Replacement Main Prioritization

A Practical Application of Using Risk and Methane Emissions

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PSEG
We make things work for you.

We have the **energy** to make things work … for you.

Getting to know PSE&G

- 6th Highest Gas Utility in US sales
- Serves 10 of the top 15 cities in NJ
- ~2,400 employees
- 12 District Headquarters
- 17,955 miles of gas distribution main
- 57 miles of gas transmission main
- 1.2 million gas services
- 1.8 million gas customers
- Sales volume growth: 1% per year

What is the Gas System Modernization Program (GSMP)?

- Accelerated cast iron and unprotected steel main and service replacement program
- Upgrades legacy low (utilization) pressure systems to medium pressure
- Relocates inside meter sets to outside
- Installs excess flow valve (EFV) safety devices
- Supports DOT focus on replacing the highest risk, most leak prone facilities

Continued replacement at these levels would replace/rehabilitate all the cast iron and unprotected steel by 2040

Gas System Modernization Program

- PSE&G currently operates and maintains over 3,900 miles of cast iron and unprotected steel gas distribution main.
- The program provides for investment and clause recovery of Utilization Pressure Cast Iron (UPCI) and Unprotected Steel replacement main, services, and associated uprating of plastic and protected steel in targeted areas
  - GSMP I started in 2016 (3 year term - $900M)
  - GSMP II started in 2019 (5 year term – $1.9B)
- Stipulated Base CapEx spend requirement associated with the program approval
  - Includes High Pressure Cast Iron (HPCI), UPCI, unprotected steel main and service replacement
  - Includes program and stipulated base inside meter set relocations
- Total ~170 miles of main replacement per year in Program and Stipulated Base
- The first two approvals are the beginning phases of a long-term 25 year replacement strategy for cast iron and unprotected steel mains
- Benefits:
  - Methane emission reduction is estimated at 30,000 metric tons of CO_2 equivalent per year*
  - Medium pressure system allows usage of high efficiency appliances by customers
  - Includes installation of excess flow valve safety devices where applicable

* EPA SUBPART W METHODOLOGY.

GSMP Stipulation

The replacement of mains in the Program shall follow the prioritization based on the grid based Leak Hazard Indices developed by PSE&G using its Hazard Assessment model.

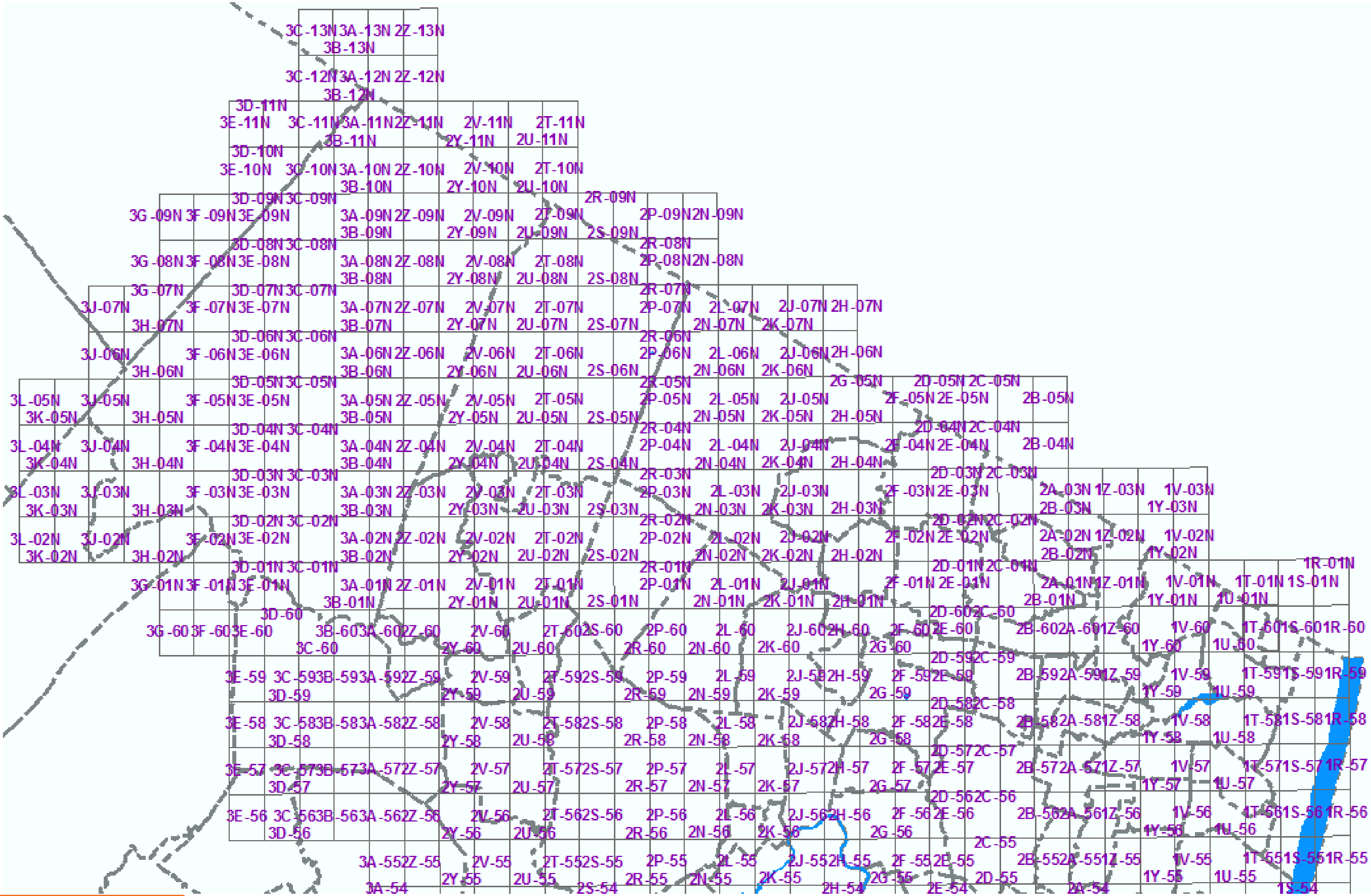
"...Recognizing that considering methane emission flow volume (i.e., emission size) as part of prioritization will reduce the amount of natural gas lost from emissions to the benefit of customers, and reduce the environmental impacts of such emissions, the Signatories agree that for grids with comparable Hazard Index/Mile, available methane emissions survey data estimating flow volumes, as prepared by the Environmental Defense Fund using Program plans, system information and maps provided by PSE&G, will be used, as appropriate, in sub-prioritizing replacement activities…"

Accelerated UP Cast Iron (UPCI) Replacement

- Goal - Replace priority areas most efficiently
  - Highest potential hazard
  - Contiguous area for construction efficiency

- Map grid system utilized
  - 1 square mile area
  - 1 – 20 miles of low pressure cast iron per grid
  - Similar environmental conditions

PSE&G Grid Mapping System



Prioritization of UPCI Replacement Main

- Hazard Index (HI) rankings used to express and compare relative hazard for main segments having a history of breaks.

- Factors used in the calculation
  - Hazard Index = Weighted Break History (WBH) x Environmental Index (E)
  - WBH = The sum of the factors multiplied by the number of annual break repairs for each period (factors higher for recent breaks)
  - Environmental Index evaluates the environmental conditions at the main segment location that may affect the relative hazard of a break and is based upon the following factors
    - Building Density
    - Operating Pressure
    - Building Occupancy
    - Underground Utility
    - Building Set-back
    - Nominal Pipe Size

- Mileage is based upon total low pressure cast iron mileage in grid

Prioritization of UPCI Replacement Main (cont'd)

- Mains with break history - Hazard Index
- Individual segments within a grid are summed to obtain total hazard index for the grid
- Miles of UPCI main in grid are summed
- Hazard score divided by miles gives HI/Mi score
- Map Grids ranked by HI/Mi

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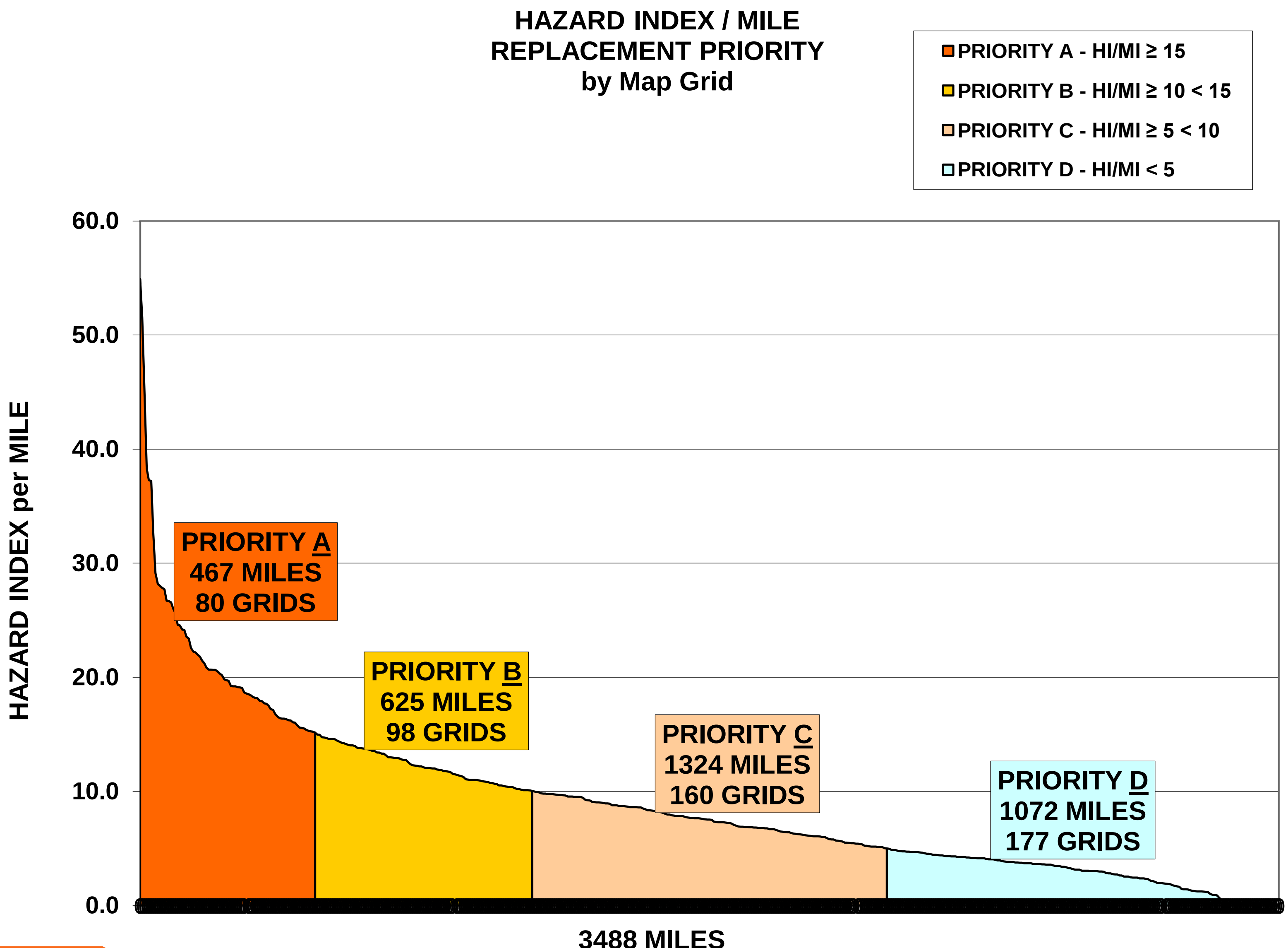
GSMP I - UP Cast Iron Main Prioritization

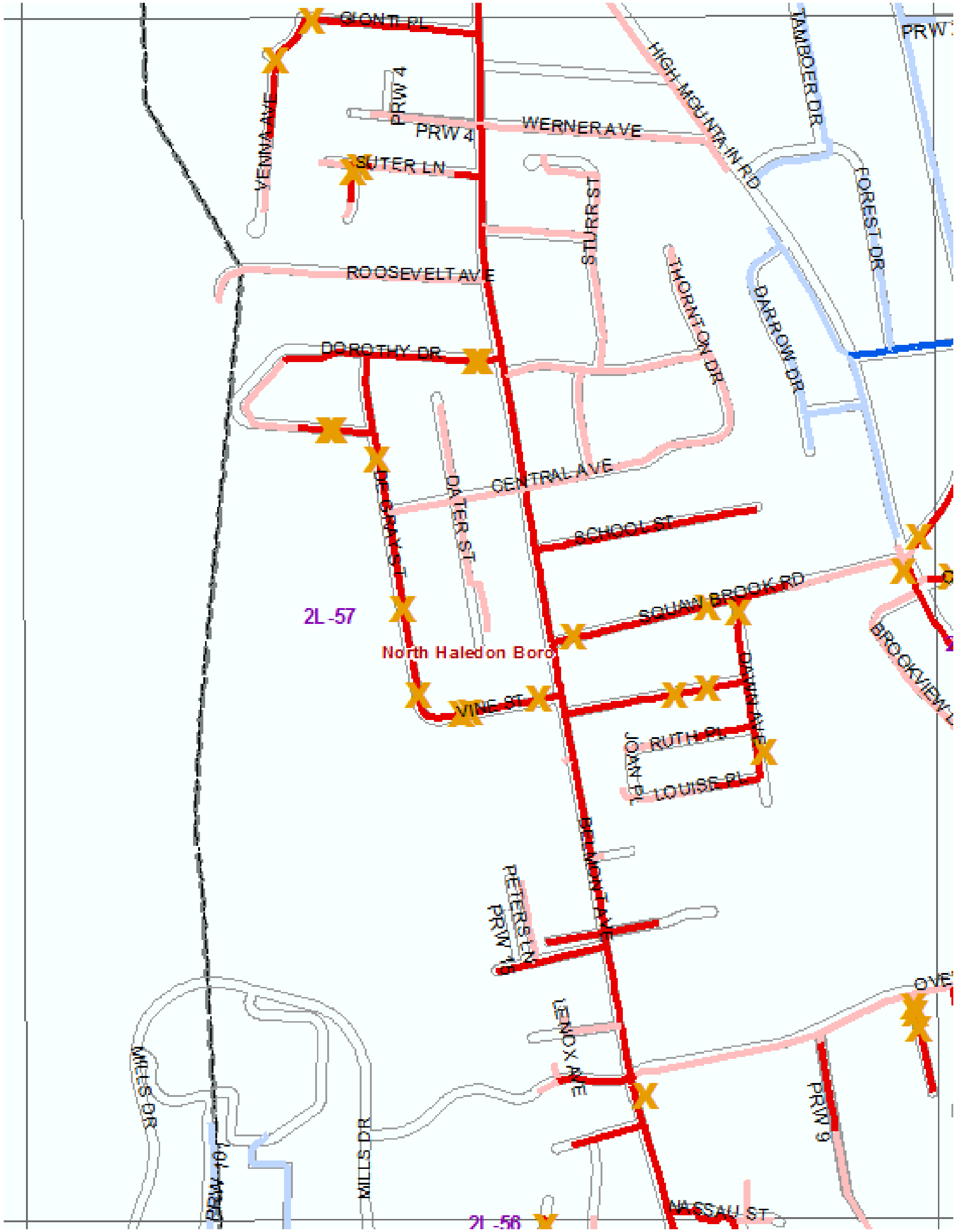


Grid 2L-57 (Rank 2)
UP CI = 3.8 miles
HI/MI = 45.4

UP Cast Iron
EP Cast Iron
UP Plastic and Steel
EP Plastic and Steel

Regulator

CI Break



Hazard Index – Grid 2L - 57

District	Street	Municipality	Install Year	Main Size	Main Type	Pressure	Segment Length	B	P	O	U	S	Last Repair Date	Number of Breaks	WBH	BPOU/S	Env Index E	Hazard Index	Wall Map Grid
DGOK	VINE ST	Haledon Boro	1900	6	CI	UP	700	4	1	4	2	1.5	1/8/2014	3	12	21	2.3012	27.615	2L-57
DGOK	DE ROON AVE	Haledon Boro	1900	4	CI	UP	458	8	1	4	3	1	4/4/2012	3	9	96	3.0307	27.2765	2L-57
DGOK	MORNINGSIDE AVE	North Haledon Boro	1953	4	CI	UP	929	8	1	4	3	1	1/28/2013	2	8	96	3.0307	24.2458	2L-57
DGOK	BELMONT AVE	North Haledon Boro	1927	8	CI	UP	460	8	1	15	4	1	11/6/2013	1	5	480	4.5596	22.7982	2L-57
DGOK	DE GRAY ST	Haledon Boro	1955	6	CI	UP	1037	4	1	4	3	1.5	2/14/2013	2	7	32	2.5705	17.9933	2L-57
DGOK	DAWN AVE	Haledon Boro	1951	6	CI	UP	426	8	1	4	3	1	1/14/2011	1	3	96	3.3	9.8999	2L-57
DGOK	GIONTI PL	North Haledon Boro	1928	6	CI	UP	885	4	1	4	2	3	2/11/2014	1	5	11	1.841	9.205	2L-57
DGOK	SQUAW BROOK RD	North Haledon Boro	1937	6	CI	UP	962	4	1	4	3	1	1/12/2009	2	2	48	2.8397	5.6794	2L-57
DGOK	MEADOW PL	North Haledon Boro	1954	4	CI	UP	187	4	1	4	4	1	2/22/2010	1	2	64	2.7615	5.523	2L-57
DGOK	DOROTHY DR	North Haledon Boro	1964	4	CI	UP	276	4	1	4	3	1	3/25/1999	2	2	48	2.5705	5.141	2L-57
DGOK	HIGH MOUNTAIN RD	North Haledon Boro	1900	8	CI	UP	109	2	1	4	3	1.5	12/30/2010	1	2	16	2.3012	4.6025	2L-57
DGOK	SUTER LN	North Haledon Boro	1954	4	CI	UP	93	4	1	4	1	1.5	2/20/2010	1	2	11	1.5718	3.1435	2L-57
DGOK	DAWN AVE	North Haledon Boro	1951	6	CI	UP	267	4	1	4	3	1	12/8/2003	1	1	48	2.8397	2.8397	2L-57
DGOK	DOROTHY DR	North Haledon Boro	1957	6	CI	UP	682	2	1	4	2	3	1/8/2001	2	2	5	1.3807	2.7615	2L-57
DGOK	VENNA AVE	Haledon Boro	1929	6	CI	UP	325	2	1	4	2	3	2/2/2009	1	1	5	1.3807	1.3807	2L-57
																Total Hazard Score		170.1051	
																Total CI Miles in Grid		3.75	
																Hazard Index Per Mile		45.36	

Top 20 Hazard Index/Mile

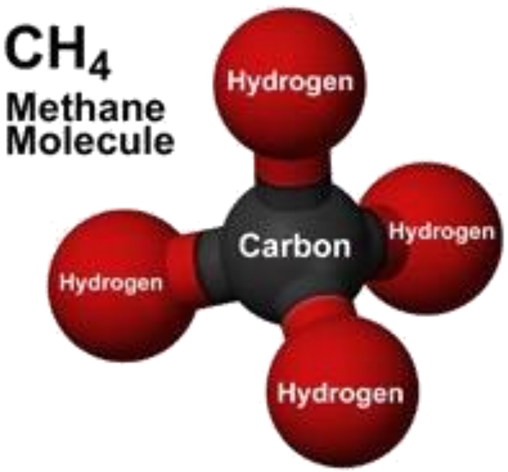
UPCI GRID	UPCI MILES	2014 HAZARD INDEX	HAZARD INDEX/MILE	HI/MILE RANK
2A-48	1.0	55.0970	54.9	1
2L-57	3.7	170.2419	45.4	2
2K-45	5.0	185.4933	37.3	3
2Z-41	1.2	43.9937	37.2	4
2K-44	3.0	109.7977	36.7	5
2B-46	2.9	103.7972	36.2	6
2K-55	11.1	360.4543	32.5	7
2J-51	10.1	294.1113	29.1	8
2D-58	3.1	87.5603	28.2	9
2A-45	2.4	66.1032	28.0	10
2K-57	4.1	115.1842	27.9	11
2L-58	1.7	48.0314	27.7	12
3D-46	2.1	55.6910	26.6	13
3J-50	1.4	37.6969	26.0	14
1Z-47	7.7	200.3936	25.9	15
3C-25	1.4	35.9431	25.6	16
2H-50	6.6	162.3633	24.8	17
2L-51	8.1	194.9827	24.2	18
2H-45	3.6	87.6968	24.2	19
2L-43	7.1	167.2065	23.6	20

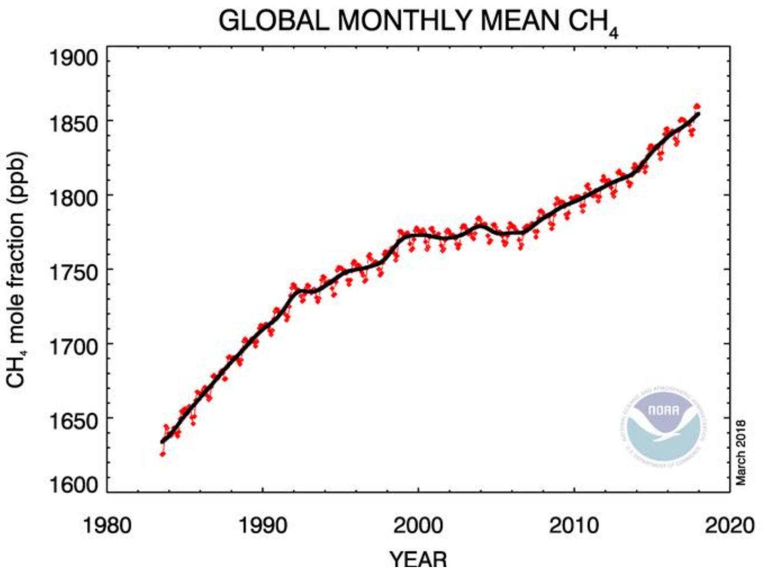
Methane as a Greenhouse Gas

- Methane has 84 times the warming effect of carbon dioxide over a 20 year period
- EDF estimates that about 25% of the manmade global warming we're experiencing today is caused by methane emissions

Typical Composition of Natural Gas

Methane	CH_4	70-90%
Ethane	C_2H_6	0-20%
Propane	C_3H_8	
Butane	C_4H_{10}	
Carbon Dioxide	CO_2	0-8%
Oxygen	O_2	0-0.2%
Nitrogen	N_2	0-5%
Hydrogen sulphide	H_2S	0-5%
Rare gases	A, He, Ne, Xe	trace





Working with the EDF

- In advance of GSMP I, PSE&G engaged the Environmental Defense Fund (EDF) to quantify methane emissions in our service territory to consider in the prioritization of the work
- Mapping was performed over a six month period
- Study was done at no cost to PSE&G
- PSE&G followed the EDF equipment with its own optical methane leakmobile to compare data

EDF
ENVIRONMENTAL DEFENSE FUND®
Finding the ways that work

EDF Overview - Continued

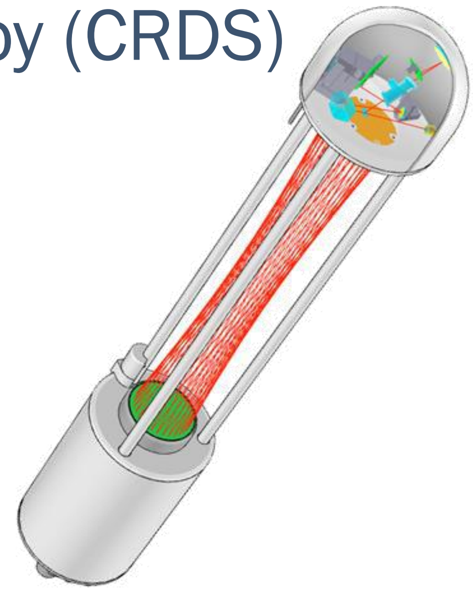
- The EDF partnered with Google and Colorado State University on a nationwide program to detect and map methane leaks from natural gas distribution systems
- A Google street-view car, equipped with state of the art methane and meteorological sensors, was driven repeatedly along streets with natural gas pipelines to map emissions
- Urban areas have been mapped across the country (Birmingham, Boston, Burlington, Chicago, Dallas, Indianapolis, Jacksonville, Los Angeles, Mesa, Pittsburgh, Staten Island, and Syracuse)
- The same technology used to map these cities was also used for the PSE&G project

Google

Colorado State University

What Technology Was Used?

- Advanced GPS technology and anemometer
- Open path, Cavity Ring-Down Spectroscopy (CRDS) LiCor analyzer



- High data collection rate
- No pumps (closed path CRDS)
- The longer the laser path, the better the sensitivity in detecting molecular signatures
- Equipment uses a series of mirrors within the sample cavity to reflect the laser path from a distance of 25 cm to over 20 km

Methane Quantification Data

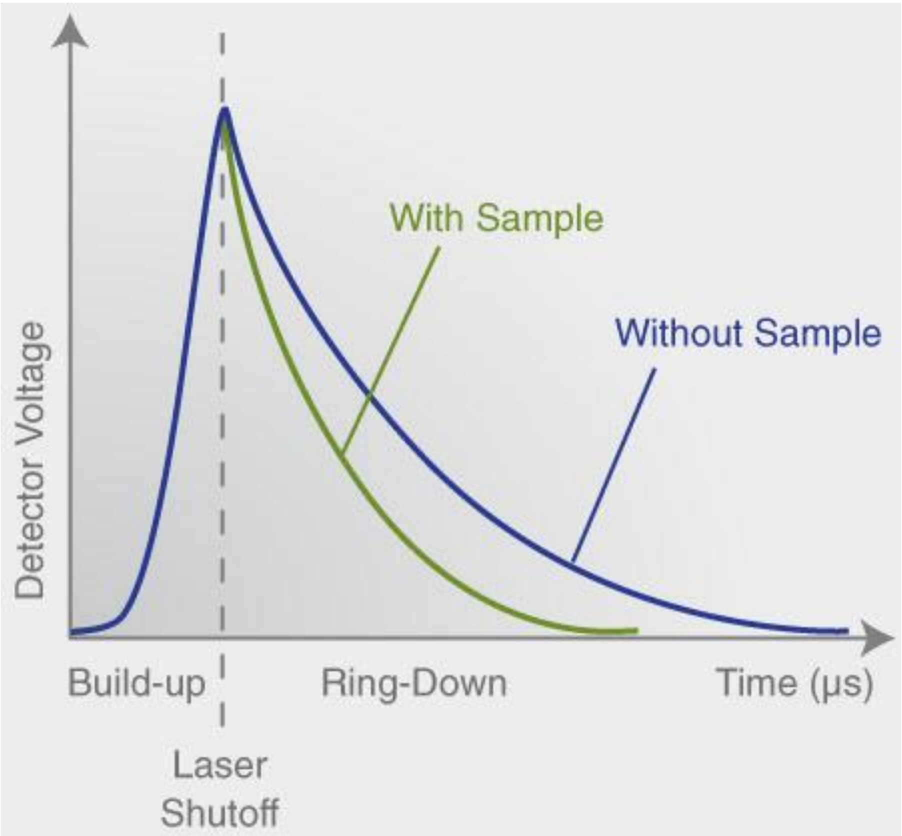
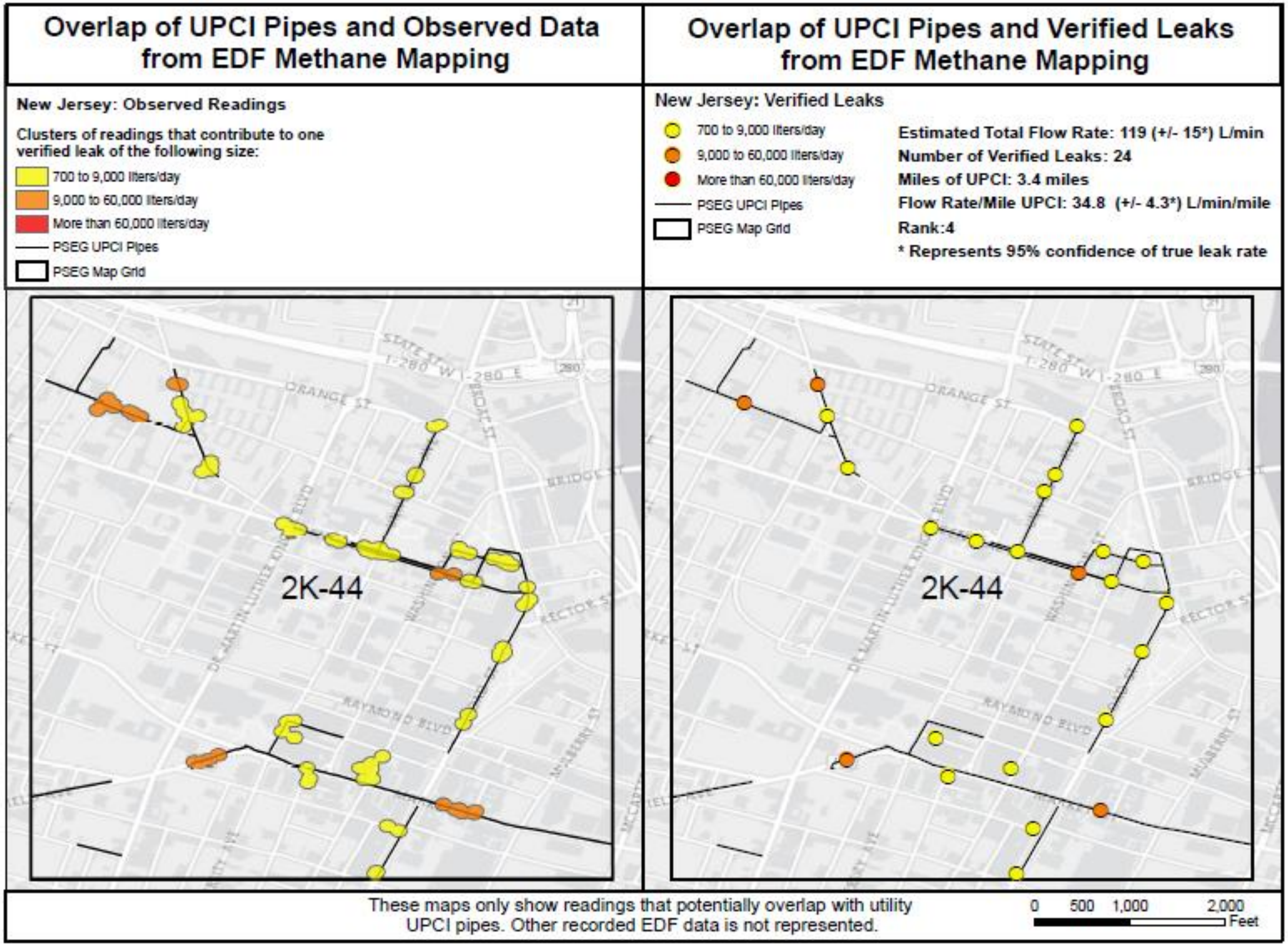


Fig 1. Ring Down Graph. Adapted from Picarro. Retrieved from Picarro.com

- Different gases absorb light (laser) at specific rates
- Normal atmospheric air has a certain decay pattern as the laser fades inside the sample chamber (blue graph)
- When a gas like methane is in the sample, it absorbs light at a different decay rate than the control (green graph)
- The laser wavelength and difference in decay rates is used to quantify methane by analyzing the sample data stream through a series of algorithms
- Wind and precipitation are factors in sampling

Readings vs Indications



Using the Results in GSMP I

- Hazard Index per Mile (HI/Mi) still primary risk ranking tool
- Any grid with HI/Mi > 25 is highest priority
- Where HI/Mi is comparable (< 25), EDF data used to help **sub-prioritize** by leak rate of liters per minute per mile of UPCI pipe in the grid (L/Min/Mi)
    - Grids with outlying leak rates of >10 L/Min/Mi take highest priority
    - Grids with leak rates of <10 L/Min/Mi as well as non-surveyed grids take secondary priority
- Grids are evaluated for construction efficiencies and logistics as well as permitting and municipality conflicts prior to setting the final prioritization
- Results reviewed with EDF and submitted to the NJ Board of Public Utilities

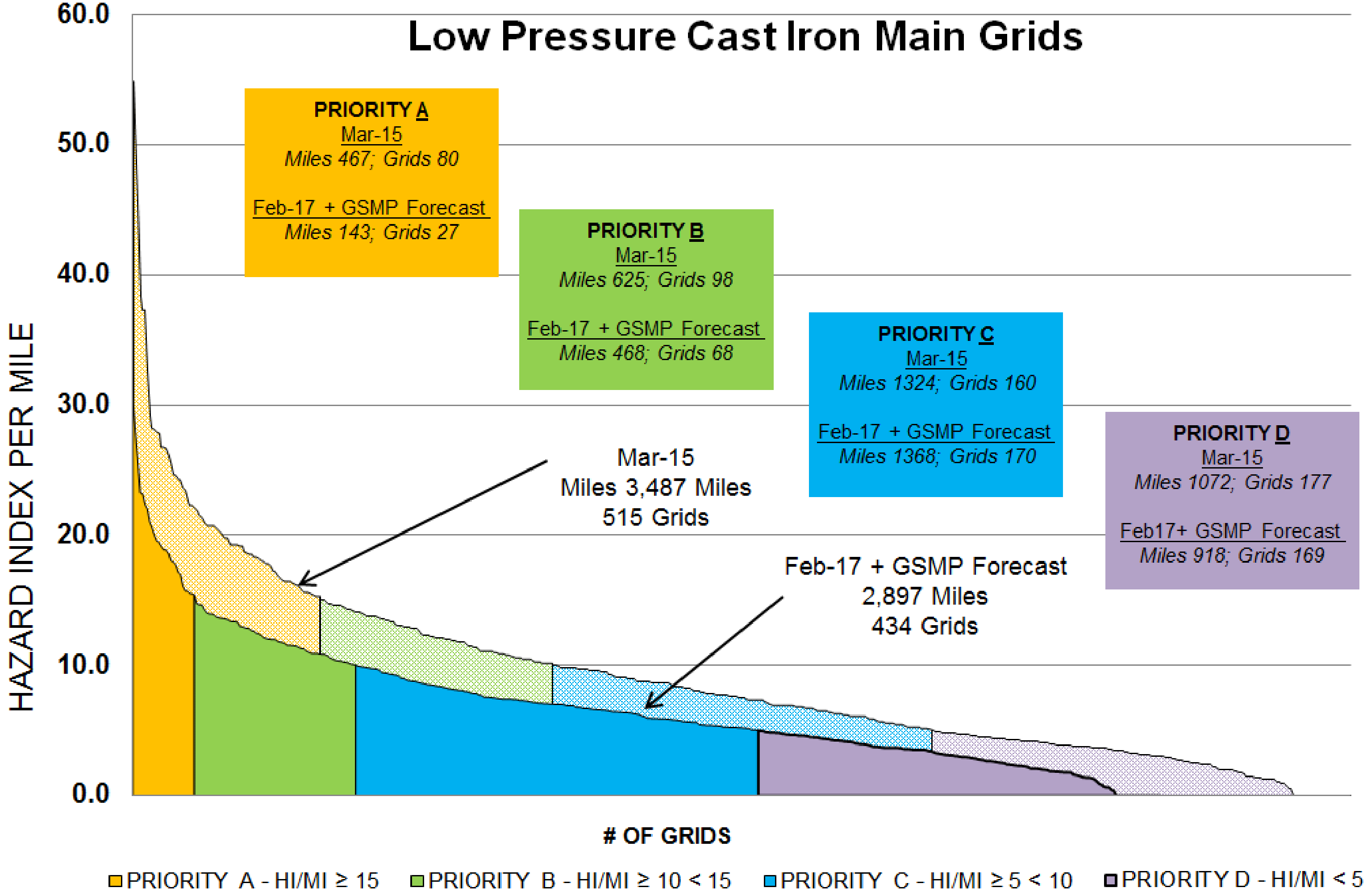
Reduction in Emissions

- Outlier grids (>10 L/min/mi) were looked to be moved up in schedule where possible
- Mains retired earlier than originally planned stop emitting methane faster
- By accelerating high emissions grids, PSE&G was able to reduce total grid emissions by 83% early in the program.
- To achieve the same emissions reductions, 35% less main abandonments were needed vs if PSE&G followed strictly by hazard ranking.
- The accelerated grids the company prioritized for upgrades accounted for more than 37% of the emissions but only 9% of the mileage on which leak rates were measured.

Continuing the Program into GSMP II

- GSMP II filed in 2017 and approved in Spring 2018 as a five year extension
- Hazard Index and methane mapping to be used again to prioritize grids
- Picarro was chosen to map 44 “B Grids” of similar HI/mi that covered the 280 miles agreed to in the stipulation

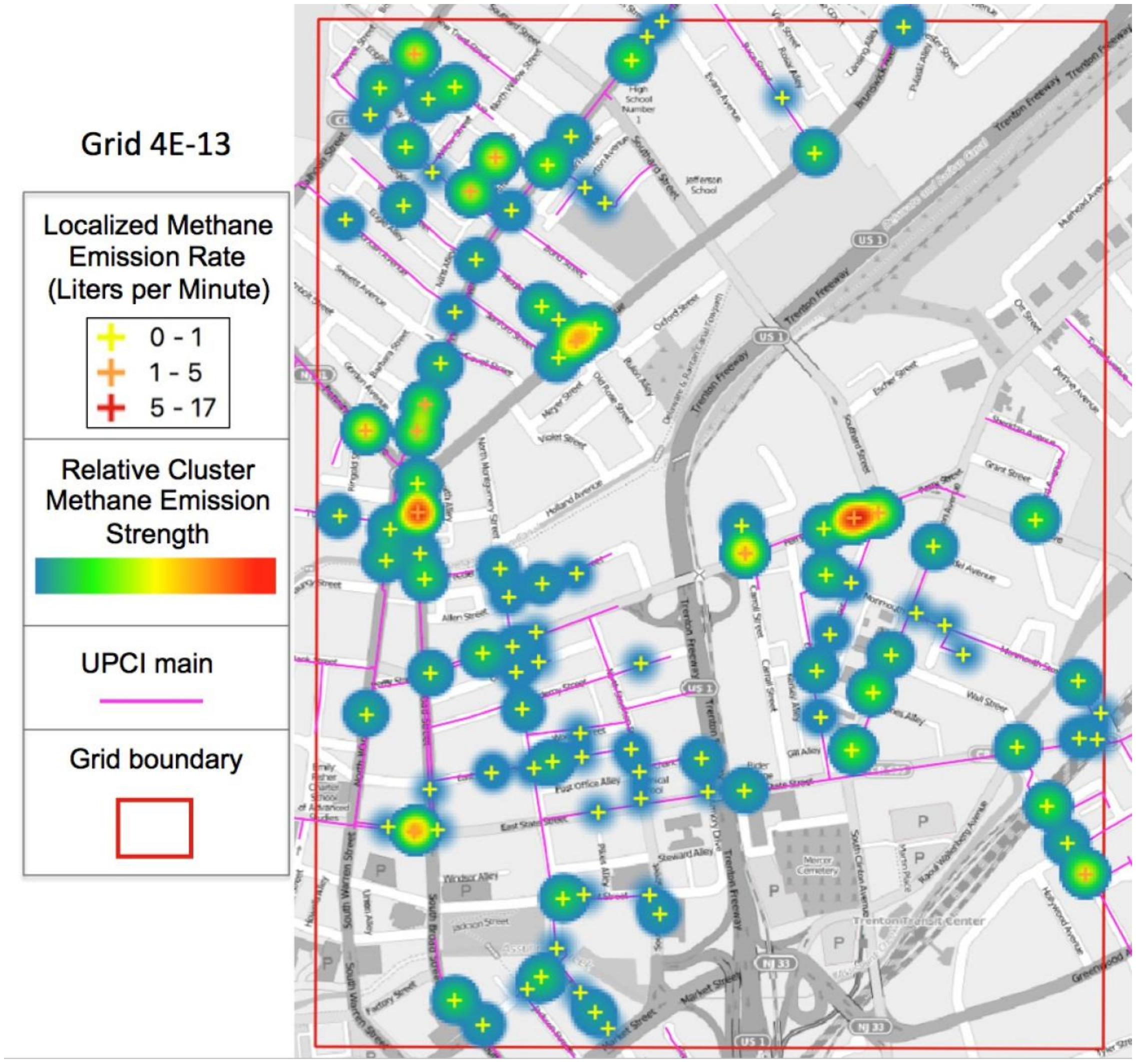
Reduction in Risk and Methane Mapping



Continuing to address the highest hazard main segments

Methane Quantification Survey

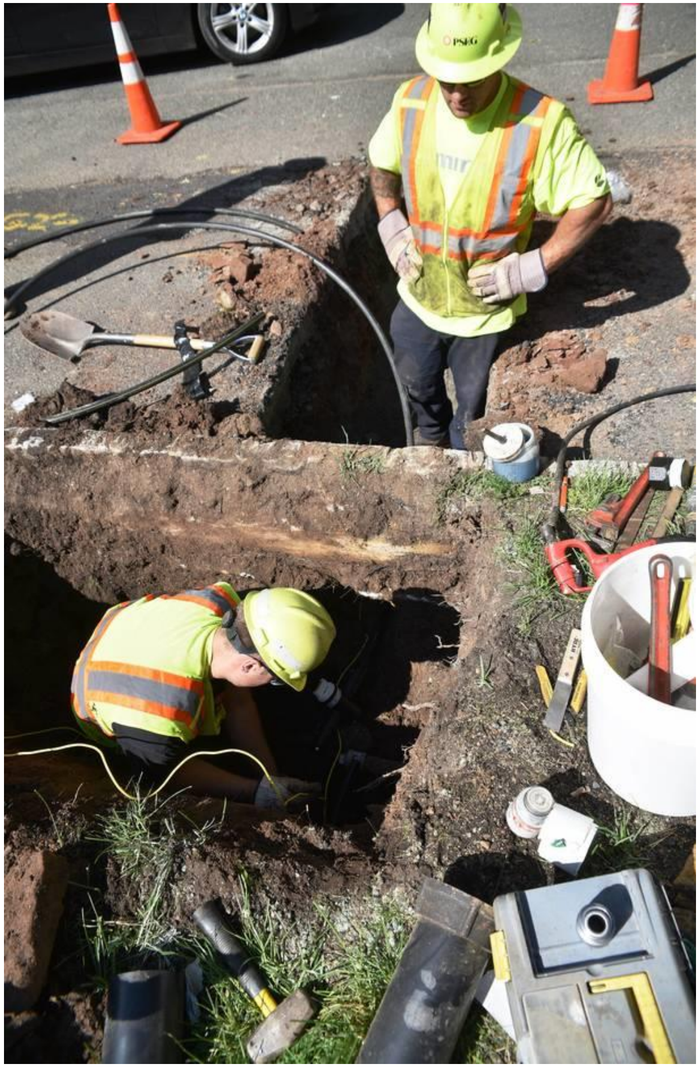
- Areas require 3 passes on each side of the street for proper sampling (95% statistical confidence interval)
- Indications are run through an algorithm with wind, vehicle speed, ethane content and other factors, leak rates are determined
- Heat maps can show areas of high emissions and calculated leak rates



Using GSMP II Results

- Discussion with EDF after data collected to set prioritization
- Threshold of 4.5 L/min/mi used for accelerating grids that were surveyed (down from 10 L/min/mi in GSMP I)
- 6 grids accelerated
- If retired sooner than “as is” plan, they account for 41% of the methane loss in only 16% of the grids surveyed
- Construction beginning in Spring of 2019

Key Takeaways



- Hazard Ranking and safety are highest priority
  - Hazard Rank and Leak Volume do not necessarily correlate

- Methane Emissions sub prioritization useful for areas of relatively equal hazard
  - Better for the environment
  - Less chance of non-hazardous leaks getting worse
  - Fewer potential customer calls/complaints

- Other LDC’s and PUC’s continue to discuss best applications for the technology's use

Questions?