Evaluating the Potential Effects of Groundwater Withdrawals on Joseph Creek, BC

LWS 548 Major Project

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1. Executive Summary

The Joseph Creek Watershed provides critical natural resources and environment for humans and wildlife, but it is facing degradation of Joseph Creek, including reduced baseflow and disturbed fish habitats. One of reasons is groundwater withdrawals from nearby well pumping.

Literature about groundwater and stream interactions was reviewed for background information regarding how groundwater plays an important role in streams, as groundwater provides base flow to the stream, moderates water temperatures, carries chemical transfers, and maintains aquatic and riparian ecological conditions. Regulations and programs about groundwater and wells have been initiated in BC, for example, the Water Sustainability Act, Groundwater Protection Regulation, well licensing or registrations, and Living Water Smart. Groundwater withdrawals from the aquifer cause large impacts on streams, by disturbing the hydrological cycle, deteriorating water quality, degrading the ecosystem, and making river channels unstable due to land subsidence. Several strategies can be applied to recover groundwater depletions and rehabilitate the stream, including direct groundwater supplements to aquifers, Integrated Water Resource Management, and baseflow augmentation.

Groundwater withdrawals on Joseph Creek were evaluated by Aquifer 526 with three research components. First, groundwater flow was simulated via MODFLOW to observe the huge disturbance of one-year constant pumping on the groundwater level. Second, the baseflow indices of Joseph Creek in 1968, 1970, 1973, and 1974 were calculated via USGS Web-based Hydrograph Analysis Tool to evaluate the possible relation between reduced baseflow of Joseph Creek and 31 active pumping wells at the same time. The result was that the index in 1974 was particularly low, which might be partially caused by groundwater withdrawals. Third, groundwater demands for irrigation in Aquifer 526 were calculated during the years 2053 to 2058 for testing the trend under climate change and the difference between good and poor irrigation management practices. The results indicated that the trend under changing climate conditions during this period was not obvious, but good irrigation management practices might effectively mitigate projected groundwater withdrawals for irrigation compared with poor irrigation management practices.

Recommendations are suggested for different watershed stakeholders. Governments could conduct more investigation in monitoring water parameters, managing water and educating stakeholders about the importance of water knowledge. Watershed management partners and organizations could provide more benefits if they implement aquifer and stream restoration tactics, update the Joseph Creek management framework, and facilitate communications and training among professionals. Local residents could learn more about water sustainability and how to implement it in their daily life. Indigenous people have their water rights within watershed, and their directions should be respectfully considered in the decision making about water and land use.

2. Acknowledgements

This project could not be completed without the critical support from Dr. Les Lavkulich, Julie Wilson, and other amazing staff in Master of Land and Water Systems. Also, I have to appreciate the help from Dr. Ali Ameli and Dr. Carl Walters, who provided constructive advice about groundwater modelling. I feel so fortunate to finish this project with their inspirations.

3. Introduction

The Joseph Creek Watershed (Figure 1) is located in the southeast of BC, Canada. The watershed has a total area of $188km^2$, the elevation ranges from 923 to 2,182 meters (BC FLNRORD, 2022), and is divided into three parts according to the topography and relief. The southeastern part of the watershed with the highest elevation supports recreation, logging, and grazing. The middle part of the watershed is an urbanized area, where citizens of Cranbrook live. The northwestern part of the watershed is the lowest in elevation, characterized by semi-rural landscapes. Joseph Creek is a tributary of the St. Mary River with a length of 33 kilometers. Joseph Creek flows from headwaters in Joseph Mountain, across Cranbrook in the middle reach, and finally into the St. Mary River in the lower reach, where is considered as the historically cultural gathering site by Ktunaxa and the ?Aq'am people. Joseph Creek Watershed has several unique features in multiple aspects. Climatically, the basin has cloudless and hot summers by surface heating, while cold arctic air provides cold winters within the basin. Geologically, the watershed experienced several glaciations, depositing silts, sands, and gravels to form lakes and rivers. Soils upstream from the Creek are acidic and porous, covering the sedimentary and metamorphic bedrock, while soils downstream from the Creek are fine texture gullied terraces. From an anthropogenic perspective, developments of Cranbrook are responsible for artificial alterations around the Creek. To meet the water demands of approximately 20,000 residents in Cranbrook, water infrastructures, such as the Phillips Reservoir and pumping wells, have been constructed for surface water and groundwater withdrawals. Aggressively developing land uses around the Creek, like grazing, agriculture, and logging, has deteriorated the riparian and aquatic environments of the Creek. Hydrologically, Joseph Creek has an average annual discharge of 0.914 m^3/s. As a snowmelt dominated regime, the upper catchment receives high snowfall in winter and yields an overwhelming freshet in spring and early summer. By contrast, the Creek in the lower catchment is highly regulated and influenced by dam operations and water withdrawals, sometimes triggering insufficient stream flow and largely degrading the local ecosystem. Water quality downstream has also been exacerbated by urbanizations, and the dilemma of low stream flow is accelerating this process. Ecologically, various kinds of plants and animals can be found within the watershed, and the Creek used to be especially characterized by providing important habitats for juvenile fish, like Cutthroat Trout and Bull Trout. However, the low flow condition has had a huge negative impact on habitat maintenance and fish survivals. Also, riparian and aquatic creatures have been deeply negatively affected by water withdrawals, irrigation, dam operations, and other human activities (VAST Resource Solutions, 2019).

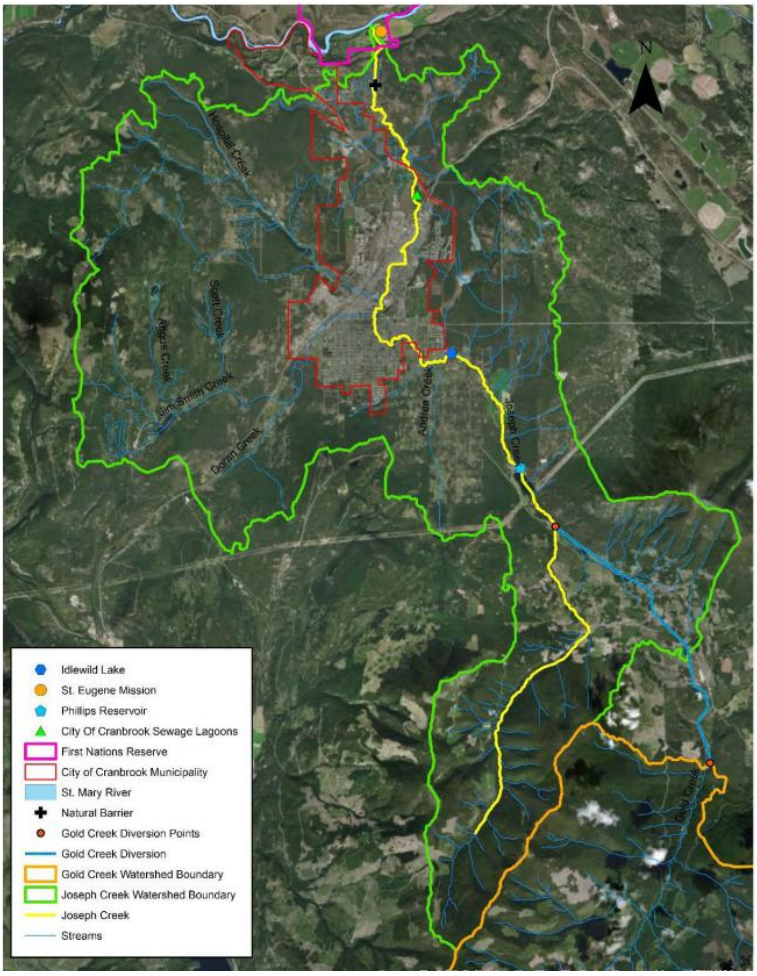

Figure 1. The map of Joseph Creek Watershed (VAST Resource Solutions, 2019)

Joseph Creek has been facing challenges recently, and the lack of data and research about the Creek is impeding the process of solving these challenges. One of problems that cannot be ignored is the insufficient discharge as baseflow. Without adequate flow during dry seasons, the water quality and temperature are less biologically suitable, and the instream and riparian ecosystems have been functionally degraded. Fish populations have been drastically reduced, since low flow maintenance is vital for fish thriving all life stages. To rehabilitate Joseph Creek, the Columbia Outdoor School initiated the Joseph Creek Management Framework in 2016, aiming to make more sustainable decisions associated with Joseph Creek. A report stating environmental conditions in Joseph Creek was completed by VAST Resource Solutions in 2019 to aid future Creek restoration strategies. Even though relevant initiatives and managements have begun to be conducted for the Creek restoration, existing information and knowledge gaps are considered as significant difficulties. The long-term water quality and water quantity data monitoring is absent, and the specific minimum flow requirements for ecosystem health and fish habitats have not been identified (VAST Resource Solutions, 2019).

The problematic situations of Joseph Creek might be associated with adjacent groundwater exploitations. However, insufficient attentions have been paid to this issue and decent groundwater managements have not been conducted for stream protections.

This paper aims to narrow the knowledge gaps about groundwater-stream interactions, evaluate the effects of groundwater withdrawals on Joseph Creek, and suggest recommendations for stakeholders within the watershed. Methods include a systematic literature review for the knowledge background, and three analysis models: MODFLOW, USGS Web-based Hydrograph Analysis Tool, and the BC Agriculture Water Demand Model.

Specific objectives:

- Documenting the importance of groundwater on streams, reviewing the BC regulations on groundwater and well pumping, how groundwater withdrawals can adversely affect streams, and list practical strategies for groundwater and stream restoration.
- Select a specific aquifer for data analysis, simulating drawdowns with one-year constant well pumping, assessing the changes of the base-flow index at a selected hydrometric station, and analyzing how groundwater demands for irrigation might be different under climate changes and different irrigation systems.
- Provide informed recommendations for governments, watershed partners, organizations, nearby residents, and the Indigenous community to better restore groundwater depleted aquifers and degraded Joseph Creek.

4. Literature Review of Groundwater and Stream Interactions

4.1 The significance of groundwater on streams

Groundwater plays an indispensable role in maintaining and supplementing streams, and also closely involves the hydrological cycle and the biosphere. Groundwater hydrology is often not studied as an independent science, but with interdisciplinary interactions with geology, ecology, meteorology and biology (Vasconcelos, 2016). Thus, it is necessary to learn about groundwater-related terminologies, groundwater categories and distributions, mechanisms of groundwater recharge and discharge, and multiple functions of groundwater provisions for streams.

Groundwater is considered as water flowing through underground water-bearing formations (Environment and Climate Change Canada, 2013). The permeable water-bearing formation is labeled as an aquifer, while the semi-pervious formation with slower flow rates is called aquitard (Şen, 2014). Beneath the land surface (Figure 2), groundwater is stored in the saturated zone, which is referred to as the space filled with water with positive pressure. The upper surface of groundwater in the saturated zone is the water table. The unsaturated zone contains not only water but also air, where water is held by capillary forces. Wells are able to pump groundwater from the saturated zone but not water from the unsaturated zone, because the pressure in the saturated zone is high enough for pumping the surrounding groundwater into the lower pumping water level, while water molecules in the unsaturated zone are held too tightly by capillary forces. The transition zone between the saturated zone and unsaturated zone is called the capillary fringe, where water occupied voids but is controlled by capillary forces. The capillary fringe effect happens in this transition zone near streams, during infiltration, shifting negative pressure to positive pressure and contributing interflow to streams. Aquifers with groundwater can be categorized into confined aquifers and unconfined aquifers (Figure 3). In unconfined aquifers, groundwater surface is exposed to the air. These aquifers are closer to the land surface. As it can more easily interact with infiltration from the land, groundwater in unconfined aquifers is more vulnerable to pollutions. Water quantity also fluctuates according to the recharge and is considered as short-term water use. In confined aquifers, groundwater is constrained by upper and lower impermeable layers. Water in confined aquifers is more distant and isolated from the land surface, and water quality is comparatively clean. The age of confined groundwater is usually old and is planned as long-term water utilizations (Bhandari, 2022).

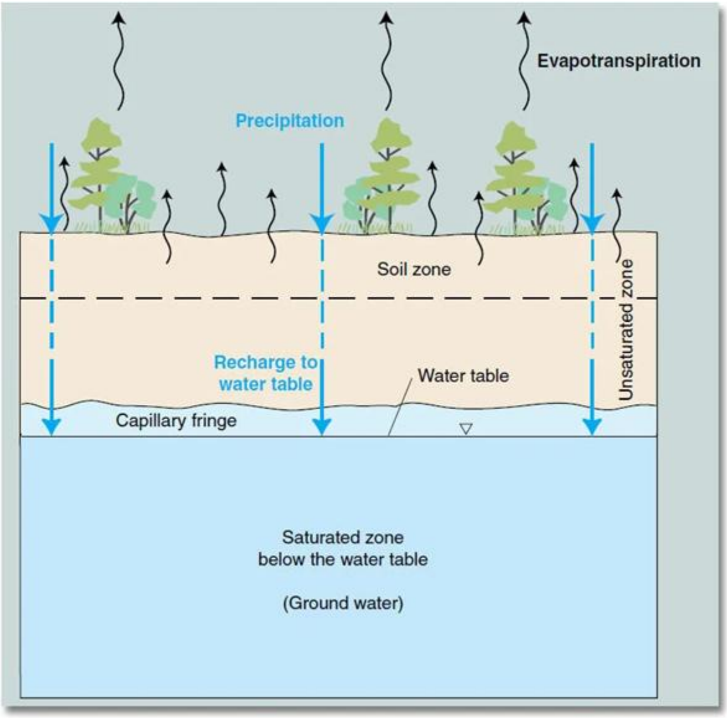

Figure 2. Water table, unsaturated zone, saturated zone, and capillary fringe (Alley et al., 1999)

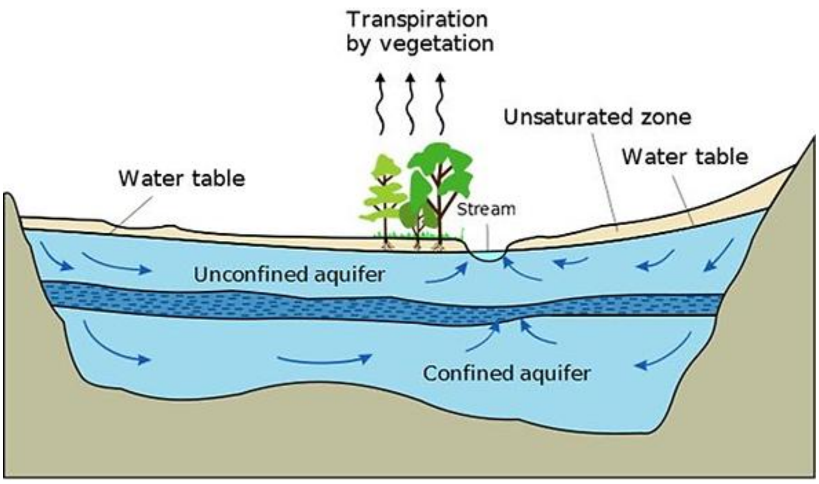

Figure 3. Unconfined and confined aquifers (Alley et al., 1999)

Groundwater may be classified by age and the volume of water contributed to the hydrological system. Depending on hydrological and geological conditions, ages of groundwater underground could range from months to decades. Up to 2 km depth, groundwater younger than 50 years old is viewed as modern groundwater, and that younger than 100 years old but older than 50 years old is viewed as young groundwater. Older groundwater is referred as groundwater older than 100 years old. Younger and older groundwater have different characteristics. First, younger groundwater is more renewable, while older groundwater is tough to be supplemented after depletion. Second, younger groundwater is more vulnerable to land uses and contaminations, but older groundwater is less likely to be affected by these disturbances. Also, younger groundwater is more active in the water cycle, while older groundwater could be stored in deeper aquifers for a long time without frequent interactions with other water bodies. Last, younger groundwater can more easily cause chemical weathering of rocks and soils, while older groundwater with lower flow rates is less capable of chemical weathering. When different types of global estimated water resources as of 2015 are compared together (Figure 4), it is not difficult to discover that modern groundwater (347,180 km^3) is incomparable in quantity for atmosphere water (12,000 km^3), water within vegetation (1,000 km^3), surface water (100,000 km^3) and soil water (16,000 km^3). Surprisingly, the volumes of modern groundwater are almost negligible compared with the volumes of older groundwater storage (21.97 million km^3) (Gleeson et al., 2015).

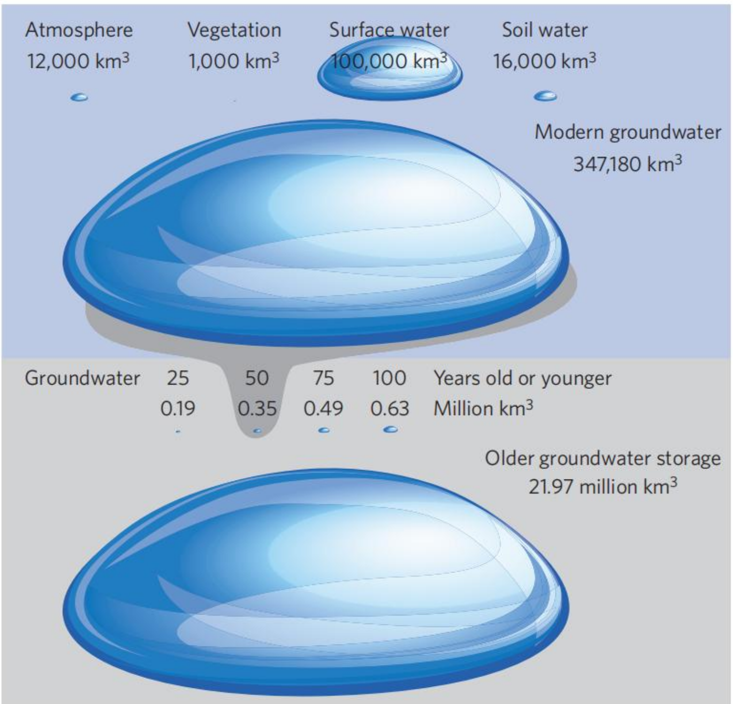

Figure 4. Distributions of estimated global freshwater resources as of 2015 (Gleeson et al., 2015)

Groundwater closely interacts with streams in the processes of discharge and recharge. Water flowing in streams comes from multiple sources, including a significant part of groundwater. Initially, precipitation directly brings water into streams or indirectly flows into streams as surface runoff. Second, above the water table, interflow comes from infiltration flows into streams through the subsurface. Next, groundwater below the water table discharges into streams. Additionally, human activities, like treated pipeline water and agricultural drainage, can also participate in stream water circulations. Globally, almost half of stream water originates from surface runoff and subsurface interflow caused by temporary precipitation, while 40-50% of stream water from groundwater, in small and middle-sized streams, is an invisible component in a relatively long-term flow pattern. In terms of interactions between groundwater and stream sections, flowing patterns vary based on specific hydrological setting (Figure 5). The sections of gaining stream occur when stream water surface is lower than the water table, resulting in the groundwater discharge from aquifers to streams (Figure 5a). Oppositely, the sections of losing stream happen when water surface is higher than the water table, leading to the groundwater recharge from streams to aquifers (Figure 5b). When the water table is distant enough from the stream water surface, losing stream sections might become disconnected from the groundwater (Figure 5c) or even become complete dry (Figure 5d) (Poeter et al., 2020). Groundwater depletion caused by well pumping is a typical cause for deteriorations of flow patterns to disconnected and dry streams. The interactions between streams and groundwater also have different spatial scales (Figure 6). The discharge into streams might partially come from nearby local aquifers (Figure 6 blue arrows), and also contain flow from more distant regional aquifers (Figure 6 red arrows) (Schuite, 2020).

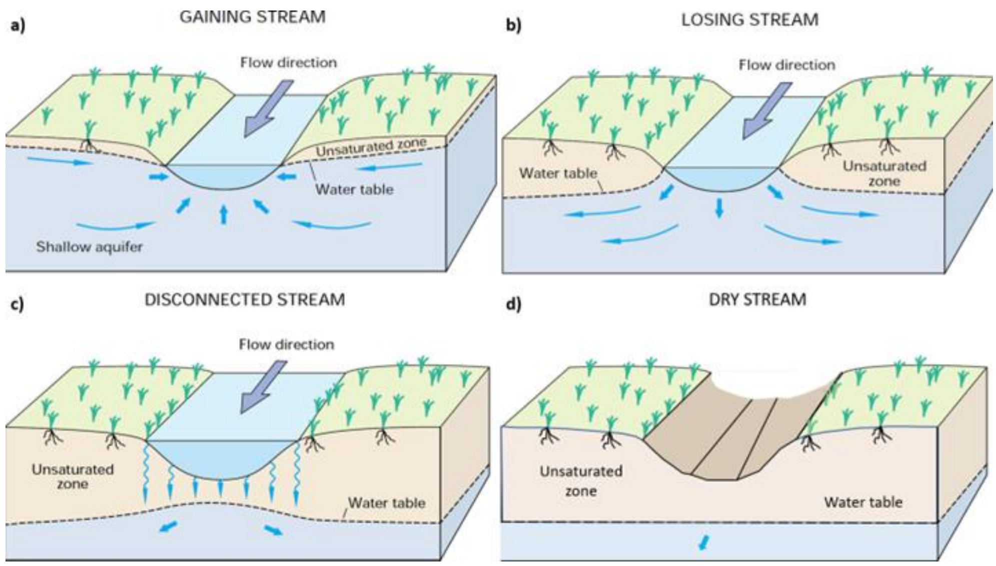

Figure 5. Different flowing patterns between streams and groundwater (Poeter et al., 2020)

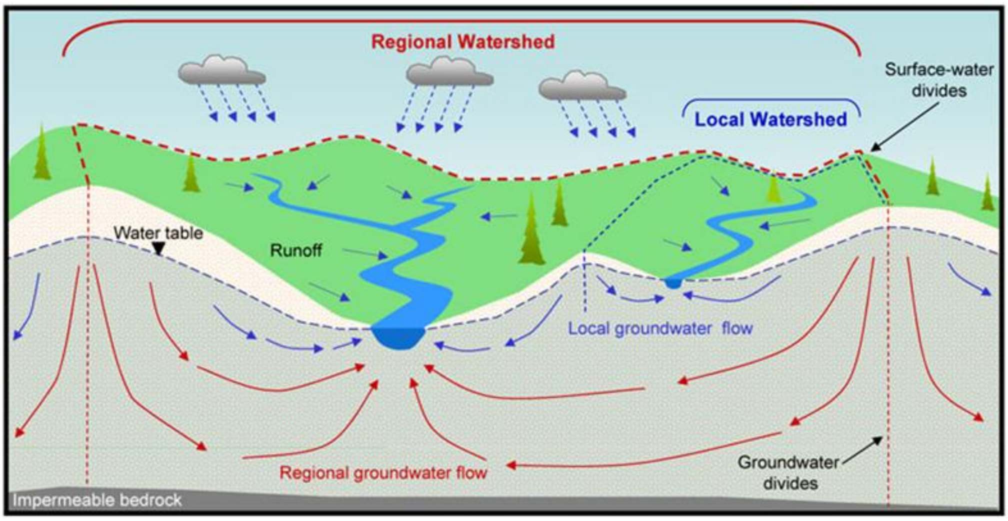

Figure 6. Different spatial scales of groundwater flow (Schuite, 2020)

Groundwater can provide countless benefits for the hydrological system and aquatic environment in streams. Primarily, groundwater enables streams to keep alive with baseflow during dry seasons. As flow rates of groundwater are slower than surface water, the timing of groundwater discharge is longer than surface water. Thus, when precipitation and runoff cease, groundwater discharge is almost the only source to provide water for streams (Vasconcelos, 2016). Also, the temperature in streams is regulated by groundwater inputs. Since groundwater is insulated from the land surface and atmosphere, it suffers less from temperature daily and seasonal variations in the atmosphere. In Figure 7, the temperature data from June 1999 to September 2000 in different media showcase that, with the increase of depth (from yellow to green, blue, and pink), the temperatures of groundwater have smaller magnitudes of variation and larger delays in peaks than surface water temperatures (Poeter et al., 2020). Next, groundwater is responsible for chemical transfers from the ground to the stream. Chemical elements, like oxygen, carbon, nitrogen and phosphorus, can be transferred from surface water to groundwater and then to streams, influencing chemical and biological characteristics in streams (Winter et al., 1139). Consequently, groundwater can be supportive for maintaining ecological services in streams, letting vegetation and animals thrive. Suitable living conditions, like environmental flow, enough oxygen and nutrients and stable temperatures, are critical for aquatic and riparian creatures. For instance, enough concentrations of oxygen are required for fish laying eggs, and the specific range of temperatures is the catalyst for successful hatching eggs (Poeter et al., 2020).

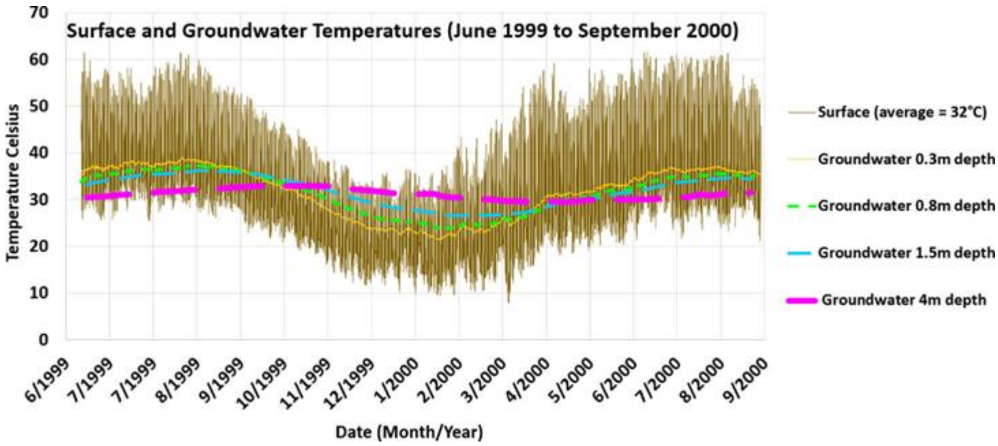

Figure 7. Surface and groundwater temperatures from June 1999 to September 2000 (Poeter et al., 2020)

4.2 Groundwater and pumping well regulations in BC

In BC, groundwater is considered as the precious freshwater resource, which is widely utilized and regulated to support daily urban and rural water consumptions (BC ENV, 2016). Groundwater supports almost 1 million of BC citizens on the daily basis, and 25% BC residents reply on groundwater as the drinking water source. In the total water consumption in BC, 9% of it is contributed by groundwater. Aquifers in BC are commonly made of sands and gravels from the former glaciation. Compared with deeper aquifers in the Canadian Prairies, aquifers in BC are usually shallower and better connected with streams and rivers, being more vulnerable to well pumping (James, 2019). The vital status and vulnerability of groundwater within the provincial water system indicates the necessity of scientifically and regularly monitoring and regulating groundwater resources. BC government now is dedicated to establishing a network of monitoring wells for groundwater level observations, and also identifying groundwater high use areas for the future management (Province of BC, 2014).

To better conserve and regulate groundwater, relevant laws and policies have been enacted and updated in BC. Water Sustainability Act, which has been updated as a living document, is treated as the reliable reference for dealing with water supplies, economic developments, climate change and ecosystem restoration. Groundwater issues are recognized and regulated in Water Sustainability Act and associated regulations.

Groundwater Protection Regulation is a part of the Water Sustainability Act, specializing on groundwater and wells. It guides groundwater activities to be conducted safely, and also provides minimum standards of the well construction, maintenance and decommission to prevent groundwater pollutions and waste. On November 1, 2005, a new regulation was enacted to provide new standards of well construction (Figure 8), including the secure well cap, well ID plate, well casing stick-up, graded wellhead and surface seal (BC ENV, 2005).

Groundwater licenses and well registrations for well users are also regulated under the Water Sustainability Act. In the current Act, depending on domestic or non-domestic purposes, wells in BC are regulated separately. Domestic wells recognized in the Water Sustainability Act are wells with groundwater utilization for private household purposes, such as drinking, cleaning, cooking or gardening. As for a non-domestic well, which might have irrigation or industrial purposes, the water license is required for groundwater exploitation, diversions and storage since March 2, 2022. The water license can clarify the amount of legally available groundwater for the well user and obtain groundwater use information for informed decisions of water management. Groundwater licensing enables water to be safely maintained in aquifers and streams, alleviating water use conflicts among different users and improving the water security in communities. However, groundwater licensing has still not completely been implemented in BC, as many non-domestic wells have not been licensed. As for a domestic well, groundwater licensing is not required for domestic water rights, while well registration is encouraged by the government to record water use data. The domestic well can be registered at no costs and then tracked in the database of Groundwater Wells and Aquifers, importantly informing BC water use decision makers and planners (BC ENV, 2022).

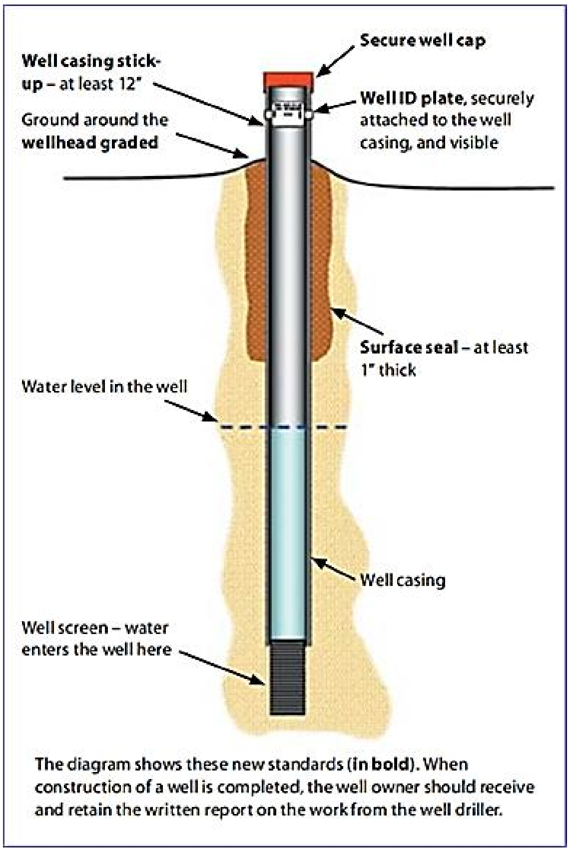

Figure 8. New standards in Groundwater Protection Regulation on November 1, 2005 (Ministry of Environment, 2005)

Living Water Smart, announced in 2018, is a provincial program in BC with governmental visions and commitments for the water sustainable stewardship and management. In the contexts of climate change and population growth, whose impacts have been causing serious water use conflicts and water degradations, Living Water Smart has recognized that only collective efforts of governments, industries, NGOs, communities and First Nations can achieve the goals of water sustainable utilizations (BC ENV, 2016). Groundwater is one of the important parts considered in this program. Groundwater in BC generally has good quality, but some aquifers as drinking water sources suffer from contamination, notably nitrates. Groundwater in BC is also not regulated appropriately, making groundwater vulnerable and adjacent streams negatively impacted by groundwater overexploitation. Noticeably, some of commitments and managements about water in BC are incorporated into the system of the Water Sustainability Act (BC ENV, 2016).

4.3 Impacts of groundwater withdrawals on groundwater and stream interactions

Groundwater-stream interactions have been deeply affected by groundwater exploitation, worldwide. Excessive groundwater withdrawals occur in areas with high water demands. The global trend of urbanization and population growth centralizes water users and demands, triggering serious problems in multiple fields, including society, economy, environment, hydrology and ecology. In order to meet surging water demands, more and more groundwater has been pumped from aquifers even without the premise of sustainability. Overexploitation of groundwater are leading to catastrophic consequences, such as changing the original hydrological cycle, polluting water, degrading ecosystems and sometimes casing land subsidence.

First, the hydrological cycle can be largely disturbed by groundwater withdrawals. During long-term groundwater depletions, groundwater is constantly pumped from aquifers, gradually lowering groundwater levels. In this case, when aquifers receive the same amount of recharge, depleted aquifers cannot discharge into streams as much as before and then the pattern of groundwater-stream interactions can be gradually altered. The stream might gradually gain less water from aquifers at the beginning, and then turn to lose water to aquifers and even become a totally dry stream. The stream response to groundwater pumping via a hypothetic well indicates the relation between the pumping time and changes of pumped water sources (Barlow & Leake, 2012) (Figure 9). Initially, the groundwater supply is storage-dominated, which means the well pumps more water from aquifers than streams. The time t_{dds} is the moment when the pumping rate from groundwater is equal to streamflow. After t_{dds}, more water tends to be pumped from streamflow than aquifers, and ideally the equilibrium of pumping is reached when streamflow depletions fully contribute to the well pumping rate. A typical example of stream hydrological alterations can be found in valleys of Southern California, US, where streams and rivers that historically flowed all year-round now shift to be intermittent owing to local decreased groundwater tables.

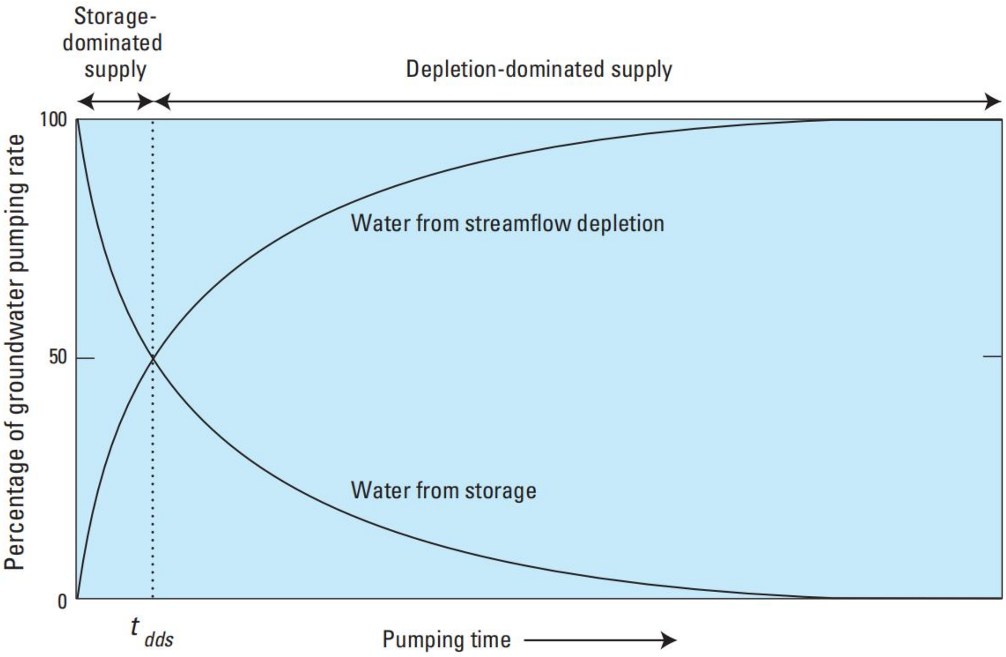

Figure 9. The percentages of pumped groundwater from storage and stream depletion with time in a hypothetic well (Barlow & Leake, 2012)

Second, water quality in both aquifers and streams might be deteriorated due to groundwater depletions. Groundwater contaminations caused by saltwater intrusions could be problematic in coastal areas (Figure 10). In normal conditions, freshwater flows towards saltwater and mixed with saltwater at the interface, effectively preventing the encroachment of saltwater on freshwater aquifers (Figure 10a). However, excessive pumping activities result in reducing flow from freshwater to saltwater areas, and even pumping saltwater to freshwater aquifers, contaminating freshwater storages in these aquifers (Figure 10b). For instance, Florida, US has saltwater intrusions, and one of reasons is that freshwater levels are lower than sea level, so saltwater intrudes into aquifers. Water managers in Florida are dedicated to preventing and reversing local saltwater intrusions (USGS, 2019). Another water quality issue comes from induced infiltration of streamflow. Well pumping can disturb original aquifer-stream interactions and let streamflow infiltrate into aquifers. If these affected streams are under the bad water quality, pollutants in water will enter aquifers, pumping wells, and then the whole water use system, adversely affecting the public health and related industries (Barlow & Leake, 2012).

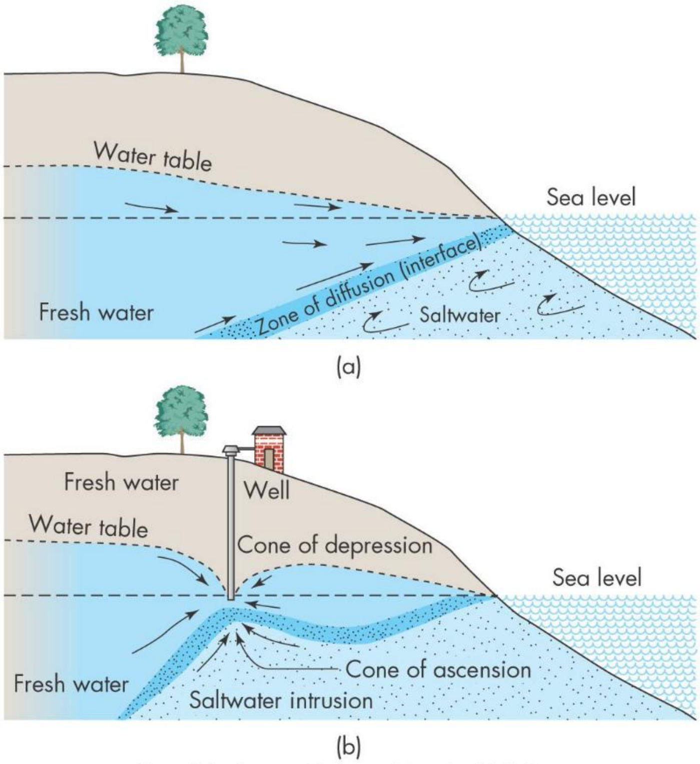

Figure 10. Saltwater intrusions induced by well pumping (GeotechEnvEq, 2012)

Third, degradations in riparian and aquatic ecosystems of streams could be exacerbated by groundwater pumping. Water tables and river levels vary between wet seasons and dry seasons (Figure 11). During dry seasons without precipitation, ecological services around streams are provided by environmental flow, the minimum criteria of flow in quantity, quality, and timing to support natural functions and living conditions for riverine flora and fauna. Environmental flow is often considered as ecological bottlenecks in streams, as it determines river depths, the minimal wetted parameter, soil moisture, and other hydraulic conditions. Constant groundwater abstractions might cause decreases of water levels in river channels, prolonged durations of dry riverine conditions, and fewer opportunities of floodplain inundations, aggravating nearby ecological degradations and thus receiving negative responses from riverine morphology, vegetation and wildlife. The stream morphology might be altered by increased sedimentation and encroached vegetation. Plant species, density, and resilience could be influenced by less soil moisture. Livelihoods of animals might also be threatened by reduces habitats, disappeared vegetation as food sources, or disturbed migration pathways (Hayes et al., 2018). As an example, numerous fish species like soho, steelhead, and cutthroat trout are struggling for survival in the Koksilah River of Vancouver Island, BC, as local habitats have been degraded to a large extent via groundwater draws. It is estimated that groundwater occupied 70% of water consumption in Koksilah River Watershed. BC Thus, the government issued a water restriction including groundwater in 2019 to mitigate negative impacts (James, 2019).

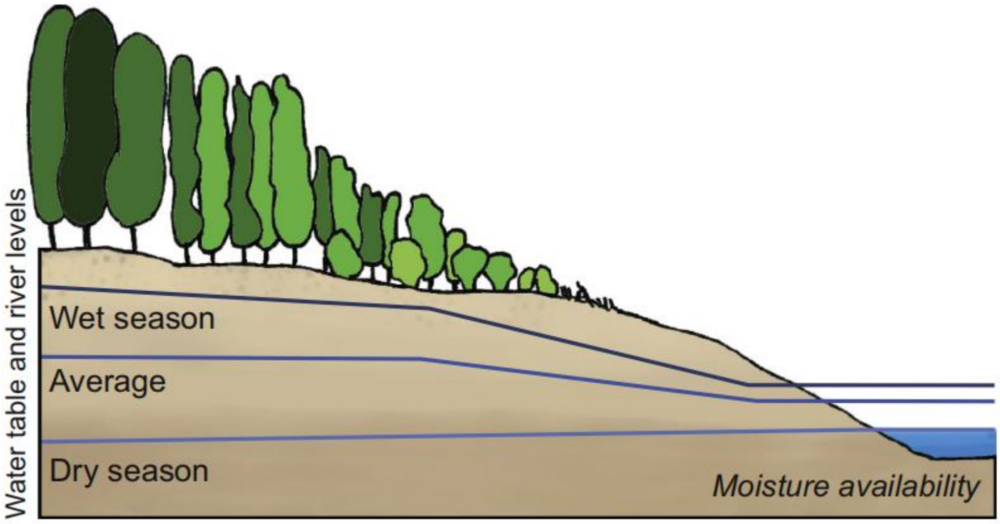

Figure 11. Changes of water tables and river levels in a temperate floodplain river under the moist condition (Hayes et al., 2018)

Land subsidence and instability of stream channels are also related to groundwater abstraction-by changing the water pressure. Groundwater aquifers might have large pore layers with sands and gravels, and also small pore layers with clay and slit (Figure 12). Sand and gravel layers are usually chosen as areas for groundwater pumping, as water flows easily in these layers. When water is drawn from sand and gravel aquifers, water pressure is lowered, triggering the water drainage from adjacent clay and slit layers to sand and gravel layers. These compressible layers with clay and silt that lose water would also lower water pressure and get compressions, thinning the depth of these layers and lowering the land surface (Leake, 2016). Land subsidence could adversely influence the stability of stream channels and nearby landscapes. As the result of excessive groundwater depletions close to Lucerne Lake, the fissures in Mojave Desert, California, US, were gradually formed, and are even over one meter in wide and deep (Water Science School, 2018).

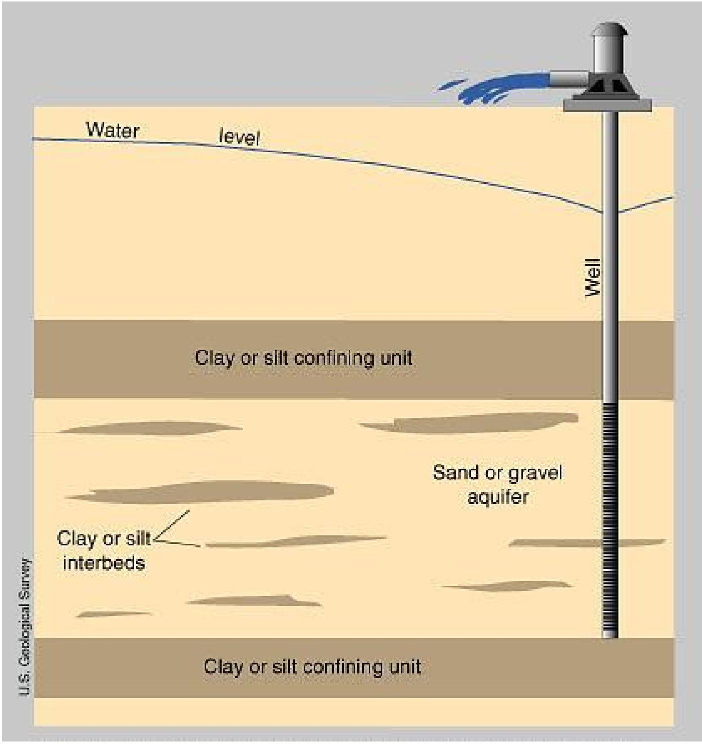

Figure 12. The process of land subsidence caused by well pumping (Leake, 2016)

4.4 Strategies of groundwater and stream restoration

To mitigate the impacts of groundwater withdrawals on the aquifer-stream system, several methods in terms of technical, political, and educational aspects have been successfully applied with satisfying results. Ideally, aquifer water replenishment, Integrated Water Resources Management, baseflow augmentation, education and dissemination of water knowledge, and water decolonization are all potentials solutions depending on specific aquifers and streams.

Primarily, supplements of groundwater to aquifers are the direct approach to dealing with groundwater depletions. Two distinct projects of groundwater replenishments might be selected based on different objectives. Aquifer recharge (AR) is the recharge process of solely replenishing water to prevent or control issues caused by groundwater withdrawals, like saltwater intrusions or land subsidence. Aquifer storage and recovery (ASR) aims at storing groundwater and then returning it back for multiple purposes, like irrigation, drinking water, industries and ecosystem maintenances (UIC, 2021). Suitable methods should also be tailored for different types of aquifers. For unconfined aquifers, infiltration basins can collect surface water from natural precipitation or artificial recharges, and gradually infiltrate it into unconfined aquifers (Figure 13). As no impermeable layers cover unconfined aquifers, water that comes from infiltration basins is able to replenish the depleted groundwater. For confined aquifers, injection wells are a more informed option (Figure 14). As surface water from infiltration cannot effectively enter confined aquifers, injection wells are used to inject water into confined aquifers for deeper groundwater supply. Enhanced infiltration from both AR and ASR projects has significant benefits for not only aquifers but also streams. Aquifers could directly receive replenishments for groundwater, increasing available groundwater storage for human water utilities and also necessary discharges into streams as a part of the hydrological cycle. Streams would also indirectly get benefits from groundwater infiltration, as increased discharges might promote the soil moisture in and around streams, nourishing the vegetation. The vegetation can provide organic matter for soils, and better maintaining the riverine baseflow and ecosystem (Vasconcelos, 2016).

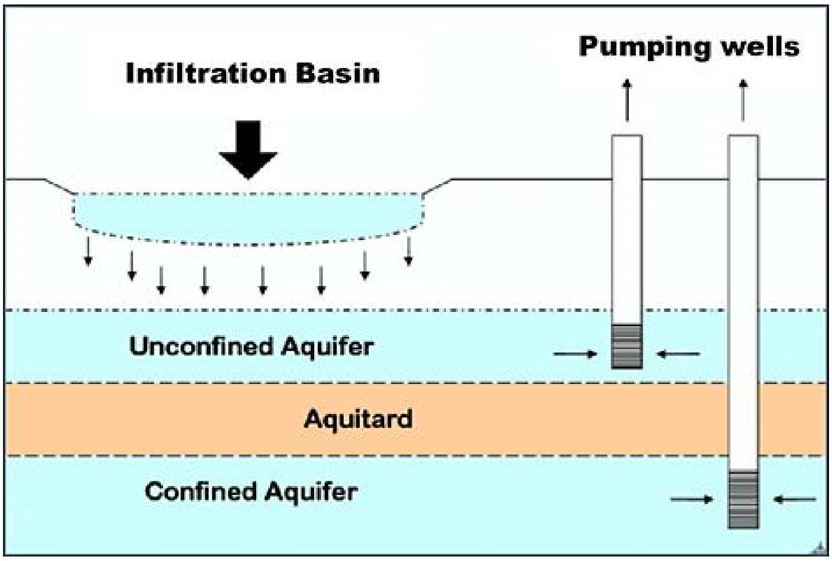

Figure 13. The process of recharging water into the unconfined aquifer from the infiltration basin (Sanchez et al., 2015)

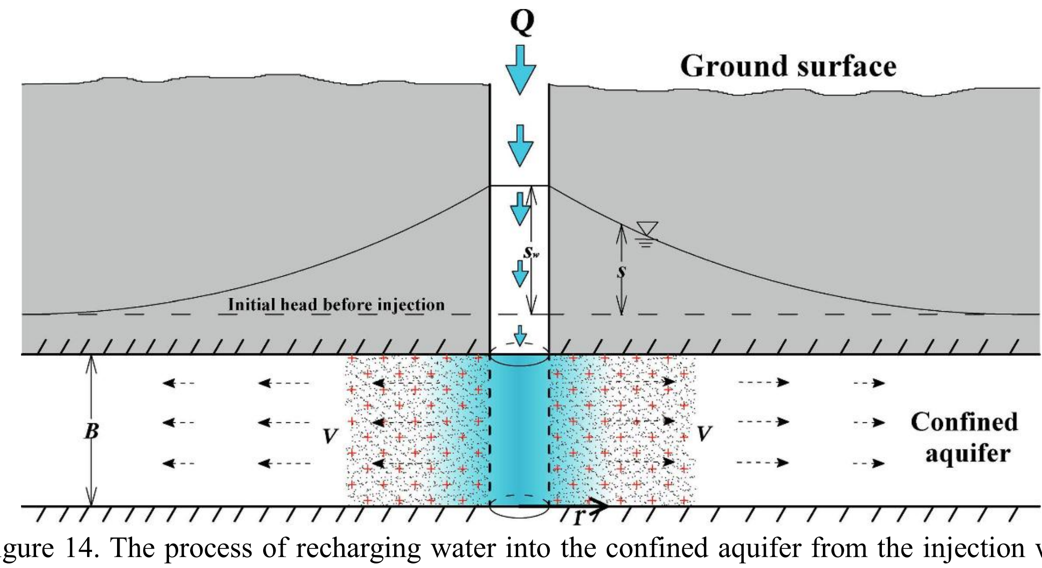

Figure 14. The process of recharging water into the confined aquifer from the injection well (Zhu et al., 2019)

Secondly, Integrated Water Resource Management (IWRM) is very valuable to look at the bigger picture of water resources management. IWRM is referred to as a systematic approach to managing surface water and groundwater in scientific, environmental, societal, and economic perspectives, including three components: alternative water resources development, water resources protection, and holistic water demand management. To better develop and regulate alternative water resources (desalinated saltwater, reclaimed water and treated stormwater), it is critical to recorrect the misconception of the unplanned water cycle management to planned water cycle management (Table 1). The unplanned water cycle management assumes that water usage comes from streams and aquifers as traditional resources, and then used and treated water directly flows back to traditional resources. Instead, the planned water cycle management will consider the step of utilizing alternative resources after treatments for drinking water, industries, recreation or irrigation, so water resources can be managed more reasonably and accurately this way. Water resources protection refers to region-specific water resources regulations and strategies to improve the quality and quantity of water bodies. Achieving holistic management of water demands requires not merely considering demands of direct water users, but also demands associated with the local environment, society, and economy (Thomas & Durham, 2003). For instance, managing groundwater extractions should not only value impacts on aquifer drawdowns and the maintenance of baseflow and ecosystem in streams, but also the economic, societal, and political impacts (Alley & Leake, 2004).

Table 1. The water flowing procedures within unplanned and planned water cycle management (Thomas & Durham, 2003)

Unplanned water cycle management	traditional resources	water usage	treatments	
Planned water cycle management	traditional resources	water usage	treatments	alternative resources

Thirdly, baseflow augmentation might also be a viable strategy for stream restoration and baseflow maintenance. The objectives of baseflow augmentation, which mean storing subsurface water in or near streams during wet seasons and then releasing it as supplements for baseflow during dry seasons, include replenishing stream baseflow, adjusting water temperatures and qualities, creating healthy ecosystems for riverine creatures, mitigating erosions and sedimentation, and improving stabilities of stream channels and banks. Some of practical methods of baseflow augmentation are range management, riparian vegetation management, upland runoff retention, and instream infrastructures. Range management aims at sustainably utilizing range resources for grazing near streams in temporal and special aspects. By over grazing, excessive vegetation consumptions could reduce soil organic matter and increase soil erosion, and frequent vegetation trampling is responsible for cover plant deaths and soil compaction, increasing surface runoff and reducing subsurface water supplements. Implementing a sound localized range management plan, like rotational grazing, is conducive to evenly grazing contribution, soil erosion prevention, flooding mitigation, habitat restoration, and baseflow augmentation. Also, appropriately managing riparian vegetation is an applicable strategy for baseflow augmentation. Riparian vegetation plays important roles in slowing down streamflow speeds, depositing sediments, and moderating streamflow as agents releasing water during low flow periods. Another potential strategy is upland runoff retention, increasing the depression storage or decreasing the velocity of runoff to get more infiltration. For example, water-spreader dikes (Figure 15), contour furrowing and strip cropping are effective approaches to increasing the depression storage from temporary runoff. To slow down the runoff and increase infiltration into aquifers, terracing is invariably a useful practice to reduce the land steepness. Finally, building artificial instream infrastructures is also an option for increasing subsurface water storage or environmental flow in streams. Large dams are powerful enough to moderate the streamflow, not only increasing the stream low flow, but also preventing floods. Check dams (Figure 16) are small hydraulic infrastructures with purposes for controlling river erosion, adjusting the stream base level, and restoring degraded watersheds. They could have great contributions for baseflow augmentation as well by facilitating infiltration from slowed flow. Trap dams are low instream infrastructures designed for trapping coarse sediments as future aquifers to store and release water for baseflow augmentation (Ponce & Lindquist, 1990).

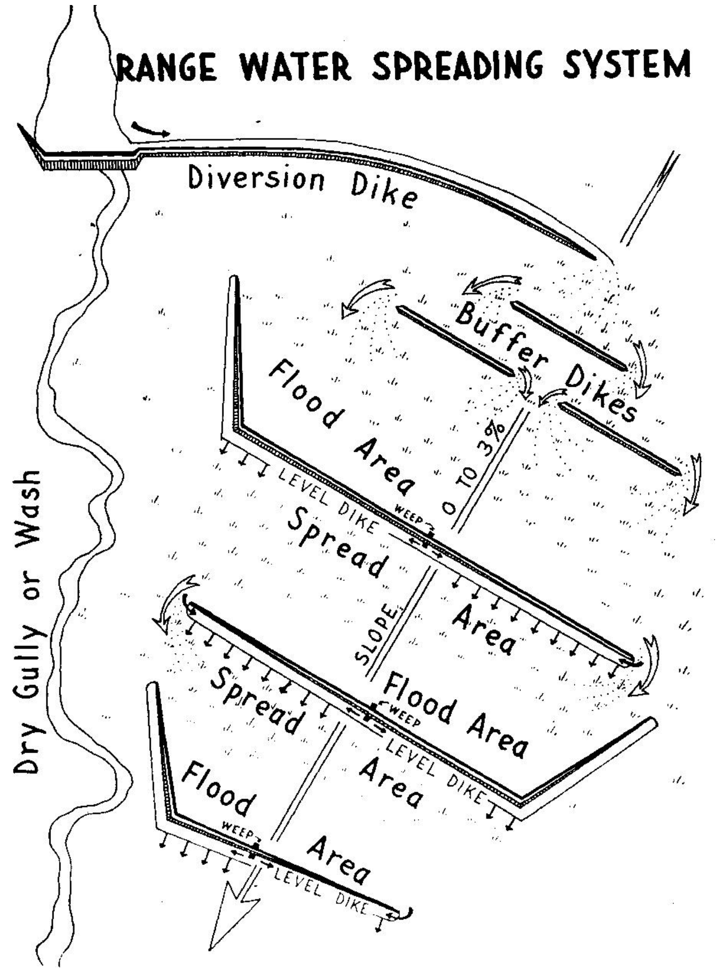

Figure 15. The water-spreader dike systems in in Southeastern Montana, US (Branson, 1956)

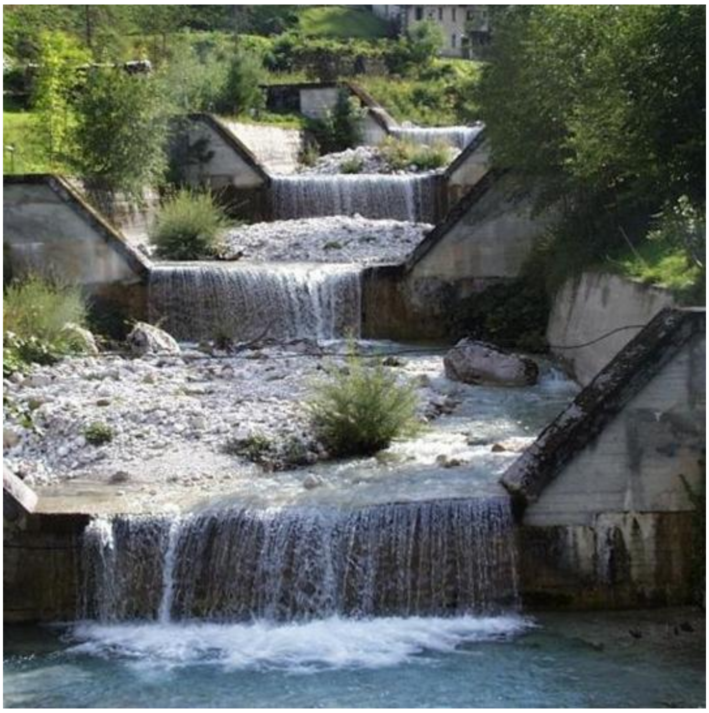

Figure 16. Check dams in Pramper River, Italy (Comiti et al., 2013)

Fourthly, it is necessary to enhance education and dissemination of water knowledge and policies. According to the process of water knowledge dissemination (Figure 17), water knowledge discovered and updated by hydrogeologists is very tough to be disseminated to other groups. Water resources professionals with relevant backgrounds accept water knowledge more easily than other groups, but they are also facing challenges, like quantitative assessments of actual water problems with constantly updated water policies. They might need to regularly attend more technical training, funded by governments to hone their professional skills. Environmental professionals might face difficulties, based on their backgrounds and interests, to understand water knowledge and incorporate it with practical environmental management. Collaborations and communications with water resources professionals are helpful for environmental professionals to enrich their knowledge systems for future working. General populations are the most difficult group to receive and understand water knowledge and water management policies. More education and policy advocacies should be implemented to let citizens understand the importance and practical strategies of protecting groundwater and streams (Vasconcelos, 2016).

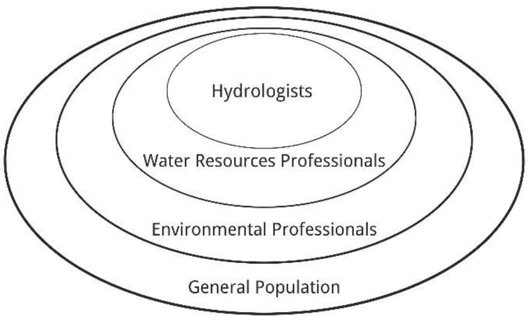

Figure 17. The process of water knowledge disseminations within different groups (Vasconcelos, 2016)

Lastly, the mindset of water decolonization should always be held with the process of water resources management. Historically, groundwater in Canada is pumped, polluted, and regulated within the framework of the western science, ignoring Indigenous People's water rights. Indigenous people inherently belong to their territories and should participate in the water governance and decision-making. Thus, when governments are planning to regulate groundwater and streams, Indigenous laws, traditions and shared agreements with governments should be respected, and trustful relationships with Indigenous people should be built before starting projects that might harm their water rights and traditional values (Lui, 2022). Decolonizing Water, as an organization supported by the Social Sciences and Humanities Research Council of Canada, is dedicated to conducting Indigenous-led community-based water monitoring, with the goal of enhancing watershed protections and the Indigenous governance (Copenace et al., 2022).

5. Evaluations of Groundwater Withdrawals on Joseph Creek

5.1 Study area

To predict the effects of groundwater withdrawals on Joseph Creek, it was necessary to select a study domain. The BC government provides a valuable online database of Groundwater Wells and Aquifers. As Joseph Creek belongs to Aquifer 526 in this database, Aquifer 526 was selected as the study area for analysis (Figure 18). According to the information table (Table 2), Aquifer 526 has the area of 10.8 km^2, and has ll B as the aquifer classification, which means the aquifer is both moderately developed and vulnerable. The geologic formation of Aquifer 526 is sand and gravel, covered by finer texture materials, like glacial till, clay or cemented gravel (BC Government, 2020).

The total annual groundwater withdrawals in Aquifer 526 are 256,000 m^3, with 123 wells correlated to the aquifer. The majority of water use for well pumping is domestic use, with the except of agricultural use and groundwater storage as smaller portions. As for well regulations, around 145,771 m^3 groundwater per year has been licensed for non-domestic utilization (0.13 million m^3 for Lawn, Fairway and Garden, while 0.02 million m^3 for Aquifer Storage). 123 domestic wells are not required to apply for licensing and have been registered in BC Groundwater Wells and Aquifers database instead.

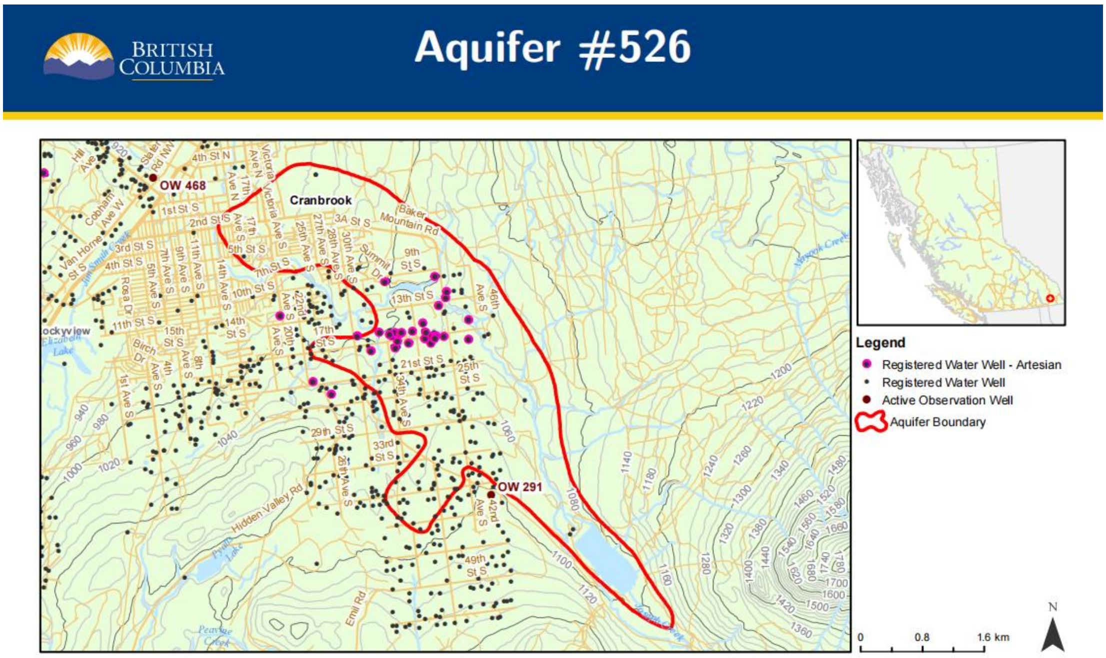

Figure 18. The map of Aquifer 526 in BC Groundwater Wells and Aquifers database (BC Government, 2020)

Table 2. Information of Aquifer 526 (BC Government, 2020)

Aquifer Details

Region	Kootenay
Water District	Cranbrook
Aquifer Area	10.8 km^2
No. Wells Correlated to Aquifer	123
Vulnerability to Contamination	Moderate
Productivity	Moderate
Aquifer Classification	IIB
Hydraulic Connectivity[1]	Not Likely
Aquifer Stress Index	Method not applicable - confined aquifer
No. Water Licences Issued to Wells	Unknown
Observation Wells (**Active**, Inactive)	None

[1] Based on broad regional assessment

5.2 MODFLOW groundwater flow simulation

In order to easily visualize the effects of well pumping, MODFLOW was selected to simulate potential drawdowns of constant pumping in the aquifer and nearby water bodies.

5.2.1 Principles

MODFLOW is a very popular and user-friendly software for hydrologists dedicated to simulating groundwater flow among different water bodies. Finite difference methods in MODFLOW aim at discretizing the real flow domain into a rectangular mesh and computing water heads or potentials at grid points via solving the differential equation in the form of finite difference (Strack, 2017). The differential equation used in finite difference methods originates from the Laplace's equation, and Darcy's law and the continuity equation are foundations of the Laplace's equation.

Darcy's law (Equation 6.1) describes that groundwater always flows from the higher head to the lower head through a porous medium. In the equation, q represents specific discharge, the volume flow rate per unit area. K is hydraulic conductivity, whose value is larger when water flows through the medium more easily. In addition, $\frac{dh}{dl}$ is the gradient of the hydraulic head.

$$q = -K\frac{dh}{dl} \tag{6.1}$$

The continuity equation (Equation 6.2) means that water flowing into a representative elementary volume is equal to water flowing out under steady-state conditions, where the water head is independent of time. Water incompressibility and not extra gained or lost water are two requisites for realizing the continuity equation.

$$\frac{\partial qx}{\partial x} + \frac{\partial qy}{\partial y} + \frac{\partial qz}{\partial z} = 0 \tag{6.2}$$

Laplace's equation (Equation 6.3) governs the pattern that groundwater flows through an isotropic and homogeneous aquifer under steady-state conditions. Isotropic and homogenous refer to the uniformities of physical properties and structure separately.

$$\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2} + \frac{\partial^2 h}{\partial z^2} = 0 \tag{6.3}$$

Setting up boundary conditions is an indispensable step to constrain the problem of groundwater we face and make the solution for the differential equation unique. Usually, for a studied aquifer, it is required to define the water levels of surrounding boundary water bodies as whether constant or time-variant. The better boundary conditions are defined, the more accurate the solution.

Ideally, the solution of the designed groundwater model should be calibrated with analytical solutions and field observations (Figure 19). When we get the approximate solution via finite difference methods, it may be compared with field observations that are currently available in order to test the accuracy of the model. The analytical solution made by calculus techniques should also be compared with the approximate solution if applicable (Wang & Anderson, 1995).

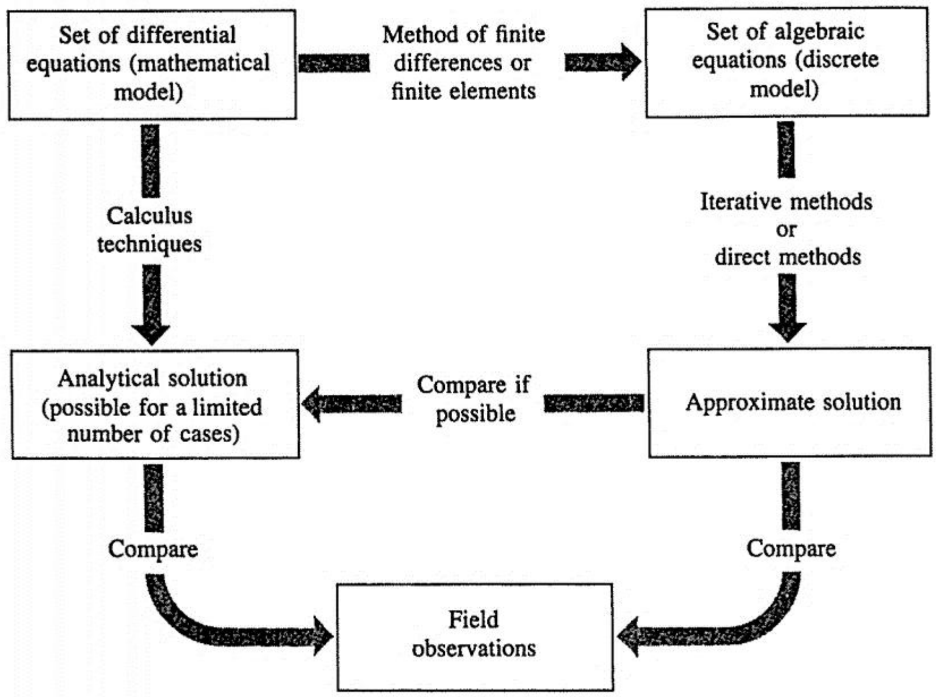

Figure 19. The procedures of groundwater modelling calibrations (Wang & Anderson, 1995)

5.2.2 Data inputs

To simplify the groundwater model, assumptions about the aquifer structure, aquifer physical characteristics, pumping wells, and water sources are listed:

1. The aquifer is considered as isotropic and homogeneous.
2. The aquifer is considered as horizontal with the constant thickness.
3. Clay depositions on riverbeds that can hinder groundwater-stream interactions are not considered.
4. As the data of pumping timing for each specific well are lacking, all wells are considered to pump at the same time.
5. The only water sources for pumping well are considered as groundwater storage in Aquifer 526 and water from Idlewild Lake, Joseph Creek, and Phillips Reservoir.
6. Water recharge into the aquifer during the year is not considered.
7. Water tables of water bodies are simplified as annual average levels rather than seasonal-variant levels.

The wells correlated to Aquifer 526 are remarked on the map for modelling (Figure 20a and 20b). Detailed information of 122 wells correlated to Aquifer 526 is provided from BC Groundwater Wells and Aquifers database (Appendix A), and the well with tag 32877 is excluded from modelling as its location is too far away from Aquifer 526.

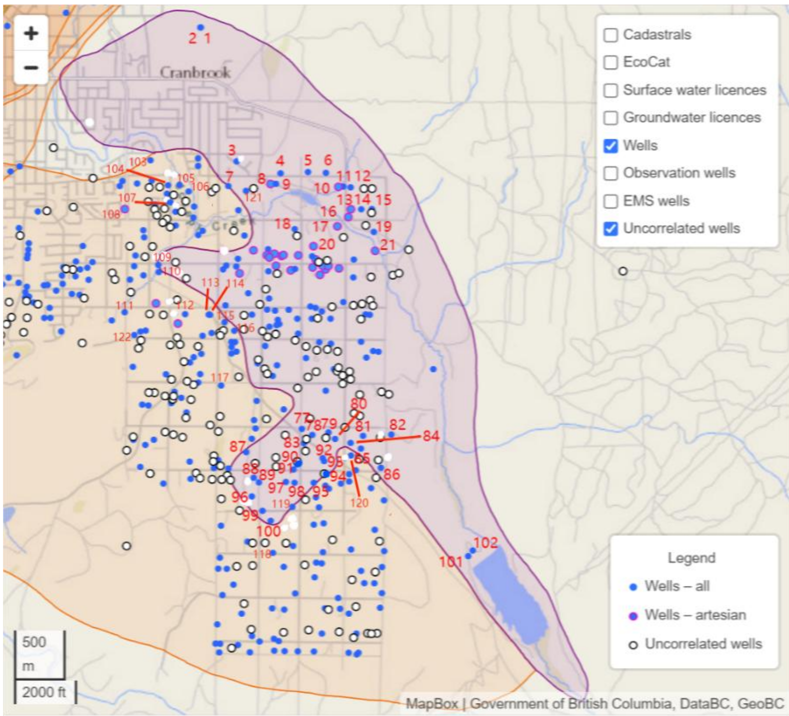

Figure 20a. The wells correlated to Aquifer 526 in map (BC Government, 2020)

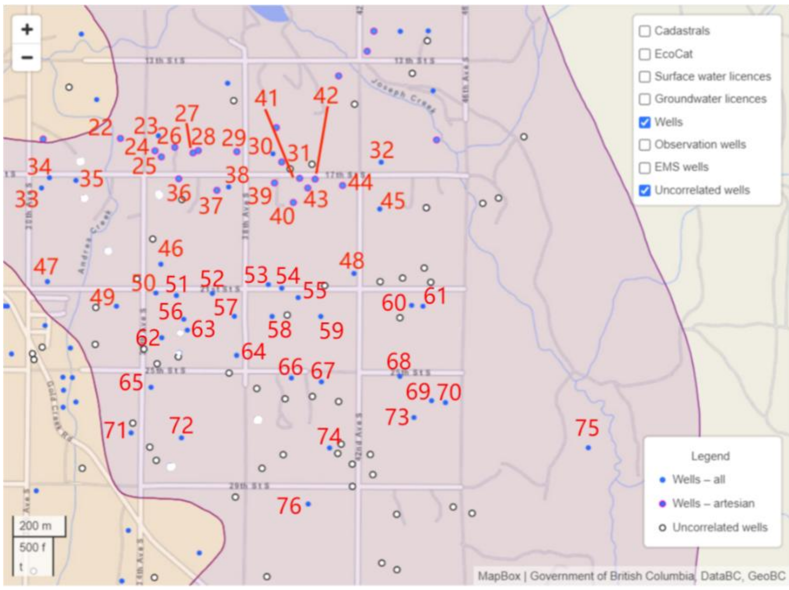

Figure 20b. The wells correlated to Aquifer 526 in map (BC Government, 2020)

Aquifer properties are listed below (Table 3). The thickness of aquifer is an average value of the gravel and sand depths in terms of 122 wells (Appendix A). Hydraulic conductivity K is provided from Aquifer Classification Work Sheet (BC Government, 2002). The porosity is estimated from BCcampus Open Education (Earle, 2015). Water levels of different water bodies are provided below (Table 4), which are estimated from topographic maps (Yamazaki et al., 2017).

Table 3. Input characteristics of Aquifer 526

Aquifer Tag	Type	Texture	Thickness (m)	K (m/s)	Porosity
526	Confined	Gravel and sand	11.37	1.77E-4	35%

Table 4. Input water levels of different water bodies

Water Body	Type of Water Level	Water Level (m)
Aquifer boundaries	Constant head	20.06
Aquifer interior	Time-variant head	20.06
Idlewild Lake	Time-variant head	31.86
Joseph Creek	Time-variant head	30.86
Phillips Reservoir	Time-variant head	14.86

The version of the modelling software is MODFLOW-2005. The modelling condition is steady state. The timing of model running for constant well pumping is one year (31,622,400 seconds).

5.2.3 Outcomes and analysis

The visualizations of drawdowns between pre-pumping (Figure 21) and pumping after one year (Figure 22) are compared below. The pink layer represents the area of Aquifer 526, and blue layers represent Idlewild Lake, Joseph Creek, and Phillips Reservoir separately from north to south. In these figures, the darker the colour, the larger the value.

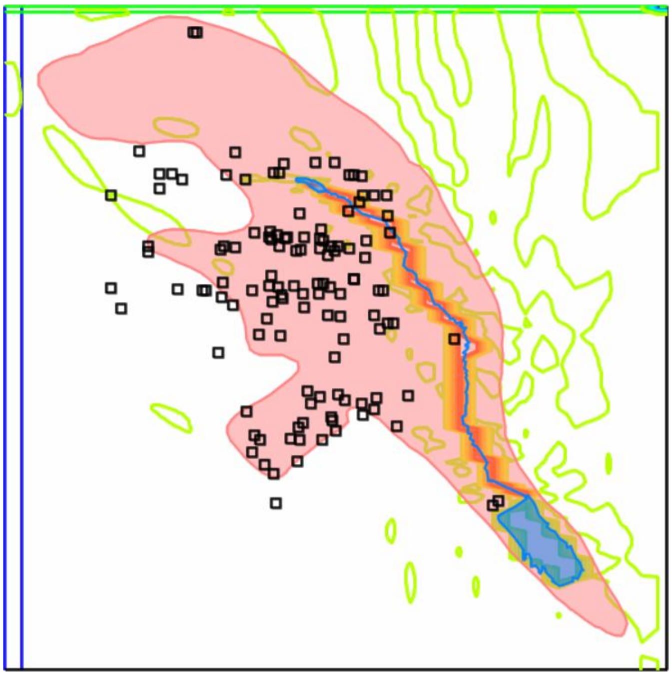

Figure 21. Drawdowns in Aquifer 526 before the one-year constant pumping

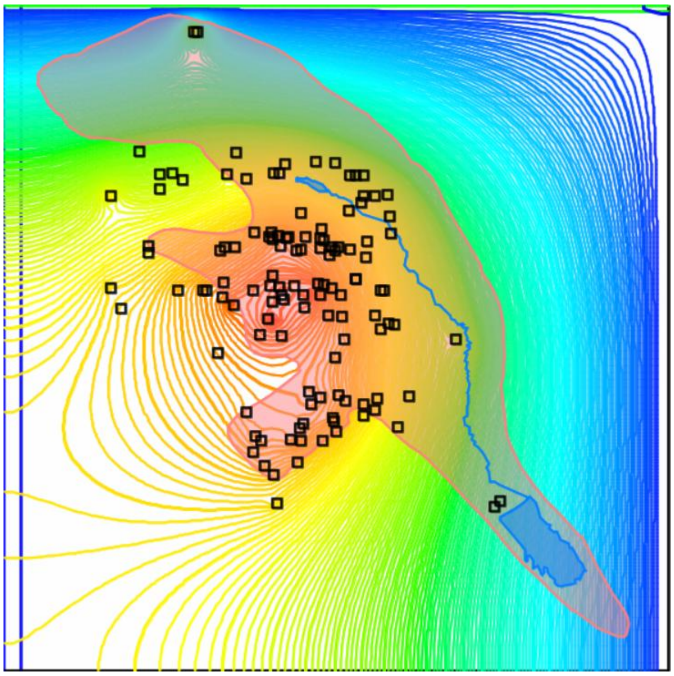

Figure 22. Drawdowns in Aquifer 526 after the one-year constant pumping

From the above significant alterations of drawdowns in Aquifer 526, we can conclude that the constant groundwater withdrawals one year might severely disturb the original groundwater system connected with Joseph Creek and other water bodies.

5.3 Baseflow index changes in Joseph Creek

The analysis of how baseflow index changed during the period of active pumping activities aimed to evaluate whether the baseflow in Joseph Creek was significantly decreased at that time, and whether the pumping could be one of triggers.

5.3.1 Principles

Baseflow index (BFI) is the ratio of baseflow volume and total flow volume. It represents the proportion of streamflow recharged from groundwater aquifers and other sources. Compared with groundwater, other sources of recharge, like rainfall, snowmelt and connected lakes, might move relatively fast and merely be sustained for a short time, while groundwater storage is able to maintain the streamflow during dry weather periods. Thus, a stream with higher BFI means groundwater from adjacent aquifers can sustain the streamflow and stream ecosystem to a large extent (Kelly et al., 2019).

5.3.2 Data inputs

To evaluate the changes of BFI in Joseph Creek during certain periods, the hydrometric data station JOSEPH CREEK IN LOT 5450 (08NG070) was selected for analysis (Figure 23). The 6-year data during 1968-1974 in station JOSEPH CREEK IN LOT 5450 are discontinued (Table 5).

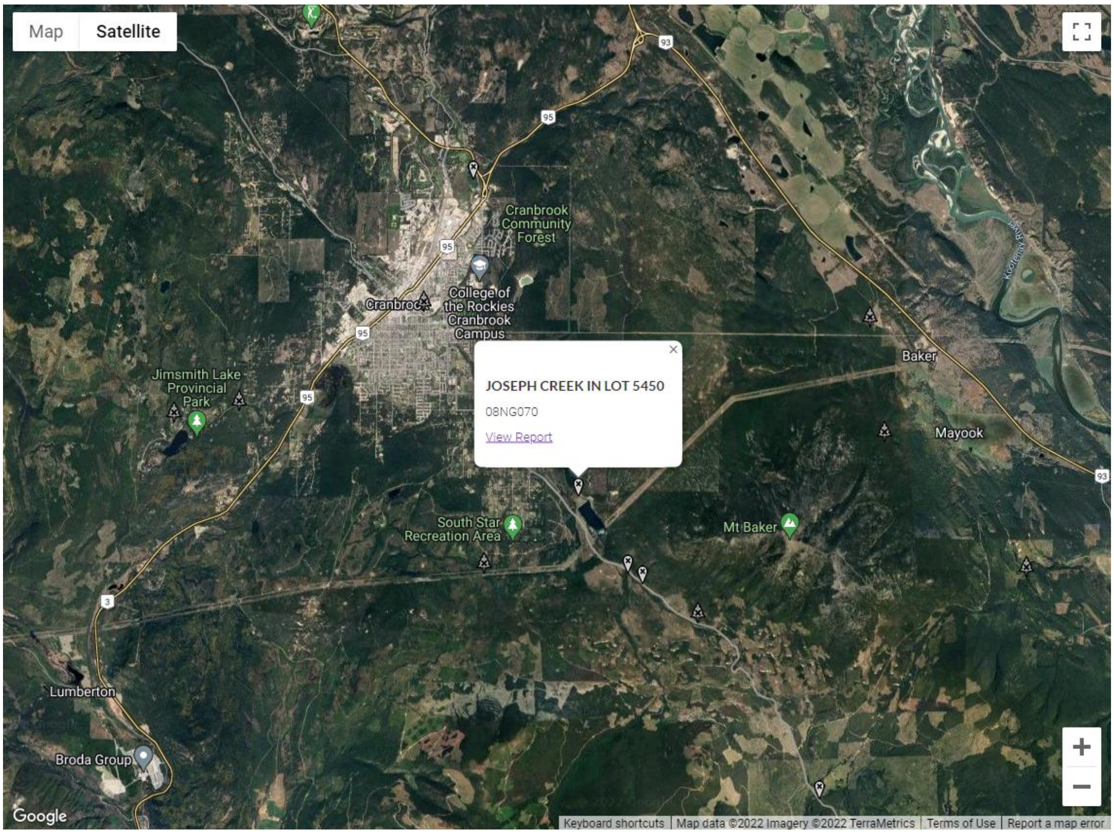

Figure 23. The station JOSEPH CREEK IN LOT 5450 in the satellite imagery (Government of Canada, 2022)

Table 5. The information of the station JOSEPH CREEK IN LOT 5450 (Government of Canada, 2022)

Station Information

Active or discontinued:	Discontinued	**Province / Territory:**	British Columbia
Latitude:	49° 28' 08" N	**Longitude:**	115° 42' 19" W
Gross drainage area:	58.5 km^2	**Effective drainage area:**	N/A
Record length:	6 Years	**Period of record:**	1968; 1969; 1970; 1971; 1973; 1974
Regulation type:	Regulated	**Regulation length:**	N/A
Real-time data available:	No	**Sediment data available:**	No
Type of water body:	River	**RHBN:**	No
EC Regional Office:	VANCOUVER	**Current Operation Schedule:**	N/A
Data contributed by:	N/A	**Operation Period:**	N/A

During 1968-1974, 31 wells started to conduct pumping activities (Appendix A in red). In order to predict BFI changes with 31 well pumping activities ongoing, the discharge data of 1968, 1970, 1973, and 1974 were selected for BFI calculations in the USGS Web-based Hydrograph Analysis Tool (WHAT) (Hancock & Engel, 2022). Discharge data in 1968 and 1973 are seasonal, while data in 1970 and 1974 are continuous (Table 6).

Table 6. The data collection history of the station JOSEPH CREEK IN LOT 5450 (Government of Canada, 2022)

Data Collection History

This table contains information pertaining to the historical changes of defined elements in the operation of a station.

	Type	Operation schedule	Gauge type
1968 - 1968	Flow	Seasonal	Manual
1969 - 1969	Flow	Miscellaneous	Manual
1970 - 1970	Flow	Continuous	Manual
1971 - 1971	Flow	Miscellaneous	Manual
1973 - 1973	Flow	Seasonal	Manual
1974 - 1974	Flow	Continuous	Manual

5.3.3 Outcomes and analysis

The total streamflow, direct runoff, baseflow, and BFI in 1968, 1970, 1973, and 1974 have been listed (Appendix B). The related four hydrographs about the total streamflow and baseflow throughout the year have been drawn below (Figure 24, 25, 26, and 27). The BFI for 1968, 1970, 1973, and 1974 are 0.863, 0.887, 0.888, and 0.679 separately.

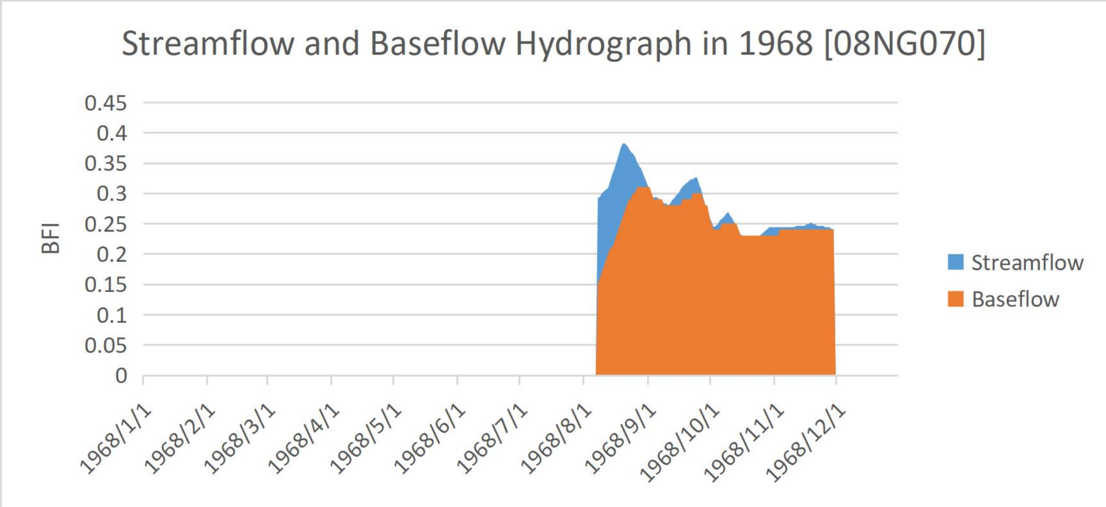

Figure 24. Streamflow and Baseflow Hydrograph in 1968 (BFI = 0.863)

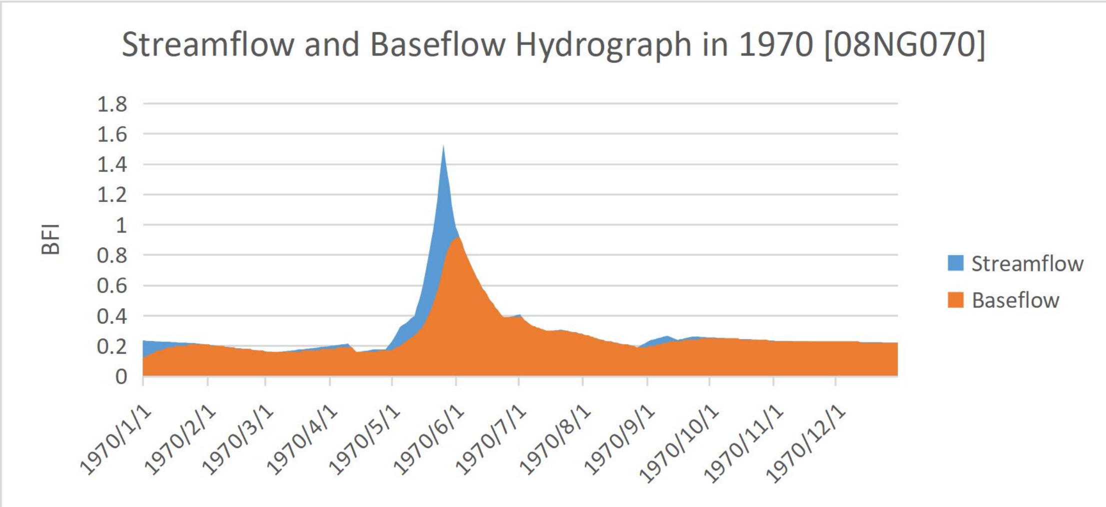

Figure 25. Streamflow and Baseflow Hydrograph in 1970 (BFI = 0.887)

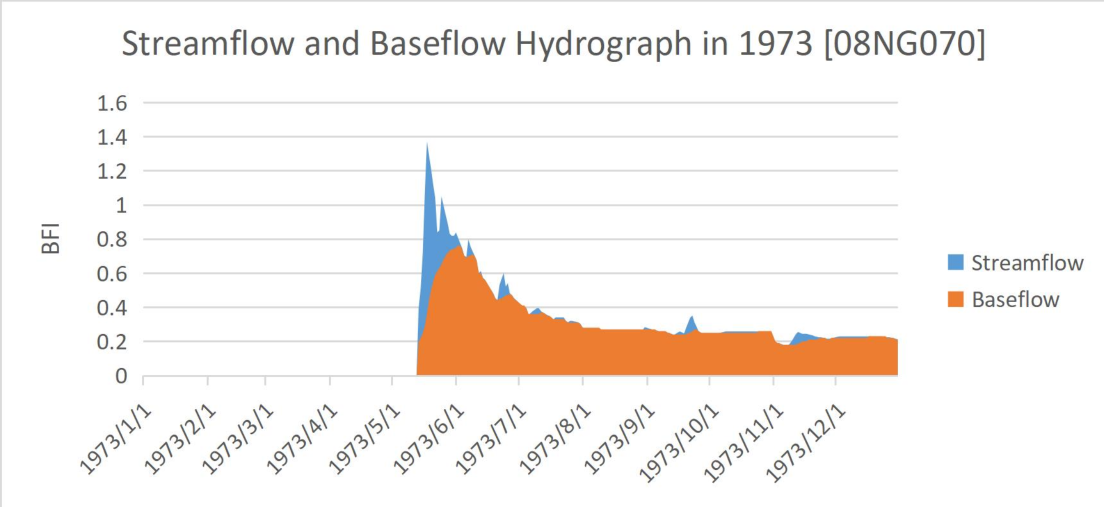

Figure 26. Streamflow and Baseflow Hydrograph in 1970 (BFI = 0.888)

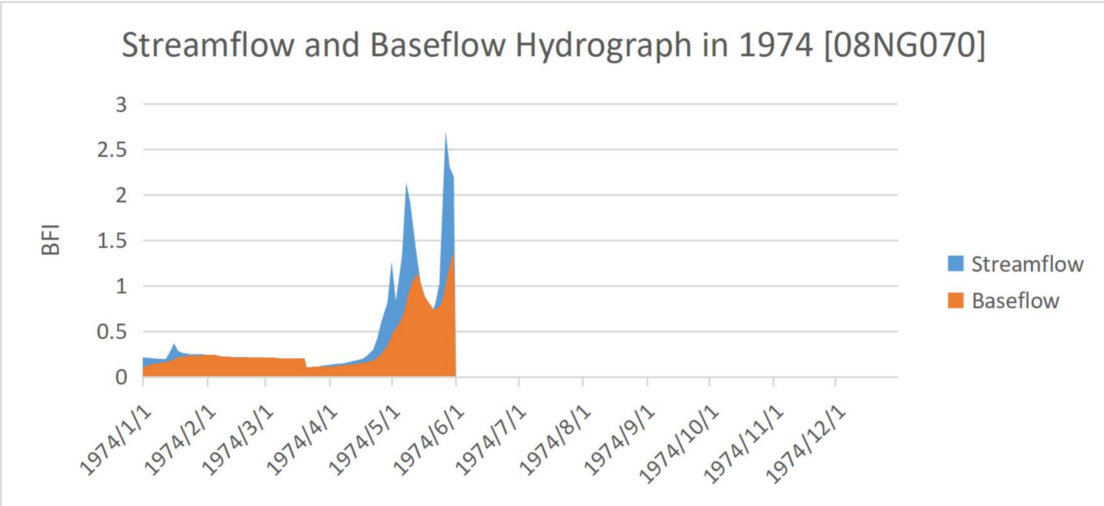

Figure 27. Streamflow and Baseflow Hydrograph in 1974 (BFI = 0.679)

From the results, we can see the sharp reduce of BFI in 1974. As several factors, like dam construction, surface water withdrawals, and climate change, can cause this phenomenon, thus we cannot make the conclusion that the sharply reduced BFI in 1974 is directly caused by groundwater withdrawals, but the analysis reminds us to pay attention to the future impacts of groundwater withdrawals on the stream baseflow.

5.4 Agriculture groundwater demand prediction

As a part of groundwater consumption from the aquifer for irrigation, the BC Agriculture Water Demand Model was utilized to predict future groundwater demands for irrigation and to analyzed results under climate change and different irrigation management practices.

5.4.1 Principles

BC Agriculture Water Demand Model (AWDM) is designed for calculating water demands to support water and land planning within BC. The studied area for AWDM could be a watershed, aquifer or municipality. With the support of Agricultural Land Use Inventory (ALUI), the robust model could estimate water demand of surface water, reclaimed water, and groundwater for various crop types, irrigation system types, and soil textures. The historical and future climatic data were integrated into the modelling process to consider the impacts of climate change on water demands. Different scenarios of irrigation management practices were also compared to evaluate how much water can be saved by advanced irrigation systems and by avoiding extra water loss to deep percolation (Canadian Agricultural Partnership, 2022).

5.4.2 Data inputs

Aquifer 526 was selected for the AWDM to predict how groundwater demands for agricultural purposes, potential changes under changing climatic conditions and different irrigation management practices. The climate model was ACCESS1 rcp8.5. From 2053 to 2058, the model simulated conditions of poor and good irrigation management practices separately. Regardless of climatic conditions, the same irrigation season limits were used to generate valid water demands within the growing seasons.

5.4.3 Outcomes and analysis

In results of the modelling of the four types of crops consumed water by Aquifer 526, with cereals and forages irrigated by surface water, while golf and pasture were irrigated by groundwater. The predicted groundwater irrigation demand in Aquifer 526 by ACCESS1 rcp8.5 from 2053 to 2058 is illustrated below (Figure 28).

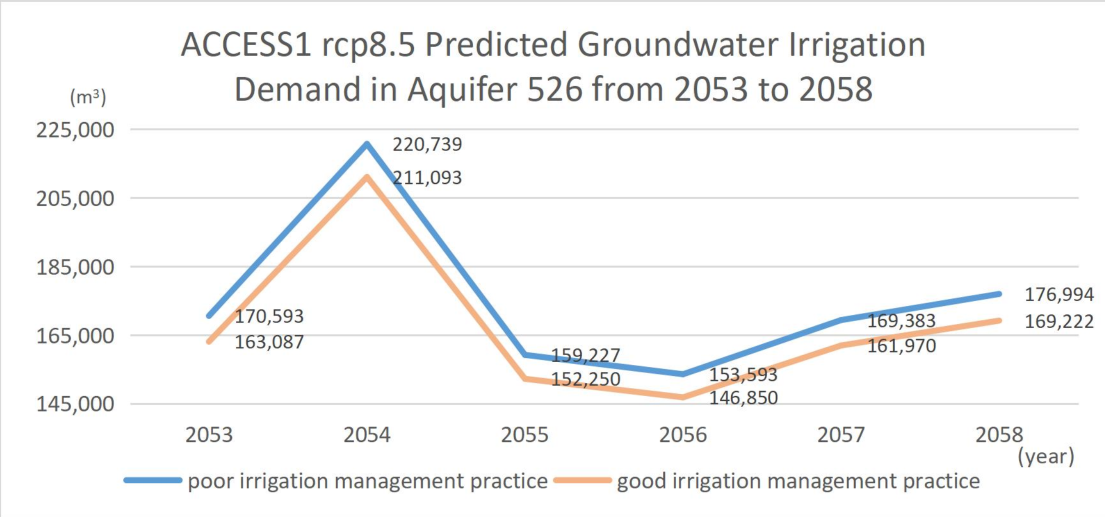

Figure 28. ACCESS1 rcp8.5 Predicted Groundwater Irrigation Demand in Aquifer 526 from 2053 to 2058 (Canadian Agricultural Partnership, 2022)

From the results, groundwater demands fluctuated during the selected six years, and no obvious trends were found. Compared with poor irrigation management practices, good irrigation management practices will enable higher water use efficiency and fewer demands for groundwater. Thus, it is necessary to make efforts of improving current irrigation systems in Aquifer 526 in order to reduce future groundwater withdrawals for irrigation, mitigating projected impacts of groundwater withdrawals on Joseph Creek.

5.5 Limitations

The analysis conducted in this study is imperfect. First, lots of assumptions made in the modelling process caused the model less realistic. For instance, in MODFLOW, depths of the aquifer in reality are not constant, and textures of aquifer materials vary depending on the location. Second, limited expertise also caused inaccurate analysis in the study. The aim of this study was not to get accurate data results for direct decision-making, but for illustrating the potential effects and trends about groundwater consumptions and encouraging further research. Third, poor data and information partially impeded the reliability of the results. For instance, the timing of each specific pumping well was lacking, and data from nearby hydrometric stations are now discontinued and outdated.

6. Recommendations for Stakeholders of Joseph Creek Watershed

To better regulate groundwater withdrawals and rehabilitate Joseph Creek, it is necessary for each stakeholder within the watershed to cooperate and work together.

As for governments, it is critical to invest in water monitoring, education, and management. More fundings for constantly monitoring groundwater levels in aquifers and stream discharges in rivers are necessary to discover recently alterations caused by urbanization and climate change. Investigating in education of water smart knowledge and water laws for the public can raise the awareness of people on groundwater sustainability. Also, encouraging wells to be licensed and registered is conducive to enhancing water planning.

As for watershed management partners and organizations, tailoring technical strategies for groundwater and stream restoration, updating the creek management framework, and enhancing communications and training among experts should be considered. Environmental professionals and practitioners are capable of tailoring suitable strategies for the watershed, like groundwater supplementation and riparian revegetation. Watershed partners should also be encouraged to solve the current issues in Joseph Creek Management Framework and make it a living document. Current knowledge gaps, like the lack of optimal flow strategies and not properly compiled data, are waiting to be integrated into the framework (Columbia Outdoor School, 2015). Creating more opportunities for training and workshops would be beneficial to entice professionals to keep growing their skills about groundwater and streams.

As for residents in Cranbrook, taking the initiative to learn more about the importance of water sustainability and taking water smart actions in daily life are applicable ways for them to save water. As most of wells in the aquifer are used for domestic purposes, choosing water efficient lifestyles is very helpful for reducing groundwater withdrawals. For example, the adoption of water-saving toilets, washing machines, or dishwashers could be considered as water smart living strategies.

As for the Indigenous people living in the watershed, it is imperative to claim and protect their water and land rights in the process of water decolonization. Ktunaxa and the ?Aq'am people were living in Joseph Creek Watershed before water was exploited and commercialized by the western society. Water and fish in rivers and streams are vital economic and spiritual resources for the Indigenous community. When new projects and activities are related to water and lands, it is essential to build respectful relationships with them, recognize their ecological, cultural, and archaeological values, and include their directions in meaningful and respectful decision making.

7. Conclusions

To summarize, this paper reviewed the significance of groundwater for streams, groundwater related regulations and programs in BC, impacts of groundwater withdrawals on streams, and suggested stream as well as groundwater restoration strategies. Also, data analysis on the effects of groundwater withdrawals on Joseph Creek were conducted by the MODFLOW, USGS Web-based Hydrograph Analysis Tool, and the BC Agriculture Water Demand Model separately, indicating that constant well pumping might cause large impacts on the groundwater level, baseflow in stream could be affected by active pumping, and groundwater withdrawals for irrigation could be reduced by improving irrigation management systems. The corresponding recommendations are provided for different watershed stakeholders to restore aquifers and Joseph Creek. More research and analysis are needed in the future to evaluate and mitigate potential huge impacts of groundwater withdrawals on Joseph Creek, as future land use changes and climate change might amplify those impacts.

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Appendix A. Details of wells correlated to Aquifer 526 (BC Government, 2020)

Modelling Tag Number	Well Tag Number	Well Activity	Street Address	Estimated Well Yield (m/s)	Depth of Sand and Gravel(ft bgl)
1	95980	2001		15.77	37
2	95963	2001		15.46	33
3	66582	1992	720 SUMMIT DR	0.19	22
4	53855	1984	NEAR IDLEWILD PARK	3.15	9
5	17730	1963		1.32	8
6	30757	1974	CITY RESERVOIR	1.26	10
7	17725	1963		3.15	12
8	25189	1971		0.50	24
9	6035	1950		0.50	27
10	66471	1994	4101 9TH ST S	0.00	0
11	45515	1980	4101 9TH ST SOUTH	0.25	3
12	66655	1991	504 10 ST S	0.32	0
13	66687	1990	1124 42 AVE S	1.51	45
14	66558	1990	4350 S 13 ST	0.88	140
15	66613	1992	4400-13TH ST S	0.95	9
16	38391	1977	BAKER MTN RD	0.76	2
17	45070	1980	IDLEWILD PK	0.13	15
18	55102	1985	42ND AVE S	0.57	4
19	66592	1992	4401-13TH ST S	0.32	27
20	51432	1983		1.26	72
21	66683	1990	4500 17 ST S	2.52	6
22	49213	1981	17TH STREET SOUTH	0.57	22
23	18911	1965		0.00	0
24	66595	1992	3426 17TH STREET S	0.38	66
25	26747	1972		0.63	40
26	66454	1994	SS 1 SITE 7 COMP 17	3.15	0
27	66632	1992	301-17TH ST S	0.32	30
28	66904	1993		0.63	83
29	66772	1995	SS 1 SITE 7-68	0.76	10
30	19710	1966		0.38	12
31	29722	1974		0.50	5
32	58160	1988	17TH ST. S.	0.95	6
33	24783	1971		0.19	0
34	24573	1971		0.25	5
35	6052	1950		0.00	85
36	17166	1962		0.00	50
37	28095	1973	17TH ST SOUTH	0.32	96
38	19281	1965		0.00	65
39	18048	1963		0.13	78
40	31348	1974	KOOTNEY ORCHARDS	0.38	100
41	18896	1964		0.06	59
42	24784	1971		0.19	3
43	46145	1980	3997 17TH STREET SOUTH	0.38	110
44	18049	1963		0.25	70
45	40804	1978	42ND AVE S	0.50	24
46	17168	1962		0.76	45
47	40634	1978	GOLD CREEK	0.19	98
48	30413	1974	MADEJA RD	0.00	0
49	66577	1992	205-21ST ST SS1 SITE 7-3	0.63	148
50	26438	1972		0.32	143
51	26959	1972		0.50	128
52	58357	1988	3600 21ST. ST. S.	0.95	28
53	47877	1981	KOOTENAY ORCHARDS RD	1.58	38
54	32841	1975	OFF KOOTNEAY ORCHARD RD	0.00	104
55	400	1983	21ST ST S	0.50	0
56	18904	1965		0.63	107
57	62714	1989	2125 38TH AVE. S	3.15	160
58	21910	1968		0.19	70
59	30412	1974		0.32	46
60	320	1983		0.19	3
61	48231	1981	21ST STREET SOUTH	0.76	6
62	56832	1987		0.00	0
63	29228	1973	MADEJA RD	0.44	15
64	35991	1976	25TH ST SOUTH	0.32	3
65	27799	1973	34TH AVE S	3.15	15
66	29737	1974	34TH AVENUE S	0.63	9
67	53971	1984		0.32	0
68	31547	1974	KOOTENAY ORCHARD	0.32	164
69	47088	1981	4301 25TH ST	0.32	5
70	46277	1980	4401 S 25TH ST	0.50	180
71	39141	1978	GOLD CREEK RD	0.32	10
72	26531	1972		0.32	31
73	36786	1977	42ND AVE S	0.06	7
74	74851	1997	25 ST SOUTH	1.58	20
75	45175	1980	OFF 15TH ST	3.79	75
76	81604	1998	3983 29TH STREET SOUTH	0.50	240
77	28682	1973	GOLD CREEK RD	0.38	22
78	26171	1972		0.76	11
79	48920	1981	33RD STREET SOUTH	0.32	15
80	37512	1977	3900 GOLD CREEK RD	1.26	10
81	33404	1975	OFF GOLD CR ROAD	0.32	4
82	34762	1976		0.53	9
83	35069	1976	GOLD CREEK RD	1.26	13
84	31091	1974	GOLD CREEK RD	1.26	120
85	33320	1975		0.32	2
86	32138	1975		0.22	2
87	30672	1974	OFF 38TH STREET	0.63	6
88	32989	1975	GOLD CREEK	0.76	19
89	36854	1977	MADIA RD	0.50	115
90	31048	1974	GOLD CREEK RD	0.50	60
91	48106	1981		0.00	0
92	44925	1980	38TH AVE S	0.95	17
93	349	1986	38TH AVE S	0.63	40
94	33758	1975	GOLD CR RD	0.32	14
95	29878	1974	3610 38TH AVE S	0.44	6
96	24906	1971	GOLD CREEK RD	0.25	27
97	58162	1988	3603 37TH ST. SOUTH	1.89	11
98	42167	1979		0.76	8
99	48653	1981		0.95	12
100	54775	1985		0.38	5
101	31082	1974	GOLD CREEK DAM SITE	0.00	9
102	31101	1974		0.00	14
103	66596	1992	3001 45 ST S	0.63	141
104	13695	1952		0.00	0
105	6072	1950		0.00	4
106	40632	1978		0.32	115
107	14588	1956		0.00	0
108	34109	1976		6.31	100
109	18912	1965	17TH STREET SOUTH	0.00	0
110	18905	1965	17TH ST SOUTH	0.00	0
111	43148	1979	21ST ST SOUTH	1.26	13
112	46814	1980	21ST STREET SOUTH	1.26	40
113	66783	1995	BOX 396	0.63	15
114	66719	1995	NORTH SIDE GOLD CREEK	0.95	44
115	18902	1965	KOOTENAY ORCHARDS	0.00	0
116	31083	1974	JAP LAKE RD	2.52	2
117	26615	1972		0.19	1
118	34111	1976		0.91	7
119	6081	1950	GOLD CREEK RD	0.13	10
120	30916	1974	GOLD CREEK ROAD	0.44	2
121	66388	1994	3245 9 ST S	0.63	5
122	45154	1980		0.44	60

Appendix B. The total streamflow, direct runoff, baseflow, and BFI in 1968, 1970, 1973, and 1974

1968				1970				1973				1974			
date	streamflow (m³/s)	direct runoff (m³/s)	baseflow (m³/s)	date	streamflow (m³/s)	direct runoff (m³/s)	baseflow (m³/s)	date	streamflow (m³/s)	direct runoff (m³/s)	baseflow (m³/s)	date	streamflow (m³/s)	direct runoff (m³/s)	baseflow (m³/s)
1968/1/1				1970/1/1	0.235	0.12	0.12	1973/1/1				1974/1/1	0.21	0.1	0.1
1968/1/2				1970/1/2	0.235	0.11	0.13	1973/1/2				1974/1/2	0.21	0.1	0.11
1968/1/3				1970/1/3	0.232	0.1	0.13	1973/1/3				1974/1/3	0.207	0.09	0.12
1968/1/4				1970/1/4	0.232	0.09	0.14	1973/1/4				1974/1/4	0.207	0.08	0.13
1968/1/5				1970/1/5	0.232	0.08	0.15	1973/1/5				1974/1/5	0.204	0.07	0.13
1968/1/6				1970/1/6	0.232	0.08	0.15	1973/1/6				1974/1/6	0.201	0.06	0.14
1968/1/7				1970/1/7	0.229	0.07	0.16	1973/1/7				1974/1/7	0.198	0.06	0.14
1968/1/8				1970/1/8	0.229	0.06	0.17	1973/1/8				1974/1/8	0.198	0.05	0.15
1968/1/9				1970/1/9	0.229	0.06	0.17	1973/1/9				1974/1/9	0.195	0.04	0.15
1968/1/10				1970/1/10	0.227	0.05	0.17	1973/1/10				1974/1/10	0.195	0.04	0.15
1968/1/11				1970/1/11	0.227	0.05	0.18	1973/1/11				1974/1/11	0.193	0.04	0.16
1968/1/12				1970/1/12	0.227	0.04	0.18	1973/1/12				1974/1/12	0.193	0.03	0.16
1968/1/13				1970/1/13	0.227	0.04	0.19	1973/1/13				1974/1/13	0.227	0.06	0.16
1968/1/14				1970/1/14	0.227	0.04	0.19	1973/1/14				1974/1/14	0.269	0.1	0.17
1968/1/15				1970/1/15	0.224	0.03	0.19	1973/1/15				1974/1/15	0.311	0.13	0.18
1968/1/16				1970/1/16	0.224	0.03	0.19	1973/1/16				1974/1/16	0.368	0.18	0.19
1968/1/17				1970/1/17	0.224	0.03	0.2	1973/1/17				1974/1/17	0.326	0.12	0.2
1968/1/18				1970/1/18	0.221	0.02	0.2	1973/1/18				1974/1/18	0.283	0.07	0.21
1968/1/19				1970/1/19	0.221	0.02	0.2	1973/1/19				1974/1/19	0.272	0.06	0.22
1968/1/20				1970/1/20	0.221	0.02	0.2	1973/1/20				1974/1/20	0.261	0.04	0.22
1968/1/21				1970/1/21	0.221	0.02	0.2	1973/1/21				1974/1/21	0.258	0.04	0.22
1968/1/22				1970/1/22	0.221	0.02	0.2	1973/1/22				1974/1/22	0.255	0.03	0.22
1968/1/23				1970/1/23	0.218	0.01	0.21	1973/1/23				1974/1/23	0.249	0.02	0.23
1968/1/24				1970/1/24	0.218	0.01	0.21	1973/1/24				1974/1/24	0.246	0.02	0.23
1968/1/25				1970/1/25	0.218	0.01	0.21	1973/1/25				1974/1/25	0.246	0.02	0.23
1968/1/26				1970/1/26	0.218	0.01	0.21	1973/1/26				1974/1/26	0.246	0.02	0.23
1968/1/27				1970/1/27	0.215	0.01	0.21	1973/1/27				1974/1/27	0.246	0.01	0.23
1968/1/28				1970/1/28	0.215	0.01	0.21	1973/1/28				1974/1/28	0.246	0.01	0.23
1968/1/29				1970/1/29	0.212	0	0.21	1973/1/29				1974/1/29	0.246	0.01	0.23
1968/1/30				1970/1/30	0.212	0	0.21	1973/1/30				1974/1/30	0.244	0.01	0.23
1968/1/31				1970/1/31	0.21	0	0.21	1973/1/31				1974/1/31	0.241	0.01	0.24
1968/2/1				1970/2/1	0.207	0	0.21	1973/2/1				1974/2/1	0.238	0	0.24
1968/2/2				1970/2/2	0.207	0	0.21	1973/2/2				1974/2/2	0.238	0	0.24
1968/2/3				1970/2/3	0.204	0	0.2	1973/2/3				1974/2/3	0.238	0	0.24
1968/2/4				1970/2/4	0.204	0	0.2	1973/2/4				1974/2/4	0.238	0	0.24
1968/2/5				1970/2/5	0.201	0	0.2	1973/2/5				1974/2/5	0.238	0	0.24
1968/2/6				1970/2/6	0.198	0	0.2	1973/2/6				1974/2/6	0.232	0	0.23
1968/2/7				1970/2/7	0.198	0	0.2	1973/2/7				1974/2/7	0.227	0	0.23
1968/2/8				1970/2/8	0.195	0	0.2	1973/2/8				1974/2/8	0.221	0	0.22
1968/2/9				1970/2/9	0.195	0	0.2	1973/2/9				1974/2/9	0.221	0	0.22
1968/2/10				1970/2/10	0.193	0	0.19	1973/2/10				1974/2/10	0.218	0	0.22
1968/2/11				1970/2/11	0.193	0	0.19	1973/2/11				1974/2/11	0.218	0	0.22
1968/2/12				1970/2/12	0.19	0	0.19	1973/2/12				1974/2/12	0.218	0	0.22
1968/2/13				1970/2/13	0.19	0	0.19	1973/2/13				1974/2/13	0.215	0	0.21
1968/2/14				1970/2/14	0.187	0	0.19	1973/2/14				1974/2/14	0.215	0	0.21
1968/2/15				1970/2/15	0.184	0	0.18	1973/2/15				1974/2/15	0.215	0	0.21
1968/2/16				1970/2/16	0.184	0	0.18	1973/2/16				1974/2/16	0.215	0	0.21
1968/2/17				1970/2/17	0.184	0	0.18	1973/2/17				1974/2/17	0.215	0	0.21
1968/2/18				1970/2/18	0.181	0	0.18	1973/2/18				1974/2/18	0.215	0	0.21
1968/2/19				1970/2/19	0.178	0	0.18	1973/2/19				1974/2/19	0.215	0	0.21
1968/2/20				1970/2/20	0.178	0	0.18	1973/2/20				1974/2/20	0.215	0	0.21
1968/2/21				1970/2/21	0.178	0	0.18	1973/2/21				1974/2/21	0.212	0	0.21
1968/2/22				1970/2/22	0.176	0	0.18	1973/2/22				1974/2/22	0.212	0	0.21
1968/2/23				1970/2/23	0.173	0	0.17	1973/2/23				1974/2/23	0.212	0	0.21
1968/2/24				1970/2/24	0.173	0	0.17	1973/2/24				1974/2/24	0.212	0	0.21
1968/2/25				1970/2/25	0.17	0	0.17	1973/2/25				1974/2/25	0.212	0	0.21
1968/2/26				1970/2/26	0.167	0	0.17	1973/2/26				1974/2/26	0.212	0	0.21
1968/2/27				1970/2/27	0.167	0	0.17	1973/2/27				1974/2/27	0.212	0	0.21
1968/2/28				1970/2/28	0.167	0	0.17	1973/2/28				1974/2/28	0.21	0	0.21
1968/3/1				1970/3/1	0.164	0	0.16	1973/3/1				1974/3/1	0.21	0	0.21
1968/3/2				1970/3/2	0.161	0	0.16	1973/3/2				1974/3/2	0.21	0	0.21
1968/3/3				1970/3/3	0.161	0	0.16	1973/3/3				1974/3/3	0.21	0	0.21
1968/3/4				1970/3/4	0.161	0	0.16	1973/3/4				1974/3/4	0.21	0	0.21
1968/3/5				1970/3/5	0.159	0	0.16	1973/3/5				1974/3/5	0.21	0	0.21
1968/3/6				1970/3/6	0.159	0	0.16	1973/3/6				1974/3/6	0.207	0	0.21
1968/3/7				1970/3/7	0.159	0	0.16	1973/3/7				1974/3/7	0.204	0	0.2
1968/3/8				1970/3/8	0.161	0	0.16	1973/3/8				1974/3/8	0.201	0	0.2
1968/3/9				1970/3/9	0.161	0	0.16	1973/3/9				1974/3/9	0.198	0	0.2
1968/3/10				1970/3/10	0.164	0	0.16	1973/3/10				1974/3/10	0.198	0	0.2
1968/3/11				1970/3/11	0.164	0	0.16	1973/3/11				1974/3/11	0.198	0	0.2
1968/3/12				1970/3/12	0.167	0.01	0.16	1973/3/12				1974/3/12	0.198	0	0.2
1968/3/13				1970/3/13	0.167	0.01	0.16	1973/3/13				1974/3/13	0.198	0	0.2
1968/3/14				1970/3/14	0.17	0.01	0.16	1973/3/14				1974/3/14	0.198	0	0.2
1968/3/15				1970/3/15	0.17	0.01	0.16	1973/3/15				1974/3/15	0.198	0	0.2
1968/3/16				1970/3/16	0.173	0.01	0.16	1973/3/16				1974/3/16	0.198	0	0.2
1968/3/17				1970/3/17	0.176	0.01	0.16	1973/3/17				1974/3/17	0.198	0	0.2
1968/3/18				1970/3/18	0.176	0.01	0.16	1973/3/18				1974/3/18	0.198	0	0.2
1968/3/19				1970/3/19	0.176	0.01	0.17	1973/3/19				1974/3/19	0.198	0	0.2
1968/3/20				1970/3/20	0.178	0.01	0.17	1973/3/20				1974/3/20	0.198	0	0.2
1968/3/21				1970/3/21	0.181	0.01	0.17	1973/3/21				1974/3/21	0.105	0	0.1
1968/3/22				1970/3/22	0.181	0.01	0.17	1973/3/22				1974/3/22	0.105	0	0.1
1968/3/23				1970/3/23	0.184	0.01	0.17	1973/3/23				1974/3/23	0.105	0	0.1
1968/3/24				1970/3/24	0.184	0.01	0.17	1973/3/24				1974/3/24	0.108	0	0.11
1968/3/25				1970/3/25	0.187	0.02	0.17	1973/3/25				1974/3/25	0.108	0	0.11
1968/3/26				1970/3/26	0.187	0.01	0.17	1973/3/26				1974/3/26	0.11	0	0.11
1968/3/27				1970/3/27	0.19	0.02	0.17	1973/3/27				1974/3/27	0.113	0.01	0.11
1968/3/28				1970/3/28	0.193	0.02	0.18	1973/3/28				1974/3/28	0.119	0.01	0.11
1968/3/29				1970/3/29	0.193	0.02	0.18	1973/3/29				1974/3/29	0.122	0.01	0.11
1968/3/30				1970/3/30	0.195	0.02	0.18	1973/3/30				1974/3/30	0.125	0.02	0.11
1968/3/31				1970/3/31	0.195	0.02	0.18	1973/3/31				1974/3/31	0.127	0.02	0.11
1968/4/1				1970/4/1	0.198	0.02	0.18	1973/4/1				1974/4/1	0.13	0.02	0.11
1968/4/2				1970/4/2	0.201	0.02	0.18	1973/4/2				1974/4/2	0.133	0.02	0.11
1968/4/3				1970/4/3	0.201	0.02	0.18	1973/4/3				1974/4/3	0.136	0.02	0.11
1968/4/4				1970/4/4	0.204	0.02	0.18	1973/4/4				1974/4/4	0.139	0.02	0.12
1968/4/5				1970/4/5	0.204	0.02	0.19	1973/4/5				1974/4/5	0.142	0.02	0.12
1968/4/6				1970/4/6	0.207	0.02	0.19	1973/4/6				1974/4/6	0.142	0.02	0.12
1968/4/7				1970/4/7	0.21	0.02	0.19	1973/4/7				1974/4/7	0.144	0.02	0.12
1968/4/8				1970/4/8	0.21	0.02	0.19	1973/4/8				1974/4/8	0.147	0.02	0.12
1968/4/9				1970/4/9	0.212	0.02	0.19	1973/4/9				1974/4/9	0.153	0.03	0.13
1968/4/10				1970/4/10	0.215	0.02	0.19	1973/4/10				1974/4/10	0.159	0.03	0.13
1968/4/11				1970/4/11	0.198	0	0.19	1973/4/11				1974/4/11	0.164	0.03	0.13
1968/4/12				1970/4/12	0.187	0	0.19	1973/4/12				1974/4/12	0.17	0.04	0.13
1968/4/13				1970/4/13	0.173	0	0.17	1973/4/13				1974/4/13	0.176	0.04	0.14
1968/4/14				1970/4/14	0.159	0	0.16	1973/4/14				1974/4/14	0.178	0.04	0.14
1968/4/15				1970/4/15	0.161	0	0.16	1973/4/15				1974/4/15	0.184	0.04	0.14
1968/4/16				1970/4/16	0.161	0	0.16	1973/4/16				1974/4/16	0.19	0.04	0.15
1968/4/17				1970/4/17	0.164	0	0.16	1973/4/17				1974/4/17	0.195	0.05	0.15
1968/4/18				1970/4/18	0.167	0.01	0.16	1973/4/18				1974/4/18	0.212	0.06	0.15
1968/4/19				1970/4/19	0.167	0.01	0.16	1973/4/19				1974/4/19	0.229	0.07	0.16
1968/4/20				1970/4/20	0.17	0.01	0.16	1973/4/20				1974/4/20	0.249	0.08	0.16
1968/4/21				1970/4/21	0.173	0.01	0.16	1973/4/21				1974/4/21	0.272	0.1	0.17
1968/4/22				1970/4/22	0.176	0.01	0.16	1973/4/22				1974/4/22	0.292	0.11	0.18
1968/4/23				1970/4/23	0.176	0.01	0.16	1973/4/23				1974/4/23	0.354	0.16	0.19
1968/4/24				1970/4/24	0.176	0.01	0.16	1973/4/24				1974/4/24	0.413	0.21	0.21
1968/4/25				1970/4/25	0.176	0.01	0.17	1973/4/25				1974/4/25	0.507	0.28	0.22
1968/4/26				1970/4/26	0.176	0.01	0.17	1973/4/26				1974/4/26	0.6	0.35	0.25
1968/4/27				1970/4/27	0.176	0.01	0.17	1973/4/27				1974/4/27	0.674	0.4	0.28
1968/4/28				1970/4/28	0.176	0.01	0.17	1973/4/28				1974/4/28	0.745	0.43	0.31
1968/4/29				1970/4/29	0.193	0.02	0.17	1973/4/29				1974/4/29	0.818	0.47	0.35
1968/4/30				1970/4/30	0.21	0.04	0.17	1973/4/30				1974/4/30	1.04	0.65	0.39
1968/5/1				1970/5/1	0.227	0.05	0.17	1973/5/1				1974/5/1	1.27	0.82	0.45

1968/5/2				1970/5/2	0.249	0.07	0.18	1973/5/2				1974/5/2	1.05	0.55	0.5
1968/5/3				1970/5/3	0.272	0.09	0.19	1973/5/3				1974/5/3	0.83	0.3	0.53
1968/5/4				1970/5/4	0.297	0.1	0.19	1973/5/4				1974/5/4	0.994	0.43	0.56
1968/5/5				1970/5/5	0.323	0.12	0.2	1973/5/5				1974/5/5	1.16	0.56	0.6
1968/5/6				1970/5/6	0.334	0.12	0.21	1973/5/6				1974/5/6	1.33	0.68	0.65
1968/5/7				1970/5/7	0.343	0.12	0.22	1973/5/7				1974/5/7	1.73	1.02	0.71
1968/5/8				1970/5/8	0.351	0.12	0.23	1973/5/8				1974/5/8	2.14	1.33	0.81
1968/5/9				1970/5/9	0.362	0.12	0.24	1973/5/9				1974/5/9	2.02	1.12	0.9
1968/5/10				1970/5/10	0.377	0.13	0.25	1973/5/10				1974/5/10	1.91	0.93	0.98
1968/5/11				1970/5/11	0.388	0.13	0.26	1973/5/11				1974/5/11	1.72	0.68	1.04
1968/5/12				1970/5/12	0.396	0.13	0.27	1973/5/12				1974/5/12	1.53	0.44	1.09
1968/5/13				1970/5/13	0.45	0.17	0.28	1973/5/13				1974/5/13	1.35	0.24	1.11
1968/5/14				1970/5/14	0.49	0.19	0.3	1973/5/14	0.394	0.2	0.2	1974/5/14	1.19	0.06	1.13
1968/5/15				1970/5/15	0.538	0.23	0.31	1973/5/15	0.51	0.29	0.22	1974/5/15	1.03	0	1.03
1968/5/16				1970/5/16	0.595	0.26	0.33	1973/5/16	0.714	0.47	0.25	1974/5/16	0.954	0	0.95
1968/5/17				1970/5/17	0.665	0.31	0.35	1973/5/17	1.07	0.78	0.29	1974/5/17	0.881	0	0.88
1968/5/18				1970/5/18	0.736	0.36	0.38	1973/5/18	1.37	1.01	0.36	1974/5/18	0.844	0	0.84
1968/5/19				1970/5/19	0.81	0.4	0.41	1973/5/19	1.29	0.85	0.44	1974/5/19	0.81	0	0.81
1968/5/20				1970/5/20	0.889	0.45	0.44	1973/5/20	1.21	0.71	0.5	1974/5/20	0.776	0	0.78
1968/5/21				1970/5/21	0.963	0.48	0.48	1973/5/21	1.12	0.57	0.55	1974/5/21	0.742	0	0.74
1968/5/22				1970/5/22	1.06	0.54	0.52	1973/5/22	1.04	0.45	0.59	1974/5/22	0.796	0.05	0.74
1968/5/23				1970/5/23	1.16	0.6	0.56	1973/5/23	0.838	0.22	0.61	1974/5/23	0.909	0.16	0.75
1968/5/24				1970/5/24	1.3	0.69	0.61	1973/5/24	0.85	0.22	0.63	1974/5/24	1.02	0.25	0.77
1968/5/25				1970/5/25	1.42	0.75	0.67	1973/5/25	1.05	0.4	0.65	1974/5/25	1.58	0.77	0.81
1968/5/26				1970/5/26	1.53	0.8	0.73	1973/5/26	0.997	0.31	0.68	1974/5/26	2.14	1.25	0.89
1968/5/27				1970/5/27	1.42	0.63	0.79	1973/5/27	0.943	0.24	0.7	1974/5/27	2.7	1.7	1
1968/5/28				1970/5/28	1.33	0.5	0.83	1973/5/28	0.892	0.17	0.72	1974/5/28	2.5	1.38	1.12
1968/5/29				1970/5/29	1.25	0.39	0.86	1973/5/29	0.83	0.1	0.73	1974/5/29	2.3	1.08	1.22
1968/5/30				1970/5/30	1.13	0.24	0.89	1973/5/30	0.818	0.08	0.74	1974/5/30	2.25	0.95	1.3
1968/5/31				1970/5/31	1.05	0.15	0.9	1973/5/31	0.818	0.07	0.74	1974/5/31	2.19	0.82	1.37
1968/6/1				1970/6/1	0.98	0.07	0.91	1973/6/1	0.838	0.09	0.75	1974/6/1			
1968/6/2				1970/6/2	0.949	0.03	0.92	1973/6/2	0.807	0.05	0.76	1974/6/2			
1968/6/3				1970/6/3	0.906	0	0.91	1973/6/3	0.776	0.02	0.76	1974/6/3			
1968/6/4				1970/6/4	0.875	0	0.88	1973/6/4	0.745	0	0.74	1974/6/4			
1968/6/5				1970/6/5	0.835	0	0.83	1973/6/5	0.702	0	0.7	1974/6/5			
1968/6/6				1970/6/6	0.801	0	0.8	1973/6/6	0.694	0	0.69	1974/6/6			
1968/6/7				1970/6/7	0.765	0	0.77	1973/6/7	0.799	0.1	0.7	1974/6/7			
1968/6/8				1970/6/8	0.736	0	0.74	1973/6/8	0.756	0.05	0.7	1974/6/8			
1968/6/9				1970/6/9	0.708	0	0.71	1973/6/9	0.728	0.02	0.71	1974/6/9			
1968/6/10				1970/6/10	0.68	0	0.68	1973/6/10	0.702	0	0.7	1974/6/10			
1968/6/11				1970/6/11	0.651	0	0.65	1973/6/11	0.674	0	0.67	1974/6/11			
1968/6/12				1970/6/12	0.626	0	0.63	1973/6/12	0.6	0	0.6	1974/6/12			
1968/6/13				1970/6/13	0.6	0	0.6	1973/6/13	0.612	0.01	0.6	1974/6/13			
1968/6/14				1970/6/14	0.575	0	0.57	1973/6/14	0.572	0	0.57	1974/6/14			
1968/6/15				1970/6/15	0.561	0	0.56	1973/6/15	0.561	0	0.56	1974/6/15			
1968/6/16				1970/6/16	0.535	0	0.54	1973/6/16	0.541	0	0.54	1974/6/16			
1968/6/17				1970/6/17	0.51	0	0.51	1973/6/17	0.521	0	0.52	1974/6/17			
1968/6/18				1970/6/18	0.493	0	0.49	1973/6/18	0.501	0	0.5	1974/6/18			
1968/6/19				1970/6/19	0.476	0	0.48	1973/6/19	0.481	0	0.48	1974/6/19			
1968/6/20				1970/6/20	0.453	0	0.45	1973/6/20	0.453	0	0.45	1974/6/20			
1968/6/21				1970/6/21	0.436	0	0.44	1973/6/21	0.442	0	0.44	1974/6/21			
1968/6/22				1970/6/22	0.419	0	0.42	1973/6/22	0.53	0.08	0.45	1974/6/22			
1968/6/23				1970/6/23	0.402	0	0.4	1973/6/23	0.566	0.11	0.45	1974/6/23			
1968/6/24				1970/6/24	0.385	0	0.39	1973/6/24	0.6	0.14	0.46	1974/6/24			
1968/6/25				1970/6/25	0.385	0	0.39	1973/6/25	0.521	0.05	0.47	1974/6/25			
1968/6/26				1970/6/26	0.388	0	0.39	1973/6/26	0.541	0.07	0.47	1974/6/26			
1968/6/27				1970/6/27	0.391	0.01	0.39	1973/6/27	0.481	0	0.48	1974/6/27			
1968/6/28				1970/6/28	0.394	0.01	0.39	1973/6/28	0.47	0	0.47	1974/6/28			
1968/6/29				1970/6/29	0.396	0.01	0.39	1973/6/29	0.453	0	0.45	1974/6/29			
1968/6/30				1970/6/30	0.402	0.01	0.39	1973/6/30	0.442	0	0.44	1974/6/30			
1968/7/1				1970/7/1	0.405	0.02	0.39	1973/7/1	0.43	0	0.43	1974/7/1			
1968/7/2				1970/7/2	0.408	0.02	0.39	1973/7/2	0.416	0	0.42	1974/7/2			
1968/7/3				1970/7/3	0.385	0	0.39	1973/7/3	0.405	0	0.41	1974/7/3			
1968/7/4				1970/7/4	0.368	0	0.37	1973/7/4	0.405	0	0.41	1974/7/4			
1968/7/5				1970/7/5	0.362	0	0.36	1973/7/5	0.394	0	0.39	1974/7/5			
1968/7/6				1970/7/6	0.348	0	0.35	1973/7/6	0.357	0	0.36	1974/7/6			
1968/7/7				1970/7/7	0.337	0	0.34	1973/7/7	0.365	0.01	0.36	1974/7/7			
1968/7/8				1970/7/8	0.331	0	0.33	1973/7/8	0.377	0.02	0.36	1974/7/8			
1968/7/9				1970/7/9	0.326	0	0.33	1973/7/9	0.385	0.02	0.36	1974/7/9			
1968/7/10				1970/7/10	0.32	0	0.32	1973/7/10	0.394	0.03	0.36	1974/7/10			
1968/7/11				1970/7/11	0.317	0	0.32	1973/7/11	0.394	0.03	0.36	1974/7/11			
1968/7/12				1970/7/12	0.311	0	0.31	1973/7/12	0.377	0.01	0.37	1974/7/12			
1968/7/13				1970/7/13	0.306	0	0.31	1973/7/13	0.368	0	0.37	1974/7/13			
1968/7/14				1970/7/14	0.303	0	0.3	1973/7/14	0.362	0	0.36	1974/7/14			
1968/7/15				1970/7/15	0.297	0	0.3	1973/7/15	0.354	0	0.35	1974/7/15			
1968/7/16				1970/7/16	0.297	0	0.3	1973/7/16	0.348	0	0.35	1974/7/16			
1968/7/17				1970/7/17	0.3	0	0.3	1973/7/17	0.34	0	0.34	1974/7/17			
1968/7/18				1970/7/18	0.3	0	0.3	1973/7/18	0.328	0	0.33	1974/7/18			
1968/7/19				1970/7/19	0.303	0.01	0.3	1973/7/19	0.34	0.01	0.33	1974/7/19			
1968/7/20				1970/7/20	0.303	0	0.3	1973/7/20	0.34	0.01	0.33	1974/7/20			
1968/7/21				1970/7/21	0.306	0.01	0.3	1973/7/21	0.34	0.01	0.33	1974/7/21			
1968/7/22				1970/7/22	0.306	0.01	0.3	1973/7/22	0.34	0.01	0.33	1974/7/22			
1968/7/23				1970/7/23	0.303	0	0.3	1973/7/23	0.34	0.01	0.33	1974/7/23			
1968/7/24				1970/7/24	0.3	0	0.3	1973/7/24	0.32	0	0.32	1974/7/24			
1968/7/25				1970/7/25	0.297	0	0.3	1973/7/25	0.311	0	0.31	1974/7/25			
1968/7/26				1970/7/26	0.294	0	0.29	1973/7/26	0.32	0.01	0.31	1974/7/26			
1968/7/27				1970/7/27	0.292	0	0.29	1973/7/27	0.32	0.01	0.31	1974/7/27			
1968/7/28				1970/7/28	0.289	0	0.29	1973/7/28	0.317	0	0.31	1974/7/28			
1968/7/29				1970/7/29	0.289	0	0.29	1973/7/29	0.314	0	0.31	1974/7/29			
1968/7/30				1970/7/30	0.283	0	0.28	1973/7/30	0.311	0	0.31	1974/7/30			
1968/7/31				1970/7/31	0.28	0	0.28	1973/7/31	0.303	0	0.3	1974/7/31			
1968/8/1				1970/8/1	0.278	0	0.28	1973/8/1	0.283	0	0.28	1974/8/1			
1968/8/2				1970/8/2	0.272	0	0.27	1973/8/2	0.275	0	0.28	1974/8/2			
1968/8/3				1970/8/3	0.269	0	0.27	1973/8/3	0.275	0	0.28	1974/8/3			
1968/8/4				1970/8/4	0.266	0	0.27	1973/8/4	0.275	0	0.28	1974/8/4			
1968/8/5				1970/8/5	0.261	0	0.26	1973/8/5	0.275	0	0.28	1974/8/5			
1968/8/6				1970/8/6	0.255	0	0.26	1973/8/6	0.275	0	0.28	1974/8/6			
1968/8/7				1970/8/7	0.252	0	0.25	1973/8/7	0.275	0	0.28	1974/8/7			
1968/8/8	0.292	0.15	0.15	1970/8/8	0.249	0	0.25	1973/8/8	0.275	0	0.28	1974/8/8			
1968/8/9	0.294	0.14	0.16	1970/8/9	0.244	0	0.24	1973/8/9	0.275	0	0.28	1974/8/9			
1968/8/10	0.3	0.13	0.17	1970/8/10	0.241	0	0.24	1973/8/10	0.266	0	0.27	1974/8/10			
1968/8/11	0.303	0.13	0.18	1970/8/11	0.238	0	0.24	1973/8/11	0.266	0	0.27	1974/8/11			
1968/8/12	0.306	0.12	0.19	1970/8/12	0.232	0	0.23	1973/8/12	0.266	0	0.27	1974/8/12			
1968/8/13	0.309	0.11	0.2	1970/8/13	0.229	0	0.23	1973/8/13	0.266	0	0.27	1974/8/13			
1968/8/14	0.32	0.11	0.21	1970/8/14	0.227	0	0.23	1973/8/14	0.266	0	0.27	1974/8/14			
1968/8/15	0.331	0.12	0.21	1970/8/15	0.227	0	0.23	1973/8/15	0.266	0	0.27	1974/8/15			
1968/8/16	0.34	0.12	0.22	1970/8/16	0.224	0	0.22	1973/8/16	0.266	0	0.27	1974/8/16			
1968/8/17	0.351	0.12	0.23	1970/8/17	0.221	0	0.22	1973/8/17	0.266	0	0.27	1974/8/17			
1968/8/18	0.362	0.12	0.24	1970/8/18	0.218	0	0.22	1973/8/18	0.266	0	0.27	1974/8/18			
1968/8/19	0.374	0.12	0.25	1970/8/19	0.215	0	0.21	1973/8/19	0.266	0	0.27	1974/8/19			
1968/8/20	0.382	0.12	0.26	1970/8/20	0.212	0	0.21	1973/8/20	0.266	0	0.27	1974/8/20			
1968/8/21	0.382	0.11	0.27	1970/8/21	0.21	0	0.21	1973/8/21	0.266	0	0.27	1974/8/21			
1968/8/22	0.379	0.1	0.28	1970/8/22	0.21	0	0.21	1973/8/22	0.266	0	0.27	1974/8/22			
1968/8/23	0.374	0.09	0.29	1970/8/23	0.207	0	0.21	1973/8/23	0.266	0	0.27	1974/8/23			
1968/8/24	0.368	0.08	0.29	1970/8/24	0.204	0	0.2	1973/8/24	0.266	0	0.27	1974/8/24			
1968/8/25	0.365	0.07	0.3	1970/8/25	0.201	0	0.2	1973/8/25	0.266	0	0.27	1974/8/25			
1968/8/26	0.36	0.06	0.3	1970/8/26	0.198	0	0.2	1973/8/26	0.266	0	0.27	1974/8/26			
1968/8/27	0.351	0.04	0.31	1970/8/27	0.187	0	0.19	1973/8/27	0.266	0	0.27	1974/8/27			
1968/8/28	0.345	0.04	0.31	1970/8/28	0.193	0.01	0.19	1973/8/28	0.266	0	0.27	1974/8/28			
1968/8/29	0.34	0.03	0.31	1970/8/29	0.201	0.01	0.19	1973/8/29	0.266	0	0.27	1974/8/29			
1968/8/30	0.331	0.02	0.31	1970/8/30	0.21	0.02	0.19	1973/8/30	0.266	0	0.27	1974/8/30			
1968/8/31	0.323	0.01	0.31	1970/8/31	0.215	0.02	0.19	1973/8/31	0.283	0.02	0.27	1974/8/31			
1968/9/1	0.314	0	0.31	1970/9/1	0.224	0.03	0.19	1973/9/1	0.28	0.01	0.27	1974/9/1			

1968/9/2	0.306	0	0.31
1968/9/3	0.297	0	0.3
1968/9/4	0.292	0	0.29
1968/9/5	0.294	0	0.29
1968/9/6	0.292	0	0.29
1968/9/7	0.289	0	0.29
1968/9/8	0.286	0	0.29
1968/9/9	0.283	0	0.28
1968/9/10	0.283	0	0.28
1968/9/11	0.28	0	0.28
1968/9/12	0.283	0	0.28
1968/9/13	0.289	0.01	0.28
1968/9/14	0.292	0.01	0.28
1968/9/15	0.297	0.01	0.28
1968/9/16	0.3	0.02	0.28
1968/9/17	0.306	0.02	0.28
1968/9/18	0.311	0.02	0.29
1968/9/19	0.314	0.03	0.29
1968/9/20	0.317	0.03	0.29
1968/9/21	0.32	0.03	0.29
1968/9/22	0.323	0.03	0.29
1968/9/23	0.323	0.03	0.3
1968/9/24	0.326	0.03	0.3
1968/9/25	0.326	0.02	0.3
1968/9/26	0.314	0.01	0.3
1968/9/27	0.306	0	0.3
1968/9/28	0.292	0	0.29
1968/9/29	0.28	0	0.28
1968/9/30	0.275	0	0.28
1968/10/1	0.261	0	0.26
1968/10/2	0.252	0	0.25
1968/10/3	0.244	0	0.24
1968/10/4	0.246	0	0.24
1968/10/5	0.249	0	0.24
1968/10/6	0.255	0.01	0.24
1968/10/7	0.258	0.01	0.25
1968/10/8	0.261	0.01	0.25
1968/10/9	0.266	0.02	0.25
1968/10/10	0.269	0.02	0.25
1968/10/11	0.263	0.01	0.25
1968/10/12	0.258	0.01	0.25
1968/10/13	0.252	0	0.25
1968/10/14	0.246	0	0.25
1968/10/15	0.238	0	0.24
1968/10/16	0.232	0	0.23
1968/10/17	0.229	0	0.23
1968/10/18	0.229	0	0.23
1968/10/19	0.229	0	0.23
1968/10/20	0.229	0	0.23
1968/10/21	0.229	0	0.23
1968/10/22	0.229	0	0.23
1968/10/23	0.229	0	0.23
1968/10/24	0.229	0	0.23
1968/10/25	0.229	0	0.23
1968/10/26	0.232	0	0.23
1968/10/27	0.235	0.01	0.23
1968/10/28	0.238	0.01	0.23
1968/10/29	0.241	0.01	0.23
1968/10/30	0.244	0.01	0.23
1968/10/31	0.244	0.01	0.23
1968/11/1	0.244	0.01	0.23
1968/11/2	0.244	0.01	0.23
1968/11/3	0.244	0.01	0.23
1968/11/4	0.244	0.01	0.24
1968/11/5	0.244	0.01	0.24
1968/11/6	0.244	0.01	0.24
1968/11/7	0.244	0.01	0.24
1968/11/8	0.244	0.01	0.24
1968/11/9	0.244	0.01	0.24
1968/11/10	0.244	0.01	0.24
1968/11/11	0.244	0	0.24
1968/11/12	0.246	0.01	0.24
1968/11/13	0.246	0.01	0.24
1968/11/14	0.246	0.01	0.24
1968/11/15	0.246	0.01	0.24
1968/11/16	0.246	0	0.24
1968/11/17	0.249	0.01	0.24
1968/11/18	0.249	0.01	0.24
1968/11/19	0.252	0.01	0.24
1968/11/20	0.249	0.01	0.24
1968/11/21	0.249	0.01	0.24
1968/11/22	0.246	0	0.24
1968/11/23	0.246	0	0.24
1968/11/24	0.246	0	0.24
1968/11/25	0.246	0	0.24
1968/11/26	0.244	0	0.24
1968/11/27	0.244	0	0.24
1968/11/28	0.244	0	0.24
1968/11/29	0.241	0	0.24
1968/11/30	0.241	0	0.24
1968/12/1			
1968/12/2			
1968/12/3			
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1968/12/5			
1968/12/6			
1968/12/7			
1968/12/8			
1968/12/9			
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1968/12/20			
1968/12/21			
1968/12/22			
1968/12/23			
1968/12/24			
1968/12/25			
1968/12/26			
1968/12/27			
1968/12/28			
1968/12/29			
1968/12/30			
1968/12/31			
Sum	32.10	4.40	27.70
BFI	0.86		

1970/9/2	0.232	0.04	0.2
1970/9/3	0.238	0.04	0.2
1970/9/4	0.241	0.04	0.2
1970/9/5	0.244	0.04	0.2
1970/9/6	0.249	0.04	0.21
1970/9/7	0.252	0.04	0.21
1970/9/8	0.255	0.04	0.21
1970/9/9	0.261	0.04	0.22
1970/9/10	0.263	0.04	0.22
1970/9/11	0.266	0.04	0.22
1970/9/12	0.261	0.03	0.23
1970/9/13	0.255	0.03	0.23
1970/9/14	0.249	0.02	0.23
1970/9/15	0.244	0.01	0.23
1970/9/16	0.238	0.01	0.23
1970/9/17	0.244	0.01	0.23
1970/9/18	0.244	0.01	0.23
1970/9/19	0.249	0.01	0.24
1970/9/20	0.252	0.02	0.24
1970/9/21	0.255	0.02	0.24
1970/9/22	0.258	0.02	0.24
1970/9/23	0.261	0.02	0.24
1970/9/24	0.261	0.02	0.24
1970/9/25	0.261	0.02	0.24
1970/9/26	0.261	0.02	0.24
1970/9/27	0.258	0.01	0.25
1970/9/28	0.258	0.01	0.25
1970/9/29	0.258	0.01	0.25
1970/9/30	0.255	0.01	0.25
1970/10/1	0.255	0.01	0.25
1970/10/2	0.255	0.01	0.25
1970/10/3	0.255	0.01	0.25
1970/10/4	0.255	0	0.25
1970/10/5	0.252	0	0.25
1970/10/6	0.252	0	0.25
1970/10/7	0.252	0	0.25
1970/10/8	0.252	0	0.25
1970/10/9	0.249	0	0.25
1970/10/10	0.249	0	0.25
1970/10/11	0.249	0	0.25
1970/10/12	0.249	0	0.25
1970/10/13	0.249	0	0.25
1970/10/14	0.246	0	0.25
1970/10/15	0.246	0	0.25
1970/10/16	0.244	0	0.24
1970/10/17	0.244	0	0.24
1970/10/18	0.244	0	0.24
1970/10/19	0.244	0	0.24
1970/10/20	0.244	0	0.24
1970/10/21	0.244	0	0.24
1970/10/22	0.241	0	0.24
1970/10/23	0.241	0	0.24
1970/10/24	0.241	0	0.24
1970/10/25	0.238	0	0.24
1970/10/26	0.238	0	0.24
1970/10/27	0.238	0	0.24
1970/10/28	0.238	0	0.24
1970/10/29	0.238	0	0.24
1970/10/30	0.235	0	0.23
1970/10/31	0.235	0	0.23
1970/11/1	0.235	0	0.23
1970/11/2	0.232	0	0.23
1970/11/3	0.232	0	0.23
1970/11/4	0.232	0	0.23
1970/11/5	0.232	0	0.23
1970/11/6	0.232	0	0.23
1970/11/7	0.232	0	0.23
1970/11/8	0.232	0	0.23
1970/11/9	0.232	0	0.23
1970/11/10	0.232	0	0.23
1970/11/11	0.229	0	0.23
1970/11/12	0.229	0	0.23
1970/11/13	0.229	0	0.23
1970/11/14	0.229	0	0.23
1970/11/15	0.229	0	0.23
1970/11/16	0.229	0	0.23
1970/11/17	0.229	0	0.23
1970/11/18	0.229	0	0.23
1970/11/19	0.227	0	0.23
1970/11/20	0.227	0	0.23
1970/11/21	0.227	0	0.23
1970/11/22	0.227	0	0.23
1970/11/23	0.227	0	0.23
1970/11/24	0.227	0	0.23
1970/11/25	0.227	0	0.23
1970/11/26	0.227	0	0.23
1970/11/27	0.227	0	0.23
1970/11/28	0.227	0	0.23
1970/11/29	0.227	0	0.23
1970/11/30	0.227	0	0.23
1970/12/1	0.227	0	0.23
1970/12/2	0.227	0	0.23
1970/12/3	0.227	0	0.23
1970/12/4	0.227	0	0.23
1970/12/5	0.227	0	0.23
1970/12/6	0.227	0	0.23
1970/12/7	0.227	0	0.23
1970/12/8	0.227	0	0.23
1970/12/9	0.227	0	0.23
1970/12/10	0.227	0	0.23
1970/12/11	0.227	0	0.23
1970/12/12	0.227	0	0.23
1970/12/13	0.224	0	0.22
1970/12/14	0.224	0	0.22
1970/12/15	0.224	0	0.22
1970/12/16	0.224	0	0.22
1970/12/17	0.224	0	0.22
1970/12/18	0.224	0	0.22
1970/12/19	0.224	0	0.22
1970/12/20	0.224	0	0.22
1970/12/21	0.224	0	0.22
1970/12/22	0.224	0	0.22
1970/12/23	0.224	0	0.22
1970/12/24	0.221	0	0.22
1970/12/25	0.221	0	0.22
1970/12/26	0.221	0	0.22
1970/12/27	0.221	0	0.22
1970/12/28	0.221	0	0.22
1970/12/29	0.221	0	0.22
1970/12/30	0.221	0	0.22
1970/12/31	0.221	0	0.22
Sum	109.47	12.36	97.11
BFI	0.89		

1973/9/2	0.275	0.01	0.27
1973/9/3	0.272	0	0.27
1973/9/4	0.266	0	0.27
1973/9/5	0.266	0	0.27
1973/9/6	0.263	0	0.26
1973/9/7	0.258	0	0.26
1973/9/8	0.258	0	0.26
1973/9/9	0.258	0	0.26
1973/9/10	0.258	0	0.26
1973/9/11	0.252	0	0.25
1973/9/12	0.246	0	0.25
1973/9/13	0.244	0	0.24
1973/9/14	0.238	0	0.24
1973/9/15	0.244	0.01	0.24
1973/9/16	0.252	0.01	0.24
1973/9/17	0.258	0.02	0.24
1973/9/18	0.252	0.01	0.24
1973/9/19	0.246	0	0.24
1973/9/20	0.28	0.04	0.24
1973/9/21	0.311	0.06	0.25
1973/9/22	0.34	0.09	0.25
1973/9/23	0.351	0.09	0.26
1973/9/24	0.311	0.05	0.27
1973/9/25	0.286	0.02	0.27
1973/9/26	0.258	0	0.26
1973/9/27	0.252	0	0.25
1973/9/28	0.246	0	0.25
1973/9/29	0.246	0	0.25
1973/9/30	0.246	0	0.25
1973/10/1	0.246	0	0.25
1973/10/2	0.246	0	0.25
1973/10/3	0.246	0	0.25
1973/10/4	0.246	0	0.25
1973/10/5	0.246	0	0.25
1973/10/6	0.249	0	0.25
1973/10/7	0.252	0.01	0.25
1973/10/8	0.255	0.01	0.25
1973/10/9	0.258	0.01	0.25
1973/10/10	0.258	0.01	0.25
1973/10/11	0.258	0.01	0.25
1973/10/12	0.258	0.01	0.25
1973/10/13	0.258	0.01	0.25
1973/10/14	0.258	0.01	0.25
1973/10/15	0.258	0.01	0.25
1973/10/16	0.258	0.01	0.25
1973/10/17	0.258	0.01	0.25
1973/10/18	0.258	0.01	0.25
1973/10/19	0.258	0	0.25
1973/10/20	0.258	0	0.25
1973/10/21	0.258	0	0.25
1973/10/22	0.258	0	0.25
1973/10/23	0.258	0	0.25
1973/10/24	0.258	0	0.25
1973/10/25	0.258	0	0.26
1973/10/26	0.258	0	0.26
1973/10/27	0.258	0	0.26
1973/10/28	0.258	0	0.26
1973/10/29	0.258	0	0.26
1973/10/30	0.258	0	0.26
1973/10/31	0.258	0	0.26
1973/11/1	0.227	0	0.23
1973/11/2	0.195	0	0.2
1973/11/3	0.19	0	0.19
1973/11/4	0.187	0	0.19
1973/11/5	0.184	0	0.18
1973/11/6	0.178	0	0.18
1973/11/7	0.176	0	0.18
1973/11/8	0.176	0	0.18
1973/11/9	0.187	0.01	0.18
1973/11/10	0.204	0.03	0.18
1973/11/11	0.224	0.04	0.18
1973/11/12	0.244	0.06	0.18
1973/11/13	0.255	0.07	0.19
1973/11/14	0.249	0.05	0.19
1973/11/15	0.244	0.05	0.2
1973/11/16	0.244	0.04	0.2
1973/11/17	0.244	0.04	0.2
1973/11/18	0.241	0.03	0.21
1973/11/19	0.238	0.03	0.21
1973/11/20	0.235	0.02	0.21
1973/11/21	0.229	0.02	0.21
1973/11/22	0.227	0.01	0.21
1973/11/23	0.224	0.01	0.22
1973/11/24	0.224	0.01	0.22
1973/11/25	0.221	0	0.22
1973/11/26	0.218	0	0.22
1973/11/27	0.215	0	0.21
1973/11/28	0.215	0	0.21
1973/11/29	0.218	0	0.22
1973/11/30	0.221	0.01	0.22
1973/12/1	0.224	0.01	0.22
1973/12/2	0.227	0.01	0.22
1973/12/3	0.229	0.01	0.22
1973/12/4	0.229	0.01	0.22
1973/12/5	0.229	0.01	0.22
1973/12/6	0.229	0.01	0.22
1973/12/7	0.229	0.01	0.22
1973/12/8	0.229	0.01	0.22
1973/12/9	0.229	0.01	0.22
1973/12/10	0.229	0.01	0.22
1973/12/11	0.229	0.01	0.22
1973/12/12	0.229	0.01	0.22
1973/12/13	0.229	0.01	0.22
1973/12/14	0.229	0	0.22
1973/12/15	0.229	0	0.22
1973/12/16	0.229	0	0.22
1973/12/17	0.229	0	0.23
1973/12/18	0.229	0	0.23
1973/12/19	0.229	0	0.23
1973/12/20	0.229	0	0.23
1973/12/21	0.229	0	0.23
1973/12/22	0.229	0	0.23
1973/12/23	0.229	0	0.23
1973/12/24	0.227	0	0.23
1973/12/25	0.227	0	0.23
1973/12/26	0.224	0	0.22
1973/12/27	0.224	0	0.22
1973/12/28	0.221	0	0.22
1973/12/29	0.218	0	0.22
1973/12/30	0.215	0	0.21
1973/12/31	0.212	0	0.21
Sum	83.73	9.38	74.34
BFI	0.89		

1974/9/2			
1974/9/3			
1974/9/4			
1974/9/5			
1974/9/6			
1974/9/7			
1974/9/8			
1974/9/9			
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1974/9/11			
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1974/9/14			
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1974/9/16			
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1974/12/25			
1974/12/26			
1974/12/27			
1974/12/28			
1974/12/29			
1974/12/30			
1974/12/31			
Sum	72.63	23.29	49.34
BFI	0.68		