Implementing a risk based GIS prioritization model to optimize routine maintenance of the sanitary sewer system.



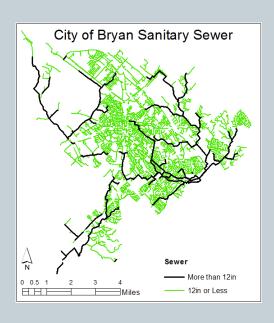
Line cleaning programs

- maintain sewer line flow velocity
- help prevent sewage from becoming septic
- reduce the number of stoppages and sanitary sewer overflows (SSO) by as much as 85% (TEEX 2013)

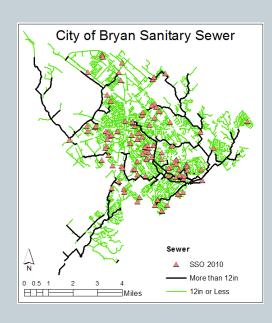




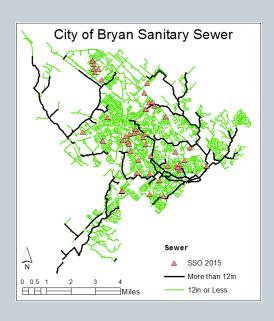
- The City of Bryan
 - 404 miles of sewer line,~80% need routinemaintenance (RM)
 - 2010 cleaning program
 - × 116 SSOs in 2010
 - Increased RM to 80 miles a year and smoke testing
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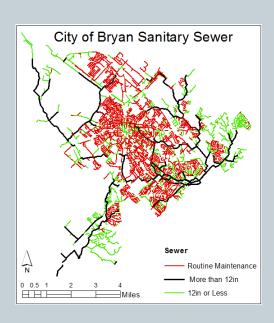


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The Problem:

 RM location is haphazard and often repetitive



Solution:

- SSO and sewer stop risk model
 - Consequence of an SSO x Likelihood of an SSO or sewer stop
- GIS + Data
- Python (ArcPy)

Risk Model:

- Based on the Risk Model from Flores et al. 2011
- Data → Processing → Consequence
 Score and a Likelihood Score → Risk
 Score

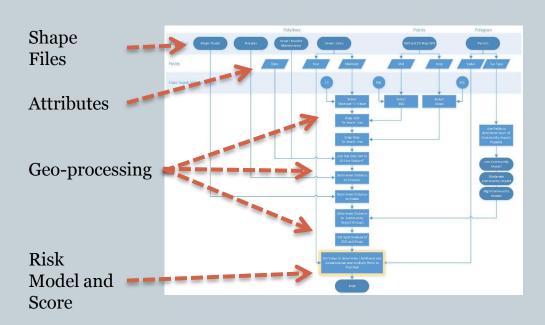
In-House Data:

- Sewer line data (all pipes GIS sewer model)
 - Sewer Line Diameter
 - Year Sewer was Installed
- Routine Maintenance data
 - Date of Maintenance
- Work order data
 - Sanitary Sewer Overflows
 - Sanitary Sewer Stops

External Data:

- Stream Data
- Road Data
- Parcel Data (Brazos CAD)
 - Property Value
 - Land Use Type

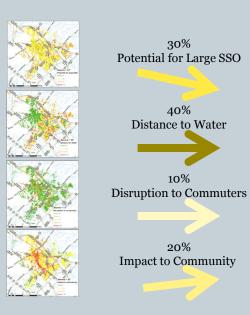
Methodology

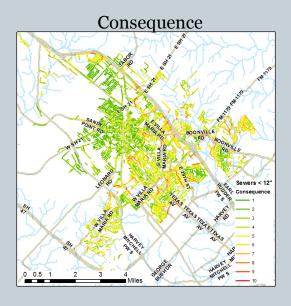


Consequence:

- Factors Considered:
 - Potential for Large SSO
 - Distance to Water
 - Disruption to Commuters
 - Impact to Community

Consequence:





Likelihood:

- Factors Considered:
 - Age Condition
 - Physical Condition
 - WO Likelihoods
 - O WO Density
 - Home Values
 - Potential for Stoppage

Likelihood:



Risk Model:

Consequence

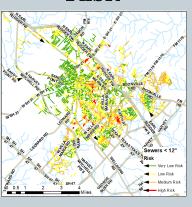


X

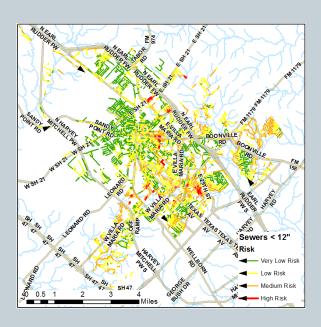
Likelihood



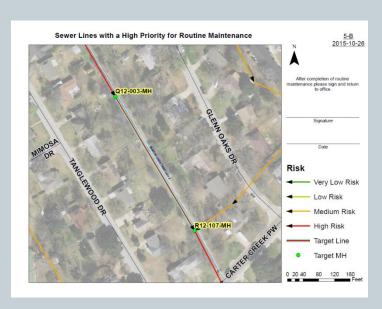
Risk



Map Automation:



Implementation:



Future Directions

- Incorporate material type
- Incorporate data from CCTV'ing
- Reassess the model after a pilot period

Summary:

- Used GIS to create risk score
 - 4 factors go into Consequence
 - o 6 factors go into Likelihood
- Used Python to produce maps of highest risk lines

Implementing a risk based GIS prioritization model to optimize routine maintenance of the sanitary sewer system.



ELIZABETH RENTSCHLAR GIS ANALYST FOR WATER DISTRIBUTION CITY OF BRYAN

https://github.com/bryansandw/Sewer_Maintenance

Running the Script

Running the Script

```
Solort Windows DownShall
 Mindows PowerShell
   Copyright (C) 2009 Microsoft Corporation. All rights reserved.
 PS V:\> cd g:\GIS_PROJECTS\WATER_SERUICES
PS G:\GIS_PROJECTS\WATER_SERUICES> python Tess\Ue
1st Process: Select Sewer lines 12 inches or less
                                                                                                                                 Evaluating the Analysis Field values
- WO WEIGHT Properties:
    and Process: Select (1)
2nd Process: Select (1)
3rd define snapping environments
4th Process: Snap (1)
5th Process: Select (2)
6th Process: Snap (2)
                                                                                                                                                     Hin: 0.0000
Hax: 35.0000
Hean: 0.7387
Std. Dev.: 2.2788
      th Adding Field mappings
                                                                                                                                 Looking for locational outliers.
   8th Process: Spatial Join (1) adding SSO MO
9th Adding Field mappings
10th Process: Spatial Join (2) adding STOP MO and
                                                                                                                                                    There were 91 outlier locations: these will not be used to compute the optimal fixed distance band.
  11th Adding Field mappings
Before adding fields there are 35 fields
After adding fields there are 56 fields.
                                                                                                                                 Looking for an optimal scale of analysis by assessing the intensity of clustering at increasing distances.
- No optimal distance was found using this method.
   12th Process: Spatial Join
13th Process: Near (1) how close are the sewers t

Otermining an optimal distance using the spatial distribution of features...

The optimal fixed distance band is based on the average distance to 30 nearest neighbors: 993.4243 US_Feet
  15th Process: Near (2) how close are the sewers
16th Process: Calculate Field (2)
                                                                                                                                  18th Process: Add Field - There a
20th Create a Update Cursor to update the fields 1 dependence.
    Ist Classify the parcels land use type based on
                                                                                                                                 Z2nd Process: Select (%) the low community impact
Z3rd Process: Add Field
 ZIFG Process: Rod Field
Ztht Classify the parcels land values to weights
Z5th Process: Select (5) the moderate community i
Z6th Process: Select (6) the high community impac
Z7th Process: Near (3) are the sewers near the lo
2th Process. Near (3) are the sewers near (6+ up 22st Process. Calculate Field (3) fill 10, Loy, May 2st Process. Near (3) are the sewers near the so 35th Process. Near (3) are the sewers near the so 35th Process. Socialist Field (3) of the Process. Calculate Field (3) of the Process. Social Soc
                                                                                                                                 will create Cursor rino the number or days since An look piace Wilst Create Field mapping for Spatial John Wind Process: Spatial Join Wind Process: Spatial Join Wind: Create a Update Cursor to update the fields Create list of the risk values to identify the highest risk lines with: Update fields with weights
 34th Process: Calculate Field (4) WO_Weight
35th Process: Buffer
                                                                                                                                    Sort list of the risk values to identify the highest risk lines
   37th Process: Optimized Hot Spot Analysis
                                                                                                                                 Process: Hake Layer where the risk is the same of
greater than the tenth highest list value
                                                                                                                                    Process: Hake Layer where the Hanholes
   Making sure there are enough weighted features fo

- There are 8503 valid input features.
                                                                                                                                 are adjacent to the high risk sewer lines
#3rd: Create a Update Cursor to select the lines
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
      valuating the Analysis Field values
- NO_NEIGHT Properties:
                                                                                                                                  Set up map document environment to create exported map documents as pdfs in map folder
                                                                                                                                  "FID" = 8
                                                                                                                                exporting maps
Layers
```

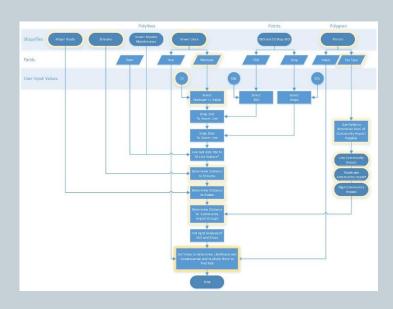
Running the Script



Consequence:

Consequence	Data Used	Weight	1 Values	4 values	7 Values	10 Values
Potential for Large SSO	Size of Sewer	30%	MAINSIZE ≤ 4 in.	MAINSIZE > 4 in. and MAINSIZE ≤ 6 in.	MAINSIZE > 6 in. and MAINSIZE ≤ 8 in.	MAINSIZE > 8 in.
Distance to Water	FEMA Stream	40%	To Water > 1000 ft.	To Water > 500 ft. and To Water ≤ 1000 ft.	To Water > 100 ft. and To Water ≤ 500 ft.	To Water ≤ 100 ft.
Disruption to Commuters	Major Roads	10%	To Road $>$ 50 ft. and To Road \le 100 ft.	To Road $>$ 20 ft. and To Road \le 50 ft.	To Road > 5 ft. and To Road ≤ 20 ft.	To Road ≤ 5 ft.
Impact to Community	Parcel	20%	Near Open Spaces or Parks	Near Residential and Golf Courses	Near Low Density Commercial	Near Hospital, School, High Density Commercial

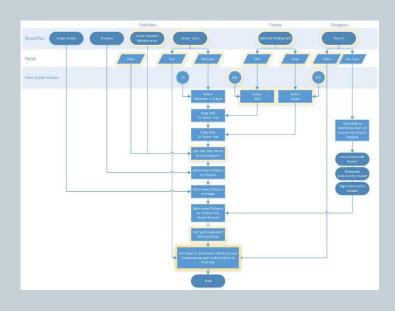
Consequence:



Likelihood:

Likelihood	Dada Used	Weight	1 Value	2 Value	4 Value	7 Value	10 Value
Age Condition	Age of Sewer	5%	Age < 30 yr.	30 to 39 yr.	40 to 49 yr.	50 to 59 yr.	Age > 60 yr.
Physical Condition	RM	35%	< 366 days since RM	366 - 731 days since RM	731 -1097 days since RM	1097 -1460 days since RM	1460 + days since RM
WO Likelihood	SSO and STOP WO	15%	None	1 STOP	≥ 2 STOPs	1 SSO	≥ 2 SSO
WO Density	SSO and STOP WO *	20%	Gi Bin < 0	Gi Bin = 0	Gi Bin > 0	Gi Bin > 1	Gi Bin > 2
Home Values	Parcels	10%	Market ≥ \$230,000	Market < \$230,000	Market < \$165,000	Market < \$130,000	Market < \$75,000
Potential for Stoppage	Size of Sewer	15%	None	MAINSIZE > 8 in. and MAINSIZE < 12 in.	MAINSIZE > 6 in. and MAINSIZE ≤ 8 in.	MAINSIZE > 4 in. and MAINSIZE ≤ 6 in.	MAINSIZE ≤ 4 in.

Likelihood:



Weight Values

Consequence	Data Used	Weight	1 Values	4 values	7 Values	10 Values	Field Name
Potential for Large SSO	Size of Sewer	30%	MAINSIZE <= 4 in	MAINSIZE > 4 in and MAINSIZE <= 6 in	MAINSIZE > 6 in and MAINSIZE <= 8 in	MAINSIZE > 8 in	Con_Size
Distance to Water	FEMA Stream	40%	To_Water > 1000 ft	To_Water > 500 ft and To_Water <= 1000 ft	To_Water > 100 ft and To_Water <= 500 ft	To_Water <= 100 ft	Con_Water
Disruption to Commuters	Major Roads	10%	To_Road > 50ft and To_Road <= 100ft	To_Road > 20 ft and To_Road <= 50 ft	To_Road > 5 ft and To_Road <= 20 ft	To_Road <= 5 ft	Con_Road
Impact to Community	Parcel	20%	Near Open Spaces or Parks	Near Residential and Golf Courses	Near Low Density Commercial	Near Hospital, School, High Density Commercial	Con_Pub

Weight Values

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WO Likelihood	SSO and STOP WO	10%	None	1 STOP	>= 2 STOPs	1 SSO	>= 2 SSO	Failure_
WO Density	SSO and STOP WO *	30%	Gi_Bin < o	Gi_Bin == o	Gi_Bin > o	Gi_Bin > 1	Gi_Bin > 2	Fail_Den
Home Values	Parcels	10%	Market >= \$230,000	Market < \$230,000	Market < \$165,000	Market < \$130,000	Market < \$75,000	Mark_Weigh
Potential for Stoppage	Size of Sewer	10%	None	MAINSIZE >8 in and MAINSIZE < 12 in	MAINSIZE > 6 in and MAINSIZE < =8 in	MAINSIZE > 4 in and MAINSIZE < =6 in	MAINSIZE <= 4 in	STOP_like

Variable Significance

SUMMARY OUTPUT

Regres	sion Statistics
Multiple R	0.39741017
R Square	0.15793484
Adjusted R Square	0.15674070
Standard Error	1.89091718
Observations	847

ANOVA

	df	SS	MS	F	Significance F
Regression	12	5674.797	472.900		132.259 0
Residual	8462	30256.455	3.576		
Total	8474	35931.251			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	0.528	0.131	4.040	0.000	0.272	0.785	0.272	0.785
MAINSIZE	-0.098	0.012	-8.060	0.000	-0.122	-0.074	-0.122	-0.074
LENGTH (did not use)	0.003	0.000	21.878	0.000	0.002	0.003	0.002	0.003
YEAR	0.000	0.000	-4.395	0.000	0.000	0.000	0.000	0.000
To_Water	0.000	0.000	-1.668	0.095	0.000	0.000	0.000	0.000
To_Road	0.000	0.000	-0.042	0.966	0.000	0.000	0.000	0.000
To_Low_Pub	0.000	0.000	-0.803	0.422	0.000	0.000	0.000	0.000
To_Mod_Pub	0.000	0.000	-1.076	0.282	0.000	0.000	0.000	0.000
To_High_Pub	0.000	0.000	-0.698	0.485	0.000	0.000	0.000	0.000
DaySinRM (Physical Condition)	0.000	0.000	-2.339	0.019	0.000	0.000	0.000	0.000
RM_Count (did not use)	0.030	0.016	1.906	0.057	-0.001	0.061	-0.001	0.061