# Integrating a Distributional Approach to Using Percent Crop Area (PCA) and Percent Crop Treated (PCT) into Drinking Water Assessments

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## 1. EXECUTIVE SUMMARY

The Office of Pesticide Programs (OPP) estimates human exposure to pesticides as part of the aggregate exposure assessment via all routes. Drinking Water Assessments (DWA) consider whether use of a pesticide according to the approved label, whether the use be to agricultural or non-agricultural sites, will lead to exposure via drinking water. Tier 1 and 2 DWAs assume that the modeled watershed supplying a community water system (CWS) is 100% planted with the crop of interest, and that 100% of the crop is treated with the pesticide of interest. These assumptions are referred to as 100 % "Percent Cropped Area" (PCA) and 100 % "Percent Crop Treated" (PCT).

One method OPP currently uses to refine its estimated drinking water concentrations (EDWC) is to refine the assumption of 100% PCA. This is done by applying a PCA that represents the multiple crops or uses for the pesticide. These PCAs are calculated from GIS land cover data and USDA crop acreages, that estimate the percentage of land in particular agricultural or other uses. The highest PCA from any single CWS watershed, either on a national or regional (HUC-2) basis, is currently used to refine the EDWC at DWA Tier 2.

This White Paper proposes methods to apply the full range of PCA values from individual CWS watersheds, not just the maximums, to the process of modeling EDWCs. Essentially, the appropriate PCA for the modeled use(s) will be applied within the particular watershed, and the resulting modified EDWCs presented as a distribution of EDWC across all CWS watersheds within a HUC-2. This distribution is compared to the Drinking Water Level of Comparison (DWLOC) supplied by the Health Effects Division, to determine what percentile of PCA-modified EDWC falls below the DWLOC (passing) and what percentile falls above the DWLOC (failing). The cut point between passing and failing is the "critical PCA," and this determines which CWS watersheds require further refinement of their EDWC.

In this White Paper OPP also proposes the application of PCT data below the default assumption of 100% to the DWA process. Data on PCT of various agricultural crops is supplied by the Biological and Economic Analysis Division (BEAD) based on United States Department of Agriculture (USDA) survey and Kynetec USA (i.e. private market survey data)[1]. This data is summarized on a state level. PCT data for non-agricultural uses is typically available on a national or regional basis. The method described here for applying PCT data to the DWA process deals in large part with bridging the spatial scale mis-match between the PCT data (state level or higher) and the PCA data, which is available at the watershed (sub-state, sub-county or cross-state) level. Methods for dealing with the uncertainty of the geographic overlap of cropped acres (PCA) and treated acres (PCT) are developed, in the context of combining these two factors that modify the EDWC.

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[1] Kynetec USA, Inc. 2019. "The AgroTrak® Study from Kynetec USA, Inc." Database Subset: 1998-2018

## 2. INTRODUCTION

### 2.1. Regulatory Context

Pesticides are regulated in the United States under both the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food, Drug and Cosmetics Act (FFDCA). Through these statutes, the Environmental Protection Agency (EPA) Office of Pesticide Programs (OPP) must ensure that aggregate exposure to the pesticide residues is safe, *i.e.*, that "there is a reasonable certainty of no harm" from exposure to the pesticide.

OPP's Environmental Fate and Effects Division (EFED) is responsible for conducting Drinking Water Assessments (DWA), which include an analysis of the potential for and magnitude of pesticide occurrence in drinking water from both surface water and groundwater sources. USEPA OPP estimates drinking water concentrations (EDWCs) in surface water that supply Community Water Systems (CWS) and compares them to benchmark values called drinking water level of comparison (DWLOC) to determine if pesticide concentrations have the potential to cause adverse effects to human health (USEPA OPP, 2019b, p. 13). EFED employs a robust, tiered DWA process designed to efficiently screen out pesticides that do not pose a potential risk to human health from those requiring more highly refined analyses to better understand potential risks (*e.g.*, in terms of when and where there may be concerns). Lower tier assessments are intended to be conservative so that the assessor can confidently screen out chemicals that represent a low risk (**Appendix A**). Higher tiers successively incorporate refinements that draw on more focused chemical, spatial, temporal, and agronomic information including consideration of available monitoring data to inform risk management decisions. For additional information on USEPA OPP's tiered approach to DWAs, including a detailed description of individual tiers, see the *Draft Framework for Conducting Pesticide Drinking Water Assessments for Surface Water* (USEPA OPP, 2019b).

### 2.2. Purpose Statement

As part of OPP's tiered approach to DWAs, OPP estimates pesticide concentrations in surface water using simulation models (*e.g.,* Pesticides in Water Calculator (PWC), and Pesticide Flooded Application Model (PFAM))[2]. At the lower tiers, OPP estimates the application of a particular pesticide as defined by the label (use) and assumes the pesticide is applied to the entire area that may be contributing to a surface water in a watershed. These conservative assumptions lead to the generation of upper-end estimates of pesticide concentrations. In an effort to advance methodologies used in DWAs, OPP developed approaches to refine these estimates for higher tiered assessments described in this document. First, OPP developed an approach to account for the variability in the PCA across watersheds nationally and within specific regions that supply CWSs. Second, OPP developed a method to incorporate data on the

[2] https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment#aquatic

amount of a target crop or group of crops that are actually treated with a given pesticide (referred to as percent crop treated or PCT). The goal of the PCA and PCT refinements are to generate EDWCs that are protective of human health that reduce the magnitude of overestimation due to variability in crop acreage and actual pesticide usage. While OPP considers potential exposure to conventional pesticides in both surface and groundwater sources of drinking water, this effort focuses on refining estimated pesticide concentrations in surface water.

OPP currently uses a suite of PWC scenarios that have been developed over time for a variety of reasons. In all cases, the scenario was developed with a goal of representing a high-end exposure setting. The current scenarios span the United States for a range of crops/use sites and while they were developed using consistent guidance, they do not all represent a similar level of runoff potential. The current scenarios can be found at the following website. https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment. Currently, OPP has a companion project to the PCA/PCT project to use spatial data sets to develop a new suite of scenarios for use in surface water DWA. Once developed these new scenarios will replace the existing scenarios and will provide a more quantitative level of runoff potential.

The PCA/PCT project begins with EDWC that are developed using PWC scenarios available at the time of the DWA. However, the approach is developed in such a way as to be independent of how they were developed. The operating assumption is that in both cases the EDWC resulting from a scenario at the national or regional scale represents an upper bound EDWC representing a high-end exposure for the geography from which it was selected.

### 2.3. Document Organization

This document presents the background on and methods for applying PCA and PCT as refinements to EDWCs in high-tier (*i.e.*, tier 3 and tier 4) DWAs. Each section of the document is dedicated to a separate component of the process. The sections in this document are organized as follows:

**Section 3** provides an overview of the previous PCA and PCT efforts to date.
**Section 4** describes application of distributional PCA refinements to DWAs.
**Section 5** describes the application of state-level PCT refinements to DWAs.
**Section 6** describes the process for comparing the refined EDWC values to monitoring data.
**Section 7** discusses the implications of the new PCA and PCT refinements to DWAs.

A case study of the application of these methods can be found in **Appendix B**.

# 3. OVERVIEW OF PCA AND PCT

## 3.1. Introduction

Lower tier assessments are intended to be conservative in order to screen out chemicals that represent a low risk (**Appendix A**). In estimating a pesticide's concentrations in surface water, OPP routinely relies on a variety of pesticide use information representing how the pesticide may be used as specified on the pesticide label and usage data which includes actual reported information on how the pesticide is actually applied including where the pesticide is applied and how much is applied. OPP incorporates more detailed pesticide use and usage data when refining EDWCs (moving from low to high tier DWAs).

Pesticide use parameters are based on labels which define how a pesticide may be applied. These label parameters generally include: use patterns (*e.g.*, target pest(s), use sites, residential uses), maximum application rates, application method (*e.g.,* aerial or ground spray), minimum retreatment intervals, and the maximum number of applications allowed per crop cycle or year. Usage data describes actual pesticide applications. These data include information such as actual application rates for a particular use site (*e.g.*, corn), timing of application, methods of application (*e.g.*, aerial) and use intensity (PCT) at the state level. OPP obtains usage data from a variety of public and proprietary surveys. The key difference between use and usage is that the use represents potential applications of a pesticide (use sites and application rates as they appear on the label) while usage represents what is typically applied for a given pesticide that are observed to occur in the field (from growers and users). OPP calculates EDWCs employing use data for low-tier assessment and integrates progressively more usage data in subsequent tiers as describe in the DWA Framework (USEPA, OPP, 2019b).

PCA and PCT are key data that can be used to refine DWA analysis moving from low to high tiers. PCA is defined as the areal fraction of a watershed with a land cover (*e.g.*, corn, wheat, vegetables, turf) that can be treated with a pesticide based on registered uses. PCT is defined as the percent of base acres treated (acres treated with a given pesticide one or more times) relative to the total number of acres grown. For low tier assessments, OPP conservatively assumes 100% percent cropped area and 100% percent crop treated within a given watershed. A better understanding of PCA and PCT allows for the calculation of EDWC values that more accurately represent the potential for exposure to a given pesticide. The following sections provide additional background on PCA and PCT and their use in DWAs.

## 3.2. Percent Cropped Area (PCA)

CWS watersheds large enough to support a drinking water facility rarely consist of a single crop (*e.g.*, apples) or land cover type (*e.g.*, orchards). To account for the variability in use patterns, in Tier 2-4 DWAs, OPP currently uses PCA adjustment factors to reflect the percentage of a watershed that is covered by a particular use or land cover type. The application of PCAs to DWAs has been extensively documented, reviewed, and utilized in OPP drinking water assessments (USEPA, 2014).[3] OPP derived the existing PCA adjustment factors from National Agricultural Statistics Service (NASS) Census of Agriculture (Ag Census) data, geospatial data (National Land Cover Database, NLCD) and CWS DWI data that spatially overlapped the crop acreage within each of the previously delineated CWS watersheds within the conterminous United States (USEPA, 2014) for a subset of crops. OPP calculated PCA values for the land cover class GIS layers for seven crops and groups of crop (corn, cotton, orchard, soybean, vegetables, wheat and turf); and for selected combinations of crops (*e.g.,* corn-wheat, soybean-wheat, turf-corn, turf-vegetable, turf-wheat, vegetable-orchard); as well as for all agricultural land ("all-agriculture") and all agricultural land plus residential turf ("all-agriculture plus turf"). The full list of land cover classes with calculated PCAs can be found in **Appendix C**. It is important to note that PCAs are not applicable to groundwater EDWCs or to areas outside the conterminous United States (*e.g.*, Alaska and Hawaii).

The current approach for using PCA refinements is to multiply the modeled base EDWCs by the PCA of the crop(s) to give the refined EDWC values that are reflective of application to the percentage of the watershed that could be treated with the pesticide. The PCA-adjusted concentrations are then used as the EDWC in human health dietary risk assessment. For Tier 2 assessments, OPP uses the most conservative (maximum) PCA value of all watersheds within the conterminous United States (for national assessments) or a specific hydrologic unit code (HUC)-02 region (for regional assessments) to refine the EDWCs.[4] OPP's current guidance for the use of PCA refinements states that if the pesticide has registered use patterns on only one crop/group of crops, then the PCA for that particular crop is used; if the pesticide is used on a combination of crops with a calculated crop pair PCA, then the PCA for that particular pair of crops is used; and, if the pesticide use include more or different crops than are captured in the existing PCA combinations, the default "all-agriculture" PCA is applied. The maximum national all-agriculture PCA is 100%, therefore PCA refinements will not alter the EDWCs or risk

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[3] In 2014 OPP identified 6,550 CWS DWI locations from EPA's Safe Drinking Water Information System (SDWIS). Of the 6,550 locations, 74% (4,840) had unique, delineated watersheds. Of these, all but two (4,838) are located in the continental United States. PCA values were calculated for these 4,838 DWI watersheds. The 1,710 CWS DWI without validated watersheds (*i.e.*, 6,550 – 4,840 = 1710) consists of the following: 195 were abandoned or outside the continental US and are therefore not relevant to EPA risk assessments; 490 were water bodies that were not appropriate to simulate with EPA standard watershed based runoff modeling (*e.g.*, canals, aqueducts, off-stream reservoirs, and large, incompletely-mixed water bodies such as the Great Lakes); 666 were not validated DWI watershed; and 359 need more information on drinking water source to evaluate pesticide exposure for these watersheds. The method described in this White Paper will ultimately be extended to all delineated CWS watersheds and the additional HUC-12 surrogates described in the *Development of Community Water System Drinking Water Intake Percent Cropped Area Adjustment Factors for use in Drinking Water Exposure Assessments: 2014 Update* (USEPA, 2014).

[4] Hydrologic Units Codes are a hierarchical system developed by United States Geological Survey to catalogue hydrological units within the United States. In this system, there are 18 individual HUC-02 regions in the contiguous drainage areas in the United States with an average size of 177,560 $mi^2$ (See **Figure 1**). The U.S. is divided and sub-divided into smaller hydrologic units. These units are arranged within each other and identified by a unique code consisting of two to eight digits based on the levels of classification in the hydrologic unit system. Additional information can be found at https://water.usgs.gov/GIS/huc.html .

conclusions in national assessments for any chemical with use patterns not covered by the existing crop combination PCAs. The HUC-02 regional PCA for a crop may be lower than the national PCA but still represents the most conservative PCA value for that HUC-02 region and is used as a refinement in OPP's current DWA approach. **Figure 1** shows the 18 HUC-02 in the United States while **Figure 2** shows the distribution of CWS watersheds with binned PCA values. For additional information on the development of the CWS PCA values and use as a refinement in DWAs see *Development of Community Water System Drinking Water Intake Percent Cropped Area Adjustment Factors for use in Drinking Water Exposure Assessments: 2014 Update* (USEPA, 2014).

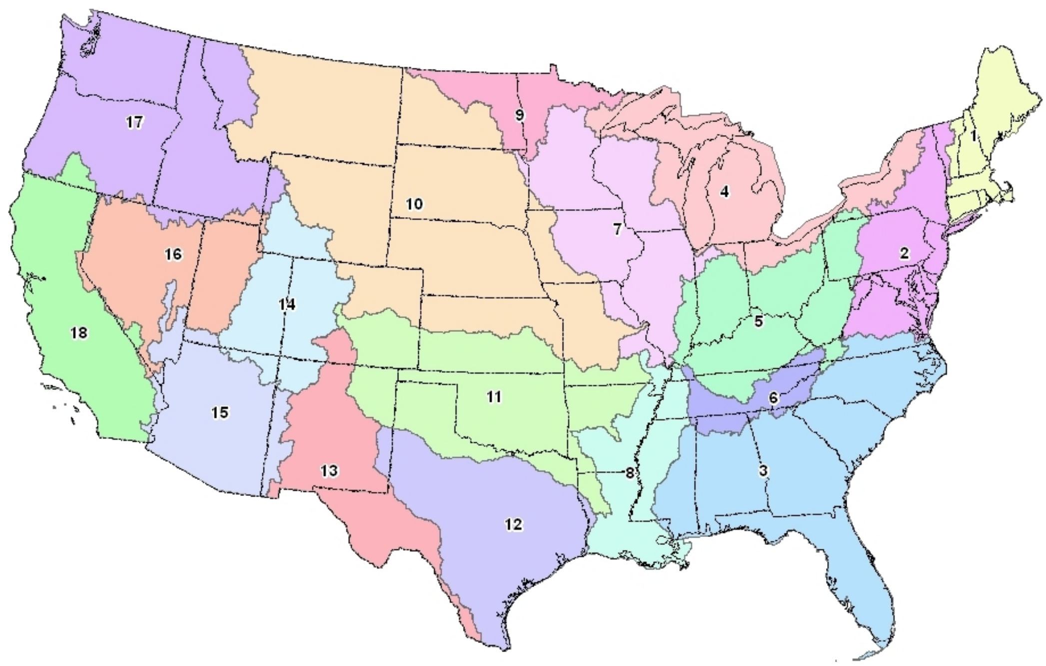



**Figure 1. The 18 Hydrologic Unit Code (HUC) System Developed by United States Geological Survey to Categorize Hydrologic Units (USEPA 2014)**

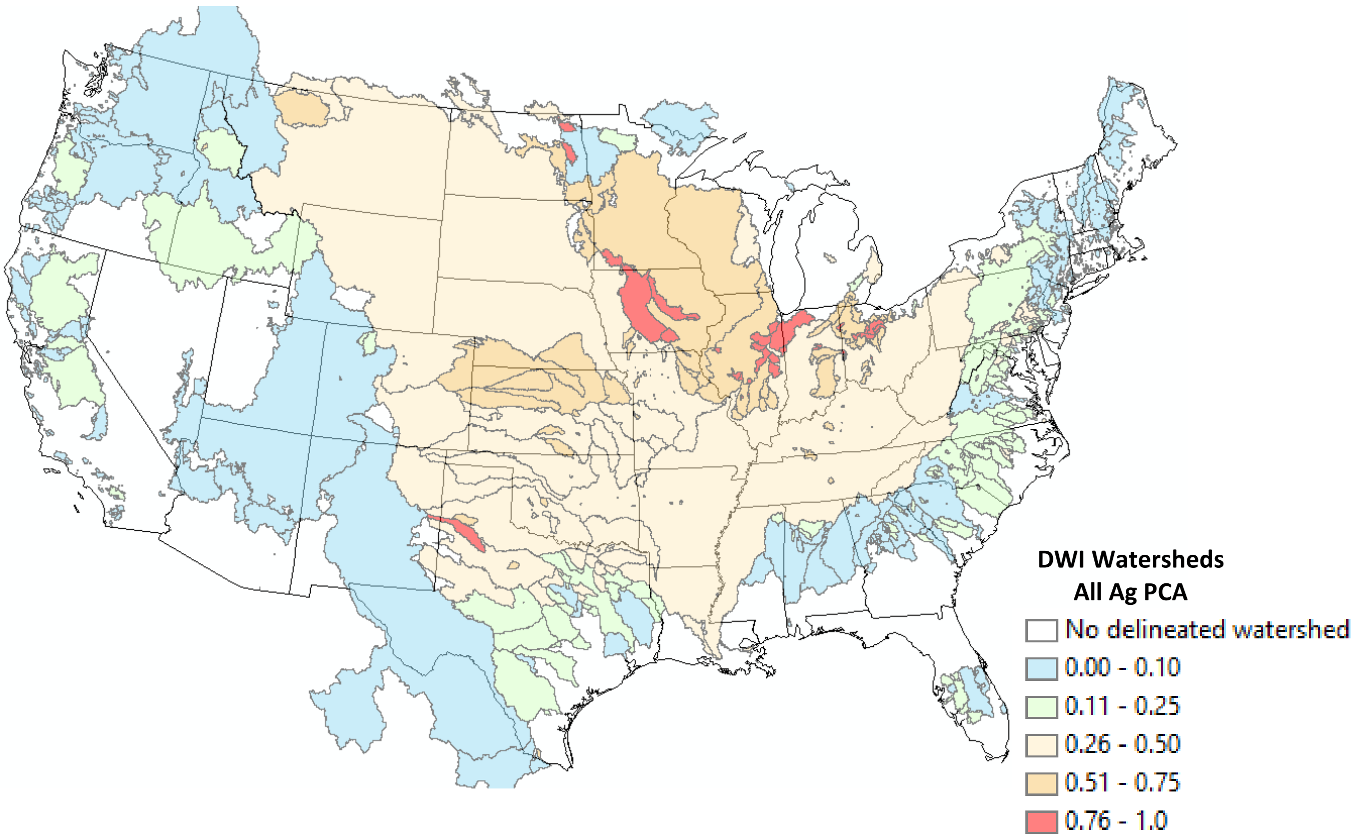



**Figure 2. Geographic Distribution of the Community Water System Drinking Water Intake Watershed and Percent Cropped Area (PCA)**

### 3.3. Proposal to Incorporate Usage Data into Endangered Species Assessments

While OPP does incorporate some usage data into high-tier assessments (*e.g.*, average use rates, typical application dates), PCT has not historically been used in the standard tiered DWA process.[5] EPA is proposing to use it now with this peer review. Pesticide concentrations are modeled on the watershed-scale, whereas PCTs are typically available at a larger scale that reflect the available data. As such, PCTs are generally calculated at the national or state level. The survey vendors that generate available usage data and OPP have determined that in most cases the state level is the lowest level of aggregation that maintains the statistical power of the studies underlying the available usage data across all years and crops. **Appendix D** lists the various usage data sources used to calculate PCT values. The majority of drinking water watersheds, however, are sub-state scale and many span portions of multiple states. The difference in scale between state or national level PCT data and drinking water intake watersheds has typically precluded the direct application of PCTs to DWA refinements. In contrast, the Health Effects Division (HED) currently uses national-level PCT values as

[5] PCT data has been used in certain high tier assessments, including the *Organophosphorus Cumulative Risk Assessment 2006 Update (USEPA, 2006)*.

refinements for national dietary exposure analysis, but does not use state or regional level PCT values in their assessments (USEPA, 2000).

OPP calculates PCT as the ratio of base acres[6] of a crop or group of crops (*e.g.*, dry beans) treated with a particular pesticide in a given area, to the Crop Acres Grown (CAG) of the same crop or group of crops in the same geographical area, based on available usage data using **Equation 1**. Since OPP did not historically have a systematic method for refining EDWCs based on PCT data, OPP generally assumed 100% PCT for a given watershed.

$$PCT_X = \frac{Base\ Acres\ Treated\ with\ Pesticide\ X}{Crop\ Acres\ Grown} \text{ X } 100$$

**Equation 1**

In May 2019, OPP proposed a process to incorporate usage data into biological evaluations for federally listed endangered and threatened species (listed species assessments) (USEPA, 2019a).[7] The proposed method calculates the fraction of a listed species range that overlaps with the area that a pesticide may be applied. This involves calculating state-level PCT aggregated across multiple crops from available usage data. OPP then uses these aggregated state-level PCT to calculate the treated acreage within a state based on the aggregated state-level PCT and the cropped acres from the land cover GIS layer. OPP then compares the treated acreage to species ranges (often at the sub-state level) within a state to determine the extent of potential overlap between the treated area and the species range. The revised method for listed species assessments can serve as a starting point for developing a method to apply PCT data to refined DWA for human health assessments. From a conceptual and geospatial analysis standpoint, a species range location and a drinking water watershed are similar; both areas represent geographically defined locations where off-target pesticide exposure could result in exposure to the populations dependent on that area. Although, the listed species assessment and DWA application and data sources are different; they both use spatial layers of land cover that were derived from satellite imagery. Therefore, it is possible to apply a similar methodology used in the proposed endangered species approach for drinking water watersheds as a refinement to higher tier drinking water assessments.

One area addressed in the revised endangered species assessment (ESA) method is uncertainty in the actual location of pesticide applications associated with available usage data. Therefore, the treated area could be located in any area within a given state where the crops are grown. To account for the uncertainty in the degree of overlap between the treated area and the species range, OPP proposed three methods for allocation of the base acres treated (BAT) within a state to the species range by bounding the assumption of where treated acres may occur using most conservative, least conservative, and mid-range assumptions of how treated

[6] Base Acres Treated (BAT) = The number of unique acres of a crop that were treated at least once with a specified active ingredient in a calendar year

[7] https://www.epa.gov/endangered-species/draft-revised-method-national-level-endangered-species-risk-assessment-process

acres are distributed. These are bounding case assumptions designed to capture the uncertainty in the distribution of the treated acres across the state and are described as the “upper”, “uniform”, and “lower” methods. Specifically, the “upper” method is completed by allocating all BAT to the species range until 100% of the species range is considered “treated”, with the excess acres allocated to areas outside the range but still in the state (“upper” overlap; excess acres may then be allocated to areas outside the range but still in the state). The “uniform” method allocates the BAT to potential use sites proportionally to the aggregated PCT (the aggregation of state level usage data for all pesticide specific uses) of the land cover class, while the “lower” method allocates the BAT to areas within the state but outside the species range until 100% of the area outside the species range is considered “treated”, with the excess acres allocated to areas inside the species range.

As described in **Section 5**, OPP is proposing to apply a similar methodology to calculate the treated area inside a drinking water watershed. **Section 5** describes and graphically presents a proposed method to apply state-level PCT and associated treated acreage data as a refinement to higher tier drinking water assessments. OPP plans to incorporate the extent of the treated area to derive watershed scale PCTs that can be used to refine EDWC.

## 4. APPLICATION OF DISTRIBUTIONAL PCA REFINEMENTS TO DWAs

### 4.1. Purpose

As previously stated, the standard method for applying PCA refinements to EDWCs is to multiply the EDWC by the maximum national or HUC-02 regional PCA. For HUC-02 regions where the standard PCA-refined EDWC still exceed the DWLOC, there are several different options to further refine the EDWC values based on available PCA data. This section explains three PCA options and how they can be applied to further refine exposure estimates. These refinements can be applied individually or in sequence, based on the available data and use patterns for a particular pesticide.

### 4.2. Available Data

OPP draws the maximum national and regional PCA values for each crop or group of crops from the full data set of PCA values calculated for each of the previously delineated CWS watershed within the conterminous United States. These data include the HUC-02 region for each CWS watershed, the watershed area, and the watershed PCA values for each crop/group of crops listed in **Appendix C**. OPP calculated crop pairing PCA values for nine crop combinations as the sum of the individual crop/group of crops PCA values within the watershed.[8]

[8] The nine crop pair combinations are corn-wheat, soybean-wheat, turf-corn, turf-orchards, turf-soybean, turf-vegetables, turf-wheat, vegetables-orchards, and all-agriculture-turf.

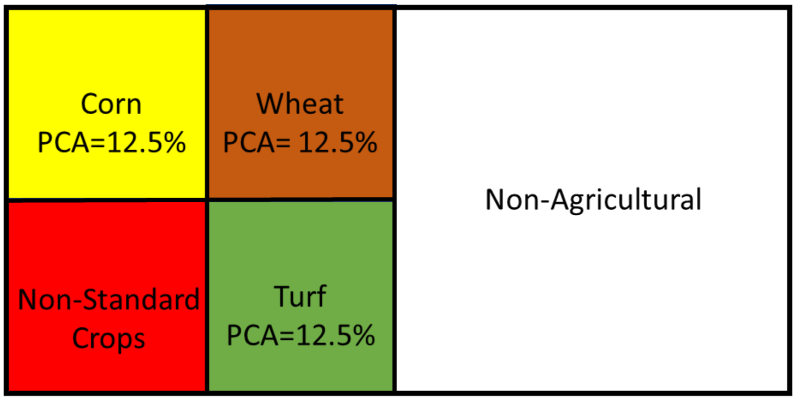
### 4.3. Method Description

The goal of the current PCA effort is to evaluate three different methods to refine EDWCs as part of a Tier 3 DWA where the EDWCs exceed the DWLOC after the standard Tier 2 HUC-02 regional PCA refinement. Some methods will be more appropriate than others based on the specific use pattern of a given pesticide. During the scoping process described in the DWA framework (USEPA, OPP 2019b), it is essential to consider the use pattern of the pesticide to determine which of these approaches will be most beneficial. These methods are described in the following sections.

#### 4.3.1. Use Pattern Specific and Non-Standard Crop PCAs

Use of the all-agriculture PCA when a pesticide is registered for use on crops not covered by one of the existing crop pair combinations can lead to overestimation of the PCA value and resulting EDWCs, particularly when the crops each have small acreage footprints relative to the all-agriculture PCA (*e.g.*, cotton plus orchards). The PCA value for any combination of crops (*e.g.,* corn-soybean-orchard) can be calculated from the full distribution of PCA values within each watershed as the sum of their individual PCA values for each crop within that watershed. Unlike in the crop pair PCA values, any number of individual PCA values can be combined to give a use pattern specific PCA. These use pattern specific PCA values can be used to refine the EDWC values in a similar fashion to the standard PCA values, *i.e.,* multiplying the EDWC value by the maximum national/HUC-02 regional use pattern specific PCA to give the refined EDWC value.

As an alternative to the all-agriculture PCA for crops with no relevant standard PCA value (*e.g.*, alfalfa, sugar beets, sorghum), a conservative estimate of the PCA for these non-standard crops can be calculated as the difference between the all agriculture PCA (or all-agriculture + turf, if the pesticide has residential turf or golf course applications) and the sum of the crop/group of crops PCA values for each watershed (**Figure 3**). This is the maximum area that could be planted with any crop that does not fall into standard PCA categories. Similarly, for non-agricultural uses without a defined PCA, OPP can assume a PCA of 100% minus the all-agriculture + turf PCA value, as that will provide a conservative estimate of all non-agricultural, non-turf uses in a watershed. While these are likely an overestimation of the cropped area for any single one of these use patterns (because it assigns all other acres to just one crop), the magnitude of the overestimation is smaller than it would be to use the all-agriculture PCA.




All-Agriculture+Turf PCA = 50%
Other PCA = All-Agriculture+Turf PCA – Corn PCA – Wheat PCA – Turf PCA
= 50% - 12.5% - 12.5% - 12.5% = **12.5%**
Non-Agricultural PCA = 100% - All-Agriculture
=100% - 50% = **50%**

**Figure 3. Example calculation of non-standard and non-agricultural PCAs**

The non-standard crops PCA can be combined with existing PCA values to calculate a use pattern specific PCA value. For example, for a pesticide that can be applied to alfalfa, soybeans, and cotton, the estimated alfalfa PCA could be combined with the existing soybean and cotton PCA to calculate the alfalfa-soybean-cotton PCA for all watersheds and the maximum national/HUC-02 regional PCAs can be used to refine the EDWCs in an identical fashion to a standard PCA. It is important to note that, if there are multiple crops without standard PCA values, the non-standard crops PCA should only be added once, as it represents the total area that could be planted with all non-standard crops.

The use pattern specific and non-standard crop PCA approaches are suited for pesticides with a broad range of use patterns spanning several crop/groups of crops with calculated PCAs and for use patterns that do not have a calculated PCA. This method is not applicable to pesticides whose use patterns are already covered by existing PCA values. If this method is not applicable to the pesticide or, after applying the use pattern specific PCA value the national/regional EDWC values still exceed the DWLOC, as a further refinement, the assessor can proceed to the either the land cover class overlap analysis (**Section 4.3.2**) or the aggregate EDWC steps (**Section 4.3.3**), as appropriate.

### 4.3.2. Full Distribution of Watershed PCAs with Land Cover Class Overlap

A more refined PCA analysis can use the full distribution of individual crop/groups of crops PCAs (including use pattern specific and non-standard PCA) for all watersheds within a HUC-2 region. In many cases the full distribution of PCA values (at either the regional or national scale) will yield many CWS watersheds with low PCA values, including some with a PCA of 0 (*i.e.*, regions with no identified agricultural cropped or turf area). The assessor may use either the existing suite of PCA values (individually or grouped) or a new localized PCA as described in **Section 4.3.1**.

Next, OPP can back-calculate the PCA below which the EDWC would no longer exceed the DWLOC, the “critical PCA”. OPP will then overlay the critical PCA to the map. The critical PCA is the PCA where the PCA-adjusted EDWC falls below the DWLOC (**Equation 2**).

**Equation 2**

$$\boldsymbol{Critical\ PCA = DWLOC/EDWC_{max}}$$

Where

| | |
|---|---|
| Critical PCA = | PCA value below which the PCA-adjusted EDWC is less than the DWLOC |
| $EDWC_{max}$ = | Maximum EDWC for all use patterns for a given pesticide |
| DWLOC = | Drinking water level of concern |

For watersheds with PCA below the critical PCA no further refinement is needed. For those that remain above the critical PCA the map of the watersheds with a use pattern specific PCA value equal or greater than the critical PCA is overlaid onto the map of the land cover dataset for all of the crops to determine the number of watersheds with potential exposure concerns that overlap with regions where the pesticide could be applied. This step entails overlaying watersheds with information from the USDA NASS agriculture of census (e.g. Ag Census) data which can show where individual crops are grown. To do this the map of watershed and associated PCAs values would be overlaid with the use area of the pesticide based on Ag Census. The overlap analysis defines watersheds with the generalized PCA landcover class (e.g. orchards) relative to areas defined by Ag Census where the pesticide specific use site (e.g. apples) are not present. Any watershed that exceeds the DWLOC based on PCA but overlaps completely with counties without acreage for the specific use (e.g. apples) can be excluded from further refinement because without the use site present the pesticide may not be applied.

For example, **Figure 4** illustrates the overlap between watersheds with a vegetable critical PCA greater than 0.6% and counties with reported vegetable acreage based on survey data. Any watershed with a PCA>Critical PCA that overlaps with the use sites has potential exposure concerns.

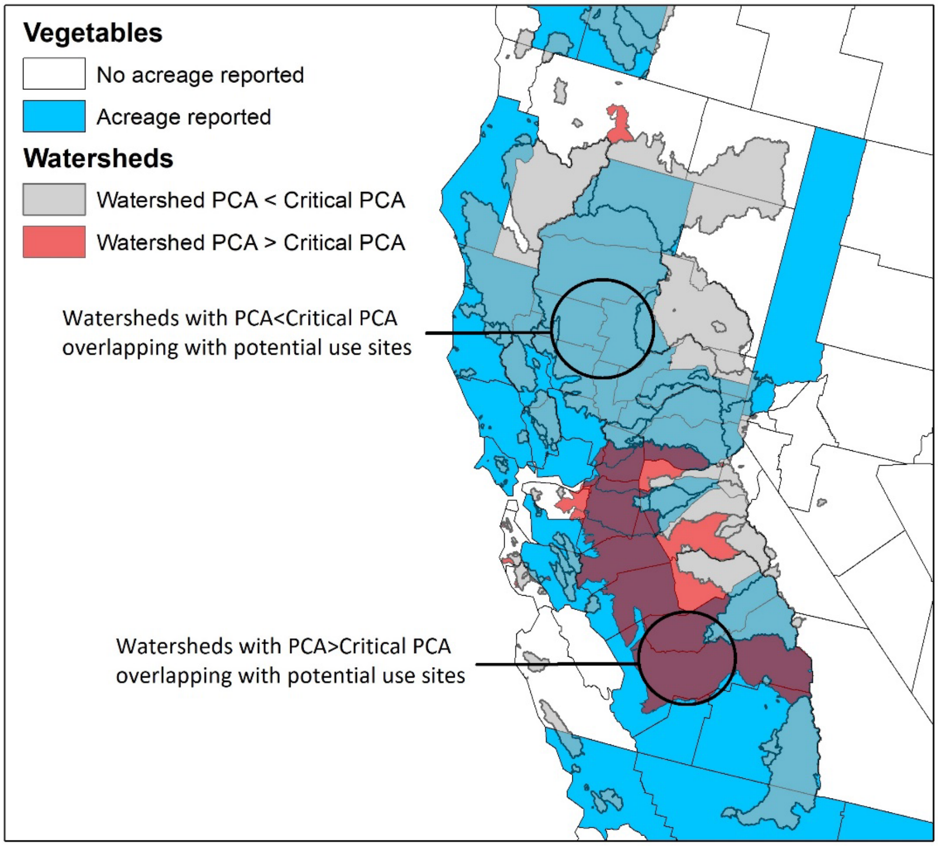



**Figure 4. Critical PCA Overlap Analysis for Vegetable Land Cover Class**

For pesticides that are applied to a single land cover class, if there is no overlap between any of the crops and a watershed with a PCA ≥ Critical PCA, then the PCA refined EDWCs would be expected to be below the DWLOC and no further refinements are necessary. If there is overlap between the watersheds that are above the critical PCA and with the areas where the crop is grown, then more refinements may be needed and an aggregate EDWC analysis would be included in the refinements (See **Section 4.3.3**).

This method is most applicable to pesticides with a small set of use patterns, pesticides used primarily on minor crops, and pesticides applied to crops grown in a small set of areas within the United States (*e.g.*, avocados, pecans, sugarcane). If there is overlap between the labeled crops and watersheds with a PCA value greater than the critical PCA, then further refine the EDWCs by considering the individual contributions of each crop to the total EWDC (**Section 4.3.3**).

### 4.3.3. Aggregated EDWC Based on Individual Crop PCA Values.

Typically at lower tiers of refinement assessors have applied the maximum PCA nationally and regionally to the maximum EDWC for any use in that region. For example, a DWA with uses on corn, soybean and orchards can have three unique maximum EDWC and three unique PCA. As a first step a DWA can multiply the maximum of the three EDWC by the aggregated PCA for all three uses providing a conservative estimate for that region. However, If further refinements are still indicated after conducting use pattern specific PCA refinements and/or the critical PCA overlap analysis, a third option for PCA refinements is to calculate an aggregate EDWC (sum total considering all uses and their relative contribution) for each CWS watershed. This is done by using the watershed scale crop (*e.g.*, apples) or group of crops (*e.g.*, orchards) specific PCA values to adjust the EDWC values for each individual crop/group of crops EDWCs (*e.g.*, apples and cherries would both be adjusted with an orchard PCA). As an example, for a pesticide with two uses in a given CWS watershed with different EDWC and use specific PCA, each EDWC is adjusted by its unique PCA and then the two PCA adjusted EDWC are added together to yield a single aggregated EDWC. This mathematically defined using **Equation 3**.

**Equation 3** $$\boldsymbol{Aggregate\ EDWC_{(Pest\ X, Watershed\ Y)}} = \sum_{i=1}^{n} (\boldsymbol{EDWC_i * PCA_i})$$

Where:

| | |
|---|---|
| Aggregate EDWC $_{(\text{Pest X, Watershed y})}$ = | Aggregate EDWC for pesticide X within watershed Y |
| i = | Crop/group of crops with registered use pattern for pesticide X |
| n = | Number of crops/groups of crops with calculated PCA values grown in watershed Y |
| $EDWC_i$ = | Maximum modeled EDWC for crop or group of crops i |
| $PCA_i$ = | Percent Cropped Area for crop or group of crops i |

When calculating the aggregate EDWC using **Equation 3**, if multiple crops use the non-standard crop PCA value calculated using the procedure in **Section 4.3.1**, then only include the use pattern with the highest EDWC in the summation to prevent double counting the cropped area.

This method does not consider the differences in the timing of the maximum EDWC values for the different modeled use patterns (maxima are added even if they are not coincident in time). If the aggregated EDWC calculated with **Equation 3** exceeds the DWLOC, it is appropriate to account for the potential variation in the timing of exposure from each pesticide use in a given region (national or HUC2) by combining 30-year daily chemographs (plots that show the changes in pesticide concentrations with time) generated by PWC modeling to examine the temporal variability in the EDWC values. This aggregation of chemographs has been done in other highly refined DWA including the Organophosphate Cumulative Assessments[9]. **Figure 5** provides an example of a single chemograph, or time series, of daily EDWCs from a modeled use. Multiple time series which have been adjusted by their individual PCA would then be added together at each daily time step to create a single aggregated time series. Similar to how a time series is rank ordered by year to derive a 1-in-10 year EDWC (USEPA OPP, 2019b) the

[9] https://www.regulations.gov/document?D=EPA-HQ-OPP-2006-0618-000

aggregated time series can be post processed to yield an aggregated 1 in 10 year EDWC which is compared to the DWLOC.

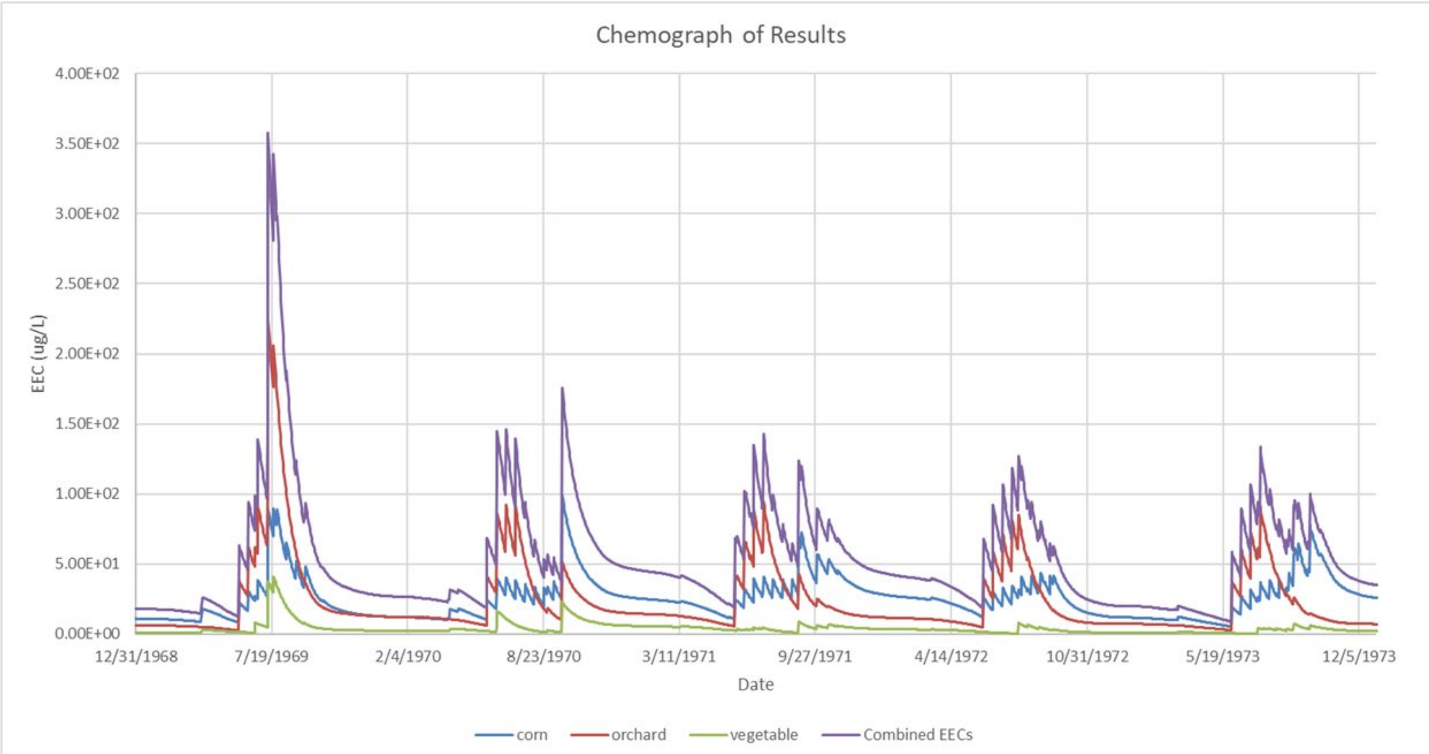



**Figure 5. Example of Combined Time Series Chemograph (5 year duration)**

The aggregated EDWC values are then ranked across watersheds nationally or within a HUC-2 region and compared to the DWLOC to determine what percentile of watersheds still exceed the DWLOC. If none of the aggregated EDWCs exceed the DWLOC, then no further refinements are necessary. If there are still watersheds where the EDWC are greater than the DWLOC, then the next step is to consider PCT refinements.

### 4.4. Summary

These new applications of existing PCA data utilize the full distribution of PCA values to calculate more granular, use pattern specific PCA values to better estimate potential pesticide exposure. The three new refinement options discussed here will allow OPP to move away from relying on the default all-agriculture PCA for chemicals with a wide range of use patterns. The first method uses the full set of PCA values to calculate use pattern specific PCA values tailored to the specific use patterns of a given pesticide. Second, the critical PCA overlap analysis helps identify if the pesticide is expected to be used in regions where PCA value is high enough to trigger risk concerns. Finally, the aggregate EDWC calculation using both peak and time series of EDWC provides a method to utilize the granular PCA information to calculate watershed-scale aggregate EDWCs to determine the number of watersheds within a region where the EDWCs are expected to be above and below the DWLOC. If there are still DWLOC exceedances after these refinements, then consider the application of the PCT refinements described in the subsequent section.

## 5. APPLICATION OF STATE LEVEL PCT REFINEMENTS TO DWA

### 5.1. Purpose

If any watersheds have EDWCs that are greater than the DWLOC after considering the full distribution of PCAs, OPP can further refine the EDWCs by considering the treated area in the watershed to better describe the exposure potential. This section describes a method for applying PCT refinements to DWAs.

### 5.2. Available Data and Integration into DWA

OPP can apply PCT refinements to EDWCs by calculating the sum of the Base Acres Treated (BAT) for all crops/group of crops within the state, distributing that sum of BAT to the individual watershed(s) where the EDWC>DWLOC (using the maximum/minimum/uniform methods described in **Section 3.3**), and then calculating the Treated Acreage Scaling Percentage (TASP), the ratio between the treated acreage and the total area of the watershed (**Equation 4**).

**Equation 4**

$$\text{TASP}_{(\text{watershed } \mathbf{X})} = \frac{\textbf{\textit{Base Acres Treated within X}}}{\textbf{\textit{Total area of X}}}$$

The TASP is specific to each watershed and is analogous to the PCA, but it incorporates both the percent cropped area (i.e. use pattern specific or non-standard) and the percent crop treated as a single multiplicative scaling factor that can be applied as a refinement to the aggregated modeled EDWC values derived as described in Section 4.3.3. The TASP-refined EDWC is equal to the modeled EDWC multiplied by the TASP.

Calculating the watershed-level BAT requires applicable state-level BAT(s) for the registered use patterns and the overlap between the potential treated area and the CWS watershed. In many cases a CWS watershed will reside wholly within a state and a single state level BAT (either for single uses or summed across multiple uses) may be all that is needed. However, some CWS watersheds will span multiple states and the watershed-level BAT across those states will be allocated to the individual CWS watershed fraction within each state using an allocation method similar to that employed for the ESA approach (ultimately the allocation can be an automated process). The aggregated PCT for all of the relevant use patterns of a pesticide is multiplied by the total cropped area for the registered use patterns. For instance, in an example with three uses (*e.g.*, apples, wheat and corn) with each having a unique number of acres treated and unique land cover derived PCA (orchard, wheat and corn), the assessor would add the acres treated across the three uses and divide by the summed acres across the three landcover types. The total BAT for the state is the sum of the individual BAT for each land cover class. The Biological and Economic Analysis Division (BEAD) derives these PCT values from state level usage data and records them in Summary Use and Usage Matrix (SUUM) reports. The usage data come from a variety of sources, including the U.S. Department of Agriculture's

National Agricultural Statistics Service (USDA NASS), Kynetec USA (i.e. private market survey data , and the California Department of Pesticide Regulation (DPR) Pesticide Use Reporting (PUR) program. These data are based on 5 years of usage data as compiled by BEAD to generate state- and national-level estimates of the maximum, minimum, and average PCT value for a given crop or set of crops. A description of the method for the PCT calculation (including surrogacy assumptions) and the underlying data sources can be found in **Appendix C** and **Appendix D**, respectively.

For each crop in the SUUM, OPP can calculate BAT by multiplying the reported PCT(s) by the reported crop area grown (CAG). For crops that are not surveyed, OPP will make assumptions about the PCT based on surrogate crop data (See **Appendix C**). OPP calculates the aggregated land cover class PCT for a given land cover class ($PCT_{tot_j}$) for each state as the sum of the base acres treated of all crops within the land cover class in the state (calculated from the individual crop PCTs in the SUUM) divided by the total CAG for all crops within the land cover class grown in the state (**Equation 5**).

$$PCT_{(totj)} = \frac{Base\ acres\ treated}{Cropped\ acres\ grown} = \frac{\sum_{i=1}^{n}(PCT_i * G_i)}{\sum_{i=1}^{n} G_i}$$

**Equation 5**

Where:

$PCT_{tot_j}$ = aggregated PCT (for land cover class j in state)
j = land cover class for registered use pattern (*e.g.*, wheat, vegetables)
i = crop (within land cover class j) that is surveyed in state
n = number of crops (within land cover class j) with acres grown in state
$PCT_i$ = percent crop treated of crop i (from extended SUUM)
$G_i$ = acres of crop i grown (in state) (from the Census of Agriculture)

The land cover classes represent potential use sites of a pesticide based on 18 classes that represent aggregated agricultural/turf uses originally developed from the 2006 NLCD, the 2007 NASS Ag Census, and the 2008 USEPA Turf Layer as part of EPA's PCA work in support of refined drinking water assessments (USEPA, 2014). These include 8 single crops/crop groups (*e.g.*, corn, orchards/vineyards, all-agriculture, residential turf), and 9 crop combinations (*e.g.,* corn-wheat, turf-soybeans, turf-all agriculture), in addition to a class for non-agricultural land. The complete list can be found in **Appendix C**.

The approach described above for calculating aggregate BAT, $PCT_{tot_j}$, and TASP in a state combines data that are at different spatial scales (land cover classes at 30-m pixel scale, Census of Agriculture at county scale, and usage (*i.e.*, $PCT_i$, at state scale)). Due to the differences in scale, the calculated $PCT_{tot_j}$ values are only reliable at the state-scale level.

### 5.3. Procedure

The following sections describe the general sequential process for applying watershed-scale $PCT_{tot_j}$ refinements:

1. Calculate the BAT for each land cover class within each state based on maximum, minimum, and average PCT and the number of crop acres grown for crops in each land cover class.
2. Allocate treated acreage to each CWS watershed.
3. Calculate the TASP (ratio of the treated area to the total watershed area) for each watershed/PCT (min, max, avg)/distribution method (upper, lower, uniform) combination (discussed below and in the documentation for the proposed ESA Methods).
4. Calculate TASP-adjusted EDWCs
5. Compare TASP-adjusted EDWCs to DWLOC.

These steps are described in the subsequent sections. Ultimately, the process will be automated.

**Step 1. Calculate the Base Acres Treated for each land cover class within each state based on maximum, minimum, and average PCT.**

Due to possible differences in the CAG reported in the SUUM report used to calculate the PCTs, and the CAG reported by the land cover class within each state, the usage data need to be scaled proportionally to the CAG in the land cover class. OPP performs this in a three step process: calculating the usage data BAT (Step 1a), converting that area to a state-level PCT value (Step 1b), and calculating the land cover class BAT from the usage data PCT value and area of the land cover class GIS layer (Step 1c). OPP calculates the BAT value for the maximum, minimum, and average PCT to generate three BAT values for each land cover class within the state. Each of these steps is described further below:

**Step 1a. Calculate the aggregated usage data Base Acres Treated for a land cover class within each state based on maximum, minimum, and average PCT.**

OPP calculates the usage data BAT by multiplying the state-level PCT by the CAG from the Census of Agriculture found in the SUUM report for each crop in the land cover class (**Equation 4**). For land cover classes with multiple crops, the land cover class BAT is then aggregated for the individual crop BATs for the crops within the land cover class.

**Step 1b. Calculate the land cover class aggregate PCTs from the usage data Base Acres Treated and the Crop Acres Grown.**

OPP then uses the usage data BAT to calculate the aggregated usage data state-level PCT for each individual land cover class, the aggregated BAT for the crops in the land cover class (*e.g.*, apples and wheat) is divided by the total CAG in the Census of Agriculture for those crops. OPP uses this aggregated usage data state-level PCT to calculate the BAT for each land cover class (*e.g.*, apples to orchards landcover class and wheat to wheat landcover class).

**Step 1c. Calculate the BAT for each land cover class in the pesticide use pattern.**

OPP calculates the BAT for each land cover class by multiplying the CAG for each relevant land cover class by state-level aggregate land cover class PCT calculated in Step 1b. This is the maximum treated acreage for each land cover class that can be allocated to a single watershed within the state.

For a given pesticide, there will be three treated acreage estimates of each land cover class, based on the maximum, minimum, and average PCT values. A detailed description of the methods to calculate the state-level treated acreage and the potential pesticide use sites in an individual drinking water watershed can be found in **Appendix C**.

**Step 2. Allocate treated acreage to each CWS watershed using upper, lower, and uniform distribution methods.**

To calculate the TASP for a watershed, it is necessary to calculate the number of treated acres within the watershed use area. The use area where treated acres can be distributed is equal to the overlap between the watershed and the relevant land cover classes for the pesticide. Since there cannot be more treated acres within a watershed than there are cropped acres, the size of the use area is capped at the PCA adjusted area of the watershed. For pesticides with application to non-cropped areas, the total non-cropped area is calculated using the non-agricultural PCA derived from the all-agriculture PCA (See **Section 4.3.1**)

While the total area of potential use sites in the watershed is known, the exact location of the treated area within the state is not known. Although the exact sub-state location of usage is unknown, because of the differences in scales, the usage of a pesticide can be limited to sub-state areas by considering the finer scaled layer representing potential use sites within CWS watersheds. To account for this unknown, OPP proposes several different methods for distributing the treated acres to an individual watershed, described below: upper, lower, and uniform distributions. These are bounding case assumptions designed to capture the uncertainty in the distribution of the treated acres across the state.

**Upper Distribution:** This approach assumes that all the treated acres for a given land cover class in a state can occur within a drinking water watershed boundary, up to the PCA adjusted acreage of the watershed including non-agricultural uses (**Figure 6**). Treated acres are only placed in counties within the drinking water watershed boundaries where there is at least 1 registered labeled use for the land cover class, as reported by the Census of Agriculture. If the number of treated acres in a state is greater than number of acres of land cover class(es) that overlap with the drinking water watershed boundaries, it is assumed that all acres within the drinking water watershed boundaries are treated. If the number of treated acres in the state is less than the total area for the potential use sites within a drinking water watershed, then it is assumed that all treated acres are located within the watershed.

**Uniform Distribution:** This approach assumes that the treated acres are distributed proportionally to the aggregate land cover class PCT throughout the state(s) containing the drinking water watersheds (**Figure 7**). The aggregated PCT is applied directly to the acres of the land cover classes occurring within the drinking water watershed boundaries to calculate the estimated treated acres. For uniform distribution, treated area = (acres within a drinking water watershed boundary that overlaps with the land cover class) X (aggregate state-level PCT).

**Lower Distribution:** This approach assumes that all the treated acres for a given land cover class occur outside the drinking water watershed boundary until there is no untreated area outside the watershed, at which point any remaining treated acres are allocated to the drinking water watershed (**Figure 8**). It is possible for the minimum distribution to allocate no treated acreage to the watershed.

The treated acreage calculated for the maximum, minimum, and average PCT in Step 1 are allocated to each watershed based on the three distribution methods to give nine separate values that are utilized in the subsequent steps to calculate the TASP scaling factor.

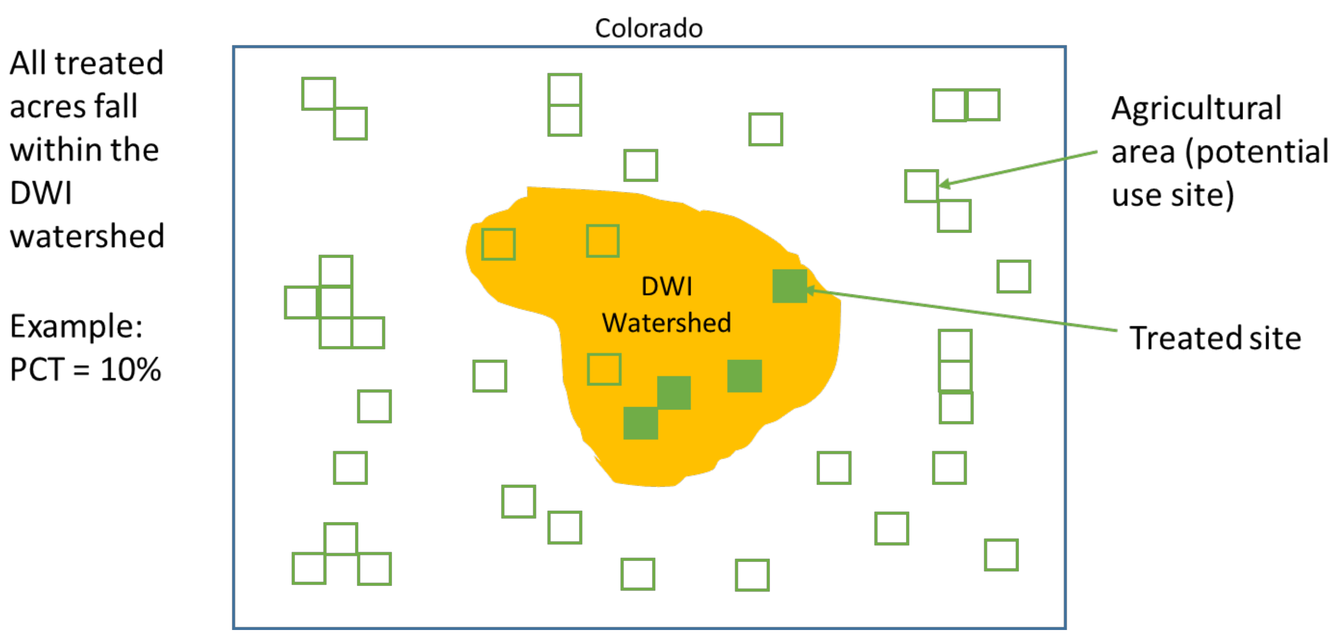



**Figure 6. Conceptual Illustration of the "upper" distribution method**

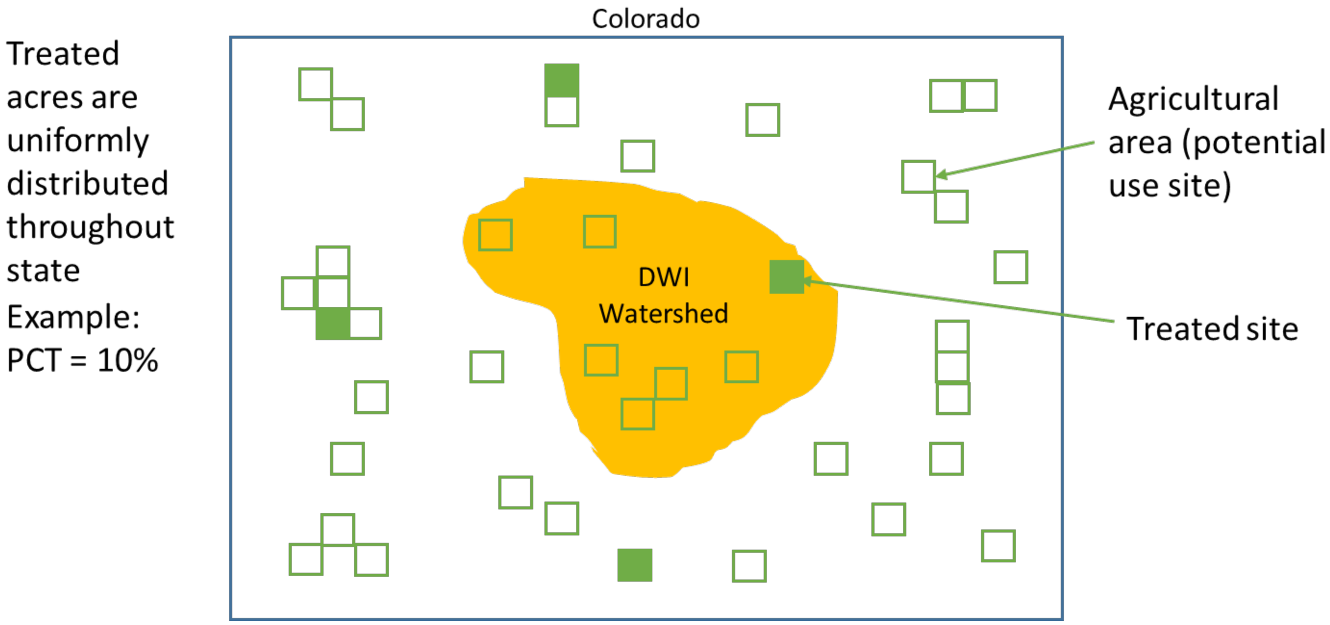



**Figure 7. Conceptual Illustration of the "uniform" distribution method**

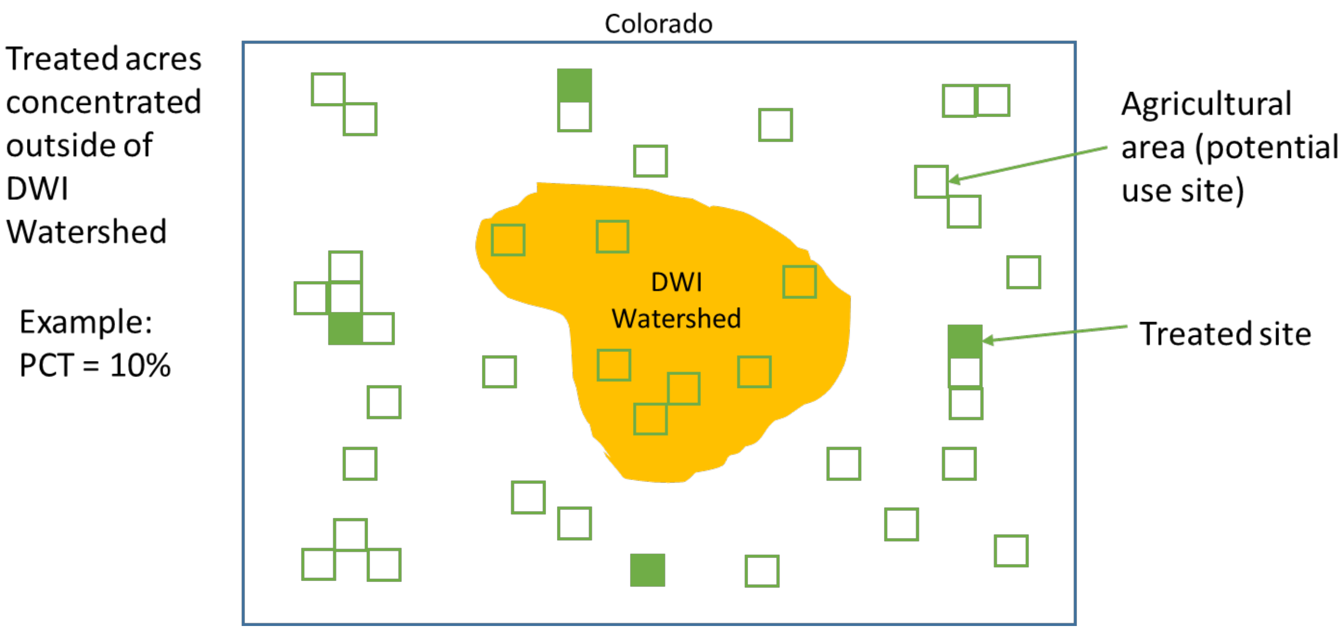



**Figure 8. Conceptual Illustration of the "lower" distribution method**

**Step 3. Calculate the Treated Area Scaling Percentage for each watershed for each watershed/PCT/distribution method combination.**

Once the treated area in a watershed has been allocated by the different distribution methods, OPP calculates the TASP value by dividing the treated area within the watershed by the total watershed area. OPP calculates a separate TASP for each combination of PCT (*i.e.*, minimum, maximum, and average) and distribution method (*i.e.*, upper, lower, uniform), for a total of nine separate TASP values. For watersheds where the treated acreage is equal to the PCA-adjusted watershed area, the TASP equals the PCA and the PCT refinement will not alter the EDWCs or the potential risk picture.

OPP calculates both an aggregate TASP and a land cover class specific TASP from the usage data. The aggregate TASP equals the total treated acreage for all land cover classes allocated to the watershed divided by the watershed area; the land cover specific TASP equals the treated acreage for a single land cover class divided by the watershed area. OPP uses the aggregate TASP for the initial PCT refinement for Tier 3 EDWC calculations, while the land cover specific TASP values further refines the EDWC by considering the contributions of the individual use patterns to the overall EDWC, as described in **Step 4**.

Allocating treated acreage to watersheds that span multiple states is handled differently since OPP calculates PCTs (and the resulting BAT values) on a state-by-state basis. The total treated acreage that is allocated to the multistate watershed is the total of the treated acreage for each separate state that overlaps with the watershed. The maximum acreage that can be allocated from each state is equal to the area of the watershed that overlaps with that state, and the maximum total treated acreage from all states is equal to the PCA adjusted area of the watershed. Since the extent of land cover class overlap is a property of the watershed and not specific to a pesticide, it can be calculated for all multi-state watersheds and incorporated into an automated PCT process.

**Step 4. Calculate TASP-adjusted EDWC**

Once OPP calculates the TASP values for a given watershed, it can directly apply the values to the individual use EDWCs. Like the application of watershed-scale PCA refinements, the TASP-adjusted EDWC = (watershed EDWC) x TASP. For the initial evaluation, OPP uses the maximum EDWC for all use patterns and the aggregate TASP to generate a conservative TASP-adjusted EDWC value. If that value exceeds the DWLOC, OPP can further refine the EDWC by calculating the aggregate EDWC as the sum of the individual TASP-adjusted EDWC values calculated from the specific crop scenario EDWCs and the associated land cover specific TASP value using a similar approach to calculating the aggregate PCA adjusted EDWC using **Equation 3**.

It is important to note that the TASP incorporates both PCA and PCT, so it should not be applied to the PCA-adjusted EDWC value. As previously stated, if the treated area within the watershed is equal to or greater than the PCA-adjusted area, then the TASP-adjusted EDWC will equal the PCA-adjusted EDWC.

**Step 5. Compare TASP-adjusted EDWCs to DWLOC**

The TASP-adjusted EDWCs can be directly compared to DWLOC to determine the percent of watersheds where there is still a potential risk. The TASP for a given watershed, and by extension the refined EDWC, will vary depending on the method used to calculate the BAT in Step 1 and to distribute the treated acres in Step 2 of the PCT method. With three different PCT values (max, min, average), and three different treated acreage distribution models (upper, lower, uniform), there are nine potential EDWC values for each watershed, each representing different degrees of conservativeness and assumptions regarding the use pattern and behavior of the chemical. This will be discussed in **Section 7**.

### 5.4. Conclusions

This new method utilizes state-level PCT data to refine watershed-scale EDWC values in high tier risk assessments (tier 3 and tier 4). It utilizes available state-level usage data to calculate the total treated acreage within a state and then allocates the treated acreage to the potential use sites within the individual watersheds using three different distributional models. The watershed-scale treated acreage is used to calculate the TASP, a multiplicative scaling factor that incorporates both the PCA and PCT, that is used to refine the EDWCs. A Case Study demonstrating the application of the PCA and PCT methods described above can be found in **Appendix B**.

## 6. METHOD EVALUATION

When fully employed and consistent with the DWA Framework (USEPA OPP, 2019b) modeled EDWCs refined using the approaches outlined above will be evaluated by considering available surface water monitoring data. USEPA OPP currently uses surface water monitoring data as a "ground truth" against modeled estimates. The goal of this comparison is not to consider the monitored values as the "true" exposure but to make sure that refinements do not provide estimates of exposure below values observed in relevant monitoring data. This comparison needs to account for the relevance, duration of exposure concern and uncertainty in both modeled and monitored values but is intended to ensure the final values used for the dietary assessment remain appropriate without underestimating expected exposures.

## 7. PROPOSED USE/DRINKING WATER ASSESSMENT IMPLICATIONS

OPP plans to incorporate the PCA and PCT refinements discussed in this paper to pesticides that present potential human health risks after incorporating refinements such as crop- and region-specific modeling scenarios, average pesticide use rates, and national- and regional-scale PCA adjustments.

As applicable, OPP plans to incorporate the distributional PCA method presented in this paper into Tier 3 analysis. The proposed approach to use the full suite of CWS PCA values builds on OPP's current surface water modeling approach. Unlike the existing approach which uses a maximum PCA either nationally or by HUC-2 watershed, the proposed approach will use the unique PCA values for all 4800+ CWS watersheds. The proposed approach will instead identify unique CWS watershed specific EDWCs which can be compared with the pesticide specific DWLOC. Using the step wise refinement process laid out above, successive refinements should be able to identify the percentage of CWS watersheds whose EDWC remain above the DWLOC.

Using the full set of PCA data to calculate use pattern specific PCA values for a given pesticide allows for more granular application of PCA data and can easily be applied to Tier 3 risk assessments for chemicals with multiple use patterns.

As stated in **Section 5**, there are 9 potential combinations of PCT and treated acreage distribution, which leads to up to 9 different sets of EDWC value. Selecting the most appropriate value will depend on the specific properties and use patterns of the pesticide. For example, the maximum PCT and "upper" distribution method are the most conservative options and generate the upper bound concentration estimates of the 9 options, and therefore can serve as a high-end screening tool. If a pesticide has a long-term (>1 year) exposure concern, then the average PCT may more accurately represent the pesticide use level over the relevant exposure window. If the usage data for the chemical indicates that it is applied to the majority of the crops within a given region, then the "uniform" treated acreage distribution may be more appropriate than the "upper" distribution. The OPP chemical team must examine the available data and determine which set of parameters most accurately represents the use pattern for a given chemical.

When interpreting application of PCT using the methods describe above consideration must be given to the strengths, weaknesses and uncertainty associated with the available usage data and methods to distribute state and national level usage data to watersheds within a state. Similarly, for watersheds that span multiple states PCT data will be allocated from multiple states to the watershed.

When considering the results of the options for PCT (state level maximum, average, and minimum of 5 years of data) and distribution methods (upper, uniform, and lower) the strength and weakness of each option within the matrix of options must be weighed. This WoE concept can point to the most likely, or reasonable outcome from the analysis.

For example, in cases where the 5 years of PCT data yield consistent estimates across all usage statistics (*i.e.*, average, maximum, and minimum) adds confidence to the outcome when considering all potential outcomes in the WoE approach. Conversely, in cases where there are wide differences between the minimum, average and maximum PCT consideration of other lines of evidence (*e.g.*, longer term trends in usage) can provide further confidence in which PCT value provides the strongest line of evidence. With distribution methods, the upper distribution method provides the most conservative approach but the assumption that all treated acres will be present in every watershed in a state is not likely. Similarly, the lower distribution method where all treated acres are outside the watershed with overlap limited to treated acres in excess of the area outside of the watershed is equally unlikely. The uniform distribution method may provide a more reasonable assumption compared with the upper and lower methods but leaves open the possibility of underestimation when pest pressure drives usage into site specific regions within a state or watershed.

Ultimately, the decision whether a specific set of CWS watersheds remain above the DWLOC after consideration of the full distribution of PCA and the matrix of options for considering PCT will have to weigh the strengths, weaknesses, and uncertainty associated with the underlying data sets.

Including PCT data onto the PCA approach allows for more realistic application of usage data which defines where the pesticide is actually being applied as opposed to where it could be applied based on landcover data. Utilizing the approach developed for ESA assessments for PCT represents a new high-end Tier 3 analysis for refining drinking water assessments and moving from the theoretical to the actual. While significantly more resource-intensive than the full distribution PCA analysis, it represents a new tool for refining high tier risk assessments. Ultimately, application of the proposed PCA/PCT should allow for more realistic DWA, is more fully consistent with the approaches described in the DWA Framework, and provides opportunity to focus options for Tier 4 evaluations on specific areas.

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**Appendix** A**. Drinking Water Assessment Tiering Framework**

The *Framework for Conducting Pesticide Drinking Water Assessments for Surface Water* documents the standard tiered assessment approach for estimating pesticide concentrations in surface water sources of drinking water. In summary, EPA utilizes a four-tiered DWA approach to conserve resources by only using time-intensive, refined risk assessment methods requiring more complex data input for pesticides failing [*i.e.*, the estimated concentration of pesticide in the source water exceeds the DWLOC] at lower tiers (**Figure** A.1). Most DWAs completed by EPA are categorized as Tier 1 or Tier 2 assessments; a few DWAs have required a Tier 3 or Tier 4 level assessment.

As part of the tiered approach for conducting pesticide DWAs, EPA utilizes aquatic model estimates and measured pesticide concentrations from surface water monitoring programs when data are available. The temporal and spatial variability of pesticide concentrations in surface water is typically not well characterized by periodic discrete samples, which represent snapshots of pesticide occurrence in specific locations. Short-term peaks in pesticide concentrations in surface water can occur because of seasonal or event-driven pesticide applications (*e.g.*, infestation or public-health hazard) and streamflow conditions (Liess *et al.*, 1999; Rabiet *et al.*, 2010). Most monitoring data are collected on a non-daily basis and the number of sites is often limited. As a result, EPA often uses pesticide concentrations estimated from aquatic models as quantitative inputs to the human health dietary exposure model rather than monitoring data because of the uncertainty that available monitoring programs capture potentially high concentrations of pesticides that may have occurred on non-sampling days, or in areas that were not sampled.

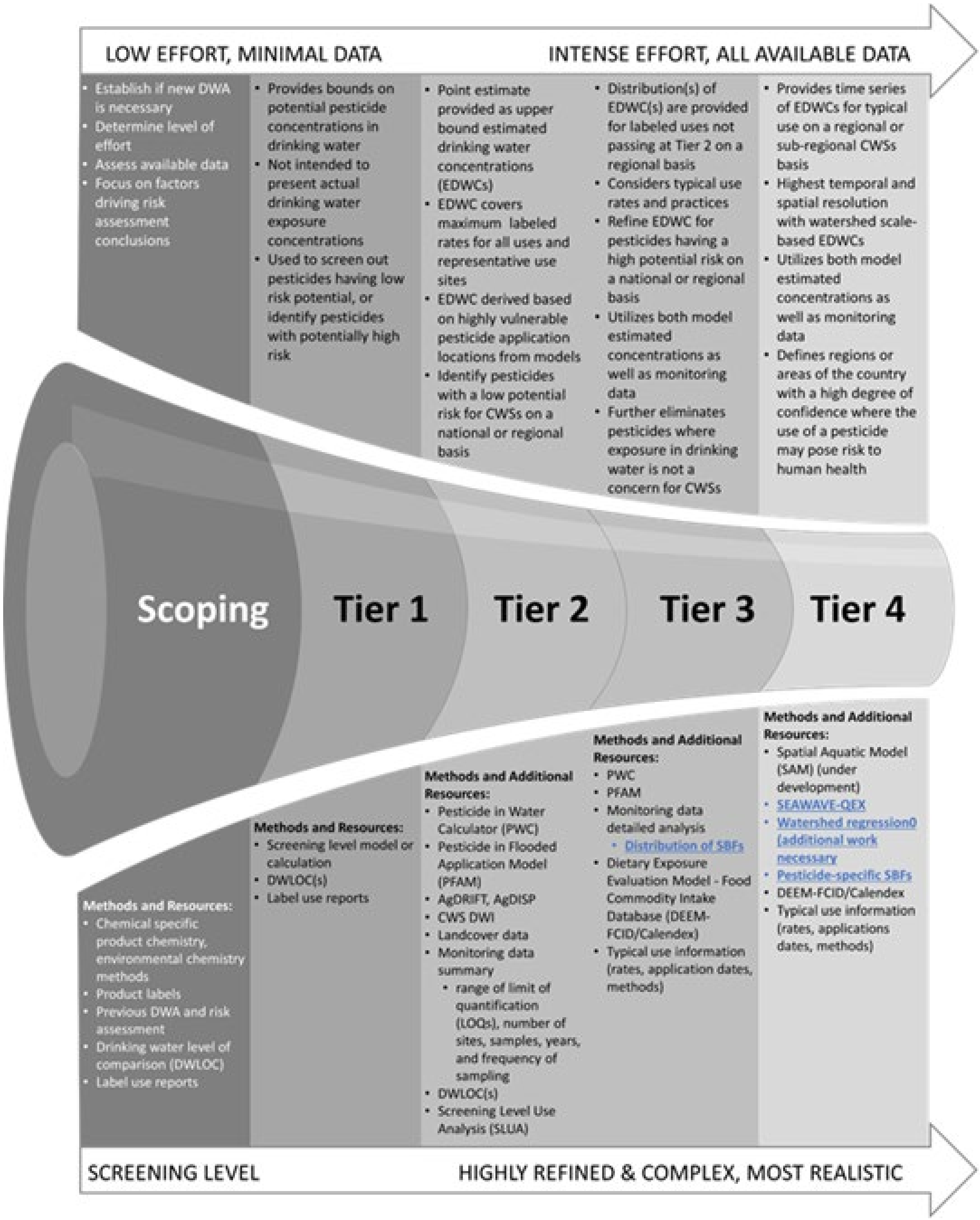


**Figure A.1 Tiered Drinking Water Assessment Framework [from the Framework for Conducting Pesticide Drinking Water Assessments for Surface Water**

In a DWA, EPA estimates pesticide concentrations in surface water sources resulting from the labeled uses, which may include a single use site (*e.g.*, corn) or multiple use sites (*e.g.*, corn, cotton, and turf). While the aquatic model inputs such as soil and weather may be localized (*e.g.*, limited to field, county, or statewide analyses), the resulting estimated concentrations are typically used to cover, or be protective of, a larger geographical scale (regional or national), encompassing a wider range of environmental conditions, use patterns, and agricultural practices and thus a wider range of potential pesticide concentrations.

To complete the work for DWAs, EPA reviews pesticide specific environmental fate and transport data to derive environmental persistence (*i.e.*, half-lives) and mobility inputs used in aquatic models. These data are considered along with the physical-chemical properties (*e.g.*, vapor pressure and solubility) of the pesticide to complete aquatic modeling. EPA also evaluates existing water monitoring data for the pesticide if available. However, rarely are monitoring data quantitatively used to estimate pesticide concentrations in drinking water. Stakeholders have expressed concern with over-reliance on models and underutilization of monitoring data.

**Appendix B. Case Study**

See Attached file.

**Appendix C. Determination of Overlap of Treated Area and Drinking Water Watersheds Located in the 48 Conterminous States**

The extent of overlap of any pesticide's potentially treated area and a given drinking water watershed integrates information on potential use sites and usage data. To address uncertainties associated with how treated acres may be distributed within a state (relative to a drinking water watershed), and the magnitude of usage on any given year, approaches are employed to represent upper, uniform, and lower estimates of potential overlap. These different estimates are considered in a weight of evidence when deciding whether use of a pesticide is likely or not likely to exceed a DWLOC in any given group of drinking water watershed. This summary describes the approach for determining the extent of overlap between drinking water watershed and treated acres.

**Potential Use Sites**

The land cover classes representing potential use sites in the 48 conterminous states and District of Columbia (CONUS) are represented by selected crops (*e.g.*, corn), groups of crops (*e.g.*, vegetable, orchards), turf, and general non-agricultural land. Potential use sites of a pesticide are represented by 18 land cover classes that represent aggregated uses originally represented as part of EPA's PCA work in support of refined drinking water assessments (USEPA, 2014). The CWS PCAs were primarily developed to better understand pesticide exposure in drinking water resulting from agricultural uses. In terms of non-agricultural uses, PCAs were developed for residential and golf course turf.

Although PCAs for other non-ag uses are not currently available in USEPA 2014, it is possible to estimate the maximum extent of these use sites using the agricultural and turf PCAs. The upper limit of the potential non-agricultural/non-turf PCA consists of all areas not used for agriculture or turf, *i.e.*, Non-Agricultural PCA = 100% - (all ag-turf PCA). This would capture all potential use sites not covered by other PCA values and provide a conservative estimate of the non-agricultural use area. This method would likely overestimate the non-agricultural PCA since it does not distinguish between different non-agricultural use sites (*e.g.*, rights-of-way, residential, commercial) and therefore would lead to upper end EDWC estimates that are appropriate for human health risk assessment.

The current DWA land cover classes are presented below.
Corn
Cotton
Orchard/Vineyards
Soybean
Vegetable
Wheat
All-agriculture
Residential Turf

Corn-Wheat
Soybean-Wheat
Turf-Corn
Turf-Orchard
Turf-Soybean
Turf-Vegetable
Turf-Wheat
Vegetable-Orchard
Turf-All Agriculture
Non-agricultural lands

**Applying Usage Data to the PCA Land Cover Classes**

The goal of this approach is to determine the area within each state that is treated one or more times with a given pesticide (referred to as "Base Acres Treated" or BAT). This is accomplished by combining data representing the potential use sites, including all land cover classes and acres grown from the 2006 National Land Cover Dataset, the 2007 National Agricultural Statistics Service Agricultural Census, and the 2008 USEPA Turf Layer and available usage data.[10]

For agricultural uses (and some non-agricultural uses) of a pesticide, usage data are available to quantify the PCT. This can then be used to adjust the extent of the potential use area overlapping with a drinking water watershed's boundaries to represent the potential extent of overlap that is directly treated with a pesticide. PCT data are available for specific crops and states. A pesticide's usage data are summarized in the Science Information and Analysis Branch (SIAB) Use and Usage Matrix (SUUM) which is provided to the chemical team by BEAD. The pesticide's SUUM reports PCT data based on usage that occurred for a given 5-year range. Three statistics for PCT are reported for each state and crop combination (where states and crops are surveyed): average, minimum and maximum annual. The method discussed below is applied separately to the average, minimum and maximum annual PCT data in order to quantify the overlap of drinking water watershed boundaries and exposure areas, while accounting for variability in usage over time.

Usage data are applied to the 18 land cover classes discussed above. For categories represented by a single crop in both the SUUMs and land cover classes (*i.e.,* corn, cotton, soybean and wheat), the available PCT data for a given state are applied directly to the acres of the land cover class in that state to calculate the acres treated (acres treated = acres grown x PCT). If the PCT is not available for a specific state/crop combination, a surrogate PCT is applied using the process described in the next section.

[10] Full details available at https://www.epa.gov/sites/production/files/2015-07/documents/development_and_use_of_community_water_system.pdf

For those categories representing multiple crops in either the SUUMs or land cover classes (*e.g.,* corn and wheat), an aggregated PCT is calculated. In order to calculate the aggregated PCT, the acres grown and PCT for each crop in the category is needed by state. Both pieces of information are found in the SUUM for each state/crop combination with reported usage. Acreage in the SUUM can come from a variety of sources, including, but not limited to, agricultural market research data, USDA's National Agricultural Statistics Service (NASS), California's Pesticide Use Reporting (PUR). If the state/crop combination does not have reported usage, the information in the SUUM is supplemented with data from the 2012[11] Census of Agriculture (USDA-NASS, 2012). The Census of Agriculture is also used to account for crop group categories in the land cover classes that are not registered (*e.g.*, vegetables, orchards). In this situation, information is not provided for these crops in the SUUM, but the crops would be included in the land cover class. This process results in three scenarios:

The land cover class crop/state combination is found in the SUUM, and the acres grown and crop specific PCT from the SUUM are used directly. The land cover class crop is registered and the crop/state combination is surveyed by one or more usage sources, but no state specific usage information reported in the SUUM. In this scenario usage is assumed to be de minimus. Thus, the acres grown for the state are extracted from the SUUM and the acres grown for the state are extracted from Census of Agriculture and a PCT of 0 is used in the calculation of the aggregated PCT. The land cover class crop is registered and the crop/state combination is not surveyed by any applicable usage sources, thus there is no state specific usage information reported in the SUUM. In this scenario the acres grown for the state are extracted from the Census of Agriculture and a surrogate for the crop specific PCT is assigned using the method described in the next section. The crop is not a registered use. In this scenario, the acres grown for the state are extracted from Census of Agriculture and a PCT of 0 is used in the calculation of the aggregated PCT. This is done to account for crops found in the land cover class that are not registered.

At the end of this process all state/crop combinations found in the Census of Agriculture are accounted for, with acres grown and a crop specific PCT as described in **Section 5.2**. For state/crops combinations with usage data, the acres grown are extracted from the SUUM; for state/crops combination without usage the acres grown are extracted from the Census of Agriculture.

Acres treated for land cover classes with multiple crops are calculated by multiplying this aggregated PCT by the area of the land cover class for the state. The total area of the land cover class for the state only includes those counties with at least 1 registered use as reported in the Census of Agriculture. The land cover classes often include multiple crops, and some of the crops included may not be registered. The Census of Agriculture is used to identify counties where all crops for a land cover class are reported as not grown. These counties are excluded from the totals prior to calculating the treated acres.

**Applying Surrogate Usage Data**

Some uses are not surveyed for usage at all and some uses are only surveyed for usage in some states. For crops that are included in aggregated land cover classes, but for which no survey usage data exists, usage data from the same state for other crops in the land cover class will be used as surrogates. If no data for crops within a PCA are available in a state, surrogate PCT will be applied using data available for the same crop or land cover class but a different state. If a land cover class has no usage data for any state, the highest available PCT from all state-crop combinations will be used. The decision tree below (**Figure 1**) outlines the approach for determining which data will be used as surrogates.

The surrogacy approach is designed to use the best available data to identify the likely extent of treated area when usage data are not available for a given crop. Surrogate data are ideally assigned using crops within the same land cover class and then using data from the same crop but different spatial location. If the first two options are not possible, then a conservative approach is employed where the greatest extent of usage on any crop-state combination is used as the surrogate. Use of surrogate data represents an uncertainty. In cases where a drinking water watershed has potential risk concerns, a weight of evidence analysis will be conducted prior to deciding that EDWC in a watershed is likely below the DWLOC. In this weight of evidence analysis, the impact of the surrogacy assumptions on the overlap analysis will be considered. This will be done by quantifying the extent of overlap when all crops with no PCT data are assumed to have no treated acres (*i.e.,* PCT is assumed to be 0). For state/crop combination where a surrogate PCT was applied, the surrogate will also be assumed to be 0, an aggregate PCT will be re-calculated for this assumption, and the overlap adjusted for comparison. The weight of evidence will consider the difference in the extent of overlap of the two approaches in order to consider whether the surrogacy assumptions impact the likelihood that an individual of a listed drinking water watershed will be exposed.

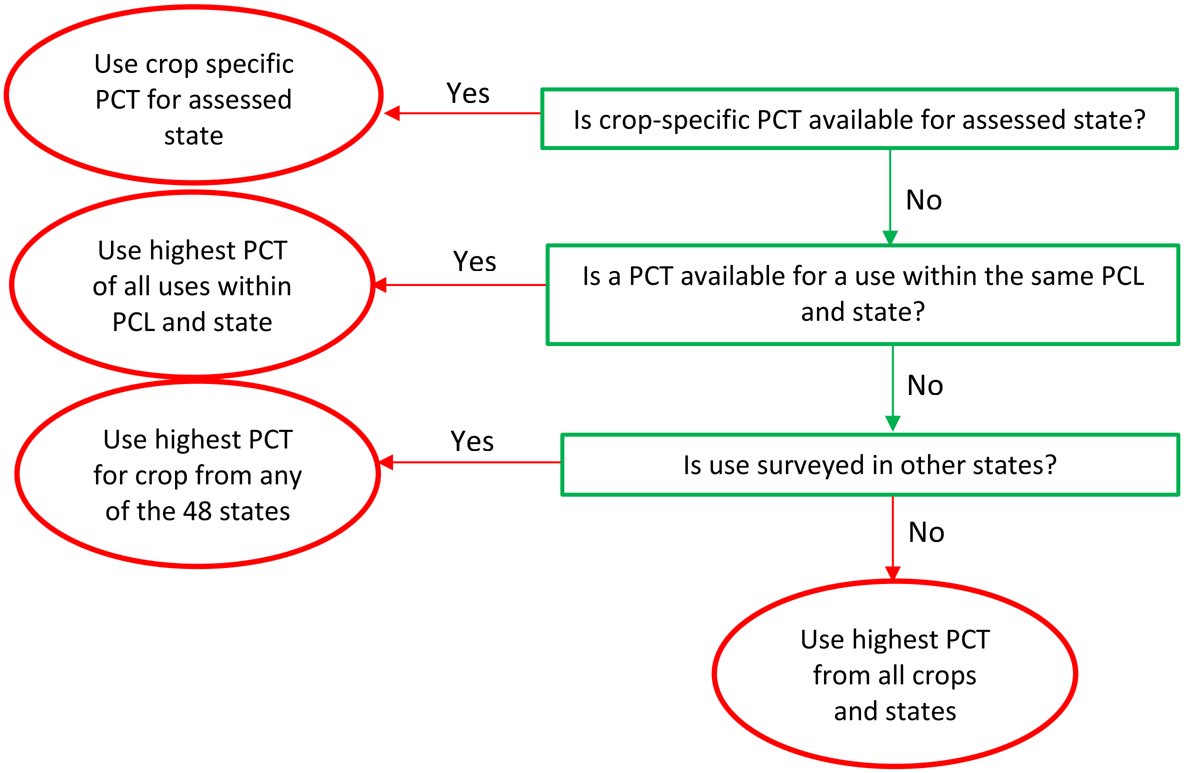


**Figure 1. Decision framework for applying surrogate usage data.**

**Calculation of Extent of Overlap of Drinking Water Watershed and Treated Acres**

Once the total treated area in the state has been calculated, the treated acreage can be distributed to the individual watershed based on the upper, lower, and uniform distribution approaches described in **Section 5** to determine the treated acreage within a given watershed.

**Appendix D. Usage Data Sources**

The usage data utilized to calculate the state-level PCT values come from the following public and proprietary sources.

Kynetec USA, Inc. 2019. "The AgroTrak® Study from Kynetec USA, Inc." Database Subset: 1998-2018 – proprietary pesticide usage data from 1998 to 2018 for historical use trend and 2013 to 2017 for current usage estimates. These data are collected and sold by a private market research firm. The data are collected by annual surveys of agricultural users in the continental United States and provides pesticide usage data for about 60 crops, including both specialty and row crops. The survey design targets at least 80 percent of US acreage/production of the surveyed commodities. Survey methodology provides statistically valid results, typically at the state-level.

United States Department of Agriculture's National Agricultural Statistics Service (NASS) – publicly available pesticide usage data from 2013 to 2017. NASS data are based on surveys that focus on the top-producing states that together account for the majority of U.S. acres or production of the surveyed commodity. NASS survey design targets a minimum of 80 percent of the acreage/production for every fruit, vegetable, and field crop surveyed. Operation level data are combined during summary and, pending compliance with disclosure rules, published at the state and national levels. NASS does not collect data annually for each crop, but surveys for various commodities on a rotating schedule.

California Department of Pesticide Regulation (CADPR) Pesticide Use Reporting (PUR) – publicly available pesticide usage data for 2012 to 2016. The PUR database contains detailed records and summaries of agricultural applications of pesticides on crops based on application permits. All agricultural growers must submit their production agricultural pesticide use reports monthly and pest control businesses must submit pesticide use reports within 7 days after application. As such, CADPR data is a census of all usage rather than a survey. The Pesticide Use Summary reports are published annually.

California Agricultural Statistics Review (CASR) – publicly available California crop production data for 2012-2016. CASR data are used as the primary source for CAG data when calculating PCT estimates for California crops and based on acres planted.

California County Agricultural Commissioners' Report (CCACR) – publicly available California crop production data for 2012-2016. CCACR data are used as a secondary source to calculate California crop PCT estimates in instances where CASR data are not available. PCT estimates using CCACR data are based on acres harvested.

Non-Agricultural Market Research Data (NMRD) – proprietary data source that provides market research data for agrochemicals/specialty pesticides for various market sectors, including professional turf and ornamental plants, professional pest control, consumer pesticides, and vegetation management. Market reports reflect usage by class/market segment and chemical and are based on sales information (manufacturer and retail) and end-user surveys. Study dates vary by market sector.