MITIGATING COSTS AND RISKS OF

OIL PIPELINE ACCIDENTS

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FROM KAGGLE.COM

DATASET

- Open source data sourced reported from the Pipeline and Hazardous Materials Safety Administration since 2010
- All within the United States
- 2795 observations of 48 variables
- Example features: Incident date and time, operator and pipeline, cause of incident, type of hazardous liquid and quantity lost, injuries and fatalities, and associated costs
- Only 5 records with complete data

PLAN OF ATTACK

- Exploratory data visualisation
- Select goal: cost and risk minimization
- Build Model
  - Feature Engineering
  - Model Creation
  - Evaluation
- Give Recommendations

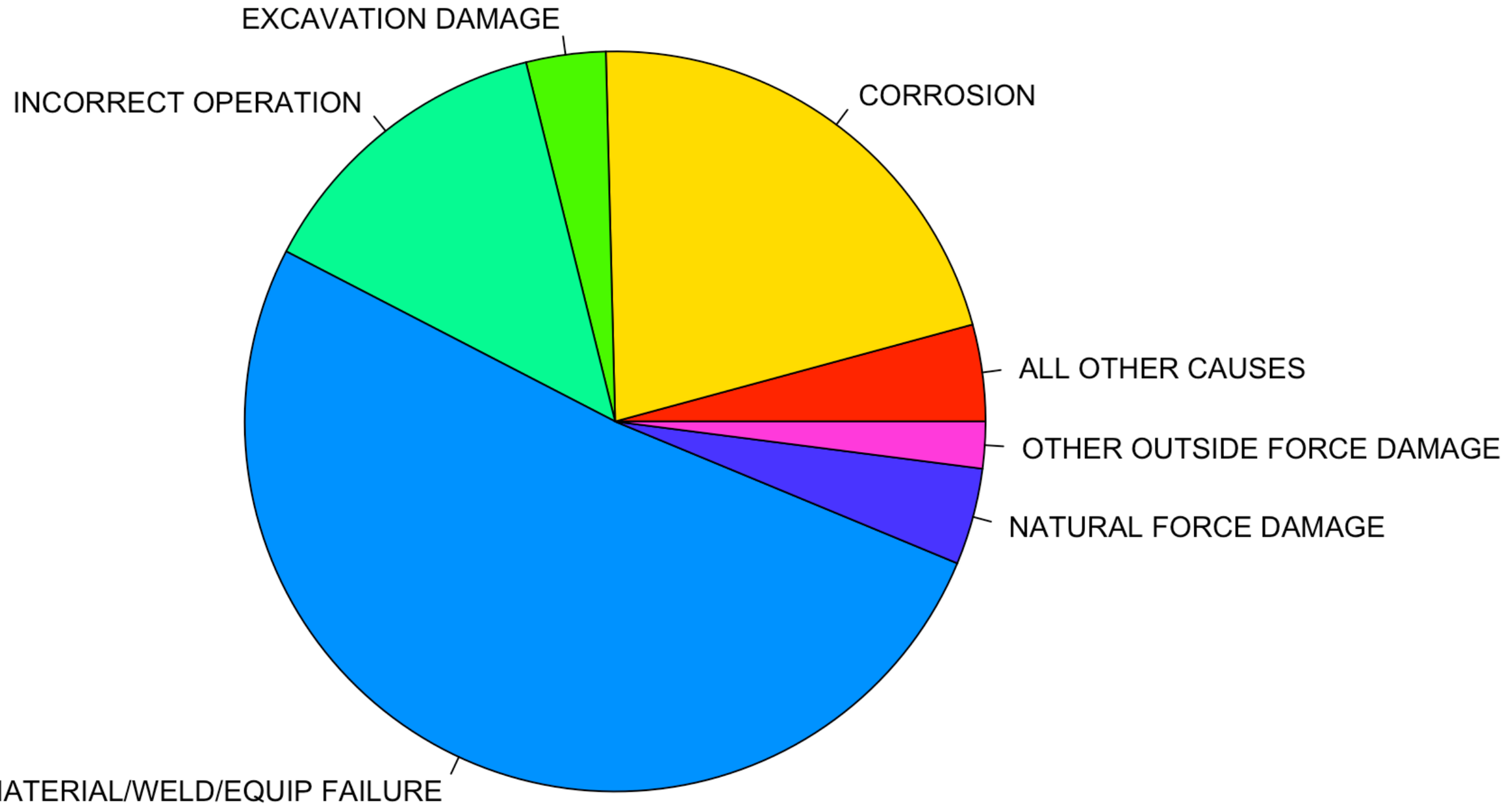
QUESTIONS TO ANSWER

- What is the main cause/subcause of accidents?
- Which causes are associated with accidents?
- Where, geographically, should we focus our attention?
- What's the best strategy to minimize costs and risks for human accidents as well?

INTERESTING FINDS

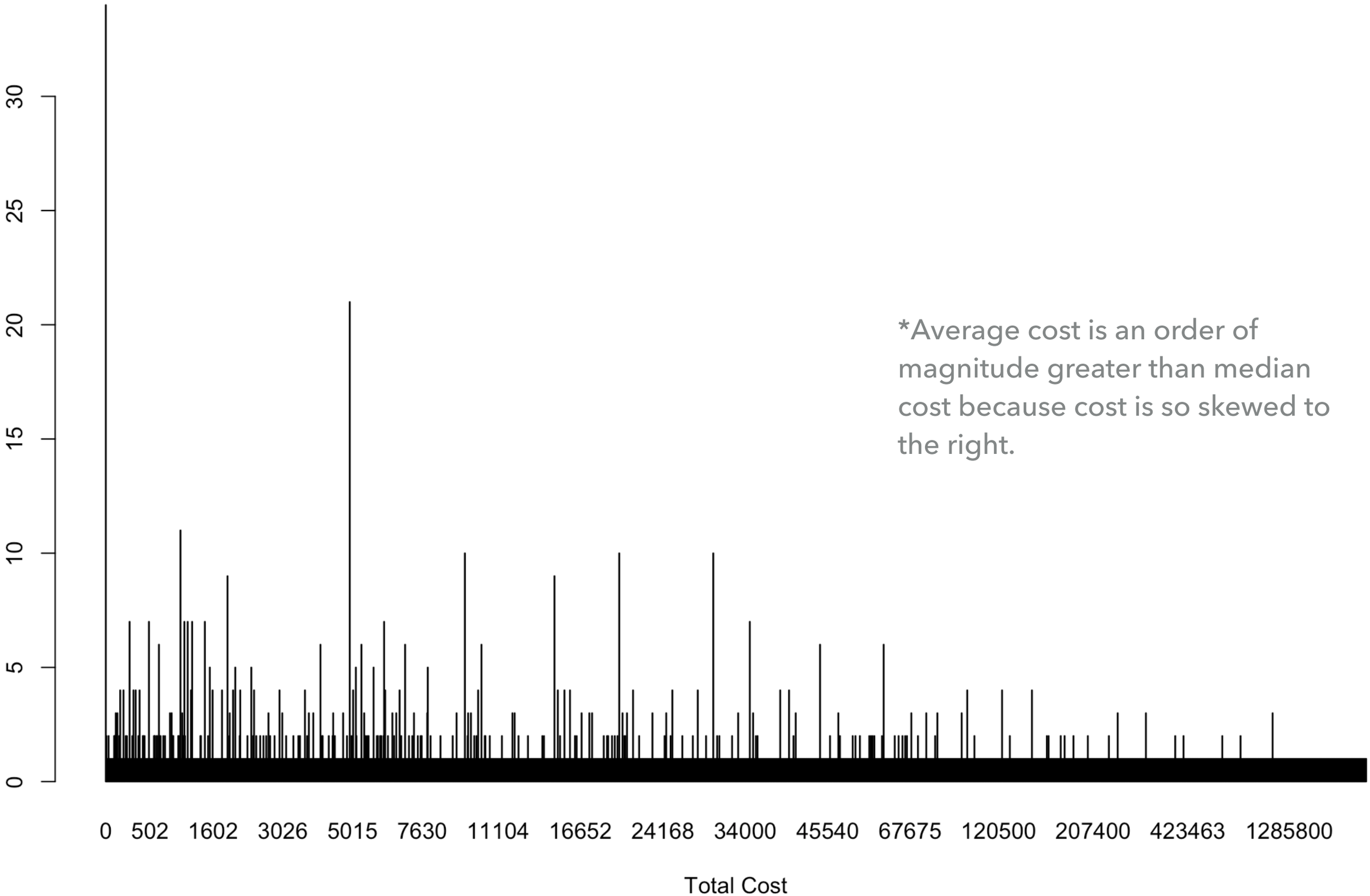
- Only 18 offshore accidents->2,777 onshore accidents
- 95 cases of accidents associated with ignition
- 15 cases of accidents associated with explosion
- 20 cases of injuries; 10 cases of fatalities
- Perhaps not factored into costs, but extra concern for risk, and safety

Distribution of Causes

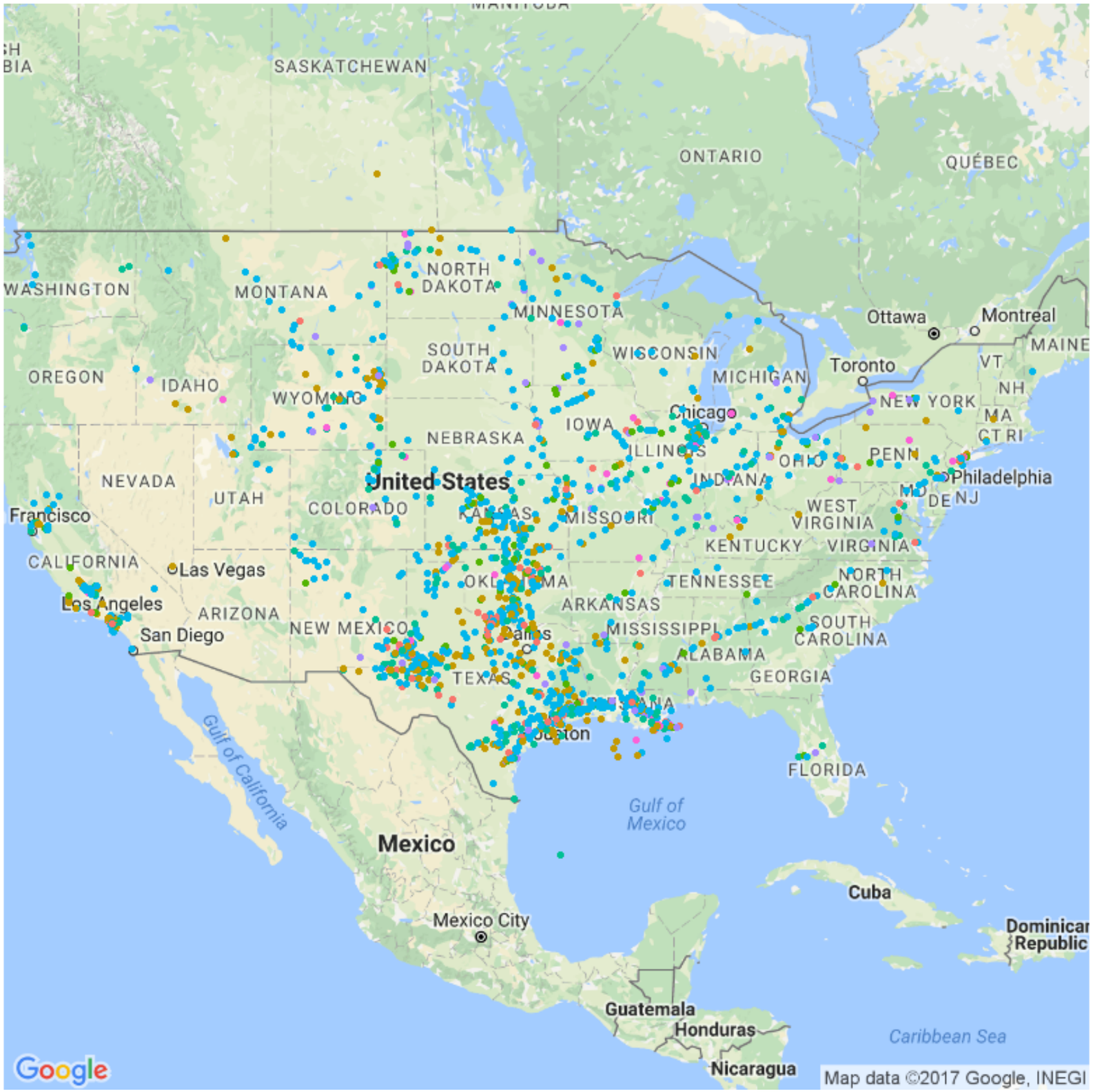


COST VS CAUSE

	TOTAL COST	AVERAGE COST	MEDIAN COST
CORROSION	395,325,677	667,779.9	46,090
EXCAVATION DAMAGE	93,101,223	959,806.4	193,841
INCORRECT OPERATION	106,140,454	280,794.9	12,750
MATERIAL/WELD/ EQUIP FAILURE	1,243,774,427	866,741.8	15,030
NATURAL FORCE DAMAGE	220,354,295	1,867,409.3	48,200
OTHER OUTSIDE FORCE DAMAGE	161,602,026	2,835,123.3	273,100
ALL OTHER CAUSES	110,824,821	939,193.4	21,632



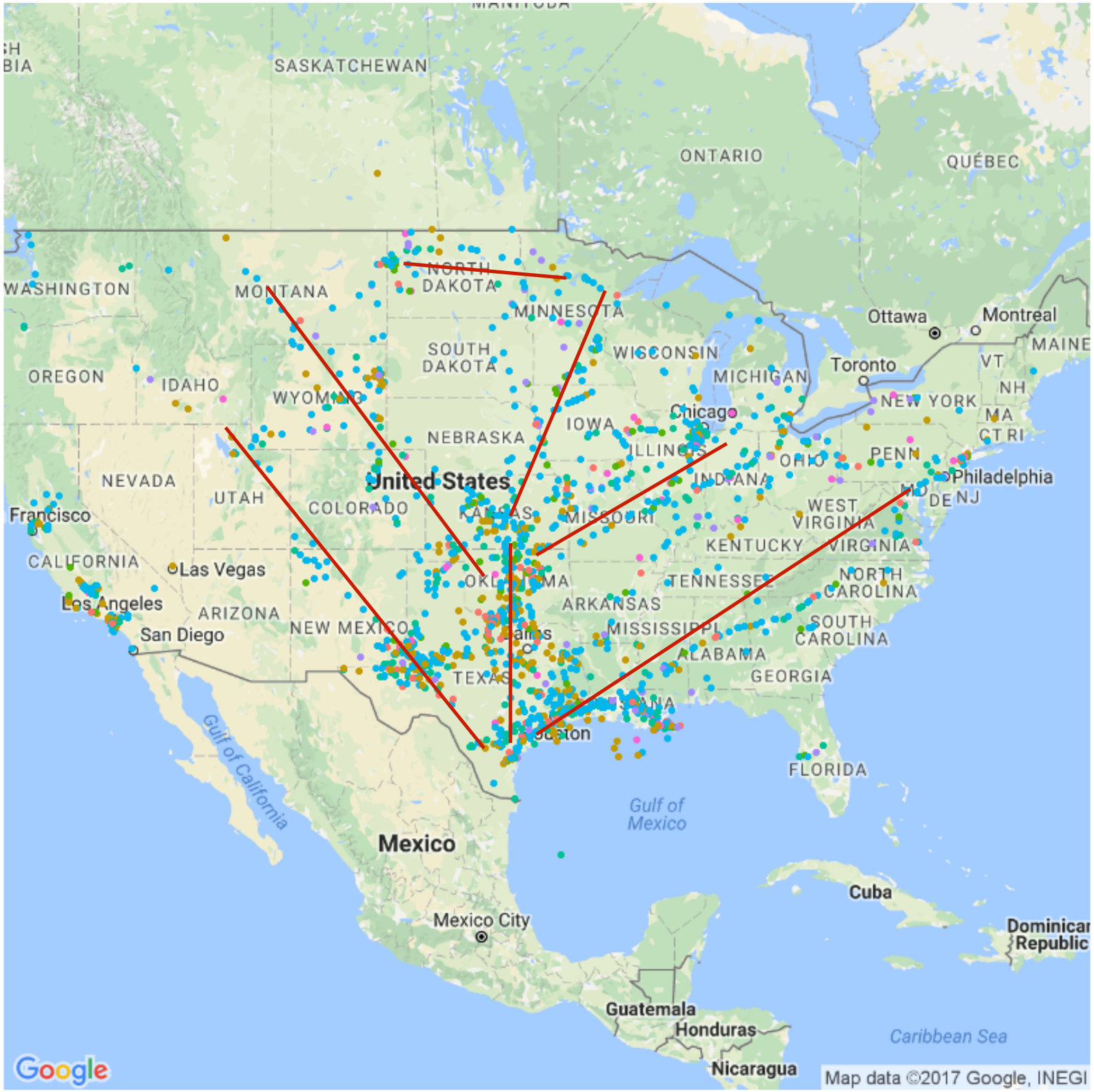
*Average cost is an order of magnitude greater than median cost because cost is so skewed to the right.



Based on sites of accidents, we can see the main extraction sites and transportation lines.

Cause.Category

- ALL OTHER CAUSES
- CORROSION
- EXCAVATION DAMAGE
- INCORRECT OPERATION
- MATERIAL/WELD/EQUIP FAILURE
- NATURAL FORCE DAMAGE
- OTHER OUTSIDE FORCE DAMAGE



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Branch-like structure originating from Texas.

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— transportation lines

Sites of accidents follow transportation lines.

Spatial clustering(Gaussian of the main cause of failure.

Cause.Category

MATERIAL/WELD/EQUIP FAILURE

Spatial clustering(Gaussian of the main cause of failure.

Cause.Category

MATERIAL/WELD/EQUIP FAILURE


SASKATCHEWAN
ONTARIO
QUÉBEC
WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WISCONSIN
MICHIGAN
Ottawa
Montreal
Toronto
MAINE
VT
NH
NEW YORK
MA
CT RI
PENN
Philadelphia
MD
DE
NJ
OREGON
IDAHO
WYOMING
NEBRASKA
IOWA
Chicago
ILLINOIS
INDIANA
OHIO
WEST VIRGINIA
KENTUCKY
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
United States
Francisco
CALIFORNIA
Las Vegas
Los Angeles
San Diego
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TENNESSEE
Dallas
MISSISSIPPI
ALABAMA
GEORGIA
TEXAS
LOUISIANA
Houston
FLORIDA
Gulf of California
Gulf of Mexico
Mexico
Cuba
Mexico City
Dominican Republic
Guatemala
Honduras
Nicaragua
Caribbean Sea
Google
Map data ©2017 Google, INEGI
Cause.Category
INCORRECT OPERATION

Corrosion is more concentrated in the South. Possible reasons: temperature/ humidity.

ANALYSIS OF MAPS

- Most drilling and accidents occur in Texas and Oklahoma
- Corrosion is concentrated in the extraction sites in the south, not in the main transportation lines
- Material/equipment failure(majority of causes) follows the transportation lines

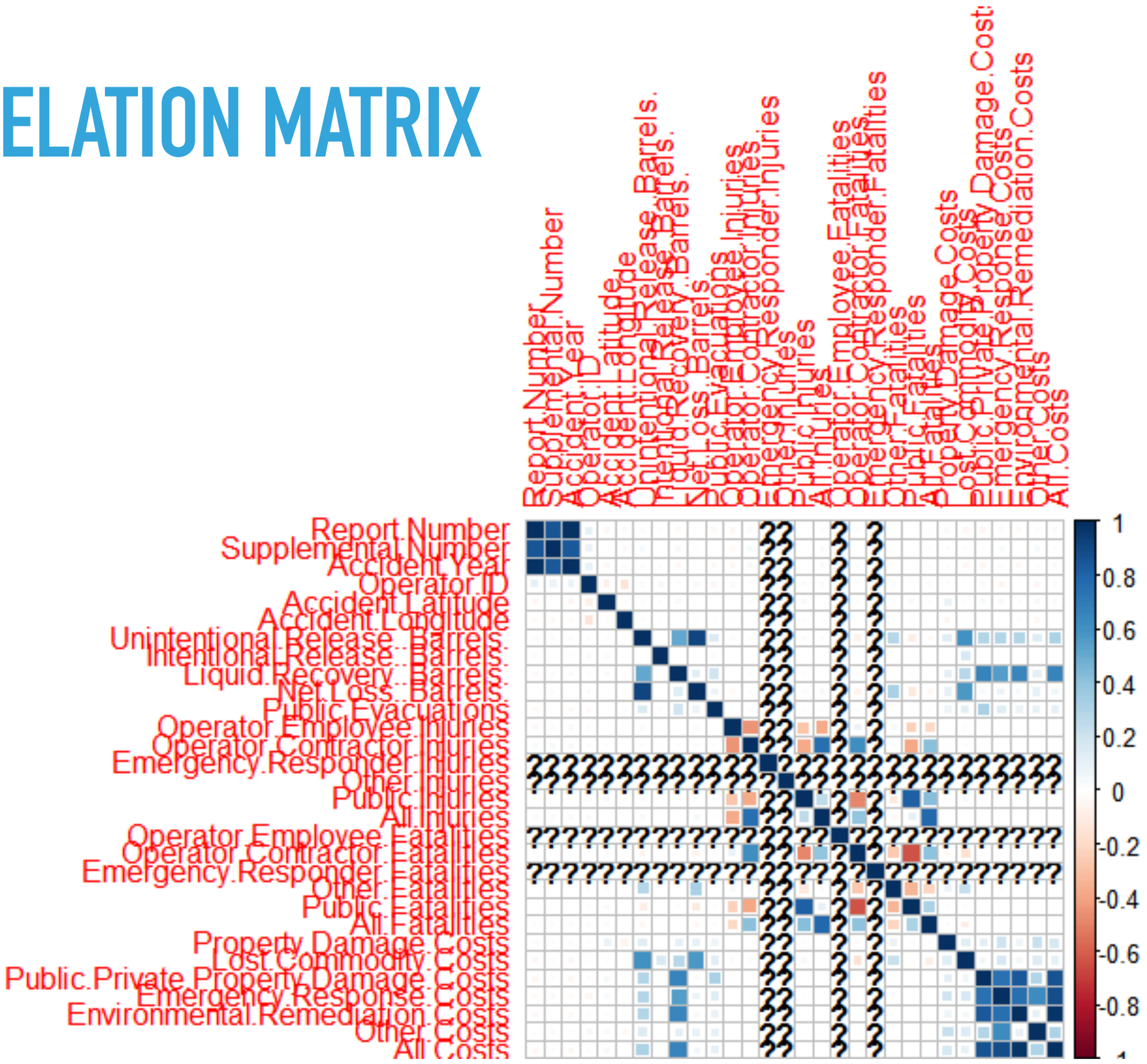
MODEL OVERVIEW

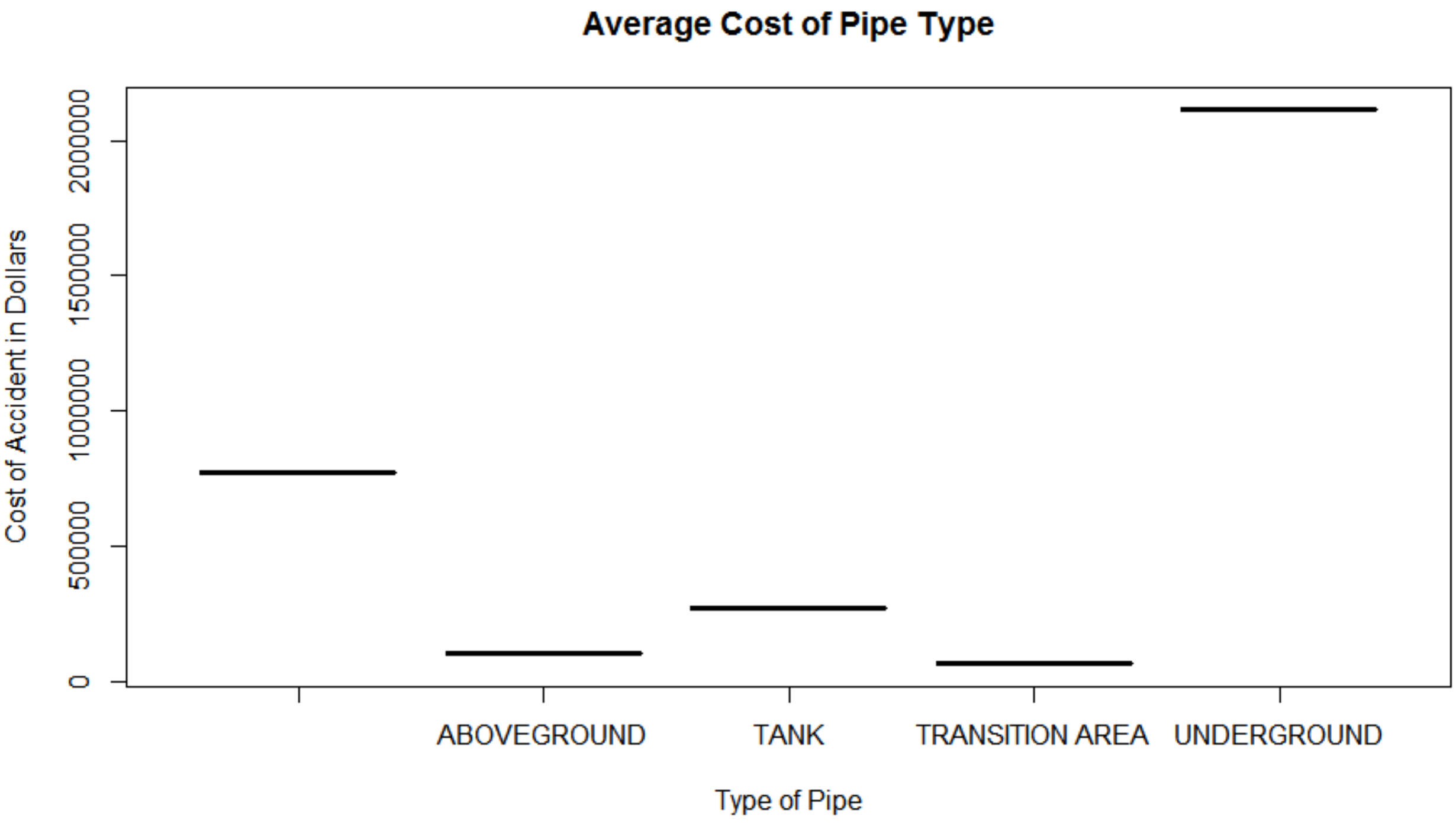
- Random Forest Prediction Model to estimate total costs
- Find relative importance of each feature
- Analyze cases with highest cost to optimize for budget constraint

MODEL FEATURE ENGINEERING

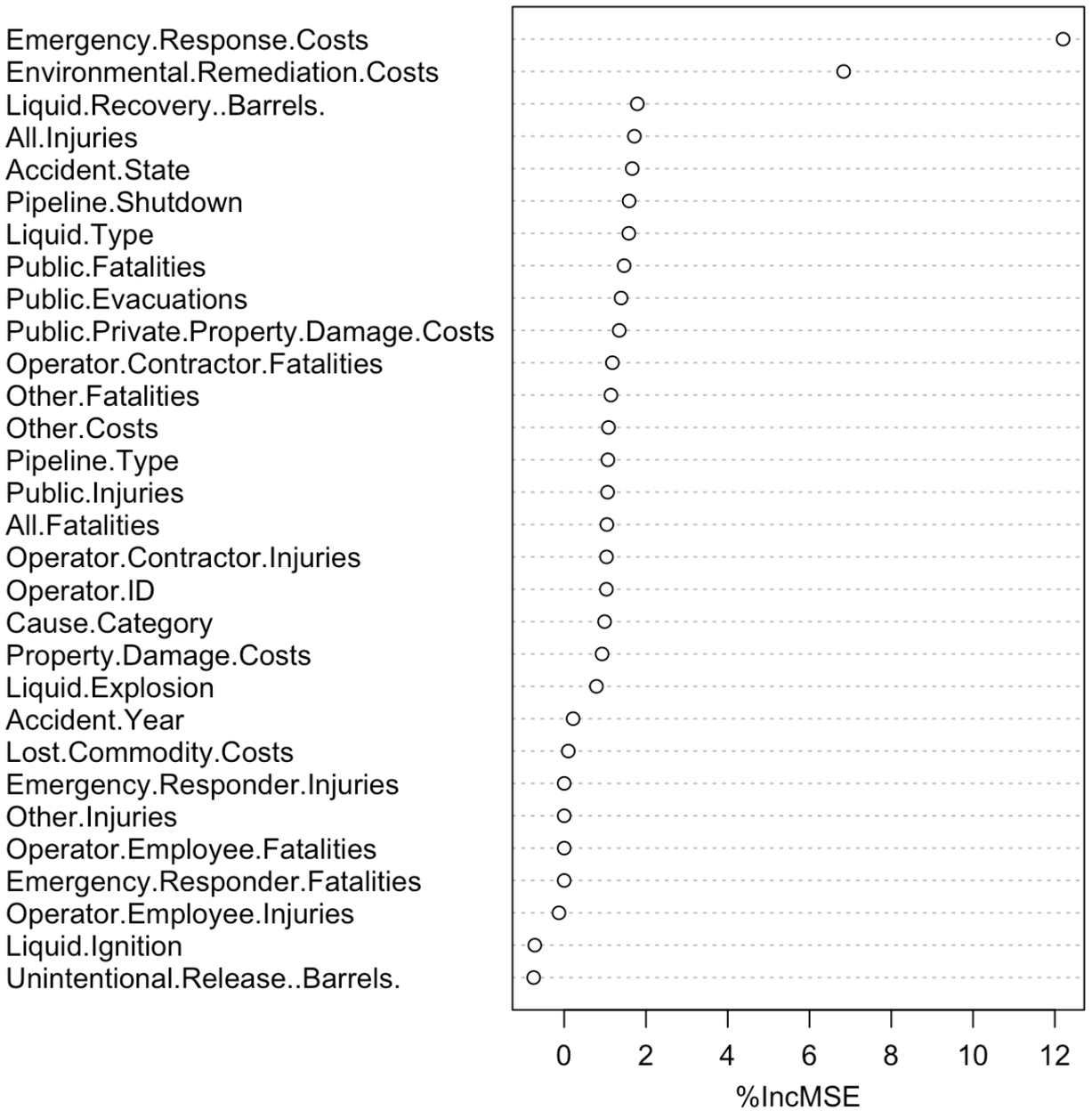
- City, county, state are correlated with longitude/latitude
- Separate all date-time data into year, month, day, time
- Remove Report.Number and Supplemental.Number
- Group Injuries and Fatalities together
- Ensure all features are the correct data type

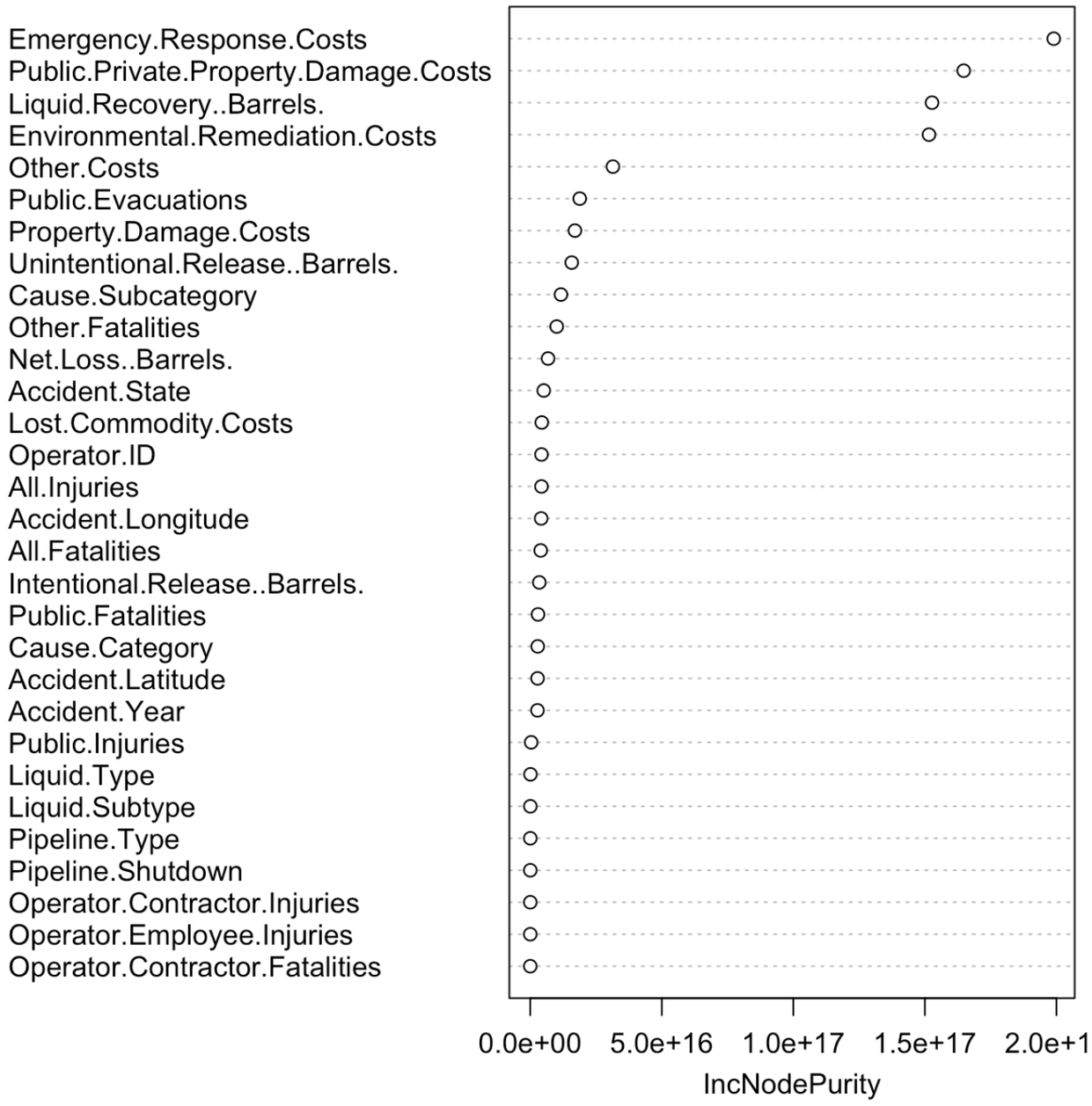
CORRELATION MATRIX




Average Cost of Pipe Type
Cost of Accident in Dollars
0
500000
1000000
1500000
2000000
ABOVEGROUND
TANK
TRANSITION AREA
UNDERGROUND
Type of Pipe

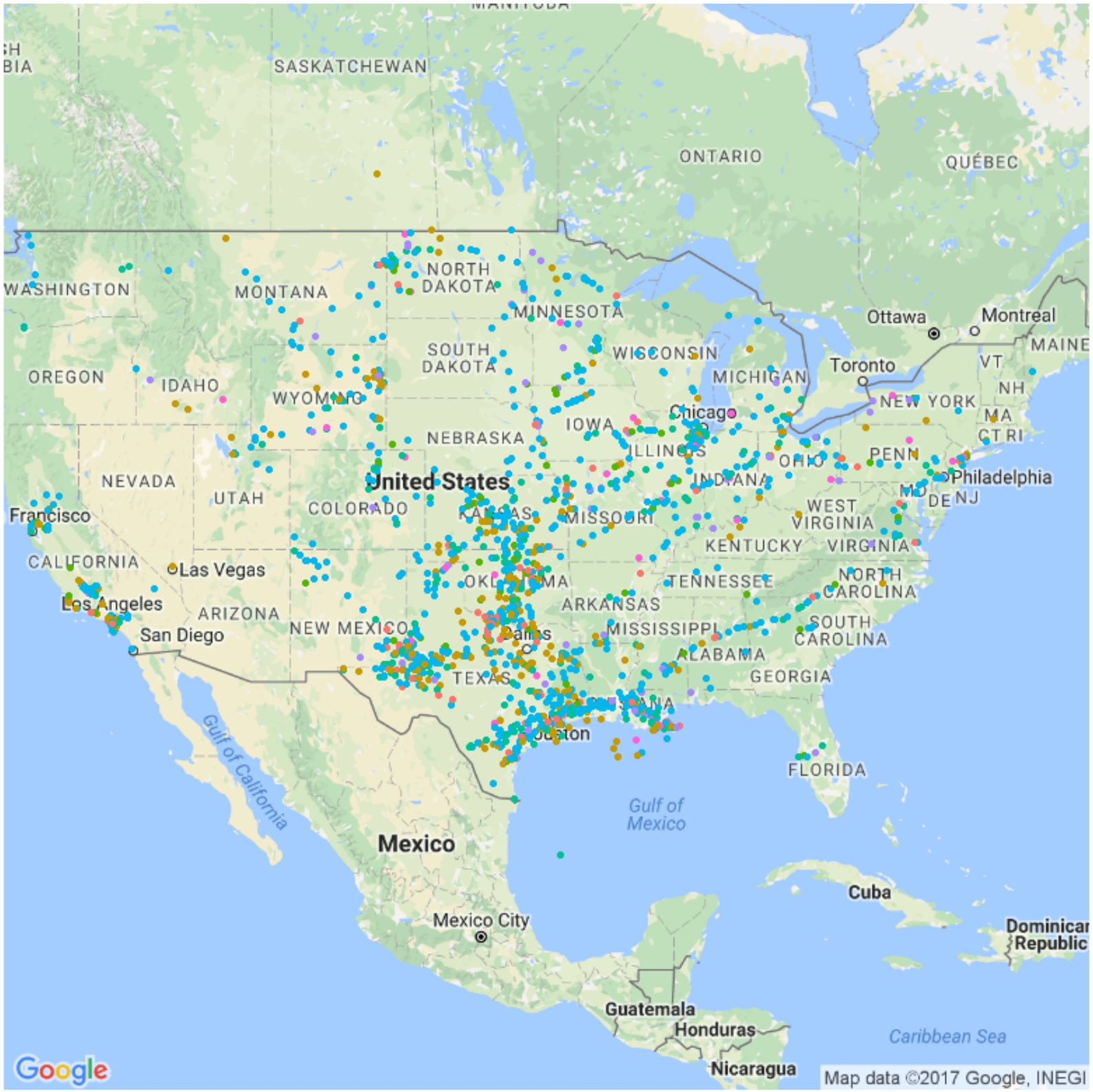
Feature Importance





ANALYSIS OF FEATURE IMPORTANCE

- Injuries are more important than shutdowns in predicting cost
- Ignition and explosion have surprisingly low effect on cost
- State has high importance on cost but can be confounding because there are more pipelines in certain areas
- Total cost is most related to emergency response costs, environmental response costs, and liquid recovery barrels



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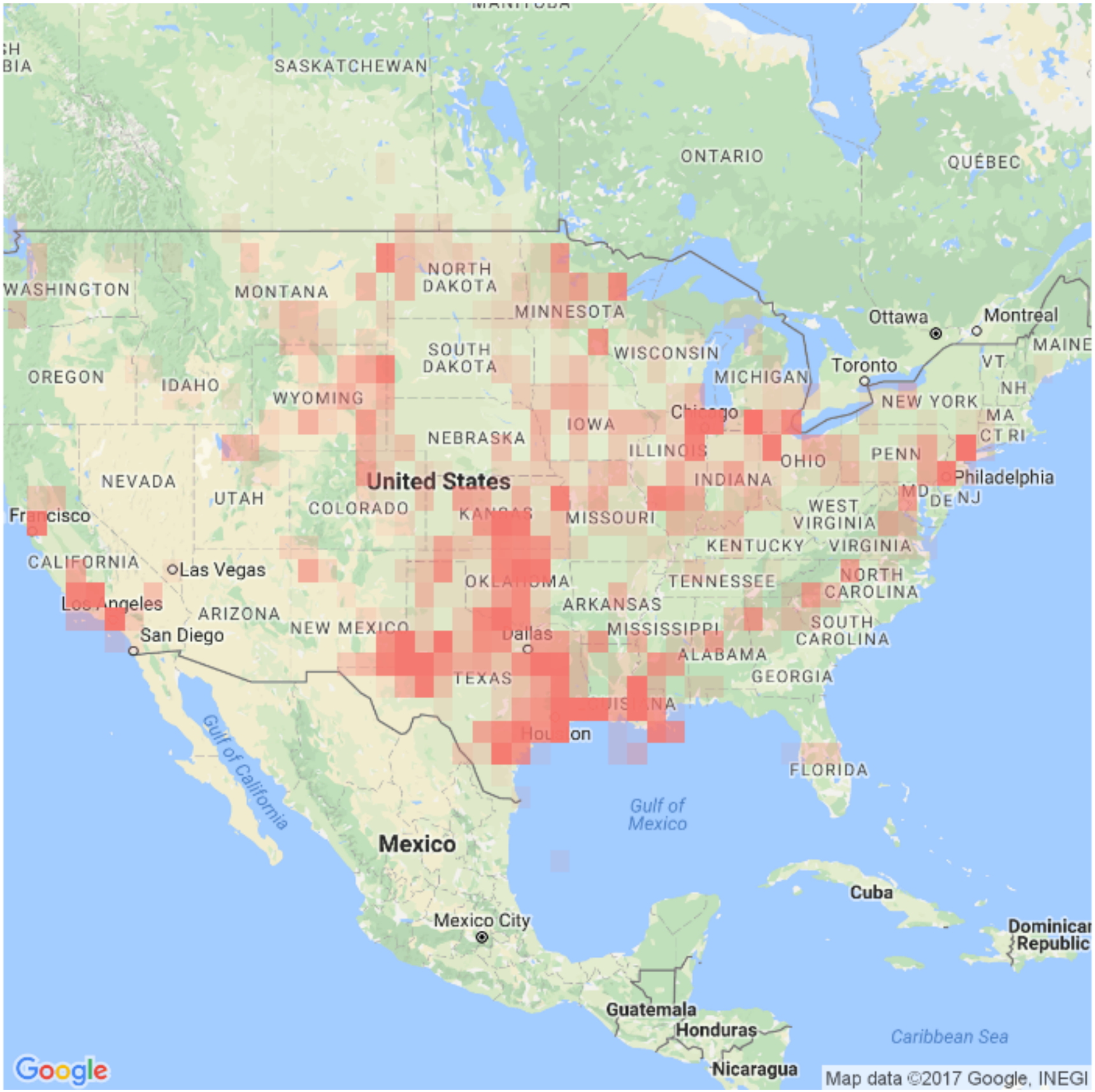

Heat map of costs overlap with distribution of causes geographically.

fill
red

All.Costs
0e+00
2e+08
4e+08
6e+08
8e+08

RECOMMENDATION FOR MAXIMIZING PROFITS

- Develop more efficient systems for emergency and environmental response (earlier detection, better ways to clean up)
- Substitute old equipment sooner or maintain it better(material/weld/equip failures account for over $1 billion)
- For areas in the South, pay particular attention to failures due to corrosion

IF YOU CARE ABOUT PEOPLE

- Extra non-monetary cost during special cases of ignitions and explosions
- These are obviously extra-negative for publicity and safety
- Main sub-causes for ignition: lightning, incorrect operation, pump-related equipment
- Main sub-causes for explosion: manufacturing and installation
- Incorrect operation and material/weld/equip failure is the cause of majority of ignitions and explosions

RECOMMENDATION IF YOU CARE ABOUT PEOPLE PT.2

Because ignition and explosion are highly correlated with injuries and fatalities, you should:

- Focus on training programs that teach workers to properly use equipment
- Substitute old equipment for newer equipment sooner
- Take special care when manufacturing and installing since it’s highly correlated with explosions

THANK YOU