# How Encroaching Infrastructure is Putting the Township of Langley's Aquifers at Risk

Kirah Corfe
Grenfell Campus
Memorial University of Newfoundland

## Abstract

*Although the Township of Langley (TOL) is located in a temperate rainforest, residents are finding their private wells going dry at an increasing rate. This paper investigates how a growing population and lack of water management has resulted in 5 of the TOL's 18 unique aquifers being put at risk of going dry. Despite being aware of the TOL's declining ground water levels, city planners continue to push for increased development without considering how this might affect future generations ability to access fresh water. Using GIS, this paper outlines the at-risk areas, while drawing from government and academic literature to determine what factors have enabled the continual over consumption of water within this township. As a result, a more aggressive water management strategy is needed to ensure the long term health of the TOL's water table.*

## Acronyms

| | |
|---|---|
| **ALR** | Agriculture Land Reserves |
| **BC** | British Columbia |
| **GIS** | Geographic Information Systems |
| **LWS** | Living Water Smart |
| **TOL** | Township of Langley |
| **WMP** | Water Management Plan |
| **WSA** | BC Water Sustainability Act |

## Introduction

The Township of Langley (TOL) is a municipality in greater Vancouver that is experiencing a shift in land use, and as a result, a growing population. This change has resulted in significant drops in the water table despite being located in a temperate rainforest. The issues the TOL is facing are due mainly to overconsumption (Inter-Agency Planning Team, 2009). Once a mainly agricultural based community, the TOL continues to increase its development and making a shift to more urban and suburban infrastructure (Inter-Agency Planning Team, 2009). Some of the more notable

contributing factors to this developmental shift is due to rising housing costs in Vancouver combined with obstacles in municipal regulations, a change in how the provincial government regulates Agricultural Land Reserves (ALR) and loopholes in the zoning bylaws. Despite these issues, municipal officials have had access to the data that outlines the TOL's declining aquifer rates for more than 20 years (Inter-Agency Planning Team, 2009). Instead of utilizing previously recommended approaches, officials have decided to take a more passive approach when it comes to water management. This passive approach coupled with the continual urban development of areas that draw from at risk watersheds will result in several aquifers within the TOL going dry if the municipal government chooses to not enact the policies needed to protect these vital aspects of the ecosystem. This paper will explore how landownership, zoning, and water rights are affecting water consumption in the TOL, while also examining the current water management policies in place and commenting on why they are not as effective as they could be.

## Methods

The TOL is a unique community that is experiencing a land use shift. As a community that relies heavily on an unseen water source, it is important to fully understand how this shift is affecting the communities' multiple aquifers. The information identified throughout this paper collectively demonstrates the importance of reevaluating the TOL's current water management plan and how land use/zoning in this municipality is aquifers at risk. Using a qualitative approach, this paper examined the following research questions:

- How has the change in ALR changed the way the TOL zones their land?
- Is the TOL purposely/ knowingly putting their aquifers at risk?
- What are realistic solutions to over consumption in Langley?
- What is limiting the current solutions?

When analyzing the data two major themes emerged, land rights and how they are linked to water rights, and water management. This came from evaluating numerous academic journals, government documents, books and articles. The research was conducted using MUN library resources, Google Scholar, and reading online forums where The Township of Langley (TOL) community members could express how they feel about municipal changes. Keywords used in combination or alone included 'aquifer', 'community-based management', 'private well management', 'municipally controlled water', and 'agricultural land reserves'.

With an information base established, further analysis was about to ensue using a quantitative approach and GIS. Using the information provided by the BC provincial government and the TOL municipal government, an analysis was done to show areas of concern within this municipality. Using spatial data, this paper outlined areas that are being developed in correlation to aquifers that are experiencing significant reduction in water levels.

## The Global Context

Despite being one of the most water rich countries in the world, Canada should not neglect the policies needed that acknowledge the importance of water conservation and water security. By protecting water, we are also protecting the ecosystem and quality of life for humans. The hydrological cycle is what enables life to flourish on earth. This cycle is powered by solar energy; it is the continual movement of water through land and the atmosphere through processes like evaporation and precipitation. In theory, the hydrological cycle should be renewable; however, in practice, this is not always the case (Harris & Roach, 2013). Solar energy powers the hydrological cycle; it circulates, purifies and distributes water around the world through evaporation and precipitation (Harris & Roach, 2013). Although the world has an abundance of salt water on earth, humans and many other creatures rely on fresh water sources to sustain life. Fresh water can be stored in plants, open bodies of surface water (ex. lakes, rivers and streams), and ground water (ex. aquifers) (Harris & Roach, 2013). Water on the earth's surface is able to replenish through precipitation, on the other hand, ground water needs long-term infiltration to develop (Harris & Roach, 2013). This can be limited by over consumption, desertification caused by human built infrastructure, and climate change.

Climate change paired with population growth have been having a profound effect on the hydrological cycle (Harris & Roach, 2013). Warmer temperatures caused by climate change have sped up the hydrological cycle (Harris & Roach, 2013). This has resulted in dry regions becoming drier and facing more instances of drought, and wet regions becoming more unstable as they are hit with more intense storms (Harris & Roach, 2013). In addition, as the global population grows, it is becoming increasingly challenging to meet the worlds basic water needs (Council of Canadian Academies, 2009).

Water scarcity is a term used to define when a region is facing limitations to their "food production, economic development and protection of natural systems" (Harris & Roach, pp. 253, 2013) due to their inability to access water. This is when a region has access to less than 1,000 cubic meters of water person per year. These are mainly countries located in North Africa and the Middle East (Harris & Roach, 2013). Although Canada receives >684,000 cubic meters of water per person per year, this does not mean that water security should not also be a Canadian issue (Statcan, 2006).

Water is a valuable resource that should not be overlooked. As other parts of the world become more water scares due to climate change, water is only going to gain value (Harris & Roach, 2013). Water can be used for many things, domestic & industrial uses, agriculture and energy. Currently, 70 percent of the world's water usage goes to agricultural needs (Harris & Roach, 2013). Although within the upcoming years we can expect this number to drop due to irrigation efficiency, water demand is expected to increase due to domestic consumption, electricity and manufacturing needs (Harris & Roach, 2013). As of 2012, almost one-quarter of the global population lives in regions where ground water is being extracted at a faster rate than it can be replenished (Mascarelli, 2012). This over use can result in the decrease in overall water availability for current and future generations (Mascarelli, 2012). As ground water level drop, aquifers begin to pull from surface water, resulting in lakes, rivers and streams also becoming depleted (Mascarelli, 2012). This results in further ecological impacts when plants and animals no longer have access to the water

they need (Mascarelli, 2012). Moreover, humans have the ability and knowledge to manage ground water sustainably; we simply must make the choice to do so (Mascarelli, 2012).

## The Issue within the Township of Langley (TOL)

The TOL is the sixth largest municipality in greater Vancouver, and it is continually growing (Council of Canadian Academies, 2009). When looking at the TOL as a whole, it is by no means water scares. It lies within a coastal temperate rainforest zone that receives an annual average rainfall of 140cm (HelloBC, 2017). Over the past four decades, the Township of Langley (TOL) has experienced a significant increase in population. In 2008, the TOL's population was approximately 100,000 residents and is forecasted to reach 165,000 by 2023 (Council of Canadian Academies, 2009). This growth is transforming the TOL into an urbanizing agricultural community (Council of Canadian Academies, 2009). Once mainly focused on developing their agricultural sector by encouraging diverse groups of farmers to cultivate the land, the TOL is making the shift to focusing on dense development and multifamily homes (Lions Gate Consulting, 2012). City planners believe that this will enable the TOL to reach its full potential (Lions Gate Consulting, 2012). Although this may be economically beneficial, city planner should fully understand the potential consequences of making this shift. A majority of the TOL population relies heavily on ground water to meet their industrial, agricultural and domestic needs (Council of Canadian Academies, 2009).

The TOL is home to the following 18 aquifers [See figure 1]:

- Abbotsford
- Brookswood
- Fort Langley
- Glen Valley
- Hopington AB
- Aldergrove AB
- Aldergrove CD
- Beaver River
- Clayton
- Hopington C
- South Hopington
- Aldergrove Quadra
- Langley Upland Interill
- Nicoeki Serpentine
- Salmon River
- South of Murrayville AC
- South of Murrayville B
- West Aldergrove

(Golder, 2009)

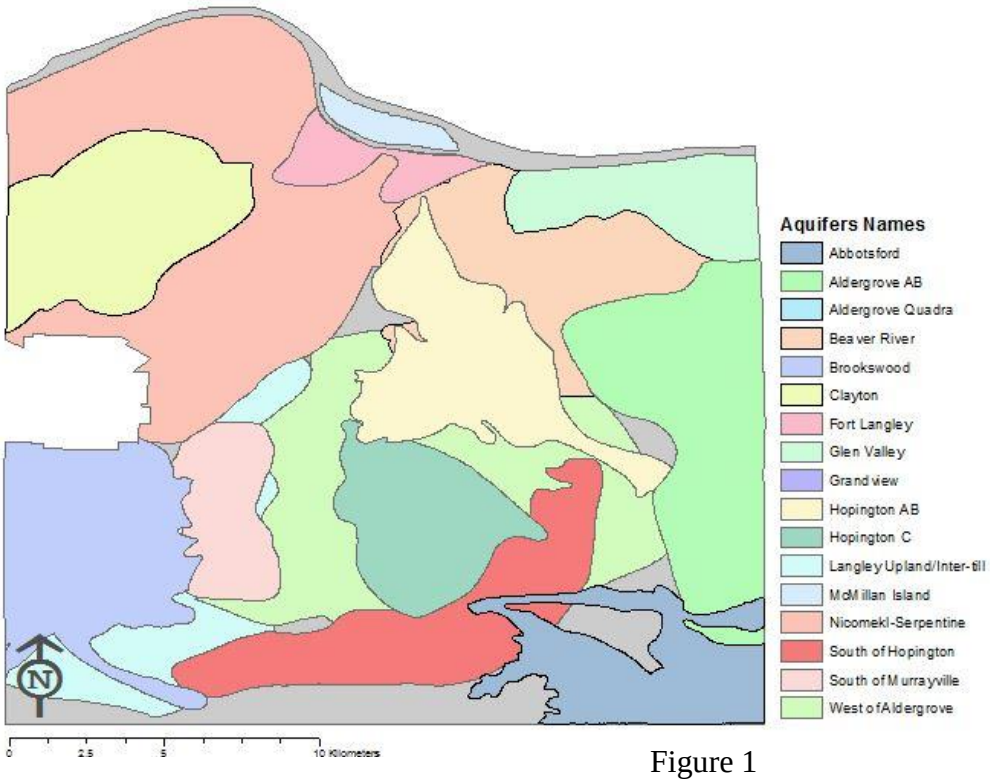



Figure 1

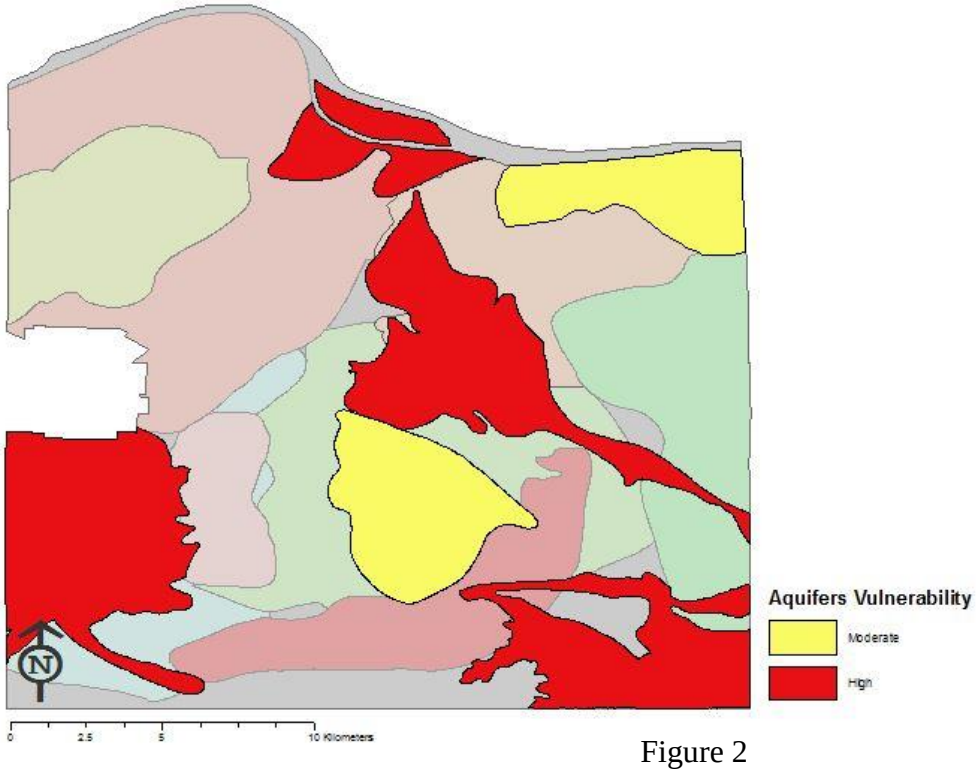



Figure 2

Although there are aquifers within the TOL that are deep and water rich, there are also several highly sensitive aquifers that are at risk of going dry. Abbotsford, Brookswood, Fort Langley, Glen

Valley, and Hopington AB are all at risk aquifers (Golder, 2009) [see Figure 2]. These are also areas of high development. Unlike many areas facing a drop in water supply, the TOL's water issues are not due to lack of precipitation of a changing climate but rather over consumption (Ministry of Environment, 2002). This is measured by using operation wells throughout the township and comparing this data to pervious measurements (British Columbia Groundwater Observation Well Network, N.D.). The TOL has 12 observation wells monitoring different aquifers (British Columbia Groundwater Observation Well Network, N.D.). These observation wells have indicated that increasing ground water demand has led to a steady decline in ground water levels over the past 40 Years (Council of Canadian Academies, 2009).

Ground water/aquifers plays an important role in the ecosystem and day to day life (Custodio, 2002). Ground water is what sustains river base flow and feeds springs, while also contributing to lakes, lagoons and wetlands (Custodio, 2002). When ground water levels are lowered river and stream levels tend to lower as well (Golder, 2009). This could potentially lead to "significant environmental and habitat damage" (Custodio, 2002, p.270). In addition to ecosystem damage, dry wells also put a financial burden on those who are effected. Especially, private well owners. When their wells go dry they have to either pay to have it re-dug with no guarantee that it will not go dry again within another few years or switch to a municipal water supply. Both of these options can be costly.

The Township of Langley (TOL) faces many challenges when dealing with the issue of the declining ground water levels. First, 75 percent of the TOL is located within agricultural land reserve (ALR) (TOL, N.D.). The TOL is home to approximately half the farms in the Metro Vancouver Area (TOL, N.D.). Developing a water management policy that encompasses both agricultural and residential stakeholders can be challenging. Second, TOL is experiencing a development boom, which is economically beneficial, yet limiting water consumption or harsher regulation may limit this development. Third, there tends to be public push back against any management strategy that is not passive, which would make implementing an unprecedented management strategy in the TOL, such as, water metering extremely challenging.

## Review of Literature

*Landownership*

One important aspect of water management is to understand water ownership. By defining who owns the water we can better define whose responsibility it is to conserve and maintain the water supply. In British Columbia (BC), no one individual truly owns a water supply. Instead, the Crown (the reigning monarch) owns all water on "behalf of the residents of the province" (BC Gov., N.D.). Landowners in the province are simply renting the ability to access these water supplies (BC Gov., N.D.). There are few regulations on water consumption in BC (Ministry of Environment, N.D.). Private well owners have almost unrestricted access to domestic ground water use, unless they are found to be contaminating their water supply (Ministry of Environment, N.D.). This unrestricted access to ground water can become an issue.

By nature, water is a fluid resource. However, this fluidity, at times, can make water a challenging resource to manage. Land ownership and property rights are systems put in place to "achieve equity, efficiency and certainty" (Mathews, 2005) when defining who is the owner of a

property or resource. In contrast, ground water is not exclusive (Mathews, 2005). Meaning you cannot truly deny a person or area access to a water supply. This results in transboundary conflicts in areas that share a joint water supply. When two or more political units have jurisdiction over the same water, finding a management strategy that adapts to both their needs can be challenging (Mathews, 2005).

Another aspect of water management and water consumption in general is land zoning. Whether a parcel of land is used for "agricultural, industrial or domestic uses" (Curran & Brandes, 2012, p. 3) will affect the water consumption patterns. Agriculture is a major consumer of water in Canada, with irrigation making up 85% of agricultural water consumption (Council of Canadian Academies, 2009). Although agricultural is a large consumer of water, Canadian farmers have been working towards becoming more water efficient with their irrigation methods, while also providing green space for rain water to permeate the soil (Council of Canadian Academies, 2009). British Columbia has approximately 4.6 million hectares of ALR (BC Gov., 2002). This land is agriculturally suitable land that has been prioritized for agricultural use (BC Gov., 2002). Originally established in 1973, ALR established a protection for farmland from the rapid urbanization that was taking over the province (BC Gov., 2002). However, in 2014, Bill 24: the agricultural land commission amendment act redefines how the province is able to use ALR (Pimm, 2014). The bill enables ALR owners to use their land for purposes other than agricultural use, opening new development opportunities throughout BC (Pimm, 2014).

*General Management Strategies*

There are several effective management strategies that are being used through the world and Canada to minimize the over consumption of water. It is important to find an effective management plan to ensure the TOL has a sustainable water source for future generations. One effective management strategy is water metering (Harris & Roach, 2013). Water metering is a way of measuring water use. By measuring the flow of water in a house, water providers are able to determine how much water is being used (Harris & Roach, 2013). Typically set up alongside a pricing scheme, this information is electronically tracked and can be set to a water company for billing (Hauber-Davidson & Idris, 2006). Water metering encourages water conservation by tracking the rate in which water is used and charging higher prices to those who consume more (Harris & Roach, 2013).

Water metering and its effective pricing is an important aspect of making water conservation in the TOL feasible. Not only should water pricing include the cost of extraction and distribution, but also it should also accurately represent the total marginal cost to minimize the chances of underpricing (Pitafi & Roumasset, 2006). Pitafi and Roumasset (2006) research showed that when a municipality bases their water pricing around the average extraction and distribution costs it results in individuals not allowing ground water to recharge. Thus, to create a pricing system that better represents the needs of the water table, price reform is needed (Pitafi & Roumasset, 2006).

*Relevant Research*

Although economically beneficial, new development opportunities will put some parts of The Township of Langley (TOL) at risk. The TOL needs to implement a stronger management strategy. The TOL is home to 18 distinct aquifers, five of these aquifers are at risk of becoming no

longer accessible or going completely dry [see Figure 2] (Golder, 2005). In 2005, Golder Associates Ltd. (Golder) conducted a comprehensive groundwater modelling assessment that the TOL bases a majority of their water management strategies on. This document outlines the overall decline in ground water rates in the TOL due to over consumption (Golder, 2005). Golder (2005) states that they expect that an increasing population, agriculture and commercial activities will only continue the steady decline in ground water levels. In addition, this decline will not only increase the risk of some aquifers going dry, but it will likely compromise the base flow of the streams and creeks in these areas which will have a greater effect on the total ecosystem (Golder, 2005).

*Local Policies*

Although more aggressive water management strategies have been suggested, the TOL has gone with a more passive water management approach. There are four major management documents that the TOL uses: Water Management Plan (WMP), Living Water Smart (LWS), and BC Water Sustainability Act (WSA).

The TOL's WMP (2009) relies heavily on the Golder (2005) research. Finalized in 2009, the WMP provides a series of recommendations that aid in the protection and conservation of aquifers in the TOL. One issue identified in this document is the fact that within BC, residents who own private wells are able to extract as much water as they want without viewing this water as a shared and limited resource (Inter-Agency Planning Team, 2009). The WMP's long term and less obtainable goal is to have a 30% reduction in groundwater use by 2020. Based on a 2007 water balance study conducted by Golder, a 30% water reduction has the potential to end the downward trend in the water supply, as well as, a possible raise water levels between 1 and 3 meters above the 2005 levels throughout a majority of the township.

Through a multi stage development approach, the WMP established 44 recommendations.24 of those recommendations were classified as core recommendations for the TOL (Inter-Agency Planning Team, 2009). Two of the most notable and potentially crucial recommendations were: 1. Implementing a water metering program that encompassed both those who use municipal water and those who use private wells (Inter-Agency Planning Team, 2009); 2. Developing a fee system that enables the TOL government to charge those who overuse and contaminate the ground water supply (Inter-Agency Planning Team, 2009). However, in 2008, the TOL council passed a motion indicating that they were to not move forward with these recommendations (Inter-Agency Planning Team, 2009).

Instead, the TOL decided to go with a more passive approach. The LWS is a provincial water management plan that focuses on education and voluntary conservation efforts (Environment Canada, 2016) LWS outlines how to conserve water in a world that is constantly changing (Environment Canada, 2016). Guided by the Water Sustainability Act (WSA), the core concepts of this project are:

- Keeping water in mind when we develop our communities, protecting sources of drinking water and strengthening flood protection to adapt to climate change.
- Ensuring wetlands and waterways will be protected and rehabilitated and land activities will not negatively impact our water.

- Modernizing B.C.'s Water Laws to ensure adequate stream flows, ecosystem health, more community involvement, and protection of groundwater.
- Setting strong water efficiency targets and working with all sectors to reduce water consumption.
- Improving science and information so British Columbians can better prepare for the impacts of climate change. (Environment Canada, 2016)

The WSA is also a provincial water management plan. The WSA was enacted in February 2016. Working off of the BC water act, the WSA modernized water management by taking an inclusive approach that better encompassed the wants and needs of the ground water stakeholders. The WSA heard form thousands of British Columbians, including "First Nations groups, industry and environmental groups, local governments, and individuals with an interest in our water resource" (WSA, 2016) and is now using their ideas to help "protect groundwater, how to ensure our streams and lakes stay healthy, to considering water when we make land use decisions" (WSA, 2016). This act focuses on seven main components: 1. Protecting stream health and aquatic environments; 2. Considering water in land use decisions; 3. Regulating groundwater use; 4. Regulating during scarcity; 5. Improve security, water use efficiency, conservation; 6. Measure and report; and 7. Enable a range of governance approaches (BC Gov, 2016). This act also invoked the implementation of penalties on those who commit ground water related offences as defined by the WSA (2016) regulations.

*First Nations Water Rights*

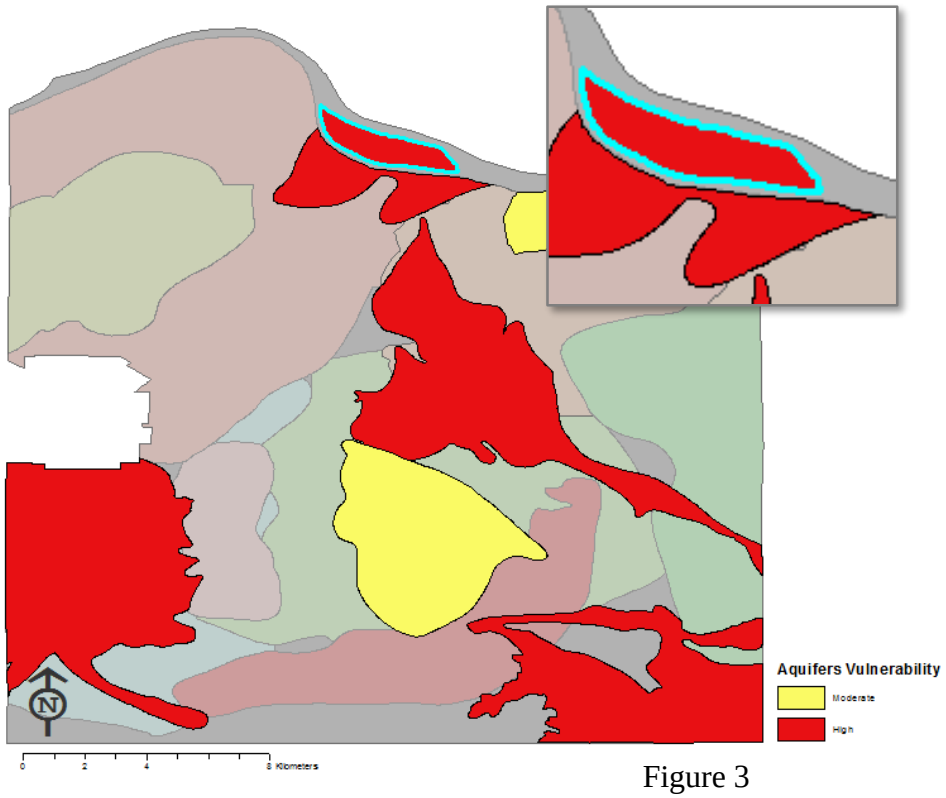
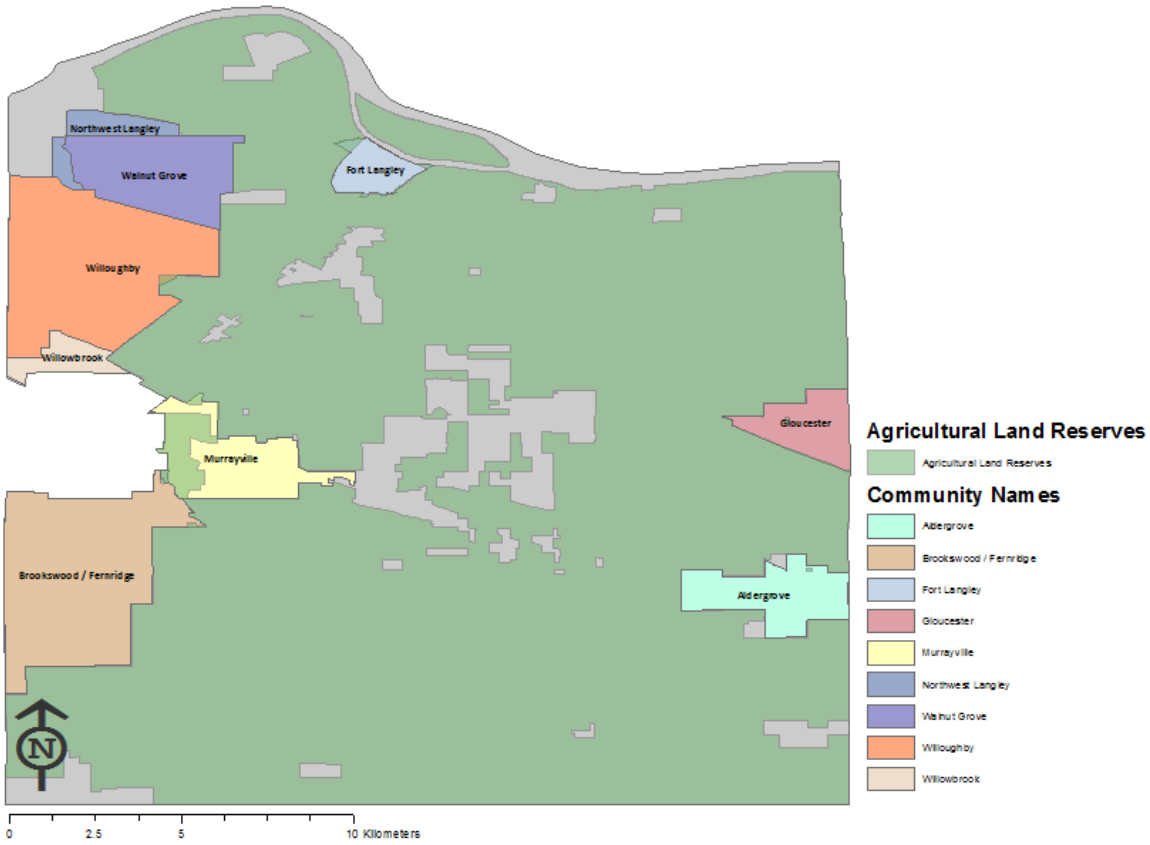



Figure 3

One aspect that makes the WSA a more well-rounded document than its predecessor is that it incorporates First Nation suggestions and knowledge into makeup. The First Nations people have been a marginalized group in through Canada's colonial history (Sarkar, Hanrahan & Hudson, 2015). The Indian Act of 1876, created "Indian reserves" or forced settlements where First Nations people were left with little support (Patrick, 2011). The land surrounding reserves were subject to "urban development, recreation, agriculture, forestry, mining, and other land uses" (Patrick, 2011, p. 387), while First Nation's people had little to no say in what took place around them. Although it is not specifically referred to in the Township of Langley's (TOL) management policies, through GIS analysis one of the at risk aquifers is within a Kwantlen First Nations reserve [See Figure 3].

The connection with water for First Nation's people goes deeper than simply economic benefit, or loss, First Nation's "people intimately connect water with physical and spiritual health and consider water to be the basis of all life" (Sarkar, Hanrahan & Hudson, 2015). When water is degraded within a Native population so is the health and culture of that group (Sarkar, Hanrahan & Hudson, 2015). The continual development of the Fort Langley area is putting this First Nations reserve at risk. First Nation's people tend to face higher rates of poverty and water contamination (Sarkar, Hanrahan & Hudson, 2015). When developing a water management plan, these complex socio-economic and cultural dynamic must be considered (Sarkar, Hanrahan & Hudson, 2015).

**Landownership and Water rights**



Development is rapidly changing the dynamic in the TOL. In the TOL's Economic Development Strategy (2012), Lions Gate Consulting state that they aim to promote development in the downtown core, densify development lands, better use of the Fraser River Lands, and promote the utilization of agricultural land reserves (ALR). Although these may have an economic benefit, this may jeopardize the stability of the TOL aquifers. Figure 4 outlines the at risk aquifers as well as areas of dense development that the TOL is hoping to densify. Areas of the TOL that are already quite dense, like Aldergrove, Brookswood, and Fort Langley are all areas that we experiencing aquifer instability. Further development of these areas will put a greater strain on the already struggling aquifers. Without a realistic management strategy, the TOL may establish irreversible damage on these aquifers.

In addition, the TOL's Economic Development Strategy (2012) suggests that the ALRs are not being fully utilized. The TOL would like find solutions to increase agricultural land use in fertile areas, while also developing less productive land in creative ways to further economic growth (Lions Gate Consulting, 2012). This document does not deny the historical significance of the ALR in the TOL; however, it has identified them as a limiting factor to the TOL's continual development.

Bill 24: the agricultural land commission amendment act may enable TOL to limit the restraints implemented by ALR. This ALR amendment has divided the region into 2 district zones (Pimm, 2014). First, Zone 1 is most of southern BC, i.e. the Lower Mainland, Fraser Valley, the Okanagan Valley and Vancouver Island. With Zone 2 being northern BC, the Kootenay and other areas within the interior (Pimm, 2014). This bill acknowledges that both south and northern BC operate differently and should have their ARL should treated differently. In theory, this bill will allow for area with less fertile land to use that land for non-farming activities (Pimm, 2014). Some believe that this will open up northern BC to further exploitation by oil and gas companies, without consideration of how the lack of farmland will affect future generations (CBC, 2014).

To protect the Township of Langley's (TOL) at risk aquifers we need to reassess how the TOL's zoning bylaws are effecting development and consequently the water table. Zoning in the TOL is constantly changing. Many areas that were once considered rural zones are making the change to becoming residential properties (TOL, N.D.). Rezoning enables landowners to develop their land if different ways. Areas that were once one home hobby farms are now being subdivided into plot that can hold multiple homes [See Figure 5] (Gathercole, 2016).

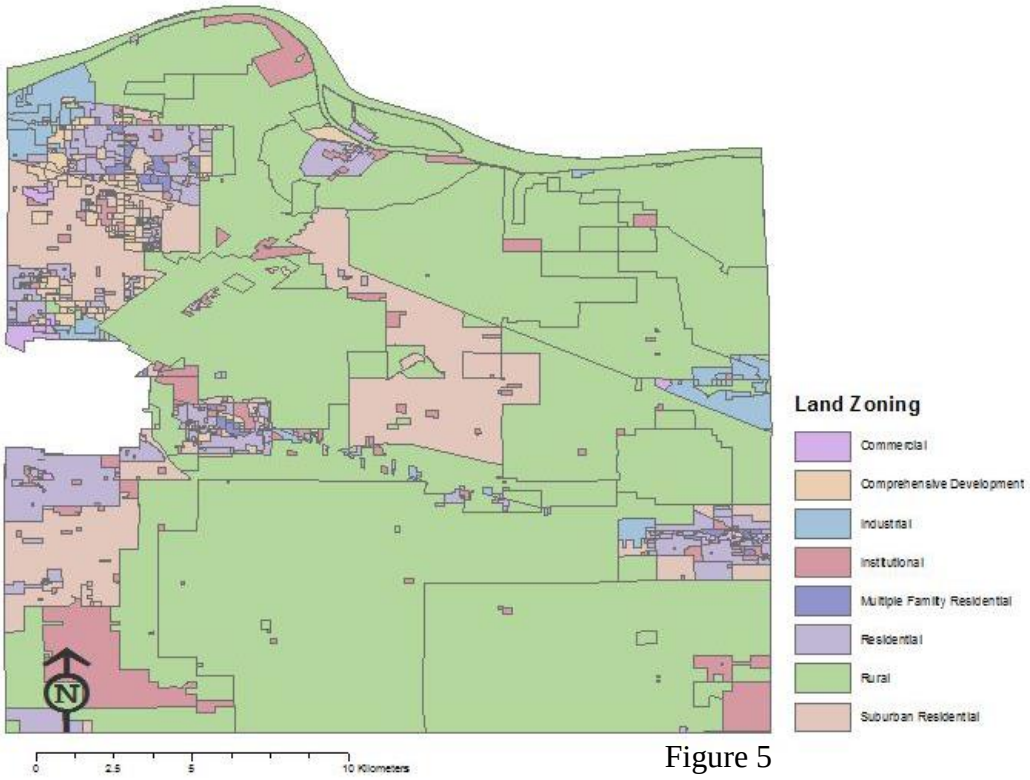



Figure 5

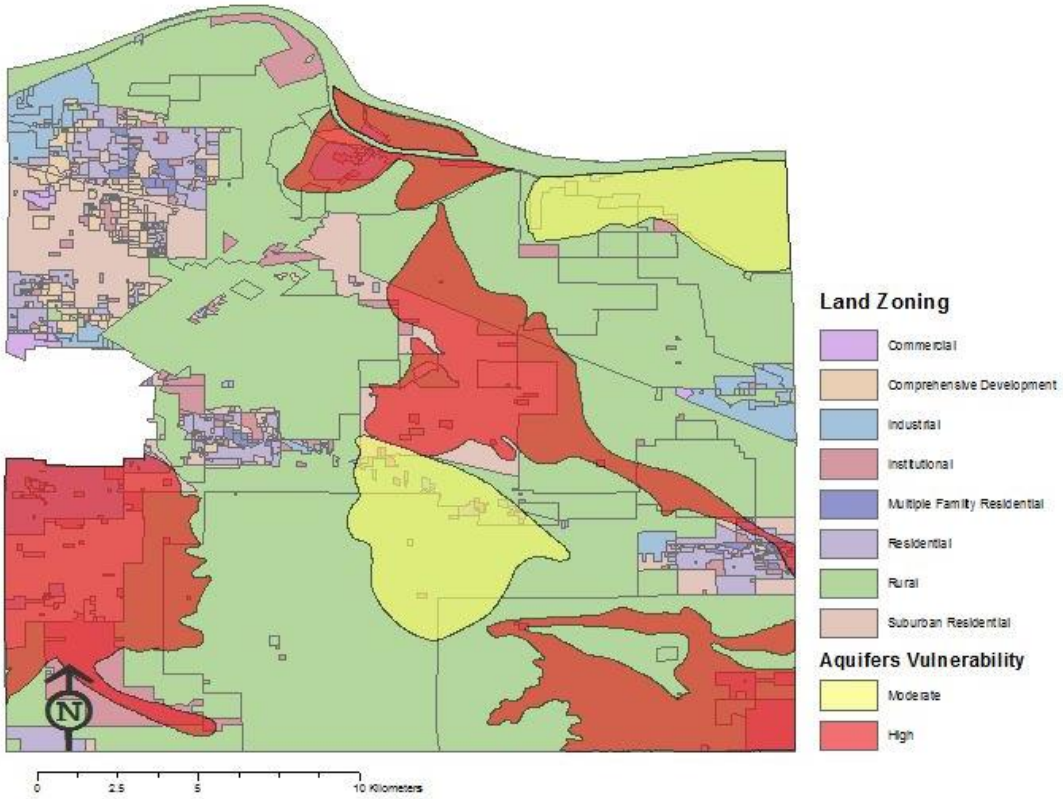



Figure 6

Recently, builders in the TOL have begun to build multiple houses on one plot without going through the process of rezoning the land (Community Development division, 2014). A TOL bylaw enables owners of rural zoned properties to build two houses on one plot of rural land (Community Development division, 2014). Historically, this bylaw was put in place to help support farming needs. It allowed farmers to provide housing for their full-time workers (Community Development division, 2014). However, the residents of the TOL's northwest Langley area have created their own subdivision using this loophole (Community Development Division, 2014). Although, landowners in this area are operating completely within the law, this type of unregulated development can be problematic. Areas like this are not equipped with "typical urban features such as curb and gutter, streetlights and sidewalks and is not part of the municipal solid waste system" (Community Development Division, 2014) that ensure the stability of areas with higher population density. In addition, creative development such as those in the Northwest Langley area put additional, unexpected strain on the water table.

In addition, like what was stated earlier, zoning plays a large effect on water consumption and how it can be managed. Rural and semi-rural areas tend to use private wells, whereas, urban, suburban and industrial tend to use municipal supplied water (Inter-Agency Planning Team, 2009). Private wells are drilled and maintained by a homeowner, and municipally supplied water is maintained by the city; however, homeowners have to pay for new installation. Out of the 5 at risk aquifers, the Hopington aquifer has the most private well owners (Inter-Agency Planning Team, 2009). Over the past 15 years, as more houses in this area are built, residents in the Hopington area have had to drill deeper wells, while older wells have begun to dry up (Inter-Agency Planning Team, 2009). The average well lasts about 25 years depending on maintenance and other factors (Inter-Agency Planning Team, 2009). However, many homeowners in the Hopington area have had to re-drill their well over the past 15 years due to these declining water levels (Inter-Agency Planning Team, 2009). The approximate cost of re-drilling a well is $20,000 (Inter-Agency Planning Team, 2009). In addition, the cost of extending water supply lines for municipal water is also costly (Inter-Agency Planning Team, 2009). A rural property can expect to pay $40,000 for a water main extension this cost excludes additional upgrades needed at pipe station to accommodate the shift (Inter-Agency Planning Team, 2009).

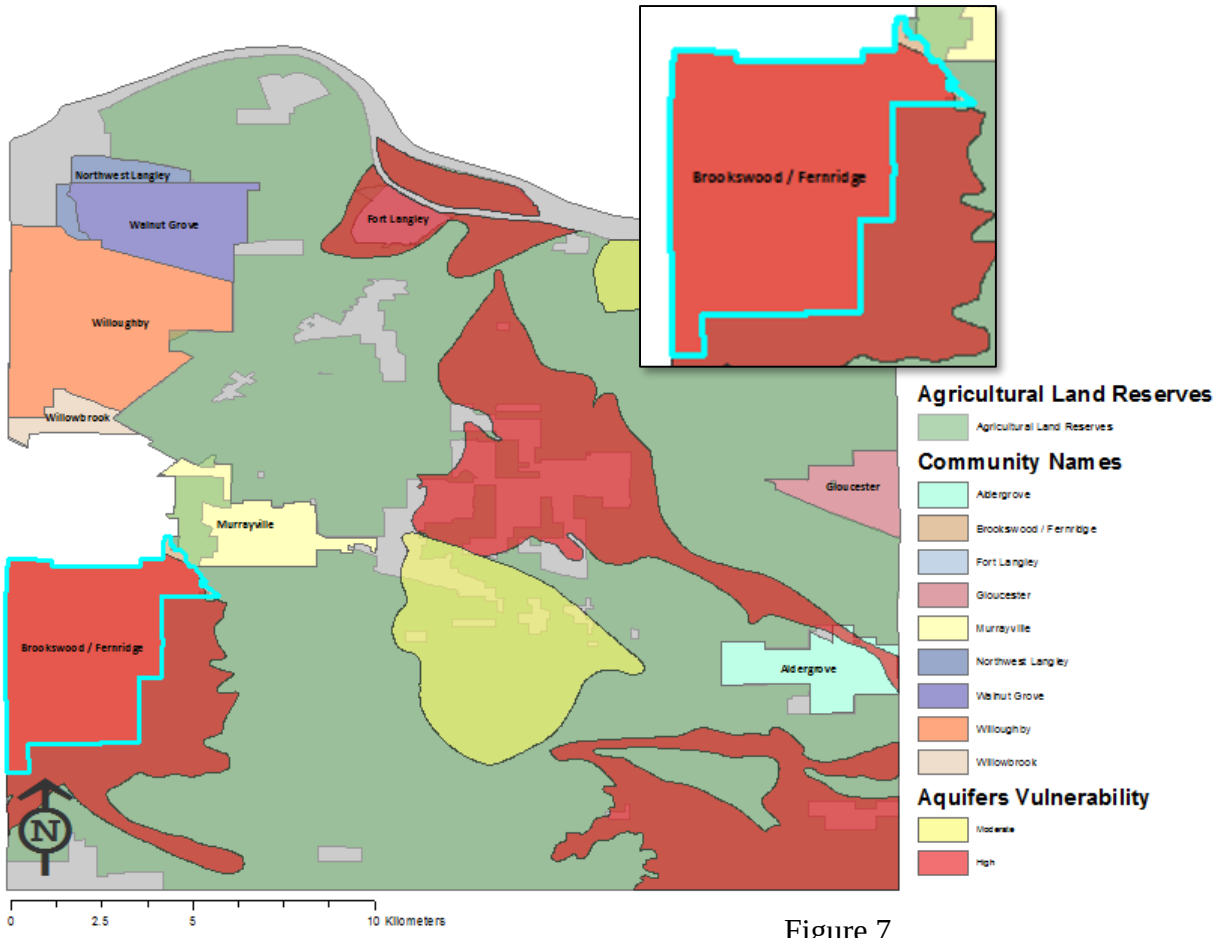



Figure 7

Brookswood is one area where city planners want to focus on developing. Figure 8 indicates that this is an area at high risk of having their aquifer go dry. A 2016 proposal submitted by McElhanney Consulting Service requested approval of the development on 19 acres of land (Gathercole, 2016). They would be building 83 new homes in this area (Gathercole, 2016). Although community members are divided on if this development should go forward, many concerns addressed at the TOL's council meeting focused on issues of overcrowding and aesthetic issue rather an environmental issue (Gathercole, 2016). If this development were to go forward, it would put a new, large strain of the Brookswood water supply and residents should be made aware of this. Those who have private well in this area may also be take on additional costs like having to dig deeper wells or switching to a municipal water supply.

## Management

This increase in development makes it clear that the TOL needs a more aggressive water management plan. The TOL's overall management goal is to "ensure safe and sustainable groundwater for the community for generations to come" (WMP, 2009, p. 26). However, TOL's goal to reduce overall demand for ground water by 30% by 2018 is not realistic; this is in direct conflict with the TOL's 2012 Economic Development Strategy. The first step to better watershed

management is eliminating or minimizing factors that contribute to the degradation of the water shed (Pitafi & Roumasset, 2006). Currently, the TOL's greatest threat to the sustainability of its watershed is over consumption (Inter-Agency Planning Team, 2009). Despite the fact that city planners are aware that the aquifer rates continue to plummet, they allow for continual development with little real solutions to these issues. The TOL is putting economic development over environmental integrity. In 2009, the TOL council was given a water management plan that had the potential to be successful; however, the council rejected many of the core recommendations.

The WMP is the TOL's water management plan, it encompasses 44 recommendations that can be categorized into four distinct groups: 1. protecting groundwater quantity; 2. protecting groundwater quality; 3. learning and raising awareness; 4. implementing and managing the WMP. Through these 44 recommendations, the three that stand out are enhancing municipal planning and development initiatives, public awareness of ground water issues and implementing water metering (Inter-Agency Planning Team, 2009).

Water monitoring is an important aspect of water management because "we can't manage what we don't measure" (Environment Canada, N.D., p. 53). The TOL does monitor most of their at risk aquifers using observation wells (British Columbia Groundwater Observation Well Network, N.D.). These wells are critical when it comes to water management. Using water measurement from the observation wells and a water-level hydro graph, researches are able to plot changes in the water level over time (Harris & Roach, 2013). These enables them to determine which changes are short-term like seasonal variations in the water level and which are long term like increase over all water consumption in that area (Harris & Roach, 2013). The more frequent the test the better, this will help researcher better detect small changes in the water table (Harris & Roach, 2013).

To meter water effectively one must first understand the difference between the price of a good and the value of a good. Price refers to the determined monetary rate that a good or service is sold for (Harris & Roach, 2013). Value refers to the willingness for a consumer to pay for a good (Harris & Roach, 2013). There can sometimes be a gap between the willingness for a consumer to pay for a good or service and its monetary price (Harris & Roach, 2013). This gap is known as consumer surplus (Harris & Roach, 2013). When the price of a good is higher than what a consumer is willing to pay, it will result in less demand for individuals purchasing that good or service (Harris & Roach, 2013). When determining pricing in a water metering system, one would have to identify where this number lies while also finding a point that covers the cost of maintaining and using a metering system (Chambouleyron, 2004).

Pricing is a major concern of some individuals in The Township of Langley (TOL) (Feldmann, 2007). Some people view water metering as a governmental money making scheme rather than a conservation effort (Feldmann, 2007). One key aspect of conserving water within the TOL is water metering and to achieve optimal water conservation the TOL would also have to meter water on private land. Water metering on private land is crucial especially when considering the one of the aquifers with some of the lowest water levels, the Hopington AB aquifer, is also an area in the TOL with a high number of private wells (Inter-Agency Planning Team, 2009).

Moreover, private water metering is regularly met with public pushback (Feldmann, 2007). It is challenging for a governing body to gain support when metering private wells because in almost all cases private owners pay to drill and maintain their wells (Inter-Agency Planning Team, 2009).

This becomes an issue of water rights and understanding if drilling a well gives an individual unlimited access to this resource. To be successful water rights must be clearly defined (Harris & Roach, 2013). In addition, a water buyer should also feel confident that their contracts will be honored and that there will be proper regulations and over sight (Harris & Roach, 2013).

Moreover, many well owners do not want the financial burden of having their well go dry. Essentially, community members want to see a water-metering program that monitors water consumption without implementing a pricing structure. Yet this would be costly and ineffective (Harris & Roach, 2013). Metering without a pricing structure does not provide an incentive to conserve (Harris & Roach, 2013). An effective pricing structure would be to implement an increasing block rate system (Harris & Roach, 2013). This is when "the price per unit of water increases as the amount of water used increases" (Harris & Roach, 2013, p. 364). This would enable buyers to use water up to a certain amount and if they go over they are billed a higher rate. By implementing an effective pricing system not only can this potentially be a profitable revenue source for the municipal government but it would also help change residents water consumption habits. If implemented in a way where the income generated by water metering was put back into water maintenance and protection, consumers could potentially save money. The money saved would be from private well owners not having to re-dig their private wells or having to take on the costs associated with switching to the municipal water supply.

The city of Santa Clara has a private well meter rebate program. This allows landowners to monitor their water usage levels while receiving a $150 rebate (Santa Clara Valley Water District, 2017). They believe that private well metering will enable owners to "better monitor their water use, more accurately report on water usage, detect leaks and other well maintenance issues, capture water savings due to conservation measures" (Santa Clara Valley Water District, 2017).

## Challenges

Water management in British Columbia (BC) is a challenging topic. Although this is a history of managing water quality throughout the province, managing domestic consumption has gone relatively unchecked (BC GOV, N.D.). What adds to this difficultly is that the Crown owns all water in BC, the BC's provincial government enacts water management policies, but the true water management onus is put on the municipal governments throughout the province and their set of bylaws (BC GOV, N.D.). Many of the provincial policies are outdated and have yet to deal with emerging issues like climate change and population growth (Council of Canadian Academies, 2009). In addition, without strict water consumption policies, towns and cities throughout BC are able to neglect water consumption management if they deem it as unnecessary. Hence, why the TOL is able to put economic growth over the conservation of their water table.

## Recommendations/Conclusion

Water management in the TOL must be a multilevel system the eases residents into better water management practices. The first step would be to have a more progressive and dynamic zoning policy. The TOL must first establish loopholes in their current policy and eliminate them so that the township is not being taken advantage of. Getting environmental consideration should be a key factor in new development plans. Although economic growth is important it should not over shadow the health of the water table and ecosystem. The Township of Langley (TOL) should focus on developing areas with richer aquifers instead of intensifying development in areas that are already at risk.

As for management policies, the TOL should implement water metering that includes municipal and private wells. This will provide a financial incentive to conserve water, which has proven to be more effective then education alone (Harris & Roach, 2013). Moreover, to minimize public backlash the TOL phase in the metering program, starting with voluntary installation accompanied by a rebate program and working their way to mandatory compliance. A strict policy must be put in place to insure an adequate amount of the revenue generated by the metering program goes back into the program and maintenance. This must include generating the fund necessary to switch private well users to municipally supplied water if an aquifer were to go dry.

Moreover, to make water metering a successful program the TOL would first have to implement a greater education plan around water conservation and the importance of ground water management. Some individuals see water metering as a way for a local government to takes its resident's money, rather than a water conservation effort. The TOL needs to stop assuming that residents care about the natural environment because unfortunately, more individuals are driven my monetary losses than ecological losses. As a result, the TOL needs to develop a simple education plan that informs residents on the financial burden associated with over consumption and the loss of an aquifer. Property owners must also understand that just because the TOL is in an area with heavy rainfall this does not mean that they are exempt from water sustainability issues. By implementing a more aggressive water management plan the TOL has the potential to access ground water sustainably while achieving their water management goals.

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