GIS Applications in a Municipal Setting

Využitie GIS aplikácií v meste Flagstaff

GeoDriven
Always tailored.

David Hatchner • Eva Putzová • April 30, 2010

About GeoDriven, LLC

Consulting services in the area of

- GIS solutions
- Strategic planning
- Higher education policy
- Market research and communication strategies

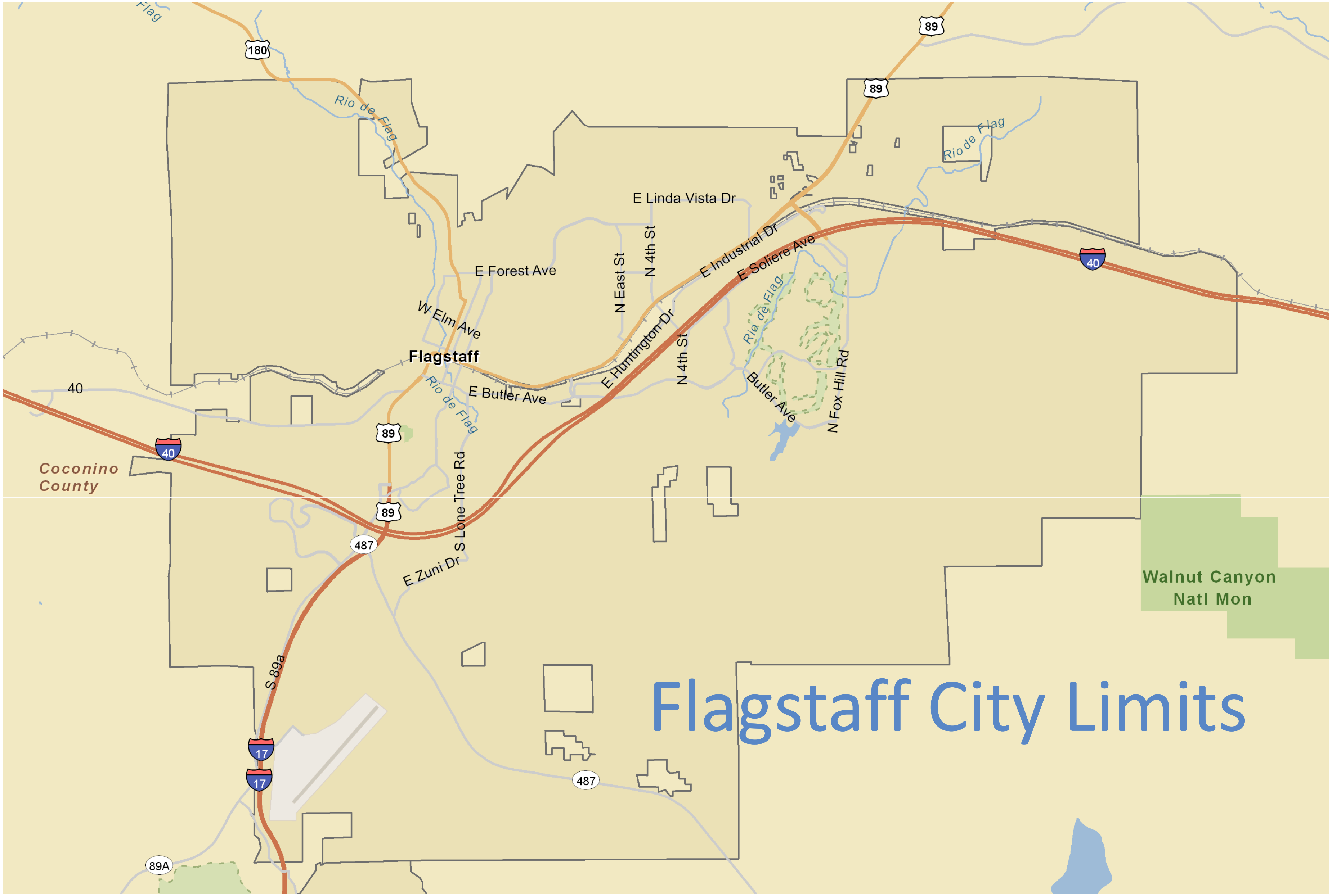
Partners: Eva Putzová, David Hatchner

Flagstaff, Arizona

David Hatchner • Eva Putzová

Flagstaff – Geographic Context

- Southwest, Arizona
  - Area: 295 000 km^2 ; (Slovakia: 49 000 km^2)
- Coconino County: 2nd largest county in the US
  - Area: 48 331 km^2
- Latitude as North Africa (Morocco)
- Elevation: 2 135 m
- At the foot of AZ's highest mountain
  - Mt. Humpheys: 3 852 m



Flagstaff City Limits

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More about Flagstaff

- 60 000 people
- Low humidity
- Average annual days of sunshine: 288
- 4 seasons (276 cm of snow annually)
  – Winter 2010: 335 cm of snow
- Average daily temperature:
  – July/August: 27-28°C (at night 9 to 10°C)
  – December/January: 6-7°C (at night -9 to -8°C)

Flagstaff: First International Dark Sky City

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City Government

- 7-member Council, including Mayor
  - Mayor: 2-year term
  - Council members: 4-year terms
  - Non-partisan elections
- 23 citizen boards and committees
  - Examples: Bicycle Advisory, Planning and Zoning, Beautification and Public Art, Library Board, Tourism, Sustainability, Water, Flagstaff Housing Authority…
  - Make recommendations to the Council
- City Manager
- City – County
- State law (Arizona Revised Statutes) governs city operations
  - Partisan politics affect local governments

Key Challenges within the City

- Budget
  - $161 million
  - Sales- and use-tax dependent
- Water resources/ infrastructure
- Comprehensive regional plan
- Affordability
- Economic development

Everyone Has a Silo

GIS DATA MANAGEMENT CHALLENGES

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Information Silos

GIS

- Land Database
  - Parcels
  - Addresses
  - Streets / ROW
- Raster Database
  - Aerials
  - Terrain Model
- Utility Database
  - Water
  - Sewer
  - Stormwater

Finance

- Utility and Environmental Services Billing Records
- Customer Database

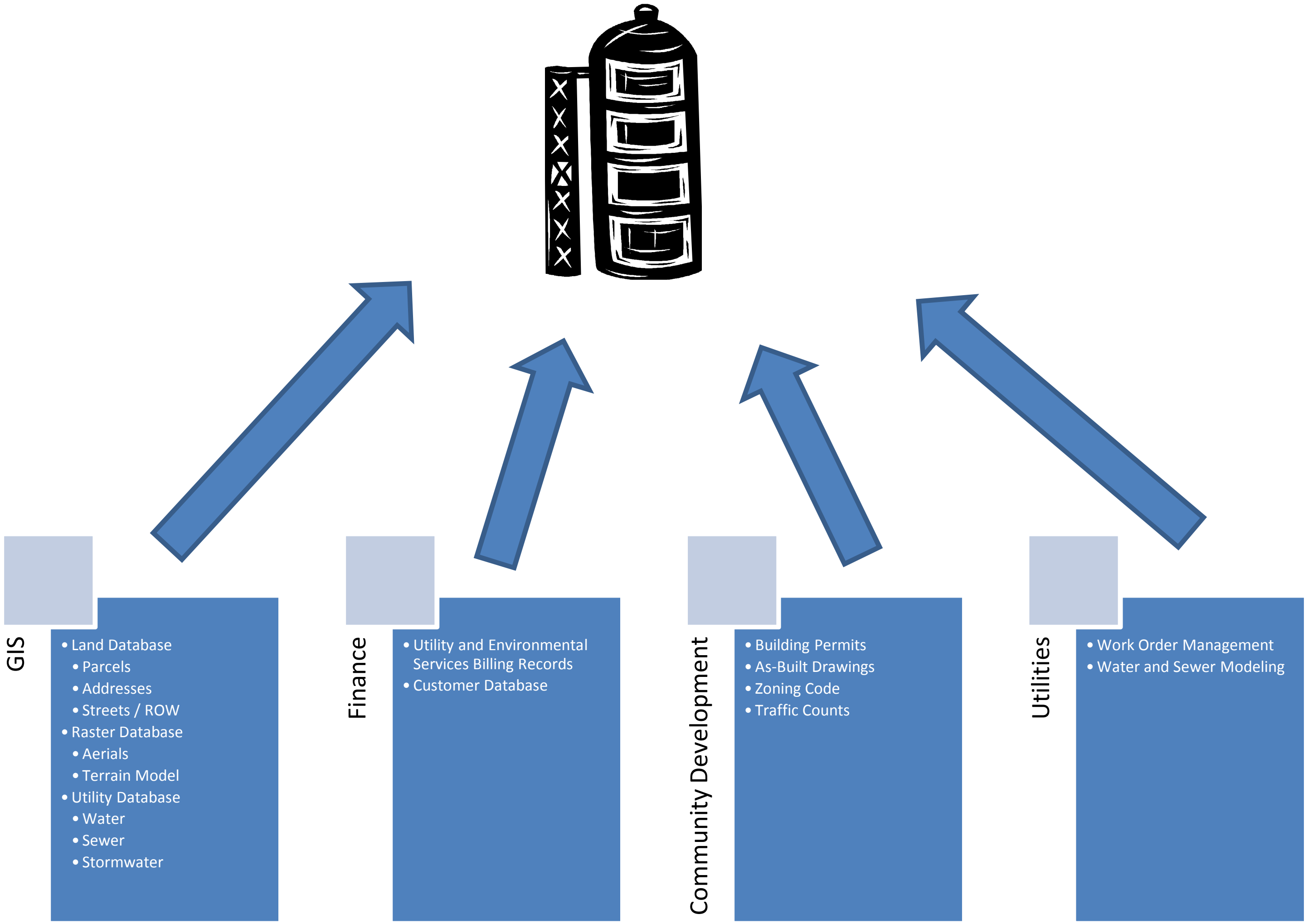
Community Development

- Building Permits
- As-Built Plans
- Zoning Code
- Traffic Counts

Utilities

- Work Order Management
- Water and Sewer Modeling

GIS Silo Integration



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GIS Examples Covered

- Regional Planning
- Landfill Management
- Stormwater Utility
- Wildfire Risk Assessment
- Wind Resource and Market Viability Assessment

One plan to rule all the plans

GIS FOR REGIONAL PLANNING

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Regional Plan 2012

- By Arizona State Statute, a municipality's general plan (regional plan) must be updated every 10 years.
- The regional plan must have input from and be approved by the voters
- The regional plan is required to include 17 elements

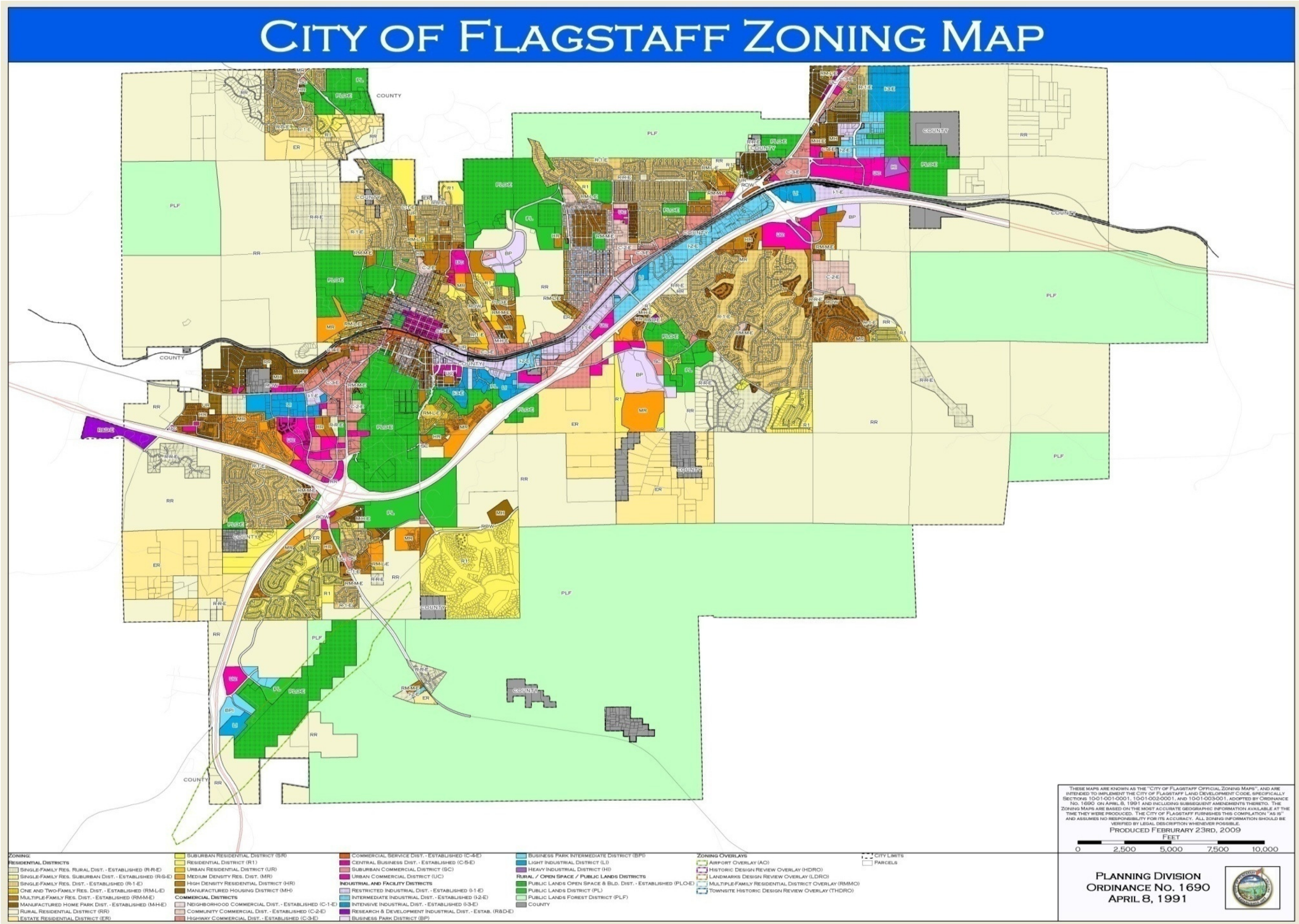
1. Land Use
2. Circulation - Transportation, Transit &Airport
3. Bicycling
4. Housing
5. Conservation, Rehabilitation and Redevelopment
6. Growth Area
7. Cost of Development
8. Open Space
9. Recreational
10. Conservation
11. Environmental
12. Water Resources
13. Public Buildings
14. Public Services and Facilities
15. Safety
16. Energy
17. Neighborhood Preservation and Revitalization

Why Use GIS in this Process?

- GIS allows the organization to:
  - Identify development already on the ground
  - Determine how things relate spatially
  - Determine what planning is actually appropriate or possible for a given area based on what's on the ground (steep slopes, floodplains, protected areas, state and federal lands, etc.)
  - Inform policy decisions

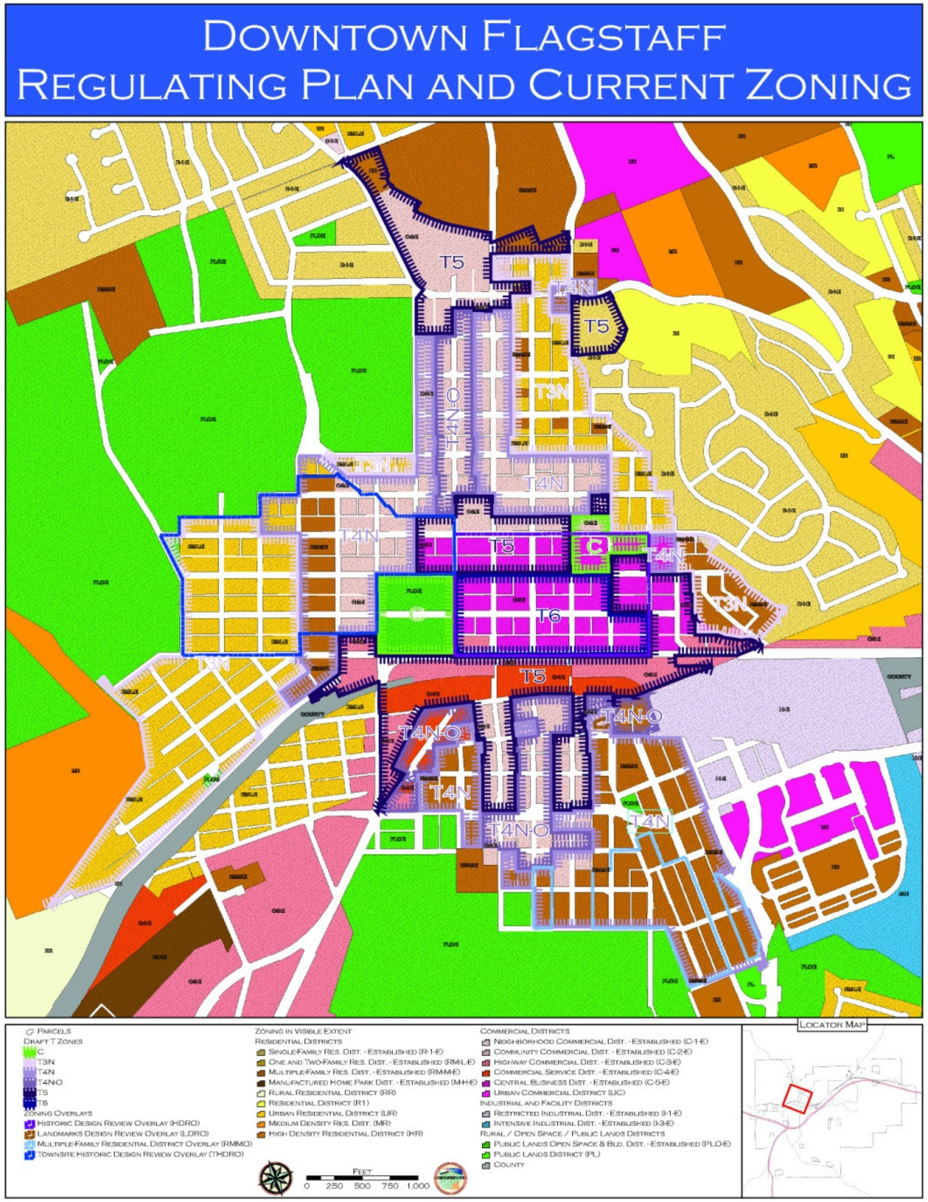
Land Use

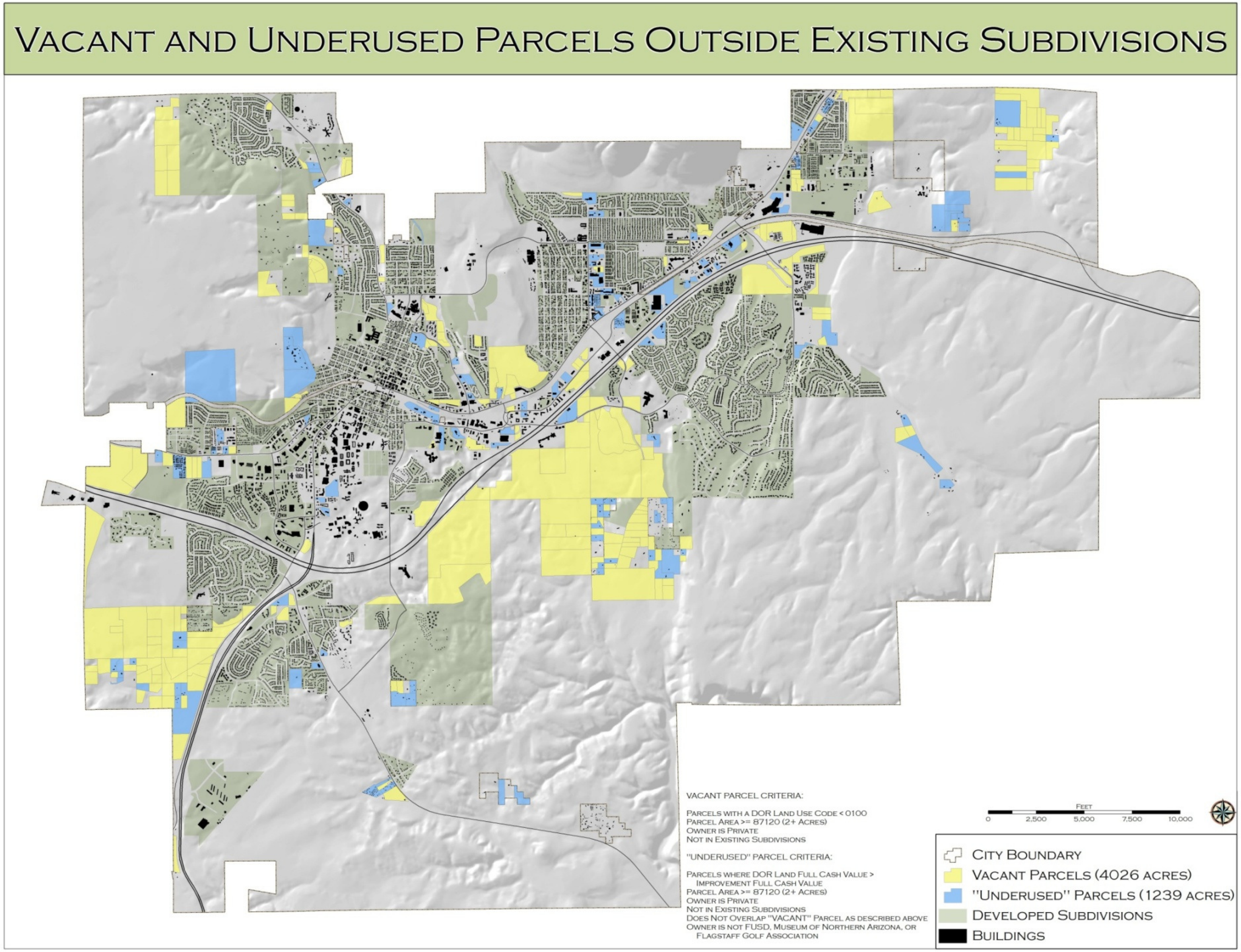
- As part of the Land Use Element, GIS was used to update the Land Development Code (Zoning)
- The Land Development Code (LDC) is the Council adopted rules and regulations used to guide development within the city
- The LDC specifies:
  - Allowed uses of property
  - Standards for development, i.e., parking, landscaping, signs, outdoor lighting and natural resource protection (trees, steep slopes and flood plains), as well as design guidelines
  - Detailed procedures for review and administration, including procedures and review processes for zone changes, variances, amendments to the general plan, or the subdivision of land


CITY OF FLAGSTAFF ZONING MAP
ZONING:
RESIDENTIAL DISTRICTS
SINGLE-FAMILY RES. RURAL DIST. - ESTABLISHED (R-R-E)
SINGLE-FAMILY RES. SUBURBAN DIST. - ESTABLISHED (R-S-E)
SINGLE-FAMILY RES. DIST. - ESTABLISHED (R-1-E)
ONE AND TWO-FAMILY RES. DIST. - ESTABLISHED (RM-L-E)
MULTIPLE-FAMILY RES. DIST. - ESTABLISHED (RM-M-E)
MANUFACTURED HOME PARK DIST. - ESTABLISHED (M-H-E)
RURAL RESIDENTIAL DISTRICT (RR)
ESTATE RESIDENTIAL DISTRICT (ER)
SUBURBAN RESIDENTIAL DISTRICT (SR)
RESIDENTIAL DISTRICT (R1)
URBAN RESIDENTIAL DISTRICT (UR)
MEDIUM DENSITY RES. DIST. (MR)
HIGH DENSITY RESIDENTIAL DISTRICT (HR)
MANUFACTURED HOUSING DISTRICT (MH)
COMMERCIAL DISTRICTS
NEIGHBORHOOD COMMERCIAL DIST. - ESTABLISHED (C-1-E)
COMMUNITY COMMERCIAL DIST. - ESTABLISHED (C-2-E)
HIGHWAY COMMERCIAL DIST. - ESTABLISHED (C-3-E)
COMMERCIAL SERVICE DIST. - ESTABLISHED (C-4-E)
CENTRAL BUSINESS DIST. - ESTABLISHED (C-5-E)
SUBURBAN COMMERCIAL DISTRICT (SC)
URBAN COMMERCIAL DISTRICT (UC)
INDUSTRIAL AND FACILITY DISTRICTS
RESTRICTED INDUSTRIAL DIST. - ESTABLISHED (I-1-E)
INTERMEDIATE INDUSTRIAL DIST. - ESTABLISHED (I-2-E)
INTENSIVE INDUSTRIAL DIST. - ESTABLISHED (I-3-E)
RESEARCH & DEVELOPMENT INDUSTRIAL DIST. - ESTAB. (R&D-E)
BUSINESS PARK DISTRICT (BP)
BUSINESS PARK INTERMEDIATE DISTRICT (BPI)
LIGHT INDUSTRIAL DISTRICT (LI)
HEAVY INDUSTRIAL DISTRICT (HI)
RURAL / OPEN SPACE / PUBLIC LANDS DISTRICTS
PUBLIC LANDS OPEN SPACE & BLD. DIST. - ESTABLISHED (PLO-E)
PUBLIC LANDS DISTRICT (PL)
PUBLIC LANDS FOREST DISTRICT (PLF)
COUNTY
ZONING OVERLAYS
AIRPORT OVERLAY (AO)
HISTORIC DESIGN REVIEW OVERLAY (HDRO)
LANDMARKS DESIGN REVIEW OVERLAY (LDRO)
MULTIPLE-FAMILY RESIDENTIAL DISTRICT OVERLAY (RMMO)
TOWNSITE HISTORIC DESIGN REVIEW OVERLAY (THDRO)
CITY LIMITS
PARCELS
THESE MAPS ARE KNOWN AS THE "CITY OF FLAGSTAFF OFFICIAL ZONING MAPS", AND ARE INTENDED TO IMPLEMENT THE CITY OF FLAGSTAFF LAND DEVELOPMENT CODE, SPECIFICALLY SECTIONS 10-01-001-0001, 10-01-002-0001, AND 10-01-003-001, ADOPTED BY ORDINANCE NO. 1690 ON APRIL 8, 1991 AND INCLUDING SUBSEQUENT AMENDMENTS THERETO. THE ZONING MAPS ARE BASED ON THE MOST ACCURATE GEOGRAPHIC INFORMATION AVAILABLE AT THE TIME THEY WERE PRODUCED. THE CITY OF FLAGSTAFF FURNISHES THIS COMPILATION "AS IS" AND ASSUMES NO RESPONSIBILITY FOR ITS ACCURACY. ALL ZONING INFORMATION SHOULD BE VERIFIED BY LEGAL DESCRIPTION WHENEVER POSSIBLE.
PRODUCED FEBRURARY 23RD, 2009
FEET
0
2,500
5,000
7,500
10,000
PLANNING DIVISION
ORDINANCE NO. 1690
APRIL 8, 1991

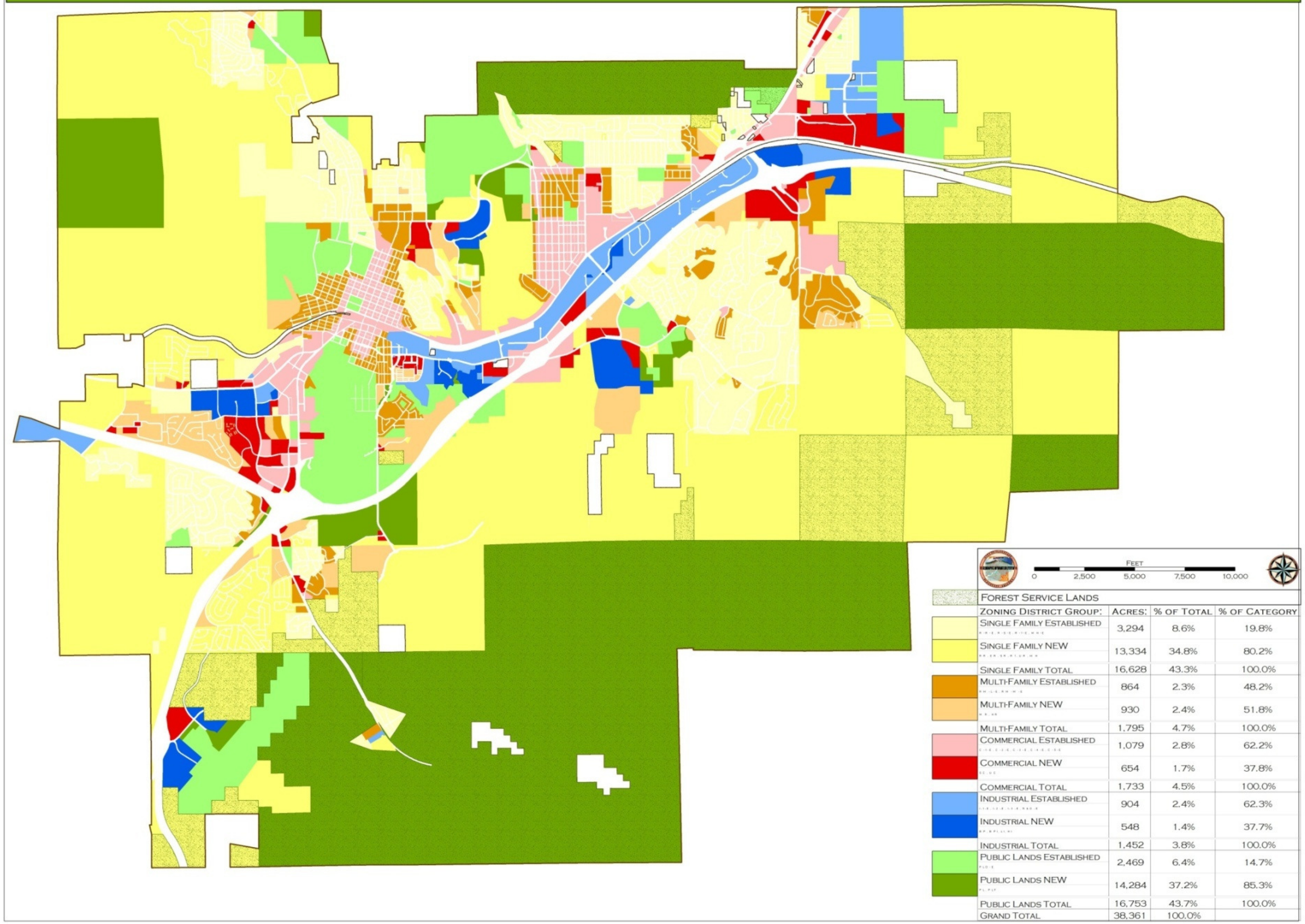
Proposed Zoning Changes

Updates to developed areas are meant to more accurately reflect what is actually on the ground, combine similar categories, use standardized zoning categories.




VACANT AND UNDERUSED PARCELS OUTSIDE EXISTING SUBDIVISIONS
VACANT PARCEL CRITERIA:
PARCELS WITH A DOR LAND USE CODE < 0100
PARCEL AREA >= 87120 (2+ ACRES)
OWNER IS PRIVATE
NOT IN EXISTING SUBDIVISIONS
"UNDERUSED" PARCEL CRITERIA:
PARCELS WHERE DOR LAND FULL CASH VALUE > IMPROVEMENT FULL CASH VALUE
PARCEL AREA >= 87120 (2+ ACRES)
OWNER IS PRIVATE
NOT IN EXISTING SUBDIVISIONS
DOES NOT OVERLAP "VACANT" PARCEL AS DESCRIBED ABOVE
OWNER IS NOT FUSD, MUSEUM OF NORTHERN ARIZONA, OR FLAGSTAFF GOLF ASSOCIATION
FEET
0
2,500
5,000
7,500
10,000
CITY BOUNDARY
VACANT PARCELS (4026 ACRES)
"UNDERUSED" PARCELS (1239 ACRES)
DEVELOPED SUBDIVISIONS
BUILDINGS

Zoning District Categories by Acres



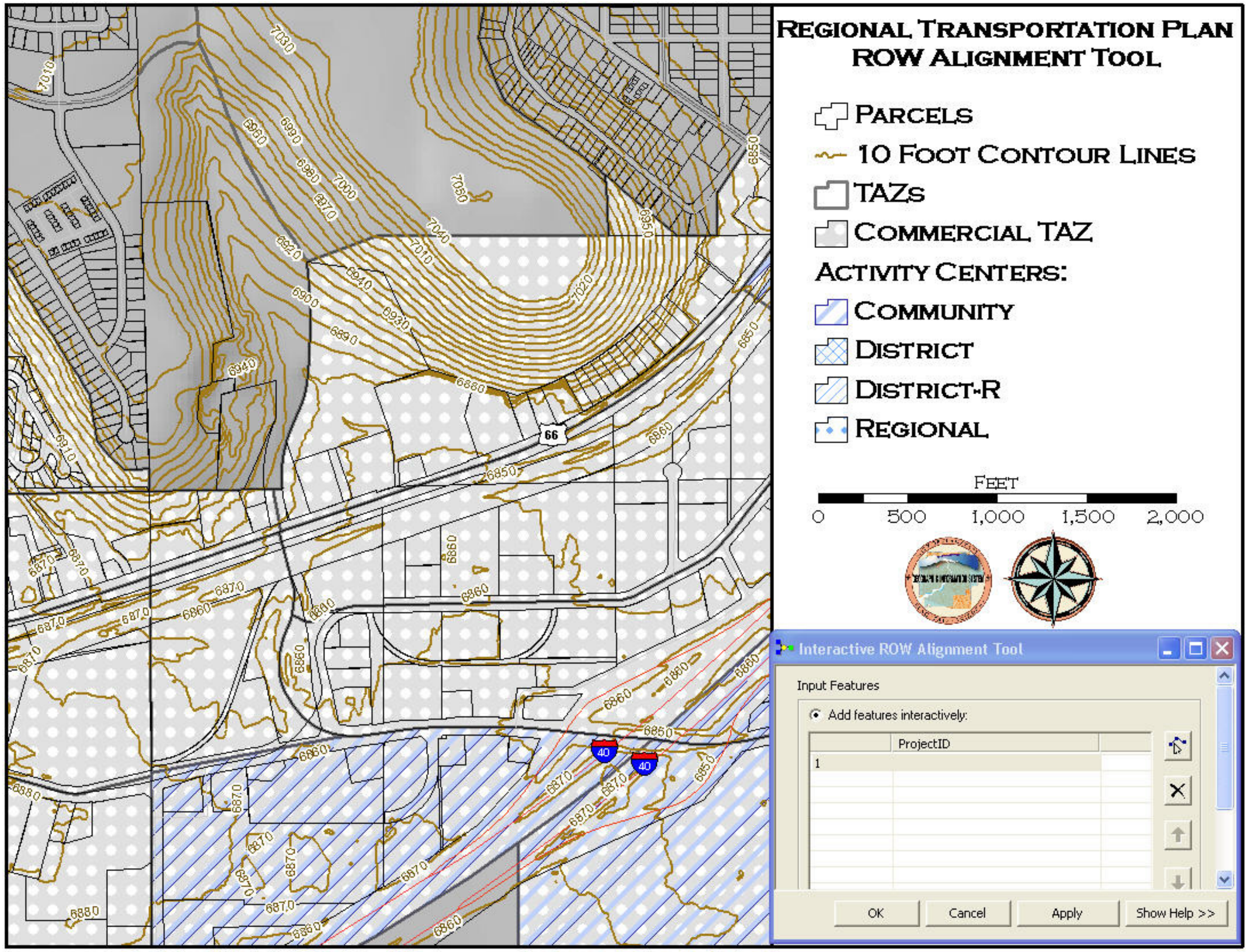
Zoning District Group:	Acres:	% of Total	% of Category
Single Family Established	3,294	8.6%	19.8%
Single Family NEW	13,334	34.8%	80.2%
Single Family Total	16,628	43.3%	100.0%
Multi-Family Established	864	2.3%	48.2%
Multi-Family NEW	930	2.4%	51.8%
Multi-Family Total	1,795	4.7%	100.0%
Commercial Established	1,079	2.8%	62.2%
Commercial NEW	654	1.7%	37.8%
Commercial Total	1,733	4.5%	100.0%
Industrial Established	904	2.4%	62.3%
Industrial NEW	548	1.4%	37.7%
Industrial Total	1,452	3.8%	100.0%
Public Lands Established	2,469	6.4%	14.7%
Public Lands NEW	14,284	37.2%	85.3%
Public Lands Total	16,753	43.7%	100.0%
Grand Total	38,361	100.0%	

Transportation Plan

- The Circulation/Transportation Element describes the general location and extent of existing and proposed freeways, arterial and collector streets, bicycle routes and any other modes of transportation as may be appropriate, all correlated with the land use element of the plan.

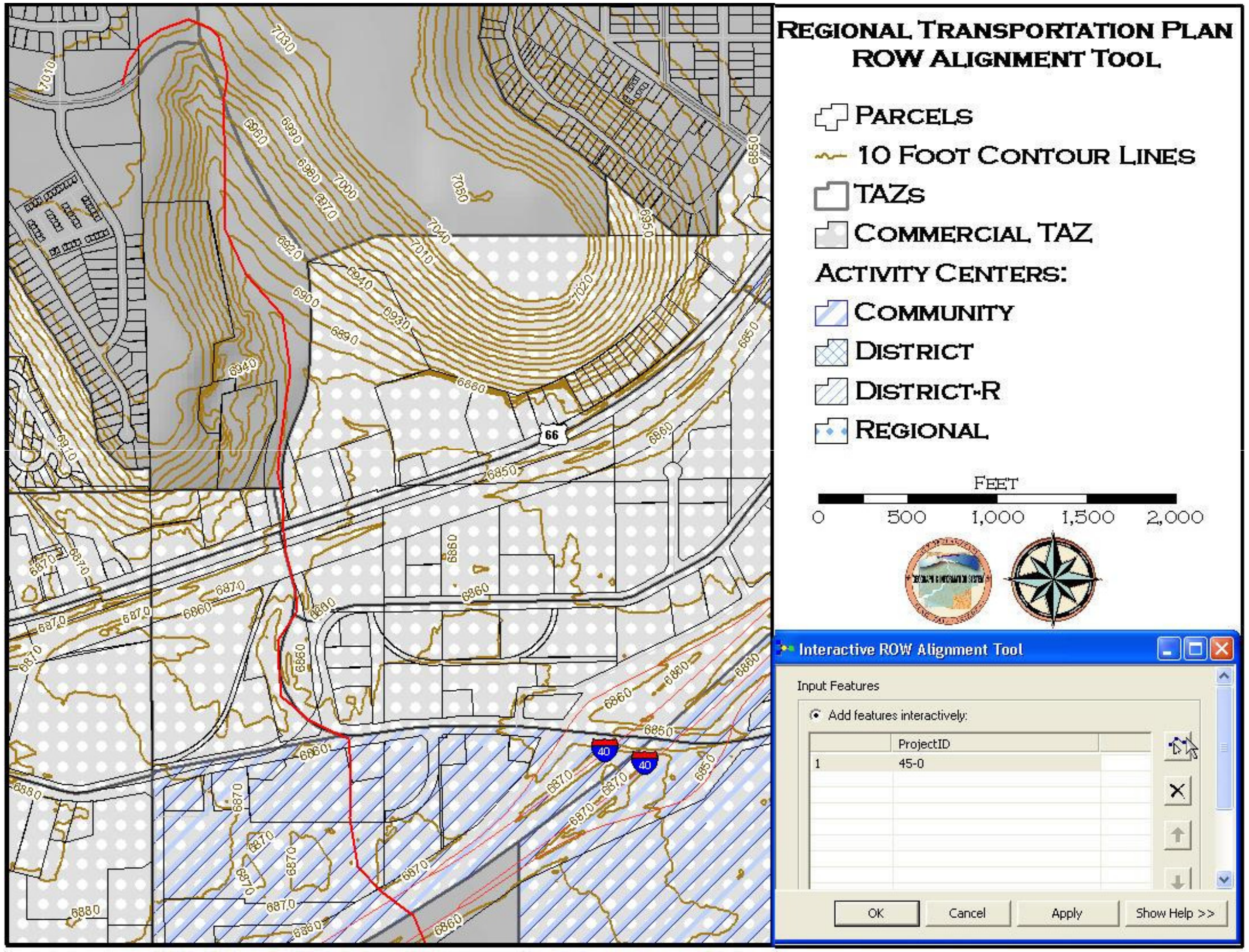
Right of Way Tool

As an aide in updating the Transportation Plan, GIS was utilized to help plan and estimate proposed road costs.



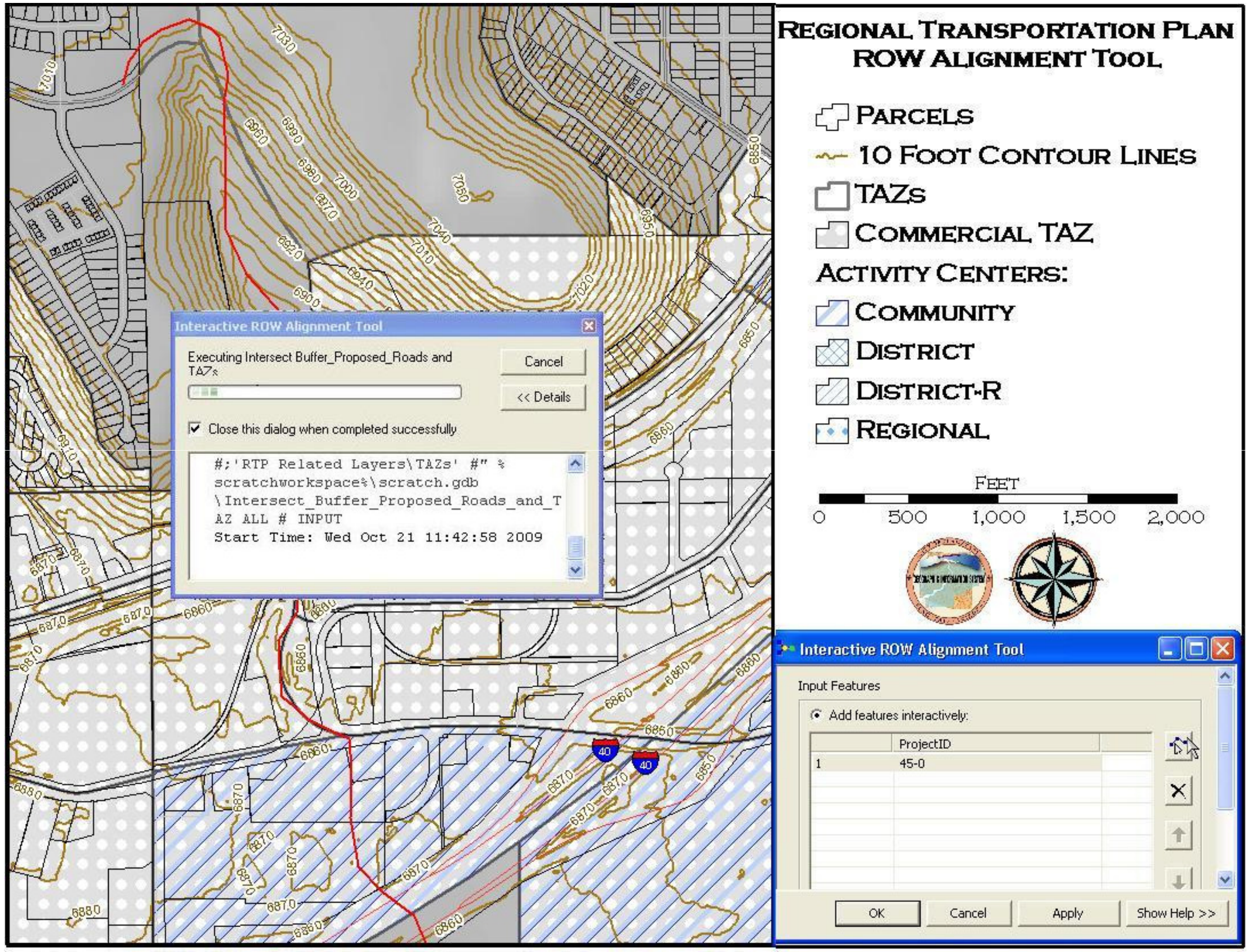
Right of Way Tool

Proposed Road



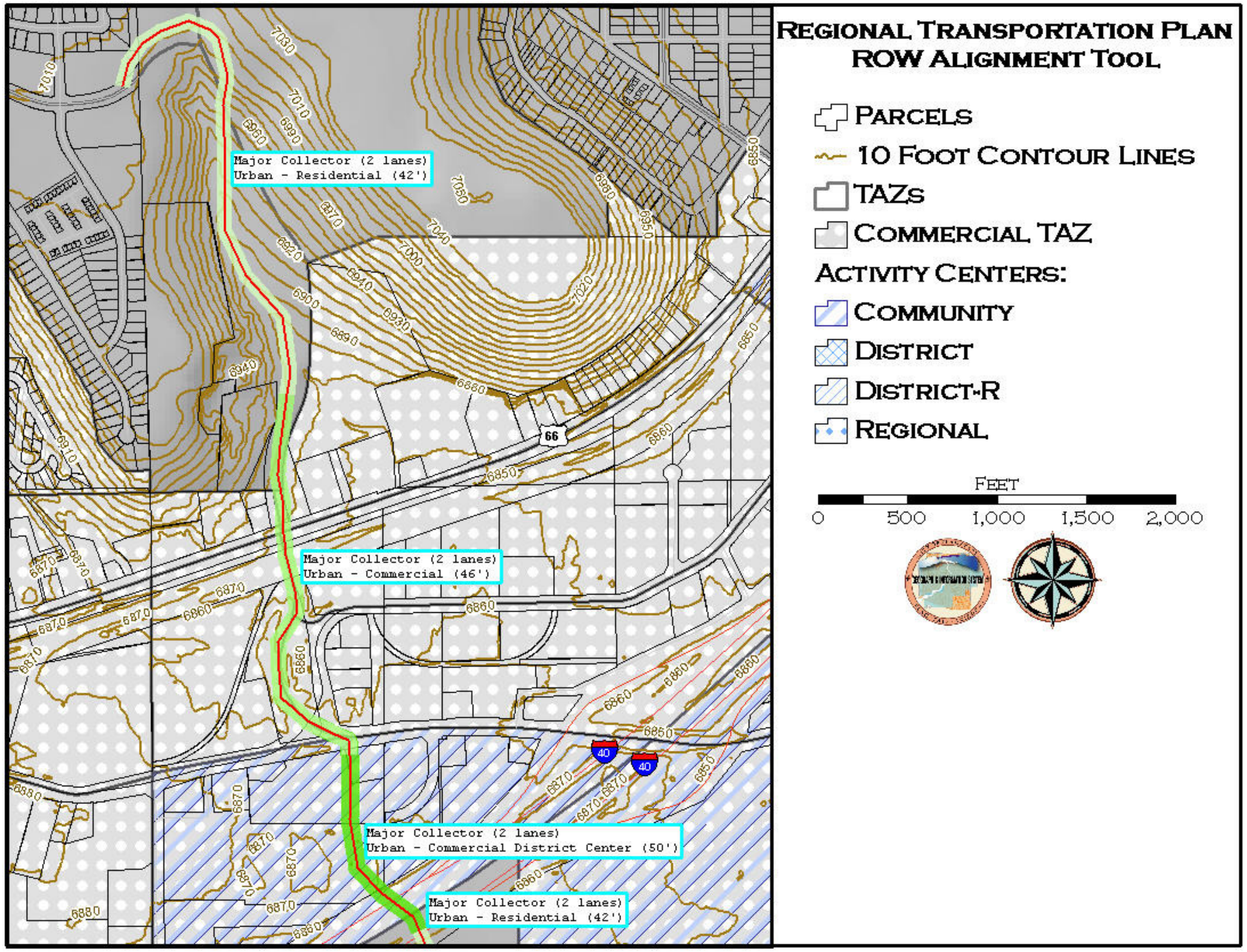
Right of Way Tool

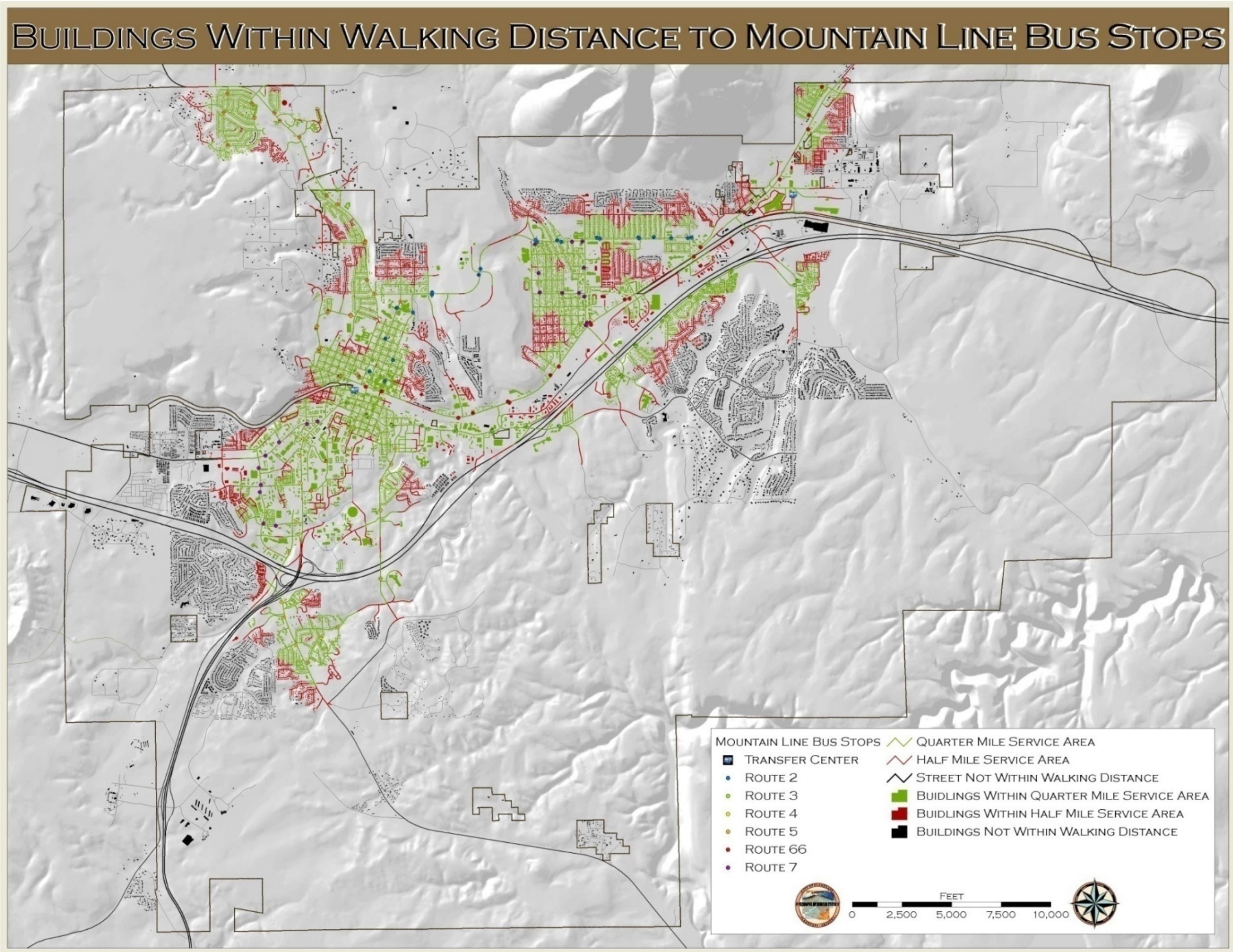
Calculations in progress



Right of Way Tool

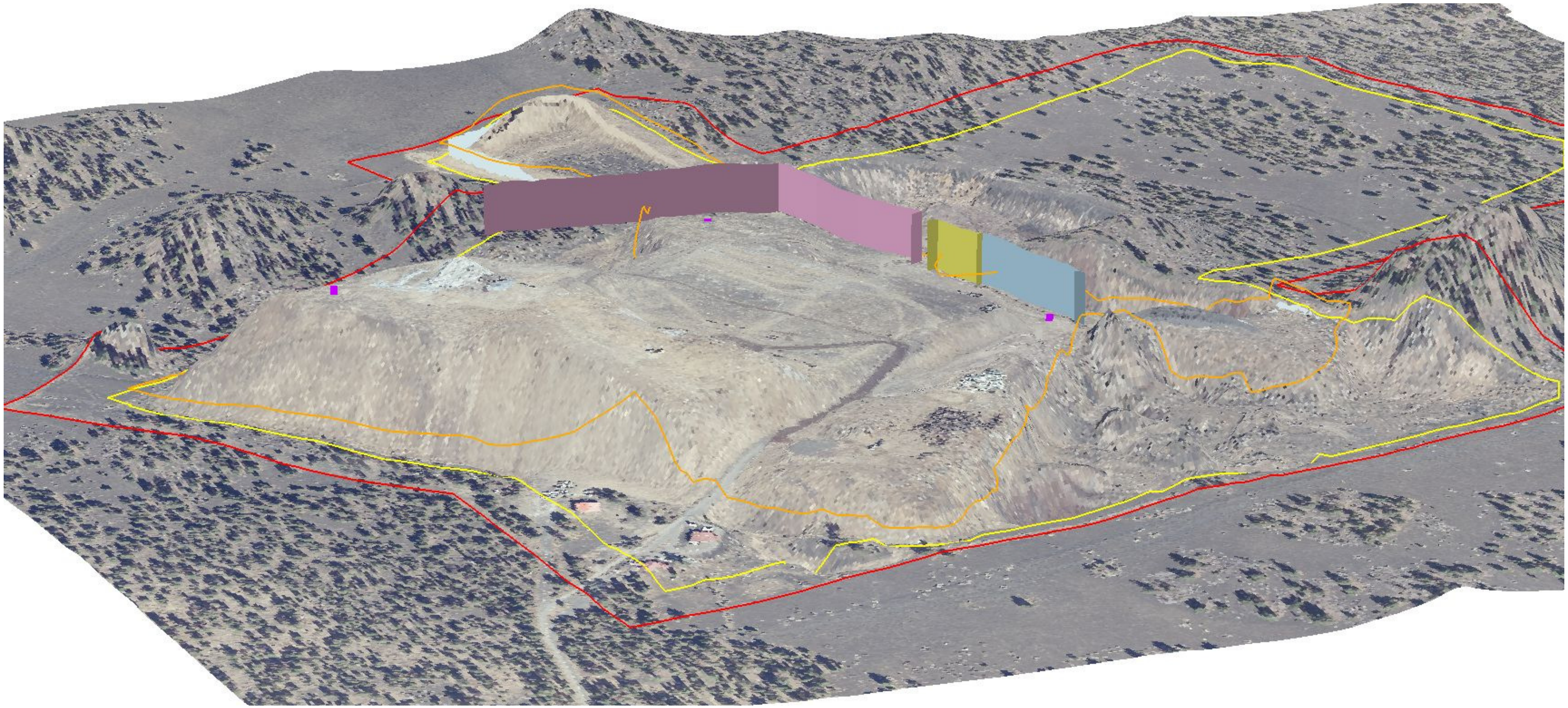
Final output





BUILDINGS WITHIN WALKING DISTANCE TO MOUNTAIN LINE BUS STOPS
MOUNTAIN LINE BUS STOPS
TRANSFER CENTER
ROUTE 2
ROUTE 3
ROUTE 4
ROUTE 5
ROUTE 66
ROUTE 7
QUARTER MILE SERVICE AREA
HALF MILE SERVICE AREA
STREET NOT WITHIN WALKING DISTANCE
BUIDLINGS WITHIN QUARTER MILE SERVICE AREA
BUIDLINGS WITHIN HALF MILE SERVICE AREA
BUILDINGS NOT WITHIN WALKING DISTANCE
FEET
0 2,500 5,000 7,500 10,000

Using 3D/Spatial Analyst to Model Changes and Efficiency of a Landfill



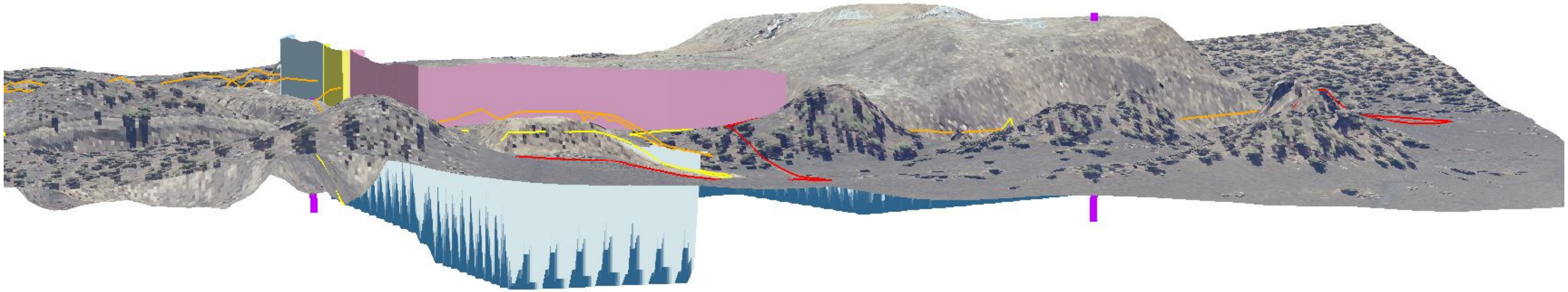
The Problem

- Running a landfill is very expensive and is subject to many federal rules and regulations making it imperative to run an efficient operation
- Major issues include:
  - Ground Cover
  - Trash Compaction
  - Planning for End of Life

Dirt?

- Top Ground Cover
  - Federal law requires the landfill is covered daily
  - Soil is taken from pits on the landfill property but the supply is limited
  - Spatial Analyst was used to calculate the amount of soil left on the property using a defined area and average depth to bedrock
    - This analysis allows for an accurate projection of the year when soil from a outside source will need to be purchased greatly increasing operational costs

The View Below the Landfill



Trash Compaction

- Knowing how fast the volume of the landfill increases allows engineers to
  - Verify they are hitting targeted compaction rates greatly reducing the cost to run the landfill
  - Project the life of the landfill
  - Plan for height limitations
  - Estimate total area designated for burying trash
- The city calculates the compaction rate between LIDAR (Light Detection and Raging) flights and land surveys to determine volume increases and compaction rates
  - Volume increases include:
    - Average amount of soil used (tracked daily)
    - Average amount paper sludge used (tracked daily)
    - Total amount of trash buried

Planning for the Future

- The US Environmental Protection Agency (EPA) requires a specific amount of money be set aside to cover the closing costs of the landfill.
- Accurately determining the closing date allows the city to determine how much money must be saved each year.
- Using GIS helps to illustrate the benefits of conservation for the city by extending the life of the landfill and therefore reducing costs

Creating a impartial and justifiable way to bill customers for a stormwater utility

STORMWATER UTILITY

David Hatchner • Eva Putzová

The Problem

- The city needed a way to recover the costs of building and maintaining a stormwater utility
- Every business and resident benefits from the stormwater system, but how charge fairly?
- How can the city sanction and defend the rate it charges?

The Solution

- Use GIS to collect a spatial database of all impervious surfaces within the city.
- The steps included:
  - Purchase new aerial photography for the city
  - Collect all impervious surface data in the city that will impact stormwater system input
  - Clip impervious surfaces to parcel boundaries
  - Identify parcels as commercial or residential
  - Calculate the total area of each parcel covered by a impervious surface
  - Use the total area and parcel type (residential or commercial) to calculate a billable amount

All Impervious Surfaces

Impervious Surfaces within Parcels

Wildfire Risk Assessment

David Hatchner • Eva Putzová

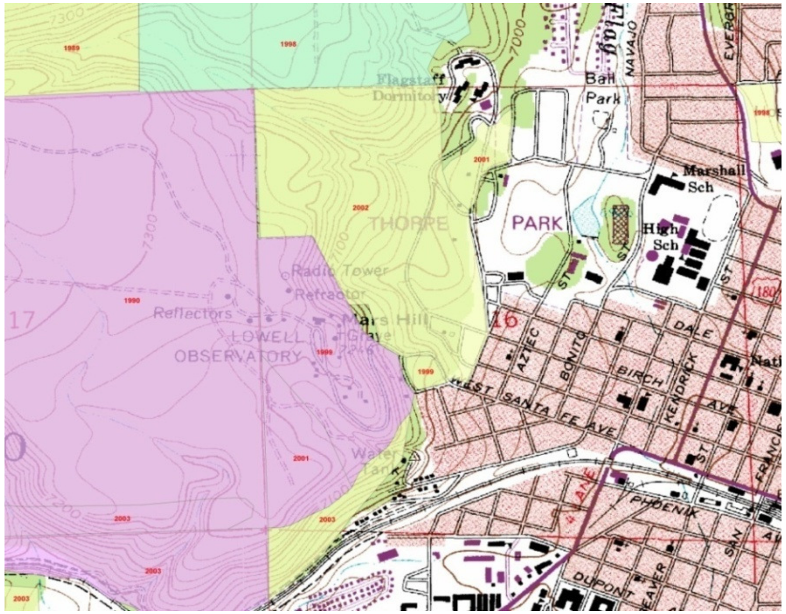
Project History

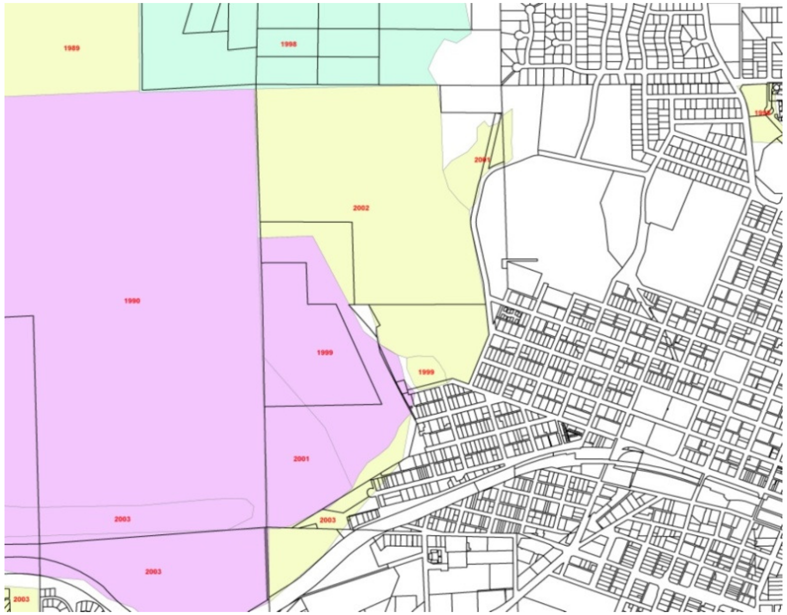
- 1996 : The city has 3 100 acre fires located within the city limits)
- 1997: Fuel Management begins in the City of Flagstaff due to the events of 1996 and focus on 5 areas;
  - Strategic Planning
  - Land Use Planning
  - Public Preparedness
  - Hazard Mitigation (prescribed burns)
  - Response

- 2002: The first Fuel Treatment map is created
- 2006: GIS is used to do a wildfire risk assessment to allow City and US Forest Service fire crews to focus on the highest risk areas
  - This GIS analysis takes into account many different variables including fuel treatment, slope, fire hydrant locations, accessibility, vegetation, and roof type.

Fuel Treatment Maps

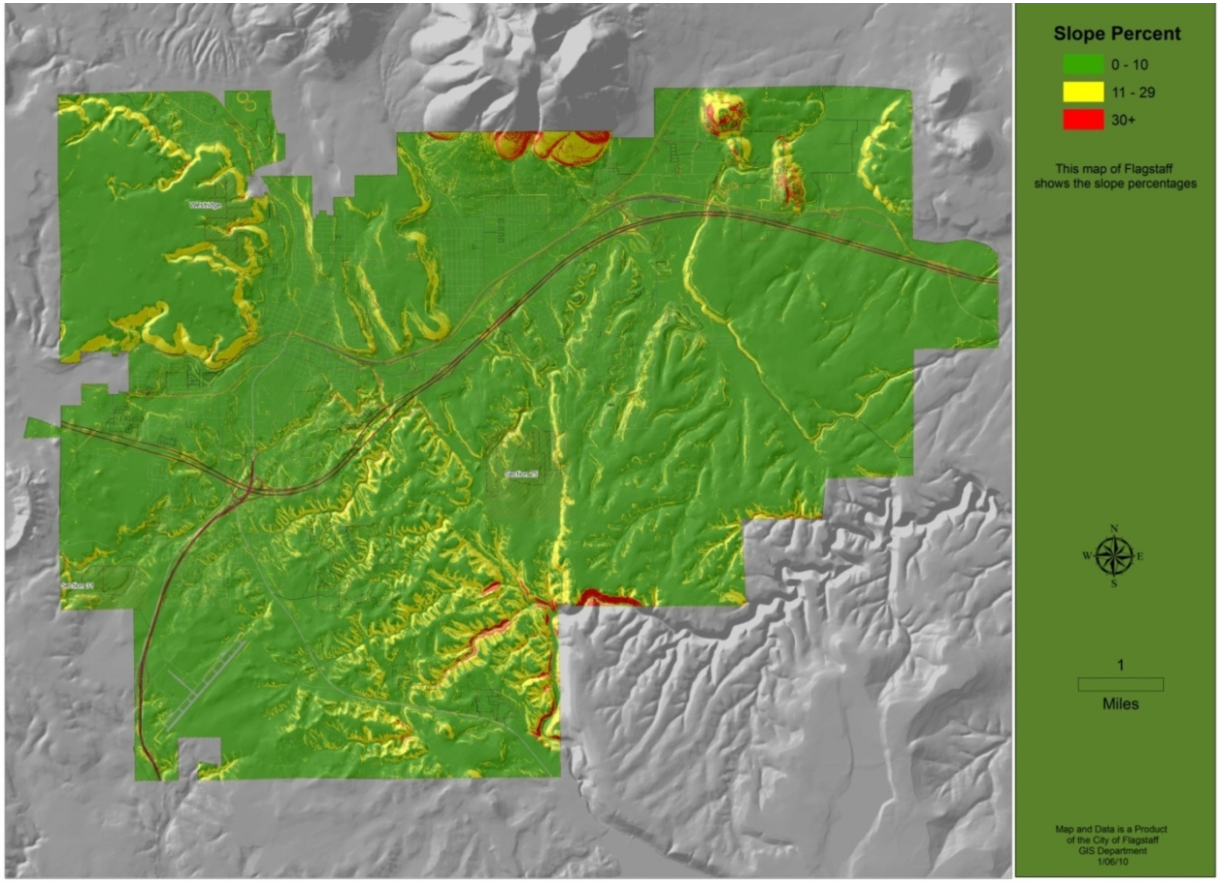
- Originally the boundaries were hand drawn by fire crews in the field on USGS topographic maps
- GIS was later used to create a fire treatment layer from the original maps
- GPS field surveys were used to improve accuracy where needed
- New fuel treatment boundaries are captured with GPS to assure accuracy





Slope

- Slope is important because fire travels most rapidly up-slopes and least rapidly down-slopes



Fire Hydrants

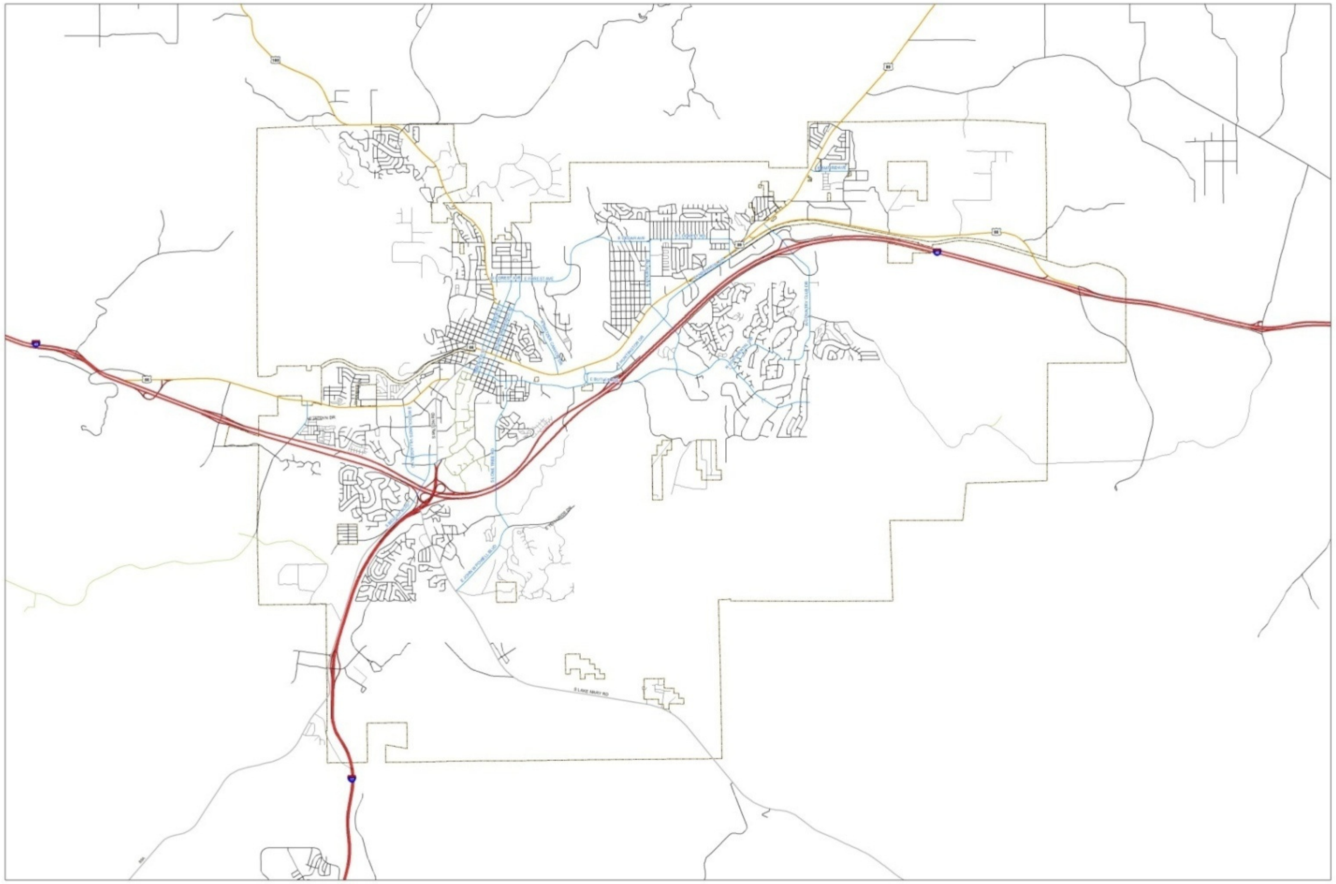
- Fire hydrants allow for immediate access to water in addition to the fire trucks onboard storage capacity
- Fire hydrant locations were buffered to 1000 feet and merged together to create an ideal coverage area

Vegetation

- A vegetation layer was created using aerial photography with a infrared band and LIDAR
  - Infrared signatures were used to help classify vegetation with a focus on identifying dense tree canopies
  - LIDAR first returns compared to second returns (bare earth) were also used to help identify tree canopies
  - Visual checks of the aerial were done to verify accuracy
  - Dense canopy coverage is represented in red in the map below to identify high fire risk
  - Grasslands, canyons, roads and large urban areas without tree coverage are marked in green identifying lower risk

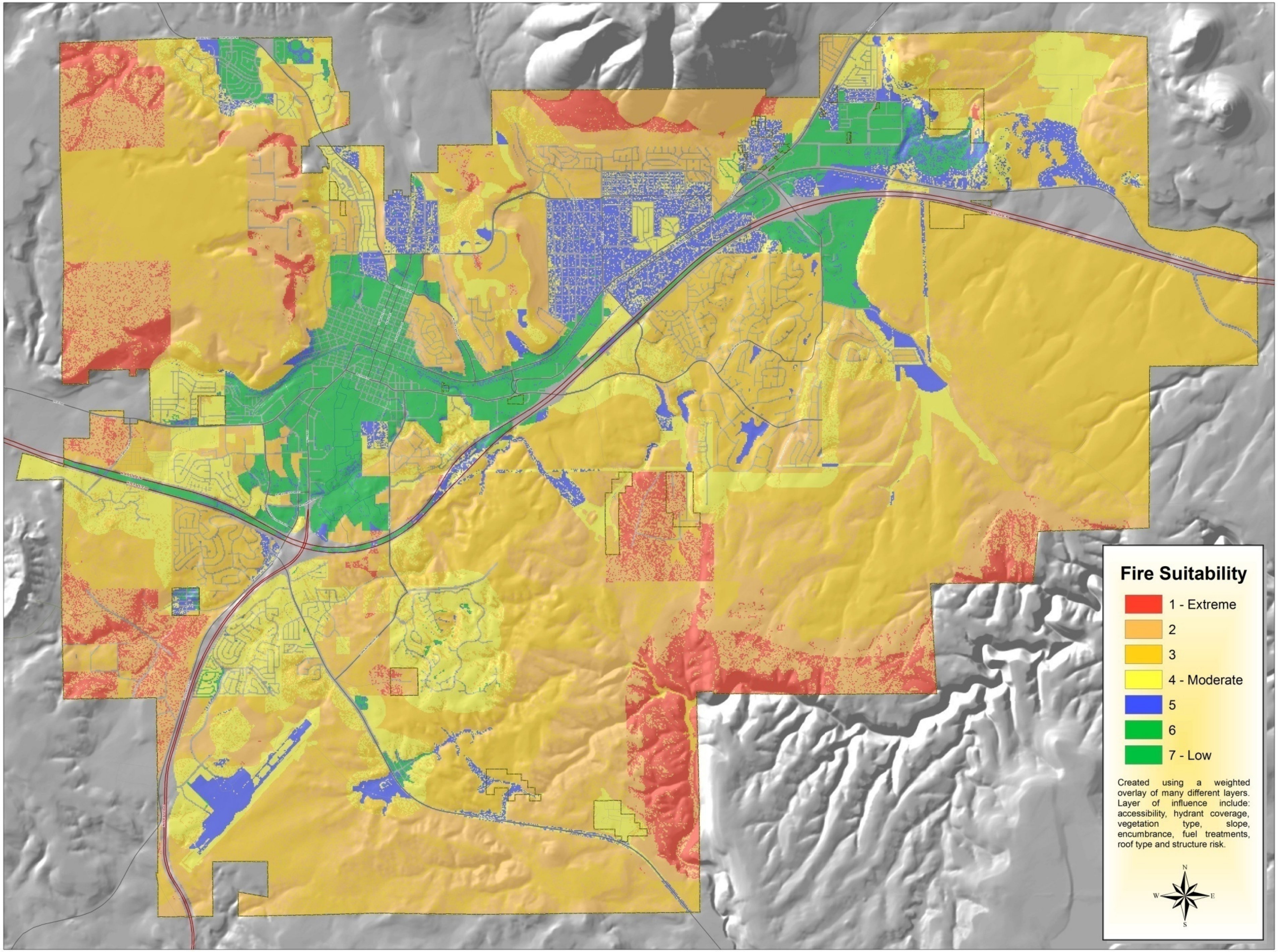
Accessibility

- The GIS road layer was used to define areas accessible by fire trucks



Final GIS Analysis and Map

- Weighted Overlay is a technique for applying a common measurement scale of values to diverse and dissimilar inputs to create an integrated analysis
- All of the different layers mentioned before were used to create the map on the following slide
- A geoprocessing model was created of this analysis process to allow this map to be updated easily each year with current inputs.


Fire Suitability
1 - Extreme
2
3
4 - Moderate
5
6
7 - Low
Created using a weighted overlay of many different layers. Layer of influence include: accessibility, hydrant coverage, vegetation type, slope, encumbrance, fuel treatments, roof type and structure risk.
N
W
E
S

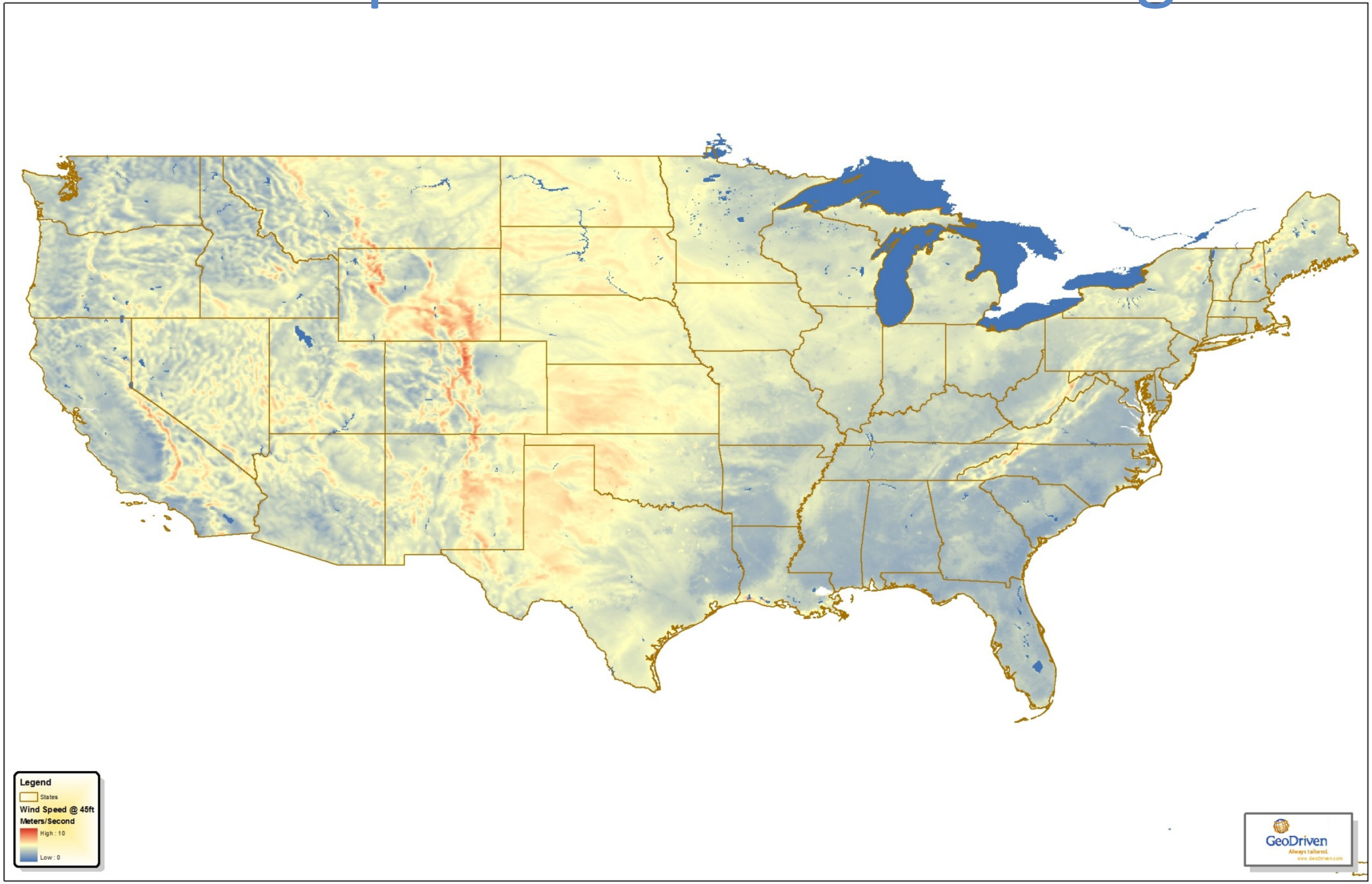
WIND RESOURCE AND MARKET VIABILITY ASSESSMENT

David Hatchner • Eva Putzová

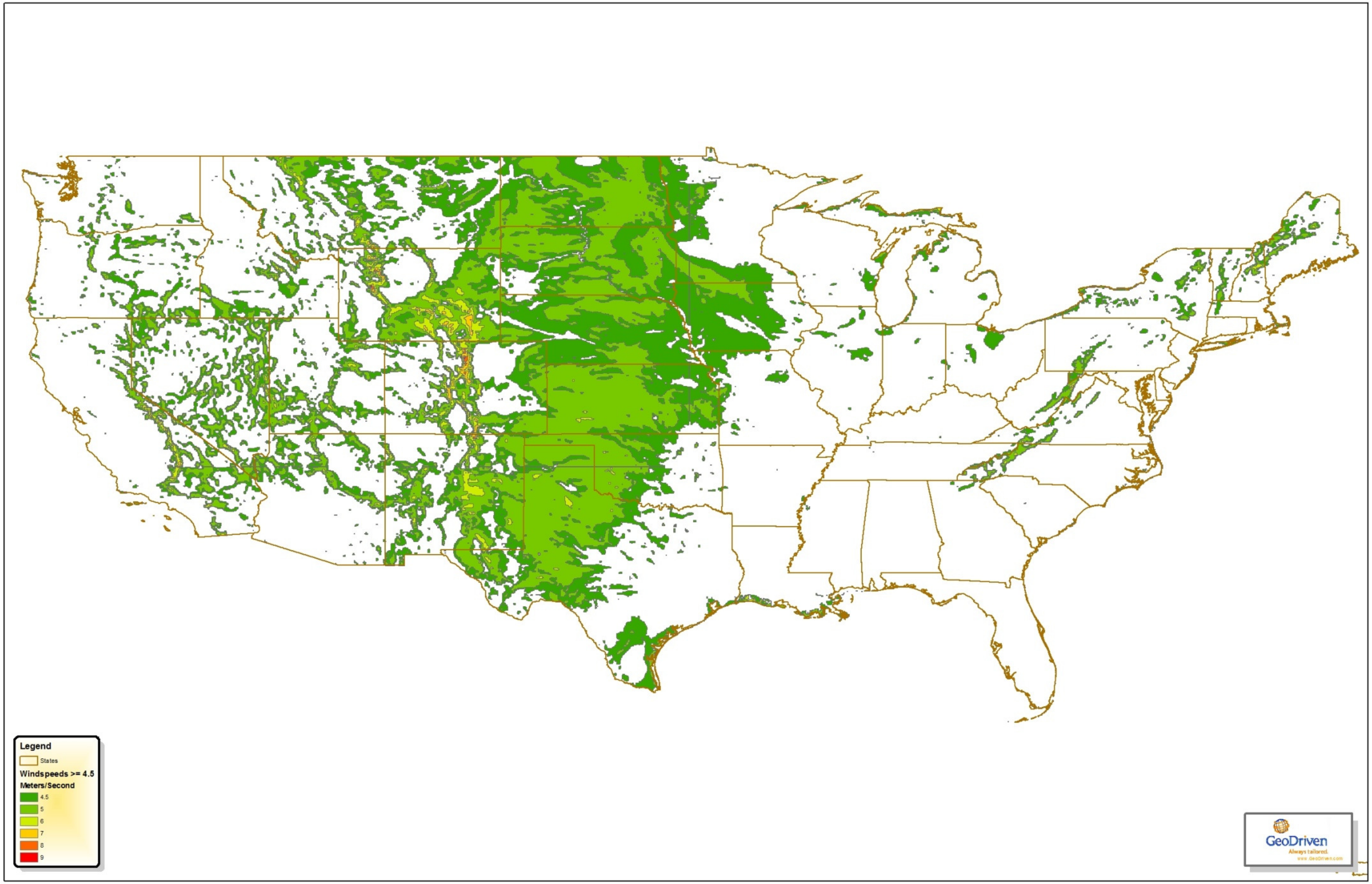
The Problem

- Wind turbine manufacture wants to market to targeted areas in the USA that have ideal circumstances for their products
- Ideal markets
  - A minimum average wind speed of 4.5 meters per second at a height of 15 meters
  - Population density is low enough to allow for adequate space but high enough to have viable sales (50-200 people per square mile)
    - government ordinances friendly to wind turbines
  - High electricity rates
  - Good incentives (tax breaks, rebates, electric utility buy backs)
  - Higher household net worth

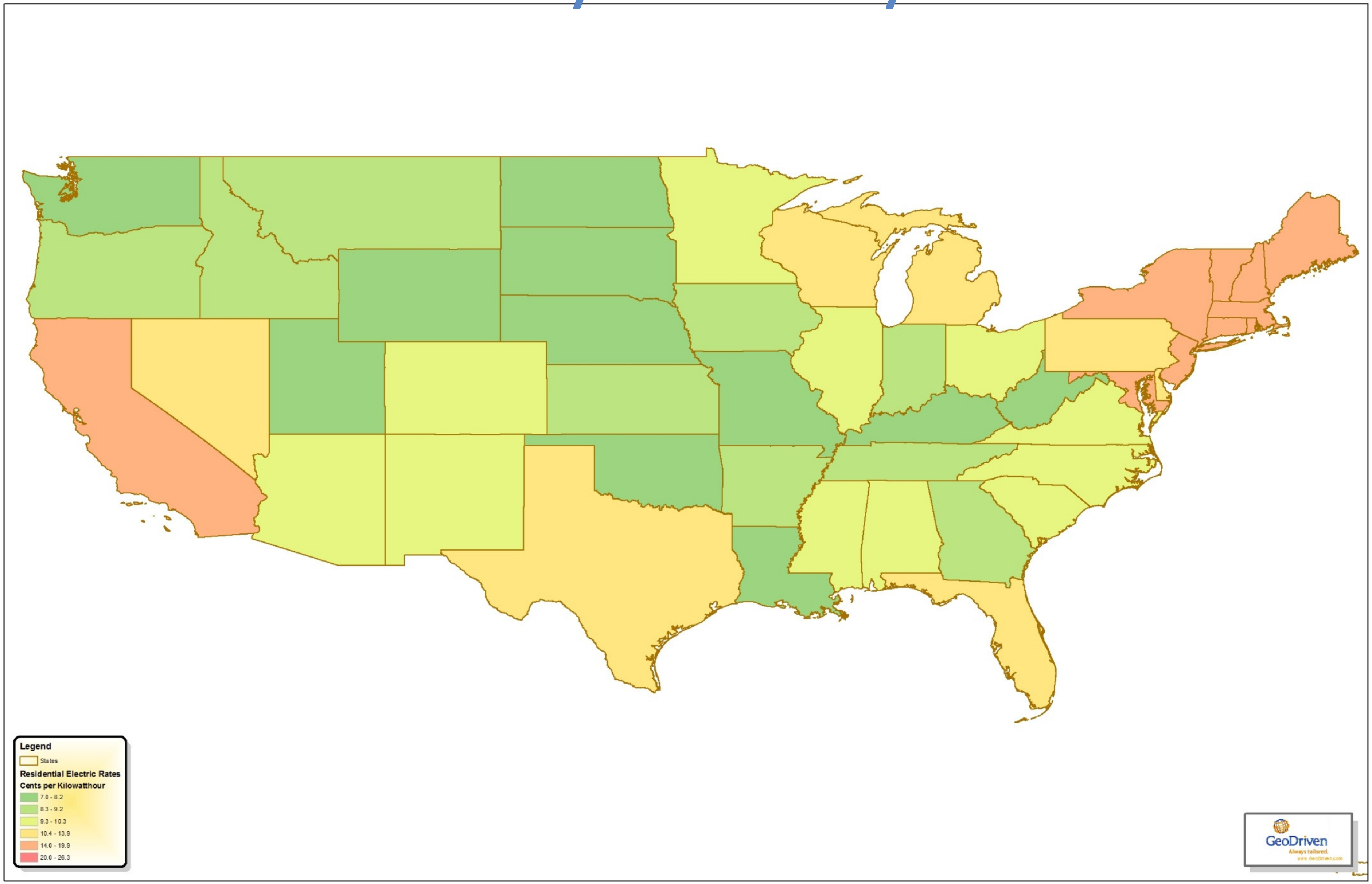
Wind Speed at 15 Meters Height



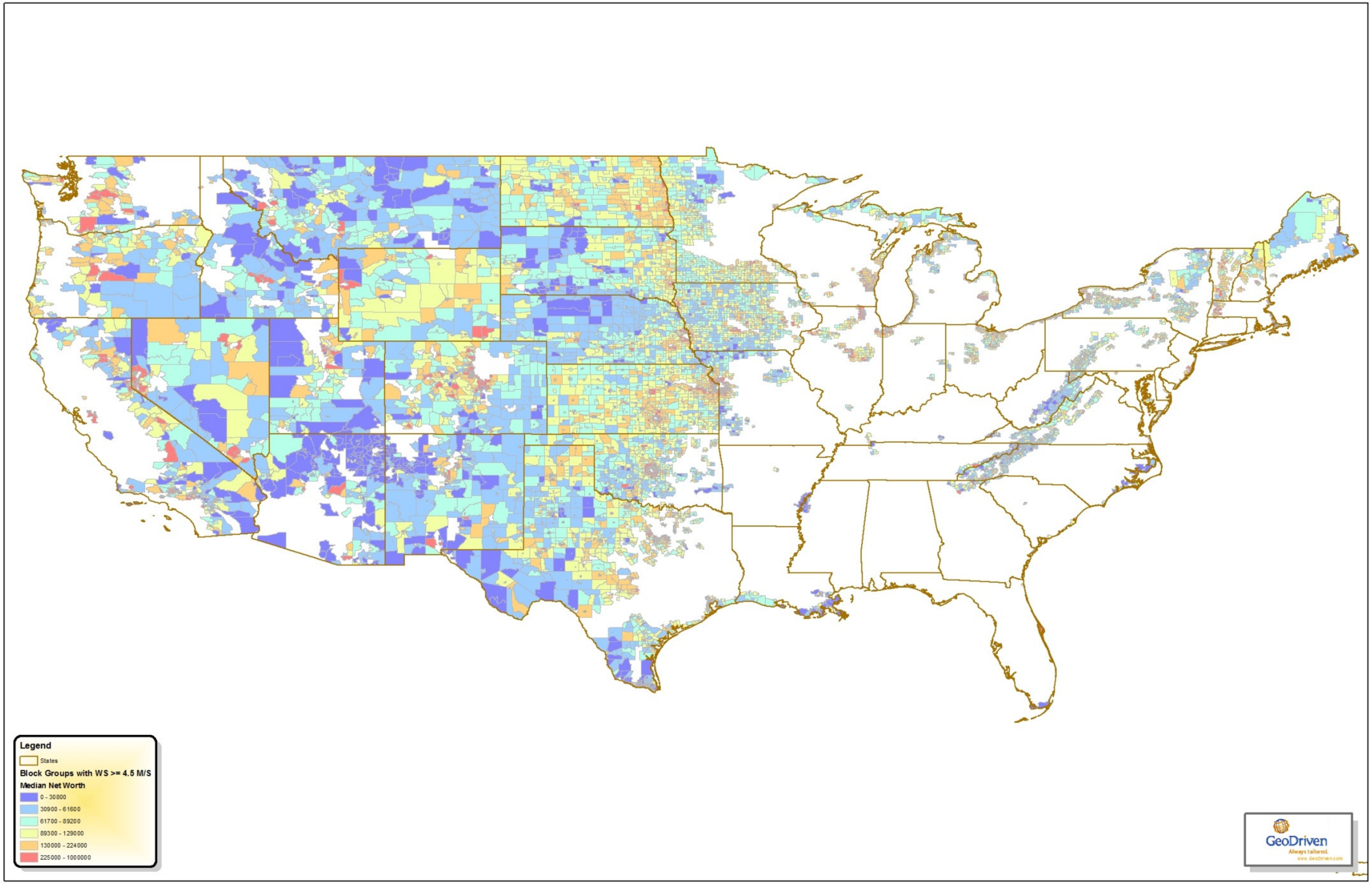
Wind Speed – Min 4.5 Meters Per Second



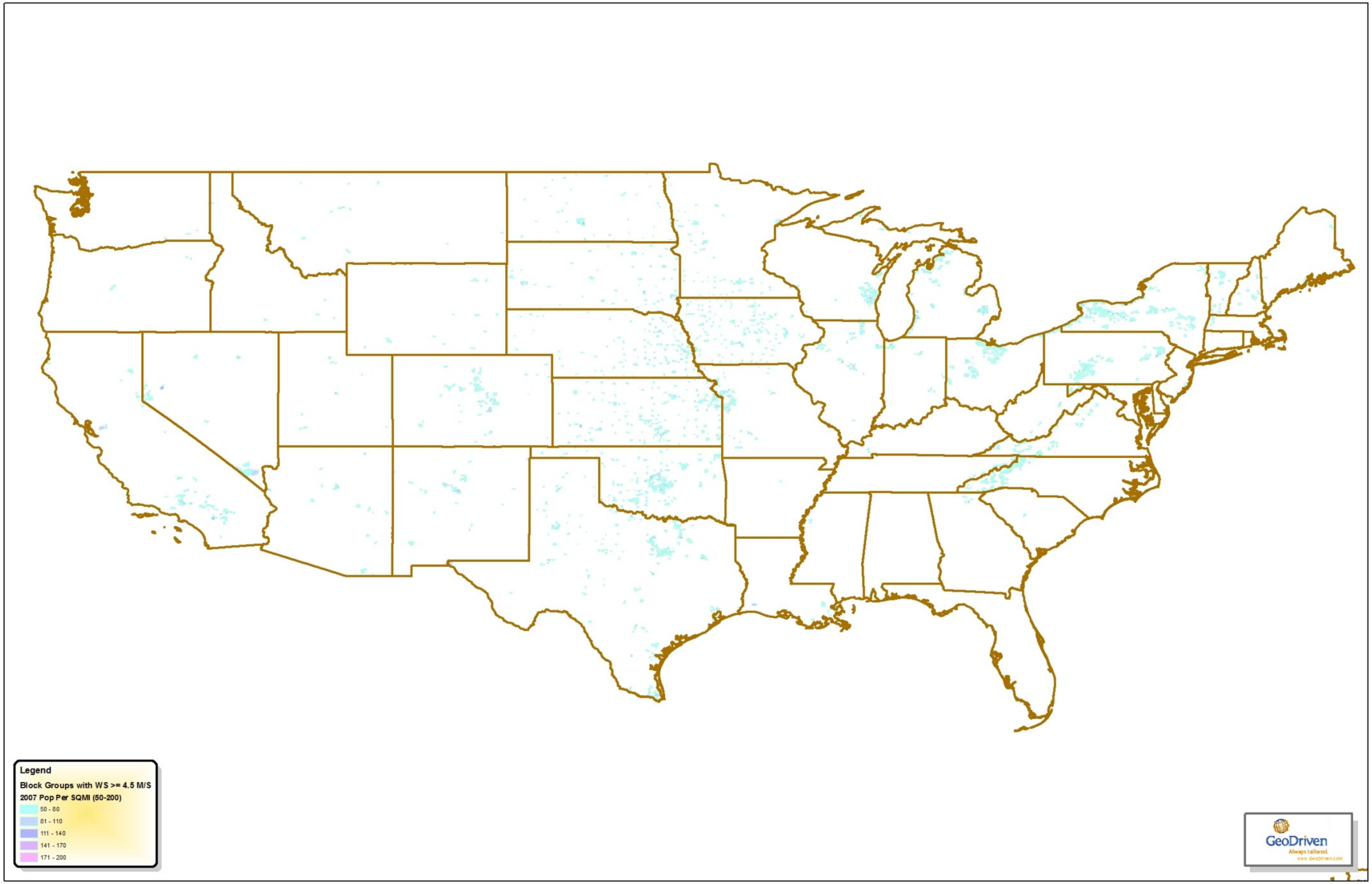
Electricity Rates by State



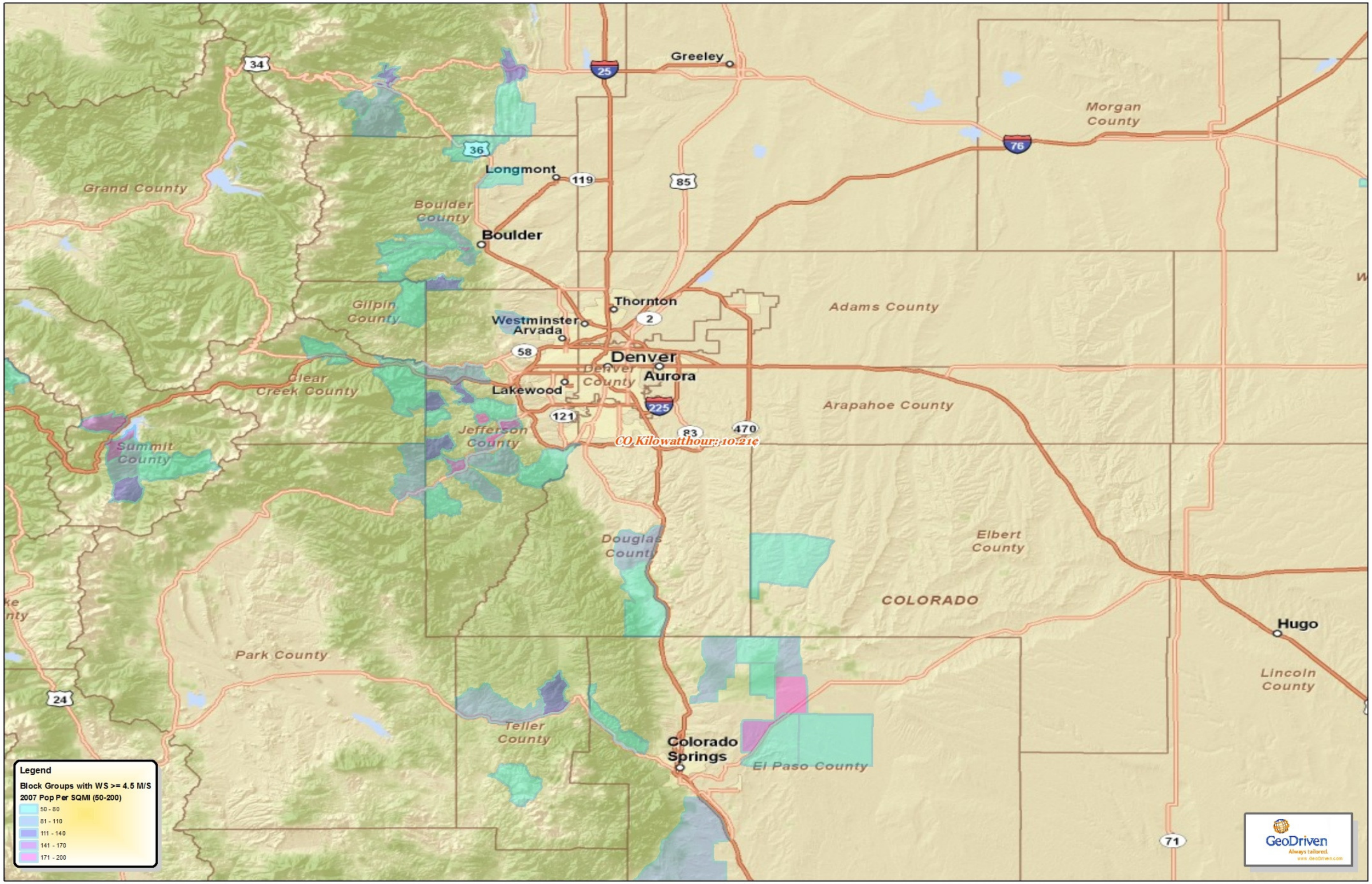
US Census Block Groups >= 4.5 M/S WS



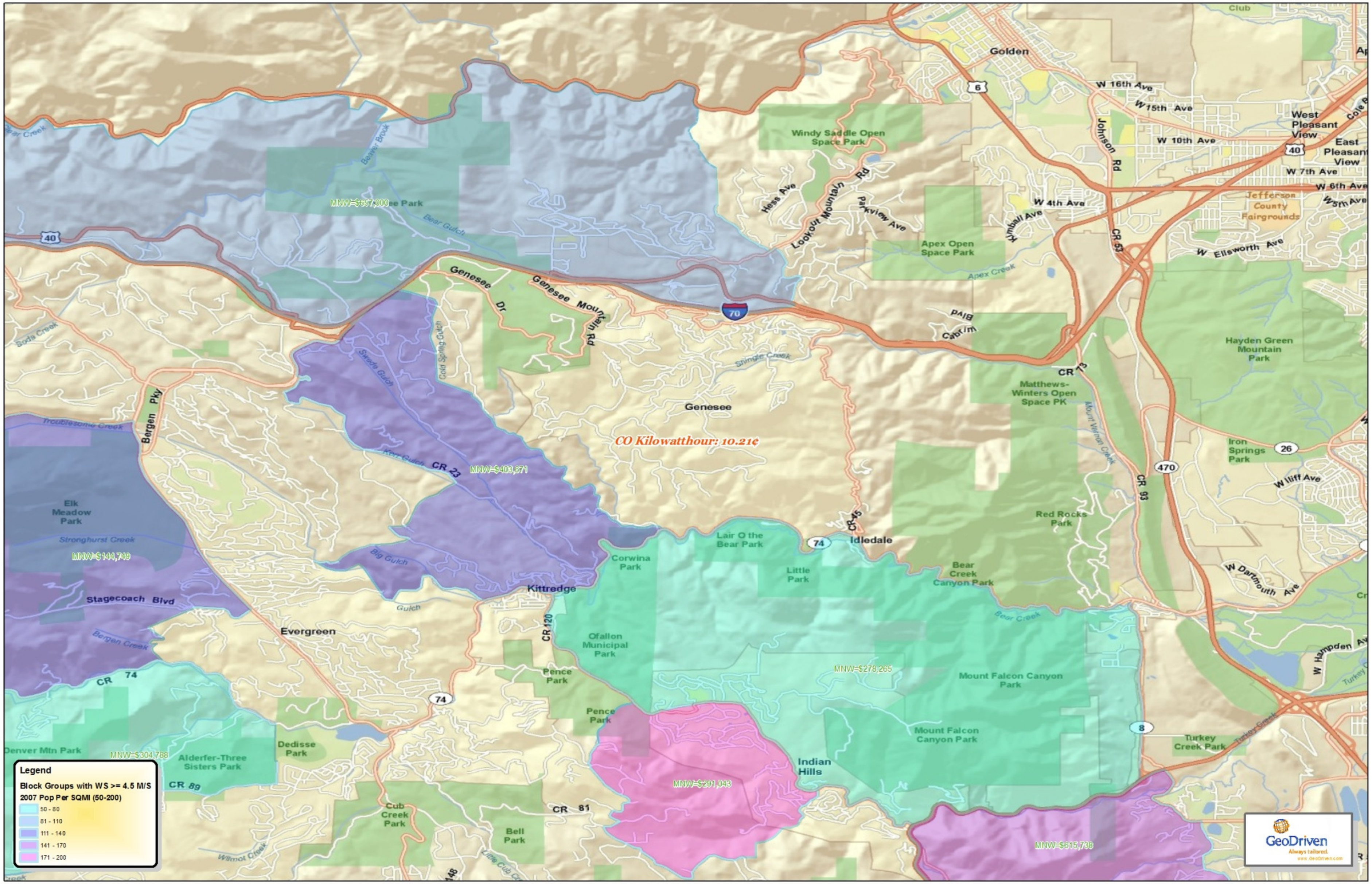
US Census Block Groups >= 4.5 M/S WS and Desired Population Density



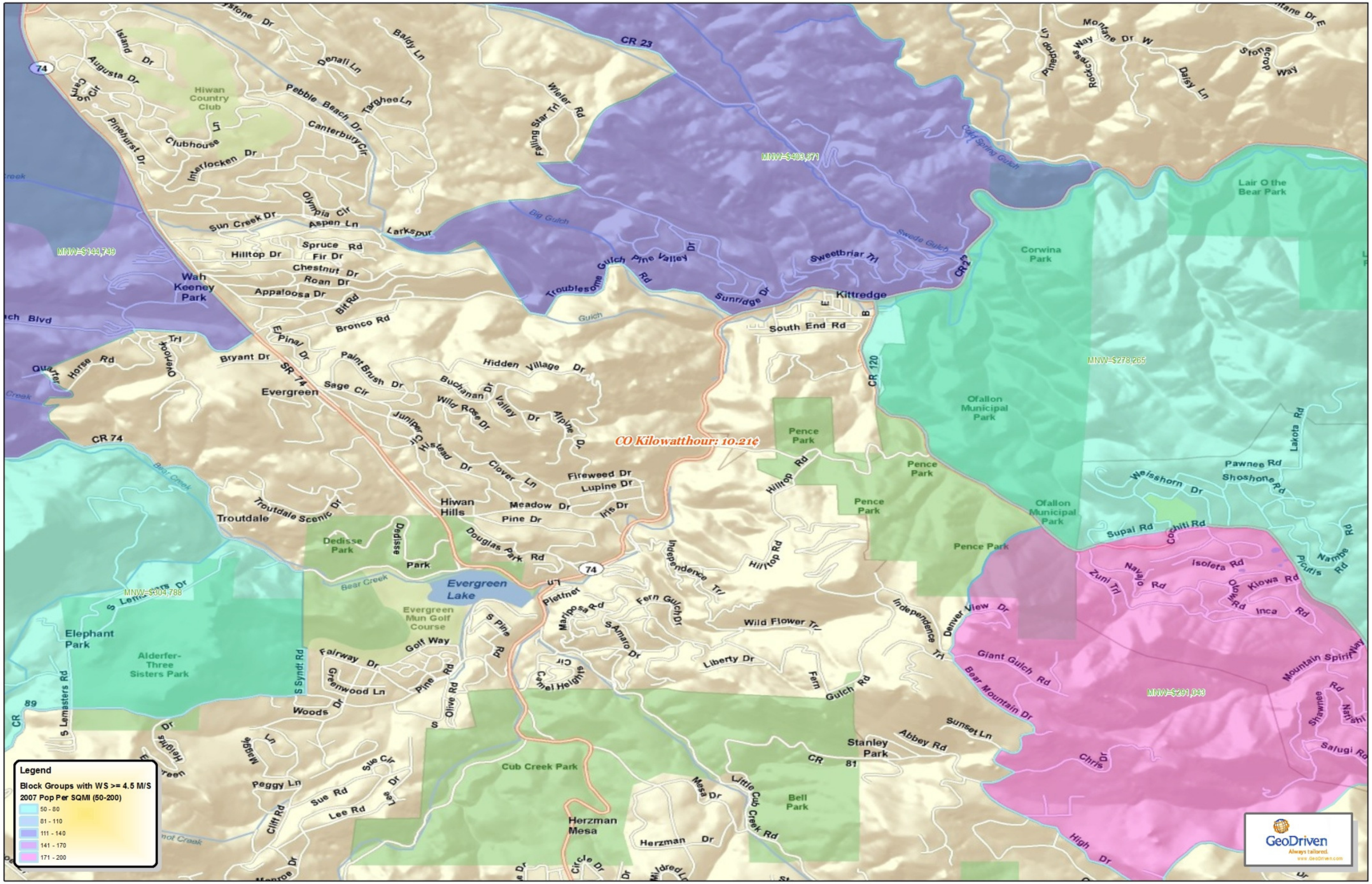
Deliverable – View 1



Deliverable – View 2



Deliverable – View 3



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