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SUBJECT: ADVANCED PROCESSESSING OF PESTICIDE USE REPORTS FOR DATA ANALYSIS CONDUCTED BY THE ENVIRONMENTAL MONITORING BRANCH'S AIR PROGRAM

The California Department of Pesticide Regulation (DPR) has implemented statewide reporting of all agricultural pesticide use since 1990 (DPR, 2000; DPR, 2017c). Certain non-agricultural uses of pesticides are also subject to pesticide use reporting requirements (*Title 3, California Code of Regulations [3 C.C.R.] § 6624-6628*). The California Agricultural Commissioner (CAC) in each county is responsible for the collection of pesticide use reporting (PUR) documentation (DPR, 2017c). These PUR records are compiled and maintained by DPR in a PUR database (DPR, 2017c), which is recognized as the most comprehensive database of pesticide use in the world (DPR, 2000; DPR, 2017c; Wilhoit, 2016).

Although various data validation processes are used to verify records in the PUR database, errors may still exist (Wilhoit, 2016). This memorandum outlines the quality control procedures that the Environmental Monitoring Branch's Air Program staff utilize when working with PUR data, including the evaluation of PUR data for potential errors, the consideration of the spatial, temporal, and other limitations of the available data, and the removal of records containing obvious errors prior to data analysis.

BACKGROUND

PUR Data Requirements

All agricultural pesticide use in California must be reported to DPR, with the primary exceptions of home-and-garden use and most industrial or institutional uses (DPR, 2017c). Reporting requirements for pesticide applications largely depend upon whether the application is considered agricultural or non-agricultural under state regulations (*3 C.C.R. § 6000;* DPR, 2014a; *F.A.C. § 11408*).

California has a broad definition of agricultural pesticide use that differs from the federal definition, and state regulations further define agriculture as "production agriculture" or "non-production agriculture" (DPR, 2014a). These distinctions influence reporting requirements and, consequently, the information available in the PUR database (DPR, 2014a; *3 C.C.R. 6624-6627*). For example, production agriculture PUR records report the date and time of each application, and the application location is reported using the Public Land Survey System (PLSS) to identify the specific one square mile (mi^2) section (DPR, 2017c). However, non-production agriculture and non-agriculture PUR records report monthly summaries of applications, and identify locations only by the county in which the applications occurred (DPR, 2017c; *3 C.C.R. 6624*).

Specific PUR requirements for production agriculture, non-production agriculture, and non-agriculture are summarized in the Appendix, Table 1. Special requirements for restricted material pesticide uses or pesticide uses at school or day care facilities are also included.

To remove as many errors as possible, the PUR data undergo a variety of quality control procedures, which are described below.

PUR Data Quality

Records contained in the PUR database are evaluated for errors in 50 different validation processes in CalAgPermits software and by DPR (DPR, 2017c); however, some errors may still occur. For example, CalAgPermits automatically verifies that the reported commodity treated is listed on the product label and that the grower has a restricted materials permit for any reported use of a restricted use pesticide, but the amount of acres treated or application rate is not compared to product label restrictions (DPR, 2017c). If DPR finds PUR records to contain potential errors, they may be returned to the applicable CAC for verification or correction (DPR, 2017c).

Statistical methods are used to improve the accuracy of reports uploaded to the PUR database by identifying PUR outliers as potential errors (DPR, 2017c; Wilhoit *et al.*, 2001; Wilhoit, 2016). Of the average 2.6 million annual PUR records submitted since 1990, the frequency of potential errors was estimated to be less than 5% from 1990-1997 and less than 0.5% from 2000-2014 (Wilhoit *et al.*, 2001; Wilhoit, 2016). Of these identified records, only the most extreme outliers are submitted to the CACs for further investigation (Wilhoit, 2016). However, information on all identified potential errors ("error flags") associated with individual PUR records may be queried from the PUR database[1] (Wilhoit, 2016).

[1] For example, the PUR database tables "OUTLIERS", "ERRORS", and "ERROR_DESCRIPTIONS" contain fields identifying PUR records with potential error flags.

PUR Data Utility and Limitations

DPR staff can query PUR records from the PUR database using the relational database management system Oracle™, structured query language (SQL), and query and scripting tools, such as SAS™ or Golden6™ from Benthic Software™.

PUR records are also publicly available using the California Pesticide Information Portal (CalPIP) on the DPR website (DPR, 2017a). However, the PUR database may contain more current information than is publicly available; CalPIP is updated up to and including data compiled in the most recent statewide annual PUR report (DPR, 2017b).

AIR PROGRAM QUALITY CONTROL PROCEDURES

Some PUR data errors may not be identified in the various data validation processes performed by the CACs or DPR (Wilhoit, 2016). For example, depending on the reporting county, PUR data entry is completed by hand or by electronic submission (Willhoit, 2016). Various issues with transposing records have been identified by PUR stakeholders, including illegible PUR forms (Willhoit et al., 2001). Other common issues include poor data entry design, such as the use of unit codes instead of unit names (e.g., acre, square feet, etc.), which may increase the frequency of incorrect entries (Willhoit et al., 2001). Due to the large size of the PUR database, and to the vast number of individual PUR records that are entered on a yearly basis (>2 million/year), the occurrence of these types of errors is unsurprising and as such, Air Program staff conducts the following additional quality control activities prior to any data analysis that includes PUR data.

Querying the PUR Database

Air program staff access PUR records using querying and scripting tools. In order to access all available PUR records, the use of outer joins instead of inner joins is considered when tables are joined in SQL code.[2]

Application Rate Information

In order to analyze PUR data for an active ingredient (AI) of interest, Air Program staff first evaluate queried PUR records for any missing information (*e.g.*, units corresponding to the application area). If the pounds of product reported per application area do not agree with the product label, the possibility of incorrectly reported units is considered. In order to obtain an application rate (*i.e.,* applied pounds of AI per acre), the application amount reported for each production-agriculture PUR record (in pounds of AI applied) is divided by the reported number of acres treated (Craig and Budahn, 2016). Air Program staff then compare the application rates to maximum application rates obtained from AI-specific regulations, or from product labels available from the Registration Resource Center, or online. Records with a calculated

[2] This consideration is important for records that may not have an entered value in the selected field (*i.e.*, FUME_CD, SITE_NAME, etc.). Use of a full outer join will return all records regardless of whether join conditions are met for PUR database fields selected from joined tables.

application rate ≥ 110% of the highest permitted application rate for the AI of interest (including quarantine and crop-specific rates) are further investigated for potential errors (Brown, 2015, 2016; Budahn, 2016; Collins, 2016; Craig and Budahn, 2016; King, 2016). When possible, the respective CAC may be contacted to verify reported PUR data containing potential errors. Depending on the error and after consultation with the Air Program Supervisor, these records may be removed from analysis or replaced with records containing corrected information.

Temporal Information

Aggregated reports sometimes occur within the PUR database due to the consolidation of several consecutive daily fumigations (commonly known as "rolling applications") into one submitted PUR record (Beauvais *et al*., 2010). Therefore, temporal errors resulting from aggregated production-agriculture PUR records can bypass the CalAgPermits and DPR's normal validation processes. When found, the Air Program staff correct these temporal errors during quality control procedures performed prior to utilizing the PUR records for further analysis (Brown, 2015; Brown, 2016).

To address any potential temporal PUR errors, Air Program staff use a 10% exceedance threshold to identify potential aggregated PUR records. For example, for products that contain methyl bromide as an AI, DPR regulations limit the total acreage for a single fumigation block to a maximum of 40 acres in any 24-hour period (*3 C.C.R. 6447[d]*). Therefore, Air Program staff set a 44-acre threshold (110% of the maximum allowed) to identify potential rolling application reporting for methyl bromide field fumigation PUR records. Reported daily application areas exceeding 44 acres may be separated into consecutive daily applications by allotting a proportional amount of applied methyl bromide to the allowable daily application area: up to 40 acres each day, with any remaining acres treated allocated to the final day (Brown, 2015; Brown, 2016). In cases where potential aggregate records are identified, the application date reported in the PUR database is considered by Air program staff to be the first day of application (Brown, 2015).

Potential temporal errors, such as incorrect application date, are more difficult to assess than other types of errors and careful consideration should be given to the possibility of errors in PUR data and their impact on data analysis efforts and policy planning (Wilhoit *et al.*, 2001).

Spatial Information

Using ESRI™ ArcGIS™ software including ArcMap™, Air Program staff can join records from the PUR database to spatial data, such as PLSS sections or townships to display the information spatially as a map of pesticide use within a certain area over a specified period of time. Since 1998, DPR and CAC staff have collaborated to encourage and develop the use of geographic information systems (GIS) to improve activities including pesticide use trend analysis, monitoring, decision making, and implementation of the statewide permitting program, CalAgPermits (Neal, 2002). CalAgPermits includes a site boundary layer that can be linked to

PUR data using the reported operator ID and the site location ID to identify the associated field boundary from data maintained by the applicable CAC.

ArcGIS™ software is used by Air Program staff to analyze pesticide use within a certain distance of a place of interest, such as Air Monitoring Network (AMN) sampling sites or community boundaries. Using ArcMap™, a linear distance from the point of interest is specified, and the resulting shapefile is used to select overlapping areas from a spatial map layer displaying pesticide use.[3] The resulting map layer is exported as a shapefile to a geodatabase prior to further analysis.

Statewide PLSS sections are not currently available from the United States Geological Survey or the Bureau of Land Management due to large areas of land originally excluded from section surveys because of their designation as land grant areas or inaccessibility for survey. These gaps (~19% of the state) facilitated the need for DPR to develop statewide PLSS sections for the purpose of pesticide use reporting. The spatial data was modified from an original data source maintained by the Teale Data Center, and is available for download from the DPR website, by county (Neal, 2003; DPR, 2013). It is important to note that the size of individual sections and townships may deviate substantially from the standard size (sections: 1mi^2; townships: 36mi^2), which may necessitate the evaluation of pesticide use density by dividing the application amount by the application area (*e.g.*, pounds of AI per acre).

Application Method Information

Application method may potentially influence pesticide air concentrations, and is reported in the PUR database in several ways. The Air/Ground Application Flag (AER_GND_IND field) is used to indicate whether an application was aerial, ground-based, or by other methods (DPR, 2002). The APPLMETH_CD field can be used to obtain further information about the type of application method (*i.e.*, spray, chemigation, fumigation, etc.). The FUME_CD field is used to identify the fumigation code for fumigations that are subject to application method reporting requirements, which are in effect for applications of certain fumigants within ozone non-attainment areas (NAAs) from May 1st to October 31st (DPR, 2014b). Reported fumigation codes are compared to the allowable application methods within each respective NAA during the ozone season to identify potential errors.

Application methods may influence levels of potential atmospheric emissions from fumigations. For example, application factors (AF) have been developed for 1,3-dichloropropene (1,3-D), which are based upon the application method (*i.e.*, tarp type, application depth) and environmental conditions (*i.e.*, month and location of the application), which influence the potential emission rate of 1,3-D into the environment (Brown, 2016; DPR, 2014c). If application

[3] The point or area of interest is first verified in ArcMap™ to be displayed in the projected coordinate system, "NAD 1983 California (Teale) Albers (Meters)," which is recommended for use in the state of California (California Department of Fish and Wildlife [CDFW], 2015). The linear distance is calculated using the "Buffer" geoprocessing tool with the "planar" option, which creates Euclidean buffers (geodesic buffers will be created by default if the map layer is in a geographic coordinate system).

method reporting is high in compliance, adjustment of the applied pounds of AI may be conducted using the fumigation code and the corresponding AF to more accurately represent the amount of 1,3-D applied that may be emitted into the atmosphere (Brown, 2016). However, use of AFs where application method was not reported may require the default assignment of the most common application method (Brown, 2016). This substitution should not be used where the application method reporting rate is relatively low, in order to avoid bias introduced by application method assumptions (Craig and Budahn, 2016).

SUMMARY

PUR records are evaluated by Air Program staff for potential errors which may not have been previously identified in routine processes by CalAgPermits, by the CACs, or by DPR. First, Air Program staff identify PUR records containing missing information and obvious errors. Product labels are then used to identify submitted records that report an application rate greater than the maximum application rate permitted by the product label. Application area restrictions are also used to identify and correct potential aggregated fumigation PUR records. If necessary, the applicable CAC is contacted to verify PUR records with potential errors.

DPR's PUR database is an extensive and valuable resource that is utilized by the Air Program with other important data in order to estimate pesticide exposures, understand pesticide environmental fate, and answer complex questions on the use trends and environmental impacts of pesticides.

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Appendix

Table 1. Requirements for pesticide applications subject to Pesticide Use Reporting, designated as production-agricultural, non-production agricultural, non-agricultural, use of a restricted use material or use at a school or day care facility as defined in Education Code section 17609(e)[1].

Requirement / Type of Pesticide Use	Production Agricultural	Non-production Agricultural	Non-Agricultural[2]	Restricted Use Material	Applications at Schools and Day Cares
Month and year of application(s)	✓	✓	✓	✓	✓
Date and Time of Each Application	✓				✓
County	✓	✓	✓	✓	✓
Location (PLSS section)	✓				
Operator ID[3]	✓	✓	✓	✓	
Operator Name/Address[4]	✓	✓	✓	✓	
Applicator Name/Address[4]	✓	✓	✓	✓	✓
Site ID[5]	✓			✓	
Commodity/Crop/Site	✓	✓	✓	✓	
Acres/Units Planted (Application Summary)	✓				
Acres/Units Treated (Application Summary)	✓				
Acres/Units Treated (Monthly Summary)		✓	✓	✓	
Aerial/Ground Indicator	✓				
Application Method	✓				
Fumigation Method[2]	✓			✓	
Amount of Product Applied	✓	✓	✓	✓	✓
Product Name	✓	✓	✓	✓	✓
Product US EPA Registration Number	✓	✓	✓	✓	✓
CA Registration Number (If applicable)	✓	✓	✓	✓	✓
Number of Applications (Monthly Summary)		✓	✓	✓	
Name/Address of Facility					✓
Application Location at School Site					✓

[1]Sources: DPR, 2017c; *3 C.C.R. 6624-6627*

[2]Required for: Pest Control Businesses (PCBs), industrial post-harvest commodity treatments, and outdoor institutional/industrial uses of pesticides on the groundwater protection list (*3 C.C.R. 6800[b]*).

[3]This is the GROWER_ID; also referred to as the operator identification number (OIN); equal to restricted materials permit number issued by the CAC (if applicable); consists of reporting county two digit county code (COUNTY_CD), two digit application year, permitting county code, and five digit permit number (the last seven digits identify individual permittees); PCBs exempt (except production agriculture: must use OIN issued to grower).

[4]This information is collected by the CAC on the PUR form but is not uploaded into the PUR database.

[5]This is the SITE_LOC_ID; the CAC may identify unique agricultural fields with the GROWER_ID + SITE_LOC_ID.

[6]Required for: field fumigations in ozone non-attainment areas from May 1st to October 31st (DPR, 2009).

PUR Quality Control Procedures Utilized by the Environmental Monitoring Branch's Air Program

I. Query the DPR Pesticide Use Reporting (PUR) database using the relational database management system Oracle™ and query and scripting software such as SAS™ from SAS Institute™ or Golden6™ from Benthic Software™

A. To include records containing null values in queried fields from joined tables in SQL code, consider the use of 'left' or 'outer' joins' instead of 'inner' joins.

II. Evaluate queried PUR records for any missing or clearly incorrect information (*e.g.*, missing or erroneous units corresponding to the application area).

A. If possible, mathematically convert the area treated to acres (*e.g.*, S = square feet)

III. Calculate the application rate (*i.e.,* applied pounds of AI per acre) by dividing the application amount reported for each production-agriculture PUR record (in pounds of AI applied) by the reported number of acres treated.

A. Determine maximum application rates, considering:

1. Regulatory requirements (*e.g.*, 225 - 400 lb/acre maximum methyl bromide application rates, depending on the application method).

2. Product label requirements (*e.g.,* 400 lb/acre maximum methyl bromide quarantine application rate). Product labels can be obtained from:

(a). Registration Resource Center

(b). Online resources (*i.e.*, US EPA product label database)

B. Compare the reported application rates to maximum application rates

1. Flag PUR records with application rate ≥ 110% of the highest permitted application rate (including quarantine and crop-specific rates) for further investigation.

(a). Speak to your supervisor about flagged records. When possible, the PUR database manager may need to contact the respective CAC to verify reported PUR data containing potential errors.

IV. Identify potential aggregated reports due to the consolidation of several consecutive daily fumigations (commonly known as "rolling applications") into one submitted PUR record.

A. For field fumigations with regulatory limitations on the maximum number of acres that are able to be treated per day, set a threshold of 110% of the allowed maximum acres treated to identify potential rolling applications.

1. For example, DPR regulations limit total acreage for a single methyl bromide fumigation block to a maximum of 40 acres in any 24-hour period (3 C.C.R. 6447[d]); therefore, PUR records for methyl bromide field fumigations with >44 acres treated should be flagged for further investigation.

B. Consider the division of PUR records exceeding the 110% threshold into consecutive daily applications by allotting a proportional amount of AI to the daily application area.

1. Set the reported application date as the first day of application, with the maximum allowable acres treated each day, and any allocate any remaining acres to the final day.

C. Speak to your supervisor about any flagged records. Potential temporal errors, such as incorrect application date, are more difficult to assess than other types of errors and careful consideration should be given to these procedures.

V. Display the data spatially by using ESRI™ ArcGIS™ software ArcMap™ to join records from the PUR database to spatial data, such as PLSS sections or townships.

The site boundary layer available from CalAgPermits can also be used to link PUR data using the reported operator ID and the site location ID to identify the associated field boundary from data maintained by the applicable CAC.

B. The point or area of interest is first verified in ArcMap™ to be displayed in the projected coordinate system, "NAD 1983 California (Teale) Albers (Meters)"

C. Join records from a statewide PLSS shapefile to records using a 1:1 join.

(1). This requires an excel document with properly formatted COMTRS information and summed pounds of pesticides in each area to be uploaded as a geodatabase table.

(a). ArcMap™ is incompatible with reserved words, spaces, and certain characters, which are defined in ESRI™ guidance documents.

C. Select the "Buffer" geoprocessing tool with the "planar" option to create Euclidean buffers.

(1). Geodesic buffers will be created by default if the map layer is in a geographic coordinate system.

D. Export the resulting feature class as a shapefile to a geodatabase prior to further analysis.

It is important to note that the size of individual sections and townships may deviate substantially from the standard size (sections: 1mi^2; townships: 36mi^2), which may necessitate the evaluation of pesticide use density by dividing the application amount by the application area (e.g., pounds of AI per acre).

V. For fumigants, in order to include application method adjustment factors, determine the level of compliance for application method reporting.

A. Calculate the percentage of records with null values in the "FUME_CD" data field.

(1) Speak to your supervisor prior to assigning a default application method for records with null values, and do not apply defaults where application method reporting is low.

Example SQL Code for a statewide query of PUR records by PLSS section

```
--Search for All California--

--Code for SQL by Colin Brown (Colin.Brown@cdpr.ca.gov) adapted and modified from SAS Scripts by Rosemary Neal

DEF chem = 573

--Change '573' to desired chemical code, obtained from http://www.cdpr.ca.gov/docs/label/lup.htm
--No need to touch anything below this line.
--Change parameters below as necessary. Press F5 to run the script.

COLUMN c1 HEADING YEAR
COLUMN c3 HEADING WEEK
COLUMN c4 HEADING APPLICATION_DATE
COLUMN c5 HEADING APPLICATION_TIME
COLUMN c6 HEADING PRODUCT_NUMBER
COLUMN c7 HEADING PRODUCT_NAME
COLUMN c9 HEADING PRODUCT_PERCENT_AI
COLUMN c10 HEADING LBS_AI_USED
COLUMN c11 HEADING AREA_TREATED
COLUMN c12 HEADING UNIT_AREA
COLUMN c13 HEADING CROP_CODE
COLUMN c14 HEADING CROP_NAME
COLUMN c15 HEADING APPLICATION_METHOD
COLUMN c18 HEADING CHEMICAL_CODE
COLUMN c21 HEADING MTRS

SELECT TO_CHAR(APPLIC_DT, 'YYYY') c1
, USE_NO
, ((TO_CHAR(APPLIC_DT, 'YYYY') - 2011) * 52 + TO_CHAR(APPLIC_DT, 'IW')) c3
, APPLIC_DT c4
, APPLIC_CNT
, APPLIC_TIME c5
, PROD_CHEM.PRODNO c6
, PRODUCT_NAME c7
, LBS_PRD_USED
, PRODCHEM_PCT c9
, (LBS_PRD_USED * (PRODCHEM_PCT/100)) c10
, ACRE_TREATED c11
, UNIT_TREATED c12
, PUR.SITE_CODE c13
, SITE_NAME c14
, AER_GND_IND c15
, GROWER_ID
, SITE_LOC_ID
, PROD_CHEM.CHEM_CODE c18
, CHEMNAME
, COUNTY_NAME
, (BASE_LN_MER || ' ' || TOWNSHIP || TSHIP_DIR || ' ' || RANGE || RANGE_DIR || ' ' || SECTION) c21
, PUR.FUME_CD
, FUME_METHOD

FROM COUNTY
INNER JOIN PUR ON COUNTY.COUNTY_CD=PUR.COUNTY_CD
INNER JOIN PROD_CHEM ON PUR.PRODNO=PROD_CHEM.PRODNO
LEFT OUTER JOIN SITE ON PUR.SITE_CODE=SITE.SITE_CODE
INNER JOIN CHEMICAL ON PROD_CHEM.CHEM_CODE=CHEMICAL.CHEM_CODE
INNER JOIN PRODUCT ON PUR.PRODNO=PRODUCT.PRODNO
LEFT OUTER JOIN PUR_FUMIGATION_METHODS ON PUR.FUME_CD=PUR_FUMIGATION_METHODS.FUME_CD

--You must change the CHEM_CODE number below to reflect the chemical of interest
WHERE PROD_CHEM.CHEM_CODE = '&chem' AND APPLIC_DT >= '1-JAN-14' AND APPLIC_DT <= '31-DEC-14'

ORDER BY 4;
```