Managing City of Kelowna Parks to Improve Sustainable Water Use

by

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF SCIENCE HONOURS

in

The Irving K. Barber School of Arts and Sciences

(Honours Computer Science Minor Mathematics and Statistics)

THE UNIVERSITY OF BRITISH COLUMBIA (Okanagan)

April 2013

Abstract

As one of B.C.'s fastest growing cities, Kelowna is committed to sustainability for the health and wealth of future generations [1]. The primary focus of the project is to provide the City of Kelowna's Parks Department Office with an easy-to-use web interface that allows them to visualize and manage all of their irrigation-related data in one place. This data consists of locations of irrigation zones and irrigation equipment on site, watering schedules, and historical water usage. This system will provide its users with accurate maps displaying GPS locations of sites and equipment, current and historical watering schedules, and charts showing monthly water usage by site or groups of sites. Users will also be able to generate reports to discover which sites use the most water. Having all of this data neatly organized and clearly presented will allow parks managers to better allocate their limited resources to make a positive impact on sustainability in our city.

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Acknowledgements

I would like to thank Dr. Ramon Lawrence, my honours supervisor, for presenting this opportunity to me and encouraging me to get involved with this project. Not only did he suggest for me to begin my Computer Science degree four years ago, but he has given me this valuable opportunity to learn and build my skills.

I would also like to thank Ryan Trenholm and Derrick Pelletier for their contributions to the application that was designed and implemented for the City of Kelowna. They helped me aggregate a lot of irrigation related data and use it to make a useful irrigation management tool for the City.

1 Introduction

1.1 Motivation

Fresh water is one of the world's most valuable resources. This is especially true in the Okanagan Valley. The Okanagan Valley lies in the rain shadow of the Coast Mountains, which means it receives very little precipitation. The Valley is also considered to be semi-arid with high evaporation rates, especially in the west-facing cities like Kelowna, where sunlight from midday to early evening drives evaporation rates up. Water is underappreciated and undervalued as the perception is that because there are numerous lakes and streams, including the large Okanagan Lake, there must be an abundance of fresh water. This, however, is not the case. In fact, the Okanagan Valley has the least amount of fresh water per person in all of Canada [1].

Water consumption increases greatly during the summer months when irrigation is required to keep yards, vineyards, agriculture, and parks green. Kelowna uses four times more water in the summer than during the rest of the year [2]. One of Kelowna's most important industries is tourism and one of Kelowna's major attractions is its abundance of parks and green spaces. In an effort to keep the city's parks green, especially key attractions like City Park and Waterfront Park, the City of Kelowna Parks Department is the biggest single user of water in Kelowna during the summer. The Parks Department accounts for roughly 20% of water use during the irrigation season [3]. Managing and maintaining almost 400 parks can be a very daunting task.

Technology is more and more prevalent in today's society and being used in many new and exciting ways. Much of the City of Kelowna's Parks Department technology is quickly becoming outdated. The Parks Department currently has two irrigation scheduling applications, weather station data, and countless spreadsheets to store park and equipment information. These tools offer numerous features but due to their unwieldy interfaces they are used improperly or not utilized to their full potential. As a result of these inaccessible systems and data storage formats, managing their irrigation system is unnecessarily complex. The Parks Department is unable to evaluate the effectiveness of the current state of their irrigation systems. Knowing how much water is being used by each site on a historical basis can help make decisions on irrigation improvements, personnel, and resource allocation, and have a greater impact on sustainability.

1.2 Goals and Objectives

The primary goals of this project were to aggregate the Parks Department's existing data into one centralized location and provide them with a user friendly interface to access their data in order to deliver them a tool that could be used to better manage their irrigation systems. A wealth of useful data existed before this project began but was being underutilized due to its inaccessible formats. It was the goal of the project to replace the way the data was currently being stored and managed with a web application built on a MySQL database. The database would serve to organize the unstructured data in a logical manner.

The web application would use the data to help Parks Department employees perform everyday tasks more efficiently while also allowing managers to analyze current and historical water usage

patterns to make more educated decisions on irrigation audits and improvements to their system. This tool was designed to provide quick access to all the basic information about each site. This includes name, location and area of a site as well as information regarding the equipment at that site. Additionally, the tool illustrates the borders of each site and the precise locations of equipment on an intuitive map interface. Using the Parks Department's existing water usage data, the application displays historical usage on an interactive chart. These charts can be generated for single sites, all sites, or specific groups of sites such as all sports fields. This information can then be used for deeper analysis of water usage efficiency and trends.

In addition to providing an easy-to-use interface for their existing data, the application and database also support several new features. Editable cells within the application allow employees to edit incorrect data or update existing data. New sites, controllers, and other pieces of equipment can also be added to the current dataset. An import feature allows managers to upload new water usage data as it is read by the meter readers. Managers may use the application to assign workers to certain tasks and parks by issuing alerts. Alerts can also be generated automatically by equipment. These features allow managers to not only manage their irrigation related data more effectively but also manage their personnel and resources more effectively.

It was hoped that by combining all of these features into one easy to access system, the City would have a tool that would lead them in the right direction towards a more sustainable future.

1.3 Contributions

The contributions of this thesis include the design and implementation of a database schema for use as the main storage structure of a web application designed to assist the City of Kelowna's Parks Department in managing their irrigation related data. This includes populating the database with existing data from various sources provided by the Parks Department and ensuring the accuracy and validity of the data. Time was also spent developing a prototype web application and ensuring the finished product allowed the users of the system to add new data and update existing data easily.

2 Data

One of the major goals of this project was to accumulate and organize the City of Kelowna's irrigation related data so that the data could be delivered back to them in an accessible format. Very early on in the project it was discovered that the City's Parks Department possessed a substantial amount of data. This data was primarily stored in spreadsheet format. Each spreadsheet was manually created and maintained independently. As a result, the structure of the data between spreadsheets (and often even within the same spreadsheet) was unstructured and inconsistent. This lack of consistency and structure makes the data difficult to analyze and retrieve any useful information from. Other data sources, such as those from the Parks Department's irrigation schedulers, proved difficult to access and limited how the data that could be retrieved. This section will discuss the data that was provided by the City of Kelowna, its relevance, and how it can be used to promote sustainability and efficiency within the Parks Department.

2.1 Master Irrigation List

The Kelowna Master Irrigation List (Figure 1) is the main source of information regarding all parks the City of Kelowna is responsible for irrigating and maintaining. The data comes in the form of an Excel spreadsheet. The spreadsheet consists of seven sheets titled Master, Sentinel, Maxicom, Stand Alone, De-Com, Future, and GPS Codes. The first sheet, Master, simply contains a list of all the parks or sites and their associated system (Sentinel, Maxicom, Stand Alone).

	A	B	C	I	J	K	L	M	N	O	P	Q	R	S	T	
1		Park Info		Controller Data						Electrical Data				Antenna Data		
2																
3	Unit ID	Park Name	Purveyor	Type of Controller	Addressing Other?	# of Zones	Availabe Stn Count	Serial Number	Software Version	Earth Grounding	Surge Protection	Resistance (ohms)	Wiring Quality	Mode of Communication	Antenna Type	
4	100	Quarry Park #1	City	Sentinel Satellite	Yes	36	48	100802-4482	2.42	no	0		Fair	Radio	Lo Pro	Doub
5	101	*Quarry Park #2*	City	Map To	n/a	24	24	061003-4684	2.42	no	0		Fair	Radio	Lo Pro	Doub
6	105	South Ridge Boulevard	City	Sentinel Satellite	yes	36	36	102504-5241	2.42	no	0		Good	Radio	Lo Pro	Doub
7	110	South Ridge Park	City	Sentinel Satellite	no	10	12	070804-5896	2.42	no	0		Fair	Radio	Lo Pro	Doub
8	111	Powerline Park	City	Sentinel Satellite Metal Cabinet	no	43	48	462.8625	2.47	yes	1	8.5 Ω	Good	Radio	Lo Pro	Singl
9	112	Frost Road Detention Pond	City	Sentinel Satellite	no	8	12	83110.4899	2.47	no	1		Fair	Radio	Lo Pro	Doub
10	115	Quilchena Park	City	Sentinel Satellite	no	33	36	062209-4365	2.44	no	1		Good	Radio	Lo Pro	Singl
11	120	Tulameen Park	City	Sentinel Satellite	yes	24	24	030206-1549	1.41	no	1		Fair	Radio	Lo Pro	Singl
12	122	Providence Park	City	Sentinel Satellite	no	11	12		2.47	no	1		Fair	Radio	Lo Pro	Singl
13	125	Jewel Park	City	Sentinel Satellite	no	9	12	032907-2399	1.41	no	1		Good	Radio	Lo Pro	Singl
14	130	McCarren Park	City	Sentinel Satellite(Hunter Pro-C)	no	11	24	032907-2403	1.41	no	1		Fair	Radio	Lo Pro	Singl
15	135	Kettle Valley Sportsfield	City	Sentinel Satellite	no	24	12	070804-5097	2.42	no	0		Fair	Radio	Lo Pro	Doub
16	140	East Kelowna Park	SEKID	Sentinel Satellite	no	18	24	021810-5196	2.42	no	2		Good	Radio	Lo Pro	Doub
17	150	Gordon Drive - Cook & Mission Creek Bridge	City	Sentinel Satellite Metal Cabinet	no	5	12	061407-2652	2.47	yes	1		Good	Radio	Lo Pro	Doub
18	200	Bennett Bridge Southside Linear Park	City	Sentinel Satellite	no	21	24	111805.11+19	2.47	no	0		Fair	Radio	Lo Pro	Singl
19	205	Pandosy/Boyce Green Space North	City	Sentinel Satellite	yes	4	12	032907-2396	2.42	no	1		Good	Radio	Lo Pro	Singl
20	206	*Pandosy/Boyce Green Space South*	City	Map To	n/a	5	12	050405-5454	2.42	no	1		Good	Radio	Lo Pro	Singl
21	210	Richter Street - Hwy 97 & Bernard	City	Sentinel Satellite	no	2	12	032907-2400	2.42	no	1		Good	Radio	Lo Pro	Singl
22	215	Richter Street - Hwy 97 & Rowcliffe	City	Sentinel Satellite	no	10	12	092303-EP0888	2.42	no	1		Good	Radio	Lo Pro	Doub
23	220	Hwy 97 Mdn - Ellis & Richter/Chamber of Commerce	City	Sentinel Satellite	no	7	12	092303-EP0887	2.42	no	0		Good	Radio	Lo Pro	Singl
24	225	Highway 97 Mdn - Gordon & Chandler	City	Sentinel Satellite	no	10	12	061003-4676	1.41	no	0		Fair	Radio	Lo Pro	Singl
25	226	Highway 97 Mdn - Gordon & Ethel	City	Sentinel Satellite	no	4	12	021510-5195	2.47	no	1		Good	Radio	Lo Pro	Singl
26	227	Highway 97 Mdn - Ethel & Richter	City	Sentinel Satellite	no	4	12	81010.5837	2.47	no	1		Fair	Radio	Lo Pro	Singl
27	230	Highway 97 & Water Street Median & Boulevard	City	Sentinel Satellite	no	14	24	072707-2751	2.42	no	1		Fair	Radio	Lo Pro	Singl
28	235	St. Paul & Cawston Community Garden/Parking Lot	City	Sentinel Satellite	no	5	12	080309-4476	2.42	no	1		Good	Radio	Lo Pro	Singl
29	250	Stuart Park	City	Sentinel Satellite	no	29	48	*unknown*	2.42	yes	4		Good	Radio	Lo Pro	Wa
30	260	Waterfront Park - Orchards	City	Sentinel Satellite	yes	22	24	90311054915	2.47	no	1		Good	Radio	Lo Pro	Singl
31	261	*Waterfront Park - Rotary Marsh*	City	Sentinel Map To	n/a	12	12	091705-1283	SEQ2	no	1		Good	Radio	Lo Pro	Doub
32	270	Waterfront Park - Promenade	City	Sentinal Satellite Metal Cabinet	yes	12	12	83110.4904	2.47	no	1		Good	Radio	Lo Pro	Singl

Sentinel | Maxicom | Stand Alone | De-Com | Future | GPS Codes

Figure 1: Kelowna Master Irrigation List

The next three sheets of the document, Sentinel, Maxicom, and Stand Alone, are very similar in terms of content. They list each of the sites with more detailed information about the site as well as information regarding the equipment at that site. Equipment data in these sheets includes controller data, electrical data, antenna data, enclosure data, flow sensor data, and component data such as information about the points of connection, valves, backflow protection, and the mainline. The data contained within these spreadsheets serves two major purposes. It gives anyone looking at the data an overview of the important details of the park such as its name and address. The equipment data allows

managers to see all the equipment they have in the field without actually having to go to each site. This is especially useful considering that most irrigation equipment is underground and can be difficult to locate. The most useful of this data may be the GPS coordinates of the points of connection. Water meters are often attached at the points of connection and being able to quickly access these can drastically improve efficiency in reading the water meter and obtaining water usage data.

The De-Com (decommissioned) sheet gives a small list of sites that are no longer maintained by the Parks Department. Some basic information about each is provided. The Future sheet provides a short list of planned parks and sites. Lastly, the GPS Codes sheet lists all sites with a file code and the phase they were built in. These sheets do not appear to be of much use in the building of the database and application.

2.2 Irrigated Green Spaces

In 2012, a joint effort between the City of Kelowna's Parks Department and Waterkind Irrigation Consulting produced a pdf document that listed a majority of the City's sites with accurate measurements of the irrigated area and total area of the site. The document warns that due to the myriad of sources and inconsistencies between site names and other descriptors, it is likely that not all sites have been included in this document [4]. Nonetheless, the irrigated area data contained in this document can be used in conjunction with the water meter readings for these sites to provide insight into current application rates and allow for more educated decision making with regards to site improvements.

2.3 Meters Information

This spreadsheet provided by the City of Kelowna Parks Department offers a list of sites and some information about the water meters that are associated with each site. The spreadsheet lists the sites in a similar fashion as the Master Irrigation List discussed earlier, but instead of including details of all the equipment for a particular site, this spreadsheet provides basic information about the water meters for a particular site. The water meter data in this spreadsheet includes billing information such as account number, rate code, and billable service id, as well as the address of the water meter. The data contained within this spreadsheet can be extremely useful to link sites to water meters. It is challenging, however, to link the sites to the water meter reading data that will be discussed in the next section. The reason for this is because this spreadsheet does not provide a meter id. The inconsistencies between site names also play a role.

2.4 City Parks Water Consumption

The City of Kelowna outsources their water meter readings to a company called Corix. Corix provides meter reading summary data in an Excel spreadsheet and submits this to the City on a monthly basis (Figure 2). Since the start of the project this spreadsheet has evolved at the requests of the Parks Department and this project. The data contained within the spreadsheet has stayed relatively the same, but the structure of the columns has become far more consistent throughout the duration of this project. In the most recent versions of the spreadsheet, the data consists of billing information such as the rate code and the account number. Also contained in this spreadsheet is the address of the meter and the route number it is on.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	account_no	occupant_code	serv_street_no	serv_street	serv_unit	route	meter_no	billcode	usage_hi	usage_low	read_type	consmonth	reading_hi	reading_lo	read_date
2	1051212	0	5056	WINDSONG CRES	PARK	25	62224220	691	55	0	MR	8/1/2012 12:00:00 AM	2299		24/07/2012
3	1051123	0	352	MCCARREN AVE	PARK	26	62578753	691	653	0	MR	8/1/2012 12:00:00 AM	10962		30/07/2012
4	1051076	0	483	LAWRENCE AVE		1	58290779	691	0	0	MR	8/1/2012 12:00:00 AM	965		26/07/2012
5								691 Total	708	0					
6	1053821	0		SPRINGFIELD RD	WILKI	78	72445676	692	11	0	MR	8/1/2012 12:00:00 AM	99		17/07/2012
7	1053823	0		SPRINGFIELD RD	E HOY	78	72566653	692	7	0	CE	8/1/2012 12:00:00 AM	91		17/07/2012
8	1053829	0		SPRINGFIELD RD	INKAR	78	72566642	692	6	0	CE	8/1/2012 12:00:00 AM	179		17/07/2012
9	1053854	0	1415	ELLIS ST		90	72445229	692	30	0	MR	8/1/2012 12:00:00 AM	503		23/07/2012
10	1053855	0	1991	BERNARD AVE	CEMET	66	72445677	692	1	0	MR	8/1/2012 12:00:00 AM	4		17/07/2012
11	1053908	0		LEASIDE AVE	ROUND	64	63241884	692	89	0	MR	8/1/2012 12:00:00 AM	660		16/07/2012
12	1053909	0		MAPPIN CRT	ROUND	14	69015651	692	4	0	MR	8/1/2012 12:00:00 AM	75		27/07/2012
13	1053754	0		SMITHSON PL	ROUND	72	69015658	692	4	0	MR	8/1/2012 12:00:00 AM	38		19/07/2012
14	1053757	0	2501	SELKIRK DR		97	69015647	692	68	0	MR	8/1/2012 12:00:00 AM	679		24/07/2012
15	1053760	0		CASCADE CRT	ROUND	97	69015656	692	0	0	MR	8/1/2012 12:00:00 AM	6		24/07/2012
16	1053764	0		UFTON CRT	ROUND	94	72445215	692	10	0	MR	8/1/2012 12:00:00 AM	123		16/07/2012
17	1053765	0		LAKELAND RD	ROUND	33	72445671	692	26	0	MR	8/1/2012 12:00:00 AM	146		03/08/2012
18	1053770	0		OMINECA PL	ROUND	97	72445675	692	0	0	MR	8/1/2012 12:00:00 AM	0		24/07/2012
19	1053822	0		SPRINGFIELD RD	DAYTO	94	72445660	692	12	0	MR	8/1/2012 12:00:00 AM	57		17/07/2012
20	1053825	0		CASSIAR CRES	PARK	97	69015661	692	74	0	MR	8/1/2012 12:00:00 AM	933		24/07/2012
21	1053826	0		SPRINGFIELD RD	BARLE	94	72445661	692	6	0	MR	8/1/2012 12:00:00 AM	59		17/07/2012
22	1053827	0		SPRINGFIELD RD	SW OF	94	72445672	692	115	0	MR	8/1/2012 12:00:00 AM	458		17/07/2012
23	1053830	0		SPRINGFIELD RD	SPALL	94	72445657	692	4	0	MR	8/1/2012 12:00:00 AM	34		17/07/2012
24	1053856	0	1750	HIGHLAND DR N		69	72445218	692	22	0	MR	8/1/2012 12:00:00 AM	204		18/07/2012
25	1053858	0	1200	WATER ST	BLVD	96	69015654	692	4	0	MR	8/1/2012 12:00:00 AM	33		24/07/2012
26	1053859	0	1200	WATER ST	WPARK	96	72445214	692	5	0	MR	8/1/2012 12:00:00 AM	106		24/07/2012
27	1053861	0		GRAND & COURTHOUSE	BLVD	96	72445670	692	15	0	MR	8/1/2012 12:00:00 AM	132		24/07/2012
28	1053864	0	842	MANHATTAN DR	BEACH	96	69015655	692	124	0	MR	8/1/2012 12:00:00 AM	495		24/07/2012
29	1053866	0	2100	CHILCOTIN CR	MTN P	97	69015660	692	51	0	MR	8/1/2012 12:00:00 AM	447		24/07/2012
30	1053468	0	2938	ABBOTT ST	PARK	40	68763781	692	95	0	MR	8/1/2012 12:00:00 AM	575		13/08/2012
31	1053735	0		CURLEW CRT	IRRIG	26	72445224	692	0	0	MR	8/1/2012 12:00:00 AM	147		26/07/2012
32	1053750	0	2188	ABBOTT ST	IRRIG	43	69015659	692	21	0	MR	8/1/2012 12:00:00 AM	204		08/08/2012

Apr 2012 | May 2012 | June 2012 | July 2012 | August 2012 | September 2012 | October 2012 | November 2012 | December 2012

Figure 2: City Parks Water Consumption provided by Corix

Of utmost importance to this project, the spreadsheet additionally lists the water meter, the raw readings of the meter, the water used since the last meter reading, the date the meter was actually read on, and the date the usage was billed. This data may be the most useful data to the managers of the Parks Department who can use this information to make educated decisions with regards to prioritizing sites for irrigation assessments, audits, and improvements. From this data we are able to create customized water usage charts that are far more accessible and interesting to explore than hundreds of rows in an Excel spreadsheet.

2.5 GPS Coordinates

Before this project began the City of Kelowna had already collected some GPS data, but they did not have a complete set of data for all parks. This dataset was largely unused because the easiest way to access the data for City employees was through the City of Kelowna Park Map Viewer or screenshots from this inconvenient interface.

Figure 3: GPS border of Dilworth Soccer Park (also known as Dilworth Sports Field)

During the course of the project we acquired a KML file containing the borders of all parks within the City of Kelowna from the City's open data catalogue. This GPS data could then be used to create a more intuitive and user friendly map interface. In addition to obtaining GPS coordinates for the borders of all parks, GPS data was collected and gathered for specific equipment in the field. This data was collected on two sites: Sumac Park and Whitman Glen Park. Precise coordinates for sprinkler heads, points of connection, valve boxes, and controllers were collected. Discussions with field employees suggested that this equipment specific GPS data would be tremendously valuable for faster completion of their day-to-day tasks. Due to much of the equipment being underground or difficult to locate having the GPS coordinates for important pieces of equipment can save tremendous amounts of time in the field.

2.6 Toro Sentinel WMS

Toro Sentinel WMS (Figure 4) is one of two irrigation scheduling programs used by the Parks Department. It is a program provided by Toro, a company that also manufactures irrigation controllers used by the City. The program provides the Parks Department a user interface to view and manage the irrigation schedules for their Sentinel controllers. The application has the capability of storing 16 schedules per controller plus information regarding the soil and plant types for each zone and make automatic adjustments based on weather conditions such as rain or ET[1] data. Schedule information consists of start times, run times for each zone, and days to water on. The application will also trigger alarms if the central system has lost contact with the controller or on irrigation related events such as exceeding the maximum flow rate set for a site.

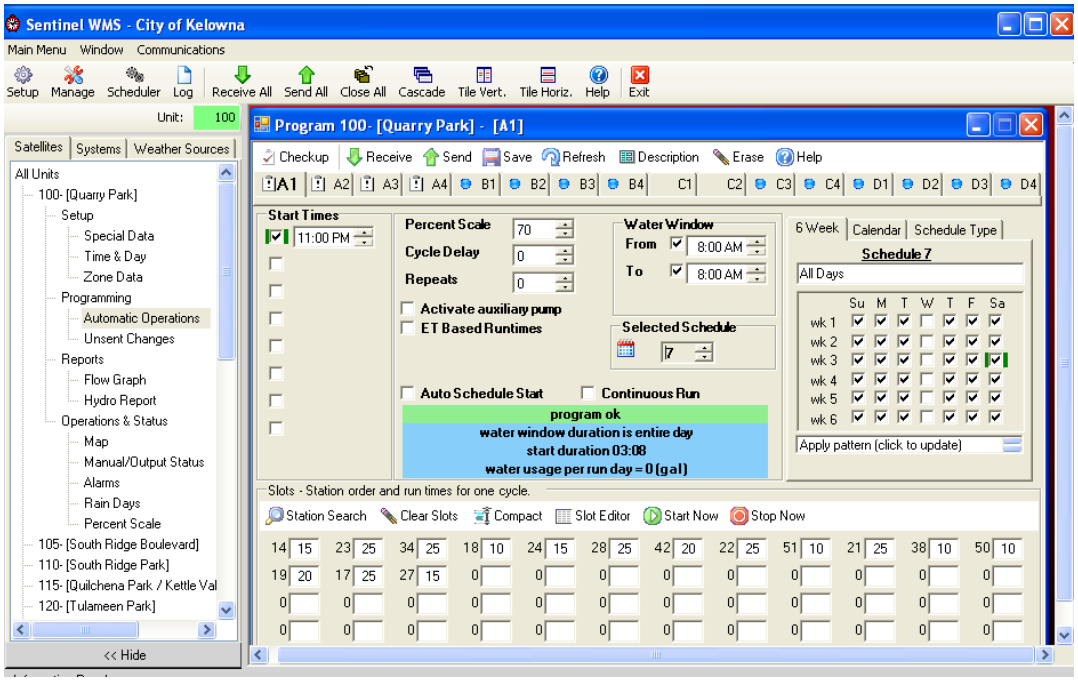


Figure 4: Toro Sentinel WMS software

[1] ET or evapotranspiration refers to the water that is evaporated from the soil and crop surface (evaporation) and the water that is released through the plant (transpiration) [9].

All of this data and more is stored by the application in a Microsoft Access database. The tables in the Access database took a great deal of time to understand and relate back to the application's interface. Due to some security concerns expressed by the City of Kelowna's IT department, the project was only granted read-only access to the application's database. With this data deciphered and understood, the project could provide field employees access to the irrigation schedules when in the field while also preserving a history of changes made to the schedules for future reference. This would allow field employees, who are principally responsible for adjusting the irrigation schedules as required, the ability to examine historical records of changes and apply this knowledge to the current schedules.

2.7 Rainbird Maxicom² Central Control System

Rainbird's Maxicom² Central Control System (Figure 5) is the second irrigation scheduling program used by the Parks Department. The core features of this application are very similar to those of the Toro Sentinel WMS. The program allows users to create and manage irrigation schedules for sites controlled by a Maxicom irrigation controller. Creating schedules requires a more programmatic approach than the Sentinel system. Users are required to type the schedules using a specified syntax. The application also supports ET data adjustments, schedule start times, run times, and run days. Like the Sentinel system, the Maxicom system triggers alarms when the central system loses contact with a controller in the field or on irrigation related events.

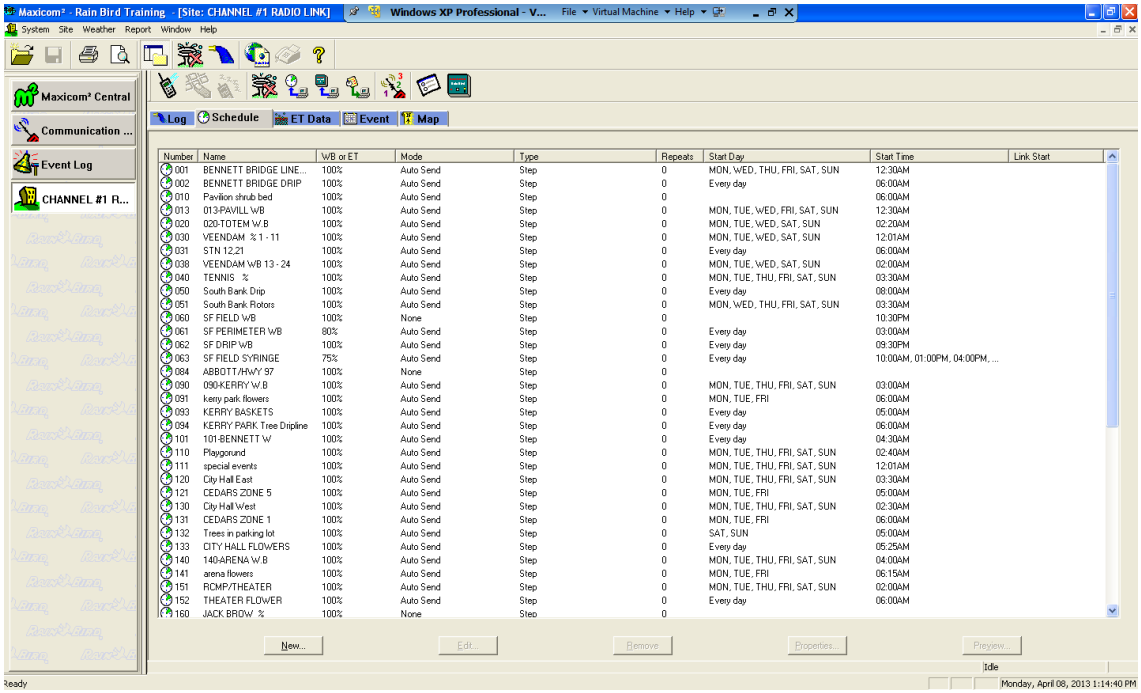


Figure 5: Rainbird Maxicom² Central Control System interface

Most of this data is also stored by the application in a Microsoft Access database. This database was even more complex than that of the Sentinel system and took a great deal of time to understand and relate to the application's user interface. The same security concerns expressed by the City of Kelowna meant that project had read-only access to this database. Acquiring the necessary information

to generate irrigation schedules that would be easily accessible by all employees of the Parks Department proved to be incredibly complicated. After careful investigation it was realized that the irrigation schedules were not actually stored in the database at all. The schedules were stored in schedule files and referenced in the Access database by a file path. For the purpose of this project the task of acquiring the schedule data from this application was postponed.

3 Database

The major contribution of this thesis is the design, implementation, and population of the database to store the Parks Department's irrigation related data. The database went through two design phases as the original design and application prototype were revised and reconstructed after receiving feedback from the client and gaining a more complete and comprehensive understanding of the data and its relationships. The web application built for the City of Kelowna's Parks Department uses this revised database to manage the necessary data.

3.1 Design

Database design requires understanding the operational requirements of the client and modeling these requirements in a database. There must be an understanding of the project's goals, the users and their requirements. A conceptual design of the database can then be constructed by specifying entities, attributes of these entities, and relationships between entities. The conceptual design involves modeling the data collected using a high-level modeling language. For this project entity-relationship (ER) diagrams were assembled. From these models, the physical database can then be implemented. The project used a MySQL relational database. It is a popular and well-documented database that supports many features needed by the project.

The initial step in designing the database for this project was to understand the data provided by the City. The data, discussed in the previous section, was not all provided in the early stages of this project, which made understanding the data and its relationships, a challenge. Initially, the only data provided to the project was the Master Irrigation List. A great deal of time was spent studying this spreadsheet in an attempt to comprehend the meaning and the relationships of this dataset. This data focused on the list of sites and the equipment associated with each of the sites. As such, the initial design focused on the site entity with all other equipment entities relating back to the site. As more data was acquired and more discussions and review of the initial prototype with the Parks Department had occurred, the project's goals and outcomes were better understood. The data itself was more complete and it was realized that the database would need to be redesigned to accommodate the new data and the new understanding of the existing data.

As the project progressed, the needs and requirements of the client were better understood. It was learned how they would want to use their water usage data to generate reports on groups of sites and the benefits to the field workers of having equipment and zones displayed on a map. Additional analysis and a growing familiarity with irrigation related data allowed for a more thorough understanding of the data and its relationships as well. It was determined that the original list of sites was actually a list of controllers and the definition of a site was revised so that a site could have multiple controllers. The assumption that all equipment related back to a site was therefore altered to have all equipment relate back to the controller. This amendment to the design created a more hierarchal structure with more logical relationships between the various entities. The web application now uses this improved design (Figure 6) and implementation of the database to interact with and perform queries on.

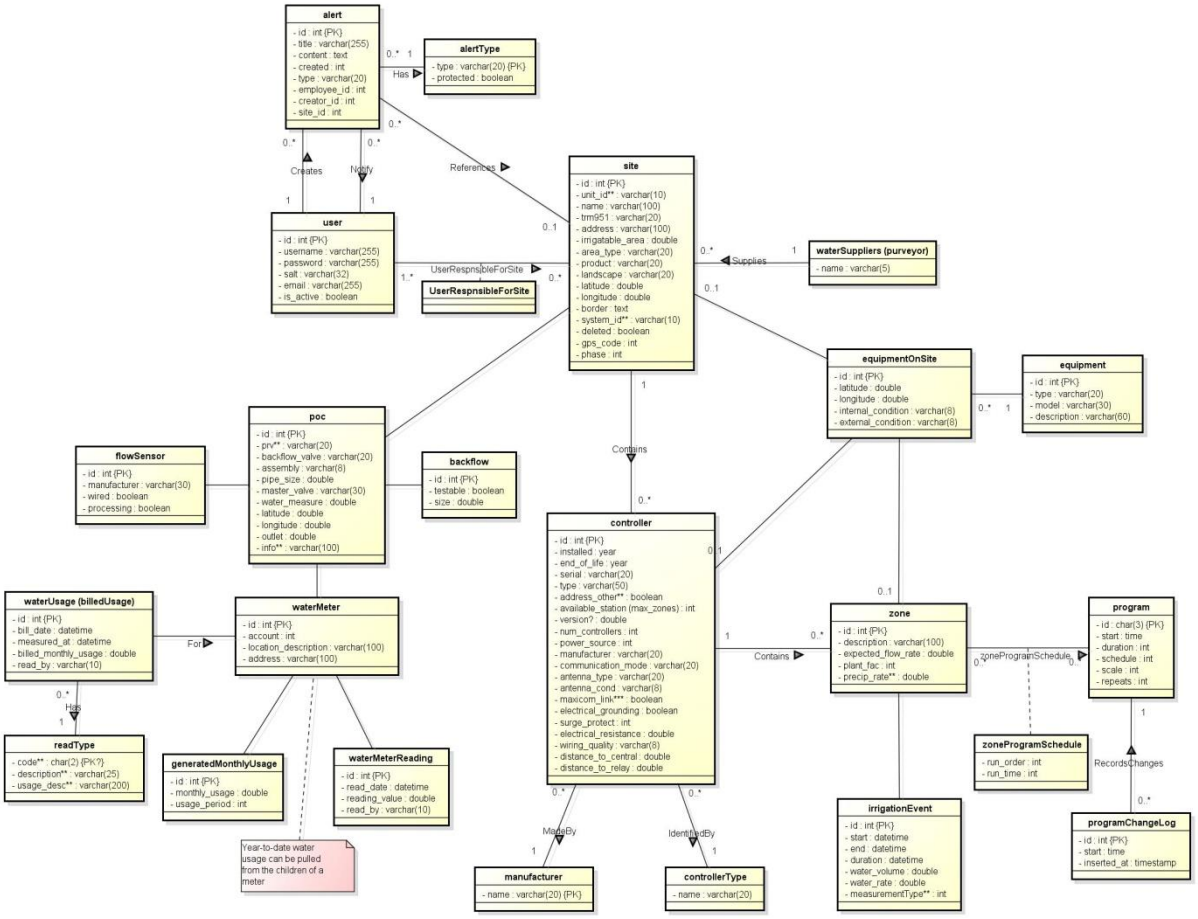


Figure 6: Entity relationship diagram displaying final database design

3.2 Population

The next phase in the project was to populate the database with the City of Kelowna's existing datasets. The database was populated primarily through several small programs that read the data source and extracted the necessary pieces from its source. With this data, the programs created insert statements to be performed on the database. Another small program took these files containing insert statements and executed them on the database to populate the tables. Once the data was entered into the database, it was checked for validity and accuracy against other sources and through discussions with the Parks Department managers.

Due to the varied nature of the different datasets collected for the project numerous import scripts were created to extract the data from its source and insert it into the appropriate tables in the database. Each of these had to be customized for its particular source and meant that one script, or even a few, would be insufficient to accomplish this task. This section will briefly describe how the main tables of the database were populated.

3.2.1 Basic Site Information

The first set of data provided to the project was the Master Irrigation List, which contains a list of sites and basic information about each of them. As mentioned in the Data section, this spreadsheet was divided into seven different sheets. The essential information is located in the sheets labeled Sentinel, Maxicom, and Stand Alone. Each sheet is also divided into several groups of columns labeled Park Info, Controller Info, Electrical Data, and many more. Each of these subsections was designed as a separate table in the database design. As such, the import scripts for each subsection had to be customized for the data in that subsection as well as for the corresponding table in the database. A template script was developed to read in the spreadsheet as a comma-separated file. This template script was then adapted for each of the sheets and their different subsections of data. For many columns in the spreadsheet the data types were varied and inconsistent. The program stripped numerical values of any attached units, converted fractional quantities into their decimal forms, interpreted “yes” and “no” strings, as well as checkmarks within the document, as Boolean values, and handled empty cells as null values. Each of the scripts created insert statements for the corresponding table in the database. These statements were outputted as texts files, which were reviewed for any obvious syntax errors. Finally, the text files were passed to a query execution program to insert the data into the database.

Later in the project, a joint effort between the City of Kelowna’s Parks Department and Waterkind Irrigation Consulting produced a .pdf document that listed a majority of the City’s sites with accurate measurements of the irrigated area and total area of each site. Many of the sites in the database had irrigated areas stored already, but this report provided a reference to compare the existing entries against for accuracy. Records were updated based on the values contained in the report. For sites that did not have any information regarding irrigated area, the document provided this new information to the project’s database.

3.2.2 Water Usage

Water consumption data is one of the most vital datasets available to the City of Kelowna, as it allows Parks Department managers discover and analyze usage patterns to make more educated decisions on irrigation improvements and resource allocation. It is provided to the City on a roughly monthly basis from Corix, which was then forwarded to the project team. Upon first receiving this data, which was roughly 18 months of meter readings, it was first necessary to create meters inside the database. This involved investigating the Corix spreadsheets, the Master Irrigation List, and the meter information provided by the Parks Department and discovering similarities between the spreadsheets. This became a very manual and time-intensive process as the shared information between the spreadsheets was very loosely associated and challenging to show relationships. These relationships were reviewed by Steve Koga of the Parks Department for correctness.

Having inserted the water meter data into the database the meter readings and water usage data could be inserted into the database and associated properly with one of the water meters. As with the basic park information, this involved extracting the data from comma-separated files. One of the major inconveniences of this task was the inconsistent format in which the data was provided. Each month’s readings were provided in one sheet of a larger document containing the readings and usage

for every month it had been collected for. Each sheet, however, did not necessarily have the same columns or the columns were in a different ordering. Consequently, the script to pull the information from the spreadsheet had to be changed constantly to match the structure of each month's sheet. Once the data was extracted, insert statements were created and executed on the database.

The web application built for this project allows users to upload .csv files and automatically insert this data into the database. This tool gives the Parks Department the freedom to enter their own data into the database as they take over and begin using the application. The import process checks the validity of the data and alerts the user if the file contains bad data or improper formatting. In order for this tool to be useful the format and structure of the spreadsheets provided by Corix, or any other company that might read the City's water meters, would need to be consistent and unchanging. A consistent format for these spreadsheets was discussed with Corix and the Parks Department and agreed upon. With roughly 180 water meters, this tool allows the Parks Department to enter data quickly without relying on another external provider to accomplish this task.

3.2.3 GPS Data

GPS data for park boundaries was obtained from the City of Kelowna's open data catalogue as a KML file. It was discovered this file listed GPS coordinates for the borders of the parks in the City of Kelowna. A PHP script was written to extract the necessary pieces of the file and generate insert statements. These insert statements were executed against the database and the accuracy of the data could be easily checked by displaying the borders on a Google map. The data is stored in the database in JSON format, a format commonly used with Google maps.

GPS data was also gathered for specific pieces of equipment on two sites, Sumac East Park and Whitman Glen Park. Using a Trimble GeoExplorer 6000 Series Handheld GPS with TerraSync software provided by the City of Kelowna, precise GPS coordinates were collected for sprinkler heads, valve boxes, points of connection, and the site's control cabinet. Using this information irrigation lines were estimated to show different irrigation zones for these two sites. These coordinates were extracted from the system's software interface and converted into a .csv format. The data was then processed by an import script to produce and execute insert statements for the database.

3.2.4 Irrigation Schedules

The City of Kelowna's Parks Department uses two irrigation scheduling programs to manage and schedule all of the watering times for all the parks they manage. This data is only accessible and updatable using these two programs. One of the goals of the project was to provide scheduling information for each zone along with the map of the zone in a format that could be accessed from anywhere. This involved studying and using both programs to gain a level of comfort and understanding of how the programs worked and what data was available in them. Because they are older programs, a 32-bit Windows XP virtual machine was installed to run these programs for testing and evaluation.

Toro Sentinel WMS stores the data it uses in a Microsoft Access database. The Access database contains numerous tables and took some time to fully comprehend. The process to retrieve and use data from these applications was very involved. Accessing a Microsoft Access database

programmatically first required downloading the correct drivers for the database. Queries were then constructed to acquire the desired information from the database. This included schedules for individual zones on a site as well as some information about the zone itself. The results of these queries were then used to build insert statements appropriate for the database used by the project. Scripts were once again used to create and execute these queries to insert this data into the database.

Rainbird Maxicom^2 Central Control System provides the user with much of the same functionality as the Sentinel WMS. This program also uses a Microsoft Access database as its main storage structure. Understanding the data available in this system took considerably longer as its database was more complex, way larger in size, and one of the key pieces of information is not actually stored in the database. After careful examination of the database it was realized that the irrigation schedules used by this system are only stored in the database as file paths to special schedule files. Due to this obstacle moving the data from this program into the project's database was never accomplished.

The City of Kelowna also expressed security concerns about allowing an external program like the project's application to access and modify its data remotely. As a result, the City only provided read access to the database. Access was arranged through an FTP server. An updated version of both databases was provided on a daily basis. This required writing a small program to download the most recent version of the database from the FTP site and store it for use by the project's application. It was also necessary to automate the unzipping process. To ensure the application has the most up-to-date data the downloader program would be required to run on a daily basis as well. This involved setting a scheduled run time for the program. While fully functioning for the Sentinel WMS database, the inability to acquire the schedule information from the Maxicom^2 Central Control System delayed the progress of this piece and eventually it was put on hold to distribute resources elsewhere.

3.3 Tables

This section will describe the database as well as how the entities are related to one another. This section will also provide meaningful descriptions of each table and their respective attributes that may not be apparent.

3.3.1 waterSupplier

The waterSupplier table simply lists all of the water suppliers, or purveyors, for all of the parks in the city. The current lists contains Black Mountain Irrigation District (BMID), City of Kelowna Water Utility (CITY), Glenmore-Ellison Improvement District (GEID), Rutland Waterworks District (RWD), and South East Kelowna Irrigation District (SEKID).

3.3.2 siteType

The siteType table lists various area types a site can be described as. Examples of a site type include cul-de-sac, green space, and sports field. The City of Kelowna can use this information to generate reports filtered by these categories.

3.3.3 site

The site table contains basic information pertaining to a site. A site can be described as one park, an area of green space, or an area irrigated along the side of a road. The data stored within this

table includes the site's name, address, irrigated area (in acres), total area (in acres), latitude and longitude of its center point, the GPS coordinates of the site's border (provided in JSON format), and whether or not the site has been deactivated. The site also contains a field (site_type_id) that describes what type of area the site is. The possible values for this field include sports field, beach access, median, and others. For more information see the siteType table. The site table also lists who provides the water to this site. Currently this can be one of BMID, CITY, GEID, RWD, or SEKID.

For future flexibility the site table contains numerous identification fields. The id attribute is an auto incrementing field used as the primary key for this table. The site_id attribute has been provided for the City of Kelowna to correspond to their internally assigned identification for a site. These two attributes are currently in use. Additionally the table has three more identification fields. The external_id attribute has been provided to reference the identifiers used by the City of Kelowna's current irrigation scheduling applications, Toro Sentinel WMS and Rainbird Maxicom^2 Central Control System. The use case for the reference_id attribute has not yet been determined, but was included in the table schema in the event that the sites were identified in some other way, such as references from meter readers.

Finally, the site table contains a parent_site_id. This gives the City of Kelowna the ability to divide larger sites, such as Parkinson Recreation Centre, into smaller sub-sites. The smaller sub-sites can then use this field to refer to their larger parent site. This allows the City of Kelowna to generate usage and efficiency reports or keep maintenance logs on the site as a whole but also on its individual sub-sites.

3.3.4 controllerType

The controllerType table lists the types and manufacturers of the irrigation controllers used by the City of Kelowna. This list includes Toro's Sentinel controllers, Rainbird's Maxicom controllers, and stand-alone controllers.

3.3.5 controller

The controller table contains all the necessary information belonging to an irrigation controller. The table has an auto incrementing id field used as its primary key. The site_id field references which site a given controller can be found at. The nickname attribute is used to further identify controllers when there are multiple controllers on a site. The controller_type_id attribute references the brand of the controller as listed in the controllerType table.

Basic information in this table includes the model and serial number of the controller. The table also lists which version of firmware is currently installed (version_number), the maximum number of zones the controller is capable of managing schedules for, and the channel number if the controller has more than one channel.

The table provides details about the mode of communication and conditions of electrical equipment and antennae associated with the controller. The address_other_controller attribute describes whether or not the controller propagates signals to another controller that may be out of

reach of the City of Kelowna's normal range. For controllers that address another controller distances to the central station and the relay controller are stored.

3.3.6 backflow

The backflow table provides data regarding the backflow valves on particular sites. This tables stores the size of the valves and whether or not they are testable.

3.3.7 flowSensor

The flowSensor table lists the flow sensors for a particular site. This table stores information about the manufacturer, how the sensor is wired and processing information.

3.3.8 pointOfConnection

The pointOfConnection table describes information relating to the point where the water purveyor connects to the irrigation lines at a site. Often a water meter will be located at this point. The table contains the type of backflow valve and the assembly of this valve. The table lists the size of the pipe, the type of master valve (often 'yes' if the master valve exists but its type was not known), and the size of the inlet and outlet valves. The table contains two fields to describe the GPS coordinates of the point of connection. Lastly, an information attribute can be used for additional details about the point of connection, such as the location of hard to find points of connection.

This table references the backflow and flowSensor tables via the back_flow_id and flow_sensor_id columns, respectively. The site_id attribute references the site the point of connection is located at.

3.3.9 readType

The readType table lists the reading codes provided by Corix for their water meter readings. The code attribute is a two-character code that abbreviates the read type. The name field is the unabbreviated code name. For example, the code 'MR' corresponds to the read type 'Meter Read'. The description attribute provides a more detailed explanation of the read type.

3.3.10 waterMeter

The waterMeter table lists all of the water meters the City of Kelowna uses to measure water usage on their parks and other irrigated areas. The id field is the meter id, as inscribed on the meter itself. The account attribute lists the account usage measured by a given meter is billed to. The table also contains the service address of the water meter as well as a more detailed location of the water meter.

3.3.11 billedWaterUsage

The billedWaterUsage table describes the amount of water used by a particular meter since the last reading, as calculated by the meter reader. This is the amount of water that is billed to the purveyor for a given billing period. Each entry has an auto incremented id, the water meter the reading is for, the amount of water that was used since the last reading, how the reading was obtained (read_type), the date the meter was read, and the date the usage was billed.

3.3.12 waterMeterReading

The waterMeterReading table describes the raw readings read by the meter reader. Each entry has an auto incremented id, the water meter for the reading, the value read by the meter reader, how the reading was obtained, and the date the meter was read. The difference between two consecutive readings for a particular meter should equal the billed usage for that meter over that time period.

3.3.13 calculatedMonthlyWaterUsage

The calculatedMonthlyWaterUsage table contains monthly water usage for a given meter calculated from the billed water usage and read dates by a database trigger. The value of these entries estimate the water used during a month by weighting the usage from consecutive readings based on when the meters were actually read. Each entry is identified by an auto increment id field. An entry also contains the associated water meter, the usage period, and the calculated usage. The usage period is a six digit integer in the from YYYYMM.

3.3.14 zones

The zones table contains information for each zone as provided by the City's irrigation scheduling programs. This information includes zone number, types of plants and grasses being irrigated, the precipitation rate (how much water the sprinklers in this zone put down), and the controller that controls the zone. Because of the difficulty in acquiring data from the scheduling programs, the data in this table is not current.

3.3.15 irrigationProgram

The irrigationProgram lists all the different irrigation programs created by the Parks Department in their irrigation scheduling applications. The program schedules consist of a start time, duration, which days the program runs, percentage scale, and the number of times the program repeats. Because of the difficulty in acquiring data from the scheduling programs, the data in this table is not current.

3.3.16 irrigationProgramForZone

This table stores the irrigation programs and the zones they run on. The table also stores the order in which the zones are irrigated and how long each zone is irrigated for. Because of the difficulty in acquiring data from the scheduling programs, the data in this table is not current.

3.3.17 irrigationProgramChangeLog

The goal of this table was to maintain a history of changes made to each individual irrigation program. This would allow the Parks Department to review historical changes and compare current programs with previous versions. Because of the difficulty in acquiring data from the scheduling programs, there is no data in this table.

3.3.18 equipment

The equipment table stores all of the information about various irrigation equipment such as sprinklers, valve boxes, and controller cabinets. The table stores the type of equipment it is, the model, and a brief description.

3.3.19 equipmentOnSite

The equipmentOnSite table stores information about each individual piece of equipment and where it is located. This data includes the GPS coordinates of the equipment, the equipment's condition, which zone and site it belongs to, and a reference to the equipment table declaring what type of equipment it is.

3.3.20 userRoles

The userRoles table lists the different roles the employees of the Parks Department can take on. These may include administrators, managerial positions, or seasonal employees.

3.3.21 users

The users table lists all of the employees that will have access to the City of Kelowna's irrigation application. The table contains a username and password for each user to log in to the site. Additionally, contact information and their user role are also stored.

3.3.22 userResponsibleForSite

This table contains a list of sites each user is responsible for maintaining.

3.3.23 alertType

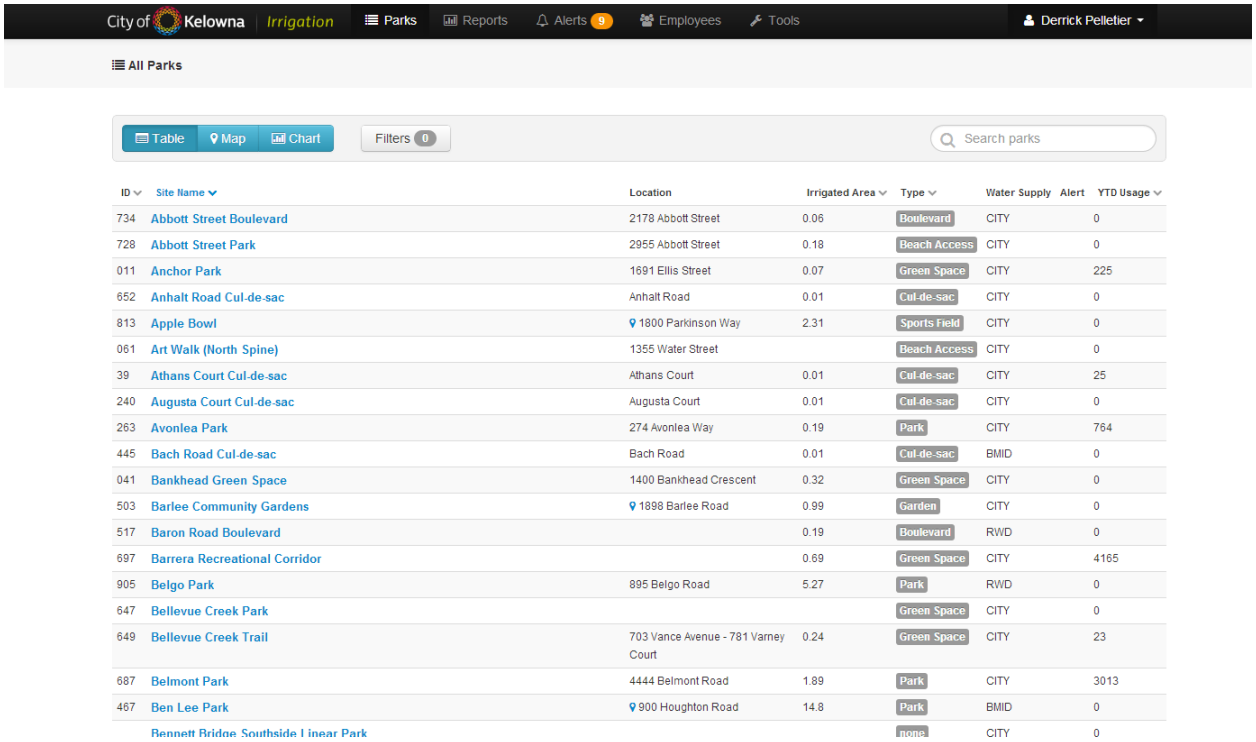
The alertType table lists the types of alerts available: warning, info, and important.

3.3.24 alert

The alert table contains all of the alerts sent out by employees or equipment. The information stored within this table includes the alert's title, creator, recipient, and the content of the alert message. It also keeps a record of the site the alert is associated to and whether or not the alert has been completed.

4 Web Application

The final product of this project was an easy-to-use web application for the City of Kelowna's Parks Department that allows the Parks Department to manage all of their irrigation related data and use this information to simplify management and ensure efficient and sustainable water use. The building of the application is not a major contribution of this thesis. This section will provide a brief overview of the application and how it uses the data that has been collected and organized in the database system. This section will also expand on the meter readings import feature of the application and the checks that are made to ensure the data is sensible.



ID	Site Name	Location	Irrigated Area	Type	Water Supply	Alert	YTD Usage
734	Abbott Street Boulevard	2178 Abbott Street	0.06	Boulevard	CITY		0
728	Abbott Street Park	2955 Abbott Street	0.18	Beach Access	CITY		0
011	Anchor Park	1691 Ellis Street	0.07	Green Space	CITY		225
652	Anhalt Road Cul-de-sac	Anhalt Road	0.01	Cul-de-sac	CITY		0
813	Apple Bowl	1800 Parkinson Way	2.31	Sports Field	CITY		0
061	Art Walk (North Spine)	1355 Water Street		Beach Access	CITY		0
39	Athans Court Cul-de-sac	Athans Court	0.01	Cul-de-sac	CITY		25
240	Augusta Court Cul-de-sac	Augusta Court	0.01	Cul-de-sac	CITY		0
263	Avonlea Park	274 Avonlea Way	0.19	Park	CITY		764
445	Bach Road Cul-de-sac	Bach Road	0.01	Cul-de-sac	BMID		0
041	Bankhead Green Space	1400 Bankhead Crescent	0.32	Green Space	CITY		0
503	Barlee Community Gardens	1898 Barlee Road	0.99	Garden	CITY		0
517	Baron Road Boulevard		0.19	Boulevard	RWD		0
697	Barrera Recreational Corridor		0.69	Green Space	CITY		4165
905	Belgo Park	895 Belgo Road	5.27	Park	RWD		0
647	Bellevue Creek Park			Green Space	CITY		0
649	Bellevue Creek Trail	703 Vance Avenue - 781 Varney Court	0.24	Green Space	CITY		23
687	Belmont Park	4444 Belmont Road	1.89	Park	CITY		3013
467	Ben Lee Park	900 Houghton Road	14.8	Park	BMID		0
	Bennett Bridge Southside Linear Park			none	CITY		0

Figure 7: Entry point to the City of Kelowna Irrigation web application

The web application's point of entry features a list of the parks the City of Kelowna manages (Figure 7). This provides quick and easy access to all the basic information about the parks. The list may be filtered, sorted or searched by site name to find desired information quickly. This page is analogous to the City's Master Irrigation List, but presented in a more accessible format. Many details from that spreadsheet are not immediately visible in this view in order to keep the page clean. Clicking on any of the sites will bring the user to a page showing more detailed information about the site including area, employees, and equipment on site such as controllers and water meters. The Site Details page also allows users to add or update any missing or incorrect data. Users may also access alerts and maintenance logs for a particular site, supplying managers with the tools to assist in managing employees and resources in addition to managing their irrigation related data.

One of the most essential features of the application is the water usage reporting charts (Figure 8). This tool provides the Parks Department with charts displaying water usage for a particular park,

groups of sites, or the entire list of sites. These charts are capable of displaying historical water usage and make comparisons against expected usage based on ET data from weather stations. With this information presented clearly in a graphical manner, managers now have the ability to assess efficiency in the sites they manage and discover usage patterns and trends that they otherwise may not have been aware of. This can improve decision making with regards to irrigation improvements.

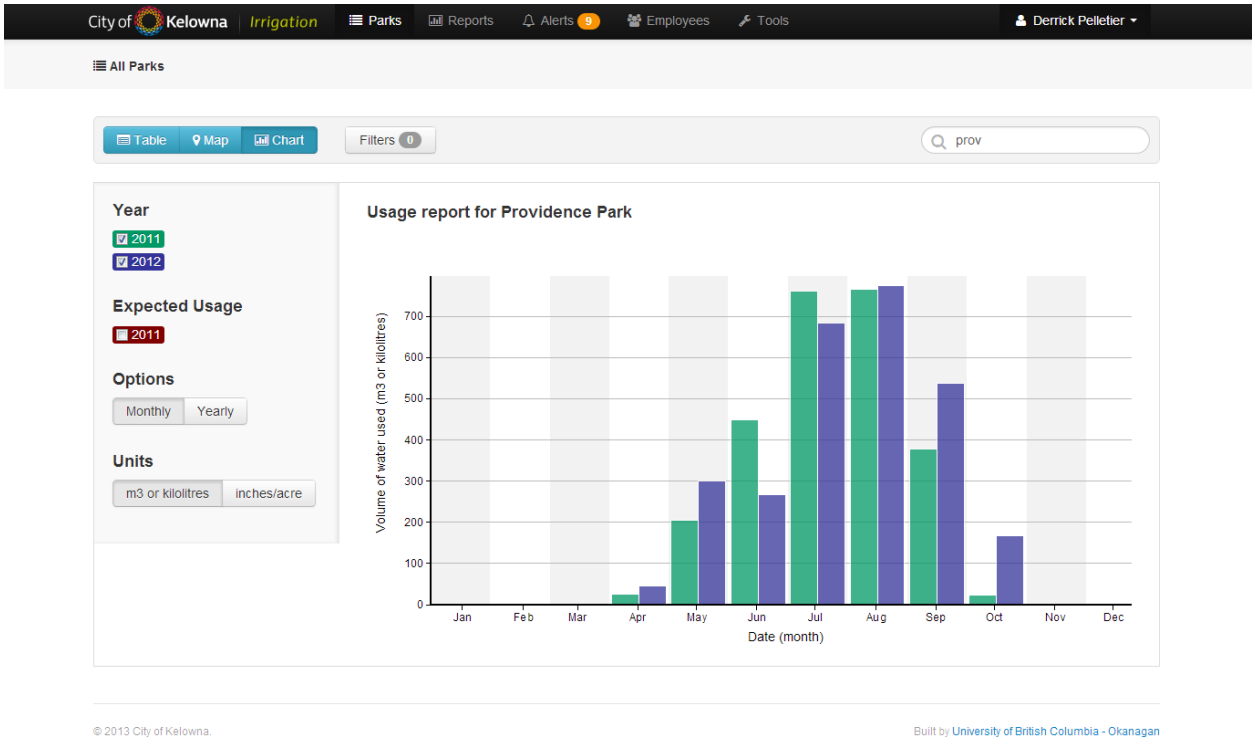


Figure 8: Water usage charts in the City of Kelowna Irrigation web application

This data can be highly influential. As such, it is necessary that it includes the latest water meter readings and water usage data from Corix. To support this functionality the application features a water usage import page that allows users to upload a .csv file containing the water usage data that will automatically load this information into the database and update all of the usage charts and reports. After a file has been uploaded the data is checked for formatting and validity. Any rows deemed to be invalid will be flagged and presented to the user. These rows can then be corrected and entered properly into the database. Rows may be flagged for a myriad of reasons. Warnings or errors may be issued if the water meter does not exist, meter information such as its address is missing, a reading already exists for that reading period, water usage is negative, or there are discrepancies between the reported usage and the differences between consecutive readings for that site. This ensures the data going into the database is correct while also notifying the user that there may be errors in the meter readings.

After this data is successfully imported, triggers on the database perform calculations to update the year-to-date usage and accurately estimate monthly usage. The monthly water usage is estimated by a series of queries and calculations stored in procedures. A query is executed against the database to

retrieve the number of days between consecutive readings for a particular water meter. The usage is then divided across the number of days between readings to give the estimated daily usage for that period. The days between readings and the most recent read date are used to determine how many days during this reading period occurred during each month. The daily usage is multiplied by the number of days in the month for that reading period and the resulting usage is added to the monthly total for that month. A quick example using the sample data in Table 1 may make this clearer.

Read Date	Usage	Daily Usage
May 16, 2012	246	8.2
June 4, 2012	361	19.0
July 16, 2012	1155	27.5
August 18, 2012	957	29.0

Table 1: Sample water meter usage data. Usage describes the usage since the last reading.

Assuming that the reading on May 16, 2012 is the first reading for this meter there is no previous reading. In this situation the procedure assumes the meter was read 30 days ago. Therefore the previous read date would be calculated as April 16, 2012. Dividing the usage of 246 across 30 days would yield a daily usage of 8.2. Starting at the previous read date, which in this case was assumed to be April 16, 2012, the procedure calculates the number of days in the reading period that were in that month and then multiplies by the daily usage. There are 14 days between April 16, 2012 and April 30, 2012 so April had 14 days during this period. Multiplying the daily usage of 8.2 by 14 days gives a monthly usage of 114.8 (Table 2). The remaining usage will then be attributed to May. There are 16 days between May 1, 2012 and the read date of May 16, 2012. Multiplying the daily usage of 8.2 by 16 days results in a monthly usage of 131.2 (Table 2).

The next reading occurred on June 4, 2012. Therefore, there are 19 days between consecutive readings. The daily usage for this period is then $361/19 = 19$. The reading took place on June 4, 2012 so it is expected that most of this usage should be attributed to the previous month, May. From the previous read date, May 16, 2012, and May 31, 2012 there are 15 days. Multiplying the daily usage of 19 by 15 days yields a monthly usage of 285 for May. This usage is then added to May's existing usage (Table 2). There are 4 days between June 1, 2012 and the current read date, June 4, 2012. This can be used to calculate June's usage of 76 for this period. The results from the rest of the readings in Table 1 are shown in Table 2.

Month	Estimated Usage
April 2012	114.8
May 2012	131.2 + 285
June 2012	76 + 715
July 2012	440 + 435
August 2012	522

Table 2: Results of monthly usage calculations.

The most exciting and useful feature for field workers is the park map tool. The map displays the GPS coordinates of all the borders of each site on a Google map. This data is pulled from the database as a JSON string and presented on the map using Google map API. Like the site list, this page can be filtered and searched to quickly find specific parks. The map automatically centers and zooms as the results of the filters change. In addition to showing the borders of each park, sites with GPS coordinates for equipment will display that equipment on the map as well (Figure 9).

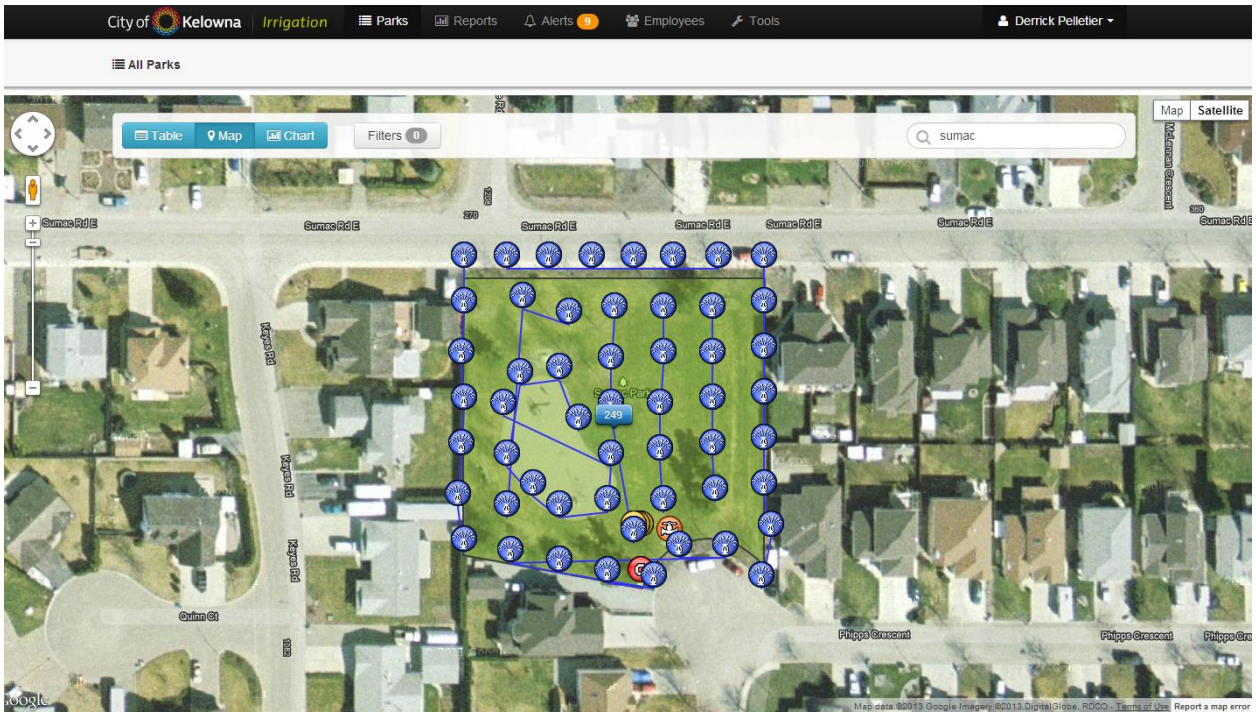


Figure 9: Map of Sumac East Park's equipment in the City of Kelowna Irrigation web application

Displaying site equipment on an interactive map was highly encouraged by the field workers. They conveyed that often time is wasted turning on and off zones to find the locations of the zones and the sprinklers within them. The map page not only shows the exact locations of sprinkler heads, but also locations of valve boxes, points of connection, control cabinets and any other relevant equipment. Each piece of equipment can be clicked to bring up an information window that provides the user with even more details about that piece of equipment, such as the type of sprinkler it is. The application also estimates where irrigation lines are using the locations of the sprinkler heads and zone information. Currently, detailed equipment location data only exists for two parks. Collecting this data and adding it to the database may be extremely beneficial to the efficiency of the Parks Department's field employees.

Additionally, tools to add new sites, manage employees, create and send alerts are also available. Therefore, this application helps manage every aspect of the Parks Department in one place.

5 Discussion and Conclusions

5.1 Discussion

The project was mostly successful but did not get produced without encountering challenges. Many of the challenges and solutions discussed were technical, but some also involved interactions with the client and their concerns.

Understanding the data available and provided was one of the major challenges in this project. Time was spent researching irrigation terms and consulting members of the City's Parks Department who were busy with regular work. Understanding the complex relationships between the different entities was very time consuming and initial attempts at designing the database were revised. The problem was amplified by the fact that there was a massive amount of unfamiliar data from several different sources and it was all organized differently. Not only was the data difficult to understand but understanding the relationships and associations between the data was complicated because of varying naming schemes and no clear identification fields in any of the data sources. Through time and perseverance a good understanding of the data was achieved and the final database structure and organization reflects a much clearer understanding of the data and its relationships.

The trickiest datasets to comprehend were the datasets coming from the Parks Department's two irrigation scheduling programs. A Windows XP virtual machine had to be installed to even run the programs. Once this data was understood and the tasks to access and retrieve the appropriate information from their respective databases were complete it was learned that direct access to the databases would not be allowed due to security concerns expressed by the City of Kelowna's IT department. To overcome this challenge an FTP server was set up for the project to download the most recent database files from the City on a daily basis. It was unclear if the database files provided were correct and up-to-date so this remains an ongoing issue.

Due to some of the difficulty understanding the data and its relationships as well as learning the uses the Parks Department had for the data, the database design needed to re-designed. During this time the web application was undergoing a change in its framework. With both pieces of the project changing at the same time, proper testing and evaluation became a challenge. As a result the web application lost some of its functionality and the data could not be transferred from the existing database to the new database in a simple manner. While ensuring the system still had the same functionality before the redesign was an unexpected and challenging process, it provided an opportunity to review and validate the data for accuracy with a more comprehensive understanding of each attribute.

5.2 Conclusion

The primary goals of this project were to aggregate the Parks Department's existing data into one centralized location and provide them with a user friendly interface to access their data in order to deliver them a tool that could be used to better manage their irrigation systems. The web application and database system built for this project have combined and organized the City's existing data into a logical structure and presented it with an accessible web interface. They now have the tools to find park

information quickly, view and analyze usage trends and patterns, keep records of equipment in the field, generate useful summary reports, and maintain tasks for employees. This application facilitates the ability for the City of Kelowna to make more educated decisions for the future of the department and its irrigation needs. This system can be used to help the City of Kelowna save money, reduce water usage while making a positive impact on sustainability.

5.3 Future Work

The database and application are functional and provide the City of Kelowna with a useful tool to analyze and manage their irrigation related data. As this is an ongoing project there is some work that can be done. Features can be added and cleaned up in the web application and more data can be acquired or entered into the database. This section will discuss some specific features or types of data that can be improved or added to.

One of the most useful features of the application for the long-term success of this project is the meter readings import function. This feature is currently incomplete due to technical problems encountered and time constraints. The ability to upload .csv files and automatically insert this data into the database was in place during an earlier iteration of development. During the last iteration, however, this functionality has yet to be implemented. It was delayed due to a challenge encountered involving permission settings while trying to create SQL triggers on the database to perform the monthly usage calculations.

The City of Kelowna requested a reports page to generate reports on water usage and efficiency. This page is in place, but it remains to be seen what type of reports will be generated and how best they will be displayed.

Time was spent investigating the Toro Sentinel WMS and the Rainbird Maxicom^2 Central Control System and the data contained within them. This was one of the most challenging aspects of the project. Code is written to download the City's database files used in these programs and store the relevant data in the project's database. Code still needs to be completed to acquire the program schedules from the Rainbird system as they are not stored in the Rainbird database. This program needs to be scheduled to run daily to ensure the most up-to-date information is in the database. Communication with the City of Kelowna needs to be initiated to ensure that the correct database files are provided to the project. Further, it would be most beneficial to have access to real-time updates and the ability to update these scheduling programs through the project's application. This remains a security concern from the City of Kelowna.

As this is a data intensive system the data stored and displayed by the application needs to be current and accurate. Data can continue to be collected to maximize the benefit of this project. More data that can be acquired are meter readings for sites purveyed by BMID, GEID, RWD, and SEKID, a complete set of GPS coordinates for sites, GPS coordinates for equipment on sites, and any other irrigation related data that the Parks Department would find useful.

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