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596A Capstone Proposal

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Mitigating Wastewater Odor Impacts Using Sensory and Modeled Observations

Presentation Overview

- Background
- Problem and Objective
    1. Collection System
    2. Treatment Plants
        - Previous Work and Proposed Methodology
- Anticipated Results
- Timeline
- References

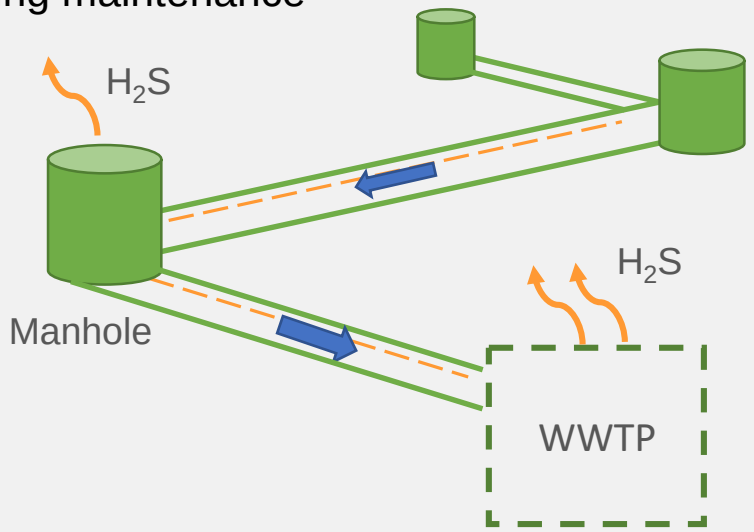
Odor Generation in Sewers

- Main cause of odor and corrosion problems in sewer systems is hydrogen sulfide (H_2S)
- Gas produced in sewers is a mixture of toxic and non-toxic gases due to the decomposition of organic wastes in sewage
- Sewer gas can contain nitrogen, oxygen, carbon dioxide, hydrogen sulfide, ammonia, and methane
- Foul odors can also be caused by organic gases such as Volatile Organic Compounds (VOCs)

Hydrogen Sulfide (H_2S) Production in Sewers

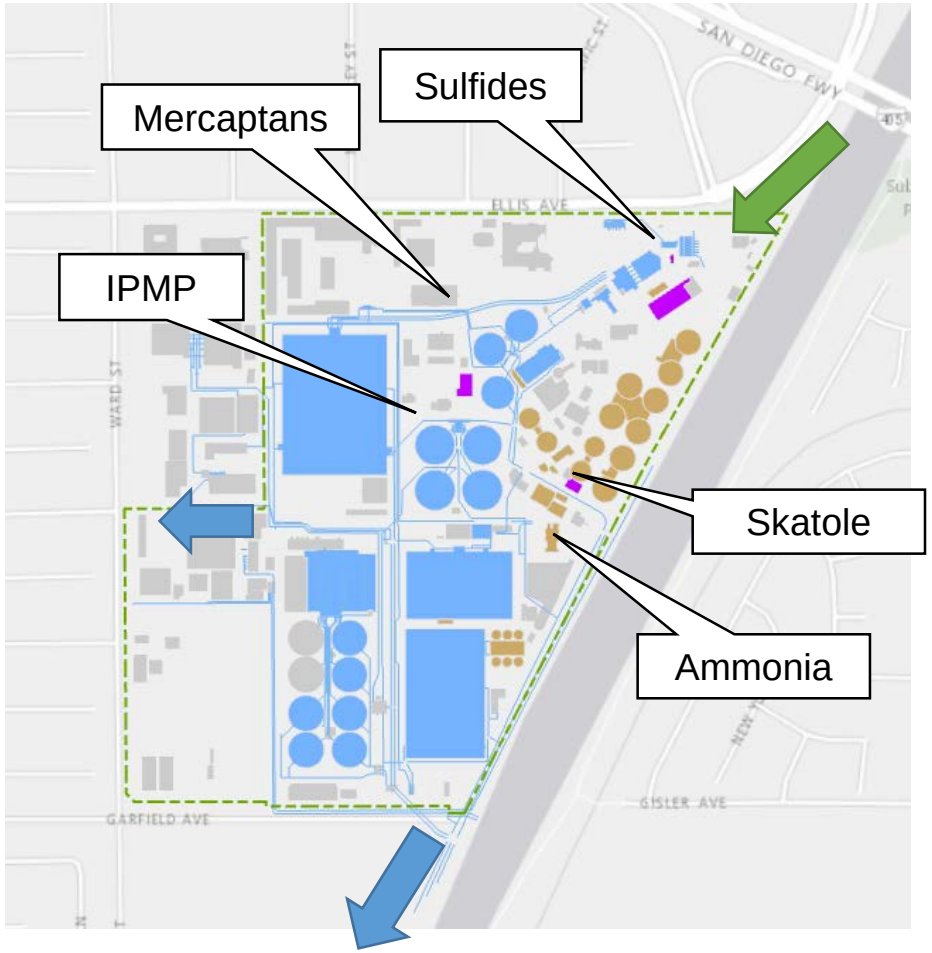
- Inorganic gas
- Detectable at low odor thresholds (.001 - .01 ppm)
- Rotten egg smell, does not easily disperse in the atmosphere
- Bacteria use up oxygen in decomposing organic matter
- Reduce sulfate (SO_4) to sulfides (SO_2)
- Sulfides can't be oxidized so they combine with hydrogen to create hydrogen sulfide (H_2S)

- Warm climates – higher wastewater temperature
- Sewers with flat grade/low slope (less than 2 feet/sec velocity)
- Long detention times
- Wastewater turbulence – drops, sharp bends, slope reductions in collection system
- H_2S odors can escape through unsealed manholes, vents, pump station wet wells, and during maintenance or construction activities
- Leads to pipe corrosion



Odor Emissions at Treatment Plants

- Plants have several interconnected mechanical, biological, and chemical processes that support the treatment of wastewater
- Wastewater at each stage differs in physical and chemical properties
- Two main processes in the plant
  - wastewater treatment
  - solids handling
- Odor control facilities – treat foul air from processes
- Different groups of air pollutants can be generated and emitted through inlet or outlet sources
- *Odors can mask each other*, making identification and quantitative determination of specific odorous compounds complex



Common Perceptions of Odor

Smelled like raw sewage for a few minutes

Smell reported earlier is back

..a stinky sludge smell

Strong sewer odor this morning

Found odor to be chemical-like

Unhealthy smell

"What did it smell like?"

Ammonia

Chlorine

Fecal/Sewage

Garbage

Moldy/Musty

Putrid/Rotten

Sewer Gas

Sour/Pungent

Rotten Eggs

Strong rotten egg smell by my home

Smell was bad past couple nights

Weird sewer smell in the neighborhood

Smell is nauseating and irritating to eyes

..very slight musty odor in the air

called regarding a skunk smell

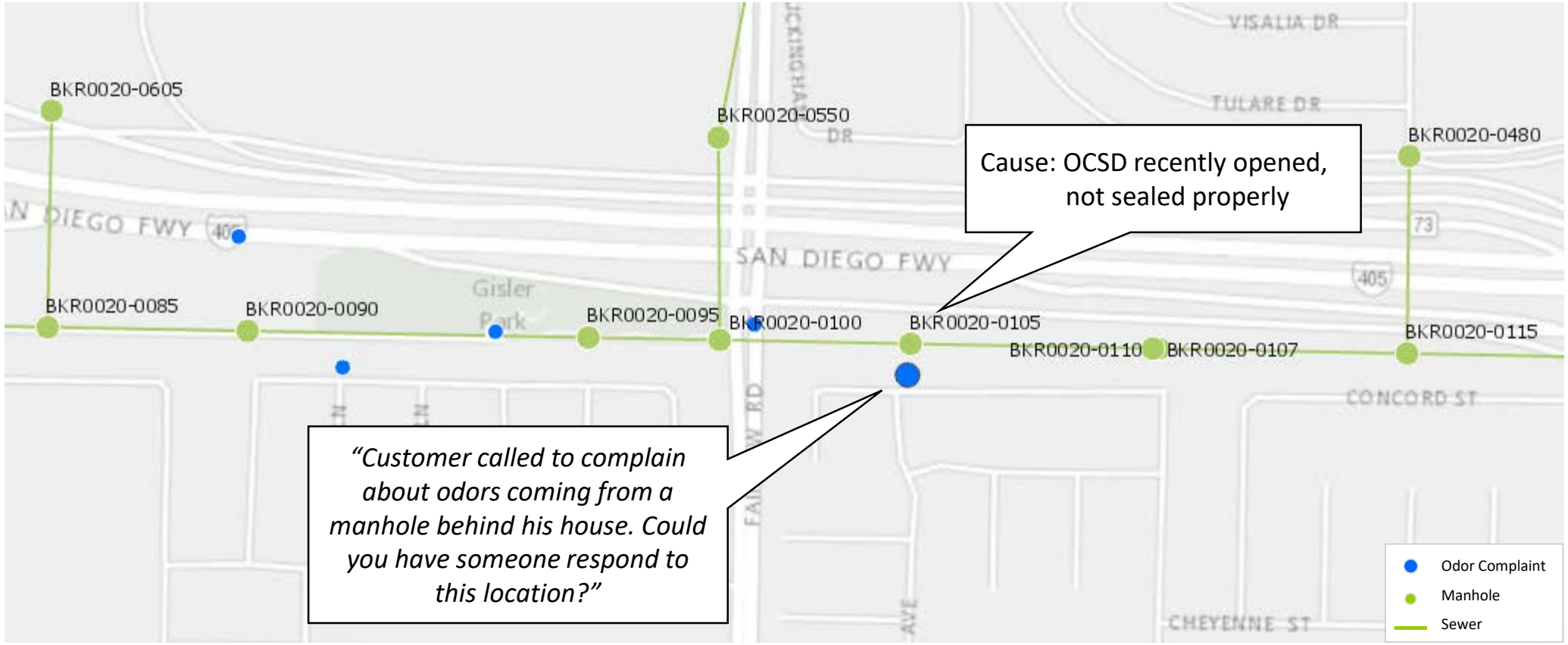
I don't know.. It just stinks

Wastewater Odors

Odor Category	Odor Characters	Chemical Compounds
Ammonia/Fishy	Ammonia Pungent Cat Urine Fishy	-Ammonia -2,4-Decadienal -2,4-Heptadienal -Trimethylamine
Oxidant/Chlorinous	Chlorinous	-Chlorine -Monochloramine -Dichloramine
Fecal/Sewery	Fecal Manure Sewery	-Indole -Skatole -Valeric Acid
Earthy/Moldy/Musty	Earthy/Musty Moldy	-Geosmin -2-Methylisoborneol -2,4,6-Trichloroanisole
Rancid/Putrid	Yeasty, Sour Milk, Rancid Fatty/Oily , Sweaty, Sour Cheese Putrid Decayed	 -Heptanal -Pyridine
Sulfide/Cabbage Garlic	Decaying Vegetation Rotten Eggs Garlicy, Canned Corn Marshy/Swampy Rotten Cabbage Skunk, Burnt Rubber Sulfidy Coffee Grounds	-Hydrogen Sulfide -Allyl mercaptan -Dimethylsulfide -Dimethyl trisulfide -Dimethyl disulfide -Methyl mercaptan

Source: (Burlingame et al., 2004)

Investigating Odor Complaints



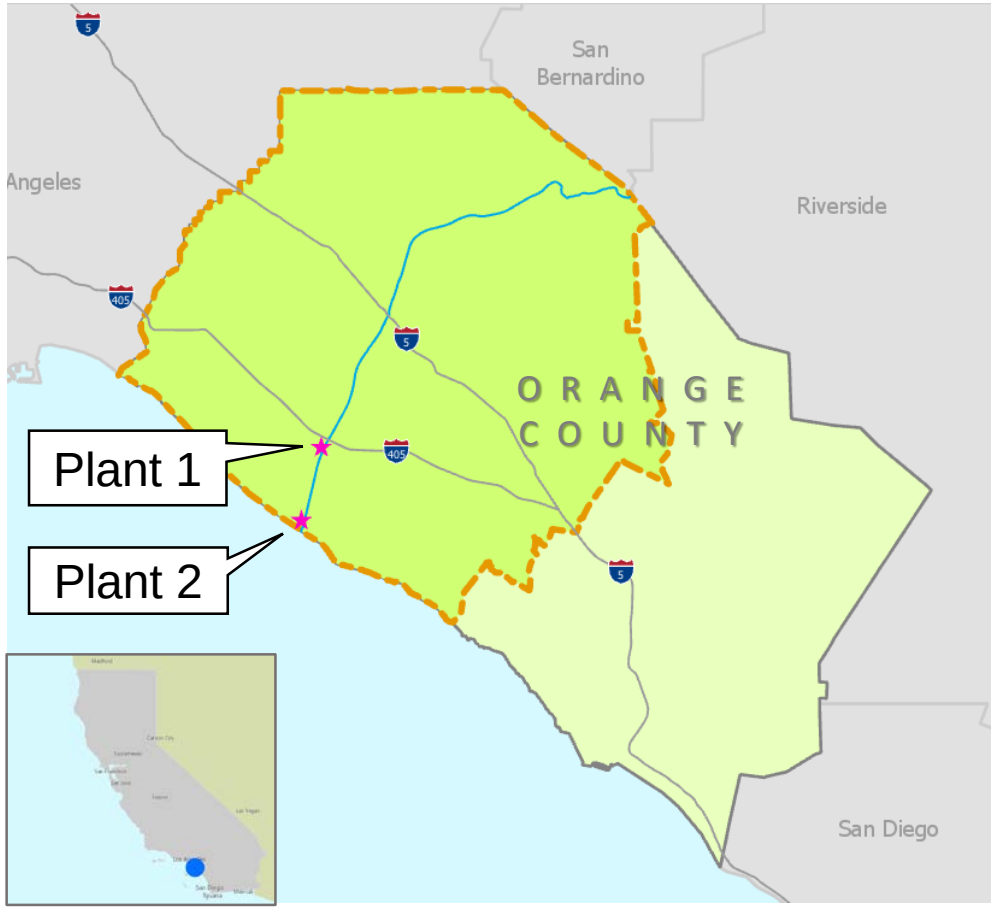
Area of Interest

- Orange County, CA
- Orange County Sanitation District (OCSD)
  - Regional wastewater agency
  - Serves 2.6 million people in central and northwest regions
  - 471 square-mile service area

  - Collection System
    - 400 miles of trunk sewers
    - 4640 manholes

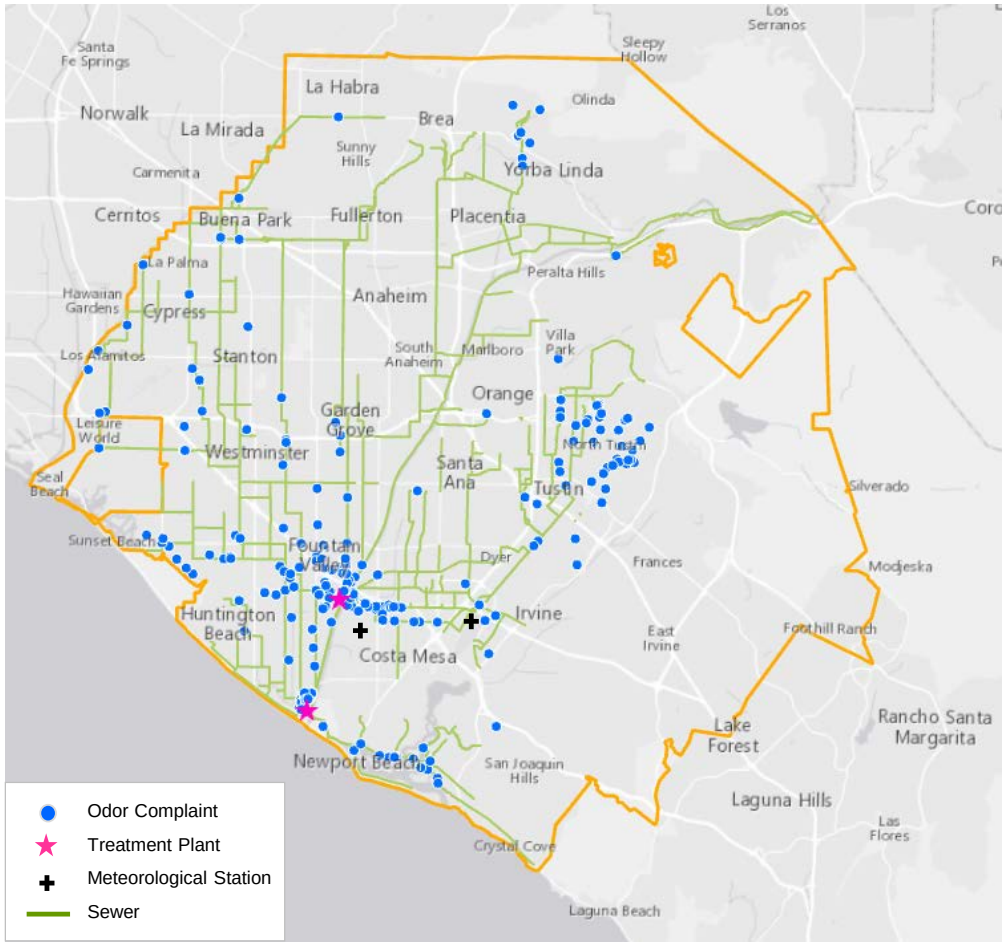
  - Reclamation Plant No. 1 – 97 MGD
    - *Fountain Valley, CA*

  - Treatment Plant Plant No. 2 – 103 MGD
    - *Huntington Beach, CA*



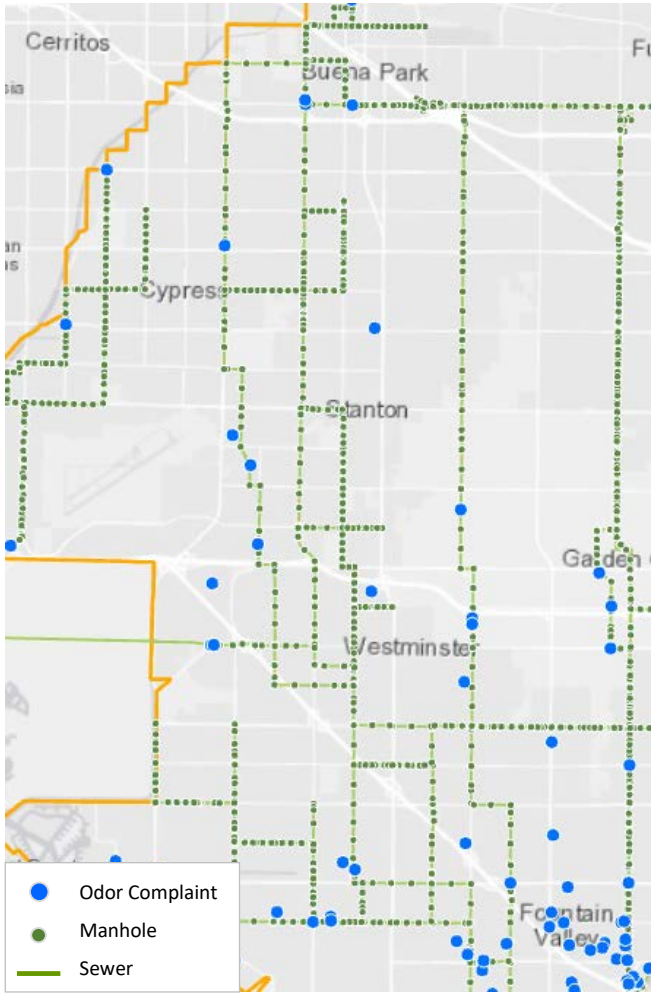
Odor Complaint Data

- OCSD Control Center at Plant No. 1 receives calls from residents in service area to report issues related to plant or sewer facilities
- 565 odor-related calls logged (2012 – 2017)
- A response is made depending on the location of the complaint:
  - Treatment plant: within 1 hour
  - Collection System: within 1 working day
- OCSD 5-year strategic plan outlines Level of Service (LOS) for Odor Control
  - 2015 LOS: 28 or less odor complaints attributed to OCSD

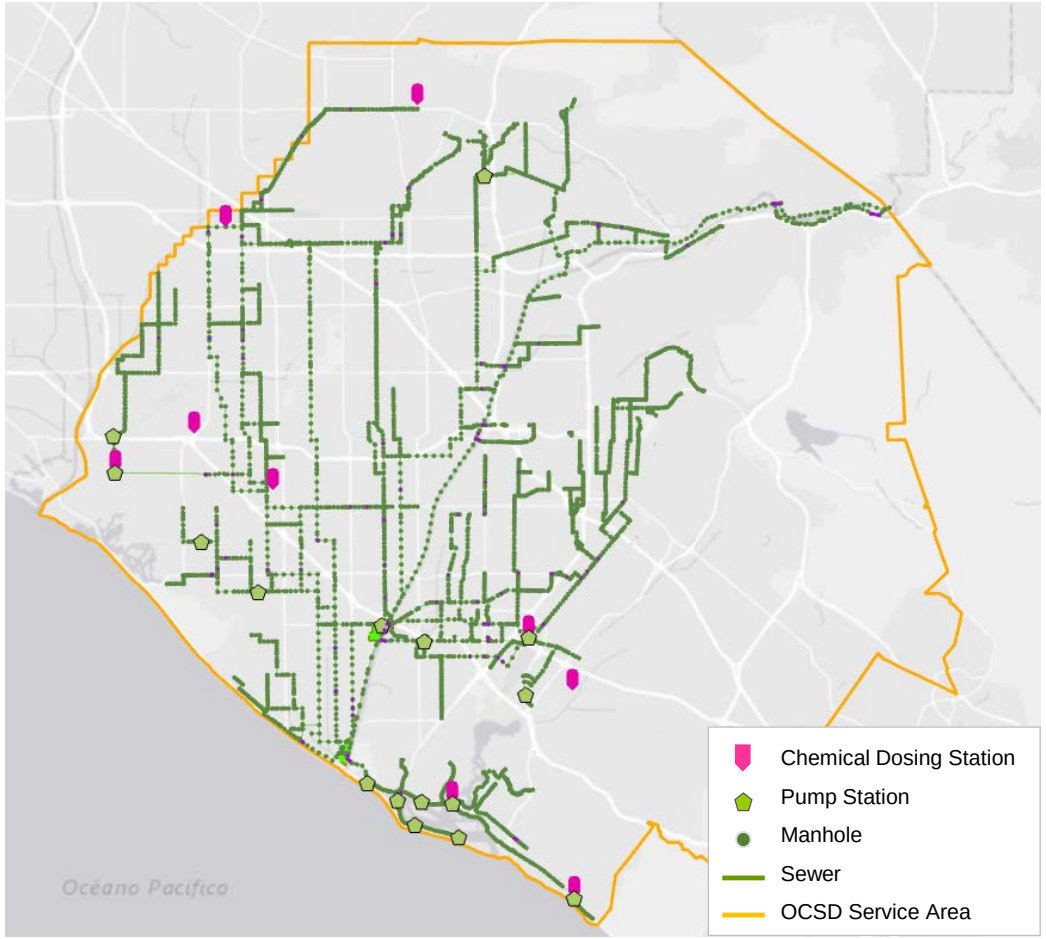


Odor Impact Assessment: Collection System

- Problem: Complaints are received from citizens within service area but may not be sourced from OCSD collection system assets
- Odor investigation can involve several actions:
  a) Review maps to determining if location of complaint is “near” OCSD sewer system or local sewer system
  b) Review historical complaints in the area
  c) Perform field assessment of all OCSD assets for odors within the vicinity of the complaint
  d) Refer complaint response to appropriate local sewer authorities (if non-OCSD source)
- Response time and mitigation may be delayed by prolonged information gathering or unnecessary field visits



Odor Impact Assessment: Collection System

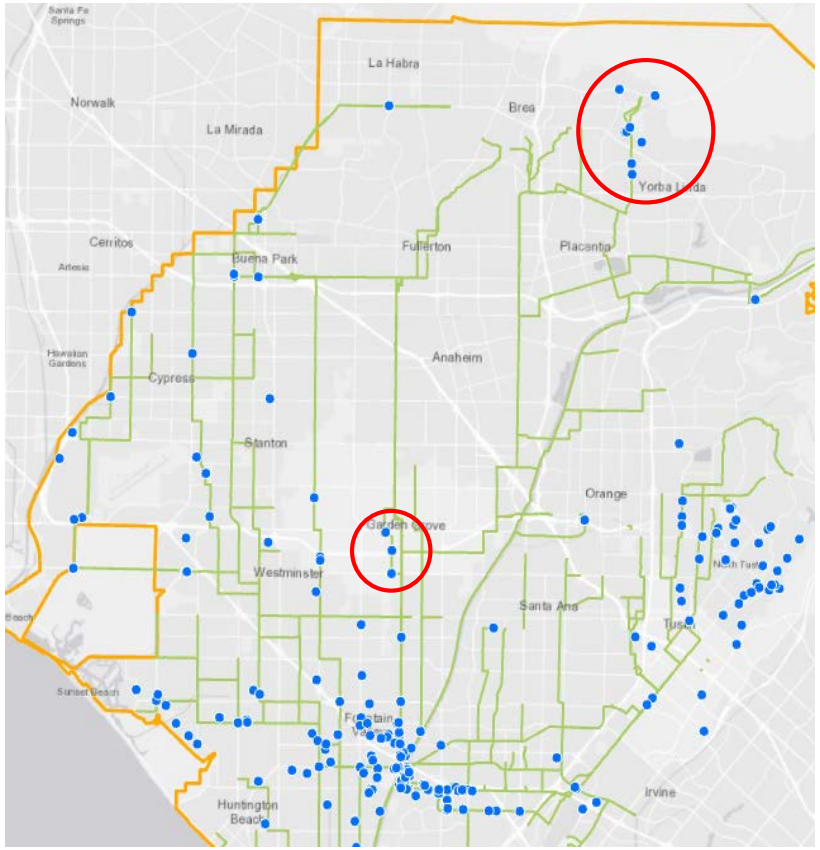


- Objectives
  - Define specific areas within OCSD service area that may be impacted by nuisance odors (i.e. H_2S) originating from OCSD assets (manholes, pump stations, chemical tanks)
  - Based on complaint location, generate list of OCSD assets to check for odor production

Odor Impact Assessment: Collection System

Nuisance Distance Analysis

Point Pattern Analysis



Odor Impact Assessment: Treatment Plants

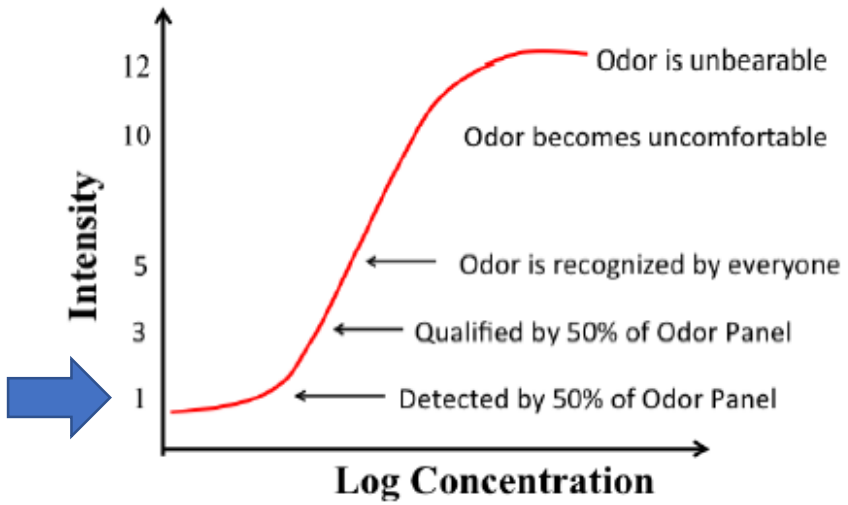
Work completed by UCLA in 2015: Odor Characterization

- Conducted Odor Profile Method (OPM)
  - Sensory method; panelists were trained to identify multiple odor characters and their respective intensities in a single sample
  - Odor intensity from OPM is proportional to the log concentration of the chemical causing odor, relationship known as the Weber-Fechner curve

Weber-Fechner Law

Odor Intensity = m * Log [conc.] + b

Odor Threshold Concentration (I = 1)



Source: (Suffet, Zhou, and Braithwaite, 2015)

Treatment Plant Odors – Odor Characterization

Work completed by UCLA in 2015: Determination of Odor Threshold Concentrations and Odor Nuisance Concentrations for major odorants

Odor Nuisance Concentration (I = 3)

Odor Threshold Concentration (I = 1)

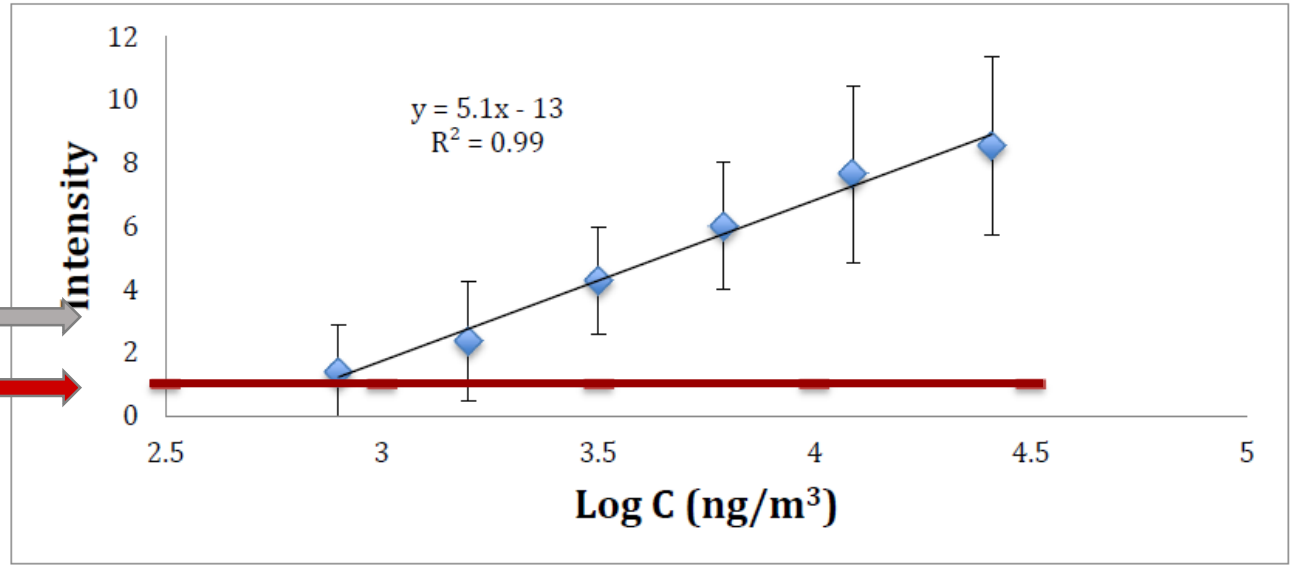


Figure 3-3-2. Panel Weber-Fechner Curve for Hydrogen Sulfide

Hydrogen Sulfide

OTC = 0.5 ppb-v

Odor Nuisance Level = 1.0 ppb-v

Source: (Suffet, Zhou, and Braithwaite, 2015)

Treatment Plant Odors – Odor Characterization

Work completed by UCLA in 2015 : Identification of nine “most detectable” odorants at OCSD plants

	Chemical	Odor Group	Odor Characteristic
1	Hydrogen Sulfide (H_2S)	Sulfur Group	Rotten Egg
2	Methyl Mercaptan (MM)	Sulfur Group	Rotten Vegetable
3	Dimethyl Sulfide (DMS)	Sulfur Group	Canned Corn
4	Dimethyl Disulfide (DMDS)	Sulfur Group	Rotten Garlic
5	2-Methylisoborneol (MIB)	Musty Group	Musty
6	2-Isopropyl-3-methoxypyrazine (IPMP)	Musty Group	Musty
7	Indole	Fecal Group	Fecal
8	Skatole	Fecal Group	Fecal
9	Ammonia (NH_3)	Ammonia Group	Pungent

Source: (Suffet, Zhou, and Braithwaite, 2015)

Treatment Plant Odors – Odor Characterization

Work completed by UCLA in 2015: Determination of OTCs for “most detectable” odorants

Linear Regression Results, OTCs, and Nuisance Levels of Odorants

Chemical	Linear Equation	R^2	OTC (Intensity Score 1)		Nuisance (Intensity Score 3)	
			ng/L in air	ppb-v	ng/L in air	ppb-v
H_2S	y=5.1x-13	0.99	0.7	0.5	2	1
MM	y=4.5x-8.7	0.99	0.2	0.08	0.4	0.2
DMS	y=4.7x-17	0.99	8	3	20	8
DMDS	y=3.7x-9.9	0.95	0.8	0.2	3	0.8
MIB	y=4.2x-8.1	0.98	0.1	0.02	0.4	0.06
IPMP	y=2.1x-1.9	0.96	0.02	0.004	0.2	0.04
Skatole	y=6.0x-11	0.94	0.09	0.02	0.2	0.04
Indole	y=5.7x-18	0.96	2	0.5	5	1
Ammonia	y=3.4x-19	0.99	900	1000	3000	5000

Source: (Suffet, Zhou, and Braithwaite, 2015)

Treatment Plant Odors – Odor Impact Assessment

Work completed by CH2M Hill in 2017: Air Dispersion Modeling

Meteorological Data

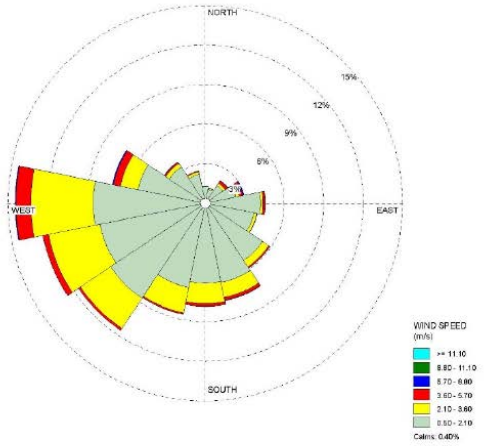


Figure 4-4. Costa Mesa 5-Year Wind Rose (2007-2011) – Plant No. 1

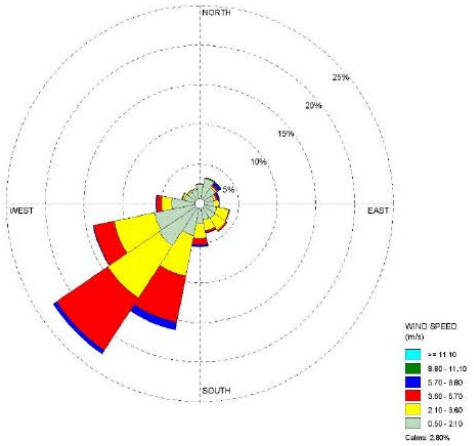


Figure 4-5. John Wayne Airport 5-Year Wind Rose (2010-2014) – Plant No. 2

Terrain Data
Receptor Locations

Source Emission Rates

AERMOD Dispersion Model

- Assess pollutant concentrations from multiple sources
- Steady state Gaussian plume model
- Worst-case conditions

Source: (CH2M Hill, 2017)

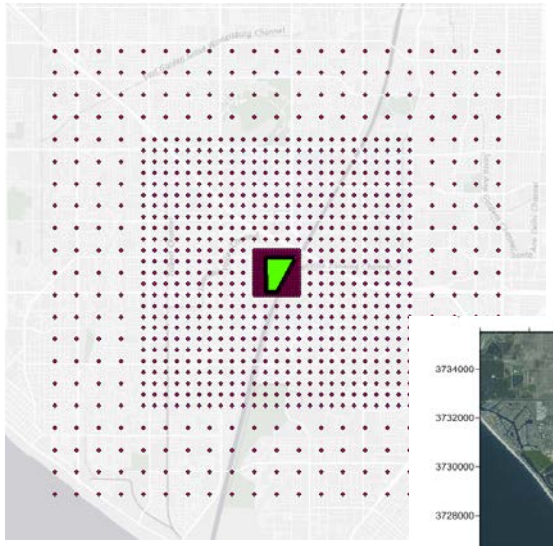
Treatment Plant Odors – Odor Impact Assessment

Work completed by CH2M Hill in 2017: Air Dispersion Modeling Output

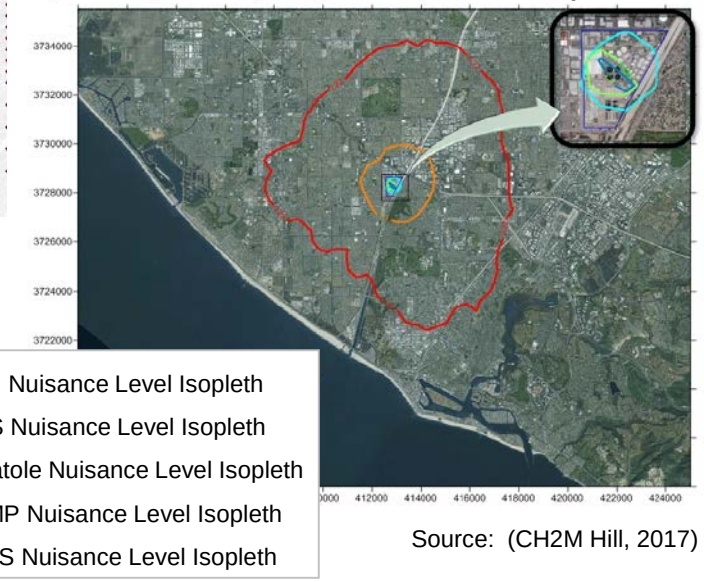
AERMOD Dispersion Model

- Maximum offsite concentrations over a 5-year period
- Baseline Existing Conditions
- Isopleths for MM, H_2S, Skatole, IPMP, DMS

Receptor Grid

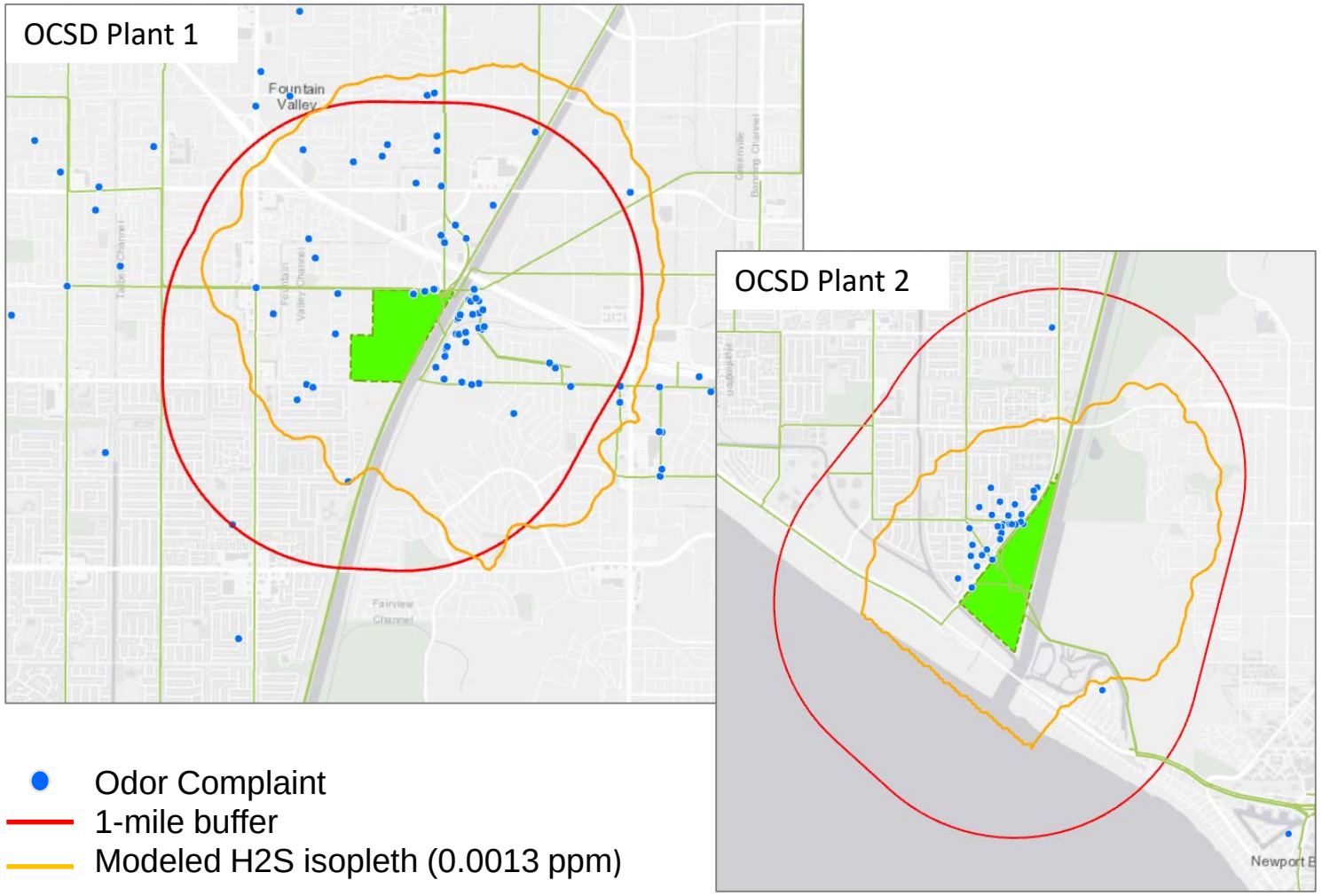


Baseline Isopleths



Source: (CH2M Hill, 2017)

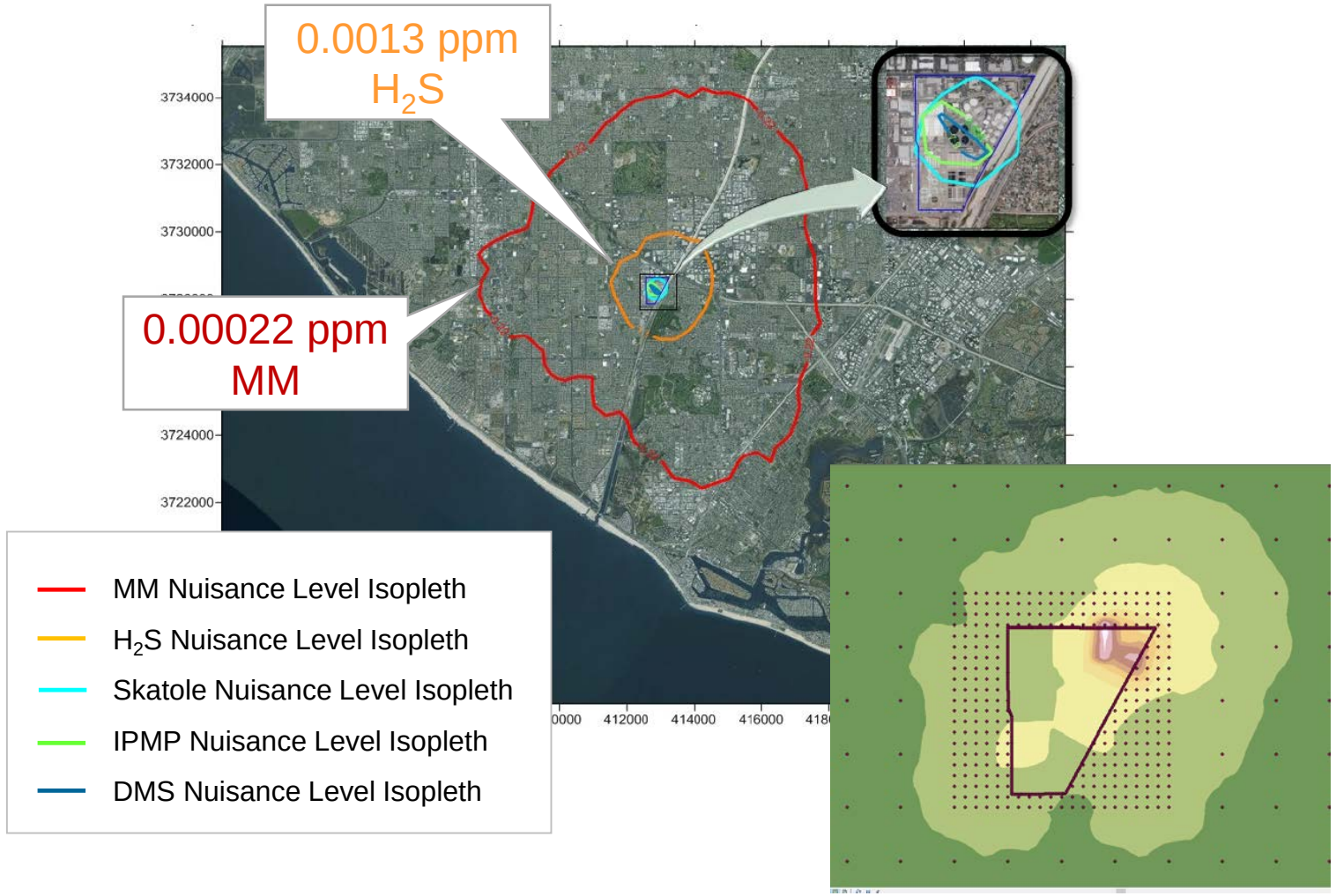
Treatment Plant Odors – Complaint Analysis



Objectives:

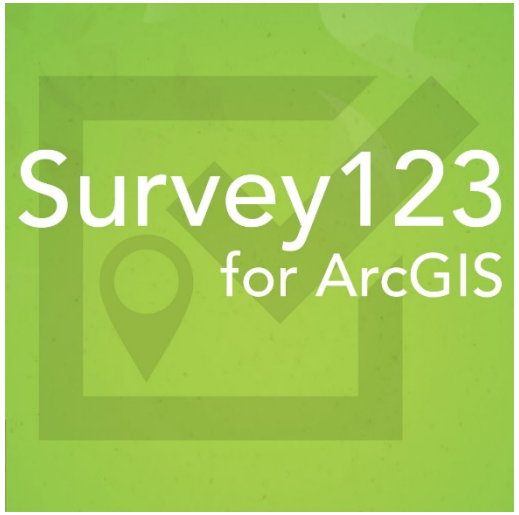
- To categorize and map historic odor complaint data in more descriptive detail to directly assess nuisance extents in the vicinity of the treatment plants
- To verify that the distribution of modeled nuisance concentrations correspond to actual odor perceptions by residents

Treatment Plant Odors – Odor Impact Assessment



Wastewater Odors - Field Observations

- Directly collect and map odor observations (i.e. H_2S) at specific locations in the collection system and treatment plants
- Compare to modeled odor concentrations and assess human perceptions of treatment plant odors
- Measure and compare odor observations before and after mitigation activities



Odor Impact Assessment – Anticipated Results

Collection System

- Map showing area surrounding OCSD assets susceptible to odor complaints from residents
- Script tool to generate list of OCSD assets within vicinity of reported complaint

Treatment Plants

- A report with definitive complaint analysis results and discussion on precision of current plant odor impact estimates and previous modeling efforts compared to reported odor complaints
- Mobile application for collection and mapping of field odor observations

Timeline

- December 2018 – Gather and prepare data
- December 18, 2018 – GEOG 596A Presentation
- January 2018 – Perform analysis, develop Survey 123 application
- February 2018 – Continue analysis, test Survey 123 application
- March – May 2018 – Refine analysis, collect sensory observations
- June 2018 – Prepare report, finalize presentation
- July 2018 – Present at 2018 Esri User Conference

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