

A DEMONSTRATION AND DISCUSSION OF SHADOW ANALYSIS TECHNIQUES APPLICABLE TO TUCSON'S DOWNTOWN

Tucson Area GIS Cooperative



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Presentation Outline

- Background / Introduction
- Research Problem
- Study Area
- Data
- Methodology
 - ▣ Shadow Analysis
 - ▣ Flex Viewer Application Development
- Results
- Conclusion

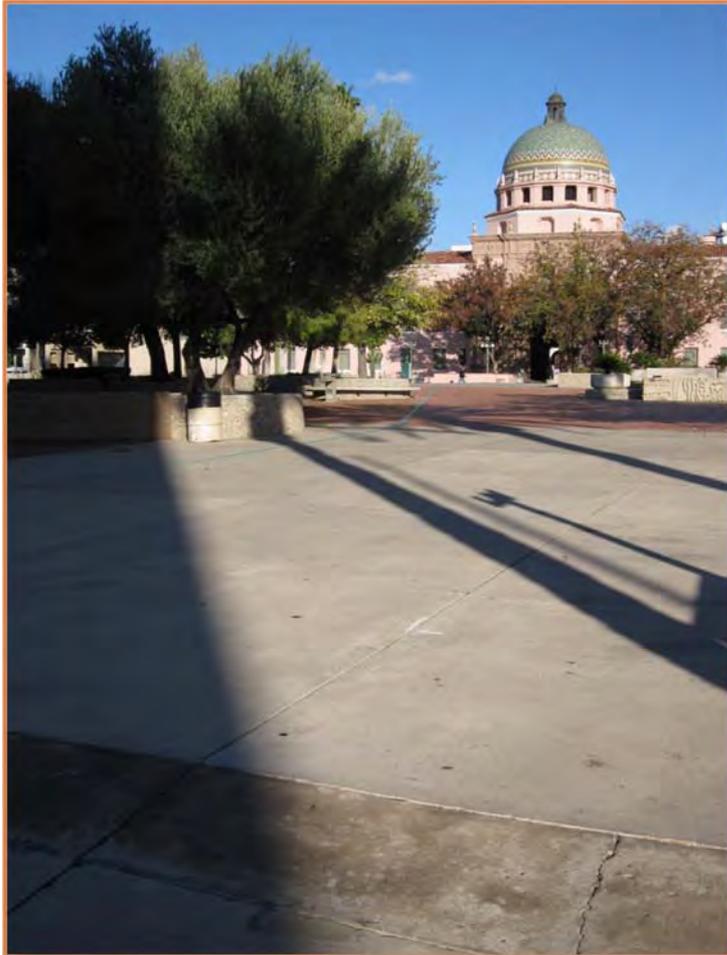


Background

- In many American downtowns, tall, closely-spaced buildings produce complex zones of shadow and sunlight.
- Identifying these patterns at fine spatial and temporal scales is often difficult.

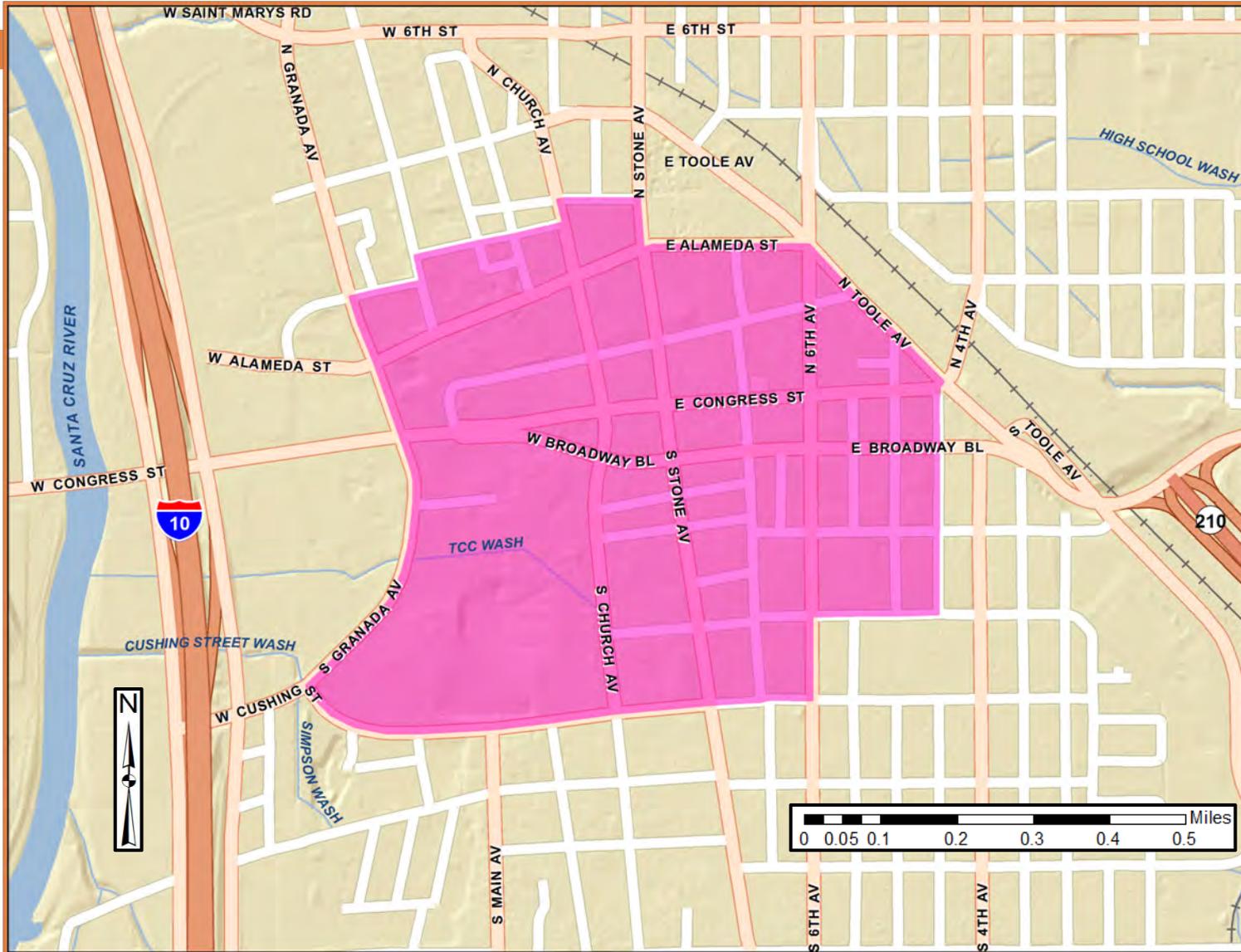


Research Problem



- Can Geographic Information Systems & Technology be used to help identify the spatial and temporal patterns of shadows?
- What data and methodology can best accomplish this goal?

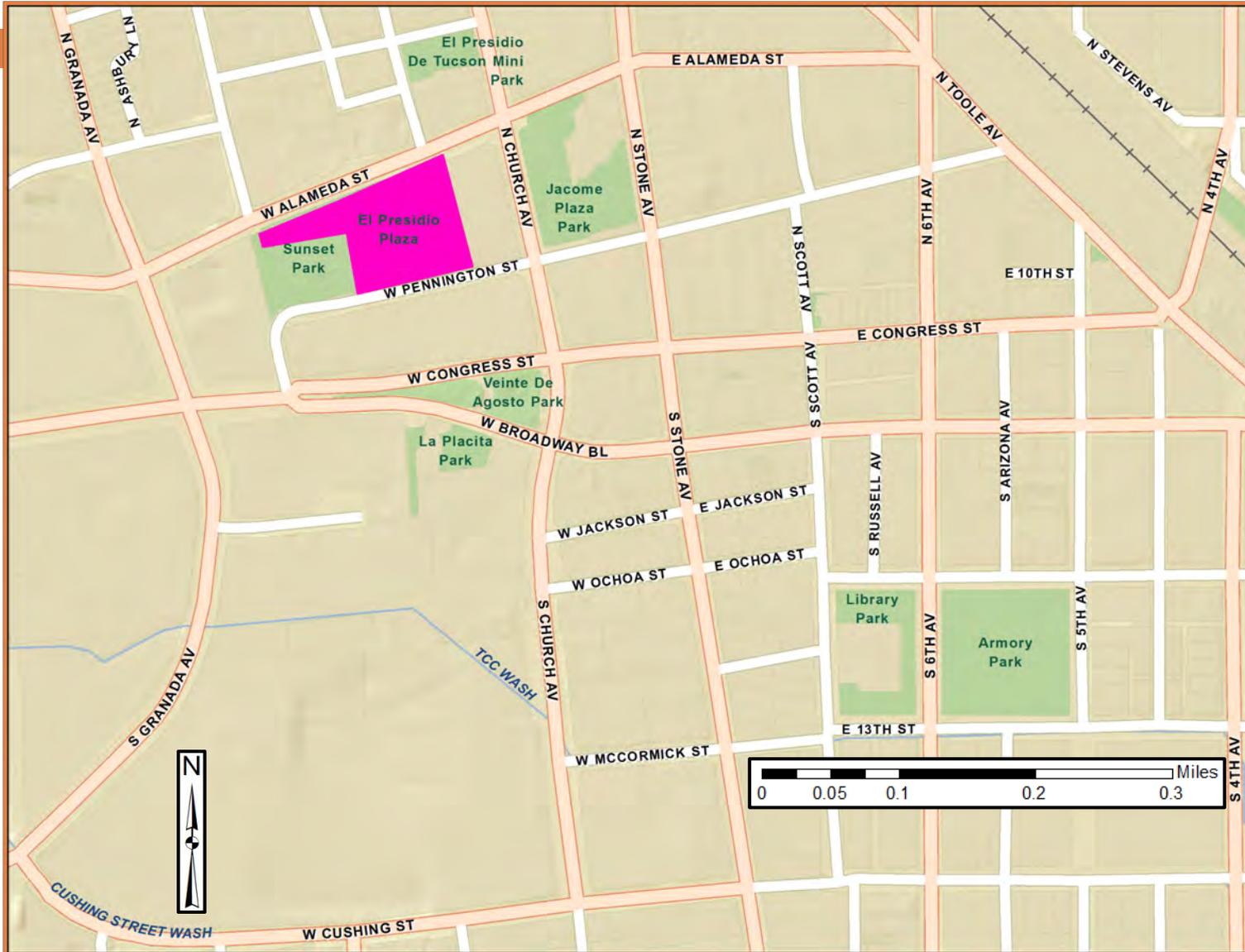
Study Area



Legend

- Downtown Study Area

Revised Study Area

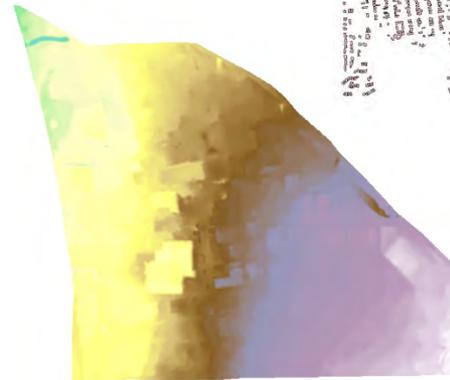


Legend

 El Presidio Park Study Area

Data Inputs and Compilation

- Aerial imagery (*City of Tucson/Pima Association of Governments, 2010*)
- LiDAR data (*CoT/PAG, 2005*)
 - ▣ Buildings polygons with elevation info (Z-values) (*CoT*)
- Digital Elevation Model (*CoT, 2008*)
- Additional City of Tucson vector and raster data
- ESRI tools, models & workflows



Methodology Overview

- Prepare/modify data inputs
- Create & manipulate **multipatch** feature classes
- Run shadow analysis
- Create shadow maps
- Add date/time data
- Merge feature classes

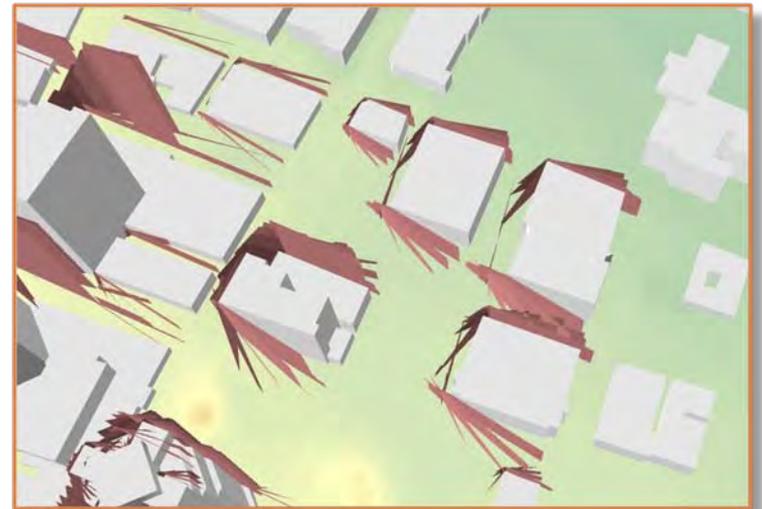
Methodology Overview



- Enable time data
- Upload shadow features and base data to server
- Publish services / cache tiles
- Create ArcGIS Viewer for Flex application

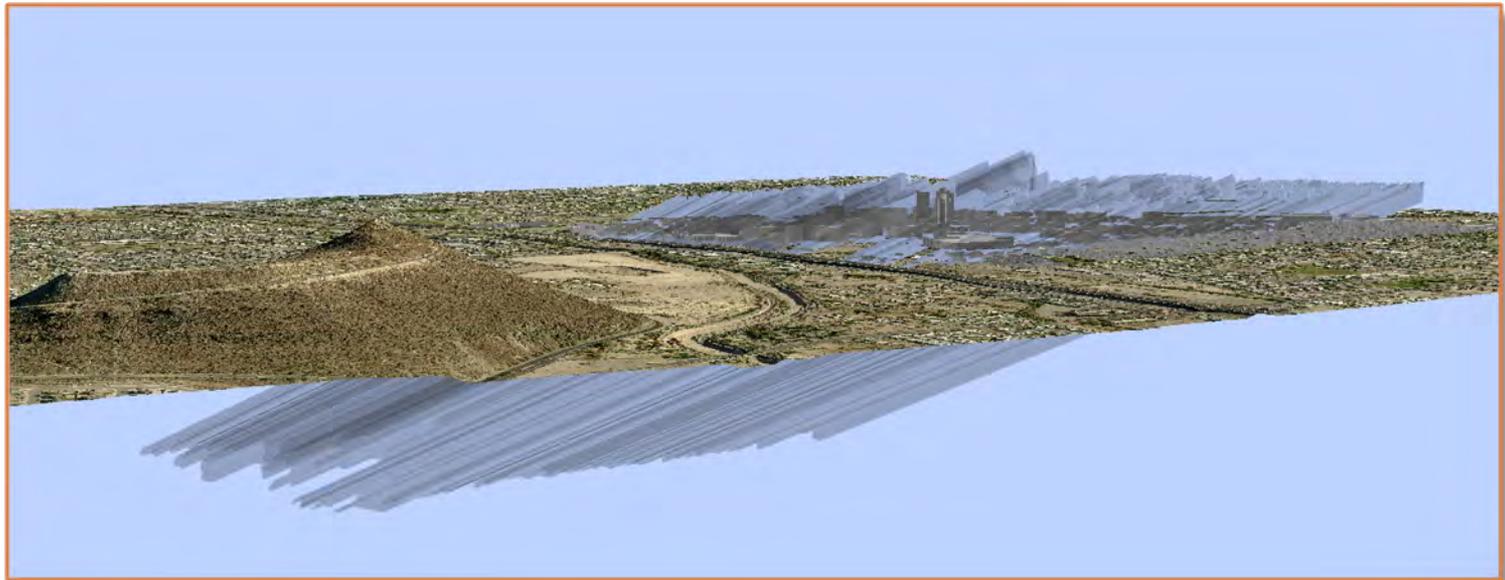
Shadow Analysis

- ESRI models created this year by 3D Product Team
- PyEphem astronomical calculator
- Sun points
- Buildings to silhouettes



Shadow Analysis

- Create shadows from sun pts & silhouettes
- 3D intersection with extruded polygon
- 3D footprint
- Join polygons



Flex Viewer Application Development

- Rebuild map documents; troubleshoot
- Publish map services
 - ▣ Two base layers
 - ▣ Four dynamic layers
- Cache tiles for base layers
- Modify main config.xml file
 - ▣ Layers
 - ▣ Initial extent
 - ▣ Select widgets
 - ▣ Layout

Flex Viewer Application Development

- Modify individual widget .xml files
 - Time Slider
 - Time format
 - Start/end times
 - Time intervals
 - Speed
 - Map Switcher
 - Static Image
- Modify styles/colors
- Upload graphics
- Test and modify

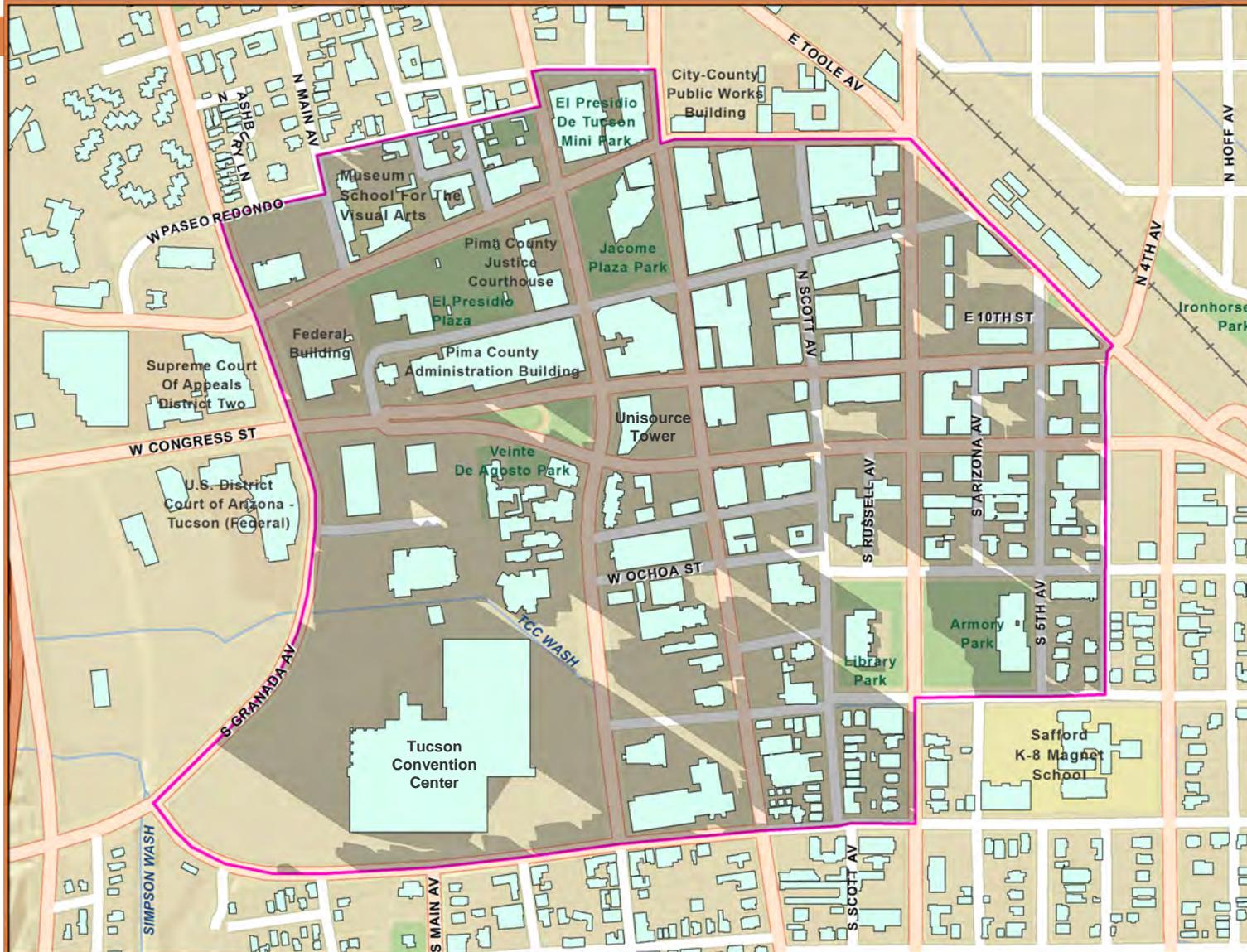
Results Overview

- Both maps and a FlexViewer application were produced
- Geoprocessing load required significant modifications, though...
- Demonstrable errors were evident; additional modifications should follow
- However, the outputs demonstrate the utility of this technique
- The current outputs also provide extremely valuable information about areas of sun and shade at different dates/times

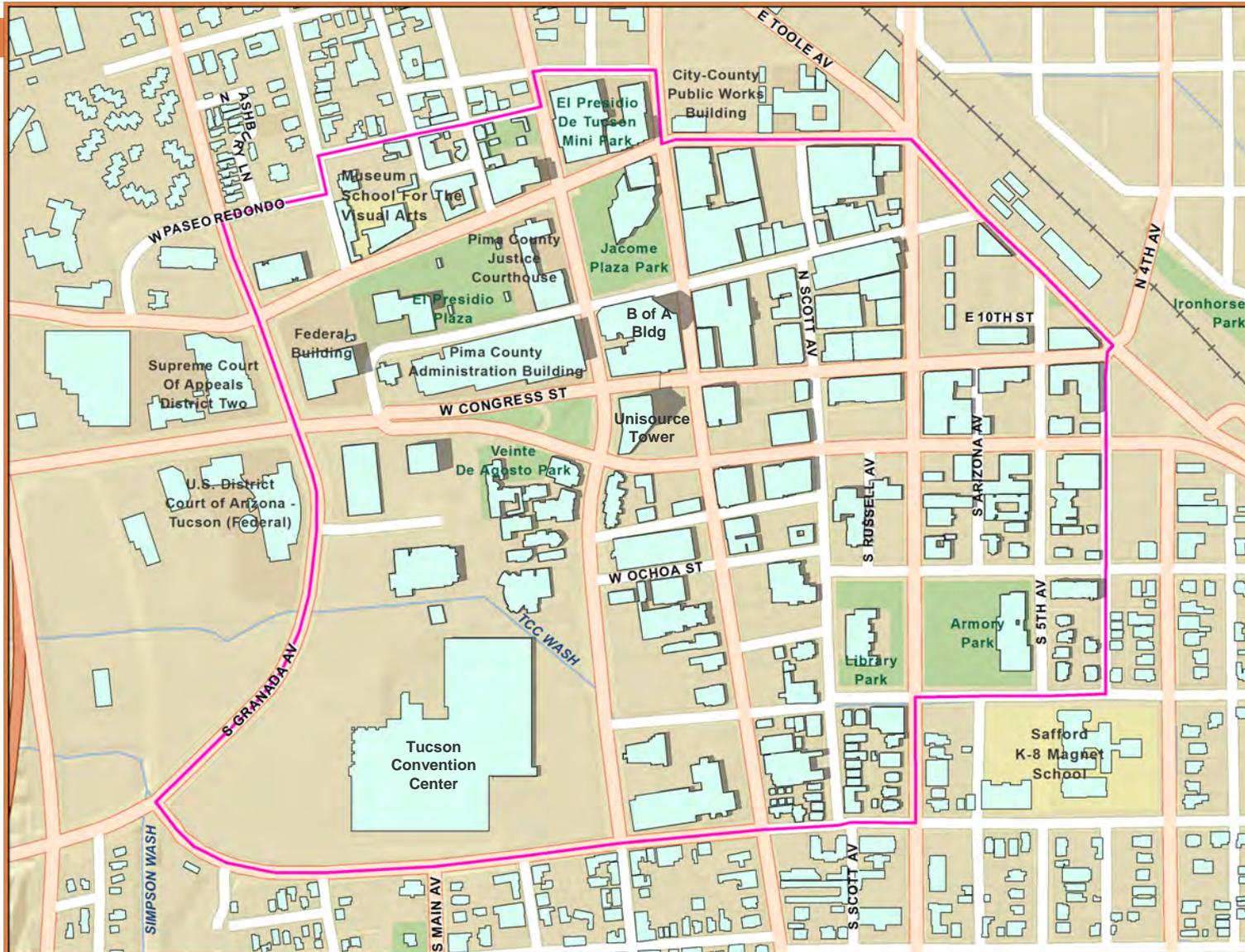
Shadow Maps

- Four discrete points in time:
 - ▣ Summer & winter solstice, spring & autumnal equinoxes
- For each date, create an individual shadow map for each whole hour of daylight (e.g. 7 a.m., 8 a.m., 9 a.m., etc.)
- Display areas of shadow overlaid on base map
 - ▣ Individual hours
 - ▣ Use time slider
- Many other techniques can be used...

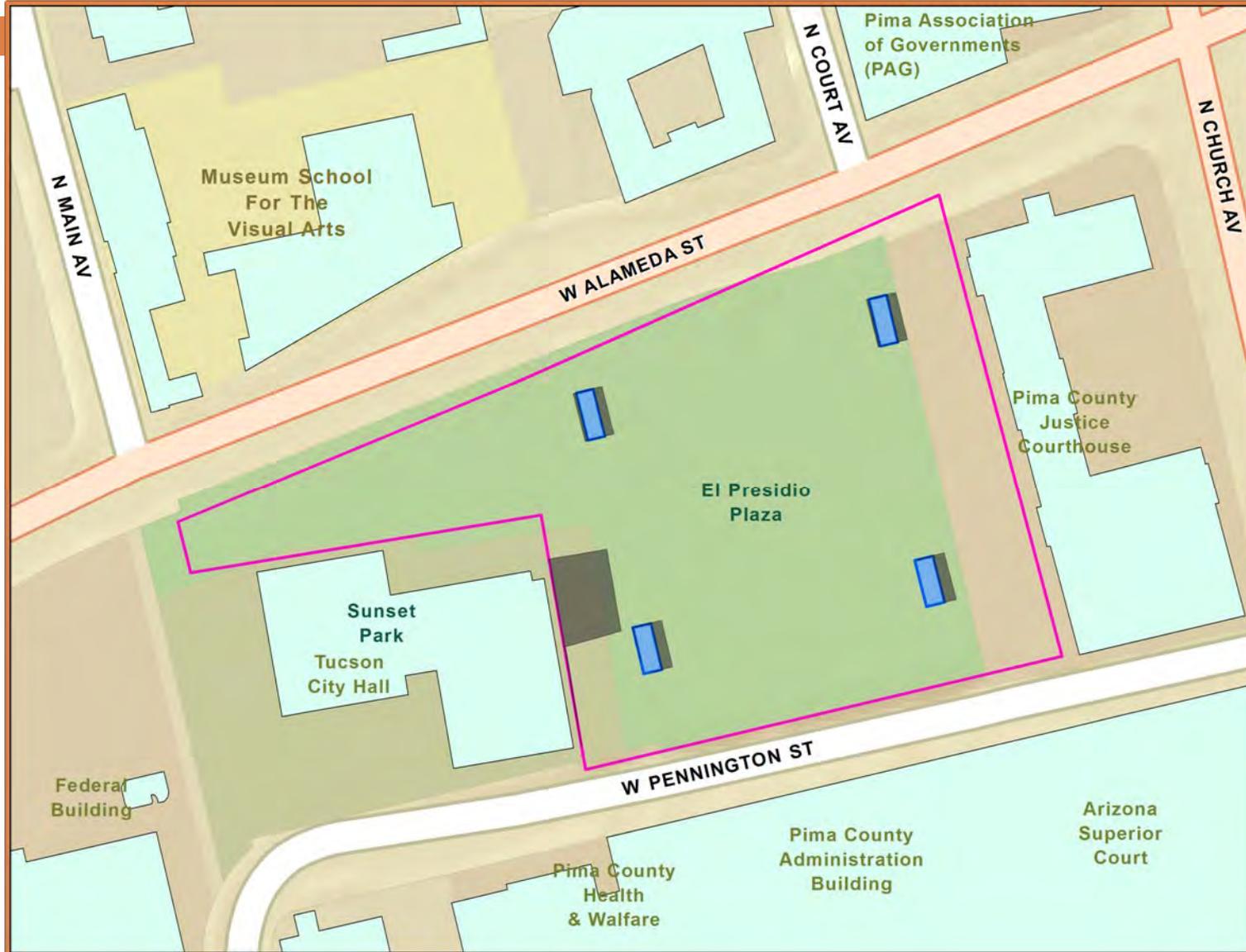
Downtown Study Area – 8:00 a.m. on Winter Solstice



Downtown Study Area – 2:00 p.m. on Summer Solstice



Details at a Larger Scale: El Presidio Park



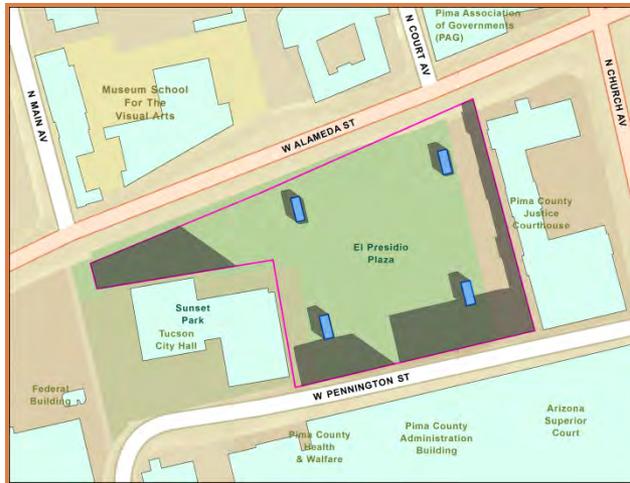
2 p.m. on
Summer
Solstice

Legend

- Areas in Shadow
- Elevator Shafts/Stairwells
- Buildings
- El Presidio Park Study Area

El Presidio Park Shadow Maps – 10:00 a.m. in All Four Seasons

March 20



June 21



September 22

December 21



Results of Flex Viewer Development

- Two base maps
 - City of Tucson base map layers
 - Aerial imagery
- Four dynamic shadow layers
- Static image legend
- Map switcher tool to toggle dynamic layers on and off
- Four individual time sliders for each shadow layer

Flex Viewer Application Demonstration



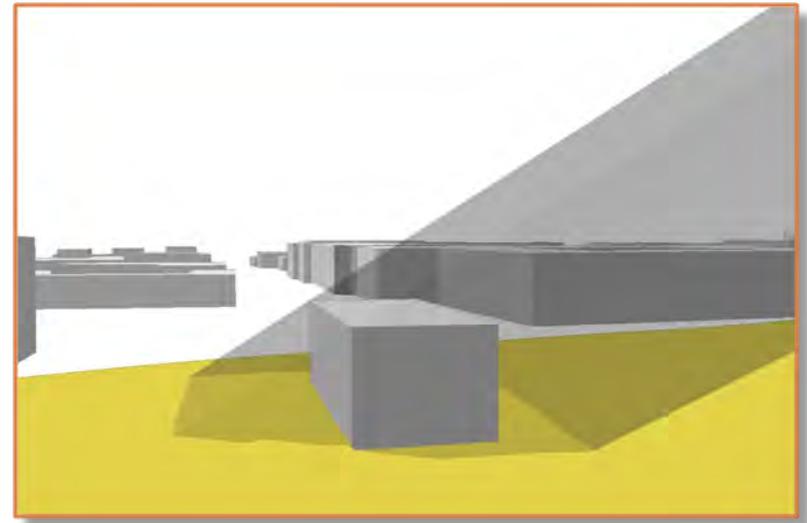
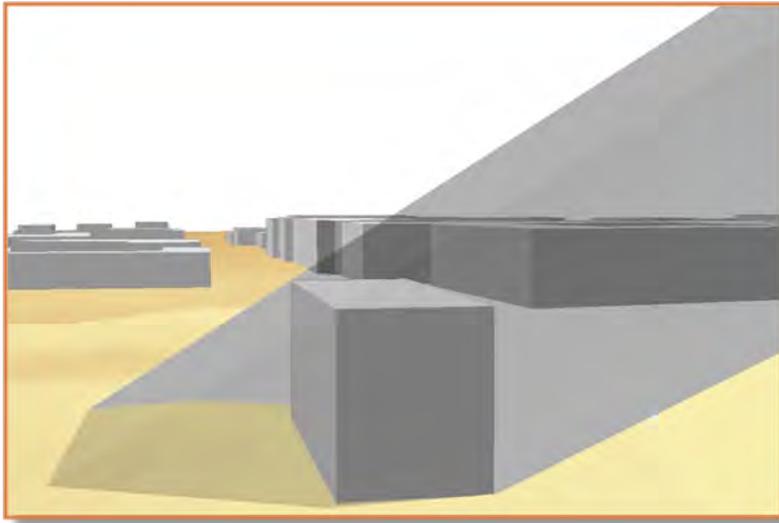
Lessons Learned

- Situation changes rapidly; data don't keep up.
- Preliminary workflows often don't have kinks worked out...
- OR, a particular methodology may need to be modified for your situation.
- Test models/tools on small areas first.
- Know your IT capabilities and staff resources.
- 3D geoprocessing can be VERY resource-intensive; build in additional time.

Primary Challenge



Primary Challenge



- Shadows must be extended *toward* sun pts to cover full area behind building
- However, one size does **not** fit all buildings
- If extended too far, and if study area extruded too high, shaded areas created *in front* of building

Next Steps

- Address shortcomings in methodology
 - ▣ Draping and extruding polygons in ArcScene
 - ▣ Appropriate ending points for shadows given differing building sizes
 - ▣ Datum conversion issues?
- Obtain and utilize the best possible data inputs
- Look at new CityEngine tools
- Find dedicated computing resources
- Present any updated results in the most beneficial form and to the appropriate parties

Conclusion / Questions

- Shadow analysis—using ESRI's tools and models—has many applications.
- Using the techniques described in this report, a variety of shadow maps can be developed with GIS tools.
- With slight modifications to the methodology developed here, downtown Tucson stakeholders will be able to help identify areas of shadow and sunlight at any point in time.
- **Questions?**