Spatial SQL I

CASA0025: Building Spatial Applications
with Big Data

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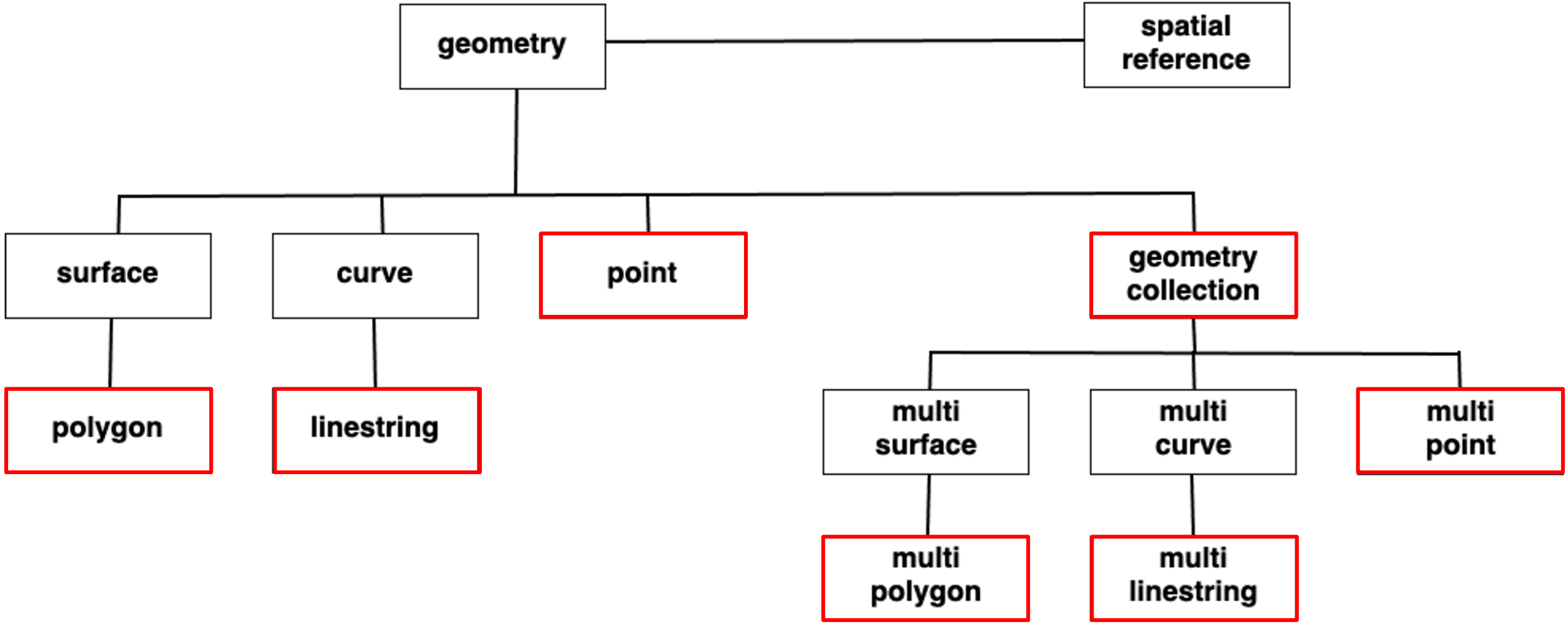
Outline

1. SQL Recap
2. Geometries
3. Spatial Relationships

Geometries

Spatial Types



Creating a table with geometry

```
CREATE TABLE geometries
(
  name varchar,
  geom geometry
);
```

Creating a table with geometry

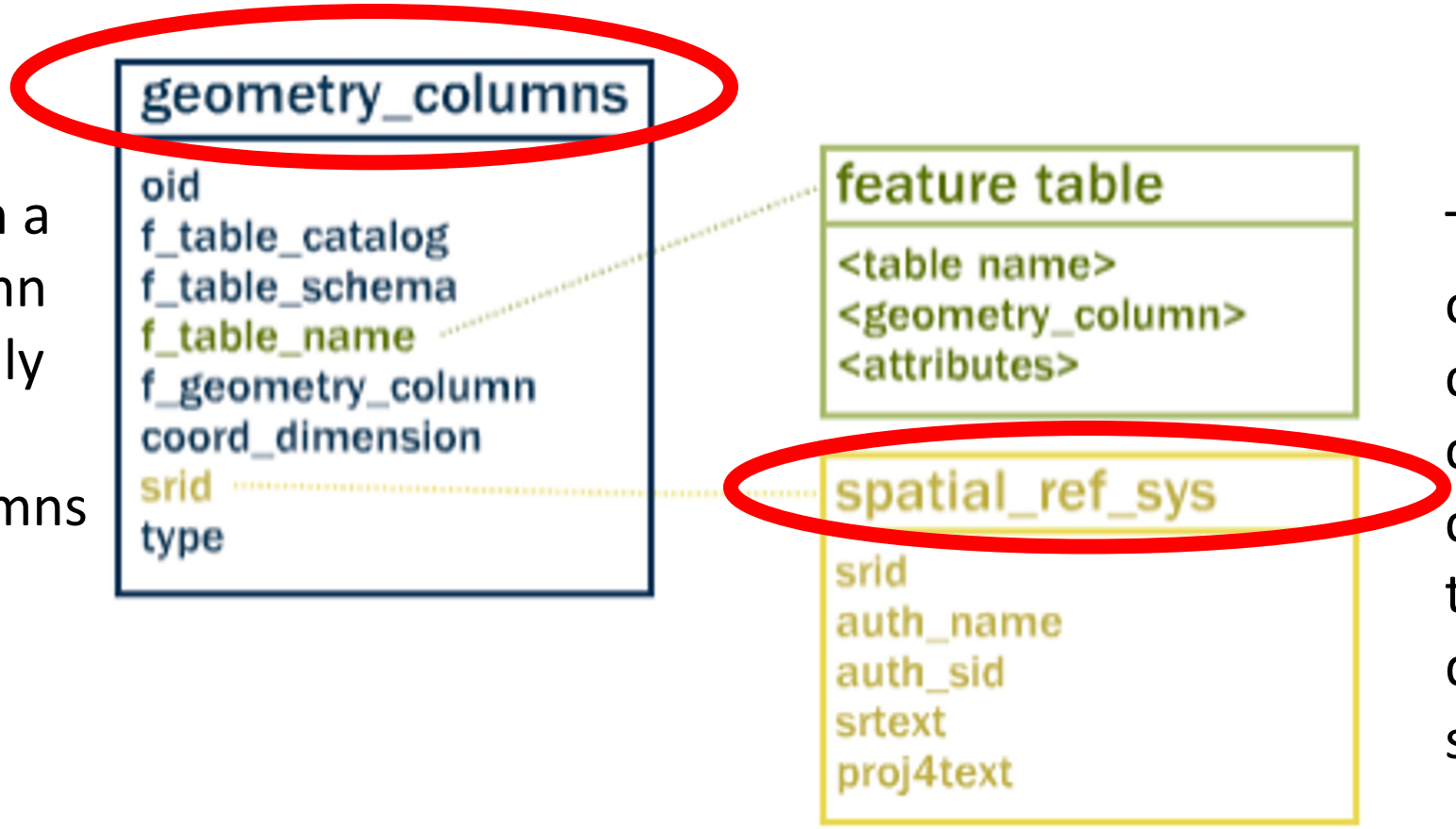
```
INSERT INTO geometries (name, geom) VALUES
  ('Point', 'POINT(0 0)'),
  ('Linestring', 'LINESTRING(0 0, 1 1, 2 1, 2 2)'),
  ('Polygon', 'POLYGON((0 0, 1 0, 1 1, 0 1, 0 0))'),
  ('PolygonWithHole', 'POLYGON((...))'),
  ('Collection', 'GEOMETRYCOLLECTION(...)');
```

Creating a table with geometry

```
SELECT name, ST_AsText(geom)
  FROM geometries;
```

Table Relationships

Every table with a geometry column will automatically appear in the geometry_columns view.



The SRID numbers on geometries and columns are converted into coordinate transforms using data from the spatial_ref_sys table.

geometry_columns

```
SELECT *
FROM geometry_columns
```

geometry_columns

nyc/postgres@localhost

Query Editor | Query History | Scratch Pad

```
1  SELECT * FROM geometry_columns;
```

Data Output | Explain | Messages | Notifications

	f_table_catalog character varying (256)	f_table_schema name	f_table_name name	f_geometry_column name	coord_dimension integer	srid integer	type character varying (30)
1	nyc	public	nyc_census_blocks	geom	2	26918	MULTIPOLYGON
2	nyc	public	nyc_homicides	geom	2	26918	POINT
3	nyc	public	nyc_neighborhoods	geom	2	26918	MULTIPOLYGON
4	nyc	public	nyc_streets	geom	2	26918	MULTILINESTRING
5	nyc	public	nyc_subway_stati...	geom	2	26918	POINT

Metadata functions

```
SELECT
   name,
   ST_GeometryType(geom),
   ST_NDims(geom),
   ST_SRID(geom)
FROM geometries;
```

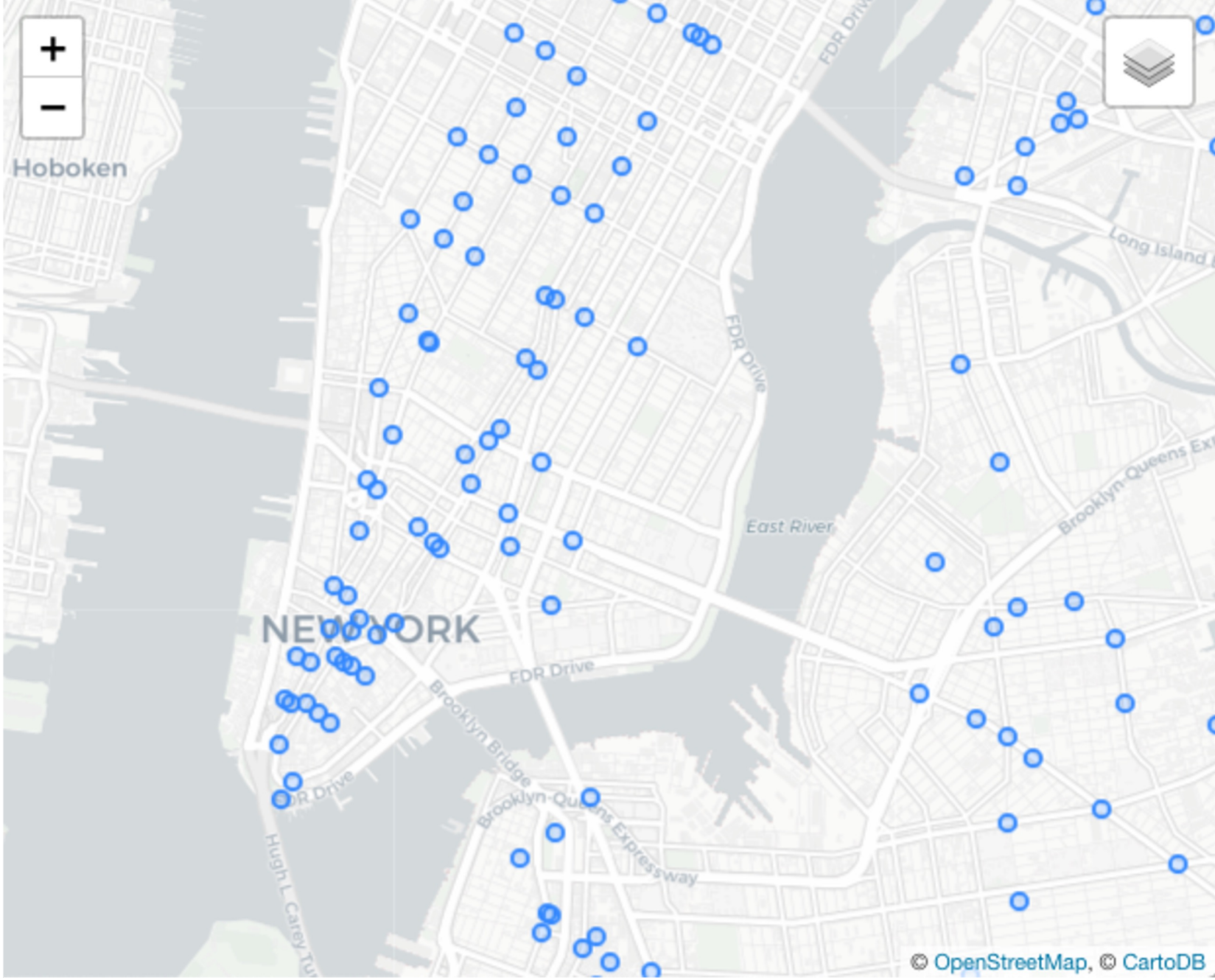
Metadata functions

name	st_geometrytype	st_ndims	st_srid
Point	ST_Point	2	0
Linestring	ST_LineString	2	0
Polygon	ST_Polygon	2	0
PolygonWithHole	ST_Polygon	2	0
Collection	ST_GeometryCollection	2	0

Points

"Point" or "MultiPoint", representing one or more 0-dimensional locations.

New York city subway stations, stop signs, man holes, address points, current locations of vehicles, might all use a "Point" geometry type.



Points

```sql
SELECT ST_AsText(geom)
FROM geometries
WHERE name = 'Point';
```

```
POINT(0 0)
```

Points

```
SELECT
   ST_X(geom),
   ST_Y(geom)
FROM geometries
WHERE name = 'Point'
```

```
0 0
```

Points

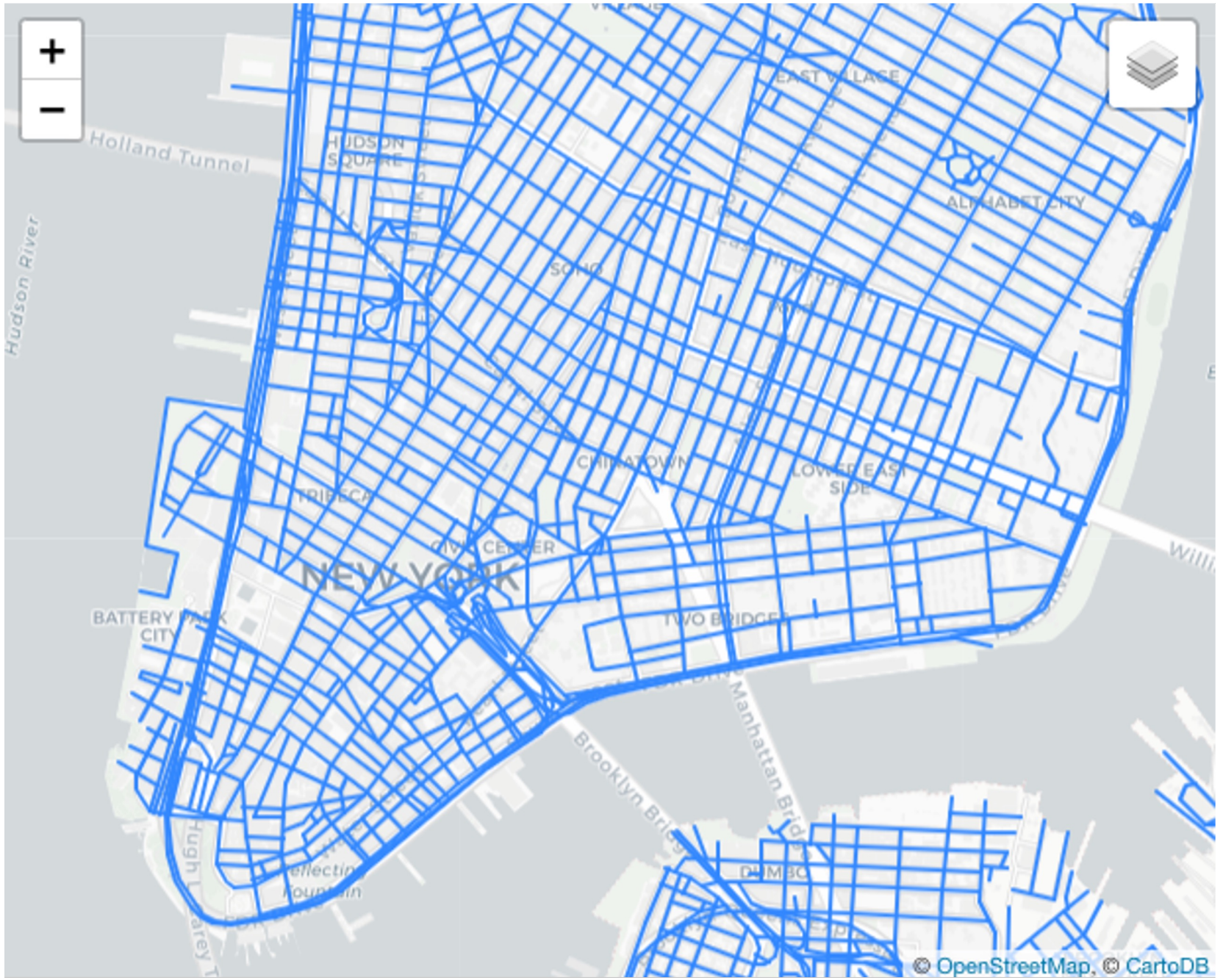
```
SELECT
   name,
   ST_AsText(geom)
FROM nyc_subway_stations
LIMIT 1;
```

```
Cortlandt St | POINT(583521 4507077)
```

LineStrings

"LineString" or "MultiLineString", representing one or more 1-dimensional objects.

Streets, streams, bus routes, power lines, driven routes, highways, might all use a "LineString" geometry type.



LineStrings

```sql
SELECT ST_AsText(geom)
FROM geometries
WHERE name = 'Linestring';
```

```
LINESTRING(0 0,1 1,2 1,2 2)
```

LineStrings

```sql
SELECT ST_Length(geom)
FROM geometries
WHERE name = 'Linestring';
```

```
3.41421356237309
```

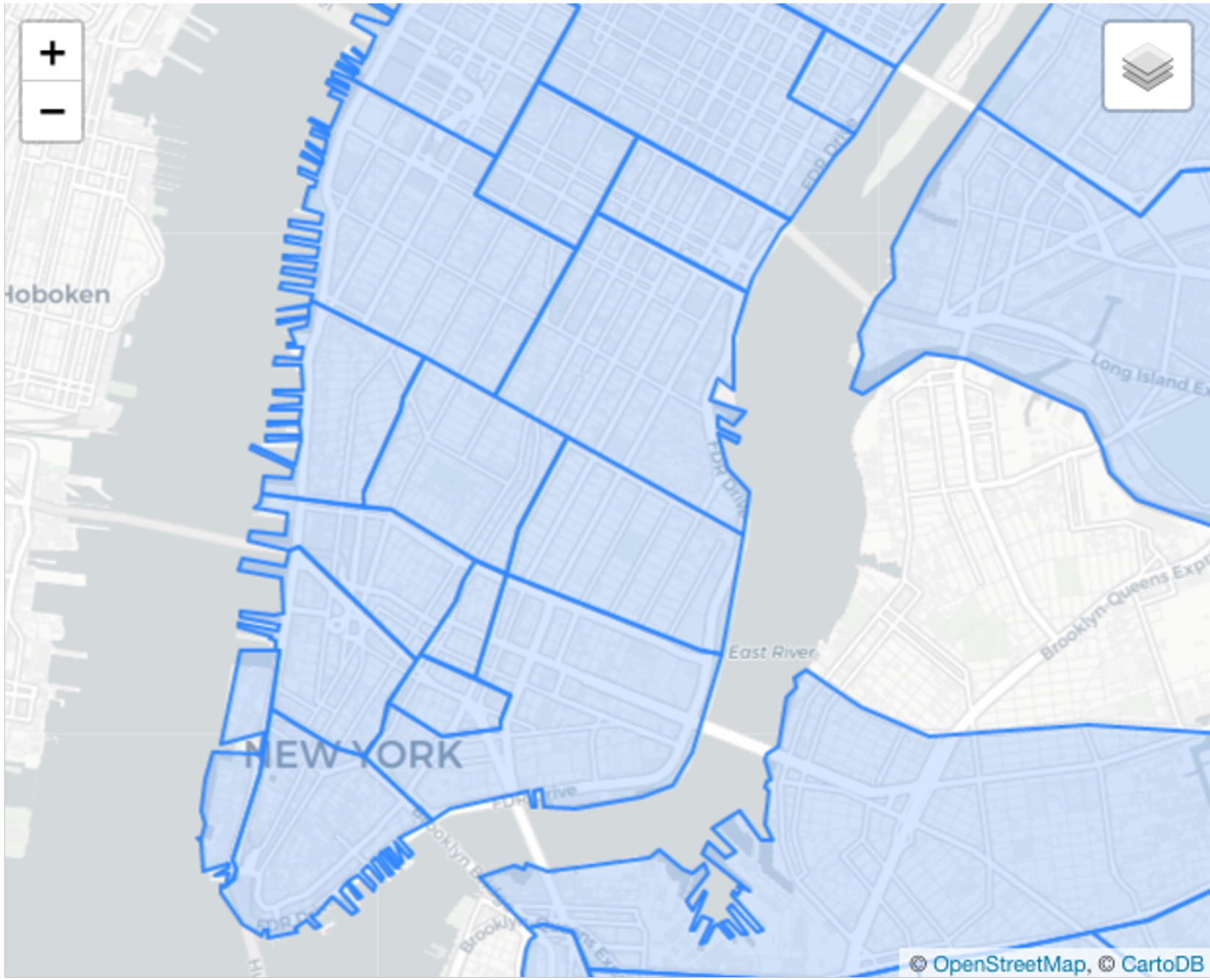
LineStrings

- ST_Length(linestring)
- ST_StartPoint(linestring)
- ST_EndPoint(linestring)
- ST_NumPoints(linestring)

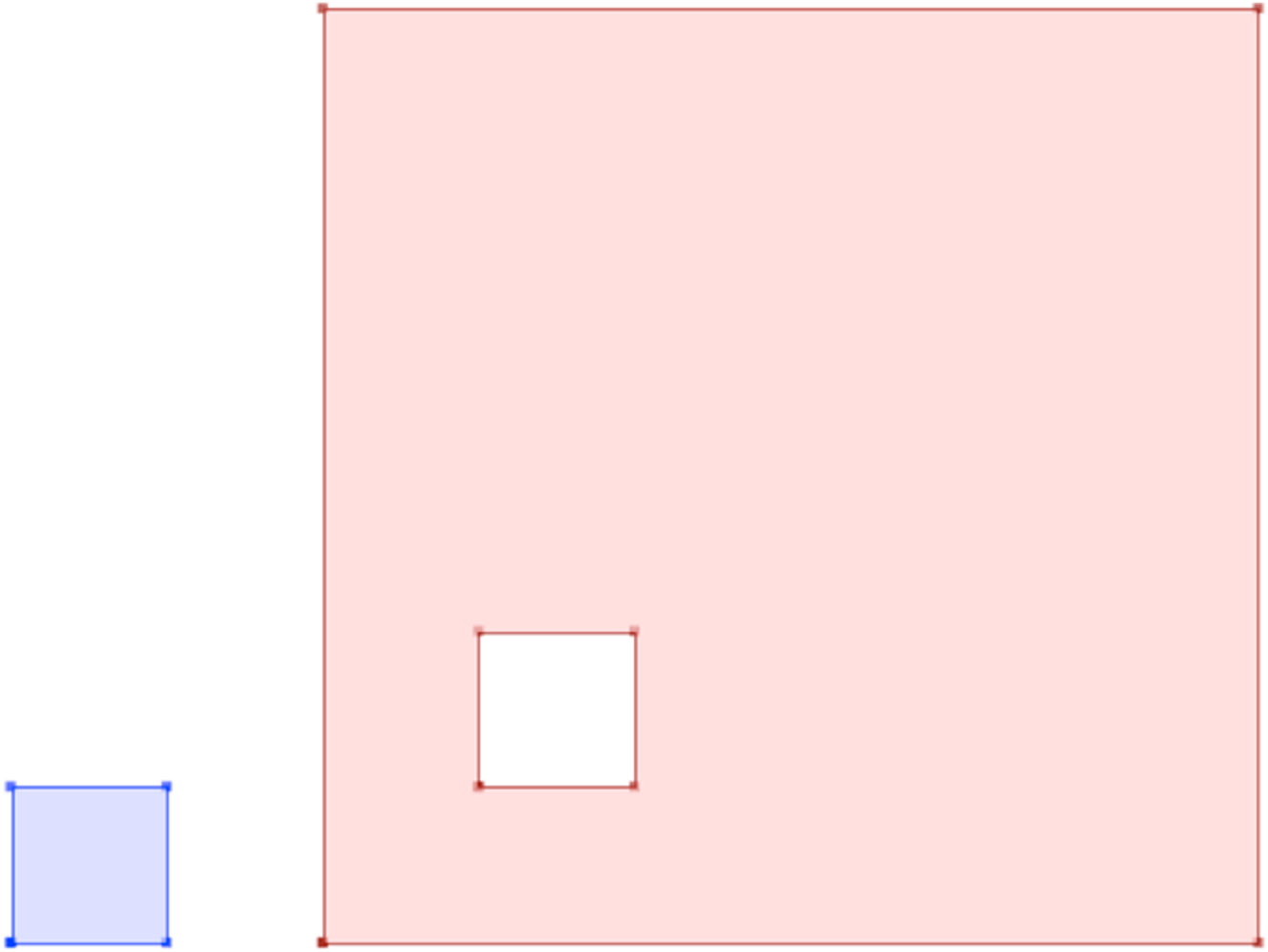
Polygons

"Polygon" or "MultiPolygon", representing one or more 2-dimensional objects.

Census areas, parcels, counties, countries, neighborhoods, zoning areas, watersheds, and more.



Polygons



Polygons

```
SELECT ST_AsText(geom)
  FROM geometries
  WHERE name LIKE 'Polygon%';
```

```
POLYGON((0 0, 1 0, 1 1, 0 1, 0 0))
POLYGON((0 0, 10 0, 10 10, 0 10, 0 0),
        (1 1, 1 2, 2 2, 2 1, 1 1))
```

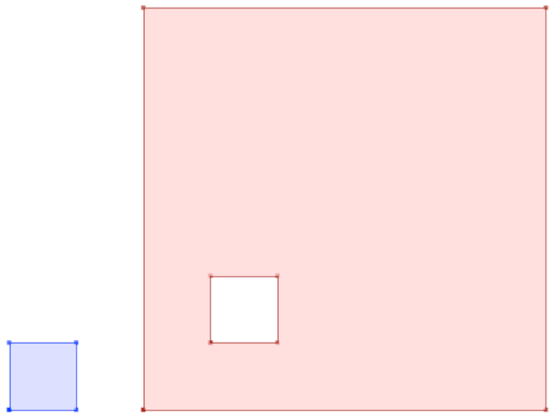
Polygons

- ST_Area(polygon)
- ST_NumInteriorRings(polygon)
- ST_ExteriorRing(polygon)
- ST_InteriorRing(polygon,n)
- ST_Perimeter(polygon)

Polygons

```sql
SELECT name, ST_Area(geom)
FROM geometries
WHERE name LIKE 'Polygon%';
```

Polygon	1
PolygonWithHole	99



All roads lead to Rome ... (Geometry construction)

```
SELECT ST_AsEWKT(
  ST_GeomFromText('POINT(1 1)', 4326)
);
```

```
SRID=4326;POINT(1 1)
```

All roads lead to Rome ... (Geometry construction)

```
SELECT ST_AsEWKT(
  ST_SetSRID(
    ST_GeomFromText('POINT(1 1)'),
    4326
  )
);
```

```
SRID=4326;POINT(1 1)
```

All roads lead to Rome ... (Geometry construction)

```
SELECT ST_AsEWKT(
  ST_SetSRID(
    ST_MakePoint(1, 1),
    4326
  )
);
```

```
SRID=4326;POINT(1 1)
```

All roads lead to Rome ... (Geometry construction)

```
SELECT ST_AsEWKT(
    ST_SetSRID(
        'POINT(1 1)'::geometry,
        4326
    )
);
```

```
SRID=4326;POINT(1 1)
```

All roads lead to Rome ... (Geometry construction)

```
SELECT ST_AsEWKT(
   'SRID=4326;POINT(1 1)'::geometry
);
```

```
SRID=4326;POINT(1 1)
```

All roads lead to Rome ... (Geometry construction)

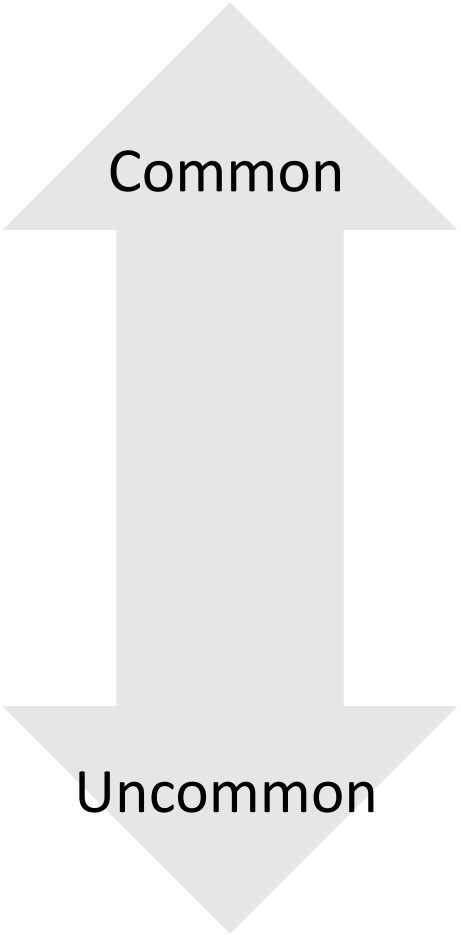
```
SELECT ST_AsEWKT(
  ST_Point(1, 1, 4326)
);
```

```
SRID=4326;POINT(1 1)
```

Spatial Relationships

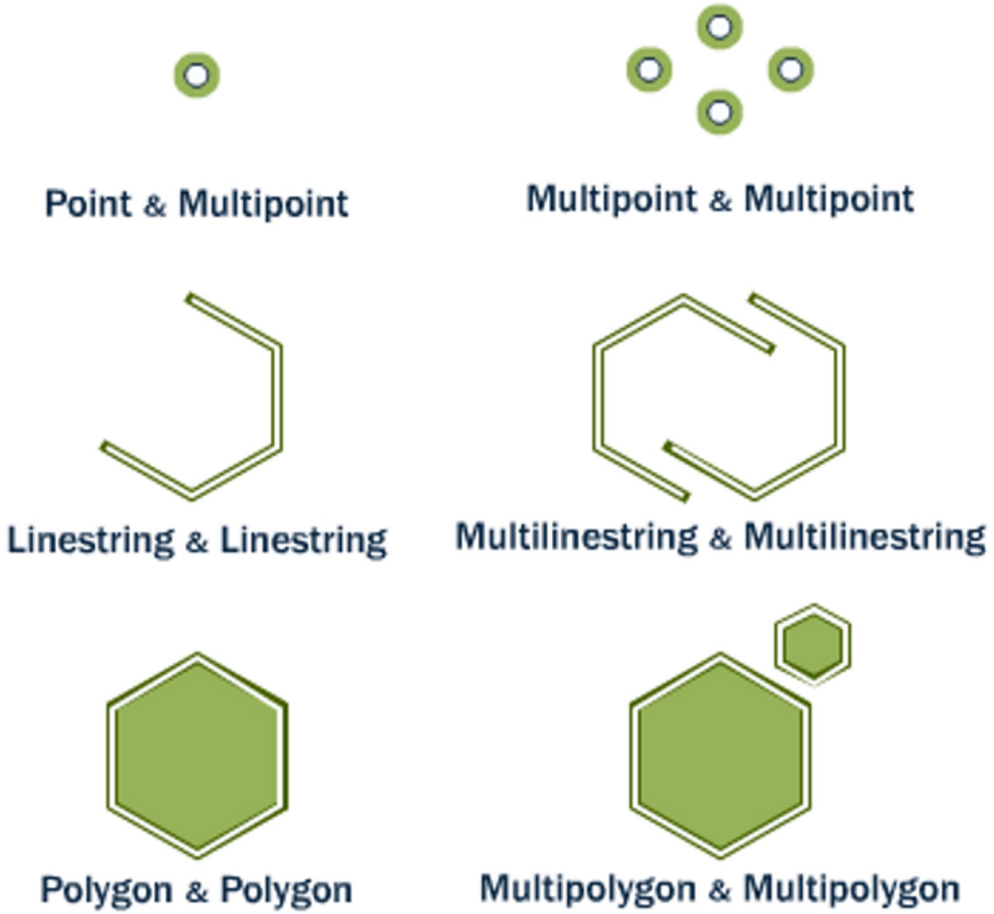
Spatial Relationship Functions

- ST_Intersects(A, B)
- ST_DWithin(A, B, d)
- ST_Distance(A, B)
- ST_Within, ST_Contains(A, B)
- ST_Equals(A, B)
- ST_Touches(A, B)
- ST_Disjoint, ST_Crosses, ST_Overlaps(A, B)



ST_Equals(A, B)
ST_OrderingEquals(A, B)

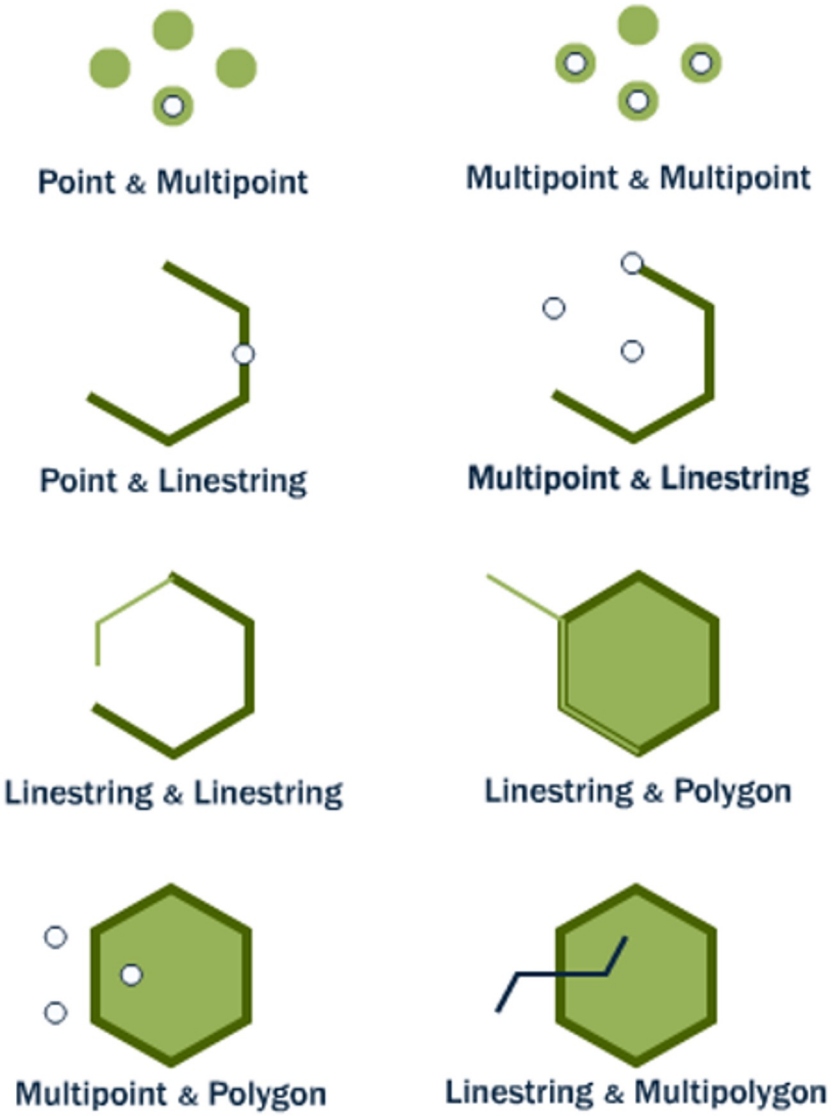
Equals tests that A and B cover the same space, regardless of representation differences (extra vertices, order of vertices). OrderingEquals insists on structural identity.



ST_Intersects(A, B)
ST_Disjoint(A, B)

Intersects and disjoint are opposites. Any kind of interactions between two shapes is an intersection, and implies the pair are not disjoint, and vice versa.

A intersects B ⇒ A not disjoint B
A disjoint B ⇒ A not intersects B



What is the well-known text (WKT) of Broad Street subway station?

```
SELECT name, ST_AsText(geom, 0)
  FROM nyc_subway_stations
  WHERE name = 'Broad St';
```

```
POINT(583571 4506714)
```

What neighborhood intersects that subway station?

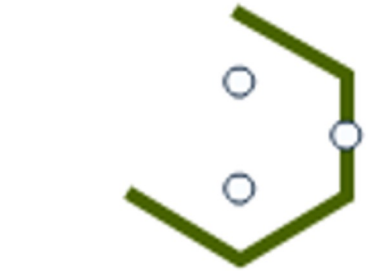
```
SELECT name, boroname
FROM nyc_neighborhoods
WHERE ST_Intersects(
  geom,
  ST_GeomFromText(
    'POINT(583571 4506714)',
    26918));
```

```
Financial District | Manhattan
```

ST_Crosses(A, B)

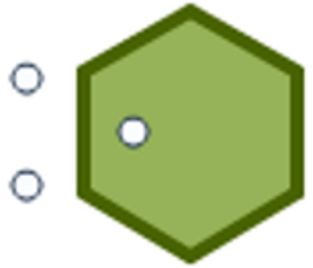
Mostly used to test linestrings, which can be said to cross when their interiors have interactions.

When linestrings cross polygon boundaries, the crosses condition is also true.



Multipoint & Linestring

Linestring & Linestring



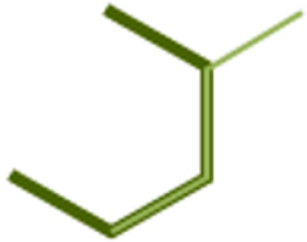
Multipoint & Polygon

Linestring & Multipolygon

ST_Overlaps(A, B)

Shapes overlap when their interiors interact with each other and also with the exterior of the shape.
So objects that are contained or within do not overlap, overlaps is what normal people might call “partial overlap”.

Multipoint & Multipoint

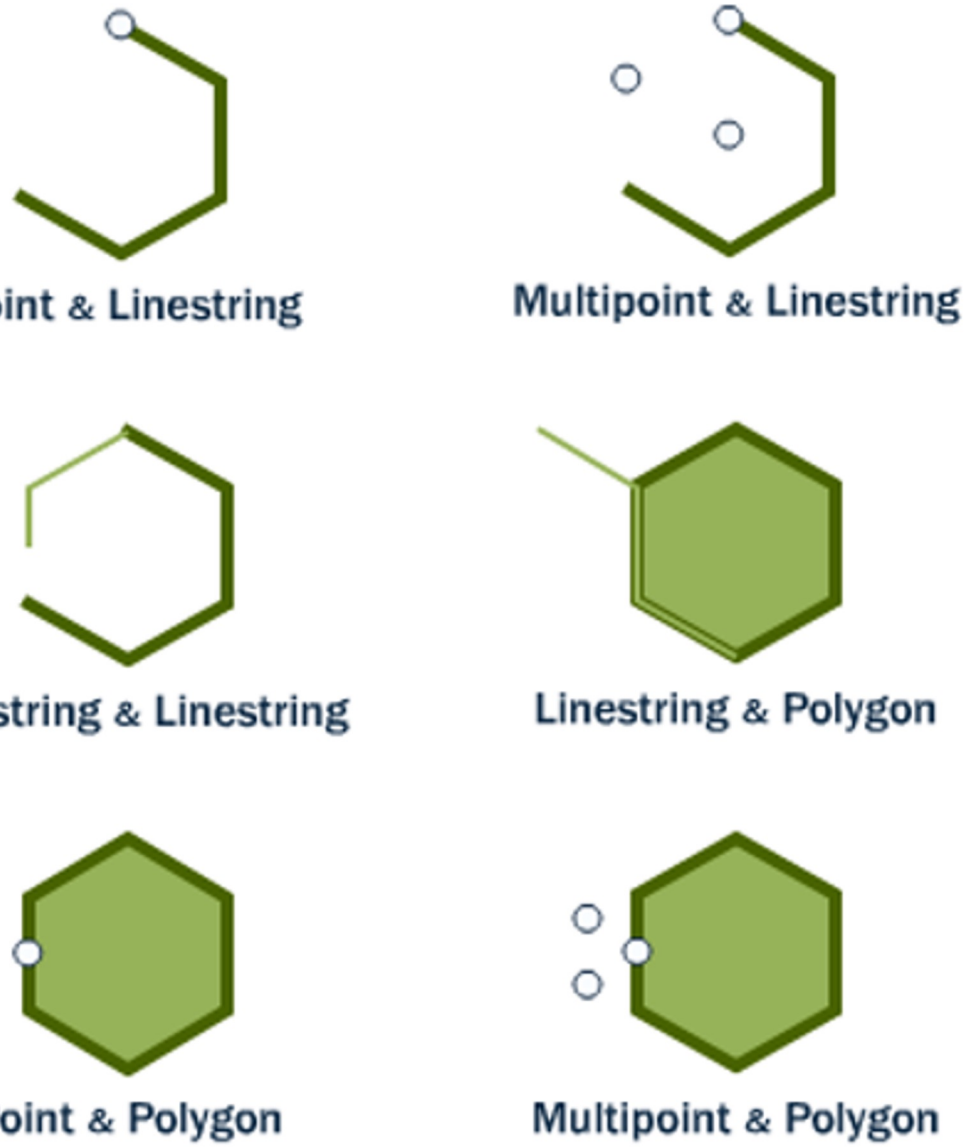


Linestring & Linestring

Polygon & Polygon

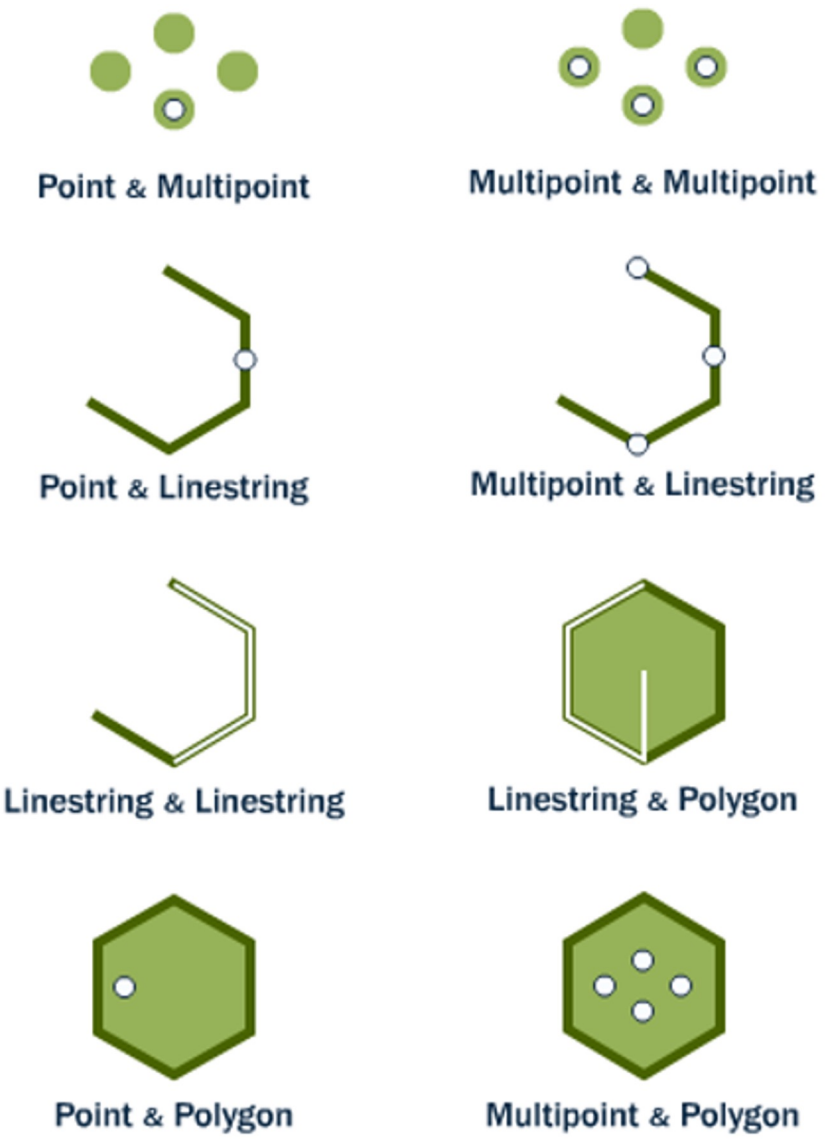
ST_Touches(A, B)

Shapes touch when their boundaries interact but their interiors do not. End points for lines, exterior rings for polygons. Usually used for testing that polygons have ring-touching only.



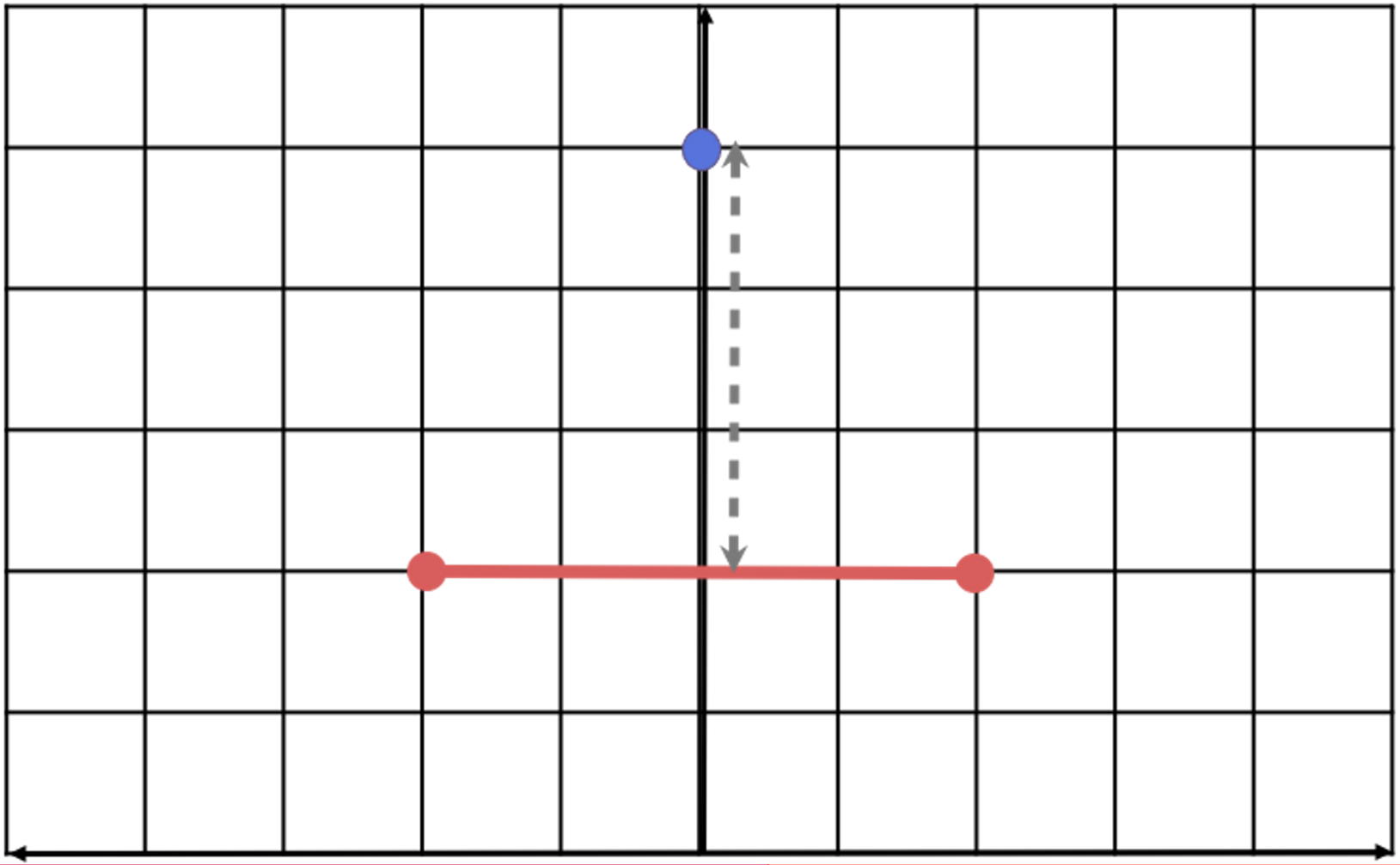
ST_Within(A, B)
ST_Contains(B, A)

Within and contains are about objects being fully inside. One important caveat, for both functions an object on the **boundary** is not considered within. So a point on the outer ring of a polygon is not within the polygon.



ST_Distance(A, B)

Returns the **shortest** distance between the two geometries, in this case the distance from the point to the line mid-point.



ST_Distance(A, B)

```
SELECT ST_Distance(
   'POINT(0 5)'::geometry,
   'LINESTRING(-2 2, 2 2)'::geometry
   );
```

```
   3
```

ST_DWithin(A, B, R)

Index-enabled radius search function. True when the distance from geometry A to geometry B is less than radius R. False otherwise.

Use instead of **ST_Distance(A, B) < R**, in order to get benefit of spatial index.

Point & Point (True)

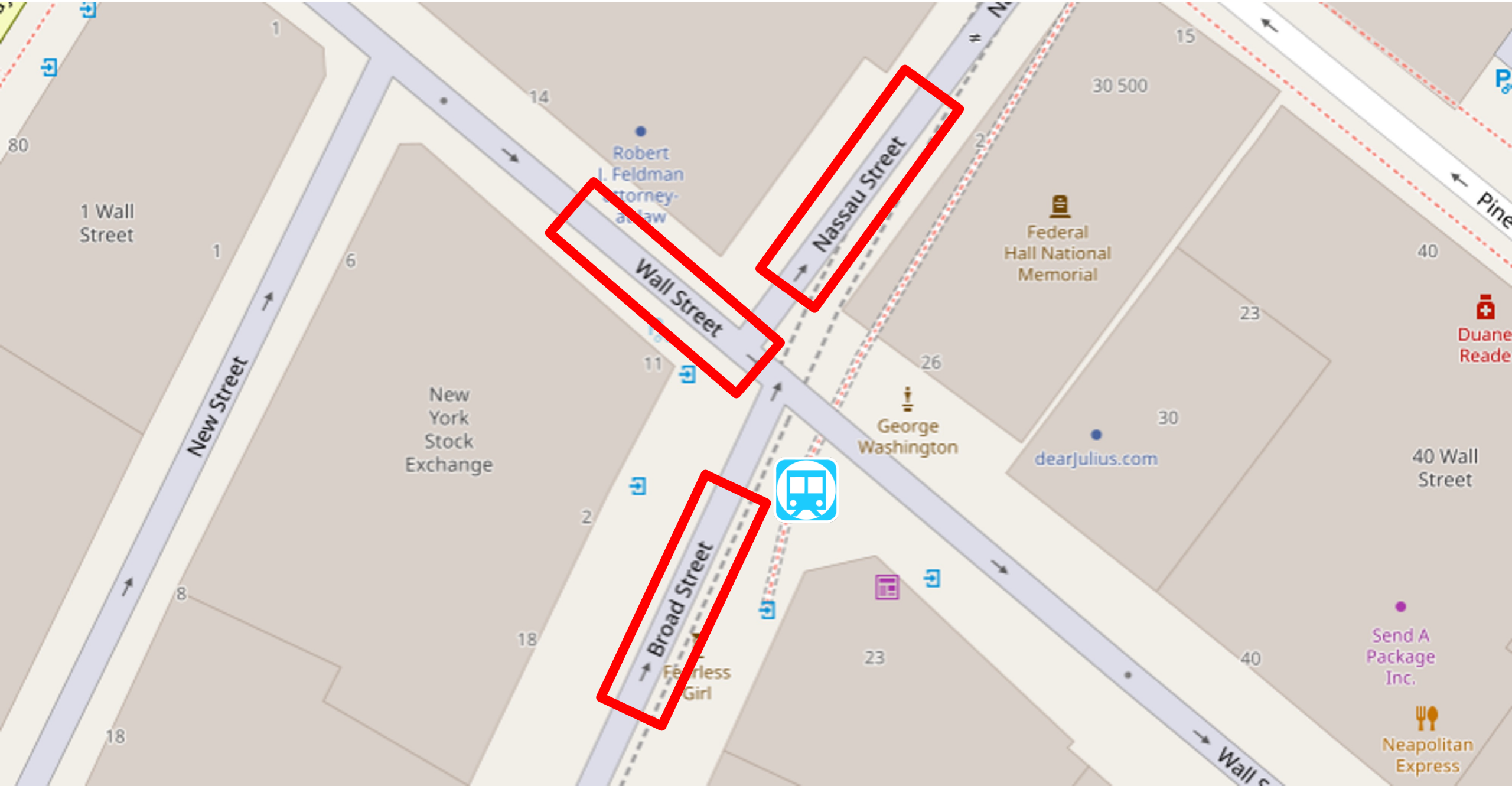
Point & Point (False)

Polygon & Point (True)

Polygon & Point (False)

What streets are within 10 meters of Broad Street subway station?

```
SELECT name
FROM nyc_streets
WHERE ST_DWithin(
  geom,
  ST_GeomFromText('POINT(583571 4506714)',26918),
  10
);
```


Wall Street
Nassau Street
Broad Street
New Street
Pine
1 Wall Street
New York Stock Exchange
Federal Hall National Memorial
George Washington
dearJulius.com
40 Wall Street
Duane Reade
Send A Package Inc.
Neapolitan Express
Fearless Girl
Robert I. Feldman
30 500
1
14
80
6
11
26
30
23
40
2
18
8
15