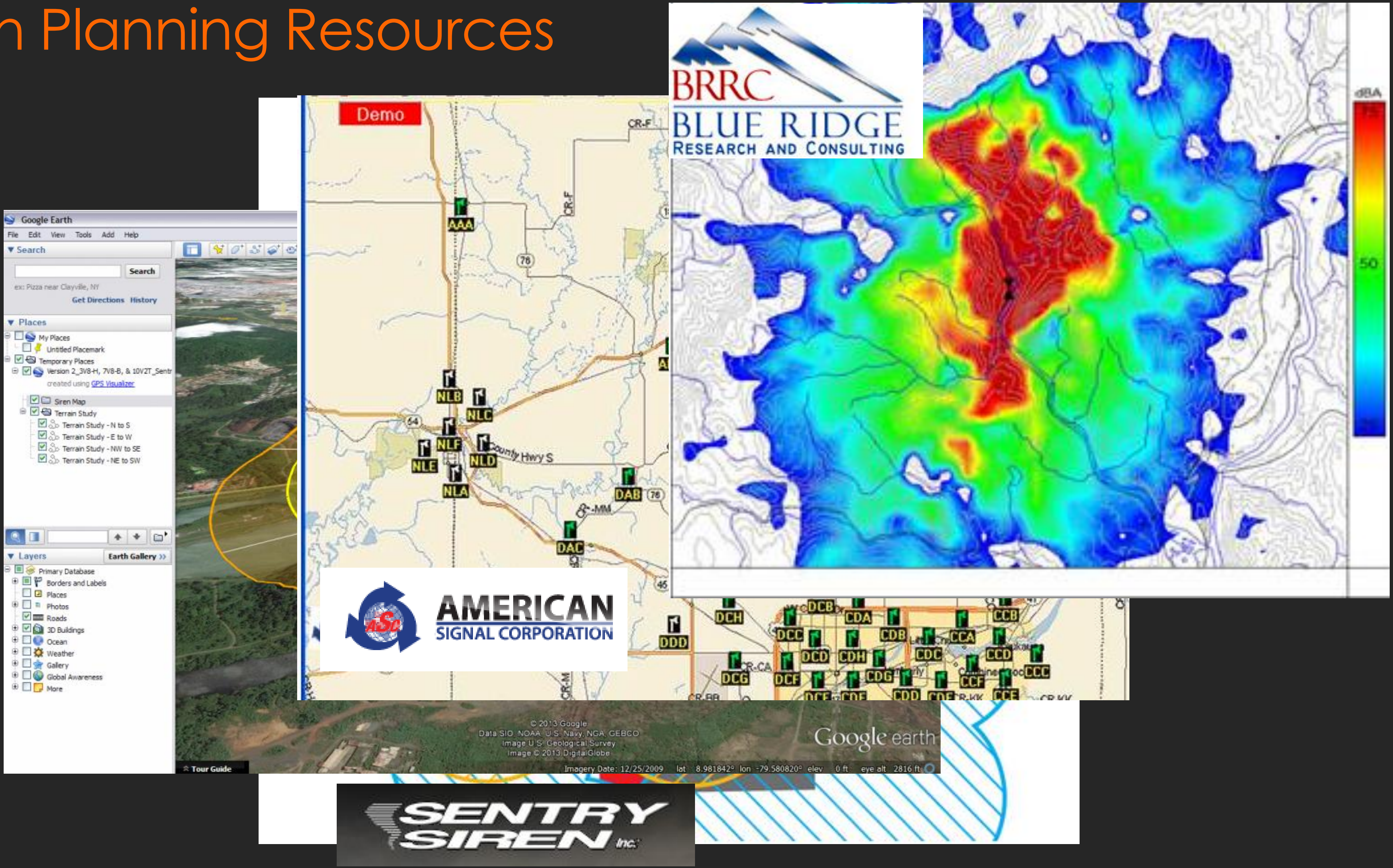
Emergency Siren Coverage Area and Optimization Analysis

Barbara Webster
MS GIS Program
University of Redlands

Siren Planning Resources



Eventual implementation in Bahrain

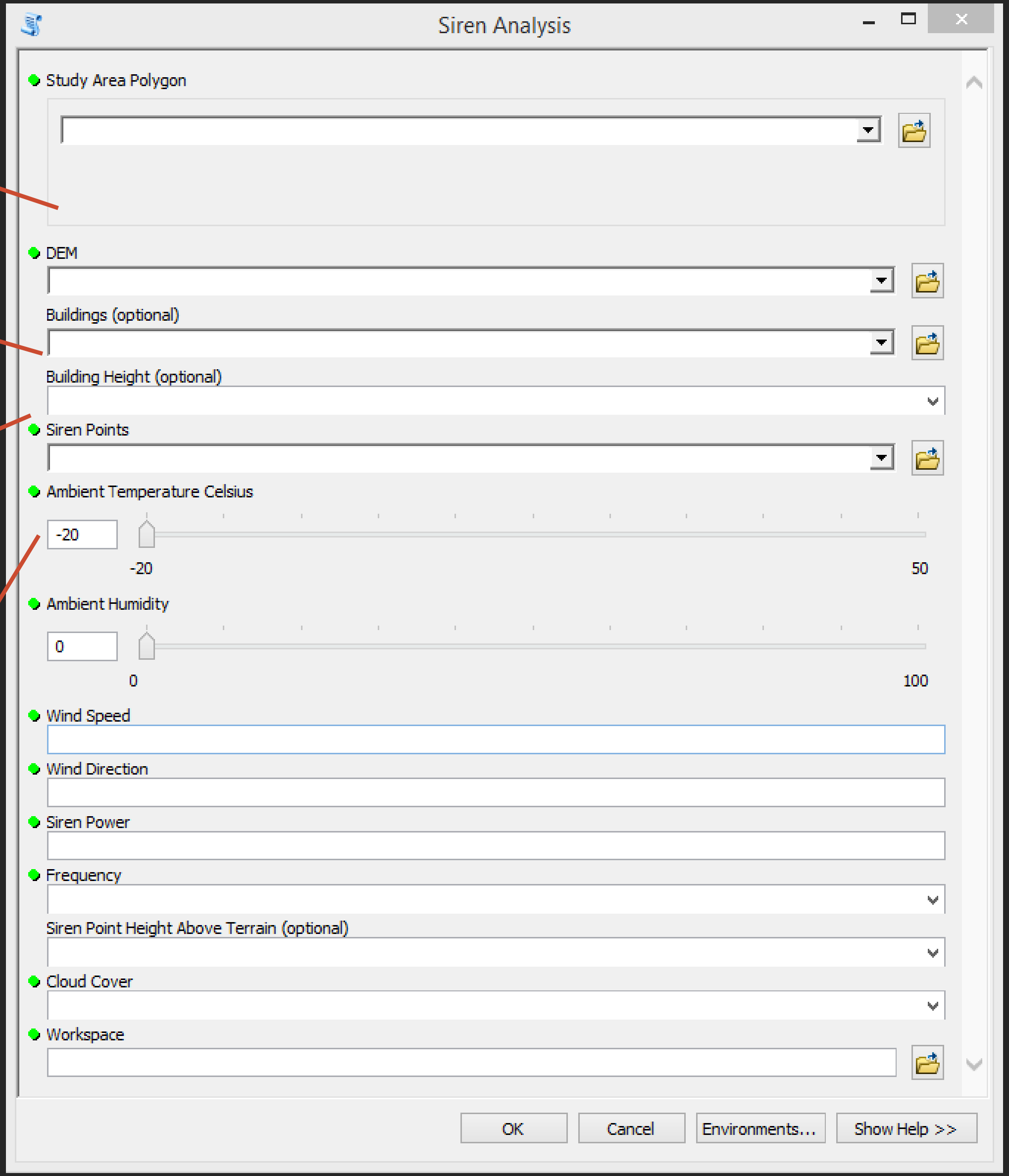
Problem Statement

- **Recommend the best locations** to put new sirens
- **Siren variables**:
  - Siren power (in decibels)
  - Siren height
- **Environmental variables**:
  - Ambient temperature
  - Ambient humidity
  - Terrain
  - Wind direction
  - Wind speed

Solution

Input Layers

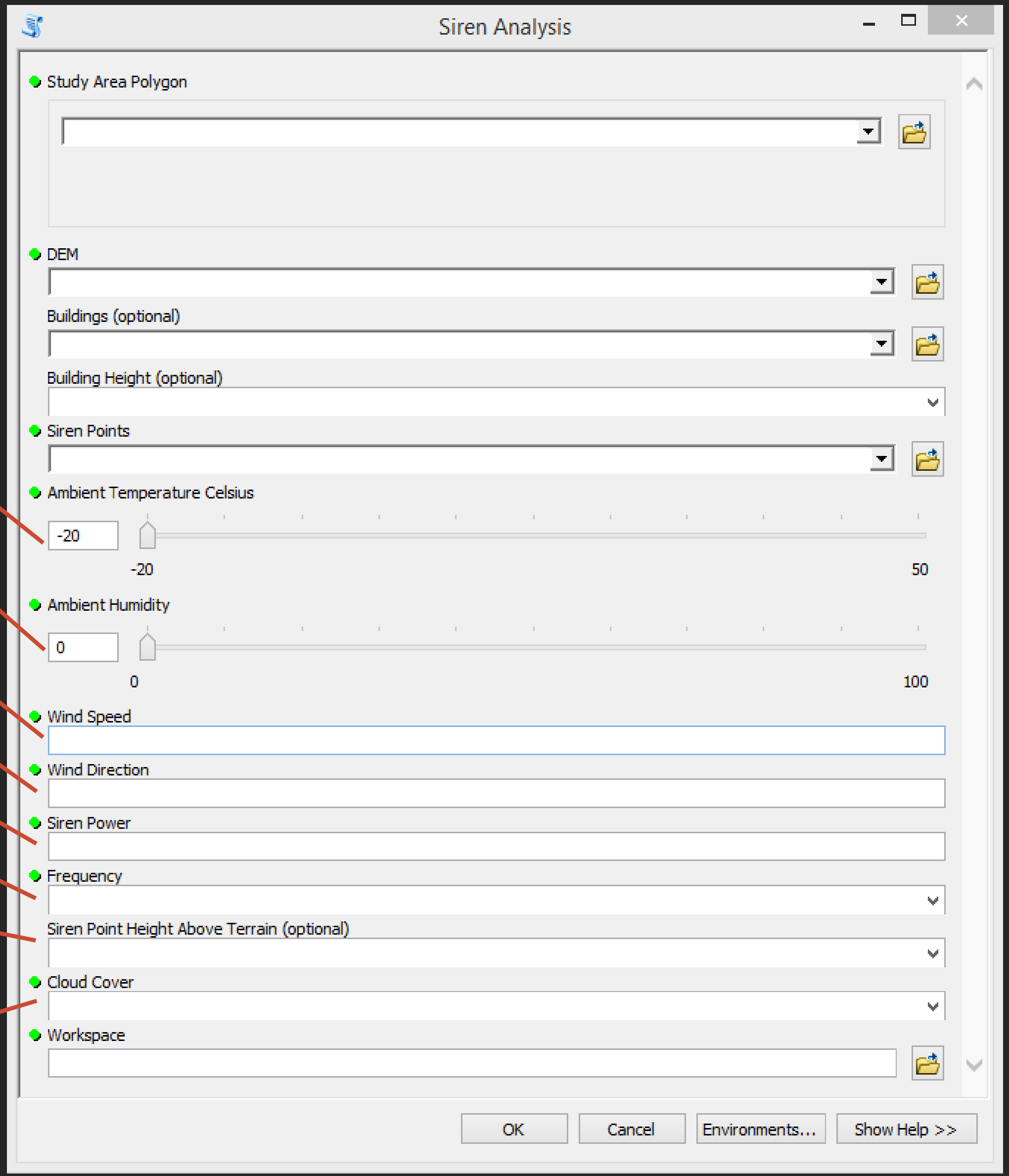
- Study area polygon
- DEM
- Buildings with height attributes
- Existing siren points



Solution

Input Integer Values

- Temperature
- Humidity
- Wind speed
- Wind direction
- Siren power
- Siren frequency
- Siren height above surface
- Cloud coverage



Overview of Analysis

Implement a sound propagation engineering model

→

Implement Rana's coverage optimization analysis

How to Find Sound Pressure at a Point:

$$L_p = L_w + D_c - A$$

L_p — Receiver Point Sound Pressure Level (dB)

L_w — Source Sound Power (dB)

D_c — Directivity Correction (dB)

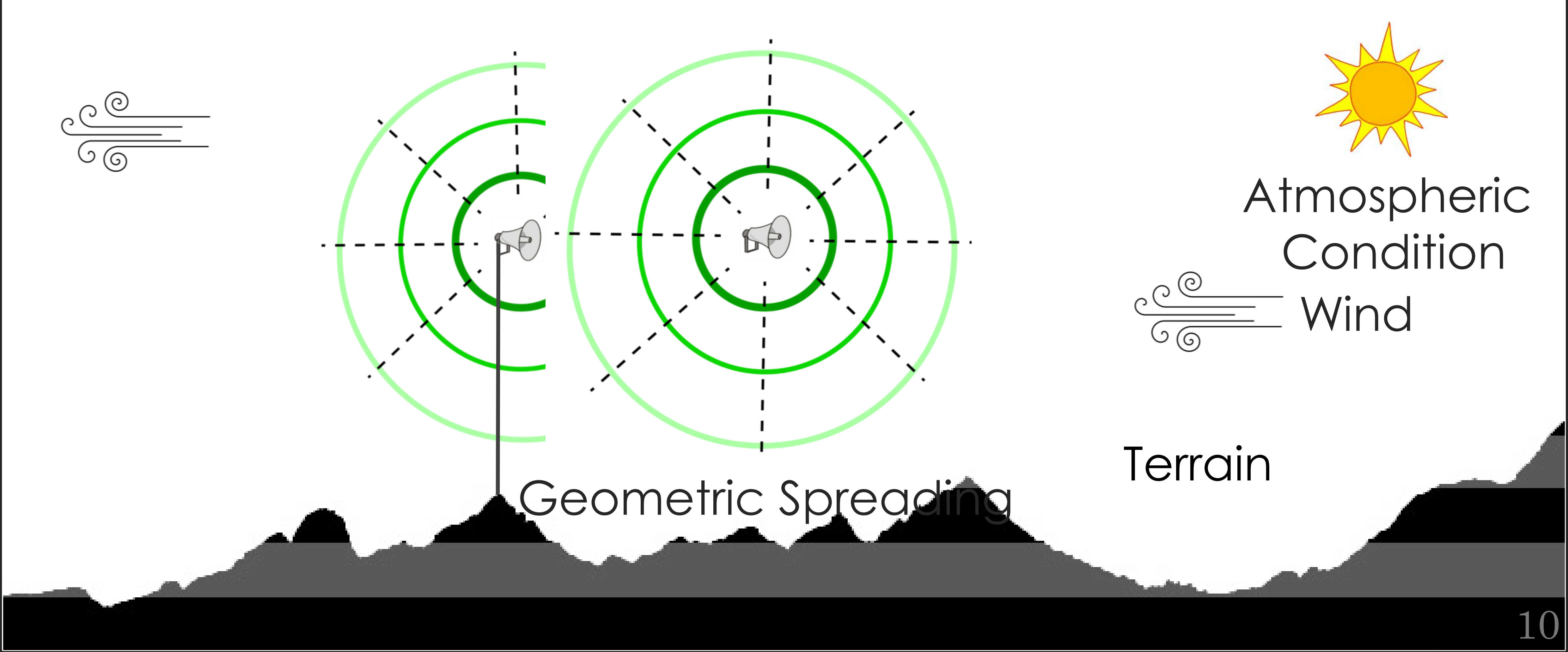
A — Attenuation (dB)

Sound Propagation Engineering Model

- Wind Farm Noise Propagation Prediction Model by (Bass, Bullmore, and Sloth, 1998)
  - Based on the IEA model (a sub model of the ISO-9613-2 model)

- CONCAWE upwind attenuation factor

Attenuation Factors Considered in This Model

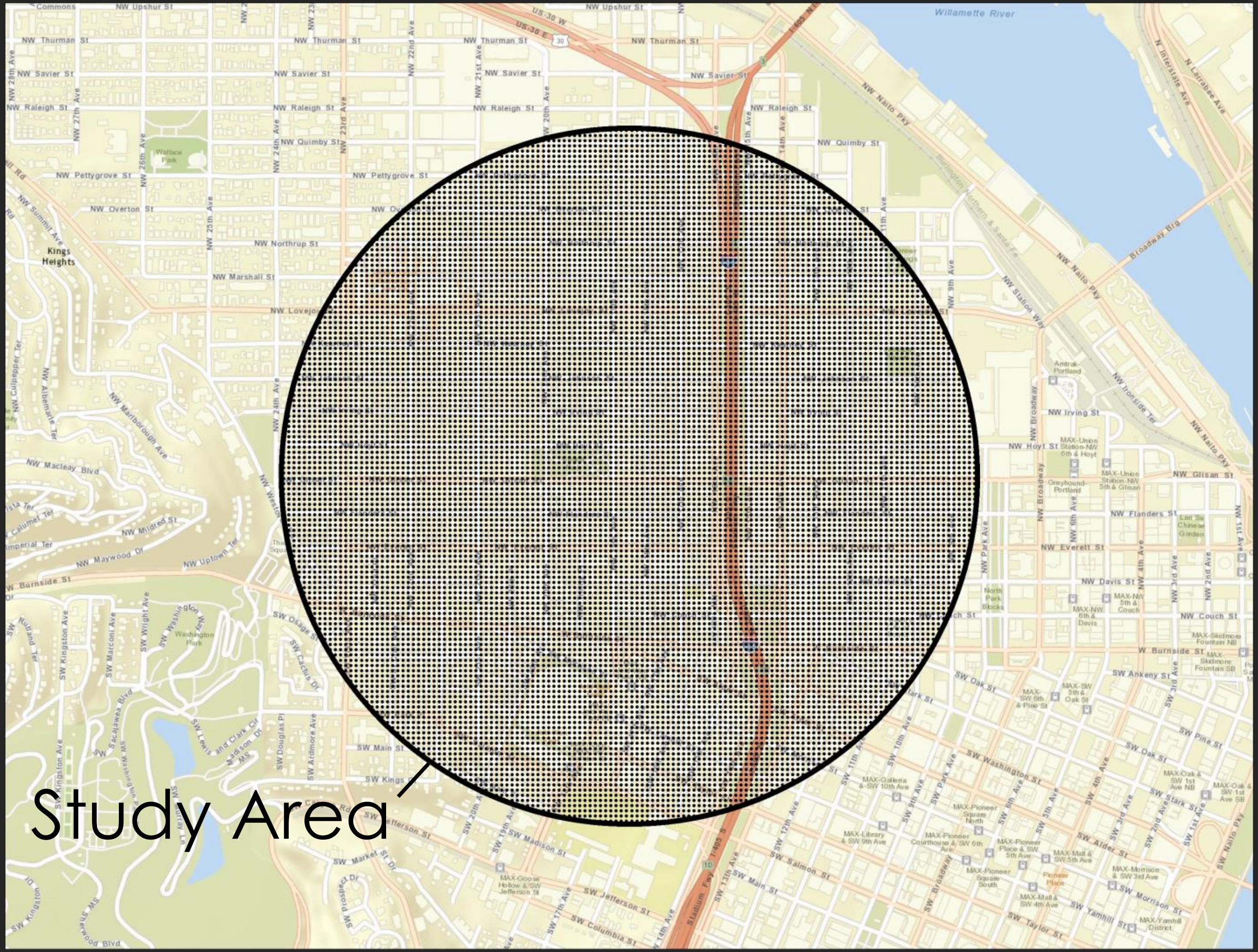


Sound Propagation Engineering Model Accuracy

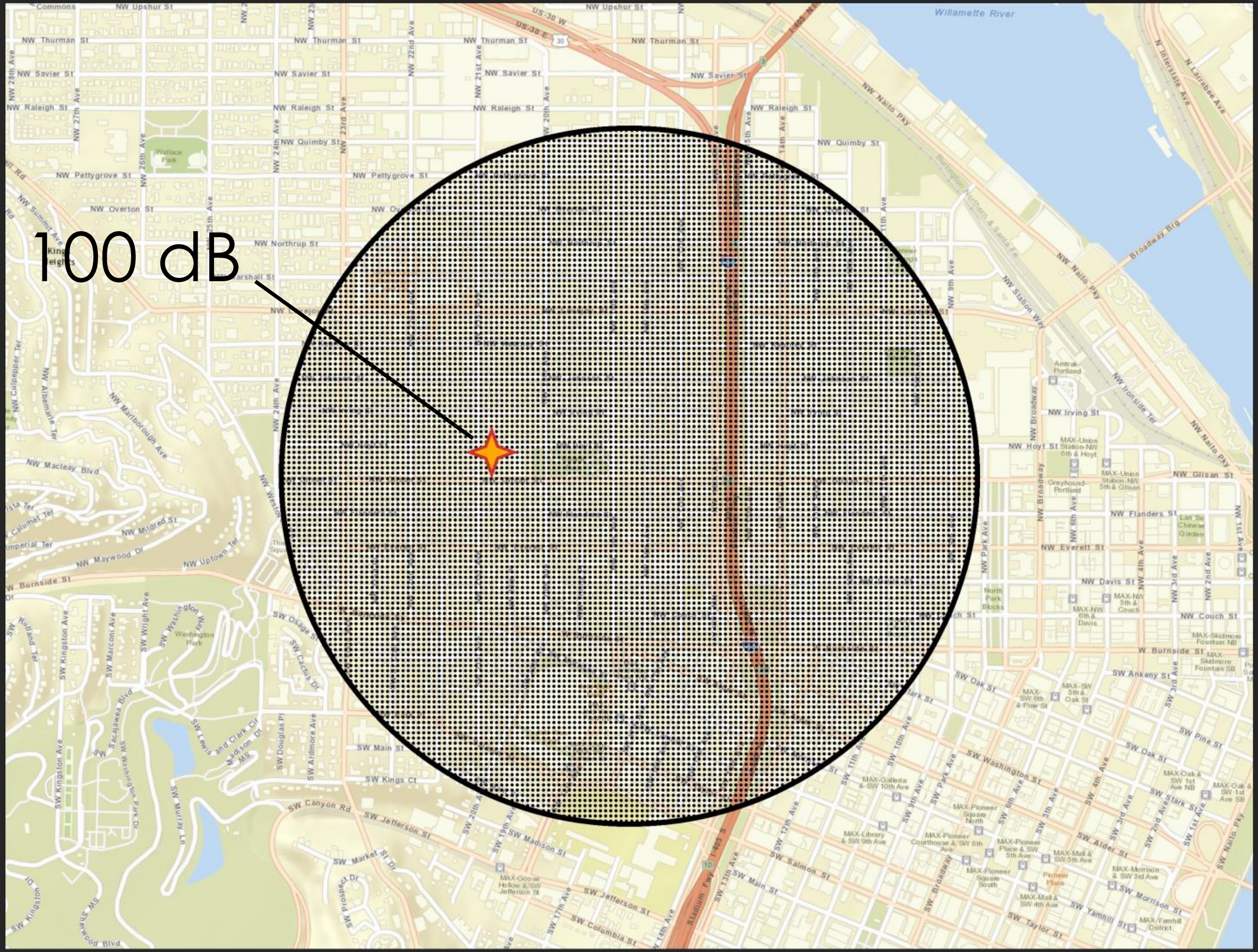
- Wind Farm Model Accuracy:
  - 2dB(A) of the level not expected to be exceeded for at least 85% of the time

- CONCAWE Model:
  - 95% confidence intervals: 6.9 dB (category 3, lowest accuracy) – 4.5 dB (category 6, highest accuracy)

Create grid of receiver points that covers the study area

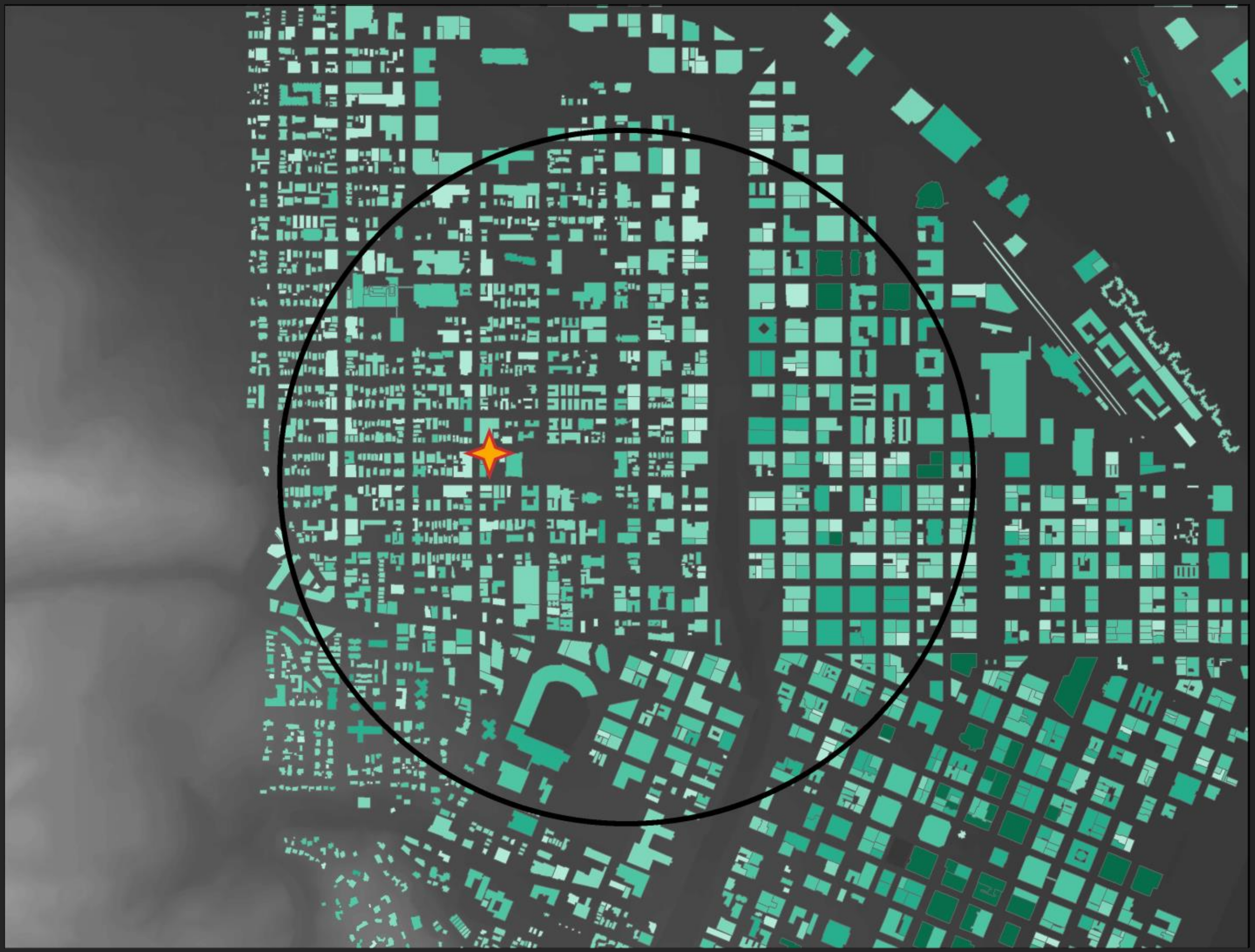


Add any existing siren points



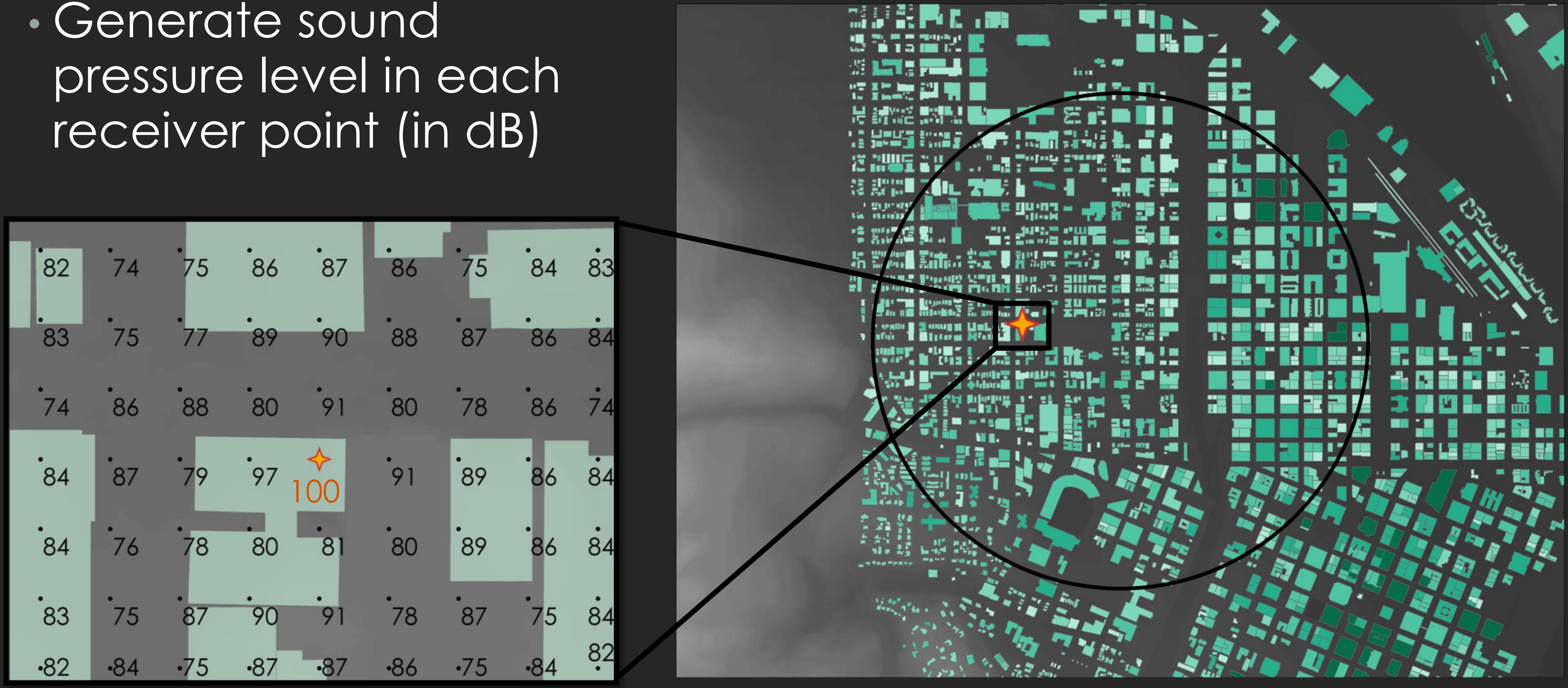
Integrate Data

- DEM
- Building polygon layer
  - with height attributes
- Integer Data
  - Temperature
  - Humidity
  - etc.

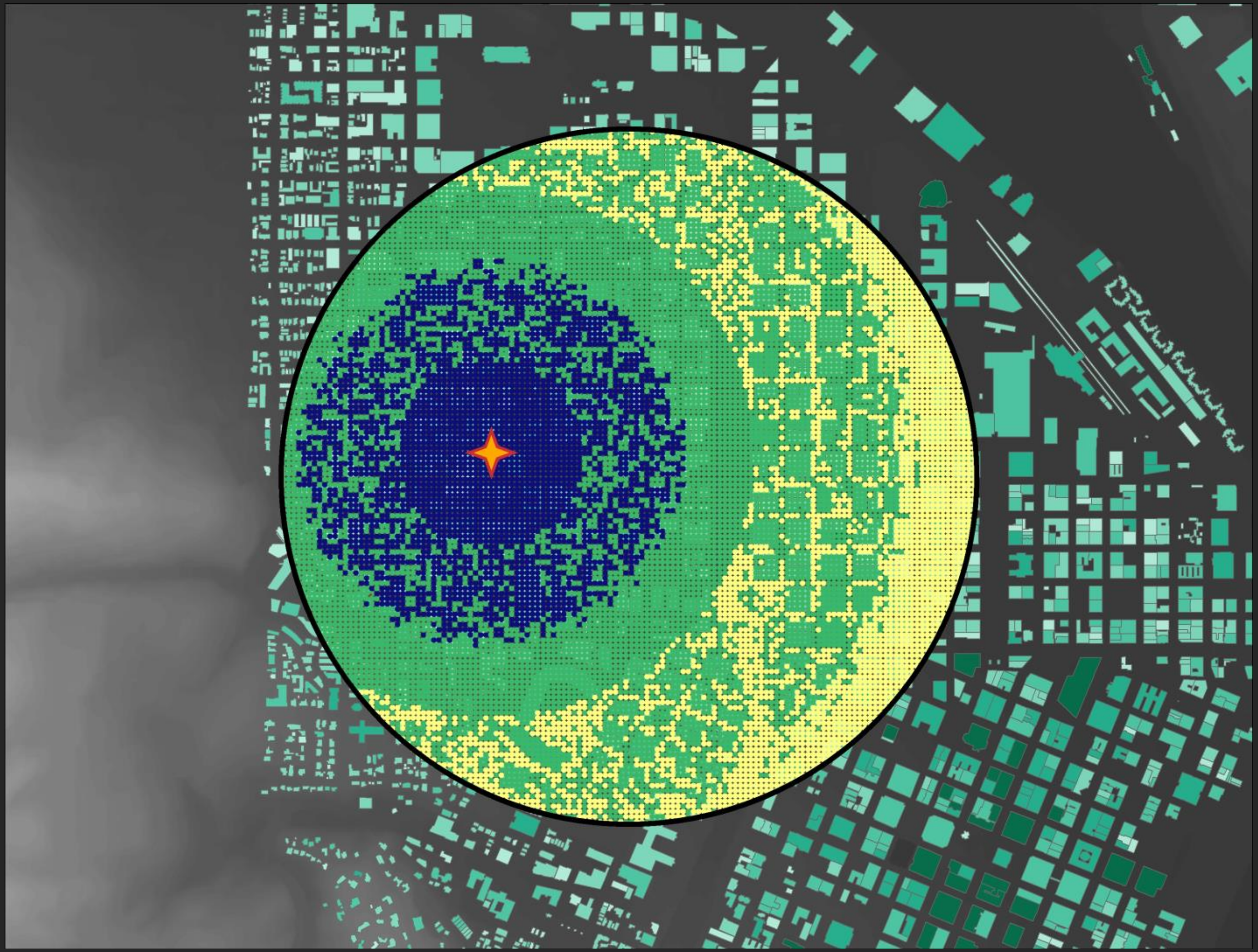


Solve the Sound Pressures at Each Receiver Point

- Generate sound pressure level in each receiver point (in dB)



Generate sound pressure level in each receiver point

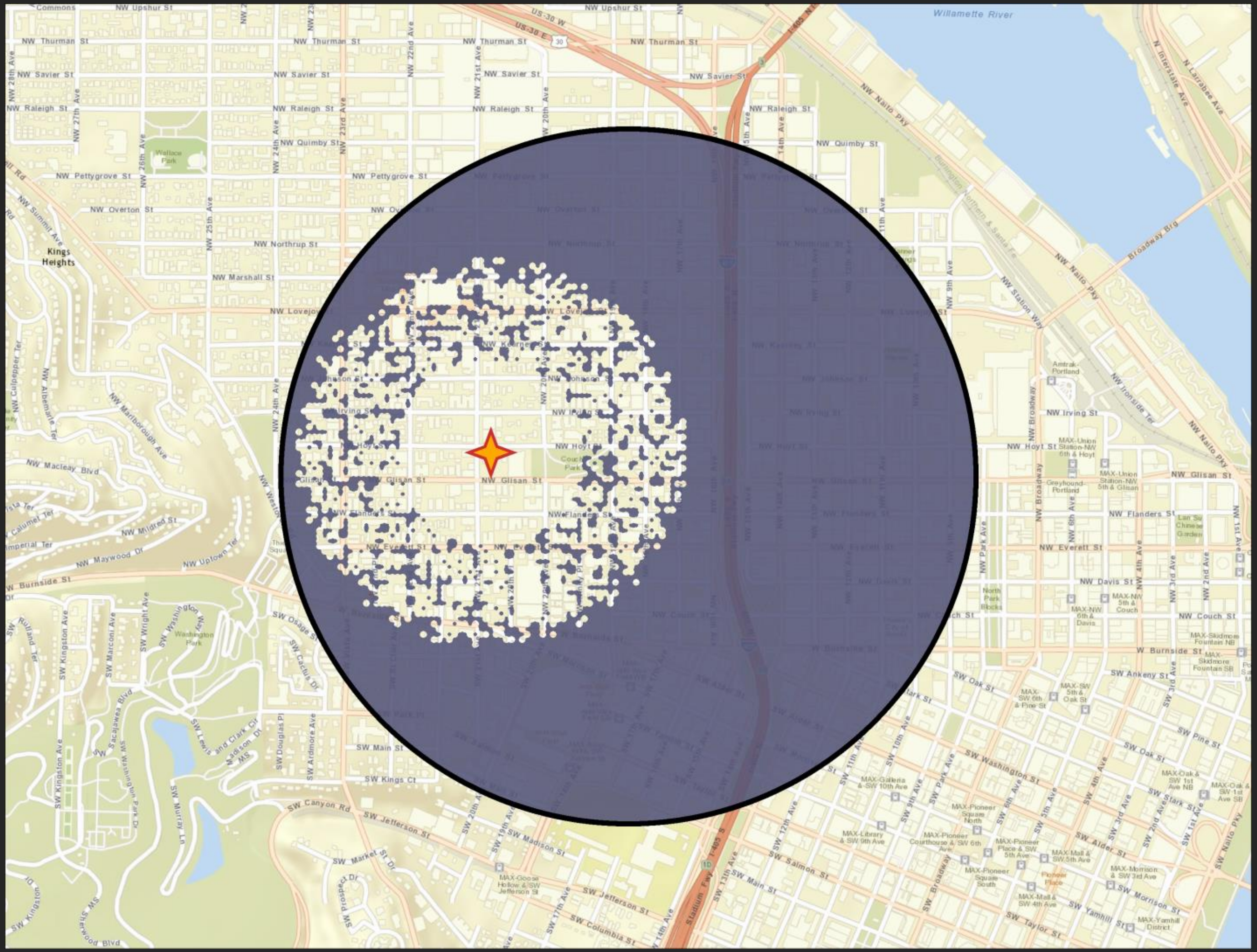


Receiver Point Sound Pressure

- 30 - 45 dB
- 45.1 - 60 dB
- 60.1 - 100 dB

Generate coverage area for existing sirens

- Subtract from area of consideration

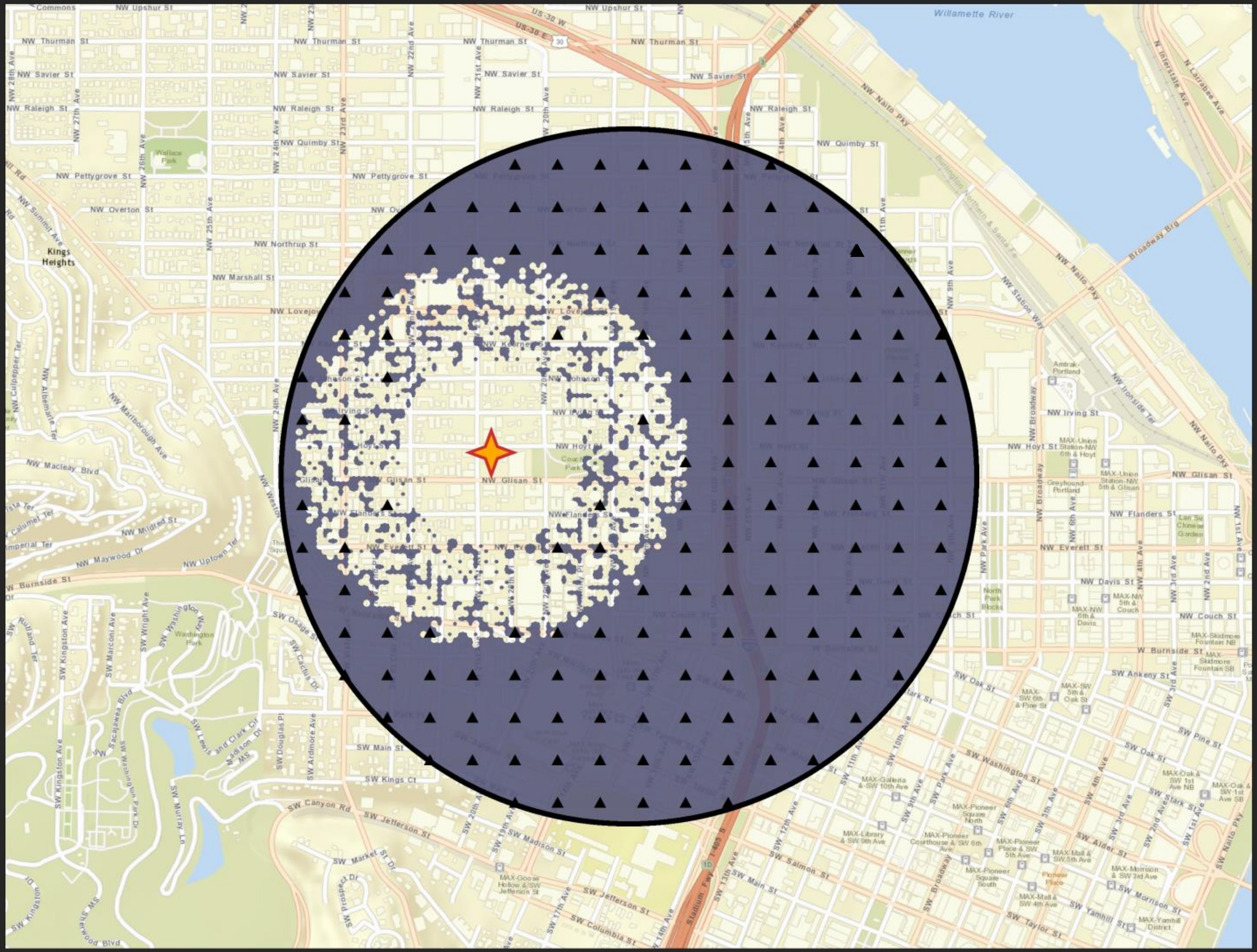


Implement Optimization Analysis

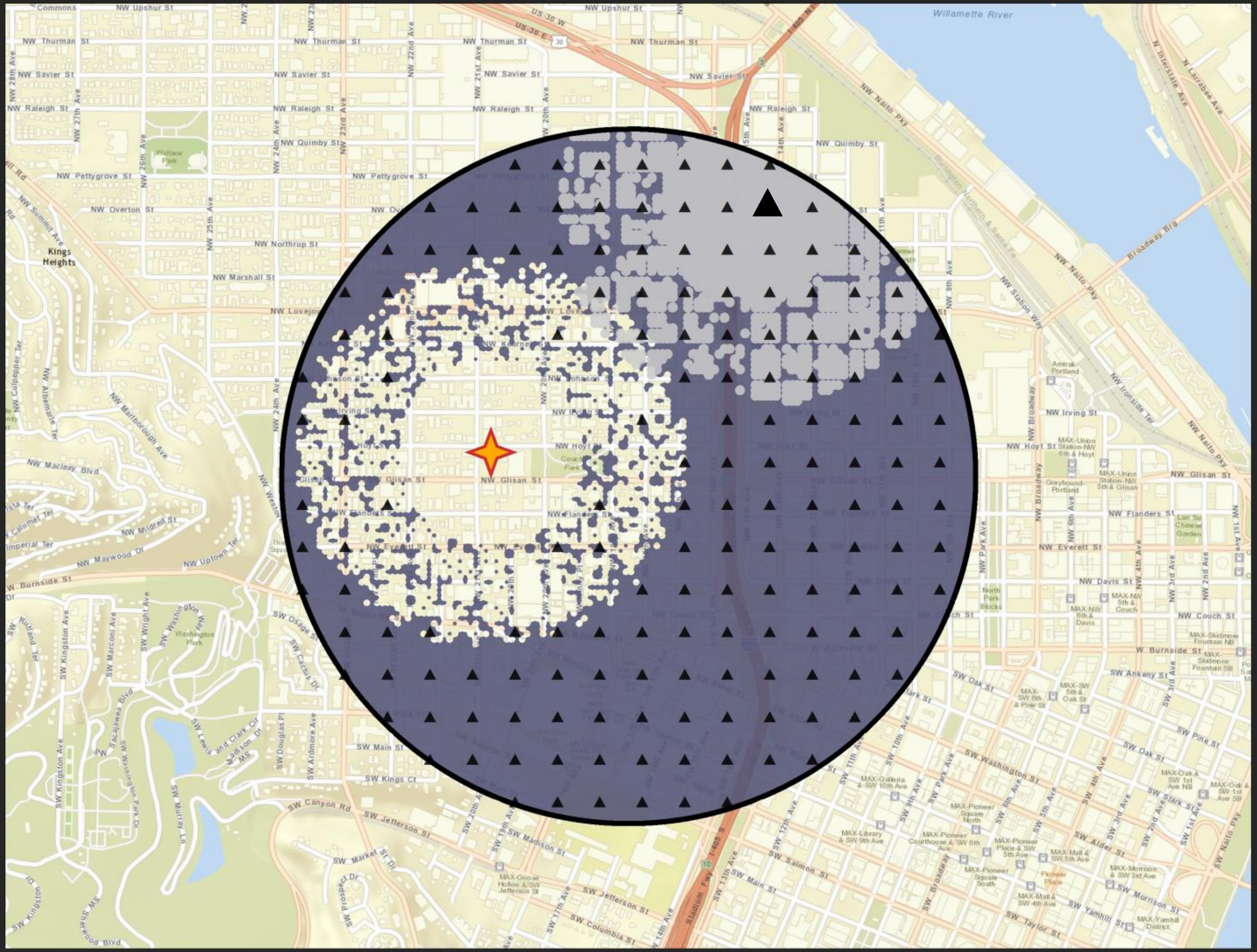
- Apply Sanjay Rana's Stochastical Rank and Overlap Elimination (S-ROPE) method
  - **Rank** – each source in a grid of potential sources
  - **Overlap elimination** – select highest ranked, eliminate overlapping sources
  - Repeat until area is completely covered.
  - Repeat entire process many times using different, random (**stochastic**), first point.

Generate grid of potential siren locations

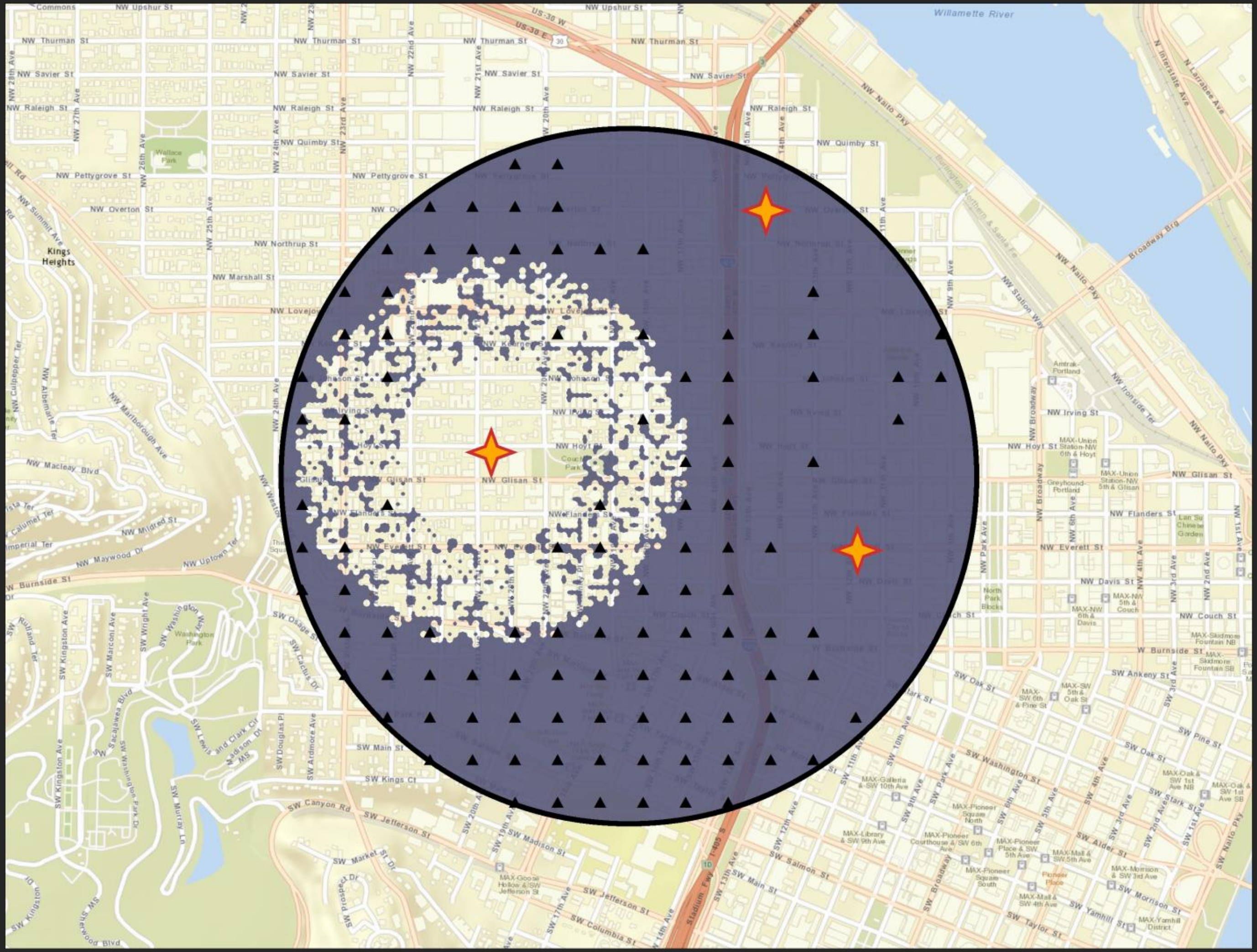
- Find coverage area for each potential siren



Find Coverage Area of Each Potential Siren Point

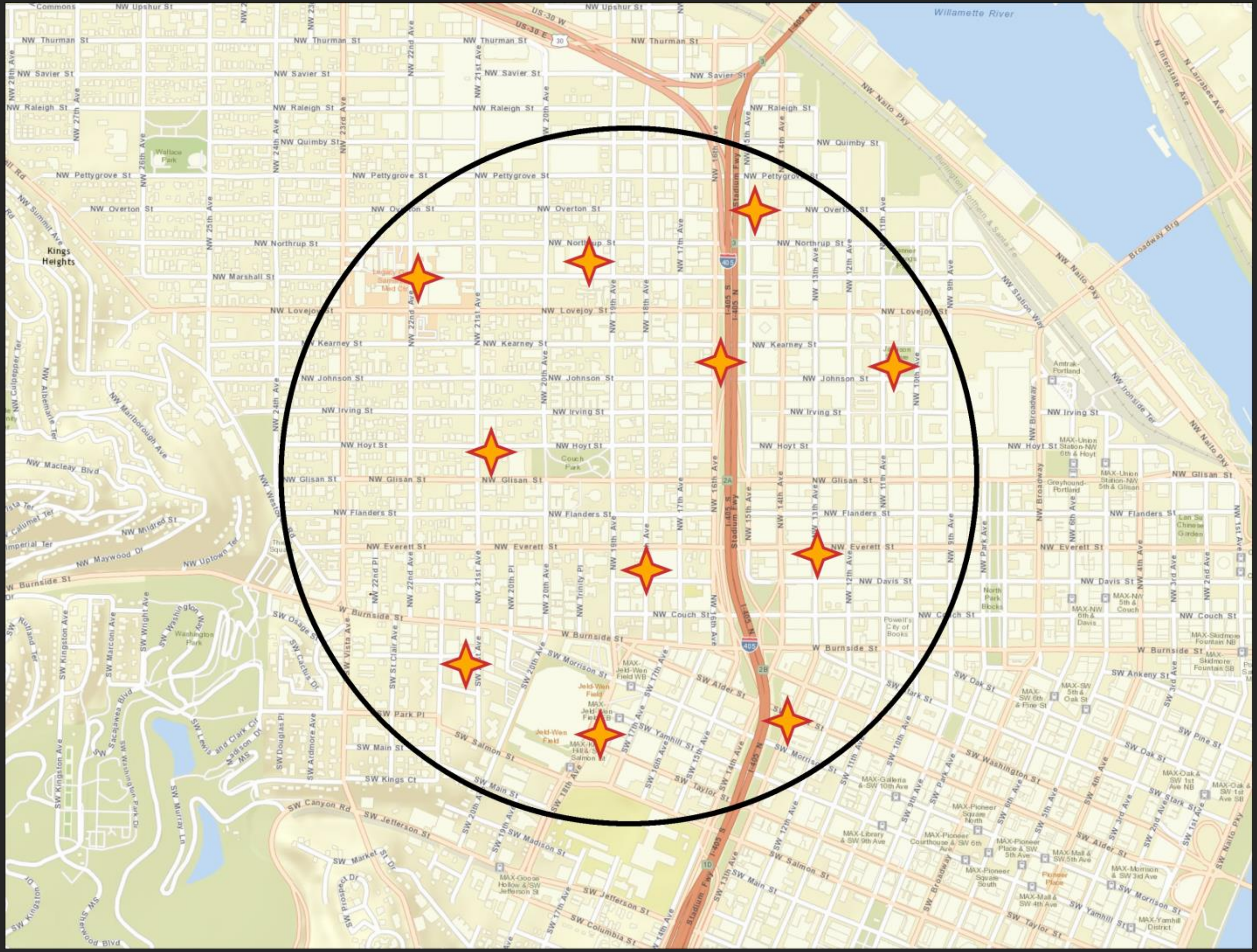


Choose Highest Ranking Siren

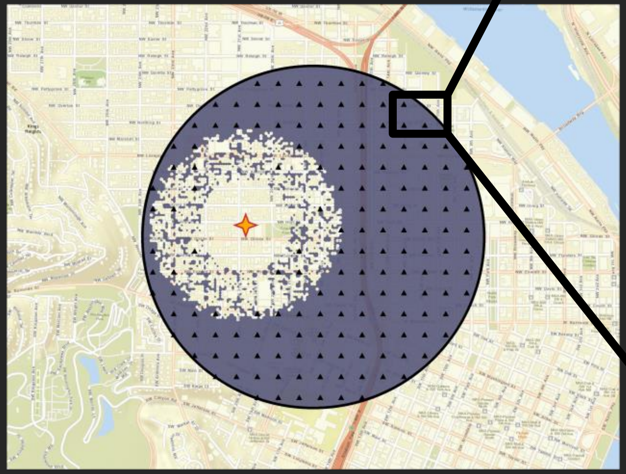


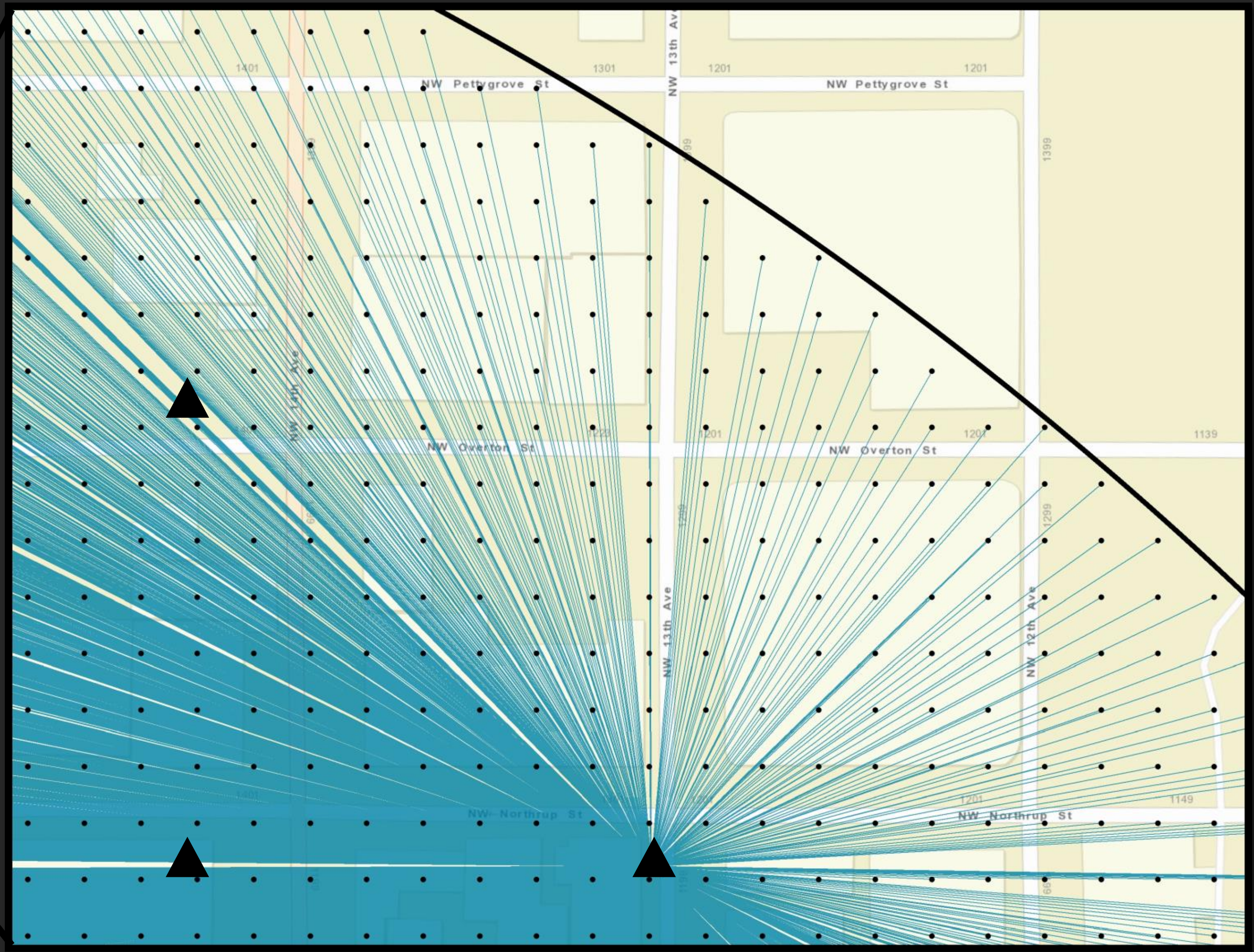
Output final results

- Output recommended siren locations

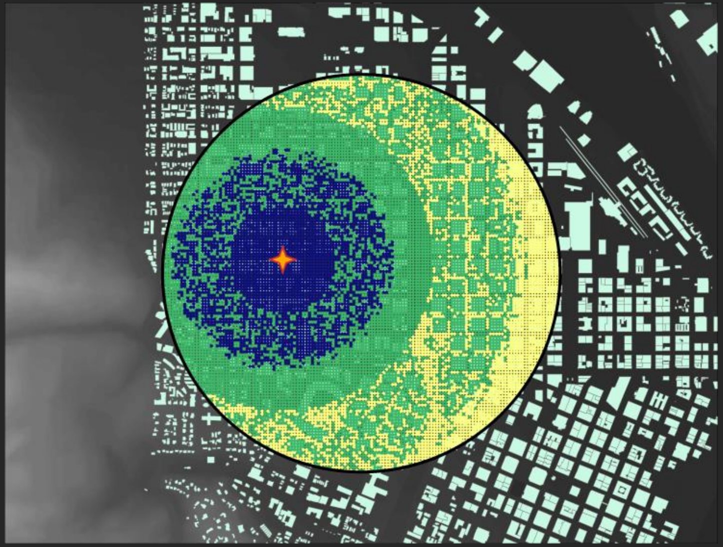


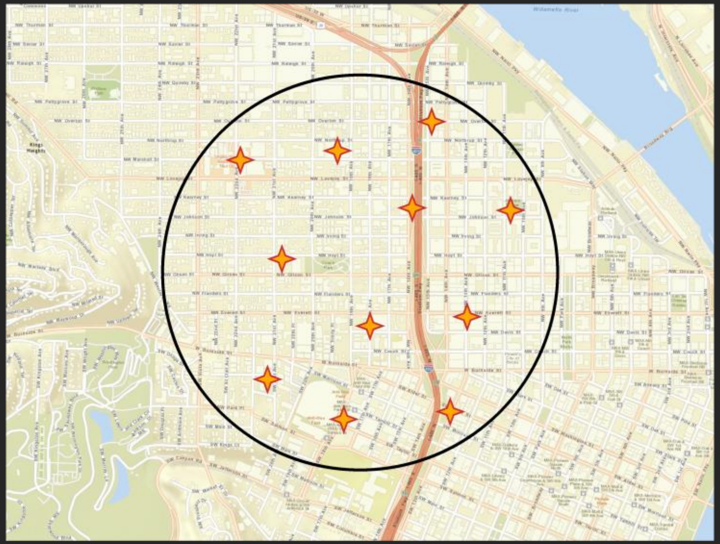
- Store sound pressure information in sight line feature layer





Summary





Future Work

- Add additional attenuation factors like buildings.
- Use advanced calculation model.
- Create visualization of the results in CityEngine

Thank You

Contact Information:
Barbara Webster
barbara_webster@redlands.edu

References

- Rana, S. (2006). Isovist Analyst - An ArcView extension for planning visual surveillance. *ESRI International User Conference*. San Diego, CA: ESRI. Retrieved February 2014, from http://eprints.ucl.ac.uk/2104/
- Manning, C. J. (1981). The Propagation of Noise from Petroleum and Petrochemical Complexes to Neighboring Communities. CONCAWE.
- Bass, J., Bullmore, A., & Sloth, E. (1998). Development of a Wind Farm Noise Propagation Prediction Model.
- International Standard for Organization. (1996). ISO-9613-2 Attenuation of sound during propagation outdoors Part 2: General method of calculation. International Standard for Organization.
- Economou, P., & Charalampous, P. (2012). A Comparison of ISO-9613-2 and Advanced Calculation Methods Using Olive Tree Lab-Terrain, An Outdoor Sound Propagation Software Application, Predictions Versus Experimetal Results. Proceedings of the Institute of Acoustics, 34. Retrieved from http://www.mediterraneanacoustics.com/portals/0/IOA%20Paper.pdf