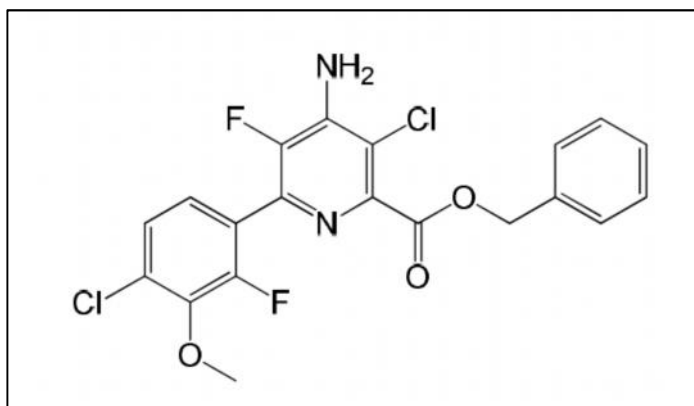


Review of Florpyrauxifen-benzyl for Application to Massachusetts Lakes and Ponds

2019

Massachusetts Department of Agriculture
Division of Crop and Pest Services
and
Massachusetts Department of Environmental Protection
Office of Research and Standards



This document summarizes the environmental fate and transport, as well as toxicological and ecological effects of the herbicide active ingredient, florpyrauxifen-benzyl. The information summarized in this review was considered in the evaluation of florpyrauxifen-benzyl for use as an aquatic herbicide for weed control in Massachusetts lakes and ponds. This review was jointly conducted by the Massachusetts Department of Environmental Protection (MassDEP) Office of Research and Standards (ORS) and the Massachusetts Department of Agricultural Resources (MDAR) in accordance with the cooperative agreement issued between the two agencies in 2011. Aquatic herbicide active ingredients in Massachusetts are subject to this review, which is conducted with an emphasis on non-target aquatic toxicity, for addition to the list of approved herbicides in the Eutrophication and Aquatic Plant Management in Massachusetts Final Generic Environmental Impact Report (GEIR) (Commonwealth of Massachusetts, 2004). Use of a product from the GEIR list implicitly confers compliance with Massachusetts Environmental Policy Act (MEPA) requirements for the application of herbicides to aquatic habitats in the Commonwealth (301 CMR 11.00).

Much of the information used to conduct this review is from the U.S. Environmental Protection Agency (US EPA), including the “Environmental Fate and Ecological Effects Risk Assessment for the Registration of the New Herbicide for the Use on Rice and Aquatics: Florpyrauxifen-benzyl” document (EPA, 2017), as well as information from several supporting documents available in the U.S. EPA docket no. HQ-OPP-2016-0560-0065. This information was supplemented by a review conducted by GEI Consultants, Inc. for the Washington State Department of Ecology, entitled the “Final Supplemental Environmental Impact Statement for the State of Washington Aquatic Plant and Algae Management.” (WSDOE, 2017).

Florpyrauxifen-benzyl (XDE-848 benzyl ester or RinskorTM; 2-pyridinecarboxylic acid,4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxy-phenyl)-5-fluoro-, phenyl methyl ester) is an arylpicolinate herbicide manufactured by SePRO Corporation intended for use for post-emergent control of grass, sedge and broadleaf weed in rice in select states as well as for national use on freshwater aquatic sites, including foliar application to emergent aquatic vegetation (foliar-aquatic) or direct application to water body (in-water) use sites. The aquatic use is intended for use in managing freshwater aquatic vegetation in slow-moving/quiescent waters with little or no continuous outflow in ponds, lakes, reservoirs, freshwater marshes, wetlands, bayous, drainage ditches, and non-irrigation canals, including shoreline and riparian areas in or adjacent to these sites, as well as management of invasive freshwater aquatic vegetation in slow-moving/quiescent areas of rivers (coves, oxbows or similar sites). Target species or aquatic use includes invasive species such as hydrilla (*Hydrilla verticillata*), Eurasian watermilfoil (*Myriophyllum spicatum*) and crested floating heart (*Nymphoides cristata*).

At the time of this active ingredient review by MDAR and MassDEP, the end-use product ProcellaCOR EC (EPA Reg. No. 67690-80), manufactured by SePRO Corporation, was submitted for review. Additional details on the evaluation of this product can be found in a separate review document.¹

Herbicidal Mode of Action

Florpyrauxifen-benzyl is a new synthetic analogue of an auxin that belongs to the arylpicolinate class of herbicides. An auxin is a plant hormone that regulates the development, growth and other functions of plants. Having insufficient auxin concentration stunts growth while having too much can cause cell wall damage, leading to death. Thus, these effects can be exploited in developing effective herbicides. Though the specific mode of action of these synthetic auxins is not fully known, they produce effects on the plant including alterations in cell wall elasticity and gene expression, and non-productive tissue growth that results in leaf curl and disruption of the plant phloem, interfering with transport of nutrients and causing death in days to weeks.

¹ ProcellaCOR Herbicide Product Evaluation and Recommendation (MDAR/MassDEP, 2019)

Florpyrauxifen-benzyl Fate and Transport

Florpyrauxifen-benzyl has a relatively low water solubility (15 ppb) and a low potential for volatilization from water, moist soils and dry surfaces. However, the water solubility of this active ingredient appears to increase when it is part of an end-use formulated product.

In aerobic water-sediment systems the parent biodegrades with a mean half-life value of 8.36 days. Under anaerobic conditions it degrades faster with a mean half-life of 2.65 days. In shallow and clear waters, the major degradation route is aqueous photolysis. Half-lives in laboratory studies were 0.0786 days in a pH 4 buffered solution and 0.16 days in natural water. Hydrolysis appears to be a slower degradation process with a half-life of 111 days at pH 7. Thus, in sediments and in deeper or turbid waters, the half-life is likely to considerably longer than that observed under conditions conducive to aqueous photolysis. Field dissipation studies conducted in Florida and North Carolina using applications of florpyrauxifen-benzyl at 50 ppb showed water half-lives of 1.4-2.3 days. Florpyrauxifen-benzyl degrades slower in soils (mean half-life of 55.3 days), readily binds to soil or sediments, and has low mobility in soils.

The major environmental aquatic metabolites of florpyrauxifen-benzyl include XDE-848 acid, its primary metabolite, which then further degrades to XDE-848 benzyl hydroxy and XDE-848 hydroxy acid. These metabolites degrade much more slowly than the parent compound with half-lives of 6.3-18 days for the acid, 6-14 days for the benzyl hydroxy and 53-121 days for the hydroxy acid. Longer half-lives are observed under flooded soil conditions.

In clear, shallow water, the parent compound may also photolyze to des-chloro XDE-8848 benzyl hydroxyl, which further breaks down to des-chloro XDE-8848 acid. Ultimately, these metabolites will break down to inorganic compounds or minerals and/or bind to sediments.

The extent of exposure by aquatic animals and plants to this compound and its metabolites is determined by its application concentration to water, environmental conditions and its fate and transport properties within that body of water.

Since florpyrauxifen-benzyl can be applied directly to water bodies, there is also the potential for exposure to florpyrauxifen-benzyl residues in food (i.e., fish and shellfish) as well as surface and groundwater (i.e., potential sources of drinking water).

Human Toxicity

MassDEP and MDAR are relying on US EPA's assessment of the human toxicity of this compound and have not conducted any additional toxicological evaluation. The following summary addresses key elements of the US EPA assessment.

Only about 40% of floryprauxifen-benzyl administered to laboratory animals was absorbed and the majority of the administered dose was eliminated within the first 24 hours post-dosing. The data suggest little potential for bioaccumulation.

Data from 2-generation reproduction and developmental toxicity studies with this herbicide indicated that the major metabolite, XDE-848 acid was found in the milk and blood of maternal animals, and also in the blood of pups and fetuses, though at a lower level.

Single-dose and repeat-dose studies conducted with floryprauxifen-benzyl by any route and duration of exposure produced no adverse effects at or above the kinetically-derived maximum dose (i.e., the dose above which the blood level of the chemical remains constant), as well as a higher dose of 1000 mg/kg/day. Chronic dosing studies in rats and mice did not result in carcinogenicity and mutagenicity testing did not indicate genotoxicity. The US EPA classified floryprauxifen-benzyl as “not likely to be carcinogenic to humans” (US EPA, 2018). Acute toxicity studies did not indicate any adverse effects via inhalation, ingestion or dermal exposures. Floryprauxifen-benzyl was not found to be an eye irritant and it only demonstrated a weak dermal sensitization potential in mice. Developmental toxicity studies in rats and rabbits in which animals were exposed to levels up to 1000 mg/kg/day as well as reproductive toxicity studies in which animals were exposed up to a maximum dose of 300 mg/kg/day did not result in any parental or fetus/offspring effects. Given the lack of adverse toxicity in animal studies, the US EPA did not conduct a quantitative risk assessment for floryprauxifen-benzyl, but instead conducted a qualitative risk assessment in support of its use.

Any floryprauxifen-benzyl reaching surface water or groundwater drinking water sources is expected to break down quickly to its environmental degradates. These degradates are structurally similar to the parent compound and US EPA concluded they are expected to have the same or lesser toxicity and similar hazard to floryprauxifen-benzyl. Thus, the US EPA has concluded that the presence of these degradates in food and water would not be expected to cause any adverse health effects.

Ecotoxicity

Terrestrial and Aquatic Animals

US EPA concluded that floryprauxifen-benzyl is practically nontoxic, both acutely and chronically, to birds, mammals, reptiles and bees at levels greater than the maximum application concentration for this herbicide.

A fish bioconcentration study as well as magnitude of residue studies in clam, crayfish, catfish and bluegill all indicate that although floryprauxifen-benzyl at high water concentrations greater than 150 ppb will temporarily bioaccumulate in these organisms, these residues are rapidly depurated and/or metabolized within these organisms within 1-3 days. Bioaccumulation of floryprauxifen-

benzyl is not expected to be of concern with this herbicide as maximum application rates of this active ingredient are much lower than 150 ppb (WSDOE, 2017).

Aquatic toxicity testing with florpyrauxifen-benzyl was made more challenging due to issues with solubility limits when the active ingredient was dissolved in water alone. Solubility limits for florpyrauxifen-benzyl in these studies ranged from about 20-60 ppb. Nevertheless, US EPA concluded that the studies presented for this compound and its metabolites provide an adequate basis for evaluating toxicity to various aquatic organisms.

When the active ingredient florpyrauxifen-benzyl was tested alone in water, it was not acutely or chronically toxic to freshwater and estuarine/marine fish up to its limit of solubility (i.e., approximately 40 ppb a.i.) in laboratory tests. In acute toxicity tests with this active ingredient formulated as part of a TEP, florpyrauxifen-benzyl was not acutely toxic to freshwater fish at concentrations up to 3,200 ppb a.i. (i.e., active ingredient). All tested transformation products were also not acutely toxic to freshwater fish up to and exceeding the application rate.

When florpyrauxifen-benzyl was tested in water alone, it was not acutely toxic to freshwater and marine/estuarine invertebrates up to the limit of solubility based on the active ingredient (i.e., approximately 25-60 ppb a.i.) as well as for the formulated products. All tested transformation products were also not acutely toxic to freshwater invertebrates up to the maximum application rate. Acute toxicity tests on transformation products were not submitted for marine/estuarine invertebrates.

Acute screening tests were also conducted on the juvenile life stage of a species of freshwater mussel with the active ingredient, the acid metabolite and two TEP formulation that showed no toxicity to juvenile mussels in any test, with No Observed Adverse Effect Concentration (NOAECs) ranging from 25-50 times greater than the maximum allowed application rate (Cope *et al.*, 2017, *in prep.*, as cited in WSDOE, 2017). Application rates used were as high as 2,187 ppb (Mark Heilman, SePRO, personal communication, 2019).

Florpyrauxifen-benzyl was not chronically toxic to freshwater-column-dwelling invertebrates up to the limit of solubility. However, in a subchronic 10-day whole sediment study conducted with the active ingredient with Midge (*Chironomus dilutus*), the herbicide was chronically toxic to freshwater benthic invertebrates at all tested concentrations in sediment pore water toxicity studies (the lowest at 4.3 ppb a.i.), so a NOAEC was not established for benthic invertebrates in this study. The toxic endpoint in this study was “ash-free dry survival”, which is a measure of growth. The NOAEC indicates that at pore water concentrations of florpyrauxifen-benzyl of 4.3 ppb and below, the growth of the test organism was impacted. However, overall survival of this organism was not affected at concentrations up to 34.6 ppb.

While the findings in the 10-day freshwater study raise a concern for potential high subchronic toxicity to benthic invertebrates, a closer examination of this study along with a review of another supplemental study submitted by the manufacturer provides more information on the benthic toxicity issue. This additional study is a 28-day chronic whole sediment study, also conducted with the active ingredient in Midge (*Chironomus dilutus*). In addition to a difference in duration, this study differs from the 10-day study in that the herbicide in this study was added to the water column as it would during an herbicide application whereas in the 10-day study, the herbicide was applied to the sediment. Modeling conducted by the manufacturer and confirmed by MDAR indicates that in order to get a concentration in sediment equivalent to that in the 10-day study, the application concentration of this compound to the water column would have to be 232 ppb. This concentration is over 4.5-fold greater than the maximum label rate of the active ingredient in a TEP. Thus, the 28-day study addresses a scenario that is closer to an actual application scenario. Application to overlying waters at the maximal rate results in pore water concentrations that are much lower (an order of magnitude in this case) than those observed in the 10-day study. A pore-water NOAEC of 0.42 ppb and a lowest observed adverse effect level (LOAEC) in pore-water of > 0.42 ppb was identified in the 28-day study. The study also provided toxicity endpoints for overlying water, including a NOAEC of 14 ppb and a LOAEC of > 14 ppb. Based on the information discussed above, MDAR conducted additional refined modeling using Massachusetts-specific input data (see Appendix 1). Model scenarios evaluated included application at the maximum dose of 50 ppb. Additionally, application at a lower dose of 10 ppb was also modeled. The product label specifies application rates for specific target weeds that are relevant for Massachusetts, e.g. water milfoils, for which it is expected that a dose of 10 ppb will be effective.

US EPA noted that studies conducted with the metabolites of florpyrauxifen-benzyl (i.e., XDE-848 acid, XDE-848 benzyl hydroxy and XDE-848 hydroxy acid) demonstrate that they are much lower in toxicity to aquatic animals than the parent compound.

Chronic toxicity testing of estuarine/marine species included a single 28-day life-cycle test on mysid shrimp, which established a chronic LOAEC of 1.1 ppb and a NOAEC of < 1.1 ppb for the active ingredient based on a statistically significant decrease in female length at this concentration as well as a decreased rate of mysid reproduction relative to controls which, while not statistically significant, was considered biologically significant. In addition, a decrease in reproduction ranging from 16% to 46% was noted across all test concentrations.

Terrestrial and Aquatic Plants

In studies with terrestrial plants, florpyrauxifen-benzyl was toxic to both monocots and dicots, though significantly more toxic to dicots by several orders of magnitude. In addition, florpyrauxifen-benzyl is toxic to non-target nonvascular and vascular aquatic plants. These non-target, sensitive plants may include plants listed under the Endangered Species Act.

Both the parent compound and the XDE-848 acid are phytotoxic to aquatic plants. Given the similarities in structure of the other degradates to the parent and its acid, these would also be expected to be phytotoxic. Due to the sensitivity of plants to this herbicide, the EPA evaluated the toxicity to both aquatic and terrestrial plants by considering the possible effects of the parent compound as well as of its three major metabolites (XDE-848 acid, XDE-848 benzyl hydroxy and XDE-848 hydroxy acid).

Since florpyrauxifen-benzyl's mode of action is specific to plant growth, the sensitivity to this compound across many types of non-target plants is not surprising. The risk posed by an herbicide to plants is a product of its toxicity and the magnitude of exposure by plants

Ultimately, the strategy to minimize the potential of non-target plant toxicity is to employ application strategies that are as targeted as possible. The EPA uses label language to advise use of strategies that minimize drift outside of the targeted treatment area. An application method that maximizes spray interception by target weeds while minimizing the amount of overspray that inadvertently enters the water should be used and appropriate spray drift management protocols should be followed where drift potential is a concern.

Related to the issue of non-target plant toxicity, EPA also noted that a compost residue study for florpyrauxifen-benzyl has not been submitted but that based on the results of laboratory persistence studies, there is the potential that residues from plants exposed to this compound that are then used as compost could cause phytotoxic injury to the plants that receive contaminated compost. While the potential for this kind of contamination is likely to be very low for aquatic use of this compound, the potential for this effect is noted here as it characterizes several other synthetic auxin herbicides.

Finally, there is some information that suggests that florpyrauxifen-benzyl offers more selectivity than other auxin-type or other herbicides. Study results indicate that there is some variability in the degree of sensitivity of tested plants to florpyrauxifen-benzyl. For example, florpyrauxifen-benzyl has shown promise for control of several invasive species, including watermilfoil, at use concentrations lower than for other herbicides intended for this purpose. In a study in which well-established watermilfoil, as well as seven native plant species, were treated within one of eight florpyrauxifen-benzyl concentration-exposure-time scenarios, all of the scenarios resulted in a significant control of watermilfoil, while the native species showed lower sensitivity, suggesting that florpyrauxifen-benzyl should provide some selectivity when used to treat target species (Beets, *et al.*, *in prep.*, Richardson *et al.*, 2016)).

Discussion/Conclusions

US EPA concluded that the profile for florpyrauxifen-benzyl indicates that this compound is of low acute and subchronic toxicity to both humans and terrestrial and aquatic freshwater organisms when applied at recommended label rates.

Supplemental modeling of exposure concentrations to aquatic organisms conducted by MDAR for this review support the conclusions reached by EPA. Modeled acute and chronic concentrations of florpyrauxifen-benzyl in freshwater aquatic applications at product label specified rates are well below toxicity levels of concern for aquatic freshwater organisms. Based upon available data however, chronic toxicity for marine/estuarine organisms is a concern.

In addition, sensitive non-target plant species have been identified as organisms of concern. Given that herbicides are designed to control plants, this is not surprising. The application of this aquatic herbicide should be targeted as much as possible to avoid impacts on non-target aquatic and terrestrial plants. Measures that minimize drift should be used in applying this product. In addition, as with any application, a preliminary field survey should be conducted prior to application to identify any plants on the endangered species list and/or any other plant species that are important to that ecosystem.

Ultimately, US EPA's conclusion with regard to this product is that, *“after weighing the risks against the benefits of the registered use, the [US] EPA finds that, when the mitigation measures are implemented, the potential risks that may remain are minimal, while the benefits are potentially significant. Therefore the [US] EPA concludes that the benefits outweigh the risks and registering these uses will not cause unreasonable adverse effects on human health or the environment”*(US EPA, 2017).

Based upon US EPA's favorable profile determination, we recommend adding florpyrauxifen-benzyl to the GEIR list of approved herbicides. As specified in the product label, this herbicide should not be applied to marine or estuarine waters or waters impacting such systems.

However, while the overall database is indicative of low toxicity to aquatic freshwater organisms, the range of solubility limits (i.e., 25-60 ppb a.i.) achieved in a couple of the laboratory studies as discussed above, are below the maximum application rate for this active ingredient of 50 ppb a.i.. To address this uncertainty and in keeping with our general recommendation for all herbicides, we recommend this active ingredient be used in accordance with label instructions using the smallest amount of herbicide possible to achieve the desired effect, which for Massachusetts is 10 ppb or below. It should be noted that the label recommended rates for various specific weeds are much lower than 50 ppb. Furthermore, the label recommends consultation with SEPRO to determine the best treatment protocols for a given target vegetation.

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Appendix 1

Aquatic System Concentrations Modeling and Benthic Invertebrates Risk Assessment

This document describes a refined modeling study and associated risk assessment for florpyrauxifen-benzyl conducted by MDAR to estimate exposures and risks to benthic invertebrates that are relevant to conditions in Massachusetts. This assessment utilizes toxicity study information that is more relevant to the application scenario expected for this herbicide than that used by the U.S. Environmental Protection Agency (US EPA).

The US EPA modeled Estimated Environmental Concentrations (EECs) resulting from direct application of florpyrauxifen-benzyl to water bodies using the Pesticides in Water Calculator (PWC). The PWC includes the Pesticide Root Zone Model (PRZM) and the Varying Volume Water Body Model (VVWM). Modeling of the in-water applications was accomplished using the VVWM module. US EPA used a model scenario based on the weather and site conditions in Florida. Since the toxicity of the florpyrauxifen-benzyl degradates is so much lower than that of the parent compound, US EPA calculated EECs for animal exposure, assuming that the parent compound was the only stressor of concern.

The MDAR modeled refined EEC estimates that are more characteristic of Massachusetts conditions, using the Surface Water Concentration Calculator (SWCC), a modeling platform that includes the modeling components described above. Initial modeling was done with the model scenario used by US EPA and confirmed the results reported by US EPA. Model input was adjusted for weather, latitude and application date to make it more representative of the situation in Massachusetts. Furthermore, the modeling considered application at a maximum single application rate of 50 ppb as well as a rate of 10 ppb that is more typically used to treat Massachusetts aquatic weed species. The 10-ppb application rate scenario was also modeled using three applications per season, which is the limit allowed by the label. In addition to the parent compound, EECs were also estimated for several degradates.

The refined modeling estimates were used to conduct a refined risk assessment, using the results of a supplemental 28-day chronic toxicity study involving an in-water application of herbicide that is a more representative application scenario for this herbicide than is the 10-day toxicity study required by US EPA in which the herbicide is spiked into sediment. In addition to being more representative, since the toxicity endpoints determined in the 10-day sediment-spiked chronic toxicity study required by US EPA are unbounded, “less than” values, a meaningful comparison of modeled EECs to these values could not be done using this study and thus the potential for exceeding the chronic Level of Concern (LOC) could not be determined nor could it be precluded. The refined risk assessment therefore addresses these uncertainties.

1. Modelling Results

1.1. Parent Compound

The modeling results for Florpyrauxifen-benzyl are summarized in Table 1. The FL-scenario results were generated to confirm consistency with US EPA modeling results. For the aquatic in-

water uses, the peak EECs were very close to the nominal concentration of 50 ppb for the maximum single application rate.

The MA-scenario was adjusted for weather input, latitude and application date (June 15th). Generally, the estimated concentrations were slightly higher for MA-scenario simulations compared to FL-scenario simulations. The MA-scenario was also modeled using a 10 ppb application rate. Both a single application and three application scenario were modeled. The repeat applications were done with a 14-day interval, the minimum interval allowed by the product label. More details on the modeling are available in Appendix 2.

Table 1. Estimated Environmental Concentrations (EEC) (ppb²) of florpyrauxifen-benzyl (parent) with in-water application. The initial modeling by US EPA used a Florida-based scenario. Simulation for Massachusetts was modified to represent weather, latitude and application date. The application rates were set to achieve an initial concentration of 50 ppb and 10 ppb, respectively. The 3× 10 ppb scenario represents three individual applications of 10 ppb with an interval of 14 days. Further information on modeling is provided in Appendix 2.

Scenario	Water Column EEC (ppb)			Pore Water EEC (ppb)		Sediment EEC (ppb)
	Peak	21-d average	60-d average	Peak	21-day avg.	21-d average
FL, 50 ppb	50	2.73	0.956	0.577	0.191	246
MA, 50 ppb	47	2.83	0.993	0.612	0.222	286
MA, 10 ppb	9.3	0.57	0.2	0.12	0.044	57
MA, 3× 10 ppb	9.3	1.11	0.58	0.12	0.072	92

The modeled concentration profiles of florpyrauxifen-benzyl in the water column and the benthic regions are shown in Figures 1 and 2.

² The unit ppb is used throughout the document and is equivalent to µg/L or µg/kg.

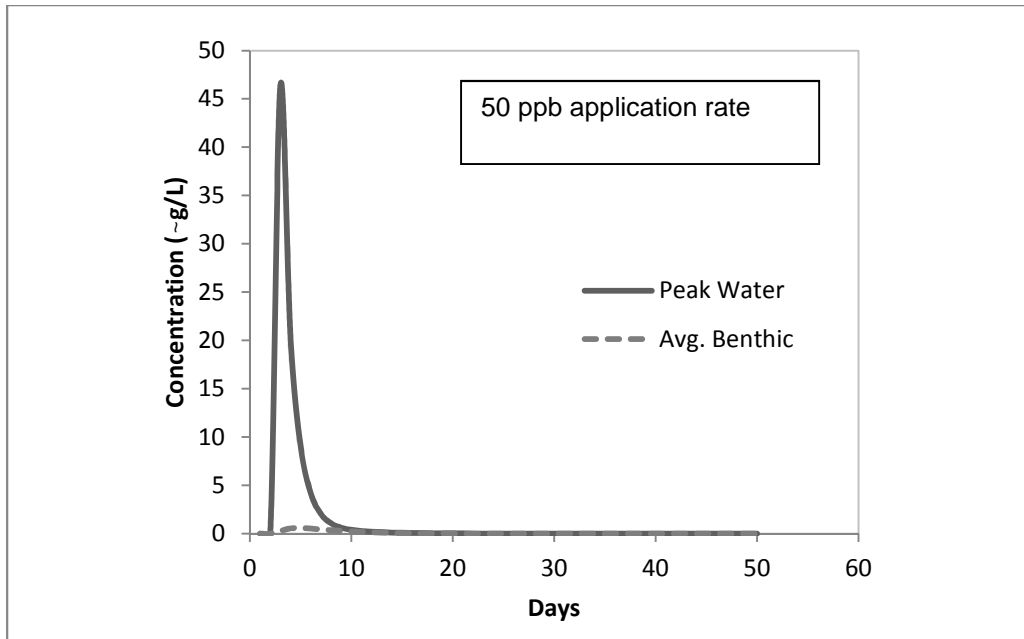


Figure 1 Florpyrauxifen-benzyl concentration profile associated with a 50 ppb initial application rate

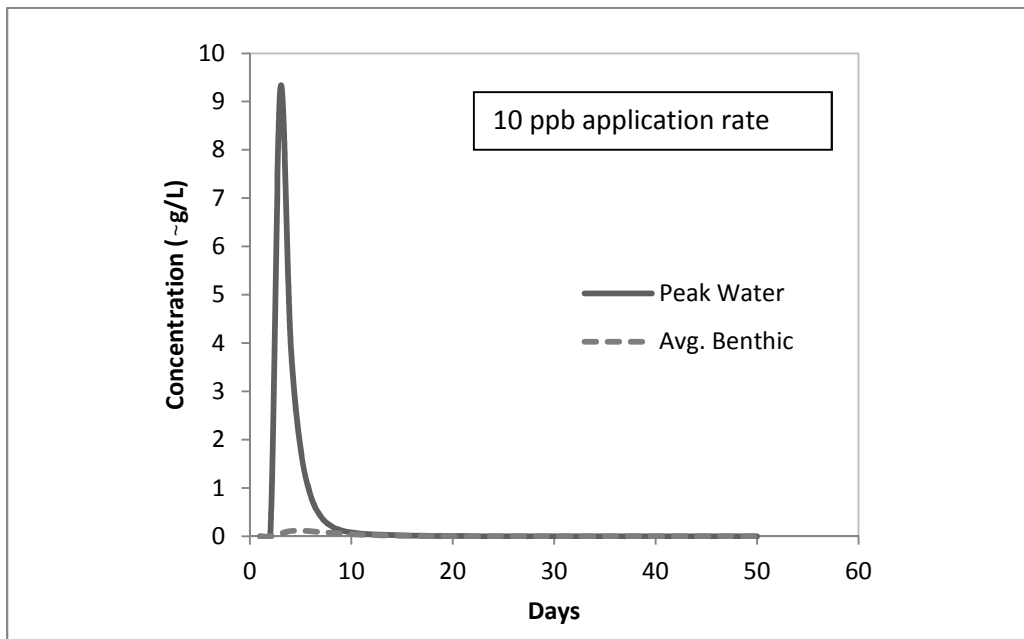


Figure 2 Florpyrauxifen-benzyl concentration profile associated with a 10 ppb initial application rate

1.2. Selected Degradates of Florpyrauxifen-benzyl

Modeling results for three degradates of florpyrauxifen-benzyl are summarized in Table 2. More details can be found in Appendix 2.

Table 2. Modeling of degradates (acid, hydroxy-benzyl ester, and hydroxy acid). Estimated Environmental Concentrations (EEC) (ppb) of three degradates associated with in-water application. Simulation was modified to represent weather, latitude and application date in Massachusetts. Application rate was equivalent to achieve an initial concentration of 50 ppb and 10 ppb, respectively. Further information on modeling is provided in Appendix 2.

MA-adjusted Florida Scenario	Water Column EEC (ppb)			Pore Water EEC (ppb)		Sediment EEC (ppb)
	Peak	21-d average	60-d average	Peak	21-day avg.	21-d average
Application rate of 50 ppb						
Acid degradate ¹	2.79	1.58	0.64	0.31	0.29	0.93
Hydroxy benzyl ester ¹	3.08	2.16	1.16	3.46	2.8	630
Hydroxy acid ²	1.13	1.02	0.71	0.37	0.36	1.65
Application rate of 10 ppb						
Acid degradate	0.56	0.32	0.13	0.06	0.06	0.18
Hydroxy benzyl ester	0.62	0.43	0.23	0.69	0.56	125
Hydroxy acid	0.23	0.21	0.14	0.07	0.07	0.34

¹ Each daughter degradate was modeled independently

² Granddaughter degradate; was modeled as a daughter of Acid degradate

2. **Chronic Risk Assessment for Benthic Invertebrates**

2.1. Florpyrauxifen-benzyl

A refined assessment for chronic risk to benthic invertebrate was conducted because of the uncertainty in US EPA's risk characterization for these organisms. The refined assessment considers additional information from the 28-day Organization for Economic Cooperation and Development (OECD) Guideline 219 study with midge using spiked water.

Table 3 shows a comparison of model-estimated concentrations with the endpoints from the midge toxicity study. This comparison shows that the model estimated concentrations in the overlying water and pore water are below the NOAEC values. The modeled concentration in sediment is higher than NOAEC for sediment. It should be noted that the LOAEC endpoints are unbounded (greater than) values. The highest spike level in the study was a 60 ppb initial concentration. Overall, there were no significant adverse effects observed in the OECD toxicity

study. As described below, the assessment of modeling results can be refined by taking into account a comparison of *measured* concentrations in OECD study and *modeled* concentrations.

Table 3. Comparison of modeled concentrations (ppb) and endpoint values for midge

Compartment	Modeled Concentration 21-d Avg 10 ppb scenario		Modeled Concentration 21-d Avg 50 ppb scenario	NOAEC 28-d	LOAEC 28-d
	1×	3×			
Water Column	0.57	1.1	2.83	14	>14
Pore Water	0.044	0.072	0.22	0.42	>0.42
Sediment (dry)	57	92	286	25	>25

Comparison of modeled concentrations with the measured levels in the OECD study shows differences. This can be expected given that the modeled concentrations are representative of the US EPA standard pond and the OECD study results represent a laboratory water-sediment system. The differences in modeled concentrations and measured levels were considered in an effort to adjust the modeled concentrations for the differences in US EPA standard pond versus laboratory tank scenario.

Comparison of modeled concentrations with measured levels in the OECD study shows that the model overestimates the sediment and water column concentrations while it underestimates pore water concentrations. Using the highest spiking level of 60 ppb, the model predicts a 21-average sediment concentration of 343 ppb, 3.4 ppb in the water column, and 0.266 ppb in pore water. The measured values in the study were 46 ppb in sediment, 3.64 ppb in the water and 0.839 ppb in pore water. These differences in modeled and measured levels were taken into account with the calculation of adjusted modeled concentrations. The comparison of adjusted modeled concentrations with toxicity endpoints is shown in Table 4. The adjusted model concentrations for the 10 ppb scenario are all below the NOAEC values. For the 50 ppb scenario, the adjusted modeled concentrations in pore water and sediment are slightly higher than the NOAEC levels.

Additional considerations regarding risk to benthic organisms include dissipation behavior and bioavailability aspects. In the benthic region, pesticide dissipates relatively quickly (4.3 days). The main source of dissipation in the benthic region is metabolism (effective average half-life = 4.3 days). The vast majority of the pesticide in the benthic region (99.97%) is sorbed to sediment rather than in the pore water.

In addition, when one considers conditions of rapid degradation mechanisms and dilution from spot-partial applications (expected to be the dominant use pattern in MA), actual bioavailability of this herbicide to benthic invertebrates is much less than simulated by the toxicity studies discussed above.

Table 4. Comparison of adjusted modeled concentrations and endpoint values for midge

Compartment	Adjusted ¹⁾ Modeled Concentration 21-d Avg. (ppb) 10 ppb scenario		Adjusted ²⁾ Modeled Concentration 21-d Avg 50 ppb scenario	NOAEC 28-d (ppb)	LOAEC 28-d (ppb)
	1×	3×			
Water Column	0.61	1.19	3.0	14	>14
Pore Water	0.14	0.23	0.69	0.42	>0.42
Sediment (dry)	8.0	12.3	38	25	>25

¹⁾ The adjusted modeled concentrations in Table were calculated as follows:

For the 10 ppb application scenario:

- Sediment adjusted concentration: $57 \text{ ppb} \times (46 \text{ ppb}/343 \text{ ppb}) = \underline{8 \text{ ppb}}$
- Pore water adjusted concentration: $0.044 \text{ ppb} \times (0.839 \text{ ppb}/0.266 \text{ ppb}) = \underline{0.14 \text{ ppb}}$
- Water column adjusted concentration: $0.57 \text{ ppb} \times (3.64/3.4) = \underline{0.61 \text{ ppb}}$

²⁾ For the 50 ppb application scenario, the model concentrations were adjusted with the same factor as described above with the 10 ppb scenario.

2.2. Degradates

An additional assessment was done based on the results from benthic toxicity studies with degradates. These studies³ were submitted to US EPA, but were not used for further detailed risk analysis by the agency. Given the potential for exposure of benthic invertebrates to these degradates, an analysis was conducted based on a comparison of model concentrations and toxicity study results.

The comparison of the modeled concentrations in Table 2 with the endpoint values is shown in Tables 5, 6 and 7 (next page). The comparison shows that modeled concentrations are well below the NOAEC values. Therefore, no risk is expected from the exposure to these degradates.

³ Freshwater sediment *Chironomus riparius* emergence test with X12300837 (hydroxy benzyl ester degradate) following OECD guideline 218; Data Evaluation Record, MRID NO.: 5001701; courtesy of US EPA; and Freshwater sediment *Chironomus riparius* emergence test with X11966341 (hydroxy acid degradate) following OECD guideline 218; Data Evaluation Record, MRID NO.: 5001702; courtesy of US EPA

Table 5. Comparison of estimated concentrations of the **acid degradate** in water and sediment with chronic toxicity endpoints for the benthic test organism midge (*Chironomus riparius*). The modeled concentrations are for the 10 ppb and 50 ppb application rates.

Acid Degradate	Model EEC (21-d Average) (ppm) ⁴		28-d NOAEC (ppm)
	10 ppb rate	50 ppb rate	
Water Column (mg/L)	0.00032	0.00158	-
Porewater (mg/L)	0.00005	0.00029	0.0068
Sediment (mg/kg)	0.00018	0.00093	0.007

Table 6. Comparison of estimated concentrations of the **hydroxy acid degradate** in water and sediment with chronic toxicity endpoints for the benthic test organism midge (*Chironomus riparius*). The modeled concentrations are for the 10 ppb and 50 ppb application rates.

Hydroxy Acid	Model EEC (21-d Average) (ppm)		28-d NOAEC (ppm)
	10 ppb rate	50 ppb rate	
Water Column (mg/L)	0.00021	0.00102	109
Porewater (mg/L)	0.00007	0.00036	885
Sediment (mg/kg)	0.00034	0.00165	410

Table 7. Comparison of estimated concentrations of **hydroxy benzyl ester degradate** in water and sediment with chronic toxicity endpoints for the benthic test organism midge (*Chironomus riparius*). The modeled concentrations are for the 10 ppb and 50 ppb application rates.

Hydroxy Benzyl Ester	Model EEC (21-d Average) (ppm)		28-d NOAEC (ppm)
	10 ppb rate	50 ppb rate	
Water Column (mg/L)	0.00043	0.00216	0.181
Porewater (mg/L)	0.00056	0.0028	0.555
Sediment (mg/kg)	0.125	0.630	1.05

⁴ The unit ppm is equivalent to mg/L or mg/kg

Appendix 2

Summary of Water Modeling of Florpyrauxifen-benzyl and three degradates in the US EPA Standard Pond

Model-generated outputs of the simulations with florpyrauxifen-benzyl are summarized below. Estimated Environmental Concentrations (EECs) for the parent compound Florpyrauxifen-benzyl and three degradates are presented in Table 1. Model output summary screens are presented in Figures 1 through 4. The model simulations represent annual applications for a period of 30 years. The model output summary includes annual peak and various time-averaged values for concentrations in the water column and benthic area. It also shows the effective water column and benthic half-lives. The EECs were generated with the Surface Water Concentration Calculator (SWCC Version 1.106) using the US EPA standard pond with the FLpeppersSTD field scenario. Critical input values for the model are summarized in Tables 2 and 3.

Table 1. Estimated Environmental Concentrations (ppb) in water column for Florpyrauxifen-benzyl (50 ppb and 10 ppb application) and degradates (10 ppb application)

Simulation Time	Parent		Acid degradate	Hydroxy acid degradate	Hydroxy benzyl ester degradate
	50 ppb	10 ppb			
Peak (1-in-10 yr)	46.4	9.27	0.558	0.226	0.616
4-day Avg (1-in-10 yr)	13.7	2.74	0.514	0.221	0.556
21-day Avg (1-in-10 yr)	2.83	0.567	0.317	0.205	0.459
60-day Avg (1-in-10 yr)	0.993	0.199	0.128	0.142	0.282
365-day Avg (1-in-10 yr)	0.163	0.0326	0.0211	0.0275	0.0505
Entire Simulation Mean	0.159	0.0319	0.0200	0.0250	0.0478

Table 2A. Summary of Model Inputs for Florpyrauxifen-benzyl ¹

Parameter	Value	Comments
K _{oc} (ml/g)	32,280	Average of values measured in six soils (21,777 – 44,278)
Water Half-Life (days) @ 20 °C	8.36	Represents the 90th percentile of the upper confidence bound on the mean out of two values (4.04 and 6.16 days)
Benthic Half-Life (days) @ 20 °C	2.65	Represents the 90th percentile of the upper confidence bound on the mean out of two values (2.37 and 2.1 days)
Photolysis Half-Life (days) @ 40 Lat	0.161	Value measured in natural water
Hydrolysis Half-Life (days)	111	Value measured at pH 7
Soil Half-Life (days) @ 20 °C	55.3	Represents the 90th percentile of the upper confidence bound on the mean out of values from four soils (67.2, 32.4, 34 and 8.9 days)
Foliar Half-Life (days)		Not used in calculations
Molecular Wt	439.2	

Vapor Pressure (torr)	3.5e-7	
Solubility (mg/l)	0.015	Solubility in purified water

¹ Input values as used by US EPA for modeling florpyrauxifen-benzyl in aquatic sites (Section 3.4.3, Table 29 in US EPA, 2017. US EPA selected values according to the “Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides”, dated November 10, 2009 and available at:

<https://www.epa.gov/pesticidescience-and-assessing-pesticide-risks/guidance-selecting-input-parameters-modeling>

Table 2B. Summary of Model Inputs for Degradates ²

Parameter	Values		
	Acid Degradate	Hydroxy Acid	Hydroxy Benzyl Ester
K _{OC} (ml/g)	71.8	106	5615
Water Half-Life (days) @ 20 °C	12	90	12
Benthic Half-Life (days) @ 20 °C	12	90	12
Photolysis Half-Life (days) @ 42 °Lat	0.199	0.199	0.199
Hydrolysis Half-Life (days)			
Soil Half-Life (days) @ 20 °C	350	1000	87
Foliar Half-Life (days)			
Molecular Wt	335	335	425
Vapor Pressure (torr)	3.5e-7	3.5e-7	3.5e-7
Solubility (mg/l)	3	3	3

² Values taken from environmental fate data in section 3.2 (Tables 7, 8, 11 and 16) in US EPA, 2017. K_{OC}: Mean of values measured in 13 different soils; Water half-life: mean values of two estimated values; Benthic half-life: used the same values as water half-life, US EPA estimated overall aquatic half-life values based on aerobic and anaerobic metabolism studies; Photolysis half-life: value for parent + acid degradate used by US EPA in total toxic residue assessment; Hydrolysis: stable to abiotic hydrolysis; Soil half-life values: values based on data reported in US EPA, 2017; soil half-life input values are not relevant for the simulation results presented here since only the aquatic segment of the model is used; Foliar half-life: not simulated here; Vapor pressure: used value for the parent compound, which was classified as non-volatile; acid degradate vapor pressure value is even lower and for the other two degradates also expected to be lower than the parent; Water solubility value for degradates of 3 mg/L (3000 ppb) was used such that the simulated concentrations of the degradates not a limit in the modeled scenarios. Experimental data for the acid degradate indicate that it is highly soluble in water. The other two degradates are also expected to have water solubility values that are much higher than the concentration scenarios modeled here (up to 50 ppb).

Table 3. Application Schedule for Florpyrauxifen-benzyl

Date (Mon/Day)	Type	Amount (kg/ha)	Eff.	Drift
06/15 (10 ppb)	Foliar	0.20	0	1
06/15 (50 ppb)	Foliar	1.00	0	1

Figure 1A: Output summary for parent Florpyrauxifen-benzyl; 50 ppb application scenario

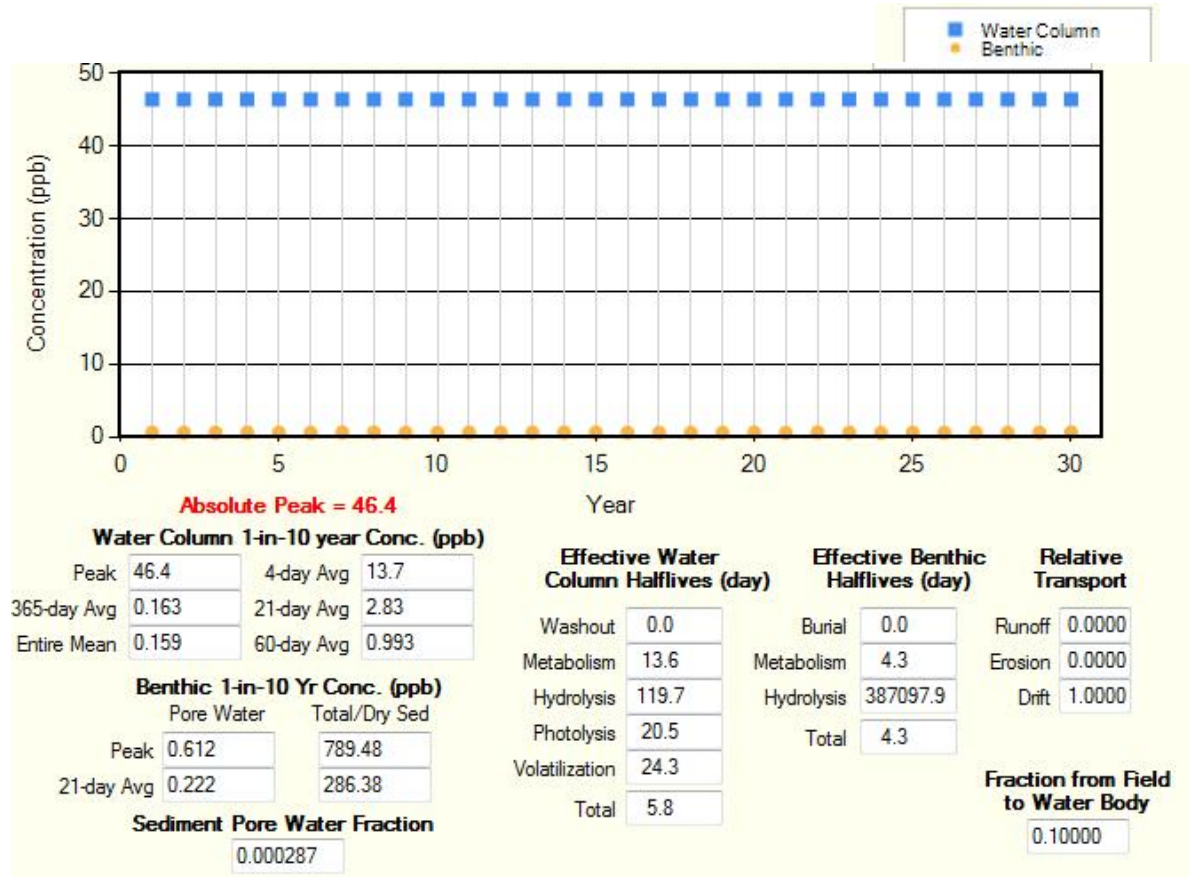


Figure 1B: Output summary for parent Florpyrauxifen-benzyl; 10 ppb application scenario

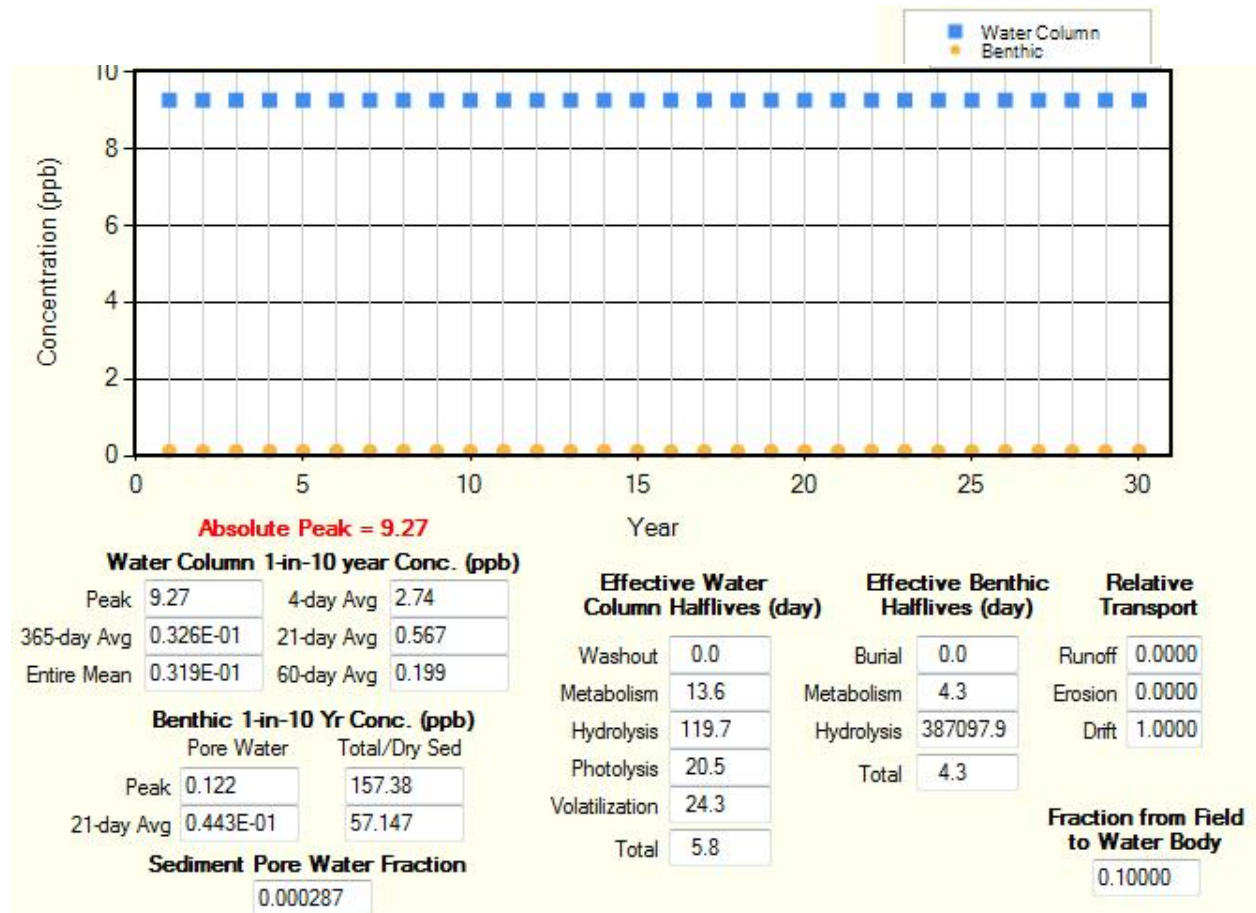


Figure 1C: Output summary for parent Florpyrauxifen-benzyl; three applications of 10 ppb at 14-day intervals.

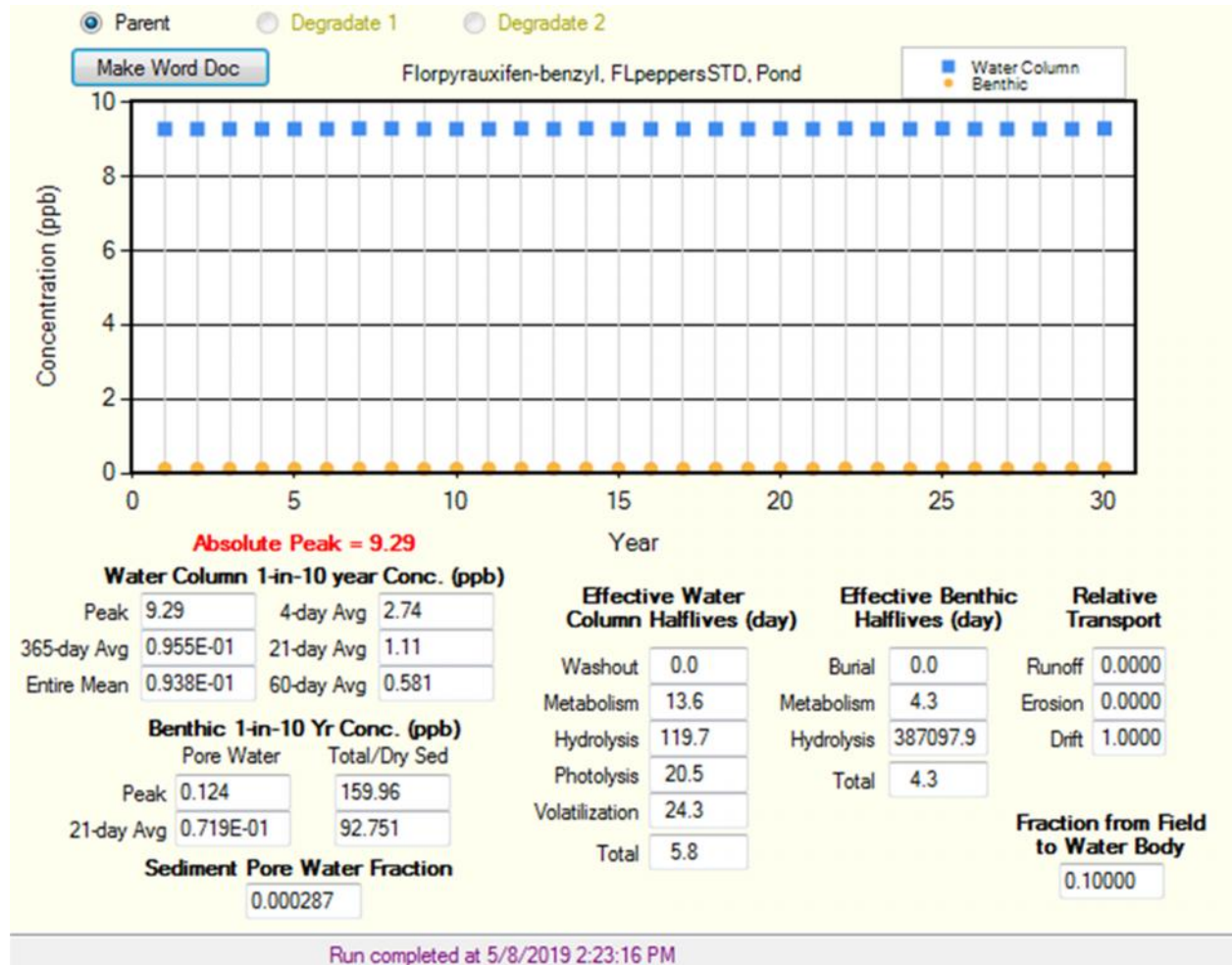


Figure 2: Output summary for Acid Degradate:

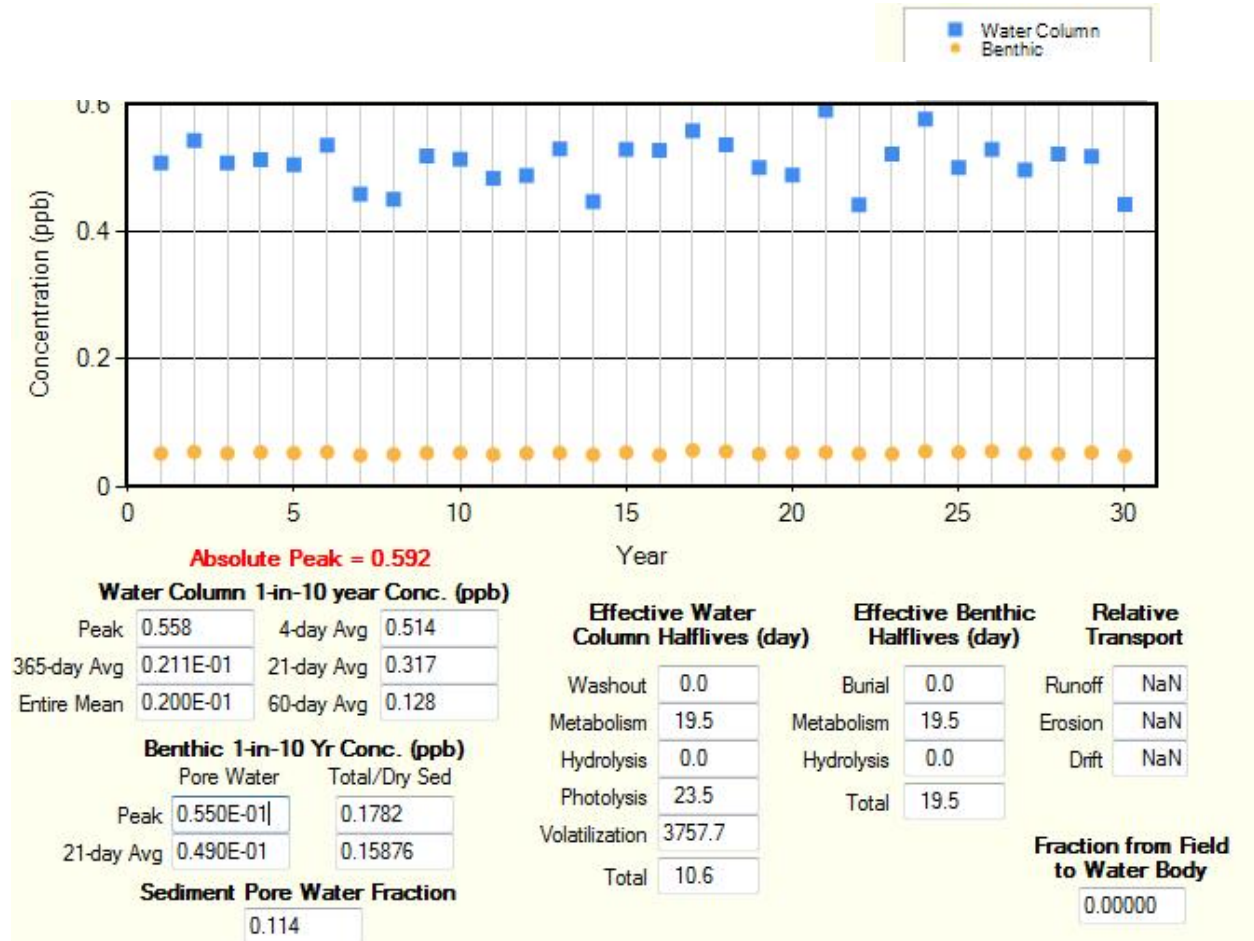


Figure 3: Output for Hydroxy Acid Degradate:

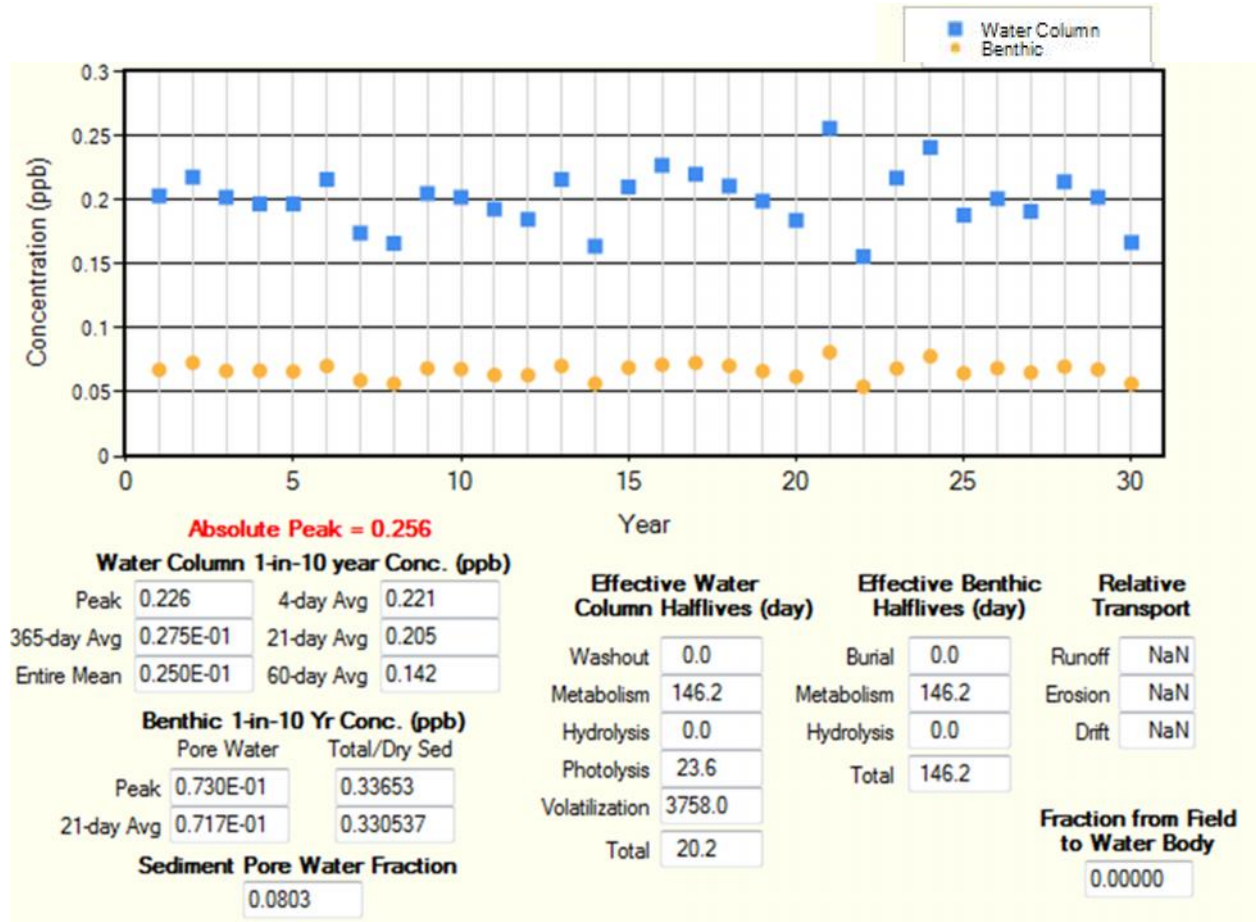
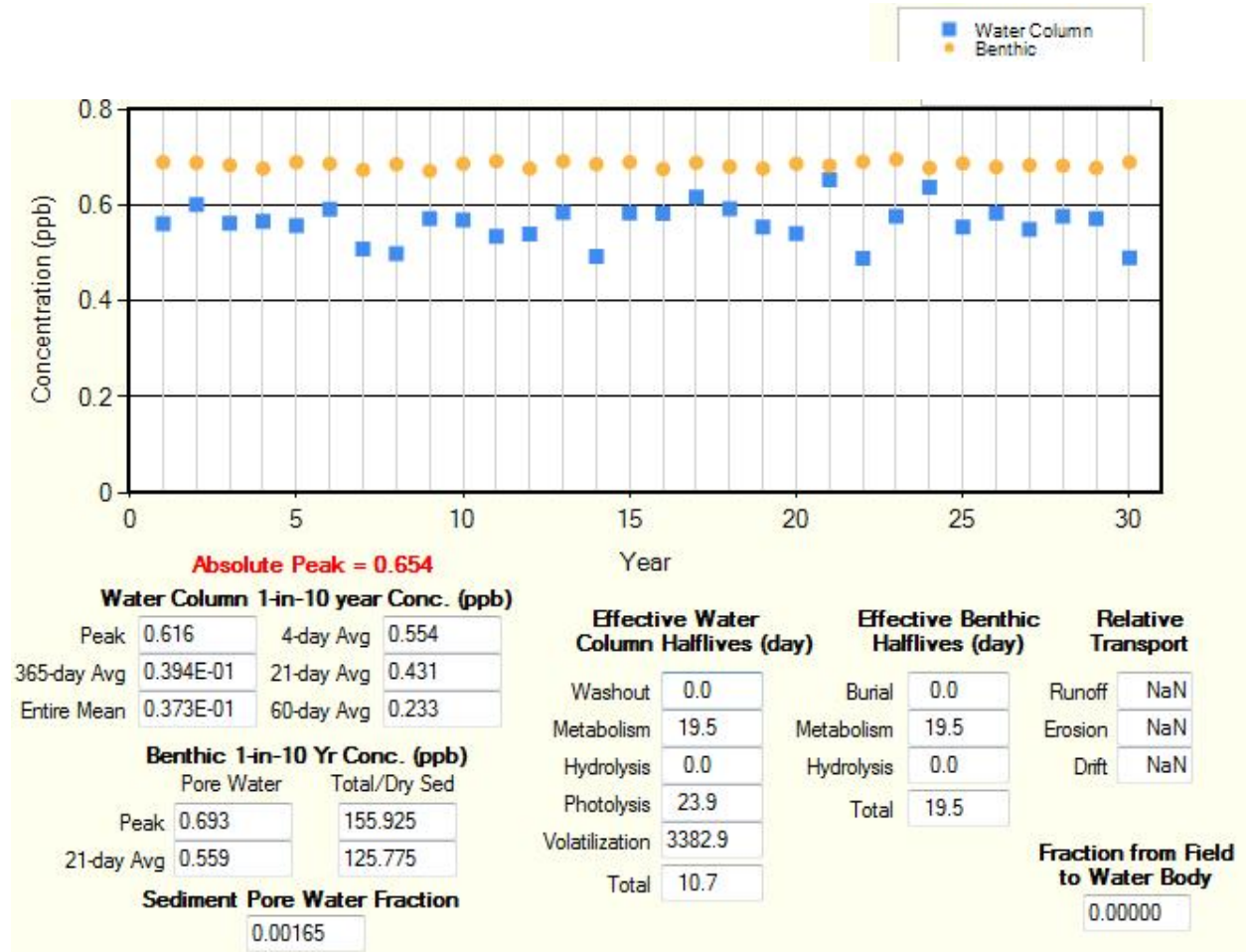


Figure 4: Output for Hydroxy Benzyl Ester Degradate:



References

US EPA (U.S. Environmental Protection Agency). 2017. Environmental Fate and Ecological Effects Risk Assessment for the Registration of the New Herbicide for the Use on Rice and Aquatics: Florpyrauxifen-benzyl. Office of Pesticide Programs. Environmental Fate and Effects Division. Washington, D.C. Accessed at: www.regulations.gov, Docket ID: HQ-OPP-2016-0560-0065