showing water level changes due primarily to human activity (i.e. pumping withdrawals).

As shown in Figure 1, between 2000 and 2005, the percentage of observation wells with declining water levels due primarily to human activities was 35%, a large increase from the 14% reported between 1995 and 2000. The increase may be attributed in part to enhanced monitoring activities in all heavily developed and highly vulnerable aquifers and areas of quantity concern since the late 1990s (Environment Trends in B.C.: 2007). A closer look at 2000–2005 well data shows that groundwater level declines are localized with the majority of wells in the Vancouver Island and Gulf Islands (39%) and in the Okanagan (36%) regions, which can be delineated as “high priority” groundwater regions.

Figure 1 Share of observation wells in B.C. that show declining levels, 1985-2005



Source: B.C. Ministry of Environment

1.2 The connection between Ground and Surface Water

Although stored underground, groundwater is an integral part of the earth's water cycle. The water cycle is comprised of three inter-connected components:

- **Falling precipitation** may be absorbed by the ground, evaporate, be used by plants, join surface water bodies (creeks, streams, lakes), or infiltrate the ground and recharge groundwater.
- **Surface water** (creeks, streams, lakes) flows to larger surface water bodies, can also be lost through evaporation, and can infiltrate through the bottom of the catchment to the groundwater below.
- **Groundwater** is contained below the ground's surface in aquifers. Groundwater can be replenished through surface water or precipitation filtering into an aquifer through a “recharge area.” In turn, groundwater can leave the aquifer by flowing into surface water bodies and sustaining their baseflow. As a result, surface water catchments can be replenished by groundwater in addition to surface water runoff. During a drought, when surface water runoff is minimal, groundwater sources can sustain the baseflow of wetlands, streams, and lakes.

Given the renewable but finite amount of water that moves through interconnected states, the overall movement of water can be described as a water budget or water balance. The water budget is a conceptual tool that can help determine the source and quantity of water flowing through a watershed. The main components of a water budget with regard to groundwater are recharge, contribution to baseflow, and groundwater withdrawal. Water budgets allow for a systems approach to understanding how much ground and surface water is available, the interactions between ground and surface water, and how quickly water gets restored once it is withdrawn from a catchment or watershed (Nowlan, 2005).

1.3 The B.C. *Water Act*

According to the federal *Water Act*, both surface and ground water are Crown-owned resources. Like most Canadian jurisdictions, the government of British Columbia owns and manages the water in the province on behalf of the Crown and its citizens. Despite the hydrological connection between surface and ground water, B.C. is the only jurisdiction in Canada that does not regulate groundwater use, even when surface water is heavily allocated.

Historically, surface and groundwater have been treated separately by lawmakers because they were thought of as separate processes of the water cycle. Surface water is easily observable and as such distributed according to riparian rights, tying water rights to property ownership. Property owners adjacent to a water body (i.e., stream, lake, river) are allowed to divert water for domestic purposes (e.g., drinking, irrigation), without harming in quantity or quality the water rights of downstream property owners.

Part 2 of the B.C. *Water Act* currently regulates surface water withdrawals through long-term appropriation permits or licenses. Surface water licenses are specific with respect to: purpose of use (i.e., irrigation, domestic, etc.), maximum quantity of water, source of water (i.e., lake, stream, river, etc.), the point of diversion, the land to which the license is attached, the period of year during which the license can be used, the date of application, and the maximum rate of withdrawal for new irrigation licenses (B.C. Ministry of Agriculture and Lands, 2006).

Agricultural surface licenses have been allocated based on historical summer peak irrigation demand for water at a time when there were no population or climate change constraints in sight. Therefore, new licenses are granted incrementally, without consideration to overall resource availability and related allocation plan as water resources were believed to be abundant when the B.C. *Water Act* was first established more than one hundred years ago in 1909. Consequently, surface water licenses have been over-allocated, providing an incentive for the excessive use of the resource, beyond what can be considered as “beneficial use” for agriculture (Robbins, 2010).

With regard to groundwater rights, legal precedence distinguished between groundwater streams, to which riparian rights were applied, and invisible aquifers which are not “known”. When a groundwater body could not be defined, the rights of absolute capture designated the landowner overlaying the aquifer as the groundwater “owner.” The absolute capture rule allowed landowners unlimited access to groundwater, no matter the effect to neighbors (Nowlan, 2005).

As summarized in Table 1, the B.C. *Water Act* does not regulate groundwater withdrawals, although it contains a groundwater licensing provision that can apply to all or certain areas of the province upon cabinet’s designation. Large groundwater withdrawals (75L or more per second) are evaluated under the *Environmental Assessment Act*, while the *Ground Water Protection Regulation* covers groundwater quality related well construction standards. As well, Part 4 of the B.C. *Water Act* enables the development of local level water management plans (WMPs) in the event of adverse groundwater conditions.

Table 1 B.C. *Water Act*: Comparison of Surface and Ground Water Withdrawal Legislation

Water Act	Surface Water	Groundwater
Part 2	Indefinite private rights can be granted by the province under a license tied to land for “beneficial use”, carrying a “first in time, first in right” (FITFIR) precedence; the rights can be transferred under principles of appurtenancy	Not applicable but can be legislated
Part 3	A group of 6 or more licensees can be incorporated as a water community (i.e. purveyor, irrigation district, etc)	Not applicable but can be legislated
Part 4	The Minister of Environment can designate an area to develop a water management plan if there are conflicts and risks to water quality	The Minister of Environment can designate an area to develop a WMP if there are conflicts and risks to water quantity and quality; can restrict well drilling
Part 5	Not applicable	Well drilling standards for construction and groundwater quality protection

1.4 Defining the Sustainable Management of Groundwater

With a lack of groundwater property rights or regulation, aquifers can be thought of as a common pool resource. Such unregulated common pool resources can be subject to the “tragedy of the commons,” where unrestricted rights of access to a common resource such as an aquifer mean that users are “unlikely to restrain their own behavior when the immediate benefits of their actions are their own but the costs are passed on to society as a whole (or other specific groups), and any longer-term or external benefits that might accrue from an individual’s” restraint are not rewarded (Sophocleous, 2010, p. 562). In the case of an aquifer, without legal restrictions on withdrawals, it is in the best interest of a user to pump before his neighbour does. Moreover, if an aquifer is connected to a surface water body, existing surface water rights will be affected by declining groundwater levels.

As a result of its common resource property, the sustainable management of groundwater is necessary to prevent its excessive exploitation. The 2009 Expert Panel on Groundwater offers a comprehensive definition of groundwater sustainability that includes five interrelated physical science and socio-economic goals:

- Protection of groundwater supplies from depletion.
- Protection of groundwater quality from contamination.
- Protection of ecosystem viability.
- Achievement of economic and social well-being.
- Application of good governance.

The BC MoE is wrapping up a consultation process started in late 2009 to modernize the B.C. *Water Act* and replace it with the *Water Sustainability Act*. The B.C. *Water Act* modernization process has engaged provincial stakeholders on potential groundwater regulations while recognizing the need for an integrated “systems approach” to ground and surface water

management because of their inter-connectedness and importance in supporting fish habitat. For example, hydrological studies commissioned by the Township of Langley for its Water Management Plan (WMP) found that groundwater pumping affected not only aquifer levels but also the flows of nearby streams (TOL, 2009). In the Nicola River watershed, it was found that during the summer low flow period, influent groundwater provides localized cooling that allows juvenile and adult salmon to survive (Workshop Report, 2007). If the use of both surface water and groundwater is not coordinated by regulation, groundwater pumping can affect river and stream levels, impacting local fish populations and existing surface water rights.

Protecting groundwater from depletion in the case of a renewable resource, such as an unconfined aquifer, can mean limiting annual withdrawals to the aquifer's "sustainable yield." The "sustainable yield" of a renewable aquifer is the annual amount that can be withdrawn in the long-term while maintaining the resource at an equilibrium quantity year over year (Olewiler and Hartwick, 1998). Generally, it is assumed that as long as the rate of groundwater withdrawal from an aquifer does not exceed the natural rate of recharge or "sustainable yield", base groundwater levels are safe. However, beyond the natural rate of recharge, sustainable groundwater withdrawals tend to be lower than the recharge rates due to the change in the system water flow resulting from the use of the resource itself (Alley et al., 1999).

Additionally, good governance should consider the region-specific "unacceptable consequences" related to social, economic, ecosystem, and other factors (Alley, et al., 1999). Each regional groundwater basin is distinct with respect to climate, hydro-geological composition, and the consequences of human development and climate change, including decreasing surface water, increasing pumping costs, deterioration of water quality, and land subsidence. The interaction of socio-economic factors and the unique physical science of aquifers at a local level can determine what sustainability means on a case-by-case basis.

The attainment of economic and social well being will be the basis of groundwater policy as all agricultural land needs a basic allotment¹ of water to be productive and preserve the relevance of the Agricultural Land Reserve (ALR) policy. The ALR is unique to B.C. as only 5 percent of provincial land is suited for agriculture. As a result, the ALR was instituted to protect agricultural land from being lost to non-agricultural development. Land part of the ALR is restricted to agriculturally related activities only. Therefore, farmers need a sufficient and reliable quantity of water to sustain their livelihoods and the purpose and value of the ALR. Overall, the ALR land base, regional soil and climate characteristics set the bounds of agricultural water demand in B.C.

¹ The basic allotment provides landowners with a seasonal volume of water for irrigation, typically equal to the volume of water required for cultivation in a drought year.

2: ECONOMIC INSTRUMENTS TO REGULATE GROUNDWATER

This section provides a brief discussion of three economic instruments – pricing, auctioned licenses, and tradable water permits – that can increase the economically efficient use of water and groundwater resources. An economically efficient outcome ensures that no one can be made better off by an alternative allocation of a resource without making at least one party worse off.

2.1 Valuing and Pricing Groundwater

In order to price groundwater, the first challenge is to value its costs comprehensively. According to a 2001 OECD report, “Ideally, water pricing should cover both the (fixed and variable) cost of supplying water, the environmental cost of its extraction, and the associated rent” (Nowlan, 2005, p. 69). Table 2 shows the components of water’s value that should be priced under a full cost approach.

The full cost approach to valuing groundwater would use the concept of total economic value (TEV), which includes both the use and non-use values of water. The use value of groundwater includes its direct use (e.g., irrigation), its indirect use by ecosystems (e.g. fish habitat), and its option value in case current non-users of groundwater might need to secure its use in the future (i.e., premium paid by non-users for the future use of the resource). Alternatively, non-use values of groundwater are related to the benefit derived by the knowledge of the resources’ current and future existence, rendering them even harder to estimate than use values (CCME, 2010).

A variety of market approaches can be used to estimate the use value of water and can serve as a lower bound assessment of its value (CCME, 2010). For example, a study of the economic value of groundwater in the Assiniboine delta aquifer in Manitoba, located in a predominantly agricultural region, estimated the total economic worth of the aquifer water to be between \$4.6-\$43.55million a year (Kulshreshtha, 1994). An Environment Canada valuation study found that if Caledon, Ontario, were to lose the use of all of its groundwater, residents would lose up to \$33 million in annual consumer surplus to replace it with the next best alternative water source (Nowlan, 2005).

Table 2 Total Costs of Groundwater Use

Costs Associated with Groundwater Use	
Opportunity Cost	Cost of foregone opportunity by using a resource for one use, which precludes it from being used in alternative applications, or by future generations in the case of groundwater
Infrastructure and Administrative Costs	- Well drilling, well abandonment, water treatment - Metering, billing, record-keeping, compliance
Social Costs	Over-exploiting an aquifer can diminish availability for future users
Environmental Costs	Habitat loss, saline intrusion, and land subsidence

Source: Nowlan, 2005

If the decision-making context is one of *water pricing* or *water allocation*, water valuation is not a pre-requisite for policy formulation but is undoubtedly desirable if the objective is to identify the ‘optimal’ outcome in terms of economic efficiency. For example, water valuation can provide an estimate of the environmental and social costs associated with abstraction of water, which can be used in the setting of a charge or tax in order for pricing to reflect the ‘full cost’ of water use (CCME, 2010).

Given the uncertainty employed in determining the full or marginal cost of water, benefits can be derived if the price charged exceeds infrastructure (i.e., water works) and administrative costs and has a variable rate structure. Such a pricing structure will signal to water users the scarcity of groundwater. For example, a volumetric charge such as an increasing block

rate (IBR) charges enough to cover infrastructure and administrative costs in the low block, and signals the scarcity of water by increasing the rate charged for higher levels of use. The price in turn can affect crop choice, irrigation method, management practice, and, the amount of water applied. As a result, potential incentives to increase the efficiency of water use are introduced in addition to, improvements to water quality, increased government revenues and better decision-making by monitoring (required for an IBR) and collection of data on water use (PRI, 2005).

2.2 Auctioned Withdrawal Licenses

Water licenses or permits are commonly used by water resource departments to restrict the total quantity of water used to a certain activity at a given point of diversion (discussed in detail in Section 4.1). Permits are not necessarily allocated according to economic principles of efficiency, but according to the availability of the resource. However, in the case of groundwater, an annual auction based on the annual volume of recharge can be one way of allocating licenses while revealing the value of groundwater to users. By auctioning off licenses, the resulting permit price would reflect groundwater's economic value or the price the marginal user is willing to pay. As a result, officials can sidestep the challenge of pricing groundwater, which would be necessary if a system of water charges is implemented instead. Secondly, auctioning permits generates revenues that can be used for compliance monitoring and watershed management (Palanca-Tan, 2003).

2.3 Tradable Water Permits

Alternatively, the introduction of tradable water permits or water markets has been proposed and implemented by governments in water scarce regions to foster more efficient water use by allocating water to its highest value use. To establish a water market, regulators decide on an aggregate amount of water that can be extracted and create tradable access rights for water

withdrawals to water users, who can then trade them at prices determined by supply and demand (PRI, 2005).

In theory, in a competitive setting, markets are self-regulated and result in the maximum resource-use efficiency by moving water to its highest value use. Additionally, markets can limit the need for overall planning and management, offering a non-political means to solve conflicts over water rights.

In practice, water markets do not operate in perfect conditions, and therefore, regulations are needed to ensure equity and minimize potential externalities. A potential issue can arise if a monopoly develops, where an individual or a company gains control over a significant portion of the water rights. A monopoly can be avoided by careful initial distribution of water use rights and regulation of transactions. Local communities can also raise concerns that water markets will lead to a potential sale of local resources to other regions.

Another concern is the potential mining of groundwater if there is no set initial allocation of groundwater withdrawal volume attached to the rights. The overall water withdrawal allocated to groundwater rights should be below the annual quantity of aquifer recharge in order to prevent depleting the aquifer. Lastly, water markets will not make water available for environmental purposes unless initially structured to do so. Alberta for example has created the possibility of a “water conservation holdback” of ten percent of the allocation of a water right upon its sale for environmental purposes (Nowlan, 2005).

An important political barrier to instituting water markets is the fear that they will lead to the commoditization of water making it accessible to whoever can pay for it, irrespective of other social and environmental goals. A survey of farmers in the Okanagan finds that farmers think that it is wrong to sell water, that a water market will lead to higher water prices and will be a means to divert water away from agricultural users (Janmaat, 2008).

2.4 Implications of Economic Policy Instruments for Agriculture

2.4.1 Conservation through Increased Efficiency

Water scarce regions experience conflicting demands on their water resources. In order to decrease overall water demands, increasing water use efficiency is often proposed as the main solution. Water use efficiency refers to technical approaches to reducing the quantity of water used to achieve a certain task or output. For example in the Okanagan, about half of the agricultural irrigated acreage can use more efficient irrigation systems than those currently used. As efficient irrigation systems – drip, microspray and microsprinkler – represent only one fifth of irrigated area, van der Gulik *et al.* (2010) estimate that if all horticulture crops with irrigation systems in the Okanagan are converted to drip, irrigation water demand can be reduced by 16.5%.

However, improved efficiency does not necessarily lead to a decrease in overall water demand, as the water “saved” in one application may become available to irrigate another crop. Economic incentives such as “full cost” pricing of groundwater, auctioned licenses, and water markets will provide incentives for water users to decrease their overall water use by increasing their water use efficiency (PRI, 2005).

2.4.2 Enabling Inter-Sectoral Transfers

The use of economic policy instruments can enable transfers of water from one sector to another, by encouraging efficiency and sending the “saved” water to its highest value use. In theory, unrestricted water markets and auctioned licenses should allow the highest price bidder to access the needed water rights, increasing the economic efficiency of water use. Similarly, introducing a pricing scheme that signals the scarcity of water and increases the use of its efficiency, will allow freed up water to flow to an underserved sector. Thus, conflicts that often arise between existing agricultural water rights and the growing water needs of the municipal sector can be resolved in a non-political manner.

3: SYNOPSIS OF INTERNATIONAL WATER GOVERNANCE POLICIES

The following section presents a survey of water and groundwater policies of international and domestic jurisdictions. I consider several key components of water policy required for sustainable management of the resource: water rights, governance frameworks, environmental externalities, decision-making tools, and demand management instruments.

3.1 Water Rights

In order to integrate groundwater and surface water regulation, a groundwater license or permit is a common way to define and limit withdrawal rights, similar to the allocation of surface water rights in B.C. A license provides the holder with the right to use a specific quantity of water for a specific activity at a particular location during a certain term. Appendix 1 provides details on groundwater permitting in Canadian jurisdictions.

Like many western provinces (e.g., Alberta, Saskatchewan, Manitoba) and states (e.g., Kansas, Colorado, New Mexico, Oregon), B.C. assigns surface water allocations according to the prior appropriation doctrine based on “First-in-Time, First-in-Right” (FITFIR) seniority (Nowlan, 2005). This method leads to a clearly defined hierarchy of rights based not on ownership of the land overlaying the aquifer, but on the act of having withdrawn groundwater and put it to “beneficial use.”

Conflicts under prior appropriation systems are resolved based on the license-holder’s level of seniority, penalizing junior licensees first. If a drought occurs, junior groundwater license-holders are issued a stop order for pumping. Some jurisdictions with FITFIR have introduced flexibility in their systems. For instance, in Colorado, junior groundwater licensees can

implement an augmentation plan that provides replacement water of appropriate quantity and quality for senior permit-holders and enables the junior license holder to circumvent the existing seniority ranking (Sophocleous, 2010).

In other US states (e.g., California, Nebraska, South Dakota) and Australia (in prescribed areas where groundwater licenses are needed), correlative rights are adopted. Correlative rights give landowners equal rights to the water of an underlying aquifer. In times of drought license holders will share the pain together and reduce their allocation proportionally (Productivity Commission, 2003). During droughts, Oregon instead gives precedence to stock watering and domestic consumption regardless of FITFIR rankings (OWRD, 2009).

Instilling flexibility in the management of water resources in case of uncertainty has led to the adoption of adaptive system approaches to managing a watershed (e.g., Australia, Colorado, South Africa, California). Within an adaptive framework, the quantity of water available each year to license-holders can vary because of evolving environmental needs or climate conditions in the basin. Therefore, adaptive water management can lead to uncertainty in the water supply available to license-holders.

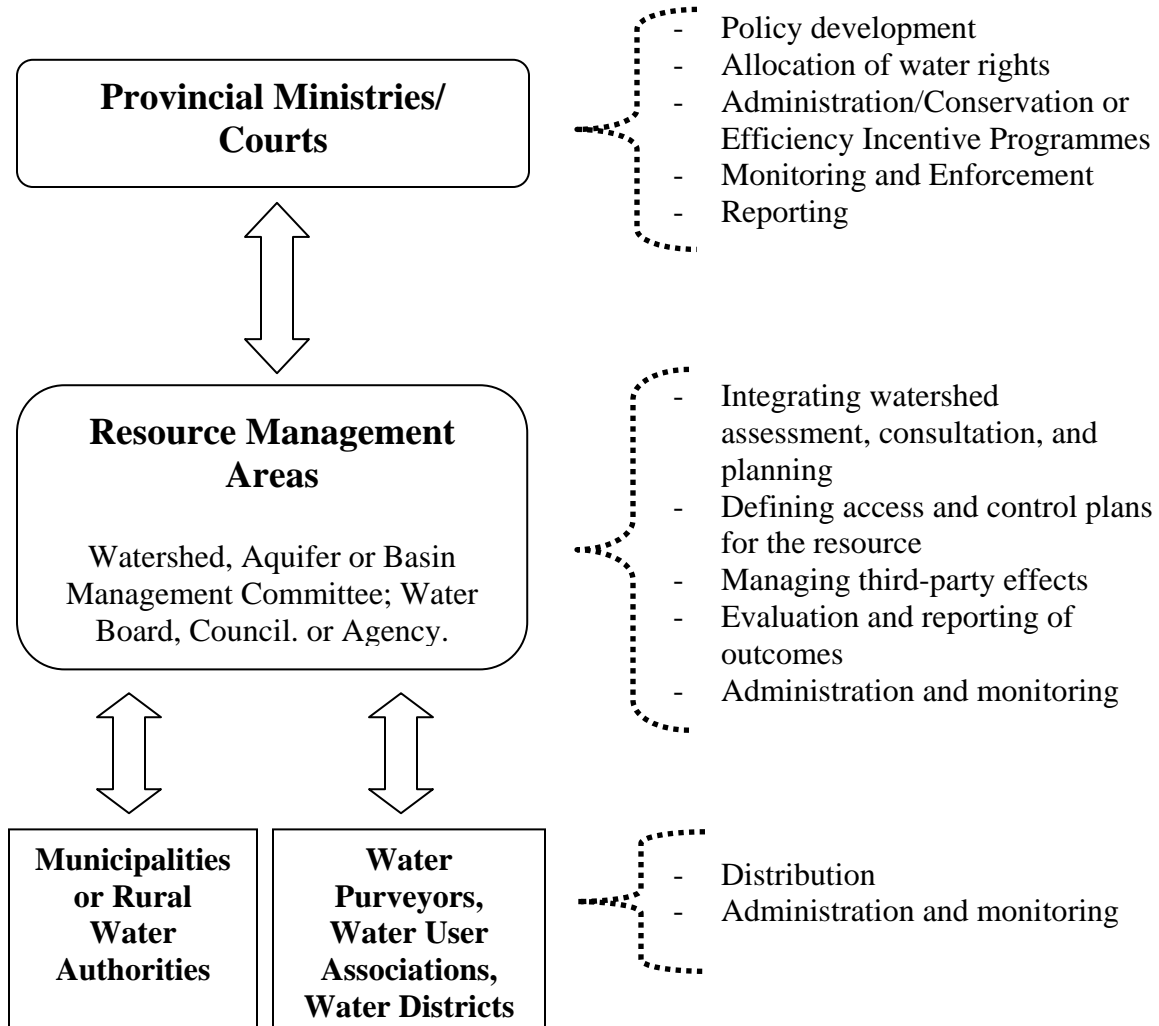
In California, state authorities attempt to introduce a level of certainty for existing water right holders by buying back water rights needed for environmental conservation. In contrast, Australian environmental flow requirements can restrict a water right from being exercised on a daily basis. However, the Australian state of Victoria ensures a highly predictable right for a minimum volume of water to license-holders (Productivity Commission, 2003).

3.2 Governance Frameworks

The number of organizations and their respective levels of responsibility in managing water resources vary among jurisdictions. Jurisdictions can distribute the authority for policy development, water allocation, administration, distribution, and monitoring and enforcement

between central government and local organizations. Figure 2 provides an illustrative example of how these functions might be assigned among a provincial government, agencies with regional jurisdiction, and authorities or user associations at the local level.

Figure 2 Water Resources Management Governance Framework



Source: Author

Generally, policy development and allocation functions are assigned to government departments and advisory bodies. Depending on the water rights regime in place, the distribution of power between government departments and courts can be instrumental in conflict resolution. When water rights are attributed to individual users (e.g., California, Chile, Colorado, Texas), the

courts can be essential in clarifying laws and settling policy reform-related disputes among license holders.

When groundwater exploitation practices become unsustainable and threaten the quantity and quality of the resource, a jurisdiction can give the regulator the ability to designate an aquifer or basin as a priority area (e.g., Kansas, Oregon). For example, the *Water Appropriation Act* in Kansas allows the Chief Engineer – usually the highest supervisory authority in prior appropriation jurisdictions – to commence public hearings and establish an Intensive Groundwater Use Control Area (IGUCA). A variety of tools including the institution of a moratorium on new permits, apportioning existing withdrawal allocations, and requiring the use of licenses to alternate, can be used to re-establish a “safe yield” for the IGUCA. For example, senior irrigation pumping rights were reduced on the basis that efficient irrigation could be achieved with lower water quantities (Sophocleous, 2010).

Nebraska has adopted a more comprehensive strategy by delegating its water governance delivery to local management agencies whose jurisdiction extends over the area of a watershed. These natural resources districts (NRDs) allow for the integration of science and decision making in managing all natural resources within their boundaries. The locally elected NRD board members are provided with a broad and flexible range of authority including abilities to tax, regulate, monitor, provide financial incentives, and enforce regulations. The legitimacy of NRDs’ decisions can be contested by license-holders in the state’s courts (Sophocleous, 2010).

The delivery of water resource management through local, self-governing water organizations can lead to conjunctive water management. Conjunctive management aims to coordinate water resource use to “reduce exposure to drought, to maximize water availability, to protect water quality, and to sustain ecological needs and aesthetic and recreational values” (Blomquist et al., 2001, p. 654). Conjunctive management methods adopt a systems approach to water resources management by capturing excess precipitation and surface water and saving it by

recharging groundwater aquifers. In turn, during periods of surface water shortage the saved water can be pumped. Essentially, water is “banked” during wet years and withdrawn during times of drought. Thus, water needs are met by shifting withdrawals from surface to groundwater, and vice versa, according to their relative availability.

In order to ensure policy effectiveness within a framework of conjunctive management, officials have to act as facilitators of the local institutions that manage water resources. Western American states (e.g., Colorado, Arizona, California) that adopt regional management of water resources have adopted a conjunctive management framework. In 1996, Arizona created the Arizona Water Banking Authority to encourage storage of unused surface water allotments to recharge groundwater. In Colorado, surface water right holders are generally senior to groundwater licensees, and preserving their right is a statutory priority when groundwater pumping affects surface water levels. Junior groundwater users use conjunctive water management in order to maintain their pumping rights and surface water levels (Blomquist et al., 2001).

3.3 Environmental Externalities

With increasing scientific knowledge of the environmental externalities of unsustainable water management, jurisdictions have attempted to incorporate environmental flow considerations in the allocation of permits by setting aside a certain quantity of water for ecosystem needs (e.g., Australia, South Africa, Alberta, Ontario). In Ontario, similarly to Manitoba and Nova Scotia, groundwater licensing statutes consider the cumulative effects of groundwater withdrawals on basin health and the rights of previously licensed users by requiring a hydrological report with a license application. Other jurisdictions (e.g., Oregon, Australia, Alberta) allow or require water right holders to sell or transfer their rights for environmental use. In Alberta, when water rights are transferred, up to ten percent of the allocation can be subject to a “water conservation holdback” to protect riparian flows or conserve water.

Alternatively, the 2002 Deschutes Groundwater Mitigation Program in Oregon requires license applicants to acquire groundwater mitigation credits. These credits are used to abate the impact of groundwater withdrawals through instream transfers, aquifer recharge, storage release, and water conservation projects within an annual zone-based framework. Applicants can purchase credits from other individuals or acquire temporary credits through the mitigation bank (Deschutes River Conservancy).

Another way to sustain ecosystem resources such as fish, wildlife and recreation is to preserve instream flows (i.e. how water is used within the stream). In light of the connection between groundwater and surface water, many US states take into account instream flows when approving groundwater wells located close to surface water. For instance, in Wisconsin, any proposed high-capacity wells (100,000 gallons/day² or 70 gallons/minute³) located in proximity to surface water or that do not return water (water bottling) have to undergo an environmental assessment.

3.4 Decision Making Tools

In order to develop effective policies and management plans, collecting and maintaining accurate and timely information concerning groundwater use is a prerequisite for informed policy and effective governance. For example, jurisdictions applying “sustainable yield” practices (e.g., Manitoba) need monitoring information in order to establish “sustainable yield” levels. Kansas’ Groundwater Management Districts require flow meters for monitoring of non-domestic groundwater use and provide tax incentives to well owners for installing meters (Sophocleous, 2010). In Canada, several provinces that license groundwater extraction (e.g., Manitoba, Newfoundland and Labrador, Nova Scotia, Prince Edward Island, Saskatchewan) require metering as well.

² 378,541 L/day

³ 265 L/minute

Although monitoring infrastructure can be expensive, it also contributes to the enforcement of groundwater licensing and pricing policies. Enforcement of rights is necessary to ensure the predictability and fairness of appropriators' rights to a defined quantity of groundwater. When rights are enforced and predictable, investment in improved infrastructure such as water works and irrigation technologies will follow. The predictability of rights is high in Western American states with licenses for the appropriation of a specified quantity of water.

In addition to monitoring, using computer modelling to assess the hydro-geologic nature of local aquifers augments the level of scientific knowledge that can inform the development of watershed plans. This technique is useful in providing a timely and detailed picture to assess the consequences of pumping and droughts on aquifer levels, as well as evaluating the potential of different groundwater management plans. On the downside, computer models require complex and extensive aquifer measurement, which can be costly and time consuming. For example, Texas spent \$8,218,682 between 2001 and 2007 on the mapping of 19 aquifers as part of its successful Groundwater Availability Modeling initiative (Sophocleous, 2010, p. 566).

3.5 Demand Management Instruments

Incentives for conserving groundwater are generally lacking in regulatory frameworks. Instead, increasing water use efficiency has been a common government goal. For example, since the early 1980s, states in the US High Plains have focused on slowing down the rate of groundwater depletion with a focus on increasing irrigation efficiency. As a result, state-run cost-sharing programs were instituted to help lower the cost for irrigators of efficient irrigation system adoption, such as low-pressure drip technology (e.g., Kansas). Although water use efficiency increased, no gross reduction in groundwater pumped occurred, and in some cases groundwater use increased as producers expanded their irrigated area and planted more water-intensive crops (Sophocleous, 2010). Therefore, if a license allows for a certain quantity of withdrawal without incentive to diminish gross water pumped, conservation may not be encouraged.

Market approaches to water management are often expected to encourage efficiency of water use. Some jurisdictions have adopted transferable or tradable water licenses (e.g., South Africa, Australia, Spain, Alberta, Colorado, Nevada, and Utah). Tradable water rights motivate investments in water efficiency, allowing for excess or “saved” water to flow to its most valuable use. For example, the Australian agricultural sector benefits from the ability to trade both temporary and long-term water allocations as will be discussed in the Australian water market case study.

Alternatively, water-right buyout programs (e.g., Nebraska, Colorado, California, Kansas, Spain) can ensure a decrease in withdrawals, while being more cost-effective than cost-sharing efficiency programs. Water-right buyouts are often to the benefit of the environment, while compensating users for the loss of their right. In cases where the rights to pump have to be reduced, compensation also ensures a level of equity for the license holders. For example, the state of Washington finances water conservation projects under the condition that saved water will be transferred back to the state (Christensen and Magwood, 2005).

Ontario requires the consideration of water conservation potential when reviewing new license applications. Conservation groups in Ontario proposed to achieve water conservation goals by limiting new permits for municipalities unless conservation measures are instituted, including metering. The B.C. government took a similar stance towards the South East Kelowna Irrigation District (SEKID). When the SEKID requested additional surface water licenses, the province denied additional water allocations until conservation measures were undertaken. As a result, both water metering and punitive pricing for excess water use were implemented in the SEKID, reducing consumption of water mainly by irrigators by 40 percent (PRI, 2007). The example of the SEKID will be further discussed in the case studies analysis section.

Charging fees for ground and surface water can represent another incentive to conserve water. Fees for extraction are commonly used in the US, Europe, Japan, and Australia. In Canada,

agricultural use charges are usually based on the number of hectares being irrigated or a volumetric flat rate granted by a water license. As license volumes are not monitored in most Canadian provinces, including B.C., both fee schemes are administratively simple and do not require metering. However, they also tend to lead to water-wasteful behaviours, as the rate charged is independent of the quantity of water used. On the other hand, the use of increasing block rates (IBR) as instituted in the SEKID can reduce excessive water demand since the price per unit increases with the quantity of water consumed (PRI, 2005).

4: CASE STUDY ANALYSIS

This section provides a detailed analysis of international and domestic jurisdictions with innovative institutional arrangements and water management practices to address water shortages in agriculture driven areas. Three cases are examined to provide input for policy analysis and options development. The cases are chosen at different jurisdictional levels underpinned by the same water rights regimes, exhibiting a variety of policies to regulate and conserve water, as well as differing involvement from communities. After exploring the key characteristics of each case, the strengths and weaknesses are evaluated. I then infer the lessons for potential groundwater regulation in B.C.

4.1 Methodology

Water resource governance can be structured at different jurisdictional levels –provincial, basin, watershed, and sub-watershed – and is instituted most often when water shortages occur in that area. Additionally, all jurisdictions experience tradeoffs between socio-economic development goals and maintaining the hydro-geological sustainability of a watershed, especially in time of water shortages. As a result, the case studies were chosen so as to explore the characteristics, including strengths and weaknesses, of those jurisdictions’ choices in structuring their water resource governance. The relevance of the case studies pertains to examining the frameworks for allocation of water rights, and the respective reform processes and policy elements that can contribute to a new groundwater framework for B.C. The three case studies examined include Australia’s national strategy for water markets in the Murray Darling Basin (MDB), the sub-basin approach of the South East Kelowna Irrigation District (SEKID) in B.C., and the Manitoba Water Stewardship collaborative water resource governance.

The case study information gathered is qualitative and collected primarily from academic articles, government statutes and documents, and in the case of the SEKID, an interview with the general manager, Toby Pike. The information gathered is assessed using a comparative evaluation framework as compiled in Table 3.

Table 3 Case Study Evaluation Framework

Jurisdiction Characteristics	Measurement
Background	<ul style="list-style-type: none"> • Size and location of the area being managed • Principal water consumptive activity in the area
Water Rights	The regime governing the allocation of water rights and irrigation demand management in case of shortages
Governance Framework	<ul style="list-style-type: none"> • Who has the authority for policy development, water allocation, administration, distribution and monitoring? • Is emphasis on bottom-up (local) or top-down management? • Is management on a case-by-case basis? • What are the conflict resolution mechanisms? • Is surface and ground water management integrated? • Is the public involved in decision-making?
Environmental Externalities	Is there a mechanism that considers environmental externalities from groundwater use?
Decision Making Tools	What are the sources of information supporting management, policy-making, and enforcement?
Demand Management Instruments	What kinds of instruments exist for water demand management (i.e., conservation, efficiency)?
Performance	What are the strengths and weaknesses of the management approach?

The evaluation framework considers seven characteristics for each case study, with some categories providing an umbrella for multiple indicators. With the exception of the background and performance categories, which are needed to provide context and evaluate the strengths and weaknesses of each case study, the remaining five categories are related to the main water resource management factors evaluated in the literature review. Therefore, the nature of water rights, governance arrangements, environmental flow considerations, decision making tools, and

demand management incentives are discussed for each jurisdiction, providing the substance for the ensuing policy analysis and options.

While Table 3 outlines the broad categories and the respective indicators needed to evaluate the case studies, Table 4 provides a summary of the results obtained from the analysis of each case study. Further detail of results in Table 4 is included in Sections 5.2, 5.3, and 5.4.

Table 4 Case Study Evaluation

Jurisdiction Characteristics	Murray Darling Basin (MDB) Water Markets - Australia	South East Kelowna Irrigation District (SEKID) -Canada	Manitoba Water Stewardship (MWS) - Canada
Background	Agriculture covers and uses about 80% of the MDB; 61,000 farms with groundwater representing 14% of their water demand.	About 500 irrigators use 85% of SEKID surface water supply; Groundwater is contingency supply in times of shortage.	Groundwater satisfies about one fifth of Manitoban water needs; about half of groundwater use is for agriculture
Water Rights	Prior Appropriation, FITFIR and Reasonable use for licenses; Correlative rights in times of shortage; Tradable rights	Prior Appropriation, FITFIR and Reasonable use for licenses; Correlative rights in times of shortage	Prior Appropriation, FITFIR and Reasonable use for licenses for >25 m ³ /day, for up to 20 years; Priority use in times of shortage
Governance Framework	Commonwealth coordinates basin strategy; States legislate and allocate watersheds in their jurisdiction	Member elected board of trustees enacts bylaws under provincial jurisdiction	Provincial government legislates and collaborates with local governments
Environmental Externalities	Environmental allocations mandated by states; Government can buyout water rights for the environment	Bylaws do not address environmental needs.	Minimum Instream Flow Need (IFN) has to be considered when allocating licenses
Decision Making Tools	<ul style="list-style-type: none"> • Metering • Annual water use reporting • Hydrological studies 	<ul style="list-style-type: none"> • Metering • Basic water allocation • Water use reporting 	<ul style="list-style-type: none"> • Metering • Annual water use reporting • Hydrological studies
Demand Management Instruments	<ul style="list-style-type: none"> • Tradable water rights • Rights buyouts 	<ul style="list-style-type: none"> • Increasing block rate (IBR) for excess water use 	<ul style="list-style-type: none"> • “Sustainable yield” aquifer allocation • Local and funded Conservation Districts (CDs)
Performance	<ul style="list-style-type: none"> • Strong trading within agriculture • Grandfathering of over-allocated rights • Little allocated to environment • Groundwater not fully integrated 	<ul style="list-style-type: none"> • Little excess use; • Overall water use declined by 40% because of IBR • Unregulated groundwater used as contingency • Participatory governance 	<ul style="list-style-type: none"> • Lowest per capita water use • Watershed level management • Shared governance • Groundwater levels constant for 25 years

4.2 Murray-Darling Basin Water Markets, Australia

Background

Australia is the driest inhabited continent on Earth, and in many parts of the country – including the Murray-Darling Basin (MDB) – water for rural and urban use is comparatively scarce. The MDB is often referred to as Australia’s “food basket” spanning over 14 percent of the country (i.e., 1,061,469 square kilometres) and four states. Agriculture is the dominant economic activity in the MDB covering about 80 percent of the Basin and using 83 percent of water in the Basin. Based on the 2006 Agricultural Census, the MDB has about 61,000 farms that use water predominantly from surface water (84%) and groundwater (14%) sources, reliance upon which increases during dry periods.

Water Rights

Historically, both surface and ground water were allocated through licenses granted at will with water rights vested in each state’s Crown. With no consideration to overall resource availability in the MDB, water resources were granted incrementally, and therefore over-allocated. In 1994 and 2004 (i.e., the National Water Initiative (NWI)), the federal, state, and territory governments agreed to a series of water law reforms that included:

- A system of water entitlements (i.e., FITFIR based grandfathered licenses) backed by separation of water from land title, allowing for their trading.
- Water access entitlements became described as a perpetual share of the consumptive pool of a water resource (both surface and groundwater).
- Groundwater licenses are granted only in jurisdictions with resource issues.

Additionally, the 2004 NWI set out the principles for risk sharing and potential associated financial compensation between water users and the government. Risk sharing principles define

the party that will bear the financial consequences in the case that water rights need to be reduced.

The principles vary for each state (Quiggin, 2008):

- In the case of drought or climate change related water shortages, water users bear all the risk of changes in allocations and are not compensated.
- Water entitlement holders bear reductions up to 3 percent at the end of a statutory planning cycle (e.g., 10 years) as a result of sustainable system limits reassessment, while the government compensates entitlement holders for reductions in excess of 3 percent.
- Government financially compensates farmers for any policy related changes or changes during a statutory planning cycle.

Governance Framework

In the early 1990s, a series of droughts, growing conflicts, and environmental issues in the MDB highlighted the need to rethink water resource management. As a result, institutional reforms separated regulatory, resource management, and service provision roles. The Commonwealth government assumed a coordinating role, and the states received hundreds of millions of dollars as incentive to fulfil the reforms. The Water Liaison Committee of the MDB is responsible for estimating the MDB water available to each state, which in turn determines the regulatory structure, allocation, administration, monitoring, and enforcement of its water market. Recently, the states conferred specific authority to the Commonwealth over the MDB, establishing the Murray-Darling Basin Authority to develop a whole-of-basin water allocation strategy by 2011 (Speed, 2009).

Watershed level authorities develop water resource strategies and plans to define the sustainable borders of a watershed, limit total water withdrawals, and allocate water for environmental purposes. Individuals hold a tradable license for a share of the total quantity of water available every year. Additionally, regional authorities set the rules determining annual

proportional “water allocations” between users, distribute allocations, manage regional water markets while safeguarding other users’ and environmental rights, and provide compensation if reforms affect the value of licenses (Reed, 2010).

On a local level, water purveyors (e.g., irrigation trust, irrigation cooperative, etc.) hold bulk water licenses and distribute the water to individuals who hold tradable licenses for a share of the water available every year. When each individual share of water is determined, it becomes water in “the bank” which can be used, traded to another user, or “banked” for future years (Janmaat, 2008).

Environmental Externalities

Each state has the statutory responsibility to develop resource management plans that specify an environmental allocation as a volume or share of watershed flows. Environmental flow requirements for ecosystems are provided by state level resource planning expert panels. Plans incorporate environmental goals, which can be achieved by restricting withdrawals, regulating infrastructure operations, and at times setting “environmental allocations” (Reed, 2010).

The Commonwealth Government is responsible for questions of national interest. Environmental objectives can be achieved by using either state water management statutes or the national *Environment Protection and Biodiversity Conservation Act 1999* to allocate water for environmental purposes. However, state environmental allocations have been insufficient to improve the health of the MDB. In response, the national Commonwealth Government has committed AU\$3.1 billion to buying back MDB water rights on a voluntary basis from farmers over ten years for environmental purposes (NWC, 2008).

Decision Making Tools

The 2004 NWI specifies the need for water metering for agriculture to support charging or water trading. Water distribution organizations are required to provide annual water reports

accounting for trading activity and water resources. Senior agencies need the reporting information in order to determine allocation for future cycles. Additionally, enforcement is delivered by state agencies that do not have a role in distributing water.

Demand Management Instruments

Creating a water market has encouraged increasing irrigation efficiency, in order to trade the saved allocation. However, the majority of trades have occurred in the agricultural sector. To transfer water to urban and municipal needs, the government has pledged AU\$12.9 billion over ten years to buy back water rights (Speed, 2009). However, water rights are usually purchased on a voluntary basis.

Performance of the MDB Water Market

Trading in the MDB is determined by the supply and demand for water allocations and tends to be restricted mainly within the agricultural sector and sections of each watershed, reflecting the hydrological constraints of transporting and storing water. Nevertheless, during the 2007-2008 year (NWC, 2008) about 76,000 surface water and 31,000 groundwater entitlements were issued with at least 4,087 water access entitlement transfers (8% of the volume was bought by governments for the environment) and 28,118 water allocation trades recorded. The estimated value of transactions amounted to \$1.68 billion and the majority of trading activity occurred during the summer months in the MDB.

Despite the successful uptake of MDB water markets there are ongoing challenges associated with the grandfathering⁴ of historically over-allocated licenses. The grandfathering of tradable permits ensures that entrenched livelihoods will not be adversely affected by reform. However, grandfathering also perpetuates existing issues in jurisdictions where reforms were intended to address historically over-allocated rights to scarce resources.

⁴ A clause in an agreement that protects certain rights granted in the past even when conditions change in the future.

Additionally, there are issues related to the regulatory framework. For example, transactions that require regulatory approval, both for entitlement and allocation transfer, can be subject to long processing delays and market depth (number of transactions). The legal complexity of interpreting a perpetual share of water volume in a watershed by courts in each state can vary from state to state (McKay, 2008). A lack of trades or transfers between the agricultural and urban sector has been the case (NWC, 2008). The entirety of groundwater resources has yet to be integrated within the existing water entitlement system (CSIRO, 2008).

Lastly, although reducing a user's water rights without compensation is legal, the government is buying water rights on a voluntary basis because of the economic and social expectations created by the granting of rights (Speed, 2009). Therefore, water quantities diverted for environmental purposes have been minimal despite the dire environmental state of the MDB.

4.3 The South East Kelowna Irrigation District, Canada

Background

The South East Kelowna Irrigation District (SEKID) is an improvement district in charge of delivering water over 9,000 acres of land for city of Kelowna residents and irrigators. The majority (85%) of the water used in the SEKID is by the agricultural sector, consisting of approximately 500 irrigation connections. The water is drawn from a reservoir part of the 65 square kilometre watershed of Mission Creek, mainly replenished by melting winter snow packs. Climate change related droughts have lead to lower snow pack levels and increased demand of water for irrigation. Instead of increasing the SEKID's water allocation, the provincial government asked the district to show water conservation measures before changing the district's water allocation.

Water Rights

Surface water rights in B.C. are based on FITFIR licenses held by the irrigation district on behalf of its members (i.e., irrigators and households). However, in times of shortage or drought, according to the district's bylaws, correlative rights apply and therefore water allocations can be reduced proportionally depending on the magnitude of the water shortage.

Governance Framework

Improvement districts in B.C. are mainly regulated by Part 23 of the *Local Government Act*, and to certain degree by the *Water Act*, the *Drinking Water Protection Act*, and the *Waste Management Act*. An improvement district is governed by a board of trustees, which has the authority to pass the district's governance bylaws in accordance with the *Local Government Act*. The board of trustees consists of district members elected by fellow members. For example, district bylaws determine the manner in which the district's activities are funded and water is distributed. The district levies fees for the delivery of its services as well as penalties for excess water use.

Environmental Externalities

Environmental needs are not within the authority of an improvement district. Therefore, the district's bylaws do not address environmental flows specifically. However, as part of the irrigation water distribution bylaws, the district can set annual irrigation allotments.

Decision Making Tools

To begin its water conservation program, in partnership with the Ministry of Agriculture and Lands and Agriculture Canada, the district started a six-year agricultural water study programme. In 1994, the SEKID began installing meters to monitor water use and inform farmers' irrigation decisions. The district's metering program was undertaken with a provincial

grant under the B.C. Green Plan. Water use information from meters is collected several times throughout a season and reported to farmers.

In addition to land use, crop type, soil, and irrigation systems' information, metered water use data allowed the board of trustees to determine basic irrigation allotments for each licensed irrigator. The basic allotment provides landowners with a seasonal volume of water for irrigation, typically equal to the volume of water required for cultivation in a drought year. Buy-in from members was sought by freezing rates for six years until the basic water allocation⁵ was determined.

As a result, a pricing scheme for water use was instituted to penalize irrigators who exceeded their basic allotment or the "beneficial use" of water for irrigation. The first block amounts to the basic water allocation and is free of charge, while exceeding quantities are charged at an incrementally increasing rate (Appendix 2). Therefore, metering is also needed to enforce the volumetric price structure while tracking the effect of pricing on water demand.

Demand Management Instruments

After six years of metering and water use research, analysis and education, in 2000, a flat rate was introduced of \$100 for water used in excess of the basic water allotment. Subsequently, in 2003, the volumetric rate became a punitive increasing block rate (IBR) for excess water use. An IBR is expected to promote water use reduction because consumers should be more responsive to prices in the higher priced blocks than in the lower priced blocks. For example, an increase in water use above the basic water allotment by up to 10 percent would be charged a nominal rate or an average of \$40. The penalty continues increasing with each incremental 10

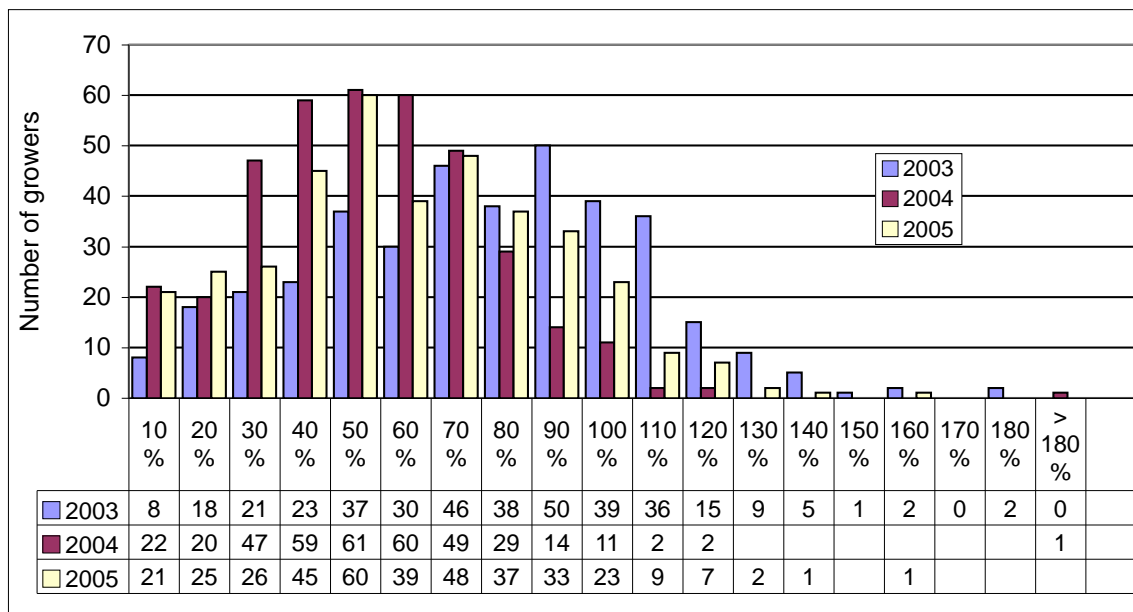
⁵ This was done by collecting data from each property on crop, irrigated area, soil type, and irrigation system. Climate information was collected from a weather station at the district yard. From this information the estimated water requirement of the irrigated acreage in the district could be calculated for a given period of time. The basic allotment is a weighted average drought year requirement covering a variety of soil types spread out over the distribution area of the district (Pike, 2005).

percent increase in water use such that when a user exceeds the base allotment by 70-80 percent, the penalty amounts to almost \$1400 in extra annual charges (Pike, 2005; PRI, 2007).

Performance of the SEKID

The basic irrigation allotments and punitive IBR were meant to allocate water according to need in a drought year, while penalizing significant water waste and encouraging water conservation. As can be noted in Figure 3 below, in 2004 there were no more large users (i.e., irrigators who exceed their basic water allotment by 130%) in the SEKID compared to an average of 5 percent in the previous three years. Overall, analysis shows that once weather conditions were accounted for, water use declined by 40 percent due to the pricing program. Metering and education alone did not have a significant impact (PRI, 2007).

Figure 3 Water Use in the SEKID as Percentage of the Basic Water Allotment, 2003-2005



Source: personal communication with SEKID's General Manager

Therefore, in the SEKID regulation through the basic water allotment and an IBR has proven more effective than education alone. The program delivered a reasonably priced service to irrigators, allowing for the equitable allocation of water during droughts, according to correlative

rights. As a result, the water savings allow the district to provide water supply security in case of repeated droughts. “This method can recognize and allow for values that are not easily measured in economic terms and may be an alternative to using systems that provide access to the resource based on the highest dollar value and ability to pay.” (Pike, 2005, p. 13)

However, because of the lack of groundwater regulation in B.C., in times of drought, the district draws on groundwater supplies as a contingency source. In fact, the SEKID commissioned a Groundwater Contingency Supply Plan to explore supplementing its water supply year round, and not just during the irrigation season.

4.4 Manitoba Water Stewardship, Canada

Background

Manitoba’s agricultural sector satisfies provincial needs and export markets. There are 19,054 farms, mainly located in central and southern Manitoba. Groundwater supplies meet one fifth of provincial water needs. Groundwater is the main source of water in rural areas, especially in the southern part of the province where some aquifers are fully allocated. Almost half of provincial groundwater demand is for agricultural use (44%), followed by the industrial (22%) and municipal (17%) sectors (Nowlan, 2005, p. 31)⁶.

Water Rights

Groundwater rights in Manitoba are vested in the Crown and are governed by the prior appropriation doctrine with licenses distributed according to FITFIR seniority and stipulation of the “beneficial use” of the resource. Groundwater licenses are required for irrigation volumes greater than 25,000 L/day. The license specifies a quantity of water with a limited term, usually less than twenty years. In times of drought, FITFIR seniority can be overridden by the Minister,

⁶ The remaining 17% include “Other” groundwater uses such as recreational, space heating/cooling, firefighting, flood control and habitat.

who can declare priority use for domestic and municipal water demand (Mathews, 2006). If higher priority uses arise and water resources are fully allocated, the Minister can cancel existing licenses upon payment of compensation (Nowlan, 2005).

Governance Framework

Manitoba is the only Canadian province with a ministry dedicated to water resources policy - Manitoba Water Stewardship (MWS). The latter is responsible for water policy development, including public consultations, license allocations, enforcement, and administration in accordance with the 1987 *Water Rights Act* and the *Ground Water and Water Well Act*, which govern groundwater rights in Manitoba.

Additionally, Manitoba's water governance emphasizes watershed level planning and local initiatives through aquifer management plans and watershed Conservation Districts (CD) under the auspices of the MWS. Aquifer management planning zones are located mainly in southern Manitoba where several important aquifers are either fully or nearly fully allocated. Regional authorities develop aquifer management plans to establish "sustainable yield" values for aquifers in their area (Mathews, 2006). Alternatively, on a watershed level, a Conservation District is a group of rural municipalities working in partnership with the province to develop programs to manage effectively the natural resources in the CD's area.

Environmental Externalities

The imperative to address ecosystem needs is pervasive through provincial water legislation. For example, the 2006 revision to the *Water Rights Act* addressed the need for minimum instream flows by giving the Minister the right to restrict water use based on scientific information. Water license allocation decisions are based on the Instream Flow Need (IFN) metric that establishes a threshold for water pumping. If the flow is lower than the IFN for a

water body, the user is not allowed to pump further. The IFN was instituted to protect both ecosystem needs and other users' rights.

Decision Making Tools

Aquifer management is based on water cycle science as water budgets are calculated to evaluate the “sustainable yield” of aquifers in southern Manitoba. “Sustainable yield” policies have led to a moratorium on new groundwater licenses in six of thirteen sub-basins of the Assiniboine Delta Aquifer in Southern Manitoba (Nowlan, 2005).

Water licensing statutes require metering and reporting of water usage. The province also has an extensive network of 470 monitoring wells mainly in the southern part of the province. This information is used for planning, allocation, and management of the resource. Groundwater records can also be made accessible to the public.

Demand Management Instruments

When aquifer management adopts a “sustainable yield” approach, a limit is effectively established on groundwater extraction from an aquifer based on its recharge rate. A share of annual recharge is allocated for licensees and domestic use (Mathews, 2006). Alternatively, where recharge volumes are insufficient, pumping moratoriums are imposed.

Conservation is encouraged at a local level by municipalities and regional agencies through the development of Integrated Watershed Management Plans. For instance, eighteen Conservation Districts (CDs) cover 60 percent of rural Southern Manitoba (i.e., Agro-Manitoba). CDs raise funds that are matched by the province for the management of natural resources in major river watersheds. The benefits of CDs include long-term resource management vision and planning, collaboration with MWS and Manitoba Agriculture, Food, and Rural Initiatives (MAFRI), local knowledge and community participation, integrated management of all resources in the basin, and education of community members.

Performance

- Manitoba has a ministry dedicated to provincial water resources stewardship;
- The MWS Minister can declare priority use in cases of water shortage;
- The MWS emphasizes integrated watershed management planning;
- Although statutory policy authority lies mainly with the Minister of MWS, regional community involvement is supported to implement policies in different watersheds. Regional involvement contributes to provincial credibility while addressing localized resource constraints with a long-term view;
- Although initial estimates of “sustainable yields” for aquifers have proven to be conservative, they provide added flexibility for affected communities (Mathews, 2006);
- Groundwater levels have remained relatively unchanged in the last 25 years;
- Manitobans have one of the lowest per capita water consumption rates in Canada, mainly because of widespread metering as required by provincial legislation.

4.5 Key Findings

Case studies of the selected jurisdictions and their water resource policies show that existing natural resource policy and political institutions (i.e., water rights), entrenched interests, and the characteristics of a watershed determine the path of reforms and water governance. As a result, most jurisdictions’ water policies have both strengths and weaknesses when considering their application to another jurisdiction, such as B.C. The three case studies help draw several important lessons for potential groundwater regulation in B.C.:

- Monitoring is an important basis for data collection, reporting, and decision-making.

- Agricultural water demand is bounded by the basic allotment of water needed during the hot season for the irrigation of an acre of land as shown in the SEKID case study.
- The ability to trade water allocations can lead to increased efficiency of water use but not necessarily environmental flows conservation, pointing to the need to buy back water rights for the environment as seen in the MDB water markets case.
- Buy-in of policy reforms from local farmers and communities is important in order to achieve effective and equitable resource governance outcomes as shown in the SEKID and Manitoba Water Stewardship case studies.
- Partnerships (i.e., funding and governance support) with watershed level organizations and agencies can lead to local buy-in and policy customization to the watershed's needs as seen with Manitoba's Conservation Districts and the SEKID.
- Flow for environmental protection should be mandated through the department responsible for water policy and allocation as done in Manitoba and the MDB.
- Shared governance between the water resources department and at the watershed level can provide a holistic approach to managing water resources in a region as instituted by Manitoba Water Stewardship.
- Punitive increasing block rate pricing for excess water use can reduce demand and non-beneficial use of water for agriculture as shown in the SEKID case study.

5: B.C. STAKEHOLDER INPUT

5.1 Methodology

My preceding review of existing groundwater policies in other jurisdictions and surface water reforms in B.C. sets a useful background for potential groundwater regulation in B.C. However, given the current lack of such regulation in B.C., I require localized context for political institutions and stakeholder expectations and preferences for future groundwater regulation. Thus, I have assessed the views, knowledge, and preferences of B.C. farmers, academics, officials, and environmental organizations with respect to provincial reforms.

The information analyzed is gathered from: 1) records of public consultations with B.C. stakeholders during the 2010 *Water Act* modernization process which includes questions on potential groundwater regulation; 2) elite interviews conducted by the author with B.C. officials and academics with expertise on water resources and agricultural policy; 3) the results of a survey of Okanagan farmers conducted by one of the interviewees, John Janmaat.

Interviewees were selected from provincial departments related to water and agricultural policy, regional water agencies, and academic institutions. Their views were sought because of their expertise on agricultural practices and water issues in the Okanagan, as well as their knowledge of groundwater science and aspects of water governance and policy development. Appendix 3 presents the list of elite interviewees and their affiliations.

The stakeholder submissions to the 2010 B.C. *Water Act* modernization process chosen for content analysis included those of environmental non-governmental organizations (NGOs) and the agricultural sector, which includes views of agricultural associations such as the British

Columbia Agriculture Council (BCAC), as well as farmers. The stakeholder submissions analyzed supplemented the categories of stakeholder views obtained from the expert interviews.

5.2 B.C. Stakeholder Views on Groundwater Policy

Background

Farmers, officials, and academics show general support for groundwater regulation. For example, a survey of Okanagan farmers implies a general concern regarding a potential groundwater tragedy of the commons, where a farmer maximizes groundwater withdrawals at the expense of adjacent landowners' access or surface water rights when ground and surface water are connected (Janmaat, 2008).

Barring a tragedy of the commons, agricultural stakeholders are intent on preserving the sector's water allocation as water is a prerequisite to cultivate land. Although, the current view is that water is plentiful, its future availability is important to the development of the Agricultural Land Reserve (Janmaat, 2010). Consequently, farmers are intent on maintaining their seniority rights over an overall pool of water and propose the creation of an Agricultural Water Reserve to match the Agricultural Land Reserve.

Moreover, they are concerned by the potential costs related to metering, water efficient irrigation, and treating water as a commodity (B.C. WAMa, 2010). Agricultural stakeholders believe that added costs would render their businesses uncompetitive. Okanagan farmers also believe that water is essential and it would be wrong to sell it (Janmaat, 2008).

Water Rights

Regulating large groundwater withdrawals and "high priority" areas are the main policy proposals explored during the B.C. *Water Act* modernization process (B.C. WAMb, 2010). However, most stakeholders support more comprehensive licensing of all groundwater

withdrawals. Within a licensing framework, given existing agricultural use, the expectation is that current agricultural wells will be “grandfathered” based on FITFIR seniority, with new regulation applying to future users. Existing rights are important because when farmers first started pumping, their right to pump was within the law. If farmers need to curtail their pumping, compensation for associated production loss is expected.

However, in times of shortage, both correlative rights and priority use should be considered (Wei, 2010). For example, Okanagan farmer survey responses give domestic use priority over irrigation needs, while considering food security to be a key priority as well (Janmaat, 2008; B.C. WAMa, 2010). In contrast, NGO stakeholders consider environmental needs to be a priority along with domestic use.

Governance framework

Although water resource jurisdiction is provincial, regional implications arise with provincial, watershed, and sub-watershed level management parameters (Pike, 2010). Almost all water systems are defined by their source. The B.C. *Water Act* gives local governments the ability to manage water resources through participatory water management planning. The majority of B.C. *Water Act* modernization submissions indicate that collaboratively developed, administered, and enforced mandatory allocation plans should be required of decision makers, especially in order to address potential water scarcity.

A collaborative, participatory, bottom-up approach to water resource management is preferred to help people who are directly affected achieve better outcomes and adopt a longer-term view to resource management (Pike, 2010). Therefore, some stakeholders suggest that provincial partnerships with local organizations, coordinated by a semi-independent watershed group (e.g., Watershed Agency). Such a collaborative partnership would include regional stakeholders to manage water resources and provide impetus and backing for reforms (B.C. WAMa, 2010).

However, water resources are a provincial responsibility and authority should not be delegated to local organizations without providing the appropriate resources to fund service delivery (Jatel, 2010). Many supporters of collaborative governance would prefer a self-sustaining funding structure for regional authorities (B.C. WAMa, 2010).

Additionally, an integrated approach to managing water resources is endorsed because of the connection between ground and surface water (B.C. WAMa, 2010). A survey of Okanagan farmers finds that more than half of respondents share concerns that groundwater pumping can threaten surface water rights (Janmaat, 2010). In that case, the pumping of groundwater means unregulated access to licensed surface water. Therefore, surface and ground water units in government need to communicate both provincially and federally to ensure the integrated management of the water cycle (Allen, 2010).

Lastly, B.C. well observation network records show that groundwater issues are often concentrated in certain areas that can be considered “high priority.” For example, groundwater quantity issues exist in the South and North Okanagan where groundwater can be an important source of water supply. Specifically, the North Okanagan suffers interference between uphill and downhill pumping and interaction between ground and surface water when pumping is close to a stream and effectively withdraws surface water (Janmaat, 2010). For groundwater problems in “high priority” areas, available resources for monitoring and enforcement would be used most effectively if groundwater withdrawal regulation were applied on a “high priority” aquifer basis (van der Gulik, 2010).

Environmental Externalities

In a survey of Okanagan irrigators’ water management attitudes and practices, a broad consensus supports preserving agricultural water allocations as a priority, especially in light of the purpose of the Agricultural Land Reserve. Therefore, if water conservation is needed for environmental flows, most farmers would prefer that water savings come first from outside of the

agricultural sector, and that if farmers are required to reduce their water use to the benefit of environmental flows, appropriate compensation should be provided for their loss (Janmaat, 2008).

While ecosystem standards are a priority for British Columbians, farmers might be tempted to forego consideration of environmental flows without provincial allocation standards (Pike, 2010). A water supply and demand model for a watershed can be developed to include environmental factors. However, neither provincial nor local government may have sufficient resources to enforce environmental flow requirements (B.C. WAMa, 2010).

Decision Making Tools

Consensus arose during elite interviews and B.C. WAM consultations about the lack of information on groundwater resources and use, and the corresponding need to increase data collection and reporting, including mandatory well registration in a provincial well registry. While groundwater accumulation has taken thousands of years, the oldest monitoring well records date since the 1960s.

Unlike surface water flows, which are observable and easily evaluated, groundwater levels cannot be observed without monitoring. Monitoring is needed to provide a scientific basis for potential regulation, and enforce it, as in the case of a pricing structure or licensing. For example, when the Township of Langley (TOL) was in the process of developing a groundwater management plan, despite initial opposition, groundwater metering was the only item that reached consensus, although it was not instituted in the agricultural and rural areas (Robbins, 2010).

Demand Management Instruments

Groundwater pricing is viewed as an alternative to encourage conservation by some interviewees. A price would internalize the value of water in agricultural production and drive water conservation through water use efficiency gains (Janmaat, 2010; Robbins, 2010). For example, the SEKID instituted penalties for excess water use through a punitive increasing block

rate. The basic water allocation or first block of water is priced to cover administrative and infrastructure costs, while water used exceeding the first block is “fined” in order to discourage excess water use. An increasing block rate is adopted to send the signal that increasing use of water is discouraged.

Another way to restrict groundwater use is by capping pump flow (van der Gulik, 2010). For example, the Township of Langley WMP recommends capping pump peak flow for irrigation to 5 US gpm/acre⁷, requires a hydrological assessment for any well with capacity exceeding 50 US gpm⁸ and mandates a 60 metre riparian setback⁹ for wells with capacity greater than 10 US gpm¹⁰ (TOL, 2009).

On the other hand, water markets are expected to be ineffective in a small agricultural watershed such as the Okanagan because of the small number of farmers compared to the size of the MDB watershed. Rather, with a small watershed and number of participants, participatory management can be more appropriate (Janmaat, 2010). Another concern for a B.C. water market is that urban development would purchase water rights away from agriculture, conflicting with farmers’ desire to preserve their water allocations (van der Gulik, 2010; Jatel, 2010).

5.3 Key Findings

The content analysis of results from elite interviews, B.C. *Water Act* modernization consultations, and an Okanagan irrigator survey (Janmaat, 2008), lead to several important findings concerning water rights, governance framework characteristics, environmental needs, decision making tools, and demand management instruments for groundwater regulation in B.C. According to all stakeholders, increased data collection (e.g., monitoring, well registration), scientific studies and reporting of results are required for informed analysis and decision-making

⁷ 18.9L/acre

⁸ 189L

⁹ Wells close to a fish bearing stream have to be at least 60 metres away from the stream.

¹⁰ 37L

on groundwater resources in the province. As well, an integrated approach to managing water resources is endorsed because of the connection between ground and surface water.

Existing groundwater users, especially those whose livelihoods depend on the current regulatory framework such as farmers, expect their interests to be factored into potential reforms. To that end, they advocate for an Agricultural Water Reserve to complement the Agricultural Land Reserve and meet the current and potential irrigation needs of productive agriculture in B.C.

Stakeholders also state preference for clear, predictable and enforceable provincial regulatory standards for water regulation as opposed to general guidelines. They also endorse a collaborative approach to governance with appropriate resources provided to both provincial and regional agencies to deliver water resource management and governance. For example, the provincial government's role is to set overall requirements for protection of environmental flows and to give precedence to domestic and environmental needs in times of shortage through the establishment of proactive localized drought management plans.

Observation network well records show that groundwater issues can be limited to "high priority" areas. Targeting groundwater reforms first to such problem areas, can allow for better distribution of limited provincial resources. In such areas, groundwater withdrawals can be controlled through licenses, a pricing scheme such as an increasing block rate or by capping well flow pump rates.

6: POLICY ANALYSIS

6.1 Objectives

From the analysis of case studies, stakeholder views and in light of population growth and climate change impacts, the regulation of groundwater for agriculture should address the sustainable management of groundwater resources in the agricultural sector of B.C.

Achieving sustainability goals for groundwater resource management is important in order to preserve the quantity of groundwater to the benefit of the social and economic well-being of current and future generations of British Columbians, as well as ecosystems affected by the connection of ground and surface water.

Groundwater resources have formed over thousands of years – a process that commands an intergenerational, long-term view to groundwater governance and management (Allen, 2010). In order to set effective long-term plans, there are short-term needs for information on groundwater demand and supply (i.e., aquifer hydrogeology), especially in “high priority” areas where the effects of depletion and climate change are already occurring. Also in the short-term, regional governance consultative processes should be undertaken and watershed areas defined in order to establish the boundaries and foundations for water allocation planning.

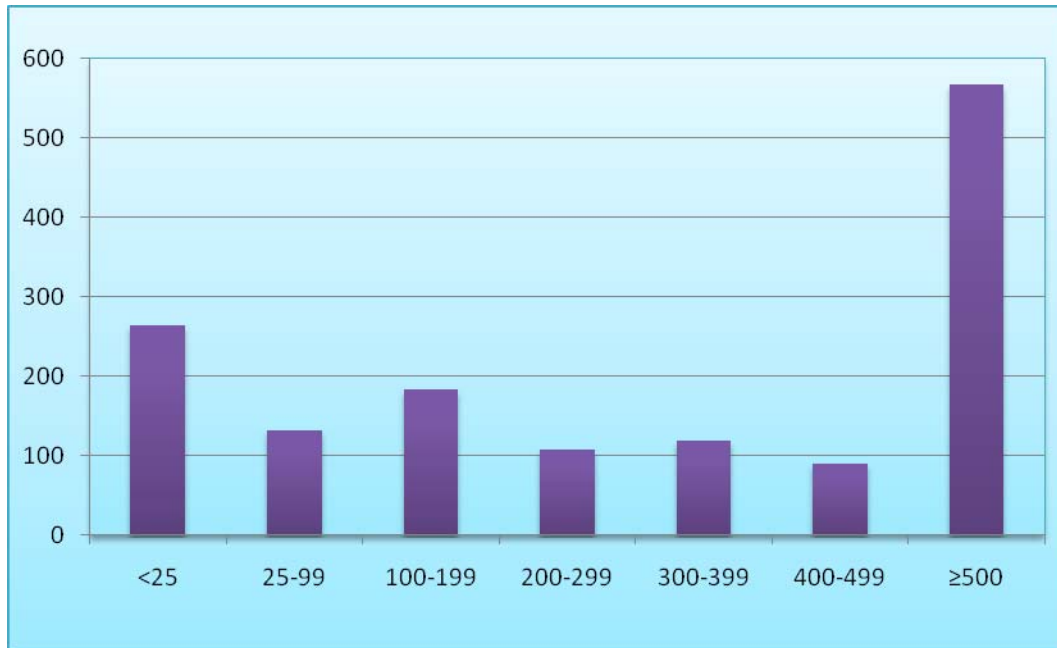
In the long-term, governance structures, water allocation and drought response plans, and conservation measures should be instituted based on the regional consultative processes and the data collected from hydro-geological aquifer and groundwater demand studies. Conservation can allow for water “saved” from agriculture to be transferred to other uses such as satisfying the needs of the growing domestic sector or protecting environmental flows.

6.2 Policy Options

The key findings from the case studies and the content analysis of B.C. stakeholder views guided my policy analysis and subsequent development of four policy alternatives to regulate groundwater resources in B.C. sustainably. As not regulating groundwater withdrawals is no longer consistent with provincial water policy, the first option, or the status quo, consists of the known details of the groundwater reforms proposed by the new B.C. *Water Sustainability Act* (BC WAMc). The second policy option develops a “high priority” groundwater area regulation framework and governance standards. The watershed governance in “high priority” areas is shared between local and provincial stakeholder agencies, such as the Ministry of Environment, the Ministry of Agriculture and Lands, and regional districts and municipalities in a watershed. As a result, shared governance leads to the development of regional Water Management Plans (WMPs) and associated water allocations.

The third option augments the second option by adding province-wide groundwater licensing for irrigators pumping groundwater volumes in excess of 25m³/day. Provincial WELLS database records in Figure 4, although only representative of about half of groundwater wells in B.C., provide an indication of irrigation well capacity throughout the province. The fourth policy alternative builds on the second policy option by capping irrigation pump flow rates to the basic allocation needed for regional productive agriculture in B.C.

Figure 4 Number of Irrigation Wells in B.C. According to Self-Reported Irrigation Well Flow Capacity (cubic metres/day)



Source: Estimated by Author from the B.C. Ministry of Environment WELLS Database Records

6.2.1 Option 1: Status Quo - Proposed Groundwater Regulation

As part of its process of B.C.’s *Water Act* modernization, the B.C. Ministry of Environment is considering policies to regulate groundwater with the new *Water Sustainability Act* (WSA), which currently proposes an area-based approach to regulate water resources in the province. “Using an area based approach means that local conditions, issues and interests, and local knowledge and information, including traditional ecological knowledge will influence water management and help inform decisions.” (BC WAMc, 2010, p. 5).

The area-based approach allocates uniform water resource management standards at the province-wide level. At the provincial level, instream flows and groundwater withdrawal regulation, as well as the need for more efficient use of water and the adoption of economic incentives would be mandated. More stringent measures would apply in chronic problem areas (i.e., experiencing declining quantity or quality of water supply, or deteriorating ecosystems) and known problem areas.

On a province-wide basis, large groundwater withdrawals would be licensed (large withdrawals are either going to be defined between 100-500m³/day or 100-250m³/day¹¹, with the lower bound applying to a consolidated aquifer and the upper bound to an unconsolidated aquifer) while more stringent policies would be implemented in problem areas, both known and chronic (BC WAMc, 2010). In problem areas, groundwater withdrawal licensing requirements would apply to smaller users. Overall, licenses for groundwater would mirror the structure of licenses for surface water in the province in terms of fees and specifications.

Groundwater licenses would be granted on a FITFIR basis with proportional reductions required as supply forecasts change, while priority of use would be given in cases where high importance water users', such as the municipal sector, supply is threatened. New costs would be sustained by groundwater users due to monitoring and reporting requirements, as well as the potential need for investments in efficient technology.

Additionally, agricultural water reserves would be enabled to maintain the purpose of the ALR. Agricultural water reserves would maintain an overall pool of water for the agricultural sector of B.C., with water use efficiencies benefiting and water use reductions remaining within the agricultural water pool, even in cases where agricultural licenses are cancelled.

6.2.2 Option 2: Allocation Framework for “High Priority” Areas

Based on hydrological studies that ascertain the “sustainable yield” of regional aquifers and participatory stakeholder decision-making, watershed allocation plans are developed for the management of water resources in “high priority” areas through representative regional Watershed Agencies, funded jointly by the province and regional watershed municipalities similarly to the Conservation Districts program in Manitoba.

¹¹ 100,000-500,000L/day or 100,000-250,000L/day

Watershed Agencies allocate water and develop drought control measures, and they monitor, enforce, and report within the context of the watershed plan, while being guided by provincial statutory standards as done by water allocation authorities in Australia. Groundwater licenses would be distributed to existing agricultural well owners according to FITFIR seniority within the allocation guidelines of the watershed allocation plan. In order to add flexibility to changing the terms of groundwater rights, licenses would have a 20-year term as is the case in Manitoba.

In order to measure and report groundwater levels, as well as enforce groundwater withdrawal limits, wells in “high priority” watersheds would be monitored. In cases of water shortage, priority use would be given to domestic and environmental needs, with remaining agricultural allocations reduced according to correlative rights where all license owners reduce their rights proportionally as is the case in the SEKID.

In addition, the Ministry of Agriculture and Lands would coordinate a cost-sharing program, similar to what is done in the US High Plains states such as Kansas, for farmers to drive conservation through investment in efficient irrigation technology and improved irrigation management. Conservation of instream flows is ensured through environmental allocation and a provincial water rights buyout program in cases where agricultural users’ rights need to be reduced to the benefit of environmental allocations as done in Australian water markets.

6.2.3 Option 3: Allocation Framework for “High Priority” Areas + Overall Licensing

In addition to the measures proposed in Option 2, this option includes the licensing of all agricultural groundwater withdrawals in B.C.:

- Licenses are distributed according to FITFIR seniority for existing agricultural well owners who pump above 25m³/day (e.g., Manitoba) and limited to the basic irrigation allotment per acre needed during a drought in an area as is the case in the SEKID. In

order to add flexibility to changing the terms of groundwater rights, licenses would have a 20-year term as is the case in Manitoba.

- WMPs in non-“high priority” areas can be developed on a voluntary basis with the same governance and funding structure as in “high priority” areas.
- The provincial well observation network is augmented in areas that do not meter groundwater use by an additional 50-75 observation wells (OAGBC, 2010).
- Agricultural groundwater well registration is mandatory along with associated reporting requirements established by provincial authorities.
- Priority use is given to domestic and environmental use in the case of water shortages anywhere in the province.
- The Ministry of Agriculture and Lands coordinates a cost-sharing program for farmers to drive conservation through investment in efficient irrigation technology and improved irrigation management province-wide.

6.2.4 Option 4: Allocation Framework for “High Priority” Areas + Capping of Well Peak Flow

In addition to the “high priority” area measures proposed in Option 2, this option includes the capping of well peak flow rates for all irrigation wells in non-“high priority” areas:

- Capping well flow rates according to basic irrigation allotments can be an administratively straightforward way to make sure farmers use efficient irrigation systems. For example, a 10 acre farm needs 40 US gallons/minute pump flow to irrigate crops when it is hot. The effective cap for a pump on a 10-acre farm in peak irrigation demand conditions is 40 US gallons/minute¹² (van der Gulik, 2010). In order to add

¹² 218m³/day for a 10-acre farm

flexibility to changing the terms of groundwater rights, the cap on well flow would be reviewed after a 20-year term as is the case in Manitoba.

- WMPs in non-“high priority” areas can be developed on a voluntary basis with the same governance and funding structure as in “high priority” areas.
- The provincial well observation network is augmented in areas that do not meter groundwater use by an additional 50-75 observation wells (OAGBC, 2010).
- Agricultural groundwater well registration is mandatory along with associated reporting requirements established by provincial authorities.
- Priority use is given to domestic and environmental use in the case of water shortages anywhere in the province.
- The Ministry of Agriculture and Lands could coordinate a cost-sharing program for farmers to drive conservation through investment in efficient irrigation technology and improved irrigation management province-wide.

6.3 Criteria for Analysis

The criteria are the standards set to evaluate the four policy options and determine the most attractive alternative to regulate agricultural groundwater use sustainably in B.C. The following criteria are selected because of their relevance to agricultural groundwater policy: effectiveness, administrative capacity, equity, and acceptability. Each criterion can have one or more measures with associated definitions. Additionally, each measure has a benchmark to rank a policy and compare it with the other policy alternatives proposed. The measures are ranked according to ‘low’ (1), ‘medium’ (3), or ‘high’ (5) as defined in Table 5. When a criterion has several measures, the average of the rankings is calculated to produce the score on that criterion for the respective option.

6.3.1 Criteria Selection

The criteria selected - effectiveness, administrative capacity, equity, and acceptability – are important to stakeholders and policy makers given the need to:

- Use groundwater resources sustainably, with consideration to governance structures, prevention of resource depletion, and accounting for the connection of surface and ground water flows.
- Respect existing rights of existing agricultural users whose ability to continue pumping groundwater is key to their livelihoods.
- Provide clear, enforceable, and predictable allocation standards that maximize provincial resources and funding.
- Ensure stakeholder buy-in given limited resources to monitor and enforce groundwater withdrawals province-wide.

Table 5 provides a summary of criteria and their corresponding definition and measures used to evaluate the policy alternatives proposed and advise the preferred policy option.

Table 5 Criteria and Measures

Criterion	Definition	Measurement	Value
Effectiveness			
Protection of groundwater depletion	Are groundwater resources protected from depletion?	Current quantity used Basic water allotment “Sustainable yield”	(1) Low (3) Medium (5) High
Protection of ecosystem viability	To what extent is ecosystem viability factored into groundwater allocation decisions?	Environmental guidelines Environmental flows Water rights buyouts	(1) Low (3) Medium (5) High
Application of good governance	Is good governance applied to groundwater resource management?	Top-down Delegated Shared	(1) Low (3) Medium (5) High
Administrative Capacity			
Administrative feasibility	How much additional staff does the B.C. MoE require?	Less than 20 staff 20 staff More than 20 staff	(5) High (3) Medium (1) Low
Equity			
Horizontal equity	Is access to groundwater shifted disproportionately among sectors (i.e., municipal, agricultural, industrial, environmental)?	FITFIR FITFIR + Priority use municipal FITFIR + Priority use municipal and environment	(1) Low (3) Medium (5) High
Intra-sector equity	Are the groundwater needs of senior and junior ranked agricultural users balanced?	FITFIR FITFIR + Correlative rights	(1) Low (5) High
Acceptability			
Stakeholder acceptability	Would stakeholders support the proposed policy reforms?	Minority Half Majority	(1) Low (3) Medium (5) High

Note: FITFIR = “First in Time, First in right”

6.3.2 Criteria Measures

6.3.2.1 Effectiveness

The effectiveness criterion includes three of the five requirements for sustainable groundwater use, including protection of groundwater depletion, ecosystem viability, and application of good governance. Licenses for groundwater withdrawals can be distributed on a FITFIR basis according to the current amounts used by existing users, which would perpetuate current problems in “high priority” areas and potentially engender issues elsewhere (**Low**). If licenses are distributed based on the basic allotment of water needed for agricultural land in a

given region as done in the SEKID, then agricultural water waste would be minimized (**Medium**). If water licenses are allocated with a view to the “sustainable yield” of an aquifer, then only the amount of groundwater would be used that can be sustained without aquifer levels decreasing due to human interference (**High**). This is the most stringent tool to stave off groundwater depletion.

From an ecosystem perspective, either environmental guidelines can be established (**Low**), or minimum environmental flows and water rights buyouts can be instituted. Water right buyouts (**High**) in addition to environmental flows (**Medium**) can provide flexibility to adjust existing allocations to the benefit of ecosystem needs.

Application of governance can be established through a top-down approach with provincially stipulated policies (**Low**), while a delegated approach leaves the governance reins in the hands of grass root organizations (**Medium**), through a bottom-up policy making approach, and a shared governance model empowers local organizations to develop water resource management approaches with the support and collaboration of provincial authorities (**High**).

6.3.2.2 Administrative Capacity

Administrative capacity relates to the availability of sufficient provincial department resources to dedicate to the policy alternative, including funding and staff. Within administrative capacity, administrative feasibility refers to the level of resources in terms of dedicated staff needed from the B.C. MoE Water Stewardship Department to license groundwater, assist local authorities in developing water management and allocation plans through Watershed Agencies, augment the provincial well observation network, etc. Given current levels of staff (approximately 150) and assuming that surface water for domestic use will be licensed, an incremental staff of approximately 20 employees would be needed for ongoing groundwater licensing and hydro-geological aquifer studies by the Water Stewardship Department of the B.C.

MoE (Wei, 2010). Therefore, additional staff of 20 is considered as **Medium** administrative feasibility, less than 20 is **High**, and more than 20 is **Low**.

6.3.2.3 Equity

Equity considerations tackle the social allocation of regulatory burdens and benefits among stakeholders impacted by regulatory reforms. Horizontal equity is concerned with disproportionate groundwater distribution among equal sectors (i.e., municipal, agricultural, industrial, and environmental). Farmers expect their groundwater rights or licenses to be distributed to existing users on a FITFIR basis and keep their allocations in times of shortage (**Low**). However, when priority use is considered in times of shortage, municipal and environmental sector groundwater needs will take precedence despite FITFIR seniority as practiced in Manitoba (**High**). Horizontal equity will be considered **Medium** if only municipal needs are prioritized,

On the other hand, intra-sector equity means balancing the groundwater needs of users in the agricultural sector who are ranked within a FITFIR rights framework. With FITFIR rights (**Low**), it is much safer for those with senior rights to make investments that rely on a secure supply of water, and consequently reap returns in good and bad times. If changes in technology or market conditions favour activities that are better suited to the junior water users, it may be beneficial to exchange or otherwise transfer senior water rights. Therefore, FITFIR can be combined with correlative rights (**High**) in times of shortage, as practiced in Australia and the SEKID, with all license holders sharing the water loss proportionally.

6.3.2.4 Acceptability

Stakeholder acceptability addresses whether a policy proposal is likely to face strong resistance from stakeholders (i.e. farmers, general public, policy makers) affected by its reforms. From the WAM consultations, the Okanagan farmers' survey, and elite interviews, support for

different policy options can be evaluated and measured according to it garnering minority (**Low**), half (**Medium**) or majority (**High**) stakeholder support.

6.4 Evaluation of Policy Options

This section evaluates the proposed policy options using the set of criteria established to assess the relative strengths and weaknesses of the alternatives to recommend the policy option in the context of B.C. stakeholders and groundwater sustainability goals. The scores resulting from the policies evaluation are summarized in Table 6.

6.4.1 Option 1: Status Quo - Proposed Groundwater Regulation

Effectiveness. The B.C. MoE will regulate large groundwater withdrawals between 100-500 m³/day or 100-250m³/day province-wide. According to the provincial WELLS database, the majority of groundwater irrigation wells are mainly pumping from unconsolidated aquifers. As a result, groundwater withdrawals of more than 250m³/day or 500m³/day from unconsolidated aquifer would be regulated. Figure 3 shows that if irrigation wells with capacity above 500m³/day are regulated, only about 40 percent of irrigation wells would be affected while if the regulation limit was at 250m³/day, about 60 percent of irrigation wells are affected. Many of these wells are also in “high priority” areas, such as the Okanagan Basin, where lower levels of groundwater extraction would be regulated based on hydrological studies. However, since groundwater rights are going to be allocated according to FITFIR seniority, it is unclear to what extent groundwater allocations will be lowered from current levels. Therefore, the prevention of groundwater depletion with the status quo is **Medium**.

Environmental flows, they will be mandated by the province (**Medium**) and the water governance model that is favoured includes local level development of water allocation plans in “high priority” known problem and chronic problem areas with the assistance of the province (**High**).

Administrative Feasibility. Given the current lack of groundwater licensing, about 3 percent of groundwater wells can be defined as large withdrawals and therefore would be licensed leading to the grandfathering of approximately 6,000 wells (about one third of large withdrawal wells are for irrigation purposes) and about 100-200 annual groundwater licenses (Wei, 2010). As a result, the B.C. MoE five regional offices would each need about 2-3 new staff for a total of about 10-15. In addition, staff would be needed for aquifer characteristics studies of approximately 5. Therefore, incremental staff of approximately 15-20 employees for ongoing groundwater licensing and hydro-geological aquifer studies would be needed (**Low-Medium**).

Equity. Groundwater extraction rights are most likely to be grandfathered to agricultural users according to FITFIR, and the sector's groundwater allocation will be preserved through the creation of an agricultural water reserve; though, in cases of shortage the municipal sector would be prioritized (**Medium**). Similarly, because of the grandfathering of groundwater pumping rights, junior rights' holders will be affected disproportionately in the case of droughts (**Low**).

Stakeholder Acceptability. Agricultural stakeholders are unlikely to oppose Option 1, as their pumping rights are recognized according to FITFIR. However, environmental groups and academics are in favour of a province-wide system of rights, with specific recognition of the connection of groundwater to instream flows (**Medium**).

6.4.2 Option 2: Allocation Framework for “High Priority” Areas

Effectiveness. As only “high priority” areas will be regulated with water allocation plans, this policy option will not be proactive in preventing potential groundwater depletion, while promoting province-wide ecosystem viability and good governance. However, where water allocation plans are implemented according to the “sustainable yield” of vulnerable aquifers, groundwater depletion will be minimized (**Medium**). As a result of “sustainable yield” aquifer extraction limits, ecosystem viability will be protected, and groundwater rights will be bought out

where they are over-allocated (**Medium**). Governance will be shared through standards established by provincial authorities and “high priority” area water allocation plans overseen by a Watershed Agency (**High**).

Administrative Feasibility. There are four designated “high priority” areas for water allocation plans: the Lower Mainland, the Okanagan Basin, the East Coast of Vancouver Island, and the Gulf Islands (B.C. WAM, 2010). B.C. MoE Water Stewardship division resources would be needed to assist Watershed Agencies to develop water allocation plans in each “high priority” watershed. If five regional offices need to be augmented by one or two employees in addition to staff needed for aquifer “sustainable yield” studies of approximately 5, a total of about 10 to 15 incremental provincial staff would be needed (**High**).

Equity. Where groundwater is regulated with a water allocation plan, FITFIR seniority still applies. However, in times of shortages priority use is given to municipal and environmental needs (**High**), while agricultural stakeholders’ allocations are decreased proportionally according to correlative rights (**High**).

Stakeholder Acceptability. Agricultural stakeholders are likely to be opposed to the lowering of sectoral water allocations, especially in giving up priority use to environmental needs. However, groundwater rights buyouts will compensate affected parties where groundwater rights are permanently decreased (**Medium**).

6.4.3 Option 3: Allocation Framework for “High Priority” Areas + Overall Licensing

Effectiveness. Groundwater depletion will be minimized as province-wide groundwater withdrawals in excess of 25m³/day are licensed according to the basic water allotment for irrigation, encompassing the majority of irrigation wells (Figure 3) in addition to those under water allocation plans in “high priority” areas that are regulated according to the “sustainable yield” of local aquifers (**High**). Good governance will be established by supporting water

allocation plans on a province-wide basis (**High**). Ecosystem viability will be protected as a result of “sustainable yield” groundwater extraction limits, province-wide licensing, and groundwater rights will be bought out where they are over-allocated in relation to instream flows (**High**).

Administrative Feasibility. In addition to the 10-15 staff needed in Option 2, another 10 staff would be added to process groundwater licensing for irrigation withdrawals in excess of 25m³/day and to monitor the additional 50-75 observation wells for a total of 20-25 additional provincial staff (**Low**).

Equity. Groundwater licenses are granted according to FITFIR seniority. However, in the case of water shortages, priority use is granted to municipal and environmental uses (**High**). In areas with water allocation plans, which tend to be areas with water shortages, correlative agricultural groundwater rights apply (**High**).

Stakeholder Acceptability. Stakeholders from the agricultural community are likely to be opposed to province-wide licensing of groundwater withdrawals in contrast to academic and environmental groups that support comprehensive provincial licensing, beyond “high priority” areas (**Low**).

6.4.4 Option 4: Allocation Framework for “High Priority” Areas + Capping of Well Peak Flow

Effectiveness. In capping peak well flows according to basic allotments for irrigation and FITFIR seniority, this policy option will proactively prevent excess use of groundwater, which will contribute to conserving ecosystem flows. As well, when water allocation plans are implemented in “high priority” areas according to the “sustainable yield” of affected aquifers, groundwater depletion will be minimized (**High**). Ecosystem viability will be protected as a result of “sustainable yield” groundwater extraction limits and groundwater rights will be bought out where they are over-allocated (**High**). Good governance will be established by supporting water allocation plans on a province-wide basis (**High**).

Administrative Feasibility. In addition to the 10-15 staff needed in Option 2, another 5-8 staff would be added to monitor the additional 50-75 observation wells and caps on well flow for a total of about 20 provincial staff (**Medium**).

Equity. In case of water shortages, priority use is granted to municipal and environmental uses (**High**). In areas with water allocation plans, correlative agricultural groundwater rights apply (**High**).

Stakeholder Acceptability. Stakeholders from the agricultural community are likely to be opposed to province-wide capping of groundwater well peak flows in contrast to academic and environmental groups that support comprehensive provincial control of groundwater withdrawals, beyond “high priority” areas (**Low**).

6.5 Policy Recommendations

Table 6 shows that according to the policy evaluation framework, Option 2 - Allocation Framework for “High Priority” Areas and Option 4 – Allocation Framework for “High Priority” Areas + Capping of Well Peak Flow – are ranked highest by the criteria and their measures (Table 5). Option 2 scores highest on administrative capacity and equity, while exhibiting average effectiveness and acceptability to stakeholders. Option 4 scores highest on effectiveness, and equity, while having relatively low acceptability to stakeholders and higher administrative capacity, because of the province-wide nature of the regulation. When comparing Options 2 and 4, there is an apparent trade-off between stakeholder acceptability and administrative capacity on one hand and effectiveness goals on the other.

Option 3, Allocation Framework for “High Priority” Areas + Licensing and Option 1, Proposed Groundwater Regulation, rank fourth and third among the four alternatives. Option 3 performs well on effectiveness, equity but low on stakeholder acceptability, similarly to Option 4. It also requires the most administrative capacity, and therefore ranks lowest on that criterion.

Option 1, or current revisions to the status quo as developed by the B.C. MoE, scores high on administrative capacity and medium on stakeholder acceptability and effectiveness. However, Option 1 scores lower on equity compared to the other three alternatives because, it does not specify consideration of priority use for the environmental sector nor within the agricultural sector in cases of groundwater shortages.

Table 6 Evaluation of Policy Options

	Option 1	Option 2	Option 3	Option 4
Criteria	Proposed Groundwater Regulation	Allocation Framework for “High Priority” Areas	Allocation Framework for “High Priority” Areas + Licensing	Allocation Framework for “High Priority” Areas + Capping Well Peak Flow
Effectiveness	3.6	3.6	5	4.6
Protection of groundwater depletion	Medium (3)	Medium (3)	High (5)	High (5)
Protection of ecosystem viability	Medium (3)	Medium (3)	High (5)	Medium-High (4)
Application of good governance	High (5)	High (5)	High (5)	High (5)
Administrative capacity	4	5	1	3
Administrative feasibility	High-Medium (4)	High (5)	Low (1)	Medium (3)
Equity	2	5	5	5
Horizontal equity	Medium (3)	High (5)	High (5)	High (5)
Intra-sector equity	Low (1)	High (5)	High (5)	High (5)
Acceptability	3	3	1	1
Stakeholder acceptability	Medium (3)	Medium (3)	Low (1)	Low (1)
Total Score	12.6	16.6	12	13.6

My analysis supports implementing Option 2 to manage agricultural groundwater use in B.C. sustainably. This option provides a regulatory framework for “high priority” groundwater

areas in the province with an administratively straightforward approach compared to Option 4. Option 2 limits groundwater regulation to “high priority” areas, such as the Okanagan that can become pilot areas to learn from for long-term groundwater reform as more information is gathered on demand and supply behaviour in the province. At the same time, in the short to medium term, Option 2 will not address proactively potential groundwater issues in the rest of the province as resources will be dedicated to “high priority” areas.

7: CONCLUSION

British Columbia is the only Canadian province with no current regulation of groundwater withdrawals. Given the changing climate, a growing population and historically over-allocated surface water licences, some agricultural regions exhibit stress in groundwater levels. As a result, the need for groundwater use regulation has come to the forefront and is being addressed by the B.C. Ministry of Environment through a consultative *Water Act* modernization process. Using three case studies, content analysis of *Water Act* modernization stakeholder engagement reports and key expert interviews, I propose that an allocation framework for “high priority” groundwater areas be developed and implemented as a first step. Such pilot areas can inform province-wide initiatives to manage agricultural groundwater use sustainably in the long-term.

This study was limited by the current lack of data on groundwater supply and demand in the province. Consequently, parallel issues, such as the transfer of water allocations from one economic sector to another (e.g., agriculture to municipal), could not be appropriately addressed by the scope of this study. However, once the allocation framework for “high priority” groundwater watersheds is in place, studies on demand and supply of groundwater, as well as collaborative governance initiatives will constitute a basis for long-term province-wide strategies, such as using economic instruments to help manage and conserve groundwater resources to the benefit of British Columbians.

Appendices

Appendix 1: Provincial Groundwater Permitting Overview

Jurisdiction	Number of Wells	Number of groundwater permits	Groundwater licensing law	Regulation	License Term
B.C.	100,000+ estimate only, submission of well records not mandatory.	No license required.	Water Act could be extended for licensing GW.	2004 Ground Water Protection Regulation, focuses on water quality.	n/a
AB	500,000 and about 5,000 new wells drilled each year.	n/a	Water Act	Water (Ministerial) Regulation	Variable: 1,2, 10 or 25 years depending on the purpose; perpetual for historic users.
SK	n/a	Approx. 3,600	Ground Water Conservation Act	Ground Water Regulations	From 5 years to perpetuity
MB	n/a	533 licenses (2004)	Water Rights Act	Water Rights Regulation	Up to 20 years
ON	500,000 approx.	2,800	Water Resources Act	Water Transfer and Taking Regulation	2-10 years, depending on purpose and environmental conditions.
QC	n/a	> 600 catchments, >75m ³ /day	Environmental Quality Act	Groundwater Catchment Regulation	10 years
NB	Estimates of 3,000 new wells each year	Approval (not permit) required to build wells above threshold.	Clean Water Act, Clean Environment Act	Environmental Impact Assessment Regulation, Water Quality Regulation	In perpetuity
NL	17,000+	n/a	Water Resources Act	Water Resources Act	5-10 years depending on the source
NS	97,000 total and estimate of 3,000 new every year	Approx. 100; only includes withdrawals >23 m ³ /day.	Environment Act	Activities Designation Regulations	Maximum of 10 years
PEI	Approx. 21,000	500-800	Environmental Protection Act	Water Well Regulations	Open ended

Adapted from: Nowlan, 2005

Appendix 2: Metered Rate Schedule in the South East Kelowna Irrigation District

Percentage of Annual Water Use in Excess of Basic Water Allotment	Rate per 1,000 USG
10%	\$0.10
20%	\$0.13
30%	\$0.16
40%	\$0.20
50%	\$0.25
60%	\$0.31
70%	\$0.38
80%	\$0.46
90%	\$0.55
100%	\$0.65

Source: Pike, 2005, p.10

Appendix 3: Interview Participant Background

Participant	Background
Allen, (Dr.) Diana	Assistant Professor, Department of Earth Sciences, SFU - Research focuses on hydrogeology with emphasis on groundwater resource evaluation and hydro-geological modelling, including climate change impacts on groundwater systems and resources.
Janmaat, John	Associate Professor of Economics, UBCO - Research on environmental and resource economics, particularly water resources and factors that determine water use in the Okanagan.
Jatel, Nelson	Water Stewardship Director of the Okanagan Basin Water Board
Pike, Toby	General Manager, South East Kelowna Irrigation District
Robbins, Mark	Regional Agrologist, Sustainable Agricultural Management – Abbotsford, BC Ministry of Agriculture and Lands
Wei, Mike	Section Head, Groundwater and Aquifer Science, Watershed and Aquifer Science, BC Ministry of Environment
van der Gulik, Ted	Senior Engineer, Sustainable Agricultural Management – Abbotsford, BC Ministry of Agriculture and Lands

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