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PRAIRIE PROVINCES WATER BOARD

Report #184

Review of Pesticide Regulations, Monitoring Programs and Concentrations of Acid Herbicides in Transboundary Prairie Rivers

Prepared for the Prairie Provinces Water Board
By the Committee on Water Quality

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Review of Pesticide Regulations, Monitoring Programs and Concentrations of Acid Herbicides in Transboundary Prairie Rivers

Prepared for the Prairie Provinces Water Board, in Response to the 2011 Pesticide Excursions in Transboundary Rivers.

PREPARED BY COMMITEEE ON WATER QUALITY

Executive Summary

In 1969, the governments of Alberta, Saskatchewan, Manitoba and Canada entered into the Master Agreement on Apportionment (MAA or Agreement). The Prairie Provinces Water Board (PPWB), which has a mandate to foster and facilitate interprovincial water quality management among the parties and to encourage the protection and restoration of the aquatic environment, administers the Agreement. As part of the Agreement the PPWB has established interprovincial water quality objectives (WQOs) on 12 eastward flowing transboundary rivers that cross the Alberta/Saskatchewan or Saskatchewan/Manitoba boundaries. Water quality objectives have been established for a wide range of parameters including nutrients, metals, major ions, general water chemistry, and pesticides and are agreed to by the provincial and federal governments that are party to the agreement. The objectives were established to protect all potential water uses of these rivers including the protection of aquatic life, agriculture uses (irrigation and livestock), recreation, fish consumption (for human and aquatic biota consumers), and source water treatability for drinking water. Therefore, to protect all water uses at each site, the lowest (most sensitive) available water use objective for each parameter was adopted by PPWB.

PPWB's interprovincial WQOs contain numerical objectives that have been established for 16 pesticides including pesticides within the acid herbicide, neutral herbicide and organochlorine groups. As part of its water quality program, PPWB undertakes regular and long-term water quality monitoring on the 12 transboundary rivers and through this program, has identified two pesticides within the acid herbicide group, notably dicamba and 2-methyl-4-chlorophenoxyacetic acid (MCPA), that regularly exceed the interprovincial WQOs. These objectives are adopted from the Canadian Environmental Quality Guidelines (CEQG) for irrigation water. This report is in response to exceedances of these pesticides and to understand and inform water quality risks from these and other pesticides..

In Canada, the Pest Management Regulatory Agency (PMRA) is the branch of Health Canada responsible for regulating pesticides nationally under the authority of the *Pest Control Products Act* (PCPA) and its Regulations. PMRA's primary mandate is to prevent unacceptable risks to Canadians and the environment from the use of pest control products. Before a pesticide can be registered for sale in Canada, pesticide applicants are required to provide the PMRA with extensive scientific data to show that their product poses an acceptable risk to health and the environment, and that the product has value. These data are reviewed by PMRA scientists to determine whether a product is acceptable for registration in Canada. The PMRA holds public consultations on their assessments prior to publishing final decisions. All registered pesticides have detailed product labels that provide information, guidance and directions for use and handling of the pest control product. These labels are legal documents and must be followed so that the product is used in a safe manner.

Once registered, pesticides on the market become subject to a system of post-market risk management control under the PCPA including re-evaluation, sales reporting, compliance and enforcement activities and reporting of health and environmental incidents.

In addition to federal regulations, the prairie provinces also have their own regulations on pesticide use within their boundaries. In Alberta, pesticides are regulated through *The Environmental Protection and Enhancement Act* (EPEA) and there are two regulations that apply to the management of pesticide use in the province: the Pesticide Sales, Handling, Use and Application Regulation and the Pesticide (Ministerial) Regulation. In Saskatchewan, pesticides are regulated provincially through *The Pest Control Products (Saskatchewan) Act* and Regulations and licenses commercial use of pesticides. Agriculture and domestic use are exempt from the licensing requirements, but not the labelling requirements for use. In Manitoba, there is a licensing program for persons/business that wish to apply or sell pesticides commercial/agricultural in nature. Manitoba Agriculture and Resource Development through the Pesticides and Manure Licensing Program, as required by Regulation under The Pesticides and Fertilizers Control Act, issue licenses to pesticide dealers and applicators and to manure applicators.

Long-term water quality monitoring programs, incorporating routine monitoring of pesticides, are undertaken federally and provincially throughout the prairies. Environment and Climate Change Canada (ECCC) conducts water quality monitoring primarily on international (Canada/United States) and inter-provincial (AB/SK/MB/ON) boundaries. Pesticide monitoring by provincial jurisdictions on the prairies is predominately conducted on mainstems or larger tributary reaches of rivers.

From 2008 to 2017 water quality monitoring at the international and interprovincial boundaries, included 18 water quality sites and tested for 20 different acid herbicides. For these inter-jurisdictional rivers all of the acid herbicides analyzed were detected with 2,4-dichlorophenoxyacetic acid (2,4-D) being detected the most frequently, followed by clopyralid and 2-methyl-4-chlorophenoxyacetic acid (MCPA). Five acid-herbicides: 2,4-D, bromoxynil, dicamba, MCPA and picloram have interprovincial water quality objectives (WQOs). Exceedances of these objectives were found for MCPA and dicamba, with MCPA having a higher exceedance rate for the PPWB interprovincial water quality monitoring sites.

Alberta Environment and Parks (AEP) routinely monitors for 14 acid herbicides from mainstem and tributaries of Alberta's streams. Among the 14 acid herbicides, 2,4-D was the most frequently detected, followed by MCPA, 2-(2-Methyl-4-chlorophenoxy)propionic acid (MCPP), picloram, dicamba, triclopyr, clopyralid and bromoxynil. Generally, MCPA was detected at a higher frequency than dicamba in all the mainstem reaches, but dicamba exceeded the WQOs more frequently than MCPA.

Saskatchewan undertakes routine water quality monitoring of pesticides at 24 sites on mainstem streams throughout the province to understand risks to aquatic life from acid herbicides. The province also undertakes non-routine monitoring of pesticides in aquatic environments that supports collaborative studies evaluating pesticides in provincial waters. For the routine monitoring, acid herbicides are sampled seasonally for eight acid herbicides including MCPA and dicamba. However, the analytical detection limits for these two acid herbicides are higher than the PPWB interprovincial WQOs and hence cannot be directly compared to these objectives. Neither dicamba nor MCPA were detected in Saskatchewan's routine monitoring between 2007 and 2017. However, trace-level monitoring at select locations found detections of most acid herbicides tested, with the exception of products that have not recently been used. The frequency of samples exceeding the interprovincial WQOs for dicamba and MCPA was 21% and 18%, respectively. 2,4-D, was also frequently detected and had a maximum concentration greater than those measured for dicamba and MCPA.

Manitoba has monitored pesticides in surface water since the early 1980s as a part of its routine long-term water quality monitoring program and watershed studies. There are 46 historic pesticide monitoring sites and currently 53 pesticides are analyzed including chlorinated phenols, acid herbicides, organochlorine pesticides, carbamate pesticides, organo-nitrogen pesticides and sulfonylurea herbicides.

From 2008 to 2017, Manitoba has monitored 21 acid herbicides in rivers and streams. Of these 21 acid herbicides, nine were detected in Manitoba rivers including 2,4-D, 4-(2,4-dichlorophenoxy)butyric acid (2,4-DB), bromoxynil, dicamba, dichlorprop, imazamethabenz-methyl, MCPA, MCPP and triclopyr. The most commonly detected acid herbicides were 2,4-D, dicamba, MCPA and imazamethabenz-methyl with detection rates of 17%, 17%, 17%, and 13%, respectively. Dicamba and MCPA were the two acid herbicides that most frequently exceeded the WQOs in Manitoba rivers and streams from 2009 to 2017. Generally, as you move east from Alberta to Manitoba there is an increase in the percentage of MCPA and dicamba exceedances to the WQOs.

In addition to reviewing long-term monitoring programs conducted both federally and provincially, this report reviewed several federal programs related to pesticides in water. The projects reviewed were studies conducted by the federal government, where both dicamba and MCPA were included since these herbicides are a focus of this report.

Several of these studies identified the presence of pesticides, including MCPA and dicamba, at low levels in air, rainfall, groundwater and other water matrices including wetlands, snow and irrigation waters. Other studies have tried to assess the effect of acid herbicides on sensitive crops that can be affected by low concentrations of these herbicides in irrigation water. In a study in the early 2000s, a mixture of four acid herbicides (2,4-D, bromoxynil, MCPA and dicamba), each at their maximum rainfall rate were sprayed on plants once and assessed 10 to 14 days later. This study demonstrated that this mixture of herbicides could affect certain crops (dry bean and tomato), while having no significant effects on others crops such as potato and sugar beet. This study demonstrates that at potential environmentally relevant concentrations pesticide mixtures can have an effect on more sensitive crops.

Since pesticides are used extensively throughout the prairies, their input into waterways is frequently associated with non-point pollution from agriculture. However, a recent study in Alberta has highlighted the importance of residential sources of herbicides such as 2,4-D, dicamba and MCPA for explaining concentrations in rivers below urban centres. Similarly, in Saskatchewan the influence of the two largest cities in the province, Regina (Qu'Appelle River) and Saskatoon (South Saskatchewan River), have also shown increased pesticide concentrations downstream of these cities. Given the presence of pesticides in riverine systems downstream of large urban centres, it is not surprising that a number of studies have also identified the presence of pesticides, including acid herbicides, in urban stormwater.

Recommendations resulting from this review of pesticides in prairie rivers that assessed both federal and provincial pesticide monitoring program are as follows:

1. The PPWB water quality objectives for MCPA and dicamba are irrigation objectives and were established based on the highest recommended application rate for the most sensitive crops. No reports have been received by any jurisdictional government regarding possible negative effects from irrigation water on sensitive crops. These are selectively toxic chemicals and applied on a regular basis and so are not natural to river waters. The PPWB anticipates a low number of exceedances to these two irrigation-based objectives will occur. As such it recommends continued monitoring, retaining and reporting against these objectives with periodic assessment of potential effects to aquatic life and other water uses, including irrigation.
2. The Committee on Water Quality recommends that PPWB share this report with the Pesticide Management Regulatory Agency (PMRA) with the following observations and recommendations:
    a. MCPA and dicamba are being detected in aquatic systems across the prairies and at concentrations exceeding the PPWB Interprovincial Water Quality Objectives set to protect all water uses, the most sensitive of which are irrigated crops. PMRA could consider a review of use of MCPA and dicamba to consider whether directions for use, handling, and applications near water require updates to protect downstream irrigators that make use of the water.
    b. Work on pesticide mixtures also highlights detections of MCPA and dicamba. PMRA could consider if regulatory requirements for MCPA and dicamba need to reflect the potential impacts of pesticide mixtures on riverine systems and different water uses.
    a. PMRA has aquatic life reference values (ALRVs) for protection of aquatic life. ALRVS and their derivation protocols should be made publicly available.
3. The Committee on Water Quality recommends that PPWB share this report with CCME and in particular with committees and/or working groups developing water quality guidelines.
    a. PPWB and member agencies recommend that priority should be given to guideline development for the acid herbicides that are frequently detected in prairie waters and for which there are no guidelines including clopyralid, 4-(4-chloro-2-methylphenoxy)butyric acid (MCPB), and triclopyr as they are ubiquitous throughout the prairies. Without published guidelines the risk to aquatic life and irrigated crops cannot be evaluated.
    b. There is a strong need to further understand the effect of pesticide mixtures and their potential impacts to the aquatic environment.
4. The Committee on Water Quality recommends that the interprovincial WQOs of other pesticides within the acid group that are based on protection of aquatic life should be met at the transboundary sites for the protection of aquatic life in these

rivers. Concentrations above these levels can affect aquatic health of these ecosystems.

5. The Committee on Water Quality recommends that glyphosate and aminomethylphosphonic acid (AMPA) should continue to be monitored and detections reported. In its 2015 water quality objective review COWQ discussed studies showing that the toxicity of non-active ingredients used in glyphosate products, including surfactants, can be greater than glyphosate. Such products include the surfactant polyoxyethylene amines (POEA), which is a chemically complex group. There are analytical limitations for undertaking routine analyses of these compounds given their chemical diversity and the different formulations of agronomic products.

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Introduction and Background

Introduction

The Prairie Provinces Water Board (PPWB) undertakes regular and long-term water quality monitoring of eastward-flowing transboundary prairie rivers. Through this monitoring program, PPWB has identified exceedances of certain pesticides, notably dicamba and MCPA, of the recently updated PPWB water quality objectives (PPWB Report #174, 2015). This report was undertaken in response to these exceedances to better understand and inform on water quality risks. Acid herbicides, including dicamba and MCPA, are among the most used group of agricultural pesticides on the prairies (Malaj et al. 2020).

Alberta, Saskatchewan and Manitoba comprise the prairie provinces in western Canada. The prairie provinces represent the largest agriculturally productive region in Canada, with cereals, oilseeds, pulses, forage and livestock as the major agricultural products. Other crops can be regionally important in the prairies, notably vegetable and specialty crops, which are often associated with irrigation.

Pesticides are used to control a range of pests including weeds, insects and fungi. These products are used within a number of sectors including the agriculture sector, commercial users and by individuals for domestic use. In 2018, 658 active ingredients were registered for use in Canada representing 7707 pesticide products (Health Canada 2020). Pesticide sales in Canada, in 2017, amounted to 132 million kg of active ingredient of which 73.4% of this was sold for use in the agriculture sector (Health Canada 2020).

Given the vast agricultural landscape of the prairie provinces, more than half of the pesticides sold in Canada annually are used in the prairies (Environment Canada 2011). Of all the different groups of pesticides, herbicides account for the majority of the pesticides applied in the prairie region (Environment Canada 2011, Messing et al. 2011). In 2017, of all farms reporting field crop production in the prairie provinces, 92 to 98% reported using herbicides, depending on the province (Statistics Canada, 2019). In Canada, 153 herbicide products have been approved for use, and this includes 55 active ingredients that can be used singularly or in mixtures (Donald et al. 2018).

The acid herbicide group of pesticides has frequently been detected in prairie waterbodies including wetlands, reservoirs, river and streams (Donald et al. 2018; Glozier et al. 2012, Degenhardt et al. 2011, Donald et al. 2007, Waite et al. 2004). Two of these herbicides, dicamba and 2-methyl-4-chlorophenoxyacetic acid (MCPA), are used extensively throughout the prairie region and have irrigation water quality guidelines (WQGs) for sensitive vegetable crops. The WQG for irrigation are sufficiently low that concentrations of these chemicals in ambient surface water have been observed to exceed the most-sensitive use level. Pesticides can enter waterways through direct runoff or through wet and dry deposition (Degenhardt et al. 2011, Messing et al. 2011).

Background

The Master Agreement on Apportionment (MAA) was signed by the governments of Alberta, Saskatchewan, Manitoba and the Government of Canada in October 1969. The agreement provides equitable sharing of eastward flowing streams across interprovincial boundaries. The PPWB was established to administer the agreement and report on findings and accomplishments to governments. In 1992, the agreement was amended to include Schedule E, a water quality agreement that defines the mandate and roles of the PPWB in interprovincial water quality management. As part of Schedule E, water quality objectives were adopted for transboundary rivers.

Interprovincial WQOs are descriptions of water quality conditions that are known to protect specific water uses and are acceptable to upstream and downstream provinces. The interprovincial WQOs for the twelve transboundary rivers monitored and reported on by the PPWB were last updated in 2019 and officially came into effect on July 26th, 2021 (PPWB Report #182, 2021). The 2019 update followed a comprehensive objectives review in 2015 (PPWB Report #174, 2015). During the 2019 and 2015 reviews, 72 objectives were established for the twelve interprovincial river reaches. Water quality objectives were established for a range of water quality parameters including nutrients, major ions, metals, pesticides, and general water chemistry (total dissolved solids, pH, dissolved oxygen, sodium adsorption ratio). Objectives were established to protect a range of water uses including: protection of aquatic life (PAL), agricultural uses, (irrigation and livestock uses), recreation, fish consumption (for human and aquatic biota consumers), and source water treatability for drinking water.

In 2015, the PPWB adopted two approaches for establishing interprovincial WQOs for the transboundary river reaches. These are, i) adopt the most protective appropriate water quality guideline/objective for each site from existing guidelines/objectives used federally, or within the prairie provinces, or ii) where there was no appropriate guideline/objective, develop a background approach based on historic ambient water quality data (PPWB Report #174, 2015).

The interprovincial WQOs include numerical objectives for 16 pesticides on 12 transboundary rivers. This includes three groups of pesticides: acid herbicides, neutral herbicides, and organochlorine insecticides. The WQOs were established based on WQGs for either the protection of aquatic life or agricultural uses (irrigation or livestock watering) and selecting the most sensitive guideline to protect all rivers for all water uses. Glyphosate is also included in PPWB reporting. Unlike the other pesticides with objectives, glyphosate is reported as frequency of detections rather than against a numerical objective. Glyphosate is a non-specific herbicide and is used extensively throughout the prairie region. The current CCME PAL guideline for glyphosate is 800 µg/L, but given its extensive use, different glyphosate formulations, which contain surfactants that might be more toxic than glyphosate, combined with varying jurisdictional guidelines/objectives and some research evidence that suggests glyphosate products at low levels can impact the aquatic environment (David Donald personnel communication 2012), the Committee on Water Quality (COWQ) opted to report detections of glyphosate rather than adopt and report against the CCME PAL guideline. The COWQ also includes reporting detections of aminomethylphoshonic acid

(AMPA), one of the primary metabolites of glyphosate. Glyphosate and AMPA are frequently detected in prairie rivers and often concentrations of AMPA are higher than concentrations of glyphosate.

The COWQ reviewed PPWB pesticide data in 2014 and concluded that of the three groups of pesticides monitored by the PPWB, the acid herbicides had the greatest number of excursions to the WQOs (PPWB 2016). The review assessed data from 1991 to 2013 and determined that of the acid herbicides monitored MCPA and dicamba had the greatest number of excursions. The corresponding WQOs for these two acid herbicides are based on the WQG for the most sensitive use, which is irrigation, specifically protecting lettuce (MCPA) and sunflower (dicamba). The guideline is based on the highest recommended level of pesticide in irrigation water. The interprovincial WQO for MCPA is 0.025 µg/L and for dicamba is 0.006 µg/L.

The internal PPWB review of pesticides made several recommendations including follow-up from each of the jurisdictions on their awareness and occurrence of MCPA and dicamba in rivers within their jurisdictions, review of provincial pesticide data and a report back to the PPWB, as well as, any actions/programs that are being implemented to address these pesticides. The review also recommended that the frequency of the acid herbicide monitoring be increased to annual monitoring from rotational — monitoring (once every four years) — on six of the interprovincial rivers (Battle, Red Deer (Bindloss), South Saskatchewan, North Saskatchewan, Saskatchewan and Qu'Appelle) and be maintained as annual monitoring on the Assiniboine and Carrot rivers. The remaining four rivers (Beaver, Cold, Churchill, and Red Deer, MB) would retain the 4 year pesticide monitoring rotation.

Objectives and Scope of this Report

This report provides the jurisdictional summaries from the three prairie provinces and the Government of Canada. The report incorporates the different regulations and governance of pesticide use in Canada, pesticide-monitoring programs undertaken by each of the provinces, and federal government. This report also examines the concentrations of acid herbicides observed in prairie streams with a focus on MCPA and dicamba. Several other areas included the effects of low levels of pesticides in waterways and contributions of pesticides to waterways from urban centres. The report provides recommendations related to pesticides in interprovincial watercourses and ongoing monitoring and reporting.

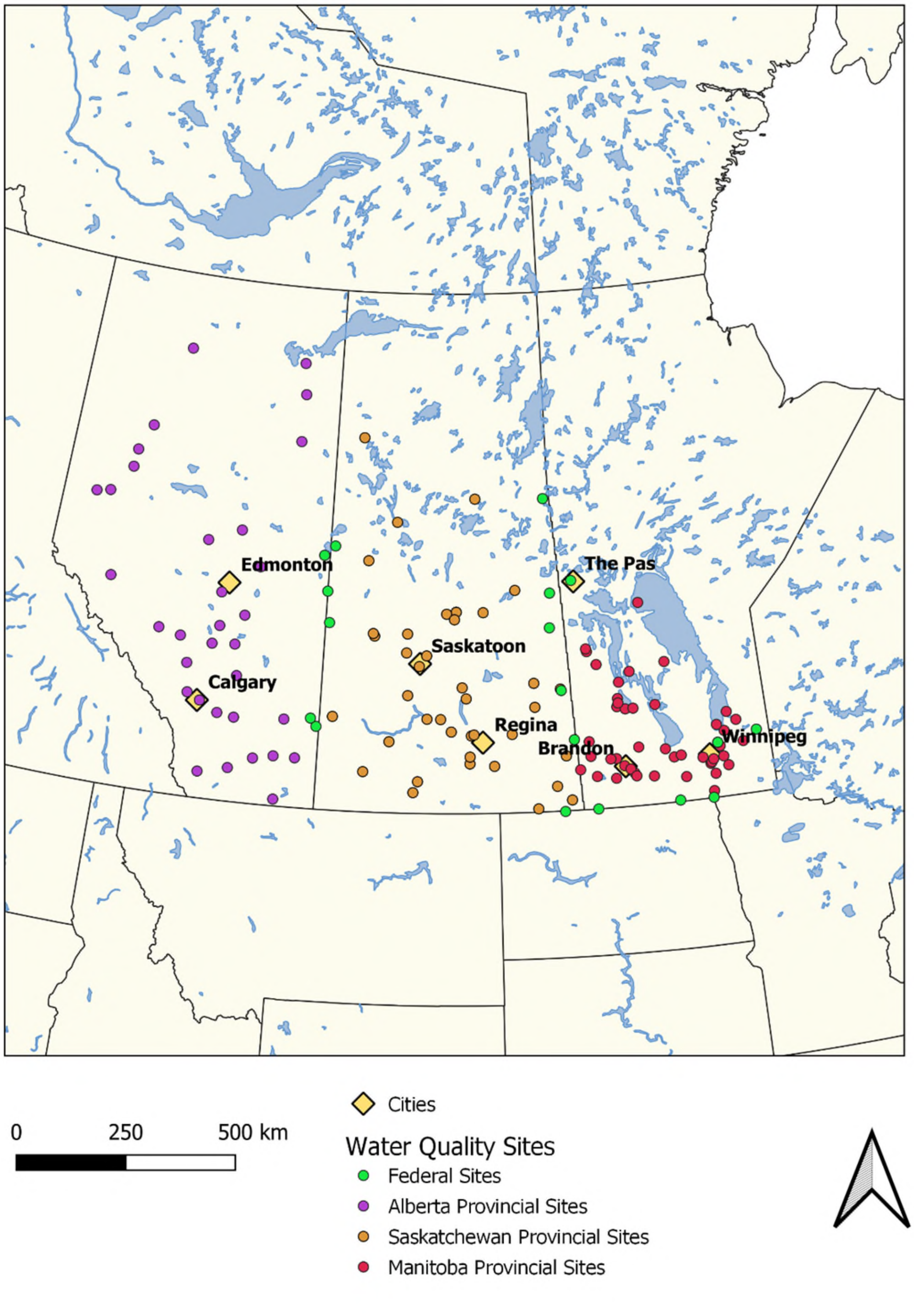

Figure 1 Water Quality Monitoring Locations across the Canadian Prairies.

Federal

Pesticide Management Policies/Regulations

Regulatory process for registrants and their products before a given active ingredient and its formulations are approved for use in Canada

Products sold in Canada with a claim of controlling or reducing pests are regulated by *The Pest Control Products Act* and Regulations, which are implemented by Health Canada's Pest Management Regulatory Agency (PMRA).

For a pesticide to be approved in Canada, registrants have to demonstrate that the product is safe for human health and the environment and have value (i.e., is efficacious as claimed on the label). To show this, registrants have to submit data developed with standardized protocols, which are to a large extent harmonized among Canada, United States, European Union and other OECD member countries. Data requirements are grouped into broad categories including:

- Product chemistry (characterization of the compound(s) and manufacturing)
- Toxicology (human toxicology — in animal models)
- Exposure (occupational and bystander exposure)
- Metabolism and toxicokinetics
- Residue (in food and feed, etc.)
- Environmental chemistry and fate
- Environmental toxicology
- Value (efficacy and other considerations)

Within these categories, there are multiple studies required, and many of these requirements are tiered (that is, if Tier I indicates a concern, this triggers Tier II, and so on). As an example, if lab contact or hive study with bees indicates concern, a more complex field study may be required.

These data requirements are described in DACO tables (data code) and can be found here for different use patterns.

https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management/registrants-applicants/product-application/use-site-category-daco-tables/agriculture-forestry-pesticides.html

Each data code will be marked R (required), CR (conditionally required), or NR (not required). An R means that the data point needs to be addressed with either a standardized study, which needs to be carried out under Good Laboratory Practices (GLP) for certain categories (such as toxicology, environment), or in some cases, a scientific waiver rationale or literature review may be sufficient. Lower risk compounds fall into the non-conventional category, which has reduced data requirements.

Decisions are made on the basis of risk, not hazard (e.g., the toxicity and likelihood of exposure). The PMRA publishes detailed documents explaining the findings and the proposed registration decision that is then open for public comment. Those decisions can be found at http://publications.gc.ca/site/eng/9.504464/issues.html.

Before making a submission, registrants usually have a pre-submission consultation meeting with the PMRA where the nature of the product and data requirements are discussed. The companies also pay review fees to support the cost of the regulatory reviews by the PMRA (from $20,000 to 30,000 for a low-sales non-conventional to several $100,000 for a new conventional chemical).

Re-evaluation process and decision

The re-evaluation process is described at the following link: https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management/public/protecting-your-health-environment/pesticide-registration-process/reevaluation-program.html

In short, by law, every registration has to be reviewed every 15 years to ensure that the risk a product poses is still acceptable as science has evolved. A special review before the mandatory 15-year period can be triggered by new evidence of a concern, a cancellation of a product by another regulatory body, or a scientifically founded concern raised by a member of the public. Decisions are based on the science and can also include other considerations.

Pesticide Incident Reports

Information on pesticide incident reporting to the PMRA is described in the following link: https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management/public/protecting-your-health-environment/report-pesticide-incident.html

Registrants must report to the PMRA any information about incidents involving their pest control product as it relates to human health, the environment or value. Canadians can also voluntarily report pesticide incidents to the PMRA. A collection of incident information allows for the monitoring of pesticide effects under realistic conditions. The PMRA uses information received through this program as further evidence in its risk assessments for humans, animals, (pets or livestock) and the environment (plants or wildlife) and in its registration decisions

Federal and Provincial Responsibilities for Regular and Minor Uses Products (MUPs)

All pesticides must be registered federally, but provinces can impose stricter limits and regulate other aspects, such as disposal, etc.

For minor uses, the provinces or Agriculture and Agri-Food Canada (AAFC) can submit URMULEs (user requested minor use label expansions) on behalf of growers. These are then reviewed by the PMRA (typically efficacy and pesticide residue on the crop) and decisions made. The company can then add it to their label. Minor Use label expansions can only be done in the same use site category (e.g., Green House food crops), as adding a use in a category currently not registered will require a full scientific risk assessment by the PMRA.

Compliance and Enforcement
The process is described here:

https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management/public/protecting-your-health-environment/compliance-enforcement.html.

Water Quality Monitoring for Pesticides in the Prairies

Environment and Climate Change Canada (ECCC) conducts water quality monitoring on the prairies at sites that support the federal mandate. The locations are primarily on international (Canada/Unites States) and interprovincial (AB/SK/MB/ON) boundaries. Information from these sites supports water quality management under the Prairie Provinces Water Board, boards that support the International Joint Commission (Red River, Souris River), and the Canada-Manitoba agreement (Table 1, Figure 2).

Table 1 Environment and Climate Change Monitoring Sites.

Station No.	Station Name	Latitude	Longitude
US05ND0004	Souris River near Sherwood North Dakota	48.99000	-101.95778
SA05JM0014	Qu'Appelle River approx. 3.2km. South*	50.48389	-101.54306
US05NF0001	Souris River near Westhope	48.99972	-100.90000
SA05MD0002	Assiniboine River at Hwy 8 Bridge*	51.53306	-101.88889
MA05OB0001	Pembina River at Windygates, Manitoba	49.03139	-98.27778
AL05AK0001	South Saskatchewan River at Hwy 41,*	50.73750	-110.09556
SA05KH0002	Carrot River near Turnberry,*	53.60000	-102.11667
AL05CK0001	Red Deer River near Bindloss, Alberta*	50.90278	-110.29694
MA05KH0001	Saskatchewan River above Carrot River*	53.84167	-101.33444
MA05OC0001	Red River at Emerson, Manitoba	49.00806	-97.21083
SA05FE0001	Battle River near Unwin, Saskatchewan*	52.94028	-109.87333
SA06AF0001	Cold River at Outlet of Cold Lake*	54.56667	-109.83611
MA05OJ0001	Red River at Selkirk, Manitoba	50.14167	-96.86778
AL06AD0001	Beaver River at Beaver Crossing,*	54.35417	-110.21194
SA06EA0003	Churchill River below Wasawakasik*	55.60806	-102.19556
SA05LC0001	Red Deer River at Erwood,*	52.86667	-102.18306
AL05EF0003	North Saskatchewan River at Highway #17 Bridge*	53.60139	-110.00833
MA05PF0022	Winnipeg River at Pointe Du Bois	50.30083	-95.55556

Note: PPWB sites denoted by an *

Monitoring on the international boundary includes the Souris, Red and Pembina rivers. The Ontario/Manitoba boundary monitoring includes the Winnipeg River. The Saskatchewan/Manitoba boundary rivers include the Churchill, Saskatchewan, Carrot, Red Deer (Erwood), Assiniboine and Qu'Appelle rivers. The Saskatchewan/Alberta monitoring occurs at the Cold River, Beaver, North Saskatchewan, Battle, Red Deer (Bindloss) and South Saskatchewan rivers.

Figure 2 **Environment Canada and Climate Change Interprovinical Water Quality Monitoring Stations.**

Acid Herbicides

From 2008 to 2017, ECCC sampled 18 sites, collecting a total of 855 samples, and, tested for 20 acid herbicides. All 20 of the acid herbicides were detected. Five (2,4-D, bromoxynil, dicamba, MCPA, picloram) have water quality objectives under the PPWB. Exceedances of these objectives were detected for dicamba and MCPA.
The pesticides with the highest frequency of detection were 2,4-D (84%, n=855), clopyralid (83%, n=855), and MCPA (76%, n=855) (Table 2). It is important to note that as testing protocols and lab instrumentation improved with time, the frequency of detection increased; however, this increase does not necessarily reflect a change in environmental concentrations.

The PPWB water quality objective for dicamba is 6 ng/L based on irrigation of sensitive crops. The maximum dicamba value (408 ng/L, July 2017) was measured in the Red River at Emerson, with the next highest values at the Red River at Selkirk (355 ng/L, July 2018), and the Souris River near Westhope (180 ng/L, July 2018).

Similarly, MCPA has a PPWB irrigation water quality objective of 25 ng/L. The maximum MCPA concentration was measured in the Assiniboine River at Hwy 8 (489 ng/L, July 2014). High concentrations of MCPA were also detected in the Red River at Emerson (404 ng/L, June 2014), the South Saskatchewan River (363 ng/L, June 2010) and the Carrot River near Turnberry (304 ng/L, June 2012). Table 3 illustrates the maximum concentrations measured for all the acid herbicides that have PPWB water quality objectives. It should be noted that while this report focuses on a comparison of results to the interprovincial WQOs, the interprovincial water quality objectives are not used for reporting results for non-PPWB sites such as the Red R., Pembina and Souris rivers.

Dicamba was detected in 36% (n=855) of samples, and exceedances were found in 14% (n=855) of samples. Dicamba was detected with the highest magnitude and frequency at international boundaries. Although, dicamba significantly exceeded the irrigation guideline, no deleterious effects were reported by downstream agricultural producers. MCPA was detected in 76% (n=855) of samples, and 13% (n=855) of samples exceeded the water quality objective of 25 ng/L. High frequencies of exceedances of MCPA were found at the Red River at Selkirk, (40%, n=20), Assiniboine River (27%, n=126), Qu'Appelle River (26%, n=46), and Carrot River near Turnberry (14%, n=122).

2,4-D, while not exceeding its objective, was detected 100% of the time in the Qu'Appelle, Saskatchewan, and the Souris (Sherwood) rivers with over 90% detection at the Souris (Westhope), Red (Selkirk and Emerson), South and North Saskatchewan, Red Deer at Bindloss, and Assiniboine rivers.

Table 2 Acid Herbicide Pesticides at ECCC Prairie Sites from 2008 to 2017.

	Canada Hudson Bay Watershed - HBWQMS						
Acid Herbicides	**% Detection**	**Method Detection Limit* (ng/L)**	**# of Exceedances**	**% Exceeding Objective**	**Min. (ng/L)**	**Max. (ng/L)**	**n**
Acid Herbicides							
2-(2,4-Dichlorophenoxy)-Propionic Acid (dichlorprop)	15.3	0.157, 0.228 ,1.07	-	-	<0.157	23.60	855
2,3,6-TBA**	0.6	0.298, 1.54	-	-	<0.298	9.19	708
2,4,5-T**	2.1	0.134, 0.213, 0.231, 1.72	-	-	<0.134	36.00	855
2,4-D	84.3	1.73	-	-	0.178	1120.0	855
2,4-DB	2.7	0.2, 1.35	-	-	<0.200	664.00	708
Bromoxynil	29.6	0.107, 0.176, 1.33	-	-	<0.107	231.00	855
Clopyralid	83.0	0.602	-	-	<0.602	382.00	855
Dicamba	36.3	0.399, 0.890, 1.63	120	14	<0.399	408.00	855
Dinoseb**	2.0	0.382	-	-	<0.382	0.43	49
Imazamethabenz-Methyl (A)	19.4	0.036, 1.13, 1.97	-	-	<0.036	131.00	851
Imazamethabenz-Methyl (B)	9.6	0.42	-	-	<0.42	15.10	513
Imazamox	38.1	0.342	-	-	<0.342	92.70	252
Imazapyr	20.2	0.692	-	-	<0.692	7.95	252
Imazethapyr	19.4	0.089, 0.126, 5.48	-	-	<0.089	35.60	851
MCPA	76.4	0.091, 0.160, 1.32	111	13	<0.091	489.00	855
MCPB	7.2	0.235, 1.45, 4.06	-	-	<0.235	90.20	794
MCPP (Mecoprop)	47.6	0.101, 0.136, 1.02	-	-	<0.101	39.50	855
Picloram	38.2	0.047, 0.632, 2.17	-	-	<0.047	170.00	855
Silvex**	1.4	0.192, 0.297, 1.17	-	-	<0.192	8.19	855
Triclopyr	37.0	3.01	-	-	<3.01	110.00	338

Notes: Units are in ng/L and not µg/L
* Multiple values represent detection limits at different times. Current DL is the lowest value
** Not currently registered for use in Canada

Table 3 Maximum of Acid Herbicide Concentrations Relative to Water Quality Objectives.

Parameter	Maximum (ng/L)	PPWB Objective (ng/L)	Most Sensitive Use Protected	Date	Site
2,4-D	1120	4000	Protection of Aquatic life	July 2009	Pembina River, Windygates
Bromoxynil	231	330	Protection of Aquatic life	July 2009	Red River at Emerson
Dicamba	408	6	Irrigation	July 2017	Red River at Emerson
MCPA	489	25	Irrigation	July 2014	Assiniboine River at Hwy 8
Picloram	170	29000	Protection of Aquatic life	May 2016	Souris River Near Westhope

Note: Units are in ng/L and not µg/L

International Rivers

Eighteen herbicides were detected in 204 samples. Dicamba and MPCA exceeded their water quality objectives. The dicamba objective was exceeded in 34% (n=204) of the samples and MPCA objectives were exceeded in 13% (n=204) of the samples.

The highest concentrations of pesticides detected were 2,4-D (1120 ng/L, July 2009, Pembina R.), dicamba (408 ng/L, July 2017, Red R.), MCPA (404 ng/L, June 2014, Red R., and Clopyralid (351 ng/L, July 2017, Red R.).

The most frequently detected herbicides were 2,4-D (98%, n=204) and clopyralid (99%, n=204). Eleven herbicides were detected in less than 50% of samples. The Souris River had detections of 18 pesticides at the United States Canada border in Manitoba, where the river re-enters Canada. ECCC detected nine pesticides on the Souris River where it flows from Canada to the United States; however, the USGS is responsible for routine monitoring at this location and ECCC only samples to cross-compare analytical results between Canada and the United States.

Interprovincial Rivers

Nineteen acid herbicides were detected in 629 samples. These sites also had exceedances of dicamba and MCPA (Tables 4 and 5). The maximum value of dicamba was 37 ng/L (December 2017) in the Red Deer (Bindloss) River. The maximum concentration of MCPA was 489 ng/L (July 2014) in the Assiniboine River near Highway 8. Other high concentrations measured included 2,4-D (581 ng/L, June 2008) in the Assiniboine River, bromoxynil (81.7 ng/L, June 2010) in the South Saskatchewan River, and picloram (96.6 ng/L, December 2011) in the Battle River.

The highest frequencies of detection were for 2,4-D (79%, n=629), clopyralid (78%, n=629), and MCPA (73%, n=629). All other detections were less than 50%. Dicamba exceeded the objective in 6% of all samples (n=629). MCPA exceeded the water quality objective in 12% (n=629) of all samples.

The rivers with the lowest MCPA pesticide detections were the Churchill River below Wasawakasik (33%, n=15) and the Winnipeg River at Point Du Bois (2%, n=41). The Churchill River had seven pesticides detected, with no exceedances, while the Winnipeg River had eight overall detections and no exceedances. This is unsurprising, as these rivers drain a largely natural landscape.

The South Saskatchewan River had 17 pesticides detected, with two exceedances, while the North Saskatchewan had 15 pesticides detected, and one exceedance. Further downstream, the Saskatchewan River above Carrot River, had 16 pesticides detected, and no exceedances. The Carrot River had 18 pesticides detected and two exceedances.

The Red Deer (Bindloss) R. at the Alberta and Saskatchewan border had 13 pesticides detected and two exceedances, while the Red Deer (Erwood) R. at the Saskatchewan and Manitoba border had 12 pesticides detected and no exceedances.

Considerations

In a spatial review, the number of rivers in which specific pesticides were detected ranged from very few detections (1) for dinoseb up to 13 rivers with detections for clopyralid. 2,4-D, MCPA and MCPB were detected in 12 of the 18 rivers monitored.

For those rivers with pesticide detections, the frequency of detection was high (>75%) for 2,4-D, clopyralid, MCPA and MCPP. Dicamba, picloram and triclopyr tended to have detection frequencies in the 50 to 75% range.

Given that 2,4-D, dicamba, MCPA and picloram are already assessed against an objective, it would be prudent for CCME to review information for clopyralid, MCPB, MCPP and triclopyr, given their wide spatial detections and/or their frequency of detection, and consider prioritizing these pesticides for guideline development.

Table 4 Dicamba Detections at Federal Sites from 2008 to 2017.

Sampling Site	Number of Samples	Number of Detections	% Detection	Method Detection Limit	Number of Samples Exceeding Objective (6 ng/L)	% of Samples Exceeding Objective	Min (ng/L)	Max (ng/L)
Churchill River below Wasawakasik	15	1	7	.399, .890, 1.63	0	0.0	<0.399	0.97
Cold River at Outlet of Cold Lake	13	1	8	.399, .890, 1.63	0	0.0	<0.399	2.43
Assiniboine River at Hwy 8 Bridge	126	48	38	.399, .890, 1.63	7	5.6	<0.399	15.3
Red Deer River at Erwood	27	3	11	.399, .890, 1.63	0	0.0	<0.399	2.73
Carrot River near Turnberry,	122	16	13	.399, .890, 1.63	2	1.6	<0.399	13.7
Qu'Appelle River approx. 3.2km South	46	16	35	.399, .890, 1.63	10	21.7	<0.399	37
Battle River near Unwin, Saskatchewan	51	8	17	.399, .890, 1.63	0	0.0	<0.399	3.74
Saskatchewan River above Carrot River	49	16	33	.399, .890, 1.63	0	0.0	<0.399	2.52
Beaver River at Beaver Crossing,	25	1	4	.399, .890, 1.63	0	0.0	<0.399	1.11
North Saskatchewan River at Highway #17 Bridge	30	10	33	.399, .890, 1.63	1	3.3	<0.399	8.38
Red Deer River near Bindloss, Alberta	29	10	35	.399, .890, 1.63	3	10.3	<0.399	36.9
South Saskatchewan River at Hwy 41,	55	34	62	.399, .890, 1.63	13	23.6	0.399	27.4
Red River at Emerson, Manitoba	123	90	73	.399, .890, 1.63	47	38.2	<0.399	408
Red River at Selkirk, Manitoba	20	16	80	.399, .890, 1.63	13	65.0	<0.399	355
Winnipeg River at Pointe Du Bois,	41	0	0	.399, .890, 1.63	0	0.0	<0.399	1.63
Pembina River at Windygates, Manitoba	41	14	34	.399, .890, 1.63	2	4.9	<0.399	82
Souris River near Westhope	40	24	60	.399, .890, 1.63	20	50.0	<0.399	180
Souris River near Sherwood N.D.	2	2	100	.399, .890, 1.63	2	100.0	10.8	21.4

Note: Units are in ng/L and not µg/L
* Multiple values represent detection limits at different times. Current DL is the lowest value

Table 5 MPCA Detections at Federal Sites from 2008 to 2017.

Sampling Site	Number of Samples	Number of Detections	% Detection	Method Detection Limit	Number of Samples Exceeding Objective (25 ng/L)	% of Samples Exceeding Objective	Min (ng/L)	Max (ng/L)
Churchill River below Wasawakasik	15	5	33	0.091, 0.160, 1.32	0	0.0	<0.16	2.86
Cold River at Outlet of Cold Lake	13	11	85	0.091, 0.160, 1.32	0	0.0	1.01	4.34
Assiniboine River at Hwy 8 Bridge	126	114	91	0.091, 0.160, 1.32	34	27.0	<0.091	489
Red Deer River at Erwood	27	13	48	0.091, 0.160, 1.32	0	0.0	<0.16	13
Carrot River near Turnberry,	122	82	67	0.091, 0.160, 1.32	17	13.9	<0.091	304
Qu'Appelle River approx. 3.2km South	46	44	96	0.091, 0.160, 1.32	12	26.1	0.58	196
Battle River near Unwin, Saskatchewan	51	39	77	0.091, 0.160, 1.32	6	11.8	<0.091	63.9
Saskatchewan River above Carrot River	49	44	90	0.091, 0.160, 1.32	0	0.0	<0.091	17.7
Beaver River at Beaver Crossing,	25	12	48	0.091, 0.160, 1.32	0	0.0	<0.16	5.39
North Saskatchewan River at Highway #17 Bridge	30	20	67	0.091, 0.160, 1.32	0	0.0	<0.16	11.4
Red Deer River near Bindloss, Alberta	29	26	90	0.091, 0.160, 1.32	1	3.4	<0.091	27.5
South Saskatchewan River at Hwy 41,	55	46	84	0.091, 0.160, 1.32	5	9.1	<0.16	363
Red River at Emerson, Manitoba	123	108	88	0.091, 0.160, 1.32	12	9.8	<0.091	404
Red River at Selkirk, Manitoba	20	20	100	0.091, 0.160, 1.32	8	40.0	2.33	268
Winnipeg River at Pointe Du Bois,	41	1	2	0.091, 0.160, 1.32	0	0.0	<0.091	1.32
Pembina River at Windygates, Manitoba	41	31	76	0.091, 0.160, 1.32	6	14.6	<0.091	176
Souris River near Westhope	40	35	88	0.091, 0.160, 1.32	9	22.5	<0.16	118
Souris River near Sherwood N.D.	2	2	100	0.091, 0.160, 1.32	1	50.0	1.36	32.8

Note: Units are in ng/L and not µg/L

* Multiple values represent detection limits at different times. Current DL is the lowest value

Alberta

Pesticide Management Policies/Regulations in Alberta

Pesticide use in Alberta is regulated at two levels:

- Federally by Health Canada through the *Pest Control Products Act* and the associated regulations. Health Canada registers the pesticides for use in Canada. All registered pesticides have detailed product labels that provide information, guidance and directions for use and handling of the pest control product. These labels are legal documents and must be followed so that the product is used in a safe manner.

- Provincially in Alberta through the *Environmental Protection and Enhancement Act* (EPEA) and two regulations that apply to the management of pesticide use in the province — the Pesticide Sales, Handling, Use and Application Regulation and the Pesticide (Ministerial) Regulation.

The Pesticide Sales, Handling, Use and Application Regulation provides specific regulatory guidance for service registrations (for businesses offering application services), protection of water, use of containers, fumigation, restrictions on sales, emergency response, storage, mixing and loading requirements, as well as specific guidance on the disposal of pesticide waste.

The Pesticide (Ministerial) Regulation outlines the requirements for pesticide applicator certification (including classes of certificates), pesticide service and vendor registrations, special use approvals, record keeping, and dispenser requirements in Alberta. It also classifies pesticides into schedules that guide sales, use, and handling in Alberta.

Besides the above two regulations, there is the Environmental Code of Practice for Pesticides, which supplements the regulations by providing additional details for the proper use of pesticides for specific situations.

In Alberta, commercial pesticide applicators are required to have the proper class of pesticide certification and a pesticide service registration in order to conduct a pesticide application service. Under the regulations, commercial agriculturists/farmers are exempt from certification, unless the label has specific requirement for certification. Acreage or hobby greenhouse users are also exempt from certification for certain pesticides, provided they follow the terms and conditions under the Environmental Code of Practice for Pesticides. There is no certification requirement for using domestic class products or products described under Schedule 4 of the Pesticide (Ministerial) Regulation.

Detailed information regarding pesticide management in Alberta can be found at the following link: https://www.alberta.ca/pesticide-management.aspx

Regulatory Requirements to Protect Water

There are several regulatory requirements in both regulations. The following highlights some of the key requirements.

Pesticide (Ministerial) Regulation
Special use approval
9(1) No person shall, unless the person holds a special use approval issued by the Director, (a) use or apply a pesticide in or on an open body of water, (b) use or apply a pesticide listed in Schedules 1, 2 or 3 within a horizontal distance of 30 metres from an open body of water, (c) store a pesticide within a horizontal distance of 30 metres from an open body of water, or (d) wash equipment or vehicles used to apply pesticides within a horizontal distance of 30 metres from an open body of water.
(4) Subsection (1)(b) does not apply to (a) an applicator using or applying pesticides in accordance with the latest edition of the *Environmental Code of Practice for Pesticides* published by the Department, or (b) a person using or applying pesticides on cultivated land.
Under Schedule 5 of the regulation, the commercial applicator must also have the proper class of applicator certificate (aquatic vegetation, biting flies, etc.) to apply pesticides in Schedules 1 to 3.

Pesticide Sales Handling Use and Application Regulation
Section 7 contains restrictions on crossing through an open body of water with any equipment used to hold, mix or apply a pesticide.
Section 8 contains restrictions on the withdrawal of water from a watering point or an open body of water directly into an aircraft, vessel, vehicle, machine, equipment or container used to hold, mix or apply a pesticide.
Section 9 contains restrictions on aerial application over open bodies of water, unless authorized by the label or a special use approval.
Section 23 contains restrictions on pesticide storage in that the floor drains leading directly or indirectly into a wastewater system, storm drainage system, waterworks system or other potable water source, groundwater or an open body of water are protected from a release of a pesticide.
Section 27 contains restrictions on mixing and loading sites to prevent the entry of pesticide to water systems, groundwater, and open bodies of water.

Pesticide Sales
Per the Overview of 2013 Pesticide Sales in Alberta, MCPA sales have hovered around the 1 million kg active ingredient (ai; the specific chemicals in a pesticide product that act to control the pests) since 1998. Dicamba sales have decreased since 1998, going from 138,000 to 54,000 kg active ingredient in 2013. Dicamba and MCPA are used for controlling broadleaf weeds in crops like wheat, barley, oat, rye, corn, pasture, rangeland, turf, etc. They are mostly used in spring to early summer.

Disposal of pesticide waste
Cleanfarms (https://cleanfarms.ca/), a non-profit environmental organization, provides a collection service from the pesticide container collection sites. It partners with ag-retailers and municipalities to collect empty commercial pesticide containers throughout the agricultural regions of Canada. In Alberta, there are approximately 100 permanent pesticide container collection sites located throughout the province to collect empty and rinsed non-returnable plastic and metal pesticide containers. Containers are collected at

least once every year. For other pesticide wastes such as leftover product (concentrate or solution), pesticide rinsate and treated seed, relevant disposal guidance are also provided on a Government of Alberta website (https://www.alberta.ca/part-six-dealing-with-pesticide-waste.aspx) to support the proper treatment of the related wastes.

Water Quality Monitoring for Pesticides in Alberta

Alberta Environment and Parks (AEP) has measured pesticides in surface waters since the mid-1980s and reports on pesticide concentrations in surface waters as part of its evaluation and reporting responsibilities. In 1995, the approach to pesticide monitoring was updated to link ambient monitoring to pesticide sale records. Every five years provincial pesticide sales data, information on pesticide behaviour and toxicity, and results of surface water monitoring programs, are reviewed to prioritize active ingredients that need to be monitored in surface waters (Alberta Environment 2005). These pesticides have been routinely monitored at the provincial Long-Term River Network sites (LTRN) for four months a year (typically from May to August, and sometimes in September). The LTRN sites are generally located on mainstem or major tributary reaches of rivers in Alberta. Sample information from the 33 LTRN stations provide an overview of pesticide levels in Alberta's major river reaches. Detailed information of the stations are illustrated in Table 6 and a map of monitoring stations are shown in Figure 3.

In 2017 and 2018, Alberta Agriculture and Forestry, in collaboration with Alberta Environment and Parks, conducted monitoring for neonicotinoids in water, as members of the Environmental Monitoring Working Group formed as part of the Multi-Stakeholder Forum on Neonicotinoids. A surface water sampling program was initiated in regions of highest agricultural intensity throughout Alberta for the 2017 and 2018 crop growing seasons. Selected sampling sites (more than 100) represented diverse types of waterbodies, including rivers, streams, irrigation canals, and tile drains (Cook, 2018). Samples were collected from May until September and analyzed for seven neonicotinoids (dinotefuran, nitenpyram, thiamethoxam, clothianidin, imidacloprid, acetamiprid and thiacloprid).

Acid Herbicides in Alberta Rivers

Concentrations of acid herbicide for mainstem and tributaries of Alberta's streams are summarized in Table 7. Among the 14 acid herbicides, 2,4-D (43.68%) was detected at the highest rate, followed by MCPA, MCPP, picloram, dicamba, triclopyr, clopyralid and bromoxynil. All the other acid herbicides were generally detected at far lower rates than 1%. Comparing to provincial surface water quality guidelines, dicamba and MCPA show slightly lower exceedance rates, than using the PPWB transboundary water quality objective due, to the adoption of new maximum irrigation rate by Alberta in calculating the guidelines (Table 7). None of the other acid herbicides exceed the most stringent provincial guidelines more than 0.1% (Table 7). It is notable that method detection limits are generally lower than the PPWB transboundary water quality objectives, and the exceedance rates for the five acid herbicides are considered valid. The exceedance rate for the 2,4-D, bromoxynil and picloram are generally lower than 0.1%. The highest exceedance rates observed were 5.07% and 3.43% for dicamba and MCPA, respectively. Prairie Province Water Board objectives for dicamba and MCPA are based on irrigation guidelines and represent the maximum recommended concentration for the most sensitive crop. They are over a magnitude lower than the other herbicides.

Table 6 Stations in Alberta that have Routine Pesticides Monitoring.

Station No	River	Station Description	Latitude	Longitude
AB07AD0100	Athabasca River	At Old Entrance Town Site	53.3675	-117.7225
AB07BD0010	Athabasca River	At Vega Ferry (Klondyke)	54.43111	-114.4606
AB07BE0010	Athabasca River	At Town of Athabasca	54.72222	-113.2861
AB07CC0030	Athabasca River	U/S Fort Mcmurray	56.72028	-111.4056
AB07DA0980	Athabasca River	Transect above the Firebag River	57.72361	-111.3792
AB07DD0010	Athabasca River	At Old Fort	58.38278	-111.5178
AB05FA0340	Battle River	At North end of Driedmeat Lake	52.93736	-112.8486
AB05FA0060	Battle River	Approx. 2 KM D/S Hwy 53	52.65881	-113.6751
AB05BH0010	Bow River	At Cochrane	51.18306	-114.4871
AB05BM0010	Bow River	Below Carseland Dam	50.83056	-113.4167
AB05BM0590	Bow River	At Cluny	50.77313	-112.8455
AB05BN0010	Bow River	Near Ronalane Bridge	50.04775	-111.4248
AB05BJ0450	Elbow River	At 9th Ave Bridge	51.04483	-114.0419
AB11AA0070	Milk River	At Hwy 880	49.14417	-111.3108
AB05DC0050	North Sask. River	1 KM U/S Clearwater River	52.34808	-114.9818
AB05DF0010	North Sask. River	At Devon	53.36889	-113.7514
AB05EC0010	North Sask. River	At Pakan Bridge	53.99092	-112.4759
AB05DC0025	North Sask. River	At Saunders Campground	52.45381	-115.7595
AB05AA1595	Oldman River	Near Brocket	49.55861	-113.8222
AB05AD0010	Oldman River	Above Lethbridge at Hwy 3	49.70667	-112.8629
AB05AG0010	Oldman River	At Hwy 36 Bridge North of Taber	49.96111	-112.0847
AB07FD0135	Peace River	U/S Smoky River near Shaftesbury Ferry	56.09319	-117.5661
AB07HF0010	Peace River	At Fort Vermilion	58.40444	-116.1281
AB07HA0230	Peace River	1.5 KM above confluence of Whitemud River	56.65639	-117.1467
AB05CD0250	Red Deer River	At Nevis Bridge	52.30639	-113.0792
AB05CE0009	Red Deer River	At Morrin Bridge	51.65056	-112.9031
AB05CJ0070	Red Deer River	D/S Dinosaur Prov Park at Hwy 884 near Jenner	50.83861	-111.1767
AB05CC0010	Red Deer River	1 KM U/S Hwy 2 Bridge	52.26722	-113.8636
AB05CA0050	Red Deer River	At Sundre	51.79583	-114.6350
AB07GJ0010	Smoky River	At Watino	55.71556	-117.6219
AB05AK0020	South Sask. River	Above Medicine Hat	50.04333	-110.7222
AB07GJ0030	Wapiti River	Above Confluence with Smoky River	55.13667	-118.3083
AB07GE0020	Wapiti River	At Hwy #40 Bridge	55.07194	-118.8047

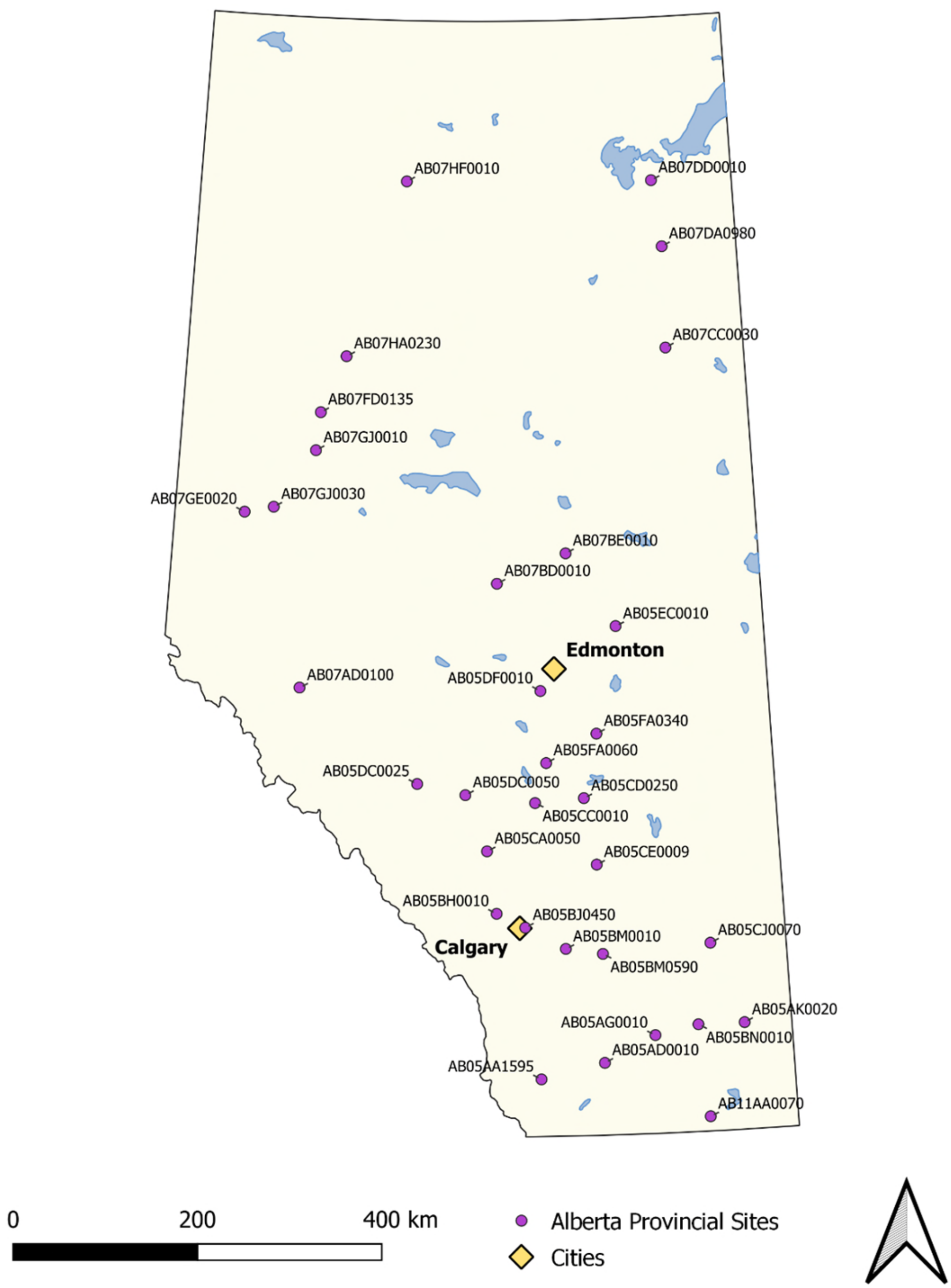

Figure 3 Water Quality Monitoring Stations in Alberta with Pesticide Monitoring.

Table 7 Overview/summary of all Acid Herbicides in Alberta from 2008 to 2017.

Pesticide	Alberta's most stringent guidelines (µg/L)	Interprovincial WQO (µg/L)	% Detection	Method detection limit (µg/L)	% exceeding objective	Min. (µg/L)	Max. (µg/L)	Number of samples
2,4-D	4	4	43.68	0.005	0.05	<0.005	7	2010
2,4-DB	25	-	0.05	0.005	-	0.006	0.006	2010
Bromoxynil	0.44	0.33	3.73	0.005	0	<0.005	0.025	2010
Clopyralid		-	4.28	0.02	-	<0.02	0.27	2010
Dicamba	0.008	0.006	8.16	0.005	5.07	<0.005	0.258	2010
Dichlorprop		-	0.15%	0.005	-	<0.005	0.009	2010
Imazamethabenz-Methyl (A/B)		-	0.15	0.005	-	0.02	0.166	2010
Imazamox		-	0.05	0.02	-	<0.02	0.008	2010
Imazethapyr		-	0.20	0.02	-	0.05	0.05	2010
MCPA	0.04	0.025	21.19	0.005	3.43	<0.005	0.753	2010
MCPB		-	0.05	0.02	-	<0.02	0.012	2010
MCPP (Mecoprop)	13	-	16.57	0.005	-	<0.005	0.135	2010
Picloram	29	29	10.65	0.005	0	<0.005	1.76	2010
Triclopyr		-	4.83	0.01	-	<0.01	0.13	2010

Summary of MCPA and Dicamba in Major Alberta River Basins

Dicamba has been generally detected at low rates ranging from 0.55 to 18.57% in mainstem reaches of the major rivers. The detection rates are at the similar levels overall in agriculture dominated areas of the province, ranging from 7.51% (North Saskatchewan River) to 18.57% (Battle River), in contrast to the low detection levels in northern rivers (e.g., Peace River, Athabasca River) where agricultural developments are still at low levels. It is noted that detection rates are not necessarily higher at tributary sites than those at mainstem stations as normally expected (only the case in Athabasca and North Saskatchewan rivers). This might be largely influenced by different dominating development types in the corresponding tributary watersheds. As illustrated in Table 8, the excursion rates greater than PPWB transboundary water quality objective follows the similar ranking as that for detection rates as expected. Since most of the samples were primarily taken in open water season from May to August, we can only get a sense of seasonality through detections in these four months. Results show inconsistent seasonal patterns among the rivers. The peaking month varies in different rivers from May to August.

Table 8 Summary of Dicamba Concentrations in Alberta by Major River Basin from 2008 to 2017.

Major Basin	Samples	Detections	% Detection	Method Detection Limit (µg/L)	Number of samples exceeding objective	% of samples exceeding objective	min (µg/L)	max (µg/L)
South Saskatchewan River - mainstem	545	64	11.74	0.005	36	6.61	<0.005	0.258
South Saskatchewan River - tributary	308	16	5.19	0.005	11	3.57	<0.005	0.153
Red Deer River - mainstem	227	31	13.66	0.005	20	8.81	<0.005	0.074
Red Deer River - tributary	57	4	7.02	0.005	2	3.51	<0.005	0.019
Battle River - mainstem	70	13	18.57	0.005	11	15.71	<0.005	0.256
Battle River - tributary	10	0	0	0.005	0	0.00		
North Saskatchewan River - mainstem	293	22	7.51	0.005	13	4.44	<0.005	0.044
North Saskatchewan River - tributary	63	6	9.52	0.005	5	7.94	<0.005	0.079
Beaver River - mainstem	4	0	0	0.005	0	0		
Peace River - mainstem	78	1	1.28	0.005	0	0	<0.005	0.003
Peace River - tributary	112	0	0	0.005	0	0		
Athabasca River - mainstem	182	1	0.55	0.005	0	0	<0.005	0.006
Athabasca River - tributary	21	1	4.76	0.005	1	4.76%	<0.005	0.01
Milk River - mainstem	40	5	12.50	0.005	3	7.50%	<0.005	0.033

MCPA has been generally detected at higher rates than those for dicamba in all the major mainstem reaches. Battle River has the highest detection rate (72.86%), followed by Red Deer (35.68%), Beaver (25%), South Saskatchewan (23.49%), Milk (22.5%), North Saskatchewan (8.19%), Peace (7.69%) and Athabasca (4.4%) rivers. Except for Beaver River, where only a small number of samples were taken, most of the high detection rates were in agriculture-dominating watersheds (e.g., Battle, Red Deer, South Saskatchewan and Milk rivers). The detection rates are at very low levels in the northern rivers (e.g., Peace and Athabasca River) where agricultural development levels are relatively low. Similar to dicamba, higher detection rates are not generally found at the tributary sites than at the mainstem sites. As illustrated in Table 9, the excursion rates greater than PPWB water quality objective generally follows the similar ranking as that for detection rates with minor differences. Given most of the samples were taken in open water season from May to August, seasonal analysis only provides a snapshot of these four months, with the highest levels generally in June and July (Battle River only).

Table 9 Summary of MCPA Concentrations in Alberta by Major River Basin from 2008 to 2017.

Major Basin	*Samples*	*Detections*	*% Detection*	*Method Detection Limit (µg/L)*	*Number of samples exceeding objective*	*% of samples exceeding objective*	*Min. (µg/L)*	*Max. (µg/L)*
South Saskatchewan River – mainstem	545	128	23.5	0.005	6	1.1	<0.005	0.076
South Saskatchewan River – tributary	308	70	22.7	0.005	17	5.5	<0.005	0.198
Red Deer River - mainstem	227	81	35.7	0.005	15	6.6	<0.005	0.063
Red Deer River - tributary	57	20	35.1	0.005	8	14.0	<0.005	0.107
Battle River - mainstem	70	51	72.9	0.005	16	22.9	<0.005	0.753
Battle River - tributary	10	8	80.0	0.005	3	30.0	<0.005	0.042
North Saskatchewan River – mainstem	293	24	8.2	0.005	2	0.7	<0.005	0.036
North Saskatchewan River – tributary	63	7	11.1	0.005	0	0.0	<0.005	0.02
Beaver River - mainstem	4	1	25.0	0.005	0	0.0	<0.005	0.021
Peace River - mainstem	78	6	7.7	0.005	1	1.3	<0.005	0.027
Peace River - tributary	112	0	0.0	0.005	0	0.0		
Athabasca River - mainstem	182	8	4.4	0.005	0	0.0	<0.005	0.024
Athabasca River - tributary	21	0	0.0	0.005	0	0.0		
Milk River - mainstem	40	9	22.5	0.005	1	2.5	<0.005	0.042

Saskatchewan

Pesticide Management Policies/Regulations in Saskatchewan

Pesticide use in Saskatchewan is regulated federally through *The Pest Control Products Act*, and provincially through *The Pest Control Products (Saskatchewan) Act* and Regulations. Under the provincial Act and Regulations, commercial pesticide applicators are licensed. Some restricted class pest control products as well as new generation products (herbicides, fungicides, insecticides and vertebrate pesticides) may have label statements requiring training to purchase and use the product. Under the provincial Act and Regulations, agricultural producers are exempt from requiring a license. However, they are not exempt from any label statement requiring training and certification. Domestic classified pesticides, commonly known as home and garden or cosmetic pesticides are exempt from the Act.

Pest Control Products Act* and Pest Control Products Regulations*: In 2015, the Saskatchewan Ministry of Agriculture introduced several regulatory amendments to The Pest Control Products Regulations. The changes modernize the regulations to reflect current industry practices, enhance the protection of the environment and harmonize regulations with other provincial jurisdictions and federal regulations. These changes were made following extensive consultation with stakeholders, partners and clients. The amendments recognize emerging trends in pest control product registration, and better meet industry needs and expectations. More information can be found at the following link: (https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/pesticide-licensing-program).

Federal Pest Control Products Act: Product labels are a legal document and set out the terms and conditions for the use of the product. They can be very prescriptive. Product labels are an important component related to direction on handling pesticides, including buffer zone requirements (distance) from surface water.

Selected Act Related Sections from Saskatchewan related to water:

Prohibition against applying pesticides into body of water without permit

5 Subject to section 39 of *The Environmental Management and Protection Act*, no person shall apply a pesticide in an open body of water unless he is the holder of a subsisting permit to do so issued to him pursuant to this Act.

Prohibition against certain cleansing, etc., of pesticide apparatus

9 No person shall:

(a) cleanse or place in an open body of water any apparatus, equipment or container used in the holding or application of a pesticide; or

(b) cause water from an open body of water to be drawn into any apparatus or equipment used for mixing or applying a pesticide unless the apparatus or equipment is equipped with a device that prevents a return flow of the mixture from the apparatus or equipment.

Power of minister to order destruction, etc., of contaminated property; compensation therefor

14(1) Where the minister is of the opinion, based upon such evidence as he considers adequate, that any crop, food, feed, animal, plant, water, produce, product or other matter is contaminated by a pesticide, the minister may by order in writing:

(a) prohibit or restrict the sale, handling, use or distribution of the crop, food, feed, animal, plant, water, produce, product or other matter permanently or for such length of time as he considers necessary; or

(b) cause the crop, food, feed, animal, plant, water, produce, product or other matter to be destroyed or rendered harmless.

(2) Compensation in respect of loss or damage incurred as the result of an order made under subsection (1) is payable in such amount and to such persons as may be prescribed by the regulations.

The provincial Pesticide Containers program is administered through cleanfarms.ca (https://cleanfarms.ca/). The program captures the lifecycle of pesticide containers (buy, use, return). Saskatchewan agriculture has a 70 to 75% return rate (Ministry of Agriculture, personal communications, 2019). There is also a collection program for obsolete products, and this program is an industry-based initiative, which is 12 to 15 years old. There is a new industry stewardship initiative aimed at recycling agricultural plastic, grain bags, bailor twine/netting and silage wrap.

Volunteer producer training is offered for pesticide application. The provincial government issues pesticide licenses to commercial pesticide applicators, application businesses and retail vendors through the Pesticide Licensing Program. A permit is required for application of pesticide near/on/over water.

Water Quality Monitoring for Pesticides in Saskatchewan

Saskatchewan undertakes routine water quality monitoring of pesticides at its long-term river monitoring stations, known as the Primary stations. Provincial routine monitoring of pesticides in aquatic ecosystems is undertaken to understand risks to aquatic life from acid herbicides. Acid herbicides are the main focus because these herbicides are the most widely used pesticides provincially and acid herbicides are generally more water-soluble. The province also undertakes non-routine monitoring of pesticides in aquatic environments and supports collaboration of studies evaluating pesticides in provincial waters. Provincial pesticide monitoring supports work within the PPWB for rivers that cross interprovincial borders and federal reporting on water quality as part of the national Canadian Environmental Sustainability Indicators (CESI) program.

The 24 Primary stations are located on the South Saskatchewan River (Leader, Outlook, upstream and downstream of Saskatoon, and Muskoday), the North Saskatchewan River (North Battleford, Borden, Prince Albert, and the north and south banks downstream of Prince Albert at the Cecil Ferry crossing), the Saskatchewan River (Highway 6 and Tobin Lake), the Battle River (Battleford), the Beaver River (Dorintosh and Beauval), the Clearwater River (Highway 955), the Souris River (Roche Percee), the Qu'Appelle River (Highway 19, Highway 2, upstream and downstream of the Wascana Creek confluence with the Qu'Appelle River and at the outlet of Katepwa

Lake), the Assiniboine River (Kamsack) and on the Churchill River (Otter Rapids). Each Primary station is sampled seasonally (spring, summer, autumn, winter) for a suite of water quality parameters, including acid herbicides. Limited monitoring of acid herbicides was conducted in 2007 and 2008 on smaller order streams (BEMLOSS sites) within the following watersheds: South Saskatchewan (Swift Current Creek below Rock Creek and near Leinan), North Saskatchewan (Oscar Creek near Krydor), Souris (Pipestone near Moosomin, Souris near Bechard, Moose Mountain above Grant Devine Lake, and Lightning Creek near Carduff), Qu'Appelle (Lanigan Creek above Boulder Lake, Saline Creek near Nokomis, Iskwao Creek near Craik, Avonlea Creek near Rouleau and Moose Jaw River near Rouleau), and Old Wives (McDonald Creek near McCord and Wood River near Lafleche). Old Wives watershed does not have an outlet, so is classified as being endorheic (Figure 4).

Analytical quantification of acid herbicides from Primary stations is presently done for eight acid herbicides [2,4,5-T; 2,4,5-TP (Silvex); 2,4-D; 2,4-DP (dichlorprop); bromoxynil (Buctril); dicamba (Banvel); MCPA; and picloram (Tordon)]. The laboratory reporting limits meet the needs for evaluating whether concentrations of the five pesticides that have protection of aquatic life guidelines meet those guidelines. As part of the province's review of its water quality monitoring program, five Primary stations were selected for a short-term study to quantify, at trace laboratory reporting limits, concentrations of acid herbicides and glyphosate. The sites are at the Primary stations located upstream and downstream of Saskatoon and Regina and on the Souris River. Six other Primary stations were monitored for trace pesticides once in the autumn of 2016.

In 2017, Saskatchewan's Ministry of Agriculture and Water Security Agency (WSA) monitored for neonicotinoids, including imidacloprid, thiamethoxam, and clothianidin in water, as members of the Environmental Monitoring Working Group formed as part of the Multi-Stakeholder Forum on Neonicotinoids. Monitoring for neonicotinoids by the WSA occurred at the BEMLOSS sites from 2017 to 2019 with multiple samples collected at each site. Samples were collected more frequently during periods of greater flow.

Acid Herbicides in Saskatchewan Rivers

None of the samples collected for routine sampling had acid herbicides that exceeded protection of aquatic life guidelines (Table 10). There were few detections of these acid herbicides at the method detection of the laboratory. Interprovincial WQOs for dicamba and MCPA are based on irrigation guidelines and represent the maximum recommended concentration for the most sensitive crop. The interprovincial WQOs (PPWB objectives) are lower than the method detection limit for provincial routine acid herbicide monitoring, thus cannot be directly compared to these objectives. Trace-level monitoring at select locations found detections of most acid herbicides tested, with the exception of products that have not been recently used (Table 11). The frequency of samples exceeding the interprovincial WQOs for dicamba and MCPA was 21 and 18%, respectively. Detection frequency of 2,4-D, whose interprovincial WQO is based on CCME's protection of aquatic life guideline, is greater than those for dicamba and MCPA, and had a maximum concentration greater than those measured for dicamba and MCPA.

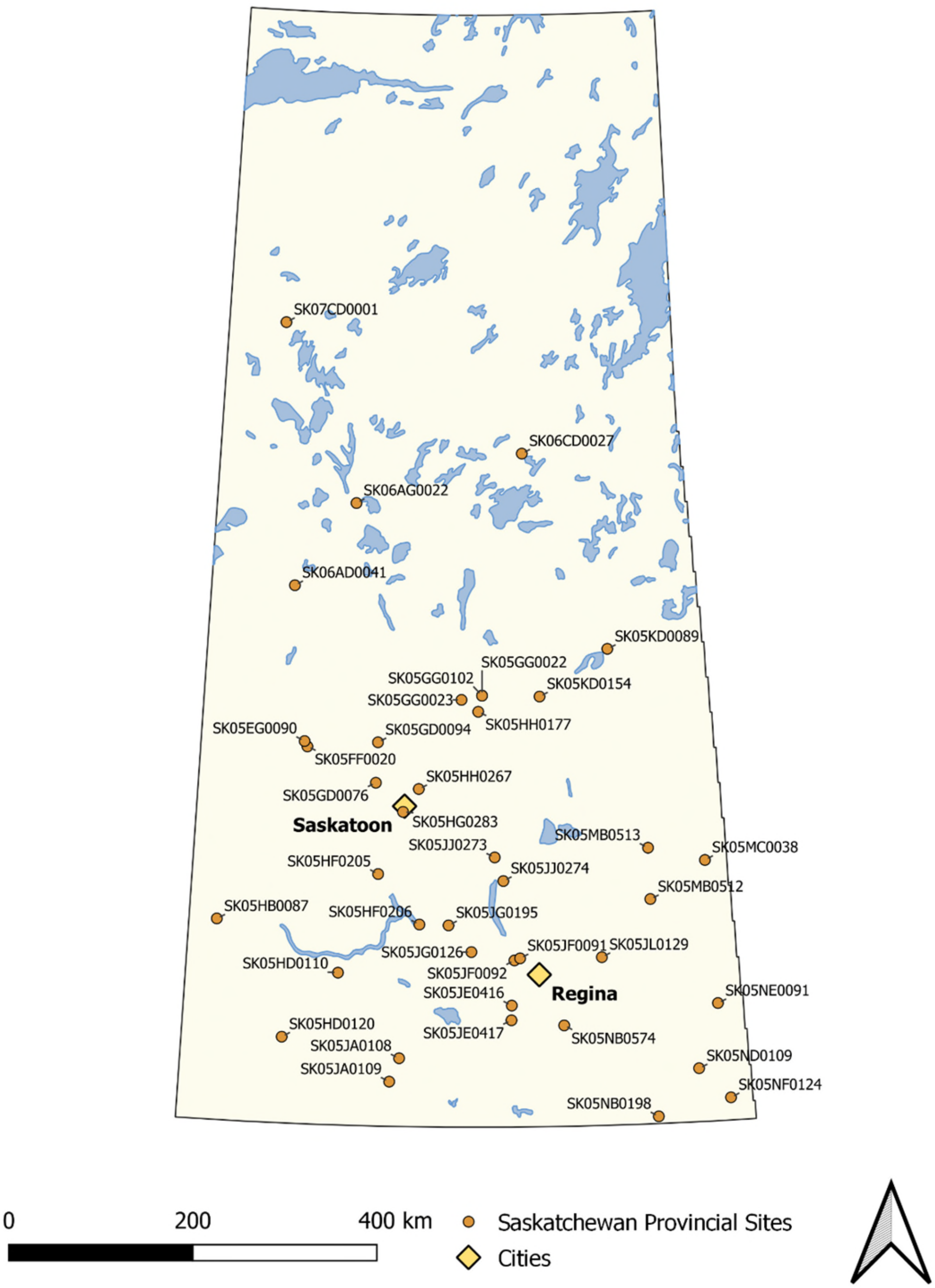

Figure 4 Water Quality Monitoring Stations in Saskatchewan with Pesticide Monitoring.

Table 10 Summary Results for Routine Acid Herbicide Monitoring in Saskatchewan Rivers between 2007 and 2017.

Pesticide	PPWB Objective (µg/L)	% Detection	Method Detection Limit (µg/L)	% Exceeding Objective	Min.* (µg/L)	Max. (µg/L)	Number of Samples
2-(2,4,5-dichlorophenoxy)-propionic acid (dichlorprop)	-	0	0.5-1.0	-	n/a	n/a	698
2,4,5-T**	-	0.1	0.5-1.0	-	1	1	918
2,4-D	4	0.2	0.5-1.0	0	1.7	2.5	918
Bromoxynil	0.33	0	0.5-1.0	--	n/a	n/a	998
Dicamba	0.006	0	0.5-1.0		n/a	n/a	998
Fenoprop (Silvex) (2-(2,4,5-trichlorophenoxy) propionic acid**	-	0.1	0.5-1.0	--	1.1	1.1	918
MCPA	0.025	0	0.5-1.0		n/a	n/a	998
Picloram	29	0	1.0	0	n/a	n/a	998

- No PPWB objective available to compare
2,4-D, Picloram – adopted from PAL guidelines; Bromoxynil, Dicamba and MCPA adopted from irrigation guidelines
* Min. values are minimum detected concentrations and do not include less than detections.
**Not currently registered for use in Canada

Table 11 Summary Results for Trace-Level Monitoring of Acid Herbicides in Saskatchewan between 2007 and 2017.

Pesticide	PPWB Objective (ng/L)	% Detection	Method Detection Limit (ng/L)	% Exceeding Objective	Min.* (ng/L)	Max. (ng/L)	Number of Samples
2-(2,4-dichlorophenoxy)-propionic acid (dichlorprop)**	-	27	<1	-	0.677	8.96	33
2,4,5-T**	--	24	<1	-	0.056	0.305	33
2,4-D	4000	97	<1	0	1.65	1070	33
2,4-DB	-	0	<1	-	n/a	n/a	33
Dicamba	6	91	<1	21	0.06	179	33
Dinoseb**	-	15	<1	-	3.67	106	33
Fenoprop (Silvex) (2-(2,4,5-trichlorophenoxy) propionic acid**	-	0	<1	-	n/a	n/a	33
MCPA	25	100	<1	18	0.982	74.9	33
MCPP	--	70	<1	-	0.073	699	33
Triclopyr		70	<1	-	0.16	57.3	27

Note: Units are in ng/L and not µg/L
- No PPWB objective available to compare
2, 4-D, Picloram – adopted from PAL guidelines; Bromoxynil, Dicamba and MCPA adopted from irrigation guidelines
* Min. values are minimum detected concentrations and do not include less than detections.
** Not currently registered for use in Canada

Summary of MCPA and Dicamba in Major Saskatchewan River Basins

A focus of this document is on dicamba and MCPA because these herbicides most frequently exceed the interprovincial WQOs aimed at protecting crops from contaminated irrigation water at PPWB sites. The analytical results for these are summarized by watershed to better understand the spatial extent of detections and exceedances (Tables 12 and 14). Routine monitoring of acid herbicides by Saskatchewan is aimed at understanding risks to aquatic life, and therefore the method detection limits used are selected based on those objectives. As noted previously, the interprovincial WQOs for dicamba and MCPA are lower than the detection limit used by Saskatchewan in its routine pesticide monitoring. Neither dicamba or MCPA were detected in Saskatchewan's routine monitoring from 2007 to 2017 (Tables 10), and therefore, results summarized by watershed only provide the additional information of how many samples were collected in each watershed (Tables 12 and 14). A summary of trace-level monitoring for dicamba and MCPA found that low level concentrations of these herbicides were typically present at the locations sampled, notably for MCPA where detections were noted for all samples at all locations (Tables 13 and 15). The number of samples from each watershed for trace-level monitoring is limited and two locations were focused on urban centres, so it is difficult to draw conclusions about prevalence and concentrations in different watersheds. Ongoing trace-level monitoring will provide additional data to evaluate concentrations of these acid herbicides at these locations.

Saskatchewan has undertaken a recent review of its pesticide monitoring program with the result that analysis of acid-extractable herbicide monitoring will now be conducted to lower detection limits than those summarized in Table 10, it will also expand in the scope of locations monitored and at certain locations the scope of pesticides analyzed.

Table 12 Summary of Analytical Results for Routine Monitoring of Dicamba, by Major Watershed, for Mainstem and Tributary Sites Monitored between 2007 and 2017.

Major Basin	Number of Samples	Number of Detections	% Detection	Method Detection Limit (µg/L)	Number of Samples Exceeding Objective	% Exceeding Objective	Min. (µg/L)	Max. (µg/L)
Assiniboine River - mainstem sites	42	0	0%	0.5–1.0	0	0%	n/a	n/a
Assiniboine River - tributary sites	10	0	0%	0.5	0	0%	n/a	n/a
Athabasca River - mainstem sites	23	0	0%	0.5–1.0	0	0%	n/a	n/a
Battle River - mainstem sites	38	0	0%	0.5–1.0	0	0%	n/a	n/a
Beaver River - mainstem sites	78	0	0%	0.5–1.0	0	0%	n/a	n/a
Churchill River - mainstem sites	37	0	0%	0.5–1.0	0	0%	n/a	n/a
North Saskatchewan River - mainstem sites	195	0	0%	0.5–1.0	0	0%	n/a	n/a
North Saskatchewan River - tributary sites	7	0	0%	0.5	0	0%	n/a	n/a
Old Wives (endorheic)	12	0	0%	0.5	0	0%	n/a	n/a
Qu'Appelle River - mainstem sites	200	0	0%	0.5–1.0	0	0%	n/a	n/a
Qu'Appelle River - tributary sites	21	0	0%	0.5	0	0%	n/a	n/a
Saskatchewan River - mainstem sites	75	0	0%	0.5–1.0	0	0%	n/a	n/a
Souris River - mainstem sites	47	0	0%	0.5–1.0	0	0%	n/a	n/a
Souris River - tributary sites	15	0	0%	0.5	0	0%	n/a	n/a
South Saskatchewan River - mainstem sites	186	0	0%	0.5–1.0	0	0%	n/a	n/a
South Saskatchewan River - tributary sites	12	0	0%	0.5	0	0%	n/a	n/a

Table 13 **Summary of Analytical Results for Trace-level Monitoring of Dicamba, by Major Watershed, for Mainstem and Tributary Sites Monitored between 2007 and 2017. Exceedances calculated based on the Interprovincial WQO of 6 ng/L.**

Major Basin	Number of Samples	Number of Detections	% Detection	Method Detection Limit (ng/L)	Number of Samples Exceeding Objective	% Exceeding Objective	Min. (ng/L)	Max. (ng/L)
Assiniboine River - mainstem sites	1	1	100%	<1.0	0	0%	0.258	0.258
Assiniboine River - tributary sites	6	4	67%	<1.0	1	17%	0.837	24.9
Battle River - mainstem sites	1	1	100%	<1.0	0	0%	0.112	0.112
Beaver River - mainstem sites	1	1	100%	<1.0	0	0%	0.06	0.06
North Saskatchewan River - mainstem sites	1	1	100%	<1.0	0	0%	1.54	1.54
Qu'Appelle River - mainstem sites	8	8	100%	<1.0	4	50%	0.205	179
Qu'Appelle River - tributary sites	2	1	50%	<1.0	0	0%	1.54	1.54
Saskatchewan River - mainstem sites	1	1	100%	<1.0	0	0%	0.792	0.792
Souris River - mainstem sites	4	4	100%	<1.0	2	50%	1.63	136
South Saskatchewan River - mainstem sites	8	8	100%	<1.0	0	0%	0.792	5.55

Note: Units are in ng/L and not µg/L

Table 14 Summary of Analytical Results for Routine Monitoring of MCPA, by Major Watershed, for Mainstem and Tributary Sites Monitored from 2007 to 2017.

Major Basin	Number of Samples	Number of Detections	% Detection	Method Detection Limit (µg/L)	Number of Samples Exceeding Objective	% Exceeding Objective	Min. (µg/L)	Max. (µg/L)
Assiniboine River - mainstem sites	42	0	0%	0.5 - 1.0	0	0%	n/a	n/a
Assiniboine River - tributary sites	10	0	0%	0.5	0	0%	n/a	n/a
Athabasca River - mainstem sites	23	0	0%	0.5 - 1.0	0	0%	n/a	n/a
Battle River - mainstem sites	38	0	0%	0.5 - 1.0	0	0%	n/a	n/a
Beaver River - mainstem sites	78	0	0%	0.5 - 1.0	0	0%	n/a	n/a
Churchill River - mainstem sites	37	0	0%	0.5 - 1.0	0	0%	n/a	n/a
North Saskatchewan River - mainstem sites	195	0	0%	0.5 - 1.0	0	0%	n/a	n/a
North Saskatchewan River - tributary sites	7	0	0%	0.5 - 1.0	0	0%	n/a	n/a
Old Wives (endorheic)	12	0	0%	0.5	0	0%	n/a	n/a
Qu'Appelle River - mainstem sites	200	0	0%	0.5 - 1.0	0	0%	n/a	n/a
Qu'Appelle River - tributary sites	21	0	0%	0.5	0	0%	n/a	n/a
Saskatchewan River - mainstem sites	75	0	0%	0.5 - 1.0	0	0%	n/a	n/a
Souris River - mainstem sites	47	0	0%	0.5 - 1.0	0	0%	n/a	n/a
Souris River - tributary sites	15	0	0%	0.5	0	0%	n/a	n/a
South Saskatchewan River - mainstem sites	186	0	0%	0.5 - 1.0	0	0%	n/a	n/a
South Saskatchewan River - tributary sites	12	0	0%	0.5 - 1.0	0	0%	n/a	n/a

Note: Units are in ng/L and not µg/L

Table 15 **Summary of Analytical Results for Trace-level Monitoring of MCPA, by Major Watershed, for Mainstem and Tributary Sites Monitored from 2007 to 2017. Exceedances calculated based on the interprovincial water quality objective of 25 ng/L.**

Major Basin	Number of Samples	Number of Detections	% Detection	Method Detection Limit (ng/L)	Number of Samples Exceeding Objective	% Exceeding Objective	Min (ng/L)	Max (ng/L)
Assiniboine River - mainstem sites	1	1	100%	<1.0	0	0%	6.63	6.63
Assiniboine River - tributary sites	6	6	100%	<1.0	4	67%	9.7	49.9
Battle River - mainstem sites	1	1	100%	<1.0	0	0%	1.16	1.16
Beaver River - mainstem sites	1	1	100%	<1.0	0	0%	1.91	1.91
North Saskatchewan River - mainstem sites	1	1	100%	<1.0	0	0%	1.08	1.08
Qu'Appelle River - mainstem sites	8	8	100%	<1.0	0	0%	1.44	15.4
Qu'Appelle River - tributary sites	2	2	100%	<1.0	1	50%	19.3	74.9
Saskatchewan River - mainstem sites	1	1	100%	<1.0	0	0%	2.44	2.44
Souris River - mainstem sites	4	4	100%	<1.0	1	25%	6.64	30.3
South Saskatchewan River - mainstem sites	8	8	100%	<1.0	0	0%	0.982	7.56

Note: Units are in ng/L and not µg/L

Manitoba

Pesticide Management Policies/Regulations in Manitoba

As in Alberta and Saskatchewan, pesticide regulation in Manitoba is through the Pest Management Regulatory Agency of Health Canada, which conducts all scientific evaluations of pesticides sold or used in Canada.

Manitoba Agriculture and Resource Development promotes judicious use of pesticides for all users that limits exposure to applicators, the public, and the environment. This includes promoting the safe storage and handling of pesticides including providing recommendations for pesticide storage facilities and recommendations for pesticide disposal and empty container handling guidelines. Manitoba Agriculture and Resource Development has a Pesticide and Manure Licensing program for persons/business that wish to apply or sell pesticides commercial/agricultural in nature.

Licenses are issued to pesticide dealers and applicators and to manure applicators by Manitoba Agriculture and Resource Development through the Pesticides and Manure Licensing Program, as required by Regulation under *The Pesticides and Fertilizers Control Act*. The purpose of the Act is to ensure the safe and proper application of pesticides and manures through education and technical support to dealers and applicators. Certification and license requirements are outlined in the Pesticides and Fertilizers License Regulation and the Manure Regulation.

Under *The Environment Act*, administered by Manitoba Conservation and Climate, Pesticide Use Permits are typically required for application of pesticides applied to spaces where there is potential exposure to the public. These permits have special requirements for applicants to annually provide public notification of the proposed pesticide program, respect no-spray zone requests where feasible and report all pesticide usage to the department. Permits issued have special limits, terms and conditions to ensure the safe application of pesticides and minimize the effects to public health and the environment. All Pesticide Use Permit holders are expected to use integrated pest management practices that minimize pesticide applications where possible. Sectors typically regulated under Pesticide Use Permits include application to open bodies of water, golf courses, municipalities, school divisions, government, utility companies, railways, forestry operations, cottage-lot associations, parks, campgrounds and lodges.

Manitoba also prohibits the application of herbicides to lawns, greenspaces areas, schools and playgrounds including by homeowners, lawn care professionals, government and municipalities under *The Environment Act* and the Non-Essential Pesticide Use Regulation. The Act and its regulation are administered by Manitoba Conservation and Climate. The regulation provides some exceptions to the prohibition. For example it allows application to destroy an invasive or poisonous plant. The prohibition also includes restrictions and requirements regarding the sale of domestic class herbicides to the public. The prohibition applies to all pesticides classified as herbicides except those specified by regulation. Herbicides are defined as a chemical or biological agent or other product or substance registered under *The Pest Control*

Products Act (Canada) that is manufactured, represented or used as a means for destroying, preventing, controlling or mitigating weeds or other plant life.

Waste management and recycling, including for pesticide containers, is managed through Manitoba Conservation and Climate's Waste Reduction and Recycling Support (WRARS) Program. Information on where to recycle pesticide containers is available on a recycling directory/map at https://www.gov.mb.ca/sd/wastewise/index.html. As in Alberta and Saskatchewan, cleanFARMS operates an industry stewardship program for empty pesticide containers (https://cleanfarms.ca/programs-at-a-glance/mb-programs-events/#toggle-id-1). The objective for Manitoba's program is 75 % or higher recovery rate for empty pesticide and fertilizer containers by June 30, 2023.

Water Quality Monitoring for Pesticides in Manitoba

Manitoba has monitored pesticides in surface water since the early 1980s as a part of routine long-term water quality monitoring and watershed studies. Long-term pesticide monitoring data are available in the Assiniboine, Red, Lake Manitoba/Winnipegosis and Souris basins and in Lake Winnipeg — western and eastern basins. There are 46 historic pesticide monitoring locations within Manitoba where most sites have been monitored long term (more than 10 years) for pesticides (Table 16; Figure 5). Locations and sampling timing and frequencies have varied with time. Generally, pesticide sampling has occurred on a monthly basis on larger mainstem tributaries (such as the Red River) and on a quarterly basis (spring, summer, fall and winter) on smaller tributary rivers with combinations of these intervals occurring at most sites.

Approximately 53 pesticides are currently analyzed including chlorinated phenols, acid herbicides, organochlorine pesticides, carbamate pesticides, organo-nitrogen pesticides, and sulfonylurea herbicides (Table 17).

Table 16 Location of Long-term Pesticide Monitoring Stations within Manitoba (>10 years of continuous data).

EMS Station	Station Description	Latitude	Longitude
MB05MES042	Assiniboine River at Pth #83, South Of Miniota	50.1097	-101.0356
MB05MHS006	Assiniboine River at Pr #340 Upstream Treesbank	49.6944	-99.6564
MB05MHS021	Assiniboine River at 18th St. Bridge, Brandon	49.8606	-99.9614
MB05MHS031	Assiniboine River at Happy Hollow Farm (Tony Horan)	49.7824	-99.7705
MB05MJS045	Assiniboine River at Reservoir of Portage La Prairie W.T.P.	49.9447	-98.3308
MB05MJS047	Assiniboine River at Tch, East of Portage La Prairie	49.9692	-98.0978
MB05MJS053	Assiniboine River at Pr #334, South of Headingley	49.8689	-97.4047
MB05MES034	Birdtail River, Below Dam at Birtle	50.4208	-101.0617
MB05LLS005	Boggy Creek (Whitemud R.) at Pth 16 at Neepawa	50.2258	-99.4550
MB05OFS060	Boyne River One Block West of Pth #13 in Carman	49.5064	-98.0036
MB05SAS038	Brokenhead River at Pth #59, South East of Scanterbury	50.3694	-96.6078

EMS Station	Station Description	Latitude	Longitude
MB05OJS006	Cooks Creek at Boundary-St.Clements and Springfield	50.0625	-96.8061
MB05OJS007	Cooks Creek at Municipal Rd., 1 Km South of Millbrook	49.8419	-96.7292
MB05MHS003	Cypress River at east of town of Cypress River	49.5911	-99.0333
MB05LMS003	Dauphin River between Anama Bay and Gypsumville	51.9657	-98.3302
MB05LJS017	Edwards Creek at Pth #5, South of Dauphin	51.1106	-100.0619
MB05OGS039	La Salle River at La Barriere Park Dam W of St. Norbert	49.7228	-97.1714
MB05LKS009	Lake Manitoba Narrows, Pth 68	51.0850	-98.7855
MB05MFS098	Little Saskatchewan River at Pth #25 Near Rivers	50.0236	-100.2067
MB05LJS006	Mossy River at Pr #364 Near Winnipegosis	51.6239	-99.9353
MB05LGS001	North Duck River at Pth #10, Near Cowan	52.0311	-100.6489
MB05MGS071	Oak River four miles west of Wheatland	50.0256	-100.3942
MB05LJS007	Ochre River At Pth #5 Near Town Of Ochre River	51.0514	-99.7878
MB05NGS026	Pipestone Diversion At Boundary Of Pipestone And Sifton	49.6803	-100.8711
MB05NGS079	Pipestone Creek Bridge At Kola (Ne18-10-29w)	49.8422	-101.3986
MB05OES026	Rat River At Pr #303 At Otterburne	49.5019	-97.0511
MB05OCS004	Red River At South Gate Of Floodway	49.7506	-97.1333
MB05OJS074	Red River At Selkirk Bridge	50.1411	-96.8686
MB05ODS032	Roseau River At Pr #200 At Dominion City	49.1456	-97.1675
MB05OHS003	Seine River At South Perimeter Hwy., Winnipeg	49.8089	-97.0658
MB05OHS007	Seine River At South East Of Ste. Anne	49.6433	-96.6081
MB05NGS003	Souris River At Pr #530 Near Treesbank	49.6275	-99.5983
MB05NGS004	Souris River At Pth #22, At Souris	49.6133	-100.2564
MB05LES011	Swan River At Pr #268 Near Lenswood	52.3181	-100.9486
MB05LJS009	Turtle River At Pth #5 At Ste. Rose Du Lac	51.0519	-99.5275
MB05LJS014	Valley River At Pth #20, North Of Dauphin	51.2822	-100.0158
MB05LJS016	Vermilion River At Pth #20, North Of Dauphin	51.1881	-100.0144
MB05LHS002	Waterhen River At Pr 328 Near Waterhen	51.8300	-99.5462
MB05PHS001	Whitemouth River At Pr #307, West Of Seven Sisters	50.1050	-96.0350
MB05LLS001	Whitemud River At Pth 16 At Westbourne	50.1333	-98.5900
MB05PFS069	Winnipeg River At Powerview Dam - Dipsample From Forebay	50.5677	-96.1770
MB05LES015	Woody River At Pr #268	52.3764	-100.9733
MB05SAS004	W11	50.7608	-96.4535
MB05SBS126	W12 - Also 99 Lake Wpg Study - Bacteria Transect	50.5169	-96.8334
MB05SHS004	(Dfo Site A)Lake Winnipeg At Site # 32 - W2 Post 2000	53.2640	-99.0244

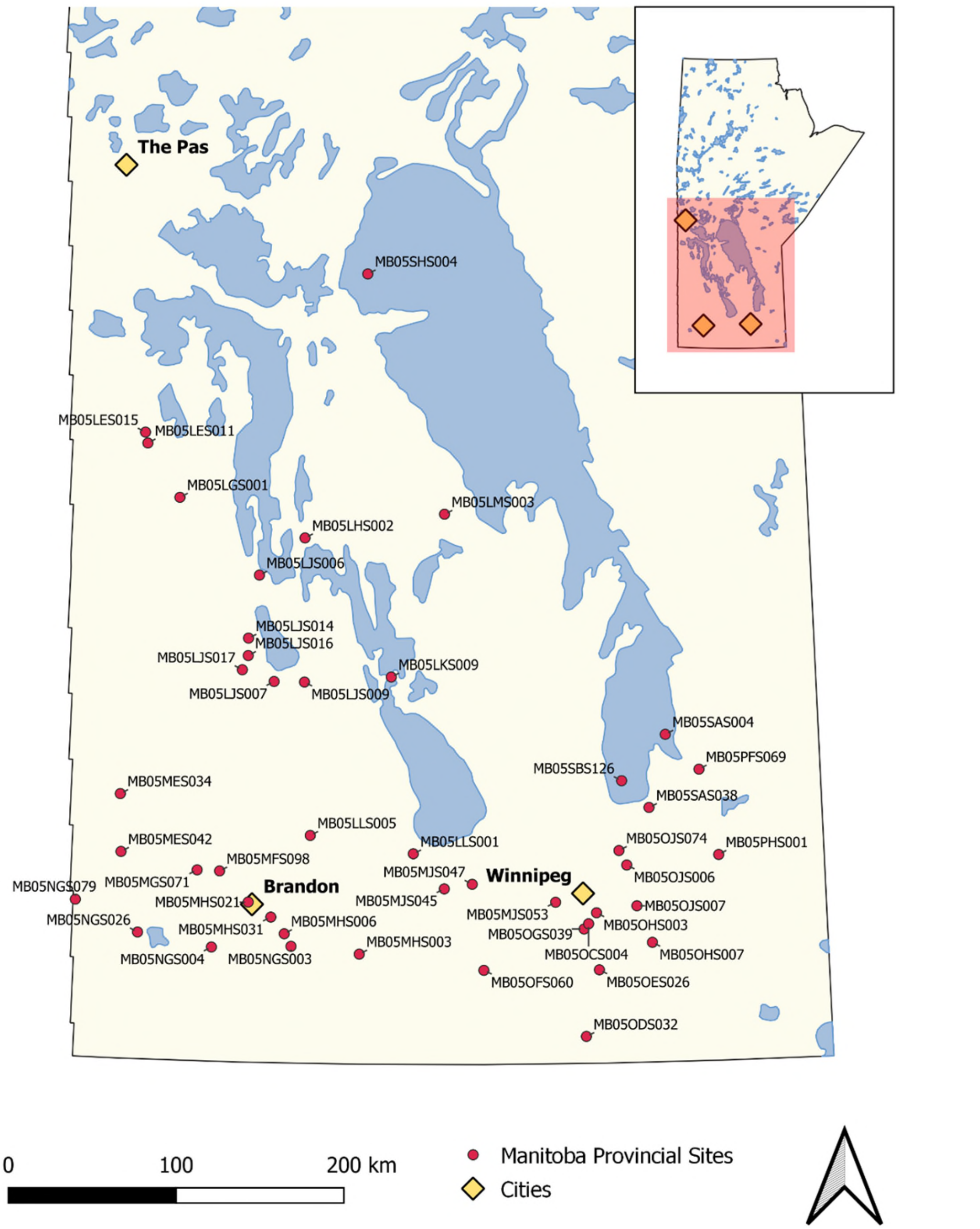

Figure 5 Water Quality Monitoring Stations in Manitoba with Pesticide Monitoring

Table 17 Current list of pesticides and metabolites analyzed in Manitoba rivers and streams.

Pesticide	Detection Limit µg/L
2,4-D	0.05
2,4-Db	0.05
2,4-Dp (Dichloroprop)	0.05
Alachlor	0.1
AMPA (Aminomethylphosphonic Acid)***	0.5
Atrazine	0.1
Atrazine Desethyl***	0.05
Azinphos Methyl**	0.1
Benomyl**	0.1
Bromacil	0.1
Bromoxynil	0.02
Carbofuran**	0.2
Carboxin (Carbathin)**	0.1
Chlorothalonil	0.05
Chlorpyrifos	0.02
Cis-Chlordane	0.008
Cyanazine	0.1
Deltamethrin	0.04
Diazinon	0.03
Dicamba	0.006
Diclofop-Methyl**	0.1
Dimethoate	0.1
Dinoseb**	0.05
Diuron	0.018
Eptam	0.2
Ethalfluralin	0.02
Fenoxaprop	0.1
Gamma-Benzene hexachloride (Lindane)**	0.008
Glyphosate	0.2
Imazamethabenz-Methyl	0.01
Malathion	0.1
MCPA	0.025
Mecoprop (MCPP)	0.05
Methoxychlor**	0.008
Methyl Parathion**	0.1
Metribuzin	0.2
Metsulfuron-Methyl	0.01
Parathion	0.1
Pentachlorophenol	0.02
Picloram	0.2
Propanil**	0.2
Propoxur	0.2
Quizalofop	0.1

Pesticide	Detection Limit µg/L
Sethoxydim	0.1
Simazine	0.1
Terbufos**	0.1
Thifensulfuron - Methyl	0.01
Tralkoxydim	0.1
Trans-Chlordane	0.008
Treflan (Trifluralin)	0.03
Triallate	0.1
Tribenuron-Methyl	0.01
Triclopyr	0.05

** Not currently registered for use in Canada

*** Transformation product (metabolite)

In addition to routine pesticide monitoring activities, Manitoba Agriculture and Resource Development (then Manitoba Sustainable Development and Manitoba Agriculture) in collaboration with multiple Agri-Industry Grower Associations, conducted additional pesticide monitoring for neonicotinoids during the 2017 and 2018 open water seasons. This additional neonicotinoid pesticide monitoring was initiated through Manitoba's participation in Health Canada's Pesticide Management Regulatory Agency's Environmental Monitoring Working Group, created as part of their Multi-Stakeholder Forum on Neonicotinoids. Surface water and groundwater samples were collected from 41 sampling sites (33 and 8 surface water and groundwater sites respectively) located throughout agro-Manitoba during the months of June (planting season), July (growing season) and October (post-harvest season) in 2017, and during the months of April (following spring freshet), June, July and October in 2018. Samples were analyzed for seven neonicotinoids pesticide species in 2017 (dinotefuran, nitenpyram, thiamethoxam, clothianidin, imidacloprid, acetamiprid and thiacloprid) and nine neonicotinoid species in 2018 (cyantraniliprole and chlorantraniliprole in addition to 2017 Neonicotinoid species).

Acid Herbicides in Manitoba Rivers

From 2008 to 2017, 21 acid herbicides were monitored in Manitoba rivers and streams as a part of the long-term water quality monitoring program. Of these 21 acid herbicides, only nine acid herbicides were detected in Manitoba rivers systems including 2,4-D, 2,4-DB, bromoxynil, dicamba, 2,4-DP (dichloroprop), imazamethabenz-methyl, MCPA, Mecoprop (MCPP) and triclopyr (Table 18). The most commonly detected acid herbicides in Manitoba from 2008 to 2017 were 2,4-D, dicamba, MCPA and imazamethabenz-methyl with detection rates of 17, 17, 17, and 12%, respectively.

Five of the acid herbicides have PPWB water quality objectives including 2,4-D, bromoxynil, dicamba, MCPA, and picloram (Table 18). Consistent with the findings of the PPWB review of acid herbicides, dicamba and MCPA were the two acid herbicides that most frequently exceeded the water quality objectives (those for dicamba, MCPA and bromoxynil are aimed at protecting crops from contaminated irrigation water while the ones for 2,4-D and picloram are aimed at protecting aquatic life) in Manitoba rivers and streams from 2009 to 2017 (Data from 2008 were excluded from the analyses because the method detection limit was higher than the water quality objective). Seventeen percent of samples exceeded the water quality objectives for dicamba (0.006 µg/L) and MCPA (0.025 µg/L). For dicamba, a total of 192 samples of 1109 exceeded the water quality objective with concentrations ranging from <0.006 to 2.92 µg/L in Manitoba rivers and streams. Concentrations of MCPA ranged from <0.025 to 1.37 µg/L over the 2009 to 2017 period with 189 samples (of 1109 samples) exceeding the water quality objective for MCPA.

Very few samples exceeded the water quality objectives for bromoxynil and 2,4-D from 2008 to 2017 (e.g., <0.5% of samples exceeded the respective guidelines for these two acid herbicides, Table 18). Although 2,4-D was the most commonly detected acid herbicide in Manitoba from 2009 to 2017, it did not frequently exceed the water quality objective. For instance, concentrations of 2,4-D ranged from <0.05 µg/L to a maximum concentration of 8.38 µg/L with only two of 1373 samples exceeding the guidelines for protection of aquatic life (4 µg/L). Similarly, only three of 1373 samples exceeded the objective for bromoxynil (0.33 µg/L) during the same period with concentrations ranging from <0.02 to 0.653 µg/L. Picloram was the only acid herbicide with a water quality objective for which there were no detections.

Summary of MCPA and Dicamba in Major Manitoba River Basins

Dicamba and MCPA were the two most frequently detected acid herbicides in prairie river systems in Manitoba. Dicamba and MCPA were summarized by major river basin in Manitoba including the Red River, Assiniboine River, Souris River, Saskatchewan River, Lake Manitoba/Winnipegosis and Lake Winnipeg (east and west) basins. Data for each acid herbicide are summarized for mainstem site and tributary sites within each river basin (Table 19).

From 2009 to 2017, dicamba was detected in most river basins in Manitoba (Table 19). Dicamba was most frequently detected in the Red River (mainstem), Souris River (mainstem) and Red River (tributaries) with detections of 50, 43, and 22%, respectively. The Assiniboine River also had some detections of dicamba with 19 and 13 % detection rates for the mainstem and tributary sites, respectively. Less than 5% or less of samples had detections of dicamba in the Lake Winnipeg Basin and the Lake Manitoba/Winnipegosis Basin. Dicamba was not detected in the Souris River tributaries or in the Saskatchewan River mainstem. However, very few samples were collected from these basins, notably for the Saskatchewan River Basin where only one sample was collected for the entire period of record.

Manitoba's laboratory detection limit for dicamba is <0.006 µg/L and the PPWB water quality objective is 0.006 µg/L. All but one detection of dicamba exceeded the water quality objective. Dicamba concentrations ranged from <0.006 to 0.516 µg/L in the Red River mainstem from 2009 to 2017. Dicamba concentrations in the Red River tributaries were comparatively lower with concentrations ranging from <0.006 to a maximum concentration of 0.283 µg/L. The maximum dicamba concentration detected in the

Souris River mainstem (0.041 µg/L) was nearly 15 times lower than the maximum concentrations detected in the mainstem of the Red River (0.516 µg/L). For the Assiniboine River mainstem and tributaries, dicamba concentrations ranged from <0.006 to 0.0534 µg/L and from <0.006 to 2.92 µg/L, respectively, from 2009 to 2017.

MCPA was most frequently detected in the Assiniboine River mainstem (30%), the Souris River tributaries (27%) and the Red River tributaries (24%). MPCA was also detected in the Souris River mainstem, the Assiniboine River tributaries, and the Red River mainstem in 22, 17 and 14% of all samples, respectively. Similar to patterns for dicamba, MCPA was not frequently detected in Lake Winnipeg and Lake Manitoba/Lake Winnipegosis (<12%) and was not detected in the Saskatchewan River Basin, although only one sample was collected from 2009 to 2017.

Given the detection limit of <0.025 µg/L for MCPA, most detections also exceeded the water quality objective. MCPA concentrations exceeded the water quality objective of 0.025 µg/L approximately 29% of the time at Assiniboine River mainstem sites in Manitoba from 2009 to 2017 (Table 19). Concentrations of MCPA in the Assiniboine River mainstem within Manitoba ranged from <0.025 to 0.803 µg/L during the same period. MCPA also exceeded the objective in the Assiniboine tributaries, but less frequently as compared to the mainstem Assiniboine River (17% exceedance in Assiniboine River tributaries). The Souris River exceeded the water quality objective for MCPA in 27% samples at tributary sites and 22% of samples at mainstem sites. Concentrations of MCPA ranged from <0.025 to 0.532 µg/L in the Souris River tributaries, whereas the maximum concentration detected in the Souris River mainstem was approximately half that of the tributaries (0.291 µg/L). MCPA also exceeded the objective on the Red River with a greater exceedance rate on the Red River tributaries (24%) as compared to the mainstem sites (13%). Maximum concentrations of MCPA observed in the Red River were the highest in comparison to all other rivers in Manitoba with maximum concentrations of 1.28 and 1.37 µg/L on the Red River mainstem and tributaries, respectively.

Table 18 Summary Statistics for all Acid Herbicides in Manitoba River Systems, 2008 to 2017.

Acid Herbicide	PPWB Objective (µg/L)	Number of Detections	% Detection	Method Detection Limit (µg/L)	Number Exceeding Objective	% Exceeding Objective	Minimum (µg/L)	Maximum (µg/L)	n
2,4,5-T**	-	0	0.00	0.05	-	-	<0.05	<0.05	2
2,4-D	4	234	17.04	0.05	2	0.15	<0.05	8.38	1373
2,4-DB	-	1	0.07	0.05	-	-	<0.05	0.059	1373
Aroclor 1016	-	0	0.00	0.1	-	-	<0.1	<0.1	2
Aroclor 1221	-	0	0.00	0.1	-	-	<0.1	<0.1	2
Aroclor 1232	-	0	0.00	0.1	-	-	<0.1	<0.1	2
Aroclor 1242	-	0	0.00	0.1	-	-	<0.1	<0.1	2
Aroclor 1248	-	0	0.00	0.1	-	-	<0.1	<0.1	2
Aroclor 1254	-	0	0.00	0.1	-	-	<0.1	<0.1	2
Aroclor 1260	-	0	0.00	0.1	-	-	<0.1	<0.1	2
Bromoxynil	0.33	54	3.93	0.02	3	0.22	<0.02	0.653	1373
Dicamba[a]	0.006	193	17.40	0.006	192	17.31	<0.006	2.92	1109
2,4-DP (Dichloroprop)	-	1	0.07	0.05	-	-	<0.05	0.054	1373
Dinoseb**	-	0	0.00	0.05	-	-	<0.05	<0.05	1373
Fenoprop (Silvex)**	-	0	0.00	0.05	-	-	<0.05	<0.05	264
Imazamethabenz-Methyl	-	77	11.96	0.010	-	-	<0.01	0.324	644
MCPA[a]	0.025	192	17.31	0.025	189	17.04	<0.025	1.37	1109
MCPB	-	0	0.00	0.05	-	-	<0.05	<0.06	2
MCPP (Mecoprop)	-	20	1.46	0.05	-	-	<0.05	0.59	1373
Picloram	29	0	0.00	0.2	0	0.00	<0.2	<0.2	1371
Triclopyr	-	50	3.63	0.050	-	-	<0.05	0.4	1376

Superscripts

a. Data from 2008 were excluded from the analyses because the method detection limit was higher than the water quality objective

\- No PPWB water quality objective to compare

\- 2, 4-D, Picloram – adopted from PAL guidelines; Bromoxynil, Dicamba and MCPA adopted from irrigation guidelines

** Not currently registered in Canada for use

Table 19 Summary of Dicamba and MCPA Concentrations in Manitoba by Major River Basin, 2009 to 2017.

Parameter	Major Basin	Number of Samples	Number of Detections	% Detection	Method Detection Limit (µg/L)	Number of Samples Exceeding Objective	% of Samples Exceeding Objective	Minimum (µg/L)	Maximum (µg/L)
Dicamba	Red River - main stem sites	138	69	50.00	0.006	69	50.00	<0.006	0.516
	Red River - tributary sites	165	36	21.82	0.006	36	21.82	<0.006	0.283
	Assiniboine River - main stem sites	224	43	19.20	0.006	43	19.20	<0.006	0.0534
	Assiniboine River - tributary sites	96	12	12.50	0.006	11	11.46	<0.006	2.92
	Souris River - main stem sites	49	21	42.86	0.006	21	42.86	<0.006	0.041
	Souris River - tributary sites	26	0	0.00	0.006	0	0.00	<0.006	<0.006
	Saskatchewan River - main stem sites	1	0	0.00	0.006	0	0.00	<0.006	<0.006
	Lake Manitoba/ Winnipegosis	200	1	0.50	0.006	1	0.50	<0.006	0.0106
	Lake Winnipeg - western and eastern	208	11	5.29	0.006	11	5.29	<0.006	0.034
MCPA	Red River - main stem sites	138	20	14.49	0.025	18	13.04	<0.025	1.28
	Red River - tributary sites	165	39	23.64	0.025	39	23.64	<0.025	1.37
	Assiniboine River - main stem sites	224	67	29.91	0.025	66	29.46	<0.025	0.803
	Assiniboine River - tributary sites	96	16	16.67	0.025	16	16.67	<0.025	1.1
	Souris River - main stem sites	49	11	22.45	0.025	11	22.45	<0.025	0.291
	Souris River - tributary sites	26	7	26.92	0.025	7	26.92	<0.025	0.532
	Saskatchewan River - main stem sites	1	0	0.00	0.025	0	0.00	<0.025	<0.025
	Lake Manitoba/ Winnipegosis	200	23	11.50	0.025	23	11.50	<0.025	0.561
	Lake Winnipeg - western and eastern	208	9	4.33	0.025	9	4.33	<0.025	0.44

Federal Pesticide Projects

The Government of Canada, through Environment and Climate Change Canada (ECCC) and Agriculture and Agri-Food Canada (AAFC), has conducted numerous projects related to pesticides in water. These studies include several projects for regulatory purposes (PPWB, PMRA), as well as for research.

As part of these projects, dicamba and MCPA have been quantified in water, air, and sediment. Water includes rainfall, irrigation water, river water, groundwater, wetland water and snow. The following is a short-list of some recent pesticide studies conducted by the federal government, where both dicamba and MCPA were included since the latter two herbicides are the focus of this report.

MCPA and Dicamba

MCPA and dicamba in air and rainfall

At least three studies were conducted in Alberta regarding the presence of pesticides in air (Kumar et al. 2001) and rainfall (Hill et al. 2002a, b).

Pesticides in ambient air: Of the 59 pesticides monitored in ambient air in southern Alberta (Lethbridge, Lacombe, Vegreville and Lundbreck), MCPA was detected at all sites, while dicamba was also detected at a few sites (Kumar et al. 2001). Detections of these two herbicides were mostly observed at the end of May until early July, with a peak detection in June (Kumar et al. 2001). Detection levels of MCPA in air ranged from 0.03 to 0.46 ng/m^3 (Kumar et al. 2001). Dicamba was detected in air samples collected in June and July at levels of 0.05 to 0.06 ng/m^3 (Kumar et al. 2001). While not required for this jurisdictional report, it should be noted that a number of other herbicides belonging to the 'auxin' family were also detected in ambient air in Alberta and on similar dates as part of this study, including clopyralid, mecoprop and 2,4-D (Kumar et al. 2001).

Pesticides in rainfall: Research on the occurrence of acid herbicides (including dicamba and MCPA) in Alberta's rainfall and their potential effects on sensitive crops was conducted by Hill et al. (2002a, b) at 17 locations in Alberta. Of the 13 herbicides included in the study, MCPA and dicamba were among the most frequently detected, and at the highest concentrations (Hill et al. 2002a). The highest detected levels of acid herbicides in rainfall were observed in farming areas, while being intermediate in the City of Lethbridge and lowest in remote areas where farming was not as prevalent (Hill et al. 2002a). Herbicide levels in rainfall were consistent with their sales and use, frequently exceeded the Canadian guidelines for protection of aquatic life (PAL), and at times exceeded those for drinking water guidelines (Hill et al. 2002a). Highest concentrations were 17 to 53 µg/L for 2,4-D, 9.1 µg/L for dicamba and 26 µg/L for MCPA.

Dicamba's detection frequency was consistent on both years of the study, ranging from 56 to 69% in urban centres and 31 to 75% in southern Alberta (Hill et al. 2002a). Detection frequency of dicamba was lower in central Alberta (11–44%) compared to elsewhere in the province (Hill et al. 2002a). The amounts (concentrations) of dicamba detected were similar among all locations of the study, with median detections ranging from 0 to 1.0 µg/m^2 (Hill et al. 2002a). However, maximum concentrations were highest in southern Alberta (1.3–23 µg/m^2), with a total amount of dicamba deposited during the sampling period estimated at 5–47 µg/m^2 in this region (Hill et al. 2002a). Samples were collected at weekly or biweekly intervals from April to September.

The detection frequency of MCPA was mostly low in that study (less than 50% of the collected samples contained MCPA), where remote locations and urban centres showed similar (6–29%) results; whereas, the detection frequency in rural (farming) areas showed a greater range of detection frequency (Hill et al. 2002a). The highest amounts of MCPA detected (35–84 µg/m^2) were consistently detected in rural areas, but total deposition levels varied extensively throughout the province, reaching as much as 114 µg/m^2 in southern Alberta and 171 µg/m^2 in central Alberta (Hill et al. 2002a). The highest concentrations of MCPA in rainfall reached 26 µg/L (Hill et al. 2002a). Dicamba and MCPA maximum concentrations were observed in 1-mm rainfall during the spray season (Hill et al. 2002a).

The study included a number of auxin herbicides other than dicamba and MCPA, including 2,4-D, bromoxynil, mecoprop, 2,4-DB, clopyralid and picloram (Hill et al. 2002a). 2,4-D, bromoxynil and mecoprop were also detected frequently in the study, demonstrating the prevalence of this family of herbicides in the environment.

Dry samples collected in 2000 as part of the same study showed much lower concentrations of herbicide compared to those observed in corresponding rainfall events (same location, same period of sampling), which demonstrated that likely dry deposition is not a contribution as important as rainfall for these herbicides (Hill et al. 2002a). Moreover, a consistent rainfall pattern showed that small rainfall events (0.1–2.0 mm) during the spray season invariably led to the highest levels of herbicides in rainfall (Hill et al. 2002a). In terms of seasonality, detection frequency and concentration were low in spring and fall, but higher during the spray season (May–July) when these herbicides are typically being used by producers (Hill et al. 2002a).

MCPA and dicamba in groundwater

A study conducted by Munira et al. (2018) investigated the presence of auxin herbicides in groundwater of southern and central Alberta. MCPA was one of the three most frequently detected herbicides in groundwater, although its overall detection frequency (4%) and range of detected concentrations (25–1293 ng/L) was low. Dicamba was only detected in one sample in central Alberta, with a concentration of 27 ng/L. Interestingly, pesticide mixtures were observed in about 3% of all samples collected and analyzed, but only in piezometers and wells at 10 m depth or deeper, and mostly in fall. The pesticide mixtures always contained either 2,4-D or MCPA, most often combined with another auxin herbicide (clopyralid, fluroxypyr). Dicamba and MCPA never exceeded their respective drinking water guidelines (Munira et al. 2018).

Other studies of pesticides in groundwater were conducted in the 1990s (Hill et al. 1996; Miller et al. 1995a, b) and highlighted the presence of auxin herbicides such as dicamba and MCPA in shallow groundwater in Alberta.

MCPA and dicamba in other water matrices

Wetlands: MCPA and dicamba have been detected in wetlands of the Canadian Prairies. In 2018, a series of wetlands showed detection of dicamba and MCPA at concentrations ranging from 0.025 to 63 µg/L (dicamba) and from 0.025 to 0.160 µg/L. Their detection frequency was lower than for 2,4-D, and lower than in irrigation, river and surface waters.

Snow: While MCPA has been frequently detected in snow samples collected along the Continental Divide, dicamba was not (Claudia Sheedy, AAFC, personal communication). This trend was apparent during the five-year study conducted to establish baseline values of pesticides in high-altitude mountain snow pack of Alberta (Jasper to Montana).

ECCC Recent Research

The current focus of ECCC research on pesticides has not been on acid herbicides but more on the neonicotinoid insecticides and glyphosate and their effects on various organisms prone to exposure. The following summary should not be considered an exhaustive list of ECCC work, but rather a snapshot of recent publications and provides perspective on the scope of work being conducted.

Exposure studies have been conducted on the effects of pesticides on frogs, amphipods (*Hyalella azteca*), freshwater mussels and hummingbirds. Additionally there has been some research on the concentration of legacy organochlorine in Arctic regions.

Robinson et al, 2019, conducted a study to assess whether exposure of wood and northern leopard frogs to two commercial formulations of neonicotinoids (clothianidin, thiamethoxam) affected their life history traits and survivability. Using artificial ponds dosed at concentrations between 2.5 and 250 µg/L, they monitored the larval development through metamorphosis. The results suggested that exposure to these concentrations did not have any effect.

Bartlett et al, 2019, assessed the acute and chronic toxicity of six neonicotinoids (imidacloprid, thiamethoxam, acetamiprid, clothianidin, thiacloprid, and dinotefuran) and one butenolide (flupyradifurone) to the freshwater amphipod, *Hyalella azteca*. Twenty-eight day chronic exposure studies produced variable results depending on the pesticide. Chronic and seven-day acute growth and survival of the amphipod was reduced at similar concentrations for thiamethoxam, acetamiprid, clothianidin, and dinotefuran. The chronic survival and growth of the amphipod to imidacloprid and thiacloprid was less than the concentrations used from acute tests. Test concentrations ranged from 3 to 290 µg/L and concentrations have been detected within this range in North American surface water.

Salerno et al, 2018, investigated the effects of 4 fungicides (azoxystrobin, boscalid, metalaxyl, and myclobutanil), 3 neonicotinoids (clothianidin, imidacloprid, and thiamethoxam), 2 carbamates (carbaryl and malathion), 1 organophosphate (chlorpyrifos), and 1 butenolide (flupyradifurone) on freshwater mussel life stages. *Lampsilis siliquoidea* and *Villosa iris* were exposed to concentrations >161 µg/L for 48h acute and 28-day chronic scenarios. The results showed that exposure to these concentrations had little to no effect on the mussels' life stages.

Bishop et al, 2018, measured the exposure of two hummingbird species: Rufous (*Selasphorus rufus*) and Anna's (*Calypte anna);* and bumble bees living near blueberry fields, to pesticide exposure by measuring concentrations in their cloacal fluid fecal pellets, in bumble bees and their pollen. Imidacloprid, thiamethoxam, and clothianidin were detected in hummingbird sources at low concentrations. Diazinon was detected in bees and both diazinon and imidacloprid in their pollen. The results show a wide-ranging chemical exposure that can be better understood by examining both vertebrate and invertebrate pollinators.

Cabrerizo et al, 2019, sampled freshwater (lakes and rivers), seawater, snow, air, and zooplankton concurrently in the high arctic and analyzed for a range of legacy polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs). Generally, the results showed higher PCBs and OCPs concentration in the spring melt with much lower concentrations measured during the snow free season. Conversely, lakes and ocean waters had higher concentration in the ice-free season presumably due to runoff. The air water equilibrium during the ice-covered season shifted dramatically over the ice-free season to a net volatilization of chlorinated contaminants.

Effects of Low Levels of Pesticides on Crops

Potential effects of phenoxy herbicides in rainfall on sensitive crops.

Following the results of the rainfall study mentioned above (Hill et al. 2002a), Hill et al. (2002b) conducted indoor bioassays to determine whether the presence of herbicides in rainfall could negatively affect sensitive crops, including dry bean, potato, and sugar beet, which are commonly grown in southern Alberta (Hill et al. 2002b). A mixture of four acid herbicides (2,4-D, bromoxynil, MCPA and dicamba) each at their maximum rainfall rate was sprayed on the plants once and potential effects were assessed 10 and 14 days later (Hill et al. 2002b). Results observed (leaf curling, growth inhibition) demonstrated that this mixture of herbicides affected dry bean and tomato, while no significant effects were observed for potato and sugar beets.

MCPA and dicamba in irrigation water of Alberta

Since 2006, Alberta Agriculture and Forestry, in partnership with the 13 irrigation districts, and Agriculture and Agri-Food Canada, assessed the quality of irrigation water in southern Alberta. This research is conducted in part to gain background knowledge on water quality (nutrients, metals, antimicrobials and pesticides) and to assess how the irrigation infrastructure (canals, pipelines, reservoirs) may play a role in water quality.

In southern Alberta, the South Saskatchewan River Basin accounts for 97% of the irrigated land in Alberta, with 597,440 ha of assessed land for irrigation in 13 irrigation districts (GOA 2020). In 2019, about 95% of the assessed land was actually irrigated. Maintaining high water quality in the region is critical for safe food production, aquatic ecosystems, and for sustainable rural development (Charest et al. 2015). In 2013, 15.2 million kg of pesticides were sold in or shipped to Alberta, with 95% of these sales in the agriculture sector (AEP 2015). Little et al. (2010) was the first to comprehensively explore water quality and pesticides in southern Alberta, where the authors noted differences among irrigation districts and types of infrastructures (primary, secondary and return flows). Herbicides were the most frequently detected pesticides in southern Alberta, reflecting the prominent use of herbicides. 2,4-D rarely exceeded water quality guidelines, while dicamba and MCPA frequently exceeded guidelines (Charest et al. 2015).

While a total suite of up to 174 different pesticides (historical and current-use) were analyzed during the study, herbicides represented the major proportion of those and by far the major detections as well. The acid herbicides included in the analytical suite consisted of 2,4-D, MCPA, dicamba, mecoprop, clopyralid, bromoxynil and picloram. MCPA has had an overall detection frequency of 25% (out of 3000 samples analyzed), while dicamba showed a detection frequency of 23% (Table 20) (Watt et al. 2021).

Table 20 MCPA and Dicamba Detection Frequencies as percentage of total number of samples (3000) and concentrations (average detected, total average, detected median, detected minimum and detected maximum) in µg/L in the Irrigation Waters of Alberta (sampled in 2006, 2007 and 2011 to 2018).

Pesticide	Detection frequency (%)	Detected Average	Average of all Samples	Detected Median	Detected Min.	Detected Max.
MCPA	25.2	0.217	0.050	0.053	0.013	151.900
Dicamba	22.9	0.427	0.074	0.270	0.011	14.514

While 2,4-D has been the pesticide most frequently detected in irrigation waters of Alberta since 2006 (detection frequency of 78%), dicamba and MCPA show higher average concentrations. MCPA had a maximum detected concentration that was almost four times higher than that of 2,4-D. Therefore, although 2,4-D is detected three times more frequently than dicamba and MCPA, it is on average detected at lower concentrations.

Trend analysis of the occurrence of dicamba and MCPA in irrigation waters has not revealed specific patterns with regards to seasonality or location.

An attempt was made in Alberta to collect evidence of potential impacts of pesticides in irrigation water on sensitive crops (such as lettuce, sunflower). Feedback from irrigation groups (i.e. East Irrigation District, Alberta Irrigation Districts Association) and relevant governmental agencies (i.e., Environment and Parks, Agriculture and Forestry) show that the related impacts were barely reported to the organizations previously. Possible reasons for this could be: a) acid herbicide levels are generally low in irrigation water where intense irrigation is applied; b) irrigation rate is lower than the rate on which guidelines are calculated based; 3) negative impacts may not be significant enough to be noticed or related to pesticide use.

MCPA and dicamba in irrigation water of Saskatchewan

In Saskatchewan, about 120 producers irrigate sensitive crops on roughly 2800 ha. Tomato, pepper, potato, bean, cucumber, melon, and squash are all considered sensitive crops. All vegetable and most potato producers irrigate. The Saskatchewan Ministry of Agriculture has not had requests from producers concerned about pesticide contamination of irrigation water (Richard Wilkins and Connie Achtymichuk, Saskatchewan Ministry of Agriculture, personal communication, 2020). Previous studies have evaluated pesticide levels in irrigation source water (e.g., Hogg 2010) and runoff from irrigated areas (e.g., Cessna et al. 2001). Hogg (2010) studied source water for three years in four irrigation districts: the Lake Diefenbaker Development Area, Saskatoon South East Water Supply, Moon Lake Irrigation District and the Qu'Appelle River in the Lumsden Valley. This study included evaluation of source water to an irrigation district and water at various locations within the irrigation district, depending on size. Six of 18 pesticides analyzed were detected (2,4-D, bromoxynil, dicamba, dichlorprop, MCPA, and mecoprop). 2,4-D was the most frequently detected (96% of samples) but only two pesticides, dicamba and MCPA, were found to exceed irrigation guidelines. For dicamba and MCPA, the guidelines used in the study were 6 ng/L and 25 ng/L, respectively; however, the detection limit for dicamba was 25 ng/L meaning the number of detections and exceedances was presumably underestimated by the study. Dicamba exceeded its irrigation guideline in 6% of samples and MCPA in 23% of samples. Other than 2,4-D, the other pesticide detections were concluded to be detected sporadically with no seasonal or yearly trends.

MCPA and dicamba in irrigation water of Manitoba

Manitoba Agriculture and Resource Development is not aware of producer concerns regarding dicamba and MCPA concentrations in irrigation water.

Input to Water Ways from Urban Centre's

MCPA and Dicamba in river water

Recent studies of pesticides in river water were conducted in Alberta and Manitoba (Sheedy et al. 2019, Gamhewage et al. 2019). Both studies quantified a range of auxin herbicides, including dicamba and MCPA.

A time-of-travel synoptic survey conducted in Alberta's South Saskatchewan River Basin (including the Red Deer, Bow, Oldman and South Saskatchewan rivers) included the analysis of 170 pesticides in river water, tributaries and wastewater treatment plant effluents, from the river's origin in the Rocky Mountains to Saskatchewan. Dicamba (15%) and MCPA (8%) were detected, and the six most frequently detected pesticides all belong to the auxin family (Sheedy et al. 2019). Most wastewater treatment plant effluents in summer contained dicamba and MCPA, but not in winter (Sheedy et al. 2019). The wastewater treatment plant effluent did not include stormwater. Concentrations of dicamba and MCPA in the effluents were invariably lower than in river and tributary waters (Sheedy et al. 2019), but this still suggests that wastewater treatment processes may not entirely remove these herbicides (Sheedy et al. 2019). The results highlighted the contribution of the residential use of herbicides, such as 2,4-

D, dicamba and MCPA, for weed control in turfgrass, and this could affect the resulting concentrations in surface waters below urban centres (Sheedy et al. 2019). The pesticides most frequently detected were all auxin herbicides, which typically have short half-lives in the environment, but tend to also have high water solubility and high levels of sales (Sheedy et al. 2019).

Dicamba and MCPA were quantified in rivers of Manitoba as part of a study of acid herbicides interactions with river-bottom sediments (Gamhewage et al. 2019). Sampling was performed along the Red, Assiniboine, Fisher, Manigotagan and Winnipeg rivers for water and sediment collection (Gamhewage et al. 2019). MCPA was detected at a high detection frequency in all river systems, with 90% frequency in water-column samples and 96% frequency in sediment samples (Gamhewage et al. 2019). Dicamba on the other hand, was only detected in water, at a fairly high (59%) detection frequency (Gamhewage et al. 2019). Pesticide mixtures were frequently observed more often in water than in sediment (Gamhewage et al. 2019). Auxin herbicides, including 2,4-D, clopyralid, dicamba, fluroxypyr and MCPA, were the most prevalent pesticides detected and mostly detected in May and June (Gamhewage et al. 2019). Pesticide mixtures were mainly detected in rivers flowing through cropland and urban centres, whereas, rivers in forested or remote locations showed fewer pesticides and fewer samples with mixtures (Gamhewage et al. 2019). The concentrations of dicamba and MCPA were less than threshold values known to indicate significant risks to aquatic plants, invertebrates and fish (Gamhewage et al. 2019).

Urban influence on prairie river pesticide concentrations

Regina and Saskatoon, in Saskatchewan, were evaluated for their influence on trace riverine pesticide concentrations as part of a scoping exercise. Regina's stormwater system and wastewater treatment plant discharge to Wascana Creek. A short distance from Regina, Wascana Creek enters the Qu'Appelle River. Samples were collected on the Qu'Appelle River upstream and downstream of the Wascana confluence at long-term water quality monitoring stations. In Saskatoon, where the South Saskatchewan River bisects the city, samples were collected upstream and downstream of the city, and similar to Regina, samples were collected from long-term water quality monitoring stations. Samples were collected from October 2016 to October 2019 for trace levels of acid herbicide and glyphosate/AMPA (AMPA is a transformation product of glyphosate). Each year, one sample was collected in three open water seasons (spring, summer, autumn). Although acid herbicides are routinely monitored at these locations as part of a long-term monitoring program, they are not routinely analyzed at trace levels.

Changes in pesticide levels from upstream to downstream on the Qu'Appelle River are principally attributed to the influence of the City of Regina. Some of the increases may be due to pesticides presence in Wascana Creek upstream of the city or entry along the short reach between the upstream and downstream sites along the Qu'Appelle River, but these are considered to be minor given the low flows of Wascana Creek upstream of Regina for most of the year and short distance between the upstream and downstream locations on the Qu'Appelle River. The Qu'Appelle River is a river with low flows for most of the year, so stormwater and treated wastewater effluent are important contributors to the flow.

For the Regina comparison, nine acid herbicide samples and ten glyphosate samples were collected between Oct 2016 and Oct 2019. On each sampling date, concentrations of 2,4-D, dicamba, MCPA, MCPP, glyphosate and AMPA were greater at the downstream location compared the upstream location (Table 21). The increase in concentration downstream was greatest for 2,4-D, MCPP and glyphosate/AMPA. Other acid herbicides were detected, but generally occurred at lower concentrations than the above listed pesticides. For example, 2,4,5-T was detected four times at the upstream location at trace concentrations (0.06 to 0.16 ng/L) and eight times at the downstream location (0.07 to 0.31 ng/L). As with all pesticides tested upstream/downstream of the Wascana Creek confluence, the concentrations downstream were always greater than those measured upstream. Dichlorprop was detected at the downstream site on eight occasions (0.51 to 96.5 ng/L) but was never detected at the upstream location. Similar to 2,4,5-T, triclopyr was only detected at sub-nanogram levels, it was detected three times upstream and eight times downstream. Glufosinate was only detected in one sample, which was at the downstream site in August 2019 (12 ng/L).

Table 21 Selected Herbicide and Glyphosate Concentrations measured on the Qu'Appelle River upstream and downstream of the Wascana Creek Confluence (n=13, sampled between 2016 to 2019).

	Median Concentration (ng/L)		**Average Concentration (ng/L)**		**Average Paired Difference (upstream to downstream)**
	Upstream	Downstream	Upstream	Downstream	
2,4-D	21.4	136.0	36.6	289.4	252.8
Dicamba	2.2	8.7	2.5	32.9	30.3
MCPA	3.7	5.3	6.7	16.0	9.3
MCPP	1.2	73.7	5.1	153.6	148.5
Glyphosate	77.3	1060	143.3	1899.3	1756.1
AMPA***	143.6	1455	284.4	2669.7	2385.3

Note: Units are in ng/L and not µg/L. Where a non-detect was reported a value of zero was used in the paired calculation.
*** Transformation product (metabolite of glyphosate)

On the South Saskatchewan River samples were collected upstream and downstream of the City of Saskatoon (Table 22). The South Saskatchewan River has much higher flow than the Qu'Appelle River, meaning the capacity for dilution is greater. Differences between upstream and downstream concentrations are summarized in Table 22. As with the Regina samples, there were nine samples collected for analysis of the acid herbicides and 10 for glyphosate/AMPA downstream of Saskatoon. The upstream location was not monitored in October 2016 so had eight and nine samples, respectively for acid herbicides and glyphosate. For 2,4-D, seven samples had concentrations downstream that were greater than those upstream; one sample had a greater concentration at the upstream location (2.8 ng/L greater). Generally, the differences upstream to downstream were small. For dicamba, five of the eight upstream samples had marginally greater concentrations than the corresponding downstream sample (average difference of these five samples was 0.44 ng/L). Similar to dicamba, MCPA in three samples upstream were marginally greater than concentrations measured downstream (average difference of these three samples was 0.44 ng/L). There was one MCPP sample greater upstream than downstream (by 0.7 ng/L) with the rest being greater downstream (on five dates the difference was less than 1 ng/L). Triclopyr was also found in all samples measured (range of upstream and downstream sites was 0.50 to 1.18 ng/L) but was greater at the upstream location for five of eight sample pairs (greater by an average of 0.11 ng/L). Only one upstream sample for glyphosate was found to be greater than the corresponding downstream concentration (by 30 ng/L), otherwise the downstream concentrations of glyphosate and AMPA were greater. On July 2017 there was no glyphosate detected upstream, but a concentration of 408 ng/L was found downstream. Apart from this date those dates with higher downstream concentration were greater by less than 18 ng/L. AMPA concentration was greater downstream for all samples. Downstream samples were greater than those upstream by an average and median concentration of 43 ng/L and 35 ng/L, respectively. For Saskatoon, AMPA was the only parameter found to be statistically greater downstream (Wilcoxon signed-rank test and paired t-test, p=0.004).

The different result between Regina and Saskatoon is presumably related to differences in riverine flow; with the lower flows in the Qu'Appelle River load inputs are more detected. This suggests that loading of pesticides from Regina can be readily detected by differences in upstream/downstream concentrations on Wascana Creek, whereas for Saskatoon a more targeted approach would be required.

Table 22 Selected Herbicide and Glyphosate Concentrations measured on the South Saskatchewan River upstream and downstream of Saskatoon (n=12, sampled between 2016 to 2019).

	Median Concentration (ng/L)		**Average Concentration (ng/L)**		**Average Paired Difference (upstream to downstream)**
	Upstream	Downstream	Upstream	Downstream	
2,4-D	33.7	39.3	34.5	38.0	3.6
Dicamba	2.9	2.7	3.2	3.0	-0.09
MCPA	7.1	7.6	6.8	7.1	0.4
MCPP	1.8	2.7	2.0	3.8	2.0
Glyphosate	17.5	23.7	27.1	62.7	49.3
AMPA***	21.2	67.7	27.9	61.8	43.0

Note: Units are in ng/L and not µg/L. Where a non-detect was reported a value of zero was used in the paired calculation.
*** Transformation product (metabolite of glyphosate)

Urban Stormwater

In a three-year study from 2012 to 2014, that analyzed stormwater samples from Lethbridge, Alberta for pesticides, 27 different pesticide were detected (Derksen et al. 2016). Of the pesticides detected, 2,4-D (79%), mecoprop (60%) and dicamba (54%) were those with the highest detection frequencies and concentrations. Of all samples analyzed during this study, 84% contained at least one pesticide. The pesticide that most frequently exceeded the protection of aquatic life guideline was 2,4-D with 14 samples (mainly collected in 2013) exceeding the 6.1 µg/L guideline. The maximum number of pesticides detected in one sample was 11 different pesticides, but on average stormwater samples contained 3 different pesticides. Samples collected during rain events often contained a larger number of pesticides, but their concentrations were lower than those collected during dry periods. For all the stormwater sites sampled during this study, nine to 12 different pesticides were detected at each of the sites. At least eight pesticides were detected at least once for every year of the study: 2,4-D, dichlobenil, bromacil, bromoxynil, mecoprop, MCPA, dicamba and picloram. Stormwater samples had a higher average number of pesticides per sample as compared to corresponding water river samples. For river water samples collected in 2013 and 2014 only 2,4-D and its metabolite 2,4-DCP were above detection levels. In Six Mile Coulee creek, a total of 11 compounds were detected in the stormwater, including urban and agricultural use pesticides (Derksen et al. 2016).

Other Considerations

Glyphosate, AMPA and glufosinate-ammonium in irrigation water of Alberta

Although glyphosate is by far the highest volume pesticide sold in Canada, including the Canadian prairies, its detection frequency in irrigation water (17%, Table 23) is lower than that of acid herbicides such as 2,4-D, MCPA and dicamba. The main metabolite of glyphosate, AMPA, is present in 10% of irrigation water samples. Glufosinate-ammonium has not been detected in irrigation waters (Watt et al, 2021).

Table 23 Glyphosate and AMPA Detection Frequencies as Percentage of total number of samples (443) and concentrations (average detected, total average, detected median, detected minimum and detected maximum) in µg/L in the irrigation waters of Alberta (sampled in 2012 to 2016).

Pesticide	Detection frequency (%)	Detected average	Average	Detected Median	Detected Min.	Detected Max.
Glyphosate	**17.4**	0.573	0.144	0.054	0.047	3.900
AMPA***	**9.7**	0.094	0.007	0.057	0.100	4.434

*** Transformation product (metabolite of glyphosate)

Neonicotinoid insecticides

The focus of this section is on the neonicotinoid insecticides , including thiamethoxam, clothianidin and imidacloprid, and their detection in streams and rivers in the prairies provinces. The PMRA has completed the pollinator re-evaluation of thiamethoxam (RVD2019-04), clothianidin (RVD2019-05) and imidacloprid (RVD2019-06), special reviews for thiamethoxam (SRD2021-04) and clothianidin (SRD2021-03) focusing on the risk to aquatic invertebrates and the full re-evaluation of imidacloprid (RVD2021-05). These pesticides are characterized by high water solubility and low octanol-water partition coefficient, and tend to be leachable.

In general, the neonicotinoid insecticides tend to occur more frequently in water in early spring, shortly after snowmelt and at the time of seeding in the Canadian prairies. Past July, their detection is much lower. Their detection frequency and concentrations vary considerably per location, per province, and per season.

Overall, concentrations observed for all neonicotinoid insecticides are low (less than 50 ng/L). When all data are pooled for streams and rivers, the average detected levels seem consistent throughout the prairie provinces (AB, SK and MB), with average concentrations of 15 ng/L for thiamethoxam, 22 ng/L for clothianidin and 30 ng/L for imidacloprid. Thiamethoxam has the highest detection frequency (31%) with clothianidin second (16%) and imidacloprid the lowest (5%). In Alberta, when different water matrices are considered, streams and tile drainage water tend to have higher detection frequencies of neonicotinoids compared to wetlands, irrigation waters and rivers.

In streams and rivers of the Maritimes (PEI and NB), all three neonicotinoid insecticides had a detection frequency greater than 20% from June to August. These regions receive much higher rainfall than the prairies, a factor that likely contributed to the findings. Average concentrations tend to exceed those found in the prairies.

While the focus has been on the neonicotinoids imidacloprid, clothianidin and thiamethoxam, trends show that cyantraniliprole and chlorantraniliprole usage and detections have increased since 2017. In addition, flonicamid and flupyradifurone were also detected in 2019.

Neonicotinoid insecticides have also been quantified in snow, soil, groundwater and tile drainage. Only imidacloprid has been quantified at low levels in snowpack, while imidacloprid and thiamethoxam have been detected in soil. Imidacloprid has also been detected in groundwater.

Conclusions and Recommendations

Conclusions

Pesticides in Canada are regulated federally by Health Canada's Pest Management Regulatory Agency under the authority of *The Pest Control Products Act* and its Regulations. All registered pesticides have detailed product labels that provide information, guidance and directions for use and handling of the pest control product. These labels are legal documents and must be followed so that the product is used in a safe manner. Each of the three prairie provinces also have regulations related to pesticide use within their boundaries, but generally this relates to their handling and application including licensing for the commercial use of pesticides within each jurisdiction.

Long-term water quality monitoring programs for pesticides are undertaken federally and provincially throughout the prairies. While the scope of the monitoring programs varies (routine or specific watershed studies, pesticides monitored and frequency of monitoring), all jurisdictions monitor a range of pesticides including acid herbicides. The number of acid herbicides monitored varies by program but ranges from eight to 21 different compounds. Five acid herbicides have interprovincial WQOs, and these are 2,4-D, bromoxynil, dicamba, MCPA, and picloram. Of these three (bromoxynil, dicamba, and MCPA) have WQO's adopted from irrigation guidelines based on the most sensitive crops and two (2,4-D and picloram) have WQOs adopted from protection of aquatic life guidelines. All five of these pesticides are incorporated into all federal and provincial water quality monitoring programs.

Of the five acid herbicides with WQOs, 2,4-D was detected the most frequently in prairie rivers from 2008 to 2017 by Alberta and Saskatchewan provincial monitoring programs and federal government programs. In Manitoba 2,4-D, dicamba and MCPA had similar detection frequencies.

In the federal program, which includes predominantly transboundary sites (international and interprovincial), 84% of the samples had detectable levels of 2,4-D. In Alberta, 44% of samples had detectable levels of 2,4-D, while in Manitoba, 2,4-D was detected in 17% of samples collected from 2008 to 2017. In Saskatchewan, routine monitoring did not detect pesticides at the analytical detection limit used (0.5 to 1 µg/L), however, more sensitive trace monitoring (detection limits of less than 1 ng/L) used in select studies did detect all acid herbicides monitored, with 2,4-D as the most detectable acid herbicide (97%) in the samples collected. While the detection of 2,4-D in prairie rivers was high, the frequency of exceedance of the interprovincial WQOs was low (0 to 0.18%). The interprovincial WQO for 2,4-D was adopted from the CEQGs for the protection of aquatic life (4 µg/L) and the objective is a couple orders of magnitude higher than the objectives for MCPA and dicamba (0.025 and 0.006 µg/L, respectively), designed to protect sensitive crops that can be negatively affected by low concentrations of these herbicides.

The detection frequency for MCPA ranged from 8 to 100% and for dicamba from 17 to 91% depending on the jurisdiction and the monitoring program. For all monitoring programs (federal and provincial), with the exception of Manitoba, MCPA was detected at a higher frequency than dicamba. In Manitoba, the detection rate for MCPA and dicamba was similar. Through the federal program at transboundary locations, MCPA and dicamba exceeded the interprovincial WQOs 13 and 14% of the time, respectively. Alberta had the lowest exceedance rates for dicamba and MCPA (3.4 and 5.1%, respectively), while Manitoba and Saskatchewan (trace studies only) were similar, with dicamba at 17% and 21%, respectively and MCPA at 17% and 18% respectively. Pooling the results from all the monitoring programs for MCPA and dicamba showed that MCPA exceeds the interprovincial WQOs the most often in the Souris, Red, Assiniboine, and Qu'Appelle watersheds, while dicamba exceeded the WQOs in the Souris, Red, Qu'Appelle, Battle and South Saskatchewan watersheds. Other acid herbicides that have been detected through routine monitoring programs included 2,4-DB, bromoxynil, dichloroprop, clopyralid, imazamethabenz-methyl, MCPP, picloram, and triclopyr.

Acid herbicides are extensively used in the Canadian prairies and their presence has been detected in almost all water matrices including rivers, streams, wetlands, lakes, reservoirs, groundwater, rainfall and snow. Despite the presence of low levels of acid herbicides in waterways throughout the prairie region, jurisdictional governments have not received any reports from producers regarding possible negative effects on sensitive crops. Research studies have been conducted to assess the effects of acid herbicides on sensitive crops including, for example, a study in the early 2000s. In this study a mixture of four acid herbicides including 2,4-D, bromoxynil, MCPA and dicamba was sprayed on a variety of plants and demonstrated that this mixture of herbicides could affect certain crops while not affecting other crops.

Similar to what was reported through long-term water quality monitoring programs, monitoring of irrigation waters in southern Alberta and Saskatchewan has shown that acid herbicides are present at low concentrations and that 2,4-D is the most frequently detected of the acid herbicides. Dicamba and MCPA are also detected regularly, although at a lower frequency to 2,4-D.

Given the vast agricultural landscape of the prairie provinces, pesticide pollution of waterways is often associated with agricultural practices. However, several studies in all three prairie provinces have shown that the use of acid herbicides, including 2,4-D, dicamba, MCPA and MCPP, for weed control in urban centres also contribute to their presence in rivers. Glyphosate, a non-selective organophosphate herbicide, and its metabolite AMPA have also been shown to increase in rivers downstream of urban centres. Stormwater from urban centres is also a source of pesticides, and a study conducted on stormwater in Lethbridge from 2012 to 2014 identified 27 different pesticides. Of the pesticides detected, 2,4-D (79%), mecoprop (60%) and dicamba (54%) had the highest detection frequencies and concentrations.

This review of federal and provincial monitoring programs and specific studies has demonstrated that pesticides are present in prairie rivers and streams but typically at low levels. Pesticides are found in a variety of other water matrices including snow, rainfall, groundwater and wetlands. Acid herbicides are a group of pesticides that are used extensively throughout the prairies for weed control and can be used singularly or in mixtures. Water quality objectives are in place for five acid herbicides, but this only represents a small number of the acid herbicides that are currently being used. Dicamba and MCPA have the lowest interprovincial WQOs and exceed their WQOs the most often. However, other acid herbicides, such as 2,4-D, clopyralid, and MCPP, are also frequently detected.

Glyphosate and neonicotinoids are within other classes of pesticides that are also used extensively throughout the prairie region, and are frequently detected in prairie waters including rivers, streams and wetlands. While this report did not focus on these pesticides, these products are present in the environment and should be continued to be monitored and reviewed. Recently, Canadian Environmental Quality Guidelines were proposed by the Canadian Council of Ministers of the Environment (CCME) for five neonicotinoids including acetamiprid, clothianidin, imidacloprid, thiacloprid and thiamethoxam.

Recommendations

1. The PPWB water quality objectives for MCPA and dicamba are irrigation objectives and were established based on the highest recommended application rate for the most sensitive crops. No reports have been received by any jurisdictional government regarding possible negative effects from irrigation water on sensitive crops. These are selectively toxic chemicals and applied on a regular basis and so are not natural to river waters. The PPWB anticipates a low number of exceedances to these two irrigation-based objectives will occur. As such it recommends continued monitoring, retaining and reporting against these objectives with periodic assessment of potential effects to aquatic life and other water uses, including irrigation.
2. The Committee on Water Quality recommends that PPWB share this report with the Pesticide Management Regulatory Agency (PMRA) with the following observations and recommendations:
    b. MCPA and dicamba are being detected in aquatic systems across the prairies and at concentrations exceeding the PPWB Interprovincial Water Quality Objectives set to protect all water uses, the most sensitive of which are irrigated crops. PMRA could consider a review of use of MCPA and dicamba to consider whether directions for use, handling, and applications near water require updates to protect downstream irrigators that make use of the water.
    b. Work on pesticide mixtures also highlights detections of MCPA and dicamba. PMRA could consider if regulatory requirements for MCPA and dicamba need to reflect the potential impacts of pesticide mixtures on riverine ecosystems and different water uses.
    b. PMRA has aquatic life reference values (ALRVs) for protection of aquatic life. ALRVs and their derivation protocols should be made publicly available.
3. The Committee on Water Quality recommends that PPWB share this report with CCME and in particular with committees and/or working groups developing water quality guidelines.
    a. PPWB and member agencies recommend that priority should be given to guideline development for the acid herbicides that are frequently detected in prairie waters and for which there are no guidelines including clopyralid, MCPB, and triclopyr as they are ubiquitous throughout the prairies. Without published guidelines the risk to aquatic life and irrigated crops cannot be evaluated.
    b. To further understanding of pesticide mixtures and potential impacts to the aquatic environment.

4. The Committee on Water Quality recommends that the interprovincial WQOs of other pesticides within the acid group that are based on protection of aquatic life should be met at the transboundary sites for the protection of aquatic life in these rivers. Concentrations above these levels can affect aquatic health of these ecosystems.
5. The Committee on Water Quality recommends that glyphosate and AMPA should continue to be monitored, and detections reported. In its 2015 water quality objective review COWQ discussed studies showing that the toxicity of non-active ingredients, including surfactants, used in glyphosate products can be greater than glyphosate. Such products include the surfactant polyoxyethylene amines (POEA), which is a chemically complex group. There are analytical limitations for undertaking routine analyses of these compounds given their chemical diversity and the different formulations of agronomic products.

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