



Vitrified Clay Pipe Corrosion

Webinar, 24-Sep-2020 12:00 Noon

VITRIFIED CLAY PIPE CORROSION

LOS ANGELES COUNTY SANITATION DISTRICTS (LACSD)

- About LACSD
- Clay pipe history and manufacturing
- Use in LACSD sewer system
- CCTV inspections and capital improvement program
- Major defects discovered in newer clay pipe
- Repairs and assessments
- Lab testing and Resolutions



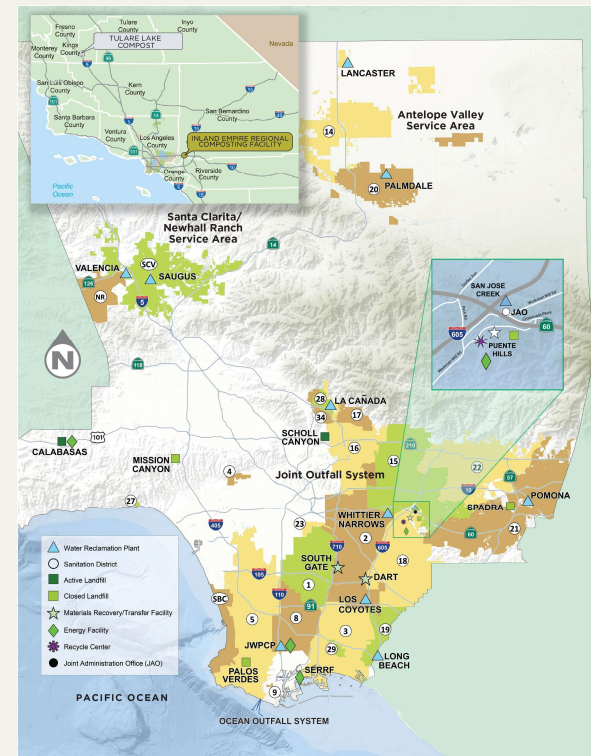
LOS ANGELES COUNTY SANITATION DISTRICTS

“CONVERTING WASTE INTO RESOURCES”

- Wastewater and solid waste management agency
- 24 independent special districts
- 5.6 million people
- 850 square miles
- 78 cities and communities



**LOS ANGELES COUNTY
SANITATION DISTRICTS**
Converting Waste Into Resources



LOS ANGELES COUNTY SANITATION DISTRICTS

SOLID WASTE MANAGEMENT

- One-fourth of countywide solid waste disposal
- Two sanitary landfills
- Three materials recovery/transfer facilities
- Refuse-to-energy facility
- Landfill gas is converted to renewable energy



**LOS ANGELES COUNTY
SANITATION DISTRICTS**
Converting Waste Into Resources



LOS ANGELES COUNTY SANITATION DISTRICTS

WASTEWATER MANAGEMENT

- One-half of the wastewater produced by Los Angeles County
- 400 million gallons per day (MGD)
- 1,400-mile trunk sewer system
- 48 pump stations
- 11 wastewater treatment plants



**LOS ANGELES COUNTY
SANITATION DISTRICTS**
Converting Waste Into Resources

LOS ANGELES COUNTY SANITATION DISTRICTS

WASTE TO ENERGY

- 81 MW of green energy
- Enough to power 81,000 homes
- 90 MGD of recycled water
- Equivalent to water needs of 300,000 homes



**LOS ANGELES COUNTY
SANITATION DISTRICTS**
Converting Waste Into Resources



LOS ANGELES COUNTY SANITATION DISTRICTS

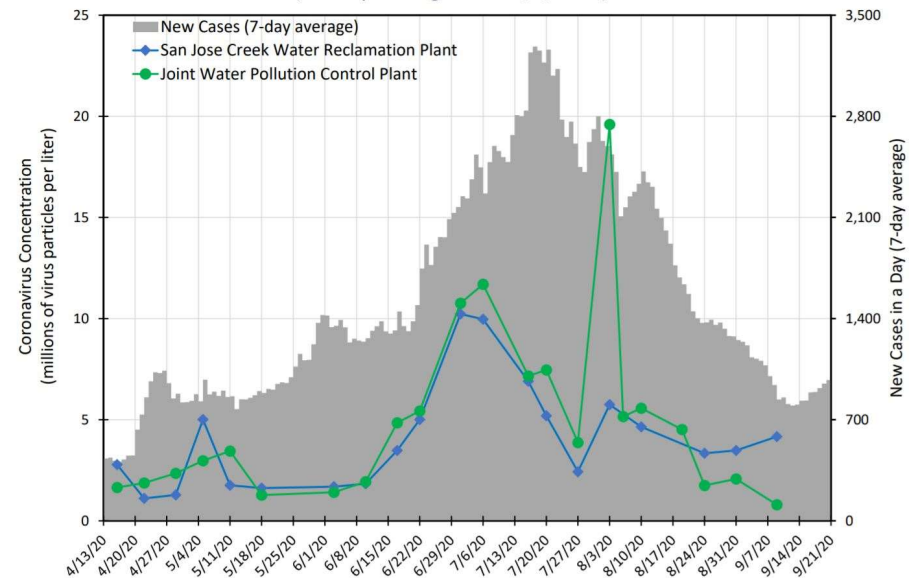
COVID-19 TRACKING IN WASTEWATER

- Coronavirus can be shed into wastewater by infected individuals
- LACSD has tested for coronavirus genetic material in influent wastewater since April
- Helpful for public health officials to indicate if infection may be increasing or decreasing in the population
- Charts are updated every two weeks
- More at www.LACSD.org



**LOS ANGELES COUNTY
SANITATION DISTRICTS**
Converting Waste Into Resources

Coronavirus in Sewage at Inlet to Two Wastewater Treatment Plants
(Weekly Averages thru 9/9/2020)



CLAY PIPE

HAS BEEN USED SINCE ANCIENT TIMES



MODERN “VITRIFIED CLAY PIPE” (VCP)

A MAJOR IMPROVEMENT

- Ancient



- Modern

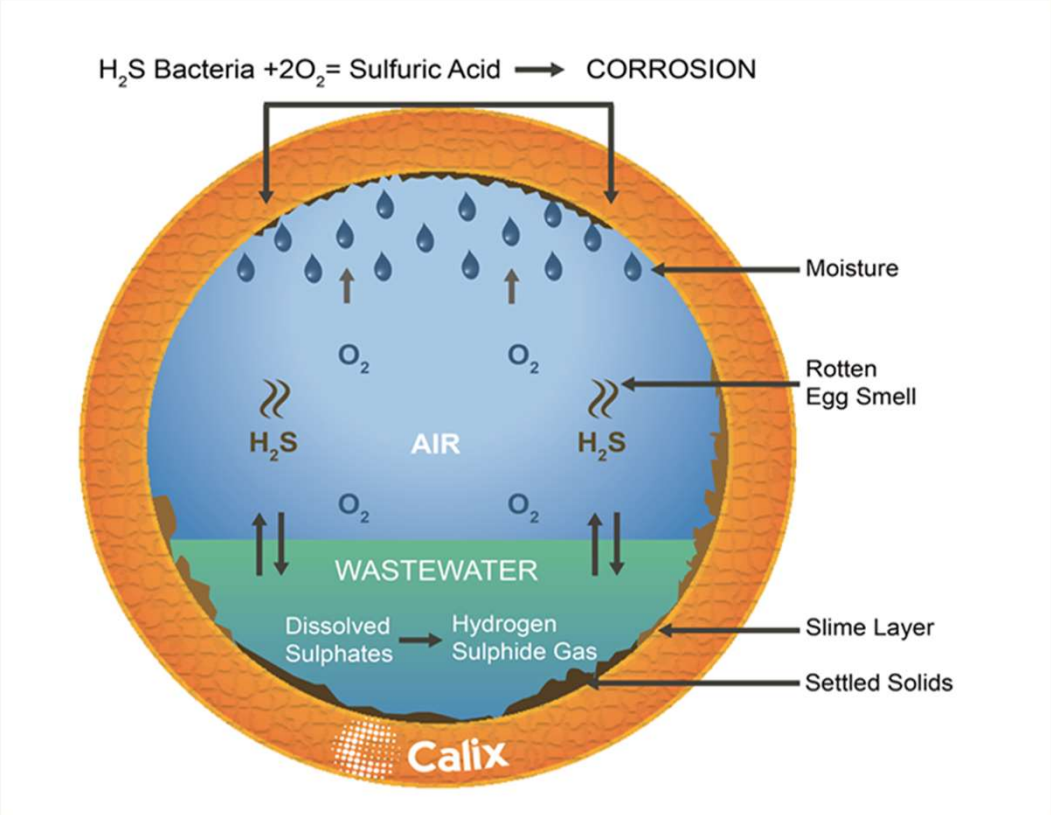


MODERN CLAY PIPE MANUFACTURING

A CONSISTENT, HIGH QUALITY PRODUCT



WASTEWATER COLLECTION SYSTEM



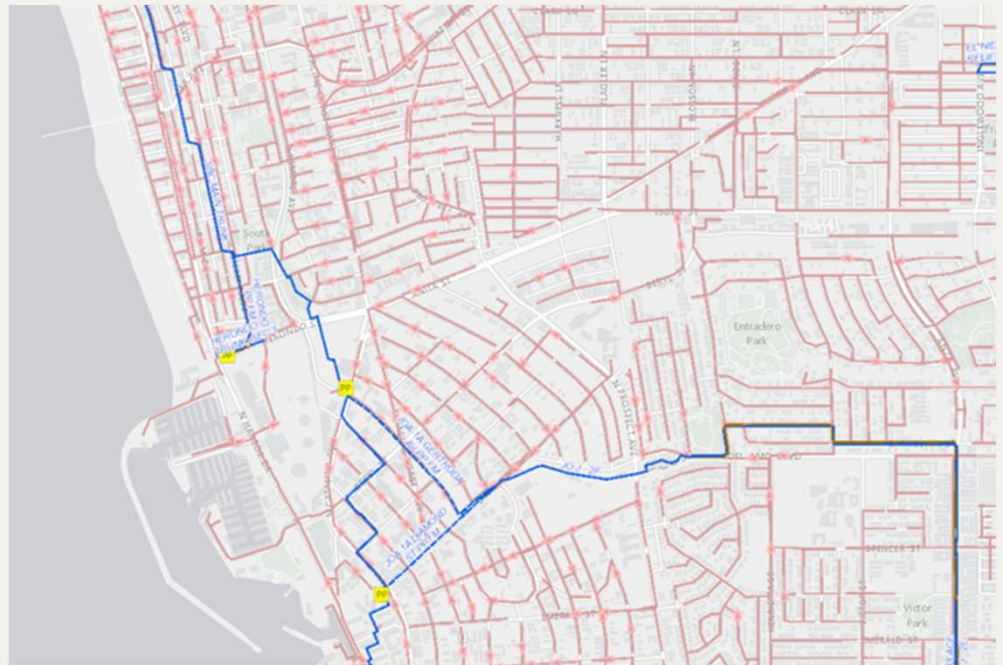
LOS ANGELES COUNTY SANITATION DISTRICTS

WASTEWATER COLLECTION SYSTEM

- 1,400 miles of gravity sewers, siphons, and force mains
- Dry weather conveyance: 450 MGD (2013)
- Wet weather conveyance: 1 BGD (2005)
- 8" to 144" diameter

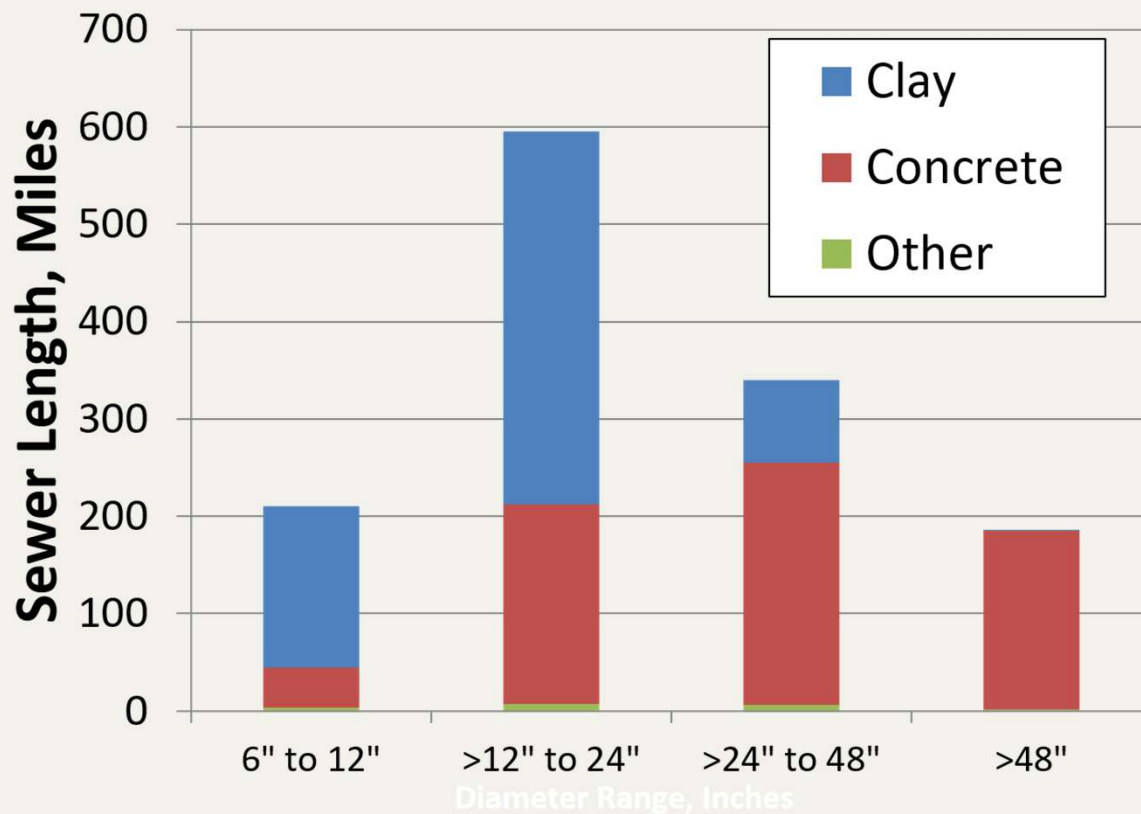


**LOS ANGELES COUNTY
SANITATION DISTRICTS**
Converting Waste Into Resources



LACSD SEWER SYSTEM

BREAKDOWN BY DIAMETER AND MATERIAL





CCTV AND CONDITION ASSESSMENT

PROGRAM HISTORY



CCTV AND CONDITION ASSESSMENT

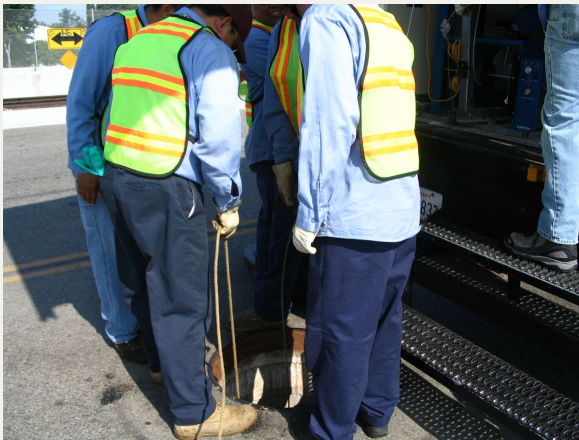
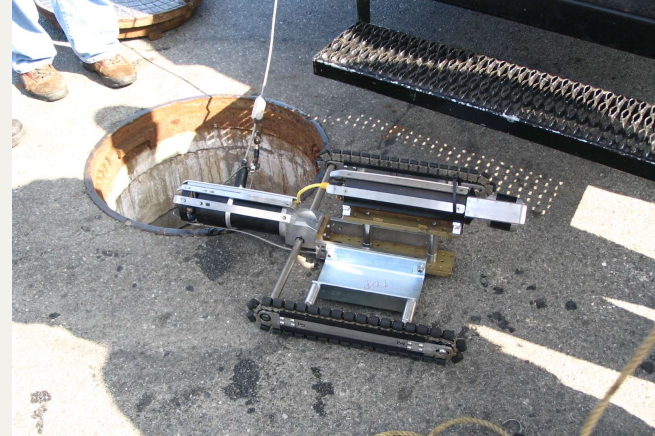
PROGRAM HISTORY



CCTV AND CONDITION ASSESSMENT

PROGRAM HISTORY

CCTV AND CONDITION ASSESSMENT



RECURRING CCTV INSPECTIONS

FAIR TO GOOD CONDITION

Pipe Type	CCTV Interval
Vitrified Clay (VCP) up to 10" diameter Non-Reinforced Concrete (NRCP) Clay-Tile Lined Reinforced Concrete	5 years
Vitrified Clay (VCP) greater than 10" diameter Reinforced Concrete (RCP)	10 years
Lined or Encased Pipes	15 years

DETERIORATED CONDITION

Pipe Type	CCTV Interval
Condition Rating "1" & "2"	1 year
Condition Rating "3" Concrete	3 years
Condition Rating "3" Clay	4 years

CONCRETE VS. CLAY DETERIORATION

- Reinforced Concrete
- Condition Rating 1

- Vitrified Clay
- Condition Rating 1



GOOD CONDITION VCP

16 ALLEN AVENUE TRUNK, SECTION 6
16 0095 → 16 0094
15.00 VCP 5/25/2018

9.5 FT

CONDITION ASSESSMENT



Condition "3"
Monitor for damage

10+ year repair
timeframe



Condition "2"
Repair: Secondary priority

6-10 year repair timeframe

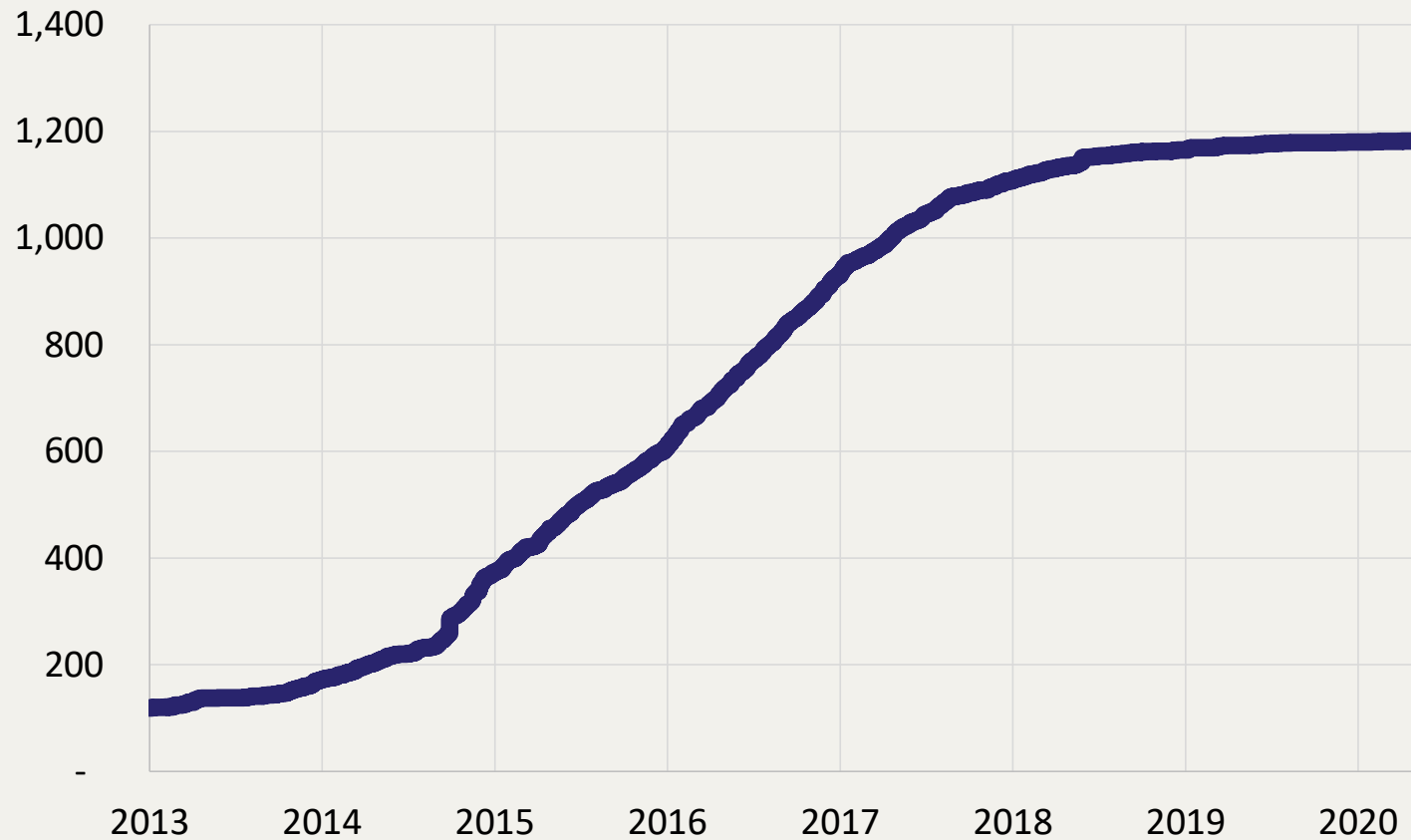


Condition "1"
Repair: High priority

0-5 year repair timeframe

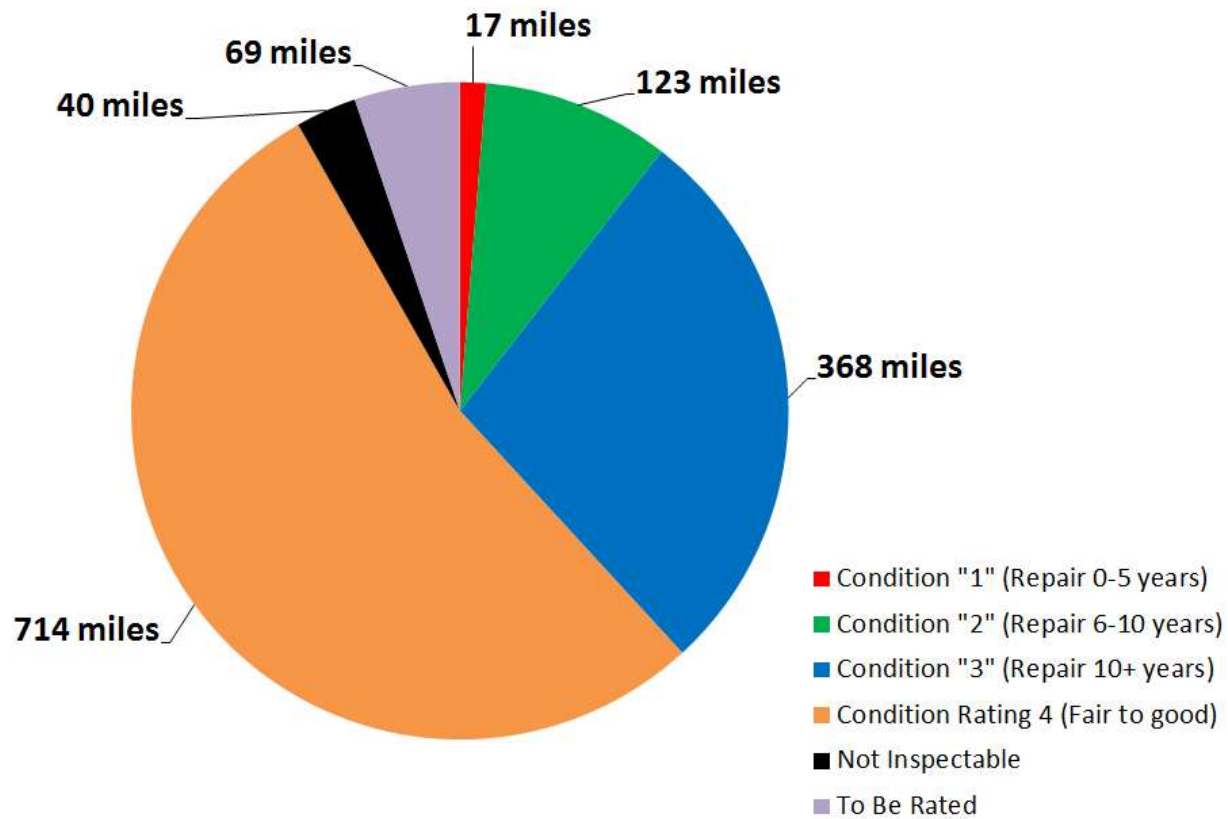
CONDITION ASSESSMENT

Cumulative Miles of Sewer Assessed and Rated

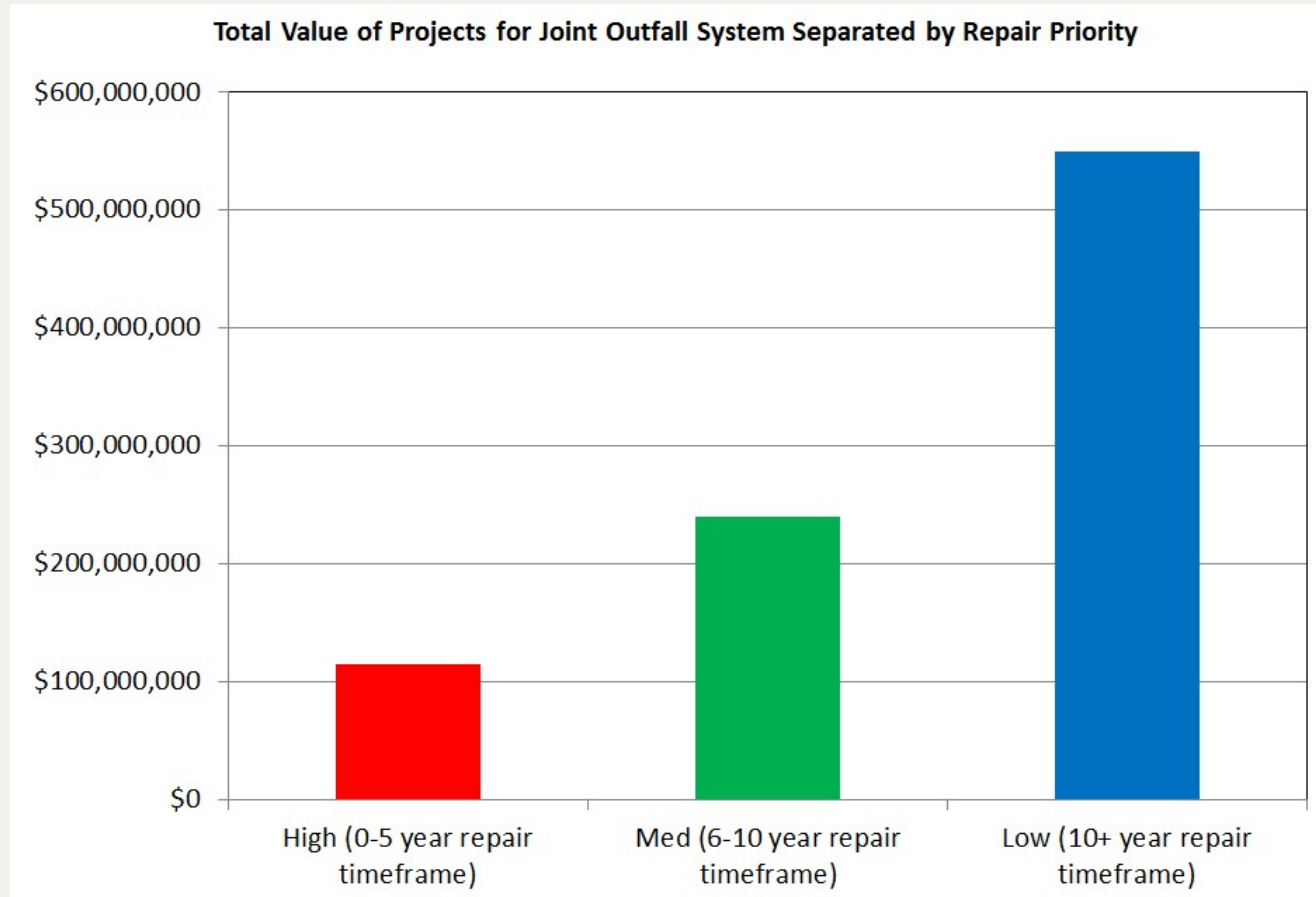


CONDITION ASSESSMENT

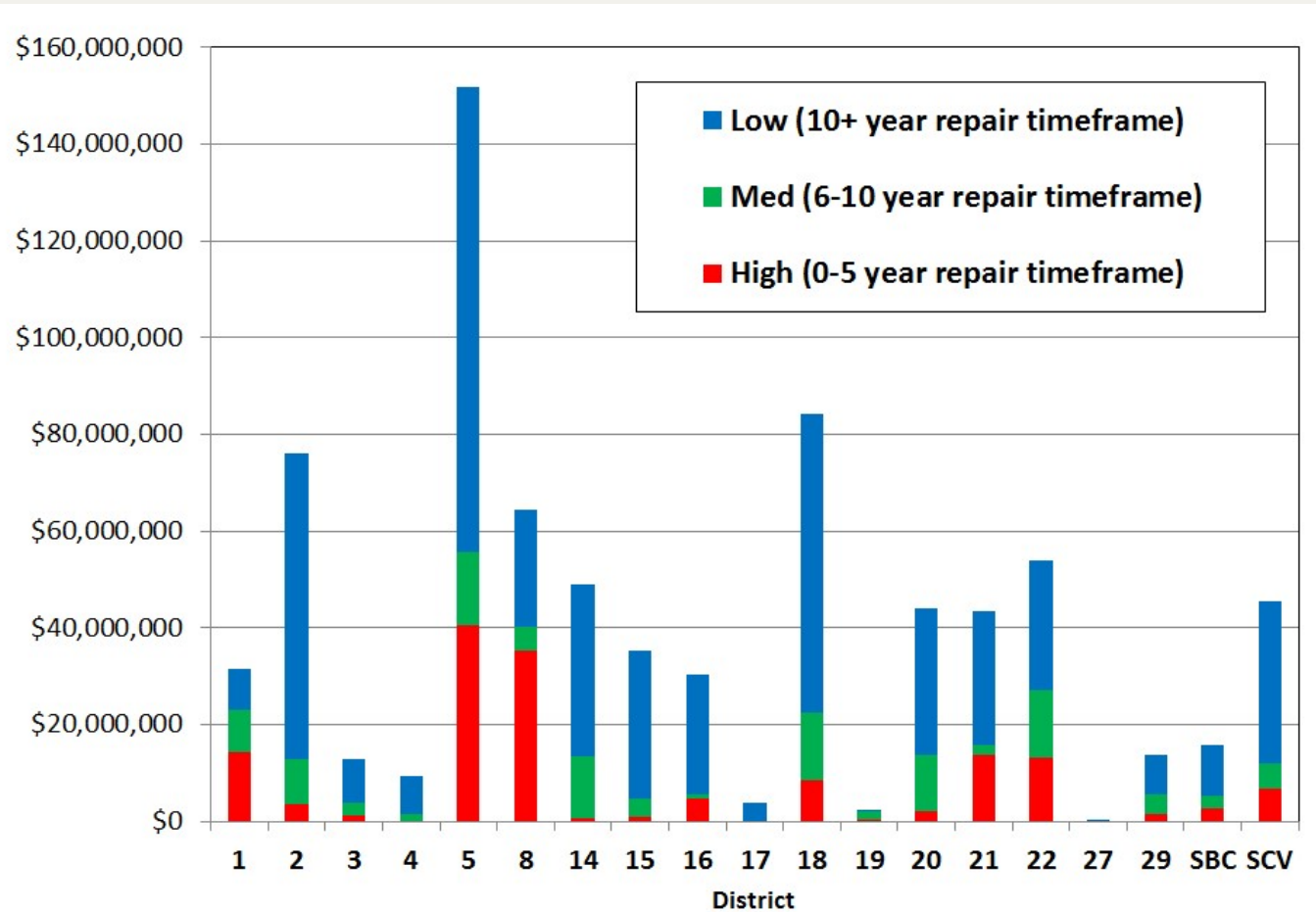
STRUCTURAL CONDITION OF THE SEWER SYSTEM



CAPITAL PLANNING



CAPITAL PLANNING

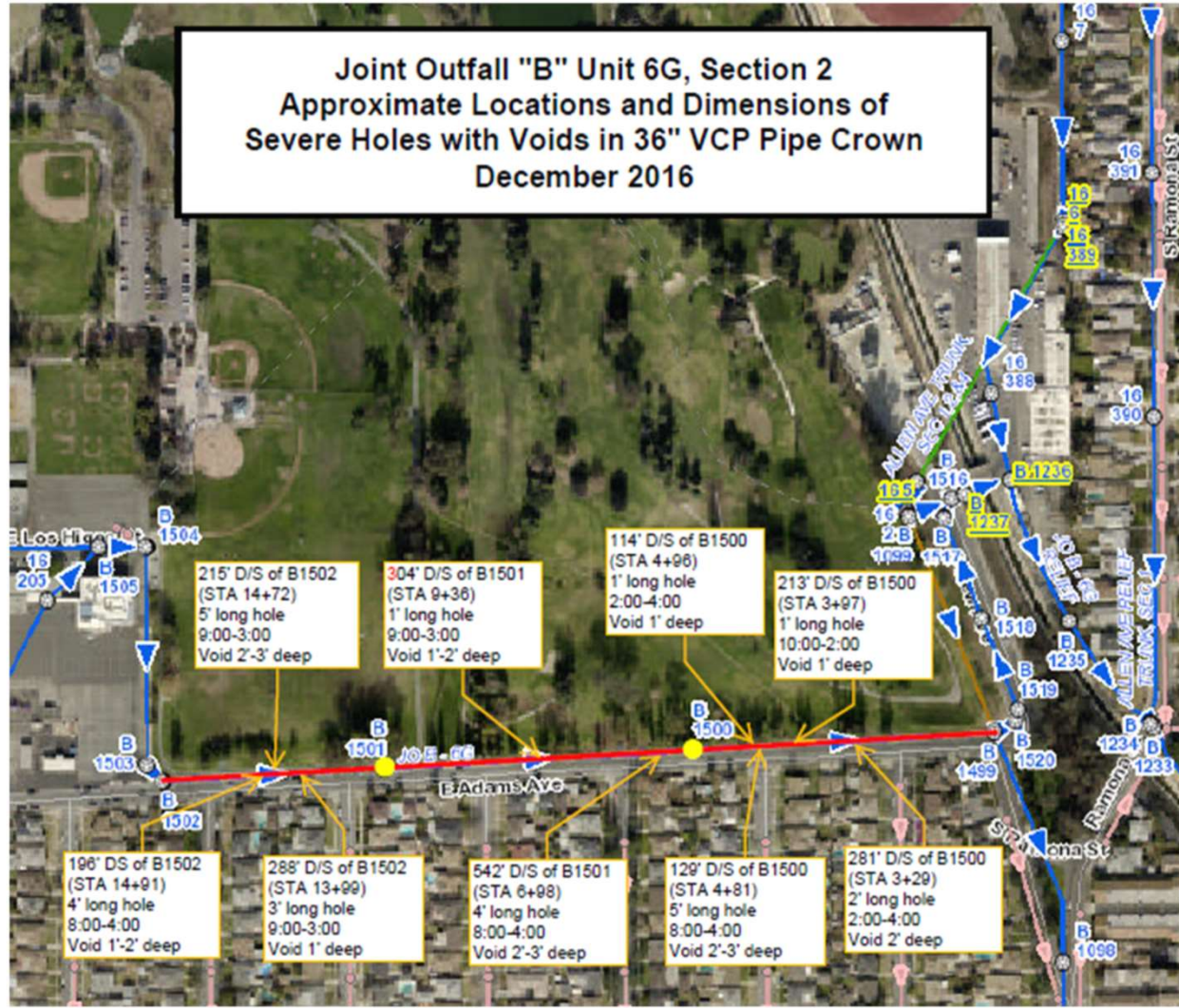


AN UNWELCOME SURPRISE

2:48 AM – MONDAY, NOVEMBER 28, 2016



**Joint Outfall "B" Unit 6G, Section 2
Approximate Locations and Dimensions of
Severe Holes with Voids in 36" VCP Pipe Crown
December 2016**



PRECARIOUS LOCATION

LOCATED UNDER HEAVILY USED WALKWAY



ALL HANDS ON DECK

- Sewer O&M Section and Sewer Design Section
- Initial Cut: All VCP Less Than 15 Years Old

Dwg Yea	Pipe ID	Sewer	DS_M	US_M	D	Length	DVE	Ta	CCTV	Manufacturer	Action	Reviewer	Reviewed Date	Condition
2008	P26243	20 TRUNK "A" RELIEF	20 0613	20 0770	36"	7.53	K1914		7.38	Mission Clay	Engineer to Review	Jilei Shan	6-Jan-17	Some sign of corrosion: Thin layer of white deposition presents from 9 to 3 clock
2008	P26244	20 TRUNK "A" RELIEF	20 0777	20 0513	24"	19.77				Mission Clay	Assigned to Propipe	Jilei Shan	13-Jan-17	Sporadic white surface
2008	P26245	20 TRUNK "A" RELIEF	20 0780	20 0083	18"	5.36	K3763		8.03	Mission Clay	Engineer to Review	Jilei Shan	6-Jan-17	Some sign of corrosion: white deposition presents on top of the pipe
2008	P26246	20 TRUNK "A" RELIEF	20 0783	20 0086	8"	5.66	K3763		8.62	Mission Clay	Engineer to Review	Jilei Shan	6-Jan-17	Apparent sign of corrosion: sporadic spalling and uniform white deposition
2008	P26247	20 TRUNK "A" RELIEF	20 0786	20 0090	8"	5.08	K3763		7.15	Mission Clay	Engineer to Review	Jilei Shan	6-Jan-17	Apparent sign of corrosion: sporadic spalling and uniform white deposition
2008	P26248	20 TRUNK "A" RELIEF	20 0542	20 0093	15"	2.80	K3763		4.02	Mission Clay	Engineer to Review	Jilei Shan	6-Jan-17	Some sign of corrosion: white deposition presents from 9 to 3
2008	P26314	20 TRUNK "A" RELIEF	20 0789	20 0542	42"	42.00	K1914		47.93	Mission Clay	Engineer to Review	Jilei Shan	6-Jan-17	Some sign of corrosion: white deposition presents on some of the pipes
2012	P26477	22 DUARTE RELIEF TRUNK	22 1459	22 1460	18"	18.27				Gladding McBean	Assigned to Propipe	John C.	9-Jan-17	Minor sporadic discoloration.
2012	P26478	22 DUARTE RELIEF TRUNK	22 1460	22 1461	18"	84.96				Gladding McBean	Assigned to Propipe	John W.	13-Jan-17	Some surface roughness, spots of whiteness.
2012	P26479	22 DUARTE RELIEF TRUNK	22 1461	22 1462	18"	341.93				Gladding McBean	Assigned to Propipe	John W.	13-Jan-17	Sporadic whiteness above 9:00 and 3:00.
2012	P26480	22 DUARTE RELIEF TRUNK	22 1462	22 1463	18"	276.29				Gladding McBean	Assigned to Propipe	John W.	13-Jan-17	Sporadic whiteness above 9:00 and 3:00.
2012	P26481	22 DUARTE RELIEF TRUNK	22 1463	22 1464	18"	371.92				Gladding McBean	Assigned to Propipe	John W.	13-Jan-17	Sporadic whiteness above 9:00 and 3:00.
2012	P26482	22 DUARTE RELIEF TRUNK	22 1464	22 1465	18"	352.54				Gladding McBean	Assigned to Propipe	John W.	13-Jan-17	Sporadic whiteness above 9:00 and 3:00.
2011	P26450	27 DISTRICT #27 GRAVITY SEWER	27 0004	27 0010	12"	170.00				TBD	Assigned to Propipe	John W.	13-Jan-17	Some sporadic whiteness above 9:00 and 3:00.
2011	P26451	27 DISTRICT #27 GRAVITY SEWER	27 0010	27 0011	12"	977.97				TBD	Assigned to Propipe	John W.	13-Jan-17	Some sporadic whiteness above 9:00 and 3:00.
2011	P26452	27 DISTRICT #27 GRAVITY SEWER	27 0011	27 0012	10"	212.37				TBD	Assigned to Propipe	John W.	13-Jan-17	Some sporadic whiteness above 9:00 and 3:00.
2011	P26453	27 DISTRICT #27 GRAVITY SEWER	27 0012	27 0008	8"	20.48				TBD	Assigned to Propipe	John W.	13-Jan-17	Some sporadic whiteness above 9:00 and 3:00.
2003	P17977	30 MALAGA COVE TRUNK	30 0281	30 0282	10"	338.46	G2287		341.36	TBD	Engineer to Review	Nate Y	6-Jan-17	Minor light white discoloration.
2007	P25953	30 SOUTH BAY CITIES MAIN P.P. FORCE MAIN (GRAVITY SEWER)	30 0375	30 0376	21"	14.30				Mission Clay	Assigned to Propipe	John W.	13-Jan-17	Surface roughness, possible corrosion above 9:00 and 3:00. (Short reach.)
2004	P26372	32 CASTAIC RELIEF TRUNK	32 0242	32 1343	24"	61.86	K2852		63.20	TBD	Engineer to Review	PATRICIAHSIA	9-Jan-17	SPORADIC WHITE SURFACES JUST ABOVE WATERLINE AT 9:00 AND 3:00. SPORADIC
2010	P26373	32 CASTAIC RELIEF TRUNK	32 1343	32 1344	39"	552.03	K2852		557.01	TBD	Engineer to Review	PATRICIAHSIA	6-Jan-17	WHITE SURFACES A CROWN. MINOR SPALLING AT 10:00 TO 2:00.
2010	P26374	32 CASTAIC RELIEF TRUNK	32 1344	32 1345	39"	638.10	K2852		635.61	TBD	Engineer to Review	PATRICIAHSIA	6-Jan-17	CONTINUOUS WHITE SURFACE FROM 8:00 TO 4:00. SOME SPORADIC PATCHES IN
2010	P26375	32 CASTAIC RELIEF TRUNK	32 1345	32 1346	39"	39.06	K2852		38.06	TBD	Engineer to Review	PATRICIAHSIA	6-Jan-17	VERY LOW VISIBILITY IN VIDEO. NO VISIBLE CORROSION. POTENTIALLY SOME
2010	P26376	32 CASTAIC RELIEF TRUNK	32 1346	32 1347	39"	507.46	K2852		506.52	TBD	Engineer to Review	PATRICIAHSIA	6-Jan-17	SPORADIC WHITE SPLOTCHES THROUGHOUT. NOT ALL SEGMENTS EXHIBIT
2010	P26377	32 CASTAIC RELIEF TRUNK	32 1347	32 1348	36"	49.94	K2852		51.08	TBD	Engineer to Review	PATRICIAHSIA	6-Jan-17	SPORADIC WHITE/ GRAY SURFACES FROM 8:00 TO 4:00.
2010	P26378	32 CASTAIC RELIEF TRUNK	32 1349	32 1350	18"	9.24	K2852		7.65	TBD	Engineer to Review	PATRICIAHSIA	6-Jan-17	CONTINUOUS WHITE SURFACE FROM 9:00 TO 3:00. SPLOTCHY AREAS.
2010	P26379	32 CASTAIC RELIEF TRUNK	32 1350	32 1351	18"	359.35	K2852		359.25	TBD	Engineer to Review	PATRICIAHSIA	6-Jan-17	CONTINUOUS WHITE SURFACE FROM 9:00 TO 3:00.
2010	P26380	32 CASTAIC RELIEF TRUNK	32 1351	32 1352	18"	11.64	K2852		13.22	TBD	Engineer to Review	PATRICIAHSIA	6-Jan-17	SPORADIC WHITE PATCHES AT 9:00 AND 3:00.

ALL HANDS ON DECK

- Researched Construction Records and Contacted Manufacturers
- Final Scope of Investigation: VCP 15 Years or Newer, 24" Diameter or Larger
- 30 miles of sewers reviewed
- 7 miles of emergency inspections into early 2017



INVESTIGATION OF PAST INSPECTIONS

2011 INSPECTION OF 36" CLAY SEWER THAT FAILED IN 2016



INVESTIGATION OF PAST INSPECTIONS

VCP CORROSION



INVESTIGATION OF PAST INSPECTIONS

VCP CORROSION ... ?

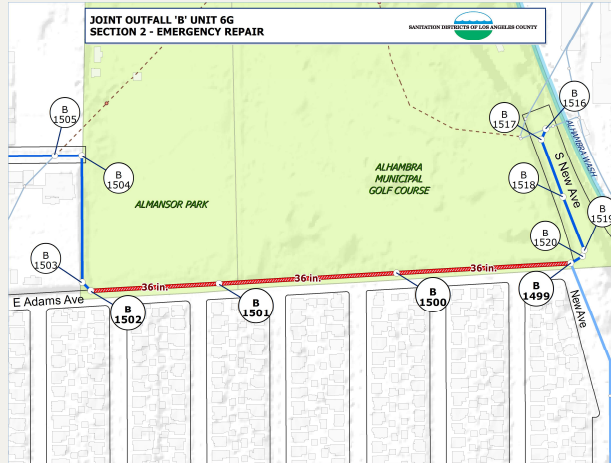


FINDINGS AND ACTIONS TAKEN

INITIAL INVESTIGATION OF 30 MILES OF VCP SEWER

- Did not discover any corrosion-related holes or collapsed pipes
- 7 miles of sewer were slated for repair due to probable corrosion
- Another 20 miles showed possible initial signs of corrosion (whiteness, pitting, etc.)
 - Were put on a more frequent CCTV inspection schedule
 - Minimal impact on CCTV budget
- Other clay sewers reviewed since then have been flagged Condition Rating “3” based on possible signs of corrosion
- Emergency repair of collapsed sewer in Alhambra

EMERGENCY REPAIR OF ALHAMBRA SEWER

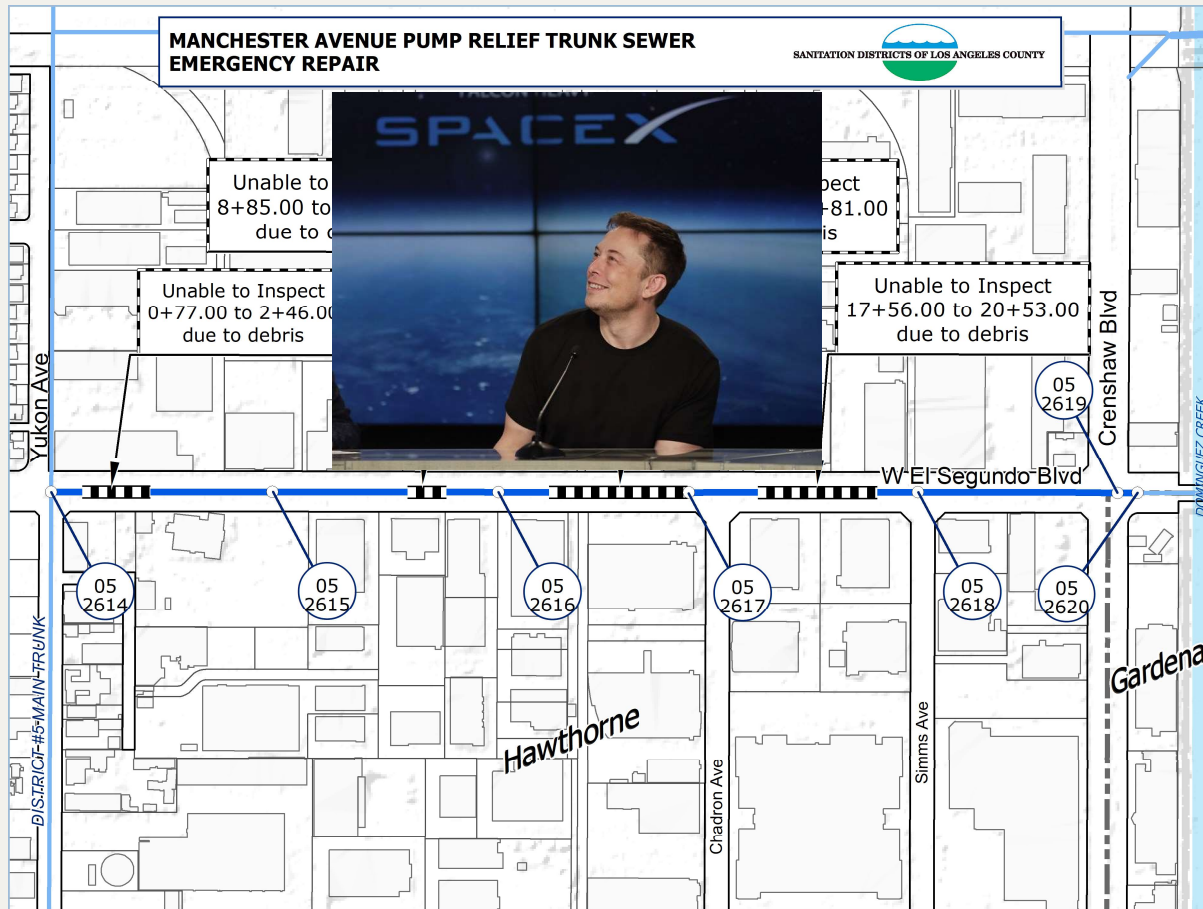


A SECOND SURPRISE

36" VCP SEWER IN THE CITY OF HAWTHORNE, BUILT IN 2007

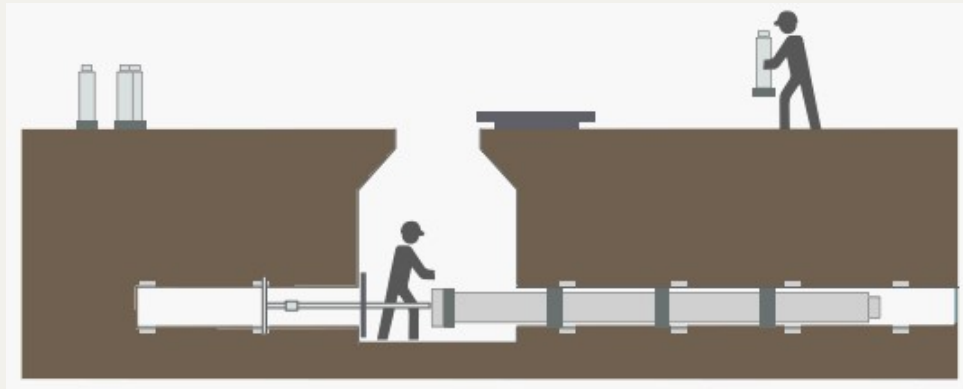


MANCHESTER AVENUE PUMP RELIEF TRUNK SEWER EMERGENCY REPAIR

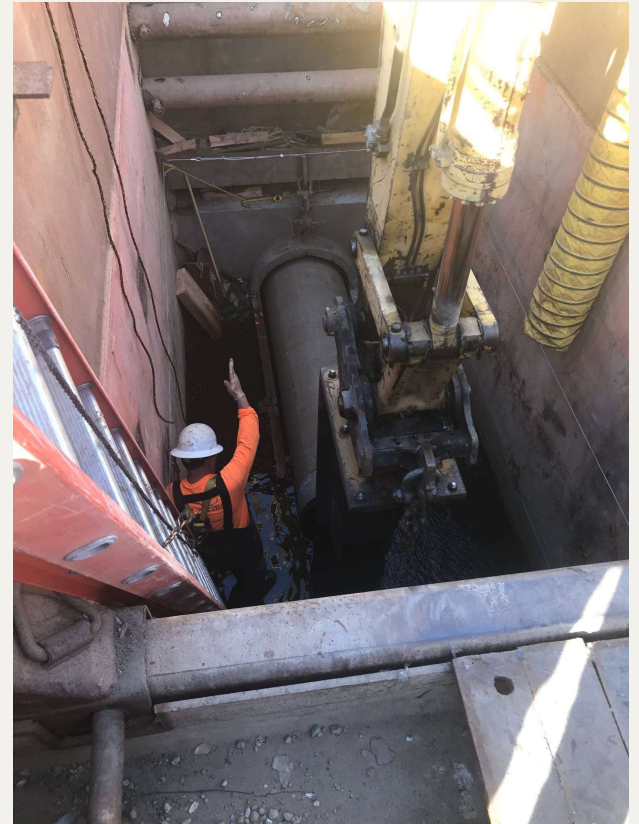


MANCHESTER AVENUE PUMP RELIEF TRUNK SEWER

- Chose slip lining method
- No need for full bypass
- VCP sampling pits are needed; can double as insertion pits

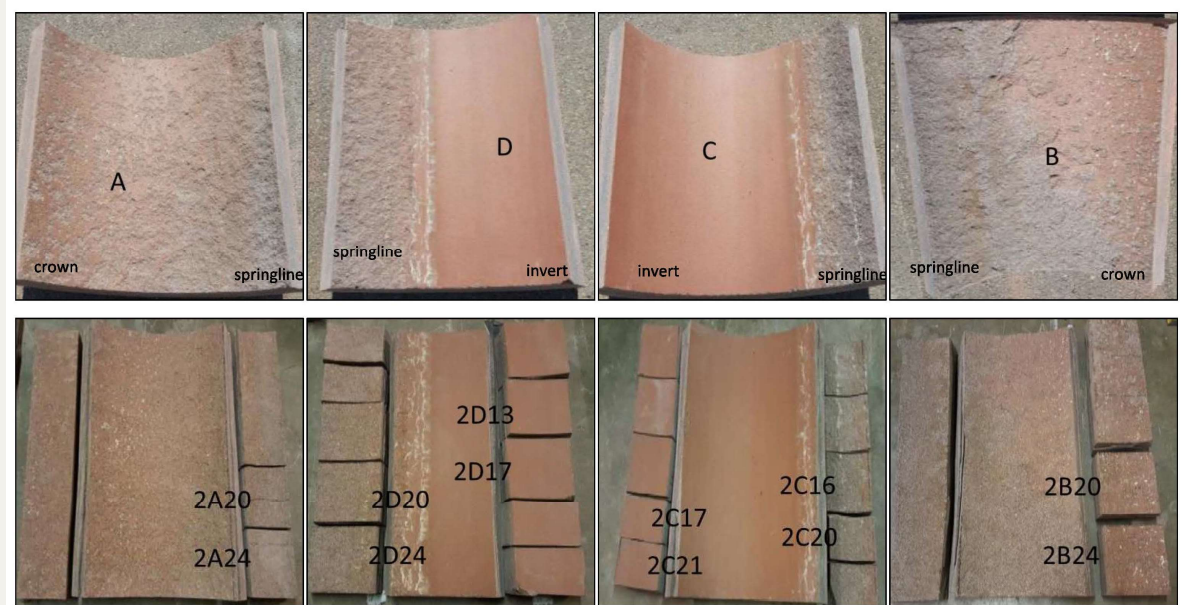


MANCHESTER AVENUE PUMP RELIEF TRUNK SEWER



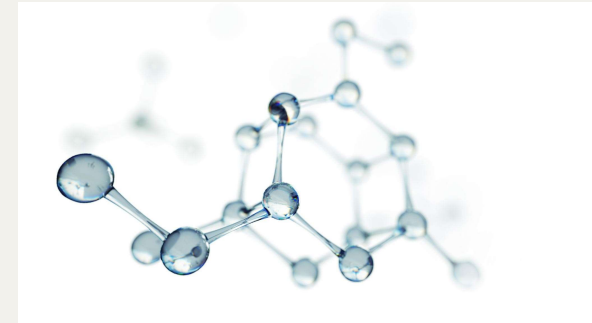
VCP LAB TESTING

- Pipe segments from both the Alhambra and Hawthorne sewers were removed for lab testing
- Sampling was overseen by a local independent third party laboratory, Ramtech



PETROGRAPHIC LAB TESTS

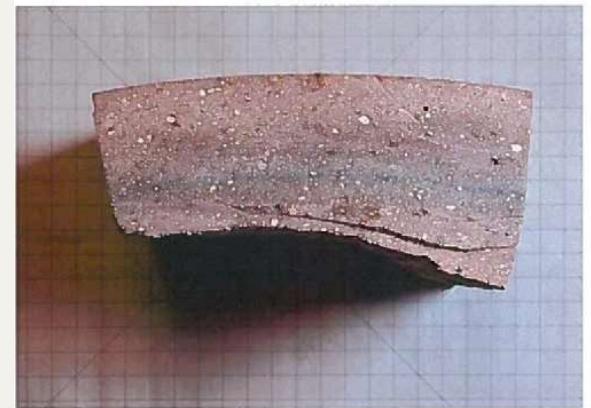
- Not pass-fail; investigative
- Petrographic Test – examines optical properties and microstructural characteristics of materials
 - Visual & Microscopic Inspection
 - X-Ray Diffraction
 - Soluble Ion Analysis
 - These three tests identify mineral and element composition and structure of the VCP particles
- Acid Soluble Matter Test
 - ASTM C301, Identifies volume of soluble material within VCP



LAB TEST RESULTS

FAILURE MECHANISM

The formation of amorphous silica and gypsum throughout the VCP matrix, which expands and causes spalling.



PRIMARY FAILURE

Primary Failure Mechanism – Amorphous Silica

Sulfuric acid from the sewer environment deteriorates calcium silicate particles to amorphous silica



Photo 34

Polished section of Sample 2B20 (crown) at interior side near area depicted in Photo 29. Black tape is marker used to locate items of interest on the surface. Red epoxy seen at top was used to preserve the surface. Red box marks location of SEM/EDS element maps shown in Photo 35.

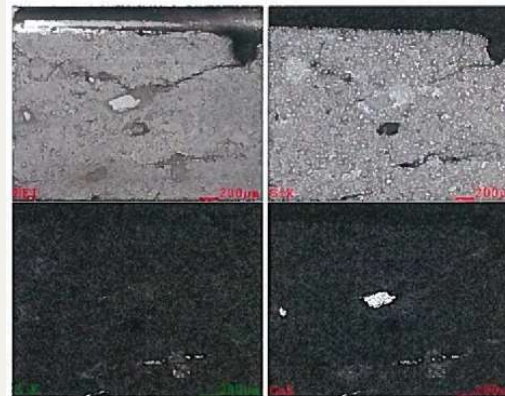


Photo 35

SEM BEI (upper left image) of area indicated in previous image of Sample 2B20 (crown), and SEM/EDS element maps of silicon (Si), sulfur (S), and calcium (Ca) of the same area. Particle in center has a calcium-rich core with a silicon shell. Near this particle, a diffuse distribution of silicon occurs in the matrix where a crack traverses to surface, and part of this crack contains calcium and sulfur. Calcium and sulfur are also present in a crack intersecting the top edge of a particle near the bottom of image, which also contains calcium and sulfur.

SECONDARY FAILURE

Secondary Failure Mechanism - Gypsum

Both acid and water can dissolve calcium particles to form gypsum.

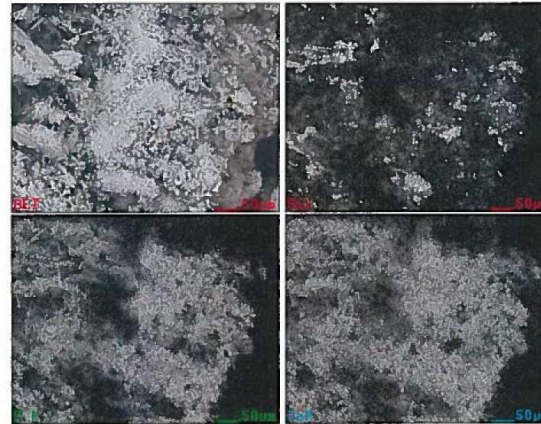


Photo 74

SEM BEI (upper left image) of particles in white extrudate obtained from Sample 2D17 (invert) after conducting ASTM C301 analysis with sulfuric acid, and SEM/EDS element maps of silicon (Si), sulfur (S), and calcium (Ca) of the same area.

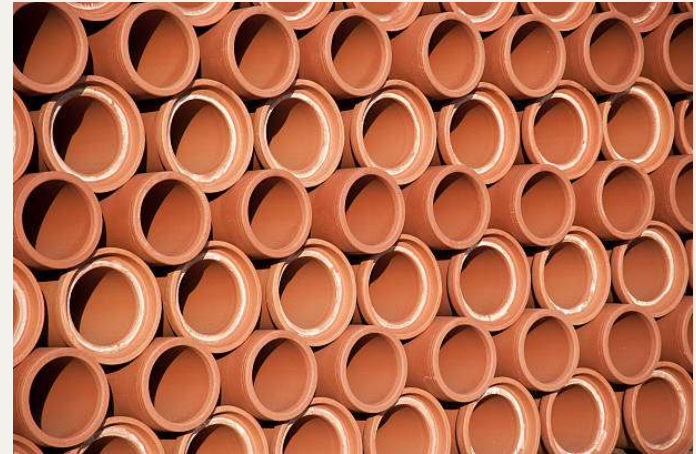


Photo 75

Enlargement of SEM BEI shown in Photo 74, showing long needle crystals of calcium sulfate (gypsum) and amorphous masses rich in silicon.

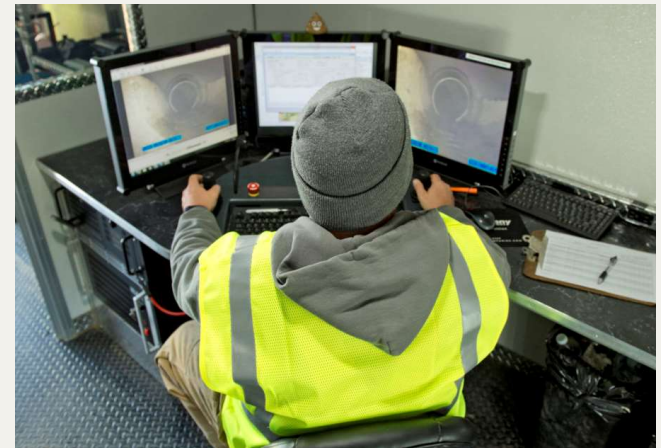
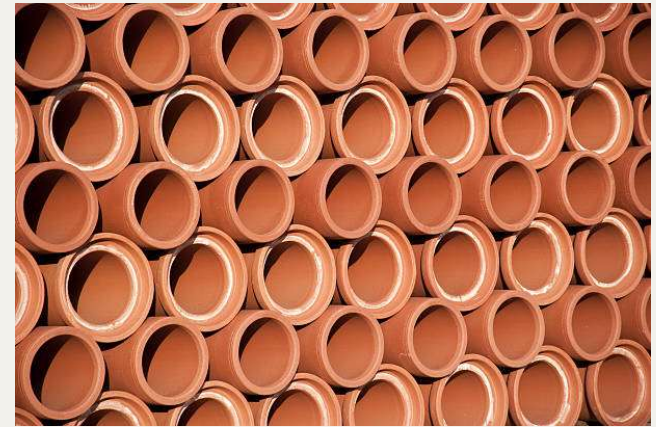
FINDINGS AND GOING FORWARD

- One manufacturer, one facility
- Wollastonite (CaSiO_3) as additive



FINDINGS AND GOING FORWARD

- One manufacturer, one facility
- Wollastonite (CaSiO_3) as additive
- CCTV IS CRITICAL
 - Corrosion can happen to any product
 - Need to identify early signs
- LACSD is still using clay pipe



THANK YOU

JOHN WESTERGAARD, P.E.
LOS ANGELES COUNTY
SANITATION DISTRICTS

BRYAN VANSELL
MISSION CLAY PRODUCTS



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