Inyo County, California

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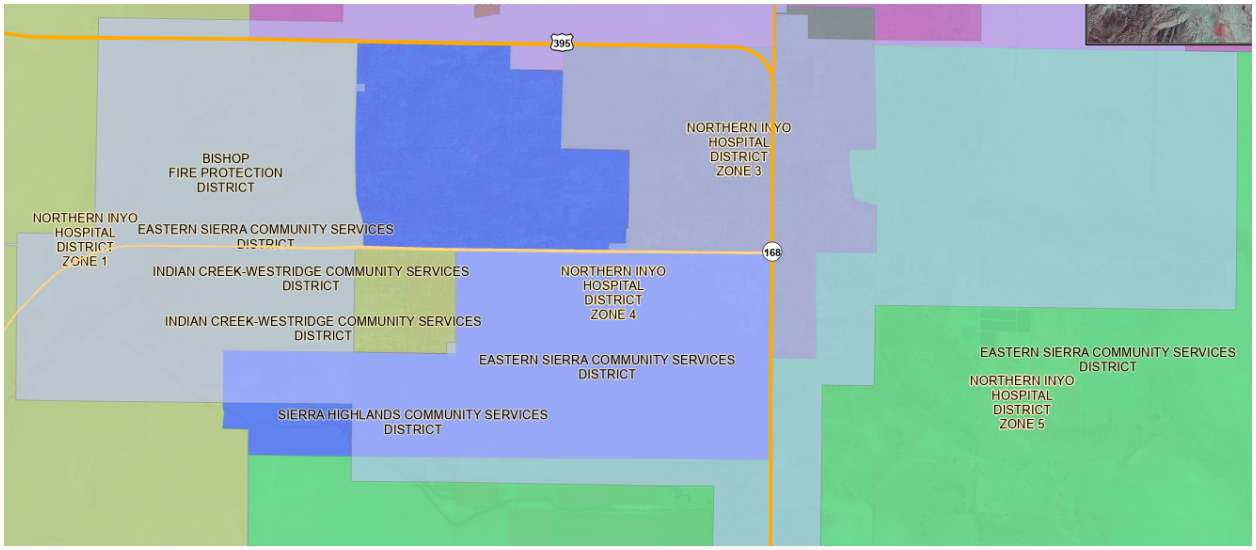
WHY?

For election officials to certify that every vote is counted accurately, they need to first ensure that every voter receives a ballot that includes all the candidates and contests that they are entitled to vote for. While this may seem like an easy task on the surface, it is a very exacting and complicated process.

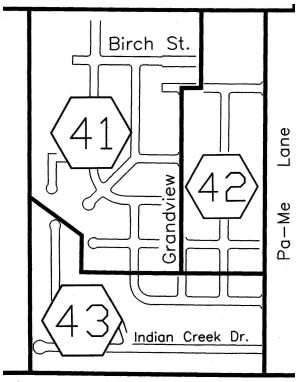
In the United States, people elect representatives for many different offices in varying hierarchical divisions of government from United States congressional districts to local hospital districts. These districts rarely coincide with each other and often have unrelated and overlapping boundaries.



Several different districts have overlapping boundaries shown by different colors

The first step in determining which contests a citizen is entitled to vote for is to divide each local government jurisdiction into the building blocks of elections – voting precincts. A voting precinct (or precinct for short) is the term used to describe a geographic area enclosed by an imaginary boundary drawn around it. This is similar to other election boundaries such as Congressional Districts, but on a much smaller scale. Traditionally, these boundary lines have been delineated and

maintained through rudimentary legal descriptions, census tracts, and fragmented maps.



Voting precincts 41, 42, and 43 on a paper map

Once the voting precincts are established, the election official must then determine which voters reside inside of these imaginary lines. This is primarily done by creating lists of addresses, and then associating a numerical range of addresses with each precinct. In the beginning, the process of creating address and associated precinct lists was completely manual. Eventually, these lists were uploaded into a computer database, known as an election management system (EMS). However, even today most election management systems do not have associated visual mapping components.

In 2010, Inyo County approved a new Geographic Information System (GIS) Department to support general county operations. Previously, there was no dedicated GIS support staff available to the elections department, so no attempt had been made to create GIS shapefiles for voting precincts. This also meant that there was no technical way to audit if the address points were accurately associated with the correct voting precincts and districts.

Using GIS, precise geographic locations, and associated attribute information (such as address number, street, town, etc.) can be created, stored, updated, and analyzed in a single database. This allows voter registration information to be audited, which ensures that the information in the election management system is correct. Inyo County had a GIS database that contained layers for streets, parcels, supervisor districts, township/range lines, and aerial photos. All that was missing was a layer for voting precincts. Working together, a GIS analyst and the Registrar of Voters created the voting precinct layer in a matter of weeks. Inyo County was then able to overlay all the relevant layers, including voter locations, and

interactively examine, correct, and verify that citizens would be voting in their correct precincts and districts.

Currently, the county's election management system does not integrate GIS within the system, so this important work is done with data extracts from the election management system, which is then imported into the GIS database. The elections office, with the help of the GIS Department, then identifies and corrects anomalies that exist in both systems.

Although this technology has allowed the county to refine and audit its voter rolls, the process of analyzing and verifying that a voter is registered in their correct precinct still requires meticulous data entry and careful manual oversight.

Before GIS

Prior to the advent of computers, election officials compiled lists of street addresses with related precinct information. The example below shows the addresses on Grandview Drive, Bishop. Please note that the addresses that fall within the range of 429-499 are within voting precinct 43:

```
Street name:   Precinct:
Grandview Drive
0-418 even........... 41
0-417 odd............ 42
429-499.............. 43
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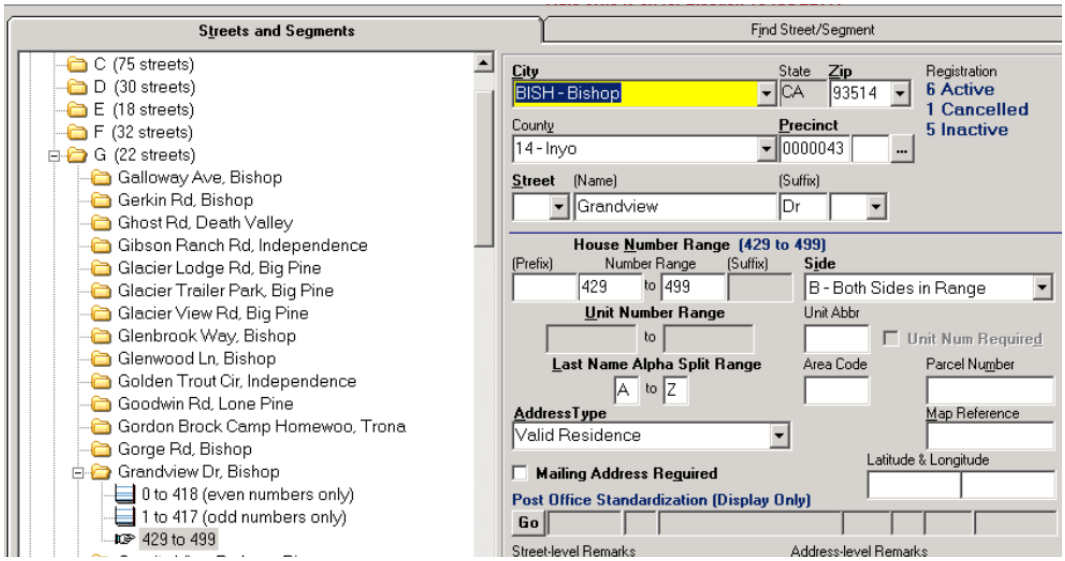
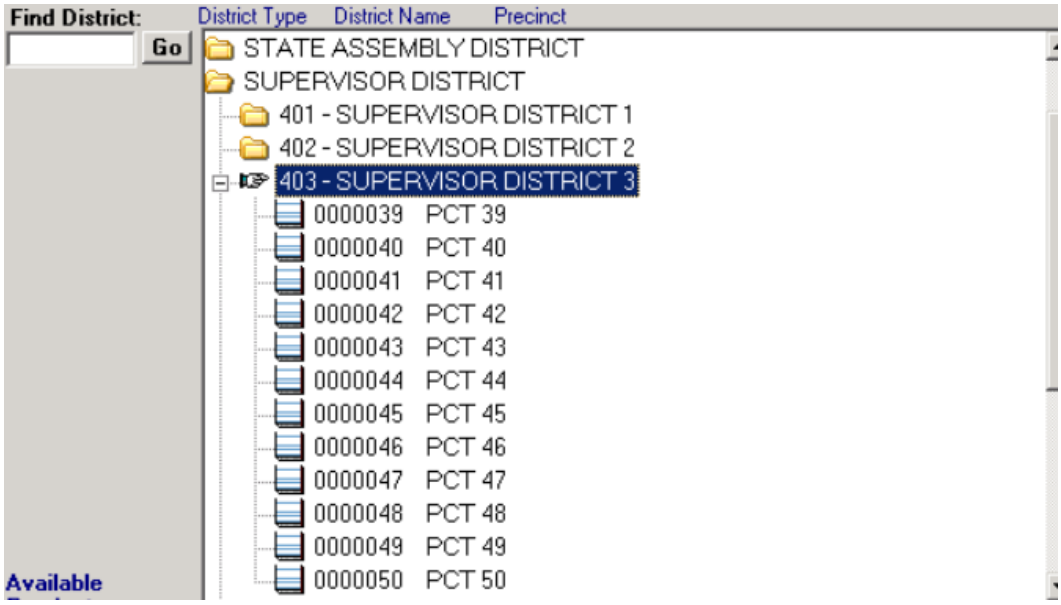
When Inyo County acquired its election management system, the street address information was uploaded so that the precincts were automatically assigned to the voter; all based on the information in the longstanding lists. This is the information being used today:



Numbers 429-499 on Grandview Drive in Bishop are in Precinct 43

Each voting district is then associated with the precincts (or portions of precincts) that are within its boundaries. In this example, you can see that precinct 43 is one of several precincts that make up Supervisorial District 3:



Precinct 43 is one of many precincts that make up Supervisor District 3

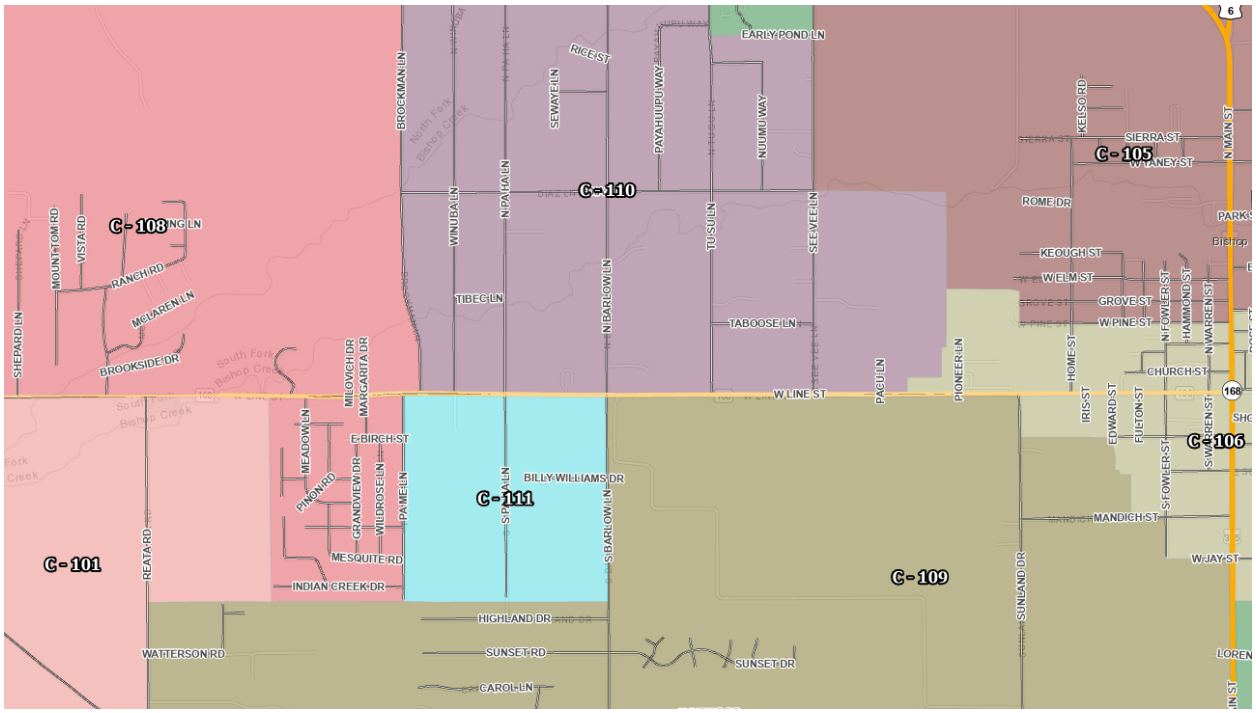
After the districts are defined, based on their connection to all of the voting precincts, an elections official groups voters into larger consolidated precincts based

on the contests and candidates for which a voter is eligible to cast a vote. In this example, precinct 43 has been combined with several other precincts to form Consolidated Precinct 111. C-111 is made up of voters that are all eligible to vote for the same contests:

CONSOLIDATED PRECINCT	REGULAR PRECINCT	BALLOT TYPE	CONTESTS
111	43,44,45,49	03	Sup District 3

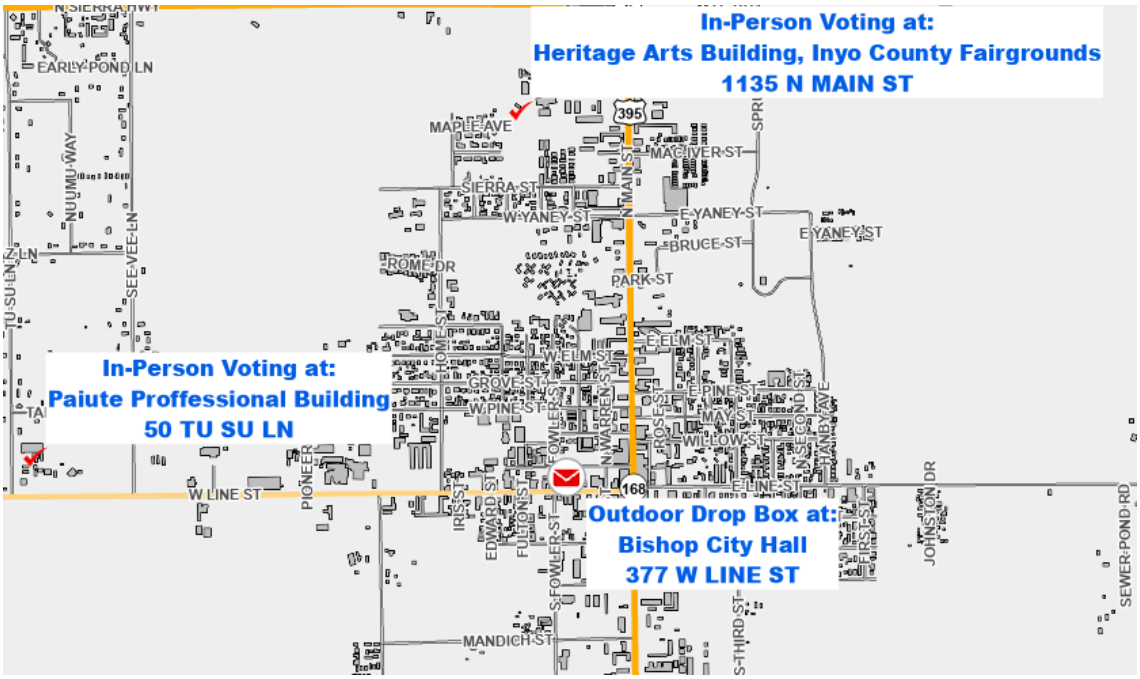
Prior to GIS, all of this was maintained and defined with paper maps.

C-111 is made up of precincts where voters are all eligible to vote for the same contests



Consolidated precinct boundaries in GIS

Districts are still maintained by street index in the election management system, but with GIS shapefiles, voting consolidation maps, precinct boundaries, voting locations, and drop boxes can all be displayed in an easy-to-use web application.



Voting and Drop Box locations displayed in a GIS website application

All the voting precincts and districts have been added into GIS shapefiles making it easier than ever to verify address data points, display important voting information, and audit the data in the election management system. In the future, it would be extremely helpful if vendors integrated GIS into their election management systems to reduce the technical expertise required to audit the system in a separate GIS database.

HOW?

To ensure that each voter received a ballot with all the contests they were eligible to vote on, and none of the contests they were ineligible to vote on, the election management system's voter precinct assignment is compared to the GIS voter precinct assignment to look for discrepancies.

The auditing process used in Inyo County consists of several steps.

First, a tab-delimited table is extracted from the EMS containing addresses and an address's associated voting precinct.

ResidenceAddress	ResidenceCity	PrecinctID
605 W Elm St	Bishop	25
615 W Elm St	Bishop	25
563 W Elm St	Bishop	26
586 W Elm St	Bishop	26
562 W Elm St	Bishop	26

Simplified example of the Election Management Systems' address and precinct table.

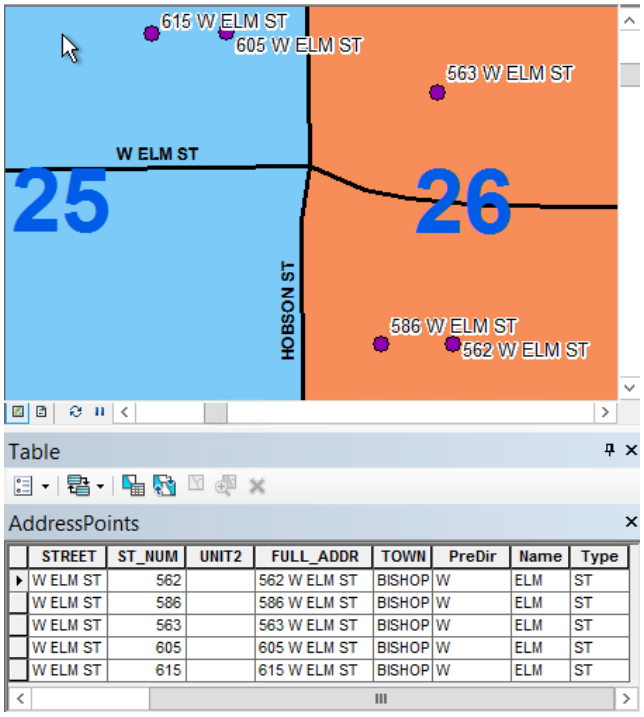
Second, the county uses a process known as geocoding. This process provides a known point-location for the physical residence of each voter. A general definition of geocoding is transforming a description of a location, such as an address, to specific coordinates such as latitude and longitude. These coordinates can be spatially compared to other spatial information like voting precincts. For instance, an address can be tested to determine if it is (or is not) within a given voting precinct, or school district, or incorporated municipality.

- The first sub-step of the geocoding process compares the EMS addresses with the county's existing AddressPoint GIS data. Any EMS addresses that match both address and town (to account for duplicate addresses in different towns) with the AddressPoint GIS data is considered to be successfully geocoded. If there are EMS addresses that do not match an address within the AddressPoint GIS data, those addresses have to be geocoded with a different dataset.

- The second geocoding sub-step is to run the unmatched addresses through the Census Bureau's geocoding application (the U.S. Census Bureau has a robust address dataset, and an easy-to-use online geocoding application). This often resolves most of the remaining addresses, but there might still be a small number that do not geocode.

- The third sub-step is to manually review each of the un-geocoded addresses in a GIS environment and visually locate where the address should be, given known address ranges for streets and aerial imagery that show unaddressed buildings.

Once all the addresses are converted to latitude and longitude coordinates and GIS point data (i.e., geocoded), the third step is to put the geocoded addresses and voting precincts into a GIS workspace where spatial relationships can be tested. Using GIS analysis tools, you can export a table that lists the addresses and each address' associated voting precinct. Now, there are two tables of addresses and precincts: one produced by EMS, and one produced by GIS.

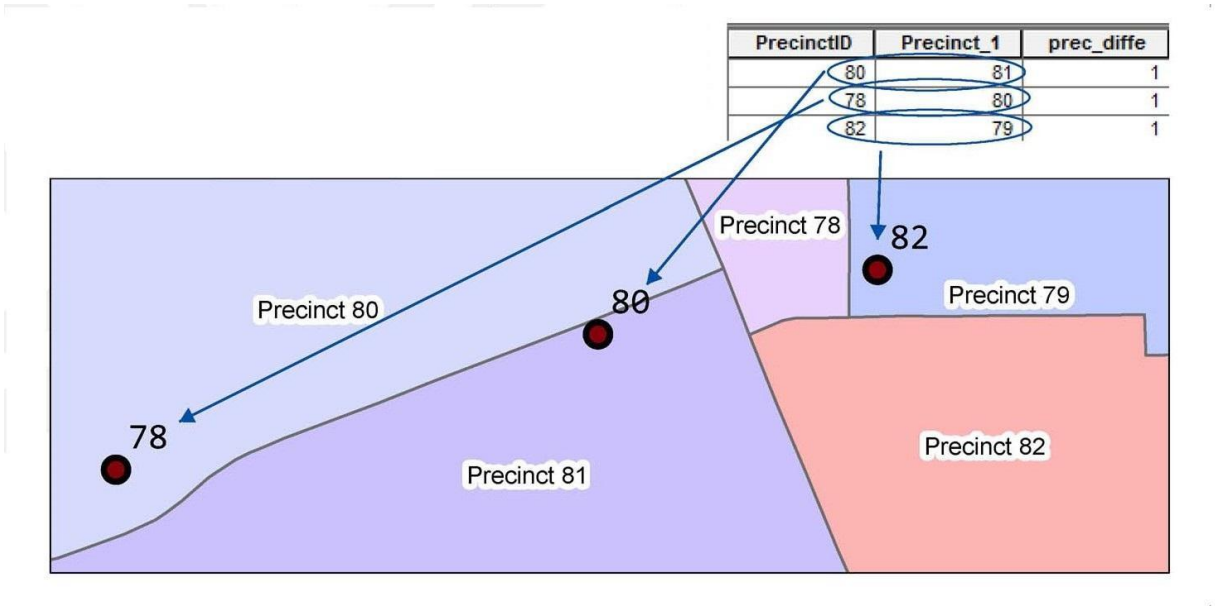


STREET	ST_NUM	UNIT2	FULL_ADDR	TOWN	PreDir	Name	Type
W ELM ST	562		562 W ELM ST	BISHOP	W	ELM	ST
W ELM ST	586		586 W ELM ST	BISHOP	W	ELM	ST
W ELM ST	563		563 W ELM ST	BISHOP	W	ELM	ST
W ELM ST	605		605 W ELM ST	BISHOP	W	ELM	ST
W ELM ST	615		615 W ELM ST	BISHOP	W	ELM	ST

Address point locations in a GIS environment. From this environment a table can be created that lists the addresses and their voting precincts. In this example, two addresses are in precinct 25 and three are in precinct 26. This table can be compared to the EMS table.

The fourth step compares the two tables for discrepancies. With several thousand voters, clearly not all of this can be done manually. A program was written to perform several tests designed to expose any discrepancies. The only test that can reasonably be performed without writing code is to compare the total number of addresses in each table. If the totals don't match, the reason for the difference will be discovered in further tests. The first coded test is to count the number of addresses in each precinct according to each table. The second test is to make sure that the addresses of each precinct in a table match the addresses in that precinct

in the other table. In other words, one table may show that a given precinct has 400 addresses, which is what the other table also shows, but the specific addresses must be compared to make sure that it is the same 400 addresses in each table. Then, a final double-check test is to run through every address and make sure the assigned precinct matches in each table. If the previous tests have been run and discrepancies resolved, there should be no problems found in this last test. Outputs for each test can be text lists of problematic addresses or precincts.

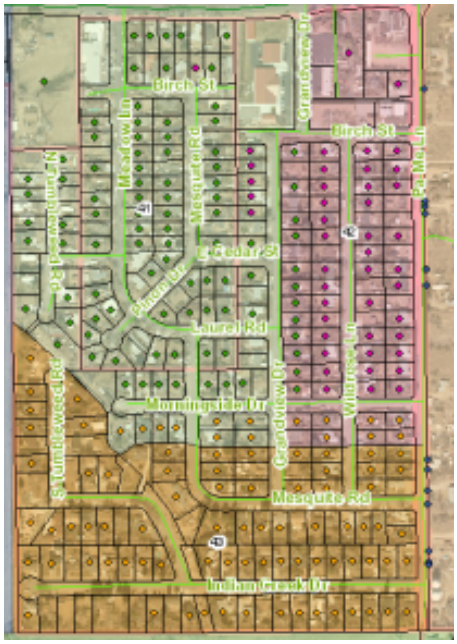


Here you can see a table with mismatched precincts in different GIS polygons that were discovered in the geocoding process

Resolution requires someone looking closely at each discrepancy and determining the possible problem. It could be a problem with the data in the EMS or it could be a problem with the data in GIS. The only way to tell is with close scrutiny of both systems. Once the erroneous data has been repaired at the source, it is advisable to go through the testing process again to make sure all problems have been resolved.

There are a couple reasons that GIS is a good tool for the job. The first reason is simply that it is a separate dataset that can be compared to the election management system. This comparison is helpful in improving both datasets. As stated above, a discrepancy may be a result of erroneous data in either system. When a discrepancy is located, the problem can be tracked down and resolved

regardless of where the problem exists. The second reason is that GIS provides a variety of separate datasets (address points, road centerlines, parcel boundaries, precinct boundaries, various district boundaries, and aerial imagery) in an environment that can be visually examined for logical consistency. For example, in the image below it can be seen that there were several discrepancies between what the color-coded geocoded EMS address points say the precinct should be, and what the GIS voting precinct boundary data say the precinct should be. This could be a problem with either dataset. By reading the written description of where the voting precinct boundaries are supposed to be, and then visually inspecting in a GIS, one can determine if the GIS precinct boundaries are correct or not. If they are correct, then the problem is with the EMS precinct assignment.



Green dots in a red-shaded precinct and red dots in a green-shaded precincts are assigned to the wrong precincts

WHO?

Sources of address point data include the U.S. Census Bureau and U.S. Postal Service. Parcel data from county assessor's offices can be used to create an address point data set by creating centroids (geometric centers) of the parcel polygons (a

sequence of individual lines forming a closed loop to define a polygon) and assigning the parcel situs address (used by the assessor's office to indicate the site location of the property) to the address point. For acquiring road centerlines (the geographic center of road right-of-ways), a starting point is the Census Bureau's TIGER/Line data. For rural areas like Inyo County, there will be many features that are not actually roads. This is an artifact of the pattern recognition algorithms used for the creation of this nationwide dataset. Address ranges and other information may have to be added and edited.

The address point data was built using a combination of contractor-collected locations and supplemented with parcel centroids. The contractor was hired to drive around the county finding posted addresses and using a mobile GIS device to drop a point on the roof of the building they were looking at. Locations that did not have a posted address had the address derived from assessor records for the parcel. An RFP process was used for deciding who to hire for the address point collection.

IMPROVEMENTS

In the future it would be helpful to have GIS fully integrated within the election management system, so the process can be seamless with less technical acumen required by election officials to manage data outside of their existing election software solutions.

There are many ways that fully integrated systems would assist elections. Some ways include having data visualizations for candidates and campaigns and displaying election results with correlated districts and geographic locations. It can also assist with ensuring equitable representation of communities of interest when redistricting and ensuring accurate administrative maintenance of election management systems.

Until GIS is fully integrated within election management systems, there will still be a knowledge curve and reliance on the expertise of a GIS professional to fully achieve the benefits of what GIS enabled elections can offer.

CHALLENGES

GIS technology does not widely exist within election offices and migrating to new software systems requires adaptation, training, data conversion, and procurement

considerations which can be difficult for local governments to navigate, especially if funding is absent or minimal.

Challenges were mostly related to coordinating between two distinct software systems and varying levels of access and knowledge base between technicians across separate disciplines. Also, the system of geocoding itself comes with its own challenges if the underlying address points or data shapefiles are inaccurate. Another problem is that there are often discrepancies in street signs, recorded maps, various databases, and US Census information. A variance as simple as St./Ave. or Ocean View/Oceanview can require manual analysis, where it may not be necessary if all data were standardized.

SUCCESSES

The process may seem overwhelming, or it may be difficult to know where to begin if you have not worked with GIS in the past, but the benefits far exceed the extra work required to create and audit election related shapefiles. Jurisdictions will have greater confidence that their elections are accurately configured, and the public will benefit from the tools that GIS has to offer.

As the 2020 election cycle demonstrated, the country needs to be moving more towards evidence-based elections so that voters can independently verify the accuracy of the elections. GIS can help provide reassurances to election officials, candidates, and voters that the election was properly configured.

GIS can be used to share any spatially explicit information with the public. For instance, Inyo County has provided online maps of voting locations and ballot drop boxes, as well as provided methods for seeing what districts and precincts an address or parcel are located within.

- Web map of voting locations:
  Voting Locations and Legitimate Ballot Drop Boxes
- Web map of GIS data including voting precincts and various districts in different layers within the map:
  Inyo County GIS Data Map
- Web map of GIS data organized by address:
  GIS Data By Address
- Web map of GIS data organized by parcel:
  GIS Data By Parcel

The county did not identify any non-election benefits, but it benefited from the process to validate and clean-up data sets across all data layers.

Special thanks to Kammi Foote, former Inyo County Clerk/Recorder & Registrar of Voters, for her work on this case study.

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