The Location Advantage MOOC

Exercise

Location and Supply Chain Management

Section 5 Exercise 1

10/2017

esri

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Location and Supply Chain Management

Instructions

Use this guide and ArcGIS Online to reproduce the results of the exercise on your own.

Note: ArcGIS Online is a dynamic mapping platform. The version that you will be using for this course may be slightly different from the screenshots you see in the course materials.

Time to complete

Approximately 45-60 minutes.

Technical note

To take advantage of the web-based technologies available in ArcGIS Online, you need to use a fairly new version of a standard web browser, such as Google Chrome, Firefox, Safari, or Internet Explorer. Older web browsers may not display your maps correctly.

For information on supported browsers, visit

Note: http://doc.arcgis.com/en/arcgis-online/reference/browsers.htm.

Introduction

In the lecture for this lesson, you learned about supply chain management (SCM). Supply chain is the sequence of processes at multiple locations, or nodes, for producing and distributing a product. Supply chain management means overseeing all of the processes in each of the nodes along the supply chain, from the supplier to the manufacturer to the customer, by way of distributors, wholesalers, retailers, and more. Information flow and logistics activities are used for this oversight to gain competitive advantage and customer satisfaction. Supply chain is usually a continuous sequence, transforming raw materials or other ingredients into products for consumers or end users. Awareness of location is critical for keeping production moving and the shipments flowing. You can answer many of the business questions and potential problems revolving around supply chain by using visualization and geospatial techniques.

Think about a common product like a tablet computer. Tablets are composed of multiple parts, which are manufactured in many different places. They are sold and used all over the world. The locations involved include places where the raw materials are obtained, where the individual parts are manufactured, where the product is assembled, and where the product is moved to, including warehouses, distribution centers and other intermediaries, and (finally) retail outlets like electronics stores. All of this information must be tracked, managed, and

made as efficient as possible. With many possible locations and methods of transporting products, small improvements in supply chain efficiency can save a company time and money. For example, some companies have saved millions of dollars by using location technologies to optimize routing of their delivery vehicles.

As you heard in the lecture, when a country suffers a natural disaster, such as the major flood in Thailand, the repercussions are felt at every one of the nodes along the supply chain, and they affect other industries, as well. Expenses can multiply, potentially costing your business millions or putting you out of business entirely if you cannot quickly change nodes, suppliers, or delivery options.

This exercise presents an approach to using the power of location information to inform your business decisions, resulting in more effective supply chain management and limiting the impact of business interruptions. While the locations are real, the scenario, analysis, and resulting decisions are hypothetical.

Exercise scenario

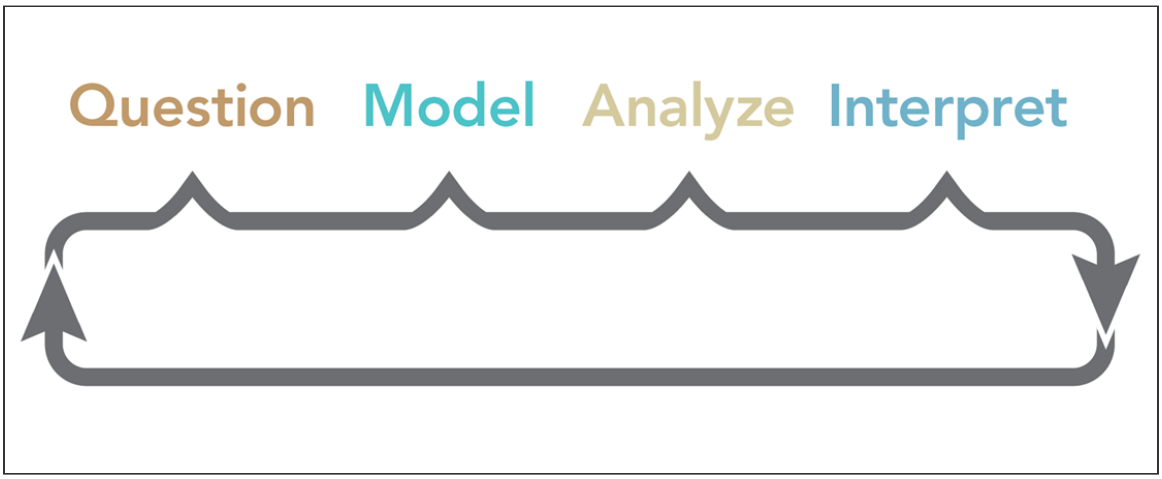
In the scenario for this exercise, you are the manager in charge of a supply chain for a large international foods company, and you will consider several challenges. Comidas Bonitas, which is modeled after a real company, is a large consumer packaged goods company in South America. Comidas Bonitas produces and distributes products ranging from cooking oil to juice to potato chips—specifically, their Perfectos brand of potato chips. With their headquarters in Colombia and distribution centers across South America, the company has a very large and diverse market to serve. You will look at some processes for part of the Perfectos supply chain in Colombia using geospatial tools to help you better understand and manage distribution logistics, warehousing, and transportation.

In this exercise, you will use the ArcGIS Online platform to perform these tasks:

- Analyze a web map with supply chain nodes
- Create distance ring buffers and view spatial relationships
- Filter layers and view capacity tables
- Apply geospatial techniques to compare layers
- Merge layers together
- Create routes

Approach

You will use the four-step decision-making workflow as you perform location analysis to help manage the Perfectos supply chain for Comidas Bonitas.



Note: The Resources section in Udemy for this lecture includes a downloadable version of the four-step decision-making workflow, with further information and tips.

You will use this workflow to examine the locations of all the nodes along the supply chain, from natural resources to suppliers, distribution points, and retail outlets. You will then see how are they are related from a geospatial perspective.

Formulate the Question

Location data can help you decide where the different supply chain nodes should be sited, making the exchanges of materials and products among them more efficient. For this exercise, you are tasked with overseeing the Perfectos supply chain end-to-end and making swift, effective decisions when problems arise. The question for this exercise involves asking how location affects your supply chain, including the risks of something interrupting your supply chain, and how you can optimally route or reroute the movements of resources and products along the supply chain.

How can location analysis make supply chain management more effective?

Model the Solution

Next, you must model the solution and create a process to answer the business question and gain the information needed to support decision making. Modeling includes gathering the location and business data and determining the geospatial techniques that can be used.

What is the locational component?
Location is involved in every phase of a supply chain, from beginning to end. For each activity in the supply chain, including raw material extraction, manufacturing, warehousing, sales, and consumption, you must understand the relationships among the locations where the activities occur.

What data do I need for my map?
To map and analyze the Perfectos supply chain relationships, you will need several types of data:

- Location information for each part of the supply chain: potato fields, processing plants, distribution centers, warehouses, and retailers.
- Attribute data for the supply chain nodes, which describes their characteristics, such as the outputs of the processing plants or the capacities of each distribution center.
- Basemaps that show road networks, natural features like mountain ranges or rivers, and population centers (retailers are typically located where the cities are—where most of the population lives).

Where can I get the data I need?
As always, look inside your organization first to find data for your analysis. The data will probably be there in some form, whether in a spreadsheet or in a business system such as the SCM (supply chain management) system. For this scenario, the supply chain locations and other dataset information you need exist in Comidas Bonitas' SCM system. Because the system does not include a location analysis component, a colleague has used the data to create feature services in ArcGIS Online, making them readily available to use via your ArcGIS Online account. ArcGIS Online also has the basemaps you need for locating supply chain nodes and visualizing spatial relationships.

Which techniques will I use?
After you secure the data that you know you will need for analysis, you must determine the analysis techniques to use to answer the larger business question. In this exercise, geospatial techniques will help you answer questions and make decisions related to supply chain management. These techniques include visualizing the locational data on a map, overlaying additional relevant layers, buffering points, summarizing areas, and creating routes to assist your supply chain management. Because there is a locational component associated with each node of the supply chain, details related to the approach and analysis techniques used for management of raw materials to end-product delivery to the customer have been divided into three parts.

Part I: Harvesting natural resources to processing plants

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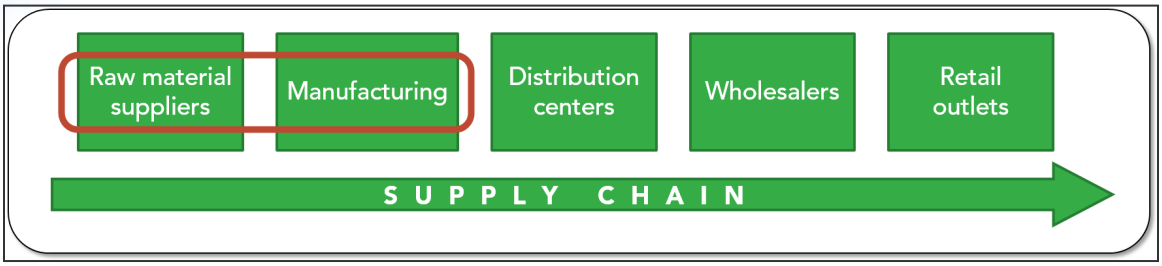
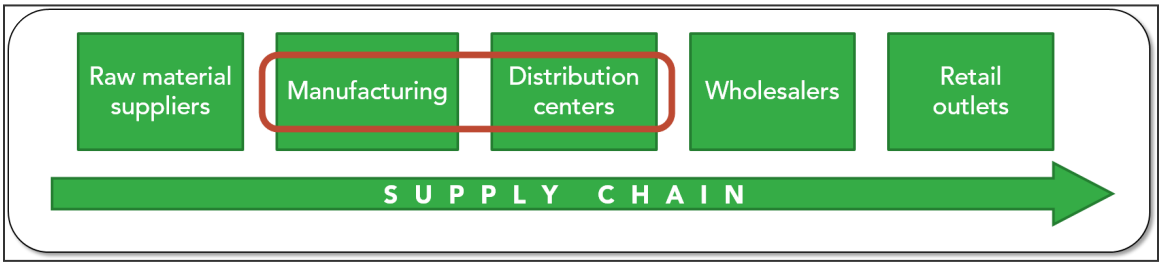


The supply chain starts with the harvesting of natural resources, which are then sent to a manufacturing facility. As a first step, you will use spatial analysis to determine where to send the harvest of the raw materials from the seven different potato fields. Which of the four Comidas Bonitas processing plants will receive product, from which fields, and in what quantities? Location plays a major role in this decision-making process, along with the transportation and distribution network from the fields to processing and manufacturing plants. You will create distance rings to show distance from the fields and to assign fields to processing plants, and you will also evaluate the cost basis for using certain fields over others.

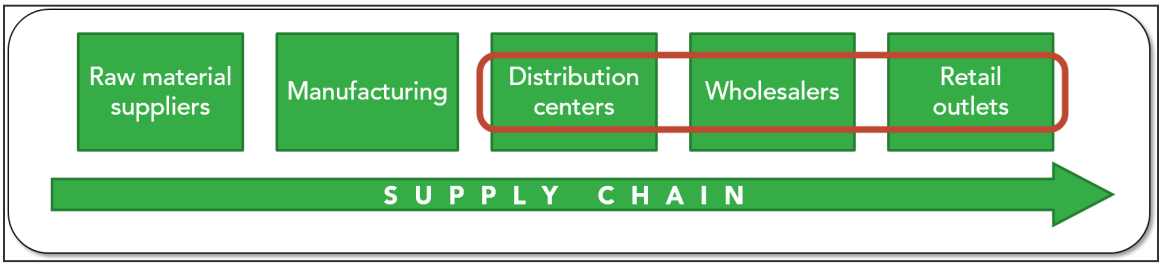
Part II: Moving product from plants to distribution centers



Next, as you explore movement of the Perfectos goods through manufacturing and distribution centers, you will model the effects of a business interruption and visualize the subsequent effects on your supply chain. You will determine how to best adapt to this interruption in your supply chain and mitigate it by finding a replacement distribution center.

You will calculate distribution center capacities before and after the interruption, and then select a replacement from two candidate distribution centers.

Part III: Routing from distribution centers to food service supplier warehouses



Finally, you will create optimized routes to deliver the finished goods from your distribution centers to warehouses or depots, and then on to retail outlets. Besides the retail channel, 30-40 percent of your business is delivering your Perfectos products to food service suppliers. These food service suppliers function as wholesalers and have their own retail customers. ArcGIS Online has tools to calculate expected trip mileage for one or more vehicles and to summarize the mileage for the region of one or more distribution centers.

In the end, you will have visualized the entire supply chain on a map: from resource extraction to processing, distribution centers, warehouse storage, and on to retailers. The information you gather and the analyses you perform can be used to keep Comidas Bonitas' goods and products flowing to the marketplace as efficiently and inexpensively as possible.

Perform the Analysis

These analysis techniques and datasets will provide you with the information you need to help you manage the Perfectos supply chain and inform your decisions about how to make the process more effective. As you perform the analyses and interpret the data, think about additional variables you might add or other predictors that could be helpful.

For this exercise, spatial analysis will help you compare locations of different supply chain nodes to optimize their placement and the routes among them. Additionally, you will learn how to better handle a supply chain interruption and identify ways to minimize business losses by applying location in determining alternative nodes and routes.

Interpret the Findings

After you complete the analyses, you may be able to answer the question, or you may have more questions. Do results like these help answer the sometimes urgent business questions that supply chain management raises every day? You can use the findings to take action and make decisions, but you should also integrate them into your organization's knowledge base. What actionable intelligence can you derive from the analysis results? The approaches may not need to be modified or repeated immediately, but with supply chain, they could be repeated on a regular basis to keep up with constant changes in the business environment.

Note: These examples provide a starting point for this exercise, but in all likelihood, these analyses in the real world would encompass additional factors and criteria.

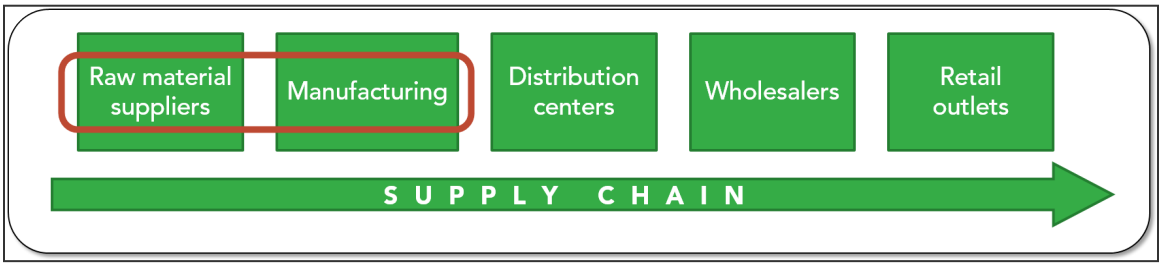
Analysis Workflow Using ArcGIS Online

After using Business Analyst for the past three sections of this course, this exercise returns to using ArcGIS Online. In this course and in business, you use the best tool for the job. Both tools provide good and useful analysis for business, and they both have applications for which they are especially strong (such as site optimization for Business Analyst). These tools are constantly being improved and integrated, but for this particular exercise, the sharing capabilities and spatial analysis tools in ArcGIS Online make it the better choice.

These links provide more information on the strengths of each application:
http://www.arcgis.com/features/features-analytics.html
http://doc.arcgis.com/en/bao/help/welcome.htm

Part I: Harvesting natural resources to processing plants

In this exercise, you will examine the advantage that location analysis provides to ensure efficient and effective management with regard to the various nodes along the supply chain. In this first section, you will look at the activities associated with sourcing raw materials and manufacturing.



Step 1: Log in to an ArcGIS Online organization

a. Open a new Internet browser tab or window.

b. Go to www.arcgis.com and sign in to ArcGIS Online using the credentials explained at the start of this course.

Note: The Section 1 Exercise 1 PDF explains how to determine your ArcGIS Online credentials (username and password) for this course. If you have trouble signing in, email GIStraining@esri.com for assistance.

Step 2: Open a web map

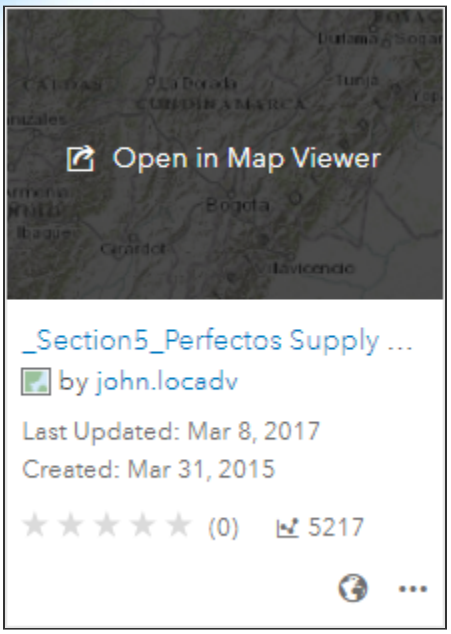
a. To help yourself and others in the Comidas Bonitas organization visualize the Perfectos supply chain, you will create a map.

b. At the top of the page in ArcGIS Online, click Groups.

c. Click the Section 5 group to open it.

d. Find the web map titled _Section5_Perfectos Supply Chain.

e. Hover your pointer over the thumbnail to reveal the Open In Map Viewer link.

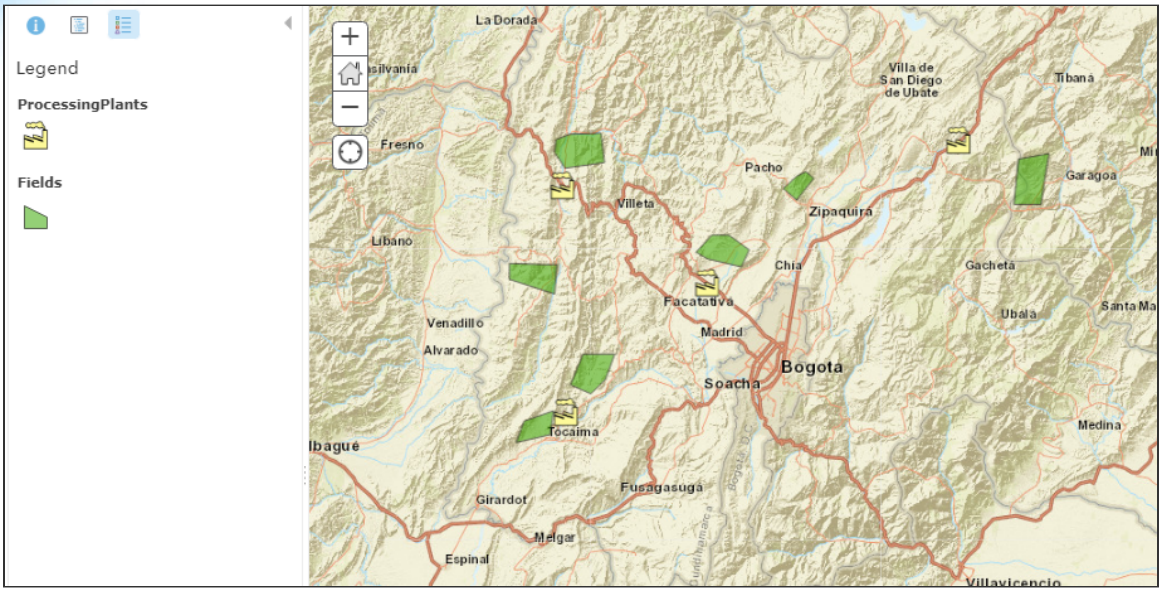


f Click Open In Map Viewer.

The Comidas Bonitas supply chain map displays, showing layers for processing plants and potato fields in the Bogotá, Colombia area of South America. This area is where the raw materials and manufacturing and processing nodes in the supply chain are centered.

The initial map uses the Topographic basemap. You want to see the distance from the potato fields to the processing plants, so the Streets basemap would help provide better context.

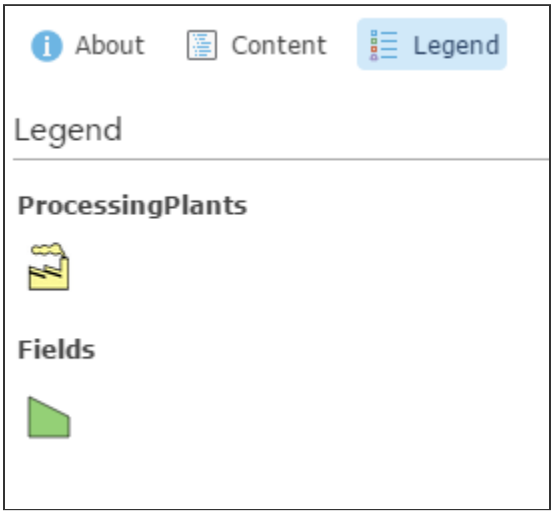
g At the top of the page, change the basemap by clicking Basemap and choosing Streets.



Next, you will examine the symbols used to represent the processing plants and fields.

h If necessary, at the top of the Contents pane, click the Legend button to see the symbols used.

Note: Depending on the size of your browser window, the buttons may be icons without the words.



Yellow factory icons are used to represent the processing plants, which is a points layer. Green polygons represent the extents of the potato fields, an area layer.

i Click the Content button to return to the Contents pane.

Step 3: Save the map

Because you want to make edits to the map and perform analysis, you will save a copy of the map for yourself.

a. From the ribbon at the top of the page, click Save and choose Save As.

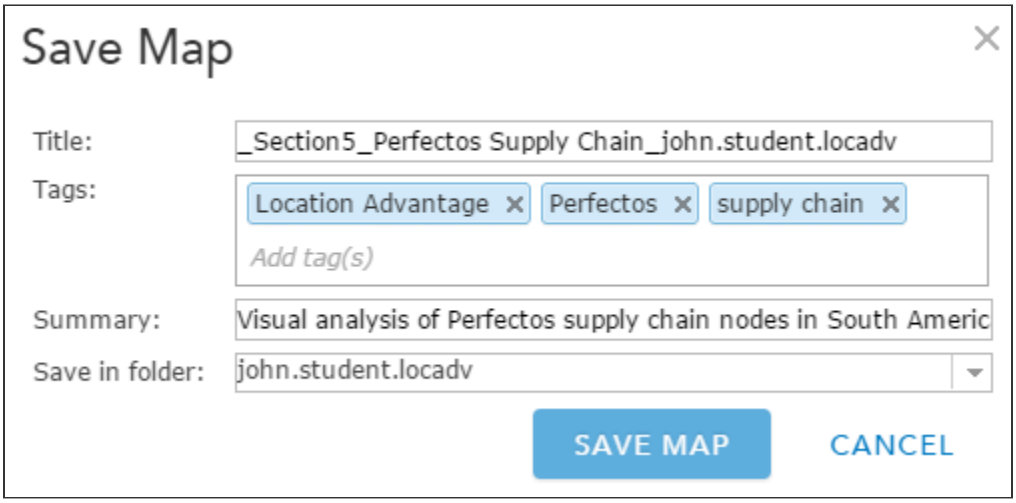
b. In the Save Map dialog box, after the existing title, add an underscore and your ArcGIS Online user name so the map has a unique name.

Note: Because there are many other students starting with the same map, it is important to click Save As so you do not save over the original copy. Adding your ArcGIS Online user name to the title will save it as your own.

Hint: Remember to add tags, which are a great way to locate or group your content by topic, project, department, and so on.

c. In the Tags field, type **supply chain, processing plants, fields**, and any additional tags you would like.

Note: Press Enter after each tag to save it in the Tags field.



d. Click Save Map, and remember to periodically save your map as you are working.

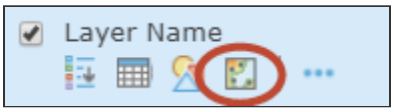
The map will be saved to your My Content collection, which you can access at any time.

Step 4: Create buffers to analyze distance

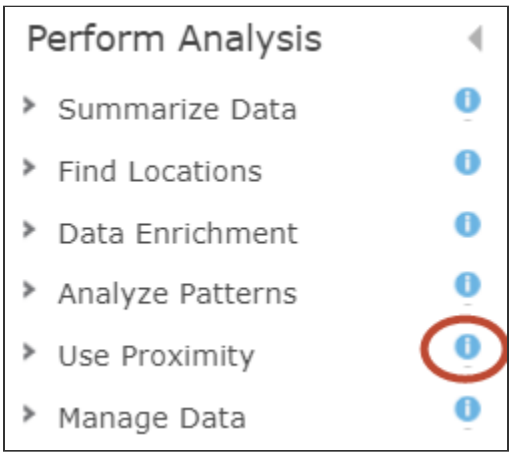
To facilitate management of the Perfectos supply chain, you would like to start by examining the distances from the potato fields to the processing plants. This will help you analyze how the plants are being utilized.

You can use distance rings to show this information on the map. Rings of a certain distance across allow you to easily visualize how far things are from each other. You can use the Create Buffer tool to create distance rings, known as buffers, around each of the plants.

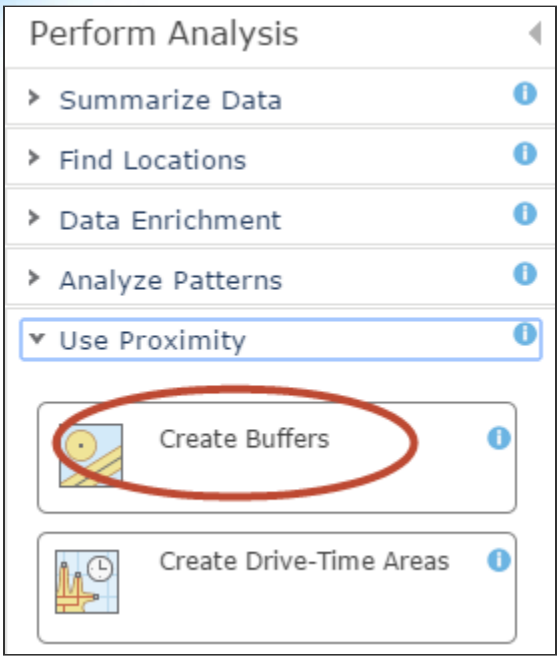
a. In the Contents pane, hover over the ProcessingPlants layer, and click the icon for Perform Analysis.



Hint: To learn more about the ArcGIS Online analysis options, in the Perform Analysis pane, click the Information icon to the right of the category or tool name.



b. In the Perform Analysis pane, expand Use Proximity.



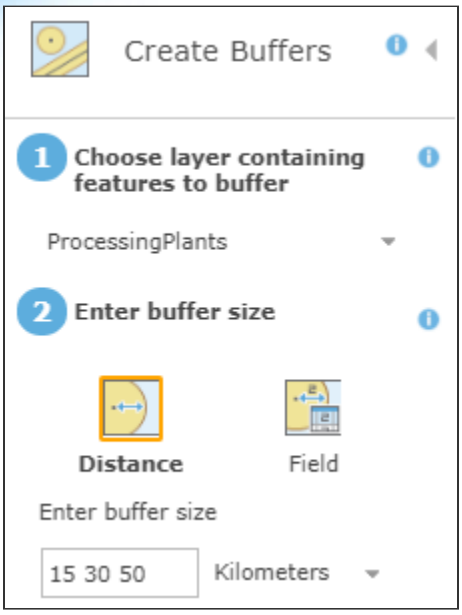
c. Choose Create Buffers.

d. In the Create Buffers dialog box, leave the default layer as ProcessingPlants, and the method for calculating buffer size as Distance.

You will create several buffers that show the area around the processing plants at 15-kilometer, 30-kilometer, and 50-kilometer distances. The largest buffer you will create will have a 50 kilometer radius. This radius is the highest practical distance your processing plants should ideally be from the fields for keeping product transportation costs down and ensuring frequent enough delivery of raw materials with the fewest possible trucks.

e. Under Enter Buffer Size, change the distance to **15 30 50**, separated by spaces as shown.

f. Change the units from Miles to Kilometers.



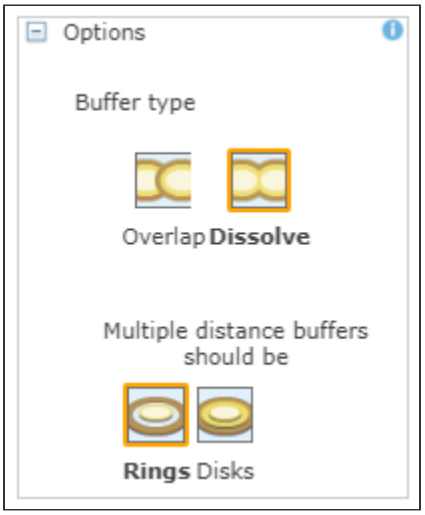
Typing multiple values in the distance field lets you create multiple nested rings to better visualize the distances.

g. Click Options to expand it.

h. For Buffer Type, choose Dissolve.

This buffer type will combine areas in common rather than overlapping them.

i. Accept the default multiple distance buffers type of Rings.



j. Add your ArcGIS Online user name to the default result layer name, such as **Buffer of ProcessingPlants_YourArcGISOnlineUsername**.

Note: The layer name must be unique within an organization. Add an underscore and your ArcGIS Online user name to ensure that your result layer name is unique. If you run the analysis multiple times, you will need to enter a unique layer name each time. You can delete previous results from your My Content section, or, add a version number (for example, **layername_YourArcGISOnlineUsername2***) to make it unique.*

The Save Result In field defaults to the folder in My Content named with your account name. You do not need to change this value for this exercise.

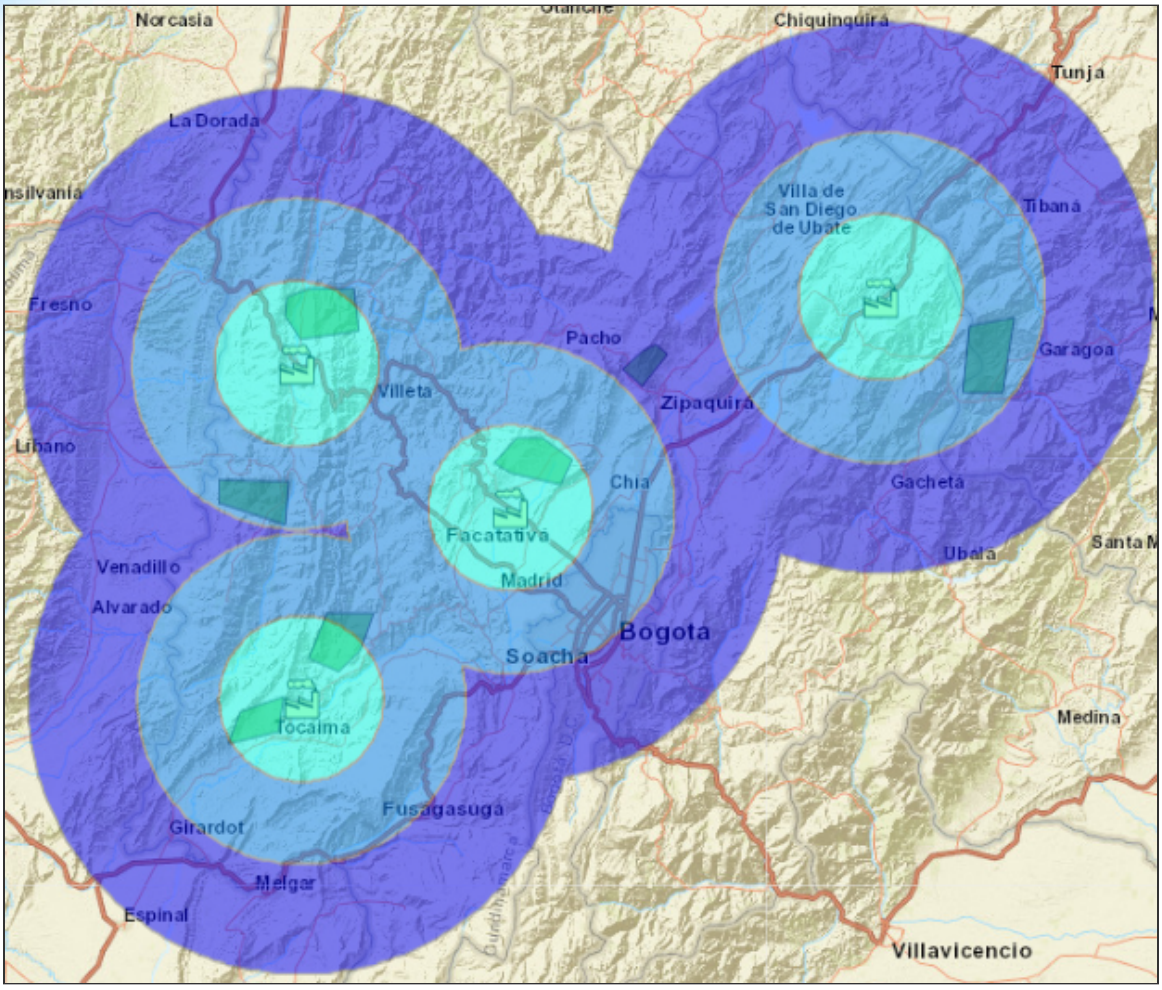
The Use Current Map Extent check box is checked on by default. This option limits the results to your current map extent (the map display on-screen at any moment).

k. At the bottom of the pane, click Run Analysis.

Note: Processing time for analyses depends on a number of factors, including the type or complexity of the analysis, the number of features in the current extent, and Internet traffic. If your analysis does not complete after three to four minutes, try saving the map and refreshing the page, or exit ArcGIS Online and try again.

The result is added as a new map layer to your Contents pane.

l. If necessary, use the zoom controls to zoom out so you can see all of the rings.



The smallest ring, in the lightest blue color, represents a 15-kilometer distance from each of the processing plants. The middle ring has a radius of 30 kilometers, and the largest ring is 50 kilometers. You can see that four of the fields are within a 15-kilometer distance of a processing plant, two are within 30 kilometers, and one is between 30 and 50 kilometers.

Examine the relative distances, and think about what they might tell you. Perhaps the fields that are farther away from the nearest processing plant are more productive than other fields and worth driving the extra distance. Crop yield is affected by precipitation, temperature, and other variables, which can vary by location. Or, the other fields that are closer to processing plants may not yield enough tonnage to keep your plants running at full capacity all the time. In that case, you may continue to utilize farther fields to keep product coming in to the plants if they threaten to dip below full capacity. It could also be that some fields produce a higher-quality product that is used in a different, more expensive product line.

You could perform load-balancing and find the break-even point quantitatively. That tactic would allow you to compare the extra cost of bringing potatoes from a more distant field

against the extra revenue from the extra raw materials, or the increased revenue from a more expensive product line. The break-even point is affected by the number of fields you use, as well as the number of plants that you have manufacturing potato products. These calculations would be subjective, depending on how you weight or value the use of the extra plant.

There is also supply chain risk management to consider. Even though it costs more to drive to a more distant processing plant, the more you spread out the load of raw material suppliers, the lower your risk if any of them has a disruption or drop in production. Spread can refer to the number of suppliers or manufacturers, or their geographic location.

Tip: You could save or share analysis results layers like this, for others in your organization to use. For now you will continue with the analysis.

m Turn off your Buffer Of ProcessingPlants layer.

Hint: To turn a layer off, clear the check box to the left of the layer name.

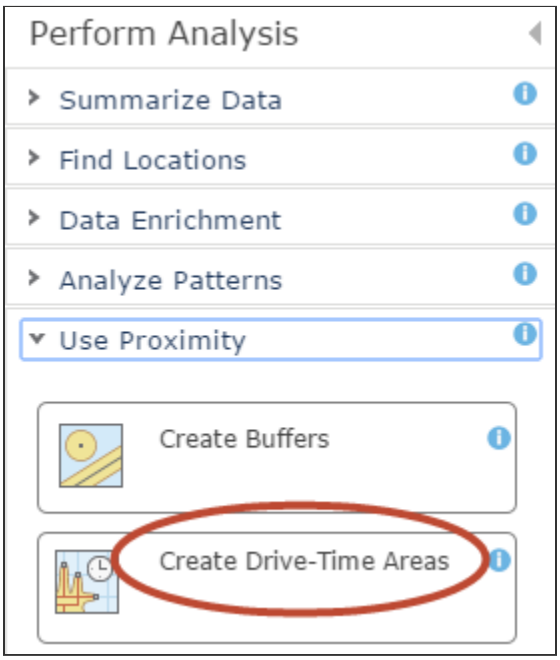
Step 5: Create drive-time areas

Besides distance from field to plant, you are interested in the time it takes a truck to travel between the fields and the processing plants. You can use another buffer analysis approach, known as drive-time areas, to visualize this. Using proximity analysis, you can identify zones around a feature (in this case, processing plants or fields) measured by the time it takes to travel by car or truck. Certain fields might be closer to a processing plant in terms of distance measured with a straight line, but the drive might take longer. The roads may not provide a direct route, or there may be varying road quality or conditions, mountainous areas, or congested urban areas. Having access to this information is a useful factor in overall management of your supply chain because it can be used to help answer questions like the following:

- Which processing plants are located within a one-hour drive from each field?
- How long should it take a truck to drive from each field to the nearest processing plant?
- How long is the drive to other processing plants that are located within a similar distance?
- Can you increase production efficiency by building a new processing plant somewhere?

a In the Contents pane, hover your mouse pointer over the ProcessingPlants layer and click the Perform Analysis button.

b. In the Perform Analysis pane, expand Use Proximity.



c. Choose Create Drive-Time Areas.

d. In the Create Drive-Time Areas dialog box, for Measure, choose Trucking Time from the drop-down list.

Trucking Time uses fixed speeds and follows rules that are applicable to heavy trucks.

e. Change the time to **45**, and leave the units set to Minutes.

f. For Areas From Different Points, choose Dissolve.

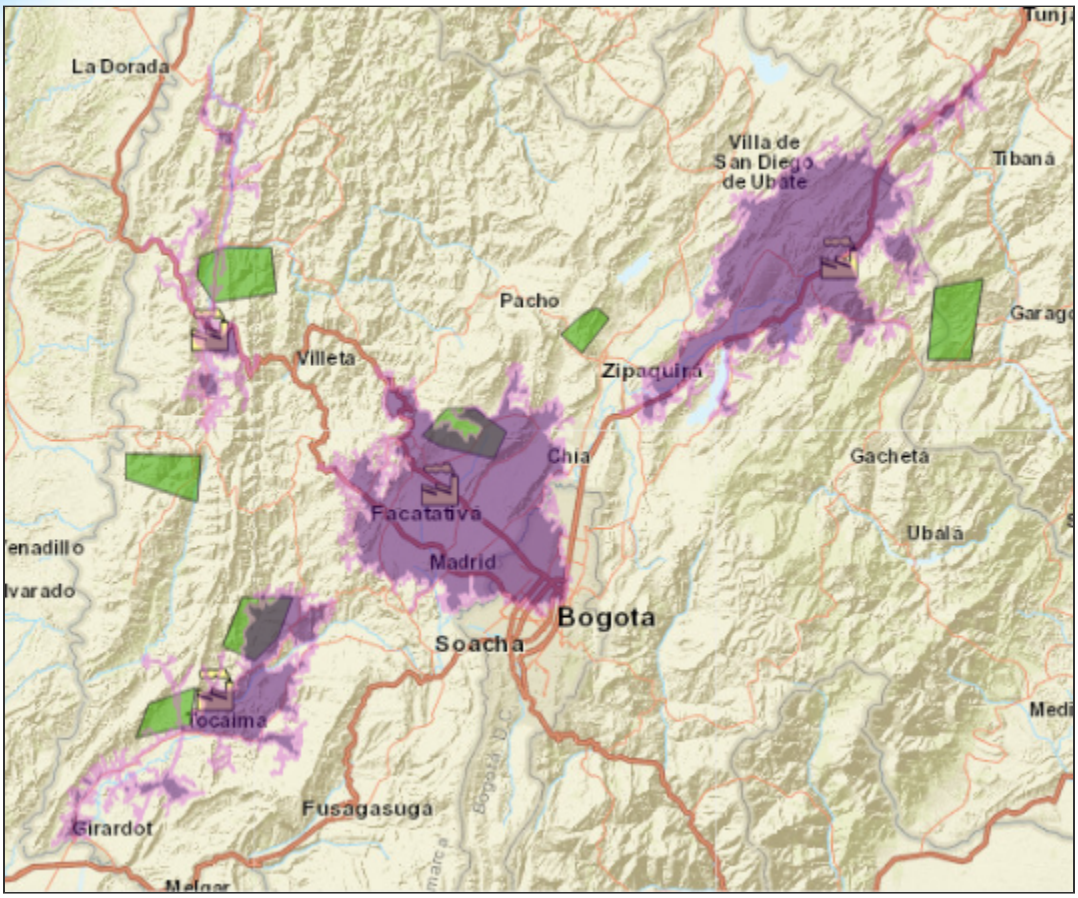
Your visualization will show the areas that can be reached within 45 minutes. All areas will be merged or dissolved into one.

g. Add your ArcGIS Online user name to the result layer name (for example, **Travel from ProcessingPlants (45 Minutes)_YourArcGISOnlineUsername**).

h. Ensure that the Use Current Map Extent check box is checked.

i. At the bottom, click Run Analysis.

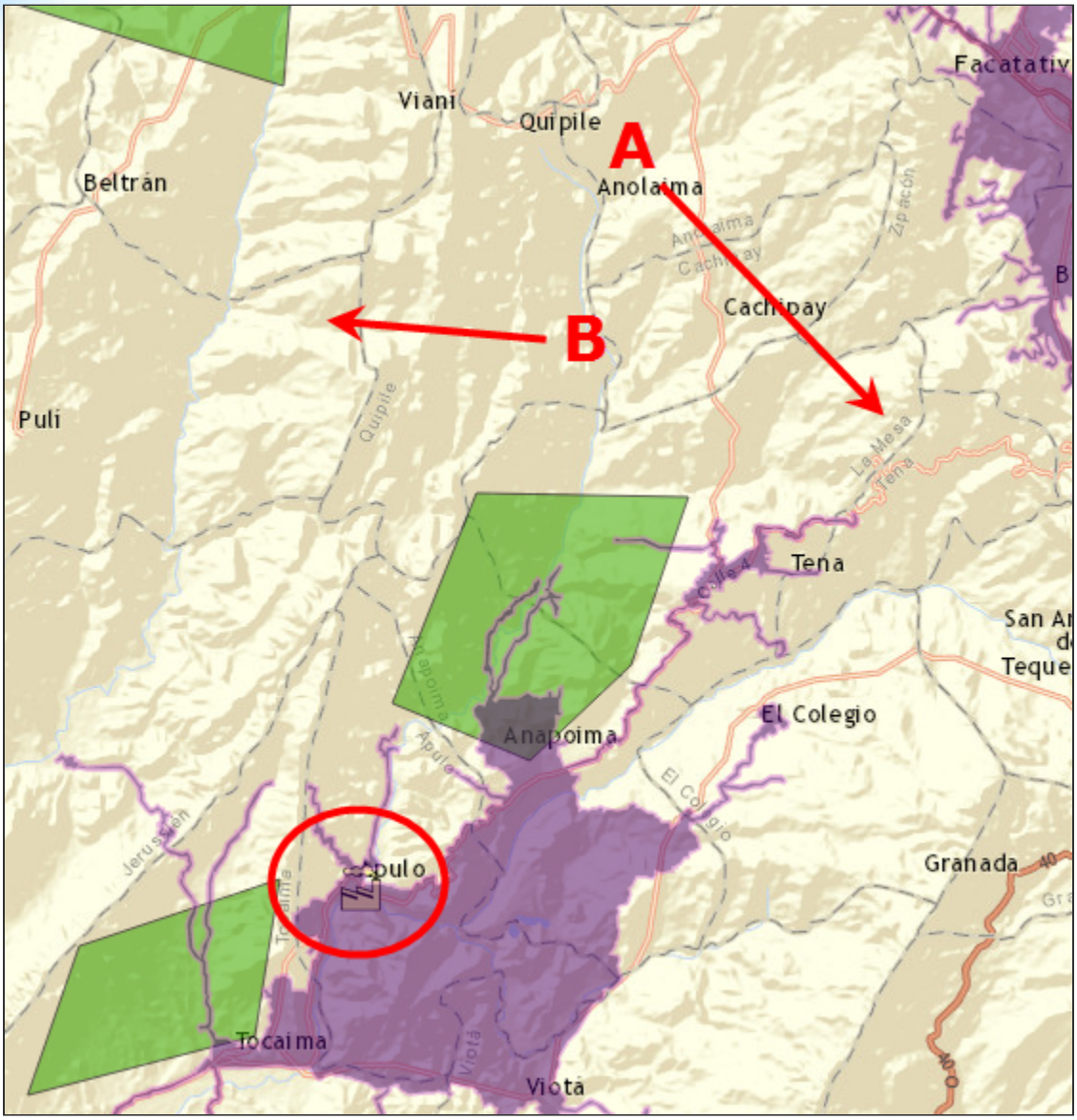
The analysis will process and add the result as a new map layer to your Contents pane.



The result shows all areas (indicated in purple) that are reachable by trucks driving at normal speeds in any direction in 45 minutes or less from each of the processing plants. You can see that some fields are located well within 45 minutes of a processing plant, while others are farther, even if they are closer in terms of straight-line distance. This analysis can reveal more about the transportation network and the locations of your supply chain nodes.

j Zoom in and pan the map to explore the results.

Notice the fields and processing plant to the southwest (bottom left on the map), and the drive times from that processing plant.



k Note the regions indicated by the arrows in the graphic above.

From the map visualization and the distance rings, it seems like another processing plant might be close enough to these fields, and the circled processing plant could be eliminated. But, when you create drive-time areas, you can see that the they don't reach across either Region A or Region B. This shows that the drives are too long, probably due to the mountainous terrain. So, having that processing plant (circled) located near those fields is necessary.

Drive times are more accurate than distance rings in this case, but they are not always better. For example, a company might pay drivers by the kilometer instead of by the hour, or a plant

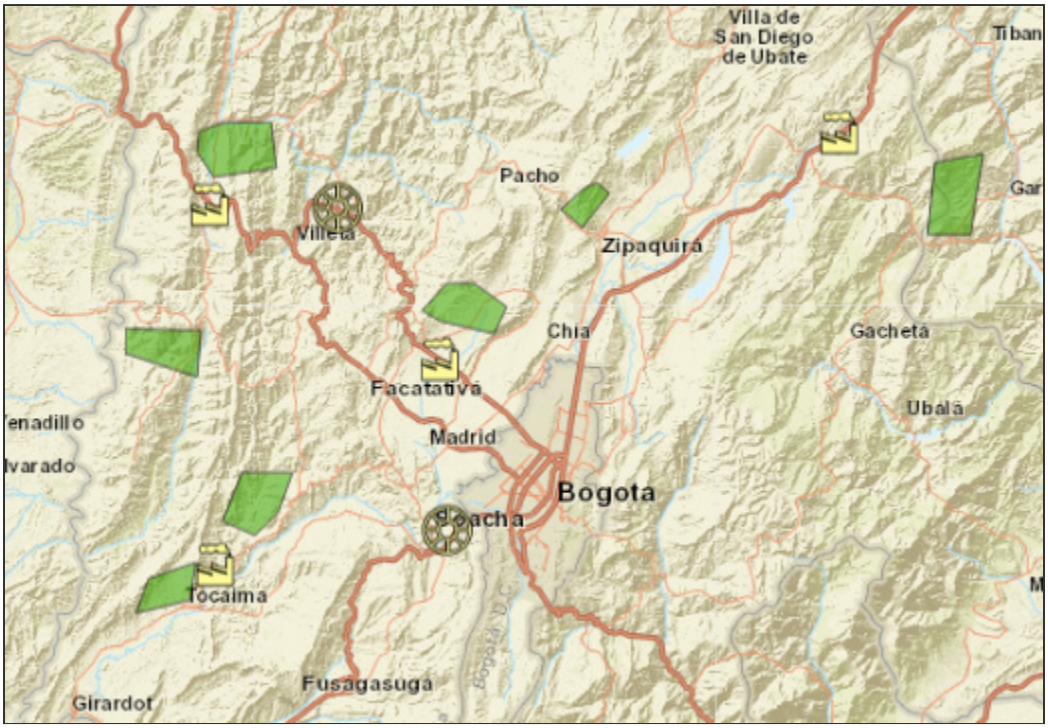
might not have the capacity to take the extra load. There are many parameters in supply chain management, as well as many complexities.

l. Turn off the Travel From ProcessingPlants (45 Minutes) layer.

m. Zoom out to return to the previous map extent to show all of the plants and fields.

From the processing plants, the Perfectos products are sent to two distribution centers.

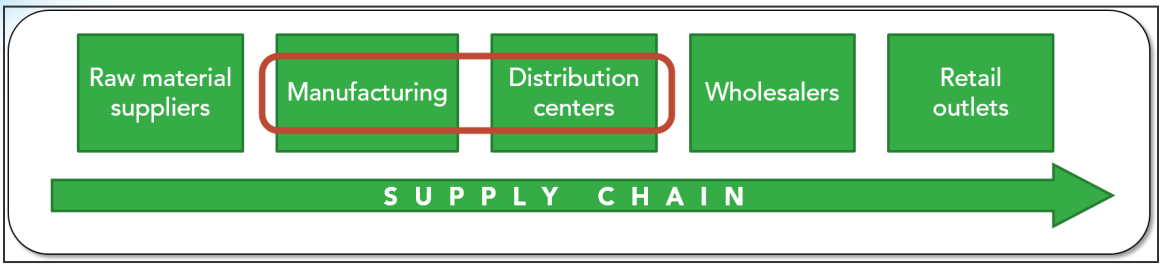
n. In the Contents pane on the left, turn on the DistributionCenters layer by checking its check box.



The distribution centers, symbolized as yellow and black wheels, are located to the northwest, near Nocaima, and to the south, near Soacha. They are situated in good locations to receive product from the four processing plants.

Part II: Moving product from plants to distribution centers, before and after a business interruption

Next, you will look at the location aspect of manufacturing and distribution center activities as part of the supply chain.

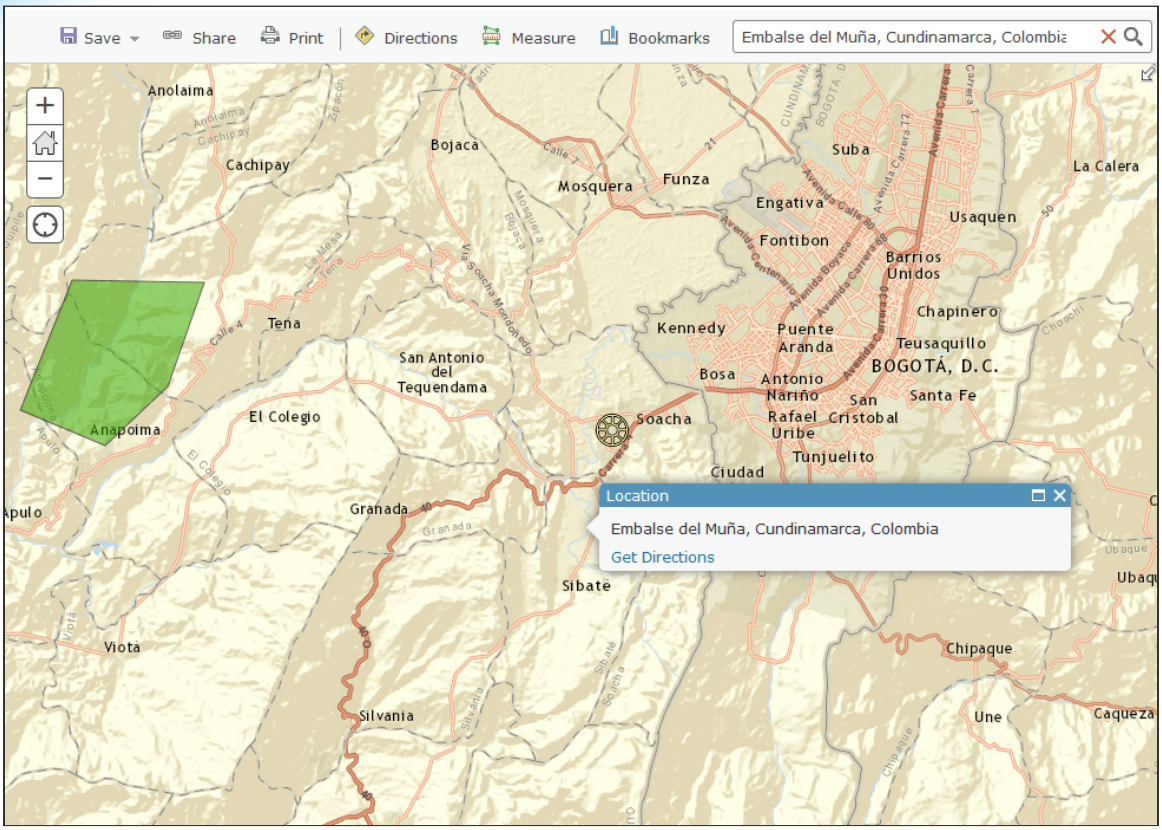


Another supply chain management task is mitigating business interruptions. Whether due to floods, earthquakes, hurricanes, civil unrest, war, or another factor, interruptions can have a major impact on business operations. (You will learn more about natural and man-made risks such as these in next week's lecture.) Contingency and continuity planning using location information can help minimize losses and keep products and goods flowing as efficiently as possible.

In this section, you will model the effects of a business interruption in the form of a natural hazard. A flood has removed one of the two Perfectos distribution centers in your supply chain. How do you adapt to this business interruption? You must repair the supply chain and find a replacement distribution center. You need to move quickly, as this interruption can impact your business in terms of increased costs and lower revenues if the interruption causes a product shortage on the shelves. It can also potentially cause damage to your brand, reputation, and customer satisfaction.

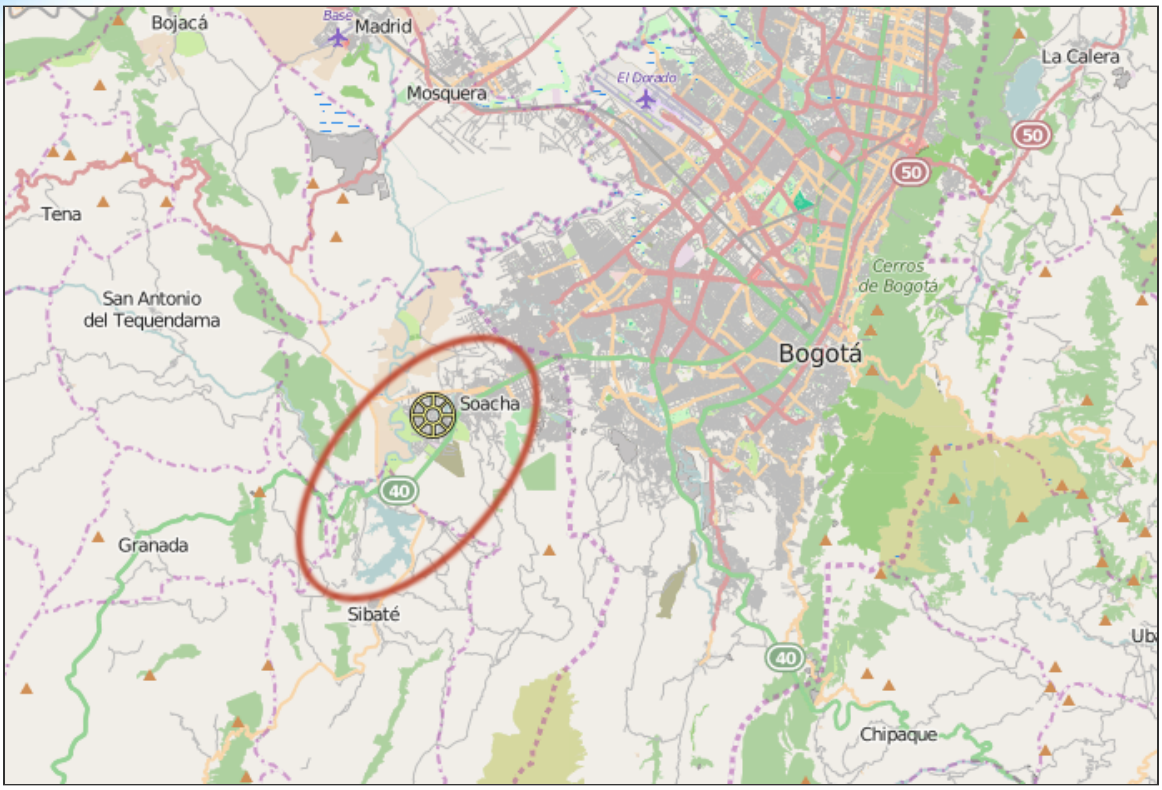
Interruptions typically occur without warning. For this scenario, you have just received an emergency notification that the dam on the Embalse del Muña, or El Muña Reservoir, in Cundinamarca, Colombia has broken. Part of the downstream town of Soacha, located just west of Bogotá, has been flooded.

- Find the location of Embalse del Muña on the map using the search field at the top right of the page.



The distribution center near Soacha has also been flooded and is offline. Product cannot be delivered to or routed from this distribution center. Costs are rising, and retailers' inventory will begin dropping soon unless another distribution center is found and brought online quickly to take its place. You need to secure a new distribution center as soon as possible to prevent further interruption to the supply chain. You will find and compare candidates for a new distribution center to replace this one.

Comparing different basemaps can provide additional insight into what is shown on a map. In this case, you could change the basemap to Topographic, or OpenStreetMap, and zoom in to observe the geographical context of the dam break. To continue with the remainder of the exercise, you will want to change it back to the Streets basemap when you are done.



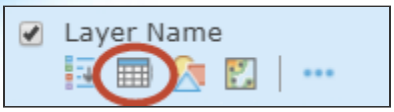
Step 6: Examine feature attributes

As a first step, you will verify the capacities of the two distribution centers before the interruption. Capacity is one of the parameters you must know in order to identify a replacement distribution center. You must also know the output volumes of your processing plants to ensure that your distribution centers will continue to be able to handle the product.

To see information about features in a layer, you can display an attribute table at the bottom of the map. Attribute tables contain additional non-spatial information about GIS features. They consist of columns of different informational attributes and rows for each of the features.

First, you will examine the attributes of the processing plants to get statistics on the total output. Then, you will view attributes of the existing distribution centers to learn their capacities before the interruption. This information will tell you how much tonnage the centers can receive from the processing plants and the minimum size that the new distribution center must be.

a. In the Contents pane, hover your mouse pointer over the ProcessingPlants layer, and click the Show Table button.

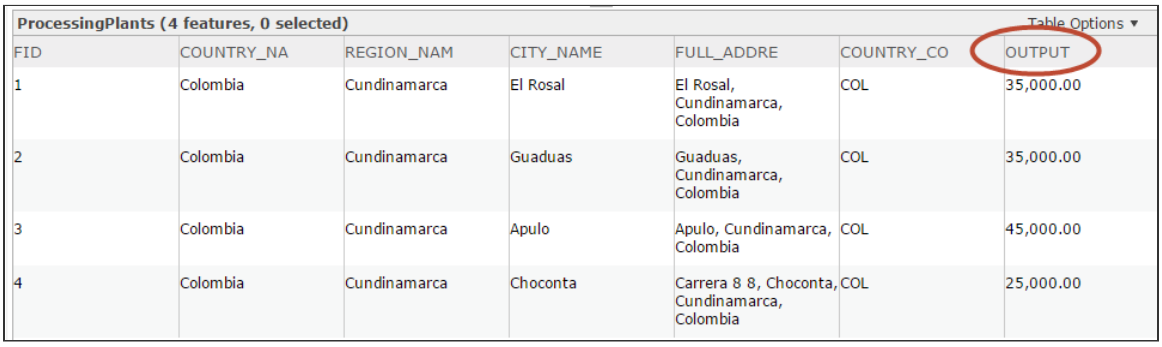


The attribute table displays at the bottom of the map.

b. Click a row in the table, and notice that the associated processing plant point feature on the map is highlighted.

Note: You may have to pan the map or zoom out to see the highlighted feature.

To obtain information on the output volume for each processing plant, you can view statistics for the Output field in the table.

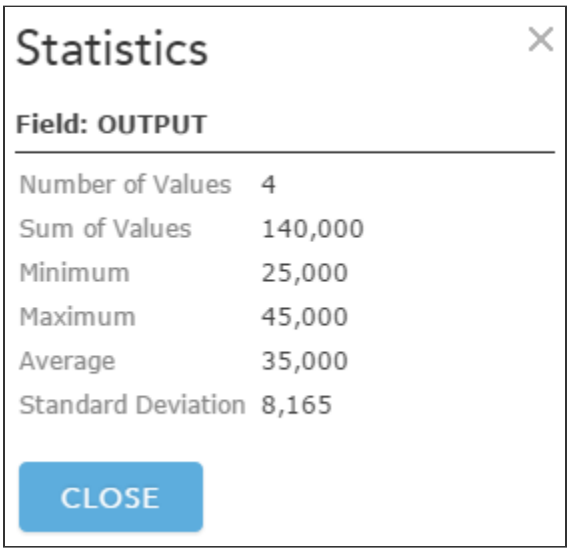


ProcessingPlants (4 features, 0 selected) — Table Options

FID	COUNTRY_NA	REGION_NAM	CITY_NAME	FULL_ADDRE	COUNTRY_CO	OUTPUT
1	Colombia	Cundinamarca	El Rosal	El Rosal, Cundinamarca, Colombia	COL	35,000.00
2	Colombia	Cundinamarca	Guaduas	Guaduas, Cundinamarca, Colombia	COL	35,000.00
3	Colombia	Cundinamarca	Apulo	Apulo, Cundinamarca, Colombia	COL	45,000.00
4	Colombia	Cundinamarca	Choconta	Carrera 8 8, Choconta, Cundinamarca, Colombia	COL	25,000.00

c. Click the header of the Output column, and choose Statistics.

This option will show you the total sum of the outputs of the four processing plants and other statistics, including the minimum and maximum outputs, as well as the average.



You can see that the sum of values, the minimum total output that both of your distribution centers must be able to handle per day, is 140,000 kilograms of product.

d. Close the Statistics pop-up.

e. Close the attribute table for the ProcessingPlants layer.

Next, view the capacities of the existing distribution centers to see what volume of product they currently can hold. This value, combined with the total output of the processing plants value, will help inform you of what you should look for in your search for a replacement distribution center.

f. View the table for the DistributionCenters layer.

DistributionCenters (2 features, 0 selected) — Table Options

FID	COUNTRY_NA	REGION_NAM	CITY_NAME	FULL_ADDRE	COUNTRY_CO	CAPACITY
1	Colombia	Cundinamarca	Soacha	Carrera 11, Soacha, Cundinamarca	COL	75,000.00
2	Colombia	Cundinamarca	Nocaima	Nocaima, Cundinamarca, Colombia	COL	80,000.00

The two distribution centers are identified by the name of the city in which they are located. The capacity of the Soacha distribution center was 75,000 kilograms of product per day, while the capacity of the Nocaima distribution center to the north, outside of Medellin, is 80,000 kilograms. This total quantity of 155,000 is just over the current total output of the processing plants of 140,000.

Note: You can determine the total capacity of 155,000 either by getting statistics on the Capacity column (as you did for the processing plants output), or by simply adding the two Capacity field values together (75,000 + 80,000).

Now that you have the information on the capacities of the existing distribution centers, you can begin comparing candidates, one of which will serve as a replacement for the Soacha distribution center which is flooded and offline. The replacement must be large enough that between the two distribution centers, they can hold a day's worth of output from all four processing plants. Additionally, you need to allow for future growth, so you decide that a new center should have at least 30 percent spare capacity. There is no way to know how long it might be until the Soacha distribution center is back online or if the replacement distribution center will have to be made permanent. Therefore, instead of a total volume of 155,000 kilograms, the two distribution centers must be able to accommodate 182,000 kilograms (140,000 * 1.30). Any candidate replacement distribution center should consequently have a capacity of at least 102,000 kilograms (182,000 - the Nocaima distribution center's capacity of 80,000).

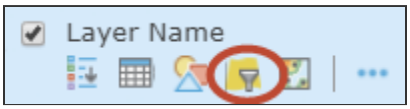
Step 7: Compare two options

Because you continually monitor your supply chain and visualize potential threats and impacts, your team is prepared for risks when they occur. As part of risk management efforts, you had previously identified two distribution centers in the region with space to accommodate your product. These candidates to replace the distribution center that was taken offline by the flood are already included as layers in the map.

To decide which of the two candidate distribution centers you will choose, you will compare them based on a number of criteria, including available capacity, locations, and cost.

First, you must update the map to show that one of the existing Perfectos distribution centers is offline because of the flood. You will do this by removing the Soacha distribution center from the map using a filter to eliminate the display of that feature.

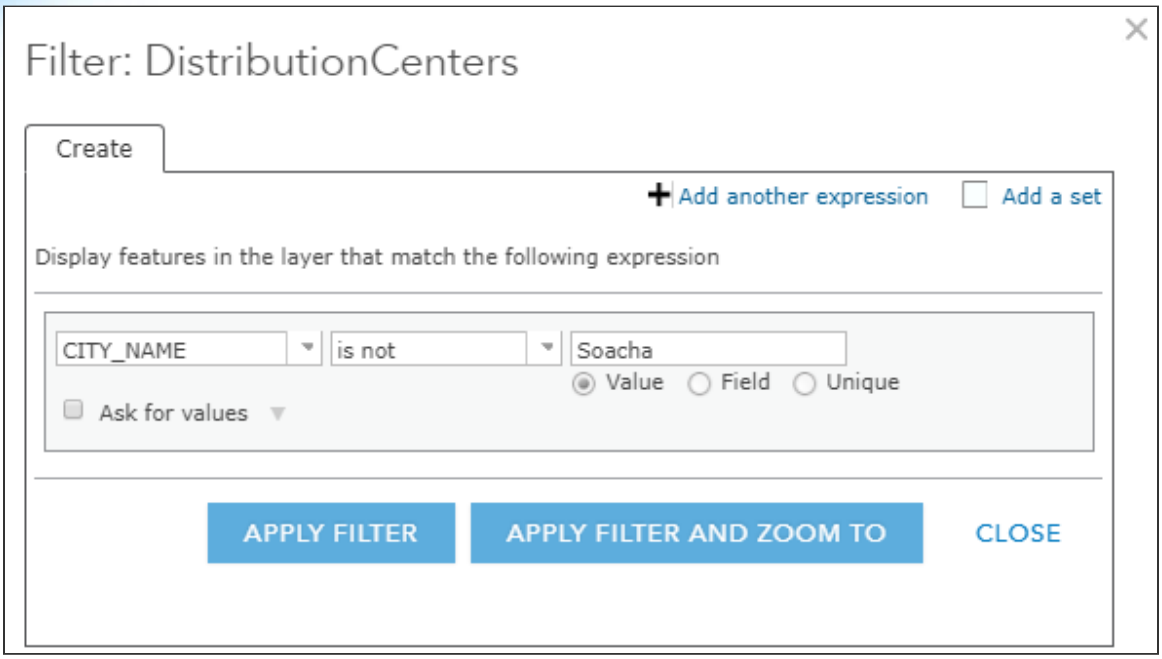
a. In the Contents pane, hover your mouse pointer over the DistributionCenters layer, and click the Filter button.



b. In the Filter dialog box, change the first drop-down to CITY_NAME

c. Change the operator to Is Not, and for the Value field, type **Soacha**.

In plain language, this filter statement reads, "Display features in the DistributionCenters layer where the name of the city is not Soacha." This filter will allow the display of any distribution centers in cities other than Soacha.



d. Click Apply Filter.

e. View the attribute table for the DistributionCenters layer.

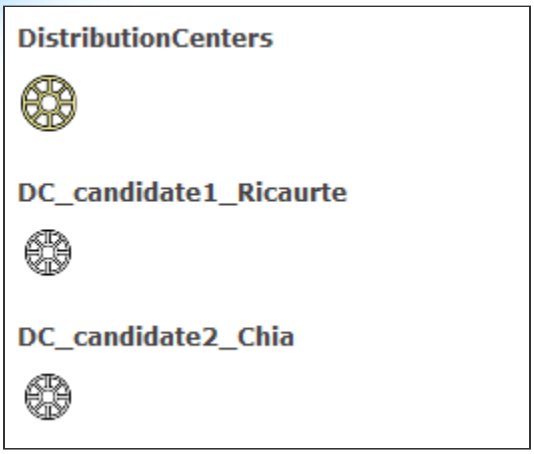
Now the DistributionCenters layer displays only the distribution center in Nocaima, located to the north of Bogotá. Notice that the attribute table is updated, along with the map, to only include the one remaining feature.

f. Close the attribute table.

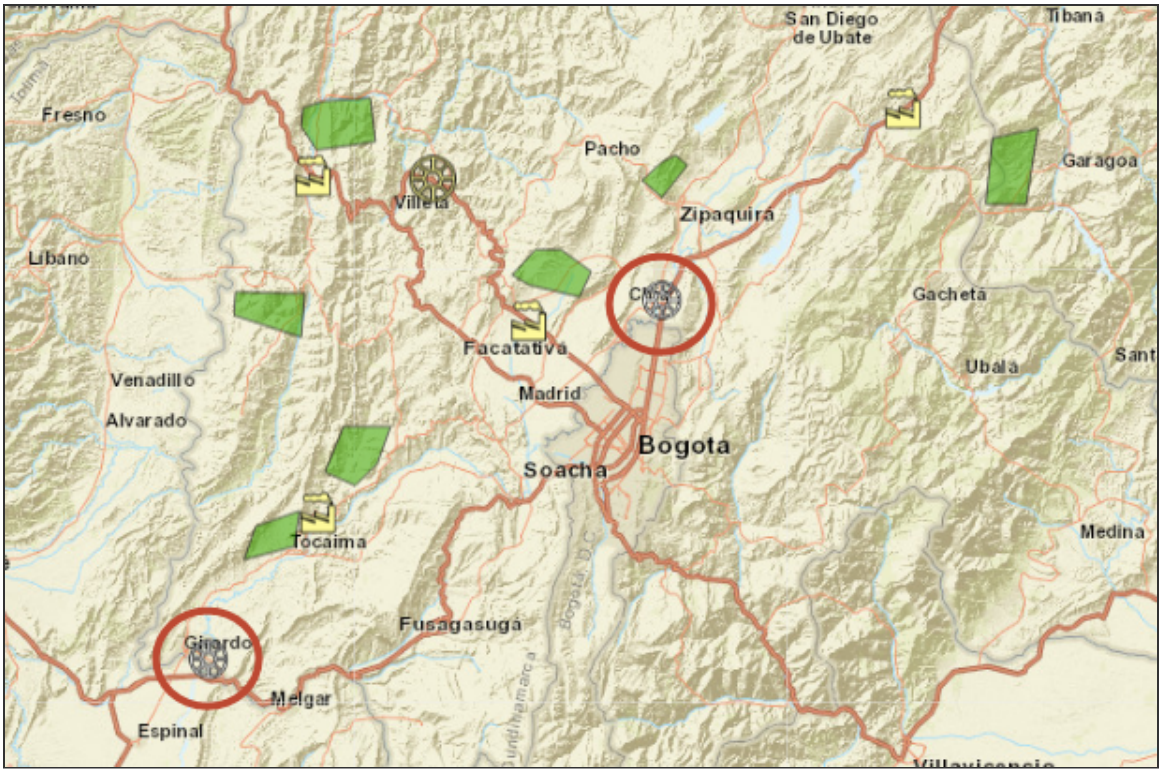
Next, you will add the new distribution center candidate layers to the map and begin the selection process.

g. In the Contents pane, turn on the layers named DC_Candidate1 Ricaurte and DC_Candidate2 Chia.

The two candidate centers in Ricaurte and in Chia are displayed on the map. The centers are symbolized slightly differently from the Nocaima distribution center, making it easier to locate and distinguish them on the map.



Note: You may need to zoom or pan the map to see both of the candidate replacement distribution centers.



Looking at the map, you can visually assess the locations of the candidate distribution centers. Note that one of them is located to the southwest, in Ricaurte, and the other is located to the northeast of the former Soacha distribution center (up and to the right on the map, near the city of Chia). It initially looks like Chia (Candidate 2) is closer to the location of the previous

distribution center and would therefore be the best replacement, but further analysis can help you decide conclusively.

Besides location, capacity and cost are also important. An ideally located distribution center is not sufficient if it cannot hold enough product to keep operations running and maintain a smooth, constant supply to your buyers. You will examine the available capacities and costs of each of the replacement candidates.

h. Show the attribute table for each of the DC Candidate layers, and compare the available information.

To assist you in comparing the information in the two tables, they are shown below. Here is the table from the first candidate distribution center, located in Ricaurte:

DC candidate1 Ricaurte (1 feature, 0 selected) — Table Options

FID	COUNTRY_NA	REGION_NAM	CITY_NAME	FULL_ADDRE	COUNTRY_CO	CAPACITY	COST
1	Colombia	Cundinamarca	Ricaurte	Ricaurte, Cudinamarca, Colombia	COL	125,000.00	10,000,000.00

And here is the table from the second candidate, located in Chia:

DC candidate2 Chia (1 feature, 0 selected) — Table Options

FID	COUNTRY_NA	REGION_NAM	CITY_NAME	FULL_ADDRE	COUNTRY_CO	CAPACITY	COST
1	Colombia	Cundinamarca	Chia	Chia, Cundinamarca, Colombia	COL	105,000.00	7,000,000.00

The capacities and costs of each candidate distribution center are shown in the columns to the right. Recall that the minimum capacity needed for the replacement distribution center is 102,000 kilograms. Candidate 1, Ricaurte to the southwest, has more capacity at 125,000 instead of 105,000. However, it is also more expensive—$10 million instead of $7 million. This situation is representative of the complex decisions you face in supply chain management, but examining additional parameters can help make the decision clearer.

i. Close any open attribute tables.

Step 8: Summarize nearby features

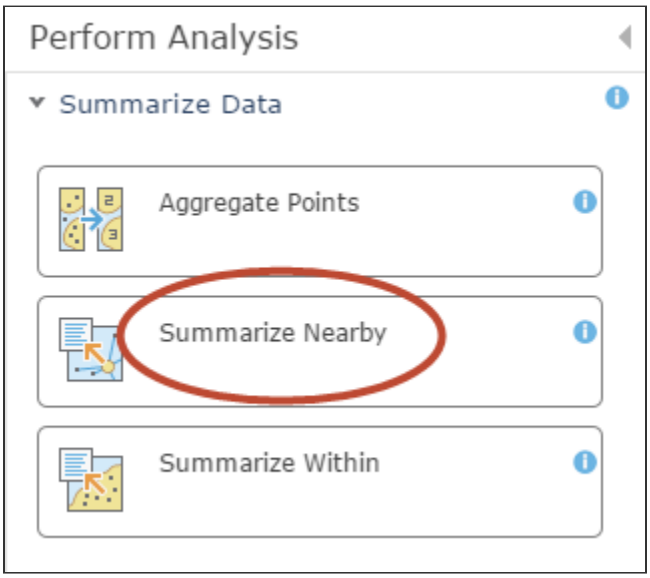
In addition to meeting the minimum requirement for capacity, it will also be more efficient if your new distribution center is close to the processing plants. To help you decide which of the two possible distribution centers is the better choice, you will now examine the amount of product that would be within the maximum desired driving distance, in the form of the total output of the plants that are located within a 50-kilometer distance of each distribution center. This distance represents the farthest your trucks would ideally drive to the distribution centers to keep costs down. It is the same distance that was used in measuring from the fields

to the plants. Combined with capacity and cost, this output amount relative to distance will be the third parameter in choosing the best replacement distribution center.

The Summarize Nearby tool finds features that are located within a specified distance of features in the analysis layer. In this case, you want to find processing plants that are within 50 kilometers of the candidate distribution center.

a. Hover your mouse pointer over the DC_Candidate1 Ricaurte layer, and click the Perform Analysis button.

b. On the Perform Analysis pane, expand Summarize Data.



c. Choose Summarize Nearby.

d. Leave the Ricaurte layer for the first drop-down, and for Choose Layer To Summarize, choose ProcessingPlants.

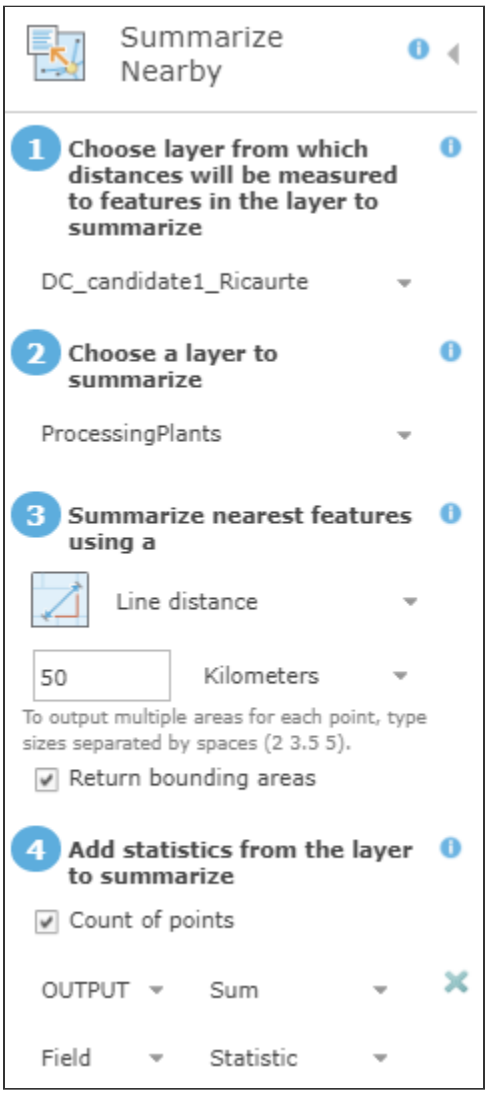
Note: You want a summary of the processing plants that are located near the selected distribution center.

e. Change the distance of the nearest features to summarize to **50** and the units to Kilometers.

In this case, straight line distance measurements are more reliable than drive-time distances and easier to compare because of the limited road network in the region.

f. Change the statistics from Field to Output, and change Statistic to Sum. Output is the only field you will summarize, so you will not need the second pair of drop-down boxes that is created.

This option will give you the sum of the outputs of all of the processing plants located within 50 kilometers of this distribution center.

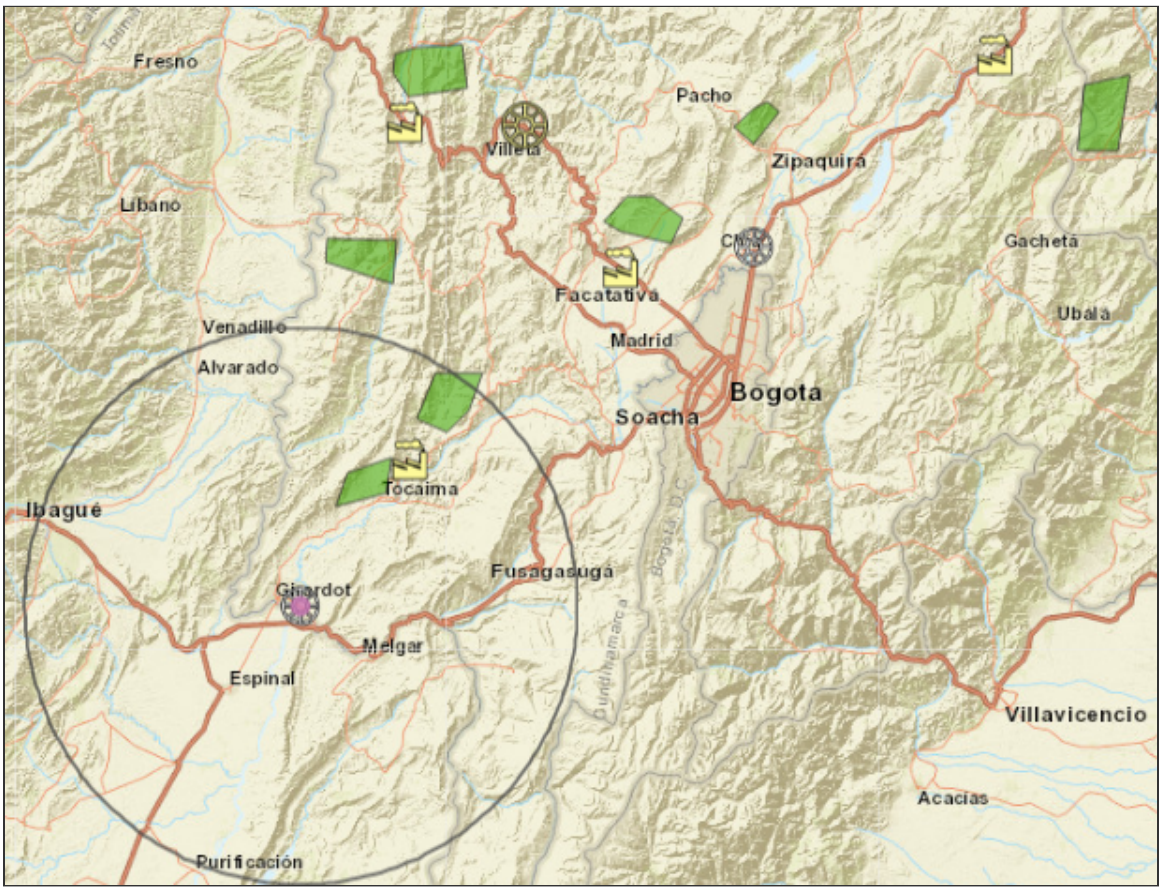


g. Change the result layer name to **Plants Within 50km of DC_candidate1_Ricaurte_YourArcGISOnlineUsername**.

h. Ensure that the box to use the current map extent is checked.

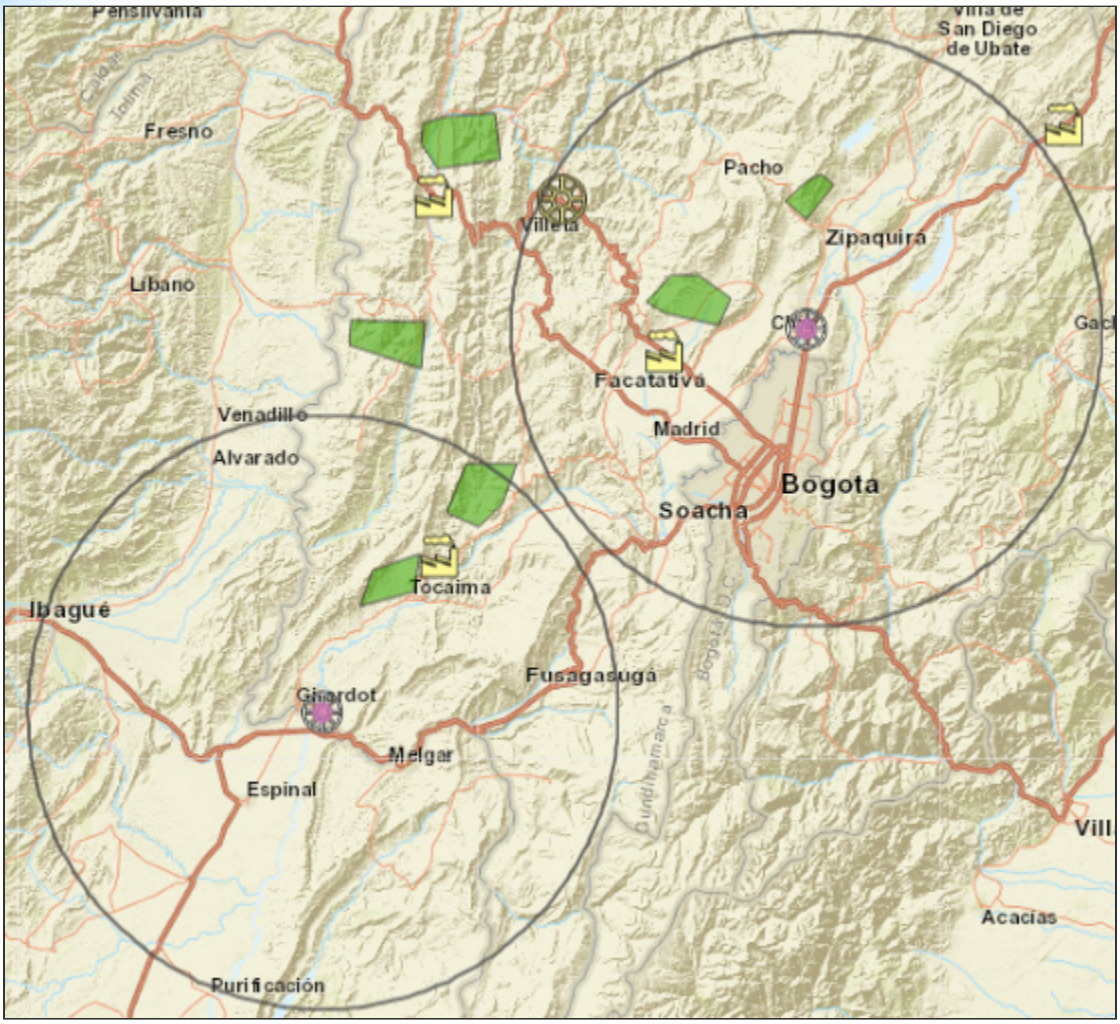
i. Click Run Analysis.

The map display updates to show a 50-kilometer buffer around the candidate location.



j Follow the same steps to perform the same analysis on the DC_candidate2_Chia layer, naming this result layer **Plants Within 50km of DC_candidate2_Chia_YourArcGISOnlineUsername**.

The map display updates, showing a buffer around the second candidate.



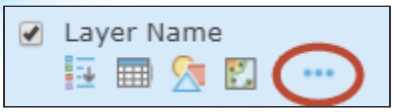
You will next perform a step that allows you to see the information behind each of these candidate distribution centers at a glance.

Note: Remember to periodically save your map as you are working.

Step 9: Create a custom attribute display pop-up

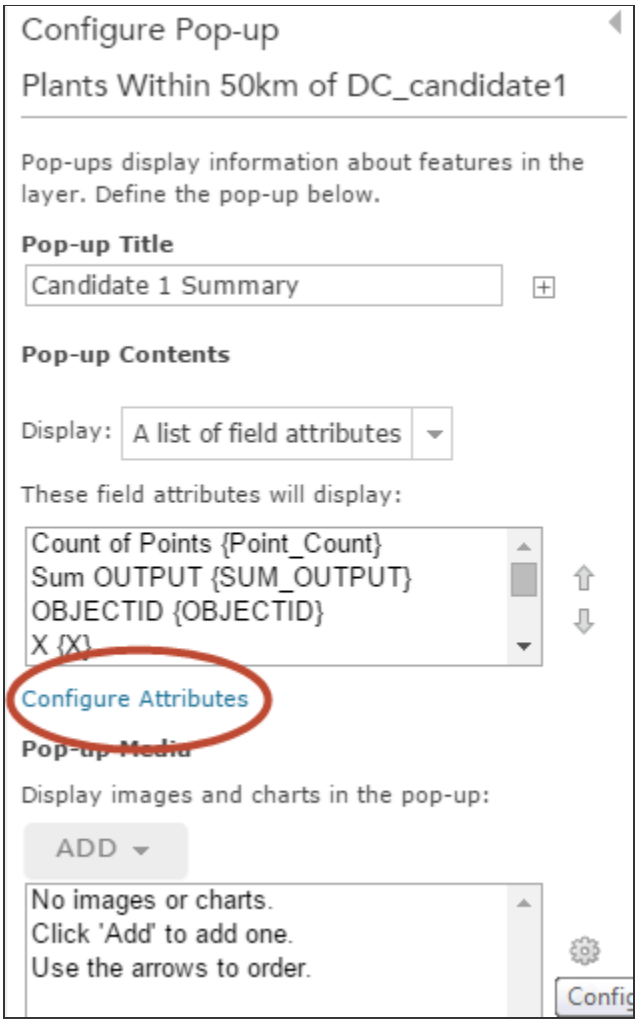
ArcGIS Online provides functionality to create and customize information pop-ups associated with features on your map. You need additional details about the candidate distribution centers to facilitate your final decision, so you will enable a pop-up for the new analysis layers. Pop-ups allow you and others to easily interpret the results.

a. Hover your mouse pointer over the new Plants Within 50km of DC_candidate1_Ricaurte layer, click the More Options button.



b. From the drop-down list, choose Configure Pop-up.

c. For Pop-up Title, type **Candidate 1 Summary**.



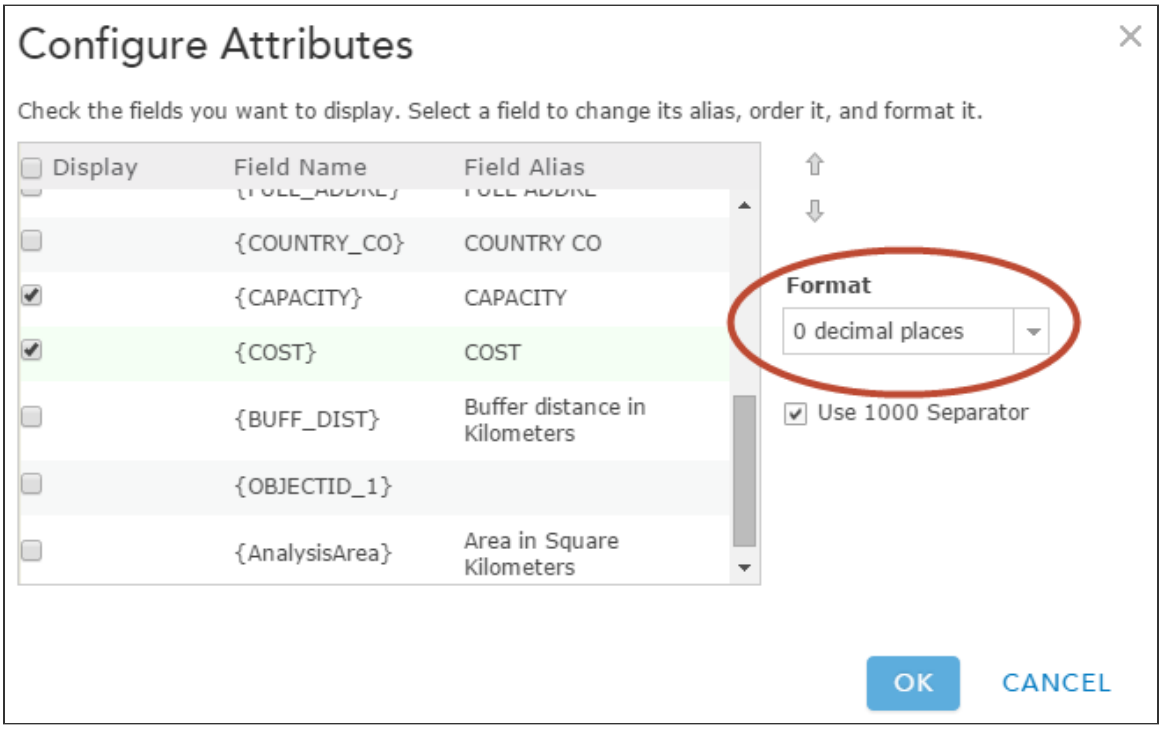
d. Click the Configure Attributes link to set the contents of the pop-up.

e In the Configure Attributes dialog box, unselect all fields except for these three:

- {SUM_OUTPUT}
- {CAPACITY}
- {COST}

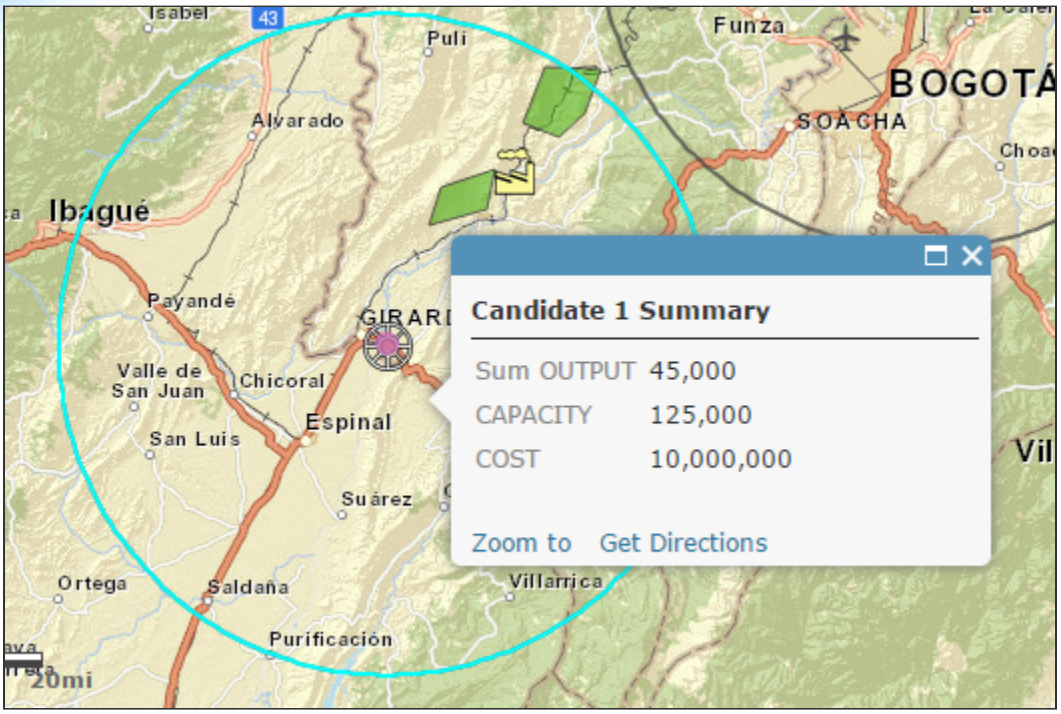
The values in all three fields have been rounded to the nearest kilogram or dollar, but you want to view them without decimal places in the pop-up.

f For each field, set the Format to 0 Decimal Places.



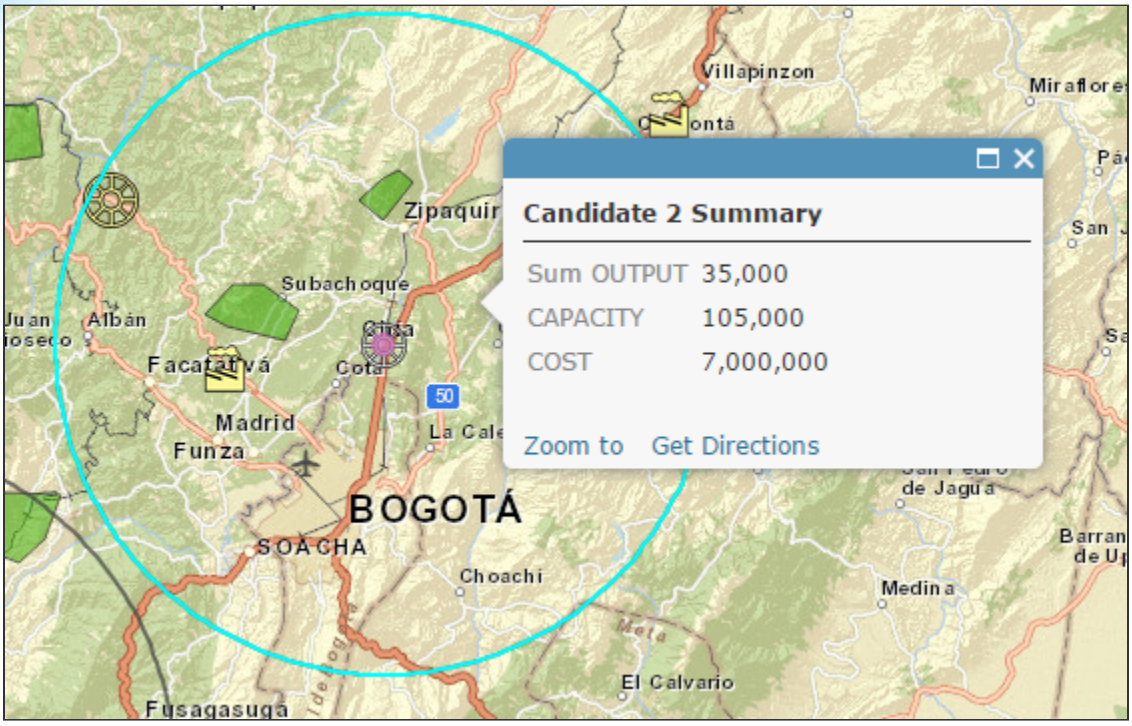
g Click OK, and then click OK.

h On the map, click anywhere in the Plants Within 50km of DC Candidate1 buffer ring to test the pop-up.



The pop-up displays a summary for processing plants located within 50 kilometers of the candidate distribution center in Ricaurte, including output, capacity, and cost. The sum of the output of the processing plants located within the maximum distance is 45,000 kilograms.

Repeat the previous steps to configure the pop-up for the second distribution center candidate layer (DC Candidate2_Chia). Use the title **Candidate 2 Summary** for the second custom pop-up.



Note: The sum of the output of the processing plants located within the maximum distance of the Chia distribution center is 35,000 kilograms, which is less than Candidate 1 (Ricaurte).

Candidate 1 (Ricaurte) not only has a higher capacity (125,000 versus 105,000), but it is also within the specified maximum distance of more processing plant output than Candidate 2 (Chia). Even though Candidate 2 (Chia) initially appeared to be better because it is closer to the distribution center it is replacing, Candidate 1 (Ricaurte) is your choice. The Ricaurte center is closer to more of the finished product coming from the plants and has a higher overall capacity. You judge these factors to be worth the extra cost. This distance parameter, which is not obvious until you perform geospatial analysis, is what leads you to the final decision to use Candidate 1 to replace the offline Soacha center.

Business interruptions are inevitable. There are always possibilities of interruptions, risks that could impact your supply chain. Multiple issues can cause disruption. For example, the supplier of other needed raw materials, like salt, could stop production because of a strike at the salt plant. Or, unplanned maintenance could impact production of the Perfectos potato chips. Perhaps a cyberattack damages computer systems at the processing plants and wreaks havoc. Whatever the interruption, proactively tracking risks and being prepared to act quickly to mitigate them when interruptions actually occur will help minimize losses and ensure continued productivity and movement of goods along the supply chain. Mitigating interruptions includes both real-time responses as interruptions happen and more proactive methods of planning and being prepared. Both approaches are valuable and necessary in supply chain management.

Step 10: Combine map layers

In your analysis of both the capacity and cost numbers associated with the candidate distribution centers, as well as the location of each, you determined that the distribution center to the southwest in Ricaurte, Candidate 1, is within reach of more of the processing output. It would be the better choice for leasing as your replacement distribution center.

Having selected Candidate 1 (Ricaurte), you now want to merge the information about this site into the DistributionCenters layer. Doing so will put all of the data (location and attributes) for your distribution centers into one layer, making the data easier to access for subsequent mapping or analysis.

a. Turn off the Plants Within 50km of DC_candidate1 Ricaurte, Plants Within 50km of DC_candidate2 Chia, DistributionCenters, DC_candidate1 Ricaurte, and DC_candidate2 Chia layers.

b. Hover your mouse pointer over the DistributionCenters layer, and click the Perform Analysis button.

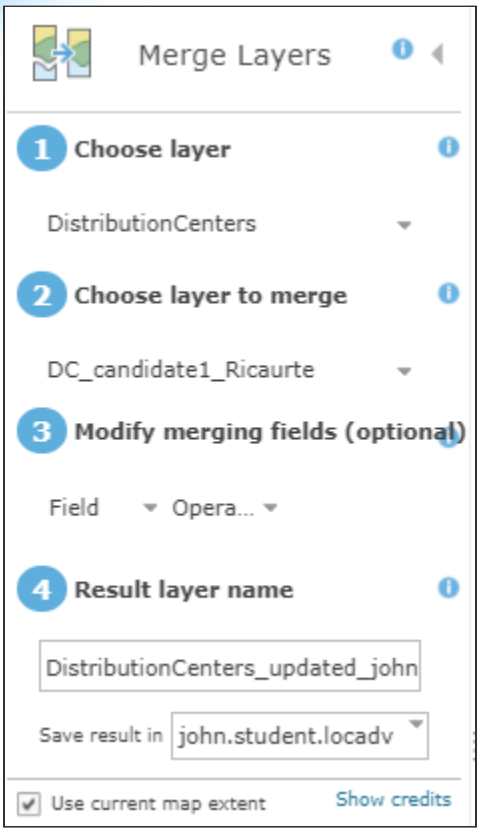
c. On the Perform Analysis pane, click Manage Data, and then choose Merge Layers.

d. Choose DC_candidate1_Ricaurte as the layer to merge with, and leave the merging fields on their default settings of Field and Operation.

This setting ensures that the operation will default to carrying all of the attribute fields from both of the input layers across to the output layer.

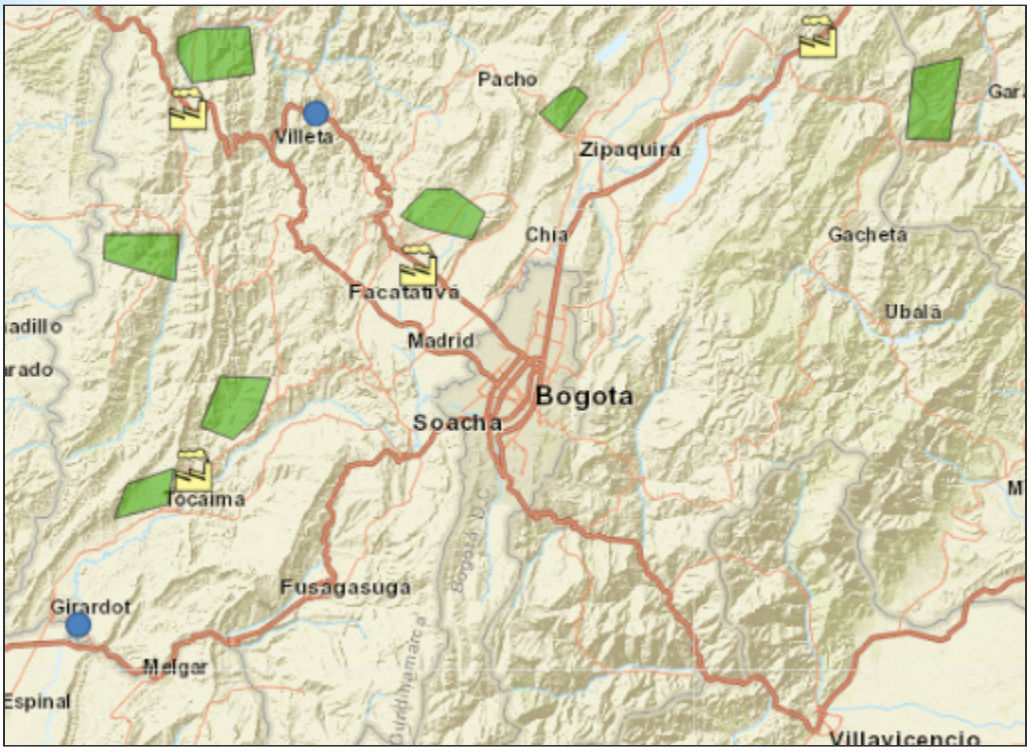
e. Change the result layer name to **DistributionCenters_updated_YourArcGISOnlineUsername**.

f. Use the current map extent.



g Click Run Analysis.

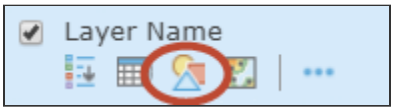
The map display updates, and the new DistributionCenters_Updated layer shows the location of the two distribution centers symbolized using default symbology (blue circles), along with the processing plants and the fields.



Step 11: Change map style

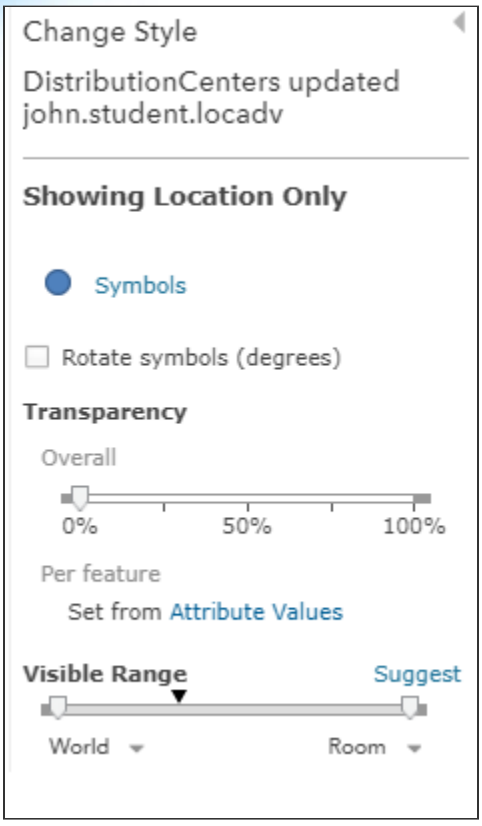
To better represent the distribution centers, you will update the symbology of the new layer.

a. In the Contents pane, hover your mouse pointer over the DistributionCenters Updated layer, and click the Change Style button.



You want to change the symbol in this new layer to match the symbol used in the original DistributionCenters layer.

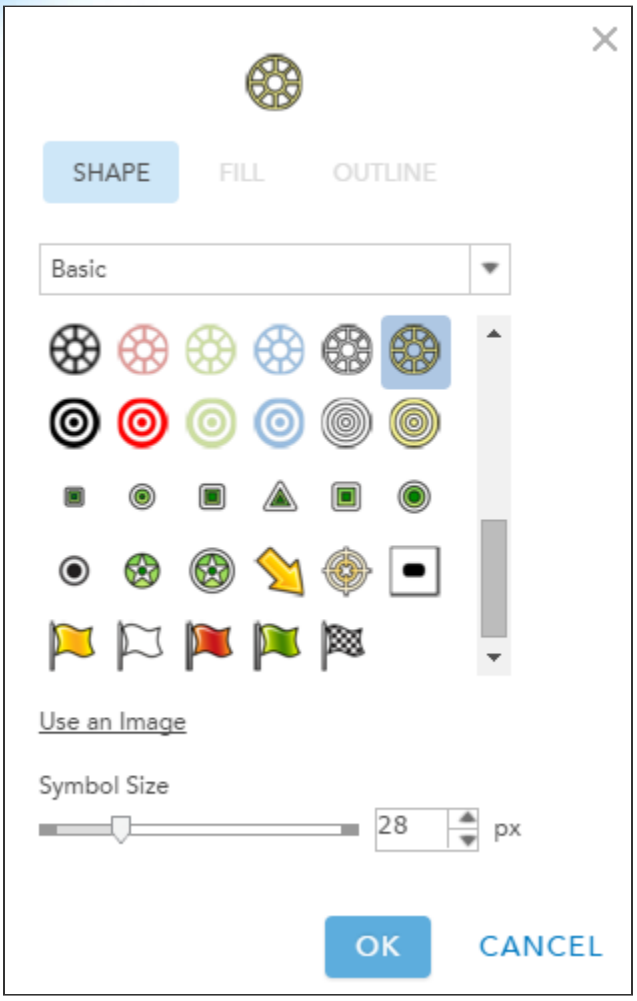
b. In the Change Style pane, click Options to customize the look of the symbol.



c. Under Showing Location Only, click Symbols.

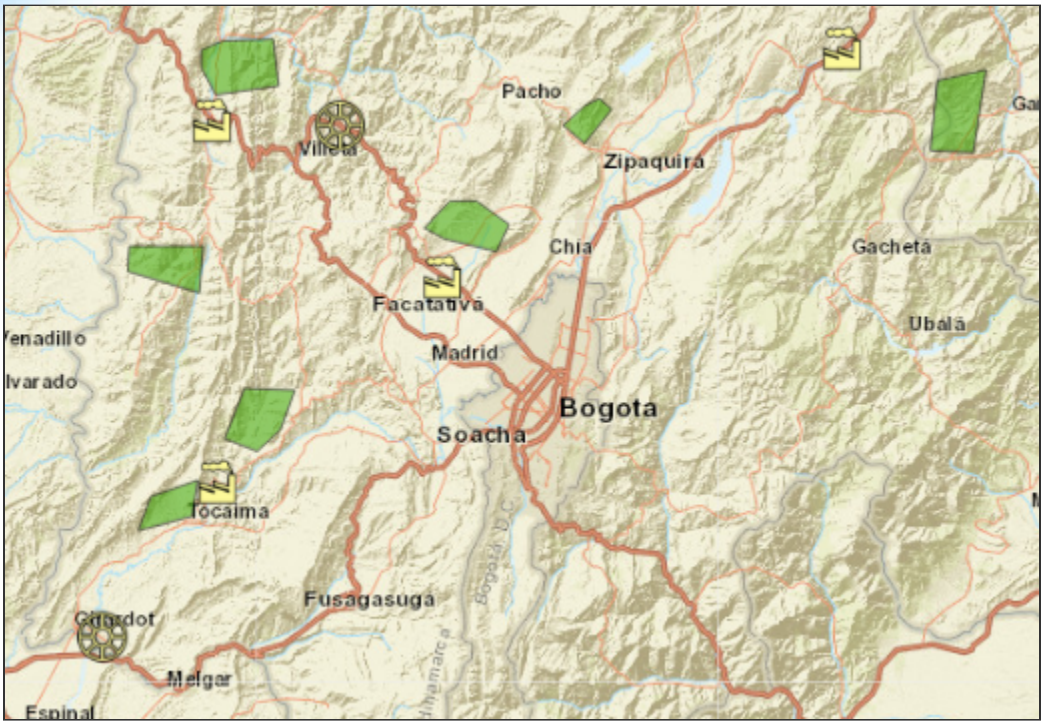
d. In the Change Symbol pop-up, set these parameters:

- From the drop-down list, choose the Basic category, and scroll down to the yellow wagon wheel symbol.
- Increase the size to 28 pixels.



- Click OK to close the Change Symbol pop-up.
- Click OK to close the Change Style Options pane.
- Click Done to close the Change Style pane.

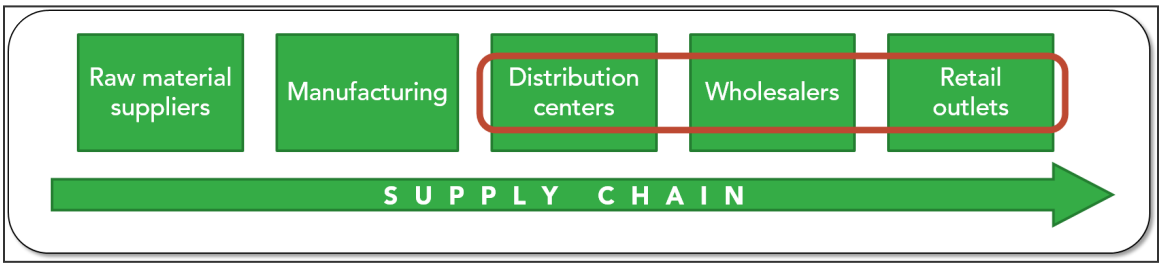
e Now, the two distribution centers are displayed on the map with the same symbology as the original DistributionCenters layer.



You have successfully shown the move of operations from the offline distribution center to the new distribution center. Your supply chain map is now updated with the most relevant information.

Now that you have the potatoes moving from the fields to the processing plants efficiently and the distribution centers are back up and running at full capacity, you will focus your attention on one of the last links in the supply chain.

Part III: Routing from distribution centers to food service supplier warehouses



Product needs to be moved from the distribution centers to food service supply warehouses, and also to direct retailers. As mentioned, a significant percentage of your business, 30-40 percent, is not direct retail customers but food service supply companies. These companies act as redistributors who deliver your products with their own transportation fleet from their

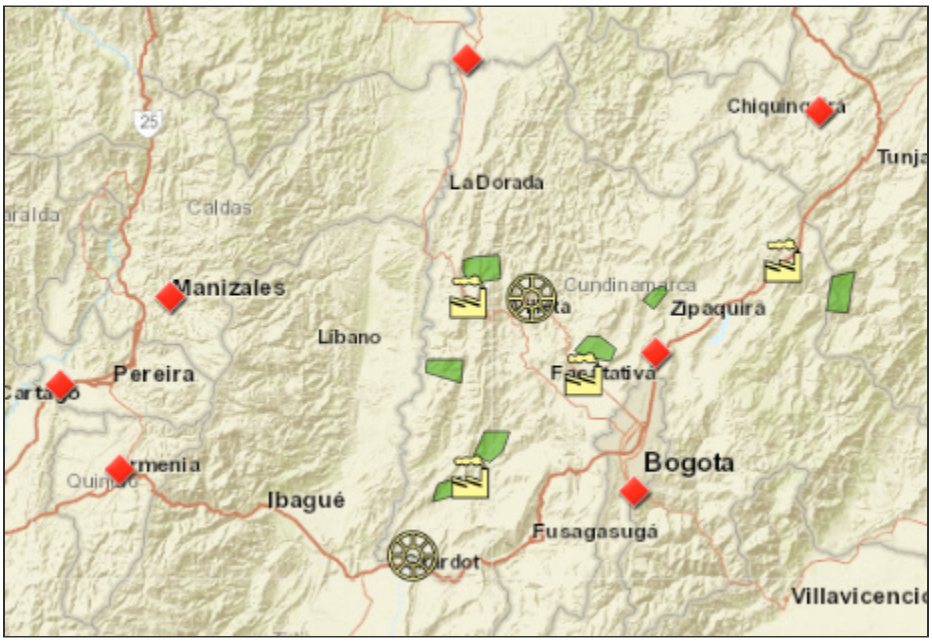
own warehouses to their own retail customers. Next, you will create routes for the product to be delivered from the distribution centers to the seven food service supply warehouses.

Step 12: Add a layer

Efficient routing can make a significant difference in costs related to time, fuel, and maintenance, which can result in a big difference in your bottom line. Location analytics must be involved to create the best, quickest path through a network.

Warehouses are used in the Comidas Bonitas supply chain to get your Perfectos product from the distribution centers to food service supply companies. To provide your delivery drivers with the most efficient routes to get product to the warehouses, you will use a geospatial technique known as routing. First, you will add a layer to your supply chain map to visualize the locations of the food service supply warehouses.

a. In the Contents pane, turn on the Warehouses layer, and zoom or pan the map until you can see all seven warehouses.



The warehouses are symbolized with red diamond-shaped symbols and are positioned to reach the food service supply companies and their retail customers around the region.

b. View the legend to see the symbols used for the layers now displayed in the map.

Step 13: Plan routing

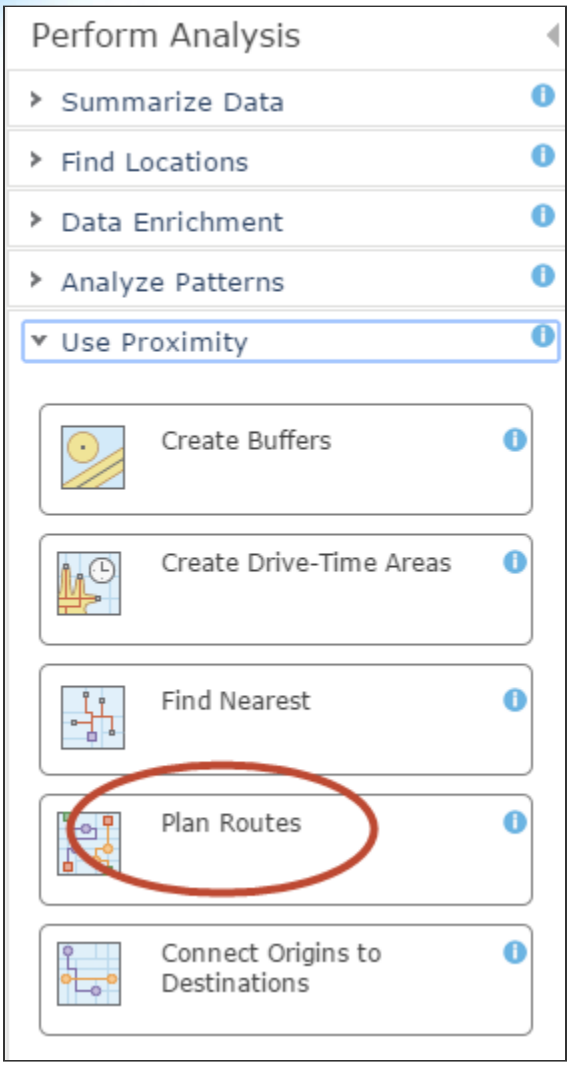
Your product is brought from the distribution centers to the warehouses frequently for re-distribution. The food service supply companies deliver the product to their customers from the warehouses.

In this step, you will create routes from the distribution centers to the seven warehouses in the region. Each stop will take no more than 20 minutes to show realistic conditions for delivery routes. Because of the size of the region, routes are long, and deliveries are not made every day.

a. If necessary, zoom out so that you can see all seven warehouses on the map.

b. In the Contents pane, hover your mouse pointer over the name of the Warehouses layer and click the Perform Analysis button.

c. Expand Use Proximity.



d. Choose Plan Routes.

With the Plan Routes tool, you provide a set of stops and the number of vehicles available to visit the stops. The tool then determines how to efficiently assign the stops to the vehicles and route the vehicles to the stops.

e. In the Plan Routes pane, change the Travel Mode For Routes to Trucking Time.

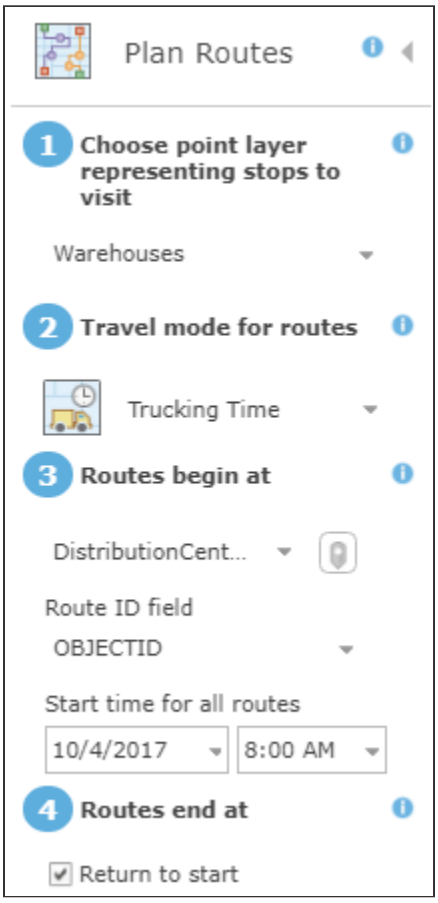
f. Set the routes to begin at the DistributionCenters_Updated layer.

This setting ensures that routes are planned from the distribution centers as the starting point.

g. Leave the default setting of OBJECTID_1 for Route ID Field, and set the start time to tomorrow at 8:00 AM.

h. Ensure that the Return To Start check box is checked. This way, the routes will show that the delivery trucks return to their origination point.

The route ending point is the same as the route starting point because you want the trucks to return to the distribution center after making the deliveries to the warehouses.



i. Set the maximum number of vehicles to 2, one per distribution center.

j. Set the maximum number of stops per vehicle to 4, so that the trucks split the seven warehouses between them.

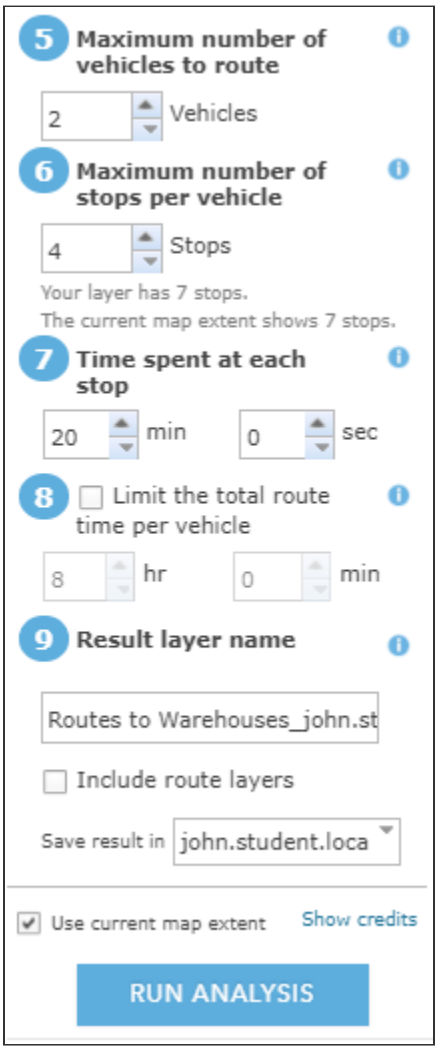
Given the size of the region, the distance from the distribution centers to the warehouses, and the number of trucks available for deliveries, it makes sense to split the seven warehouse locations between them. The Plan Routes tool will decide which distribution center and truck are best for keeping each warehouse supplied.

k. For Time Spent At Each Stop, set it to 20 minutes.

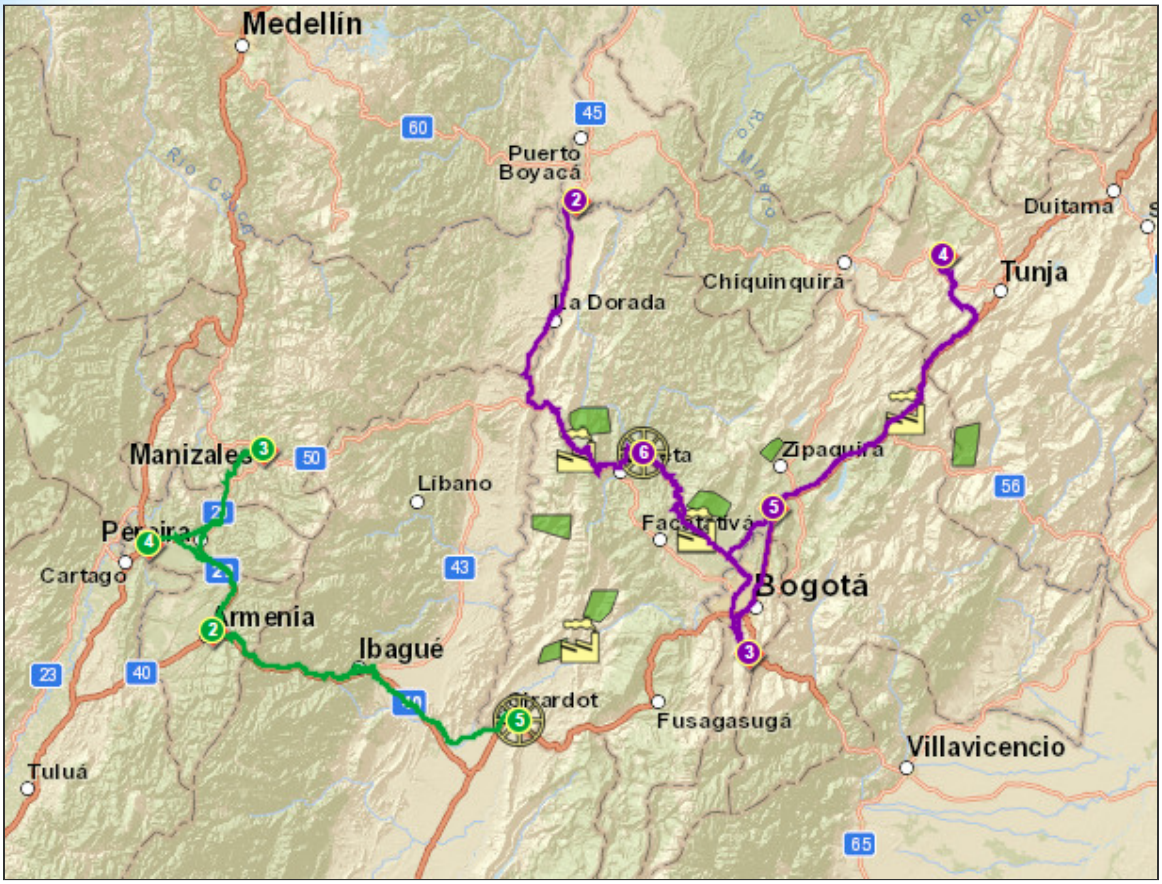
l. Uncheck the Limit The Total Route Time Per Vehicle check box.

m. Set the result layer name to **Routes to Warehouses_YourArcGISOnlineUsername**.

n. Use the current map extent (all warehouse locations should be visible in the current extent).



o. Click Run Analysis.



The map display updates with a new lines layer for the routes and a points layer for the assigned stops.

One truck is assigned the route symbolized with a green line, beginning and ending at the Ricaurte distribution center; the warehouse stops for this truck are numbered in the order of the route the truck will take when making deliveries. The second truck is assigned the route symbolized with a purple line, beginning and ending at the Nocaima distribution center.

p Visually inspect the map to see how the routes include each of the warehouses, starting and ending at a distribution center.

Step 14: Examine attribute data

To learn more about the routes created by the Plan Routes tool, you will examine the attribute data for the layer.

a Open the attribute table for the Routes To Warehouses layer (not Routes To Warehouses - Assigned Stops).

You can see information about the time and distance for both routes.

Route Name	Stop Count	Total Time (Minutes)	Total Service Time (Minutes)	Total Travel Time (Minutes)	Total Miles	Total Kilometers	Start Time	End Time
16693	4	1,054.20	80.00	974.20	509.15	819.39	10/4/2017, 7:00 AM	10/5/2017, 12:34 AM
18898	3	781.27	60.00	721.27	355.02	571.35	10/4/2017, 7:00 AM	10/4/2017, 8:01 PM

The tool used 8:00 AM local time for the start time, which might not be 8:00 AM where you are located; in this case, it was 7:00AM. Your times may vary slightly from the graphic above.

b. Next, open the attribute table for the Routes To Warehouses - Assigned Stops layer.

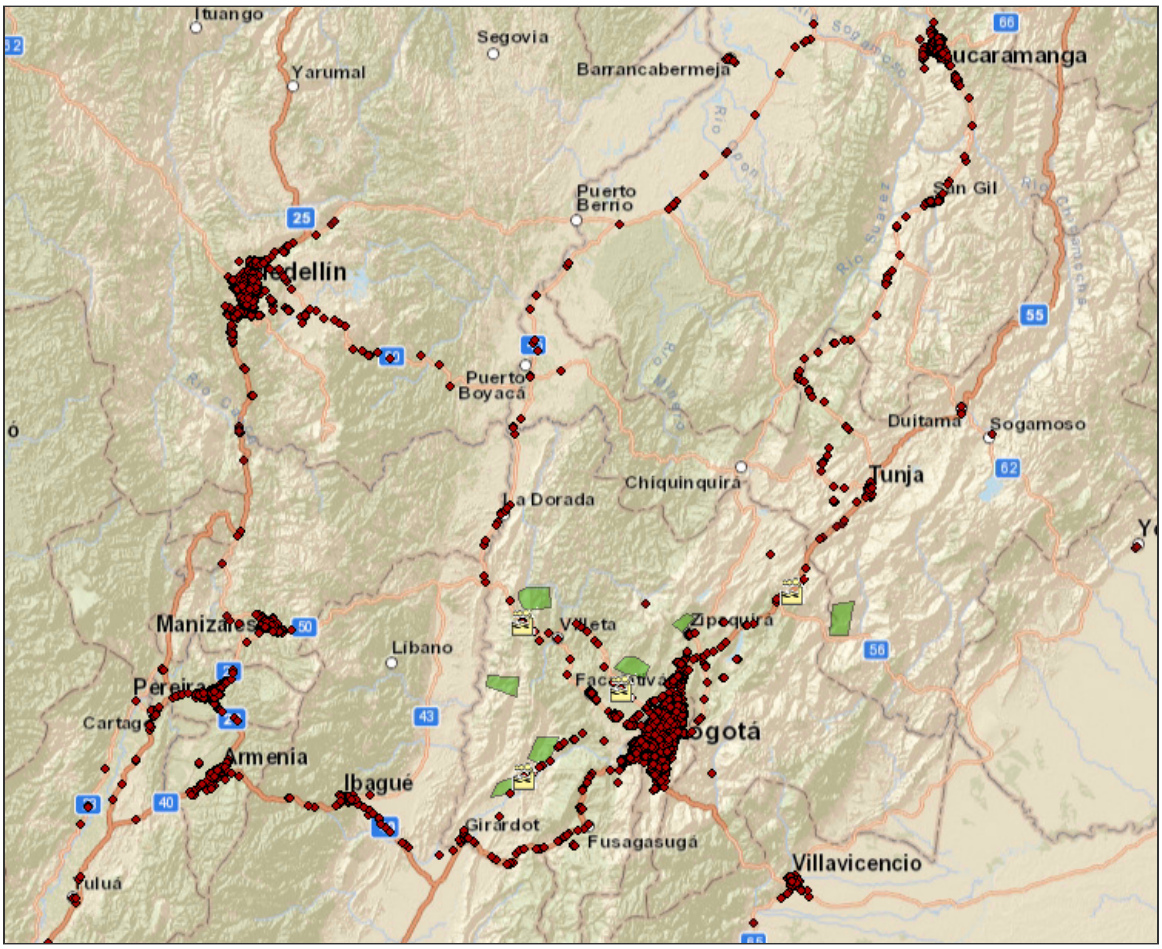
Notice that there are 11 features in this layer. Each leg of each route is included, from the distribution center to the first stop, from the first stop to the second stop, and so on, including the final trip back to the distribution center.

This table displays information about every stop, time, distances, and more. This information can be useful for resource planning and scheduling. You can also view the original information on each of the warehouses from the Warehouses layer if you scroll to the right.

Driving the routes in this region is time-consuming, which means that the trips might need to be split up over two days and re-calculated, increasing delivery costs. If the business continues to grow, and more warehouses are added to the routes, you could have to add a third distribution center or additional trucks.

c. After examining the attribute data, close the table.

Although you will not calculate it in this exercise, you can imagine the complex routing that would be required when you perform calculations to route deliveries from warehouses to all of the retailers that sell Perfectos. There are 20,000 retailers in this region, including grocery stores, gas stations, hotels, pharmacies, and even mobile sellers who sell Comidas Bonitas' products on carts and bicycles. Additionally, there are more than 250,000 retailers across South America. These seven warehouse points would be scaled up many times over, and that number of retailers or even more is typical for a global producer of a popular, inexpensive product like potato chips.



Routing is a process that can frequently change based on factors like weather, road closures, or other interruptions similar to the type you explored earlier when the Soacha distribution center was removed from the Perfectos supply chain. To stay competitive and productive, you must continually verify that the routes are as efficient as possible, and you must also react quickly to any issues or interruptions. Other routing improvements could involve these changes:

- Addressing sustainability as part of routing would both decrease gas costs and reduce your carbon footprint, which are increasingly desirable today. It may also be appreciated by customers or suppliers and improve your company's image.
- Reusing some of the packaging or other recyclable materials and building those pickups into your delivery routes would increase efficiency by keeping trucks from running without cargo as much as possible.
- You could also make your delivery routes more efficient by adding a parameter for how retailers are clustered and adjusting the routing accordingly.

You can better understand distribution logistics by examining more factors, such as the type of freight being hauled, different vehicle sizes or heights, or changing customer demand. You can also include GPS and mobile technologies to understand real-time impacts on your network, such as traffic conditions or time windows imposed by the delivery recipients.

Making routes more efficient makes your entire supply chain more effective.

Step 15: Sign out of ArcGIS Online

a When you have finished the exercise and are done exploring ArcGIS Online, sign out.

Conclusion

In this exercise, you examined how you can use location to help manage your supply chain activities more effectively.

You visualized and analyzed an entire supply chain from resource extraction of raw materials for your products to processing plants to manufacture the products, to distribution centers and warehouses to store and distribute your products, and on to retailers to sell your products.

The techniques you used can be applied to other similar situations, as well. Your supply chain can be for anything: tablet computers (which you thought about at the beginning of this exercise), food, clothing, car parts, or any other product. If it involves a process of creating or

building a product and delivering it to consumers, there is always a location aspect to each step of the journey. You can see how location analysis can be used to increase efficiency, reduce costs, mitigate and minimize business interruptions, and help you more effectively manage your supply chain.