TECHNICAL MEMORANDUM

TO: Central Valley Drinking Water Policy Working Group

FROM: NewFields Agricultural & Environmental Resources

DATE: March 21, 2011

SUBJECT: Technical Documentation and Limitations for Development of WARMF Model Input Parameters

1 INTRODUCTION

The Central Valley Regional Water Quality Control Board (CVRWQCB), with support from California Urban Water Agencies (CUWA) and the Sacramento Regional County Sanitation District (SRCSD), is leading an effort to improve policies for protecting surface water sources of drinking water in the Central Valley of California. This effort is directly managed and overseen by the Central Valley Drinking Water Policy Working Group (Work Group).

The CVRWQCB is committed to developing improved policies for protecting sources of drinking water in the Central Valley. The Central Valley Drinking Water Policy will be incorporated into the Water Quality Control Plan for the Sacramento and San Joaquin Rivers (Basin Plan) through a Basin Plan amendment. The Work Group, comprised of interested stakeholders, was formed to assist CVRWQCB staff and provide stakeholder input in developing the policy. In 2003, the Work Group developed a work plan for the technical studies needed to support the policy development. The work plan tasks included gathering existing data, developing conceptual and analytical models, and evaluating control strategies for the priority constituents of concern: organic carbon, pathogens, nutrients, and salinity including bromide.

As part of the control strategies evaluation, the Work Group hired a consultant to evaluate drinking water treatment costs under various water quality scenarios including existing conditions and reasonable estimates of future water quality degradation and water quality improvement (through implementation of source control strategies). The Work Group is tasked with providing the water quality scenarios to the consultant. First, the Work Group defined existing conditions based on available data to determine monthly or seasonal (depending on the amount of data available) median concentrations for the constituents of concern. Currently, the Work Group is working on defining future water quality scenarios by evaluating available information on the sources of drinking water constituents of concern in storm water runoff, wastewater discharges, and agricultural runoff. For wastewater, future scenarios are based on future population estimates and planned and potential treatment system improvements. Estimates of future water quality from storm water and agriculture will be based on land use projections and potential management practice implementation. The water quality estimates will then be used to estimate future changes in conditions and exactly what the implications of those changes are for drinking water treatment. In addition, the scenarios will be used to conduct sensitivity analyses as part of the analytical modeling task.

AGRICULTURAL COMPONENT

The Sacramento and San Joaquin rivers and their tributaries convey the vast majority of the surface water to the Delta providing urban, industrial, and agricultural water supply for much of California. Throughout this hydrologic network, urban, industrial, agricultural and natural pollutant sources exist and contribute to the degradation of surface water quality. It is the goal of the Work Group to identify and evaluate approaches, and to offer recommendations, for the potential improvement of water quality in the Central Valley. As part of these efforts, the influence of agriculture on the region's water quality is being evaluated.

An Agricultural Subgroup comprised of agricultural interests from throughout the Central Valley advises the Work Group on agricultural water quality aspects of the effort, and will help to guide implementation of this work. The relationship of specific agricultural practices to water quality was not evaluated as a component of this work to date. Only when these relationships have been fully developed should policy recommendations regarding these practices be developed. Policy recommendations should also take into full account the inter-relationships of various water uses and seek efficient, equitable means to better manage future pollutant loads.

PROJECT PRIORITIES AND FOCUS

This work was intended to provide a scientific approach to objectively and reasonably describe the impact of existing and potential future agricultural management practices on the Central Valley surface water resources; however, not all of the original scope of work was approved due to budget constraints. Therefore, actual management practice modifications were not developed. Only land use, nitrogen management, irrigation management and biomass production were roughly developed and considered. Parameters of concern included salinity, nutrients, and organic carbon. If ever conducted, the evaluation of agricultural management practices through this effort should be considered strictly for the development and justification of practical and successful improvements to surface water quality. The actual use and implementation of agricultural management practices by individual growers in the Central Valley and elsewhere is determined by many other factors than those that were capable of being conducted with the resources available for this project. Thus, the scope of this effort is not intended to identify specific management practices for adoption.

This document is developed in the following format by main topic:

- Land Use Data Development
    - Current Condition Scenario
    - Future Condition Scenario (2030)
- WARMF Model Agricultural Parameters
    - Applied Water
    - Nitrogen
    - Biomass
- Conclusions and Recommendations

2 LAND USE DATA DEVELOPMENT

Land use data were developed for the WARMF modeling domain with the goal of representing two distinct scenarios:

- current land use conditions
- 2030 future land use conditions

In general, land use classes established from the Central Valley SALTS (CV-SALTS) project were used to group lands that have similar characteristics with respect to the irrigation, fertilizer requirements, and nutrient removal parameters (Larry Walker Associates, 2010). Land conditions with important distinctions among these parameters (e.g., different percent impervious surface, or rates of irrigation) were placed into separate classes for the WARMF model input (Table 1).

TABLE 1. LAND USE CLASSES FOR WARMF MODEL INPUT.

WARMF Code	WARMF Land Use Class
1	Paved areas
2	Urban residential
3	Urban landscape and Open Space
4	Urban commercial
5	Urban Industrial
6	Barren land
7	Sewage treatment plant including ponds
8	Shrub/Scrub
9	Mixed Forest
10	Deciduous Forest
11	Evergreen Forest
12	Marsh
13	Fallow
14	Rice
15	Vines
16	Cotton
17	Orchard
18	Flowers and nursery
19	Other CAFOs
20	Olives, citrus, and sub-tropicals
21	Other row crops
22	Dairy production area
23	Lagoon
24	Farmsteads
25	Grassland/Herbaceous
26	Perennial forages
27	Perennial forages - dairy land application
28	Warm season cereals, grain only
29	Warm season cereals & forages/Winter grain double crop-dairy land app
30	Winter grains and safflower
31	Water

The following sections detail methodology and data sources compiled to provide input data to the WARMF model for the current and 2030 future land use scenarios.

CURRENT CONDITION SCENARIO

Current condition land use data for input in the WARMF model were derived from various existing sources of data. These include:

- California Department of Water Resources (DWR) land use data, representing parcel land use for all counties in the WARMF modeling domain
- The National Land Cover Database (NLCD), representing about 15 classes of land use
- Sacramento Area Council of Governments (SACOG), urban land use for the Sacramento Metro Area (six county region)
- Data reported to the CVRWQCB under the Dairy General Waste Discharge Requirements (DWDRs), indicating location, herd size, facility size, lagoon size, and land application area

AGRICULTURAL LAND USE

Agricultural land use data were developed primarily from the DWR land use datasets. Although a current condition dataset was the focus, it should be noted that DWR land use survey dates vary by county. DWR survey dates varied significantly for counties within the WARMF modeling domain (Table 2); however, were still used for WARMF model land use input even with these variations. These data represent an easily accessible and expansive land use data set and are considered the best available information. Itt should be noted that agricultural land use in the Central Valley is dynamic and changes yearly based on market demand, water availability, and climate.

TABLE 2. DWR SURVEY YEARS BY COUNTY AND VERSIONS USED FOR WARMF INPUT.

County	Survey Years	Survey Used for WARMF Input
Alpine	2001	2001
Amador	1997	1997
Butte	1994, 1999, 2004	2004
Calaveras	2000	2000
Colusa	1993, 1998, 2003	2003
Fresno	1986, 1994, 2000	2000
Glenn	1993, 1998, 2003	2003
Lake	1995, 2001	2001
Lassen	1997	1997
Legal Delta	1976, 1991, 1993	1993
Madera	1995, 2001	2001
Marin	1999	1999
Mariposa	1998	1998
Merced	1995, 2002	2002
Placer	1994	1994
Sacramento	1993, 2000	2000
San Benito	1997, 2002	2002
San Joaquin	1988, 1996	1996
Shasta	1995	1995
Sonoma	1999	1999
Stanislaus	1996, 2004	2004
Sutter	1998, 2004	2004
Tehama	1994, 1999	1999
Tuolumne	1997	1997
Yolo	1989, 1997	1997
Yuba	1995	1995

DAIRY LAND USE

Dairy land use information reported by DWDR to the CVRWQCB was used to develop dairy land application acreages and nitrogen loading rates. The dairy locations within the WARMF modeling domain are diverse both in density and in geographic distribution (Figure 1). Individual dairy locations and all associated data on number of cows and land application acres were aggregated to the catchment level for analysis.

This information allowed development of relationships among the sizes of herds, production areas, lagoons, and land application areas. Herd sizes in each WARMF catchment were then calculated (based on the locations given for each dairy production area), and required production, lagoon, land application acreages, and nitrogen loading rates for each catchment were calculated using the following assumptions:

1. Total nitrogen for land application: 253 lbs/cow/yr
2. Lagoon area: 0.0026 acres/cow
3. Production area: 0.04 acres/cow

Custom programming was developed to locate these acreages within each catchment according to the following rules:

1. Replace blocks of areas mapped as farmsteads within the same catchment with lagoons and dairies (production areas) until the required acreages have been delineated.
2. Denote blocks of warm season cereals and forages, winter grains and safflower, and perennial forages as dairy land application area.
3. If there is insufficient cropland in these land cover classes within a catchment to provide needed land application area, follow the same process in adjacent catchments until the needed acreage is delineated.

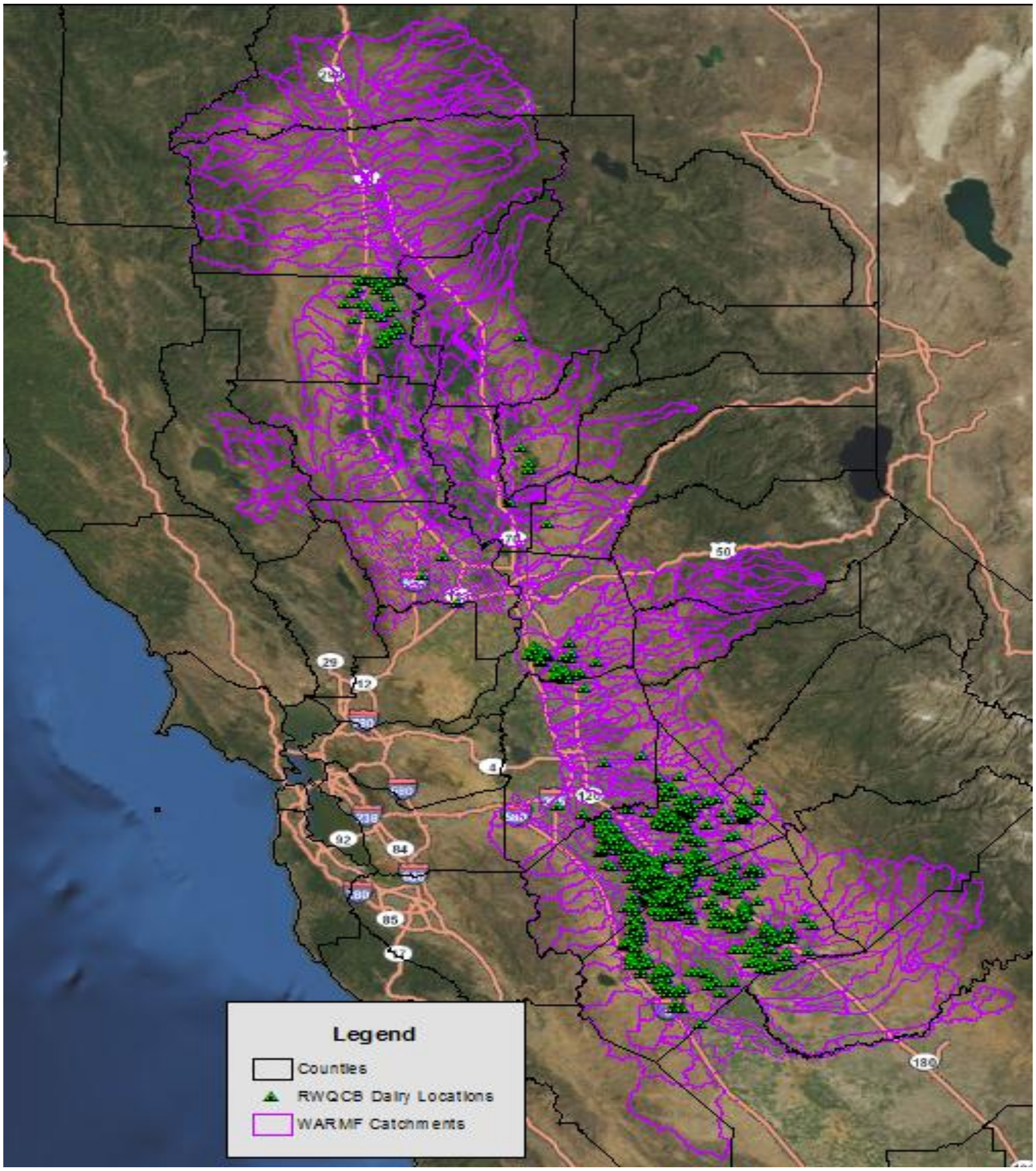

Figure 1. Dairy locations within the WARMF modeling domain.

These assumptions are consistent with those used in the CV-Salts project (Larry Walker Associates, 2010). The spatial location of 132 catchments with dairy land application as well as the distribution of nitrogen loading rates for those catchments is diverse as to geographic distribution throughout the entire modeling domain (Figure 2). A distribution of estimated nitrogen loading from dairies based on estimated manure production and suitable land application areas (Figure 2) showed a wide range of approximately 100 to 3,250 lbs/acre with an average of around 750 lbs/acre. It was assumed that nothing was applied below an agronomic rate of 500 lbs/acre. To do this, the land area was reduced to increase the loadings per unit land area. It should be noted that land application of dairy waste represents only a portion of the potential animal waste land application within the Central Valley. Estimates of the total amount of nitrogen from other potential sources of animal waste not accounted for within the WARMF model is significant in many cases (Figure 3).

These data sources are aggregated from county agricultural statistics and therefore could not be incorporated into the WARMF model because of their coarse spatial resolution (county level) as compared to the dairy data which had corresponding point (XY) locations.

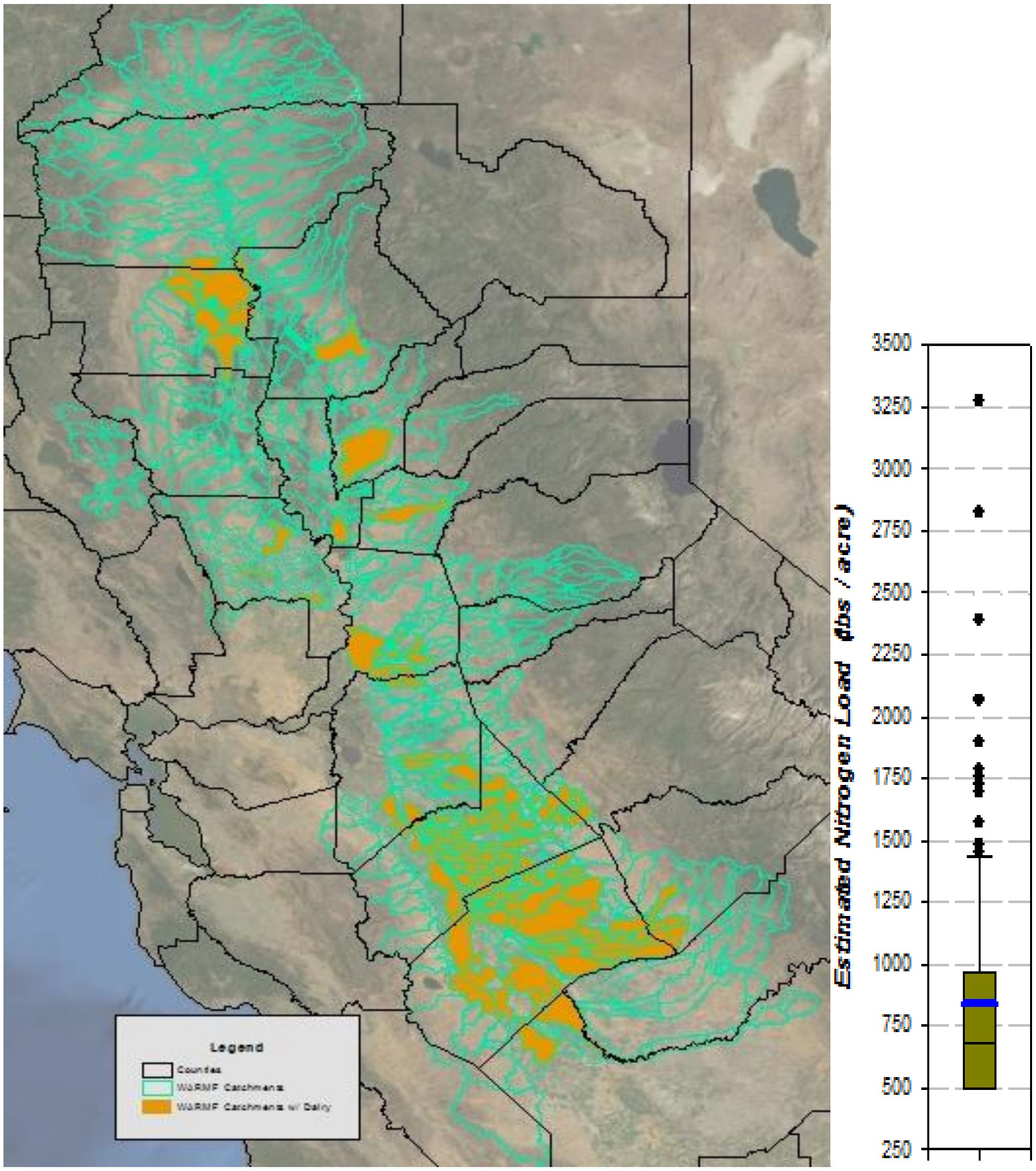

Figure 2. Distribution of catchments containing dairies and estimated nitrogen loadings (RWQCB Data) by operation.

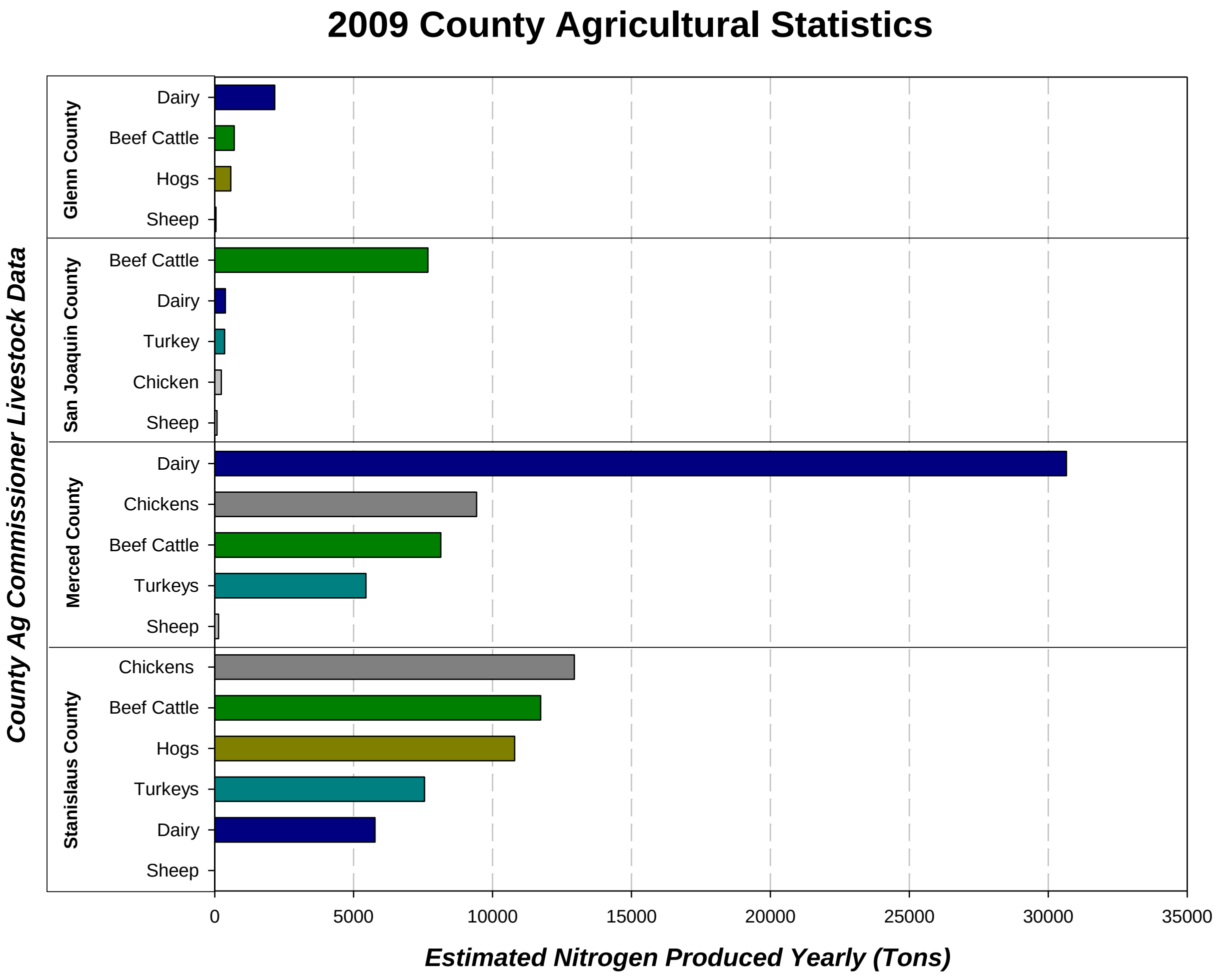

Figure 3. Estimated nitrogen produced (tons) by county for various livestock populations.

RANGELAND AND NATIVE VEGETATION LAND USE

The NLCD datasets were used where DWR classes were most sparsely mapped (e.g., rangeland, wild land, and native classes). In general, only native classes where retained from the NLCD dataset and these include: deciduous forests, evergreen forests, mixed forests, shrub/scrub, and grassland/herbaceous.

URBAN LAND USE

Urban data from the SACOG land use database was used for the Sacramento Metro Area. This data included approximately 50 classes, which were summarized into five urban classes in the WARMF modeling legend. Detailed information on the urban class summarization can be found in the storm water summary report. Where SACOG urban land use data was unavailable, DWR land use data for urban areas were used.

FUTURE CONDITION SCENARIO (2030)

Land use data were also developed for the future condition modeling scenario. This scenario was designed to represent conditions in 2030. Projecting future agricultural land use for 2030 generally does not exist, nor was it feasible to project or conduct enhanced development for this dataset given the time and budget constraints of this project. Therefore, agricultural land use distribution was not changed from that developed for the current condition. Urban projections however, were available from SACOG and UC Davis for Sacramento and some other urban centers. This information will be described in detail in the storm water report. Where available, urban land use projections were used to replace “current condition” land use. In general, this resulted in current condition agricultural and native classes being converted to urban land use. Detailed discussion on these changes in land use is documented in the storm water report.

3 WARMF MODEL AGRICULTURAL PARAMETERS

Applied water, nitrogen management, and biomass estimates were developed as input parameters for the purposes of WARMF modeling efforts. It should be noted that these parameters were developed in a fairly broad and cursory manner and no spatial variation other than broad assumptions were made over the 12.3 million-acre modeling area. It should also be noted that some of the information and approaches developed for a previous CV-Salts effort were used as guidelines for expansion from 2+ million (CV Salts) to the 12.3 million (CVDWQPWG) acre area; however, it was not possible within the timeframe allowed to complete this effort in the same manner. Therefore, it was necessary to make broad-reaching assumptions and use generalized information.

Major differences in irrigation methods, nitrogen management, and overall farm management practices occur over an area of 12.3 million acres. Those differences were not accounted for in this evaluation, rather standardized/averaged estimates for input parameters were used. For example, irrigation management of vineyards in the Sacramento Valley area is significantly different from that in the central San Joaquin area due to differences in climatic regimes, soil type, grape production purposes, frost protection, and general farm management. The same is true for almonds within the northern part of the Central Valley versus the southern portion of the analysis area.

APPLIED WATER

APPROACH AND LIMITATIONS

Applied water estimates were developed using the following methods:

- The dominant crop grown in each crop category was selected for development of crop water use and irrigation assumptions.
- CIMIS Reference Crop (ETo) zones were used to develop ETo for all catchments. In cases where a catchment spanned two or more zones, the zone with the greatest area was selected. In some cases catchments span agricultural regions to higher elevation foothills. This may result in selection of ETo values that represent higher elevation foothill rather than agricultural areas. Refinement of catchment assignment to ETo zones is recommended for more detailed future modeling efforts.
- One weather station within each ETo zone was selected to represent rainfall for all catchments within that zone. Refined rainfall information is likely available but would require manual selection of nearest, most representative weather station information for each catchment and is recommended for any future refined modeling efforts.
- Crop coefficients (multiplied by ETo to determine crop water requirement) were obtained from Food and Agriculture Organization, Paper Number 56 – Crop Evapotranspiration (Allen, et al. 1998) for each of the representative crops in the modeled crop categories.
- Irrigation type and average efficiencies were also developed considering the dominant crop in each of the modeled crop categories. In reality, irrigation practices vary throughout the study area based on management approaches, cultural practices and varied climatic

conditions. In future refined modeling efforts, consideration of these regional and sub-regional variations should be considered.

Applied water estimates by land use type can be found at the end of this document (Table 5).

NITROGEN

APPROACH AND LIMITATIONS

It was necessary to estimate the portion of fertilizer nitrogen that was in the nitrate form as a required input variable for the WARMF model. Nitrogen fertilizers chosen by growers vary significantly between and even within crop systems and also vary from year to year. With the increasing cost of petroleum products, the corresponding cost of fertilizers has also increased significantly. Growers are making "non-traditional" decisions about how much, when and what types of fertilizers they will be using – if any at all. Most recently, these decisions are dominated by individual grower financial considerations, are not predictable, nor are consistent across the modeling domain. Saying this, some broad assumptions can be made for the nitrate portion of fertilizer materials. Fertilizer nitrate proportion was estimated from professional experience and knowledge about common fertilizers used for various crop production and irrigation systems within each crop category. It is likely that as market conditions for fertilizer materials continues to change, so will decisions about which fertilizer to use and when, how much and how frequent to use it. In general, the nitrate contributions from fertilizers were relatively low as compared to other nitrogen sources. Results of estimated fertilizer nitrogen forms and loadings are determined by crop type (Table 5).

BIOMASS

APPROACH AND LIMITATIONS

Professional knowledge of cropping systems within the modeling domain as well as literature information was used to estimate two required WARMF model input parameters:

- biomass removed from the system
- biomass recycled back to the soil/plant system

Cursory literature reviews provided some reasonable estimates for quantification of biomass removal and that which would be recycled back into the soil system. For example, Lindstrom (1986) found increased runoff and soil loss with decreasing residue remaining on the soil surface under no-till with grain, with the study results suggesting a normal 30% removal rate not significantly increasing soil loss in the systems modeled. Other researchers indicated for grain crops, approximately 40% of the total residue produced is collected, with the remaining residues left to maintain soil quality (Walsh, 1999).

Including literature reviews, professional judgment and knowledge of cropping systems within the modeling regime also aided in developing reasonable assumptions of proportional crop removal versus recycled crop components. For example, the vast majority of an alfalfa or silage crop total biomass produced is removed (assumed to be approximately 90+ percent) with the exception of some leaf drop and remaining rooting systems.

Some cropping systems are extremely dynamic both regionally and also with the actual amount of biomass removed versus that which is recycled. Prunings from almonds and the entire trees themselves when complete orchards are removed are managed very differently in different parts of the state. In the Sacramento Valley the fate of almond prunings is predominantly burning. In the San Joaquin Valley, restrictions on burning has resulted in significant chipping of prunings, with either the chipped product being applied back to the orchard floor (100 percent recycled) or completely removed from the site (near 100 percent removal (minus leaf drop)) for purposes of co-generation or composting. Biomass management on this type of crop is extremely variable from farm to farm and from region to region (Edstrom, 2011). Average assumptions had to be made within this case that may or may not be accurate for a give catchment or more regional area.

Estimation of biomass removal versus that recycled is variable and changing rapidly over time for some crops while relatively known and consistent quantities exist for other crops. It will likely be important to understand the sensitivity to changes in biomass removal or recycling within the WARMF model.

Estimates of biomass removed and recycled can be found at the end of this document (Table 5).

4 CONCLUSIONS AND RECOMMENDATIONS

The work performed by NewFields Agricultural & Environmental Resources was directed to provide necessary agricultural-based inputs for the WARMF modeling efforts. The modeling domain represented approximately 12.3 million acres of diverse cropping systems, water sheds and irrigation and drainage management systems. NewFields provided a complete dataset for the modeling efforts however due to available time and budget constraints could only grossly estimate some of the input parameters. It was essential to provide a complete dataset first, then refine the inputs as possible with remaining resources.

It is recommended that sensitivity analyses be performed with the WARMF model to determine which of the input parameters result the in the most influential changes in model outputs. If any additional resources are made available in the future, then these impactful parameters can be investigated further to improve the model accuracy.

5 REFERENCES

Allen, R.G., L.S. Pereira, D. Raes, and M. Smith. 1998 – FAO Irrigation and Drainage Paper No. 56. Crop Evapotranspiration. Rome.

Edstrom, J. 2011. Personal Communication. Farm Advisor, Pomology. Nickels Soil Lab, Arbuckle, CA.

Larry Walker Associates, et al. 2010. CV-Salts - Salt and Nitrate Sources Pilot Implementation Study Report. February.

Lindstrom, M.J. 1986. Effects of residue harvesting on water runoff, soil erosion and nutrient loss. Agriculture, Ecosystems and Environment 16:103-112.

Walsh, M. 1999. Oakridge National Laboratories. http://bioenergy.ornl.gov/papers/misc/resource_estimates.html

Table 4. WARMF model dairy input parameters by catchment.

Catchment ID	Lagoon Area (Acres)	Production Area (Acres)	Est Land Application Area (Acres)	Est Nitrogen Load (lbs/acre)
38	1.2	19	219	555
40	1.4	22	270	506
44	5.8	90	1133	500
49	1.3	20	253	500
54	3.8	58	732	500
55	2.3	36	455	500
62	7.4	114	495	1453
70	1.4	22	180	759
89	2.2	33	120	1754
91	1.2	18	66	1725
104	3.8	59	420	892
107	0.4	7	29	1483
109	4.1	62	788	500
117	20.1	309	3710	527
121	4.3	66	670	625
229	0.8	12	110	713
250	1.2	19	128	919
265	0.7	11	95	751
267	18.6	285	2593	696
269	2.1	33	269	765
270	13.4	206	2052	634
279	4.6	71	820	549
282	6.2	96	1215	500
308	2.0	31	305	643
369	8.5	130	823	1002
387	2.1	32	405	500
395	1.6	25	319	500
437	7.3	112	1417	500
456	0.3	5	63	500
463	0.9	14	145	611
498	35.2	542	3558	964
499	20.6	317	3022	663
502	38.3	589	3541	1053
506	16.7	256	3243	500
508	18.8	290	3666	500
510	1.6	24	304	2066
519	2.1	32	240	833
521	1.4	22	277	500
525	46.7	719	9092	500
528	1.2	18	209	548

Catchment ID	Lagoon Area (Acres)	Production Area (Acres)	Est Land Application Area (Acres)	Est Nitrogen Load (lbs/acre)
529	19.0	293	3378	549
530	1.9	29	368	500
532	4.4	68	859	500
535	4.3	66	127	3274
549	36.1	555	5470	642
550	5.0	77	976	500
560	8.3	127	390	2066
562	3.1	48	250	1214
565	30.4	468	2944	1006
568	1.3	19	149	820
571	14.3	220	2762	505
575	14.0	216	1413	967
576	4.3	66	484	864
578	1.4	21	235	560
579	16.5	253	3120	514
580	1.5	22	190	611
581	5.2	80	1007	500
583	7.9	121	611	1253
584	12.4	191	2421	500
585	1.6	25	220	710
586	1.8	28	195	921
587	20.1	309	2842	687
592	1.0	16	202	500
593	11.4	176	1575	706
595	6.8	104	1320	500
596	12.5	193	2408	507
597	7.9	122	749	1026
599	1.4	21	271	500
600	41.6	640	4664	867
602	5.0	78	947	518
605	1.7	26	97	1695
607	3.7	56	256	1394
609	2.7	42	500	526
610	2.9	44	215	1294
613	3.1	48	533	518
615	3.5	54	191	1784
617	4.2	65	315	1308
619	15.6	240	2067	734
620	9.7	148	1222	769
622	3.3	51	645	500
623	16.5	254	2214	725

Catchment ID	Lagoon Area (Acres)	Production Area (Acres)	Est Land Application Area (Acres)	Est Nitrogen Load (lbs/acre)
624	0.6	10	112	542
625	2.1	32	405	725
626	5.8	89	508	1113
628	10.2	157	1701	584
629	7.4	114	951	755
630	4.2	65	603	682
631	3.6	55	698	500
632	11.0	170	1236	868
633	23.2	356	2956	762
634	22.3	344	1557	1396
636	4.5	69	424	1023
637	75.5	1161	5030	1400
638	58.7	903	4643	1231
639	36.0	553	2445	1398
640	16.8	258	1848	885
641	16.7	257	2896	561
642	1.4	21	70	1898
643	21.1	325	2913	705
644	33.0	508	4658	636
645	36.5	561	6221	571
652	5.9	91	1155	500
654	8.7	134	883	963
657	13.9	214	1401	966
660	2.5	39	493	500
662	15.0	230	2916	500
664	4.6	71	382	1094
665	5.0	77	312	1569
667	5.6	85	495	1092
668	7.1	109	1378	500
672	4.4	68	480	896
675	7.6	117	1160	638
679	37.2	572	3995	889
683	3.4	52	625	525
684	11.1	170	855	1258
687	3.7	58	385	947
691	7.0	107	1359	500
692	4.8	74	941	500
693	2.2	34	90	2389
694	9.7	149	1540	613
696	70.9	1090	8619	800
699	11.1	171	1416	762

Catchment ID	Lagoon Area (Acres)	Production Area (Acres)	Est Land Application Area (Acres)	Est Nitrogen Load (lbs/acre)
700	2.4	38	476	500
702	12.5	192	2267	536
707	3.3	50	219	1449
708	38.4	591	5922	631
709	0.9	14	32	2823
715	8.4	129	792	810
717	9.4	144	1822	500
719	1.5	23	275	529
720	3.3	51	250	1285
723	12.7	195	1802	684
725	20.0	308	2018	966
730	1.8	27	348	500

Table 5. Estimates of applied water and nitrogen, fertilizer nitrate component, biomass removed and recycled, nitrogen removed and other parameters according to land use type and CIMIS zone.

WARMF Land Use and CIMIS ETo Zone	Applied Water (acre-Feet)	Months Irrigated (#)	Applied Nitrogen (lbs/acre)	Nitrate Fertilizer (%)	Biomass Removed (dry - lbs/acre)	Biomass Recycled (dry - lbs/acre)	Nitrogen Removed (lbs/acre)	Impervious (%)	Irrigated Area (%)
Barren land_8	0	0	0	0	0	0	0	0	0
Barren land_10	0	0	0	0	0	0	0	0	0
Barren land_11	0	0	0	0	0	0	0	0	0
Barren land_12	0	0	0	0	0	0	0	0	0
Barren land_13	0	0	0	0	0	0	0	0	0
Barren land_14	0	0	0	0	0	0	0	0	0
Barren land_15	0	0	0	0	0	0	0	0	0
Cotton_8	3.41	5-9	180	0	500	2500	180	0	100
Cotton_10	3.18	5-9	180	0	500	2500	180	0	100
Cotton_12	4.19	4-10	180	0	500	2500	180	0	100
Cotton_14	4.33	4-10	180	0	500	2500	180	0	100
Cotton_15	4.59	4-10	180	0	500	2500	180	0	100
DairyPA_8	0	0	0	0	0	0	0	35	0
DairyPA_12	0	0	0	0	0	0	0	35	0
DairyPA_14	0	0	0	0	0	0	0	35	0
DairyPA_15	0	0	0	0	0	0	0	35	0
Deciduous Forest_8	0	0	0	0	0	0	0	0	0
Deciduous Forest_10	0	0	0	0	0	0	0	0	0
Deciduous Forest_11	0	0	0	0	0	0	0	0	0
Deciduous Forest_12	0	0	0	0	0	0	0	0	0
Deciduous Forest_13	0	0	0	0	0	0	0	0	0
Deciduous Forest_14	0	0	0	0	0	0	0	0	0
Deciduous Forest_15	0	0	0	0	0	0	0	0	0
Double Crop DLA_12	4.59	3-9	variable	0	28000	3200	340	0	100
Double Crop DLA_14	4.23	3-9	variable	0	28000	3200	340	0	100
Double Crop DLA_15	4.54	3-9	variable	0	28000	3200	340	0	100
Evergreen Forest_8	0	0	0	0	0	0	0	0	0
Evergreen Forest_10	0	0	0	0	0	0	0	0	0
Evergreen Forest_11	0	0	0	0	0	0	0	0	0
Evergreen Forest_12	0	0	0	0	0	0	0	0	0
Evergreen Forest_13	0	0	0	0	0	0	0	0	0
Evergreen Forest_14	0	0	0	0	0	0	0	0	0
Evergreen Forest_15	0	0	0	0	0	0	0	0	0
Fallow_8	0	0	0	0	0	0	0	0	0
Fallow_10	0	0	0	0	0	0	0	0	0
Fallow_12	0	0	0	0	0	0	0	0	0
Fallow_13	0	0	0	0	0	0	0	0	0
Fallow_14	0	0	0	0	0	0	0	0	0
Fallow_15	0	0	0	0	0	0	0	0	0
Farmsteads_8	4	4-10	280	20	2400	600	240	10	10
Farmsteads_10	3.36	5-9	280	20	2400	600	240	10	10
Farmsteads_11	4.41	4-10	280	20	2400	600	240	10	10
Farmsteads_12	5.27	3-11	280	20	2400	600	240	10	10
Farmsteads_13	4.12	4-10	280	20	2400	600	240	10	10

WARMF Land Use and CIMIS ETo Zone	Applied Water (acre-Feet)	Months Irrigated (#)	Applied Nitrogen (lbs/acre)	Nitrate Fertilizer (%)	Biomass Removed (dry - lbs/acre)	Biomass Recycled (dry - lbs/acre)	Nitrogen Removed (lbs/acre)	Impervious (%)	Irrigated Area (%)
Farmsteads_14	5.38	3-11	280	20	2400	600	240	10	10
Farmsteads_15	6.00	2-11	280	20	2400	600	240	10	10
Flowers and nursery_8	1.91	4-10	200	50	18000	0	200	0	100
Flowers and nursery_12	2.65	3-10	200	50	18000	0	200	0	100
Flowers and nursery_13	1.98	5-9	200	50	18000	0	200	0	100
Flowers and nursery_14	2.70	3-10	200	50	18000	0	200	0	100
Flowers and nursery_15	3.04	3-11	200	50	18000	0	200	0	100
Grassland/Herbaceous_8	0	0	0	0	0	0	0	0	0
Grassland/Herbaceous_10	0	0	0	0	0	0	0	0	0
Grassland/Herbaceous_11	0	0	0	0	0	0	0	0	0
Grassland/Herbaceous_12	0	0	0	0	0	0	0	0	0
Grassland/Herbaceous_13	0	0	0	0	0	0	0	0	0
Grassland/Herbaceous_14	0	0	0	0	0	0	0	0	0
Grassland/Herbaceous_14	0	0	0	0	0	0	0	0	0
Grassland/Herbaceous_14	0	0	0	0	0	0	0	0	0
Grassland/Herbaceous_14	0	0	0	0	0	0	0	0	0
Grassland/Herbaceous_14	0	0	0	0	0	0	0	0	0
Grassland/Herbaceous_14	0	0	0	0	0	0	0	0	0
Grassland/Herbaceous_14	0	0	0	0	0	0	0	0	0
Grassland/Herbaceous_15	0	0	0	0	0	0	0	0	0
Lagoon_12	0	0	0	0	0	0	0	90	0
Lagoon_14	0	0	0	0	0	0	0	90	0
Lagoon_15	0	0	0	0	0	0	0	90	0
Marsh_8	0	0	0	0	0	0	0	0	0
Marsh_10	0	0	0	0	0	0	0	0	0
Marsh_11	0	0	0	0	0	0	0	0	0
Marsh_12	0	0	0	0	0	0	0	0	0
Marsh_13	0	0	0	0	0	0	0	0	0
Marsh_14	0	0	0	0	0	0	0	0	0
Marsh_15	0	0	0	0	0	0	0	0	0
Mixed Forest_8	0	0	0	0	0	0	0	0	0
Mixed Forest_10	0	0	0	0	0	0	0	0	0
Mixed Forest_11	0	0	0	0	0	0	0	0	0
Mixed Forest_12	0	0	0	0	0	0	0	0	0
Mixed Forest_13	0	0	0	0	0	0	0	0	0
Mixed Forest_14	0	0	0	0	0	0	0	0	0
Mixed Forest_15	0	0	0	0	0	0	0	0	0
Native Classes Unsegregated_11	0	0	0	0	0	0	0	0	0
Native Classes Unsegregated_12	0	0	0	0	0	0	0	0	0
Native Classes Unsegregated_15	0	0	0	0	0	0	0	0	0
Olives, citrus, and subtropicals_8	1.91	4-10	265	0	18000	100	265	0	100
Olives, citrus, and subtropicals_11	2.16	4-10	265	0	18000	100	265	0	100
Olives, citrus, and subtropicals_12	2.65	3-10	265	0	18000	100	265	0	100
Olives, citrus, and subtropicals_13	1.98	3-10	265	0	18000	100	265	0	100
Olives, citrus, and subtropicals_14	2.70	3-10	265	0	18000	100	265	0	100
Olives, citrus, and subtropicals_15	3.04	3-10	265	0	18000	100	265	0	100

WARMF Land Use and CIMIS ETo Zone	Applied Water (acre-Feet)	Months Irrigated (#)	Applied Nitrogen (lbs/acre)	Nitrate Fertilizer (%)	Biomass Removed (dry - lbs/acre)	Biomass Recycled (dry - lbs/acre)	Nitrogen Removed (lbs/acre)	Impervious (%)	Irrigated Area (%)
Orchard_8	2.83	4-9	200	0	6000	1000	200	0	100
Orchard_10	2.54	4-9	200	0	6000	1000	200	0	100
Orchard_11	3.16	4-10	200	0	6000	1000	200	0	100
Orchard_12	3.66	4-10	200	0	6000	1000	200	0	100
Orchard_13	3.05	4-10	200	0	6000	1000	200	0	100
Orchard_14	3.78	4-10	200	0	6000	1000	200	0	100
Orchard_15	4.03	3-9	200	0	6000	1000	200	0	100
Other CAFOs_8	0	0	0	0	0	0	0	15	0
Other CAFOs_11	0	0	0	0	0	0	0	15	0
Other CAFOs_12	0	0	0	0	0	0	0	15	0
Other CAFOs_13	0	0	0	0	0	0	0	15	0
Other CAFOs_14	0	0	0	0	0	0	0	15	0
Other CAFOs_15	0	0	0	0	0	0	0	15	0
Other row crops_8	3.22	5-9	180	10	12000	10000	180	0	100
Other row crops_10	2.98	5-9	180	10	12000	10000	180	0	100
Other row crops_12	3.71	5-9	180	10	12000	10000	180	0	100
Other row crops_13	3.55	5-9	180	10	12000	10000	180	0	100
Other row crops_14	3.87	5-9	180	10	12000	10000	180	0	100
Other row crops_15	3.98	5-9	180	10	12000	10000	180	0	100
Paved areas_8	0	0	0	0	0	0	0	100	0
Paved areas_11	0	0	0	0	0	0	0	100	0
Paved areas_12	0	0	0	0	0	0	0	100	0
Paved areas_13	0	0	0	0	0	0	0	100	0
Paved areas_14	0	0	0	0	0	0	0	100	0
Paved areas_15	0	0	0	0	0	0	0	100	0
Perennial forages_8	3.72	4-10	100	0	14000	1000	480	0	100
Perennial forages_10	3.12	5-9	100	0	14000	1000	480	0	100
Perennial forages_11	4.09	4-10	100	0	14000	1000	480	0	100
Perennial forages_12	4.89	3-11	100	0	14000	1000	480	0	100
Perennial forages_13	3.83	4-10	100	0	14000	1000	480	0	100
Perennial forages_14	4.99	3-11	100	0	14000	1000	480	0	100
Perennial forages_15	5.57	2-11	100	0	14000	1000	480	0	100
Perennial forages DLA_12	4.89	3-11	Vrbl	0	14000	1000	480	0	100
Perennial forages DLA_14	4.99	3-11	Vrbl	0	14000	1000	480	0	100
Perennial forages DLA_15	5.57	2-11	Vrbl	0	14000	1000	480	0	100
Rice_8	3.42	5-9	110	0	8000	14000	110	0	100
Rice_12	3.91	5-9	110	0	8000	14000	110	0	100
Rice_13	3.77	5-9	110	0	8000	14000	110	0	100
Rice_14	4.06	5-9	110	0	8000	14000	110	0	100
Rice_15	4.20	5-9	110	0	8000	14000	110	0	100
Sewage trtmnt plant _8	0	0	0	0	0	0	0	95	0
Sewage trtmnt plants_12	0	0	0	0	0	0	0	95	0
Sewage trtmnt plant _13	0	0	0	0	0	0	0	95	0
Sewage trtmnt plants_14	0	0	0	0	0	0	0	95	0
Sewage trtmnt plant_15	0	0	0	0	0	0	0	95	0
Shrub/Scrub_8	0	0	0	0	0	0	0	0	0

WARMF Land Use and CIMIS ETo Zone	Applied Water (acre-Feet)	Months Irrigated (#)	Applied Nitrogen (lbs/acre)	Nitrate Fertilizer (%)	Biomass Removed (dry - lbs/acre)	Biomass Recycled (dry - lbs/acre)	Nitrogen Removed (lbs/acre)	Impervious (%)	Irrigated Area (%)
Shrub/Scrub_10	0	0	0	0	0	0	0	0	0
Shrub/Scrub_11	0	0	0	0	0	0	0	0	0
Shrub/Scrub_12	0	0	0	0	0	0	0	0	0
Shrub/Scrub_13	0	0	0	0	0	0	0	0	0
Shrub/Scrub_13	0	0	0	0	0	0	0	0	0
Shrub/Scrub_13	0	0	0	0	0	0	0	0	0
Shrub/Scrub_13	0	0	0	0	0	0	0	0	0
Shrub/Scrub_13	0	0	0	0	0	0	0	0	0
Shrub/Scrub_13	0	0	0	0	0	0	0	0	0
Shrub/Scrub_14	0	0	0	0	0	0	0	0	0
Shrub/Scrub_14	0	0	0	0	0	0	0	0	0
Shrub/Scrub_14	0	0	0	0	0	0	0	0	0
Shrub/Scrub_14	0	0	0	0	0	0	0	0	0
Shrub/Scrub_14	0	0	0	0	0	0	0	0	0
Shrub/Scrub_14	0	0	0	0	0	0	0	0	0
Shrub/Scrub_14	0	0	0	0	0	0	0	0	0
Shrub/Scrub_15	0	0	0	0	0	0	0	0	0
Urban commercial_8	2.17	5-9	150	20	2000	0	150	80	10
Urban commercial_10	1.82	5-9	150	20	2000	0	150	80	10
Urban commercial_11	2.39	5-10	150	20	2000	0	150	80	10
Urban commercial_12	2.87	4-10	150	20	2000	0	150	80	10
Urban commercial_13	2.30	5-9	150	20	2000	0	150	80	10
Urban commercial_14	2.93	4-10	150	20	2000	0	150	80	10
Urban commercial_15	3.18	4-10	150	20	2000	0	150	80	10
Urban industrial_8	2.17	5-9	150	20	2000	0	150	90	5
Urban industrial_10	1.82	5-9	150	20	2000	0	150	90	5
Urban industrial_11	2.39	5-10	150	20	2000	0	150	90	5
Urban industrial_12	2.87	4-10	150	20	2000	0	150	90	5
Urban industrial_13	2.30	5-9	150	20	2000	0	150	90	5
Urban industrial_14	2.93	4-10	150	20	2000	0	150	90	5
Urban industrial_15	3.18	4-10	150	20	2000	0	150	90	5
Urban landscape and open space_8	3.47	5-9	280	20	2400	600	240	20	70
Urban landscape and open space_10	2.91	5-9	280	20	2400	600	240	20	70
Urban landscape and open space_11	3.82	4-10	280	20	2400	600	240	20	70
Urban landscape and open space_12	4.56	3-11	280	20	2400	600	240	20	70
Urban landscape and open space_13	3.57	4-10	280	20	2400	600	240	20	70
Urban landscape and open space_14	4.66	3-11	280	20	2400	600	240	20	70
Urban landscape and open space_14	4.66	3-11	280	20	2400	600	240	20	70
Urban landscape and open space_14	4.66	3-11	280	20	2400	600	240	20	70
Urban landscape and open space_14	4.66	3-11	280	20	2400	600	240	20	70
Urban landscape and open space_15	5.20	2-11	280	20	2400	600	240	20	70
Urban residential_8	4.00	5-10	280	20	2400	600	240	15	25
Urban residential_10	3.36	5-9	280	20	2400	600	240	15	25
Urban residential_11	4.41	4-10	280	20	2400	600	240	15	25
Urban residential_12	5.27	3-11	280	20	2400	600	240	15	25
Urban residential_13	4.12	4-10	280	20	2400	600	240	15	25

WARMF Land Use and CIMIS ETo Zone	Applied Water (acre-Feet)	Months Irrigated (#)	Applied Nitrogen (lbs/acre)	Nitrate Fertilizer (%)	Biomass Removed (dry - lbs/acre)	Biomass Recycled (dry - lbs/acre)	Nitrogen Removed (lbs/acre)	Impervious (%)	Irrigated Area (%)
Urban residential_14	5.38	3-11	280	20	2400	600	240	15	25
Urban residential_15	6.00	2-11	280	20	2400	600	240	15	25
Vines_8	1.74	4-9	110	20	3600	500	110	0	100
Vines_10	1.45	4-9	110	20	3600	500	110	0	100
Vines_11	1.87	4-9	110	20	3600	500	110	0	100
Vines_12	2.23	4-9	110	20	3600	500	110	0	100
Vines_13	1.81	4-9	110	20	3600	500	110	0	100
Vines_14	2.28	4-9	110	20	3600	500	110	0	100
Vines_15	2.48	4-9	110	20	3600	500	110	0	100
Warm season cereals and forages_8	3.08	5-8	250	0	18000	2000	250	0	100
Warm season cereals and forages_10	2.91	5-8	250	0	18000	2000	250	0	100
Warm season cereals and forages_11	3.30	5-8	250	0	18000	2000	250	0	100
Warm season cereals and forages_12	3.59	4-8	250	0	18000	2000	250	0	100
Warm season cereals and forages_13	3.42	5-8	250	0	18000	2000	250	0	100
Warm season cereals and forages_14	3.73	4-8	250	0	18000	2000	250	0	100
Warm season cereals and forages_15	3.93	4-8	250	0	18000	2000	250	0	100
Water_8	0	0	0	0	0	0	0	0	0
Water_10	0	0	0	0	0	0	0	0	0
Water_11	0	0	0	0	0	0	0	0	0
Water_12	0	0	0	0	0	0	0	0	0
Water_13	0	0	0	0	0	0	0	0	0
Water_14	0	0	0	0	0	0	0	0	0
Water_15	0	0	0	0	0	0	0	0	0
Winter grains and safflower_8	0.62	4-5	165	0	10000	1200	135	0	100
Winter grains and safflower_10	0.20	4-5	165	0	10000	1200	135	0	100
Winter grains and safflower_11	0.62	4-5	165	0	10000	1200	135	0	100
Winter grains and safflower_12	1.23	3-5	165	0	10000	1200	135	0	100
Winter grains and safflower_13	0.34	4-5	165	0	10000	1200	135	0	100
Winter grains and safflower_14	1.22	3-5	165	0	10000	1200	135	0	100
Winter grains and safflower_15	1.58	3-5	165	0	10000	1200	135	0	100