Urban Imperviousness and Urban Runoff Pollutants Analysis:

ArcGIS 10.3 and BASINS 4.1 PLOAD Model

Department of Research and Analysis

2015 ESRI UC, San Diego, CA

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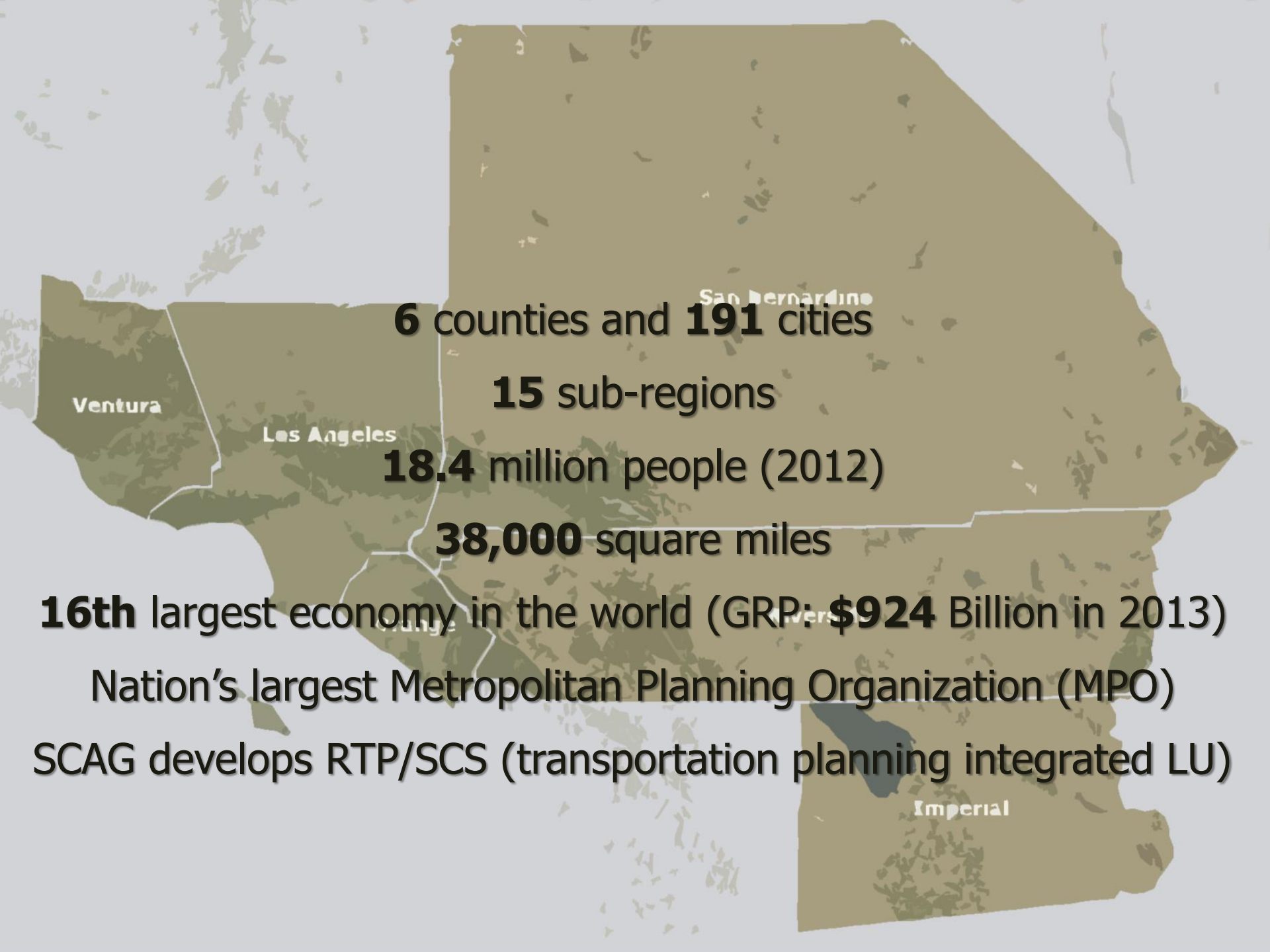
SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS
50 YEARS

Content

- What is SCAG?
- Research Intention
- Theoretical Background
- Methodology
- Case Demonstration
- Next Steps

What is SCAG?

SCAG Region
San Francisco
Los Angeles
San Diego
Phoenix
Chicago
New York
Philadelphia
Dallas
San Antonio
Houston



6 counties and **191** cities

15 sub-regions

18.4 million people (2012)

38,000 square miles

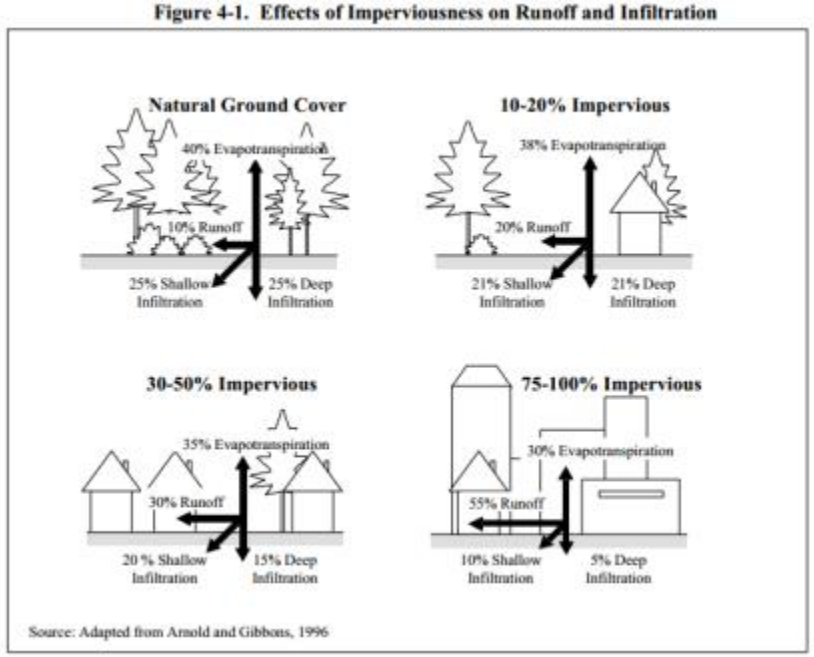
16th largest economy in the world (GRP: **$924** Billion in 2013)

Nation's largest Metropolitan Planning Organization (MPO)

SCAG develops RTP/SCS (transportation planning integrated LU)

Research Intention

- Urbanization, Imperviousness, and Urban Run-off Pollutants
  - Non-point source (NPS) pollutants from urban run-off, hard to monitor, exert significant impacts on watershed environment
  - Many local jurisdictions have concerns about the water quality control within their administrative boundary
  - Urbanization changes land use pattern, which is related to the urban imperviousness pattern and NPS spatial distribution



Input Data

- Available Data
  - **Hydrologic Units**: Watershed Boundary Dataset (WBD) from USGS and USDA
  - **Land Use**: land use data from 197 jurisdictions within SCAG region and future year scenarios
  - **Climate Zone**: 30-Year Annual Precipitation Dataset from USDA (1981-2010)

Theoretical Background

- The imperviousness as an indicator is commonly used as benchmarks in local, watershed, and regional planning efforts.
- Predicted stormwater loads are highly sensitive to land use designations and their associated EMC estimates (Park and Stemstrom, 2008).
- EMCs were developed by the EPA's Nationwide Urban Runoff Program (NURP) (1983) to serve as a national measures of the magnitude of urban runoff, specifically pollutant loadings

What is EMC?

- Event Mean Concentration (EMC)
  - An EMC is defined as the total constituent mass discharge divided by the total runoff volume (EPA 1983)
  - EMC table is developed by water resource engineers, based on values available from the literature, or it can be developed based on analysis of watershed storm water monitoring data

EMC Tables

Source: Review of Published Export Coefficient and Event Mean Concentration (EMC) Data – Jeff P. Lin

Table 1
Mean, Range, and Sample Size of all TP and TN Export Coefficients[1]

Land Use	TP and TN Export Coefficients (kg/ha/yr)					
	Mean		Range		Sample Size	
	TP	TN	TP	TN	TP	TN
Forested	.236	2.86	.019 - .830	1.38 - 6.26	26	11
Row Crops	4.46	16.09	.26 - 18.6	2.1 - 79.6	26	26
Non Row Crops	1.08	5.19	.10 - 2.90	.97 - 7.82	13	10
Pasture	1.50	8.65	.14 - 4.90	1.48 - 30.85	14	13
Feedlot/Manure Storage	300.7	3110.7	21.28 – 795.20	680.5 - 7,979.9	13	7
Mixed Agriculture	1.134	16.53	.08 - 3.25	2.82 - 41.50	20	21
Urban	1.91	9.97	.19 - 6.23	1.48 - 38.47	23	19

[1] Adapted from Reckhow et al. (1980).

Table 2
General TP and TN Export Coefficients

Land Use	Nutrient Export Coefficients (kg/ha/yr)		
	TP	TN, Eastern U.S.	TN, Western U.S.
Urban	1.0	5.0	2.5
Rural/Agriculture	0.5	5.0	2.0
Forest	0.05-0.1	3.0	1.0

[1] Adapted from Rast and Lee (1978).

Table 11
EMCs of Select Constituents Measured During the 1997-98 Storm Season for Various Urban Land Uses in Los Angeles County, CA[1]

Land Use	Event Mean Concentration (mg/l)				
	NO_3+NO_2	TKN	NH_3	TP	TSS
High-density residential	0.38	2.27	0.29	0.28	81.54
Light industrial	0.48	3.09	0.38	0.50	404.39
Vacant	0.91	0.72	0.11	0.13	96.86
Retail/commercial	0.65	1.67	0.30	0.40	48.80
Multi-family residential	0.27	1.50	0.39	0.13	30.90
Mixed residential	0.44	2.23	0.46	0.25	65.18

[1] Adapted from Los Angeles County Stormwater Monitoring Report: 1998-1999).

Table 3
Ranges of Measured TP and TN Export Coefficients for Various Land Uses[1]

Land Use	Range of TP and TN Coefficients (kg/ha/yr)	
	TN	TP
Rural cropland	2.1 - 79.6	0.06 - 2.9
Idle land	0.5 - 6.0	0.05 - 0.25
Forest	1.0 - 6.3	0.007 - 0.88
Pasture	3.2 - 14	0.05 - 0.6
Manure storage	4 - 13	0.8 - 2.9
Feedlots	100 - 1600	10 - 620

Table 12
EMCs of Select Constituents Measured for Various Land Uses in Central and South Florida)[1]

Land Use	Event Mean Concentration (mg/l)			
	TN	TP	TSS	BOD
Low-density residential	1.77	0.18	19.10	4.40
Single family residential	2.29	0.30	27.00	7.40
Multi-family residential	2.42	0.49	71.70	11.00
Low-intensity commericial	1.18	0.15	81.00	8.20
High-intensity commercial	2.83	0.43	94.30	7.20
Industrial	1.79	0.31	93.90	9.60
Highway	2.08	0.34	50.30	5.60
Pasture	2.48	0.476	94.3	5.1
Citrus	2.05	0.14	16.3	2.55
Row crops	2.68	0.562		
General agriculture	2.32	0.344	55.3	3.8
Open space	1.25	0.053	11.1	1.45
Mining	1.18	0.15	93.94	9.64
Wetland	1.6	0.19	10.2	4.63
Open water/lake	1.25	0.11	3.1	1.6

[1] Adapted from Harper, H. H. (1998).

EMC Tables (Cont.)

Nationwide EMC

Table 4-1. Median Event Mean Concentrations for Urban Land Uses

Pollutant	Units	Residential		Mixed		Commercial		Open/ Non-Urban	
		Median	COV	Median	COV	Median	COV	Median	COV
BOD	mg/l	10	0.41	7.8	0.52	9.3	0.31	--	--
COD	mg/l	73	0.55	65	0.58	57	0.39	40	0.78
TSS	mg/l	101	0.96	67	1.14	69	0.85	70	2.92
Total Lead	µg/l	144	0.75	114	1.35	104	0.68	30	1.52
Total Copper	µg/l	33	0.99	27	1.32	29	0.81	--	--
Total Zinc	µg/l	135	0.84	154	0.78	226	1.07	195	0.66
Total Kjeldahl Nitrogen	µg/l	1900	0.73	1288	0.50	1179	0.43	965	1.00
Nitrate + Nitrite	µg/l	736	0.83	558	0.67	572	0.48	543	0.91
Total Phosphorus	µg/l	383	0.69	263	0.75	201	0.67	121	1.66
Soluble Phosphorus	µg/l	143	0.46	56	0.75	80	0.71	26	2.11

COV: Coefficient of variation
Source: Nationwide Urban Runoff Program (US EPA 1983)

Local EMC

Table 4-9. Cumulative Event Mean Concentrations 1994-2000 Storm Season

GROUP	Constituent	Unit	High Density Single Family Residential	Light Industrial	Vacant	Retail/ Commercial	Multi-family Residential	Transportation	Education	Mixed Residential
GENERAL MINERALS	Dissolved Phosphorus	mg/ℓ	0.29	0.28	0.06	0.30	0.16	0.36	0.27	0.20
	Kjeldahl-N	mg/ℓ	2.80	3.07	0.81	3.37	1.86	1.81	1.62	2.70
	NH3-N	mg/ℓ	0.36	0.48	0.08	0.91	0.38	0.23	0.26	0.58
	Nitrate-N	mg/ℓ	1.04	0.86	1.11	0.58	1.73	0.75	0.63	0.71
	Nitrite-N	mg/ℓ	0.09	0.09	0.05	0.14	0.08	0.09	0.08	0.10
	Suspended Solids	mg/ℓ	104.65	229.37	164.68	67.40	46.35	75.35	103.02	69.06
	Total Phosphorus	mg/ℓ	0.39	0.44	0.11	0.41	0.19	0.44	0.31	0.26
HEAVY METALS (DISSOLVED)	Dissolved Cadmium	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Chromium	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Copper	µg/ℓ	8.44	20.22	n/m	14.60	6.75	32.68	12.80	11.52
	Dissolved Lead	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Mercury	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Nickel	µg/ℓ	n/m	4.85	n/m	n/m	n/m	3.73	n/m	n/m
	Dissolved Selenium	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Silver	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Zinc	µg/ℓ	39.11	460.19	n/m	164.12	75.36	203.89	65.97	125.83
HEAVY METALS (TOTAL)	Total Cadmium	µg/ℓ	n/m	n/m	n/m	0.71	n/m	1.05	n/m	n/m
	Total Chromium +6	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Total Copper	µg/ℓ	15.30	31.04	9.12	34.77	12.23	51.86	21.49	17.33
	Total Lead	µg/ℓ	9.59	14.87	n/m	11.53	5.13	9.08	4.53	8.70
	Total Mercury	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Total Nickel	µg/ℓ	n/m	8.92	n/m	6.71	n/m	5.76	4.65	n/m
	Total Selenium	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Total Silver	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Total Zinc	µg/ℓ	80.35	565.60	38.81	238.53	134.88	279.45	123.69	184.85
MISCELLANEOUS	Cyanide	mg/ℓ			n/m					n/m
										n/m
										n/m
										n/m

Source: Los Angeles County 1994-2000 Integrated Receiving Water Impacts Report

Research Questions and Purpose

- How the spatial distribution of imperviousness will effect the NPS-pollutants distribution (within different land use scenarios)?
- What is the impact of environmental results (pollutants load) on environmental justice population?
- The purpose of the study is to assess our land use planning policies.

Methodology

- Using ArcGIS 10.3 and BASINS 4.1-PLOAD model testing on Orange County land use data
- Intro of BASINS and PLOAD
  - Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) is a geographic information system based tool developed by EPA's Office of Water to help states more efficiently target and evaluate water-bodies that are not meeting water quality standards.
  - PLOAD (Pollutant Loading Estimator): estimates NPS of pollution on **an annual average basis**

Model Selection: Simple (EMC) Method

- The Simple Method Model is applied to estimate the pollutant exporting from urban development sites and is limited to small drainage areas of less than one square mile.
  - Two Equations in the Model:

$$Rvu = 0.05 + (0.009 * Iu)$$

- Rvu = Runoff Coefficient for land use type u,
- Iu = Percent Imperviousnes

$$Lp = \Sigma u(P* Pj*Rvu*Cu*Au*2.72/12)$$

- Lp = Pollutant Load, lbs
- P = Precipitation, inches/year
- Pj = Ratio of storms producing runoff (default = 0.9)
- Cu = Event Mean Concentration for land use u, miligrams/liter
- Au = Area of Land use type u, acres

- Export Coefficient (the areal export coefficient model) is provided for agricultural and undeveloped land uses or larger watersheds for which the Simple Method may not apply.

Input Variables

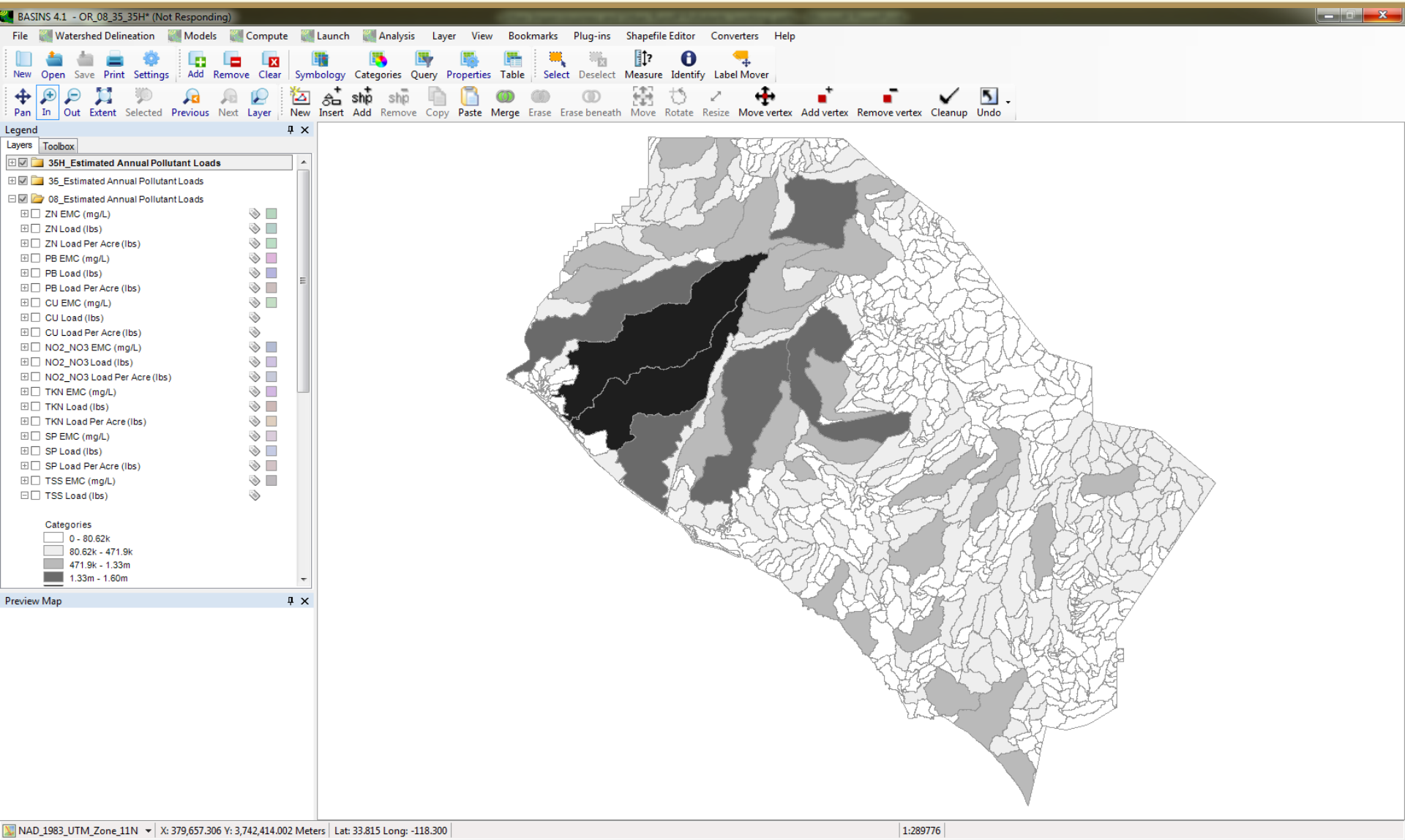
- **Annual Average Precipitation Data (1981-2010)**
  - From USGS
  - Raster file
- **SCAG Land Use Data**
  - 2008 and 2035 RTP/SCS Scenarios (Case I)
  - 2012 and 2040 Scenario Planning Model (SPM) Land Use Level (Case II)
- **Percent Imperviousness for Land Use**
- **EMC for Land Use**

Output Data

- Total Phosphorus (TP)
  - Pollutant Load by acre (annual load per acre in lbs)
  - Sources of phosphorus include soil and rocks, wastewater treatment plants, runoff from fertilized lawns and cropland, runoff from animal manure storage areas, disturbed land areas, drained wetlands, water treatment, decomposition of organic matter, and commercial cleaning preparations.

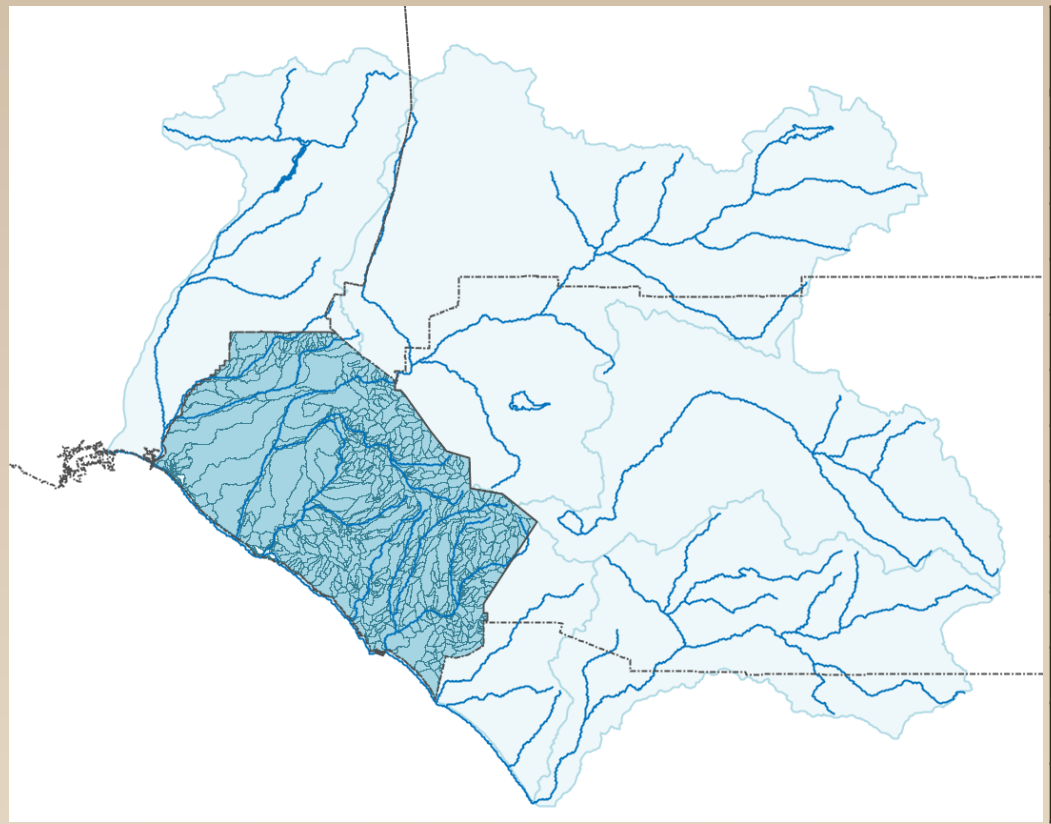
Collecting Algae Samples for Testing

BASINS 4.1-PLOAD



Case Demonstration I

- Drainage Catchments within Watersheds of Orange County



LU Type Correspondence Table

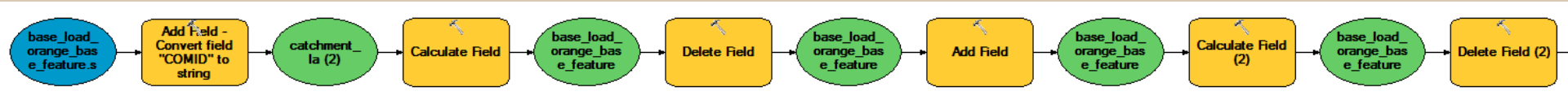
Land Development Type	Value	DEV_TYPE
Urban Center	1	Urban Cent
Urban Residential	2	Urban Resi
Urban Employment	3	Urban Empl
City Center	4	City Cente
City Residential	5	City Resid
City Employment	6	City Emplo
Town Center	7	Town Cente
Town Residential	8	Town Resid
Town Employment	9	Town Emplo
Suburban Center	10	Suburban C
Suburban Residential	11	Suburban R
Suburban Employment	12	Suburban E
Rural	13	Rural

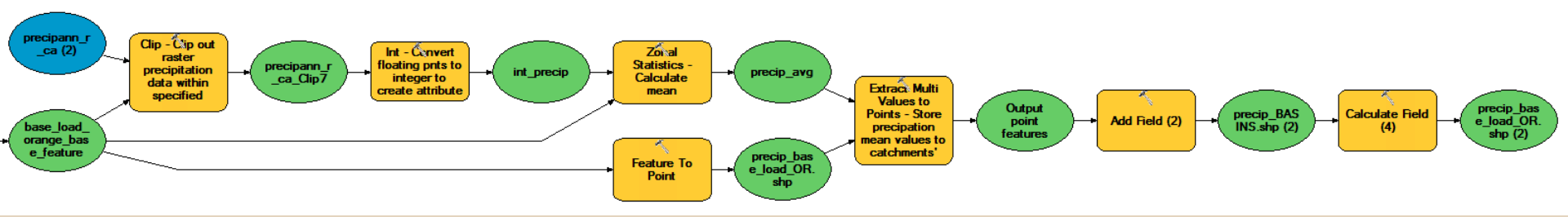
EMC Correspondence Table based on LU Development Types (units: mg/l)

Value	DEV_ TYPE	IMP_ RATE	BOD	COD	TSS	TP	SP	TKN	NO2/ NO3	CU	PB	ZN
1	Urban Cent	64%	7.8	65	67	0.263	0.056	1.288	0.558	0.027	0.114	0.154
2	Urban Resi	64%	10	73	101	0.383	0.143	1.9	0.736	0.033	0.144	0.135
3	Urban Empl	50%	9.3	57	69	0.201	0.08	1.179	0.572	0.029	0.104	0.226
4	City Cente	50%	7.8	65	67	0.263	0.056	1.288	0.558	0.027	0.114	0.154
5	City Resid	50%	10	73	101	0.383	0.143	1.9	0.736	0.033	0.144	0.135
6	City Emplo	50%	9.3	57	69	0.201	0.08	1.179	0.572	0.029	0.104	0.226
7	Town Cente	49%	7.8	65	67	0.263	0.056	1.288	0.558	0.027	0.114	0.154
8	Town Resid	49%	10	73	101	0.383	0.143	1.9	0.736	0.033	0.144	0.135
9	Town Emplo	49%	9.3	57	69	0.201	0.08	1.179	0.572	0.029	0.104	0.226
10	Suburban C	49%	7.8	65	67	0.263	0.056	1.288	0.558	0.027	0.114	0.154
11	Suburban R	49%	10	73	101	0.383	0.143	1.9	0.736	0.033	0.144	0.135
12	Suburban E	49%	9.3	57	69	0.201	0.08	1.179	0.572	0.029	0.104	0.226
13	Rural	37%	0	40	70	0.121	0.026	0.965	0.543	0	0.03	0.195

Incorporate 30-Y Annual Precipitation Data (processing)

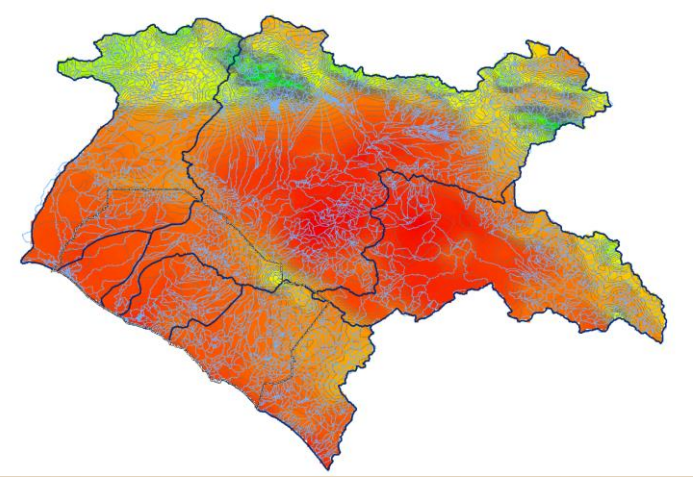
- Utilize ModelBuilder function in ArcGIS to calculate average annual precipitation for each zone

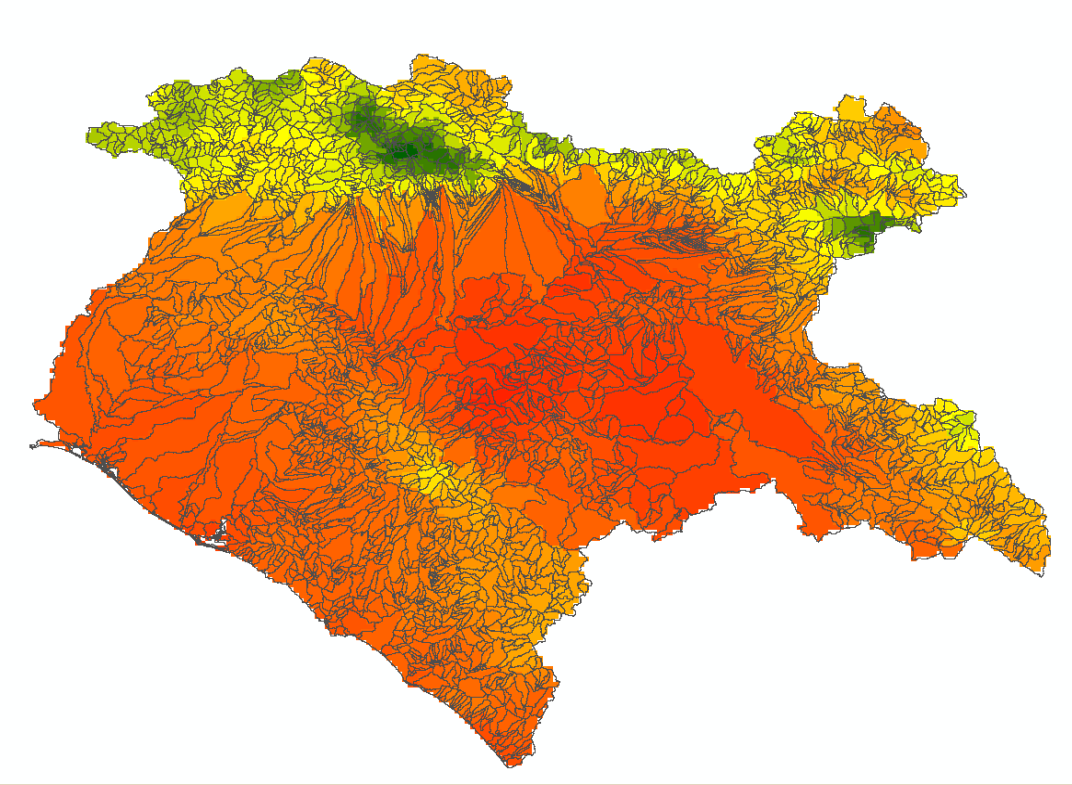




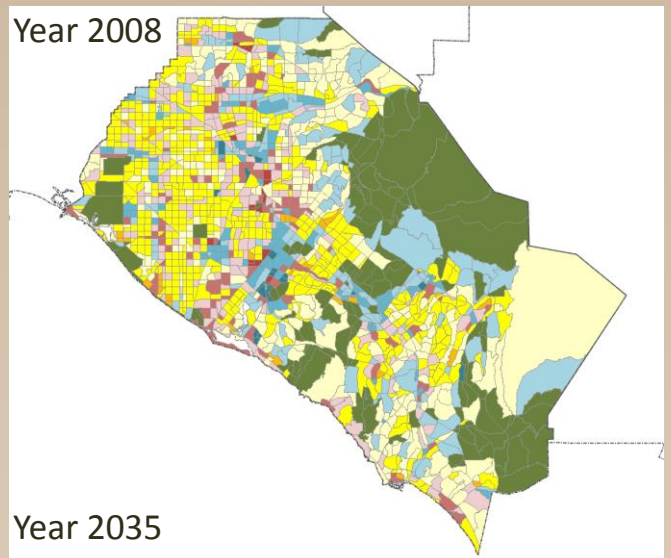
Incorporate 30-Y Annual Precipitation Data (result)

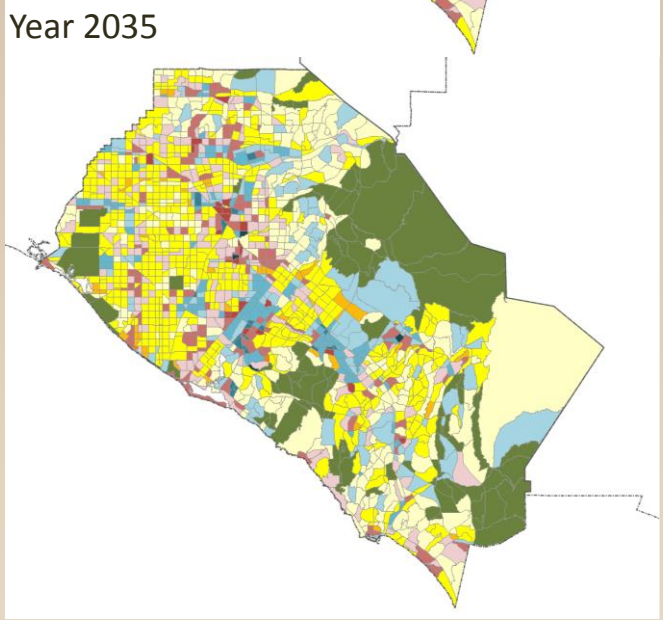
- Annual Precipitation from 1981 to 2010 within OR County watersheds by drainage catchments



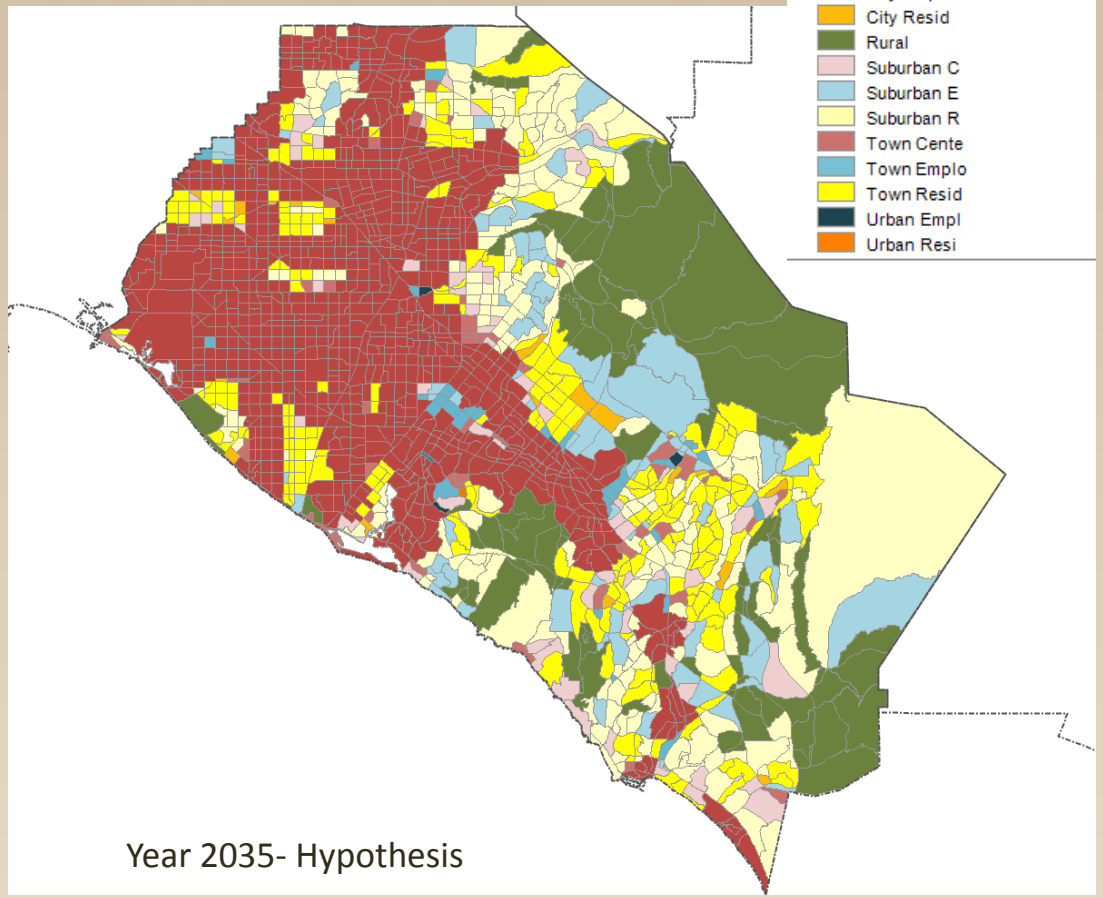


LU Development Patterns in 2008 and 2035 Scenario (input)



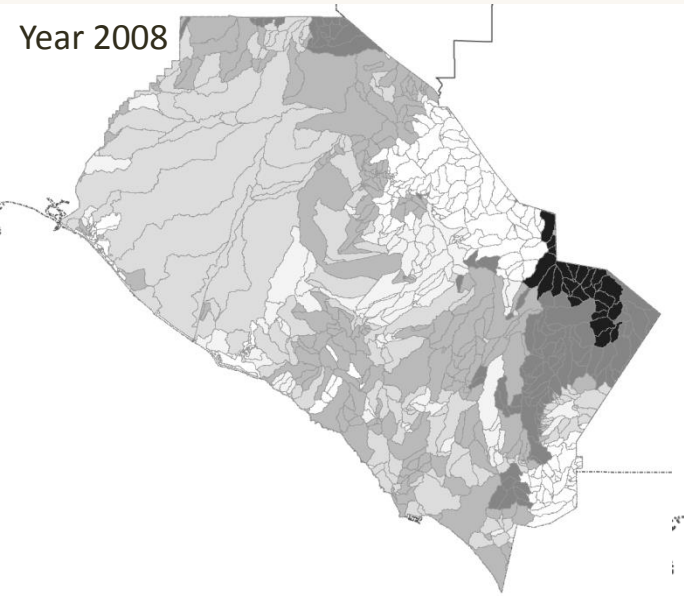


2035 Land Use Hypothesis:
Increasing mixed-use type within/nearby HQTC/HQTA

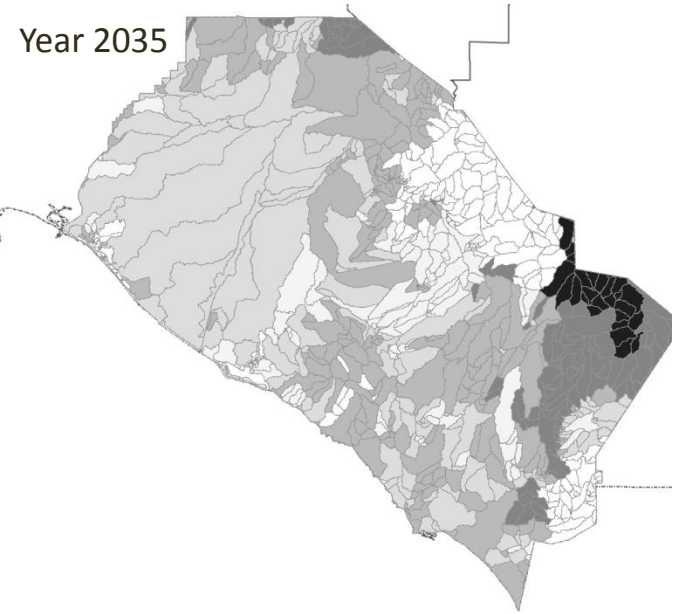


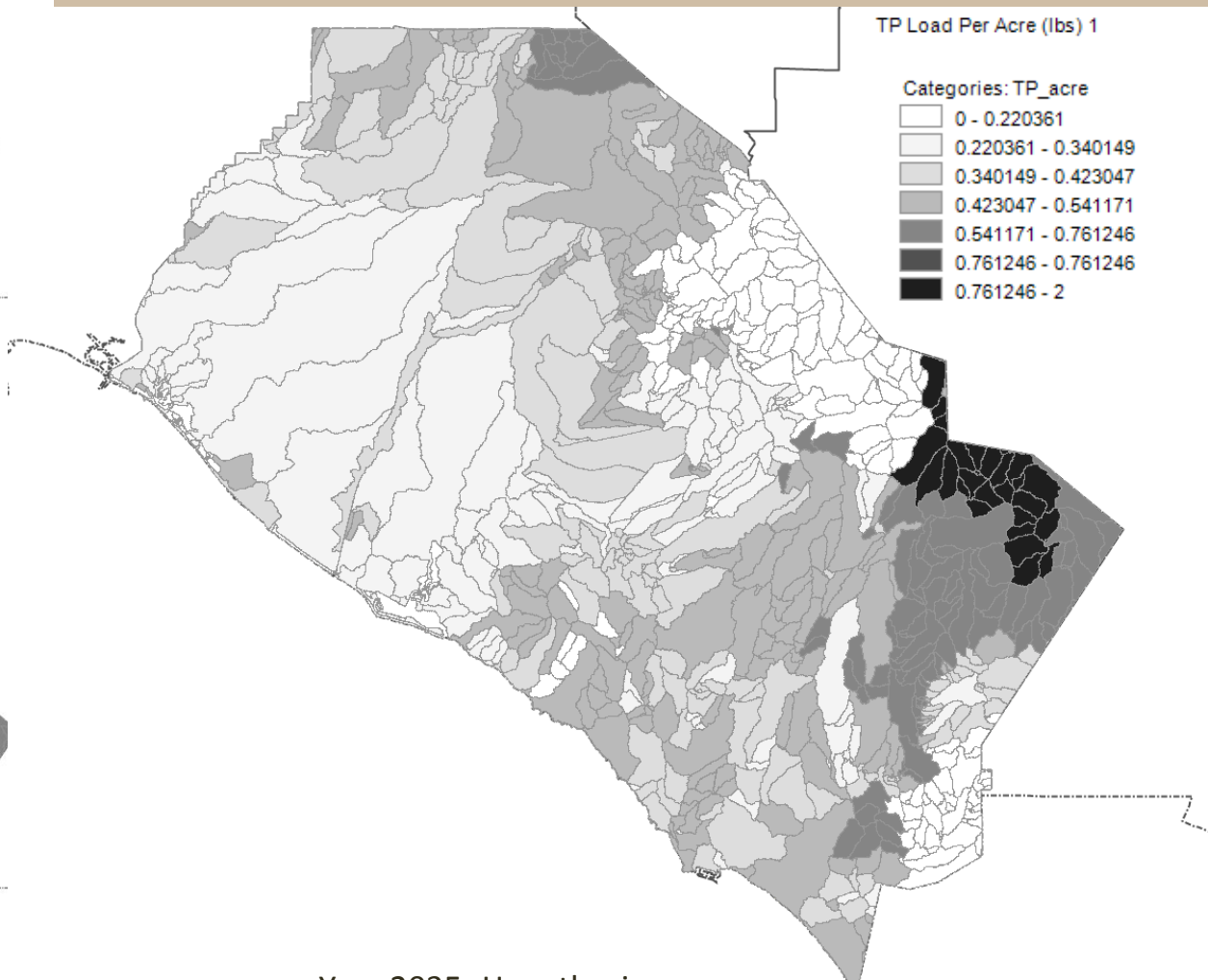
Total Phosphorus Load by Acre Distribution Pattern in 2008 and 2035 (output)

Year 2008



Year 2035





Year 2035- Hypothesis

Case Demonstration II

Orange County Canvas from Scenario Planning Model (Base Load)			
built_form	Imp %	LA County DWP LU	Total Phosphorus (TP)
pt__city_commercial	50%	Ret/Com	0.41
pt__city_mixed_use	50%	Ret/Com+MFR	0.30
pt__city_residential	50%	MFR	0.19
pt__high_intensity_activity_center	57%	Ret/Com+LI+MFR+trans+edu	0.36
pt__industrial_focus	49%	LI	0.44
pt__industrialofficeres_mixed_high	49%	LI+COM	0.42
pt__industrialofficeres_mixed_low	49%	LI+COM	0.42
pt__large_lot_residential_area	49%	Mixed Residential	0.26
pt__low_density_employment_park	50%	Ret/Com+LI	0.42
pt__low_intensity_retail_centered_nhood	49%	Ret/Com	0.41
pt__mid_intensity_activity_center	50%	Ret/Com+LI+SFR+trans+edu	0.40
pt__mixed_office_and_co[illegible]	49%	Ret/Com+LI	0.44
pt__neighborhood_low	49%	high density SFR	0.39
pt__neighborhood_residential	49%	Mixed Residential	0.26
pt__office_focus	49%	[illegible]	0.4[illegible]
pt__officeindustrial	49%	[illegible]	0.44
pt__residential_subdivision	52%	Mixed Residential	0.26
pt__retail_strip_mall_big_box	49%	Ret/Com	0.41
pt__rural_employment	[illegible]	Ret/Com	0.4[illegible]
pt__rural_ranchettes	37%	Vacant	0.11
pt__rural_residential	37%	Mixed Residential	0.26
pt__suburban_mixed_residential	49%	Mixed Residential	0.26
pt__suburban_multifamily	49%	MFR	0.19
pt__town_commercial	49%	Ret/Com	0.41
pt__town_mixed_use	49%	Ret/Com+Mixed Res	0.34
pt__town_residential	49%	Mixed Residential	0.26
pt__urban_commercial	50%	Ret/Com	0.41
pt__urban_residential	64%	high density SFR	0.39
pt__village_commercial	49%	Ret/Com	0.41
pt__village_mixed_use	49%	Ret/Com+LI+mixed res	0.37
pt__village_residential	49%	Mixed Residential	0.26

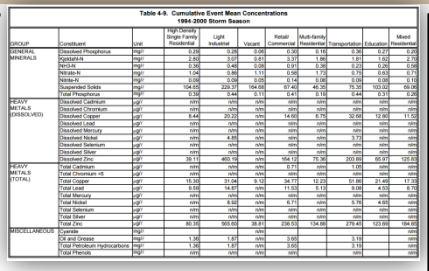


Table 4-9. Cumulative Event Mean Concentrations
1994-2000 Storm Season

GROUP	Constituent	Unit	High/Density Single-Family Residential	Light Industrial	Vacant	Retail/ Commercial	Multi-family Residential	Transportation	Education	Mixed Residential
GENERAL MINERALS	Dissolved Phosphorus	mg/l	0.29	0.28	0.06	0.30	0.16	0.36	0.27	0.20
	Kjeldahl-N	mg/l	2.82	3.07	0.81	3.37	1.86	1.61	1.62	2.73
	NH3-N	mg/l	0.36	0.46	0.08	0.91	0.36	0.23	0.26	0.56
	Nitrate-N	mg/l	1.04	0.86	1.11	0.58	1.73	0.75	0.63	0.73
	Nitrite-N	mg/l	0.09	0.08	0.05	0.14	0.08	0.08	0.08	0.10
	Suspended Solids	mg/l	104.02	229.37	164.08	87.42	46.35	75.35	103.02	69.06
	Total Phosphorus	mg/l	0.38	0.44	0.11	0.41	0.18	0.44	0.31	0.26
HEAVY METALS (DISSOLVED)	Dissolved Cadmium	µg/l	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Chromium	µg/l	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Copper	µg/l	8.44	20.22	n/m	14.92	6.75	32.68	12.86	11.52
	Dissolved Lead	µg/l	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Mercury	µg/l	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Nickel	µg/l	n/m	4.88	n/m	n/m	n/m	3.73	n/m	n/m
	Dissolved Selenium	µg/l	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Silver	µg/l	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Zinc	µg/l	38.11	465.19	n/m	164.12	75.36	220.80	66.97	125.63
HEAVY METALS (TOTAL)	Total Cadmium	µg/l	n/m	n/m	n/m	0.71	n/m	1.08	n/m	n/m
	Total Chromium VI	µg/l	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Total Copper	µg/l	15.30	31.04	8.12	34.77	12.23	61.66	21.49	17.33
	Total Lead	µg/l	5.58	14.87	n/m	11.55	5.18	8.08	4.93	8.73
	Total Mercury	µg/l	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Total Nickel	µg/l	n/m	8.32	n/m	6.71	n/m	5.74	4.85	n/m
	Total Selenium	µg/l	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Total Silver	µg/l	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Total Zinc	µg/l	80.35	565.60	38.81	236.53	134.86	279.40	122.09	184.85
MISCELLANEOUS	Cyanide	mg/l			n/m					n/m
	Oil and Grease	mg/l	1.36	1.87	n/m	3.55		3.19		n/m
	Total Petroleum Hydrocarbons	mg/l	1.36	1.87	n/m	3.55		3.19		n/m
	Total Phenols	mg/l	n/m	n/m	n/m	n/m		n/m		n/m

2012 RTP Development	
Development Type	Imp %
City Emp High Mix	50%
City Emp Low Mix	50%
City Res High Mix	50%
City Res Low Mix	50%
Neighborhood Emp High Mix	49%
Neighborhood Office Low Mix	49%
Neighborhood Res High Mix	49%
Neighborhood Res Low Mix	49%
Neighborhood Retail Low Mix	49%
Rural Low Mix	37%
Suburban Emp High Mix	49%
Suburban Industrial Low Mix	49%
Suburban Office Low Mix	49%
Suburban Res High Mix	49%
Suburban Res Low Mix	49%
Suburban Retail Low Mix	49%
Town Emp High Mix	49%
Town Emp Low Mix	49%
Town Res High Mix	49%
Town Res Low Mix	49%
Urban Core Emp High Mix	50%
Urban Core Emp Low Mix	50%
Urban Core Res High Mix	77%
Urban Core Res Low Mix	50%

Change of EMC table to local (nation -> local)

Change of geographical unit (catchment -> TAZ)

Change computation process in ArcGIS

Utilized LA County Department ob Public Works' Cumulative Event Mean Concentrations 1994-2000 Storm Season to calculate the Total Phosphorus (TP) for SPM base load of Orange County.

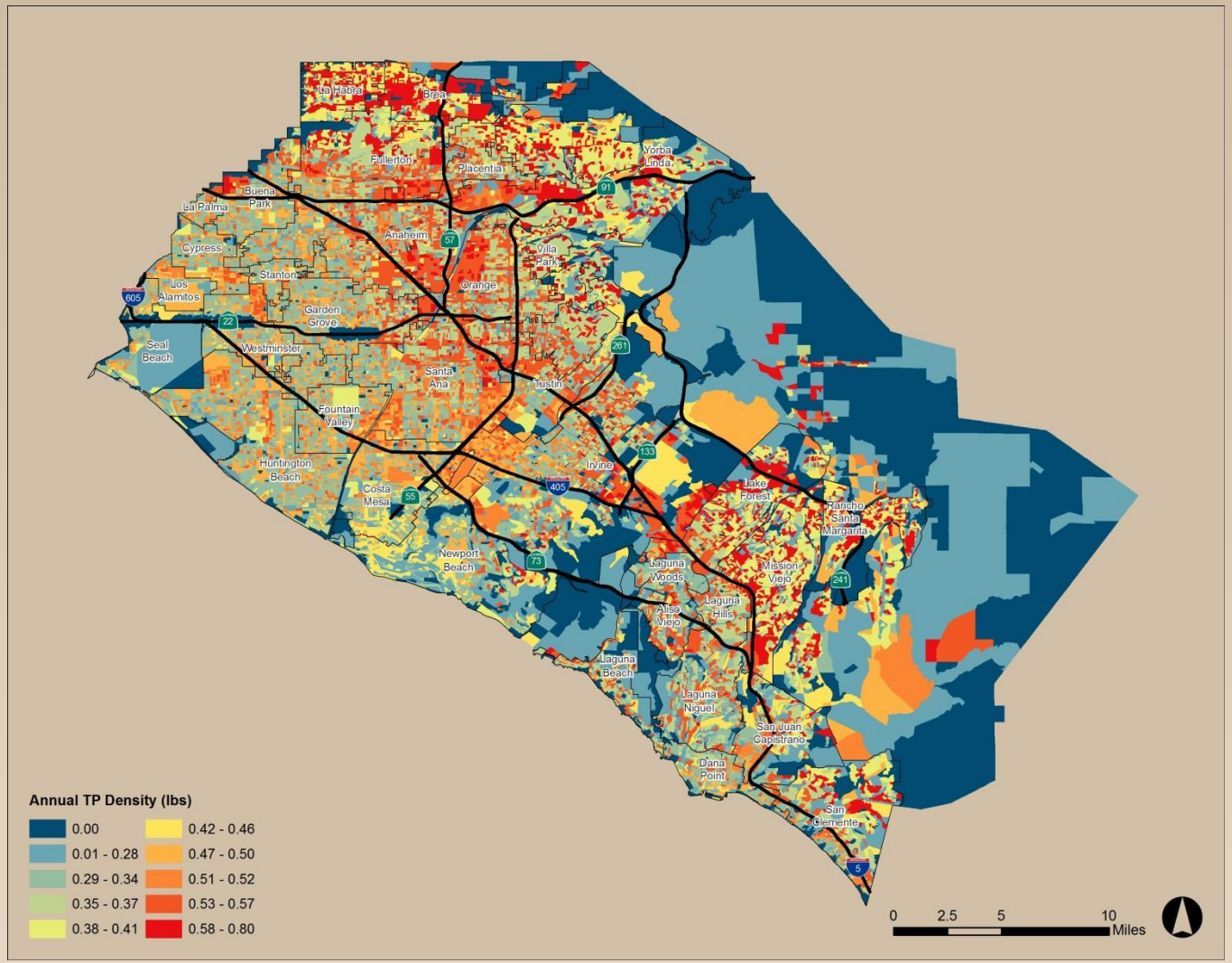
Method: combined multiple land use types and calculated the average of

Utilized the impervious rate (%) identified in 2012 RTP development type to re-create impervious rate for the SPM base load.

Method: combined multiple development types and calculated the average.

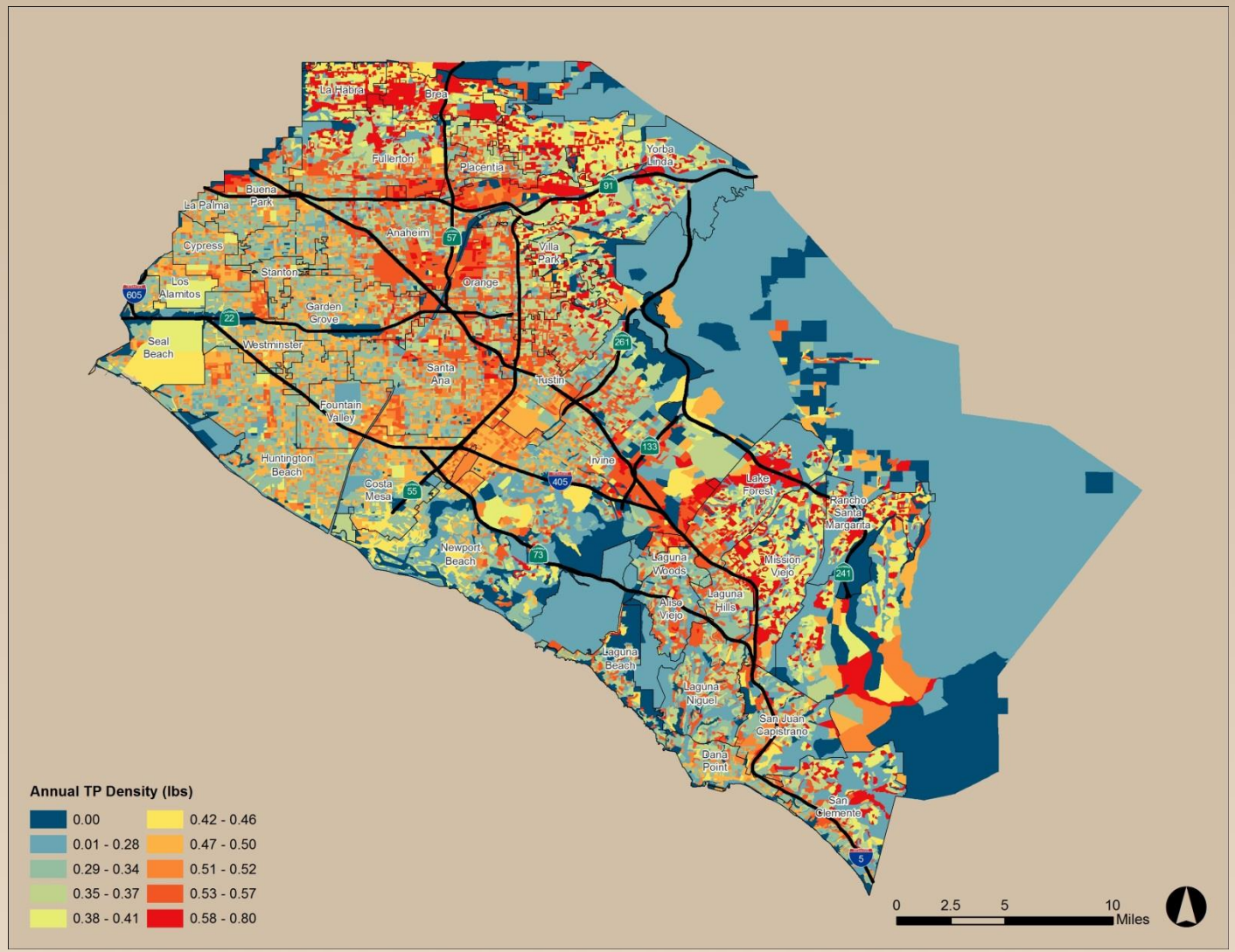
Total Phosphorus Load by Acre Distribution Pattern in 2012 (output)

Land Use	Avg TP
city_commercial	0.5183
city_mixed_use	0.1543
city_residential	0.2269
high_intensity_activity_center	0.4925
industrial_focus	0.5510
industrialofficeres_mixed_high	0.5127
industrialofficeres_mixed_low	0.5234
large_lot_residential_area	0.3505
low_density_employment_park	0.5358
low_intensity_retail_centered_nhood	0.5174
mid_intensity_activity_center	0.4914
mixed_office_and_rd	0.5176
neighborhood_low	0.4867
neighborhood_residential	0.3199
office_focus	0.5101
officeindustrial	0.5505
residential_subdivision	0.3446
retail_strip_mall_big_box	0.5102
rural_employment	0.4228
rural_ranchettes	0.1153
rural_residential	0.2753
suburban_mixed_residential	0.3209
suburban_multifamily	0.2345
town_commercial	0.4540
town_mixed_use	0.3808
town_residential	0.3043
urban_commercial	0.5437
urban_residential	0.5977
village_commercial	0.4993
village_mixed_use	0.4310
village_residential	0.3162

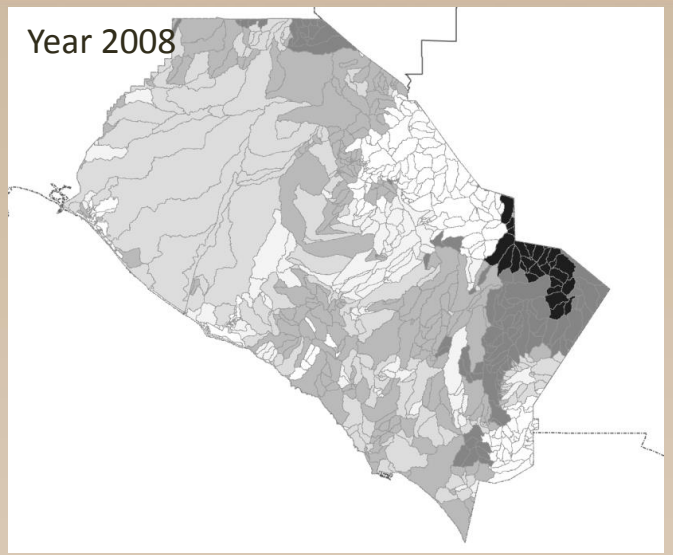


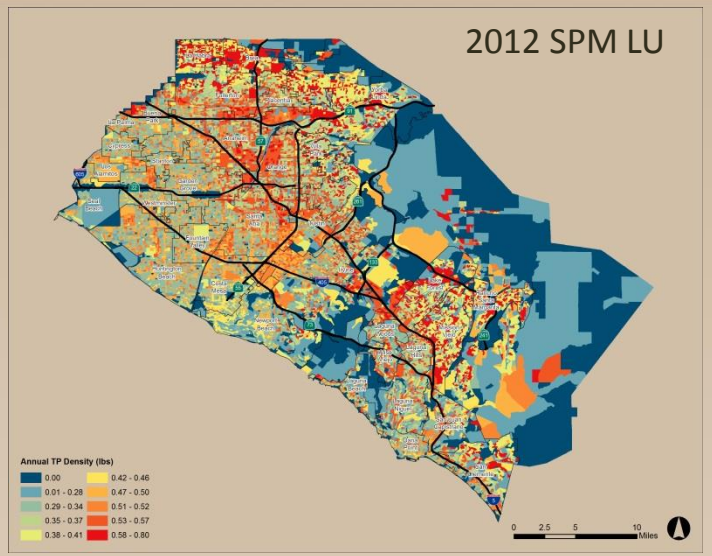
Total Phosphorus Load by Acre Distribution Pattern in 2040 (output)

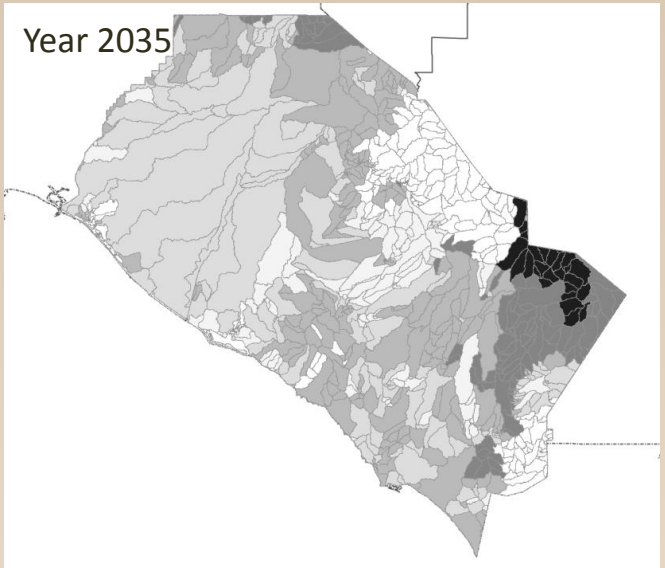
Land Use	Avg TP
campus_university	0.4215
city_commercial	0.4901
city_mixed_use	0.3344
city_residential	0.2356
high_intensity_activity_center	0.4943
industrial_focus	0.5494
industrialofficeres_mixed_high	0.5205
industrialofficeres_mixed_low	0.5187
institutional	0.5154
large_lot_residential_area	0.3510
low_density_employment_park	0.5463
low_intensity_retail_centered_nhood	0.5137
mid_intensity_activity_center	0.5013
military	0.4177
mixed_office_and_rd	0.5184
neighborhood_low	0.4782
neighborhood_residential	0.3221
office_focus	0.5100
officeindustrial	0.5460
parks_open_space	0.1155
residential_subdivision	0.3470
retail_strip_mall_big_box	0.5083
rural_employment	0.4273
rural_ranchettes	0.1202
rural_residential	0.2753
suburban_mixed_residential	0.3225
suburban_multifamily	0.2358
town_commercial	0.4993
town_mixed_use	0.4042
town_residential	0.3085
urban_commercial	0.5344
urban_mixed_use	0.5972
urban_residential	0.6380
village_commercial	0.5051
village_mixed_use	0.4491
village_residential	0.3145

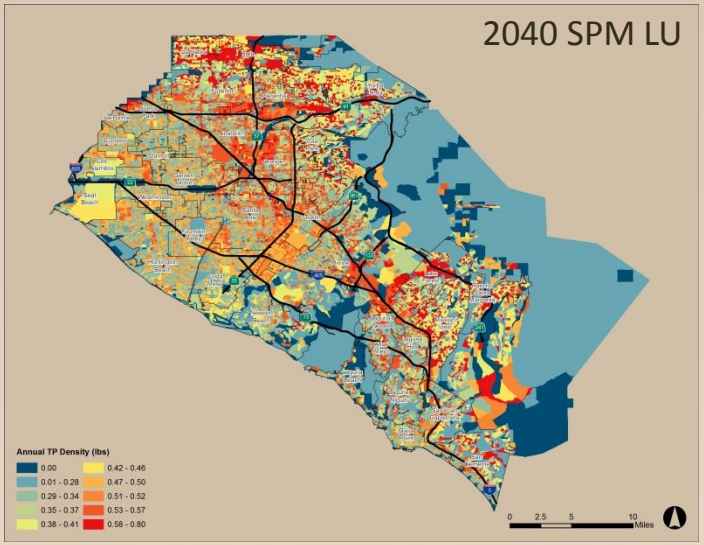


Comparison


Year 2008


2012 SPM LU
Annual TP Density (lbs)
0.00
0.01 - 0.28
0.29 - 0.34
0.35 - 0.37
0.38 - 0.41
0.42 - 0.46
0.47 - 0.50
0.51 - 0.52
0.53 - 0.57
0.58 - 0.80
0 2.5 5 10 Miles


Year 2035


2040 SPM LU
Annual TP Density (lbs)
0.00
0.01 - 0.28
0.29 - 0.34
0.35 - 0.37
0.38 - 0.41
0.42 - 0.46
0.47 - 0.50
0.51 - 0.52
0.53 - 0.57
0.58 - 0.80
0 2.5 5 10 Miles

Future Studies

- Refine the EMC table to better characterize the pollutant coefficients into SCAG region
- Display more type of pollutants and distribution
- Further analyzing urban runoff pollutant results with different land use types
- Assess the impact of transportation and land use policies on urban runoff pollutant
- Identify the impact of environmental results (pollutants load) on environmental justice population
- Frame Policy recommendations

Thank you!

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Southern California Association of Governments (SCAG)

Land Use and Environmental Planning Division

Research and Analysis Department

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

50 YEARS