There's a Map for That! What's New and Coming Soon in SAS®
Mapping Technologies

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ABSTRACT

The last **few years have been an exciting time for the map geeks at SAS. We've added a lot** of geospatial functionality throughout SAS®**, and we can't wait to show it off. This** paper goes over all the additions, including GeoEnrichment, geocoding, the SGMAP procedure, contours, WebMap support, routing, location pins, clustering, and custom polygon support. We also show you the enhancements in progress and detail the roadmap for the future.

INTRODUCTION

The mapping team has been busy adding features to many SAS products including Base SAS®, ODS Graphics, SAS® Studio, SAS® Visual Analytics, and SAS® Graph Builder. This paper will show you the latest features added to these SAS products and allow you to catch a glimpse of what is coming soon.

PROC SGMAP

With the introduction of the SGMAP procedure to ODS Graphics, geographic mapping has never been easier. PROC SGMAP is not just a replacement for the GMAP procedure. PROC SGMAP allows you to draw points, lines, polygons, and text without having to create an Annotate data set. Furthermore, the points, bubbles, lines, and polygons can be easily placed into a legend for comparison.

CURRENT FUNCTIONALITY

PROC SGMAP was first introduced in SAS 9.4M5, with enhancements and performance improvements added in 9.4M6. The current functionality allows you to combine several plot types on a map, including scatter, bubble, text, and series plots in various combinations. Map polygons can be included to highlight or encapsulate areas of interest, and map backgrounds can be used to better identify more specific locations.

Consider the simplicity of this sample code to produce a bubble plot of the population and locations of cities in Texas on top of an OpenStreetMap background as seen in Figure 1:

```
title 'Five Largest Cities in Texas';
proc sgmap plotdata=geo_cities;
  openstreetmap;
  bubble x=x y=y size=population;
run;
quit;
```

Figure 1. PROC SGMAP Bubbles on an OpenStreetMap Background

In the past, this would have taken quite a bit of DATA step code to create an annotation data set, with the locations and relative sizes calculated. Now with PROC SGMAP, layers of data can be represented on the map in various ways. Figure 2 is an example of a choropleth map (using colored regions) that represents school districts in Dallas. The code uses the CHOROMAP, SCATTER, and KEYLEGEND statements, and the map displays scatter plot points representing school locations overlaid on an Esri background map. Notice how the regions use the *transparency* option to allow the background map to be seen.

```
title1 'SGMap with Choromap Outlines and Transparencies';
title2 'Dallas High School Districts and School Locations';
proc sgmap mapdata=hs_boundaries_wgs84
           maprespdata=regions
           plotdata=campuses_wgs84;

    esrimap url='http://myesri.myorg.com/arcgis/rest/services/World_Map';
    choromap name / mapid=name id=name
                    lineattrs=(thickness=2px color=green) transparency=.3
                    name="Districts";
    scatter x=x y=y / markerattrs=(symbol=trianglefilled size=10px
                                   color=red);
    keylegend "Districts" / title="High School";
run;
```
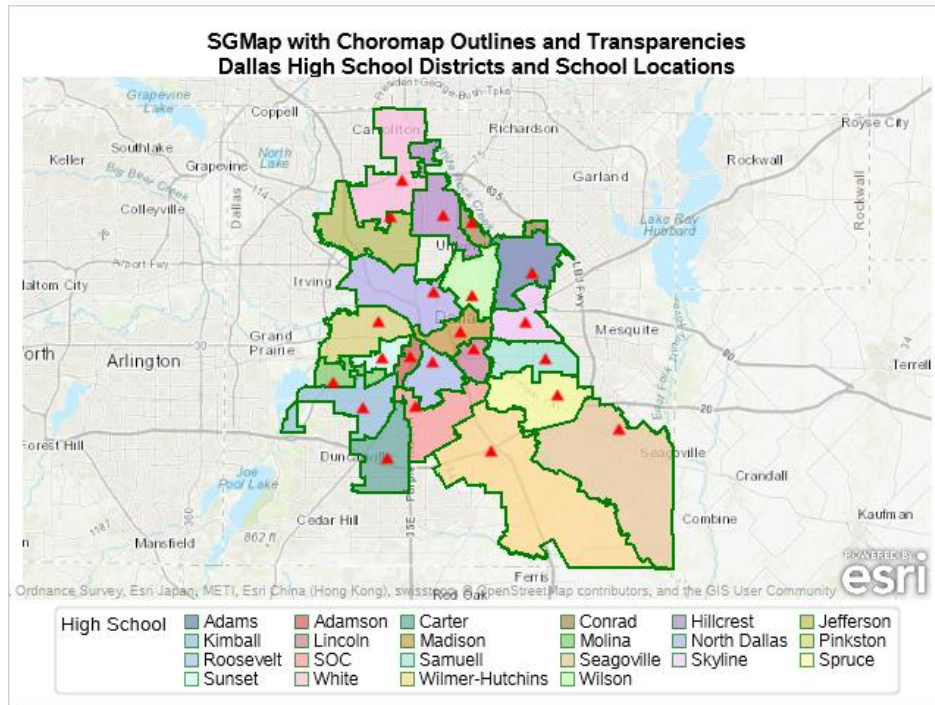
Figure 2: SGMAP CHOROMAP and SCATTER on an Esri Map

Beginning with SAS 9.4M6, PROC SGMAP supports lines with the SERIES statement. Here is an example of plotting hurricane tracks. In Figure 3, notice how the hurricanes are grouped by name. This code draws unique lines for each hurricane.

```
title1 'SGMap with Series Plot';
title2 '2005 North America Hurricanes';
proc sgmap plotdata=tracks;
  openstreetmap;
  series x=x y=y / group=name;
run;
```
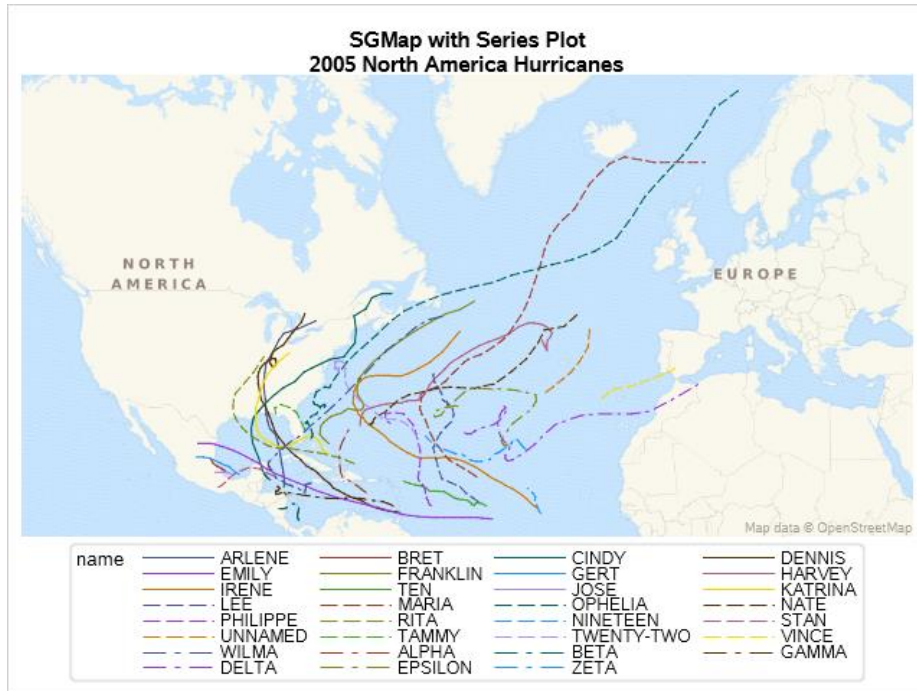
Figure 3. PROC SGMAP Grouped Series Lines

FUTURE ENHANCEMENTS

In a future release of Base SAS, PROC SGMAP will have the following enhancements:

- The STYLEATTRS statement, with the following options:
    - DATACOLORS
    - DATACONTRASTCOLORS
    - DATALINEPATERNS
    - DATASYMBOLS
    - BACKCOLOR
- COLORRESPONSE on the SCATTER and BUBBLE statements
- COLORMODEL on the CHOROMAP, SCATTER, and BUBBLE statements
- DATTRMAP and ATTRID support for the CHOROMAP, SERIES, SCATTER, and BUBBLE statements.
- RATTRMAP and RATTRID support for the CHOROMAP, SCATTER, and BUBBLE statements
- URL support for the CHOROMAP, SERIES, SCATTER, and BUBBLE statements
- TIP, TIPLABEL, and TIPFORMAT support for CHOROMAP, SERIES, SCATTER, and BUBBLE statements.
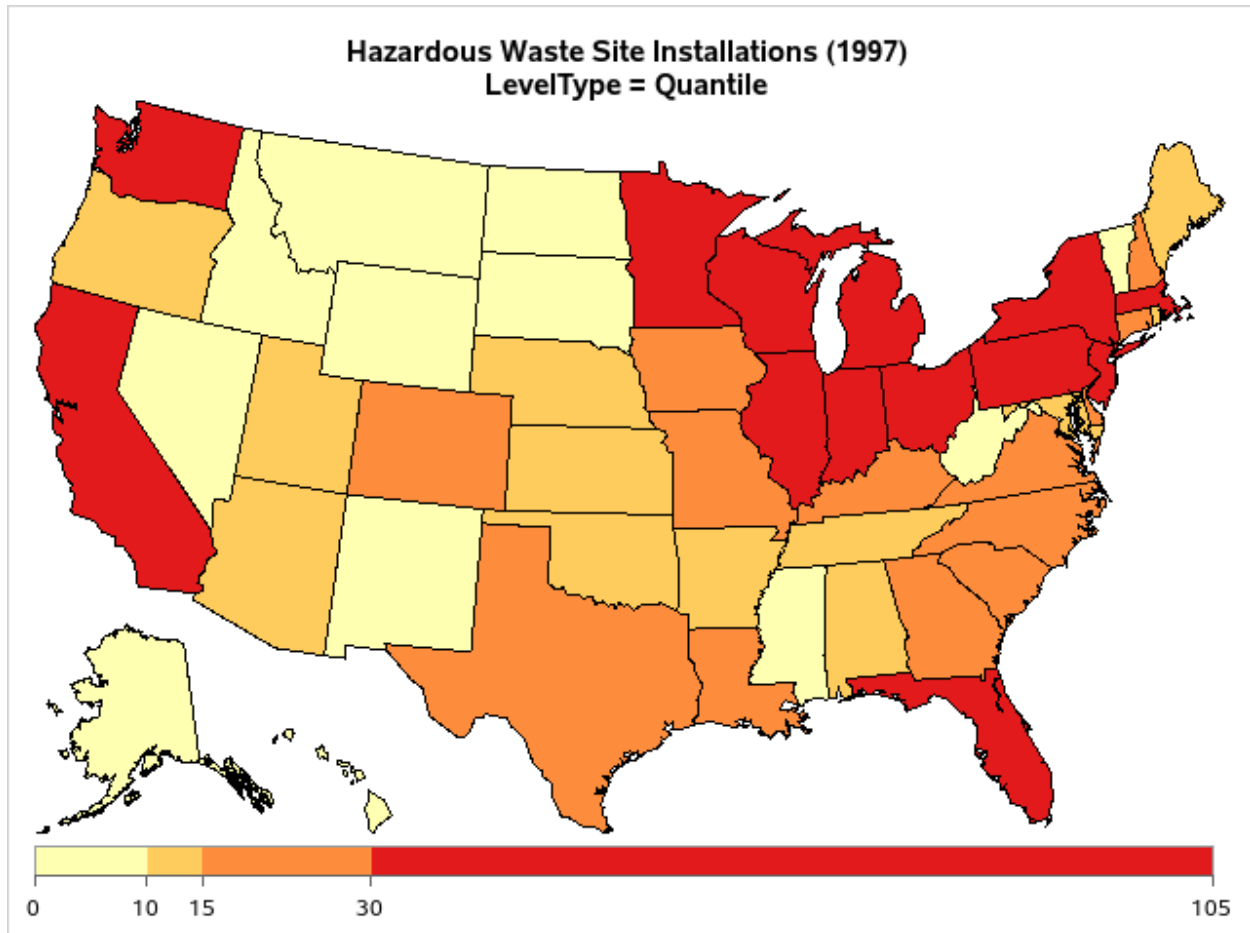- Quantile (equal-distribution) support (Figure 4)

Hazardous Waste Site Installations (1997)
LevelType = Quantile

Figure 4. PROC SGMAP with Quantile Binning

SAS STUDIO TASKS FOR PROC SGMAP

PROC SGMAP became available in SAS Studio 3.7. Beginning with SAS Studio 3.8, PROC SGMAP tasks were added for each of the overlay types: bubble, choropleth, scatter, series, and text. These tasks are a convenient way to get started with the new mapping procedure by using the graphical interface of SAS Studio. Once you create code using the task in the SAS Studio interface, you can modify it as needed to achieve the desired results.

You can find the PROC SGMAP tasks in the tree menu on the left side of SAS Studio under *Tasks and Utilities > Tasks > Map.* To get started, simply double-click on the desired task or drag and drop the task name to the SAS Studio canvas. This will open a vertically split screen with the graphics options on the left and the code editor on the right as shown in Figure 5.
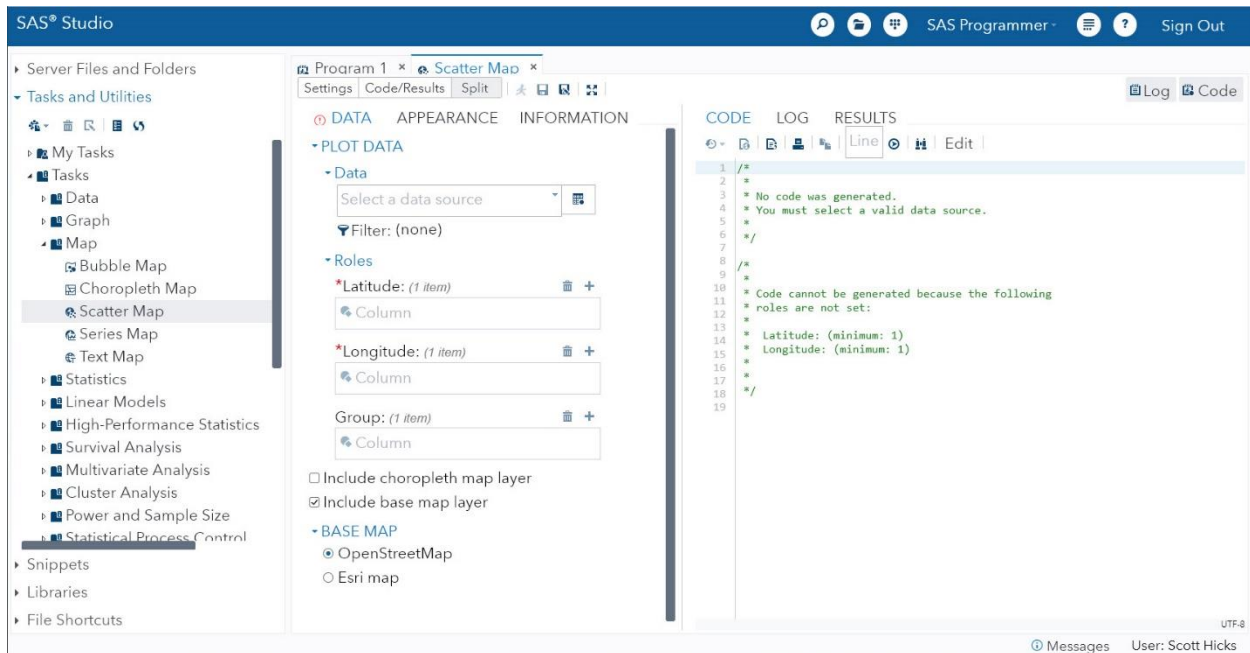
Figure 5. The Scatter Map Task in SAS Studio 3.8

The task view has three available tabs to assist in creating your map: *Data*, *Appearance*, and *Information*. Specify the required information to create a map in the *Data* tab. The *Appearance* tab defines the styling or look-and-feel of the map with items such as labels, legend, and title. The *Information* tab displays content about the task and provides links to the underlying PROC SGMAP documentation and the SAS Studio task reference guide.

In Figure 6, the SASHELP.ZIPCODE data set was chosen to create a scatter map. The ZIP code data was filtered to the state of Washington and grouped by the County variable. The example selects an OpenStreetMap background for reference. The map displays in the *Results* tab and can be printed and shared in various formats supported by SAS Studio.
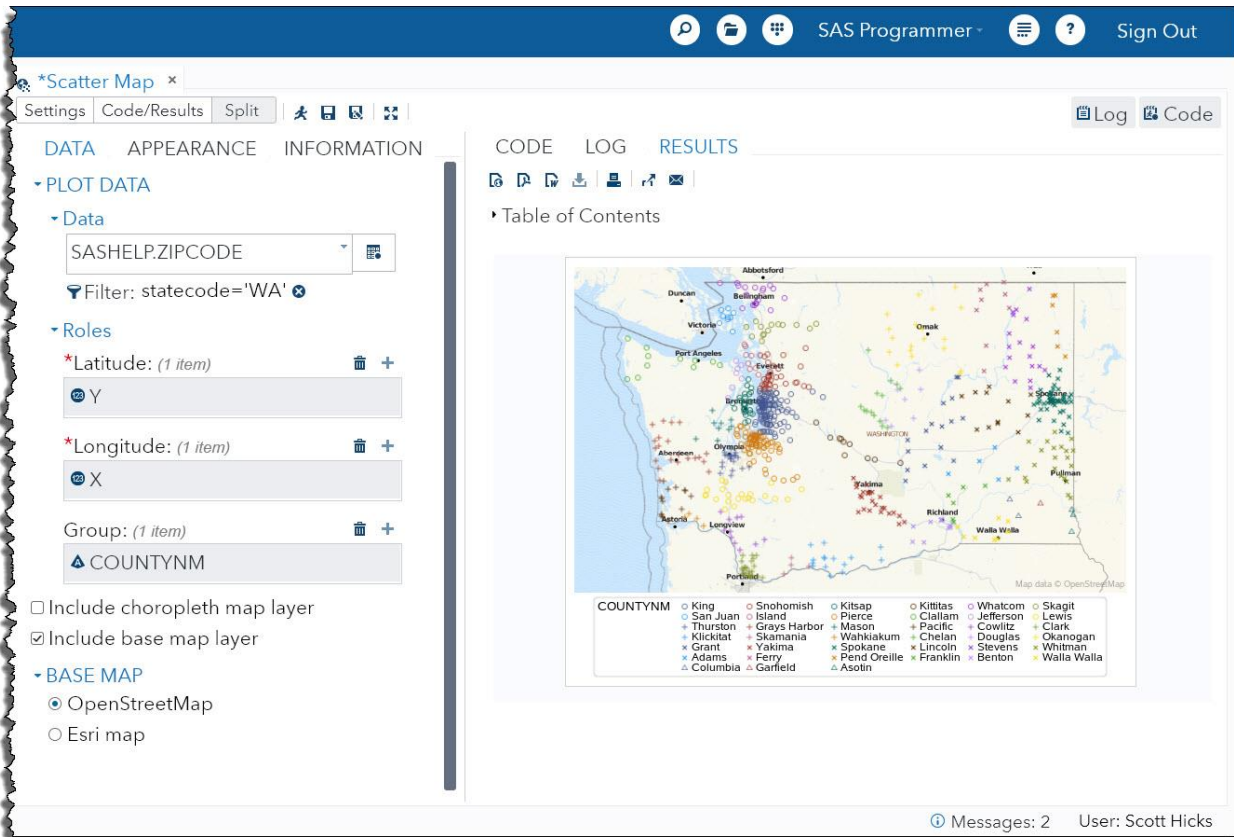
Figure 6. Scatter Map Output Using SAS Studio 3.8

SAS Studio also generates PROC SGMAP code, which can be run in any SAS session. The following code was generated from the scatter map task in Figure 6:

```
ods graphics / reset width = 7in height=5in;

proc sgmap plotdata=SASHELP.ZIPCODE(where=(statecode='WA'));
   Openstreetmap;
   scatter x=X y=Y/ group=COUNTYNM name="scatterPlot" markerattrs=
      (size=7);
   keylegend "scatterPlot"/ title='COUNTYNM';
run;

ods graphics / reset;
```

SAS VISUAL ANALYTICS

There are many new mapping features in SAS Visual Analytics, such as routing, geocoding, and data enrichment. We will also introduce some enhancements to existing features such as custom polygons and location pins.

CUSTOM POLYGONS

Beginning with SAS Visual Analytics 8.2, you can access polygon layers within a map or feature service located on your organization's Esri server. In a coming release, the ability to access point layers will also be available, as well as the ability to calculate the centroids of polygon features. By default, SAS Visual Analytics only allows administrators to create, edit, or delete a custom map provider. However, an administrator could set up a custom group of individuals with these privileges.

You can begin to create the provider by choosing *Custom Polygons* from the *Edit Geography Item* window and the contents of the window will update. Create the provider by choosing the *Custom polygon provider* drop-down list and then selecting the *Define new polygon provider...* button.

This opens a new window, as seen in Figure 7. Give the provider a unique name and a label. After the label is created, it will then be available as a choice in the *Custom polygon provider* drop-down list. There are two types of custom polygon providers: *CAS table reference* and *Esri feature service*. The content of the window changes based on your selection.

When you reference a shape table, you will specify the location of the table, an identifier variable for referencing each polygon, and a sequence column. The sequence column is necessary for keeping the vertices in order. Because the SAS® Cloud Analytics Services (CAS) is a distributed memory data environment, it needs a column for sorting in order to preserve the original order. You also need to set the coordinate space so that SAS Visual Analytics knows how to interpret the location values and show them correctly on the map. If you expand the *Advanced* section, you can specify the *X*, *Y* and *Segment* columns. The segment column defines each polygon within a multi-polygon set (for example, Hawaii consists of several islands forming a multi-polygon group that is identified together, so each island needs a different segment value).

When you change the type to *Esri feature service,* you can now enter the FeatureServer or MapServer URL for the Esri service. The *Feature Service Layer* updates to allow you to choose which layer to access. You also need to choose the polygon identifier column used in the feature service layer. This is the column in the Esri database that will match the identifier in the currently loaded table.
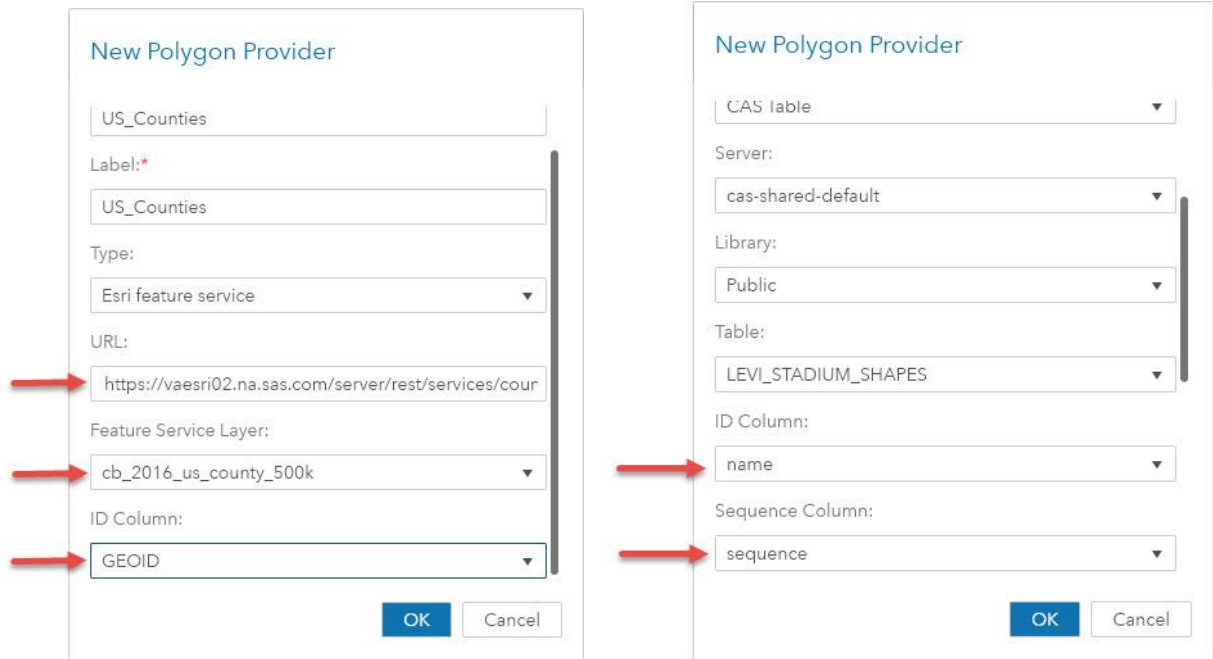
Figure 7. New Polygon Provider Setup

After you have saved the provider and return to the *Edit Geography Item* window, you should see the label for your new provider as the currently selected provider. Now you need to enter the identifier column from your table that is needed to match with the Esri database. As was stated earlier, often this can be a column that you don't wish to show on the map because it might have no meaning to someone viewing the report. Other times the columns use the same value, such as U.S. ZIP Codes or unique region names. In our example shown in Figure 8, we are using "STATE_CTY_FIPS" for the identifier, but "County Name" for the displayed column.

Figure 8. Geography Column with Custom Polygon Provider Selected

The right side of the *Edit Geography Item* window shows the confidence of the matched columns, including a small thumbnail map of your regions. If you do not see a map or if the confidence has a low percentage, you might have either chosen the wrong column from your data or there is some other type of mismatch. You might want to inspect your data more closely to produce a better match.

If you have coordinate data in your loaded table, you can optionally add those to the latitude and longitude column entries. The *Coordinate Space* entry refers to your latitude and longitude columns and not the polygon provider. The Esri service provides the coordinate space to SAS Visual Analytics so that the regions will display correctly.

Now that the geography column has been defined, you can drag and drop the column onto the canvas to display your map, as seen in Figure 9.
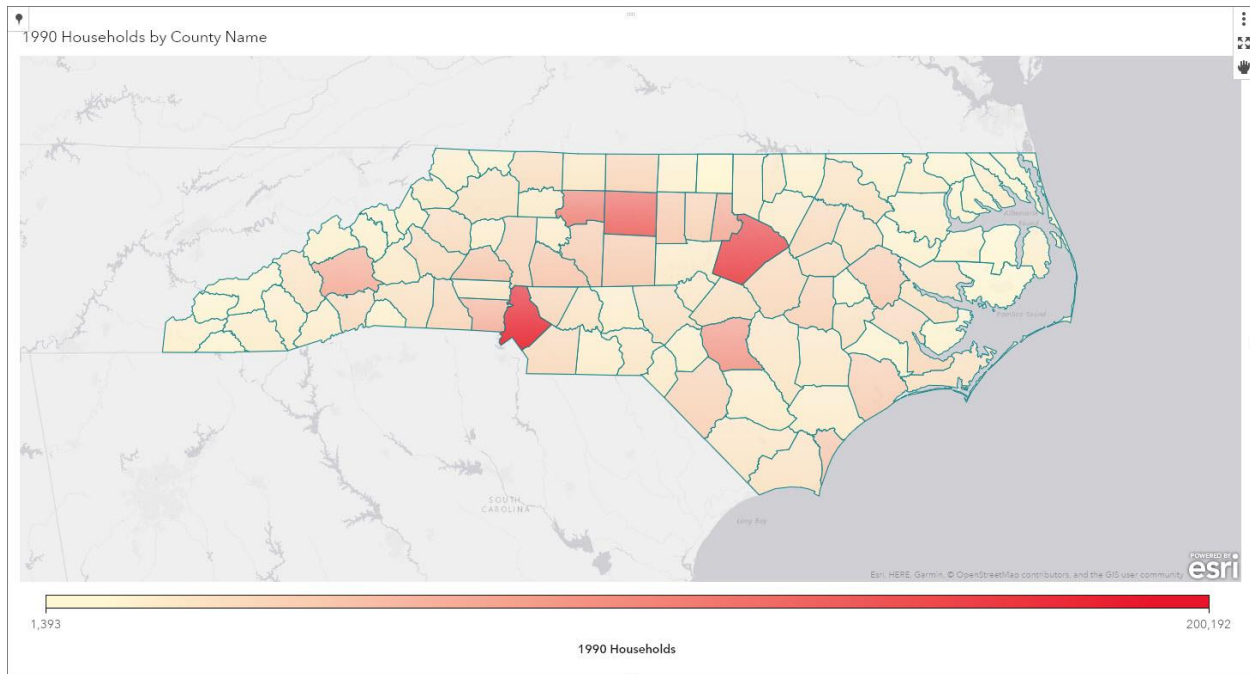
Figure 9. Choropleth Map Using Custom Polygons for North Carolina Counties

After you have created the polygon provider, it is available to all report designers to use. It is defined in SAS Visual Analytics and not in the individual report. Because this is a shared resource, you should take caution in making many changes to the provider, because it can adversely affect other reports.

In a future release, you will be able to use the polygon providers to show centroids represented as bubbles or coordinate maps. Furthermore, you will be able to define coordinate providers for more static locations that you reference. This will remove the burden of having to include your coordinate data with your business data. Many locations referenced in data are permanent or semi-permanent locations, such as factories, drilling sites, pumping stations, electrical substations, and refineries.

LOCATION PINS

Starting in version 8.3 of SAS Visual Analytics, **you can place a marker, or "pin,"** on the map. Clicking the pin icon in the upper left of the map view reveals a menu where you can enter search criteria or select the *New location pin* button. Selecting this button enables you to click anywhere on the map to place the pin. Once placed, the pin is added to the menu with a unique name and a reverse-geocoded address. Figure 10 shows a pin that has already been created and highlights the *New location pin* button.
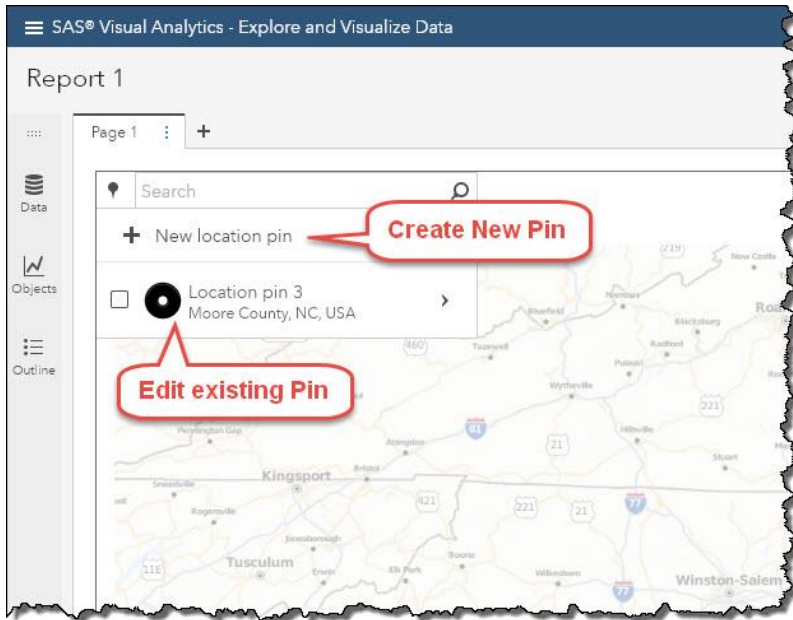
Figure 10. New Pin Menu

Selecting the pin reveals a new pop-up menu. You can create a geographic selection based on distance from the pin, create a route to or from the pin, or create a second pin at the same location. Figure 11 shows this new pop-up menu.
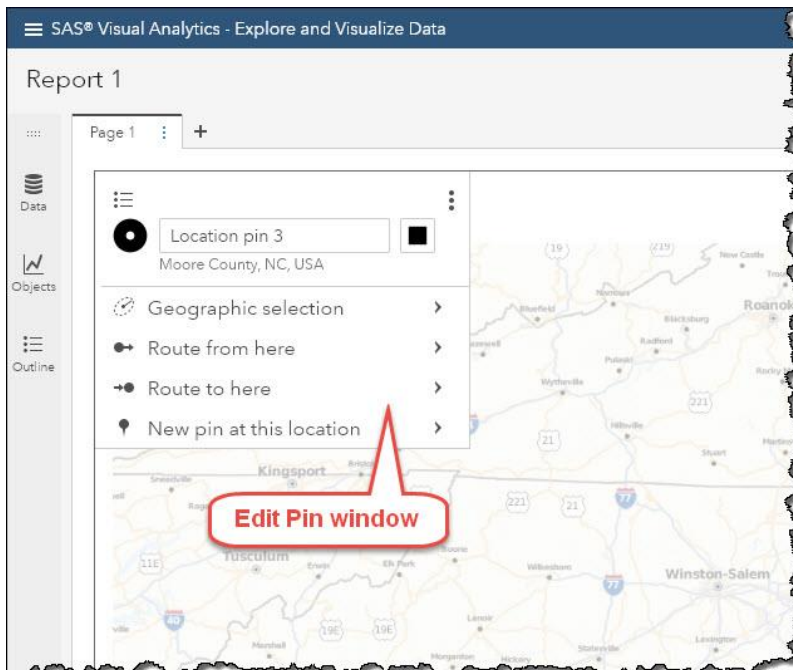

Figure 11. Edit Pin Menu

LOCATION DISCOVERY AND EXPLORATION

There are many ways for you to discover and explore your maps in SAS Visual Analytics, with added functionality provided by services from Esri. Routing can show the fastest or shortest path between two points. Calculating an area, or buffer, around a point using straight-line distance, Drive-Time, or Drive-Distance allows you to see an area representing all possible routes within a specified distance. After a buffer is created, you can explore the demographics of the area using GeoEnrichment from Esri.

Many factors can be applied in the routing and buffering analysis including historical traffic conditions, traffic conditions at a specific time of day and day of week, live traffic conditions, and truck routing and walking paths. Routing, Drive-Time analysis, and GeoEnrichment are premium services and require an Esri login and available service credits.

Drive-Time and Drive-Distance Analysis

From a known point, you can calculate a buffer that represents all the places that someone could walk, drive a car or drive a truck in a given time. By selecting all the data points that are within that buffer, you can explore and reveal additional information. You can combine up to three concentric values at a time. For example, Figure 12 shows how to select 5- and 10-minute drive times in Hamburg, Germany, and Figure 13 shows the resulting buffers. Data points that fall within any of these buffers will be selected, and they can potentially interact with other visuals in your report.

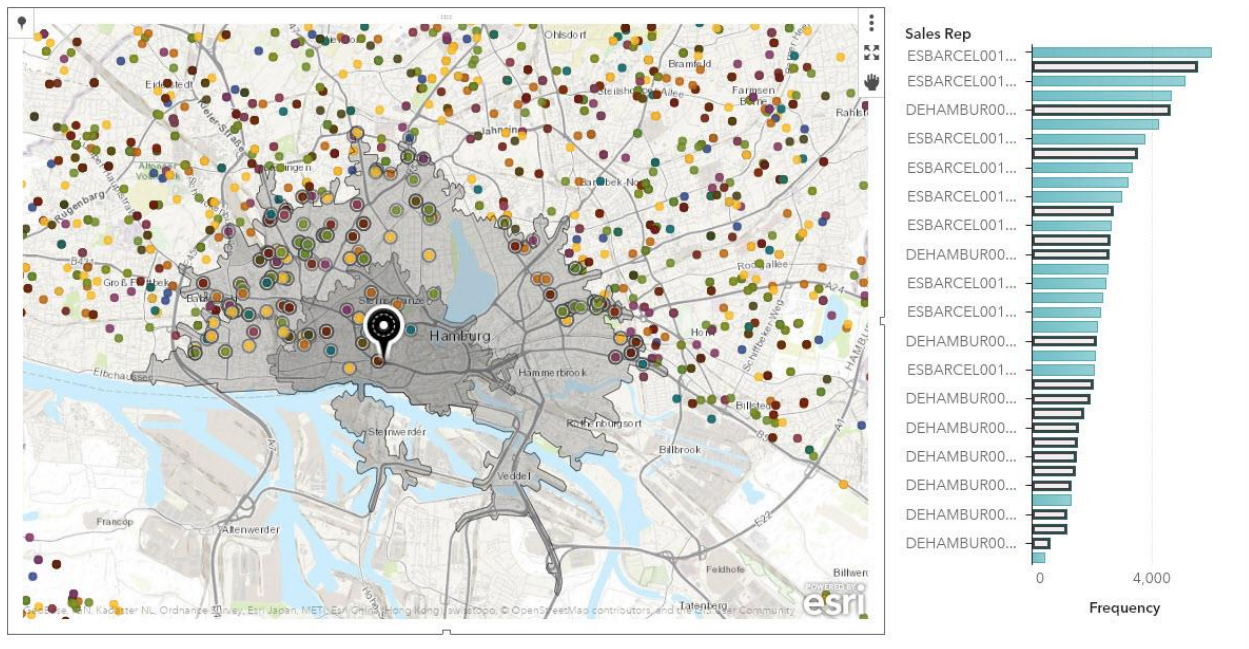

Figure 12. Geographic Selection Setup Window.

Figure 13. Drive-Time Analysis in Hamburg, Germany with Linked Bar Chart

GeoEnriching a Buffer

After you have created a buffer, you can click the *Show Demographics* button to display a data selector to choose variables based on data for the country being displayed, as seen in Figure 14.

SAS Visual Analytics queries the location of the origin of the buffer in order to attempts to determine the current country of interest and help initialize the data selector. Some countries contain a much larger number of variables to choose than others. In Figure 14, the buffer has been placed in Germany, where there are over 400 variables available.
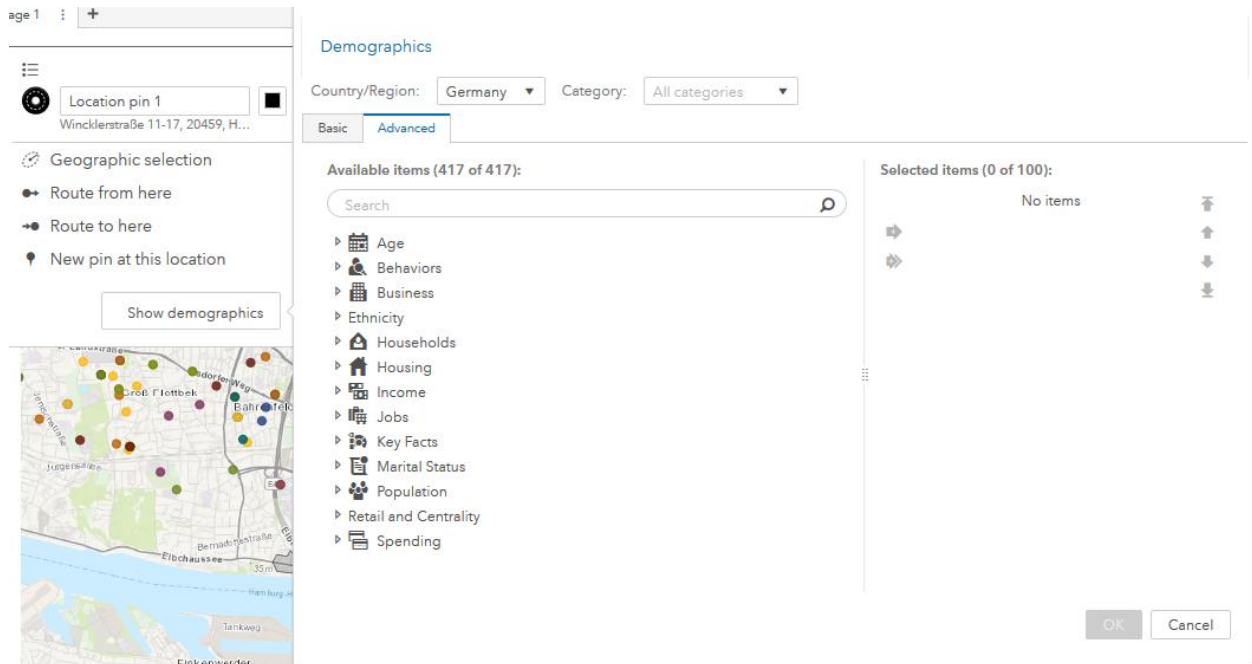
Figure 14. Demographics Data Selector for Esri GeoEnrichment

The results are aggregated for the outermost buffer and displayed as a pop-up window, shown in Figure 15. Each set of values is displayed in its own panel that can be paged to reveal the information. Some fields can be combined into a single graphical representation based on age, gender, or year collected, for example.
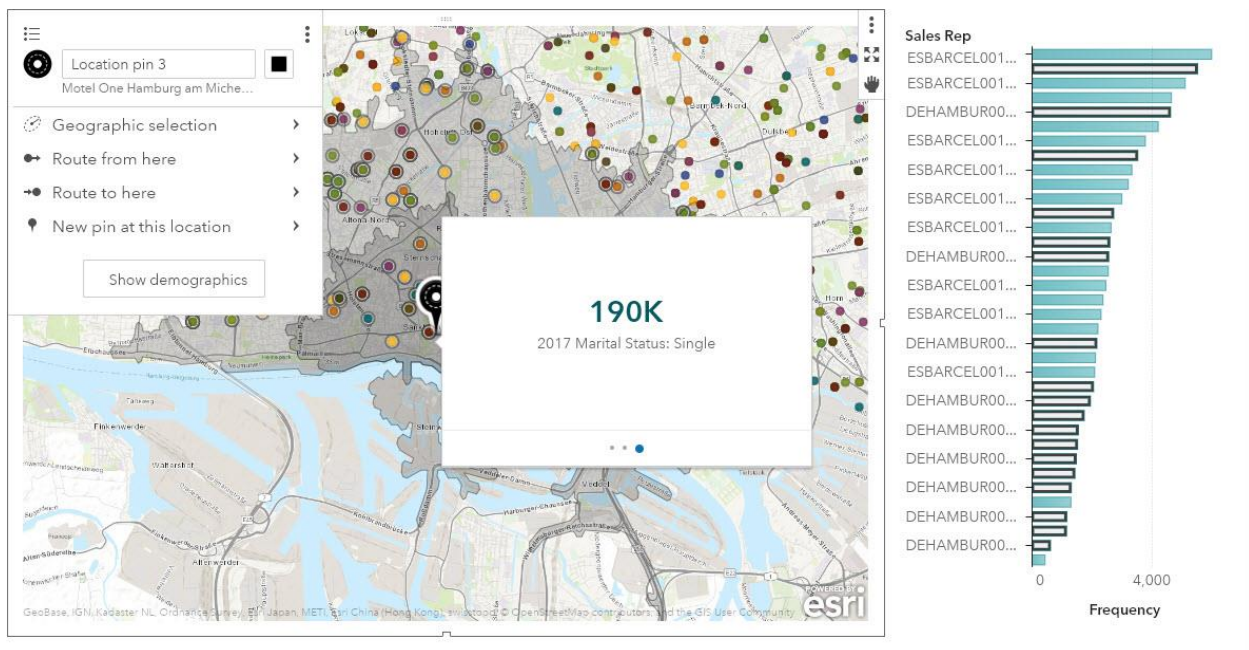

Figure 15. Demographic Enrichment Using Drive Time Analysis
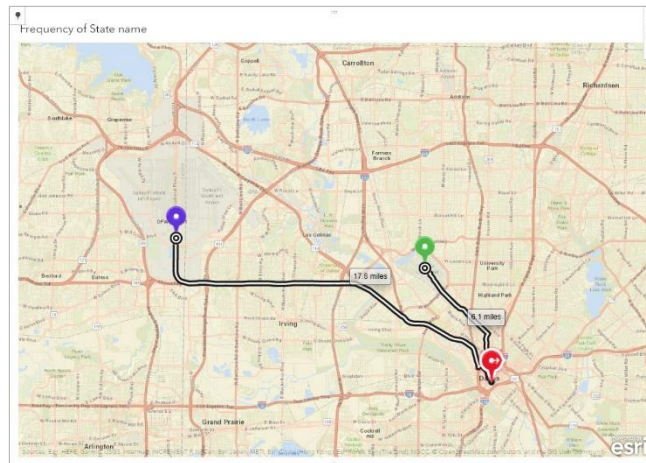
Routing

Figure 16. Routing from Dallas Convention Center to DAL and DFW Airports

Beginning with version 8.3, SAS Visual Analytics allows you to add a pin on the map and determine a route to or from another location or pin. A route returning to a location might not be the same as leaving from that location due to limitations such as one-way streets and highway ramps. Routes can be easily reversed, and are shown on printouts. Figure 16 shows the routes to both Dallas-Love Field and Dallas-Fort Worth airports from the convention center downtown.

PROXIMITY CLUSTERING

SAS Visual Analytics was created for quickly visualizing very large amounts of data. This is accomplished through fast data processing in CAS, where the data is aggregated into logical groups based on values unrelated to location. Many times**, these groups won't make sense** on a map. However, displaying millions of unaggregated points on a map is costly and inefficient.

In version 8.3, SAS Visual Analytics solved this problem by adding proximity clustering for geographic maps. Rather than creating logical groups, CAS creates geographic groups, or clusters, and represents those groups with a marker whose size is based on the number of points within the cluster. The default map created when you drag a geography column onto the canvas automatically changes to a clustered coordinate map when your data reaches 40,000 rows.
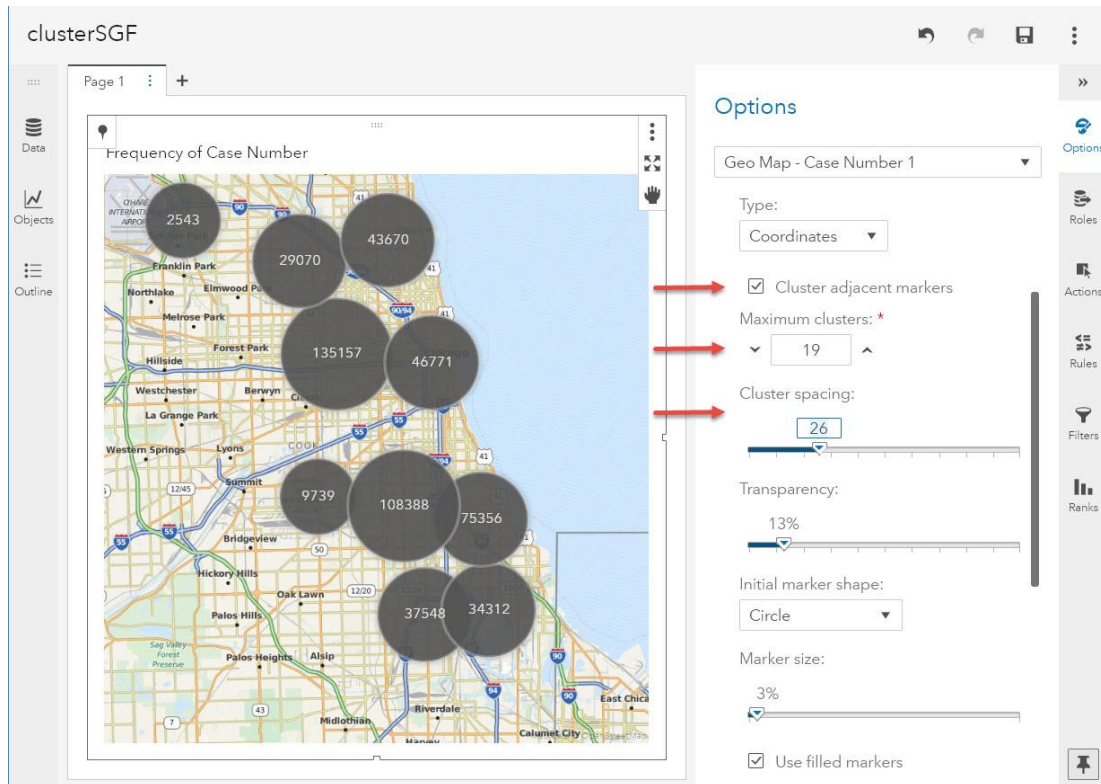
Figure 17. Clustered Coordinate Map with Options Pane

The example in Figure 17 shows a map with over 250,000 data points. Notice how the *Cluster adjacent markers* box is checked. This will reveal the *Maximum clusters* and *Cluster spacing* controls, where you can fine-tune the display.

Figure 18 shows that, as you zoom or pan, SAS Visual Analytics requests new data based on your latest view, and can expose individual, non-clustered data points. In this way, you can further explore your data without loading too many points onto the map.
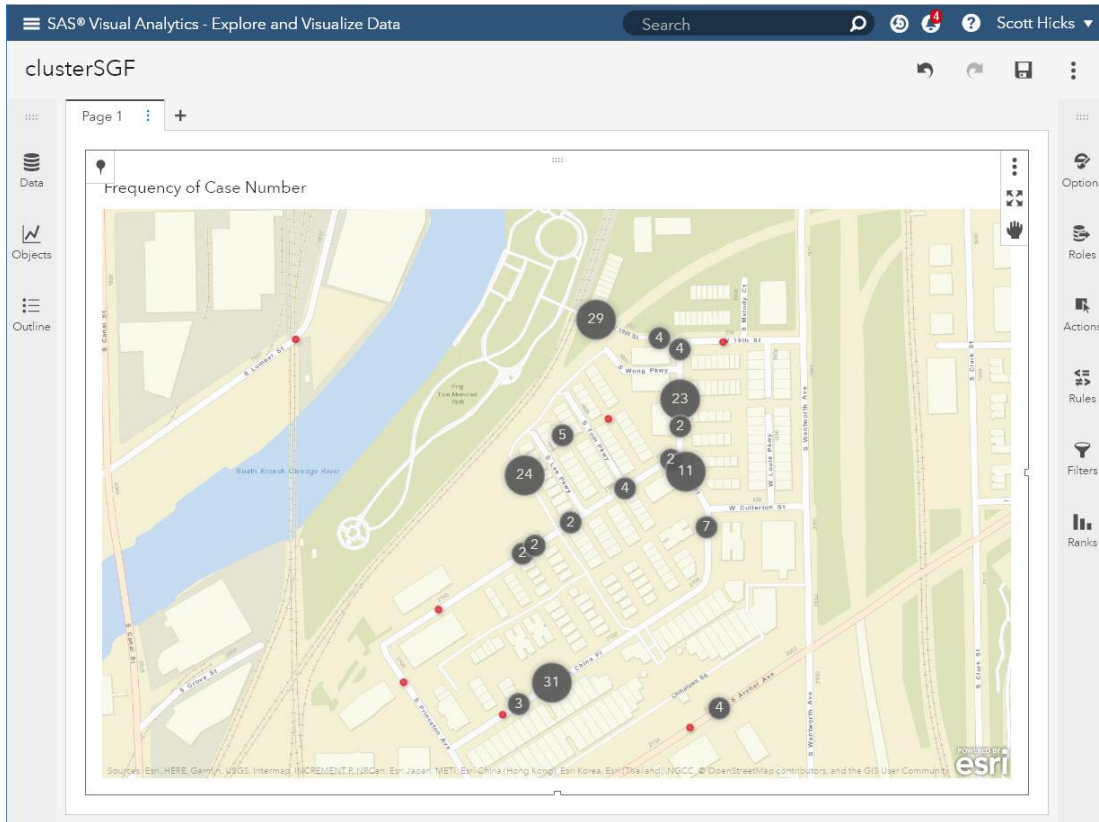
Figure 18. Clustered Coordinate Map After Zooming Revealing Individual Points in Red

In Figure 19, the same data is being displayed without clustering. SAS Visual Analytics truncates your data when it tries to display more than 40,000 rows. If this happens, a warning icon appears in the bottom right corner of the map. Hovering over that icon displays **the text: "Only 40,000 rows of data appear."** To work with all of your data instead of just a subset, you should use the clustering option.
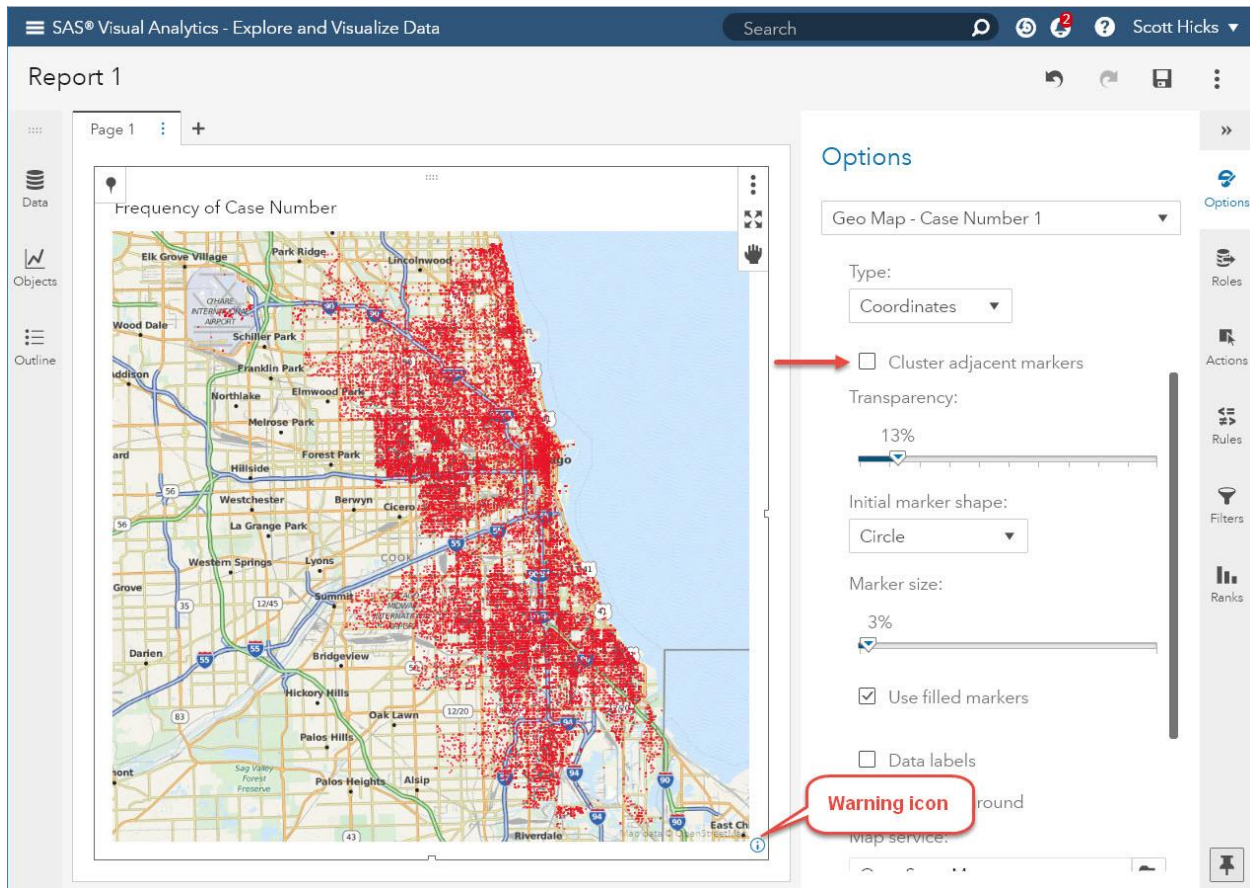
Figure 19. High-Cardinality Map without Clustering and Data Truncation Warning

ENHANCING YOUR DATA WITH ESRI

The partnership between SAS and Esri enables SAS Visual Analytics to enhance your data with locations provided through importing geocoded locations. You can also add demographic data that can be aggregated down to the city block level, depending on the country. Both tasks are premium services from Esri and require a valid login to Esri's ArcGIS Online. You also need to have enough available service credits with Esri to perform the specific operation.

GEOCODING

Geocoding is the process of looking up addresses and finding locations. Each time you search for a point of interest or address when accessing any online map, that is a single instance of geocoding. When you want to find the locations for numerous locations at once, you need a geocoding service.

The result of geocoding is to add a latitude and longitude to each address entry. Esri's World Geocoding Service also provides additional information, such as the address that was matched from the service's database and an overall accuracy score.

Esri has a vast database of locations around the world, and most of the time any valid address that is requested will be returned with a relatively high accuracy rating. New, rare, unique, or undocumented addresses might only match at a state our country level, which will be reflected in the score.

To access the Esri World Geocoding Service from within SAS Visual Analytics, open the Data selector and choose the *Import* tab (Figure 20).
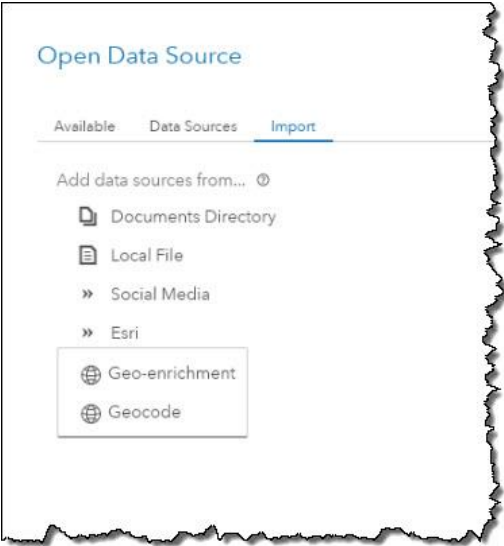

Figure 20. The Import Tab of the Data Selector

At this point you are prompted for an input table. After you've chosen the table, you are presented with an import window that also prompts for the name and location for the output table. The default name of the table has "_GEO_CODED" added to the end of the name. The location is the same library in which the input data resides. You can choose to change this name and even overwrite the input data.

You are also asked to supply, in order, the columns that make up the full address. You see a sample of an address, which is read from the first row of data, as seen in Figure 21. Once you are satisfied with the address sample and order, you can choose to test this one address by selecting the *Test* button. Figure 21 also shows that the test returns a location and a score. In this example, we have chosen a table containing 5,000 voters.

Figure 21. Address Sample and Tested Location

When you are ready to geocode all the addresses, select the *Import Item* button, which then estimate the amount of Esri service credits this action will consume (Figure 22). The calculation is not exact, because SAS Visual Analytics does not know how many duplicate or invalid addresses might be in the data.

Figure 22. Esri Service Credit Estimation

Depending on the size of your data, the geocode process can take a few seconds to complete. Figure 23 shows the results of geocoding our 5,000 voter addresses along with a chart that shows how accurate the results are. The first five rows show some address mismatches that have a slightly lower score. However, well over 99 percent of the data matched with a score of 99 to 100. Figure 24 shows the points plotted on a map. You can even see which side of the road each address is on.
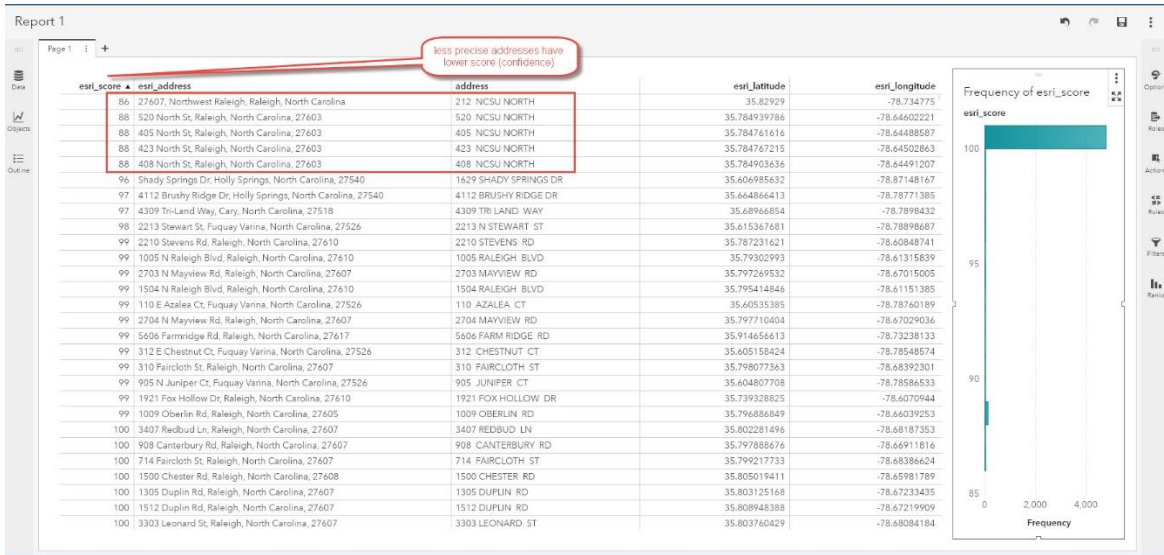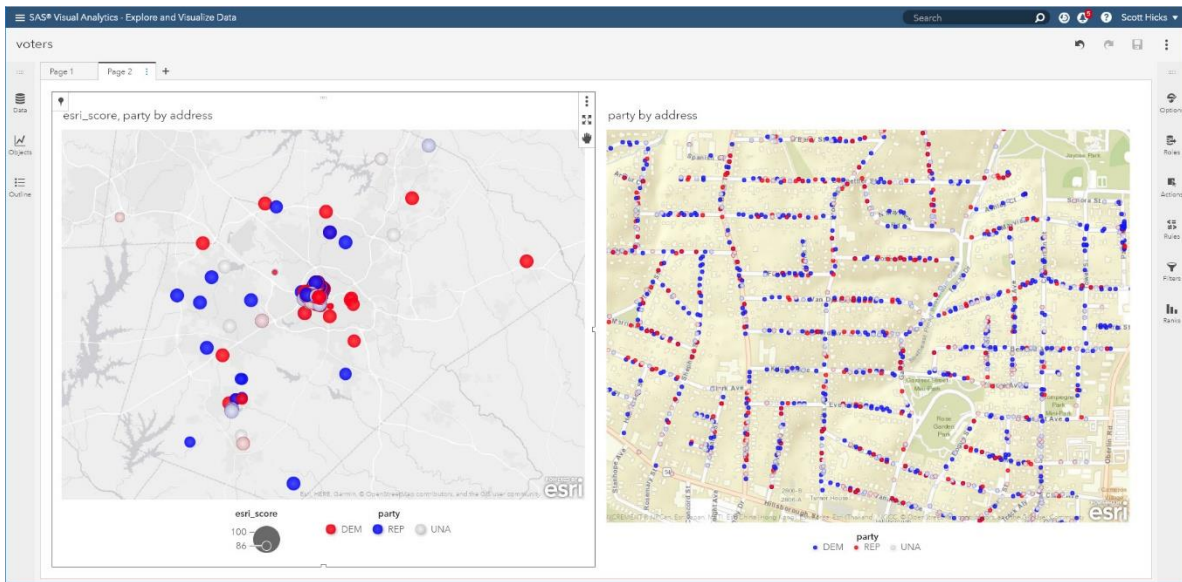
Figure 23. Table of Geocoded Results

Figure 24. Map of Geocoded Addresses

DATA ENRICHMENT

While geocoding adds location information to your data, Esri can also enrich your location data with a wide variety of demographic information. There is data available on almost every country in the world - some countries have thousands of columns of data and others a few dozen. To access Esri GeoEnrichment, return to the *Import* tab of the data selector as shown in Figure 20. After you have chosen the input table, select an output destination. To enrich your data, you must choose the country where your data is located. Setting this value changes the *Level* options appropriately. For example, the *States* or *ZIP Codes* level is present for the United States, but the *Provinces and Territories* or *Census Districts* are present in Canada. You need to configure the importer to use a column from your table

that represents the level you have chosen. Figure 25 shows an example of setting the source column to *zip* **for the level of "ZIP Codes".**
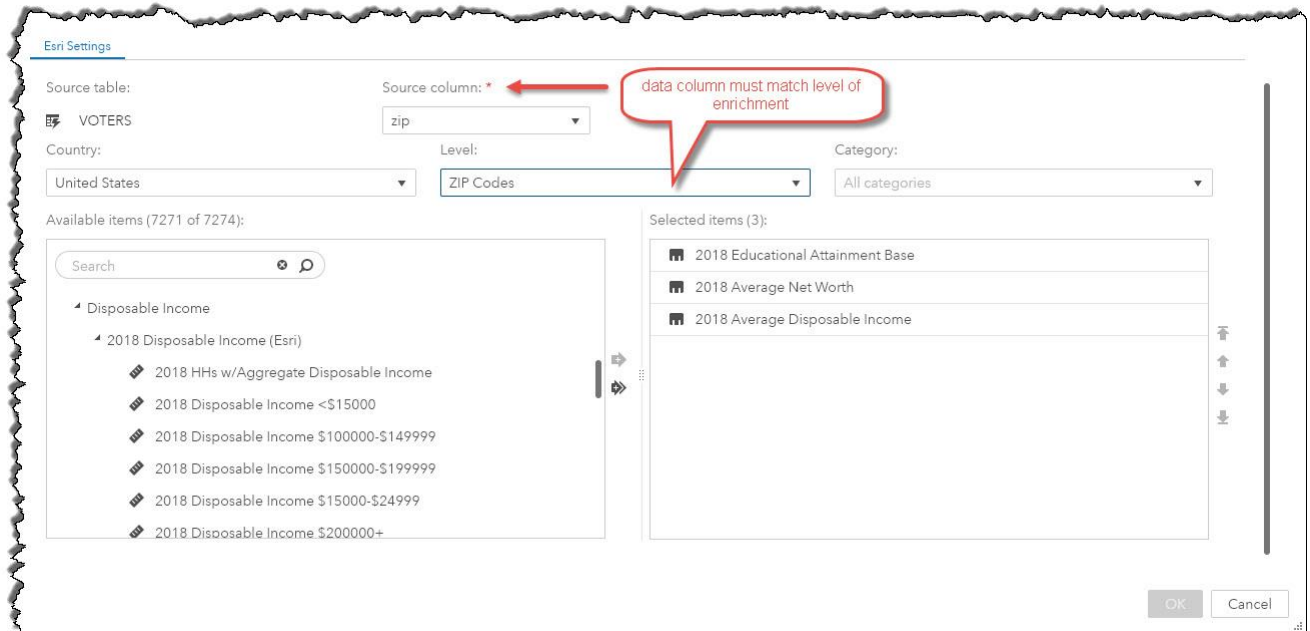

Figure 25. GeoEnrichment Configuration

After selecting the appropriate source column, you can choose the columns you would like **to be added to your data from the categorized list. After you've selected all of the items,** click the *Import Item* button to display the Esri service credit estimation dialog box (Figure 22). The credits are estimated based on the number of rows in your data and the number of columns you want to add.

After importing, the new columns are available to use in a map or any other type of chart. Figure 26 shows a bubble map with size and color based on the average income and net worth variables imported from Esri based on the ZIP code provided.
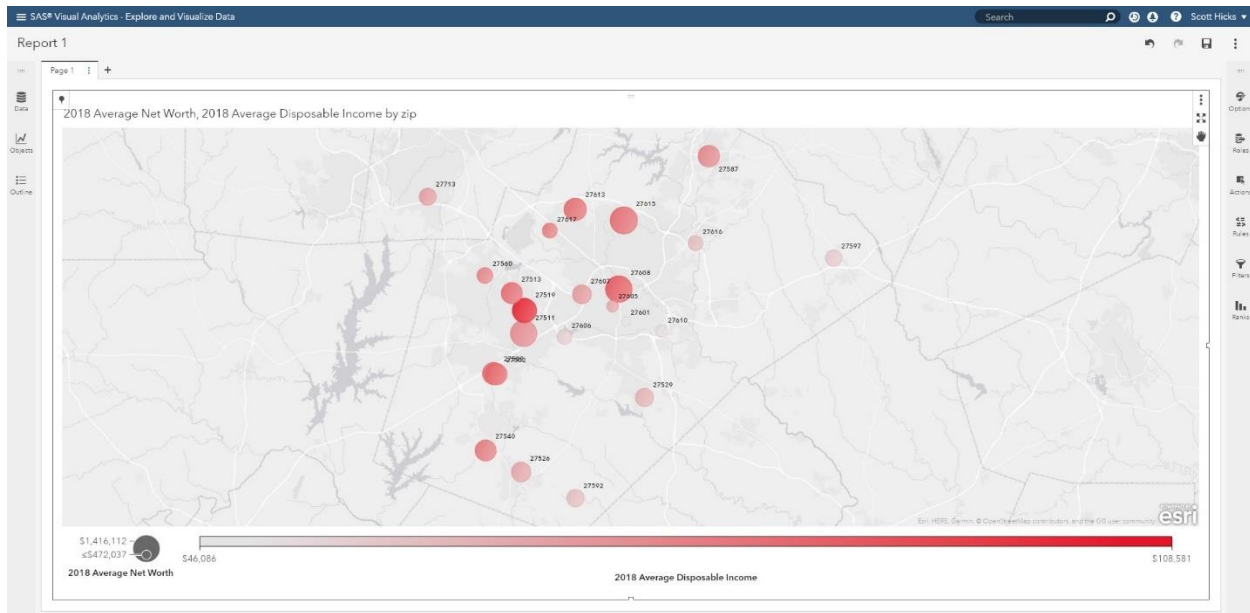
Figure 26. Bubble Map using Geo-enriched Data

Geo-enriched data can give your reports greater meaning and allow you to further analyze and explore for results and solutions.

ESRI WEB MAPS

Esri's web maps are combinations of maps and feature service layers that users bundle together and publish as a single unit—often built and hosted on **Esri's** ArcGIS Online—which can be served to any viewer with a web browser. Now, you can include them in SAS Visual Analytics reports, not just as inert web content, but as a data-driven control, supporting the **dynamic insertion of a SAS data layer and responding naturally to the report's filters,** selections, and interactions.

To include an Esri web map in your report, download the open-source "geowebmap" project from GitHub at https://github.com/sassoftware/sas-visualanalytics-geowebmap, build and host the result on the web, and follow these steps:

First, obtain the identifier of the web map that you want to display. When you build the **web map, you'll find the** identifier **listed in your web browser's address bar** after you save your results (Figure 27).
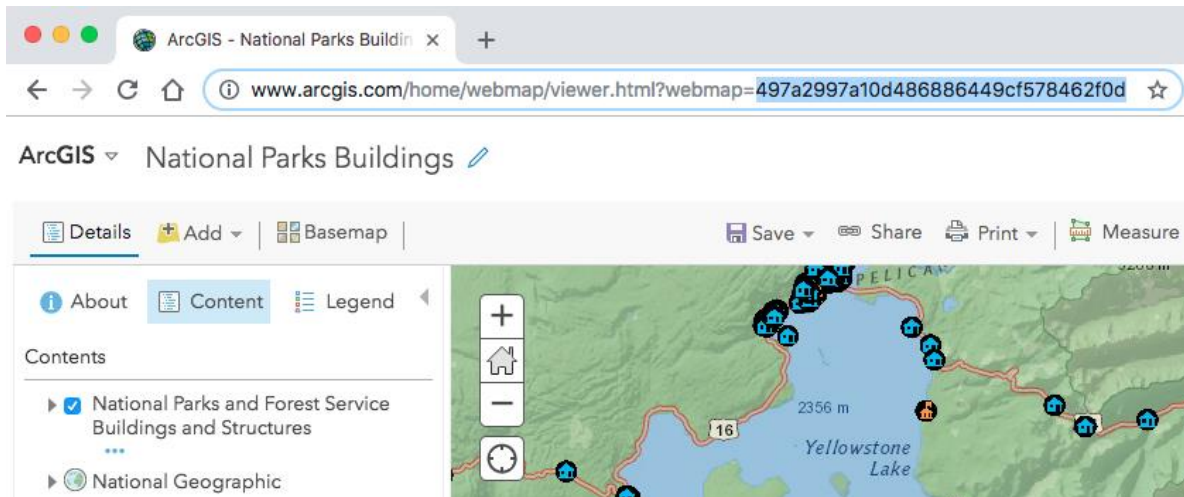
Figure 27. Finding the Web Map Identifier (Address Bar)

Next, if you aren't including a SAS layer, add a *Web Content* object to your report. Set the **object's** *Content URL* property (found on the *Options* panel seen in Figure 28) to the URL of your "geowebmap" site, and set the URLs **"portalItemId"** to the identifier of your web map. Your web map appears in your report.

`http://[example.geowebmap.site]/portalItemId=497a2997a10d486886449cf578462f0d`
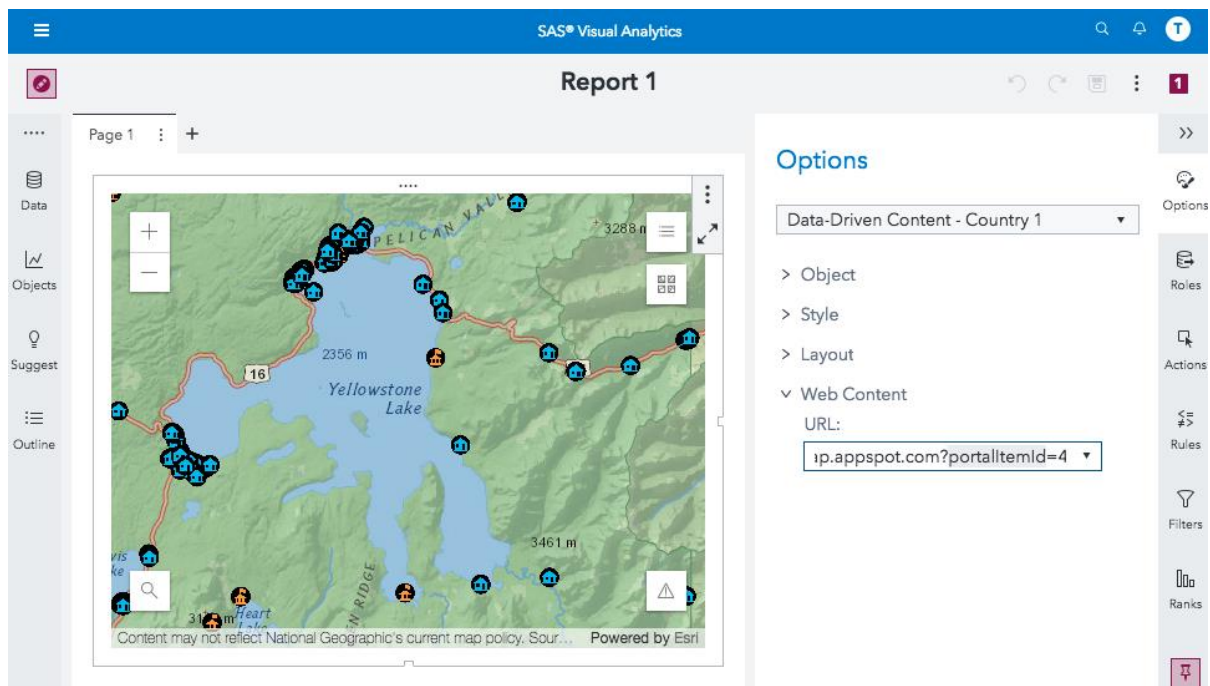

Figure 28. Web Map in SAS Visual Analytics as Web Content

If you want to include a SAS layer, use the *Data Driven Object* instead of the *Web Content* object, and assign your data to it. Then append to your URL the parameters necessary to

specify the layer you want. To add a scatter plot, for example, include a "visualizationType=scatter" parameter, and name your "x" and "y" columns from your data.

```
http://[example.geowebmap.site]/?portalItemId=497a2997a10d486886449cf578462f0
d&visualizationType=scatter&x=LongitudeColumnName&y=LatitudeColumnName
```

The example in Figure 29 uses the "portalItemID" of the National Parks Buildings web map from Figure 28 and adds a SAS choropleth layer of park lands. The resulting report allows you to navigate through the national parks and to control the visibility of the SAS layer and all the web map's original layers.
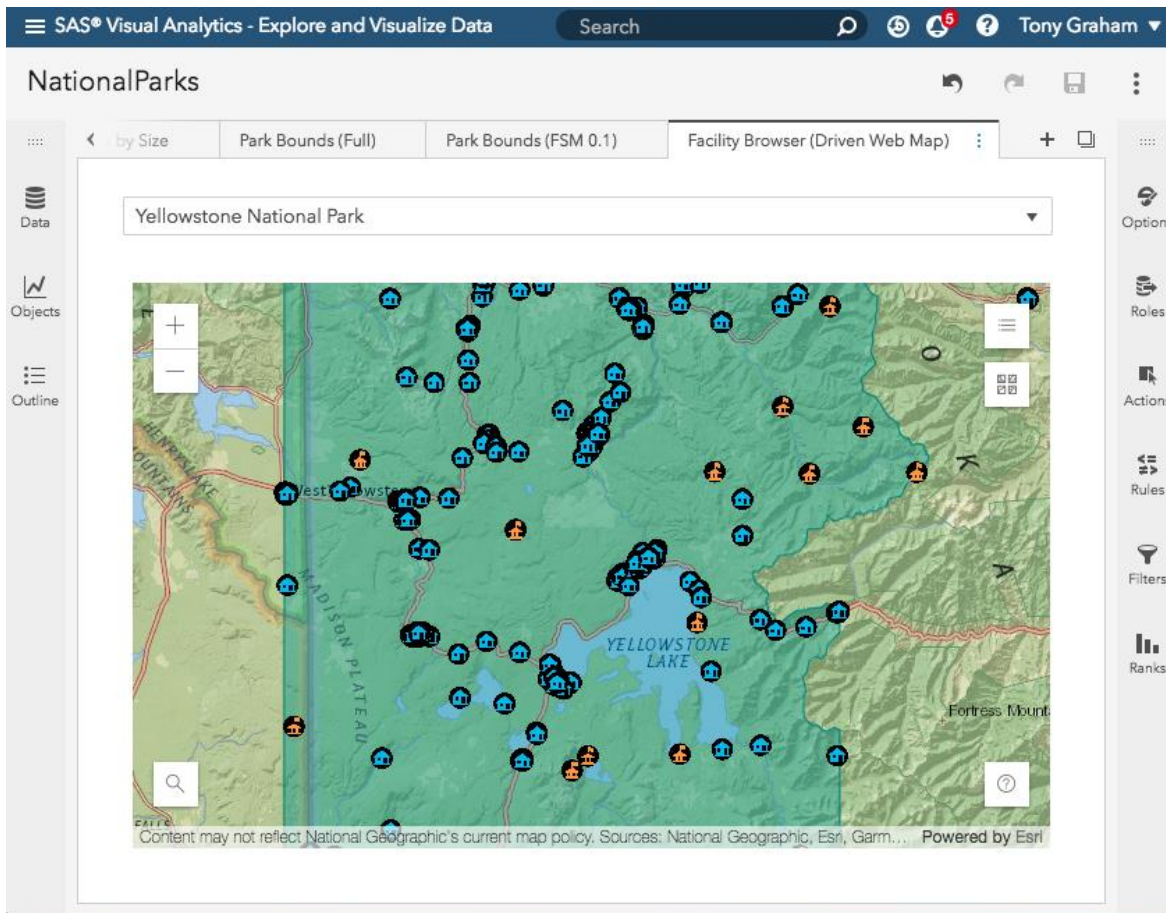

Figure 29. Navigating a Web Map with a SAS Layer in SAS Visual Analytics

In Figure 30 the wind speeds and atmospheric pressures of hurricanes were used to construct a bubble plot, which was projected over a three-dimensional map.
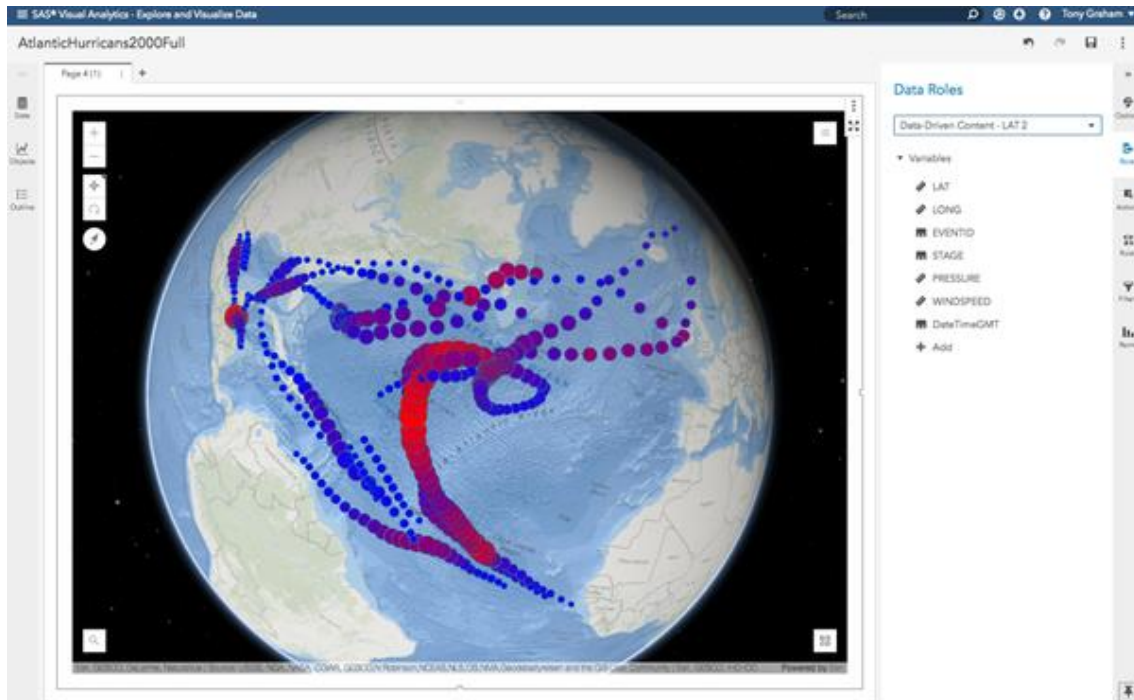
Figure 30. SAS Visual Analytics Data in an Esri Web Map: Atlantic Hurricanes in 2000

In Figure 31 SAS Visual Analytics shows data above live Esri traffic and weather data.
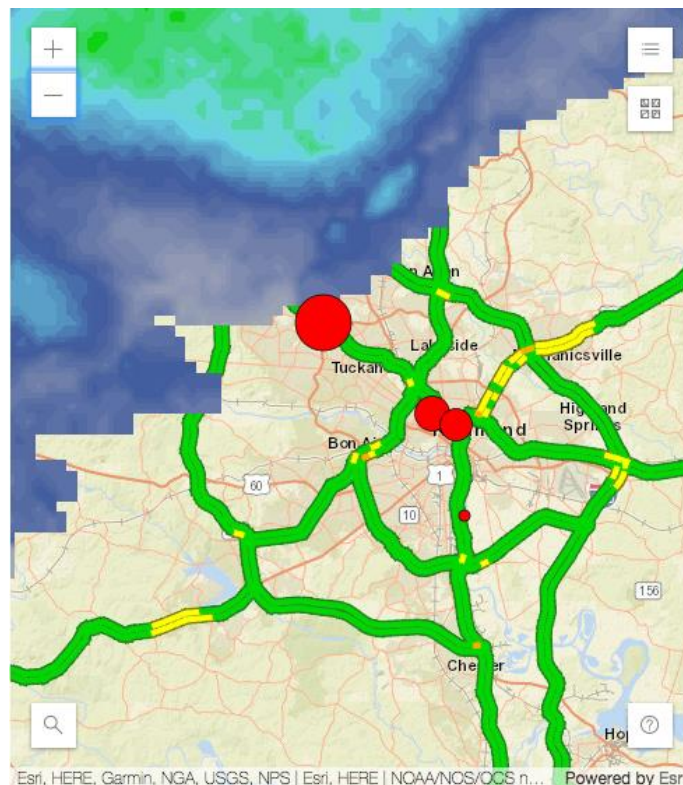

Figure 31. Richmond Locations in SAS Visual Analytics over Live Traffic and Weather Radar Layers from ArcGIS.com, Feb. 1, 2019, 11:15 AM EST

Figure 32 is an Esri SceneView with various waypoints in Everest selected by a SAS Visual Analytics *List Table.*
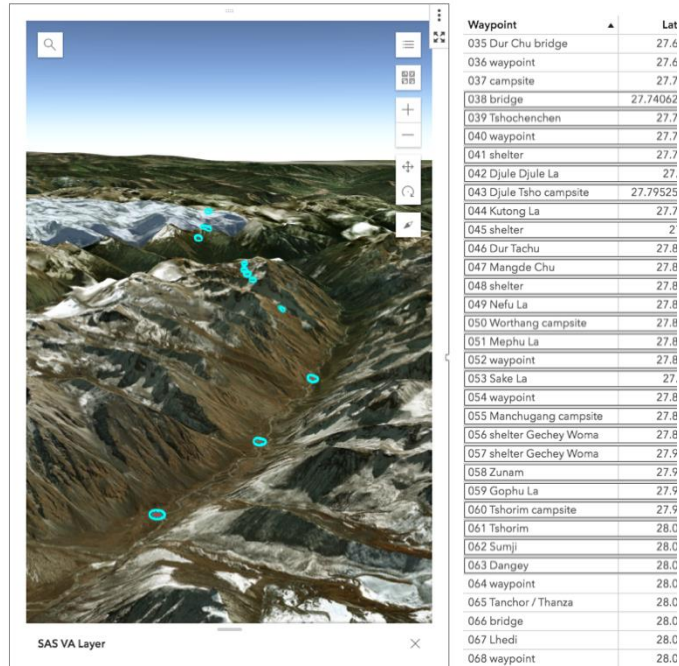

Figure 32. Selecting Everest Waypoints in SAS Visual Analytics

See the "geowebmap" GitHub page for a complete list of supported visualizations and parameters. Collaboration in the code base is welcome. SAS continues to research closer integration with Esri web maps.

MAPS AND LAYERS INTRODUCED IN SAS GRAPH BUILDER

Users have long been able to build complex, multi-layered graphs in SAS Graph Builder, which they could reuse as *Custom Graph* objects in SAS Visual Analytics. In a future release, you will also be able to use SAS Graph Builder to build multi-layered maps.

Figure 33 shows an example of building a multi-layered map in SAS Graph Builder.

Figure 33. Building a Multi-Layered Map in SAS Graph Builder

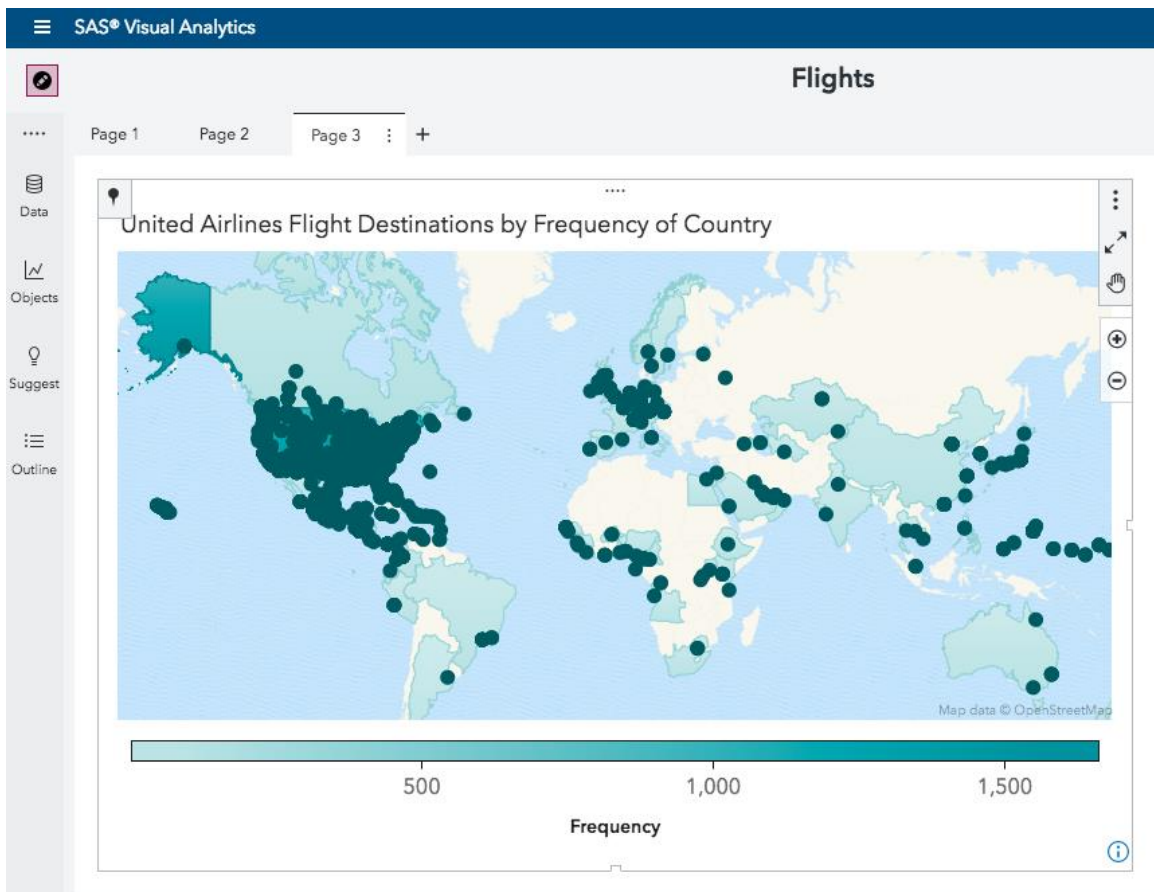Figure 34 is an example of using a multi-layered map in SAS Visual Analytics.

Figure 34. Applying Data to a Multi-Layered Map in SAS Visual Analytics

CONCLUSION

We have shown new features that we have added to various SAS products, including new SAS Studio mapping tasks, location pins, proximity clustering, routing, web maps, and data enrichment in SAS Visual Analytics. **We've also discussed enhancements to existing** features such as new statements and support for colors and grouping in PROC SGMAP. And **we've revealed some quick glimpses of what is to** come. Regardless of whether you work in Base SAS or SAS Visual Analytics**, now you know there's a map for that!**

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RECOMMENDED READING

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