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Pesticides in Urban/Suburban Water Wells in Milwaukee, Ozaukee, Washington, and Waukesha Counties in Wisconsin

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PESTICIDES IN URBAN/SUBURBAN WATER WELLS IN MILWAUKEE, OZAUKEE, WASHINGTON, AND WAUKESHA COUNTIES IN WISCONSIN

by

Leslie Bychinski

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ABSTRACT

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Under the Supervision of Professor Shangping Xu

The professional lawn care business has developed into a multibillion-dollar industry (Mazareanu, 2019) over the last few decades with a rise in home and garden market sector for urban/suburban use (Atwood & Paisley-Jones, 2017). Some homeowners purchase and apply the pesticides themselves while others hire professional lawn care companies. The US EPA states that “all pesticides are toxic to some degree” and the prevalent, widespread use of pesticides is both a major environmental problem and a public health issue (EPA, 1992). There have been many studies tracing agricultural pesticides application and contamination of public drinking water, and less on (sub)urban, residential pesticide application. This study targets active, private wells within four Wisconsin counties in the Milwaukee metropolitan area: Milwaukee, Ozaukee, Washington, and Waukesha, which consist of large portions of non-agricultural, suburban land use. The groundwater samples collected were tested for seven pesticide compounds that are active ingredients in some of the most commonly applied residential pesticides: 2,4−Dichlorophenoxyacetic Acid (2,4-D), Carbaryl, Dicamba, imidacloprid, Malathion, 2-methyl-4-chlorophenoxyacetic acid (MCPA), and methylchlorophenoxypropionic

acid (MCPP). Of these seven compounds, only three (2,4-D, Carbaryl, and Dicamba) have health-based enforcement standards, and none of them have a maximum contaminant level.

In this study, 16 active, private wells were sampled; two in Milwaukee county, four in Ozaukee county, six in Washington county, and four in Waukesha county. These wells were selected primarily based on their location within well-kept, more densely populated, suburb neighborhood, away from agricultural fields, to ensure the groundwater collected was representative of residential pesticide application. Samples were collected during June/July, August/September, and November of 2019, and February 2020 and analyzed for 2,4-D, carbaryl, dicamba, imidacloprid, malathion, MCPA, and MCPP. There were seven wells that detected one or more of the targeted pesticides between June and August, no other sampling event resulted in any pesticide detections. The pesticide most frequently detected being 2,4-D, showing up in three separate wells, followed by malathion showing up in two wells; carbaryl, dicamba, MCPA, and MCPP each making an appearance once.

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1. INTRODUCTION

Pesticides are a class of substances designed to disrupt the growth of weeds, insects, fungi, or any undesirable living organism in both agricultural and (sub)urban settings. (Sub)urban uses include home and garden application, as well as golf course and roadside applications (Hoffman et al, 2000). A survey conducted by the U.S. Environment & Human Health, Inc. (EHHI) suggests that around 72 percent of homeowners have applied pesticides on their lawns (EHHI, 2003). The U.S. Fish and Wildlife Service reported that homeowners used up to ten times more chemical pesticides per acre on their lawns than farmers use for agriculture (USFWS, 2000). It is estimated that more than 60 million pounds of the active ingredients of home and garden pesticides are used in the United States per year (Grube et al, 2011).

The National Water Quality Assessment (NAWQA) Program of the U.S. Geological Survey (USGS) has been monitoring pesticide contamination in drinking water sources in the United States since the early 1990's. Their results show that 97 percent of surface water samples from both agricultural and (sub)urban areas contain one or more pesticides at detectable levels (Giliom et al, 2006). Meanwhile, 55 percent of the shallow groundwater samples from the (sub)urban areas have detectable pesticide levels, which is comparable to that of agricultural areas (61%) (Giliom, 2007). More surprisingly, higher pesticide concentrations exceeding human-health benchmarks have been observed in shallow groundwater in (sub)urban areas than that in agricultural areas (Giliom, 2007). A separate survey suggests that 17 of the 30 commonly used home and garden pesticides have been detected in groundwater, and 23 have potential to contaminate groundwater (US GAO, 1990).

So far, U.S. Environmental Protection Agency (EPA) authorizes over 200 different pesticides to be used for residential purposes, and 30 of them are commonly applied. Many studies over the past few decades have suggested that pesticides may pose adverse health effects, with children, infants, and fetuses being particularly susceptible. A study in 1998 found that exposure to pesticides may cause childhood malignancies, such as neuroblastoma, Wilms' tumor, Ewing's sarcoma and non-Hodgkin's lymphoma (Zahm and Ward, 1998). Other studies have found evidence of kidney and liver damage and neurotoxicity (EHHI, 2003).

Due to this rising concern in pesticide detection nationally, the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP), the Wisconsin Department of Natural Resources (DNR), and other agencies have implemented groundwater monitoring programs in the state. Groundwater provides drinking water for approximately 2/3 of Wisconsin's population - It is estimated that around 25 percent of Wisconsin residents obtain their drinking water from over 800,000 private wells (DNR, 2017). In the most recent statewide survey provided by the DATCP in 2016, 401 private drinking wells were sampled for pesticide and nitrate analysis (DATCP, 2017). Pesticides and their metabolites were detected in 41.7 percent of the selected wells, which shows a rise from 33.5 percent from the 2007 survey. However, it is important to note that this survey used a stratified random sampling approach that focused its efforts on areas cultivated for agricultural production, while urban and non-agricultural areas were excluded (DATCP, 2017). Limited efforts have been made on suburban/urban areas, leaving incomplete information on the occurrence and impact of residential pesticides on local groundwater supply. This project will aid as a complimentary study to current pesticide monitoring practices and provide necessary data towards the potential risk of residential pesticide contamination in a local groundwater setting.

2. SETTING

Study Area

The focus of this research occupies Milwaukee (i.e. Wauwatosa and Franklin), Ozaukee (i.e. Mequon and Grafton), Washington (i.e. Hubertus, Germantown and Richfield), and Waukesha (i.e. Muskego and Elm Grove) counties of Southeastern Wisconsin (Figure 1). These four counties incorporate the Milwaukee metropolitan area and consist of large portions of non-agricultural suburban land use (Appendix A) (SEWRPC, 2006).

Figure 1: Location of Milwaukee, Ozaukee, Washington, and Waukesha Counties of Wisconsin

Source: Greater Milwaukee Foundation

Hydrogeologic Setting

Glaciation has largely characterized the physiography, topography, and soils of Wisconsin. Southeastern Wisconsin displays evidence of multiple glaciation events, with the last stage ending about 11,000 years ago (SEWRPC & WGNHS, 2002). A variety of complex glacial landforms and features (Appendix B) characterize the surface water drainage patterns of Southeast Wisconsin in 11 watersheds (Appendix C).

Wisconsin has four main aquifers, from shallowest to deepest: the sand and gravel aquifer, the eastern dolomite aquifer, the sandstone aquifer, and the crystalline bedrock aquifer (Figure 2) (WGNHS, 2020). The first two aquifers collectively are referred to as the "shallow aquifer" and the "deep aquifer" collectively for the latter (SEWRPC & WGNHS, 2002).

Private, residential wells are commonly drilled into the “shallow aquifer” from <100 to roughly 300 feet into unlithified glacial material of the sand and gravel aquifer or into the fractured dolomite aquifer (Figure 3) (Bradbury, 2007).

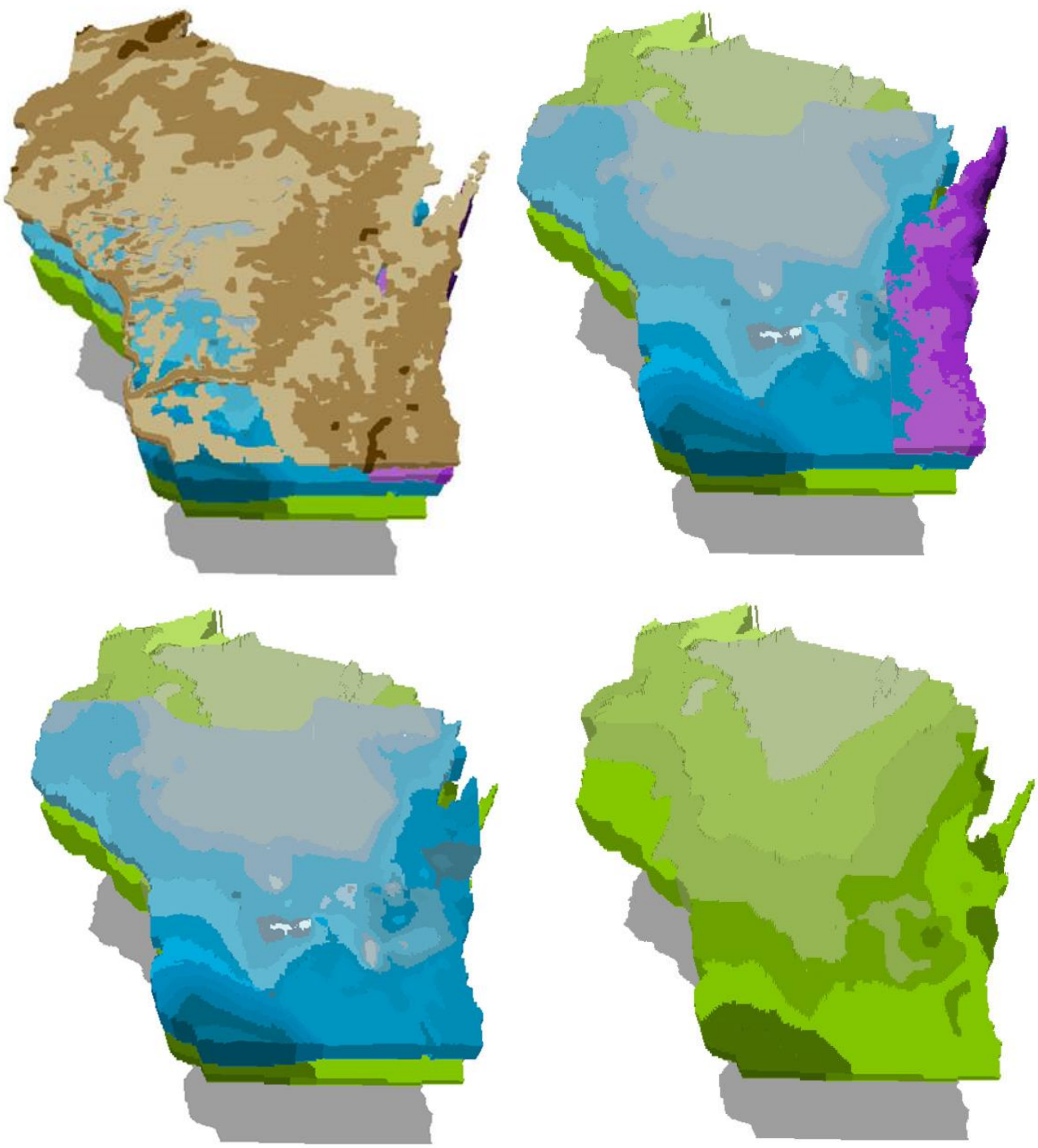


Figure 2: Wisconsin's Aquifers from Shallowest to Deepest (darker shades of each color represent thicker deposits)

Brown: Sand and Gravel Purple: Eastern Dolomite Blue: Sandstone Green: Crystalline Bedrock

Source: Wisconsin Geological and Natural History Survey

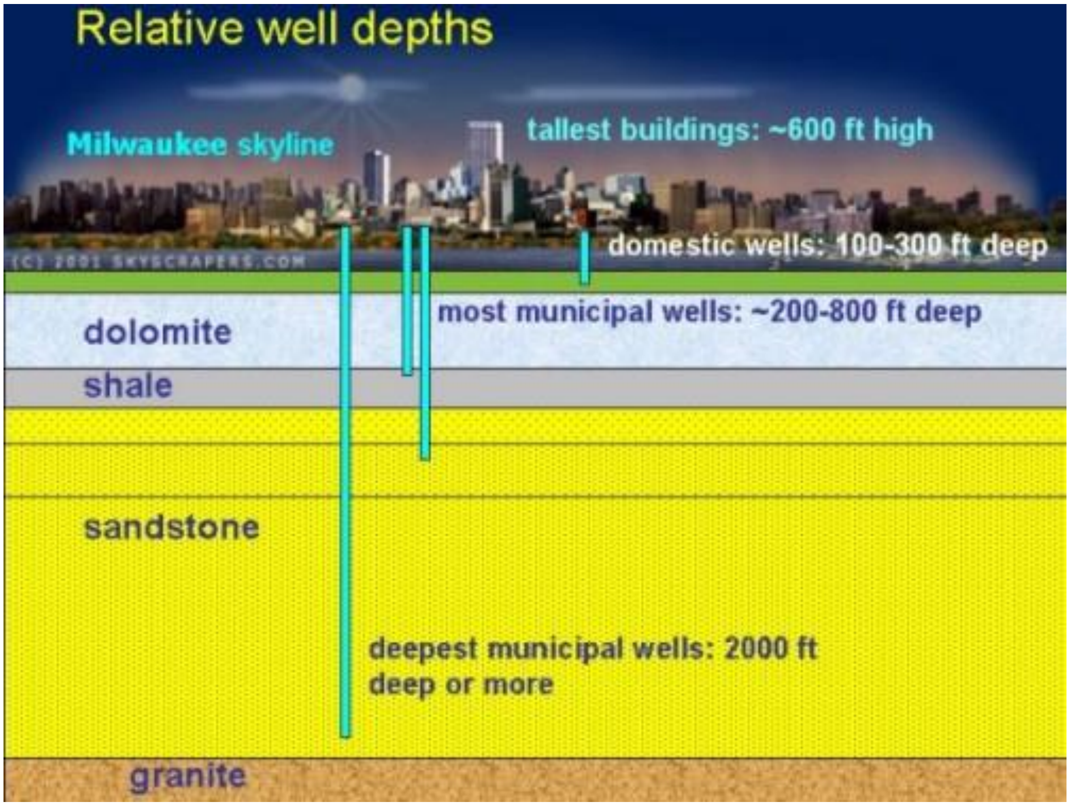


Figure 3: Schematic Cross Section of Relation Well Depths to Rock Units in Southeastern Wisconsin

Source: K.R. Bradbury, Wisconsin Geological and Natural History Survey

Groundwater Availability

The total use of surface and ground water has been relatively stable in Southeastern Wisconsin (Lawrence and Ellefson, 1982; Ellefson and others, 1987; 1993; 1997). However, there has been an increase in groundwater usage, primarily due to population growth in suburban and rural subdivisions that depend on wells for water supply (SEWRPC & WGNHS, 2002).

Recharge into the groundwater system is almost entirely from precipitation, in the form of rain or snow that infiltrates the land surface downward towards the water table. On average, precipitation brings 32 inches of water to the land surface of Southeastern Wisconsin, however, *approximately 80 percent of that is lost by evapotranspiration* (Cotter et al, 1969). The amount of recharge entering the groundwater system is not uniform and can vary substantially over space and time. Spatial variation is due to differences in surface topography, soil type, and land use while temporal changes are due to annual climatic variability (SEWRPC & WGNHS, 2008). Climate affects recharge in that recharge typically increases with an increase in precipitation, in addition to the intensity and timing of precipitation as well as the temperature (SEWRPC & WGNHS, 2008). Some groundwater recharge models suggest a higher correlation between groundwater recharge and temporal controls (i.e. timing of precipitation and snowmelt) (Dripps et al, 2006).

Groundwater monitoring data typically exhibits isolated, seasonal recharge events, characteristically in the late spring (May-June) due to the spring rains and melting snow.

Pesticide Application Trends

The EPA reports on the U.S. pesticide industry's expenditures and sales reports on an annual basis. Figure 4 shows total U.S. expenditures by pesticide type and market sector from 2005 to 2012. Within the agricultural sector, herbicides accounted for over 50 percent of the total market in 2009 and 2012. In the industrial/commercial/government, insecticides accounted for 50 percent of the market in 2009 and 2012, while insecticides in the home and garden sector accounted for approximately 80 percent of the total market in 2009 and 2012 (Atwood & Paisley-Jones, 2017). Figure 5 summarizes the total user expenditures on conventional pesticides in the U.S. by market sector (Atwood & Paisley-Jones, 2017) (Appendix D).

In Wisconsin, the main source of pesticides in groundwater is agricultural herbicides and insecticides (WGCC,2016). Current research and monitoring programs have been primarily focusing on the use of agricultural pesticides and assessing groundwater quality in agricultural areas while limited information is available on the occurrence and effects residential pesticides on local groundwater quality. Table 1 shows the most commonly used pesticide active ingredients from the home and garden sector as of 2012 from the EPA market estimates report (Atwood & Paisley-Jones, 2017). Although several pesticides (e.g. 2,4-D, dicamba, malathion) have been used for both residential and agricultural purposes, due to their different end-use purposes, their doses can be relatively different. Thus, their determination in groundwater within agricultural areas does not reflect the risk of residential pesticide groundwater contamination in (sub)urban areas.

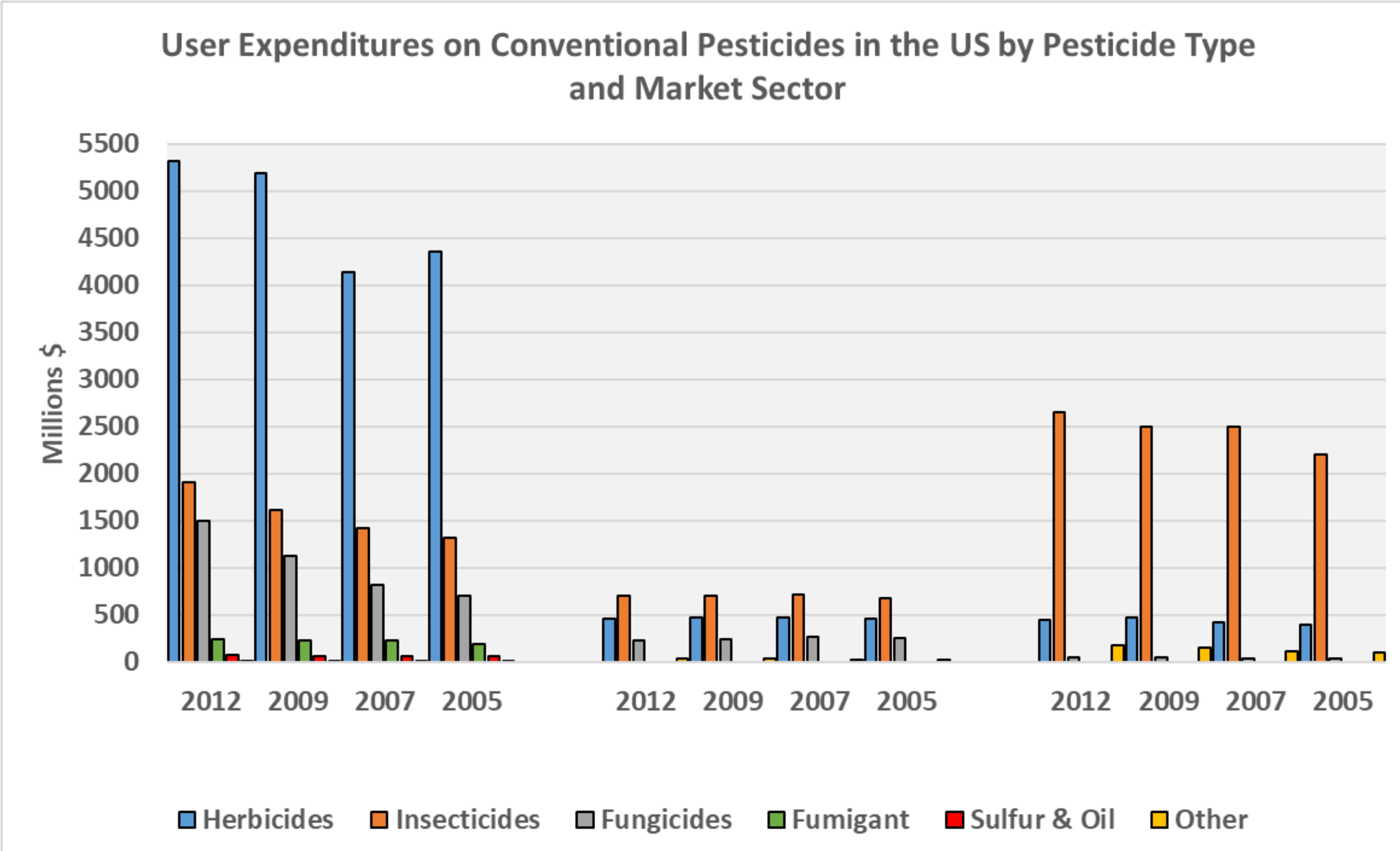


Figure 4: User Expenditures on Conventional Pesticides in the U.S. by Pesticide Type and Market Sector

Sources: Agricultural Market Research Proprietary Data (2005-2012)
Non-Agricultural Market Research Proprietary Data (2005-2012)
USDA/NASS Quick Stats

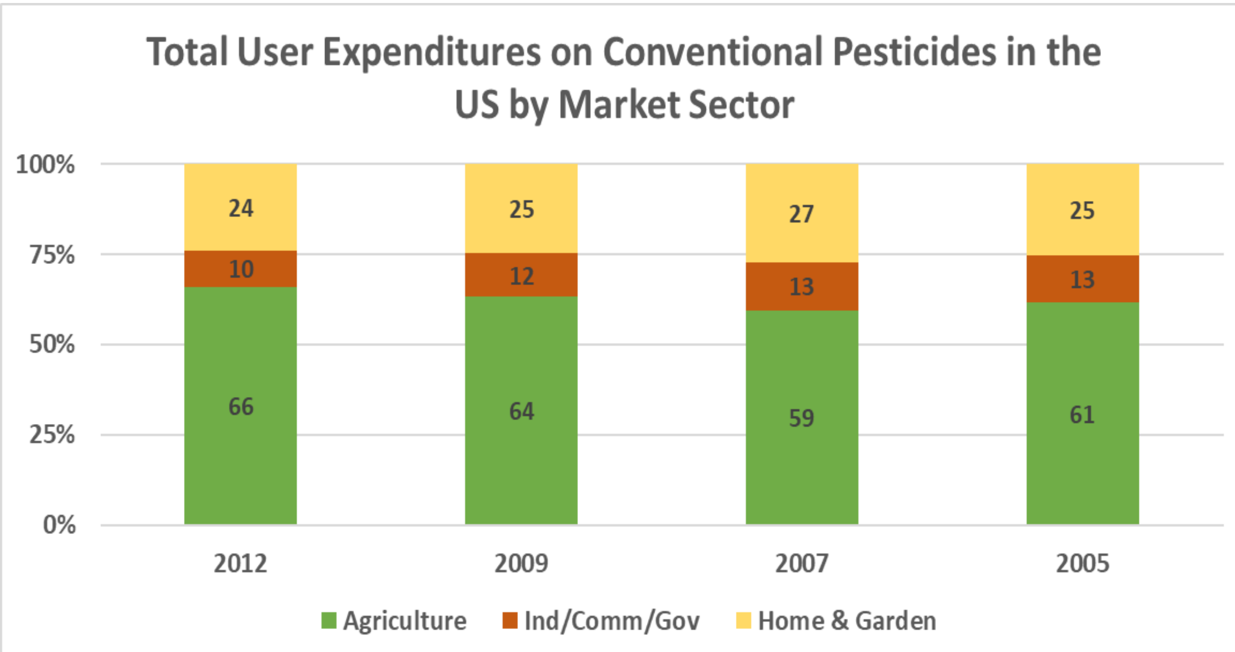


Figure 5: Total User Expenditures on Conventional Pesticides in the U.S. by Market Sector

Sources: Agricultural Market Research Proprietary Data (2005-2012)
Non-Agricultural Market Research Proprietary Data (2005-2012)
USDA/NASS Quick Stats

Active Ingredient	Type	Rank 2012	Rank 2009
2,4-D	H	1	1
Glyphosate	H	2	2
MCPP	H	3	4
Pendimethalin	H	4	5
Carbaryl	I	5	3
Acephate	I	6	10
Permethrin and other Pyrethroids	I	7	6
Dicamba	H	8	7
MCPA	H	9	-
Malathion	I	10	6

Table 1: Most Commonly Used Pesticide Active Ingredients from the Home and Garden Sector

*Note: H = Herbicide; I = Insecticide; a dash (-) means no estimate available

Sources: Non-Agricultural Market Research Proprietary Data (2012 and 2009)
USDA/NASS Quick Stats

3. OBJECTIVE

Hypothesis

A majority of Wisconsin homeowners use a professional lawn care company or apply pesticides themselves to their lawns to rid of various pests. Current monitoring programs in Wisconsin have been focusing their efforts on pesticide application in agricultural areas and lack information on the occurrence and subsequent effects of residential pesticides on local groundwater quality. In order to fill this knowledge gap, the focus of this study will be on active, shallow, transient non-community wells in (sub)urban locations.

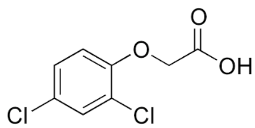
The wells would be away from agricultural fields, within more densely populated, well-kept, suburban locations, and reside in the sand and gravel aquifer or the slightly deeper dolomite aquifer. Targeting wells away from agricultural fields would ensure that the water sample was representative of residential pesticide application, focusing on populated, well-kept, suburban neighborhoods to have the greatest likelihood of application and frequency of application. The higher permeability of the sand and gravel aquifer increases the overall vertical permeability of the glacial material above the water table (SEWRPC & WGNHS, 2002), and therefore would increase the likelihood of pesticide downward leaching. The dolomite aquifer is often hydraulically connected to the sand and gravel aquifer. Although groundwater flow in the dolomite aquifer is still heavily dominated by fracturing, some studies have also shown that several areas within the dolomite aquifer have behaved as a porous medium and generally control the local-scale bulk hydraulic conductivity (Rovey & Cherkauer, 1994a, b).

In the selection of the sampling wells, efforts were made to exclude wells that are either along lake shorelines and/or had thick clay or hardpan layers. Clayey deposits are the least permeable deposits and can hinder local, downward leaching. Wells along lake shorelines likely draw more water from the lake and would more so reflect the lake water chemistry.

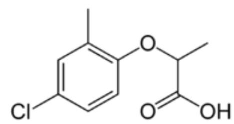
We hypothesized that the wells located within criteria previously listed would be subjected to residential pesticide leaching and local groundwater contamination.

Pesticide Selection

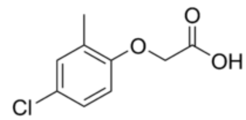
Among the 30 most popular residential pesticides from EPA sales and market data, this project analyzed seven commonly used home and garden pesticide active ingredients that include: 2,4−Dichlorophenoxyacetic Acid (2,4-D), carbaryl, dicamba, imidacloprid, malathion, 2-methyl-4-chlorophenoxyacetic acid (MCPA), and methylchlorophenoxypropionic acid (MCPP) (Figure 6). These chemicals were selected because of their high-end usage, high water solubility, moderate to low soil organic carbon-water partitioning coefficients (K_{OC}), and relatively long half-life (Table 2) (PAN, 2019). Each of these pesticides has been previously observed in groundwater sources across the globe, especially in shallow groundwater (Howard, 1991; Hill et al., 1996; Buss et al., 2006; Börjesson et al., 2004; Gilliom, 2007; Newhart, 2006; Bonmatin et al., 2015). It is worth mentioning that the soil sorption characteristic constants for each of the pesticides may vary based on different references, soil properties, and environmental matrices. Therefore, reported values may not fully reflect the affinity between a given pesticide and soil (Ahmed and Rahman, 2009), and a case-by-case investigation is required to determine the pesticide leaching potential to local groundwater sources.



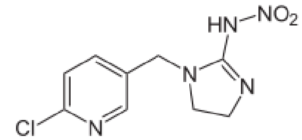
2,4-D



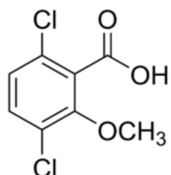
MCPP



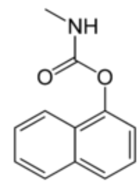
MCPA



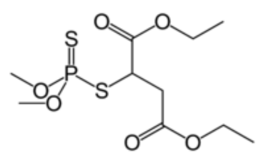
imidacloprid



dicamba



carbaryl



malathion

Figure 6: Home and Garden Pesticides Monitored for this Project

Pesticide	Avg. Water Solubility (mg/L)	K_{OC} (L/kg)	Avg. Hydrolysis Half-Life ($t_{1/2}$, d)	Avg. Aerobic Soil $t_{1/2}$ (d)	Avg. Anaerobic Soil $t_{1/2}$ (d)
2,4-D	27,600	46	39	34	333
Dicamba	27,200	5	30	10	88
MCPA	29,390	74	N.A.	15	N.A.
MCPP	734	26	31	13	541
Carbaryl	116	375	12	6	87
Malathion	125	291	6	3	30
Imidacloprid	514	262	30	997	27

Table 2: Physical Property Data for Pesticides in this Project

All values are cited from PAN Pesticide Database at http://www.pesticideinfo.org/

4. METHODOLOGY

Collecting Well Information

The Wisconsin DNR's provides multiple Well Inventory search engines by inputting criteria such as WI Unique Well Numbers, County, Well Use, Well Status, etc. Searching active, non-transient non-community wells within each county queried a table of the unique well numbers and well depth. With the help of Google Maps and trial and error, each address on the well construction report was searched for its comparative suburban location as well as its geologic significance.

A formal letter was sent to over 70 home owners in ideal or close to ideal locations for approval, in hopes that at least 15 would respond. Inaccurate address inputs on well construction reports proved to be more of an issue than initially intended, as several of them were sent back. In the end, ten homeowners participated. A few of them knew other interested homeowners and resulted in 16 initial sampling locations among Milwaukee, Ozaukee, Washington, and Waukesha County (Table 3). See Figure 8 for a Google Earth map image of the locations.

County	Sample ID
Ozaukee	1
	2
	3
	4
Washington	5
	6
	7
	8
	9
	10
Milwaukee	11
	12
Waukesha	13
	14
	15
	16

Table 3: Sample Well ID by Wisconsin County

A survey was sent for each of the homeowners concerning the pesticide products used, or the company hired, and the temporal application throughout the year (Appendix E).

Well Sample Collection

Groundwater samples were collected and handled following the protocols addressed in the DATCP survey (DATCP, 2017) and returned to our analytical lab. They were further prepared under standard EPA and USGS methods.

Each of the samples were chosen based primarily as a function of the location within a well-kept neighborhood in the sand and gravel or dolomite aquifer. All locations except for Well 2, 4, and 8 are less than or equal to a depth of 100 feet. All of the locations, but Well 7 and 15 accredited applying pesticides/insecticides/herbicides to their lawn multiple times a season either personally or through a company. With this in mind, there could be some level of detection for the deeper wells.

Samples were collected from the spigot right before the water pump within each of the homeowner's basements into two 1-liter amber glass bottles. As extra precaution, each bottle was wrapped in tin foil, and transported for further testing in a cooler.

Basic Water Chemistry Data

Initial temperature, pH, conductivity, pressure, and ORP measurements was taken with a YSI probe. Titration calculations with a Hach Manual-Digital Titrator (Model 16900) along with Iron (II) and Total Iron measurements with a Hach Multiparameter Portable Colorimeter were also taken at the time of collection, and then transported to the School of Freshwater Sciences to be prepped for major ion analysis. Titrations were done by taking 20ml of the well sample and titrating with 1.6 N sulfuric acid cartridge. The conversions for the Hach Manual-Digital Titrator were found by downloading Method 10244 from DOC316.53.01308, Table 1 on page 4. On the Hach Multiparameter Portable Colorimeter, ferrous iron was programed by Method 8146 from DOC316.53.01049 and total iron was programmed by Method 8008 from DOC316.53.01053.

Roughly 30-40 mL of the well sample was filtered through 0.22 µm filter into a 50mL polypropylene centrifuge test tube with the addition of 100 µL of nitric acid to ensure a pH below 2 for major cation analysis using Thermo Scientific Flame Atomic Absorption Spectrometer (AAS) iCE 3000 Series. An additional 20-30 mL of the well sample was filtered through 0.22 µm filter into a 50mL polypropylene centrifuge test tube for the major ion analysis through the ion chromatography (IC) equipped with a conductivity detector (Dionex ICS-1000).

The major cations analyzed are calcium, magnesium, potassium, and sodium. Dilutions of each are based off previous tests conducted on Waukesha wells: Ca 1:50, Mg 1:50, K 1:10, and Na 1:100. The major anions analyzed are chloride, nitrate, phosphate, and sulfate.

See Appendix F for Basic Water Chemistry Data by Well.

Pesticide Detection Data

All samples were tested at the University of Wisconsin Milwaukee (UWM) Kenwood Interdisciplinary Research Center (IRC) using the Shimadzu Triple Quadrupole Liquid Chromatography - Mass Spectrometry (LCMS) 8040. Samples were prepped for the Shimadzu Triple Quad LCMS-8040 by liquid-liquid separation with two organic solvents: Dichloromethane (DCM) and Diethyl Ether. DCM was used for positive ion analysis for carbaryl, imidacloprid, and malathion. Diethyl Ether was used for negative ionization analysis for 2,4-D, dicamba, MCPA, and MCPP. All samples are filtered first through Whatman GF/B (1 µm) filter.

For positive ionization analysis, 250 mL of the sample was measured out and adjusted to a pH between 5.5 and 6 before pouring into a separatory funnel. The equipment used for filtering and measuring the sample was washed with 10 mL each of DCM and added to the separatory funnel. An additional 30 mL of DCM (total of 50 mL) was added into the funnel. Then, the funnel was hand-shook for two minutes and left to settle for ten minutes before transferring the organic layer into a 600 mL nitrogen evaporation flask. Another 30 mL of DCM is added to the funnel and this process repeats for a total of three times. After the third organic layer transfer, the aqueous layer is drained into a waste container. The separatory funnel was washed again with 20 mL of DCM, which is also transferred to the nitrogen evaporation flask.

For negative ionization analysis, 250 mL of the sample was measured out and poured into a separatory funnel. An addition of 3mL of 12N sulfuric acid is added to the sample. The equipment used for filtering and measuring the sample was washed with 10 mL each of diethyl ether and added to the separatory funnel. An additional 30 mL of diethyl ether (total of 50 mL) was added into the funnel. Then, the funnel was hand-shook for two minutes and left to settle for ten minutes before transferring the organic layer into a 600 mL nitrogen evaporation flask. Another 30 mL of diethyl ether is added to the funnel and this process repeats for a total of three times. After the third organic layer transfer, the aqueous layer is drained into a waste container. The separatory funnel was once more with 20 mL of diethyl ether, which is also transferred to the nitrogen evaporation flask.

All samples were placed into a nitrogen evaporation system for roughly 20-30 minutes. Once the solvent was fully evaporated an additional 20 mL of the corresponding organic solvent was added into the 600 mL nitrogen evaporation flask and then transferred into a nitrogen evaporation vial. Each sample was then evaporated to complete dryness. 100 µL of ACN is added to each vial, swirled for 30-45 seconds, and left to settle for 2-3 minutes. 900 µL of ultra-distilled water (type 1 water) is added to each vial, swirled for 30-45 seconds, and left to settle for 2-3 minutes. Lastly, the sample is transferred to an analytical vial for the Shimadzu Triple Quad LCMS-8040.

As shown in Figure 7, the obtained calibration curves indicate acceptable linearity, with R^2 values greater than 0.99, which would be used for the target pesticide detection in real groundwater samples.

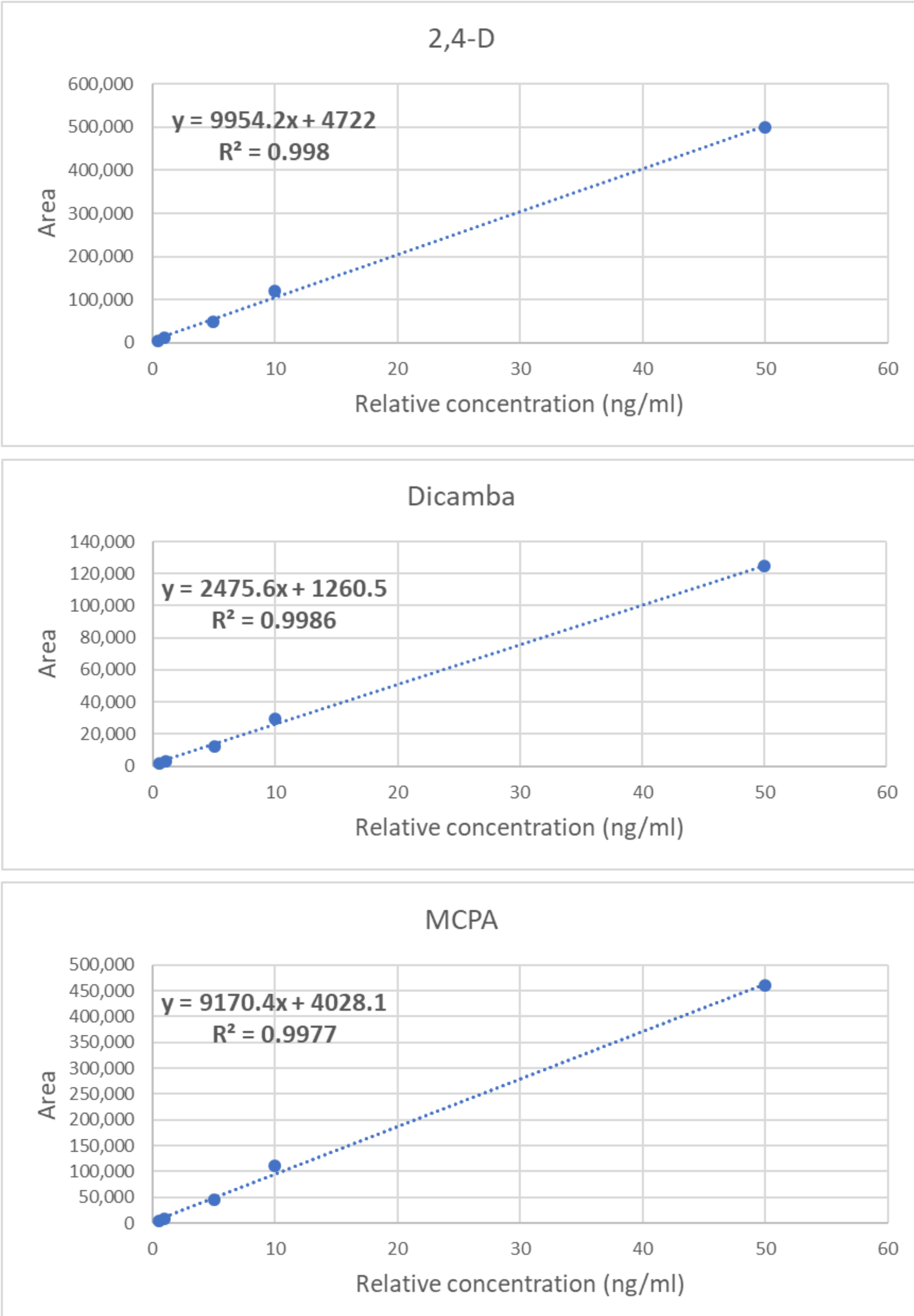


Figure 7: Calibration Curves for Target Pesticide Detection

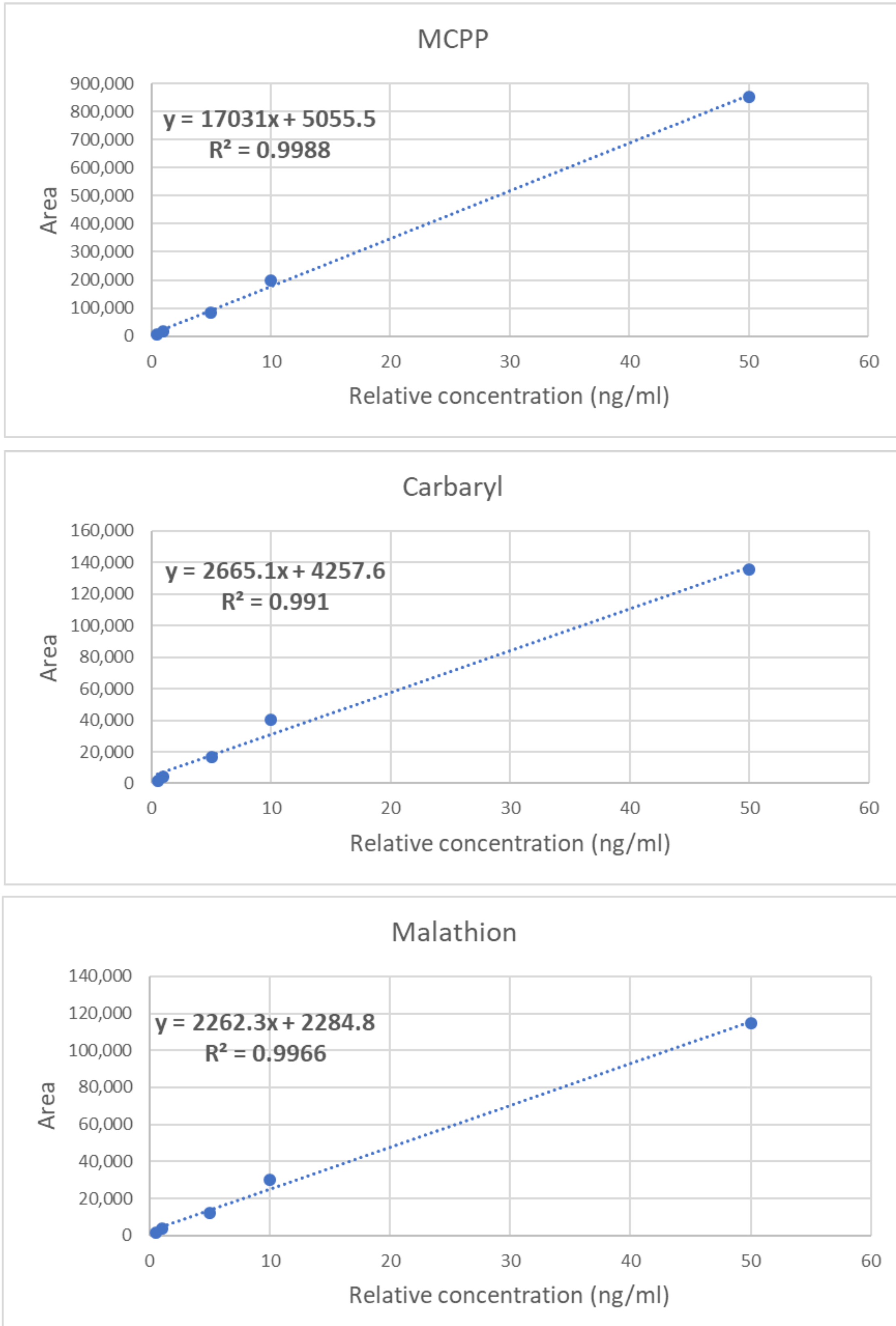


Figure 7 (cont.): Calibration Curves for Target Pesticide Detection

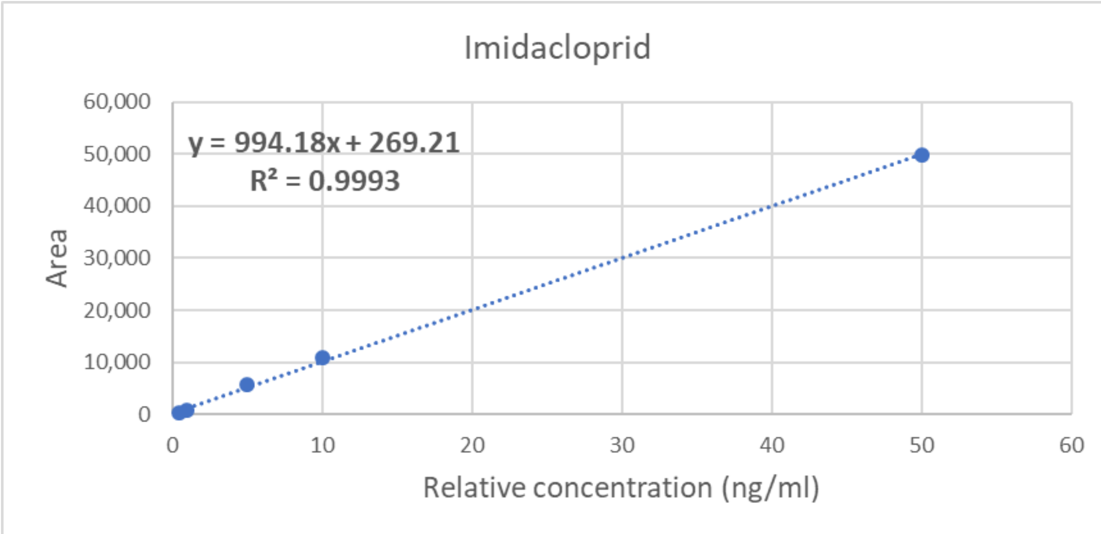


Figure 7 (cont.): Calibration Curves for Target Pesticide Detection

5. RESULTS AND DISCUSSION

Selected Wells

A total of 16 wells were sampled for pesticides from June 2019 to February 2020 over four sampling events: thirteen participated in the first round (June-July), up to sixteen by the second sampling event (August), and down to eleven for the third and fourth event (November and February). The eleven selected wells in the third and fourth sampling event were the wells that showed previous pesticide detection or were in ideal suburb locations that better highlighted the focus of this study. Not all could be tested due to budget constraints. Wells 1, 4, 6, and 16 were not tested after the second sampling event in August. Figure 8 shows a Google Earth Image of the sample locations by the given Well ID. The well logs for each of these locations by county is shown in Figure 9a-d.

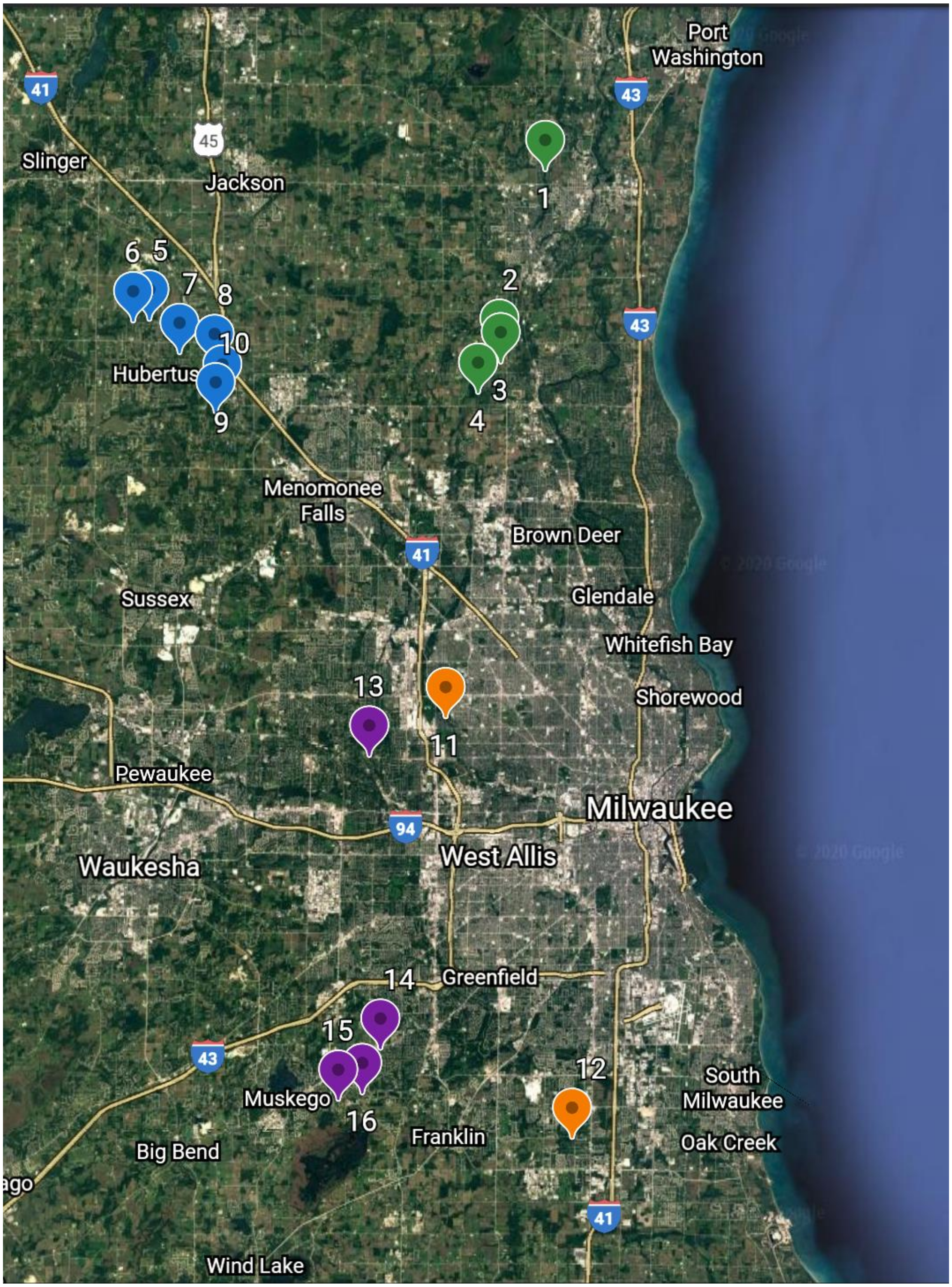


Figure 8: Google Earth of Sample Well Locations

Blue: Washington County Green: Ozaukee County
Purple: Waukesha County Orange: Milwaukee County

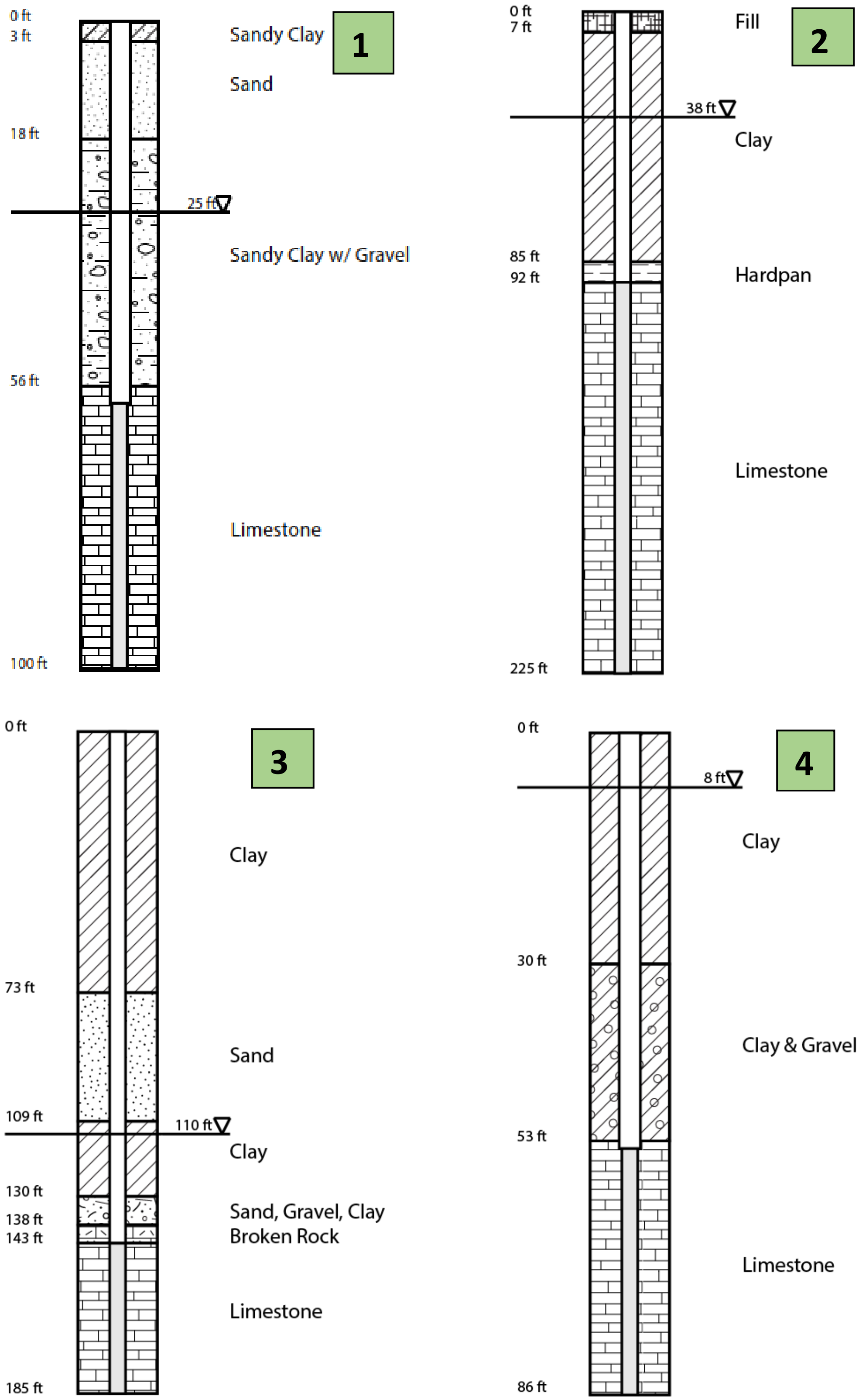


Figure 9a: Well Logs for Ozaukee County. Well ID 1, 2, 3, 4. Depicted in Green in Figure 7.

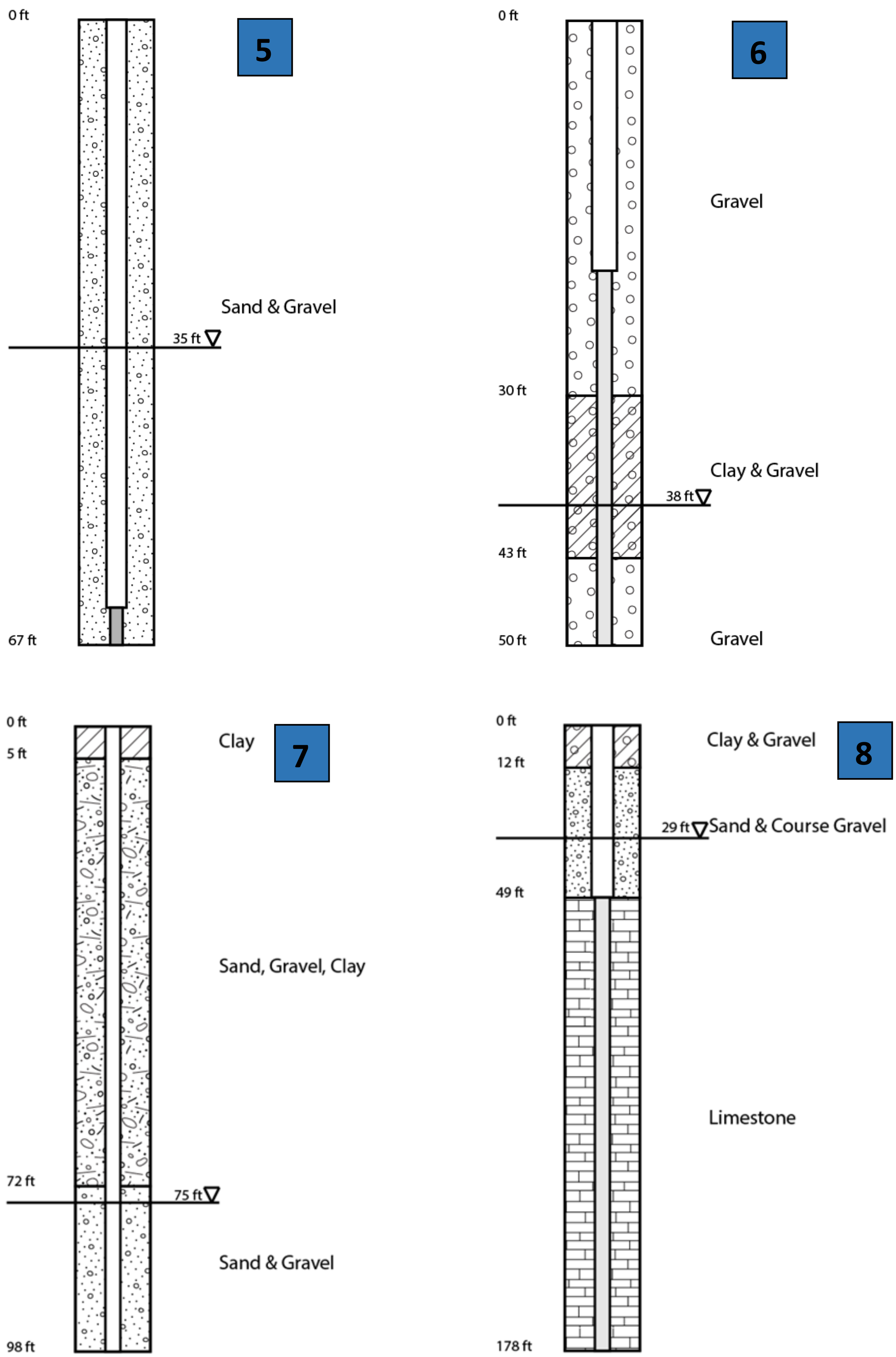


Figure 9b-1: Well Logs for Washington County. Well ID 5, 6, 7, 8. Depicted in Blue in Figure 7.

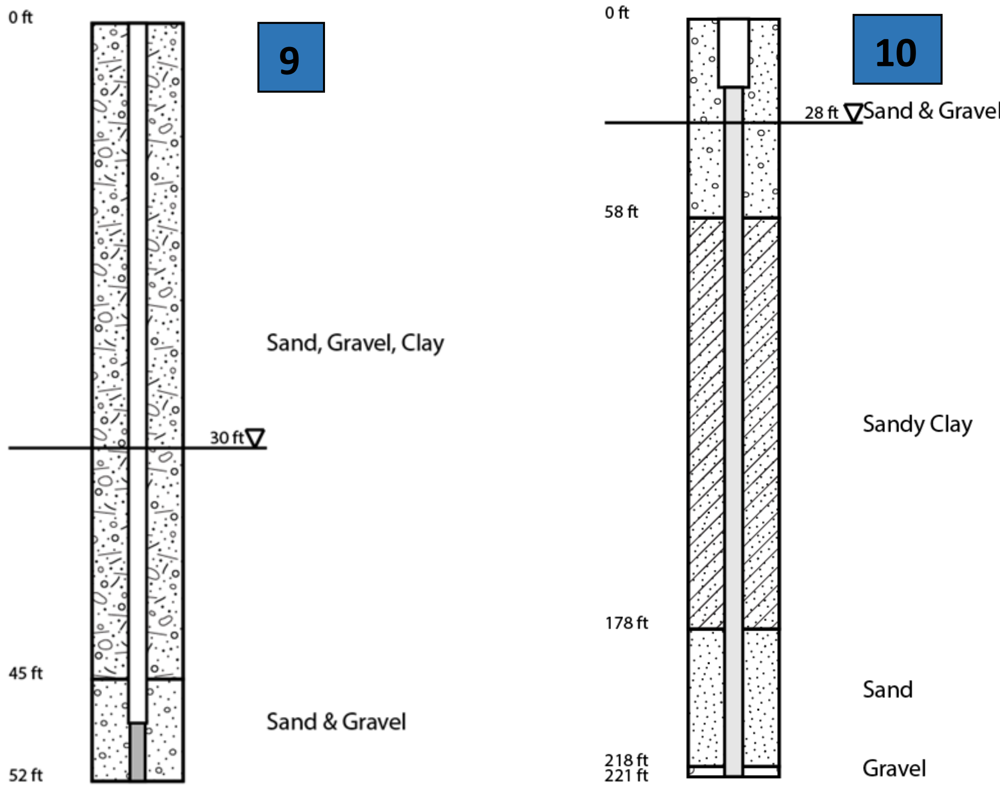


Figure 9b-2: Well Logs for Washington County. Well ID 9, 10. Depicted in Blue in Figure 7.

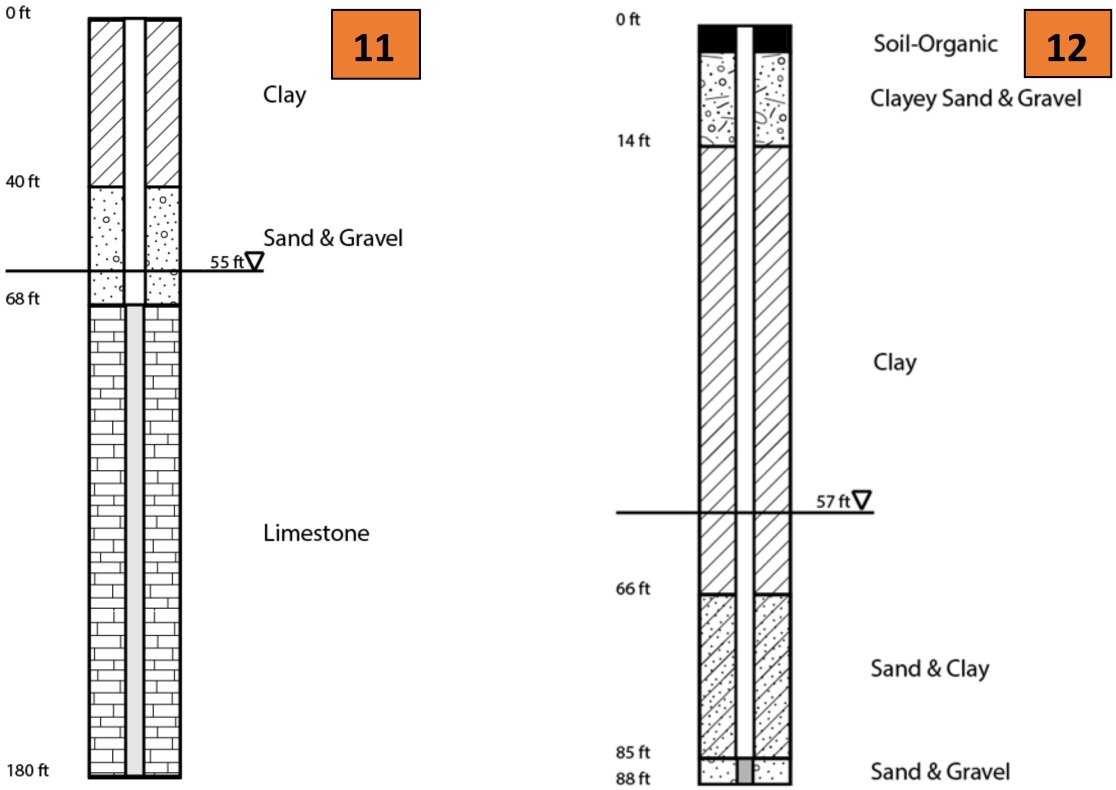


Figure 9c: Well Logs for Milwaukee County. Well ID 11, 12. Depicted in Orange in Figure 7.

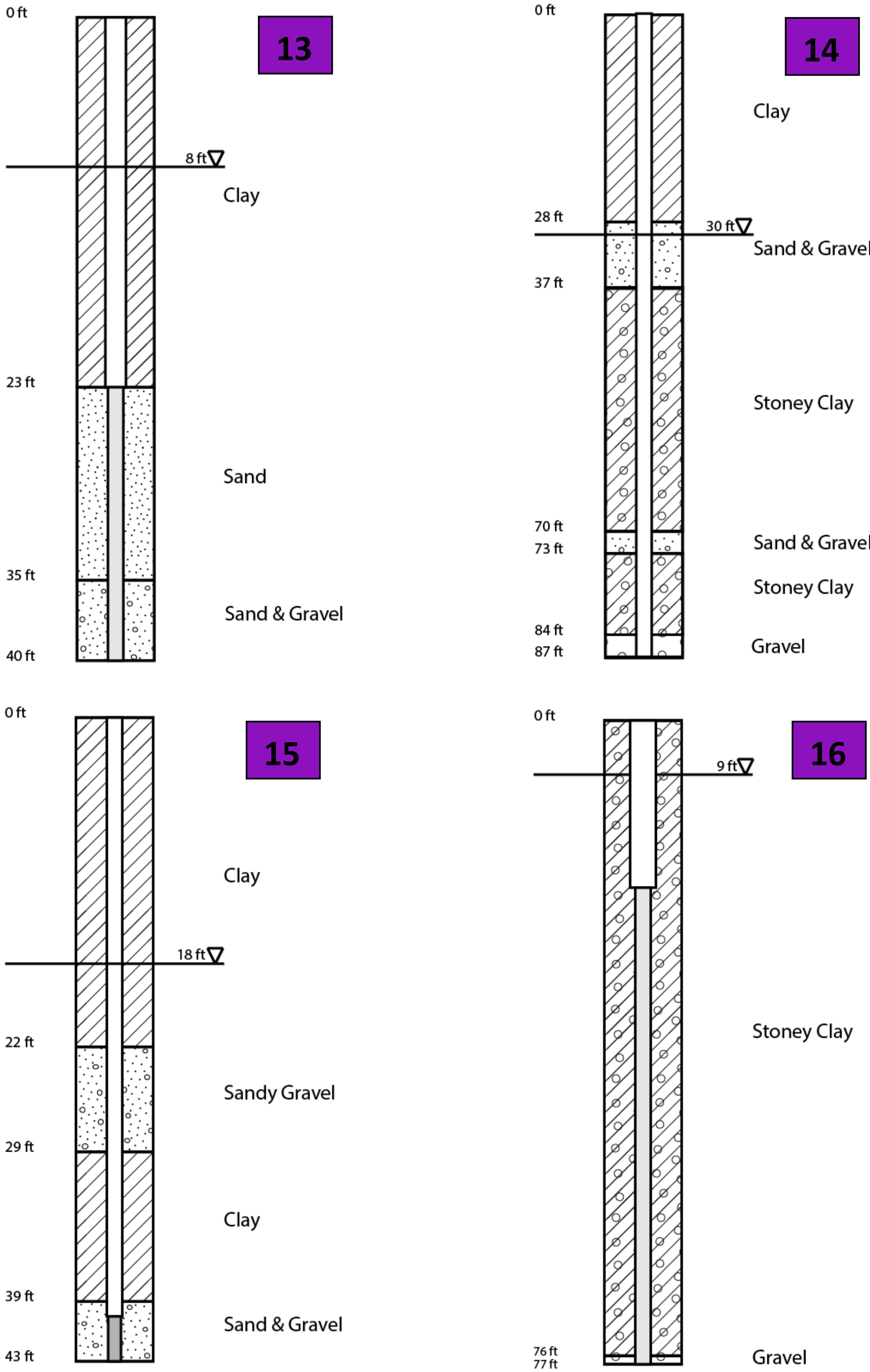


Figure 9d: Well Logs for Waukesha County. Well ID 13, 14, 15, 16 Depicted in Purple in Figure 7.

Water Standards and Health Criteria

Wisconsin only has a groundwater quality health-based enforcement standard (ES) for 30 pesticides (WI NR 140.10), with even less having a maximum contaminant level (MCL) (WI NR 809.20) regulated in drinking water systems (WGCC, 2018) (Table 4). Pesticides that do not have groundwater quality ES or public drinking water MCL have been detected in drinking water supplies and their health effects are inadequately understood (WGCC, 2018). Several studies have also pointed out that the coexistence of pesticide mixtures can produce augmented health effects because of their synergistic effects (Jaeger et al, 1999; Hayes et al, 2006).

	WI NR 140.10	WI DATCP Report 2017	WI NR 809.20
Compound	**Health-Based Enforcement Standard (ES)**	**Reporting Limit**	**Maximum Contaminant Level (MCL)**
	µg/L	**µg/L**	**mg/L**
2,4-D	70	0.05	~
Carbaryl	40	0.067	~
Dicamba	300	0.89	~
Imidacloprid	~	0.05	~
Malathion	~	0.05	~
MCPA	~	0.05	~
MCPP	~	0.055	~

~ = no data

Table 4: Wisconsin Groundwater Standards

The World Health Organization (WHO) reported on the **acute** toxicity of the pure chemical ingredient to distinguish between the hazardous nature of selected pesticides (Table 5) (2010). The WHO bases its ratings on the lowest lethal dose that kills 50 percent of the tested rats (Appendix H). The highest hazard ranking is classified as Ia Extremely Hazardous and the lowest is classified as III Slightly Hazardous. The pesticides in this research rank on the lower end of hazardous risk, however, a lack research has left them insufficiently understood, particularly for the health effects caused by long-term exposure.

Chemical Ingredient	WHO Acute Hazard Ranking
2,4-D	II, Moderately Hazardous
Carbaryl	II, Moderately Hazardous
Dicamba	III, Slightly Hazardous
Imidacloprid	II, Moderately Hazardous
Malathion	III, Slightly Hazardous
MCPA	III, Slightly Hazardous
MCPP	III, Slightly Hazardous

Table 5: WHO Acute Hazard Rankings by Pesticide

Local Water Elevation Data

The Village of Richfield, Wisconsin installed Wellntel system units in various wells throughout the village designed to create a groundwater measurement network in order to track the spatial distribution of seasonal water level trends (Cherkauer, 2013). Figure 10 and Figure 11 show data collected from two wells in the network. Figure 10 correlates to Well 10 in this study and shows data from January 1, 2017 to March 2, 2020. Figure 11 does not correlate to a groundwater well in this study, but is located approximately 0.06 miles from Well 5, 0.45 miles from Well 6, and 1.44 miles from Well 7. The data varies from year to year, with somewhat of a trend in groundwater recharge during the spring and a lack of infiltration during the summer months.

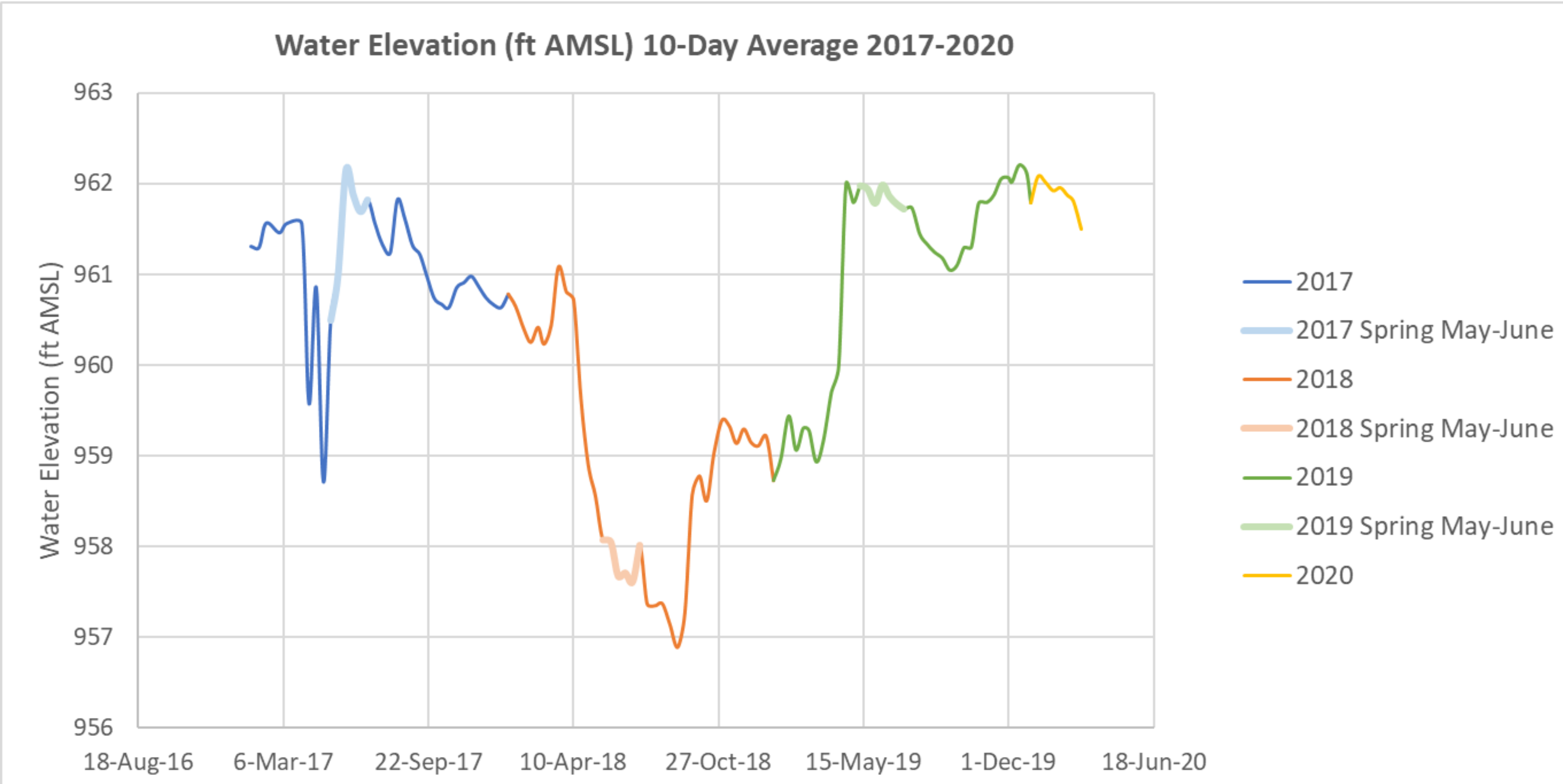


Figure 10: Water Elevation from Well 10 by WellIntel

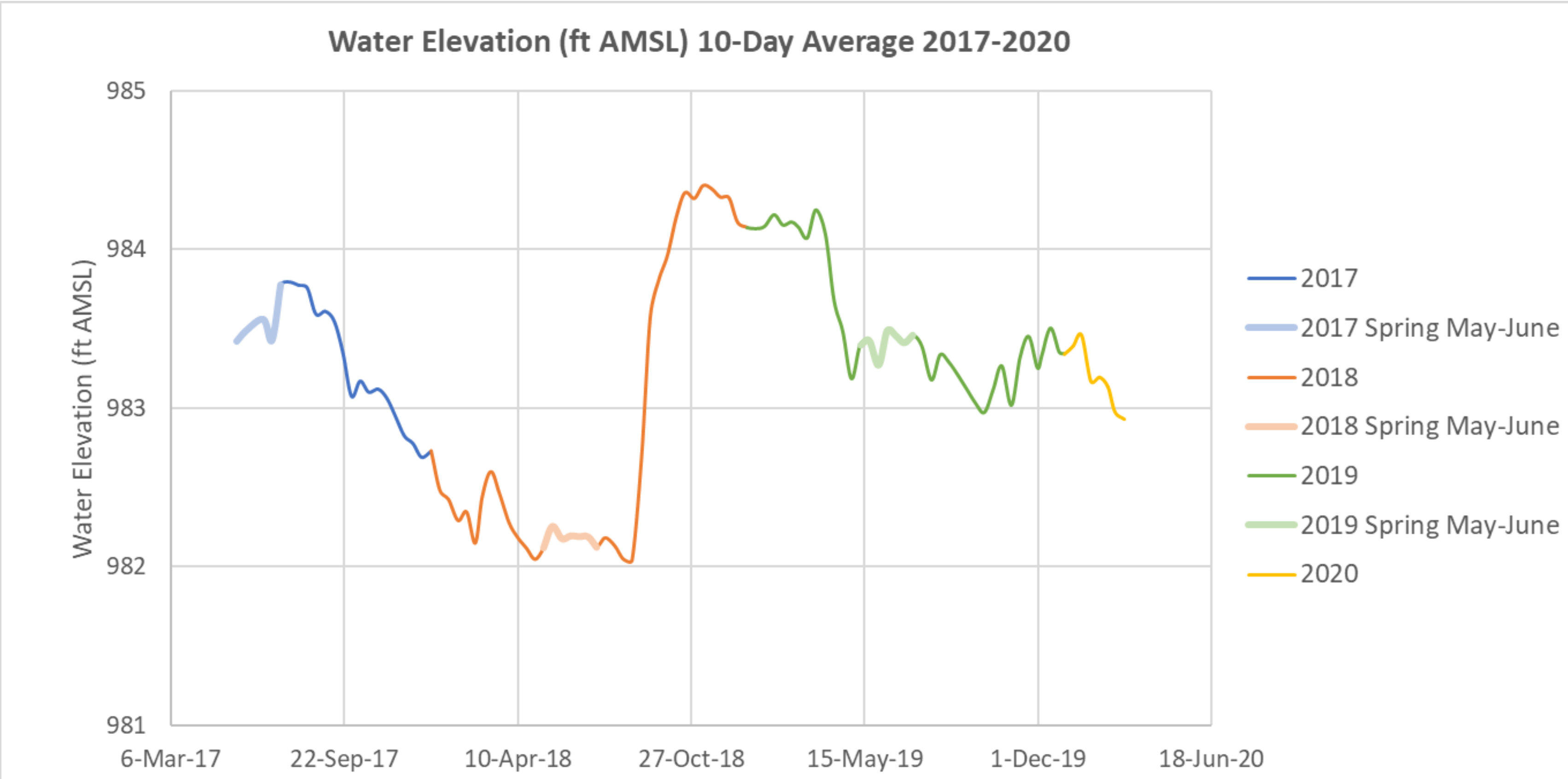


Figure 11: Water Elevation located near Well 5 by Wellntel System

$\delta\ ^{18}O$ and $\delta\ ^{2}H$ Isotope Data from Samples

Each groundwater sample collected was analyzed for oxygen and hydrogen isotopes with the Picarro Cavity Ring Down Spectroscopy (L2130-i) at UW-Milwaukee's School of Freshwater Sciences. The differences in isotopic compositions of groundwater and precipitation stem from the seasonal differences in the ratio of groundwater recharge as a proportion of precipitation (Jasechko et al, 2014). The local meteoric water line (LMWL) (Figure 12) was established for Madison, Wisconsin using precipitation samples between August 1998 and November 1999 (Swanson et al, 2006). The isotopic concentrations between the LMWL and the global meteoric water line (GMWL) contrast as a result of local climatic and geographic characteristics. Summer precipitation is isotopically heavier than winter precipitation values. The process of evaporation leaves waters to plot below the LMWL, which is demonstrated especially for the June and July samples in Figure 12 (Benettin et al, 2018). Figure 12 also illustrates that the summer groundwater is isotopically lighter than the early winter groundwater, showing that there is a lag in groundwater recharge from summer precipitation infiltration.

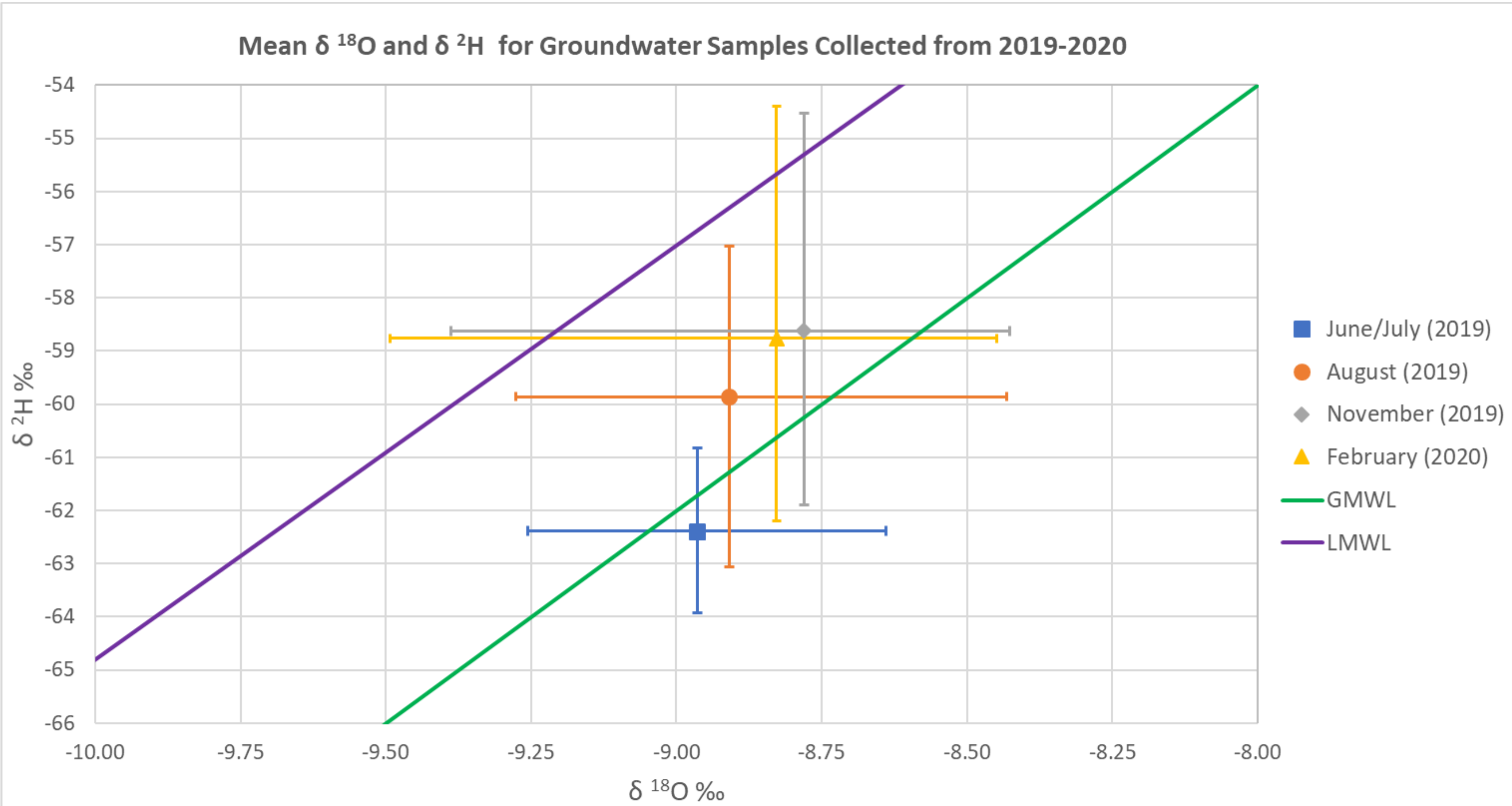


Figure 12: Mean Stable Oxygen and Hydroen Isotope Data from Groundwater Samples

Pesticide Detection Results

Round 1: June-July 2019

Well Study #	Sample Date	*Concentration of 1L Sample (ppb)*						
		MCPP	**MCPA**	**DICAMBA**	**2,4-D**	**Carbaryl**	**Imidacloprid**	**Malathion**
1	1-Jul	~	~	~	~	~	~	~
2	18-Jun	~	0.16	~	~	1.9312	~	~
3	24-Jun	~	~	~	~	~	~	~
4	12-Jun	~	~	~	~	~	~	~
5	11-Jun	~	~	2.1824	~	~	~	~
6	11-Jun	~	~	~	~	~	~	~
9	22-Jul	~	~	~	0.0256	~	~	~
11	23-Jul	~	~	~	~	~	~	~
12	3-Jul	~	~	~	0.0592	~	~	~
13	4-Jul	~	~	~	~	~	0.0432	0.27
14	19-Jun	~	~	~	~	~	~	~
15	19-Jun	~	~	~	0.008	~	~	~
16	12-Jun	~	~	~	~	~	~	~

Round 2: August-September 2019

Well Study #	Sample Date	*Concentration of 1L Sample (ppb)*						
		MCPP	**MCPA**	**DICAMBA**	**2,4-D**	**Carbaryl**	**Imidacloprid**	**Malathion**
1	21-Aug	~	~	~	~	~	~	~
2	10-Sep	~	~	~	~	~	~	~
3	16-Aug	~	~	~	~	~	~	~
4	23-Aug	~	~	~	~	~	~	~
5	28-Aug	~	~	~	~	~	~	~
6	19-Aug	~	~	~	~	~	~	~
7	30-Aug	~	~	~	~	~	~	~
8	28-Aug	~	~	~	~	~	~	~
9	28-Aug	0.0112	~	~	~	~	~	~
10	27-Aug	~	~	~	~	~	~	~
11	27-Aug	~	~	~	~	~	~	~
12	26-Aug	~	~	~	~	~	~	~
13	19-Aug	~	~	~	~	~	~	~
14	29-Aug	~	~	~	~	~	~	0.032
15	29-Aug	~	~	~	~	~	~	~
16	26-Aug	~	~	~	~	~	~	~

Round 3: November 2019

Well Study #	Sample Date	*Concentration of 1L Sample (ppb)*						
		MCPP	MCPA	DICAMBA	2,4-D	Carbaryl	Imidacloprid	Malathion
2	26-Nov	~	~	~	~	~	~	~
5	21-Nov	~	~	~	~	~	~	~
7	13-Nov	~	~	~	~	~	~	~
8	14-Nov	~	~	~	~	~	~	~
9	22-Nov	~	~	~	~	~	~	~
10	22-Nov	~	~	~	~	~	~	~
11	20-Nov	~	~	~	~	~	~	~
12	8-Nov	~	~	~	~	~	~	~
13	12-Nov	~	~	~	~	~	~	~
14	11-Nov	~	~	~	~	~	~	~
15	11-Nov	~	~	~	~	~	~	~

Round 4: February 2020

Well Study #	Sample Date	*Concentration of 1L Sample (ppb)*						
		MCPP	MCPA	DICAMBA	2,4-D	Carbaryl	Imidacloprid	Malathion
2	14-Feb	~	~	~	~	~	~	~
3	14-Feb	~	~	~	~	~	~	~
5	6-Feb	~	~	~	~	~	~	~
7	2-Feb	~	~	~	~	~	~	~
8	6-Feb	~	~	~	~	~	~	~
9	12-Feb	~	~	~	~	~	~	~
11	10-Feb	~	~	~	~	~	~	~
12	3-Feb	~	~	~	~	~	~	~
13	4-Feb	~	~	~	~	~	~	~
14	3-Feb	~	~	~	~	~	~	~
15	3-Feb	~	~	~	~	~	~	~

~	No Detection

Table 6: Pesticide Detection Results from the Shimadzu Triple Quad LCMS-8040 at UW- Milwaukee

Target Analytes		Instrument LOQ (ng/ml)	Method LOQ (ng/mL)
1	Carbaryl	8.1	0.032
2	Imidacloprid	7.4	0.030
3	Malathion	2.0	0.008
4	MCPA	0.3	0.001
5	MCPP	0.5	0.002
6	2,4-D	1.1	0.004
7	Dicamba	1.6	0.006

Table 6-a: Limit of Quantitation for Pesticide Detection from the Shimadzu Triple Quad LCMS-8040 at UW- Milwaukee

Pesticide detection only occurred within the first and second sampling events from June to August 2019, which takes place through Wisconsin's growing season (mid May to early October), and when pesticides are actively applied. There were no pesticides detected, at least above ppb levels, in the wells during the months of November and February. This is to be expected from the absence of lawn application during the non-growing season, as well as the environmentally short-lived soil sorption characteristics of the pesticides (Table 2). Somewhat higher concentrations of the pesticides were detected in the early summer months compared to late summer months. Lawn care companies commonly follow a five or six step application process, others as low as two to three step application process (Table 7). Typical, over-the-counter lawn care products also follow this multistep application process. Each application process consistently applies pesticides during the spring months to allow pre-emergent pesticide control to be effective throughout the growing season. Summer month applications are typically spot treatments.

Overall, 2,4-D was the most frequently detected, appearing the most in June and July. 2,4-D is ranked as the number one most commonly used pesticide active ingredient in the home and garden sector (Table 1) (Atwood & Paisley-Jones, 2017). 2,4-D is an herbicide used to eliminate a variety of grasses and broadleaf weeds (UC IPM, 2019). From the physical property data on Table 2, 2,4-D is very highly water soluble (27,600 mg/L) and has a low soil organic carbon-water partitioning coefficient (K_{OC}) (46 L/kg) (PAN, 2020). Wells 9, 12, and 15 detected concentrations under 0.0592 ppb, which is well under the Wisconsin health-based enforcement standard (ES) of 70 ppb (WI DNR, 2020). Wells 9, 12, and 15 have variable levels of clay content (Figure 9b-2, 9c, and 9d).

Dicamba was also detected in the first sampling event in June at Well 5 at 2.18 ppb, substantially below the Wisconsin health-based enforcement standard (ES) of 300 ppb. Dicamba is highly water soluble (27,200 mg/L) and has a very low K_{OC} (5 L/kg) (Table 2) (PAN, 2020). According to the EPA sales and market data, Dicamba ranks as the eighth most commonly used pesticide in the home and garden market sector (Table 1) (Atwood & Paisley-Jones, 2017). Dicamba is an herbicide commonly found in products targeting dandelions and poison oak (UC IPM, 2019).

Carbaryl was detected during mid-June at Well 2 (1.93 ppb) along with MCPA (0.16 ppb). Carbaryl's health-based ES is 40 ppb, considerably above the detection in Well 2 (WI DNR, 2020). MCPA does not have a health-based ES, but it does meet the WI DATCP reporting limit standard of 0.05 ppb (2017). Carbaryl is the least water soluble of the pesticides targeted in this research, nonetheless is still fairly soluble (116 mg/L) (Table 2) (PAN, 2020). It has the highest K_{OC} of the pesticides at 375 L/kg (Table 2) (PAN, 2020). Carbaryl is ranked the fifth most common pesticide in the home and garden sector (Table 1) (Atwood & Paisley-Jones, 2017). It is found in products that target a range of lawn insects and mites (UC IPM, 2019). MCPA is the ninth most common home and garden pesticide (Table 1) (Atwood & Paisley-Jones, 2017) and is frequently found in products designed to rid of dandelions and other general weed management products (UC IPM, 2019).

5-6 Step Application Program			
Step	**Season**	**Months**	**Process**
1	Spring	Mar/Apr	Crabgrass/Broadleaf Weed Control, Fertilizer
2	Spring	Apr/May	Broadleaf/Blanket Weed Control, Fertilizer
3	Summer	Jun/Jul	Spot Weed Control/ Insect Control Application, Slow Release Nitrogen
4	Summer	Jul/Aug	Spot Weed Control/ Insect Control Application, Fertilizer
5	Fall	Sept/Oct	Blanket Weed Control, Fertilizer
6	Fall	Oct/Nov	Winterization Fertilization

2-3 Step Application			
Step	**Season**	**Months**	**Process**
1	Spring	Mar-May	Pre-Emergent Crabgrass & Broadleaf Weed Control, Post-Emergent Broadleaf Control, Fertilization
2	Mid-Late Summer	Jul/Aug	Broadleaf Weed Control, Fertilizer
3	Fall	Sept-Oct	Low-Rate Fertilizer

Table 7: Common Multistep Weed Control and Fertilization Application Programs

Source: Naturescape® Lawn and Landscape Care
La Rosa Landscape Co, Inc.
GreenWorks LLC.
Sunburst Environmental Services Inc.

Imidacloprid and malathion were detected together at Well 13 during July. Imidacloprid was detected at 0.04 ppb. Imidacloprid does not have a health-based ES and the reporting limit for the WI DATCP is 0.05 ppb (WI DNR, 2020) (WI DATCP, 2017). Imidacloprid is quite water soluble (514 mg/L) and has a moderate K_{OC} (262 L/kg) (Table 2) (PAN, 2020). It did not rank in the top ten for the most common pesticides in the home and garden sector for the EPA market and sales report, but it is commonly used as the active ingredient designed to rid of common lawn insects and mites, as well as cockroaches, carpenter ants, and fleas (UC IPM, 2019). Malathion was detected at 0.27 ppb. It also does not have a health-based ES and a reporting limit for the WI DATCP at 0.05 ppb (WI DNR, 2020) (WI DATCP, 2017). It is water soluble (125 mg/L) and has a moderate K_{OC} (291 L/kg) (Table 2) (PAN, 2020). It is ranked as the tenth most common pesticide in the home and garden sector (Table 1) (Atwood & Paisley-Jones, 2017) and targets lawn insects and mosquitoes (UC IPM, 2019). Trace amounts of Malathion (0.03 ppb) were also detected in Well 14 during the month of August.

Well 9 also showed a 0.01 ppb detection of MCPP at the end of August. MCPP does not have a health-based ES and a reporting limit of 0.055 ppb (WI DNR, 2020) (WI DATCP, 2017). It ranks third most popular home and garden pesticide (Table 1) (Atwood & Paisley-Jones, 2017). MCPP is water soluble (734 mg/L) and has a low K_{OC} (26 L/kg) (Table 2) (PAN, 2020). MCPP is used in a variety of products targeting various lawn weed, such as clovers and dandelions (UC IPM, 2019).

One or More Pesticide Detection

Reference Appendix G for Complete Survey Results

Well 2 (Figure 9a) is drilled 225 feet down into the dolomite aquifer. It has a rather thick clay layer (78 feet) followed by a 7-foot hardpan layer. The homeowner's have lived there between seven to ten years and have hired a landscape company with a five-step application program for their lawn (Table 7). Carbaryl and MCPA were detected in the early summer which correlates to the spring and early summer weed and insect control application. The presence of a thick clay layer did not completely hinder downward pesticide leaching.

Well 5 (Figure 9b-1) is drilled 67 feet down into the sand and gravel aquifer with no clay presumably present. The homeowner's have lived at this location for over ten years. They hire a lawn care company that has a six-step application program (Table 7) and apply their own spot treatment, mostly insecticides. Higher levels of dicamba were detected in June. This correlates to the spring and early summer pesticide application. The all sand and gravel pathway permit pesticide leaching.

Well 9 (Figure 9b-2) is 52 feet deep into the sand and gravel aquifer. The homeowner's have lived there between four and seven years and apply pesticides themselves. This includes a Stein's Garden and Home four-step lawn treatment, as well as multiple herbicides and insecticides. This well detected 2,4-D in July and MCPP in August. 2,4-D and MCPP are both active ingredients in Stein's Garden and Home four-step lawn treatment. Clay content varies within a sand and gravel layer; it does not hinder leaching potential.

Well 12 (Figure 9c) resides in the sand and gravel aquifer, 88 feet deep. Clay appears through most of the well with a clay-rich layer occupying 52 feet between to sandy layers. The homeowners have lived at this location for over 10 years and have hired multiple lawn care companies over the years. Each, however, each having a five-step application program throughout the growing season (Table 7). 2, 4-D was detected in early July and correlates with the heavy spring/early summer weed control application.

Well 13 (Figure 9d) is 40 feet into the sand and gravel aquifer with a rather significant clay layer taking up the first 23 feet. The homeowner's have lived at this location between seven and ten years and apply pesticides themselves. This includes various weed and grass killers, along with insecticides. Well 13 detected imidacloprid and malathion early July. This correlates to the time insecticides are frequently applied.

Well 14 (Figure 9d) is drilled 87 feet into the sand and gravel aquifer. Clay makes up the first 28 feet and is mixed into larger grained intervals. The homeowner's have lived here between one to three years and hire a lawn care company with a five-step application program (Table 7). Even with the presence of thick clay layers, malathion was detected in the groundwater at the end of August. This likely is due to an application right before the sample was taken.

Well 15 (Figure 9d) resides in the sand and gravel aquifer at a depth of 43 feet. Clay layers make up the first 22 feet as well as another 10 feet just above the bottom of the well. The home was under construction and subsequently unoccupied since the start of sample collection. The detection of 2,4-D at this well in June would likely be the result of neighboring application methods. Nonetheless, it correlates to the spring/early summer weed control application patterns.

Wells in the sand and gravel aquifer show the highest potential for pesticide leaching. Of the twelve wells that reside in the sand and gravel aquifer, six showed detectable pesticide levels. Of the four wells that reside in the dolomite aquifer, one resulted in pesticide detection. Table 8 shows the number of detections by well depth. The majority of the samples were between 50–150 foot range and had the greatest number of detections. Table 9 shows the number of wells with pesticide detection by the percent of clay content. Pesticide were detectable in wells that varied from 0 to about 75 percent clay content. Table 10 shows the means of application from the wells that had one or more pesticide detection. All but one had pesticide detections relating to their application. The unoccupied home had pesticide detection and can likely attribute this detection to any of the surrounding neighbors.

Well Depth (feet)	Number of Sample Locations	Number of Detections						
		MCPP	MCPA	Dicamba	2,4-D	Carbaryl	Imidacloprid	Malathion
Under 50	3				1		1	1
50-150	8	1		1	2			1
Over 150	5		1			1		

Table 8: Number of Detections by Well Depth

% Clay Content	Number of Wells with One or More Pesticide Detection
0-25	2
25-50	2
50-75	3

Table 9: Number of Wells with One or More Pesticide Detection by Percent Clay Content

Hire Professional Lawn Care Company	Self Application	Both	Neither
3	2	1	1

Table 10: Means of Pesticide Application from Wells with One or More Pesticide Detection

No Pesticide Detection

Reference Appendix G for Complete Survey Results

Well 1 (Figure 9a) is drilled 100 feet into the dolomite aquifer with clay mixed into sandy layers. The homeowners have lived at this location for over ten years and have hired two professional lawn care companies with five-step application programs, along with self-application. Due to a personal concern, the homeowners were not able to allow a sample collection after August.

Well 3 (Figure 9a) is drilled 185 feet into the dolomite aquifer. Clay makes up the first 73 feet, with another 29-foot clay layer before the well screen. The homeowners did not disclose any information in the survey. However, most home in the area hire a professional lawn care companies that have a five-step application program.

Well 4 (Figure 9a) is located 86 feet into the dolomite aquifer. A 30-foot clay layer caps a 23-foot clay and gravel layer and the dolomite/limestone aquifer. The homeowners have lived there for over ten years and have hired a professional lawn care company every year. They did not disclose which company but did confirm application processes happened three times a season.

Well 6 (Figure 9b-1) is drilled 50 feet into the sand and gravel aquifer. The well is mostly gravel, with a little bit of clay present in the middle. The homeowners have lived at this location between seven and ten years. From 2014-2018 they hired a professional lawn care company with a five-step application program. However, in 2019 they applied pesticides themselves.

Well 7 (Figure 9b-1) is drilled 98 feet into the sand and gravel aquifer with only a five-foot clay cap. The homeowners have lived there for seven years and have never applied pesticides to their lawn. It is important to note that this location was added late and did not have any groundwater samples tested in June or July.

Well 8 (Figure 9b-1) is located 178 feet into the dolomite aquifer with clay mixed into the top layers. There is no specific homeowner that resides here. The lawn is managed by a professional lawn care company that comes three times a season. This location was also added in August and was not tested in June or July.

Well 10 (Figure 9b-2) is drilled 221 feet into the sand and gravel aquifer with a sandy clay mixture making up 120 feet in the middle. The homeowners have lived at this location for over ten years. They apply pesticides themselves once a season but will call a professional animal control company as needed and not consecutively. This location was added late and missed the first round of sampling in the late spring/early summer.

Well 11 (Figure 9c) is 180 feet into the dolomite aquifer and is capped by 40 feet of clay. The homeowners have lived here over ten years and have hired two different professional lawn care companies over the years. In 2019, they made the switch from a company with a five-step application program to one with a two to three step application program. They also will apply pesticides themselves as needed.

Well 16 (Figure 9d) is drilled 77 feet into the sand and gravel aquifer. Almost the entire well is drilled through stony clay. The homeowners have lived at this location for more than ten years. They do not hire a lawn care company and self-apply three times a season.

Pesticides and Nitrate Detection

Each groundwater sample from each sampling event was tested for nitrate (as nitrate) (Appendix F) and the results are shown below in Table 11. The rate and amount of leaching of nitrate in groundwater can be linked to physical characteristics such as well depth and sediment structure. It is also linked to water quality characteristics that reflect biological and geochemical conditions, such that nitrate is stable in aerobic conditions (Burow et al., 1998). This table shows evidence to support in-situ degradation of pesticides in the aerobic conditions (Table 2) of the vadose zone, even if downward leaching is occurring (i.e. movement of nitrate).

It is important to note the source of nitrate contamination versus pesticide contamination. Pesticides are applied as single events, multiple times a season and therefore show up in groundwater in pulses. The detection of nitrate can be caused by excessive fertilizer application, but also improper manure management or leaking septic tanks, resulting in a more continual contamination source (Wick et al., 2012).

	Event 1		Event 2		Event 3		Event 4	
	Jun/Jul 2019	Pesticide Dectection	Aug 2019	Pesticide Dectection	Nov 2019	Pesticide Dectection	Feb 2020	Pesticide Dectection
Well	NO_3^- (mg/L)	yes/no	NO_3^- (mg/L)	yes/no	NO_3^- (mg/L)	yes/no	NO_3^- (mg/L)	yes/no
1	0.00	no	0.00	no	N.A.	N.A.	N.A.	N.A.
2	10.97	yes	15.14	no	14.69	no	15.01	no
3	0.00	no	0.00	no	N.A.	N.A.	0.00	no
4	0	no	0	no	N.A.	N.A.	N.A.	N.A.
5	11.23	yes	17.90	no	16.90	no	16.42	no
6	24.59	no	36.30	no	N.A.	N.A.	N.A.	N.A.
7	N.A.	N.A.	34.27	no	34.51	no	34.59	no
8	N.A.	N.A.	1.90	no	3.32	no	2.71	no
9	13.04	yes	14.58	yes	17.11	no	17.04	no
10	N.A.	N.A.	0	no	0	no	N.A.	N.A.
11	0.80	no	0.16	no	1.24	no	0.25	no
12	0	yes	0	no	0	no	0	no
13	0	no	0	no	0	no	0	no
14	0	no	0	yes	0	no	0	no
15	0	yes	0	no	0	no	0	no
16	0	no	0	no	N.A.	N.A.	N.A.	N.A.

1 or More Pesticides Detected

NO_3^- Detected, No Pesticides Detected

Table 11: Nitrate and Pesticide Detections for Groundwater Samples

6. CONCLUSION

There is no real correlation or trend between the hydrology, chemical properties, and/or application of chemicals to the wells in this study. However, even with the limited data set of this study, it is observed that groundwater is the most susceptible to pesticide contamination during the late spring and early summer months. This time frame is when homeowners and professional lawn care companies apply the most pesticides to lawns. Recharge into the local groundwater also typically takes place during the late spring and early summer. Continuing research and testing should make sure to take into account this seasonal variability. All of the pesticides detected showed results in parts per billion (ppb) and did not exceed any known health standards. Although the severity and frequency of detection does not compare to those done in an agricultural setting, testing for residential pesticides should continue to be monitored for historical trends and potential health-based implications.

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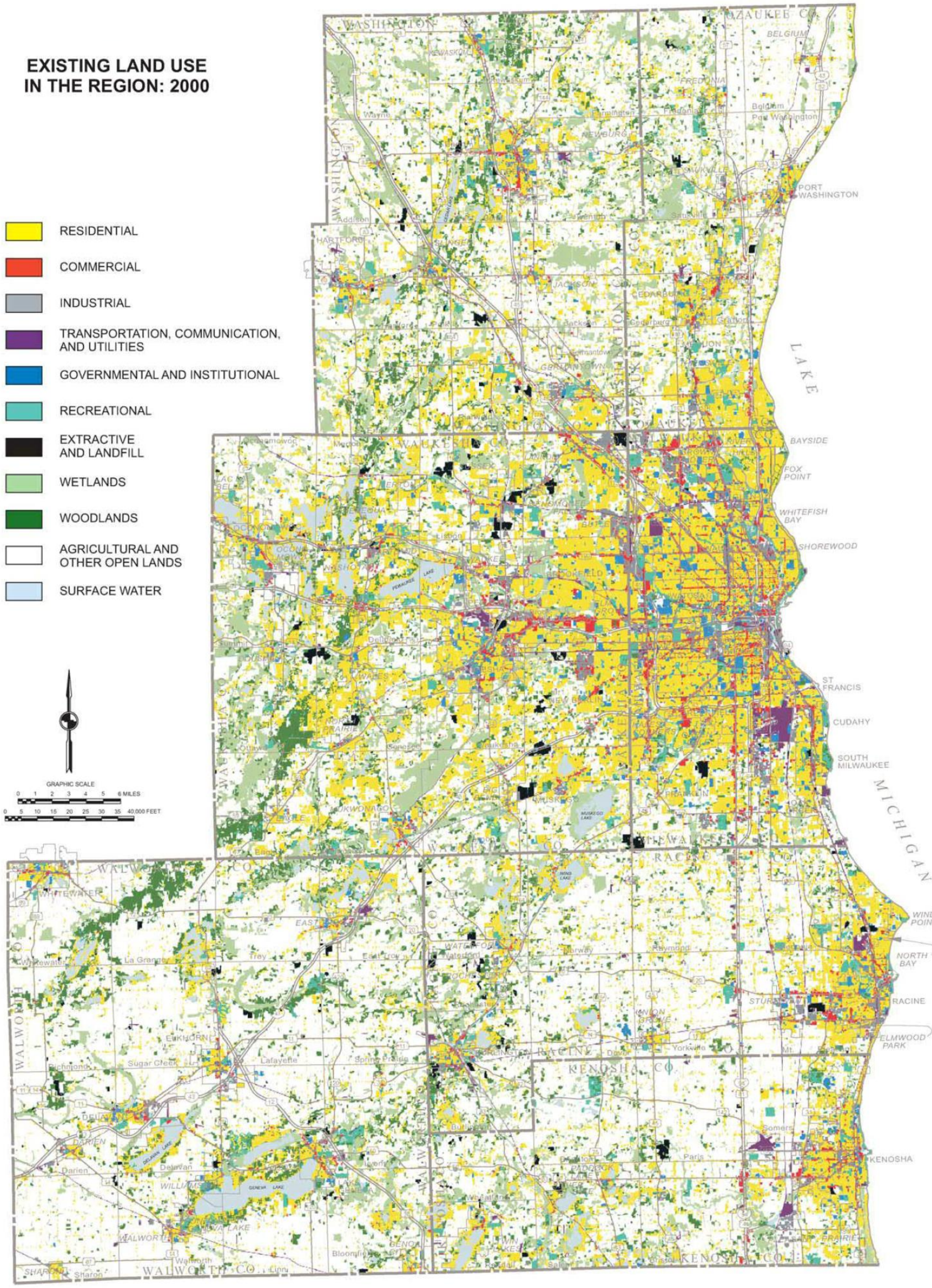
APPENDIX A

LAND USE TRENDS OF SE WISCONSIN FROM 1963-2000

(SEWRPC, 2006)

A-1



Source: SEWRPC.

A-2

LAND USE IN THE REGION: 1963, 1970, 1980, 1990, AND 2000

Land Use Category[a]	1963 Acres	1963 Percent of Total	1970 Acres	1970 Percent of Total	1980 Acres	1980 Percent of Total	1990 Acres	1990 Percent of Total	2000 Acres	2000 Percent of Total
Urban										
Residential	115,170	6.7	134,890	7.8	172,222	10.0	192,267	11.2	231,737	13.5
Commercial	7,390	0.4	9,494	0.6	12,360	0.7	15,788	0.9	19,397	1.1
Industrial	8,651	0.5	11,093	0.6	14,100	0.8	16,707	1.0	21,053	1.2
Transportation, Communication, and Utilities	86,366	5.0	96,019	5.6	106,305	6.2	109,934	6.4	128,570	7.5
Governmental and Institutional	13,980	0.8	17,410	1.0	19,181	1.1	19,710	1.1	21,543	1.3
Recreational	16,669	1.0	21,215	1.2	25,176	1.5	27,061	1.6	32,245	1.9
Unused Urban Land	34,895	2.0	32,617	1.9	28,798	1.7	25,939	1.5	32,566	1.9
Subtotal Urban	283,123	16.4	322,738	18.7	378,142	22.0	407,407	23.7	487,111	28.4
Nonurban										
Natural Areas										
Surface Water	45,794	2.7	47,339	2.8	48,769	2.8	49,228	2.9	49,566	2.9
Wetlands	175,564	10.2	172,994	10.0	170,623	9.9	171,963	10.0	176,450	10.2
Woodlands	119,583	6.9	117,979	6.9	116,396	6.8	118,954	6.9	116,905	6.8
Subtotal Natural Areas	340,941	19.8	338,312	19.7	335,789	19.5	340,145	19.8	342,921	19.9
Agricultural	1,047,740	60.9	1,001,399	58.2	944,236	54.8	893,025	51.8	806,011	46.8
Unused Rural and Other Open Land	49,378	2.9	58,602	3.4	62,949	3.7	80,629	4.7	85,413	4.9
Subtotal Nonurban	1,438,059	83.6	1,398,313	81.3	1,342,974	78.0	1,313,799	76.3	1,234,345	71.6
Total	1,721,182	100.0	1,721,051	100.0	1,721,116	100.0	1,721,206	100.0	1,721,456	100.0

[a]Off-street parking is included with the associated land use.

A-3

LAND USE IN MILWAUKEE COUNTY: 1963, 1970, 1980, 1990, AND 2000

Land Use Category[a]	1963 Acres	1963 Percent of Total	1970 Acres	1970 Percent of Total	1980 Acres	1980 Percent of Total	1990 Acres	1990 Percent of Total	2000 Acres	2000 Percent of Total
Urban										
Residential	40,273	26.0	43,101	27.8	47,016	30.3	48,968	31.5	50,774	32.7
Commercial	3,569	2.3	4,308	2.8	5,266	3.4	6,405	4.1	7,141	4.6
Industrial	5,128	3.3	5,692	3.7	6,516	4.2	7,160	4.6	7,610	4.9
Transportation, Communication, and Utilities	25,664	16.5	29,211	18.8	30,374	19.6	30,728	19.8	33,252	21.4
Governmental and Institutional	6,646	4.3	7,523	4.8	7,902	5.1	8,042	5.2	8,214	5.3
Recreational	6,012	3.9	6,829	4.4	7,314	4.7	7,615	4.9	7,764	5.0
Unused Urban Land	17,153	11.1	13,598	8.8	10,838	7.0	9,617	6.2	10,669	6.9
Subtotal Urban	104,445	67.4	110,262	71.1	115,226	74.3	118,536	76.3	125,424	80.8
Nonurban										
Natural Areas										
Surface Water	1,193	0.8	1,261	0.8	1,327	0.9	1,317	0.8	1,298	0.8
Wetlands	4,176	2.7	4,139	2.7	4,129	2.7	4,702	3.0	5,298	3.4
Woodlands	5,467	3.5	5,087	3.3	4,856	3.1	4,773	3.1	4,550	2.9
Subtotal Natural Areas	10,836	7.0	10,487	6.8	10,311	6.7	10,792	6.9	11,146	7.1
Agricultural	34,046	21.9	27,801	17.9	23,051	14.8	18,767	12.2	12,933	8.3
Unused Rural and Other Open Land	5,750	3.7	6,586	4.2	6,605	4.2	7,164	4.6	5,830	3.8
Subtotal Nonurban	50,632	32.6	44,874	28.9	39,967	25.7	36,724	23.7	29,910	19.2
Total	155,077	100.0	155,136	100.0	155,193	100.0	155,259	100.0	155,333	100.0

[a]Off-street parking is included with the associated land use.

A-4

LAND USE IN OZAUKEE COUNTY: 1963, 1970, 1980, 1990, AND 2000

Land Use Category[a]	Existing Land Use									
	1963		1970		1980		1990		2000	
	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
Urban										
Residential	7,000	4.6	9,190	6.1	12,706	8.4	14,503	9.6	18,256	12.1
Commercial	321	0.2	424	0.3	594	0.4	793	0.5	975	0.6
Industrial	313	0.2	463	0.3	655	0.4	813	0.5	1,084	0.7
Transportation, Communication, and Utilities	5,807	3.9	6,654	4.4	8,053	5.4	8,397	5.6	9,685	6.4
Governmental and Institutional	745	0.5	957	0.6	1,122	0.7	1,213	0.8	1,263	0.8
Recreational	825	0.5	1,460	1.0	1,780	1.2	1,866	1.2	2,436	1.6
Unused Urban Land	1,479	1.0	1,840	1.2	1,629	1.1	1,570	1.0	2,134	1.4
Subtotal Urban	16,489	10.9	20,987	13.9	26,540	17.6	29,154	19.2	35,833	23.6
Nonurban										
Natural Areas										
Surface Water	1,723	1.1	1,823	1.2	1,986	1.3	2,063	1.4	2,147	1.4
Wetlands	16,357	10.9	16,274	10.8	15,988	10.6	16,334	10.9	16,914	11.2
Woodlands	6,805	4.5	6,664	4.4	6,620	4.4	6,993	4.6	7,150	4.7
Subtotal Natural Areas	24,884	16.5	24,761	16.4	24,594	16.3	25,390	16.9	26,211	17.3
Agricultural	104,153	69.3	99,162	66.0	93,833	62.5	89,410	59.5	81,201	54.0
Unused Rural and Other Open Land	5,015	3.3	5,546	3.7	5,489	3.6	6,504	4.4	7,463	5.1
Subtotal Nonurban	134,053	89.1	129,468	86.1	123,916	82.4	121,304	80.8	114,875	76.4
Total	150,542	100.0	150,455	100.0	150,456	100.0	150,458	100.0	150,708	100.0

[a] *Off-street parking is included with the associated land use.*

A-5

LAND USE IN WASHINGTON COUNTY: 1963, 1970, 1980, 1990, AND 2000

Land Use Category[a]	Existing Land Use									
	1963		1970		1980		1990		2000	
	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
Urban										
Residential	7,058	2.5	9,410	3.4	14,947	5.4	18,449	6.6	25,590	9.2
Commercial	346	0.1	491	0.2	727	0.3	960	0.3	1,311	0.5
Industrial	342	0.1	522	0.2	826	0.3	1,135	0.4	1,549	0.6
Transportation, Communication, and Utilities	10,029	3.6	10,636	3.8	11,593	4.2	12,557	4.5	15,617	5.6
Governmental and Institutional	733	0.3	981	0.4	1,224	0.4	1,287	0.5	1,477	0.5
Recreational	964	0.3	1,322	0.5	1,829	0.7	2,177	0.8	3,067	1.1
Unused Urban Land	916	0.3	1,246	0.4	1,187	0.4	1,521	0.5	2,129	0.8
Subtotal Urban	20,388	7.2	24,607	8.9	32,333	11.7	38,086	13.6	50,739	18.3
Nonurban										
Natural Areas										
Surface Water	3,910	1.4	4,085	1.5	4,311	1.5	4,366	1.6	4,507	1.6
Wetlands	41,794	15.0	41,779	15.0	41,910	15.0	42,029	15.1	42,771	15.3
Woodlands	21,008	7.5	20,905	7.5	21,540	7.7	22,595	8.1	23,057	8.3
Subtotal Natural Areas	66,712	23.9	66,768	24.0	67,762	24.2	68,990	24.8	70,336	25.2
Agricultural	185,893	66.8	178,972	64.1	169,574	60.8	158,532	56.9	141,755	50.8
Unused Rural and Other Open Land	5,840	2.1	8,485	3.0	9,164	3.3	13,225	4.7	15,927	5.7
Subtotal Nonurban	258,445	92.8	254,226	91.1	246,500	88.3	240,747	86.4	228,017	81.7
Total	278,833	100.0	278,833	100.0	278,833	100.0	278,833	100.0	278,756	100.0

[a] *Off-street parking is included with the associated land use.*

A-6

LAND USE IN WAUKESHA COUNTY: 1963, 1970, 1980, 1990, AND 2000

Land Use Category[a]	Existing Land Use									
	1963		1970		1980		1990		2000	
	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
Urban										
Residential	28,148	7.6	35,476	9.5	50,745	13.7	59,247	15.9	75,221	20.2
Commercial	1,197	0.3	1,831	0.5	2,754	0.7	3,827	1.0	5,351	1.4
Industrial	924	0.2	1,758	0.5	2,747	0.7	3,802	1.0	5,525	1.5
Transportation, Communication, and Utilities	16,079	4.3	18,545	5.0	21,867	5.9	22,805	6.1	30,001	8.1
Governmental and Institutional	2,550	0.7	3,587	1.0	4,037	1.1	4,215	1.1	4,887	1.3
Recreational	3,311	0.9	4,605	1.2	5,756	1.5	6,465	1.7	8,253	2.2
Unused Urban Land	8,509	2.3	8,516	2.3	8,017	2.2	7,025	1.9	7,806	2.1
Subtotal Urban	60,717	16.3	74,319	20.0	95,923	25.8	107,386	28.7	137,045	36.8
Nonurban										
Natural Areas										
Surface Water	16,076	4.3	16,461	4.4	16,753	4.5	16,878	4.5	16,892	4.5
Wetlands	52,588	14.2	51,660	13.9	51,233	13.8	51,978	14.0	52,661	14.2
Woodlands	31,181	8.4	30,818	8.3	29,472	7.9	29,584	8.0	28,932	7.8
Subtotal Natural Areas	99,846	26.9	98,939	26.6	97,458	26.2	98,439	26.5	98,484	26.5
Agricultural	200,242	53.9	184,389	49.6	161,558	43.5	142,429	38.4	112,611	30.4
Unused Rural and Other Open Land	10,786	2.9	13,943	3.8	16,651	4.5	23,336	6.4	23,397	6.3
Subtotal Nonurban	310,873	83.7	297,271	80.0	275,668	74.2	264,205	71.3	234,492	63.2
Total	371,591	100.0	371,591	100.0	371,591	100.0	371,591	100.0	371,537	100.0

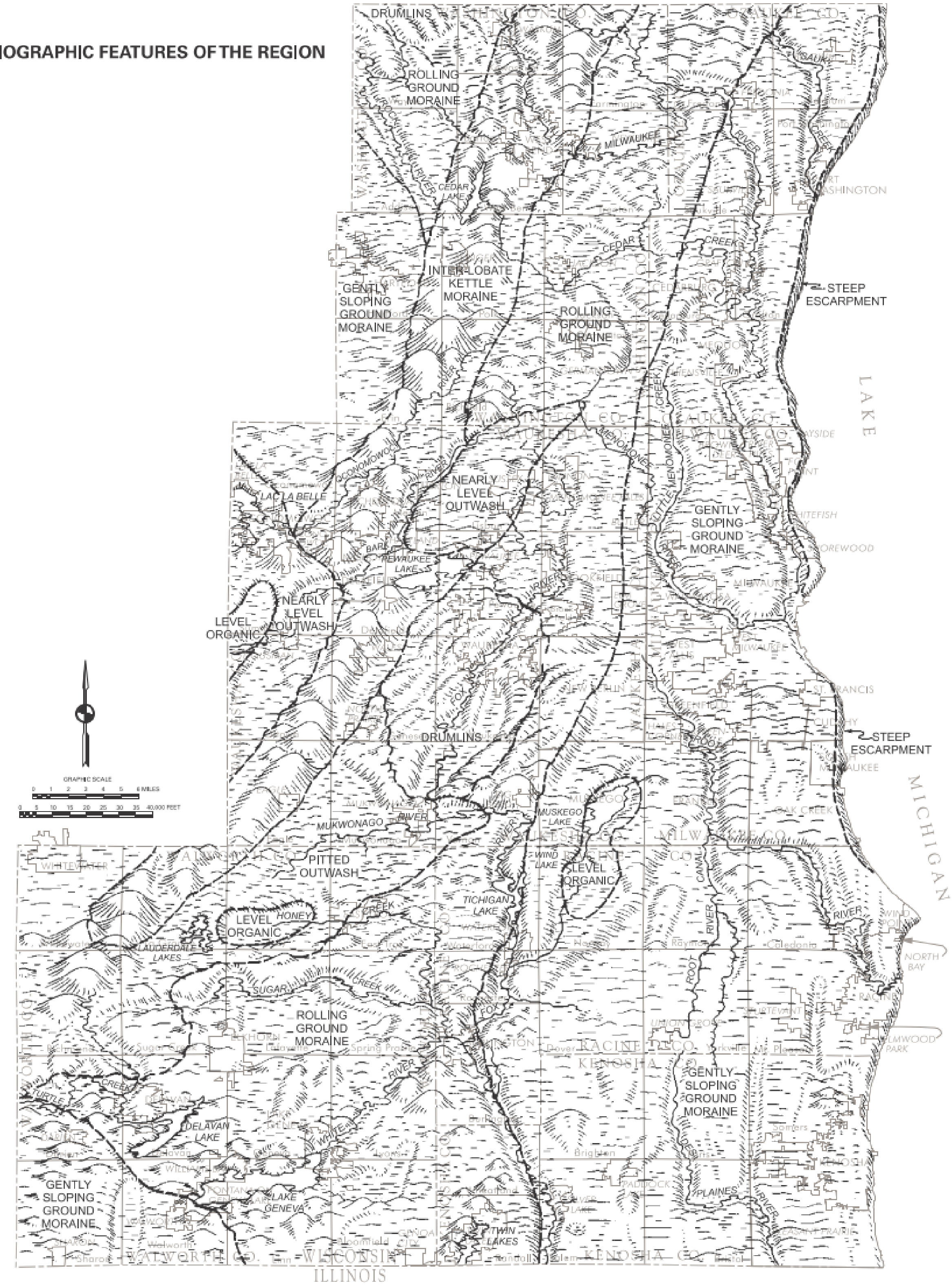
[a]*Off-street parking is included with the associated land use.*

APPENDIX B

PHYSIOGRAPHIC FEATURES OF SE WISCONSIN

(SEWRPC, 2002)

PHYSIOGRAPHIC FEATURES OF THE REGION



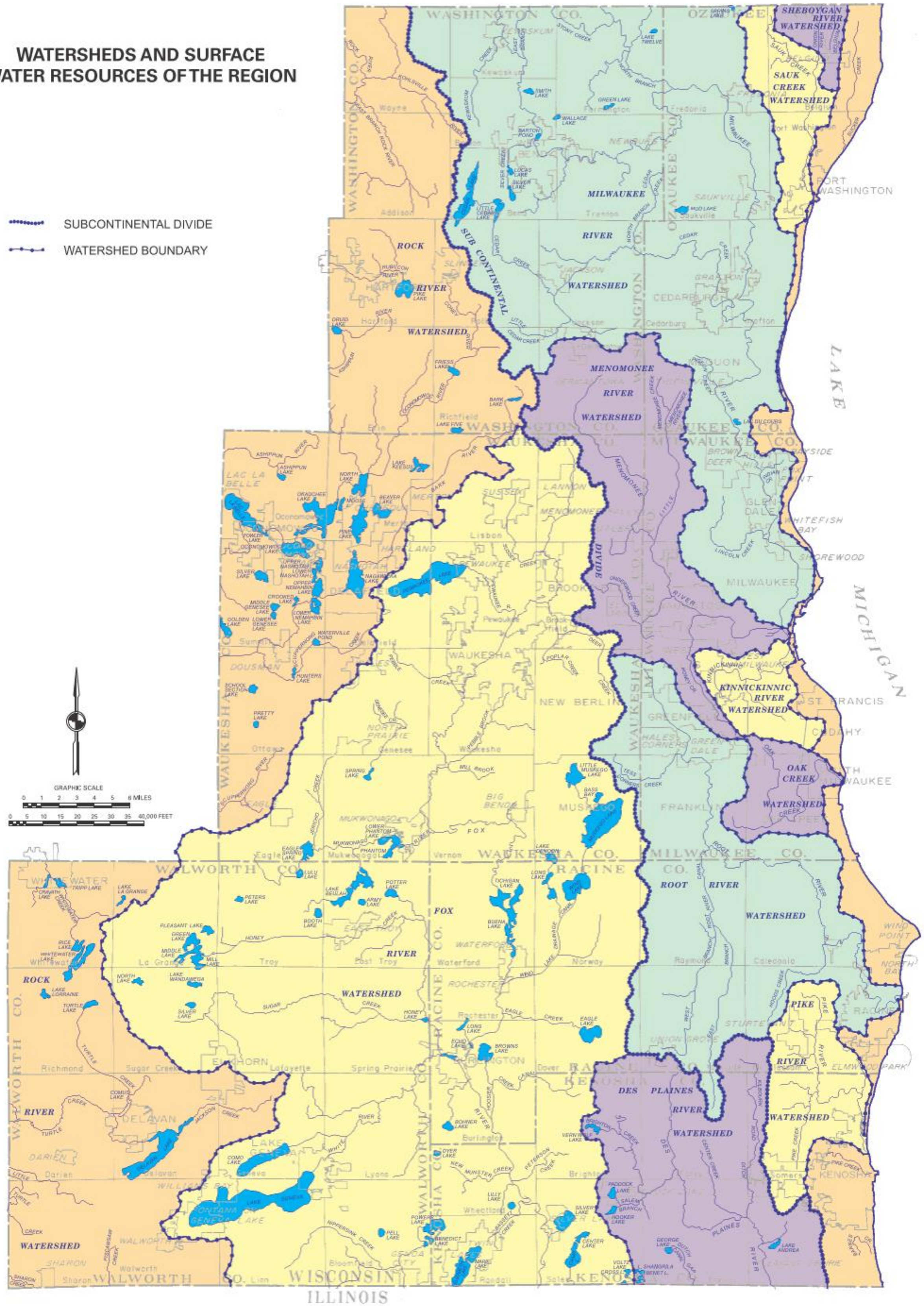
Source: SEWRPC.

APPENDIX C

WATERSHEDS AND SURFACE WATER RESOURCES OF SE WISCONSIN

(SEWRPC, 2006)

WATERSHEDS AND SURFACE WATER RESOURCES OF THE REGION



Source: SEWRPC.

APPENDIX D

USER EXPENDITURES ON CONVENTIONAL PESTICIDES IN THE U.S. BY PESTICIDE TYPE AND MARKET SECTOR – 2012, 2009, 2007, AND 2005 ESTIMATES

(Atwood & Paisley-Jones, 2017)

Table 2.2. User Expenditures on Conventional Pesticides in the United States by Pesticide Type and Market Sector - 2012, 2009, 2007, and 2005 Estimates

Year and Market Sector	Herbicides/ PGR		Insecticides		Fungicides		Fumigant		Sulfur and Oil[1]		Other[2]		Total	
	Mil $	%	Mil $	%	Mil $	%	Mil $	%	Mil $	%	Mil $	%	Mil $	%
2012														
Agriculture[3]	5,313	85	1,909	36	1,499	84	245	100	82	100	7	3	9,055	66
Ind/Comm/Gov	460	7	700	13	230	13	—	—	—	—	40	18	1,430	10
Home & Garden	450	7	2,650	50	55	3	—	—	—	—	175	79	3,330	24
Total	6,223		5,259		1,784		245		82		222		13,815	
2009														
Agriculture[3]	5,192	85	1,618	34	1,128	79	229	100	70	100	4	2	8,241	64
Ind/Comm/Gov[4]	470	8	708	15	248	17	—	—	—	—	35	18	1,490	12
Home & Garden	475	8	2,500	52	50	4	—	—	—	—	155	80	3,180	25
Total	6,147		4,833		1,443		229		70		189		12,911	
2007*														
Agriculture[3]	4,135	82	1,428	31	820	73	227	100	66	100	6	4	6,682	59
Ind/Comm/Gov	480	10	715	15	265	23	—	—	—	—	30	20	1,490	13
Home & Garden	420	8	2,500	54	45	4	—	—	—	—	115	76	3,080	27
Total	5,035		4,643		1,130		227		66		151		11,252	
2005*														
Agriculture[3]	4,352	84	1,314	31	699	70	197	100	63	100	5	3	6,630	61
Ind/Comm/Gov	460	9	675	16	260	26	—	—	—	—	30	21	1,425	13
Home & Garden	395	8	2,200	53	40	4	—	—	—	—	109	76	2,744	25
Total	5,207		4,189		999		197		63		144		10,799	

Sources: Agricultural Market Research Proprietary Data (2005-2012).
Non-Agricultural Market Research Proprietary Data (2005-2012)
USDA/NASS Quick Stats (*http://www.nass.usda.gov/Quick_Stats/*)

Note: *Includes the cost of insecticides, herbicides, fungicides, and other pesticides, excluding the cost of custom application. Insecticide and fungicide values include seed treatment uses. Totals may not be exact due to rounding.*

1 "Sulfur and Oil" includes sulfur, petroleum distillate, and petroleum oil.

2 "Other" includes chemicals used as pesticides which are not primarily produced as pesticides for the agricultural market (e.g., sulfuric acid and phosphoric acid) as well as rodenticides and repellant use in the home and industrial markets. It does not cover specialty biocides or wood preservatives.

3 USDA/NASS data incorporated into agricultural expenditures to account for malathion expenditures in the Boll Weevil Eradication Program (BWEP).

4 Due to lack of data, the values presented for 2009 for the Industrial/Commercial/ Government category are an average of the 2012 and 2007 values. This value may over or underestimate actual 2009 usage, due to fluctuations in annual usage.

* Updated values for 2007 and 2005 presented for continuity. See Data Reporting Changes.

APPENDIX E

PESTICIDE SURVEY SENT OUT TO PARTICIPATING HOMEOWNERS

UNIVERSITY of WISCONSIN
UWMILWAUKEE

College of Letters and Science

Department of Geosciences

Leslie Bychinski
Graduate Student
Department of Geosciences
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1. How long have you lived at this location? (circle one)
   a. Less than 1 year
   b. 1-3 years
   c. 4-7 years
   d. 7-10 years
   e. More than 10 years

2. Do you use pesticides, herbicides, insecticides, etc. of any kind? And in what season (circle all that apply)
   a. Yes, 1 time a season (Spring, Summer, Fall)
   b. Yes, 2 times a season (Spring, Summer, Fall)
   c. Yes, 3 times a season (Spring, Summer, Fall)
   d. No, never

3. Do you use any of these products (see back of page and circle all that apply)? If you hire a company to do so, please indicate in the space below.

4. Are you willing to allow us to take a water sample from your well? (see attached note for further information)

Producer	Commercial Name	✓
	HERBICIDE	
Bayer	DuraZone® Weed and Grass Killer	
Bayer	Bayer Advanced® Weed Killer for Lawn	
Bonide	Weed Beater® Ultra Weed Killer	
Gordon's	Speed Zone® Lawn Weed Killer	
Lebanon Seaboard Corporation	Preen® Garden Weed Preventer	
Scotts	Ortho® Weed B Gon	
Scotts	Roundup® Max Control 365 Weed Killer	
Scotts	Ortho®Weed B Gon Max Plus Crabgrass Control	
Spectrum Brand	Spectracide® Weed and Grass Killer	
Vigoro	Vigoro® Concentrate Weed and Feed	
	INSECTICIDE	
Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	
Bayer	Bayer Advanced® Concentrate Tree and Shrub Protect with Feed	
BlackFlag	Black Flag® Spider and Scorpion Killer	
GardenTech Inc.	Sevin® Dust Garden Insect Killer Shaker Canister	
Scotts	Ortho® Home Defense Max Ready-to-Use Insect Killer Granules	
PF Harris	Harris® Asian Lady Beetle and Box-Elder Bug Killer	
Spectrum Brand	Triazicide® Concentrate Lawn and Landscape Insect Killer	
United Industries Corporation	HotShot Cutter® Bug Free Backyard Hose End Sprayer	
Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	

APPENDIX F

BASIC WATER CHEMISTRY DATA BY WELL

F-1: WELL 1

	Temp	pH	Conductivity	TDS	Pressure	ORP	D.O.	D.O.
Sample Date	°C		µS/cm	mg/L	mmHg	mV	mg/L	%
2-Jul-19	12.70	7.43	1670.00	1085.50	737.70	-92.10	n.a.	n.a.
19-Aug-19	12.90	7.56	1765.00	1147.25	738.50	-78.00	4.66	44.40

	Fe II	Fe Total	Fe III	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
Sample Date	mg/L										
2-Jul-19	n.a.	n.a.	n.a.	162.37	103.27	24.67	2.86	n.a.	95.90	37.70	0.00
19-Aug-19	1.85	1.89	0.04	101.21	59.64	16.99	1.91	405.00	112.70	49.16	0.00

F-2: WELL 2

	Temp	pH	Conductivity	TDS	Pressure	ORP	D.O.	D.O.
Sample Date	°C		µS/cm	mg/L	mmHg	mV	mg/L	%
18-Jun-19	11.10	7.27	1338.00	869.70	740.40	234.70	n.a.	n.a.
10-Sep-19	14.90	7.18	1834.00	1192.10	742.20	176.80	0.04	0.40
26-Nov-19	11.40	7.51	1464.00	951.60	736.90	68.20	5.54	50.90
14-Feb-20	10.80	7.36	650.00	422.50	n.a	n.a	n.a	n.a

	Fe II	Fe Total	Fe III	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
Sample Date	mg/L										
18-Jun-19	n.a.	n.a.	n.a.	184.15	84.51	24.17	3.40	n.a.	40.05	62.23	10.97
10-Sep-19	0.20	0.21	0.01	104.93	44.63	15.12	2.22	405.00	53.97	86.36	15.14
26-Nov-19	0.38	0.40	0.02	280.32	72.05	25.44	0.31	390.00	48.71	85.12	14.69
14-Feb-20	0.35	0.37	0.02	111.39	46.07	19.59	1.66	395.00	49.77	85.92	15.01

F-3 WELL 3

	Temp	pH	Conductivity	TDS	Pressure	ORP	D.O.	D.O.
Sample Date	°C		µS/cm	mg/L	mmHg	mV	mg/L	%
24-Jun-19	15.90	7.27	1343.00	872.95	730.60	64.50	n.a.	n.a.
16-Aug-19	14.70	7.81	1364.00	886.60	738.70	64.50	1.40	14.00
14-Feb-19	10.40	7.60	610.00	396.50	n.a	n.a.	n.a.	n.a.

	Fe II	Fe Total	Fe III	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
Sample Date	mg/L										
24-Jun-19	n.a.	n.a.	n.a.	143.92	68.10	15.76	2.76	n.a.	20.28	70.33	0.00
16-Aug-19	0.55	0.64	0.09	135.04	34.92	8.22	2.03	320.00	27.52	93.37	0.00
14-Feb-19	0.62	0.96	0.34	98.99	40.05	11.01	1.14	360.00	26.75	92.51	0.00

F-4: WELL 4

	Temp	pH	Conductivity	TDS	Pressure	ORP	D.O.	D.O.
Sample Date	°C		µS/cm	mg/L	mmHg	mV	mg/L	%
12-Jun-19	11.60	7.25	1820.00	1183.00	740.70	43.00	n.a.	n.a.
23-Aug-19	11.70	7.42	1862.00	1210.30	747.60	-59.40	6.83	63.50

	Fe II	Fe Total	Fe III	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}
Sample Date	mg/L										
12-Jun-19	n.a.	n.a.	n.a.	263.95	75.06	147.91	3.46	n.a.	77.97	55.48	0.00
23-Aug-19	2.33	2.45	0.12	105.11	51.20	53.53	1.96	405.00	114.04	70.60	0.00

F-5: WELL 5

	Temp	pH	Conductivity	TDS	Pressure	ORP	D.O.	D.O.
Sample Date	°C		µS/cm	mg/L	mmHg	mV	mg/L	%
11-Jun-19	21.10	7.00	2198.00	1428.70	738.60	-24.70	n.a.	n.a.
28-Aug-19	16.90	7.14	2341.00	1521.65	731.50	-0.70	7.92	82.40
21-Nov-19	14.00	7.70	2155.00	1400.75	722.90	-52.00	5.88	57.50
6-Feb-20	11.60	7.56	2020.00	1313.00	*720.10*	112.70	7.04	65.00

	Fe II	Fe Total	Fe III	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}
Sample Date	mg/L										
11-Jun-19	n.a.	n.a.	n.a.	226.91	63.34	274.74	3.45	n.a.	137.68	12.24	11.23
28-Aug-19	0.01	0.03	0.02	90.74	40.95	117.82	2.29	515.00	183.11	17.98	17.90
21-Nov-19	0.04	0.10	0.06	160.45	77.97	126.08	0.24	485.00	170.90	18.22	16.90
6-Feb-20	0.00	0.61	0.61	99.21	42.16	110.19	1.54	425.00	179.74	17.29	16.42

F-6: WELL 6

	Temp	pH	Conductivity	TDS	Pressure	ORP	D.O.	D.O.
Sample Date	°C		µS/cm	mg/L	mmHg	mV	mg/L	%
11-Jun-19	12.00	7.00	1405.00	913.25	738.70	-32.40	n.a.	n.a.
19-Aug-19	14.80	7.44	1511.00	982.15	735.40	143.10	8.90	88.40

	Fe II	Fe Total	Fe III	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}
Sample Date	mg/L										
11-Jun-19	n.a.	n.a.	n.a.	173.71	68.07	179.72	2.49	n.a.	50.39	4.57	24.59
19-Aug-19	0.00	0.14	0.14	72.57	33.81	52.22	2.25	350.00	66.63	4.74	36.30

F-7: WELL 7

	Temp	pH	Conductivity	TDS	Pressure	ORP	D.O.	D.O.
Sample Date	°C		µS/cm	mg/L	mmHg	mV	mg/L	%
30-Aug-19	12.90	7.21	2183.00	1418.95	736.50	58.40	5.04	48.10
13-Nov-19	12.40	7.24	2208.00	1435.20	733.30	-82.70	n.a.	n.a.
2-Feb-19	10.70	7.30	2072.00	1346.80	*732.50*	177.00	5.76	52.10

	Fe II	Fe Total	Fe III	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
Sample Date	mg/L										
30-Aug-19	0.00	0.16	0.16	106.31	49.67	102.17	2.91	400.00	175.55	31.58	34.27
13-Nov-19	0.02	0.22	0.20	198.82	97.88	117.53	1.03	505.00	177.28	30.70	34.51
2-Feb-19	0.00	0.10	0.10	100.08	49.48	105.46	2.24	465.00	172.22	29.83	34.59

F-8: WELL 8

	Temp	pH	Conductivity	TDS	Pressure	ORP	D.O.	D.O.
Sample Date	°C		µS/cm	mg/L	mmHg	mV	mg/L	%
28-Aug-19	19.50	7.19	1686.00	1095.90	731.50	46.90	3.64	39.80
14-Nov-19	21.00	7.59	1824.00	1185.60	739.30	71.80	2.67	30.10
6-Feb-20	16.60	7.46	1674.00	1088.10	727.60	150.70	2.41	24.90

	Fe II	Fe Total	Fe III	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
Sample Date	mg/L										
28-Aug-19	0.04	0.24	0.20	89.22	44.97	11.81	1.99	410.00	60.08	50.72	1.90
14-Nov-19	0.01	0.14	0.13	186.99	95.88	27.59	0.15	440.00	64.34	57.44	3.32
6-Feb-20	0.00	0.07	0.07	106.49	51.05	16.43	1.27	455.00	59.84	52.04	2.71

F-9: WELL 9

	Temp	pH	Conductivity	TDS	Pressure	ORP	D.O.	D.O.
Sample Date	°C		µS/cm	mg/L	mmHg	mV	mg/L	%
22-Jul-19	13.60	7.53	2804.00	1822.60	737.60	221.70	7.45	72.10
28-Aug-19	12.80	7.02	2399.00	1559.35	731.80	-7.20	7.86	75.10
22-Nov-19	12.40	7.74	2935.00	1907.75	739.80	-22.30	6.11	57.90
12-Feb-20	11.20	7.74	2739.00	1780.35	733.20	99.50	0.10	0.90

	Fe II	Fe Total	Fe III	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
Sample Date	mg/L										
22-Jul-19	0.00	0.08	0.08	120.50	56.02	208.42	3.35	n.a.	197.61	15.72	13.04
28-Aug-19	0.00	0.09	0.09	116.39	60.36	167.03	2.00	520.00	277.11	20.25	14.58
22-Nov-19	0.03	0.03	0.00	188.87	102.78	193.85	0.00	525.00	297.45	20.43	17.11
12-Feb-20	0.00	0.05	0.05	112.84	52.12	180.91	1.31	560.00	298.18	20.36	17.04

F-10: WELL 10

	Temp	pH	Conductivity	TDS	Pressure	ORP	D.O.	D.O.
Sample Date	°C		µS/cm	mg/L	mmHg	mV	mg/L	%
27-Aug-19	12.90	7.45	1276.00	829.40	729.90	-49.80	3.82	36.40
22-Nov-19	11.60	7.96	1232.00	800.80	739.60	-97.30	2.04	18.70

	Fe II	Fe Total	Fe III	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
Sample Date	mg/L										
27-Aug-19	>3.00	>3.00		77.82	40.04	19.25	1.93	400.00	47.68	28.51	0.00
22-Nov-19	>3.00	>3.00		140.84	78.69	29.58	0.00	465.00	44.00	25.95	0.00

F-11: WELL 11

	Temp	pH	Conductivity	TDS	Pressure	ORP	D.O.	D.O.
Sample Date	°C		µS/cm	mg/L	mmHg	mV	mg/L	%
23-Jul-19	18.40	7.70	1362.00	885.30	744.90	131.70	n.a.	n.a.
27-Aug-19	12.40	7.52	1200.00	780.00	736.60	-74.80	2.89	27.20
20-Nov-19	12.90	8.08	1201.00	780.65	745.10	89.80	6.56	62.30
10-Feb-20	10.40	8.17	1315.00	854.75	745.50	87.00	6.09	54.60

	Fe II	Fe Total	Fe III	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
Sample Date	mg/L										
23-Jul-19	0.06	0.32	0.26	56.71	43.32	54.62	3.08	300.00	54.85	82.80	0.80
27-Aug-19	0.39	0.63	0.24	49.87	39.07	33.89	2.09	205.00	63.69	104.43	0.16
20-Nov-19	0.00	0.10	0.10	88.16	76.72	45.48	0.00	295.00	61.77	100.12	1.24
10-Feb-20	0.22	0.66	0.44	57.12	39.42	36.88	1.24	220.00	57.57	104.15	0.25

F-12: WELL 12

	Temp	pH	Conductivity	TDS	Pressure	ORP	D.O.	D.O.
Sample Date	°C		µS/cm	mg/L	mmHg	mV	mg/L	%
3-Jul-19	12.80	7.84	1404.00	912.60	740.00	-93.60	n.a.	n.a.
26-Aug-19	13.00	8.16	1495.00	971.75	738.80	-37.60	5.30	50.80
8-Nov-19	12.90	8.11	1455.00	945.75	749.70	64.40	n.a.	n.a.
3-Feb-20	8.90	7.90	1349.00	876.85	*741.20*	1.20	6.34	55.10

	Fe II	Fe Total	Fe III	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
Sample Date	mg/L										
3-Jul-19	n.a.	n.a.	n.a.	104.18	88.95	61.45	2.82	n.a.	5.51	188.92	0.00
26-Aug-19	0.63	0.68	0.05	64.25	49.64	49.99	1.91	275.00	5.06	273.45	0.00
8-Nov-19	0.78	0.94	0.16	120.13	97.58	61.32	0.00	90.00	8.75	267.70	0.00
3-Feb-20	0.67	0.72	0.05	73.30	51.23	51.31	1.19	235.00	8.01	280.47	0.00

F-13: WELL 13

	Temp	pH	Conductivity	TDS	Pressure	ORP	D.O.	D.O.
Sample Date	°C		µS/cm	mg/L	mmHg	mV	mg/L	%
4-Jul-19	14.30	7.44	1716.00	1115.40	740.80	-62.90	n.a.	n.a.
19-Aug-19	15.70	7.69	1776.00	1154.40	742.10	12.10	6.66	67.60
12-Nov-19	15.50	7.65	1602.00	1041.30	753.20	-51.60	n.a.	n.a.
4-Feb-20	13.10	7.63	1493.00	970.45	*749.30*	43.00	3.88	37.00

	Fe II	Fe Total	Fe III	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
Sample Date	mg/L										
4-Jul-19	n.a.	n.a.	n.a.	161.79	95.09	40.74	7.48	n.a.	50.90	64.42	0.00
19-Aug-19	2.25	2.57	0.32	94.42	52.09	33.07	2.31	500.00	61.33	87.70	0.00
12-Nov-19	2.24	2.88	0.64	174.58	101.51	41.91	0.22	535.00	58.15	87.69	0.00
4-Feb-20	1.45	2.12	0.67	110.01	60.54	25.03	1.41	440.00	43.22	95.17	0.00

F-14: WELL 14

	Temp	pH	Conductivity	TDS	Pressure	ORP	D.O.	D.O.
Sample Date	°C		µS/cm	mg/L	mmHg	mV	mg/L	%
19-Jun-19	12.00	7.58	1560.00	1014.00	736.00	n.a.	n.a.	n.a.
29-Aug-19	13.30	7.33	1550.00	1007.50	738.50	-79.80	3.82	36.70
11-Nov-19	14.30	7.81	1553.00	1009.45	746.20	-13.30	n.a.	n.a.
3-Feb-20	12.00	7.90	1521.00	988.65	735.80	-121.00	2.40	22.40

	Fe II	Fe Total	Fe III	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
Sample Date	mg/L										
19-Jun-19	n.a.	n.a.	n.a.	100.00	88.34	71.05	3.53	n.a.	86.77	33.44	0.00
29-Aug-19	2.46	2.55	0.09	58.28	47.73	58.22	2.19	310.00	104.50	42.86	0.00
11-Nov-19	1.86	2.47	0.61	112.57	91.47	72.09	0.14	380.00	101.59	42.51	0.00
3-Feb-20	2.47	2.54	0.07	68.88	49.56	60.99	1.50	430.00	101.42	39.83	0.00

F-15: WELL 15

	Temp	pH	Conductivity	TDS	Pressure	ORP	D.O.	D.O.
Sample Date	°C		µS/cm	mg/L	mmHg	mV	mg/L	%
19-Jun-19	14.70	7.31	2534.00	1647.10	736.40	-73.50	n.a.	n.a.
29-Aug-19	16.60	7.08	2544.00	1653.60	738.10	-35.10	2.82	29.20
11-Nov-19	13.50	7.45	2342.00	1522.30	747.50	-44.70	n.a.	n.a.
3-Feb-20	12.50	7.60	2239.00	1455.35	*749.20*	-52.40	4.01	38.00

	Fe II	Fe Total	Fe III	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
Sample Date	mg/L										
19-Jun-19	n.a.	n.a.	n.a.	231.18	88.12	67.97	4.40	n.a.	98.47	118.04	0.00
29-Aug-19	>3.00	>3.00	n.a.	134.26	76.02	57.77	2.66	455.00	137.49	165.96	0.00
11-Nov-19	2.45	>3.00	~0.55	258.08	124.63	64.35	0.78	455.00	137.57	164.53	0.00
3-Feb-20	>3.00	>3.00	n.a.	130.34	77.17	55.01	2.00	560.00	135.67	159.95	0.00

F-16: WELL 16

	Temp	pH	Conductivity	TDS	Pressure	ORP	D.O.	D.O.
Sample Date	°C		µS/cm	mg/L	mmHg	mV	mg/L	%
12-Jun-19	12.80	7.61	1363.00	885.95	739.50	-46.00	n.a.	n.a.
26-Aug-19	15.40	7.53	1432.00	930.80	737.90	-21.50	4.75	47.80

	Fe II	Fe Total	Fe III	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
Sample Date	mg/L										
12-Jun-19	n.a.	n.a.	n.a.	195.09	55.34	64.14	2.74	n.a.	29.63	58.19	0.00
26-Aug-19	2.55	2.96	0.41	69.59	54.52	13.55	2.31	400.00	39.95	76.37	0.00

APPENDIX G

SURVEY RESULTS FOR EACH WELL

G-1: WELL 1 SURVEY

How long have you lived at this location? 10+ Years
How many times a season do you use pesticides? Yes, 2 times a season (spring, summer, fall)
Do you hire a lawn care company or self apply? NatureScape® Lawn and Landscape Care (5 Step Application Program) Aptive Environmental

Summary of some popular pesticide brands and their active ingredients in Wisconsin market

	Producer	Commercial Name	Active Ingredient(s)
Herbicide	Bayer	DuraZone® Weed and Grass Killer	Indaziflam, Diquat Bibromide
	Bayer	Bayer Advanced® Weed Killer for Lawn	2,4-D, MCPP, Dicamba
	Bonide	Weed Beater® Ultra Weed Killer	MCPA, MCPP, Dicamba, Carfentrazone-ethyl
	Gordon's	Speed Zone® Lawn Weed Killer	2,4-D, MCPP, Dicamba, Carfentrazone-ethyl
	Lebanon Seaboard Corporation	***Preen® Garden Weed Preventer***	***Trifluralin***
	Scotts	Ortho® Weed B Gon	MCPA, Triclopyr, Dicamba
	Scotts	***Roundup® Max Control 365 Weed Killer***	***Glyphosate, Diquat Dibromide, Imazapyr***
	Scotts	Ortho® Weed B Gon Max Plus Crabgrass Killer	MCPP, 2,4-D, Dicamba
	Spectrum Brand	Spectracide® Weed and Grass Killer	Diquat Dibromide
	Vigoro	Vigoro® Concentrate Weed and Feed	2,4-D, Dicamba, MCPP
	Producer	**Commercial Name**	**Active Ingredient(s)**
Insecticide	Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	Zeta-Cypermethrin
	Bayer	Bayer Advanced® Concentrate Tree and Shrub Protect with Feed	Imidacloprid
	BlackFlag	Black Flag® Spider and Scorpion Killer	Prallethrin, Lambda-Cyhalothrin
	GardenTech Inc.	***Sevin® Dust Garden Insect Killer Shaker Canister***	***Carbaryl***
	Scotts	***Ortho® Home Defense Max Ready-to-Use Insect Killer Granules***	***Bifenthrin, Zeta-Cyfluthrin***
	PF Harris	Harris® Asian Lady Bettle and Box-Elder Bug Killer	Deltamethrin
	Spectrum Brand	Triazicide® Concentrate Lawn and Landscape Insect Killer	Gamma-Cyhalothrin
	United Industries Corporatio	HotShot Cutter® Bug Free Backyard Hose End Sprayer	Lambda-Cyhalothrin
	Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	Pyrethrins

G-2: WELL 2 SURVEY

How long have you lived at this location? 7-10 years
How many times a season do you use pesticides? 3 times a season; spring, summer, fall
Do you hire a lawn care company or self apply? La Rosa Landscape Company, Inc (5 Step Application Program)

Summary of some popular pesticide brands and their active ingredients in Wisconsin market

	Producer	Commercial Name	Active Ingredient(s)
Herbicide	Bayer	DuraZone® Weed and Grass Killer	Indaziflam, Diquat Bibromide
	Bayer	Bayer Advanced® Weed Killer for Lawn	2,4-D, MCPP, Dicamba
	Bonide	Weed Beater® Ultra Weed Killer	MCPA, MCPP, Dicamba, Carfentrazone-ethyl
	Gordon's	Speed Zone® Lawn Weed Killer	2,4-D, MCPP, Dicamba, Carfentrazone-ethyl
	Lebanon Seaboard Corporation	Preen® Garden Weed Preventer	Trifluralin
	Scotts	Ortho® Weed B Gon	MCPA, Triclopyr, Dicamba
	Scotts	Roundup® Max Control 365 Weed Killer	Glyphosate, Diquat Dibromide, Imazapyr
	Scotts	Ortho® Weed B Gon Max Plus Crabgrass Killer	MCPP, 2,4-D, Dicamba
	Spectrum Brand	Spectracide® Weed and Grass Killer	Diquat Dibromide
	Vigoro	Vigoro® Concentrate Weed and Feed	2,4-D, Dicamba, MCPP
	Producer	**Commercial Name**	**Active Ingredient(s)**
Insecticide	Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	Zeta-Cypermethrin
	Bayer	Bayer Advanced® Concentrate Tree and Shrub Protect with Feed	Imidacloprid
	BlackFlag	Black Flag® Spider and Scorpion Killer	Prallethrin, Lambda-Cyhalothrin
	GardenTech Inc.	Sevin® Dust Garden Insect Killer Shaker Canister	Carbaryl
	Scotts	Ortho® Home Defense Max Ready-to-Use Insect Killer Granules	Bifenthrin, Zeta-Cyfluthrin
	PF Harris	Harris® Asian Lady Bettle and Box-Elder Bug Killer	Deltamethrin
	Spectrum Brand	Triazicide® Concentrate Lawn and Landscape Insect Killer	Gamma-Cyhalothrin
	United Industries Corporatio	HotShot Cutter® Bug Free Backyard Hose End Sprayer	Lambda-Cyhalothrin
	Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	Pyrethrins

G-3: WELL 3 SURVEY

How long have you lived at this location?
How many times a season do you use pesticides? Not stated
Do you hire a lawn care company or self apply? Not stated

Summary of some popular pesticide brands and their active ingredients in Wisconsin market

	Producer	Commercial Name	Active Ingredient(s)
Herbicide	Bayer	DuraZone® Weed and Grass Killer	Indaziflam, Diquat Bibromide
	Bayer	Bayer Advanced® Weed Killer for Lawn	2,4-D, MCPP, Dicamba
	Bonide	Weed Beater® Ultra Weed Killer	MCPA, MCPP, Dicamba, Carfentrazone-ethyl
	Gordon's	Speed Zone® Lawn Weed Killer	2,4-D, MCPP, Dicamba, Carfentrazone-ethyl
	Lebanon Seaboard Corporation	Preen® Garden Weed Preventer	Trifluralin
	Scotts	Ortho® Weed B Gon	MCPA, Triclopyr, Dicamba
	Scotts	Roundup® Max Control 365 Weed Killer	Glyphosate, Diquat Dibromide, Imazapyr
	Scotts	Ortho® Weed B Gon Max Plus Crabgrass Killer	MCPP, 2,4-D, Dicamba
	Spectrum Brand	Spectracide® Weed and Grass Killer	Diquat Dibromide
	Vigoro	Vigoro® Concentrate Weed and Feed	2,4-D, Dicamba, MCPP
	Producer	**Commercial Name**	**Active Ingredient(s)**
Insecticide	Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	Zeta-Cypermethrin
	Bayer	Bayer Advanced® Concentrate Tree and Shrub Protect with Feed	Imidacloprid
	BlackFlag	Black Flag® Spider and Scorpion Killer	Prallethrin, Lambda-Cyhalothrin
	GardenTech Inc.	Sevin® Dust Garden Insect Killer Shaker Canister	Carbaryl
	Scotts	Ortho® Home Defense Max Ready-to-Use Insect Killer Granules	Bifenthrin, Zeta-Cyfluthrin
	PF Harris	Harris® Asian Lady Bettle and Box-Elder Bug Killer	Deltamethrin
	Spectrum Brand	Triazicide® Concentrate Lawn and Landscape Insect Killer	Gamma-Cyhalothrin
	United Industries Corporatio	HotShot Cutter® Bug Free Backyard Hose End Sprayer	Lambda-Cyhalothrin
	Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	Pyrethrins

G-4: WELL 4 SURVEY

How long have you lived at this location? 10+ Years
How many times a season do you use pesticides? Yes, 3 times a season (spring, summer, fall)
Do you hire a lawn care company or self apply? Hire a company - Not stated Self Application (as needed)

Summary of some popular pesticide brands and their active ingredients in Wisconsin market

	Producer	Commercial Name	Active Ingredient(s)
Herbicide	Bayer	DuraZone® Weed and Grass Killer	Indaziflam, Diquat Bibromide
	Bayer	Bayer Advanced® Weed Killer for Lawn	2,4-D, MCPP, Dicamba
	Bonide	Weed Beater® Ultra Weed Killer	MCPA, MCPP, Dicamba, Carfentrazone-ethyl
	Gordon's	Speed Zone® Lawn Weed Killer	2,4-D, MCPP, Dicamba, Carfentrazone-ethyl
	Lebanon Seaboard Corporation	Preen® Garden Weed Preventer	Trifluralin
	Scotts	***Ortho® Weed B Gon***	***MCPA, Triclopyr, Dicamba***
	Scotts	Roundup® Max Control 365 Weed Killer	Glyphosate, Diquat Dibromide, Imazapyr
	Scotts	Ortho® Weed B Gon Max Plus Crabgrass Killer	MCPP, 2,4-D, Dicamba
	Spectrum Brand	***Spectracide® Weed and Grass Killer***	***Diquat Dibromide***
	Vigoro	Vigoro® Concentrate Weed and Feed	2,4-D, Dicamba, MCPP
	Producer	**Commercial Name**	**Active Ingredient(s)**
Insecticide	Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	Zeta-Cypermethrin
	Bayer	Bayer Advanced® Concentrate Tree and Shrub Protect with Feed	Imidacloprid
	BlackFlag	Black Flag® Spider and Scorpion Killer	Prallethrin, Lambda-Cyhalothrin
	GardenTech Inc.	Sevin® Dust Garden Insect Killer Shaker Canister	Carbaryl
	Scotts	Ortho® Home Defense Max Ready-to-Use Insect Killer Granules	Bifenthrin, Zeta-Cyfluthrin
	PF Harris	Harris® Asian Lady Bettle and Box-Elder Bug Killer	Deltamethrin
	Spectrum Brand	Triazicide® Concentrate Lawn and Landscape Insect Killer	Gamma-Cyhalothrin
	United Industries Corporation	HotShot Cutter® Bug Free Backyard Hose End Sprayer	Lambda-Cyhalothrin
	Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	Pyrethrins

G-5: WELL 5 SURVEY

How long have you lived at this location? 10+ years
How many times a season do you use pesticides? 1 time a season; spring, summer
Do you hire a lawn care company or self apply? Self, Spot Application (As Needed) Brandt's Lawn Care, Inc (6 Step Application Program)

Summary of some popular pesticide brands and their active ingredients in Wisconsin market

	Producer	Commercial Name	Active Ingredient(s)
Herbicide	Bayer	DuraZone® Weed and Grass Killer	Indaziflam, Diquat Bibromide
	Bayer	Bayer Advanced® Weed Killer for Lawn	2,4-D, MCPP, Dicamba
	Bonide	Weed Beater® Ultra Weed Killer	MCPA, MCPP, Dicamba, Carfentrazone-ethyl
	Gordon's	Speed Zone® Lawn Weed Killer	2,4-D, MCPP, Dicamba, Carfentrazone-ethyl
	Lebanon Seaboard Corporation	Preen® Garden Weed Preventer	Trifluralin
	Scotts	Ortho® Weed B Gon	MCPA, Triclopyr, Dicamba
	Scotts	Roundup® Max Control 365 Weed Killer	Glyphosate, Diquat Dibromide, Imazapyr
	Scotts	Ortho® Weed B Gon Max Plus Crabgrass Killer	MCPP, 2,4-D, Dicamba
	Spectrum Brand	Spectracide® Weed and Grass Killer	Diquat Dibromide
	Vigoro	Vigoro® Concentrate Weed and Feed	2,4-D, Dicamba, MCPP
	Producer	**Commercial Name**	**Active Ingredient(s)**
Insecticide	Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	Zeta-Cypermethrin
	Bayer	Bayer Advanced® Concentrate Tree and Shrub Protect with Feed	Imidacloprid
	BlackFlag	Black Flag® Spider and Scorpion Killer	Prallethrin, Lambda-Cyhalothrin
	GardenTech Inc.	Sevin® Dust Garden Insect Killer Shaker Canister	Carbaryl
	Scotts	***Ortho® Home Defense Max Ready-to-Use Insect Killer Granules***	***Bifenthrin, Zeta-Cyfluthrin***
	PF Harris	Harris® Asian Lady Bettle and Box-Elder Bug Killer	Deltamethrin
	Spectrum Brand	Triazicide® Concentrate Lawn and Landscape Insect Killer	Gamma-Cyhalothrin
	United Industries Corporatio	HotShot Cutter® Bug Free Backyard Hose End Sprayer	Lambda-Cyhalothrin
	Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	Pyrethrins

Not Listed		
Bayer	***Bayer Advanced® Triple Action Ant Killer***	***Imidacloprid***
Scotts	***KleenUp® Systemic Weed & Grass Killer***	***Glyphosate, Isopropylamin Salt***

G-6: WELL 6 SURVEY

How long have you lived at this location? 7-10 Years
How many times a season do you use pesticides? Yes, 3 times a season (spring, summer, fall)
Do you hire a lawn care company or self apply? Schoofs GreenWorks,LLC

Summary of some popular pesticide brands and their active ingredients in Wisconsin market

	Producer	Commercial Name	Active Ingredient(s)
Herbicide	Bayer	DuraZone® Weed and Grass Killer	Indaziflam, Diquat Bibromide
	Bayer	Bayer Advanced® Weed Killer for Lawn	2,4-D, MCPP, Dicamba
	Bonide	Weed Beater® Ultra Weed Killer	MCPA, MCPP, Dicamba, Carfentrazone-ethyl
	Gordon's	Speed Zone® Lawn Weed Killer	2,4-D, MCPP, Dicamba, Carfentrazone-ethyl
	Lebanon Seaboard Corporation	***Preen® Garden Weed Preventer***	***Trifluralin***
	Scotts	Ortho® Weed B Gon	MCPA, Triclopyr, Dicamba
	Scotts	***Roundup® Max Control 365 Weed Killer***	***Glyphosate, Diquat Dibromide, Imazapyr***
	Scotts	***Ortho® Weed B Gon Max Plus Crabgrass Killer***	***MCPP, 2,4-D, Dicamba***
	Spectrum Brand	Spectracide® Weed and Grass Killer	Diquat Dibromide
	Vigoro	Vigoro® Concentrate Weed and Feed	2,4-D, Dicamba, MCPP
	Producer	**Commercial Name**	**Active Ingredient(s)**
Insecticide	Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	Zeta-Cypermethrin
	Bayer	Bayer Advanced® Concentrate Tree and Shrub Protect with Feed	Imidacloprid
	BlackFlag	***Black Flag® Spider and Scorpion Killer***	***Prallethrin, Lambda-Cyhalothrin***
	GardenTech Inc.	Sevin® Dust Garden Insect Killer Shaker Canister	Carbaryl
	Scotts	Ortho® Home Defense Max Ready-to-Use Insect Killer Granules	Bifenthrin, Zeta-Cyfluthrin
	PF Harris	Harris® Asian Lady Bettle and Box-Elder Bug Killer	Deltamethrin
	Spectrum Brand	Triazicide® Concentrate Lawn and Landscape Insect Killer	Gamma-Cyhalothrin
	United Industries Corporation	***HotShot Cutter® Bug Free Backyard Hose End Sprayer***	***Lambda-Cyhalothrin***
	Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	Pyrethrins

G-7: WELL 7 SURVEY

How long have you lived at this location? 4-7 Years
How many times a season do you use pesticides? No, never
Do you hire a lawn care company or self apply? N.A.

Summary of some popular pesticide brands and their active ingredients in Wisconsin market

	Producer	Commercial Name	Active Ingredient(s)
Herbicide	Bayer	DuraZone® Weed and Grass Killer	Indaziflam, Diquat Bibromide
	Bayer	Bayer Advanced® Weed Killer for Lawn	2,4-D, MCPP, Dicamba
	Bonide	Weed Beater® Ultra Weed Killer	MCPA, MCPP, Dicamba, Carfentrazone-ethyl
	Gordon's	Speed Zone® Lawn Weed Killer	2,4-D, MCPP, Dicamba, Carfentrazone-ethyl
	Lebanon Seaboard Corporation	Preen® Garden Weed Preventer	Trifluralin
	Scotts	Ortho® Weed B Gon	MCPA, Triclopyr, Dicamba
	Scotts	Roundup® Max Control 365 Weed Killer	Glyphosate, Diquat Dibromide, Imazapyr
	Scotts	Ortho® Weed B Gon Max Plus Crabgrass Killer	MCPP, 2,4-D, Dicamba
	Spectrum Brand	Spectracide® Weed and Grass Killer	Diquat Dibromide
	Vigoro	Vigoro® Concentrate Weed and Feed	2,4-D, Dicamba, MCPP
	Producer	**Commercial Name**	**Active Ingredient(s)**
Insecticide	Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	Zeta-Cypermethrin
	Bayer	Bayer Advanced® Concentrate Tree and Shrub Protect with Feed	Imidacloprid
	BlackFlag	Black Flag® Spider and Scorpion Killer	Prallethrin, Lambda-Cyhalothrin
	GardenTech Inc.	Sevin® Dust Garden Insect Killer Shaker Canister	Carbaryl
	Scotts	Ortho® Home Defense Max Ready-to-Use Insect Killer Granules	Bifenthrin, Zeta-Cyfluthrin
	PF Harris	Harris® Asian Lady Bettle and Box-Elder Bug Killer	Deltamethrin
	Spectrum Brand	Triazicide® Concentrate Lawn and Landscape Insect Killer	Gamma-Cyhalothrin
	United Industries Corporatio	HotShot Cutter® Bug Free Backyard Hose End Sprayer	Lambda-Cyhalothrin
	Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	Pyrethrins

G-8: WELL 8 SURVEY

How long have you lived at this location?	10+ Years
How many times a season do you use pesticides?	Yes, 3 times a season (spring, summer, fall)
Do you hire a lawn care company or self apply?	HMB Lawn & Landscape

Summary of some popular pesticide brands and their active ingredients in Wisconsin market

	Producer	Commercial Name	Active Ingredient(s)
Herbicide	Bayer	DuraZone® Weed and Grass Killer	Indaziflam, Diquat Bibromide
	Bayer	Bayer Advanced® Weed Killer for Lawn	2,4-D, MCPP, Dicamba
	Bonide	Weed Beater® Ultra Weed Killer	MCPA, MCPP, Dicamba, Carfentrazone-ethyl
	Gordon's	Speed Zone® Lawn Weed Killer	2,4-D, MCPP, Dicamba, Carfentrazone-ethyl
	Lebanon Seaboard Corporation	Preen® Garden Weed Preventer	Trifluralin
	Scotts	Ortho® Weed B Gon	MCPA, Triclopyr, Dicamba
	Scotts	Roundup® Max Control 365 Weed Killer	Glyphosate, Diquat Dibromide, Imazapyr
	Scotts	Ortho® Weed B Gon Max Plus Crabgrass Killer	MCPP, 2,4-D, Dicamba
	Spectrum Brand	Spectracide® Weed and Grass Killer	Diquat Dibromide
	Vigoro	Vigoro® Concentrate Weed and Feed	2,4-D, Dicamba, MCPP
	Producer	**Commercial Name**	**Active Ingredient(s)**
Insecticide	Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	Zeta-Cypermethrin
	Bayer	Bayer Advanced® Concentrate Tree and Shrub Protect with Feed	Imidacloprid
	BlackFlag	Black Flag® Spider and Scorpion Killer	Prallethrin, Lambda-Cyhalothrin
	GardenTech Inc.	Sevin® Dust Garden Insect Killer Shaker Canister	Carbaryl
	Scotts	Ortho® Home Defense Max Ready-to-Use Insect Killer Granules	Bifenthrin, Zeta-Cyfluthrin
	PF Harris	Harris® Asian Lady Bettle and Box-Elder Bug Killer	Deltamethrin
	Spectrum Brand	Triazicide® Concentrate Lawn and Landscape Insect Killer	Gamma-Cyhalothrin
	United Industries Corporatio	HotShot Cutter® Bug Free Backyard Hose End Sprayer	Lambda-Cyhalothrin
	Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	Pyrethrins

G-9: WELL 9 SURVEY

How long have you lived at this location?	4-7 years
How many times a season do you use pesticides?	3 times a season; spring, summer, fall
Do you hire a lawn care company or self apply?	Self apply

Summary of some popular pesticide brands and their active ingredients in Wisconsin market

	Producer	Commercial Name	Active Ingredient(s)
Herbicide	Bayer	DuraZone® Weed and Grass Killer	Indaziflam, Diquat Bibromide
	Bayer	***Bayer Advanced® Weed Killer for Lawn***	***2,4-D, MCPP, Dicamba***
	Bonide	Weed Beater® Ultra Weed Killer	MCPA, MCPP, Dicamba, Carfentrazone-ethyl
	Gordon's	Speed Zone® Lawn Weed Killer	2,4-D, MCPP, Dicamba, Carfentrazone-ethyl
	Lebanon Seaboard Corporation	Preen® Garden Weed Preventer	Trifluralin
	Scotts	Ortho® Weed B Gon	MCPA, Triclopyr, Dicamba
	Scotts	Roundup® Max Control 365 Weed Killer	Glyphosate, Diquat Dibromide, Imazapyr
	Scotts	Ortho® Weed B Gon Max Plus Crabgrass Killer	MCPP, 2,4-D, Dicamba
	Spectrum Brand	Spectracide® Weed and Grass Killer	Diquat Dibromide
	Vigoro	***Vigoro® Concentrate Weed and Feed***	***2,4-D, Dicamba, MCPP***
	Producer	**Commercial Name**	**Active Ingredient(s)**
Insecticide	Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	Zeta-Cypermethrin
	Bayer	***Bayer Advanced® Concentrate Tree and Shrub Protect with Feed***	***Imidacloprid***
	BlackFlag	Black Flag® Spider and Scorpion Killer	Prallethrin, Lambda-Cyhalothrin
	GardenTech Inc.	Sevin® Dust Garden Insect Killer Shaker Canister	Carbaryl
	Scotts	Ortho® Home Defense Max Ready-to-Use Insect Killer Granules	Bifenthrin, Zeta-Cyfluthrin
	PF Harris	Harris® Asian Lady Bettle and Box-Elder Bug Killer	Deltamethrin
	Spectrum Brand	***Triazicide® Concentrate Lawn and Landscape Insect Killer***	***Gamma-Cyhalothrin***
	United Industries Corporatio	HotShot Cutter® Bug Free Backyard Hose End Sprayer	Lambda-Cyhalothrin
	Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	Pyrethrins

Not Listed		
Stein's Garden and Home	***4 Step Lawn Treatment***	***2,4-D, MCPP***

G-10: WELL 10 SURVEY

How long have you lived at this location?	10+ Years
How many times a season do you use pesticides?	Yes, 1 time a season (spring, summer, fall)
Do you hire a lawn care company or self apply?	American Animal Control® LLC Self Application (as needed)

Summary of some popular pesticide brands and their active ingredients in Wisconsin market

	Producer	Commercial Name	Active Ingredient(s)
Herbicide	Bayer	DuraZone® Weed and Grass Killer	Indaziflam, Diquat Bibromide
	Bayer	Bayer Advanced® Weed Killer for Lawn	2,4-D, MCPP, Dicamba
	Bonide	Weed Beater® Ultra Weed Killer	MCPA, MCPP, Dicamba, Carfentrazone-ethyl
	Gordon's	Speed Zone® Lawn Weed Killer	2,4-D, MCPP, Dicamba, Carfentrazone-ethyl
	Lebanon Seaboard Corporation	Preen® Garden Weed Preventer	Trifluralin
	Scotts	Ortho® Weed B Gon	MCPA, Triclopyr, Dicamba
	Scotts	***Roundup® Max Control 365 Weed Killer***	***Glyphosate, Diquat Dibromide, Imazapyr***
	Scotts	Ortho® Weed B Gon Max Plus Crabgrass Killer	MCPP, 2,4-D, Dicamba
	Spectrum Brand	Spectracide® Weed and Grass Killer	Diquat Dibromide
	Vigoro	Vigoro® Concentrate Weed and Feed	2,4-D, Dicamba, MCPP
	Producer	**Commercial Name**	**Active Ingredient(s)**
Insecticide	Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	Zeta-Cypermethrin
	Bayer	Bayer Advanced® Concentrate Tree and Shrub Protect with Feed	Imidacloprid
	BlackFlag	Black Flag® Spider and Scorpion Killer	Prallethrin, Lambda-Cyhalothrin
	GardenTech Inc.	Sevin® Dust Garden Insect Killer Shaker Canister	Carbaryl
	Scotts	Ortho® Home Defense Max Ready-to-Use Insect Killer Granules	Bifenthrin, Zeta-Cyfluthrin
	PF Harris	Harris® Asian Lady Bettle and Box-Elder Bug Killer	Deltamethrin
	Spectrum Brand	Triazicide® Concentrate Lawn and Landscape Insect Killer	Gamma-Cyhalothrin
	United Industries Corporatio	HotShot Cutter® Bug Free Backyard Hose End Sprayer	Lambda-Cyhalothrin
	Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	Pyrethrins

G-11: WELL 11 SURVEY

How long have you lived at this location? 10+ Years
How many times a season do you use pesticides? 3 times a season (spring, summer, fall)
Do you hire a lawn care company or self apply? NatureScape Lawn and Landscape Care (Previously) (5 Step Application Program) Sunburst Environmental Services (2019) (2-3 Step Application Program)

Summary of some popular pesticide brands and their active ingredients in Wisconsin market

	Producer	Commercial Name	Active Ingredient(s)
Herbicide	Bayer	DuraZone® Weed and Grass Killer	Indaziflam, Diquat Bibromide
	Bayer	Bayer Advanced® Weed Killer for Lawn	2,4-D, MCPP, Dicamba
	Bonide	Weed Beater® Ultra Weed Killer	MCPA, MCPP, Dicamba, Carfentrazone-ethyl
	Gordon's	Speed Zone® Lawn Weed Killer	2,4-D, MCPP, Dicamba, Carfentrazone-ethyl
	Lebanon Seaboard Corporation	Preen® Garden Weed Preventer	Trifluralin
	Scotts	Ortho® Weed B Gon	MCPA, Triclopyr, Dicamba
	Scotts	***Roundup® Max Control 365 Weed Killer***	***Glyphosate, Diquat Dibromide, Imazapyr***
	Scotts	Ortho® Weed B Gon Max Plus Crabgrass Killer	MCPP, 2,4-D, Dicamba
	Spectrum Brand	Spectracide® Weed and Grass Killer	Diquat Dibromide
	Vigoro	Vigoro® Concentrate Weed and Feed	2,4-D, Dicamba, MCPP
	Producer	**Commercial Name**	**Active Ingredient(s)**
Insecticide	Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	Zeta-Cypermethrin
	Bayer	Bayer Advanced® Concentrate Tree and Shrub Protect with Feed	Imidacloprid
	BlackFlag	Black Flag® Spider and Scorpion Killer	Prallethrin, Lambda-Cyhalothrin
	GardenTech Inc.	Sevin® Dust Garden Insect Killer Shaker Canister	Carbaryl
	Scotts	Ortho® Home Defense Max Ready-to-Use Insect Killer Granules	Bifenthrin, Zeta-Cyfluthrin
	PF Harris	Harris® Asian Lady Bettle and Box-Elder Bug Killer	Deltamethrin
	Spectrum Brand	Triazicide® Concentrate Lawn and Landscape Insect Killer	Gamma-Cyhalothrin
	United Industries Corporatio	HotShot Cutter® Bug Free Backyard Hose End Sprayer	Lambda-Cyhalothrin
	Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	Pyrethrins

G-12: WELL 12 SURVEY

How long have you lived at this location? 10+ years
How many times a season do you use pesticides? 1 time a season; spring, summer, fall
Do you hire a lawn care company or self apply? Naturescape (most consistent) (5 Step Application Program NaturaLawn & Happy Lawns (for 1 year)

Summary of some popular pesticide brands and their active ingredients in Wisconsin market

	Producer	Commercial Name	Active Ingredient(s)
Herbicide	Bayer	DuraZone® Weed and Grass Killer	Indaziflam, Diquat Bibromide
	Bayer	Bayer Advanced® Weed Killer for Lawn	2,4-D, MCPP, Dicamba
	Bonide	Weed Beater® Ultra Weed Killer	MCPA, MCPP, Dicamba, Carfentrazone-ethyl
	Gordon's	Speed Zone® Lawn Weed Killer	2,4-D, MCPP, Dicamba, Carfentrazone-ethyl
	Lebanon Seaboard Corporation	Preen® Garden Weed Preventer	Trifluralin
	Scotts	Ortho® Weed B Gon	MCPA, Triclopyr, Dicamba
	Scotts	Roundup® Max Control 365 Weed Killer	Glyphosate, Diquat Dibromide, Imazapyr
	Scotts	Ortho® Weed B Gon Max Plus Crabgrass Killer	MCPP, 2,4-D, Dicamba
	Spectrum Brand	Spectracide® Weed and Grass Killer	Diquat Dibromide
	Vigoro	Vigoro® Concentrate Weed and Feed	2,4-D, Dicamba, MCPP
	Producer	Commercial Name	Active Ingredient(s)
Insecticide	Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	Zeta-Cypermethrin
	Bayer	Bayer Advanced® Concentrate Tree and Shrub Protect with Feed	Imidacloprid
	BlackFlag	Black Flag® Spider and Scorpion Killer	Prallethrin, Lambda-Cyhalothrin
	GardenTech Inc.	Sevin® Dust Garden Insect Killer Shaker Canister	Carbaryl
	Scotts	Ortho® Home Defense Max Ready-to-Use Insect Killer Granules	Bifenthrin, Zeta-Cyfluthrin
	PF Harris	Harris® Asian Lady Bettle and Box-Elder Bug Killer	Deltamethrin
	Spectrum Brand	Triazicide® Concentrate Lawn and Landscape Insect Killer	Gamma-Cyhalothrin
	United Industries Corporatio	HotShot Cutter® Bug Free Backyard Hose End Sprayer	Lambda-Cyhalothrin
	Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	Pyrethrins

G-13: WELL 13 SURVEY

How long have you lived at this location? 7-10 years
How many times a season do you use pesticides? 2 times a season; spring, summer, fall
Do you hire a lawn care company or self apply? Self apply

Summary of some popular pesticide brands and their active ingredients in Wisconsin market

	Producer	Commercial Name	Active Ingredient(s)
Herbicide	***Bayer***	***DuraZone® Weed and Grass Killer***	***Indaziflam, Diquat Bibromide***
	Bayer	***Bayer Advanced® Weed Killer for Lawn***	***2,4-D, MCPP, Dicamba***
	Bonide	Weed Beater® Ultra Weed Killer	MCPA, MCPP, Dicamba, Carfentrazone-ethyl
	Gordon's	Speed Zone® Lawn Weed Killer	2,4-D, MCPP, Dicamba, Carfentrazone-ethyl
	Lebanon Seaboard Corporation	Preen® Garden Weed Preventer	Trifluralin
	Scotts	***Ortho® Weed B Gon***	***MCPA, Triclopyr, Dicamba***
	Scotts	Roundup® Max Control 365 Weed Killer	Glyphosate, Diquat Dibromide, Imazapyr
	Scotts	Ortho® Weed B Gon Max Plus Crabgrass Killer	MCPP, 2,4-D, Dicamba
	Spectrum Brand	***Spectracide® Weed and Grass Killer***	***Diquat Dibromide***
	Vigoro	Vigoro® Concentrate Weed and Feed	2,4-D, Dicamba, MCPP
	Producer	**Commercial Name**	**Active Ingredient(s)**
Insecticide	Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	Zeta-Cypermethrin
	Bayer	Bayer Advanced® Concentrate Tree and Shrub Protect with Feed	Imidacloprid
	BlackFlag	Black Flag® Spider and Scorpion Killer	Prallethrin, Lambda-Cyhalothrin
	GardenTech Inc.	Sevin® Dust Garden Insect Killer Shaker Canister	Carbaryl
	Scotts	***Ortho® Home Defense Max Ready-to-Use Insect Killer Granules***	***Bifenthrin, Zeta-Cyfluthrin***
	PF Harris	Harris® Asian Lady Bettle and Box-Elder Bug Killer	Deltamethrin
	Spectrum Brand	***Triazicide® Concentrate Lawn and Landscape Insect Killer***	***Gamma-Cyhalothrin***
	United Industries Corporatio	HotShot Cutter® Bug Free Backyard Hose End Sprayer	Lambda-Cyhalothrin
	Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	Pyrethrins

Not Listed		
	Mosquito Repellant	***Malathion***

G-14: WELL 14 SURVEY

How long have you lived at this location? 1-3 years
How many times a season do you use pesticides? 2 times a season; spring, summer, fall
Do you hire a lawn care company or self apply? NatureScape Lawn and Landscape Care (5 Step Application Program)

Summary of some popular pesticide brands and their active ingredients in Wisconsin market

	Producer	Commercial Name	Active Ingredient(s)
Herbicide	Bayer	DuraZone® Weed and Grass Killer	Indaziflam, Diquat Bibromide
	Bayer	Bayer Advanced® Weed Killer for Lawn	2,4-D, MCPP, Dicamba
	Bonide	Weed Beater® Ultra Weed Killer	MCPA, MCPP, Dicamba, Carfentrazone-ethyl
	Gordon's	Speed Zone® Lawn Weed Killer	2,4-D, MCPP, Dicamba, Carfentrazone-ethyl
	Lebanon Seaboard Corporation	Preen® Garden Weed Preventer	Trifluralin
	Scotts	Ortho® Weed B Gon	MCPA, Triclopyr, Dicamba
	Scotts	Roundup® Max Control 365 Weed Killer	Glyphosate, Diquat Dibromide, Imazapyr
	Scotts	Ortho® Weed B Gon Max Plus Crabgrass Killer	MCPP, 2,4-D, Dicamba
	Spectrum Brand	Spectracide® Weed and Grass Killer	Diquat Dibromide
	Vigoro	Vigoro® Concentrate Weed and Feed	2,4-D, Dicamba, MCPP
	Producer	**Commercial Name**	**Active Ingredient(s)**
Insecticide	Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	Zeta-Cypermethrin
	Bayer	Bayer Advanced® Concentrate Tree and Shrub Protect with Feed	Imidacloprid
	BlackFlag	Black Flag® Spider and Scorpion Killer	Prallethrin, Lambda-Cyhalothrin
	GardenTech Inc.	Sevin® Dust Garden Insect Killer Shaker Canister	Carbaryl
	Scotts	Ortho® Home Defense Max Ready-to-Use Insect Killer Granules	Bifenthrin, Zeta-Cyfluthrin
	PF Harris	Harris® Asian Lady Bettle and Box-Elder Bug Killer	Deltamethrin
	Spectrum Brand	Triazicide® Concentrate Lawn and Landscape Insect Killer	Gamma-Cyhalothrin
	United Industries Corporatio	HotShot Cutter® Bug Free Backyard Hose End Sprayer	Lambda-Cyhalothrin
	Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	Pyrethrins

G-15: WELL 15 SURVEY

How long have you lived at this location? 1-3 years (Not lived in - Under Renovation)
How many times a season do you use pesticides? N.A.
Do you hire a lawn care company or self apply? N.A.

Summary of some popular pesticide brands and their active ingredients in Wisconsin market

	Producer	Commercial Name	Active Ingredient(s)
Herbicide	Bayer	DuraZone® Weed and Grass Killer	Indaziflam, Diquat Bibromide
	Bayer	Bayer Advanced® Weed Killer for Lawn	2,4-D, MCPP, Dicamba
	Bonide	Weed Beater® Ultra Weed Killer	MCPA, MCPP, Dicamba, Carfentrazone-ethyl
	Gordon's	Speed Zone® Lawn Weed Killer	2,4-D, MCPP, Dicamba, Carfentrazone-ethyl
	Lebanon Seaboard Corporation	Preen® Garden Weed Preventer	Trifluralin
	Scotts	Ortho® Weed B Gon	MCPA, Triclopyr, Dicamba
	Scotts	Roundup® Max Control 365 Weed Killer	Glyphosate, Diquat Dibromide, Imazapyr
	Scotts	Ortho® Weed B Gon Max Plus Crabgrass Killer	MCPP, 2,4-D, Dicamba
	Spectrum Brand	Spectracide® Weed and Grass Killer	Diquat Dibromide
	Vigoro	Vigoro® Concentrate Weed and Feed	2,4-D, Dicamba, MCPP
	Producer	**Commercial Name**	**Active Ingredient(s)**
Insecticide	Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	Zeta-Cypermethrin
	Bayer	Bayer Advanced® Concentrate Tree and Shrub Protect with Feed	Imidacloprid
	BlackFlag	Black Flag® Spider and Scorpion Killer	Prallethrin, Lambda-Cyhalothrin
	GardenTech Inc.	Sevin® Dust Garden Insect Killer Shaker Canister	Carbaryl
	Scotts	Ortho® Home Defense Max Ready-to-Use Insect Killer Granules	Bifenthrin, Zeta-Cyfluthrin
	PF Harris	Harris® Asian Lady Bettle and Box-Elder Bug Killer	Deltamethrin
	Spectrum Brand	Triazicide® Concentrate Lawn and Landscape Insect Killer	Gamma-Cyhalothrin
	United Industries Corporatio	HotShot Cutter® Bug Free Backyard Hose End Sprayer	Lambda-Cyhalothrin
	Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	Pyrethrins

G-16: WELL 16 SURVEY

How long have you lived at this location? 10+ Years
How many times a season do you use pesticides? Yes, 3 times a season (spring, summer, fall)
Do you hire a lawn care company or self apply? Hire a company - Not stated Self Application (as needed)

Summary of some popular pesticide brands and their active ingredients in Wisconsin market

	Producer	Commercial Name	Active Ingredient(s)
Herbicide	Bayer	DuraZone® Weed and Grass Killer	Indaziflam, Diquat Bibromide
	Bayer	Bayer Advanced® Weed Killer for Lawn	2,4-D, MCPP, Dicamba
	Bonide	Weed Beater® Ultra Weed Killer	MCPA, MCPP, Dicamba, Carfentrazone-ethyl
	Gordon's	Speed Zone® Lawn Weed Killer	2,4-D, MCPP, Dicamba, Carfentrazone-ethyl
	Lebanon Seaboard Corporation	Preen® Garden Weed Preventer	Trifluralin
	Scotts	Ortho® Weed B Gon	MCPA, Triclopyr, Dicamba
	Scotts	Roundup® Max Control 365 Weed Killer	Glyphosate, Diquat Dibromide, Imazapyr
	Scotts	***Ortho® Weed B Gon Max Plus Crabgrass Killer***	***MCPP, 2,4-D, Dicamba***
	Spectrum Brand	Spectracide® Weed and Grass Killer	Diquat Dibromide
	Vigoro	Vigoro® Concentrate Weed and Feed	2,4-D, Dicamba, MCPP
	Producer	**Commercial Name**	**Active Ingredient(s)**
Insecticide	Ambrands	Amdro® Quick Kill Lawn and Landscape Insect Killer	Zeta-Cypermethrin
	Bayer	***Bayer Advanced® Concentrate Tree and Shrub Protect with Feed***	***Imidacloprid***
	BlackFlag	Black Flag® Spider and Scorpion Killer	Prallethrin, Lambda-Cyhalothrin
	GardenTech Inc.	Sevin® Dust Garden Insect Killer Shaker Canister	Carbaryl
	Scotts	Ortho® Home Defense Max Ready-to-Use Insect Killer Granules	Bifenthrin, Zeta-Cyfluthrin
	PF Harris	Harris® Asian Lady Bettle and Box-Elder Bug Killer	Deltamethrin
	Spectrum Brand	Triazicide® Concentrate Lawn and Landscape Insect Killer	Gamma-Cyhalothrin
	United Industries Corporation	HotShot Cutter® Bug Free Backyard Hose End Sprayer	Lambda-Cyhalothrin
	Woodstream Corporation	Safer Brand® Tomato & Vegetable Insect Killer	Pyrethrins

Not Listed		
	Repel® Camp Shield Outdoor Insect Control	***Tetramethrin, Phenothrin***

APPENDIX H

WORLD HEALTH ORGANIZATION ACUTE HAZARD RANKINGS BASED OFF RAT LD_{50}

(WHO, 2010)

WHO Toxicity Classification			Rat LD_{50} (mg of chemical per kg of body weight)			
Class	**Description**		**Solids (oral)**	**Liquids (oral)**	**Solids (dermal)**	**Liquids (dermal)**
Ia	Extremely Hazardous		< 5	< 20	< 10	< 40
Ib	Highly Hazardous		5-50	20-200	10-100	40-400
II	Moderately Hazardous		50-500	200-2,000	100-1,000	400-4,000
III	Slightly Hazardous		> 500	> 2,000	> 1,000	> 4,000
Table 5	Unlikely to present acute hazard in normal use		> 2,000	> 3,000		
Table 6	Not classified: believed obsolete					
Table 7	Fumigants not classified by WHO					

Reference: *The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 2004*, World Health Organization, May 2010