**Chapter 1 – Final Atrazine Problem Formulation**

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Introduction

This problem formulation provides the foundation for the atrazine Biological Evaluation (BE) for all federally listed endangered and threatened species, as well as those that are proposed and candidates for listing and experimental populations (in sum referred to as “listed species”). This BE also includes an analysis of designated critical habitats. The methods employed in this BE follow the Revised Method for National Level Listed Species Biological Evaluations of Conventional Pesticides (referred to as the “Revised Method”)[[1]](#footnote-2). The assessment for atrazine represents EPA’s Biological Evaluation (BE) for all listed species and designated critical habitats.

Included in this chapter is a description of the federal action; the mode and mechanism of action of atrazine; summaries of its uses (based on registered product labels and commitment letters from all technical registrants), usage, and fate; definition of the residue of concern and an analysis plan for how the BE will be conducted. As part of the FIFRA registration review process, a detailed Problem Formulation for the FIFRA ecological risk assessment of atrazine was finalized in May 2013[[2]](#footnote-3) (USEPA, 2013, DP Barcode D407490). The problem formulation considered data needs for both a FIFRA ecological risk assessment and an assessment for potential impacts on listed species.

Description of the Federal Action

In 2006, the U.S. Environmental Protection Agency (EPA) initiated Registration Review to reevaluate all registered pesticide active ingredients on a regular cycle. EPA is required to review each pesticide active ingredient at least every 15 years to make sure that it has the ability to assess risks to human health and the environment as science evolves and policies and practices may change, all pesticide products in the marketplace continue to meet the standard of registration. Registration Review includes labels registered under Sections 3, 24(c), and 18 of FIFRA. The federal action relevant to this BE is the Registration Review for atrazine, which encompasses the review of all the registered uses and the approved product labels for all pesticide products containing atrazine.

Mode and Mechanism of Action

Three chlorotriazine herbicides have current registrations in the United States: atrazine (6-chloro-N-ethyl-N′-(1-methylethyl)-1,3,5-triazine-2,4-diamine; PC code 080803); simazine (6-chloro-N,N′-diethyl-1,3,5-triazine-2,4-diamine; PC code 080807); and propazine (6-chloro-N,N′-bis(1-methylethyl)-1,3,5-triazine-2,4-diamine; PC code 080808). These three chemicals differ only in number and/or position of methyl groups on moieties branched in identical positions off the triazine ring, thus are structurally nearly identical.  Based upon the available guideline and non-guideline toxicity studies, these chlorotriazines result in similar herbicidal effects to terrestrial and aquatic plants.

In plants, atrazine binds with a protein complex of the photosystem II in chloroplast photosynthetic membranes (Schulz et al., 1990). The result is an inhibition in the transfer of electrons through the light reactions of photosynthesis that in turn inhibits the formation and release of oxygen, production of adenosine triphosphate, and the fixation of carbon dioxide into sugars. Plant death results from starvation and oxidative damage caused by the breakdown in photosynthesis.

While this pathway is not found in animals, atrazine and the 3 chlorinated degradates all exhibit neuroendocrine effects seen across mammals and can alter hormone levels in rats that may result in developmental and reproductive consequences. In addition to this primary effect in mammals, acute and chronic exposure of animals has shown significant reduction in body weight and organ weights across multiple mammal and bird species.

Use and Usage Characterization

Use data are based on registered product labels and include pesticide application information relevant to a treatment site (*e.g.*, an orchard). EPA determines the uses based on registered labels, including any agreed upon changes to these labels from the technical registrants, and defines crop or non-crop sites to which a pesticide may be applied. Use data also describe the maximum application rates, method (*e.g.,* aerial or ground spray), re-treatment intervals and number of applications that may occur according to registered product labels.

Usage data describe how the pesticide has been applied to multiple use sites within a state, region or the US. EPA also reviews actual usage data that documents the actual applications of a pesticide, including information such as actual application rates and timing, and spatial distribution of applications across multiple sites (usually based on survey data). The key difference between use and usage is potential applications vs. actual applications.

## Use Data (as Defined on Registered Product Labels)

The label on a pesticide package or container is legally enforceable. The label provides information about how to handle and safely use the pesticide product and avoid harm to human health and the environment. Using a pesticide in a manner that is inconsistent with the use directions on the label is a violation of FIFRA and can result in enforcement actions to correct the violations. Atrazine is currently registered on a variety of agricultural and non-agricultural use sites (**APPENDIX 1-1**). This BE assesses all currently registered labels and any agreed upon changes to these labels from the technical registrants (for implementation on all formulated product labels). While the current labels may not reflect all the agreed upon changes, the technical registrants have agreed in the form of commitment letters (see **APPENDIX 1-2**) to update the atrazine formulated product labels to be reflective of these changes (uses summarized in **APPENDIX 1-3**). Major changes to the use of atrazine that are included in the commitment letters include restriction of applications to the contiguous United States (ConUS) only, removal of certain use patterns (*e.g.*, forest trees), and implementation of new buffers and mandatory spray drift language (see **APPENDIX 1-2** for specific details). EPA plans to formalize these changes through the appropriate processes prior to finalizing the BEs.

Atrazine is one of the most widely used herbicides in North America. It is a chlorotriazine herbicide registered in the U.S. to control annual broadleaf and grass weeds primarily in corn, sorghum, and sugarcane. Additionally, atrazine products are registered for use on wheat, guava, macadamia nuts, soybeans, fallow crop lands and for several non-agricultural use sites. The primary non-agricultural use of atrazine is turf for fairways and residential sites, including homes, daycare facilities, schools, playgrounds, parks, recreational areas, and sports fields. Additional non-agricultural uses include special local needs (SLN) uses of atrazine on conservation reserve program (CRP) land in Iowa and highway rights-of-way use in Oklahoma. Atrazine can be applied as a liquid formulation for all crops as well as a granular formulation for turf. Atrazine may be applied by ground or aerial applications, which may occur at different times throughout the year, including multiple applications to the same crop.

Current labels for atrazine include spray drift language that specifies a 66 ft aerial or ground buffer on the point of runoff to streams and a 200 ft aerial or ground buffer on lakes, reservoirs, or other impounded natural waterbodies. The technical registrant has committed to additional 15 ft ground and 150 ft aerial buffers on streams, rivers, estuarine/marine environments, and listed species habitats. This results in 81 ft ground and 216 ft aerial stream buffers, 200 ft ground and aerial buffers on ponds, and 15 ft ground and 150 ft aerial buffers for the wetland (assuming listed species habitat for this assessment). In general, the single maximum atrazine application rates do not exceed 4 lb a.i./A nationwide for flowable formulations.

## Usage Data

Based on usage data compiled by EPA’s Office of Pesticide Program’s Biological and Economic Analysis Division (BEAD), during the most recent five years of available survey data (2013-2017), an annual average of 72,000,000 pounds of atrazine were applied to an average of 75,000,000 acres of agricultural crops. The majority of atrazine is applied to corn, both in terms of pounds a.i. applied (87% of total; 62 million lbs applied annually) and acres treated (88%). Sorghum and sugarcane make up the majority of the remaining annual usage. Annual use of atrazine on sorghum is approximately 6.4 million pounds; annual sugarcane use is estimated at 1.7 million pounds; and annual sweet corn use is estimated around 300,000 pounds. Total usage has remained relatively constant over the past decade. Use rates per acre have decreased, while total acres treated with atrazine have remained relatively stable **(APPENDIX 1-4**)**.**

Most recent non-agricultural usage data from 2013 – 2017 shows that for non-agricultural sites, thousands of pounds of atrazine were applied to non-agricultural sites with average annual applications of 300,000 pounds to residential turfgrass, 200,000 pounds to non-residential turfgrass (institutional facilities and sod farms) and 7,000 pounds to CRP land **(APPENDIX 1-4**).

# Overview of Environmental Fate

The major transport routes off the treated area for atrazine include runoff and spray drift. The main routes of dissipation for atrazine are microbial degradation under aerobic conditions in water and soil, runoff, and leaching. Because of its persistence and mobility, atrazine can move into surface and ground water. Atrazine has a low vapor pressure and Henry’s Law Constant, suggesting low potential for volatilization. Atrazine is highly soluble in water with a reported aqueous solubility value of 33 mg/L at 20-25oC. Bioaccumulation of atrazine is expected to be low due to a low octanol water partitioning coefficient (Kow = 501) and low bioconcentration factors (BCF). Soil sorption coefficients for atrazine (KF) range from 0.203-2.71 mL/g (1/n=0.89-0.94); average Koc= 75 mL/gOC (MRID 41257901). Information on leaching and adsorption/desorption indicate that atrazine is considered moderately mobile according to the Food and Agricultural Organization (FAO) mobility classification system[[3]](#footnote-4). Additional details on the fate of atrazine are provided in **Chapter 3** of the Biological Evaluation.

# Residue of Concern

Environmental fate data indicate that deethylatrazine (DEA), diadealkylatrazine (DACT) and hydroxyatrazine (HA) are the major transformation products of atrazine (>10% applied a.i.) and that deisopropylatrazine (DIA), deisopropylhydroxyatrazine (DIHA) and deethylhydroxyatrazine (DEHA) are minor chlorotriazine degradation product (<10% applied a.i.). DEA and DACT are formed through dealkylation of the amino groups on the atrazine molecule, while HA is formed through substitution of a chlorine by a hydroxy group. Dealkylation is a microbial-mediated process, while hydroxylation is both abiotic and microbial-mediated process. Formation of transformation products is further discussed in **Chapter 3**.

An analysis of the residues of concern is provided in **APPENDIX 1-8**. Based on the analysis of formation and toxicity data of the known transformation products, aquatic modeling of the parent compound alone is considered adequate for determining potential exposure concentrations to aquatic organisms. In the terrestrial environment, consideration is given to formation of transformation products, including deethylatrazine (DEA), diaminochlorotriazine (DACT) and hydroxyatrazine (HA), through the consideration of toxicity data and foliar dissipation half-lives (**Chapters 2 and 3**).

# Analysis Plan

Listed species and designated critical habitats that were listed as of Jan 30, 2019 are considered in this BE (see **APPENDIX 4-1** for complete species lists). Effects determinations were made for 1795 listed species and 792 designated critical habitats.

As described in the Revised Method, listed species risk assessments for pesticides include three steps. Steps 1 and 2 are represented by the BE, which evaluates whether an individual of a listed species is reasonably expected to be exposed to a pesticide, and, if so, distinguishes effects that are likely to adversely affect an individual of a species from those that are not likely to adversely affect an individual. This process is also applied to the designated critical habitat of listed species (when available). In Step 1, for every listed species and designated critical habitat, EPA determines whether atrazine will have No Effect (NE) or May Affect (MA) (separate determinations made for each species and critical habitat). For those species and critical habitats with MA determinations in Step 1, EPA will determine if atrazine is Not Likely to Adversely Affect (NLAA) or Likely to Adversely Affect (LAA) each individual species or critical habitat.

Details on the method, models and tools used for making NE, NLAA and LAA determinations are provided in the Revised Method. This analysis plan identifies atrazine specific information that is used in the Revised Method to complete this BE.

Step 1 begins with an analysis of the potential overlap of the action area and individual species ranges or critical habitat. For species or critical habitats with no overlap (*i.e.,* species found outside of the action area), NE determinations are made. The atrazine overlap analysis is conducted using ArcGIS version 10.7. The action area is derived using potential use sites and the off-site transport zone. The currently registered uses, incorporating changes based on commitment letters (summarized in **Section 3** and **APPENDIX 1-3**) include agricultural, and non-agricultural uses. For atrazine, agricultural and non-agricultural use sites are used to derive the action area (along with the associated off-site transport zone).

A number of spatial data sources were used to generate Use Data Layers (UDLs), which map the potential use sites for atrazine. In ConUS, agricultural use patterns UDLs are represented by using the US Department of Agriculture’s (USDA) Crop Data Layer (CDL)[[4]](#footnote-5). This analysis utilizes data from 2013-2017. As the commitment letters restrict the use of atrazine to the areas outside of ConUS, outside areas (*e.g.,* Hawaii, Puerto Rico, etc.) were not included in the analysis. **APPENDIX 1-6** includes a crosswalk between atrazine’s registered agricultural crops and the CDL. **APPENDIX 1-6** also defines how individual CDL layers are grouped into UDL categories[[5]](#footnote-6) and temporally combined to account for the accuracy of the data. USDA’s 2012 Census of Agriculture (CoA) is also used to improve accuracy by expanding the agricultural UDLs to meet or exceed the reported acres in the CoA (**ATTACHMENT 1-3**). Fallow UDLs were generated by combining the individual UDLs for each crop found in the rotations. For non-agricultural use patterns in ConUS additional UDLs were created to represent atrazine’s registered uses. The data sources used for these UDLs included but are not limited to the NLCD 2011, GAP Protected Areas Database, LandFire and NAVTEQ; for additional details see **APPENDIX 1-6** which summarizes all spatial data used to generate the agricultural and non-agricultural UDLs used for atrazine’s potential use site footprints.

The Step 2 overlap analysis incorporates atrazine usage data, which are provided in the SUUM (SIAB Use and Usage Matrix) combining it with information from the CoA (**APPENDIX 1-4****, ATTACHMENT 1-4**). **APPENDIX 1-7** describe how the usage data for atrazine, the CoA, and the potential use sites are combined to estimate the number of treated acres relevant to a given species located in ConUS. These appendices also explain how the off-site transport zone (specifically spray drift) is adjusted based on available usage data.

The Revised Method document stated “Over time, EPA expects to update the MAGtool and other models and tools described in this document. When a pesticide BE is conducted, it will incorporate the most current versions of models and tools intended for use in the BEs.” This BE is consistent with the Revised Method and includes two method updates that are intended to improve the methods for assessing exposure and effects to plants. First, this BE utilizes a refined exposure model for plants inhabiting terrestrial, wetland and aquatic habitats. Second, this BE incorporates surrogate endpoints for plants when No Observed Adverse Effects Concentrations (NOAEC) values are not available. These approaches are discussed below.

To estimate exposures to plants in aquatic, wetland, and terrestrial habitats, this BE uses the Plant Assessment Tool (PAT), a new tool designed to refine screening-level exposure estimates to plants typically generated using TerrPlant. PAT employs mechanistic representations of fate (e.g., degradation) and transport (e.g., runoff), using data that are typically available for pesticides, to model runoff and spray drift exposure to terrestrial and wetland environments. For terrestrial plants, runoff and erosion are modeled using the Pesticide Root Zone Model (PRZM; which is part of PWC) and spray drift is modeled using AgDRIFT deposition values (also incorporated into the MAGtool). The model uses a mixing cell approach to represent water within the active root zone area of soil, and accounts for flow through the terrestrial plant exposure zone (T-PEZ) caused by both treated field runoff and direct precipitation onto the T-PEZ. Pesticide losses from the T-PEZ occur from transport (i.e., washout and infiltration below the active root zone) and degradation. Wetlands are modeled using PRZM and the Variable Volume Water Model (VVWM) and are then processed in PAT to estimate aquatic (mass per volume of water) and terrestrial (mass per area) concentrations. Aquatic plants exposure is modeled using the PRZM/VVWM models and the standard pond. The results from PAT are summarized for use in the MAGtool in the same way as the results from PWC.

For listed terrestrial and wetland plant species, NOAECs from seedling emergence and vegetative vigor studies are used to represent toxicity endpoints. There are often cases where NOAECs are not available (e.g., statistically significant effects occurred at all test concentrations) or are considered unreliable. Consistent with OPP’s longstanding practice, in cases where NOAECs are not available or reliable, an ICx value is used as a surrogate. Based on an analysis of the variability in the dry weight and height data of the controls of commonly tested species in vegetative vigor and seedling emergence studies, x values were assigned based on test type and endpoint (**Table 1-1**; supporting details in **ATTACHMENT 1-5**). This analysis does not consider the biological significance of the percent effect but rather identifies an ICx value at which we have confidence the measured effect is discernible. **Table 1-1** Presents the ICx values that will be used as the Step 1 and 2 thresholds when a reliable NOAEC value is not available.

 **Table 1-1.** Alternate Step 1 and 2 thresholds.

|  |  |  |
| --- | --- | --- |
| **Test Type** | **Dry Weight** | **Shoot Height** |
| Vegetative Vigor | IC15 | IC10 |
| Seedling Emergence | IC20 | IC10 |

**Chapter 2** of this BE includes atrazine’s toxicity endpoints and **Chapter 3** includes the exposure analysis. These toxicity endpoints and exposure estimates are used in Steps 1 and 2. **Chapter 2** also summarizes incident reports that are associated with applications of atrazine (incident reports associated with illegal uses or misuses are not included in the assessment). **Chapter 3** summarizes available monitoring data. **Chapter 4** includes the species and critical habitat-specific determinations for atrazine. For exposure in terrestrial habitats, the MAGtool[[6]](#footnote-7) (version 2.2) is used (additional details in **ATTACHMENT 1-1** and tool documentation). For aquatic habitats, exposure is estimated using the Pesticide in Water Calculator (PWC; version 1.52[[7]](#footnote-8)). Aquatic scenarios (referred to as “bins”) used to estimate exposures for each listed species with aquatic habitats are provided in **ATTACHMENT 1-2.** For plants, exposure is estimated using PAT. The MAGtool is used to integrate exposure, effects, and listed species life history information in order to make NE, NLAA and LAA determinations.

1. Available at: <https://www.epa.gov/endangered-species/revised-method-national-level-listed-species-biological-evaluations-conventional> [↑](#footnote-ref-2)
2. Atrazine Registration Review Docket Folder. <https://www.regulations.gov/docket?D=EPA-HQ-OPP-2013-0251-0002> [↑](#footnote-ref-3)
3. [↑](#footnote-ref-4)
4. USDA National Agricultural Statistics Service Cropland Data Layer. 2013-2017. Published crop-specific data layer [Online]. Available at <https://www.nass.usda.gov/Research_and_Science/Cropland/SARS1a.php> (accessed 3/2018; verified 2/2020). USDA-NASS, Washington, DC. [↑](#footnote-ref-5)
5. Categories include: corn, cotton, rice, soybeans, wheat, vegetables and ground fruit, other grains, other row crops, other crops, pasture/hay, citrus, vineyards and other orchards. [↑](#footnote-ref-6)
6. Information on the models and tools used to support this biological evaluation are available at: <https://www.epa.gov/endangered-species/models-and-tools-endangered-species-pesticide-assessments> (Accessed September 2020). [↑](#footnote-ref-7)
7. Available online at: [https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment#aquatic](https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment%23aquatic) (Accessed September 2020). [↑](#footnote-ref-8)