

Sample: Oil and gas pipelines, Midland: report

Project: Sample: Oil and gas pipelines, Midland

Goal: Describe the project Sample: Oil and gas pipelines, Midland: run the analyses that tell the most about its data, draw every result, and write a cited report.

Run: debf2e20-caf9-45f0-b26f-597c66cae39f (running, 11 agent run(s))

Generated: 2026-10-18T05:56:24Z, version 1

Model cost: USD 0.0000 over 0 model call(s)

Data used

Data	Kind	Rows	Time span	Summary	Source
Pipeline segments	vector, LineString	99		99 line features; 'coating' has 3 values (top: FBE 54, tape 23, coal tar 22); 'station_from_m' 0 to 28,000 (mean 1.302e+04); 'station_to_m' 800 to 28,785 (mean 1.381e+04); 'diameter_in' 12 to 24 (mean 17.82); total length 78.44 km; extent -102.2108,31.9243 to -101.9449,32.0740. Lines (Pipeline segments) such as routes or networks.	[94]
In-line inspection anomalies	vector, Point	1,118	2021-06-14 to 2025-06-09	1,118 point features; dated by 'inspected_on' from 2021-06-14 to 2025-06-09; 'feature' has 4 values (top: metal loss 454, crack-like 233, dent 220); 'clock' has 12 values (top: 4:00 105, 11:00 101, 7:00 100); 'depth_pct' 3 to 41.1 (mean 15.7); 'length_mm' 15 to 472 (mean 68.66); 'station_m' 157 to 28,769 (mean 1.203e+04); extent -102.2093,31.9267 to -101.9451,32.0732. Dated point events by feature: where and when In-line inspection anomalies happen.	[2]
Incidents	vector, Point	70	2016-04-07 to 2026-06-14	70 point features; dated by 'date' from 2016-04-07 to 2026-06-14; 'cause' has 5 values (top: external corrosion 28, third-party damage 14, equipment 11); 'release_bbl' 0.5 to 157.2 (mean 12.33); 'station_m' 216 to 27,926 (mean 1.288e+04); extent -102.2063,31.9262 to -101.9486,32.0725. Dated point events by cause: where and when Incidents happen.	[3]
Valves and stations	vector, Point	25		25 point features; 'type' has 3 values (top: test station 14, block valve 8, pump station 3); 'station_m' 0 to 25,600 (mean 1.19e+04); named by 'name' (e.g. L100 pump station 1, L100 test station 2, L100 block valve 3); extent -102.2109,31.9243 to -101.9659,32.0570. Point locations of Valves and stations by type.	[95]
High consequence areas	vector, Polygon	6		6 polygon (area) features; 'type' has 2 values (top: populated area 5, water body 1); 'population' 0 to 2,400 (mean 728.3); named by 'name' (e.g. Mesa Verde colonia, Ranch Road 12 homes, County school campus); total area 19.01 km2; extent -102.1694,31.9544 to -101.9683,32.0709. Areas (High consequence areas) with population to compare and map.	[96]
Crossings	vector, Point	14		14 point features; 'type' has 2 values (top: road 10, draw 4); 'cased' has 2 values (top: True 7, False 7); 'station_m' 186 to 23,139 (mean 1.149e+04); extent -102.1577,31.9259 to -101.9846,32.0445. Point locations of Crossings by type.	[97]

Data	Kind	Rows	Time span	Summary	Source
Right of way	vector, Polygon	3		3 polygon (area) features; 'width_m' 30 to 30 (mean 30); named by 'name' (e.g. Line 100 crude right of way, Line 200 gas right of way, Line 300 NGL lateral right of way); total area 2.353 km2; extent -102.2110,31.9242 to -101.9447,32.0742. Areas (Right of way) with width_m to compare and map.	[98]
Cathodic protection readings	table	168	2023-10-01 to 2026-06-28	Table of 168 rows and 4 columns without geometry; dated by 'date' from 2023-10-01 to 2026-06-28; 'pipe_to_soil_on_mv' -1,031 to -863 (mean -948.8); 'pipe_to_soil_off_mv' -1,172 to -974 (mean -1065). A table of Cathodic protection readings without locations.	[4]
Segment operating limits	table	99		Table of 99 rows and 4 columns without geometry; 'maop_psi' 1,100 to 1,440 (mean 1247); 'class_location' 1 to 3 (mean 1.626); 'last_hydrotest_year' 2,008 to 2,022 (mean 2015). A table of Segment operating limits without locations.	[99]
Integrity management summary	document			1-page pdf document 'Integrity management summary'; language en; mentions 5 place(s): 31.97837, -102.14691 (1), Highway rest area (1), Highway (1), Mesa Verde colonia (1), County school campus (1). A document about 31.97837, -102.14691, Highway rest area, Highway.	[100]
Sample: Oil and gas pipelines, Midland	record				[101]
Emerging hot spots: Incidents	layer, Polygon	13			[102]
Emerging hot spots: In-line inspection anomalies	layer, Polygon	56			[103]
Hot spot analysis: Incidents	layer, Point	70			[104]
Hot spot analysis: In-line inspection anomalies	layer, Point	1,118			[105]
Calculate density: Valves and stations	layer, Polygon	41			[106]
Calculate density: Incidents	layer, Polygon	144			[107]
Calculate density: In-line inspection anomalies	layer, Polygon	1,039			[108]
Summarize within: Right of way	layer, Polygon	3			[109]
Summarize within: Right of way	layer, Polygon	3			[110]
Summarize within: Right of way	layer, Polygon	3			[111]
Find point clusters: Valves and stations	layer, Point	25			[112]
Find point clusters: cluster hulls	layer, Polygon	1			[113]
Find point clusters: Incidents	layer, Point	70			[114]
Find point clusters: cluster hulls	layer, Polygon	1			[115]

Data	Kind	Rows	Time span	Summary	Source
Find point clusters: Crossings	layer, Point	14			[116]
Find point clusters: cluster hulls	layer, Polygon	1			[117]
Find nearest: Valves and stations	layer, Point	24			[118]
Find nearest: Valves and stations	layer, Point	25			[119]
Repeat and near repeat classification: Incidents	layer, Point	70			[120]

Timeline

Timeline: events per year by dataset

Per year: 11 years from 2016-01-01 to 2026-01-01; trend +25 per year; first half 26, second half 902 (+3369.2%)

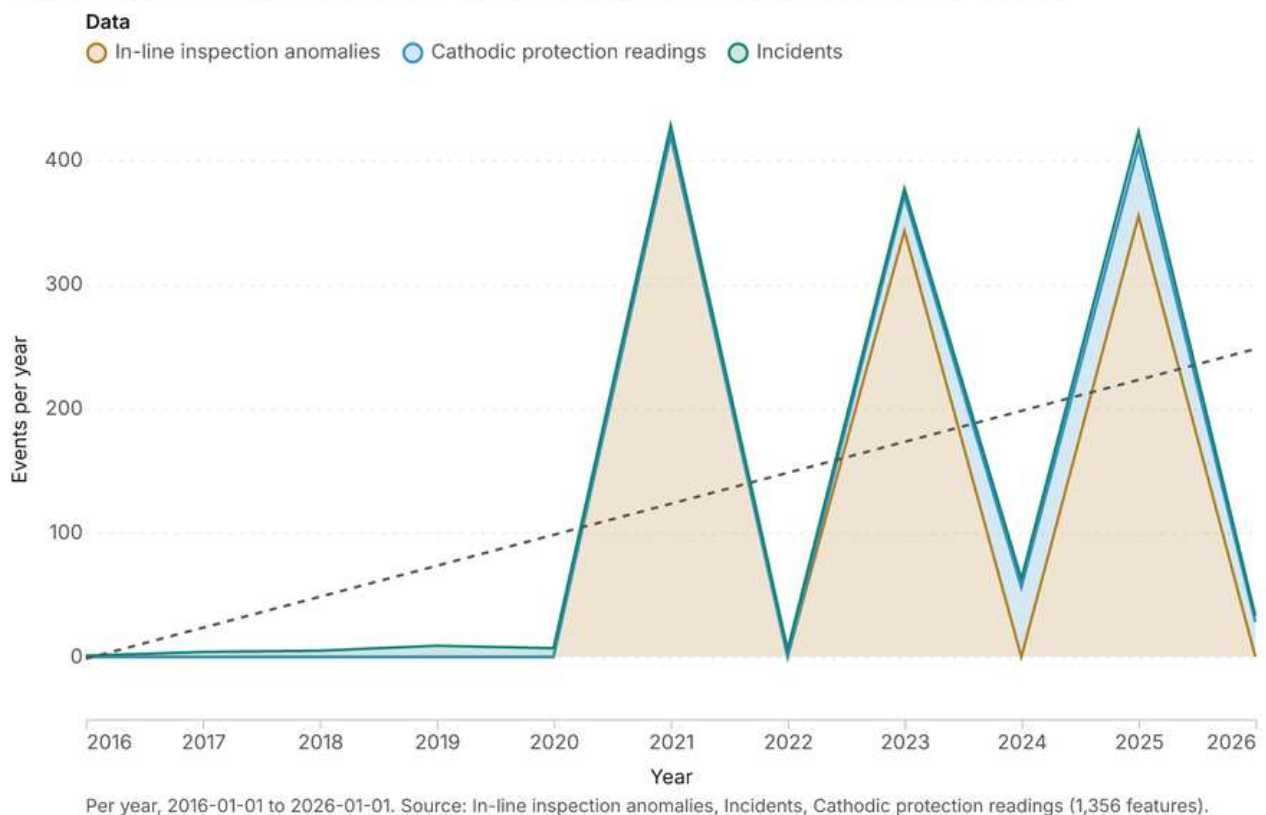


Figure 1. Timeline: events per year by dataset [1]. Per year, 2016-01-01 to 2026-01-01. Source: In-line inspection anomalies, Incidents, Cathodic protection readings (1,356 features). The data is in the appendix.

The timeline counts 1,356 dated events in In-line inspection anomalies, Incidents, Cathodic protection readings per year, from 2016 to 2026 [1][2][3][4]. By dataset: In-line inspection anomalies 1,118; Cathodic protection readings 168; Incidents 70 [1]. The trend is +25 events per year; the second half of the years has 902 against 26 in the first (+3369.2%) [1].

Busiest years

- 2021: 428 events [1]
- 2025: 423 events [1]
- 2023: 377 events [1]

Quietest years

- 2016: 1 event [1]
- 2017: 4 events [1]
- 2018: 5 events [1]

Space time hot spots

What this analysis is. Emerging hot spots: Where hot spots are new, consecutive, intensifying, persistent, diminishing, sporadic, oscillating or historical over time [5]. In ArcGIS it is Emerging Hot Spot Analysis or Create Space Time Cube [5].

Why it was run on this data. Incidents carry dates in 'date': emerging hot spot analysis finds new, intensifying and fading hot spots per year [6].

What it found. The analysis generated an output layer titled "Emerging hot spots: Incidents" which contained 13 features [7]. The input data for this analysis was the `Incidents` layer [8]. The process completed quickly, generating the result in 3 milliseconds [7].

Result	Value
result, count	13
result, elapsed ms	3
result, resolution	6
result, features used	70
result, time neighbors	0
billing, cost	0.1035
billing, list price	0.1035
billing, upstream cost	0

Findings

Evidenced: Space time hot spots on Incidents: Emerging hot spots: 1 layer saved: Emerging hot spots: Incidents (13 features) [7][8].

Evidenced: It reported result, count 13; result, elapsed ms 3; result, resolution 6; result, features used 70; result, time neighbors 0; billing, cost 0.1035 [7].

Tool gp_space_time_hot_spots; parameters {"agg": "sum", "project": "814309a7-f84e-4437-a8ec-209438a3f0a6", "features": {"layer": "Incidents (f9c94228)"}, "interval": "year", "bin_shape": "h3", "resolution": 6, "time_field": "date", "value_field": "station_m"}

Space time hot spots

What this analysis is. Emerging hot spots: Where hot spots are new, consecutive, intensifying, persistent, diminishing, sporadic, oscillating or historical over time [5]. In ArcGIS it is Emerging Hot Spot Analysis or Create Space Time Cube [5].

Why it was run on this data. In-line inspection anomalies carry dates in 'inspected_on': emerging hot spot analysis finds new, intensifying and fading hot spots per month [9].

What it found. The tool utilized the In-line inspection anomalies data as input [11]. The analysis identified 56 features for emerging hot spots, saving a layer named Emerging hot spots: In-line inspection anomalies [10].

Result	Value
result, count	56
result, elapsed ms	13
result, resolution	7
result, features used	1,118
result, time neighbors	0

Result	Value
billing, cost	0.1559
billing, list price	0.1559
billing, upstream cost	0

Findings

Evidenced: Space time hot spots on In-line inspection anomalies: Emerging hot spots: 1 layer saved: Emerging hot spots: In-line inspection anomalies (56 features) [10][11].

Evidenced: It reported result, count 56; result, elapsed ms 13; result, resolution 7; result, features used 1,118; result, time neighbors 0; billing, cost 0.1559 [10].

Tool gp_space_time_hot_spots; parameters {"agg": "sum", "project": "814309a7-f84e-4437-a8ec-209438a3f0a6", "features": {"layer": "In-line inspection anomalies (47cf738b)"}, "interval": "month", "bin_shape": "h3", "resolution": 7, "time_field": "inspected_on", "value_field": "station_m"}

Hot spots

What this analysis is. Hot spot analysis: Getis-Ord Gi* hot and cold spots with z-scores, p-values and confidence bins [12]. In ArcGIS it is Find Hot Spots or Hot Spot Analysis (Getis-Ord Gi*); in QGIS, qgis:hotspot (plugin) [12].

Why it was run on this data. 70 points: Getis-Ord Gi* tests whether the concentrations in Incidents are statistically significant [13].

What it found. Hot spots on Incidents: Hot spot analysis: 1 layer saved: Hot spot analysis: Incidents (70 features) [8][14]. It reported result, count 70; result, elapsed ms 2; result, excluded null 0; result, distance band m 5,000; billing, cost 0.0514; billing, list price 0.0514 [14].

Result	Value
result, count	70
result, elapsed ms	2
result, excluded null	0
result, distance band m	5,000
billing, cost	0.0514
billing, list price	0.0514
billing, upstream cost	0

Findings

Evidenced: Hot spots on Incidents: Hot spot analysis: 1 layer saved: Hot spot analysis: Incidents (70 features) [8][14].

Evidenced: It reported result, count 70; result, elapsed ms 2; result, excluded null 0; result, distance band m 5,000; billing, cost 0.0514; billing, list price 0.0514 [14].

Tool gp_hot_spots; parameters {"field": "station_m", "project": "814309a7-f84e-4437-a8ec-209438a3f0a6", "features": {"layer": "Incidents (f9c94228)"}, "aggregation": "hexagon", "cell_size_m": 5000.0, "distance_band_m": 5000.0}

Hot spots

What this analysis is. Hot spot analysis: Getis-Ord Gi* hot and cold spots with z-scores, p-values and confidence bins [12]. In ArcGIS it is Find Hot Spots or Hot Spot Analysis (Getis-Ord Gi*); in QGIS, qgis:hotspot (plugin) [12].

Why it was run on this data. 1118 points: Getis-Ord Gi* tests whether the concentrations in In-line inspection anomalies are statistically significant [15].

What it found. The hot spot analysis was performed using the In-line inspection anomalies data [11].

Result	Value
result, count	1,118

Result	Value
result, elapsed ms	22
result, excluded null	0
result, distance band m	2,000
billing, cost	0.07236
billing, list price	0.07236
billing, upstream cost	0

Findings

Evidenced: Hot spots on In-line inspection anomalies: Hot spot analysis: 1 layer saved: Hot spot analysis: In-line inspection anomalies (1118 features) [11][16].

Evidenced: It reported result, count 1,118; result, elapsed ms 22; result, excluded null 0; result, distance band m 2,000; billing, cost 0.07236; billing, list price 0.07236 [16].

Tool gp_hot_spots; parameters {"field": "station_m", "project": "814309a7-f84e-4437-a8ec-209438a3f0a6", "features": {"layer": "In-line inspection anomalies (47cf738b)"}, "aggregation": "hexagon", "cell_size_m": 1000.0, "distance_band_m": 2000.0}

Calculate density

What this analysis is. Calculate density: Kernel density per square kilometer on a grid [17]. In ArcGIS it is Calculate Density or Kernel Density; in QGIS, native:heatmapkerneldensityestimation [17].

Why it was run on this data. 25 points in Valves and stations: a density surface shows where they concentrate [18].

What it found. Calculate density on Valves and stations: Calculate density: 1 layer saved: Calculate density: Valves and stations (41 features) [19][20]. It reported result, count 41; result, elapsed ms 2; result, bandwidth m 10,000; result, cell size m 5,000; result, excluded null 0; result, max density per km2 1,474 [19].

Result	Value
result, count	41
result, elapsed ms	2
result, bandwidth m	1e+04
result, cell size m	5,000
result, excluded null	0
result, max density per km2	1,474
billing, cost	0.0505
billing, list price	0.0505
billing, upstream cost	0

Findings

Evidenced: Calculate density on Valves and stations: Calculate density: 1 layer saved: Calculate density: Valves and stations (41 features) [19][20].

Evidenced: It reported result, count 41; result, elapsed ms 2; result, bandwidth m 10,000; result, cell size m 5,000; result, excluded null 0; result, max density per km2 1,474 [19].

Tool gp_calculate_density; parameters {"kernel": "quartic", "project": "814309a7-f84e-4437-a8ec-209438a3f0a6", "features": {"layer": "Valves and stations (db114367)"}, "bandwidth_m": 10000.0, "cell_size_m": 5000.0, "weight_field": "station_m"}

Calculate density

What this analysis is. Calculate density: Kernel density per square kilometer on a grid [17]. In ArcGIS it is Calculate Density or Kernel Density; in QGIS, native:heatmapkerneldensityestimation [17].

Why it was run on this data. 70 points in Incidents: a density surface shows where they concentrate [21].

What it found. Calculate density on Incidents: Calculate density: 1 layer saved: Calculate density: Incidents (144 features) [8][22]. It reported result, count 144; result, elapsed ms 4; result, bandwidth m 5,000; result, cell size m 2,000; result, excluded null 0; result, max density per km2 1.124e+04 [22].

Result	Value
result, count	144
result, elapsed ms	4
result, bandwidth m	5,000
result, cell size m	2,000
result, excluded null	0
result, max density per km2	1.124e+04
billing, cost	0.0514
billing, list price	0.0514
billing, upstream cost	0

Findings

Evidenced: Calculate density on Incidents: Calculate density: 1 layer saved: Calculate density: Incidents (144 features) [8][22].

Evidenced: It reported result, count 144; result, elapsed ms 4; result, bandwidth m 5,000; result, cell size m 2,000; result, excluded null 0; result, max density per km2 1.124e+04 [22].

Tool gp_calculate_density; parameters {"kernel": "quartic", "project": "814309a7-f84e-4437-a8ec-209438a3f0a6", "features": {"layer": "Incidents (f9c94228)", "bandwidth_m": 5000.0, "cell_size_m": 2000.0, "weight_field": "station_m"}}

Calculate density

What this analysis is. Calculate density: Kernel density per square kilometer on a grid [17]. In ArcGIS it is Calculate Density or Kernel Density; in QGIS, native:heatmapkerneldensityestimation [17].

Why it was run on this data. 1118 points in In-line inspection anomalies: a density surface shows where they concentrate [23].

What it found. The density calculation processed 1,039 features from the in-line inspection anomalies data [24]. The resulting maximum density per km2 was 2.813e+05 [24]. This analysis took an elapsed time of 35 ms [24]. Furthermore, the associated billing cost for this tool was 0.07236 [24].

Result	Value
result, count	1,039
result, elapsed ms	35
result, bandwidth m	2,000
result, cell size m	500
result, excluded null	0
result, max density per km2	2.813e+05
billing, cost	0.07236
billing, list price	0.07236
billing, upstream cost	0

Findings

Evidenced: Calculate density on In-line inspection anomalies: Calculate density: 1 layer saved: Calculate density: In-line inspection anomalies (1039 features) [11][24].

Evidenced: It reported result, count 1,039; result, elapsed ms 35; result, bandwidth m 2,000; result, cell size m 500; result, excluded null 0; result, max density per km2 2.813e+05 [24].

Tool gp_calculate_density; parameters {"kernel": "quartic", "project": "814309a7-f84e-4437-a8ec-209438a3f0a6", "features": {"layer": "In-line inspection anomalies (47cf738b)"}, "bandwidth_m": 2000.0, "cell_size_m": 500.0, "weight_field": "station_m"}

Summarize within

What this analysis is. Summarize within: Count and aggregate the features inside each polygon (or bin), proportionally for lines and polygons [25]. In ArcGIS it is Summarize Within or Aggregate Points; in QGIS, native:countpointsinpolygon or native:sumlinelengths [25].

Why it was run on this data. Count Valves and stations inside each feature of Right of way by type; the counts map as a choropleth (natural breaks, sequential colors) [26].

What it found. Summarize within on Valves and stations, Right of way: Summarize within: 1 layer saved: Summarize within: Right of way (3 features) [20][27][28]. It reported result, count 3; result, elapsed ms 2; billing, cost 0.01058; billing, list price 0.01058; billing, upstream cost 0 [27].

Result	Value
result, count	3
result, elapsed ms	2
billing, cost	0.01058
billing, list price	0.01058
billing, upstream cost	0

Findings

Evidenced: Summarize within on Valves and stations, Right of way: Summarize within: 1 layer saved: Summarize within: Right of way (3 features) [20][27][28].

Evidenced: It reported result, count 3; result, elapsed ms 2; billing, cost 0.01058; billing, list price 0.01058; billing, upstream cost 0 [27].

Tool gp_summarize_within; parameters {"stats": [{"stat": "sum", "field": "station_m"}], "project": "814309a7-f84e-4437-a8ec-209438a3f0a6", "features": {"layer": "Valves and stations (db114367)", "group_by": "type", "polygons": {"layer": "Right of way (73b1c8fe)"}}

Summarize within

What this analysis is. Summarize within: Count and aggregate the features inside each polygon (or bin), proportionally for lines and polygons [25]. In ArcGIS it is Summarize Within or Aggregate Points; in QGIS, native:countpointsinpolygon or native:sumlinelengths [25].

Why it was run on this data. Count Valves and stations inside each feature of Right of way by type; the counts map as a choropleth (natural breaks, sequential colors) [26].

What it found. A summary within of right of way was generated using the gp_summarize_within tool [29]. The inputs for this process included incidents [8] and right of way data [28] [29]. The result produced contained 3 entries [29], and the process required 2 elapsed milliseconds [29].

Result	Value
result, count	3
result, elapsed ms	2
billing, cost	0.01148
billing, list price	0.01148
billing, upstream cost	0

Findings

Evidenced: Summarize within on Incidents, Right of way: Summarize within: 1 layer saved: Summarize within: Right of way (3 features) [8][28][29].

Evidenced: It reported result, count 3; result, elapsed ms 2; billing, cost 0.01148; billing, list price 0.01148; billing, upstream cost 0 [29].

Tool gp_summarize_within; parameters {"stats": [{"stat": "sum", "field": "station_m"}], "project": "814309a7-f84e-4437-a8ec-209438a3f0a6", "features": {"layer": "Incidents (f9c94228)", "group_by": "cause", "polygons": {"layer": "Right of way (73b1c8fe)"}}

Summarize within

What this analysis is. Summarize within: Count and aggregate the features inside each polygon (or bin), proportionally for lines and polygons [25]. In ArcGIS it is Summarize Within or Aggregate Points; in QGIS, native:countpointsinpolygon or native:sumlinelengths [25].

Why it was run on this data. Count Valves and stations inside each feature of Right of way by type; the counts map as a choropleth (natural breaks, sequential colors) [26].

What it found. Summarize within on Crossings, Right of way: Summarize within: 1 layer saved: Summarize within: Right of way (3 features) [28][30][31]. It reported result, count 3; result, elapsed ms 2; billing, cost 0.01036; billing, list price 0.01036; billing, upstream cost 0 [30].

Result	Value
result, count	3
result, elapsed ms	2
billing, cost	0.01036
billing, list price	0.01036
billing, upstream cost	0

Findings

Evidenced: Summarize within on Crossings, Right of way: Summarize within: 1 layer saved: Summarize within: Right of way (3 features) [28][30][31].

Evidenced: It reported result, count 3; result, elapsed ms 2; billing, cost 0.01036; billing, list price 0.01036; billing, upstream cost 0 [30].

Tool gp_summarize_within; parameters {"stats": [{"stat": "sum", "field": "station_m"}], "project": "814309a7-f84e-4437-a8ec-209438a3f0a6", "features": {"layer": "Crossings (d8fae91e)", "group_by": "type", "polygons": {"layer": "Right of way (73b1c8fe)"}}

Find point clusters

What this analysis is. Find point clusters: Density-based clusters (DBSCAN, HDBSCAN or OPTICS, optionally space-time) with hulls and noise [32]. In ArcGIS it is Find Point Clusters or Density-based Clustering; in QGIS, native:dbscanclustering or native:stdbscanclustering [32].

Why it was run on this data. DBSCAN finds dense groups of Valves and stations and separates noise [33].

What it found. Find point clusters on Valves and stations: Find point clusters: 2 layers saved: Find point clusters: Valves and stations (25 features); Find point clusters: cluster hulls (1 feature) [20][34]. It reported result, count 25; result, noise 0; result, distance m 5,000; result, elapsed ms 2; result, min points 3; billing, cost 0.0505 [34].

Result	Value
result, count	25
result, noise	0
result, distance m	5,000
result, elapsed ms	2
result, min points	3
billing, cost	0.0505
billing, list price	0.0505
billing, upstream cost	0

Findings

Evidenced: Find point clusters on Valves and stations: Find point clusters: 2 layers saved: Find point clusters: Valves and stations (25 features); Find point clusters: cluster hulls (1 feature) [20][34].

Evidenced: It reported result, count 25; result, noise 0; result, distance m 5,000; result, elapsed ms 2; result, min points 3; billing, cost 0.0505 [34].

Tool gp_find_point_clusters; parameters {"method": "dbscan", "project": "814309a7-f84e-4437-a8ec-209438a3f0a6", "features": {"layer": "Valves and stations (db114367)"}, "distance_m": 5000.0, "min_points": 3}

Find point clusters

What this analysis is. Find point clusters: Density-based clusters (DBSCAN, HDBSCAN or OPTICS, optionally space-time) with hulls and noise [32]. In ArcGIS it is Find Point Clusters or Density-based Clustering; in QGIS, native:dbscanclustering or native:stdbcanclustering [32].

Why it was run on this data. DBSCAN finds dense groups of Incidents and separates noise [35].

What it found. Find point clusters on Incidents: Find point clusters: 2 layers saved: Find point clusters: Incidents (70 features); Find point clusters: cluster hulls (1 feature) [8][36]. It reported result, count 70; result, noise 2; result, distance m 5,000; result, elapsed ms 2; result, min points 3; billing, cost 0.0514 [36].

Result	Value
result, count	70
result, noise	2
result, distance m	5,000
result, elapsed ms	2
result, min points	3
billing, cost	0.0514
billing, list price	0.0514
billing, upstream cost	0

Findings

Evidenced: Find point clusters on Incidents: Find point clusters: 2 layers saved: Find point clusters: Incidents (70 features); Find point clusters: cluster hulls (1 feature) [8][36].

Evidenced: It reported result, count 70; result, noise 2; result, distance m 5,000; result, elapsed ms 2; result, min points 3; billing, cost 0.0514 [36].

Tool gp_find_point_clusters; parameters {"method": "dbscan", "project": "814309a7-f84e-4437-a8ec-209438a3f0a6", "features": {"layer": "Incidents (f9c94228)"}, "distance_m": 5000.0, "min_points": 3}

Find point clusters

What this analysis is. Find point clusters: Density-based clusters (DBSCAN, HDBSCAN or OPTICS, optionally space-time) with hulls and noise [32]. In ArcGIS it is Find Point Clusters or Density-based Clustering; in QGIS, native:dbscanclustering or native:stdbcanclustering [32].

Why it was run on this data. DBSCAN finds dense groups of Crossings and separates noise [37].

What it found. Find point clusters on Crossings: Find point clusters: 2 layers saved: Find point clusters: Crossings (14 features); Find point clusters: cluster hulls (1 feature) [31][38]. It reported result, count 14; result, noise 4; result, distance m 5,000; result, elapsed ms 1; result, min points 3; billing, cost 0.05028 [38].

Result	Value
result, count	14
result, noise	4
result, distance m	5,000

Result	Value
result, elapsed ms	1
result, min points	3
billing, cost	0.05028
billing, list price	0.05028
billing, upstream cost	0

Findings

Evidenced: Find point clusters on Crossings: Find point clusters: 2 layers saved: Find point clusters: Crossings (14 features); Find point clusters: cluster hulls (1 feature) [31][38].

Evidenced: It reported result, count 14; result, noise 4; result, distance m 5,000; result, elapsed ms 1; result, min points 3; billing, cost 0.05028 [38].

Tool gp_find_point_clusters; parameters {"method": "dbscan", "project": "814309a7-f84e-4437-a8ec-209438a3f0a6", "features": {"layer": "Crossings (d8fae91e)"}, "distance_m": 5000.0, "min_points": 3}

Find nearest

What this analysis is. Find nearest: The k nearest features for each input, with geodesic distance and bearing [39]. In ArcGIS it is Find Nearest or Near; in QGIS, native:joinbynearest or native:nearestneighbouranalysis [39].

Why it was run on this data. The nearest of Crossings to each of Valves and stations, with distances [40].

What it found. Find nearest on Crossings, Valves and stations: Find nearest: 1 layer saved: Find nearest: Valves and stations (24 features) [20][31][41]. It reported result, count 24; result, elapsed ms 2; billing, cost 0.01078; billing, list price 0.01078; billing, upstream cost 0 [41].

Result	Value
result, count	24
result, elapsed ms	2
billing, cost	0.01078
billing, list price	0.01078
billing, upstream cost	0

Findings

Evidenced: Find nearest on Crossings, Valves and stations: Find nearest: 1 layer saved: Find nearest: Valves and stations (24 features) [20][31][41].

Evidenced: It reported result, count 24; result, elapsed ms 2; billing, cost 0.01078; billing, list price 0.01078; billing, upstream cost 0 [41].

Tool gp_find_nearest; parameters {"k": 1, "to": {"layer": "Crossings (d8fae91e)"}, "from": {"layer": "Valves and stations (db114367)"}, "project": "814309a7-f84e-4437-a8ec-209438a3f0a6", "max_distance_m": 5000.0}

Find nearest

What this analysis is. Find nearest: The k nearest features for each input, with geodesic distance and bearing [39]. In ArcGIS it is Find Nearest or Near; in QGIS, native:joinbynearest or native:nearestneighbouranalysis [39].

Why it was run on this data. The nearest of Crossings to each of Valves and stations, with distances [40].

What it found. The `gp\_find\_nearest` tool was utilized, taking Valves and stations [20] and Pipeline segments [43] as input [42]. The function successfully returned 25 results [42]. The operation completed with an elapsed time of 12 ms [42], and the associated costs were reported as 0.01248 [42].

Result	Value
result, count	25

Result	Value
result, elapsed ms	12
billing, cost	0.01248
billing, list price	0.01248
billing, upstream cost	0

Findings

Evidenced: Find nearest on Pipeline segments, Valves and stations: Find nearest: 1 layer saved: Find nearest: Valves and stations (25 features) [20][42][43].

Evidenced: It reported result, count 25; result, elapsed ms 12; billing, cost 0.01248; billing, list price 0.01248; billing, upstream cost 0 [42].

Tool gp_find_nearest; parameters {"k": 1, "to": {"layer": "Pipeline segments (07d2778e)"}, "from": {"layer": "Valves and stations (db114367)"}, "project": "814309a7-f84e-4437-a8ec-209438a3f0a6", "max_distance_m": 5000.0}

Near repeat

What this analysis is. Repeat and near repeat classification: Classify incidents as originators, repeats (same place) or near repeats within a distance and time window, with a Knox test table [44]. In ArcGIS it is Repeat and Near Repeat Classification or Near Repeat Calculator [44].

Why it was run on this data. Near repeat analysis tests whether Incidents close in space also follow each other within 30 days [45].

What it found. The Near repeat classification tool was run using Incidents data [8] and generated a layer containing 70

Result	Value
result, days	30
result, count	70
result, chains	3
result, distance m	2,000
result, elapsed ms	4
result, pairs linked	3
billing, cost	0.0521
billing, list price	0.0521
billing, upstream cost	0

Findings

Evidenced: Near repeat on Incidents: Repeat and near repeat classification: 1 layer saved: Repeat and near repeat classification: Incidents (70 features) [8][46].

Evidenced: It reported result, days 30; result, count 70; result, chains 3; result, distance m 2,000; result, elapsed ms 4; result, pairs linked 3 [46].

Tool gp_near_repeat; parameters {"days": 30, "project": "814309a7-f84e-4437-a8ec-209438a3f0a6", "features": {"layer": "Incidents (f9c94228)"}, "distance_m": 2000.0, "time_field": "date"}

Maps and charts

The run also made 20 map image(s) [47][48][49][50][51][52][53][54][55][56][57][58][59][60][61][62][63][64][65][66] and 27 chart(s) [67][68][69][70][71][72][73][74][75][76][77][78][79][80][81][82][83][84][85][86][87][88][89][90][91][92][93].

Emerging hot spots: Incidents

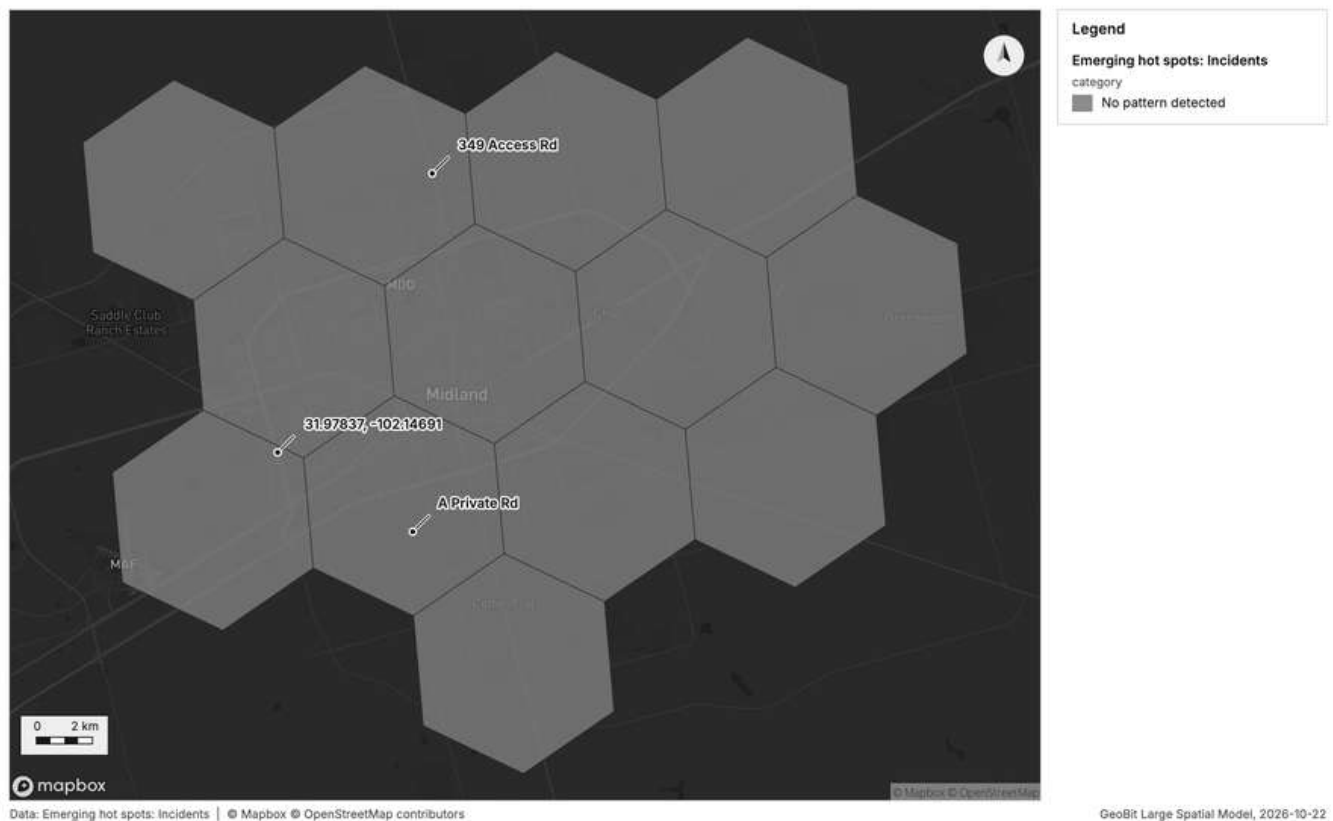


Figure 2. Emerging hot spots: Incidents [47]

Emerging hot spots: In-line inspection anomalies



Figure 3. Emerging hot spots: In-line inspection anomalies [48]

Hot spot analysis: Incidents



Figure 4. Hot spot analysis: Incidents [49]

Hot spot analysis: In-line inspection anomalies



Figure 5. Hot spot analysis: In-line inspection anomalies [50]

Calculate density: Valves and stations

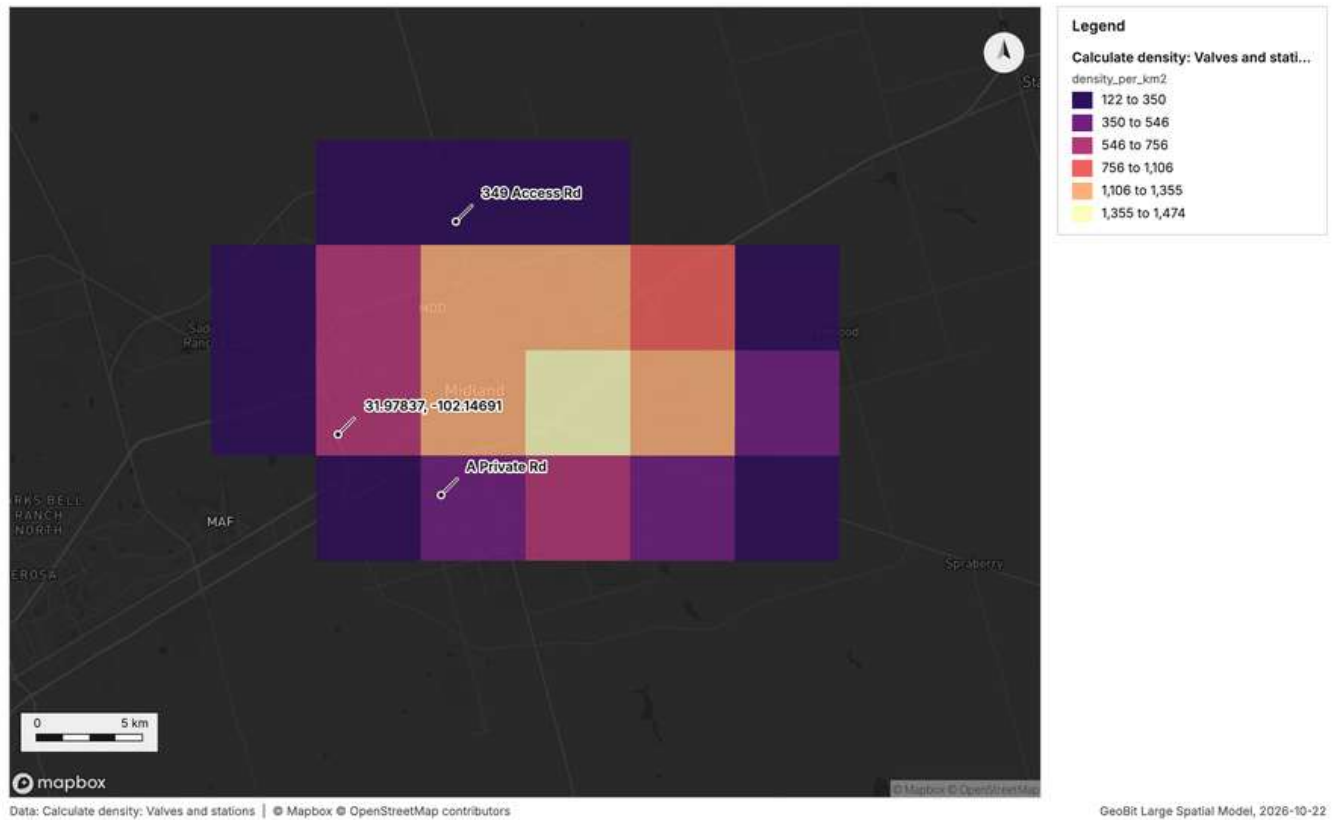


Figure 6. Calculate density: Valves and stations [51]

Calculate density: Incidents

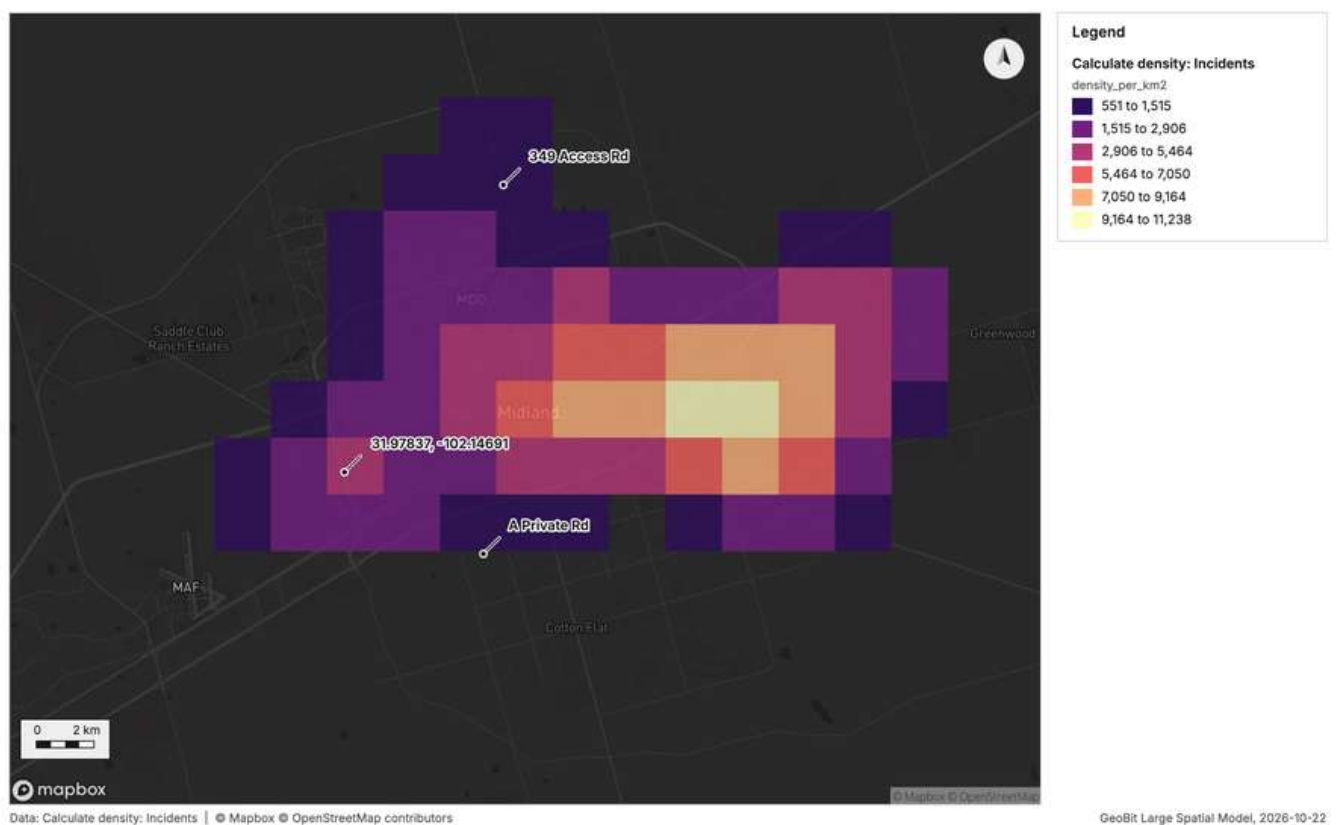


Figure 7. Calculate density: Incidents [52]

Calculate density: In-line inspection anomalies

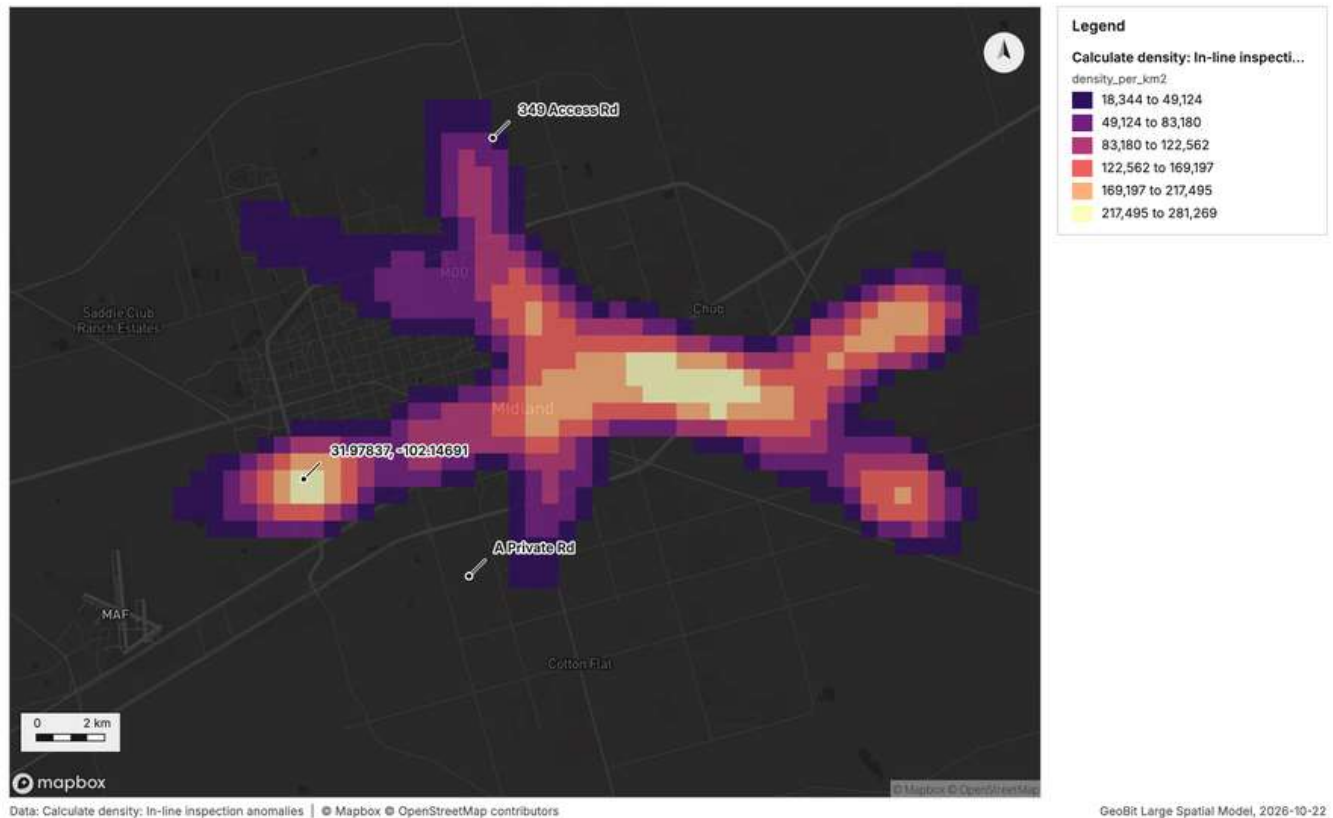


Figure 8. Calculate density: In-line inspection anomalies [53]

Summarize within: Right of way

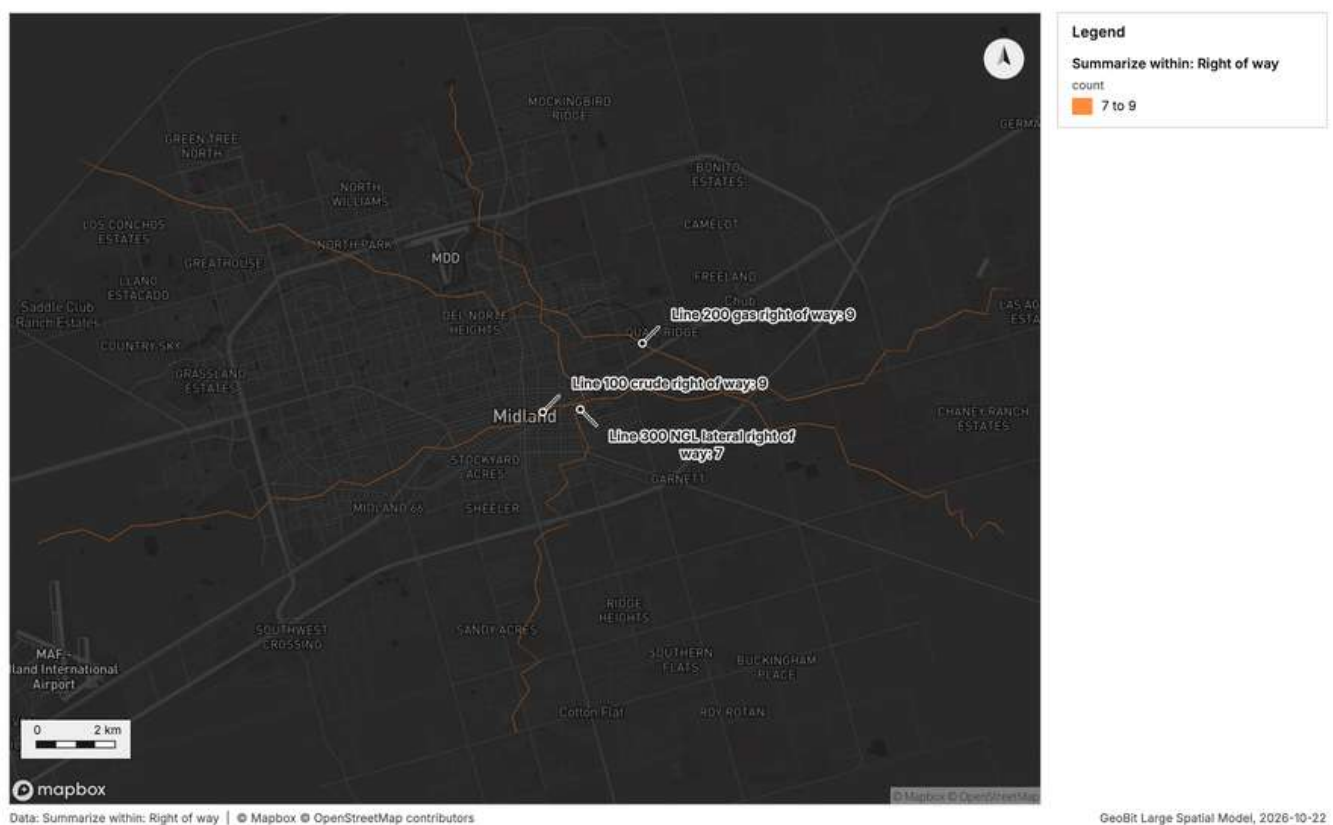


Figure 9. Summarize within: Right of way [54]

Summarize within: Right of way



Figure 10. Summarize within: Right of way [55]

Summarize within: Right of way

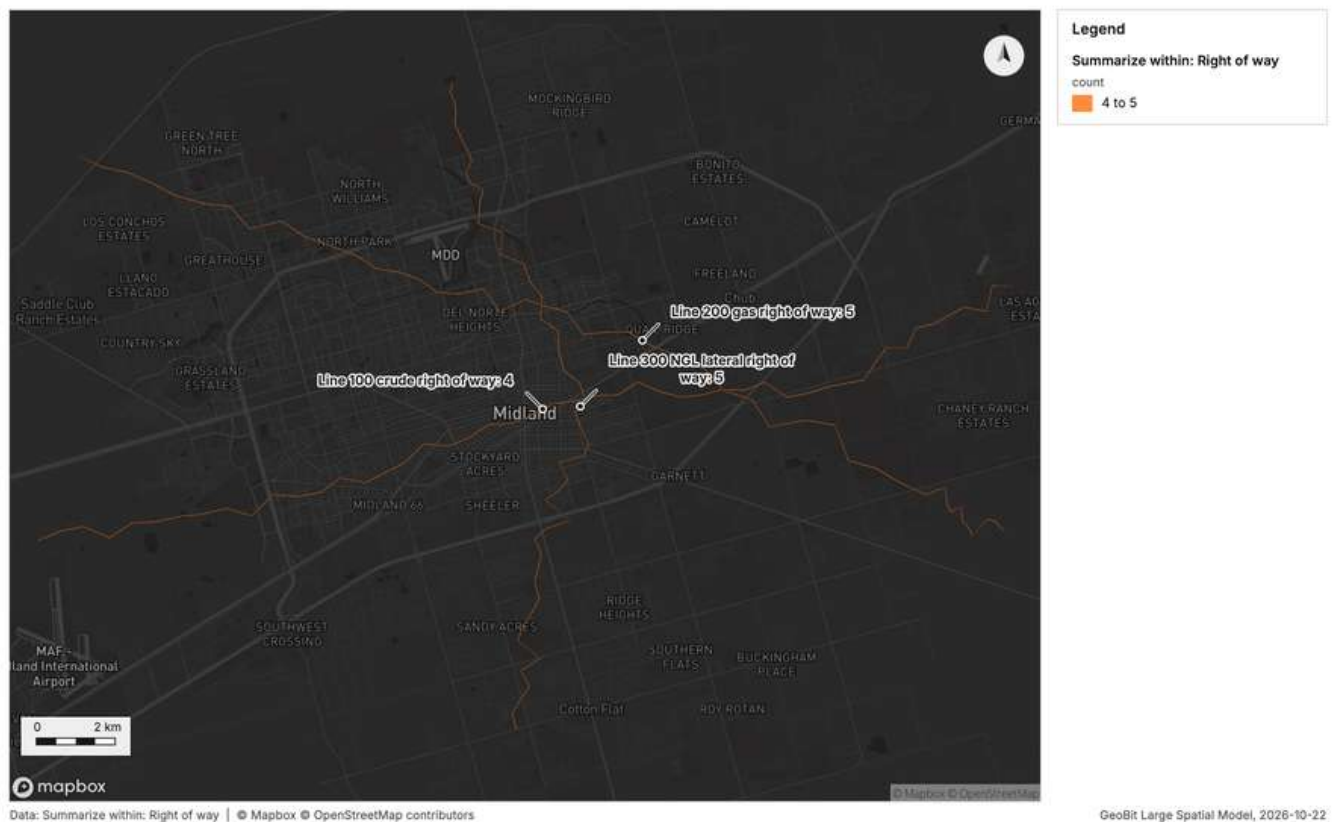


Figure 11. Summarize within: Right of way [56]

Find point clusters: Valves and stations

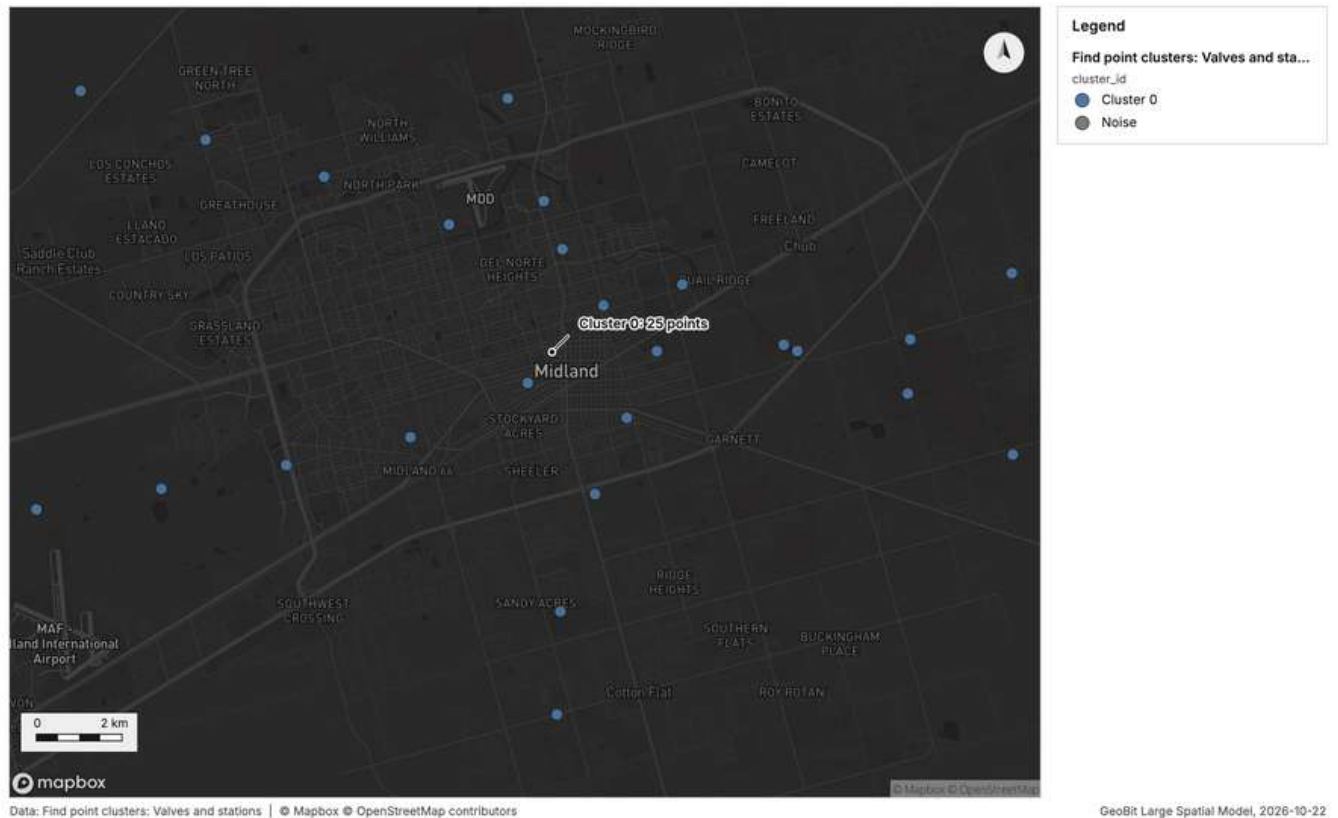


Figure 12. Find point clusters: Valves and stations [57]

Find point clusters: cluster hulls



Figure 13. Find point clusters: cluster hulls [58]

Find point clusters: Incidents

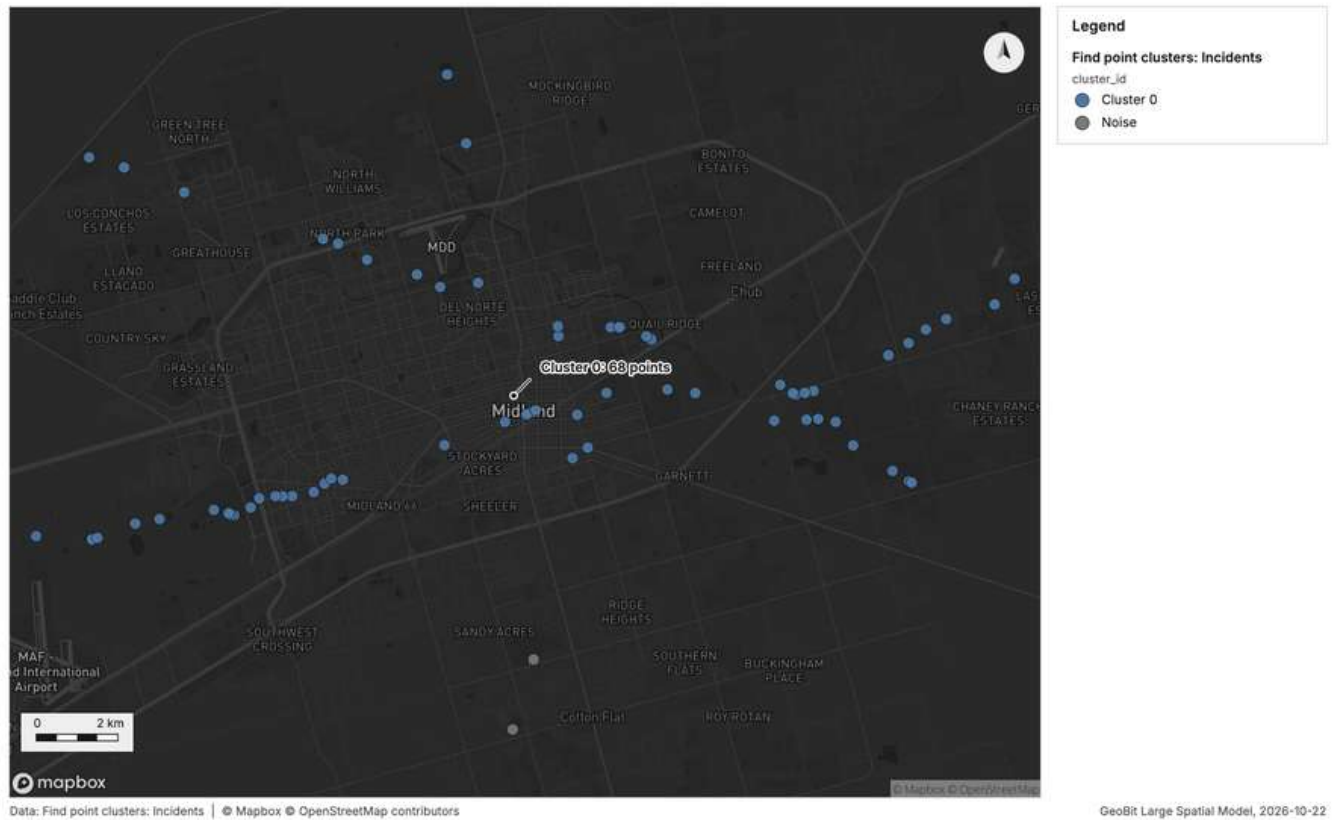


Figure 14. Find point clusters: Incidents [59]

Find point clusters: cluster hulls

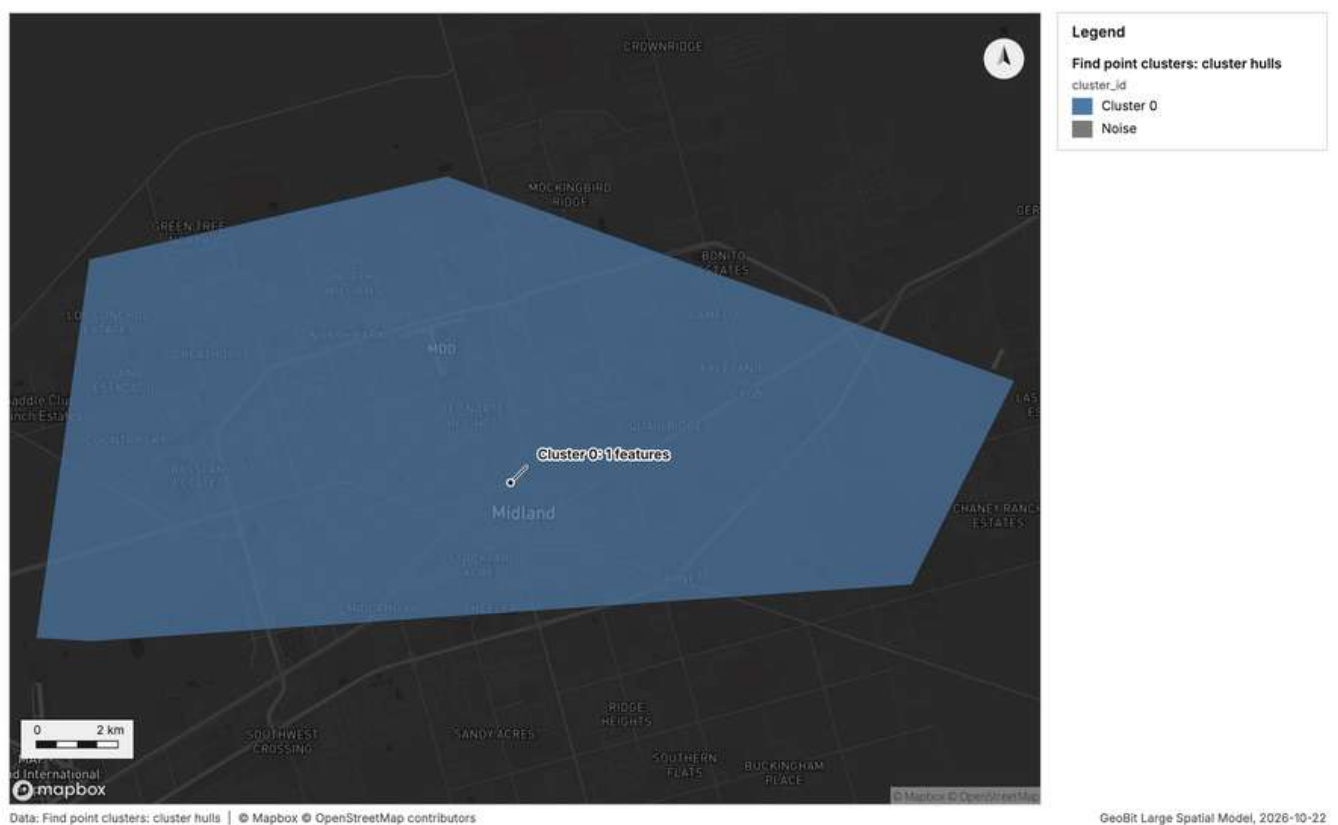


Figure 15. Find point clusters: cluster hulls [60]

Find point clusters: Crossings

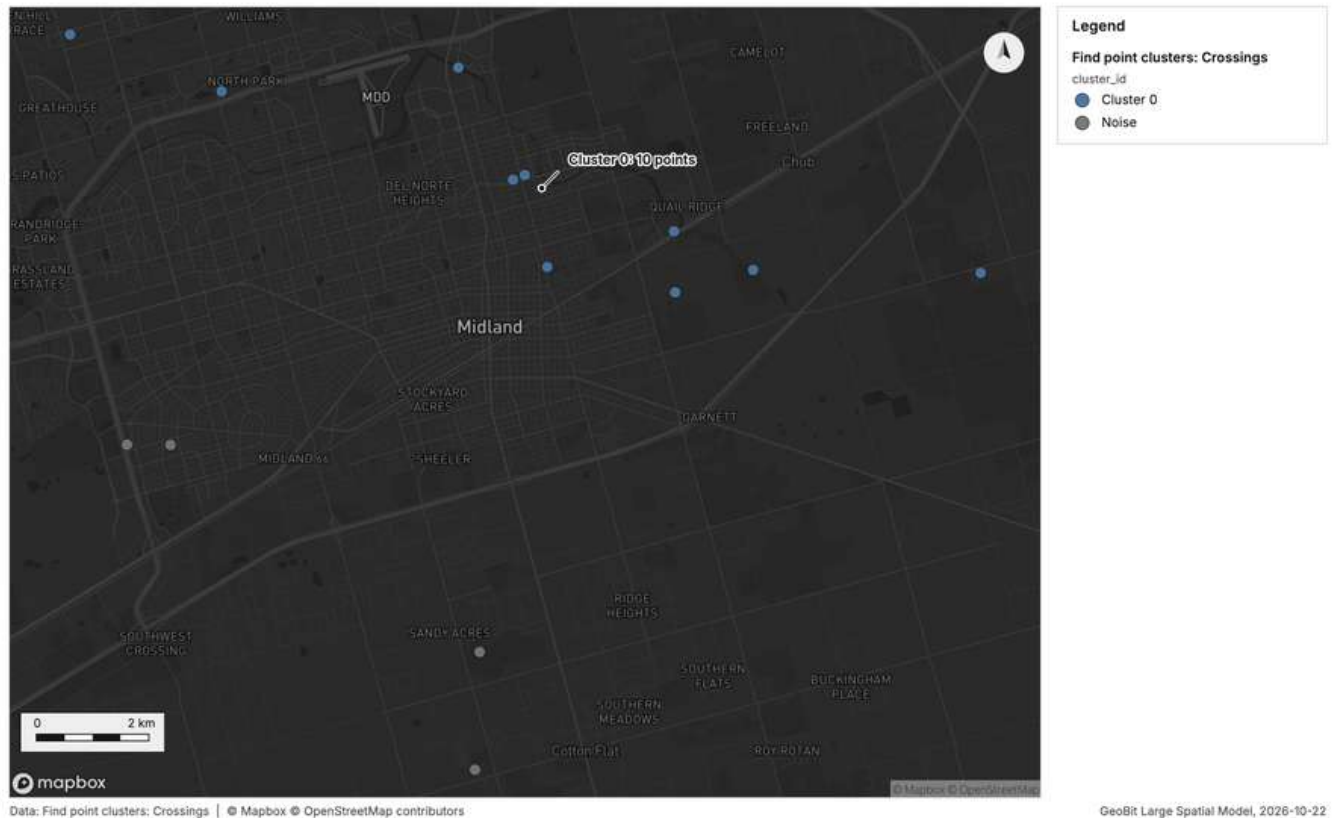


Figure 16. Find point clusters: Crossings [61]

Find point clusters: cluster hulls



Figure 17. Find point clusters: cluster hulls [62]

High consequence areas by population



Figure 18. High consequence areas by population [63]

Find nearest: Valves and stations



Figure 19. Find nearest: Valves and stations [64]

Find nearest: Valves and stations

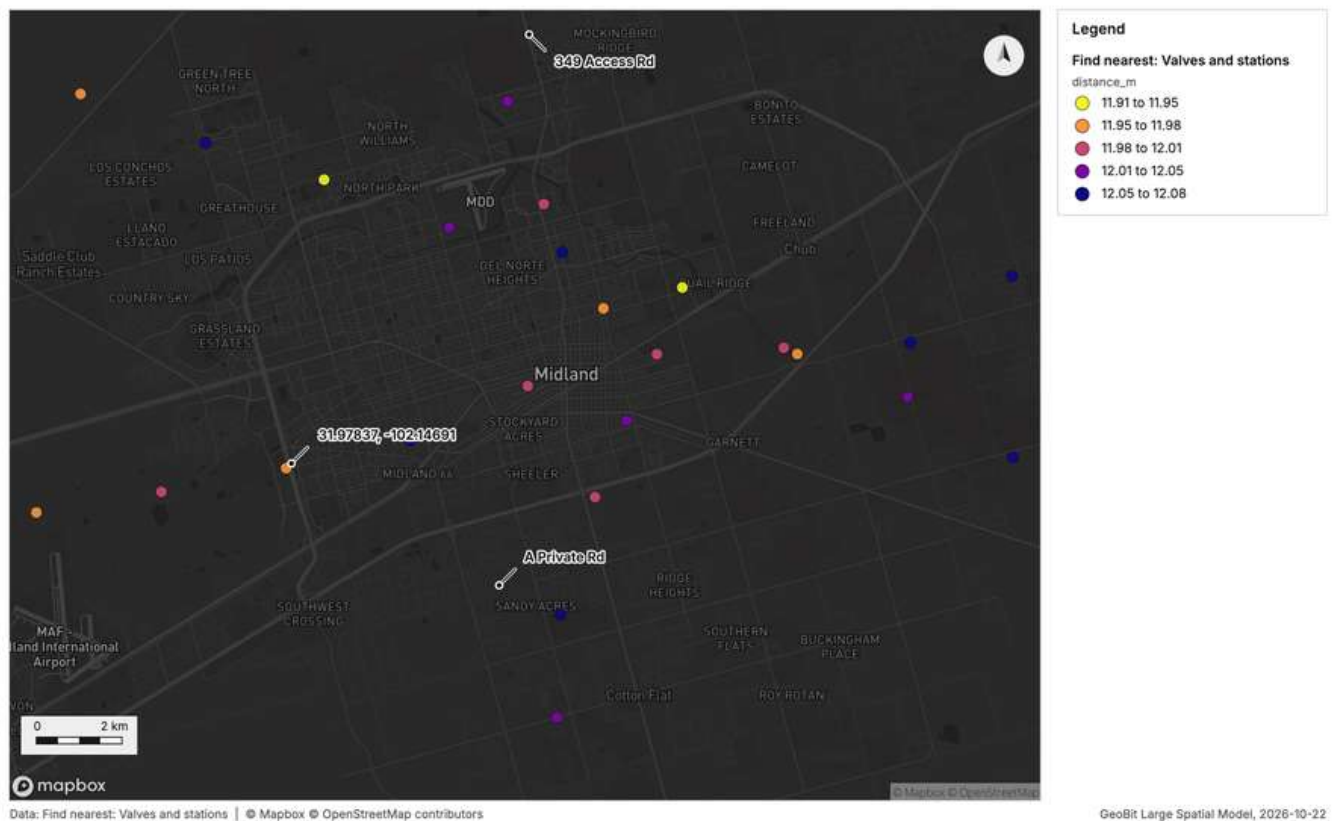


Figure 20. Find nearest: Valves and stations [65]

Repeat and near repeat classification: Incidents

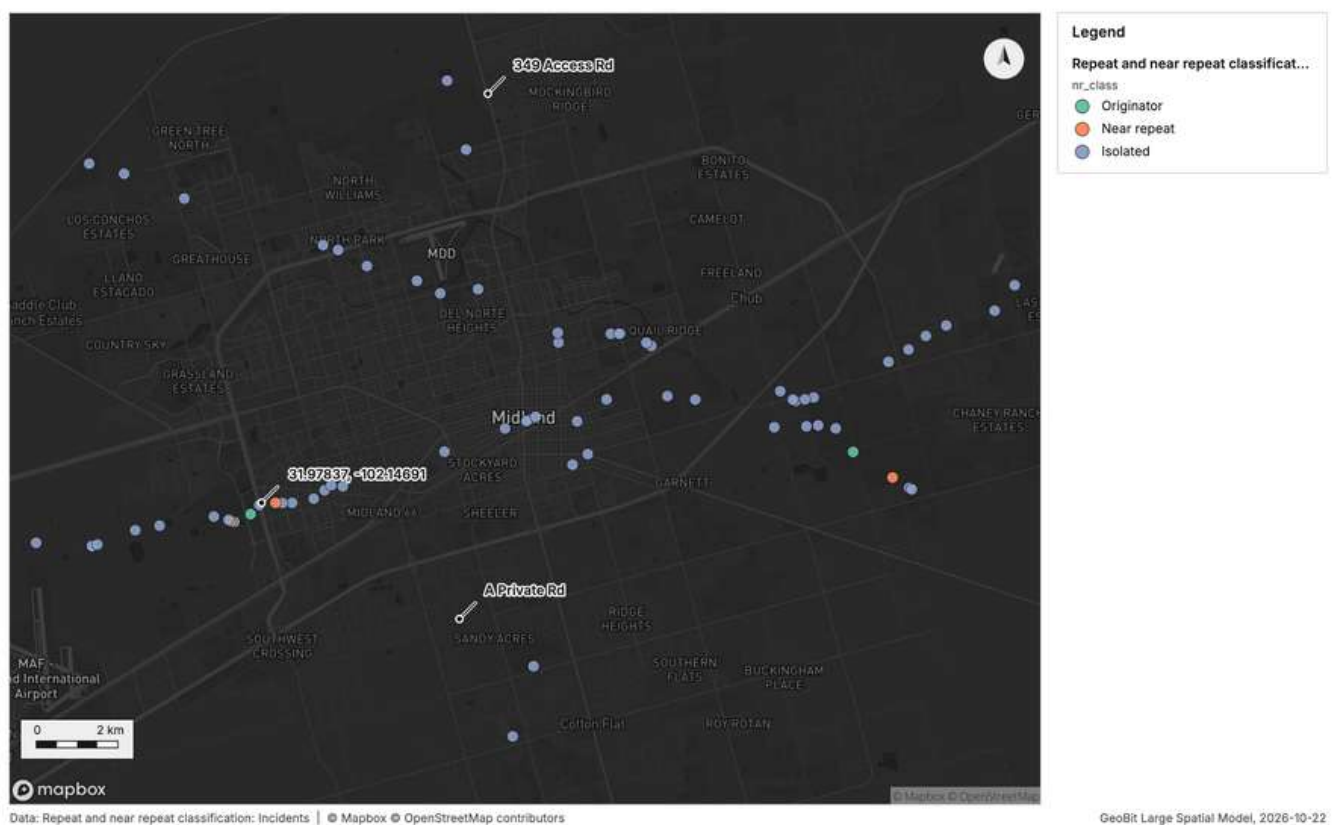


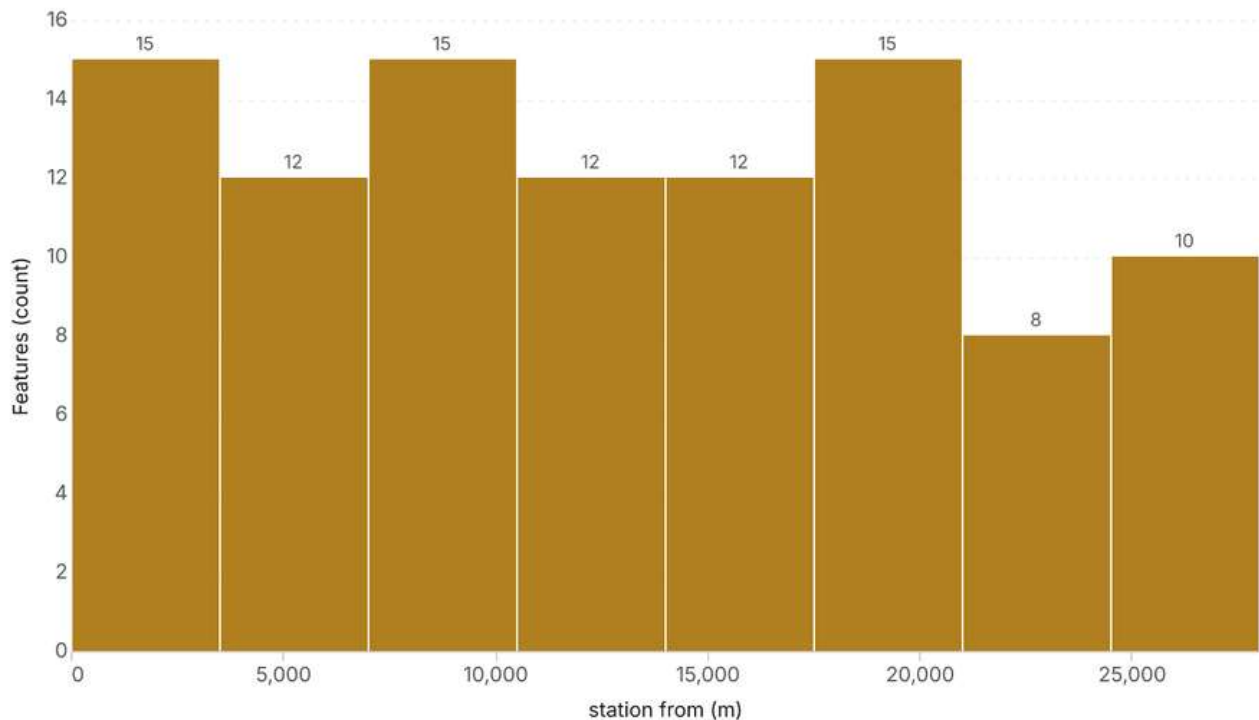
Figure 21. Repeat and near repeat classification: Incidents [66]

What the map shows. This map visualizes the analysis of emerging hot spots for incidents across the mapped area. The legend explicitly states that no pattern was detected for this category of incidents. Graphically, the map is drawn using a tessellation of hexagonal polygons, all of which are uniformly filled with a solid grey shade. Because no pattern was detected, the map does not display any visible clusters, significant gradients, or distinguishable high or low activity areas. [47]

Inferred: read from the image by gemma4:e4b, not evidence.

Distribution of station_from_m

99 values in 8 bins



Source: Pipeline segments (99 features).

Figure 22. Pipeline segments over time (install_year) [67]. Source: Pipeline segments (99 features). The data is in the appendix.

Sum of station_m per year by date and cause

Per year: 11 years from 2016-01-01 to 2026-01-01; trend $+7.62e+03$ per year; first half $2.935e+05$, second half $4.709e+05$ (+60.4%)

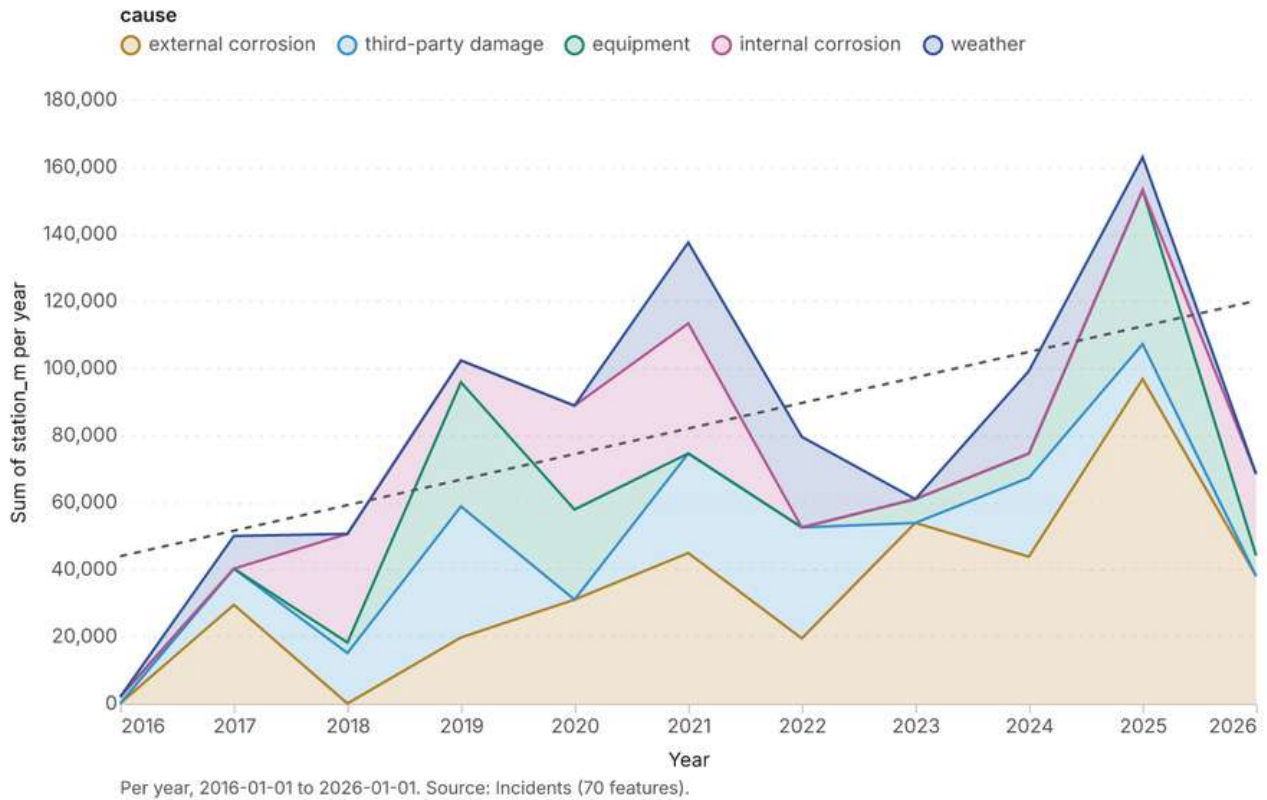


Figure 23. Incidents over time (date) [68]. Per year, 2016-01-01 to 2026-01-01. Source: Incidents (70 features). The data is in the appendix.

Count per month by date

Per month: 33 months from 2023-10-01 to 2026-06-01; trend -0.0234 per month; first half 84, second half 84 (+0.0%)

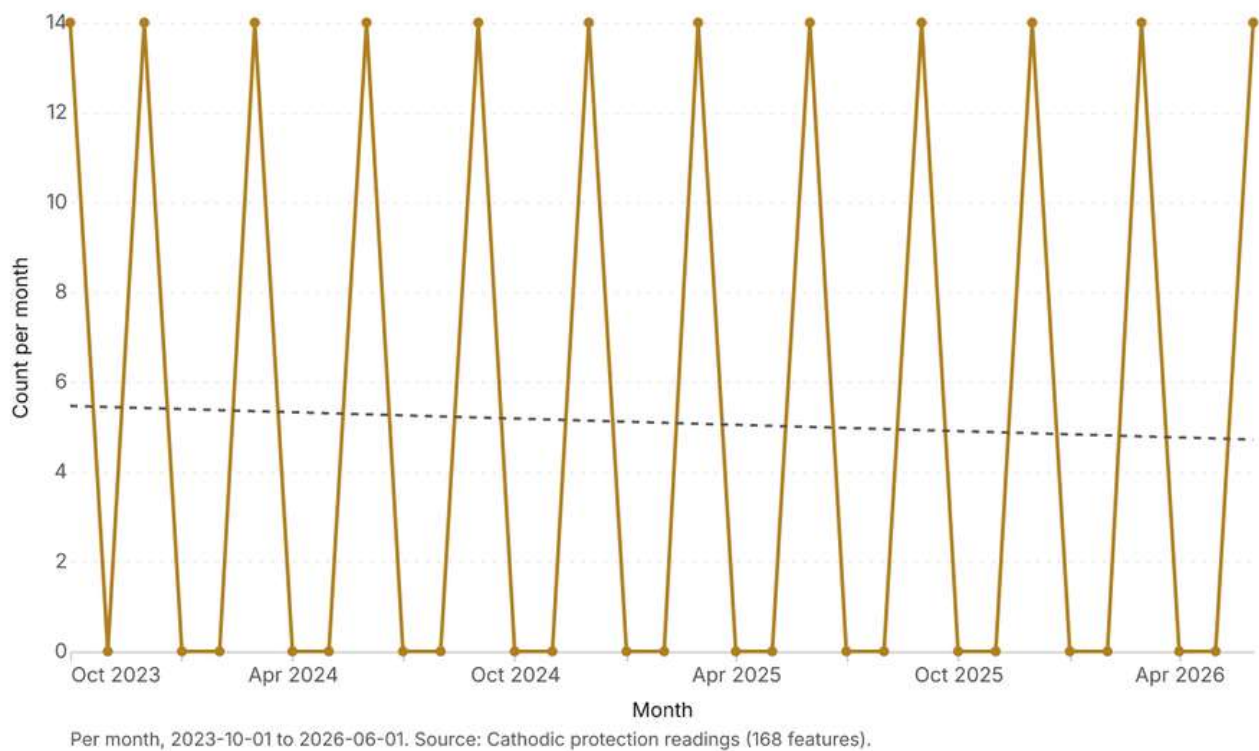


Figure 24. Cathodic protection readings over time (date) [69]. Per month, 2023-10-01 to 2026-06-01. Source: Cathodic protection readings (168 features). The data is in the appendix.

Distribution of maop_psi

99 values in 8 bins

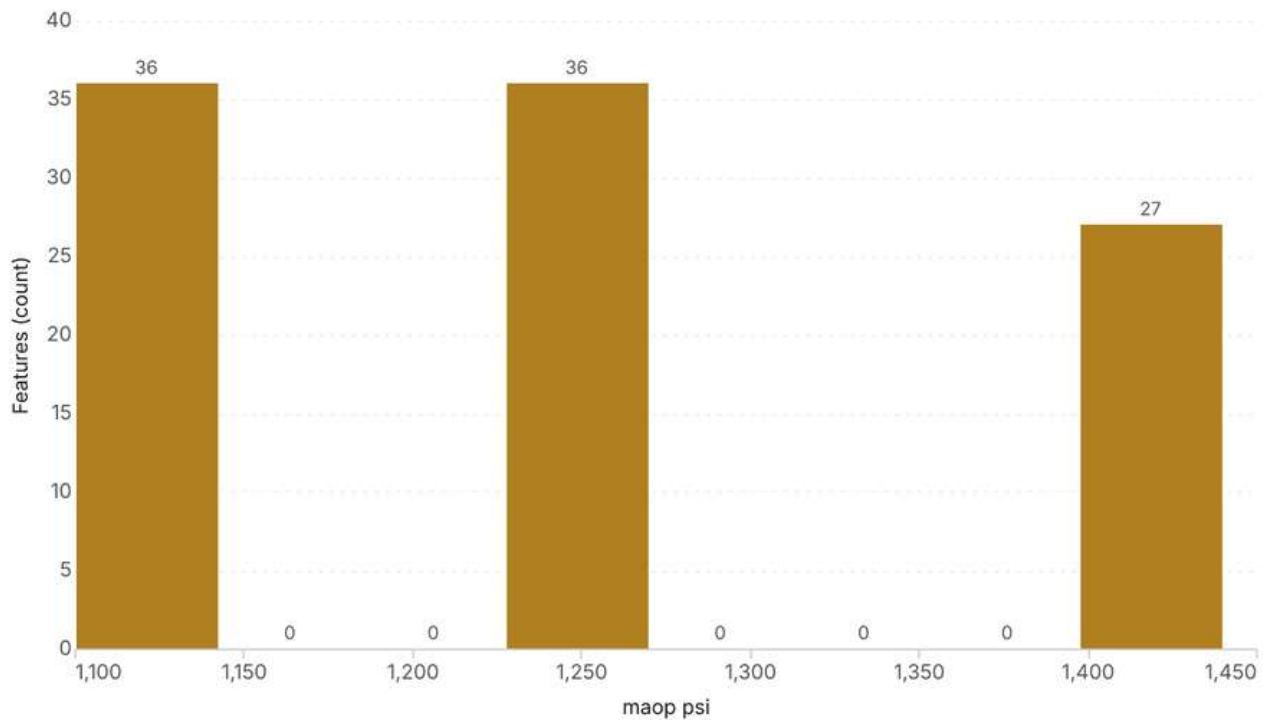


Figure 25. Segment operating limits over time (last_hydrotest_year) [70]. Source: Segment operating limits (99 features). The data is in the appendix.

Distribution of last_z

13 values in 5 bins

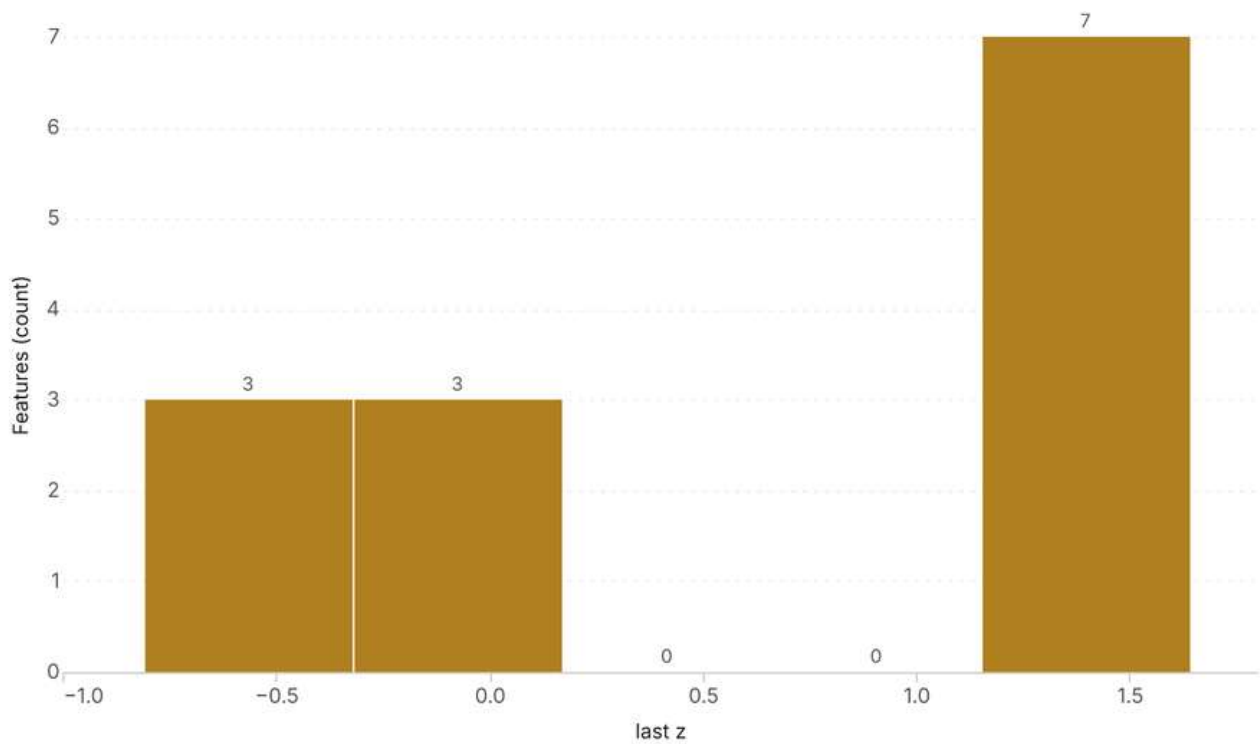
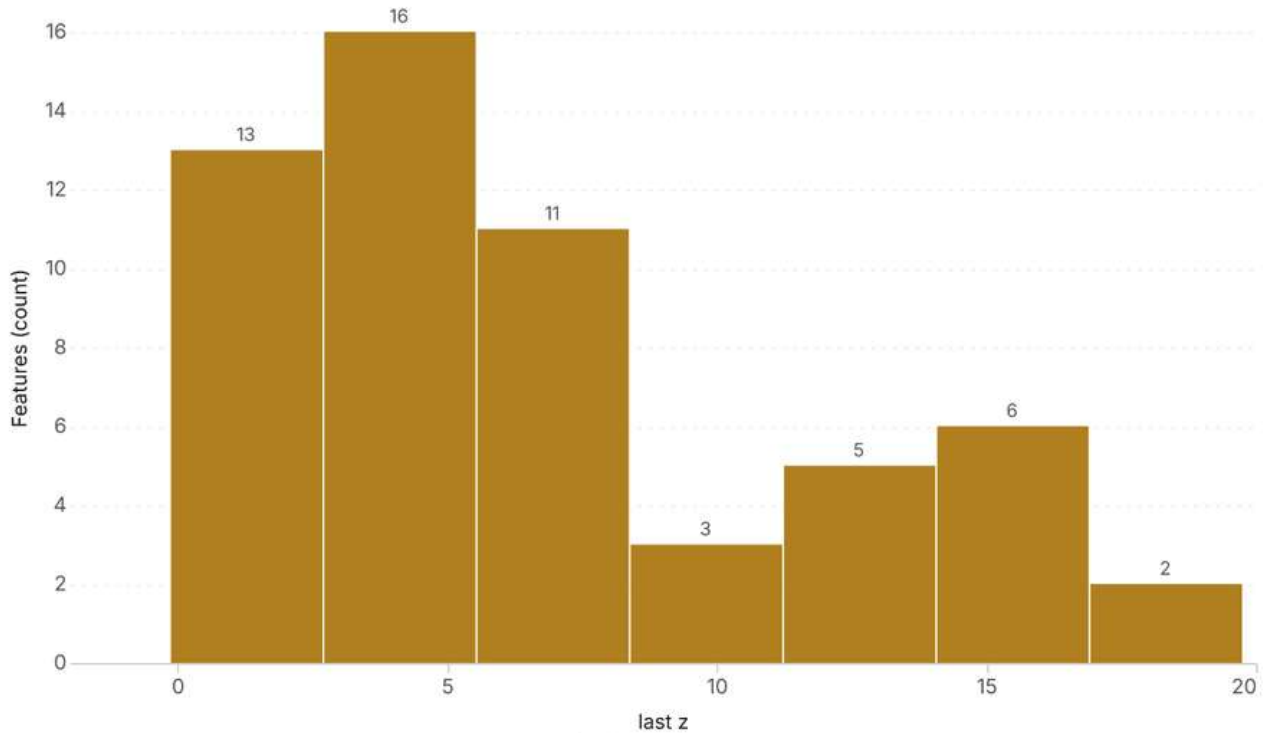


Figure 26. Emerging hot spots: Incidents [71]. Source: Emerging hot spots: Incidents (13 features). The data is in the appendix.

Distribution of last_z

56 values in 7 bins

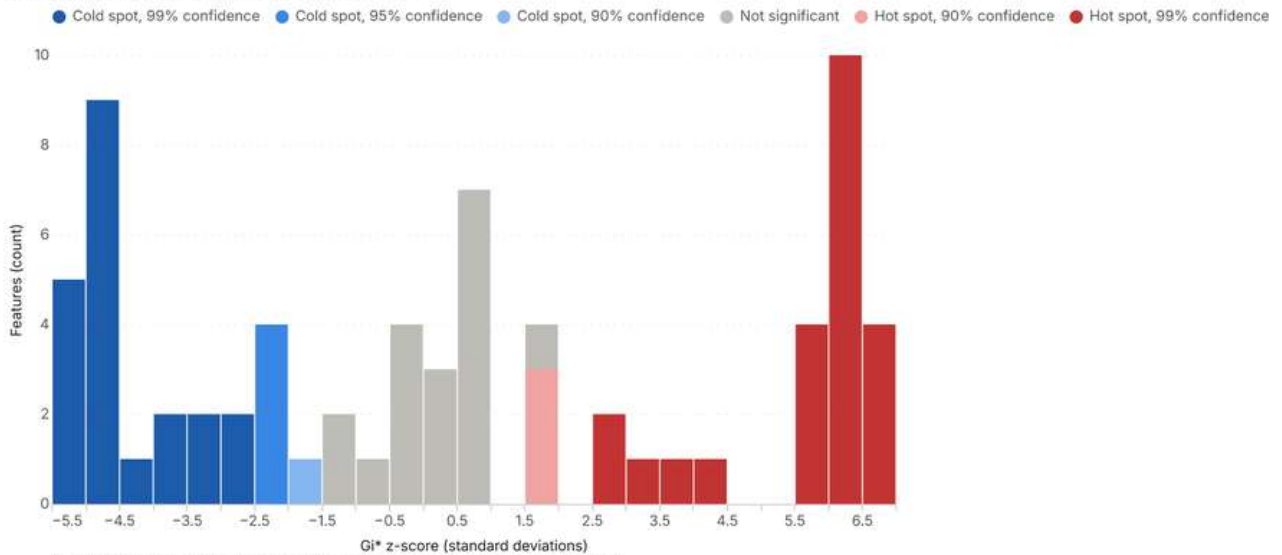


Source: Emerging hot spots: In-line inspection anomalies (56 features).

Figure 27. Emerging hot spots: In-line inspection anomalies [72]. Source: Emerging hot spots: In-line inspection anomalies (56 features). The data is in the appendix.

Gi* z-score distribution

70 features: 26 hot and 26 cold at 90% confidence or more



Period: 2016-04-07 to 2026-06-14 (date). Source: Hot spot analysis: Incidents (70 features).

Figure 28. Hot spot analysis: Incidents [73]. Period: 2016-04-07 to 2026-06-14 (date). Source: Hot spot analysis: Incidents (70 features). The data is in the appendix.

Gi* z-score distribution

1,118 features: 457 hot and 540 cold at 90% confidence or more

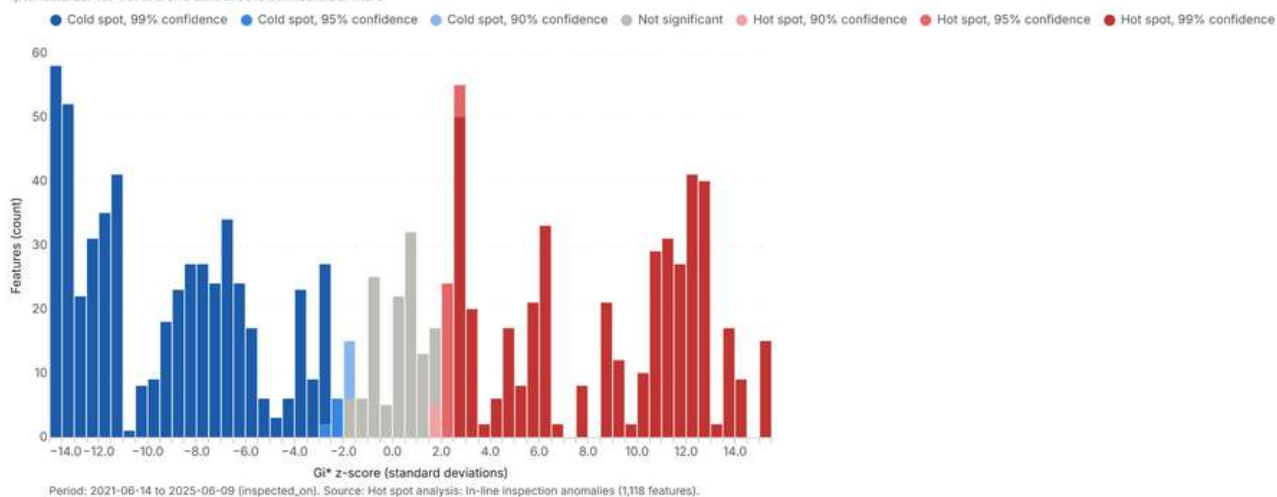


Figure 29. Hot spot analysis: In-line inspection anomalies [74]. Period: 2021-06-14 to 2025-06-09 (inspected_on). Source: Hot spot analysis: In-line inspection anomalies (1,118 features). The data is in the appendix.

Distribution of density_per_km2

41 values in 7 bins

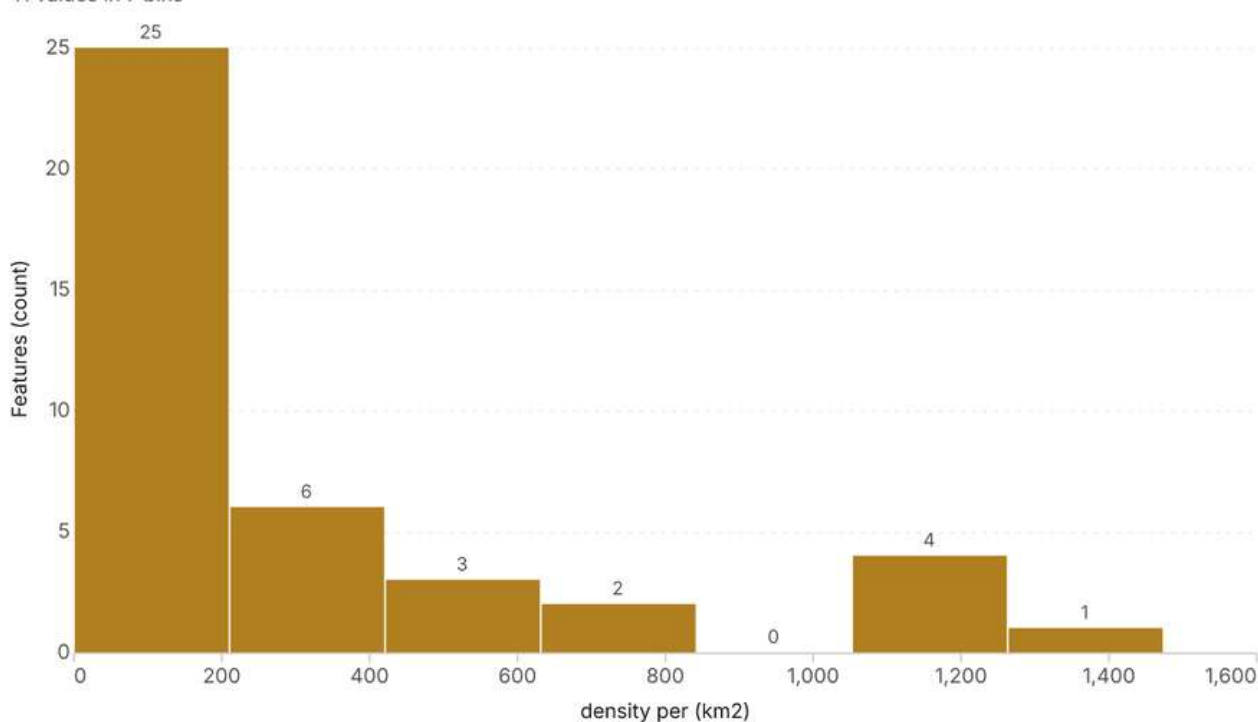
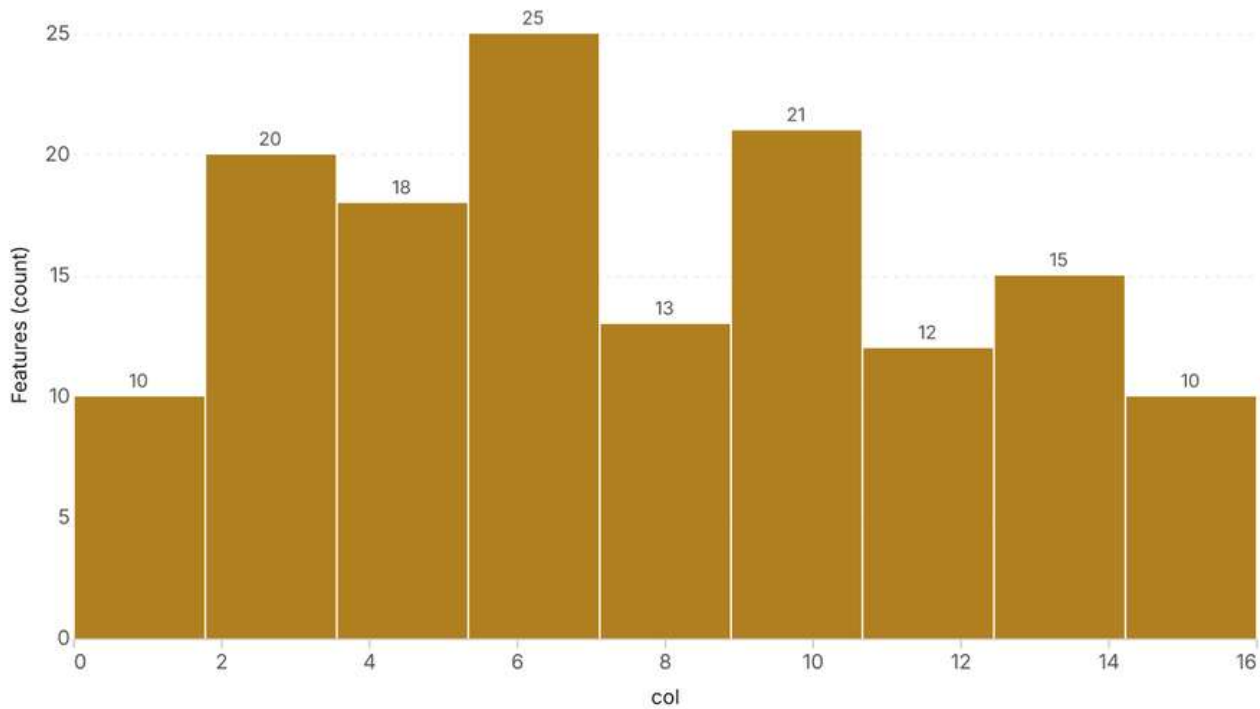


Figure 30. Calculate density: Valves and stations [75]. Source: Calculate density: Valves and stations (41 features). The data is in the appendix.

Distribution of col

144 values in 9 bins

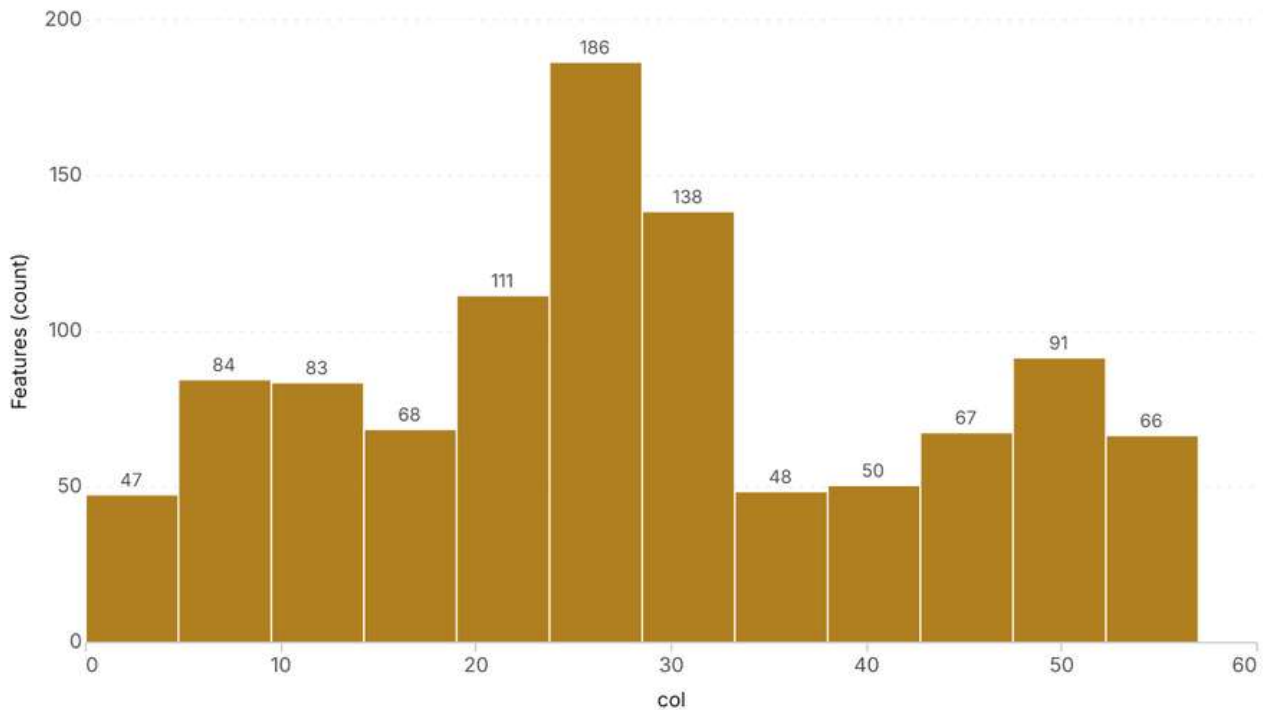


Source: Calculate density: Incidents (144 features).

Figure 31. Calculate density: Incidents [76]. Source: Calculate density: Incidents (144 features). The data is in the appendix.

Distribution of col

1,039 values in 12 bins

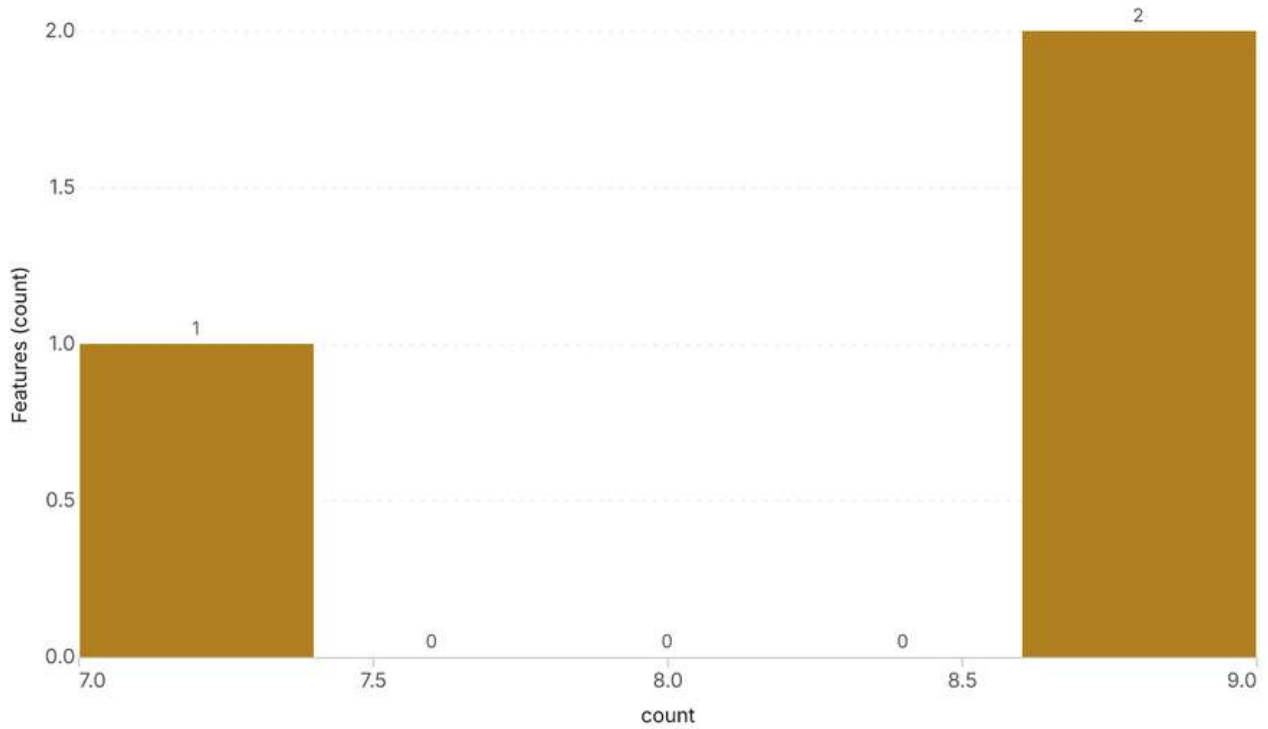


Source: Calculate density: In-line inspection anomalies (1,039 features).

Figure 32. Calculate density: In-line inspection anomalies [77]. Source: Calculate density: In-line inspection anomalies (1,039 features). The data is in the appendix.

Distribution of count

3 values in 5 bins

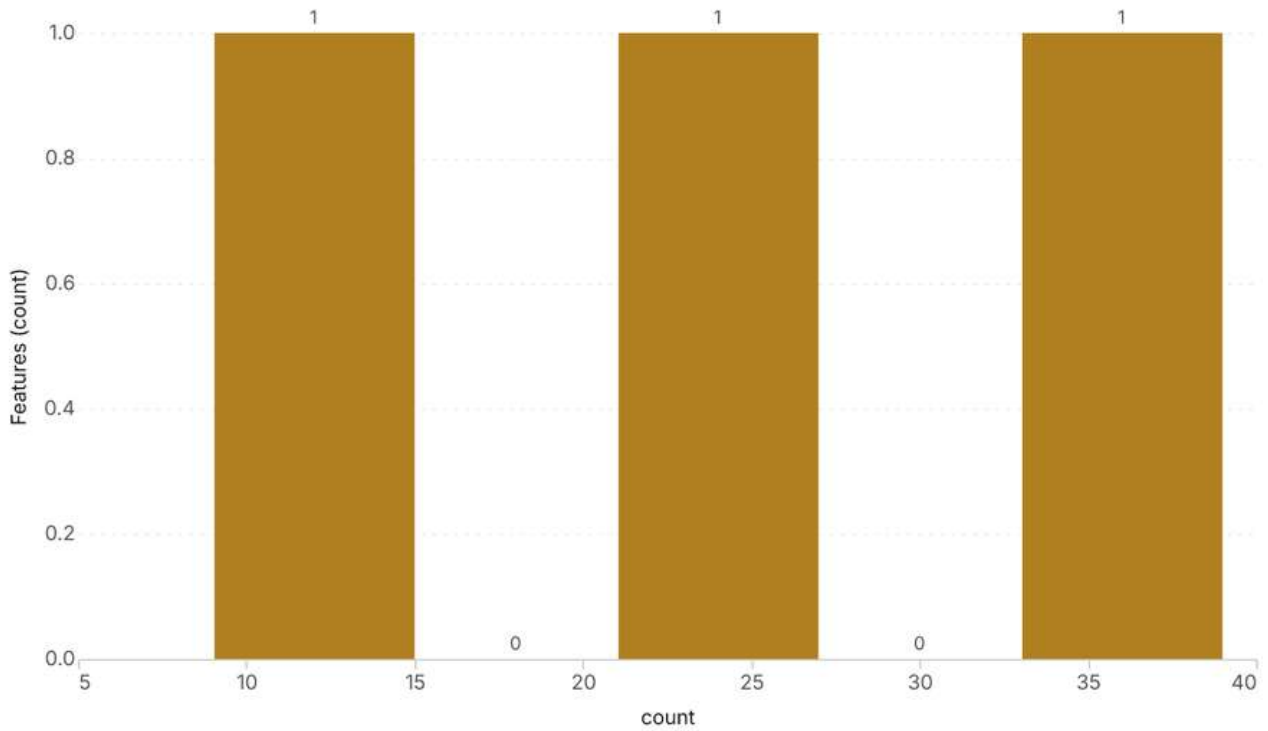


Source: Summarize within: Right of way (3 features).

Figure 33. Summarize within: Right of way [78]. Source: Summarize within: Right of way (3 features). The data is in the appendix.

Distribution of count

3 values in 5 bins

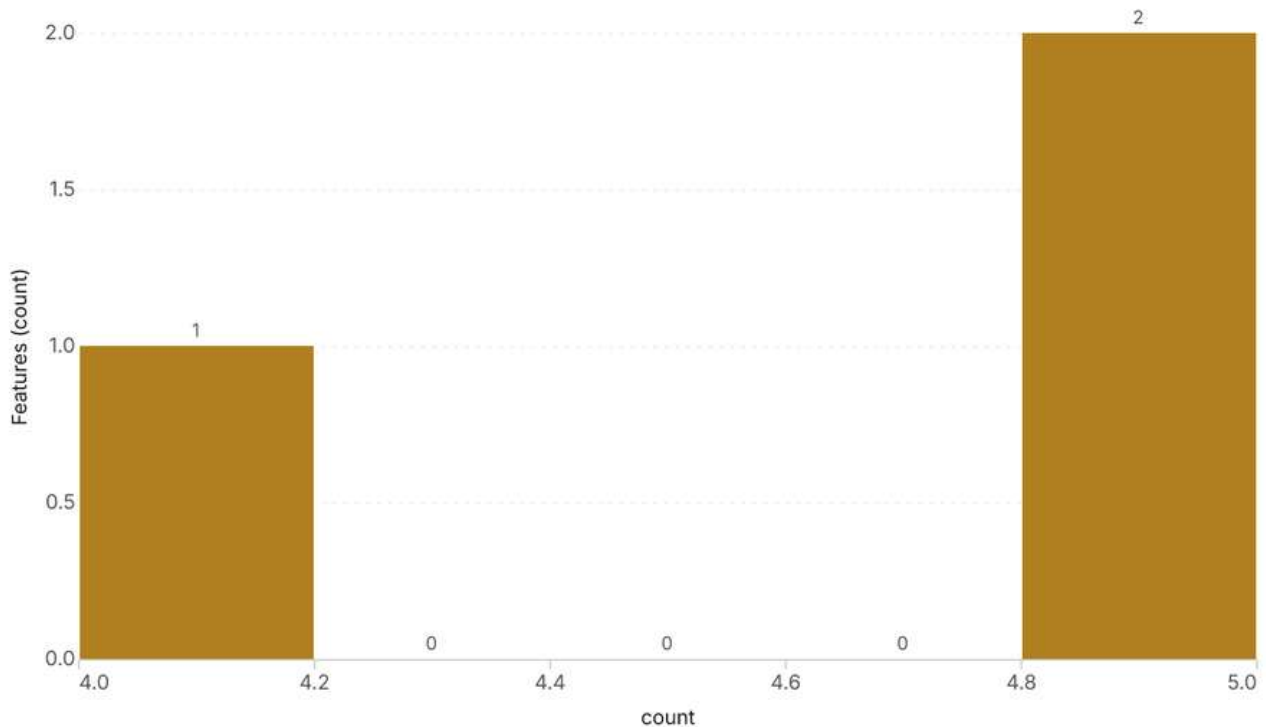


Source: Summarize within: Right of way (3 features).

Figure 34. Summarize within: Right of way [79]. Source: Summarize within: Right of way (3 features). The data is in the appendix.

Distribution of count

3 values in 5 bins



Source: Summarize within: Right of way (3 features).

Figure 35. Summarize within: Right of way [80]. Source: Summarize within: Right of way (3 features). The data is in the appendix.

Cluster sizes

1 clusters over 25 features

cluster	features	share
0	25	100.0%

Source: Find point clusters: Valves and stations (25 features).

Figure 36. Find point clusters: Valves and stations [81]. Source: Find point clusters: Valves and stations (25 features). The data is in the appendix.

Cluster sizes

1 clusters over 1 features

cluster	features	share
0	1	100.0%

Source: Find point clusters: cluster hulls (1 features).

Figure 37. Find point clusters: cluster hulls [82]. Source: Find point clusters: cluster hulls (1 features). The data is in the appendix.

Cluster sizes

1 clusters over 70 features

cluster	features	share
0	68	97.1%
Noise	2	2.9%

Period: 2016-04-07 to 2026-06-14 (date). Source: Find point clusters: Incidents (70 features).

Figure 38. Find point clusters: Incidents [83]. Period: 2016-04-07 to 2026-06-14 (date). Source: Find point clusters: Incidents (70 features). The data is in the appendix.

Cluster sizes

1 clusters over 1 features

cluster	features	share
0	1	100.0%

Source: Find point clusters: cluster hulls (1 features).

Figure 39. Find point clusters: cluster hulls [84]. Source: Find point clusters: cluster hulls (1 features). The data is in the appendix.

Cluster sizes

1 clusters over 14 features

cluster	features	share
0	10	71.4%
Noise	4	28.6%

Source: Find point clusters: Crossings (14 features).

Figure 40. Find point clusters: Crossings [85]. Source: Find point clusters: Crossings (14 features). The data is in the appendix.

Cluster sizes

1 clusters over 1 features

cluster	features	share
0	1	100.0%

Source: Find point clusters: cluster hulls (1 features).

Figure 41. Find point clusters: cluster hulls [86]. Source: Find point clusters: cluster hulls (1 features). The data is in the appendix.

Ranked by rank

Top 20 of 24 (smallest first)

rank	name
1	draw
1	draw
1	road
1	road
1	road
1	road
1	road
1	road
1	road
1	road
1	road
1	road
1	draw
1	road
1	road
1	road
1	road
1	draw
1	road
1	road

Source: Find nearest: Valves and stations (24 features).

Figure 42. Find nearest: Valves and stations [87]. Source: Find nearest: Valves and stations (24 features). The data is in the appendix.

Ranked by rank

Top 20 of 25 (smallest first)

rank	name
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1

Source: Find nearest: Valves and stations (25 features).

Figure 43. Find nearest: Valves and stations [88]. Source: Find nearest: Valves and stations (25 features). The data is in the appendix.

Count per year by date and cause

Per year: 11 years from 2016-01-01 to 2026-01-01; trend +0.464 per year; first half 26, second half 36 (+38.5%)

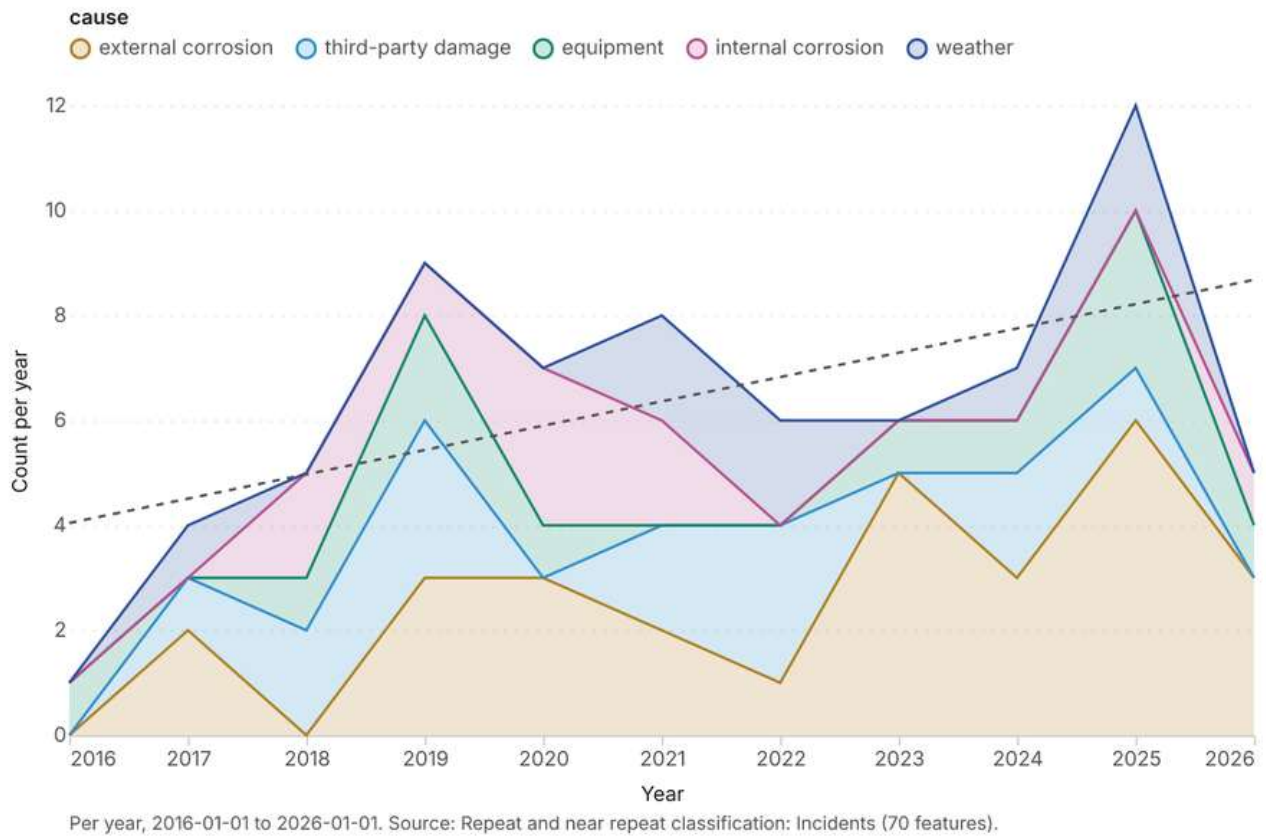


Figure 44. Repeat and near repeat classification: Incidents [89]. Per year, 2016-01-01 to 2026-01-01. Source: Repeat and near repeat classification: Incidents (70 features). The data is in the appendix.

Count per year by date and cause

Per year: 11 years from 2016-01-01 to 2026-01-01; trend +0.464 per year; first half 26, second half 36 (+38.5%)

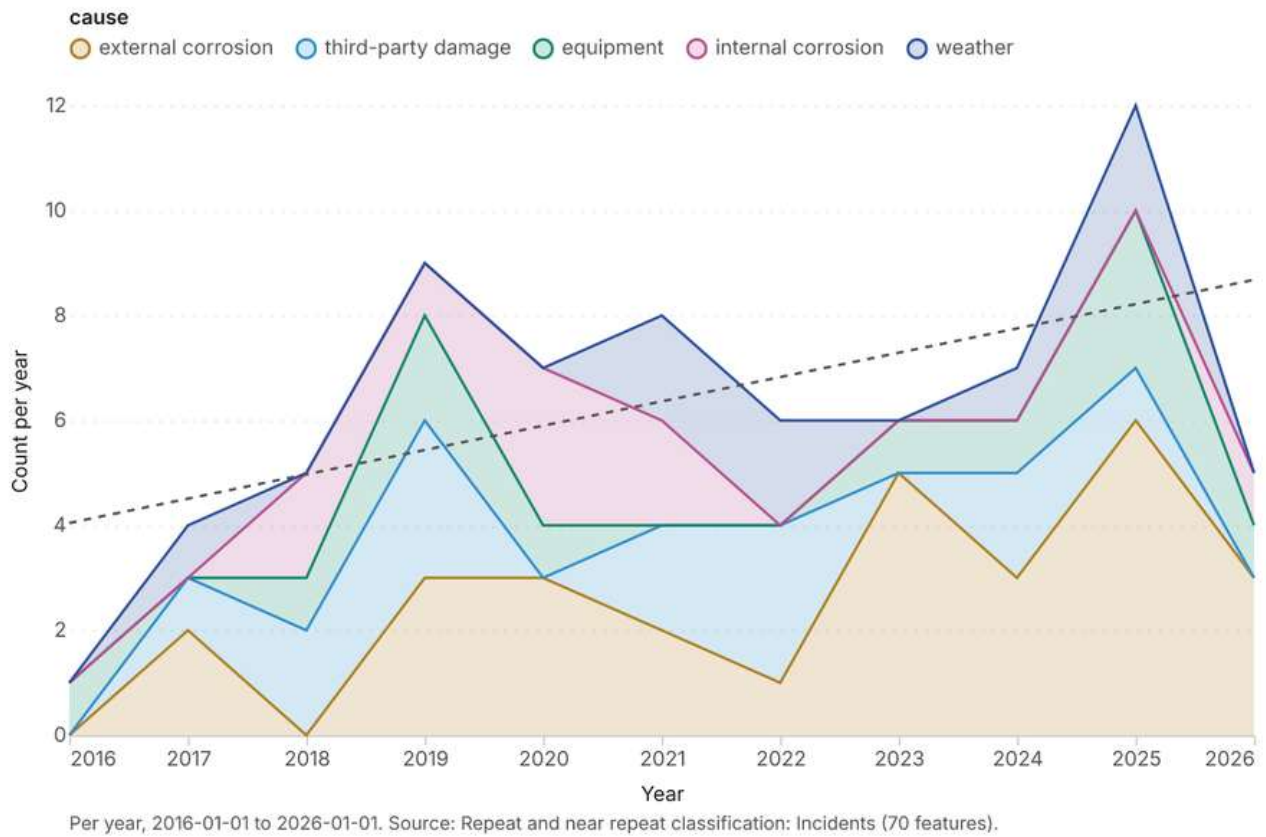


Figure 45. Repeat and near repeat classification: Incidents over time [90]. Per year, 2016-01-01 to 2026-01-01. Source: Repeat and near repeat classification: Incidents (70 features). The data is in the appendix.

Count per year by date and cause

Per year: 11 years from 2016-01-01 to 2026-01-01; trend +0.464 per year; first half 26, second half 36 (+38.5%)

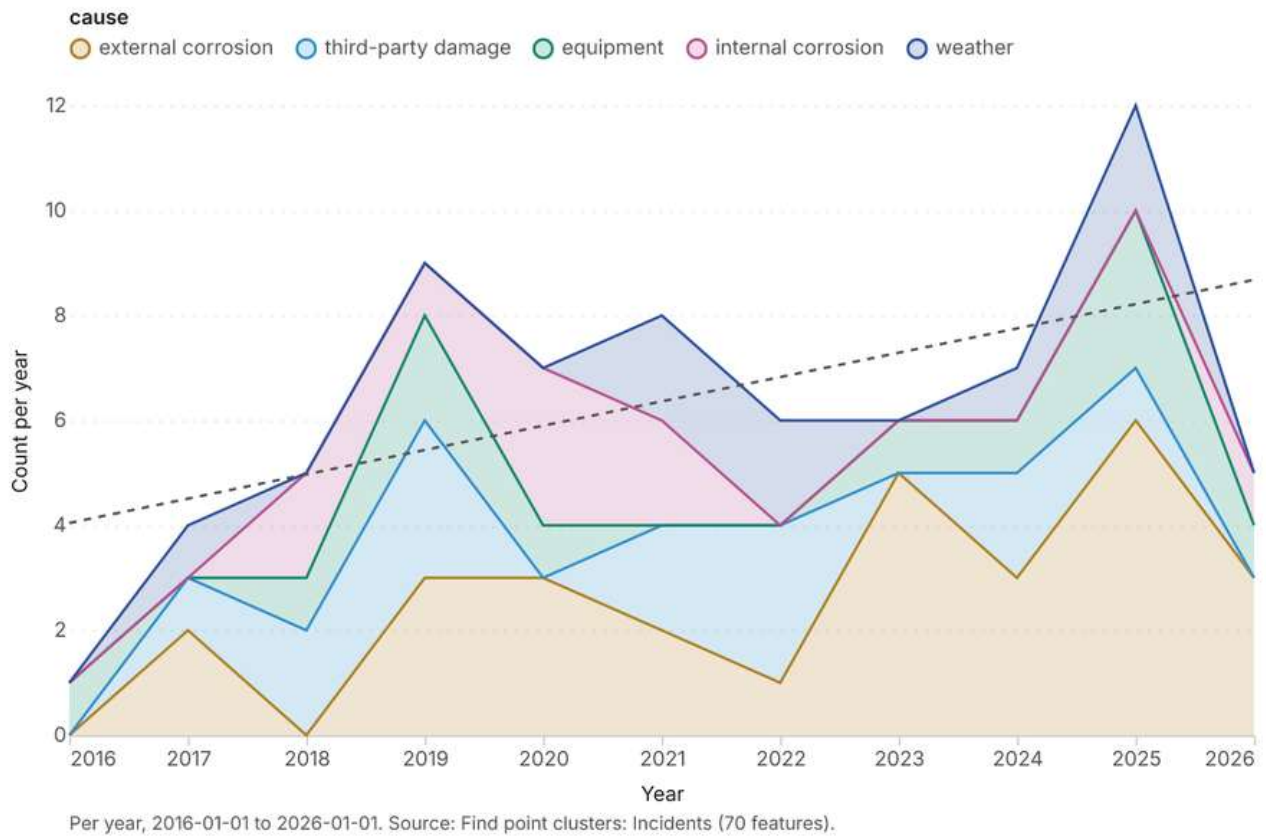


Figure 46. Find point clusters: Incidents over time [91]. Per year, 2016-01-01 to 2026-01-01. Source: Find point clusters: Incidents (70 features). The data is in the appendix.

Count per month by inspected_on and clock

Per month: 49 months from 2021-06-01 to 2025-06-01; trend -0.159 per month; first half 420, second half 355 (-15.5%)

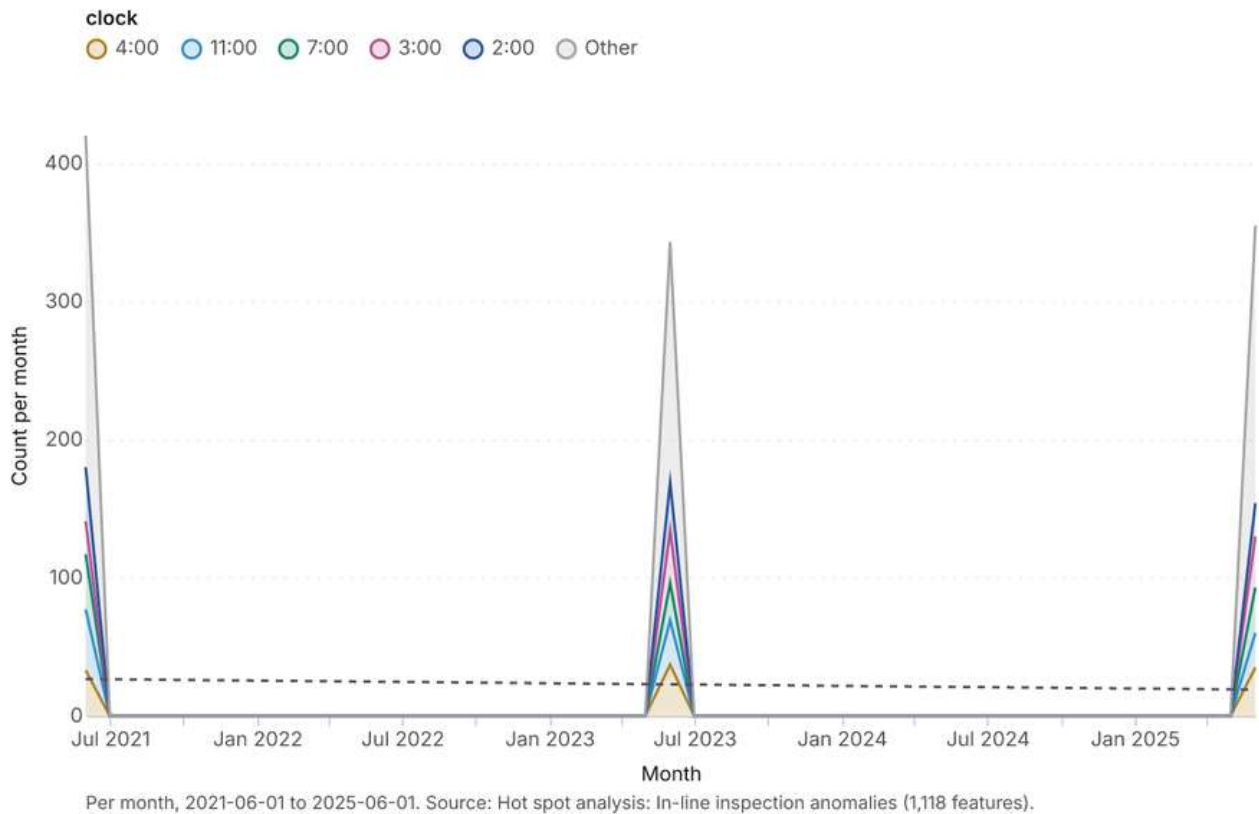


Figure 47. Hot spot analysis: In-line inspection anomalies over time [92]. Per month, 2021-06-01 to 2025-06-01. Source: Hot spot analysis: In-line inspection anomalies (1,118 features). The data is in the appendix.

Count per year by date and cause

Per year: 11 years from 2016-01-01 to 2026-01-01; trend +0.464 per year; first half 26, second half 36 (+38.5%)

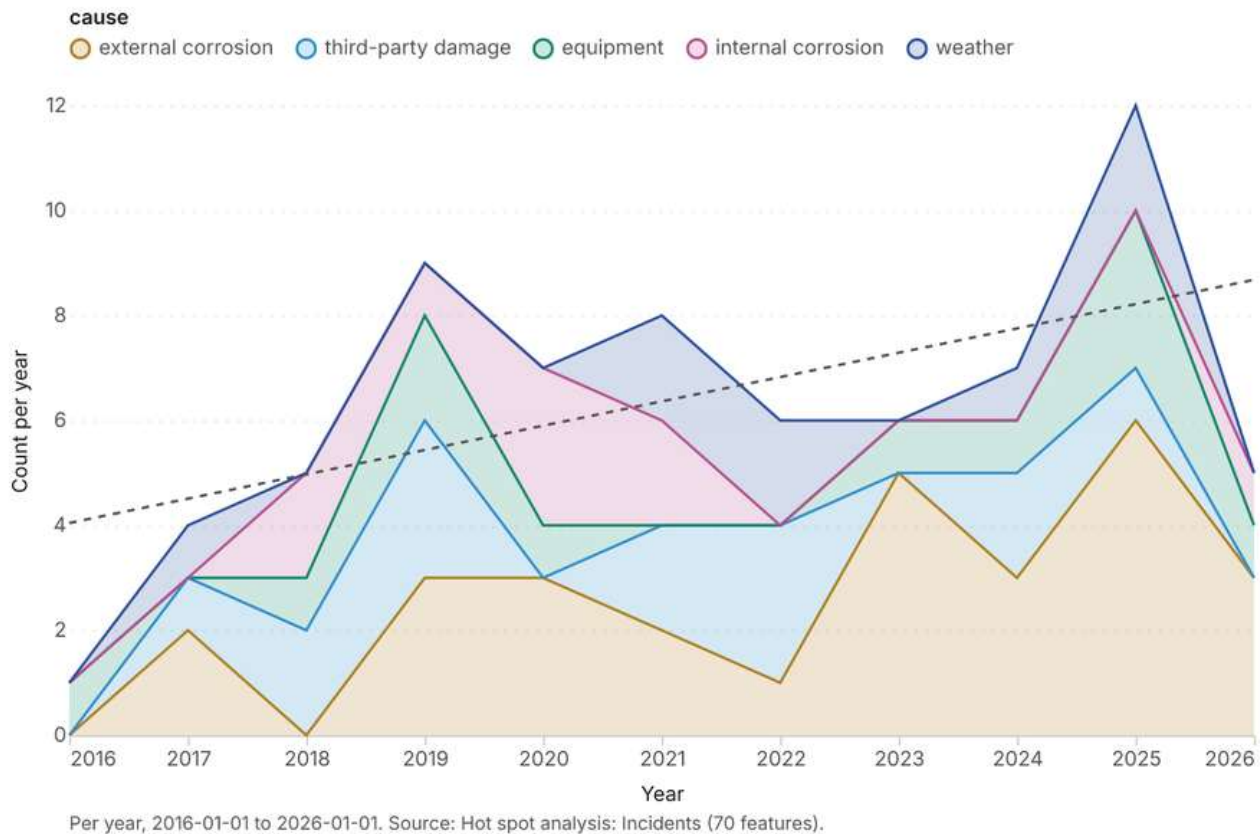


Figure 48. Hot spot analysis: Incidents over time [93]. Per year, 2016-01-01 to 2026-01-01. Source: Hot spot analysis: Incidents (70 features). The data is in the appendix.

Changes since the last run

This is the first report of this project.

Sources

- [1] Rendering: Chart: Timeline: events per year by dataset. 33 rows (id 27fa3a89-f6f1-4b50-8932-e49cafec5ffa)
- [2] Dataset: In-line inspection anomalies. vector, 1118 rows (id ab2540a1-9c20-423b-b653-0cf763c5cc8e)
- [3] Dataset: Incidents. vector, 70 rows (id 663eca22-c04e-4522-8f28-ddc430b2a25c)
- [4] Dataset: Cathodic protection readings. table, 168 rows (id aa287ab3-e04d-46e8-9c49-c47c5badeaec)
- [5] Catalog: Emerging hot spots (operation catalog, gp_space_time_hot_spots). Where hot spots are new, consecutive, intensifying, persistent, diminishing, sporadic, oscillating or historical over time. ArcGIS: Emerging Hot Spot Analysis, Create Space Time Cube. (id gp_space_time_hot_spots)
- [6] Plan: Space time hot spots of Incidents (the Start plan's candidate c_4bb802ff0ca3). Incidents carry dates in 'date': emerging hot spot analysis finds new, intensifying and fading hot spots per year. (id 448d8646-960a-4050-9835-47097cdccdec:c_4bb802ff0ca3)
- [7] Tool result: gp_space_time_hot_spots, step 0. Emerging hot spots: 1 layer saved: Emerging hot spots: Incidents (13 features). (id 23f4a12e-8bc2-4bed-8142-0185e3507423:0)
- [8] Layer: Incidents. 70 features (id f9c94228-f003-4199-ac8c-9f7c7ce6573e)
- [9] Plan: Space time hot spots of In-line inspection anomalies (the Start plan's candidate c_ae37f1059eb0). In-line inspection anomalies carry dates in 'inspected_on': emerging hot spot analysis finds new, intensifying and fading hot spots per month. (id 448d8646-960a-4050-9835-47097cdccdec:c_ae37f1059eb0)
- [10] Tool result: gp_space_time_hot_spots, step 1. Emerging hot spots: 1 layer saved: Emerging hot spots: In-line inspection anomalies (56 features). (id 23f4a12e-8bc2-4bed-8142-0185e3507423:1)
- [11] Layer: In-line inspection anomalies. 1,118 features (id 47cf738b-1c03-4bc9-bfb4-57cf3a587582)

[12] Catalog: Hot spot analysis (operation catalog, gp_hot_spots). Getis-Ord Gi* hot and cold spots with z-scores, p-values and confidence bins. ArcGIS: Find Hot Spots, Hot Spot Analysis (Getis-Ord Gi*). QGIS: qgis:hotspot (plugin). (id gp_hot_spots)

[13] Plan: Hot spots of Incidents (the Start plan's candidate c_08af186146f2). 70 points: Getis-Ord Gi* tests whether the concentrations in Incidents are statistically significant. (id 448d8646-960a-4050-9835-47097cdccdec:c_08af186146f2)

[14] Tool result: gp_hot_spots, step 0. Hot spot analysis: 1 layer saved: Hot spot analysis: Incidents (70 features). (id 20eab220-57ff-40eb-9e8f-f1ba9a425785:0)

[15] Plan: Hot spots of In-line inspection anomalies (the Start plan's candidate c_5c37a51e83ac). 1118 points: Getis-Ord Gi* tests whether the concentrations in In-line inspection anomalies are statistically significant. (id 448d8646-960a-4050-9835-47097cdccdec:c_5c37a51e83ac)

[16] Tool result: gp_hot_spots, step 1. Hot spot analysis: 1 layer saved: Hot spot analysis: In-line inspection anomalies (1118 features). (id 20eab220-57ff-40eb-9e8f-f1ba9a425785:1)

[17] Catalog: Calculate density (operation catalog, gp_calculate_density). Kernel density per square kilometer on a grid. ArcGIS: Calculate Density, Kernel Density. QGIS: native:heatmapkerneldensityestimation. (id gp_calculate_density)

[18] Plan: Kernel density of Valves and stations (the Start plan's candidate c_43c88752b5a9). 25 points in Valves and stations: a density surface shows where they concentrate. (id 448d8646-960a-4050-9835-47097cdccdec:c_43c88752b5a9)

[19] Tool result: gp_calculate_density, step 0. Calculate density: 1 layer saved: Calculate density: Valves and stations (41 features). (id b394d06b-54ec-4401-9565-ef318584fd16:0)

[20] Layer: Valves and stations. 25 features (id db114367-2f18-40d1-b793-29e91297403d)

[21] Plan: Kernel density of Incidents (the Start plan's candidate c_d907267d52f7). 70 points in Incidents: a density surface shows where they concentrate. (id 448d8646-960a-4050-9835-47097cdccdec:c_d907267d52f7)

[22] Tool result: gp_calculate_density, step 1. Calculate density: 1 layer saved: Calculate density: Incidents (144 features). (id b394d06b-54ec-4401-9565-ef318584fd16:1)

[23] Plan: Kernel density of In-line inspection anomalies (the Start plan's candidate c_61f2c99818e2). 1118 points in In-line inspection anomalies: a density surface shows where they concentrate. (id 448d8646-960a-4050-9835-47097cdccdec:c_61f2c99818e2)

[24] Tool result: gp_calculate_density, step 2. Calculate density: 1 layer saved: Calculate density: In-line inspection anomalies (1039 features). (id b394d06b-54ec-4401-9565-ef318584fd16:2)

[25] Catalog: Summarize within (operation catalog, gp_summarize_within). Count and aggregate the features inside each polygon (or bin), proportionally for lines and polygons. ArcGIS: Summarize Within, Aggregate Points. QGIS: native:countpointsinpolygon, native:sumlinelengths. (id gp_summarize_within)

[26] Plan: Valves and stations per feature of Right of way (the Start plan's candidate c_b6eafe06ef22). Count Valves and stations inside each feature of Right of way by type; the counts map as a choropleth (natural breaks, sequential colors). (id 448d8646-960a-4050-9835-47097cdccdec:c_b6eafe06ef22)

[27] Tool result: gp_summarize_within, step 0. Summarize within: 1 layer saved: Summarize within: Right of way (3 features). (id ea2f3752-846d-448f-8548-5b0a1c92e970:0)

[28] Layer: Right of way. 3 features (id 73b1c8fe-ccbe-4a85-be57-8b42d4cb2f98)

[29] Tool result: gp_summarize_within, step 1. Summarize within: 1 layer saved: Summarize within: Right of way (3 features). (id ea2f3752-846d-448f-8548-5b0a1c92e970:1)

[30] Tool result: gp_summarize_within, step 2. Summarize within: 1 layer saved: Summarize within: Right of way (3 features). (id ea2f3752-846d-448f-8548-5b0a1c92e970:2)

[31] Layer: Crossings. 14 features (id d8fae91e-ebf5-4f86-914b-576c03ec8036)

[32] Catalog: Find point clusters (operation catalog, gp_find_point_clusters). Density-based clusters (DBSCAN, HDBSCAN or OPTICS, optionally space-time) with hulls and noise. ArcGIS: Find Point Clusters, Density-based Clustering. QGIS: native:dbscanclustering, native:stdbscanclustering. (id gp_find_point_clusters)

[33] Plan: Cluster points of Valves and stations (the Start plan's candidate c_7d2ecc0e9b43). DBSCAN finds dense groups of Valves and stations and separates noise. (id 448d8646-960a-4050-9835-47097cdccdec:c_7d2ecc0e9b43)

[34] Tool result: gp_find_point_clusters, step 0. Find point clusters: 2 layers saved: Find point clusters: Valves and stations (25 features); Find point clusters: cluster hulls (1 feature). (id 507d8dab-fdbf-4108-a054-5cc8d7218340:0)

[35] Plan: Cluster points of Incidents (the Start plan's candidate c_4583222e078a). DBSCAN finds dense groups of Incidents and separates noise. (id 448d8646-960a-4050-9835-47097cdccdec:c_4583222e078a)

[36] Tool result: gp_find_point_clusters, step 1. Find point clusters: 2 layers saved: Find point clusters: Incidents (70 features); Find point clusters: cluster hulls (1 feature). (id 507d8dab-fdbf-4108-a054-5cc8d7218340:1)

[37] Plan: Cluster points of Crossings (the Start plan's candidate c_8f718b3a3142). DBSCAN finds dense groups of Crossings and separates noise. (id 448d8646-960a-4050-9835-47097cdccdec:c_8f718b3a3142)

[38] Tool result: gp_find_point_clusters, step 2. Find point clusters: 2 layers saved: Find point clusters: Crossings (14 features); Find point clusters: cluster hulls (1 feature). (id 507d8dab-fdbf-4108-a054-5cc8d7218340:2)

[39] Catalog: Find nearest (operation catalog, gp_find_nearest). The k nearest features for each input, with geodesic distance and bearing. ArcGIS: Find Nearest, Near, Generate Near Table. QGIS: native:joinbynearest, native:nearestneighbouranalysis. (id gp_find_nearest)

[40] Plan: Find nearest of Valves and stations and Crossings (the Start plan's candidate c_e87a78f2fa16). The nearest of Crossings to each of Valves and stations, with distances. (id 448d8646-960a-4050-9835-47097cdccdec:c_e87a78f2fa16)

[41] Tool result: gp_find_nearest, step 0. Find nearest: 1 layer saved: Find nearest: Valves and stations (24 features). (id 98d845c3-a74a-4d63-8fbd-35eec3976f40:0)

[42] Tool result: gp_find_nearest, step 1. Find nearest: 1 layer saved: Find nearest: Valves and stations (25 features). (id 98d845c3-a74a-4d63-8fbd-35eec3976f40:1)

[43] Layer: Pipeline segments. 99 features (id 07d2778e-6a97-4ea5-9c49-141bc281a75e)

[44] Catalog: Repeat and near repeat classification (operation catalog, gp_near_repeat). Classify incidents as originators, repeats (same place) or near repeats within a distance and time window, with a Knox test table. ArcGIS: Repeat and Near Repeat Classification, Near Repeat Calculator. (id gp_near_repeat)

[45] Plan: Near repeat of Incidents (the Start plan's candidate c_4d0990e5511d). Near repeat analysis tests whether Incidents close in space also follow each other within 30 days. (id 448d8646-960a-4050-9835-47097cdccdec:c_4d0990e5511d)

[46] Tool result: gp_near_repeat, step 0. Repeat and near repeat classification: 1 layer saved: Repeat and near repeat classification: Incidents (70 features). (id 17f2580a-7f80-4b8b-8777-ba9b5e830194:0)

[47] Rendering: Map: Emerging hot spots: Incidents (id 9d77b25c-7721-4e11-a5b8-69e26ace1947)

[48] Rendering: Map: Emerging hot spots: In-line inspection anomalies (id 90c2582b-d73c-4982-b407-80c5f9808033)

[49] Rendering: Map: Hot spot analysis: Incidents (id 0b24f3d0-b06f-47f1-b372-43fc67cd8551)

[50] Rendering: Map: Hot spot analysis: In-line inspection anomalies (id 646edb97-f9c0-4bb5-8f51-a08c09d511e1)

[51] Rendering: Map: Calculate density: Valves and stations (id fa84664f-57a4-4a31-9378-cdfa74fa2ba5)

[52] Rendering: Map: Calculate density: Incidents (id b5fc9dfb-5cc7-4f8a-949d-ff6deb264068)

[53] Rendering: Map: Calculate density: In-line inspection anomalies (id 91e61349-3f8f-4df0-b85a-43246e0fba55)

[54] Rendering: Map: Summarize within: Right of way (id 43517d52-4c91-4a8a-b917-7c411a38d5ca)

[55] Rendering: Map: Summarize within: Right of way (id df7b3a24-22a5-4690-8eb3-f3af1d42b294)

[56] Rendering: Map: Summarize within: Right of way (id 6a8fcbbf-760e-42ab-86f6-975c6006fbff)

[57] Rendering: Map: Find point clusters: Valves and stations (id 39caaf58-743b-4be4-920b-cf81ce83ab6f)

[58] Rendering: Map: Find point clusters: cluster hulls (id 1c7d602b-58b5-4916-ae6b-1c8f781c42bc)

[59] Rendering: Map: Find point clusters: Incidents (id 23a515ac-6326-42d9-9b84-da366f111f0e)

[60] Rendering: Map: Find point clusters: cluster hulls (id 747a058e-9c8c-4dba-b805-099266717c23)

[61] Rendering: Map: Find point clusters: Crossings (id 880dba8e-22b4-42a1-bc63-5b6f17eba956)

[62] Rendering: Map: Find point clusters: cluster hulls (id 98f83533-fdad-4c1e-acfc-495e89277355)

[63] Rendering: Map: High consequence areas by population (id be0e9735-069a-4144-bcc3-4a5076868b7c)

[64] Rendering: Map: Find nearest: Valves and stations (id bc01fc55-62d8-4244-a6d8-2793a3a96a49)

[65] Rendering: Map: Find nearest: Valves and stations (id 389dedf9-c64f-4e07-bdee-1671f0aac289)

[66] Rendering: Map: Repeat and near repeat classification: Incidents (id 406a8b02-086d-430d-8e92-300ea2f58ebd)

[67] Rendering: Chart: Pipeline segments over time (install_year). 8 rows (id deca339b-546d-42f4-b999-c2fdb81c2551)

[68] Rendering: Chart: Incidents over time (date). 55 rows (id 28e9d8db-0969-4b8d-83d8-bd378ada30cc)

[69] Rendering: Chart: Cathodic protection readings over time (date). 33 rows (id 725b8aba-f6b3-4275-a079-6901dd4884a9)

[70] Rendering: Chart: Segment operating limits over time (last_hydrotest_year). 8 rows (id e6a700bd-e844-4aab-9f11-fb5d6ff8d9ac)

[71] Rendering: Chart: Emerging hot spots: Incidents. 5 rows (id ed2a12a0-1331-4e78-9b34-65bbc3466482)

[72] Rendering: Chart: Emerging hot spots: In-line inspection anomalies. 7 rows (id 568b890a-b0be-491f-b8c3-f5baca0de437)

[73] Rendering: Chart: Hot spot analysis: Incidents. 22 rows (id d61118a9-f614-4df7-96ea-d1853818f5cf)

[74] Rendering: Chart: Hot spot analysis: In-line inspection anomalies. 60 rows (id 8ceccacc9-055e-4d3f-9f80-ad5581542518)

[75] Rendering: Chart: Calculate density: Valves and stations. 7 rows (id bbe9d65a-31d2-4828-a906-2d7744159241)

[76] Rendering: Chart: Calculate density: Incidents. 9 rows (id 648c7e0d-4975-4e6e-a88d-8be424d7ce73)

[77] Rendering: Chart: Calculate density: In-line inspection anomalies. 12 rows (id 45573bae-3b31-4aab-9b04-e8beccc02c66)

[78] Rendering: Chart: Summarize within: Right of way. 5 rows (id 80a42914-05e4-4d36-8d7a-4764e8358c4f)

[79] Rendering: Chart: Summarize within: Right of way. 5 rows (id 3dfd97cb-7ffa-42e4-a600-ff2a1546d530)

[80] Rendering: Chart: Summarize within: Right of way. 5 rows (id a91d845a-309d-4fb0-b09d-704693b7a33b)

[81] Rendering: Chart: Find point clusters: Valves and stations. 1 rows (id d116571e-86a6-4d39-89f0-a9b3ba40672e)

[82] Rendering: Chart: Find point clusters: cluster hulls. 1 rows (id a9ae9300-1702-49d4-bd47-7cc40008cadb)

[83] Rendering: Chart: Find point clusters: Incidents. 2 rows (id 6038f799-99b3-4a72-971a-4641713d3bc3)

[84] Rendering: Chart: Find point clusters: cluster hulls. 1 rows (id 01936942-9161-4210-a318-1e6ed3863d39)

[85] Rendering: Chart: Find point clusters: Crossings. 2 rows (id 708723bf-3747-4536-aa03-97d38d05bdf3)

[86] Rendering: Chart: Find point clusters: cluster hulls. 1 rows (id 0f980414-a050-4d48-9c30-1718d1a53d68)

[87] Rendering: Chart: Find nearest: Valves and stations. 20 rows (id ab68370c-1fcf-4a5a-bbf1-95daec887c63)

[88] Rendering: Chart: Find nearest: Valves and stations. 20 rows (id 03a124ee-3f3c-47e6-8427-457bea343092)

[89] Rendering: Chart: Repeat and near repeat classification: Incidents. 55 rows (id e0888086-d628-40b1-8e42-a28e2ad03314)

[90] Rendering: Chart: Repeat and near repeat classification: Incidents over time. 55 rows (id f7464338-c561-4ab3-8d45-b9664fa68c68)

[91] Rendering: Chart: Find point clusters: Incidents over time. 55 rows (id 3f3f2588-8f02-47f7-8ee8-b3b05074a4c0)

[92] Rendering: Chart: Hot spot analysis: In-line inspection anomalies over time. 294 rows (id 9615d7aa-ad69-493e-bcb4-301f153345a1)

[93] Rendering: Chart: Hot spot analysis: Incidents over time. 55 rows (id 5ed77f86-ae16-45fc-a707-ffe729229767)

[94] Dataset: Pipeline segments. vector, 99 rows (id aa24fa37-25a4-401a-aa0f-50268903f48d)

[95] Dataset: Valves and stations. vector, 25 rows (id 3d5c604b-238e-40fa-bcba-7a9411f150fb)

[96] Dataset: High consequence areas. vector, 6 rows (id c293e365-7a24-403b-9a39-f76e3b3326f1)

[97] Dataset: Crossings. vector, 14 rows (id 782618e2-11ce-41b2-b4fd-45a0e8fece3e)

[98] Dataset: Right of way. vector, 3 rows (id bb3c91ac-eea5-46a8-8560-01a305ee1a0d)

[99] Dataset: Segment operating limits. table, 99 rows (id 09899115-5eca-4e48-a25a-e02a48f1f415)

[100] Dataset: Integrity management summary. document, ? rows (id e4123571-4649-4ac8-85d6-bae9373cef36)

[101] Record: Sample: Oil and gas pipelines, Midland (id 814309a7-f84e-4437-a8ec-209438a3f0a6)

[102] Layer: Emerging hot spots: Incidents. 13 features (id 5ccaefcf-cff1-4e9d-b2e3-765c77156339)

[103] Layer: Emerging hot spots: In-line inspection anomalies. 56 features (id 353953a9-5c13-479e-8f1b-6501da1582af)

[104] Layer: Hot spot analysis: Incidents. 70 features (id ec8a6c4b-e103-4cfc-9121-a54f3cec6e6e)

[105] Layer: Hot spot analysis: In-line inspection anomalies. 1,118 features (id bacc7686-f7e9-4955-a0cf-9db64aa4870e)

[106] Layer: Calculate density: Valves and stations. 41 features (id cc1d20be-5dca-4029-8f6b-33c27e79db1c)

[107] Layer: Calculate density: Incidents. 144 features (id 2e0cc790-5fb1-484a-9922-bc678772fb7d)

[108] Layer: Calculate density: In-line inspection anomalies. 1,039 features (id 6b4b4463-7e80-40f9-93a0-0cb62e92dcb4)

[109] Layer: Summarize within: Right of way. 3 features (id 13538db0-7d38-497b-94d1-40cf60ad245d)

[110] Layer: Summarize within: Right of way. 3 features (id 227062b6-aa48-4440-a0f6-277e670c7170)

[111] Layer: Summarize within: Right of way. 3 features (id 06a7dd75-70ab-43d0-8420-66697a994dcc)

[112] Layer: Find point clusters: Valves and stations. 25 features (id 3110df92-7371-4f5e-8e6c-b97b894bb024)

[113] Layer: Find point clusters: cluster hulls. 1 features (id 060ccd5c-fd41-45f5-a05f-e6acaf40d13a)

[114] Layer: Find point clusters: Incidents. 70 features (id 6114c590-c23e-4ea0-a8b5-64c271fd3ab1)

[115] Layer: Find point clusters: cluster hulls. 1 features (id 3b9663d6-98db-48e7-91e9-6c73f7269773)

[116] Layer: Find point clusters: Crossings. 14 features (id d6bec857-d779-4b62-a669-ed072d7ff82e)

[117] Layer: Find point clusters: cluster hulls. 1 features (id 97d9231b-03fd-4842-802d-d3268005cde9)

[118] Layer: Find nearest: Valves and stations. 24 features (id 93cedf1e-ed61-4ee9-81a7-acea61799ce3)

[119] Layer: Find nearest: Valves and stations. 25 features (id 07d06af9-ca9c-459d-905a-591ff5b8a7b4)

[120] Layer: Repeat and near repeat classification: Incidents. 70 features (id 190a3e17-cf0e-4dd6-b885-45720a8e06f1)

Appendix: the data behind the charts

Figure 1. Timeline: events per year by dataset [1]

period	series	value
2016-01-01	In-line inspection anomalies	0
2016-01-01	Cathodic protection readings	0
2016-01-01	Incidents	1
2017-01-01	In-line inspection anomalies	0
2017-01-01	Cathodic protection readings	0
2017-01-01	Incidents	4
2018-01-01	In-line inspection anomalies	0
2018-01-01	Cathodic protection readings	0
2018-01-01	Incidents	5
2019-01-01	In-line inspection anomalies	0
2019-01-01	Cathodic protection readings	0
2019-01-01	Incidents	9
2020-01-01	In-line inspection anomalies	0
2020-01-01	Cathodic protection readings	0
2020-01-01	Incidents	7
2021-01-01	In-line inspection anomalies	420
2021-01-01	Cathodic protection readings	0
2021-01-01	Incidents	8
2022-01-01	In-line inspection anomalies	0
2022-01-01	Cathodic protection readings	0
2022-01-01	Incidents	6
2023-01-01	In-line inspection anomalies	343
2023-01-01	Cathodic protection readings	28
2023-01-01	Incidents	6
2024-01-01	In-line inspection anomalies	0
2024-01-01	Cathodic protection readings	56
2024-01-01	Incidents	7
2025-01-01	In-line inspection anomalies	355
2025-01-01	Cathodic protection readings	56
2025-01-01	Incidents	12
2026-01-01	In-line inspection anomalies	0
2026-01-01	Cathodic protection readings	28
2026-01-01	Incidents	5

Figure 22. Pipeline segments over time (install_year) [67]

bin_start	bin_end	count
0	3,500	15
3,500	7,000	12
7,000	1.05e+04	15
1.05e+04	1.4e+04	12
1.4e+04	1.75e+04	12
1.75e+04	2.1e+04	15
2.1e+04	2.45e+04	8
2.45e+04	2.8e+04	10

Figure 23. Incidents over time (date) [68]

period	series	value
2016-01-01	external corrosion	0
2016-01-01	third-party damage	0
2016-01-01	equipment	1,913
2016-01-01	internal corrosion	0
2016-01-01	weather	0
2017-01-01	external corrosion	2.942e+04
2017-01-01	third-party damage	1.078e+04
2017-01-01	equipment	0
2017-01-01	internal corrosion	0
2017-01-01	weather	9,750
2018-01-01	external corrosion	0
2018-01-01	third-party damage	1.504e+04
2018-01-01	equipment	3,140
2018-01-01	internal corrosion	3.239e+04
2018-01-01	weather	0
2019-01-01	external corrosion	1.968e+04
2019-01-01	third-party damage	3.909e+04
2019-01-01	equipment	3.703e+04
2019-01-01	internal corrosion	6,487
2019-01-01	weather	0
2020-01-01	external corrosion	3.097e+04
2020-01-01	third-party damage	0
2020-01-01	equipment	2.688e+04
2020-01-01	internal corrosion	3.096e+04
2020-01-01	weather	0
2021-01-01	external corrosion	4.487e+04
2021-01-01	third-party damage	2.968e+04
2021-01-01	equipment	0
2021-01-01	internal corrosion	3.876e+04
2021-01-01	weather	2.415e+04
2022-01-01	external corrosion	1.941e+04
2022-01-01	third-party damage	3.309e+04
2022-01-01	equipment	0
2022-01-01	internal corrosion	0
2022-01-01	weather	2.702e+04
2023-01-01	external corrosion	5.385e+04
2023-01-01	third-party damage	0
2023-01-01	equipment	7,096
2023-01-01	internal corrosion	0
2023-01-01	weather	0
2024-01-01	external corrosion	4.377e+04
2024-01-01	third-party damage	2.353e+04
2024-01-01	equipment	7,225

period	series	value
2024-01-01	internal corrosion	0
2024-01-01	weather	2.458e+04
2025-01-01	external corrosion	9.675e+04
2025-01-01	third-party damage	1.043e+04
2025-01-01	equipment	4.588e+04
2025-01-01	internal corrosion	0
2025-01-01	weather	9,842
2026-01-01	external corrosion	3.798e+04
2026-01-01	third-party damage	0
2026-01-01	equipment	6,176
2026-01-01	internal corrosion	2.427e+04
2026-01-01	weather	0

Figure 24. Cathodic protection readings over time (date) [69]

period	value
2023-10-01	14
2023-11-01	0
2023-12-01	14
2024-01-01	0
2024-02-01	0
2024-03-01	14
2024-04-01	0
2024-05-01	0
2024-06-01	14
2024-07-01	0
2024-08-01	0
2024-09-01	14
2024-10-01	0
2024-11-01	0
2024-12-01	14
2025-01-01	0
2025-02-01	0
2025-03-01	14
2025-04-01	0
2025-05-01	0
2025-06-01	14
2025-07-01	0
2025-08-01	0
2025-09-01	14
2025-10-01	0
2025-11-01	0
2025-12-01	14
2026-01-01	0
2026-02-01	0

period	value
2026-03-01	14
2026-04-01	0
2026-05-01	0
2026-06-01	14

Figure 25. Segment operating limits over time (last_hydrotest_year) [70]

bin_start	bin_end	count
1,100	1,142	36
1,142	1,185	0
1,185	1,228	0
1,228	1,270	36
1,270	1,312	0
1,312	1,355	0
1,355	1,398	0
1,398	1,440	27

Figure 26. Emerging hot spots: Incidents [71]

bin_start	bin_end	count
-0.811	-0.3204	3
-0.3204	0.1702	3
0.1702	0.6608	0
0.6608	1.151	0
1.151	1.642	7

Figure 27. Emerging hot spots: In-line inspection anomalies [72]

bin_start	bin_end	count
-0.151	2.691	13
2.691	5.532	16
5.532	8.374	11
8.374	11.22	3
11.22	14.06	5
14.06	16.9	6
16.9	19.74	2

Figure 28. Hot spot analysis: Incidents [73]

bin_start	bin_end	band	band_label	count
-5.5	-5	cold_99	Cold spot, 99% confidence	5
-5	-4.5	cold_99	Cold spot, 99% confidence	9
-4.5	-4	cold_99	Cold spot, 99% confidence	1
-4	-3.5	cold_99	Cold spot, 99% confidence	2
-3.5	-3	cold_99	Cold spot, 99% confidence	2
-3	-2.5	cold_99	Cold spot, 99% confidence	2

bin_start	bin_end	band	band_label	count
-2.5	-2	cold_95	Cold spot, 95% confidence	4
-2	-1.5	cold_90	Cold spot, 90% confidence	1
-1.5	-1	not_significant	Not significant	2
-1	-0.5	not_significant	Not significant	1
-0.5	0	not_significant	Not significant	4
0	0.5	not_significant	Not significant	3
0.5	1	not_significant	Not significant	7
1.5	2	hot_90	Hot spot, 90% confidence	3
1.5	2	not_significant	Not significant	1
2.5	3	hot_99	Hot spot, 99% confidence	2
3	3.5	hot_99	Hot spot, 99% confidence	1
3.5	4	hot_99	Hot spot, 99% confidence	1
4	4.5	hot_99	Hot spot, 99% confidence	1
5.5	6	hot_99	Hot spot, 99% confidence	4
6	6.5	hot_99	Hot spot, 99% confidence	10
6.5	7	hot_99	Hot spot, 99% confidence	4

Figure 29. Hot spot analysis: In-line inspection anomalies [74]

bin_start	bin_end	band	band_label	count
-14	-13.5	cold_99	Cold spot, 99% confidence	58
-13.5	-13	cold_99	Cold spot, 99% confidence	52
-13	-12.5	cold_99	Cold spot, 99% confidence	22
-12.5	-12	cold_99	Cold spot, 99% confidence	31
-12	-11.5	cold_99	Cold spot, 99% confidence	35
-11.5	-11	cold_99	Cold spot, 99% confidence	41
-11	-10.5	cold_99	Cold spot, 99% confidence	1
-10.5	-10	cold_99	Cold spot, 99% confidence	8
-10	-9.5	cold_99	Cold spot, 99% confidence	9
-9.5	-9	cold_99	Cold spot, 99% confidence	18
-9	-8.5	cold_99	Cold spot, 99% confidence	23

bin_start	bin_end	band	band_label	count
-8.5	-8	cold_99	Cold spot, 99% confidence	27
-8	-7.5	cold_99	Cold spot, 99% confidence	27
-7.5	-7	cold_99	Cold spot, 99% confidence	24
-7	-6.5	cold_99	Cold spot, 99% confidence	34
-6.5	-6	cold_99	Cold spot, 99% confidence	24
-6	-5.5	cold_99	Cold spot, 99% confidence	17
-5.5	-5	cold_99	Cold spot, 99% confidence	6
-5	-4.5	cold_99	Cold spot, 99% confidence	3
-4.5	-4	cold_99	Cold spot, 99% confidence	6
-4	-3.5	cold_99	Cold spot, 99% confidence	23
-3.5	-3	cold_99	Cold spot, 99% confidence	9
-3	-2.5	cold_95	Cold spot, 95% confidence	2
-3	-2.5	cold_99	Cold spot, 99% confidence	25
-2.5	-2	cold_95	Cold spot, 95% confidence	6
-2	-1.5	cold_90	Cold spot, 90% confidence	9
-2	-1.5	not_significant	Not significant	6
-1.5	-1	not_significant	Not significant	6
-1	-0.5	not_significant	Not significant	25
-0.5	0	not_significant	Not significant	5
0	0.5	not_significant	Not significant	22
0.5	1	not_significant	Not significant	32
1	1.5	not_significant	Not significant	13
1.5	2	hot_90	Hot spot, 90% confidence	5
1.5	2	not_significant	Not significant	12
2	2.5	hot_95	Hot spot, 95% confidence	24
2.5	3	hot_95	Hot spot, 95% confidence	5
2.5	3	hot_99	Hot spot, 99% confidence	50
3	3.5	hot_99	Hot spot, 99% confidence	20
3.5	4	hot_99	Hot spot, 99% confidence	2

bin_start	bin_end	band	band_label	count
4	4.5	hot_99	Hot spot, 99% confidence	6
4.5	5	hot_99	Hot spot, 99% confidence	17
5	5.5	hot_99	Hot spot, 99% confidence	8
5.5	6	hot_99	Hot spot, 99% confidence	21
6	6.5	hot_99	Hot spot, 99% confidence	33
6.5	7	hot_99	Hot spot, 99% confidence	2
7.5	8	hot_99	Hot spot, 99% confidence	8
8.5	9	hot_99	Hot spot, 99% confidence	21
9	9.5	hot_99	Hot spot, 99% confidence	12
9.5	10	hot_99	Hot spot, 99% confidence	2
10	10.5	hot_99	Hot spot, 99% confidence	10
10.5	11	hot_99	Hot spot, 99% confidence	29
11	11.5	hot_99	Hot spot, 99% confidence	31
11.5	12	hot_99	Hot spot, 99% confidence	27
12	12.5	hot_99	Hot spot, 99% confidence	41
12.5	13	hot_99	Hot spot, 99% confidence	40
13	13.5	hot_99	Hot spot, 99% confidence	2
13.5	14	hot_99	Hot spot, 99% confidence	17
14	14.5	hot_99	Hot spot, 99% confidence	9
15	15.5	hot_99	Hot spot, 99% confidence	15

Figure 30. Calculate density: Valves and stations [75]

bin_start	bin_end	count
0.005559	210.5	25
210.5	421.1	6
421.1	631.6	3
631.6	842.1	2
842.1	1,053	0
1,053	1,263	4
1,263	1,474	1

Figure 31. Calculate density: Incidents [76]

bin_start	bin_end	count
0	1.778	10
1.778	3.556	20
3.556	5.333	18
5.333	7.111	25
7.111	8.889	13
8.889	10.67	21
10.67	12.44	12
12.44	14.22	15
14.22	16	10

Figure 32. Calculate density: In-line inspection anomalies [77]

bin_start	bin_end	count
0	4.75	47
4.75	9.5	84
9.5	14.25	83
14.25	19	68
19	23.75	111
23.75	28.5	186
28.5	33.25	138
33.25	38	48
38	42.75	50
42.75	47.5	67
47.5	52.25	91
52.25	57	66

Figure 33. Summarize within: Right of way [78]

bin_start	bin_end	count
7	7.4	1
7.4	7.8	0
7.8	8.2	0
8.2	8.6	0
8.6	9	2

Figure 34. Summarize within: Right of way [79]

bin_start	bin_end	count
9	15	1
15	21	0
21	27	1
27	33	0
33	39	1

Figure 35. Summarize within: Right of way [80]

bin_start	bin_end	count
4	4.2	1
4.2	4.4	0

bin_start	bin_end	count
4.4	4.6	0
4.6	4.8	0
4.8	5	2

Figure 36. Find point clusters: Valves and stations [81]

cluster	features	fraction	share
0	25	1	100.0%

Figure 37. Find point clusters: cluster hulls [82]

cluster	features	fraction	share
0	1	1	100.0%

Figure 38. Find point clusters: Incidents [83]

cluster	features	fraction	share
0	68	0.9714	97.1%
Noise	2	0.02857	2.9%

Figure 39. Find point clusters: cluster hulls [84]

cluster	features	fraction	share
0	1	1	100.0%

Figure 40. Find point clusters: Crossings [85]

cluster	features	fraction	share
0	10	0.7143	71.4%
Noise	4	0.2857	28.6%

Figure 41. Find point clusters: cluster hulls [86]

cluster	features	fraction	share
0	1	1	100.0%

Figure 42. Find nearest: Valves and stations [87]

rank	name
1	draw
1	draw
1	road
1	road
1	road
1	road
1	road
1	road
1	road
1	road
1	road
1	road
1	draw
1	road
1	road

rank	name
1	road
1	road
1	draw
1	road
1	road

Figure 43. Find nearest: Valves and stations [88]

rank	name
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1

Figure 44. Repeat and near repeat classification: Incidents [89]

period	series	value
2016-01-01	external corrosion	0
2016-01-01	third-party damage	0
2016-01-01	equipment	1
2016-01-01	internal corrosion	0
2016-01-01	weather	0
2017-01-01	external corrosion	2
2017-01-01	third-party damage	1
2017-01-01	equipment	0
2017-01-01	internal corrosion	0
2017-01-01	weather	1
2018-01-01	external corrosion	0
2018-01-01	third-party damage	2
2018-01-01	equipment	1

period	series	value
2018-01-01	internal corrosion	2
2018-01-01	weather	0
2019-01-01	external corrosion	3
2019-01-01	third-party damage	3
2019-01-01	equipment	2
2019-01-01	internal corrosion	1
2019-01-01	weather	0
2020-01-01	external corrosion	3
2020-01-01	third-party damage	0
2020-01-01	equipment	1
2020-01-01	internal corrosion	3
2020-01-01	weather	0
2021-01-01	external corrosion	2
2021-01-01	third-party damage	2
2021-01-01	equipment	0
2021-01-01	internal corrosion	2
2021-01-01	weather	2
2022-01-01	external corrosion	1
2022-01-01	third-party damage	3
2022-01-01	equipment	0
2022-01-01	internal corrosion	0
2022-01-01	weather	2
2023-01-01	external corrosion	5
2023-01-01	third-party damage	0
2023-01-01	equipment	1
2023-01-01	internal corrosion	0
2023-01-01	weather	0
2024-01-01	external corrosion	3
2024-01-01	third-party damage	2
2024-01-01	equipment	1
2024-01-01	internal corrosion	0
2024-01-01	weather	1
2025-01-01	external corrosion	6
2025-01-01	third-party damage	1
2025-01-01	equipment	3
2025-01-01	internal corrosion	0
2025-01-01	weather	2
2026-01-01	external corrosion	3
2026-01-01	third-party damage	0
2026-01-01	equipment	1
2026-01-01	internal corrosion	1
2026-01-01	weather	0

Figure 45. Repeat and near repeat classification: Incidents over time [90]

period	series	value
2016-01-01	external corrosion	0
2016-01-01	third-party damage	0
2016-01-01	equipment	1
2016-01-01	internal corrosion	0
2016-01-01	weather	0
2017-01-01	external corrosion	2
2017-01-01	third-party damage	1
2017-01-01	equipment	0
2017-01-01	internal corrosion	0
2017-01-01	weather	1
2018-01-01	external corrosion	0
2018-01-01	third-party damage	2
2018-01-01	equipment	1
2018-01-01	internal corrosion	2
2018-01-01	weather	0
2019-01-01	external corrosion	3
2019-01-01	third-party damage	3
2019-01-01	equipment	2
2019-01-01	internal corrosion	1
2019-01-01	weather	0
2020-01-01	external corrosion	3
2020-01-01	third-party damage	0
2020-01-01	equipment	1
2020-01-01	internal corrosion	3
2020-01-01	weather	0
2021-01-01	external corrosion	2
2021-01-01	third-party damage	2
2021-01-01	equipment	0
2021-01-01	internal corrosion	2
2021-01-01	weather	2
2022-01-01	external corrosion	1
2022-01-01	third-party damage	3
2022-01-01	equipment	0
2022-01-01	internal corrosion	0
2022-01-01	weather	2
2023-01-01	external corrosion	5
2023-01-01	third-party damage	0
2023-01-01	equipment	1
2023-01-01	internal corrosion	0
2023-01-01	weather	0
2024-01-01	external corrosion	3
2024-01-01	third-party damage	2
2024-01-01	equipment	1

period	series	value
2024-01-01	internal corrosion	0
2024-01-01	weather	1
2025-01-01	external corrosion	6
2025-01-01	third-party damage	1
2025-01-01	equipment	3
2025-01-01	internal corrosion	0
2025-01-01	weather	2
2026-01-01	external corrosion	3
2026-01-01	third-party damage	0
2026-01-01	equipment	1
2026-01-01	internal corrosion	1
2026-01-01	weather	0

Figure 46. Find point clusters: Incidents over time [91]

period	series	value
2016-01-01	external corrosion	0
2016-01-01	third-party damage	0
2016-01-01	equipment	1
2016-01-01	internal corrosion	0
2016-01-01	weather	0
2017-01-01	external corrosion	2
2017-01-01	third-party damage	1
2017-01-01	equipment	0
2017-01-01	internal corrosion	0
2017-01-01	weather	1
2018-01-01	external corrosion	0
2018-01-01	third-party damage	2
2018-01-01	equipment	1
2018-01-01	internal corrosion	2
2018-01-01	weather	0
2019-01-01	external corrosion	3
2019-01-01	third-party damage	3
2019-01-01	equipment	2
2019-01-01	internal corrosion	1
2019-01-01	weather	0
2020-01-01	external corrosion	3
2020-01-01	third-party damage	0
2020-01-01	equipment	1
2020-01-01	internal corrosion	3
2020-01-01	weather	0
2021-01-01	external corrosion	2
2021-01-01	third-party damage	2
2021-01-01	equipment	0
2021-01-01	internal corrosion	2

period	series	value
2021-01-01	weather	2
2022-01-01	external corrosion	1
2022-01-01	third-party damage	3
2022-01-01	equipment	0
2022-01-01	internal corrosion	0
2022-01-01	weather	2
2023-01-01	external corrosion	5
2023-01-01	third-party damage	0
2023-01-01	equipment	1
2023-01-01	internal corrosion	0
2023-01-01	weather	0
2024-01-01	external corrosion	3
2024-01-01	third-party damage	2
2024-01-01	equipment	1
2024-01-01	internal corrosion	0
2024-01-01	weather	1
2025-01-01	external corrosion	6
2025-01-01	third-party damage	1
2025-01-01	equipment	3
2025-01-01	internal corrosion	0
2025-01-01	weather	2
2026-01-01	external corrosion	3
2026-01-01	third-party damage	0
2026-01-01	equipment	1
2026-01-01	internal corrosion	1
2026-01-01	weather	0

Figure 47. Hot spot analysis: In-line inspection anomalies over time [92]

period	series	value
2021-06-01	4:00	33
2021-06-01	11:00	44
2021-06-01	7:00	40
2021-06-01	3:00	24
2021-06-01	2:00	39
2021-06-01	Other	240
2021-07-01	4:00	0
2021-07-01	11:00	0
2021-07-01	7:00	0
2021-07-01	3:00	0
2021-07-01	2:00	0
2021-07-01	Other	0
2021-08-01	4:00	0
2021-08-01	11:00	0
2021-08-01	7:00	0

period	series	value
2021-08-01	3:00	0
2021-08-01	2:00	0
2021-08-01	Other	0
2021-09-01	4:00	0
2021-09-01	11:00	0
2021-09-01	7:00	0
2021-09-01	3:00	0
2021-09-01	2:00	0
2021-09-01	Other	0
2021-10-01	4:00	0
2021-10-01	11:00	0
2021-10-01	7:00	0
2021-10-01	3:00	0
2021-10-01	2:00	0
2021-10-01	Other	0
2021-11-01	4:00	0
2021-11-01	11:00	0
2021-11-01	7:00	0
2021-11-01	3:00	0
2021-11-01	2:00	0
2021-11-01	Other	0
2021-12-01	4:00	0
2021-12-01	11:00	0
2021-12-01	7:00	0
2021-12-01	3:00	0
2021-12-01	2:00	0
2021-12-01	Other	0
2022-01-01	4:00	0
2022-01-01	11:00	0
2022-01-01	7:00	0
2022-01-01	3:00	0
2022-01-01	2:00	0
2022-01-01	Other	0
2022-02-01	4:00	0
2022-02-01	11:00	0
2022-02-01	7:00	0
2022-02-01	3:00	0
2022-02-01	2:00	0
2022-02-01	Other	0
2022-03-01	4:00	0
2022-03-01	11:00	0
2022-03-01	7:00	0
2022-03-01	3:00	0

period	series	value
2022-03-01	2:00	0
2022-03-01	Other	0
2022-04-01	4:00	0
2022-04-01	11:00	0
2022-04-01	7:00	0
2022-04-01	3:00	0
2022-04-01	2:00	0
2022-04-01	Other	0
2022-05-01	4:00	0
2022-05-01	11:00	0
2022-05-01	7:00	0
2022-05-01	3:00	0
2022-05-01	2:00	0
2022-05-01	Other	0
2022-06-01	4:00	0
2022-06-01	11:00	0
2022-06-01	7:00	0
2022-06-01	3:00	0
2022-06-01	2:00	0
2022-06-01	Other	0
2022-07-01	4:00	0
2022-07-01	11:00	0
2022-07-01	7:00	0
2022-07-01	3:00	0
2022-07-01	2:00	0
2022-07-01	Other	0
2022-08-01	4:00	0
2022-08-01	11:00	0
2022-08-01	7:00	0
2022-08-01	3:00	0
2022-08-01	2:00	0
2022-08-01	Other	0
2022-09-01	4:00	0
2022-09-01	11:00	0
2022-09-01	7:00	0
2022-09-01	3:00	0
2022-09-01	2:00	0
2022-09-01	Other	0
2022-10-01	4:00	0
2022-10-01	11:00	0
2022-10-01	7:00	0
2022-10-01	3:00	0
2022-10-01	2:00	0

period	series	value
2022-10-01	Other	0
2022-11-01	4:00	0
2022-11-01	11:00	0
2022-11-01	7:00	0
2022-11-01	3:00	0
2022-11-01	2:00	0
2022-11-01	Other	0
2022-12-01	4:00	0
2022-12-01	11:00	0
2022-12-01	7:00	0
2022-12-01	3:00	0
2022-12-01	2:00	0
2022-12-01	Other	0
2023-01-01	4:00	0
2023-01-01	11:00	0
2023-01-01	7:00	0
2023-01-01	3:00	0
2023-01-01	2:00	0
2023-01-01	Other	0
2023-02-01	4:00	0
2023-02-01	11:00	0
2023-02-01	7:00	0
2023-02-01	3:00	0
2023-02-01	2:00	0
2023-02-01	Other	0
2023-03-01	4:00	0
2023-03-01	11:00	0
2023-03-01	7:00	0
2023-03-01	3:00	0
2023-03-01	2:00	0
2023-03-01	Other	0
2023-04-01	4:00	0
2023-04-01	11:00	0
2023-04-01	7:00	0
2023-04-01	3:00	0
2023-04-01	2:00	0
2023-04-01	Other	0
2023-05-01	4:00	0
2023-05-01	11:00	0
2023-05-01	7:00	0
2023-05-01	3:00	0
2023-05-01	2:00	0
2023-05-01	Other	0

period	series	value
2023-06-01	4:00	37
2023-06-01	11:00	32
2023-06-01	7:00	27
2023-06-01	3:00	38
2023-06-01	2:00	35
2023-06-01	Other	174
2023-07-01	4:00	0
2023-07-01	11:00	0
2023-07-01	7:00	0
2023-07-01	3:00	0
2023-07-01	2:00	0
2023-07-01	Other	0
2023-08-01	4:00	0
2023-08-01	11:00	0
2023-08-01	7:00	0
2023-08-01	3:00	0
2023-08-01	2:00	0
2023-08-01	Other	0
2023-09-01	4:00	0
2023-09-01	11:00	0
2023-09-01	7:00	0
2023-09-01	3:00	0
2023-09-01	2:00	0
2023-09-01	Other	0
2023-10-01	4:00	0
2023-10-01	11:00	0
2023-10-01	7:00	0
2023-10-01	3:00	0
2023-10-01	2:00	0
2023-10-01	Other	0
2023-11-01	4:00	0
2023-11-01	11:00	0
2023-11-01	7:00	0
2023-11-01	3:00	0
2023-11-01	2:00	0
2023-11-01	Other	0
2023-12-01	4:00	0
2023-12-01	11:00	0
2023-12-01	7:00	0
2023-12-01	3:00	0
2023-12-01	2:00	0
2023-12-01	Other	0
2024-01-01	4:00	0

period	series	value
2024-01-01	11:00	0
2024-01-01	7:00	0
2024-01-01	3:00	0
2024-01-01	2:00	0
2024-01-01	Other	0
2024-02-01	4:00	0
2024-02-01	11:00	0
2024-02-01	7:00	0
2024-02-01	3:00	0
2024-02-01	2:00	0
2024-02-01	Other	0
2024-03-01	4:00	0
2024-03-01	11:00	0
2024-03-01	7:00	0
2024-03-01	3:00	0
2024-03-01	2:00	0
2024-03-01	Other	0
2024-04-01	4:00	0
2024-04-01	11:00	0
2024-04-01	7:00	0
2024-04-01	3:00	0
2024-04-01	2:00	0
2024-04-01	Other	0
2024-05-01	4:00	0
2024-05-01	11:00	0
2024-05-01	7:00	0
2024-05-01	3:00	0
2024-05-01	2:00	0
2024-05-01	Other	0
2024-06-01	4:00	0
2024-06-01	11:00	0
2024-06-01	7:00	0
2024-06-01	3:00	0
2024-06-01	2:00	0
2024-06-01	Other	0
2024-07-01	4:00	0
2024-07-01	11:00	0
2024-07-01	7:00	0
2024-07-01	3:00	0
2024-07-01	2:00	0
2024-07-01	Other	0
2024-08-01	4:00	0
2024-08-01	11:00	0

period	series	value
2024-08-01	7:00	0
2024-08-01	3:00	0
2024-08-01	2:00	0
2024-08-01	Other	0
2024-09-01	4:00	0
2024-09-01	11:00	0
2024-09-01	7:00	0
2024-09-01	3:00	0
2024-09-01	2:00	0
2024-09-01	Other	0
2024-10-01	4:00	0
2024-10-01	11:00	0
2024-10-01	7:00	0
2024-10-01	3:00	0
2024-10-01	2:00	0
2024-10-01	Other	0
2024-11-01	4:00	0
2024-11-01	11:00	0
2024-11-01	7:00	0
2024-11-01	3:00	0
2024-11-01	2:00	0
2024-11-01	Other	0
2024-12-01	4:00	0
2024-12-01	11:00	0
2024-12-01	7:00	0
2024-12-01	3:00	0
2024-12-01	2:00	0
2024-12-01	Other	0
2025-01-01	4:00	0
2025-01-01	11:00	0
2025-01-01	7:00	0
2025-01-01	3:00	0
2025-01-01	2:00	0
2025-01-01	Other	0
2025-02-01	4:00	0
2025-02-01	11:00	0
2025-02-01	7:00	0
2025-02-01	3:00	0
2025-02-01	2:00	0
2025-02-01	Other	0
2025-03-01	4:00	0
2025-03-01	11:00	0
2025-03-01	7:00	0

period	series	value
2025-03-01	3:00	0
2025-03-01	2:00	0
2025-03-01	Other	0
2025-04-01	4:00	0
2025-04-01	11:00	0
2025-04-01	7:00	0
2025-04-01	3:00	0
2025-04-01	2:00	0
2025-04-01	Other	0
2025-05-01	4:00	0
2025-05-01	11:00	0
2025-05-01	7:00	0
2025-05-01	3:00	0
2025-05-01	2:00	0
2025-05-01	Other	0
2025-06-01	4:00	35
2025-06-01	11:00	25
2025-06-01	7:00	33
2025-06-01	3:00	37
2025-06-01	2:00	24
2025-06-01	Other	201

Figure 48. Hot spot analysis: Incidents over time [93]

period	series	value
2016-01-01	external corrosion	0
2016-01-01	third-party damage	0
2016-01-01	equipment	1
2016-01-01	internal corrosion	0
2016-01-01	weather	0
2017-01-01	external corrosion	2
2017-01-01	third-party damage	1
2017-01-01	equipment	0
2017-01-01	internal corrosion	0
2017-01-01	weather	1
2018-01-01	external corrosion	0
2018-01-01	third-party damage	2
2018-01-01	equipment	1
2018-01-01	internal corrosion	2
2018-01-01	weather	0
2019-01-01	external corrosion	3
2019-01-01	third-party damage	3
2019-01-01	equipment	2
2019-01-01	internal corrosion	1
2019-01-01	weather	0

period	series	value
2020-01-01	external corrosion	3
2020-01-01	third-party damage	0
2020-01-01	equipment	1
2020-01-01	internal corrosion	3
2020-01-01	weather	0
2021-01-01	external corrosion	2
2021-01-01	third-party damage	2
2021-01-01	equipment	0
2021-01-01	internal corrosion	2
2021-01-01	weather	2
2022-01-01	external corrosion	1
2022-01-01	third-party damage	3
2022-01-01	equipment	0
2022-01-01	internal corrosion	0
2022-01-01	weather	2
2023-01-01	external corrosion	5
2023-01-01	third-party damage	0
2023-01-01	equipment	1
2023-01-01	internal corrosion	0
2023-01-01	weather	0
2024-01-01	external corrosion	3
2024-01-01	third-party damage	2
2024-01-01	equipment	1
2024-01-01	internal corrosion	0
2024-01-01	weather	1
2025-01-01	external corrosion	6
2025-01-01	third-party damage	1
2025-01-01	equipment	3
2025-01-01	internal corrosion	0
2025-01-01	weather	2
2026-01-01	external corrosion	3
2026-01-01	third-party damage	0
2026-01-01	equipment	1
2026-01-01	internal corrosion	1
2026-01-01	weather	0