Mapping Vulnerability: A Geospatial Assessment for National City

Conducted as part of The Sage Project – GEOG 584: Spatial Analysis

Introduction and Background

The Sage Project is a program within the Center for Regional Sustainability at San Diego State University with a simple goal: improving quality of life in our region through community-based projects, in alignment with the UN Sustainable Development Goals.

2 Phases

1. Phase 1 (Spring 2025)
    a. Building Inventory (Current phase)
    b. Policy Proposals
    c. Resiliency Planning
2. Phase 2 (Fall 2025/Spring 2026)
    a. Disaster Modeling
    b. Branding & Marketing
    c. Resident Survey

Group Members

Gianna Salazar (MCP)

Micha Goll (MSIS)

Charles Dare (BS)

Timothy Boyd (BA)

Maxwell Johnson (BS)

Steffany Chavez (MCP)

Angel Resendiz

Andrew Fakhri

Ian Liermann

Brett Iverson

Advisor: Dr. Atsushi Nara

Project Objectives

To conduct a comprehensive assessment of building types in National City to identify structures most vulnerable to earthquake damage. Our assessment identifies structures built before 1980 that consist of the following building types.

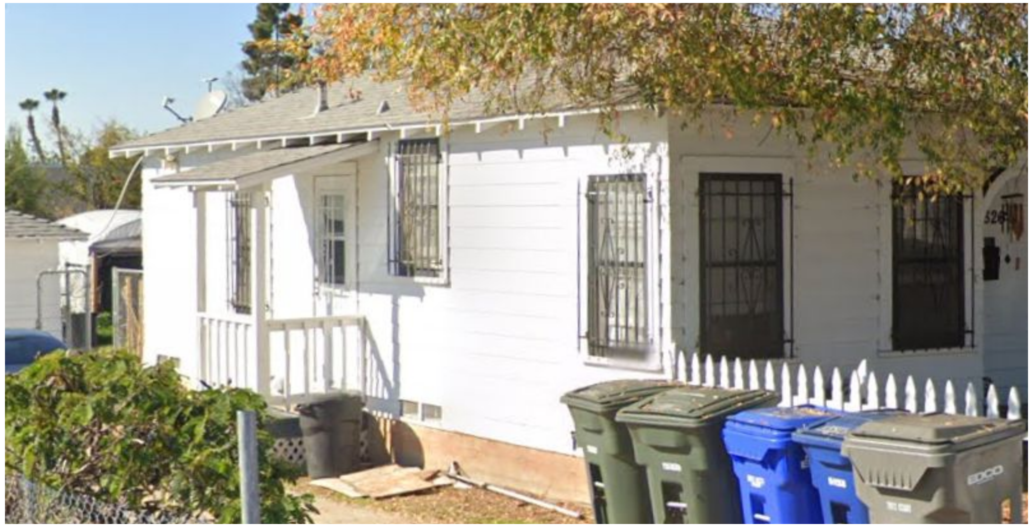
- Wood frame buildings
- Manufactured homes
- Unreinforced/Reinforced masonry structures
- Steel construction
- Concrete buildings

Building Examples

- Wood Frame: Wood framing with beams, studs, and panels. Typically finished with exterior siding or shingles.
- Manufactured Housing: Box-shaped, uniform structure with metal or vinyl siding, often raised on a platform or base.

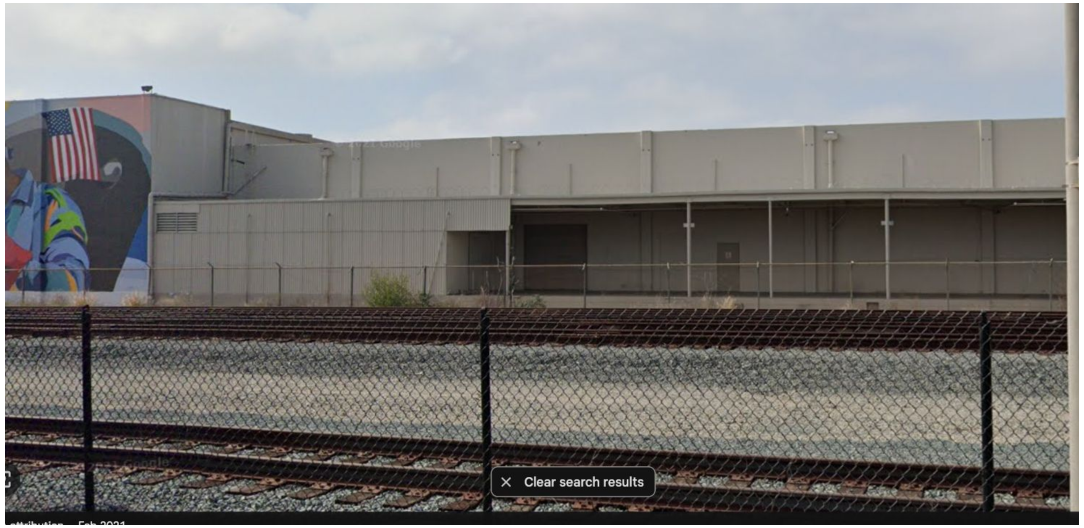
Building Examples

- Unreinforced Masonry: Brick or stone walls with exposed mortar joints, this building type has been prohibited in San Diego since 1939.
- Reinforced Masonry: Brick or concrete block walls that are reinforced with steel, featuring uniform block patterns and neat mortar lines.



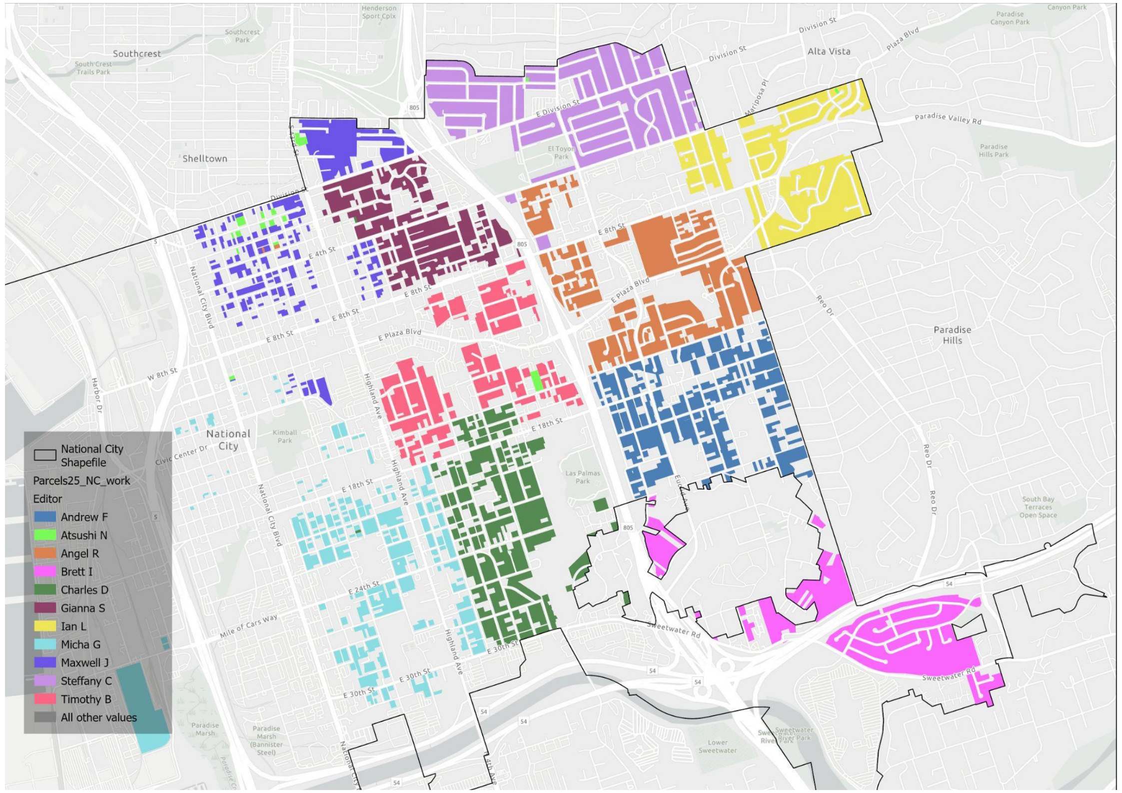
Building Examples

- Steel structures: Industrial style construction with steel beams and columns
- Concrete buildings: Heavy walls that are either smooth or rough. Usually massive, continuous sections with few visible joints.



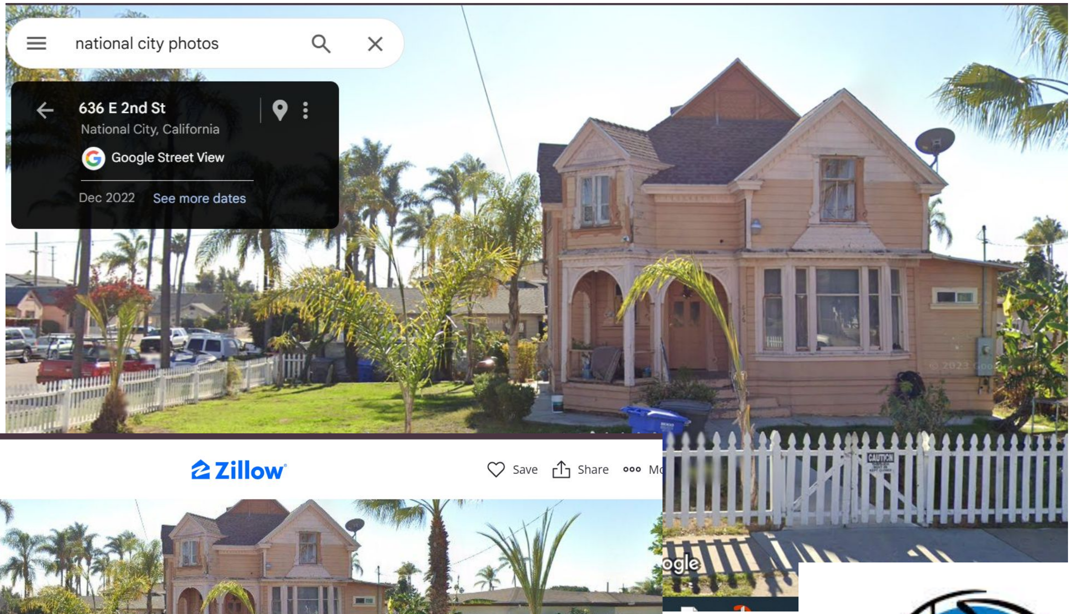
Methods: Workload Division

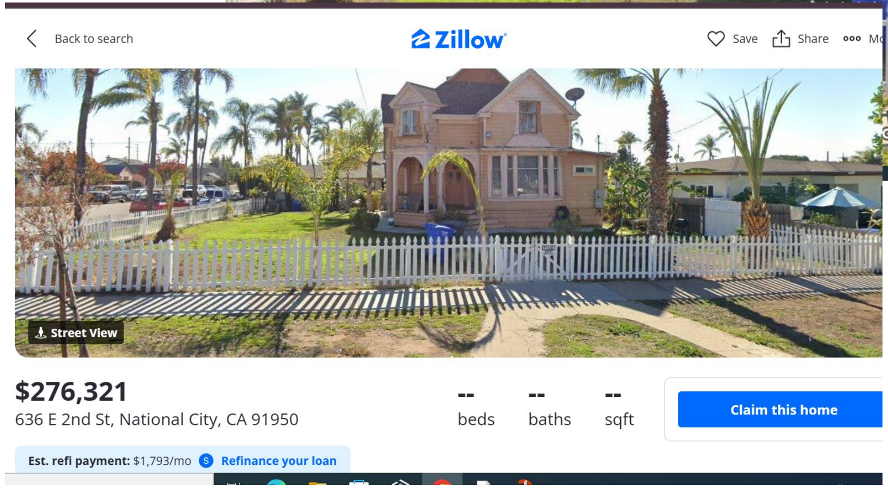
- The study area was initially divided into two main regions based on the I-5 Freeway:
  - West of I-5
  - East of I-5
- The residential parcel layer was subdivided into 10 equal parts, each assigned to a team member.
- Each person was responsible for analyzing and annotating approximately 500–800 parcels.



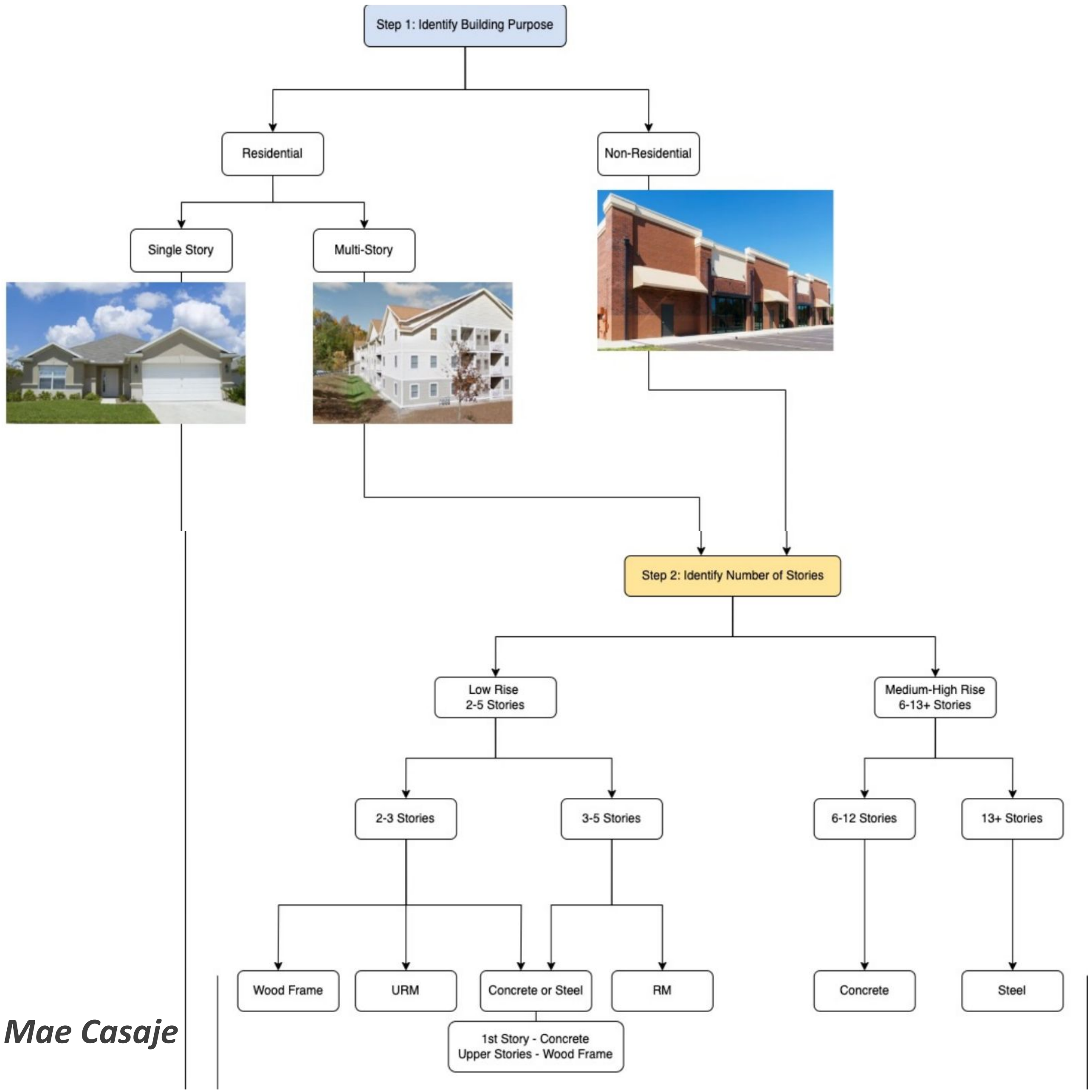
Methods: Platforms & Tools

- ArcGis Online Group
  - Sage Project
  - Feature Layer “Parcels25_NC_work”
- Google Street View
- Redfin, Zillow, Realtor.com
- Flow Chart (next slide)

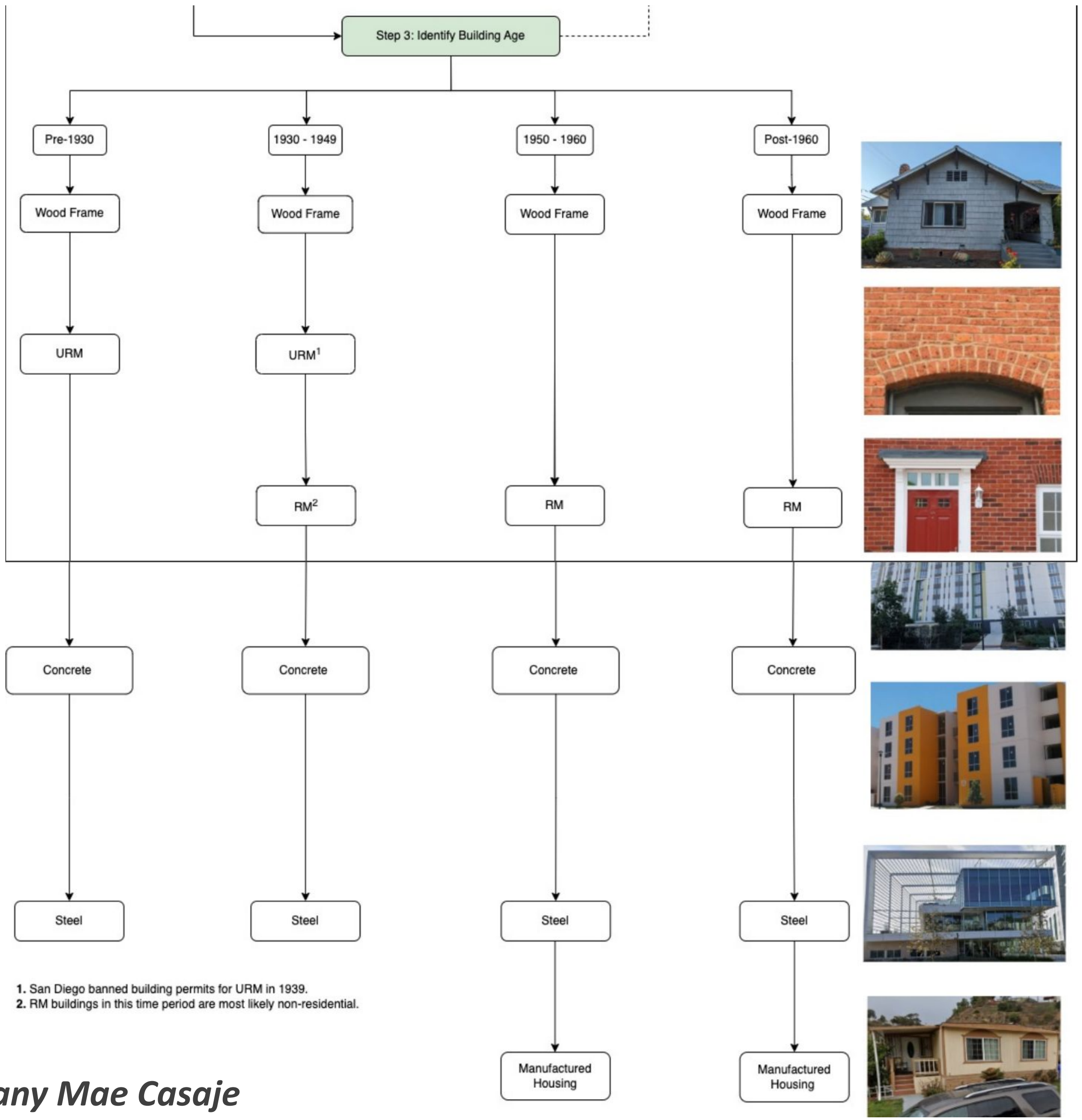




Flow Chart



Credits:
Dr. Gloria Faraone, Docean Park, Tiffany Mae Casaje

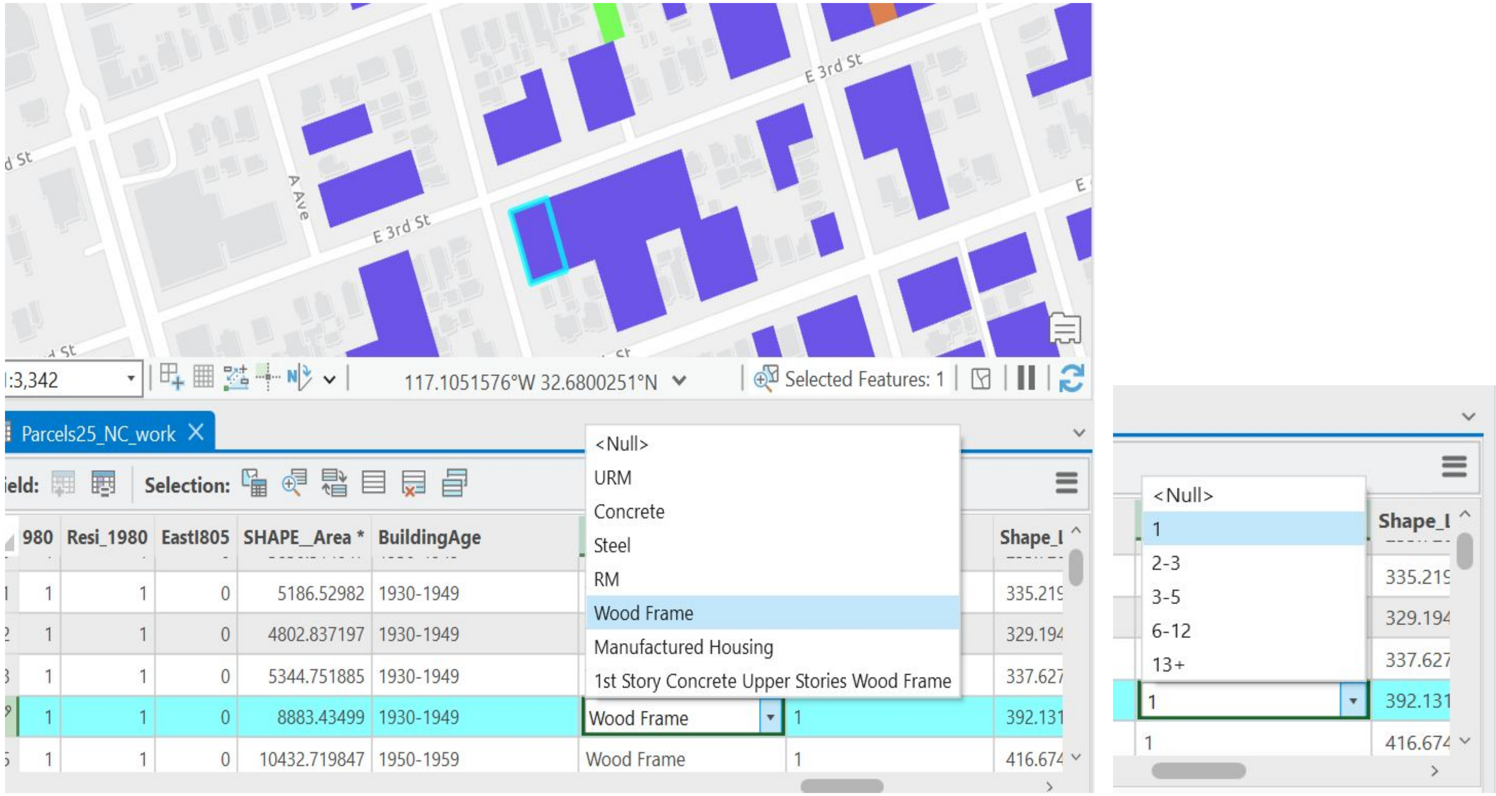


1. San Diego banned building permits for URM in 1939.
2. RM buildings in this time period are most likely non-residential.

Credits:
Dr. Gloria Faraone, Docean Park, Tiffany Mae Casaje

Methods: Annotating Parcel Attributes

- Attributes were manually reviewed for:
    - Building type
    - Number of stories
    - Presence of crawl space



Project Challenges and Data Constraints

- Reaching out for clarification
- Incorrect building age data
- Parcels not visible through Google Street View & other online databases
- Creating a “Note” Field

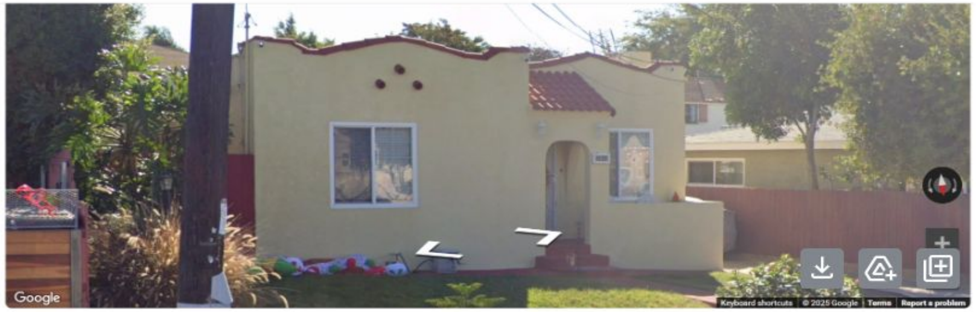
1039 E 3rd St House to be **masonry**.
And, it seems to be **RM**.
One way to distinguish RM and URM is looking at the year built.
Looking online the year built is 1947.
URM building permits were no longer issued in San Diego after 1939.

Parcels25_NC_work

Field: Selection:

		Editor *	Note	Craw
1	ı.758 AM	cdare269...	This is a multi-Family structure with at least 6 Units visible from 18th Street. Wood Frame, Multi-Family	
2	ı.758 AM	cdare269...	Single Story front facing housing with multi story, multi-unit, ADU on the back of the property.	
3	ı.758 AM	cdare269...	SFR primary residence, with 1 story 3 unit ADU on the back of the property	
4	ı.758 AM	cdare269...	Primary structure is 1 story Wood Frame. 2 Story ADU added to the back of the property later.	
5	;.339 AM	tboyd423...	PLOT	
6	ı.758 AM	cdare269...	One story primary residence, with 2 Story, Multi Unit ADU on the back of the property	
7	).321 AM	tboyd423...	NOT ON GOOGLE STREETVIEW	
8	ı.087 AM	tboyd423...	NOT ON GOOGLE STREETVIEW	
9	ı.102 AM	tboyd423...	NOT ON GOOGLE STREETVIEW	

1122 E 5th St house to be a **wood-framed** structure.



Map: Year Built Distribution

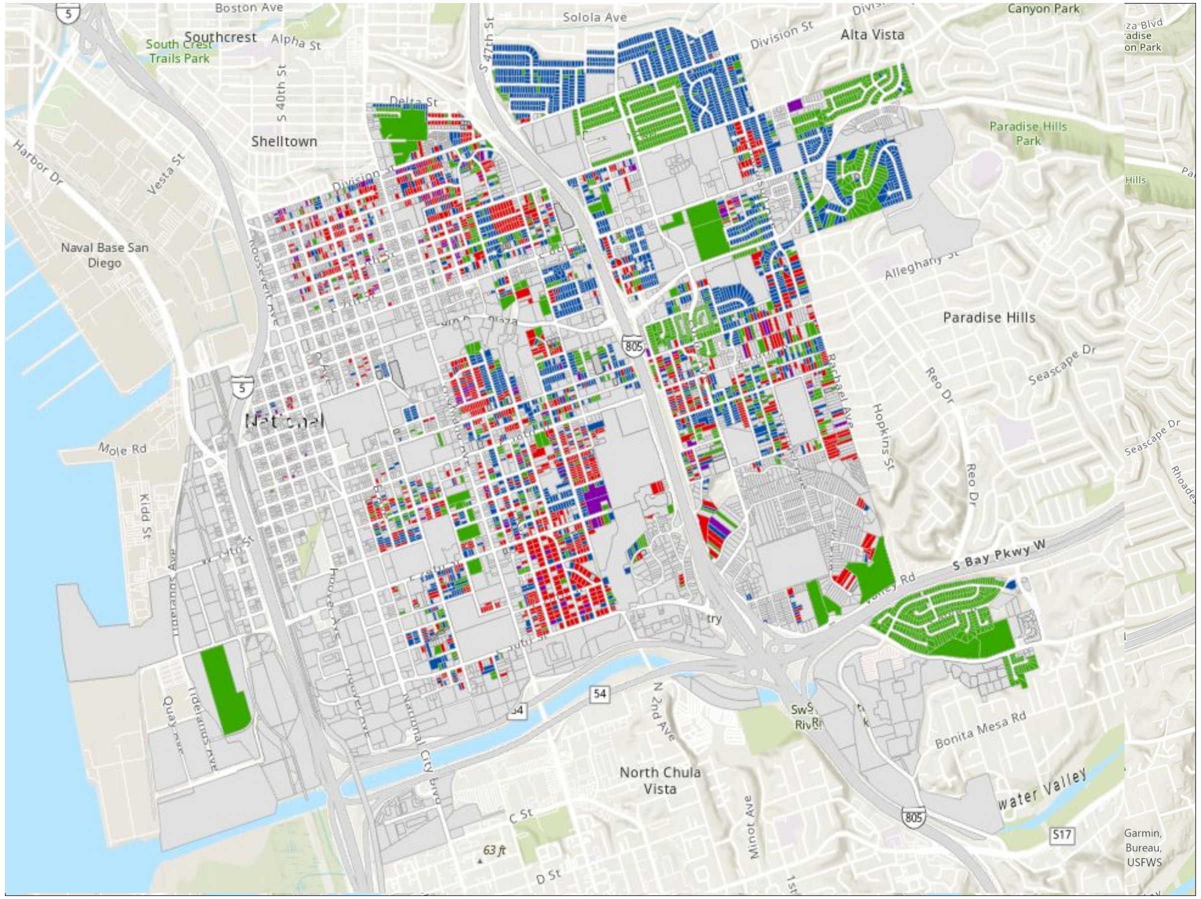
Color categorized by the year built

Legend

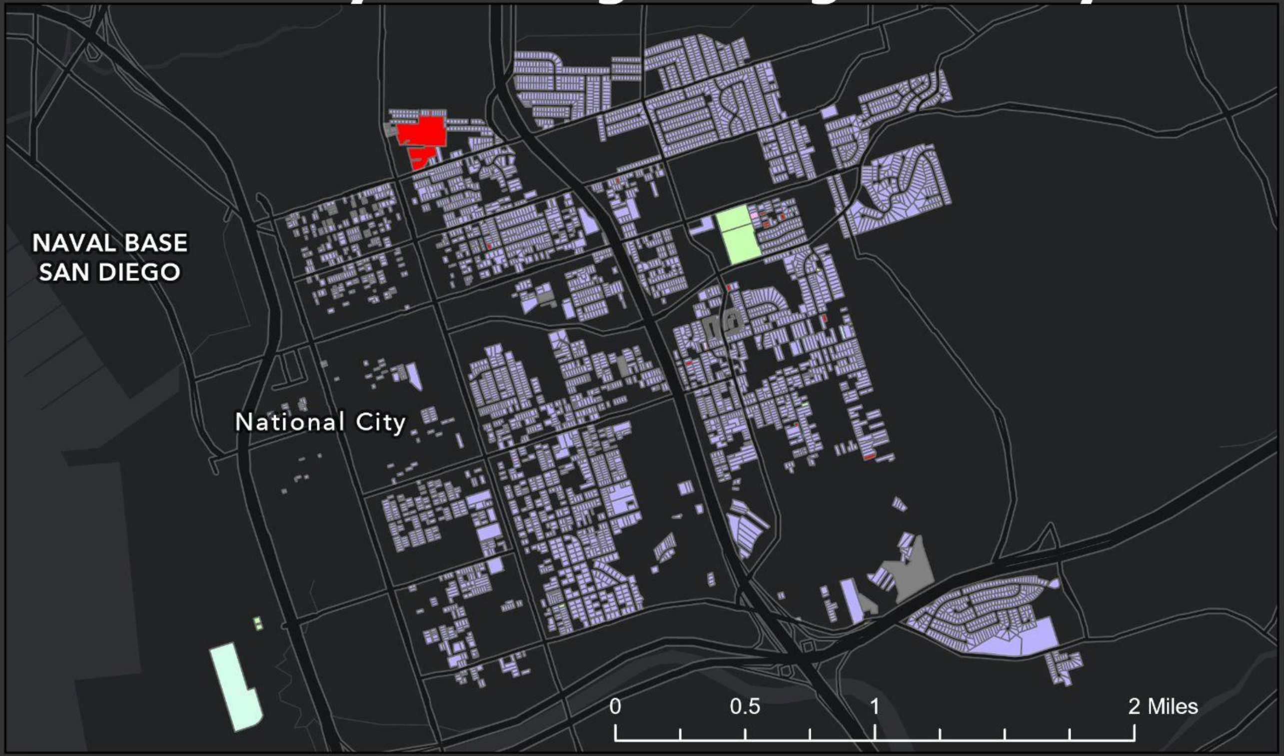
Building Age

- pre-1930
- 1930-1949
- 1950-1959
- 1960-1979
- *All other parcels*

Residential built before 1980



National City Buildings Categorized by Building Structure



BuildingStructure

- 1st Story Concrete Upper Stories Wood Frame
- Concrete
- Manufactured Housing
- RM
- Steel
- URM
- Wood Frame
- <all other values>

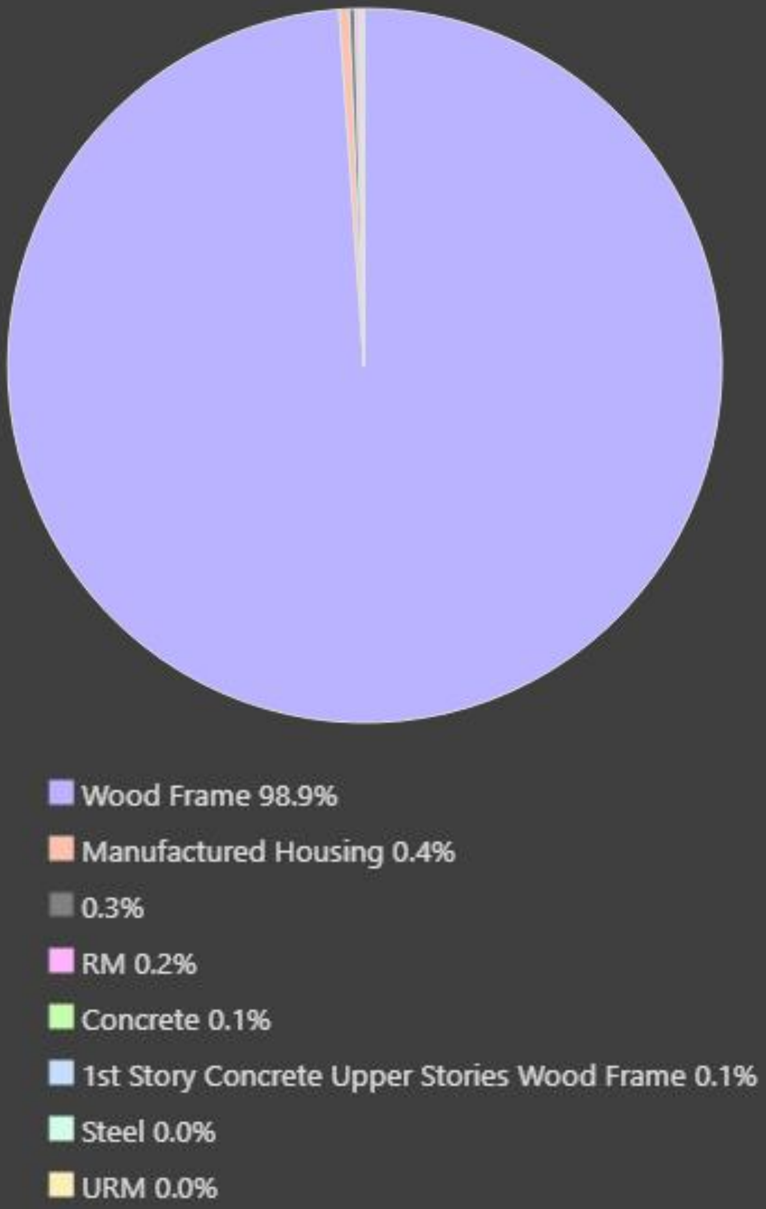
Outliers

Steel

Concrete

Manufactured Housing

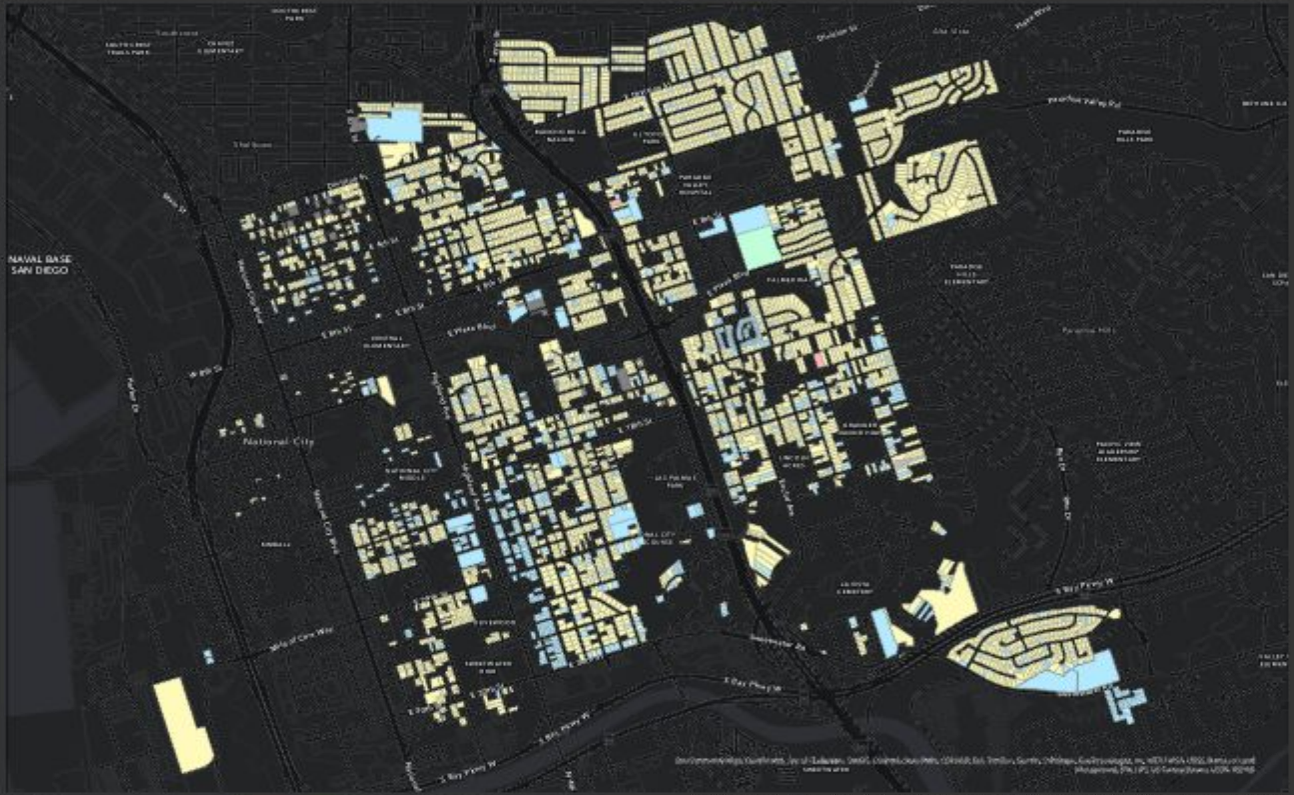
- 5088 wood frame structures
- 23 manufactured housings
- 9 reinforced masonry
- 6 concrete
- 3 concrete with upper wood frame
- 1 steel
- 1 unreinforced masonry



City of Chula Vista, SanGIS, California State Parks, CONANP, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA, USFWS, City of Chula Vista, San Diego Unified Port District, SanGIS, California State Parks

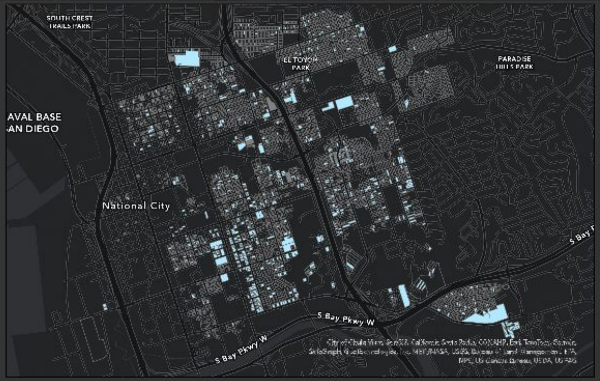
Possible Unpermitted add ons/Multiple Building Materials

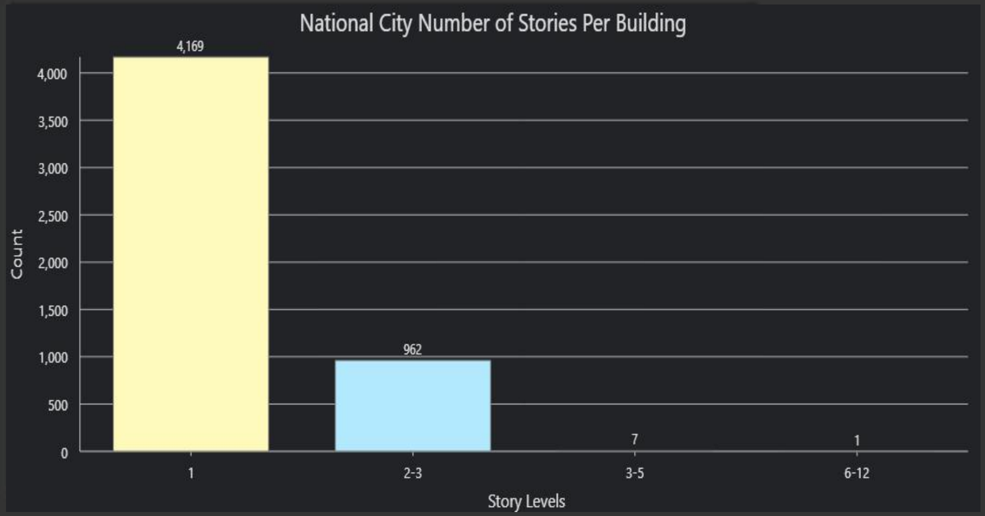
National City Buildings Categorized by Number of Stories



NumStories
- 1
- 13+
- 2-3
- 3-5
- 6-12
- <all other values>

- 1 Story: 4169
- 2-3 Story: 962
- 3-5-Story: 7
- 6-12 Story: 1





Methods: Identifying Crawl Spaces

Visual identification of crawl spaces:

- Vents
- Raised foundations
- Access panels
- Steps or ramp up to front door

Issues with identifying crawl spaces

Most properties were surveyed with a combination of Google Street View, and Google Earth. Per the request of some homeowners, some properties are blurred out on Google Street view.

Properties under these viewing restrictions were assessed with Google Earth, or via public information searches such as through Redfin or Zillow for property information and images.

Blurred Property on Google Street View

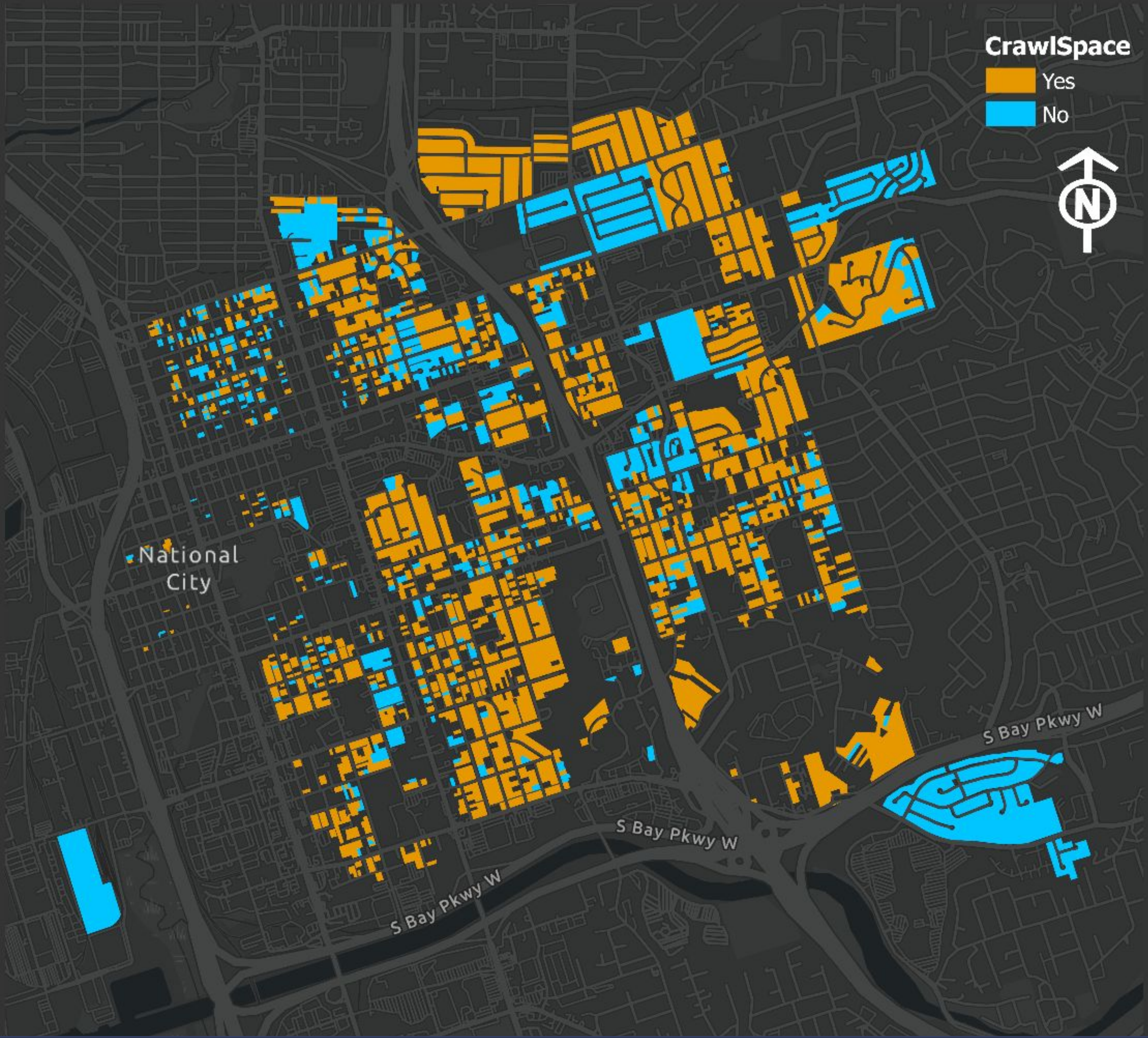
Crawlspace ID through Google Earth

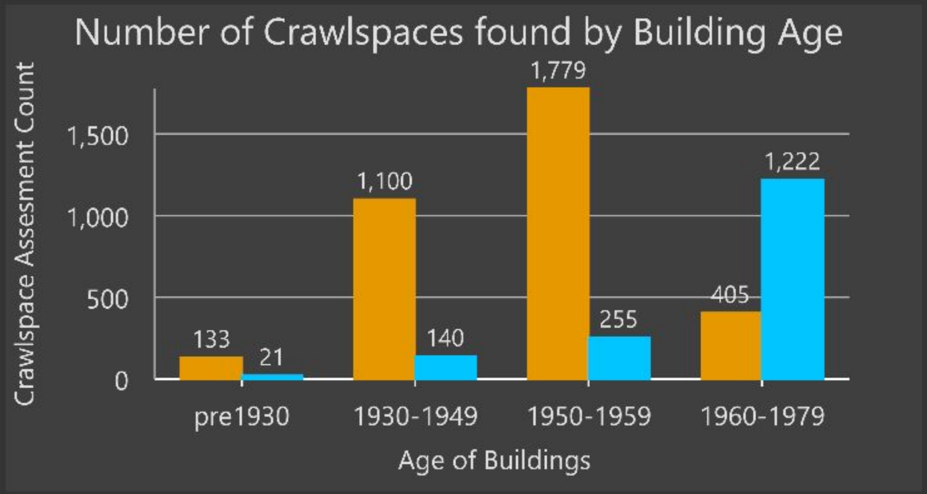
Crawlspace ID through Redfin Photos

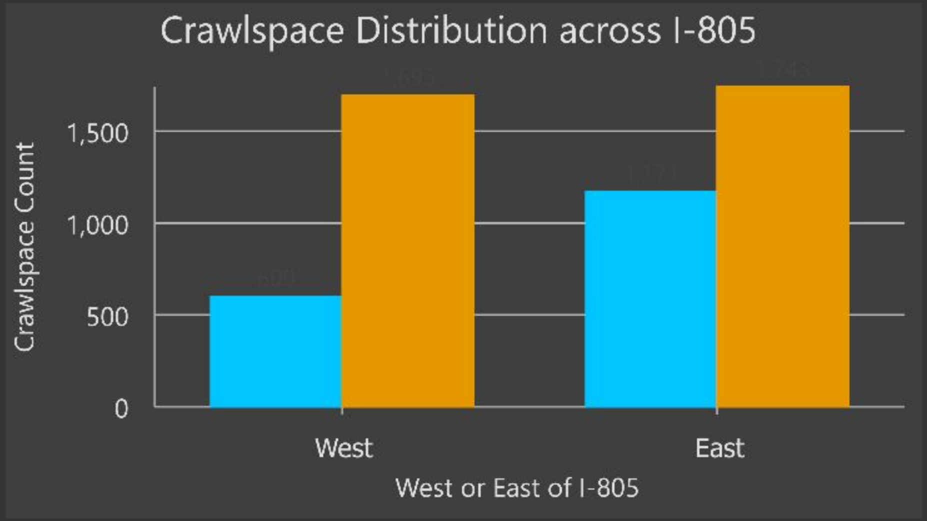
Homogeneous zones on the east showing more uniform construction methods. Further to the east we see even larger homogeneous zones with larger planned home communities with very uniform construction types.

Heterogenous crawlspaces to the west indicating more individualized and non-uniform construction methods.

Crawlspace Distribution



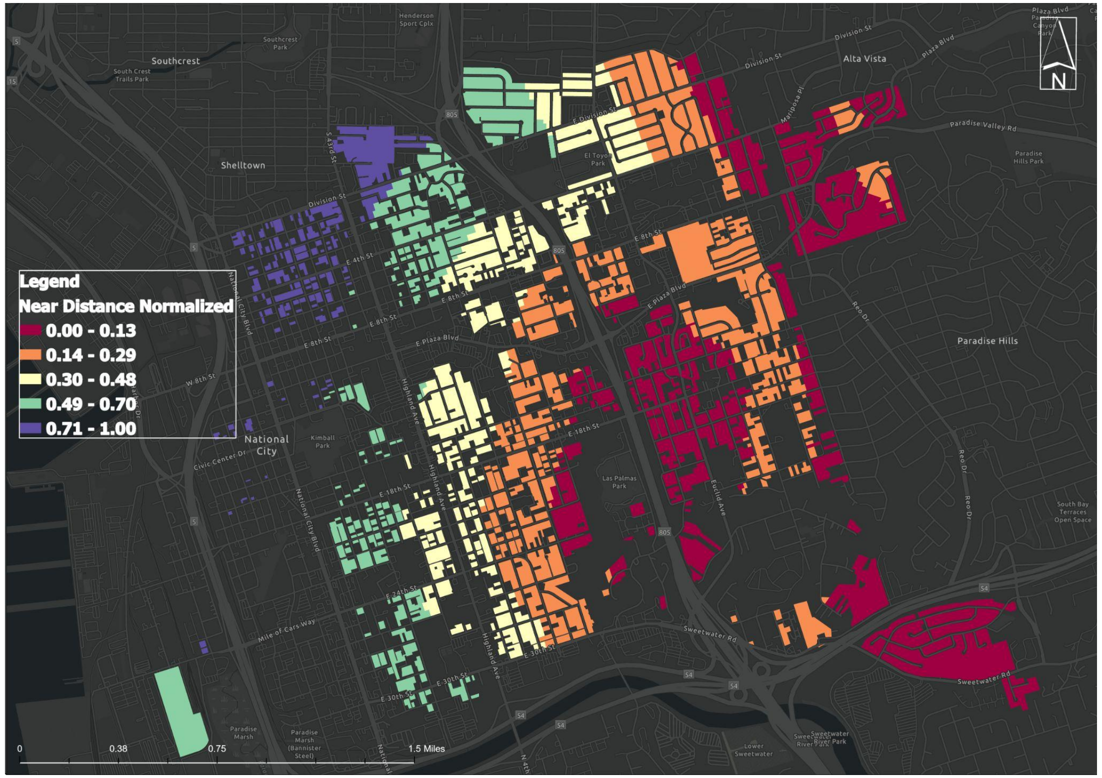




Analysis: Weighted Linear Combination

- Objective: To assess earthquake-related risk to residential parcels in National City using a weighted composite score based on 3 geophysical factors.
- Selected our risk factors
  - Fault Proximity- USGS
  - Soil Type- USDA
  - Slope- USGS DEM
- Parcel Layer
  - National City Residential Parcels
- Normalized scores 0-1,
- Higher scores indicate greater risk based on physical site conditions.
- Weighted each risk factor for our WLC Model
  - Each factor was weighted equally

Fault Proximity: Normalizing Near Distance



Data Source: U.S. Geological Survey (USGS), Faults, Earthquake Hazards Program. Retrieved from https://www.usgs.gov/programs/earthquake-hazards/faults

Liquefaction during Earthquake

- Phenomenon where particular soil particles lose cohesion due to seismic movement and “liquify,” causing object on top to flow with the soil movement
- Example: when you wiggle your toes in the wet sand near the water at the beach and you start to sink
- Mainly happens with sand, silt, and gravel soils.
- More reason to care what type of soils our parcels are on

Liquefaction Risk Zone

Source: SANDAG, SANDAG Parcels (2022). Retrieved from SANDAG GeoHub

Importance of Soil Types during Construction

- Soil type plays significant role in the success of structures still standing during and after natural hazards (earthquakes and flooding).
- 3 Basic Classifications of Soils: Sand, Silt, and Clay
- Combinations of these three produce different bases
- Clay is prone to expanding and shrinking
- The USDA identifies twelve specific soil texture classes, including combinations like loamy sand, sandy loam, and silty clay.

Leaning Tower of Pisa, Italy is the most famous result of building on unstable soil

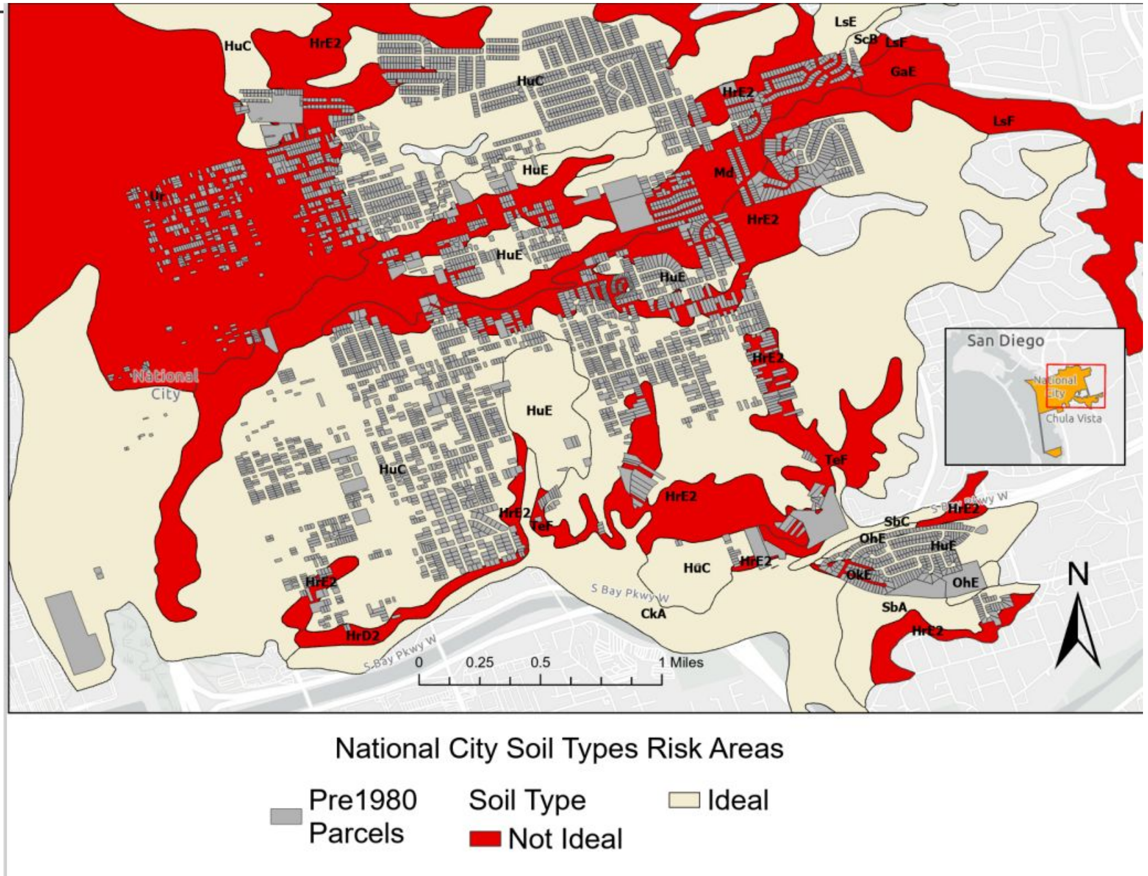
National City Soil Risks

Most Risk: **HrE2,** TeF, HrD2, LsF, GaE, *Ur, Md, OkE*

HrE2: Huerhuero loam, 15 to 30 percent slopes, eroded

Red flag at Northeast parcels, as it lies in HrE2

Overall Safe Soil: SbA, **HuC**, **HuE**, CkA, OhE, SbC, ScB, LsE



USDA Web Soil Survey

Slope Risk Assessment by Building: Average Slope per Structure

Slope gradient affects **ground motion** amplification and potential for soil movement.

Where **hills** are present like in National City, gravity, shaking, and weak ground can result in landslides, foundation slide, or **building collapse**.

Residential buildings on or near **steep slopes** are very susceptible.

Identification and assessment of slope exposure is one of the initial steps to identify the structural resilience of residential buildings in seismic risk zones.

3411 Lou Street, National City. built on HrE2 soil at base of slope

National City Slope per Building

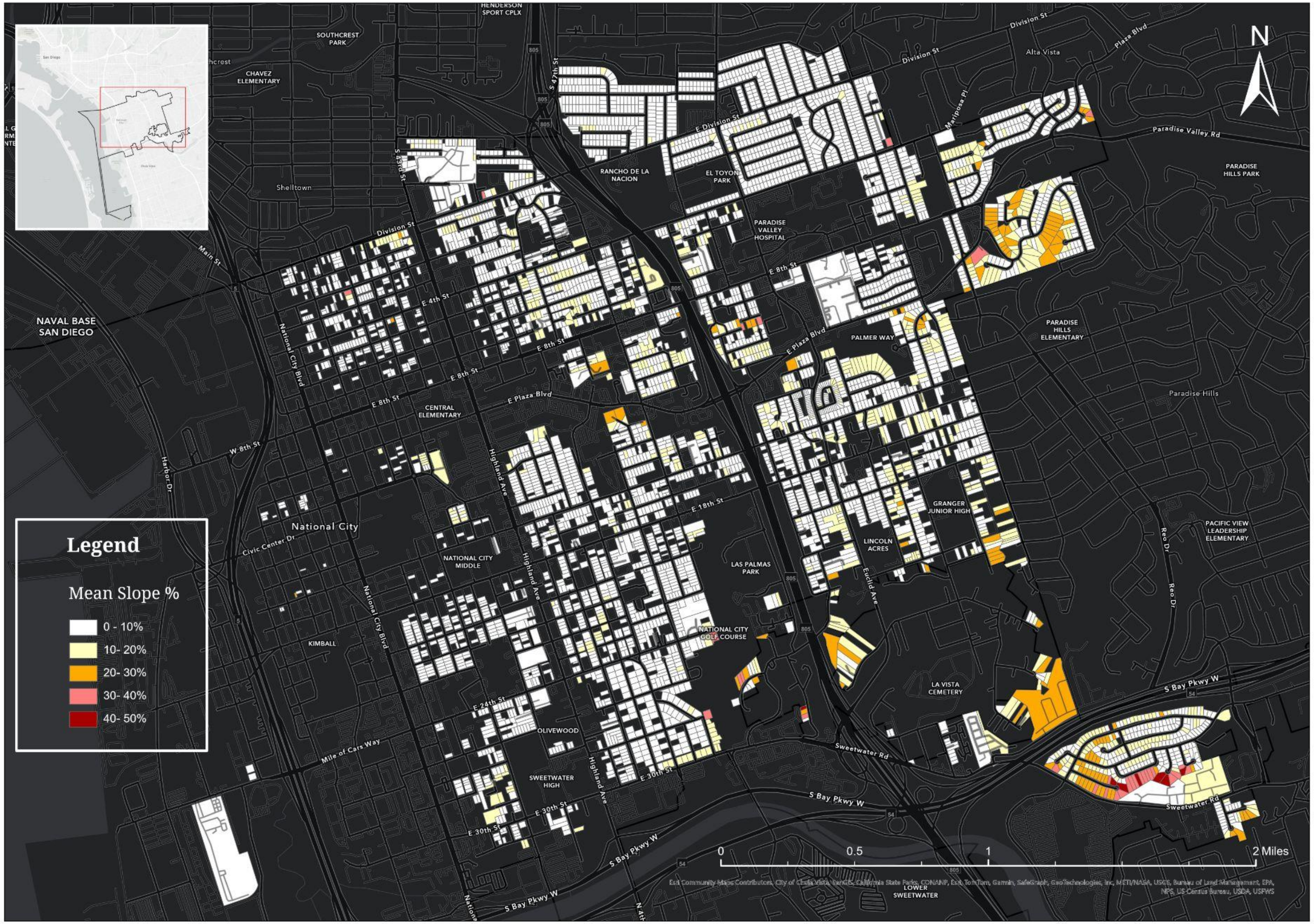
Percentage rise slope raster derived from **USGS DEM**

Used **zonal statistics** with national city building footprints as zone layer and slope as value raster

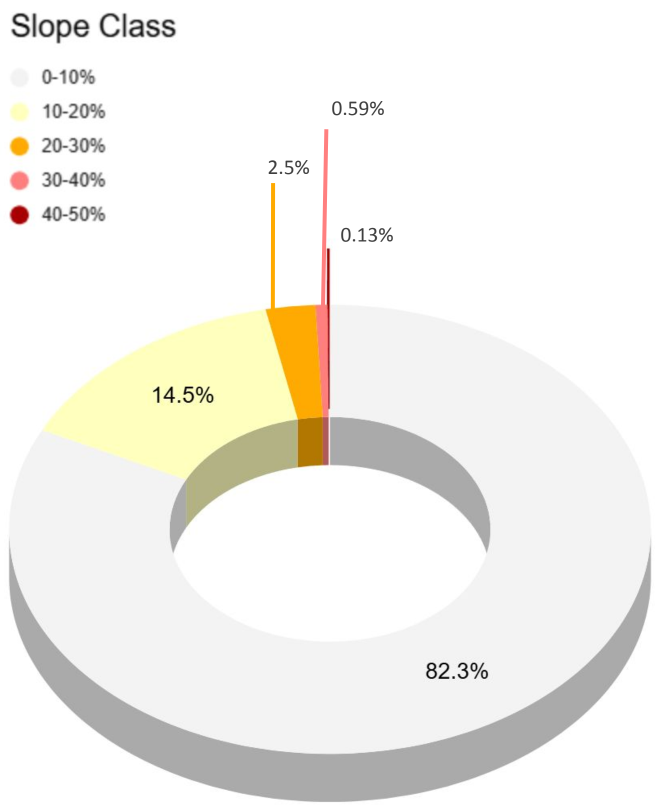
Calculated the **mean slope** per building

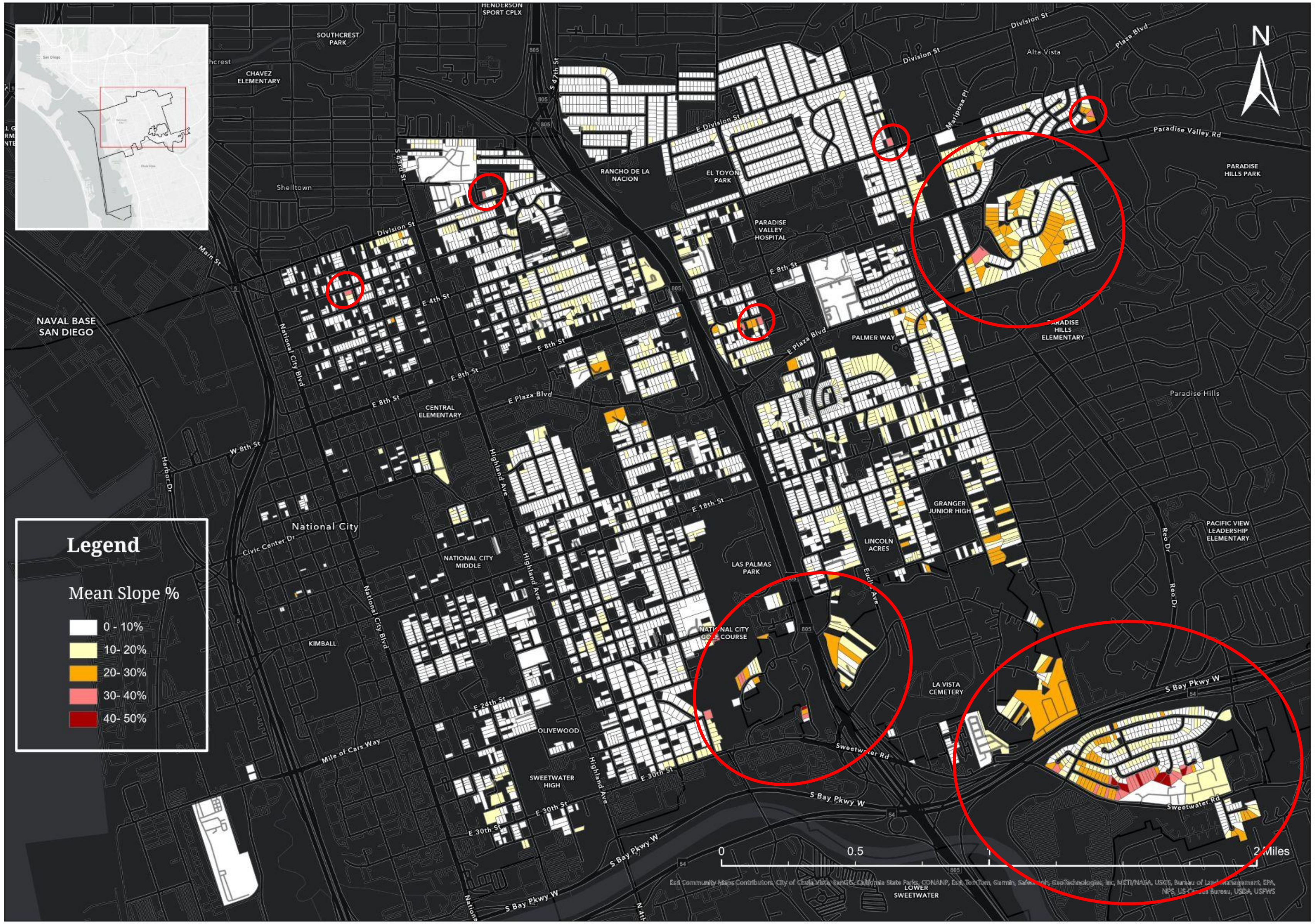
Normalized values ranging from 0 to ~50% yielding a score from 0 to 1 as input for the following weighted analysis

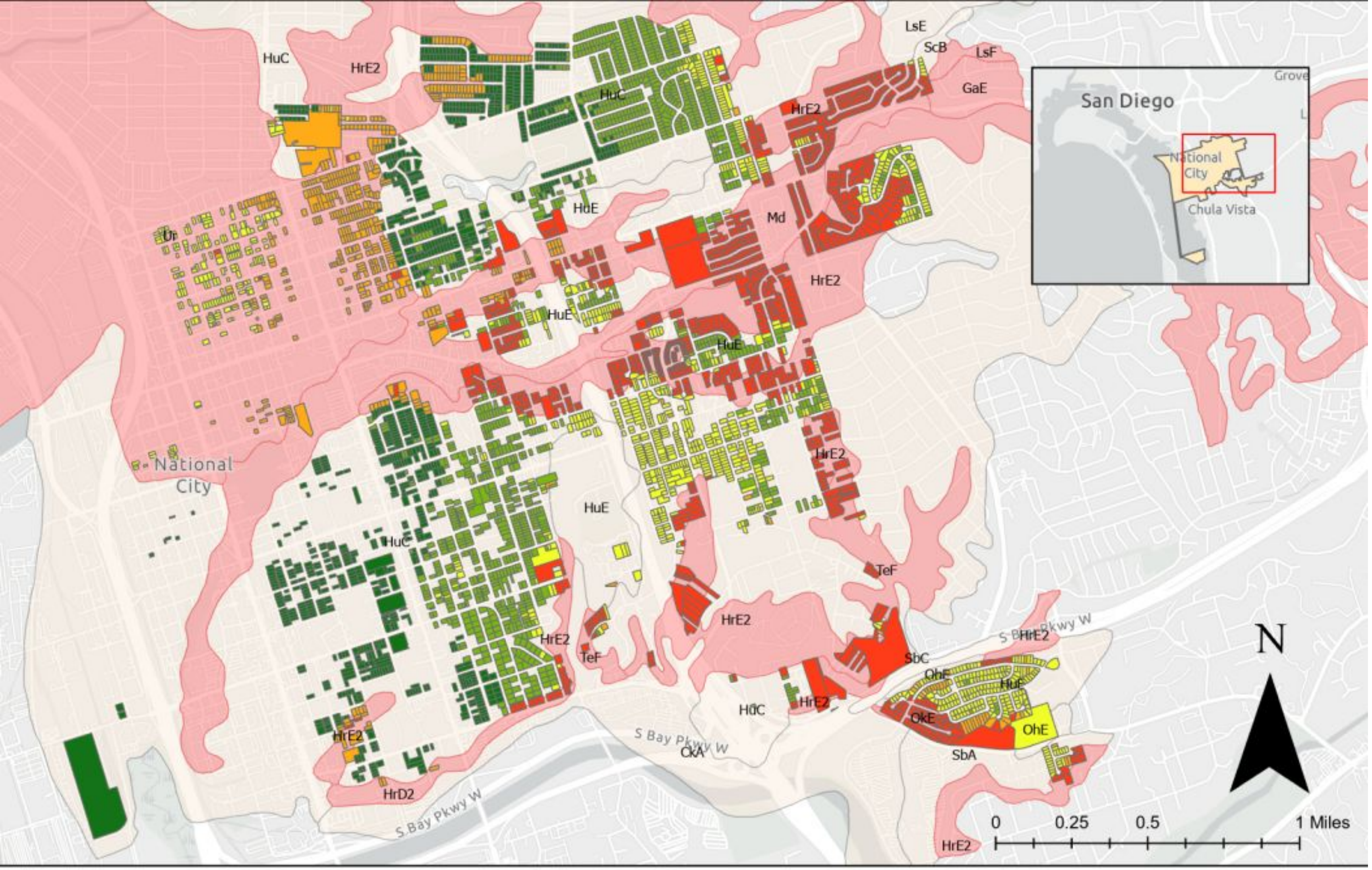
Visualized slope per building in **five classes**



National City Slope per Building







National City Risk Analysis

Risk Percentage

- 4.82% - 23.80%
- 23.81% - 32.26%
- 32.27% - 42.58%
- 42.59% - 58.77%
- 58.78% - 95.84%

Soil Type Risk

- No Risk
- Risk

Number Format

Category: Percentage

Percentage

- (•) Number already represents a percentage
- ( ) Number represents a fraction. Adjust it to show as a percentage

Rounding

- (•) Decimal places: 2
- ( ) Significant digits: 6

Alignment

- (•) Left
- ( ) Right: 12

- [ ] Show thousands separators
- [ ] Pad with zeros
- [ ] Show plus sign

Display number as a percentage

OK Cancel

Risk_facto =

```
(!NormSlope! * .33 + !soil_class! * .33 + (1-!
  Norm_Dist2!) * .33) * 100
```

Limitations & Future Improvement

Limitations:

- Limited to online platforms (Satellite imagery, Google Street, Redfin ect)
- Limited visibility of structural features (crawl spaces, foundation type, building structure)
- Missing property data for older or unlisted homes (blurred homes on google)
- Inconsistent/outdated data for building age

Future Improvements:

- Refine the risk factor weighting with expert opinions, explore changing the weighting options
- Excluded Property Review

  Verify previously excluded properties are not pre-1980 due to initial filtering methods.

Conclusion

Wood frame was primary structure material

Collecting data from multiple perspectives is key when analyzing structure safety

Building structure, number of stories, crawl spaces

Weight Risk of 3 Factors contributing to structure safety

Proximity to fault lines + Soil type + Slope

Retrofit units with emphasis on high risk areas in Northeastern and Southeastern parcels.

Analysis: Data Sources

- National City Parcel Layer
  -
- Liquefaction Risk Zone Layer
  - https://geo.sandag.org/portal/home/item.html?id=e8d1f45ac7e44c1cb734487dd25064de
- California Fault Lines
  - https://www.usgs.gov/programs/earthquake-hazards/faults
- Soil Layer
  - https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx
- Slope Layer (Based on USGS DEM)
  - https://www.sciencebase.gov/catalog/item/5f77840982ce1d74e7d6c318

Acknowledgement

- GEOG 584
- National City
- The Sage Project
  - Dr. Jessica Barlow
- SDSU Engineering Team
  - Dr. Gloria Faraone, Docean Park, Tiffany Mae Casaje

Any Questions?

Individual Contributions

Member	Contribution
Steffany Chavez	Parcels on northeast side, slides 8,9,12,13, 21, 22, 24, and analysis
Micha Goll	Analyzed the southwest parcels, created the mean slope per parcel raster with zonal statistics, visualized slope classes and high-slope spots, slides 27,28,29
Timothy Boyd	Filled in the Parcels on the Northeast Side of the Parcels West of the 805. Crated Layouts for slides 15 and 17 categorizing the parcels by building structure type and number of stories.
Max Johnson	Worked on the parcels in the northwestern section West of the I-805 for the building stories, type and crawlspaces. Did slides 18 and 19 to show how we identified crawlspaces.
Charles Dare	Review of Parcels West of I-805, Review of all Parcels for crawlspaces, Assembled data for Slides 19 & 20, Presented on Slides 20 and 31-33, Desktop Dashboard showing progress of initial parcel review and attribution by all team members.
Gianna Salazar	Review of parcels West of 805– Northwest parcels. Presented analysis slides 25 and 26
Brett Iverson	Worked on area East of 805 54 junction, Plaza Bonita, created and presented year built distribution and unpermitted add-ons slides.
Ian Liermann	Worked on area northeast of I-805, east of the E 8th St exit. Created introduction slide.
Angel Resendiz	Worked on parcel data east of the 805 from E 8th to E 16th, my data is colored in orange. Organized slides 4 thru 7 using images from building structures found in National City.
Andrew Fakhri	Worked on my designated Parcels East of the I-805. Presented slides 10,11

1. Introduction & Background
2. Project Objectives
3. Method
- Annotating building structure types, # of stories, and existence of crawl space: Use of the ArcGIS platform (online & Pro), flow chart, and team efforts
- Analysis
-- Map visualization: Year built, Structure types, # of Stories, existence of Crawl Space, Slopes, Sociodemographic characteristics, Geophysical seismic risk factors (Proximity to fault lines (active/inactive fault), historical earthquake frequency and magnitude, soil characteristics (type, density, stiffness), liquefaction susceptibility, etc).
-- Specific analysis led by Graduate students
--- Terrain analysis to map slopes (use finer scale DEM), overlay with parcels, examine the relationship with slopes and parcel attributes (e.g., structure types, crawl space), possibly discuss landslide risk
--- Collect sociodemographic characteristics data at Census Block Group (or Tract) and analyze the relationship between them and aggregated parcel characteristics at each census unit. Possibly conduct Regression Analysis or GWR
--- Collect geophysical seismic risk factor data and associate them with parcels.
--- Conduct Weighted Linear Combination analysis to generate earthquake risk map
4. Results
- Present results
5. Discussion
- Discuss the results
- Limitations & Future Improvement
6. Conclusion & Acknowledgement
- Make sure to acknowledge National City, Sage Project, and the Engineering Team.

Methods: Graduate Student Analysis

Terrain analysis to map slopes (use finer scale DEM), overlay with parcels, examine the relationship with slopes and parcel attributes (e.g., structure types, crawl space), possibly discuss landslide risk
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