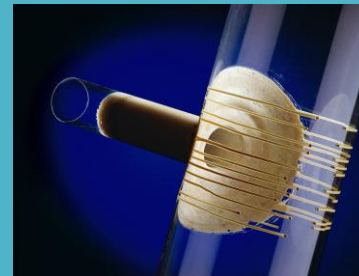
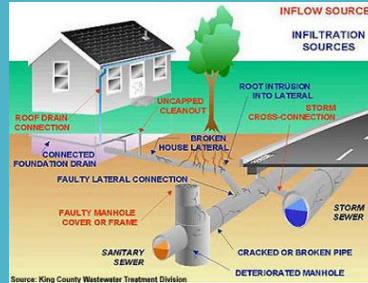
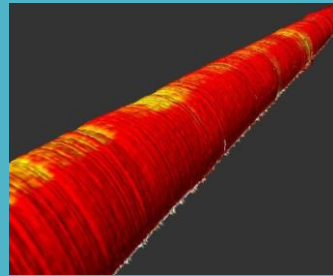




IS IT A BIRD... OR A SWARM OF BEES?

SMOKE TESTING USING DRONES



National Plant Services, Inc.
Hayward, CA

The Environmental Protection Specialists

Michelle Beason, PE
Regional Manager



CLEANING

- LARGE AND SMALL DIAMETER PIPE CLEANING
- ROOT REMOVAL
- WWTP CLEANING SERVICES



INSPECTION

- LATERAL AND MAINLINE CCTV INSPECTION
- MULTI-SENSOR INSPECTIONS
- MANHOLE INSPECTIONS
- WATER MAIN INSPECTIONS
- SSES – SMOKE, DYE, FLOW

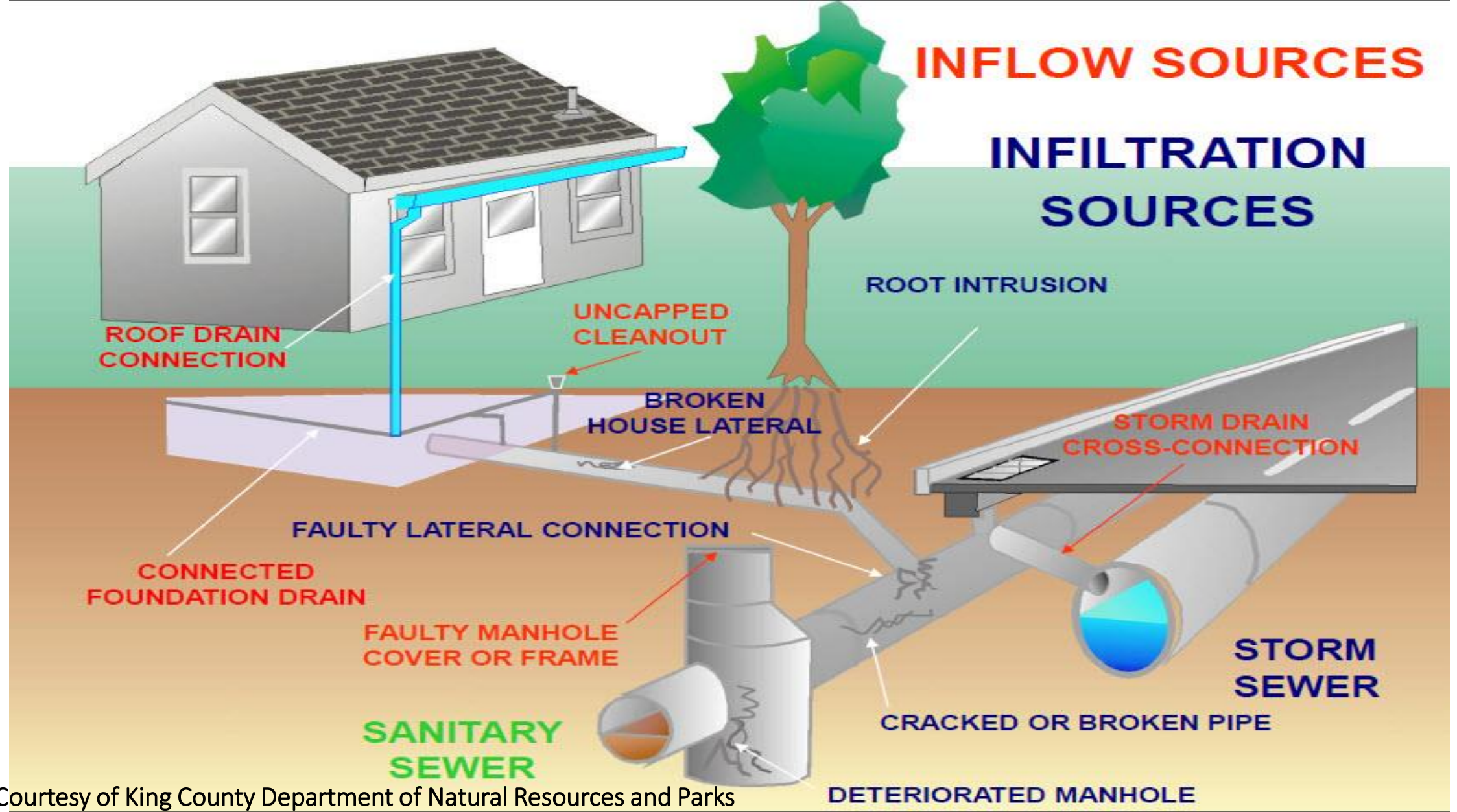


REPAIR

- LATERAL LINING
- CENTRIFUGALLY CAST STRUCTURAL COATINGS
- GROUTING
- CIPP POINT REPAIRS

INFLOW SOURCES

INFILTRATION SOURCES



Courtesy of King County Department of Natural Resources and Parks

INFLOW – FROM PRIVATE CONNECTIONS

INFILTRATION - RESULTS FROM STRUCTURAL PIPE DEFECTS

SMOKE TESTING 101

Why Smoke Test?

- We can inspect a lot of footage quickly
- Lower overall cost as it will gather information on laterals and mainlines simultaneously
- Smoke testing will tell you what a CCTV camera may be unable to see:
 - *Unsealed pipe joints*
 - *Cross connections between storm and sanitary sewer systems*
 - *Illegal private connections (downspouts, driveway or yard drains, foundation drains, etc)*
 - *Broken House laterals*



Smoke Test Equipment



Superior[®] 30 Series Smoke Blowers Common Product Specs:

- Briggs & Stratton 5 hp Gasoline Engine
- 10 Blade High-Output Propeller Blower
- Carrying Weight = 65 lbs.
- Output = 4,300 CFM
- 30" Base made of thick cast aluminum
- Meets recommendations of WEF, EPA and NASSCO
- Proudly Made in the USA

Superior[®] Blower # 30-L 4300 CFM w/ Liquid Smoke System



Smoke Testing Inefficiencies

- Will not 'see' critical structural pipe defects or O&M Issues that may exist. Does not replace periodic CCTV inspections.
- May need to enter private property to look for smoke returns.
- You may introduce smoke into a structure if a resident does not fill their p-traps as directed in the notification letters (the smoke is non-toxic).
- Not as effective in wet weather if the ground is saturated. Better results in drier soils.

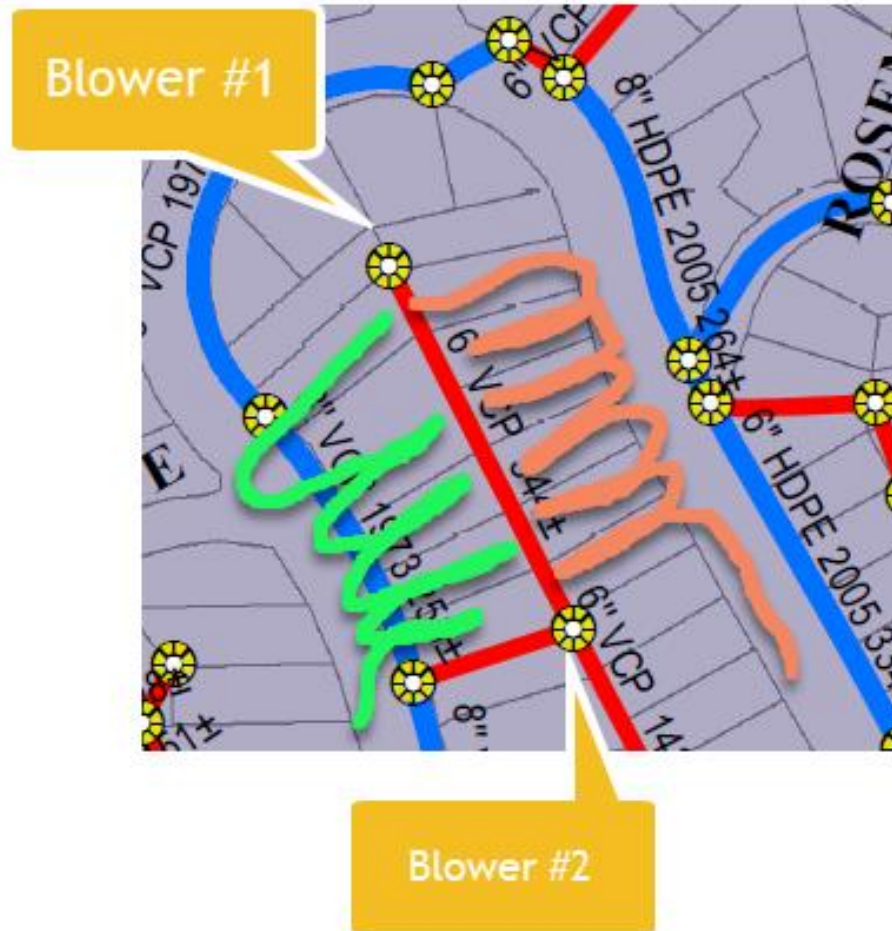


EASEMENT SEWERS ARE DIFFICULT TO INSPECT

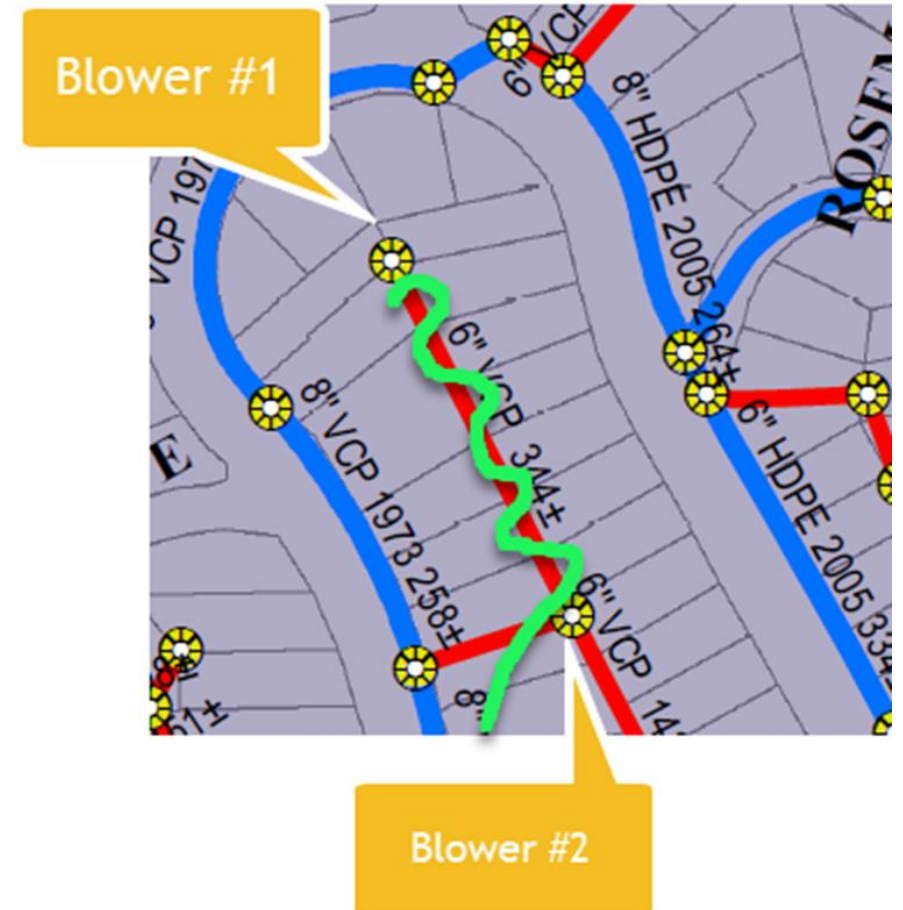
- Must arrange and get access from residents
- Need a lot more people to smoke test easements
- Takes a lot more time to investigate each easement
- Some locations are too treacherous or wooded to enter

Backyard Easements

OPTION 1 – 4 PERSON CREW
ENTERING EACH BACKYARD

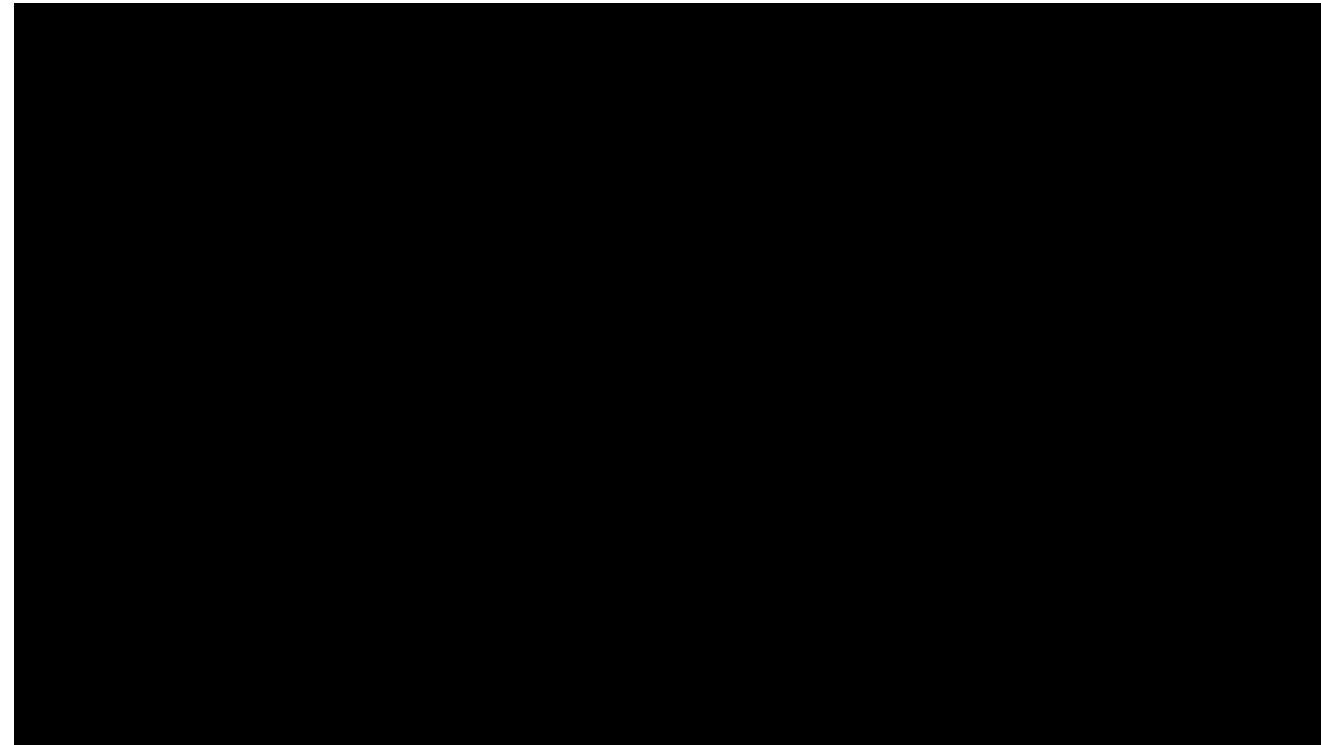


OPTION 2 – DRONE FLYING
THROUGH THE BACKYARDS

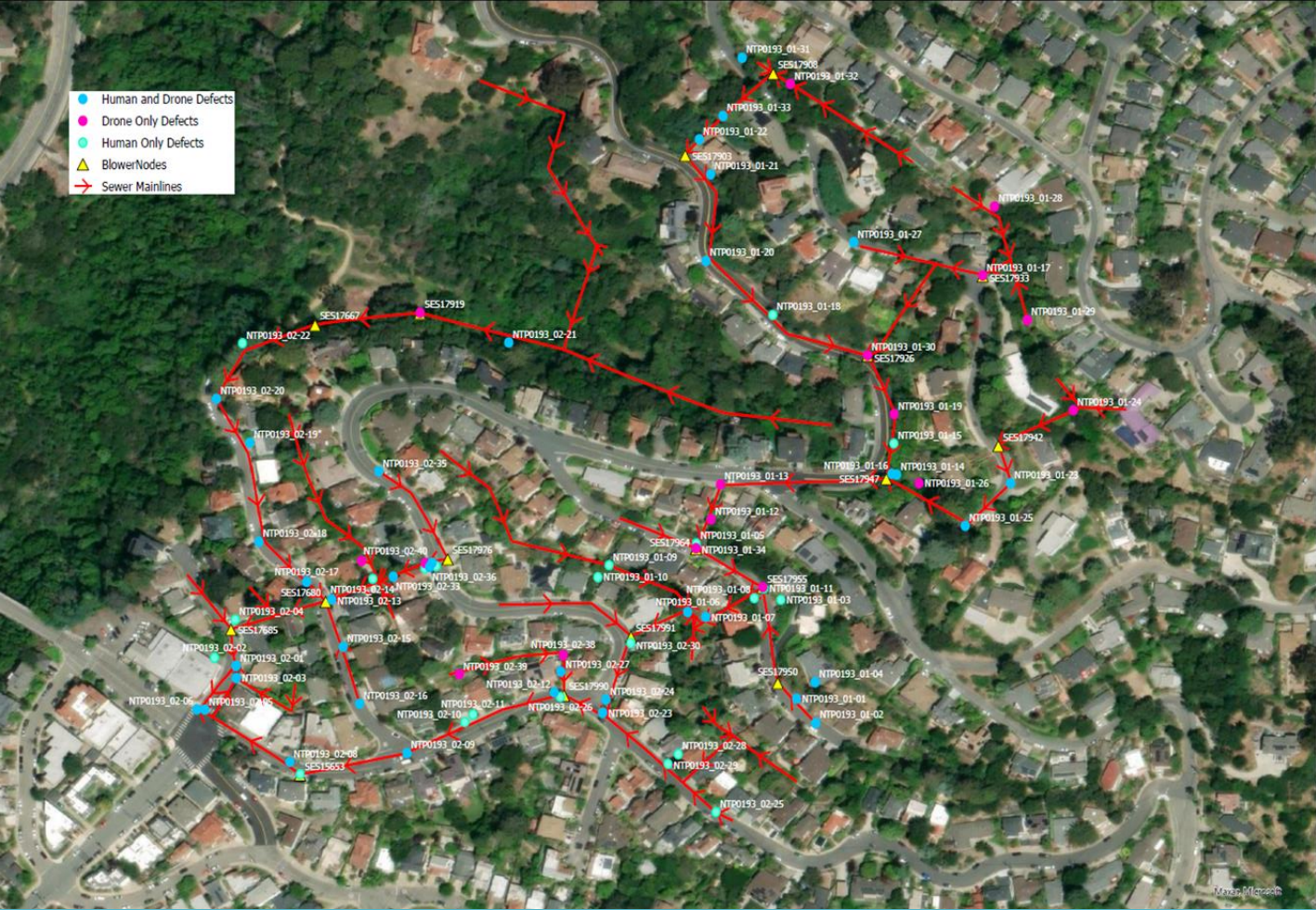


DRONE ADVANTAGES

- FASTER THAN ENTERING EACH BACKYARD
- DON'T HAVE TO WORRY ABOUT RESIDENTS OPENING GATES OR SECURING PETS
- CAN ACCESS REMOTE OR STEEP AREAS
- OBTAIN LIVE VIDEO AND IMAGES OF SMOKE DEFECTS
- GPS CAPABILITY

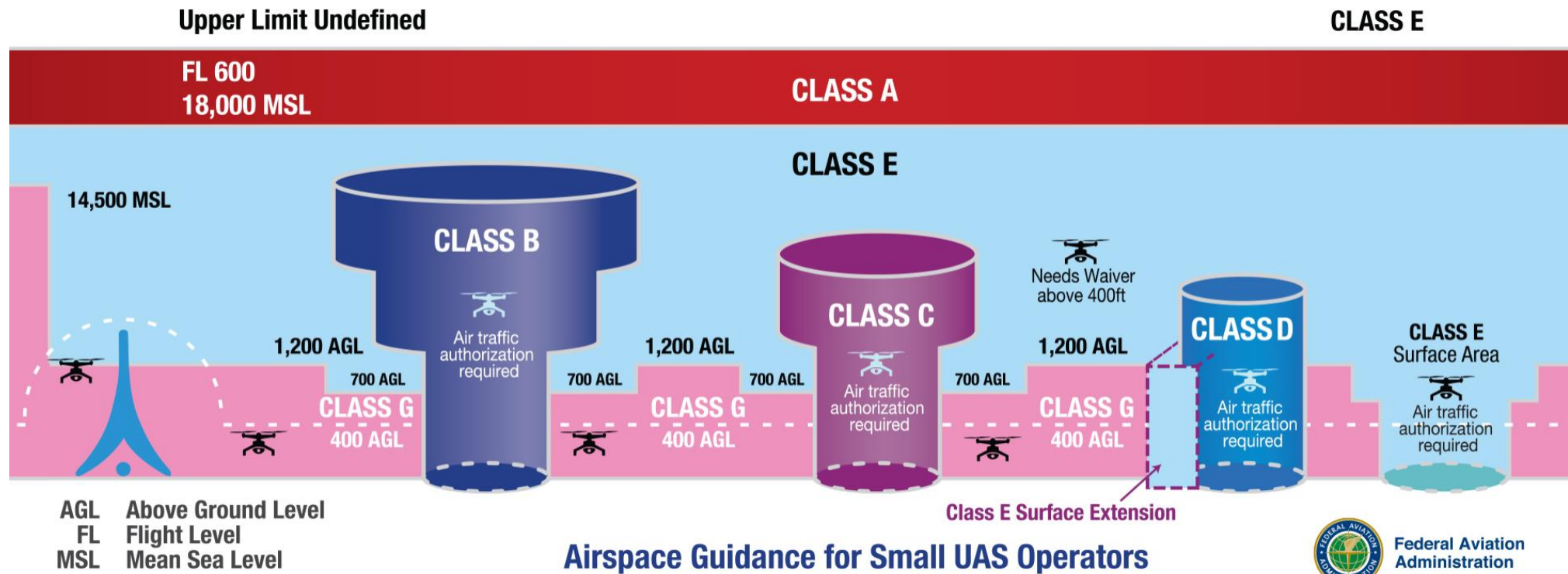
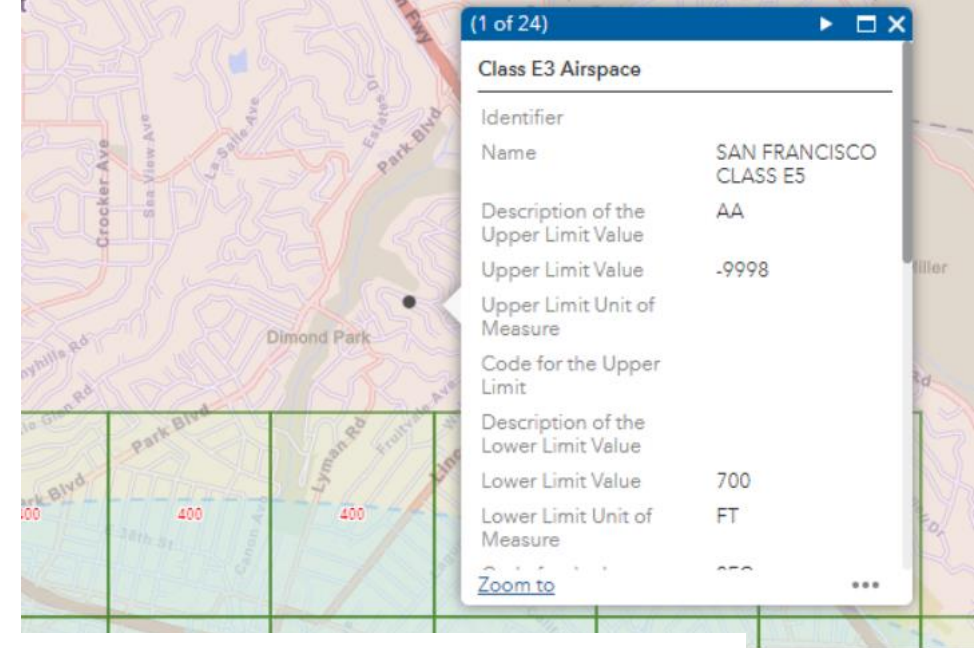


EBMUD/CITY OF OAKLAND SMOKE TESTING 2-DAY DRONE PILOT NOVEMBER 2-3, 2023



Airspace Approval

FAA has set a legal limit of 400 feet for both recreational and commercial drone flying.



Hiring a Drone Pilot

- NPS obtained several proposals from FAA licensed pilots
- Drone technology options were reviewed
- CopterOptics was chosen for the work



Technology Options



MAVIC 2 PRO WAS USED

Mavic 2 pro

- Single Operator
- Proprietary camera
- Fixed ~24mm equivalent lens
- 4K up to 60fps @100Mbps (H.265) recording
- 2.7K up to 60fps @100Mbps (H.265) recording

Inspire 2 X5S

- Single or Dual Operator
- Proprietary camera
- Interchangeable MFT 15mm, 30mm, 50mm, and 90mm equivalent lenses
- 4K up to 60fps H.264 @100Mbps
- ProRes recording
 - 5.2K up to 30fps 422 HQ @1.3Gbps
 - 4K up to 30fps 422 HQ @900Mbps
 - 4K up to 30fps 4444 XQ @2.0Gbps
- Optional CinemaDNG RAW recording
 - 4K DCI up to 60fps 12 bit

Inspire 2 X7

- Dual Operator
- Proprietary Super 35mm sensor camera
- Interchangeable 16mm, 24mm, 35mm, and 50mm lenses
- 4K up to 60fps H.264 @100Mbps
- ProRes recording
 - 4K Ultra HD up to 30fps, 10-bit, HQ/XQ, full FOV
 - 5.2K (5280×2160), up to 30fps, 10-bit, HQ, full FOV
 - 2.7k up to 60fps, 10-bit, HQ, narrow FOV
 - 1920×1080, up to 60fps, 10-bit, HQ/XQ, narrow FOV
- Optional CinemaDNG RAW or ProRes RAW recording
 - Up to 6K 14 bit (see [link](#) for full specs)

Film Permit

- Permit Application
- Detailed Flight Plan
- UAS (Unmanned Aircraft Systems) FAA Pilot License
- COI from drone vendor listing City of Oakland
- Registration paperwork for drone

FILM PERMIT City of Oakland

Oakland Film Office www.oaklandca.gov

1 Frank H. Ogawa Plaza, 9th Floor Oakland, CA 94612
Telephone: (510) 238-4734 - Fax: (510) 238-6149 - E-mail: film@oaklandca.gov

Project Title: Sewer Smoke Testing for EBMUD	Permit ID: 3373
Project Type: PSA	Issue Date
Production Company Office: National Plant Service INC. 2159 National Ave Hayward Ca 94545	Local Production Office:
Telephone (925) 262-7366	Permit contact email: mbeason@nationalplant.com

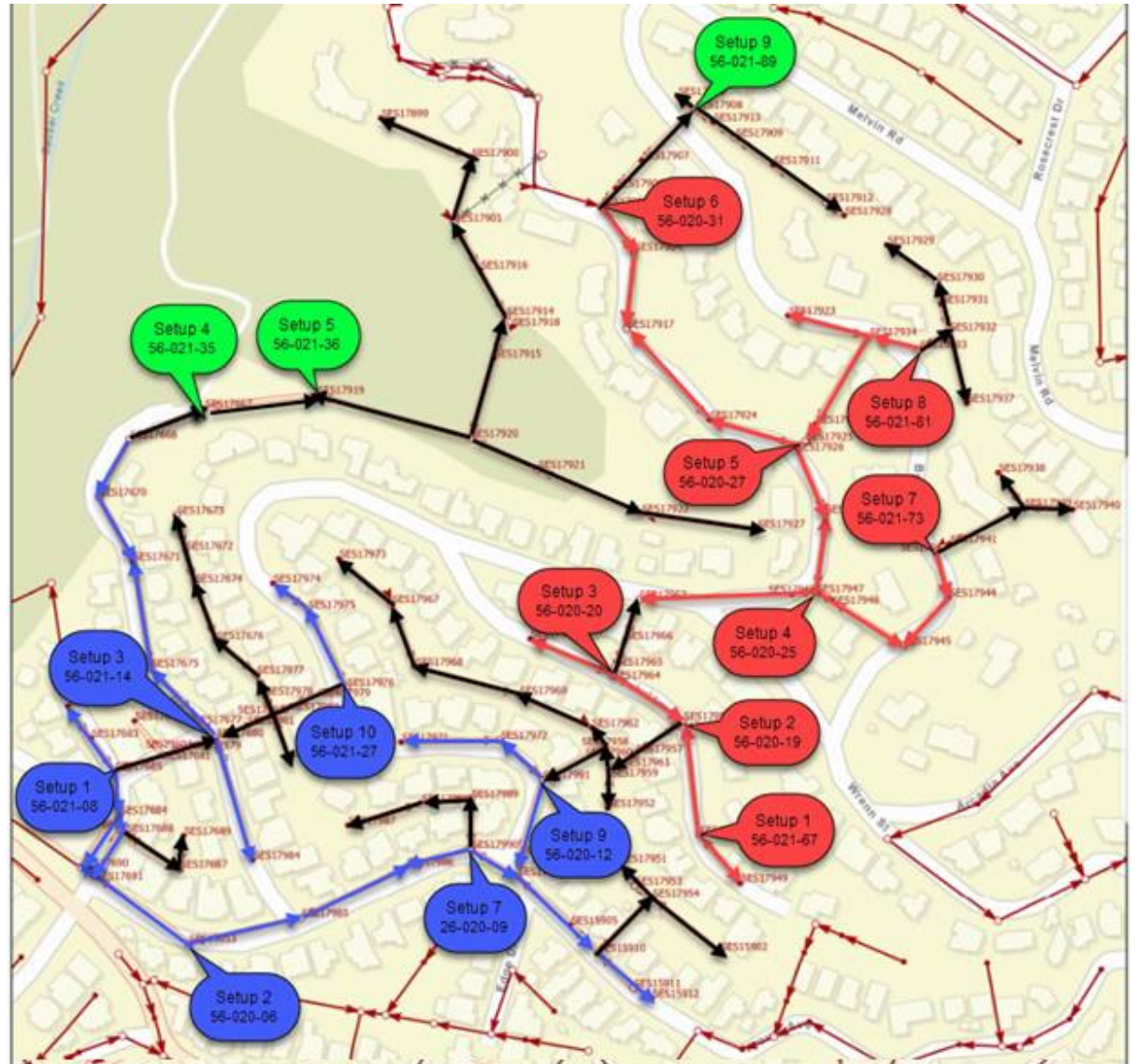
Producer: EBMUD	Police Services: None requested
Director:	Traffic Control: None requested
Location Manager: Michelle Beason	Reserved Parking: None requested
L.M. Telephone	Crew Number: 2 Cast Number: 0
L.M. Cell phone: (925) 262-7366	

Location:	Int/Ext:	Date:	Start Time:	End Time:	Special Conditions:
Multiple areas of Oakland sewer line smoke test	EXT	2023-11-02	08:00 AM	05:00 PM	
Multiple areas of Oakland sewer line smoke test	EXT	2023-11-03	08:00 AM	05:00 PM	

SMOKE TESTING FIELD PLAN WAS DEVELOPED

- HUMANS TO WALK THE STREETS ONLY AND RECORD DEFECTS
- DRONES TO FLY OVER THE STREETS, AND THE EASEMENTS

**WE WANTED TO COMPARE
WHAT COULD BE SEEN BY
DRONES VS HUMANS**



EBMUD RTSP I&I Investigations
NTP0193 Smoke Testing w/Drone - Oakland

Created By: Tracy Heidersbach
Date: 10/11/2023



Legend

- SmokeDroneTesting_NTP0193_20232024_OAK_Mains_PRELIM
- <Null>,LH/CO; <Null>,NS; <Null>,Other; <Null>,UNK
- <Null>,MH
- Abandoned
- Gravity Sewer
- Drone Route
- Day 1 MHE
- Day 2 MHE
- Updated Setup

TWO WEEK AND ONE WEEK DOOR HANGER NOTICES DELIVERED

Second

Smoke Testing with Aerial Drone Survey Notice

Testing is Happening This Week!

A contractor will be working with East Bay Municipal Utility District (EBMUD) to perform smoke tests on sanitary sewer lines in your area. Testing will take place this week. Because the sewers in your neighborhood are in easements (mostly running through backyards), a drone will be flown over the sewer easement to observe the smoke testing.

TESTING WILL TAKE PLACE BETWEEN THE HOURS OF:	8AM - 5PM
--	-----------

SMOKE TESTING WITH AERIAL DRONE FAQs:

Why is EBMUD smoke testing?

EBMUD smoke tests to find damaged pipes, improper connections and areas where unwanted water may enter the sanitary sewer collection system. When water inadvertently leaks into the sewer system, it can overwhelm the system and cause untreated and partially treated wastewater to be released to the San Francisco Bay.

How does smoke testing work?

During smoke testing, the contractor blows smoke into the sanitary sewer system through manholes in the street or on easements. The smoke will follow the path of any leak to the ground surface, quickly revealing the source of a problem.

During testing, the smoke may be seen coming from roof vents, building foundations, catch basins, clean-outs, downspouts, sewer laterals and manhole covers.

Notify City, Police, and Fire



LET'S FLY!
SMOKE TESTING BEGINS

SET UP TRAFFIC CONTROL AND SIGNAGE



SANDBAGGING TO DIVERT SMOKE



BLOWER WITH LIQUID SMOKE



Superior® 30 Series Smoke Blowers Common Product Specs:

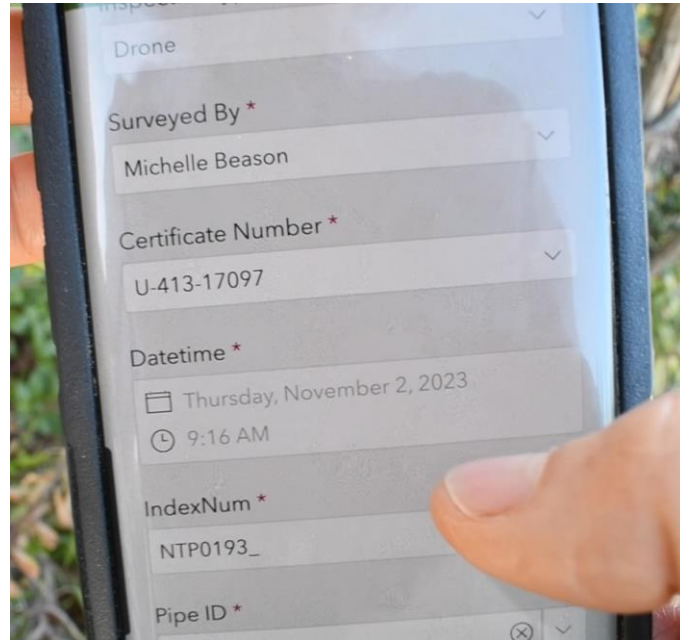
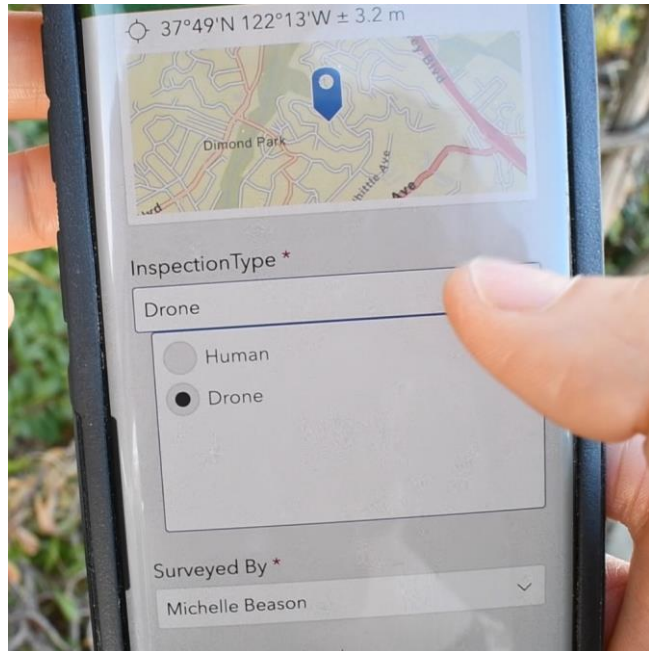
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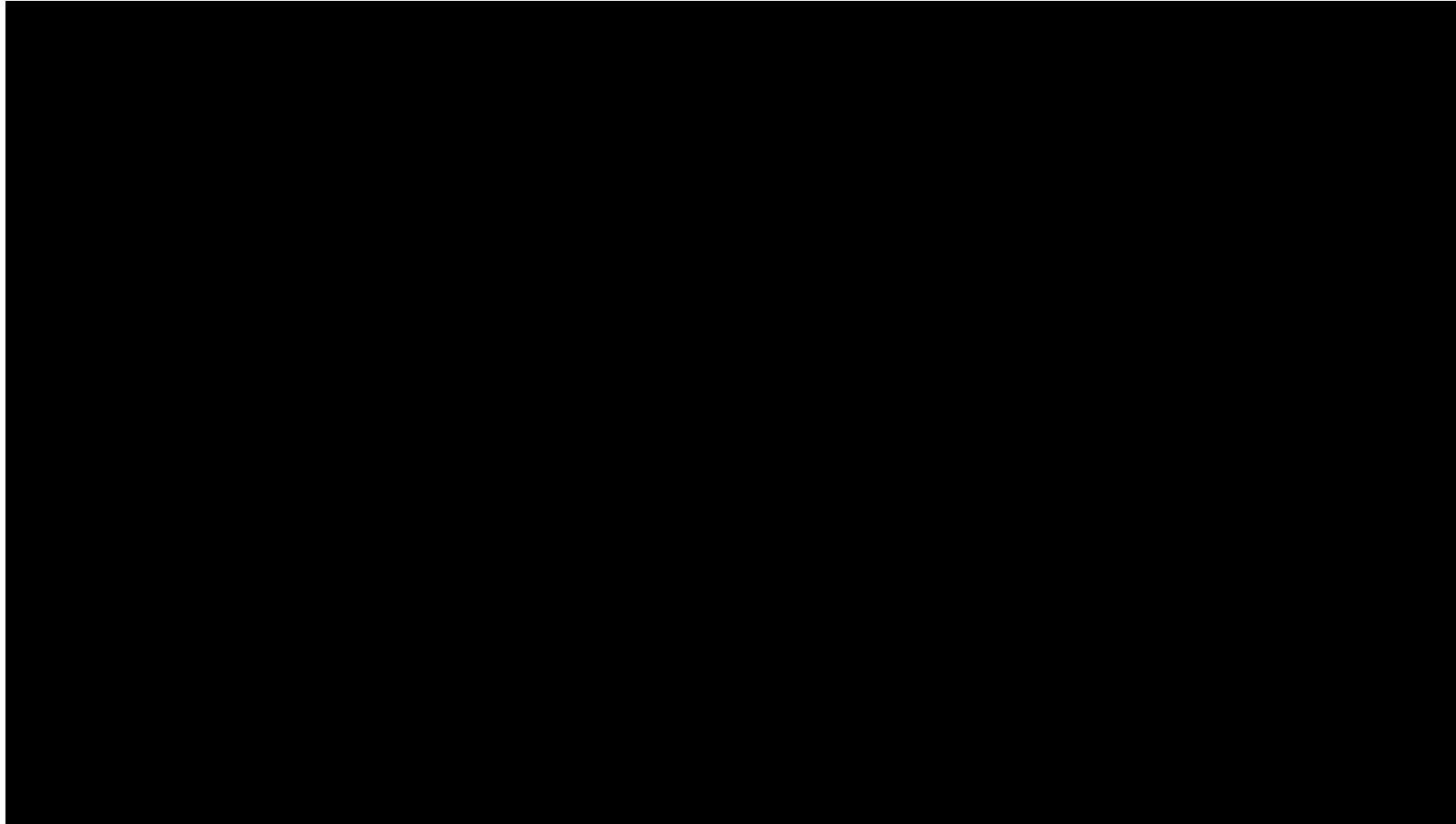


SMOKE CANDLES ARE NOT SUFFICIENT FOR LARGE AREAS

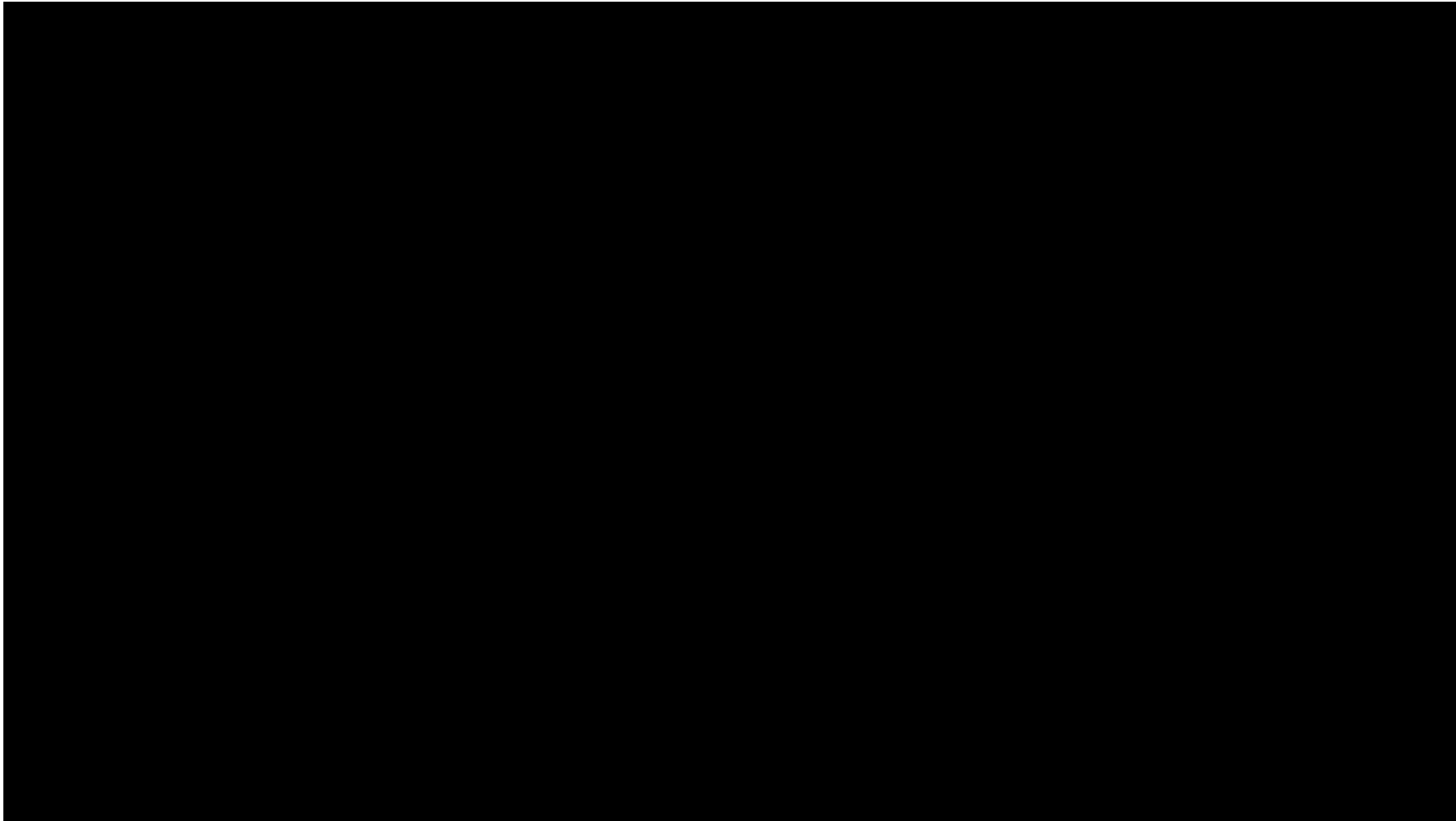
SPOTTERS WALK THE TEST AREA – RECORD SMOKE OBSERVATIONS



DEFECTS OBSERVED BY HUMANS



DEFECTS OBSERVED BY DRONES



THE FINDINGS

Human vs. Drone Smoke Defects

INSPECTOR	NUMBER OF DEFECTS RECORDED	PERCENT OF TOTAL
Human Only Recorded Defects	22	28.9%
Drone Only Recorded Defects	17	22.4%
Human and Drone Recorded Defects	37	48.7%
TOTAL SPOTTED BY HUMANS	59	77.6%
TOTAL SPOTTED BY DRONES	54	71.1%
	TOTAL DEFECTS	76

- Most of the drones' efforts were focused on easements and lateral alignments/property yards, with less time spent looking at the street, so this is the reason why the drone missed some of the more obvious street defects.
- Of a total of 76 defects recorded, 44 of the defects were from manufactured vent holes in the sanitary manhole covers,

VENTED MANHOLE COVERS

- Were helpful as we had locations for smoke to exit the pipes
- Unless the pipes had known defects, how could we check the drone effectiveness?



Drone was able to identify defects that are medium to heavy smoke density, if they were not obscured by dense tree cover.



Humans could see smoke from smaller defects like cracks along pavements, cleanouts and water meters that was harder for the drone to see.



Lessons Learned

1. Use liquid smoke to maintain a steady and substantial level of smoke
2. Dense tree coverage can obscure the visibility of smoke in the drone videos



Lessons Learned (Cont.)

3. Fly looking straight down, then fly back looking at an angle.
 - The sunlight combined with the light color of the smoke posed challenges in detecting the smoke with the drone. See below how much more visible the smoke is when the drone views at an angle, than straight above.



Lessons Learned (Cont.)

4. The background color of the ground was very close to 'smoke' color.
5. Having a breeze helps to blow the smoke, makes it easier to spot.
6. Fly as low as possible to get best images when zooming later



Lessons Learned (Cont.)

7. In many instances, the drone had to view the defect at an angle, so the GPS reading is not precise.



PUBLIC RESPONSE TO THE TESTING

- Very positive response from all residents! A few comments that were mentioned to me:
 - “Let us know if you needed to access our yard”
 - “What a cool use of technology!”
 - “How innovative”
 - “Did you see any smoke coming from my yard? I just replaced my lateral and want to make sure it’s tight”
 - “I’m glad you are doing this study”
 - “Any of my neighbors have violations?”

QUESTIONS?



MICHELLE BEASON, PE
NATIONAL PLANT SERVICES, INC.
925-262-7366

MBEASON@NATIONALPLANT.COM

