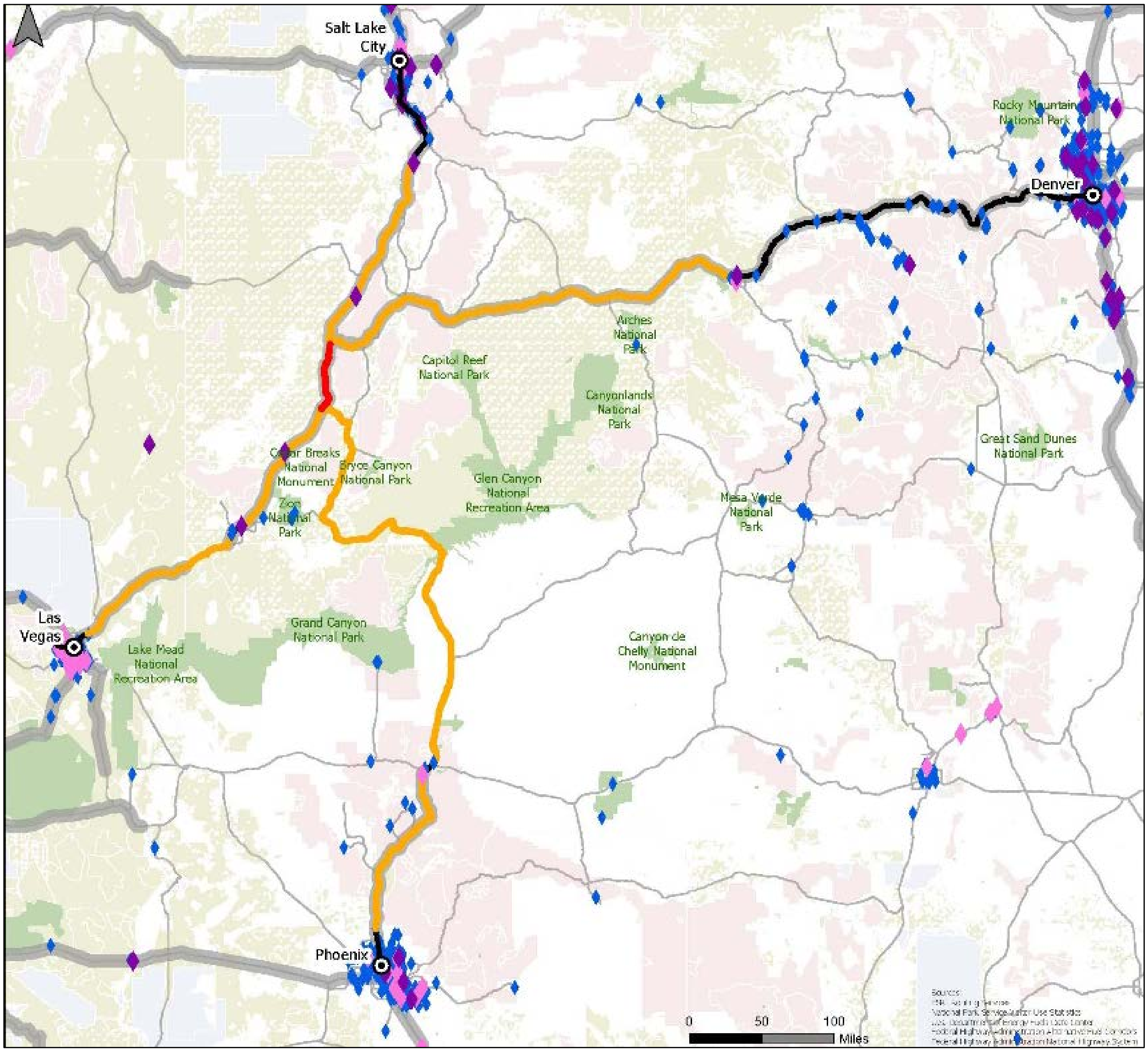
National Park Service
U.S. Department of the Interior

Washington Support Office

Electric Vehicle Charging Stations Gap Analysis
Summary Memo and Instructions for Automated Tool



Excerpt from a Gap Analysis in the Four Corners Area of the Intermountain Region
Source: Volpe Center

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Volpe The National Transportation Systems Center

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Contents

Report notes

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Definitions

The following terms are used in this report:

AFDC	Alternative Fuels Data Center
AC	Alternating current
BLM	Bureau of Land Management
Corridor ready	Corridor has DCFC stations with a maximum distance of 50 miles in between each station. See "EV Corridors" below.
Corridor pending	Corridor is targeted to achieve "Corridor Ready" status, but does not yet meet the criteria. See "EV Corridors" below.
CSV	Comma-separated values (file type that opens in Microsoft Excel)
DCFC	Direct current fast charge (covers all "level 3" entries below) Provides 60-80 miles of driving range per 20 minute charge
DOE	Department of Energy
Esri	Environmental System Research Institute
EV	Electric Vehicle
EV Corridors	Refers to corridors designated as part of the FHWA Alternative Fuel Corridors Program. See "corridor ready" and "corridor pending" definitions above.
FHWA	Federal Highway Administration
FS	Forest Service
GIS	Geospatial Information Systems
LAT	Latitude
LON	Longitude
Level 2 (SAE J1772)	EV station that provides 10-20 miles of driving range per 1 hour charge Compatible with all commercially available EVs
Level 3 (SAE)	EV station that provides 60-80 miles of driving range per 20 minute charge Compatible with U.S. and German EVs
Level 3 (CHAdeMO)	EV station that provides 60-80 miles of driving range per 20 minute charge Compatible with Japanese and Korean EVs
NPS	National Park Service
NREL	National Renewable Energy Laboratory
SAE	Society of Automotive Engineers
U.S.	United States
V	Volt
Volpe	Volpe, the National Transportation Systems Center

Overview

This document summarizes the methodology and major deliverables resulting from the "NPS Electric Vehicle Charging Stations Gap Analysis" project funded through Interagency Agreement (P15PG00231) between the U.S. National Park Service (NPS) and Volpe, the National Transportation Systems Center (Volpe) for transportation technical support.

Purpose

The primary purpose of this project, as delineated in the project agreement, was to identify and map:

- Existing and proposed electric vehicle (EV)-accessible routes connecting NPS units to key population centers and transportation hubs; and,
- Potential gaps in EV charging station infrastructure along proposed routes.

The project was intended to help NPS answer these questions:

- Can a visitor access a given park from a given origin via an EV?
- Where are the key "gaps," where such access is relevant (given latent or likely future demand) but is not possible due to long distances in between available charging stations?

Background and Context

At the time the project commenced, there were approximately 50 existing level 2 EV charging stations at NPS units and NPS had received a donation of up to 100 new level 2 EV charging stations for park visitor use nationwide. In addition, the California Energy Commission set aside funds to facilitate access to NPS units by installing EV charging stations along priority California routes identified by the state of California.

There are a variety of related analytical efforts underway, and NPS is actively coordinating with project partners. The National Renewable Energy Laboratory (NREL), in addition to being a participant in this project, is working with the state of California to model future demand for EV stations in and around NPS park units. NREL is also working on a variety of other related projects, both nationally and regionally focused. The Federal Highway Administration (FHWA) continues to work on the National Alternative Fuel Corridors Designation Project, with support from both NREL and Volpe. Furthermore, state and local jurisdictions continue to analyze and support the development of additional EV charging infrastructure.

Task 1

The purpose of Task 1 was to develop a framework for park-level gap analyses of EV charging infrastructure.

Methodology, Data Inputs, and Outputs

Collaborative discussions with NPS, NREL, and Volpe identified data inputs and parameters to inform this Task 1 EV gap analysis. Discussions revealed that the analytical framework should be dynamic, given that:

- NPS needs to consider the results of multiple types of gap analyses rather than one single gap analysis for each park; and,
- Some of the input assumptions and values may need to change in the future and cannot be predicted at this time.

For these reasons, Volpe geographic information systems (GIS) specialists scripted the gap analysis; the script semi-automates the geospatial process such that the analysis can be easily updated and re-run to produce new results. It also means that the same script can be applied to any park in the nation to produce an output in the same format.

The following are the editable inputs that can be customized to produce new output results, as needed:

- **Threshold distance between charging stations that defines a "gap":** Initially the project proceeded under the assumption that the analysis would use one distance-based rule of thumb to define all gaps (e.g. distances between stations greater than 50 miles). However, considering that EV ranges will likely increase over time (including even entry-level models), NPS expressed interest in analyzing future scenarios with longer allowable distances between stations. Conversely, there may also be situations where the gap analysis should consider shorter threshold distances (such as areas with steep topography).
- **Maximum allowable offset distance between a route and a qualifying en route station:** This could change in the future and may vary by state. States often specify a maximum distance that a resource can be from a route in order for the state to provide wayfinding signage along the route alerting drivers of the resource. Currently the FHWA National Alternative Fuel Corridors Designation process uses five miles as the maximum allowable offset distance.
- **Charging station locations:** Data on current stations are available from the U.S. Department of Energy (DOE) Alternative Fuels Data Center (AFDC) website, downloadable as a comma-separated values (.csv) file. Since the data are constantly changing, an analysis could quickly become outdated. In the future, NPS may want to download the latest data on station locations and rerun gap analyses to ensure the most current information.
- **Charging station type:** There are multiple charging station types (see Table 1). Not all vehicles can use all types, and some individuals may have a higher desired level of service (direct current fast charge (DCFC) versus level 2). Thus, a gap analysis for a given park could really be comprised of a series of gap analyses, each focused on a particular set of stations (i.e. level 2 only, DCFC/Level 3 CHAdeMO only, DCFC/Level 3 Society of Automotive Engineers (SAE) combo combined charging system (Level 3 SAE) only, Level 2+ Level 3 Chademo, Level 2+ Level 3 SAE). The default for this automated analytical framework is that the analysis considers all stations that have level 2 and all stations that have both of the Level 3 port types (CHAdeMO and SAE) to be valid stations for the purpose of identifying gaps. Such stations should be usable

for the vast majority of EVs on the road. This analysis does consider stations with only Tesla port types, given that they are only usable by Tesla vehicles and not the general public.

Table 1
Summary of EV charging station types

Station type	Electrical service required	Charging rate	Notes
Level 1	120 volt (V) alternating current (AC)	2-5 miles of driving range per 1 hour charge	Not considered in this analysis.
Level 2/SAE J1772	Either 208V or 240V AC	10-20 miles of driving range per 1 hour charge	All commercially available EVs may use the SAE J1772 charge port.
Level 3/Direct current fast charge (DCFC)	Either 208V or 480V AC	60-80 miles of driving range per 20 minute charge	There are three types of DC fast charging systems, depending on the type of charge port on the vehicle: SAE, CHAdeMO, or Tesla.

- **Number of ports:** Some stations only have a few ports, raising concerns that a queue could form if too many vehicles arrive at the site at one time. If desired in the future, one could filter out sites with fewer than some threshold number of ports.
- **Origins:** Origins were selected after combining data on EV ownership[*] with data on NPS park visitation (by county of origin).[†] Areas with high EV ownership and park visitation were identified as focus areas, and the most populous municipality within each of those areas was selected as a key origin to connect to the park. These demographic data may change in the future and NPS may want to re-run analyses with new origins; thus, the origins are another editable input.
- **Destinations:** Destinations were initially conceived as park entrances.[‡] However, a subsequent recommendation was to use the most popular sites[§] within the park as key destinations, wherever such information is available. The park destinations could also be modified before re-running the script.
- **Existing versus planned stations:** NPS is interested in understanding both current gaps (considering only existing charging stations), as well as projected future gaps (including planned as well as existing charging stations). The inclusion or exclusion of planned stations is thus another aspect that one could change in the analyses.

[*] NREL provided data on EV ownership, aggregated by county.

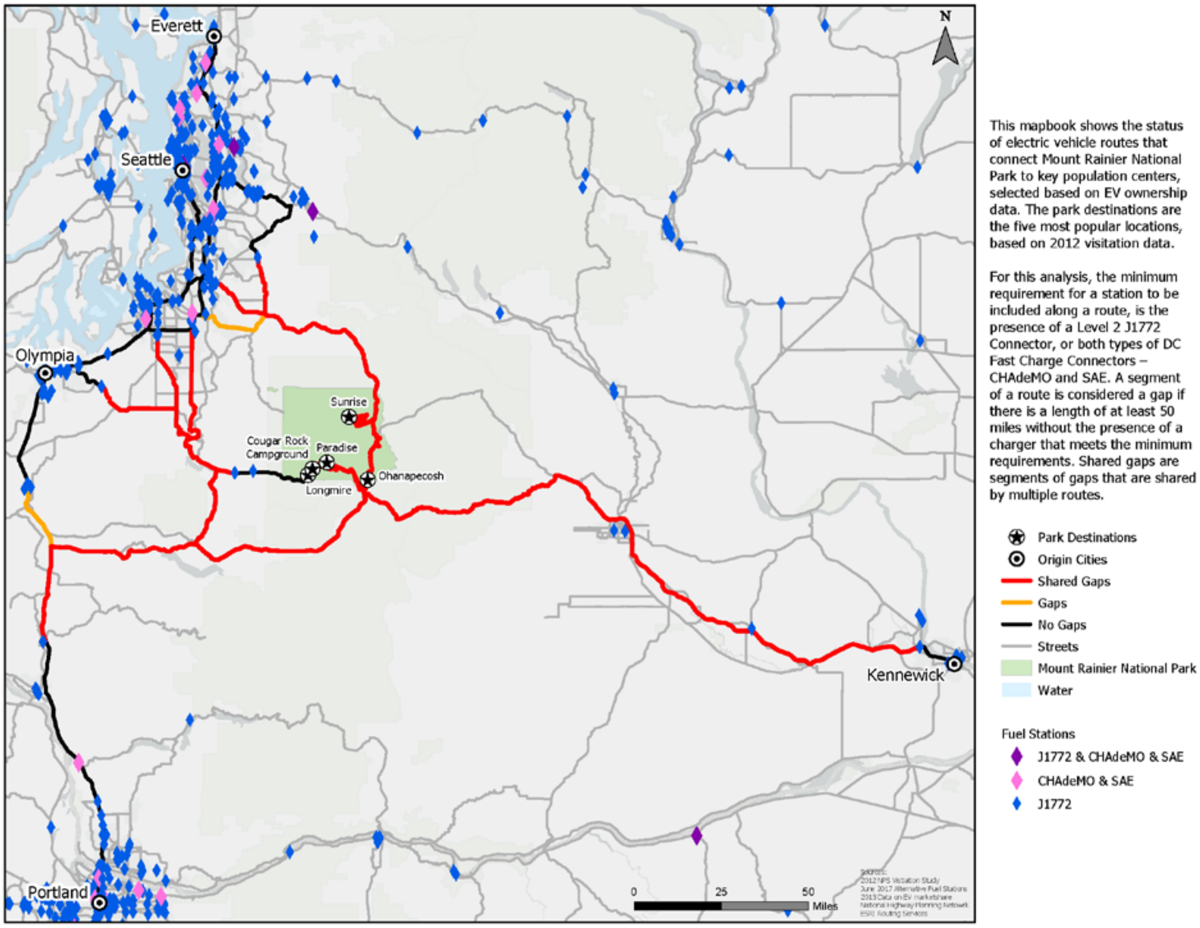
[†] Available for many but not all park units at Washington State University NPS projects page (https://sesrc.wsu.edu/national-park-service-projects/).

[‡] NPS Visitor Use Statistics website (https://irma.nps.gov/Stats/) provides data on the numbers of motor vehicles entering each separate entrance to each park.

[§] Available for many but not all park units at Washington State University NPS projects page (https://sesrc.wsu.edu/national-park-service-projects/).

An initial example park analysis focused on Mount Rainer National Park. The output of the analysis script includes maps (see Figure 1 example) and tables showing all routes and identified EV charging gaps. The output also includes a linear diagram (Figure 2) of each route (i.e., unique origin-destination pair). These diagrams supplement the overview map and table.

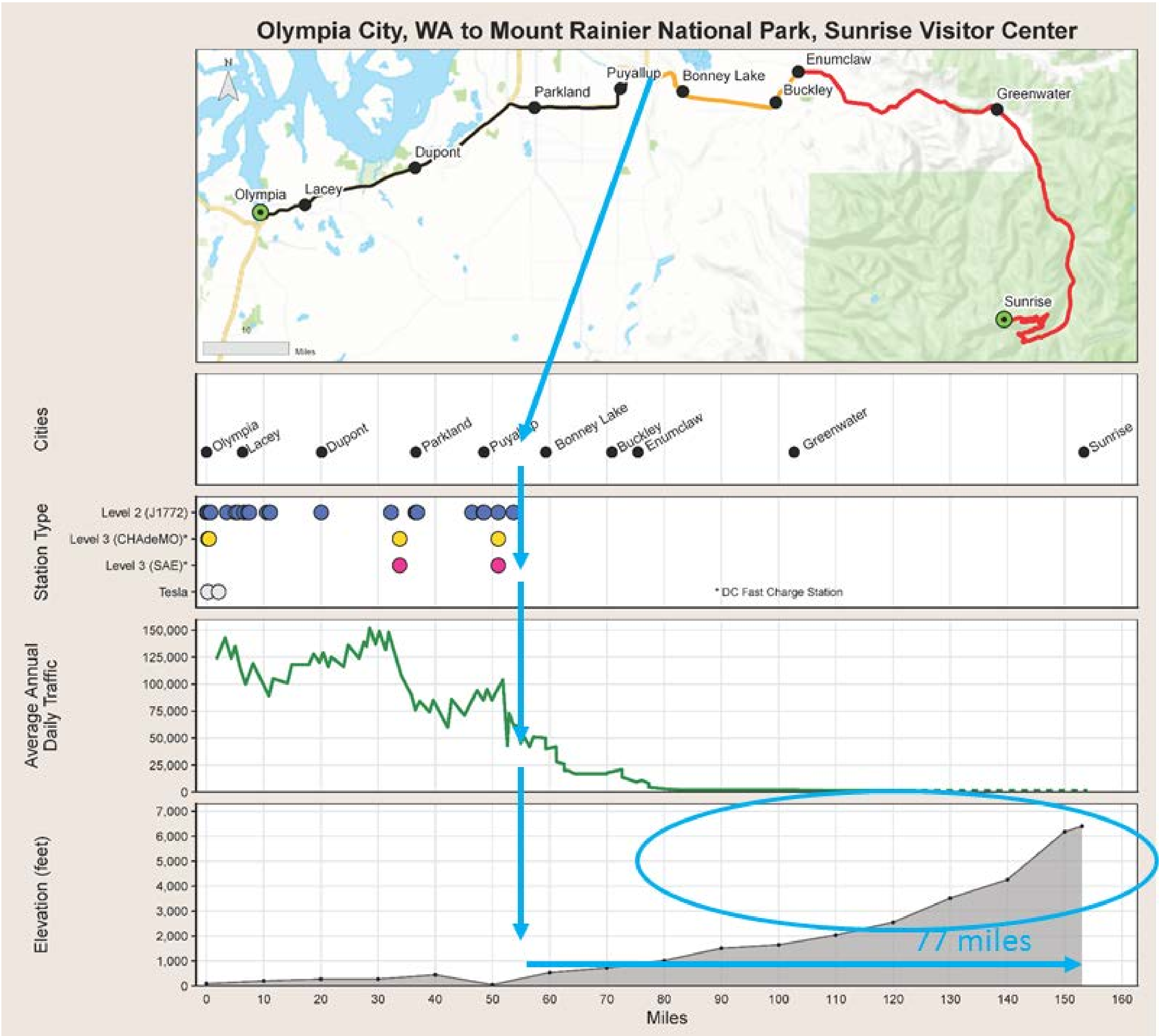
Figure 1
Example overview map from park-level analysis



As mentioned above, a park analysis also includes one linear diagram per route; in this example case for Mount Rainier, there are 20 such pages, as there are 5 origins and 4 destinations (5 x 4 = 20). Figure 2 provides an example. The map at the top of the linear diagram matches the overview map (Figure 1), but shows only the route in question. The segments below the map translate the route into a straight line in order to show layers of information. The four lower segments all line up with one another exactly at the same scale, and correspond to the miles shown at the bottom along the x-axis. By moving up or down in a vertical line, one can view key circumstances for any given point along the route.

The first row of Figure 2 shows the cities; the second shows the charging stations of various types. Tesla stations appear for awareness, but they are not used in gap analysis since they are not publicly accessible. The third panel shows average annual daily traffic, giving an indication of how many drivers are using the roadway, but not differentiating between park visitors versus other travelers. The last panel shows elevation. In this Figure 2 example, the last panel shows that not only is there a 77 mile gap, but there is also significant elevation gain within that segment. Elevation changes can drastically reduce driving range, so elevation is an important factor for considering optimal spacing distances between charging stations.

Figure 2
Example linear diagram from park-level analysis



Although the script is generally applicable to all park units, it may need to be modified to accommodate specific circumstances. For example, in some cases NPS may desire to exclude a particular roadway from routing consideration if it is only seasonally accessible. Also, a cross-check may be necessary to confirm that the network analysis correctly routes according to the directions provided on the NPS "plan your visit" website for the park. Minor modifications could be incorporated on an as-needed basis to address these and other issues.

Deliverables

As outlined in the project agreement, Task 1 deliverables for this project include draft and final versions of this memo as well as map books showing the resulting gap analyses for pilot park units. The script to semi-automate the gap analysis (i.e., semi-automated tool) is an additional deliverable. Although it was not originally mentioned in the project agreement, Volpe used this script as a tool in order to accomplish the project objectives. Since the tool has independent utility, Volpe provided it to NPS as a supplementary deliverable. The appendix of this report provides instructions for using the tool. The tool could be used in the future (by NPS, Volpe, or another party) to update the analyses or to create new analyses as new information becomes available.

Task 2

The purpose of Task 2 was to help NPS review modeling efforts produced by NREL in California, on behalf of their sponsor, the California Energy Commission. However, the scope of NREL's work for the California Energy Commission changed over the course of the project, such that Task 2 became irrelevant, and NPS decided to focus instead on Tasks 1 and 3.

Task 3

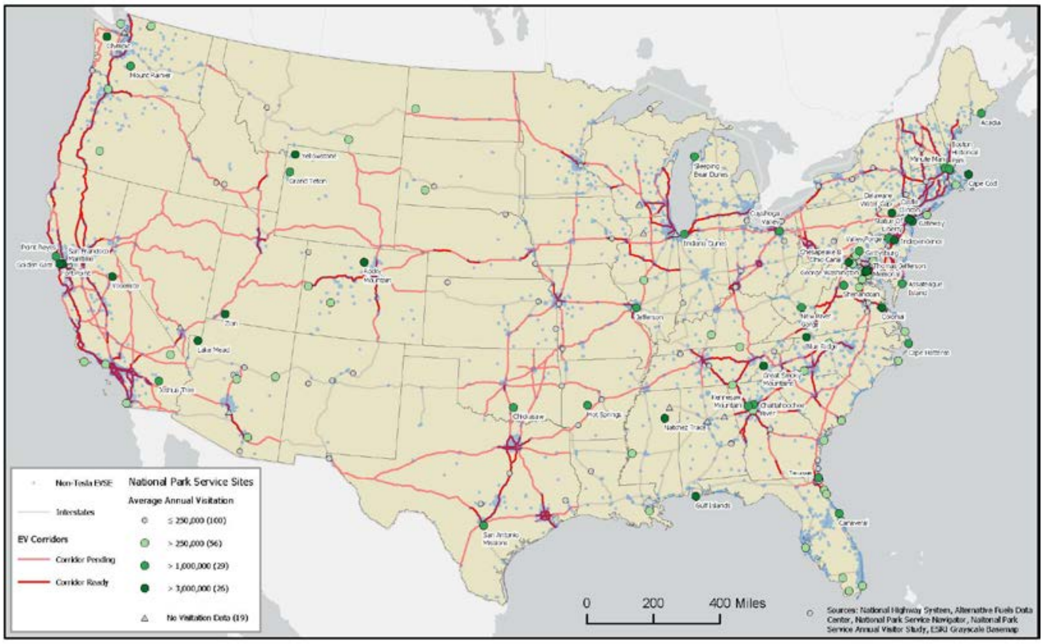
The purpose of Task 3 was to begin exploring methods for prioritizing EV charging infrastructure investments at a nationwide scale. The first step was to develop a coarse, initial filter for estimating which park units might already have sufficient EV-accessibility thanks to existing or anticipated charging stations (level 2 and DCFC/level 3) in the vicinity.

This initial coarse filter assumed that park units within five miles of (1) a charging station ***OR*** (2) an interstate highway have a higher probability of being EV-accessible in the near future. The latter assumption is based on an NREL analysis describing plans in the near future to expand EV station infrastructure along the Nation's interstate highway network.[*] Conversely, the coarse filter assumed that park units further than five miles from the nearest charging station or interstate were less likely to be EV-accessible, and therefore may warrant closer inspection and analysis. Volpe used GIS to produce two maps based on the above assumptions, showing: Figure 3, park units assumed to have coverage (EV-accessible); and Figure 4, park units assumed be without coverage (not EV-accessible).

NPS and Volpe recognize that while these coarse assumptions represent an initial step to visualize the current status, they are imperfect and result in a delineation that may be inaccurate in some cases. Possible future work could include refinement of the national level filter. However, to truly determine which park units are EV-accessible would require data inputs and methods at the same level of complexity as developed in Task 1 of this project. The challenge moving forward will be to identify methods that improve upon this national coarse filter without becoming overly complex so as to become unmanageable.

[*] Electrify America plans to install a nationwide network of DCFC stations along interstate corridors, as described in the NREL National Plug-In Electric Vehicle Infrastructure Analysis (https://www.nrel.gov/news/press/2017/nrel_evaluates_national_charging_infrastructure_needs.html).

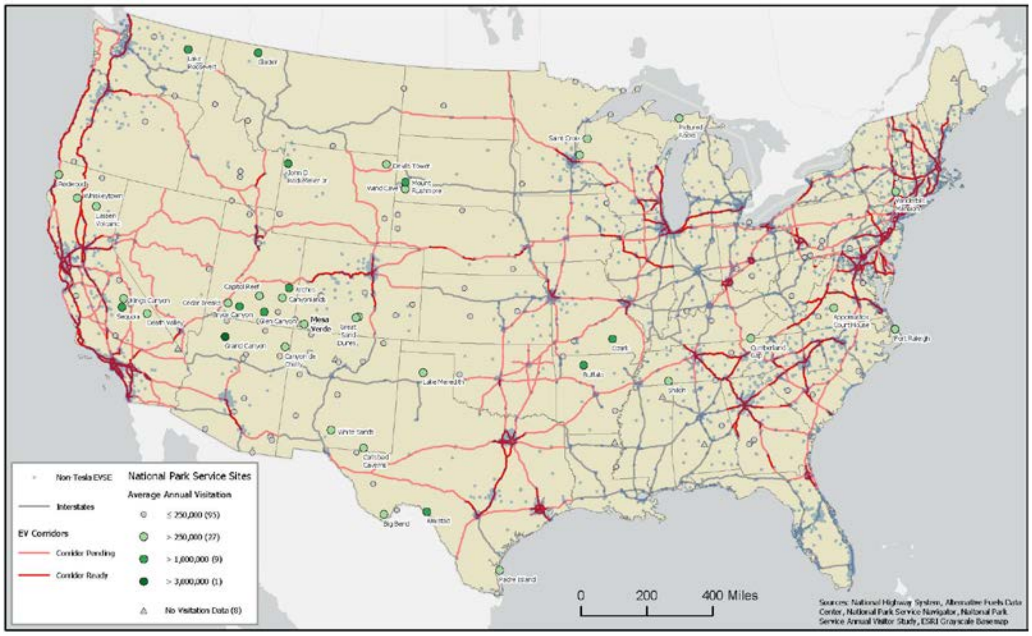
Figure 3
Park units with assumed future coverage (EV-accessible) based on the coarse filter*



The NPS sites reflect those that are located within 5 miles of electric vehicle supply equipment (EVSE), or are within 5 miles of an interstate. The analysis includes both existing and planned EVSE and does not include Tesla EVSE. Only the omitted parks with an average annual visitation rate greater than 1,000,000 people are labeled.

* Map also includes FHWA National EV Corridors from round 1 and round 2 (round 3 designations not represented). Charging stations include all level 2 and DCFC stations that are non-Tesla.

Figure 4
Park units assumed to be without coverage (not EV-accessible), based on the coarse filter*



The NPS sites reflect those that are not located within 5 miles of electric vehicle supply equipment (EVSE) and are farther than 5 miles from an interstate. The analysis includes both existing and planned EVSE and does not include Tesla EVSE. Only the retained parks with an average annual visitation rate greater than 250,000 are labeled.

* Map also includes FHWA National EV Corridors from round 1 and round 2 (round 3 designations not represented). Charging stations include all level 2 and DCFC stations that are non-Tesla.

Both maps (Figure 3 and Figure 4) have different symbols to represent parks with different levels of visitation. Parks with lower average annual visitation (less than 1,000,000 for Figure 3 and less than 250,000 for Figure 4) appear on the maps, but are un-named.

Both maps also show the FHWA National Alternative Fuel Corridors for EVs, from round 1 and round 2 of the designation process. FHWA approved a subsequent round 3 of designations, which are not reflected in these maps. The thick red lines represent "Corridor Ready" EV charging corridors designated through the FHWA National Alternative Fuel Corridors effort. The thinner pink lines represent "Corridor Pending" corridors designated through that effort. "Corridor Ready" means that the corridor has DCFC stations with a maximum distance of 50 miles in between stations. "Corridor Pending" means that the corridor is targeted to achieve "Corridor Ready" status, but does not yet meet the criteria.

The smallest grey dots on each map represent existing or planned charging stations and the light grey lines represent interstate highways that are not yet designated as FHWA National Alternative Fuel Corridors for EVs.

Figure 3 shows that most of the park units in the eastern U.S. are assumed to be EV-accessible. Many park units are situated in close proximity to existing interstate corridors and/or charging stations.

Figure 4 shows that the largest gap is in the "four corners" area of the Intermountain Region in Utah, Colorado, Arizona, and New Mexico, where there is a concentration of high-visitation parks with no assumed coverage (non EV-accessible).

Figure 5 shows the average annual visitation for each NPS unit with annual visitation greater than 250,000 and with no assumed coverage (not EV-accessible) based on the coarse filter. Dark bars represent units in the four corners area of the Intermountain Region.

Table 2, Table 3, and Figure 6 show summary statistics on the park units with and without assumed EV access based on the coarse national filter. The key points from all of these visuals are that:

- Most of NPS visitation is to park units that are already likely to be covered (EV-accessible).
- Of the parks that are assumed to not be EV-accessible, almost half of the visitation is concentrated in only 14 parks; 4 of these are in the four corners area of the Intermountain Region.
- The largest remaining gap for EV access (as measured by visitation) is in the four corners area of the Intermountain Region.

Figure 5
NPS units with annual visitation greater than 250,000 and with no assumed coverage (not EV-accessible) based on coarse filter. Dark bars represent units in the four corners area of the Intermountain Region.

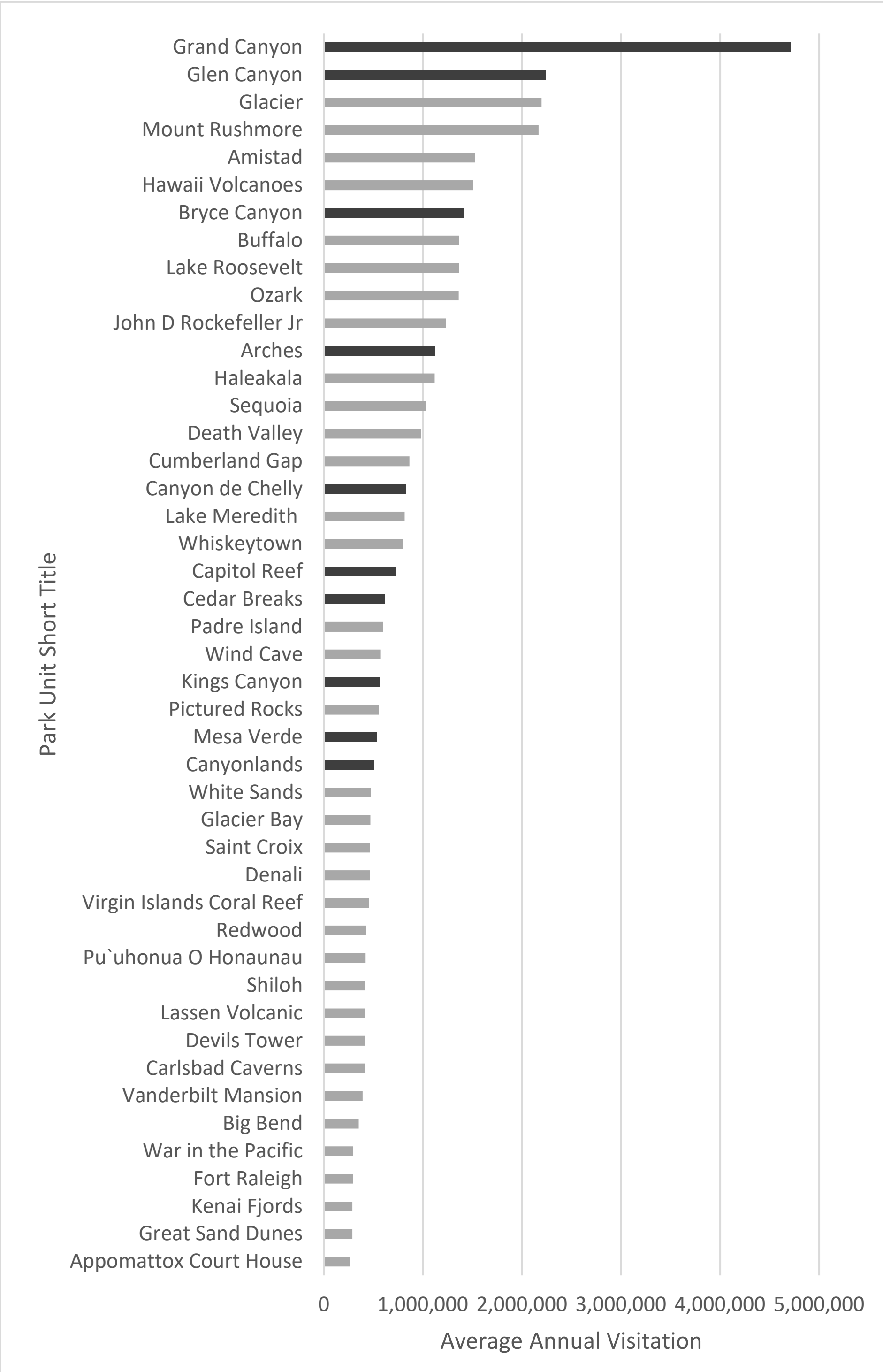


Table 2

Summary statistics for units assumed to have coverage in the near future (EV-accessible)

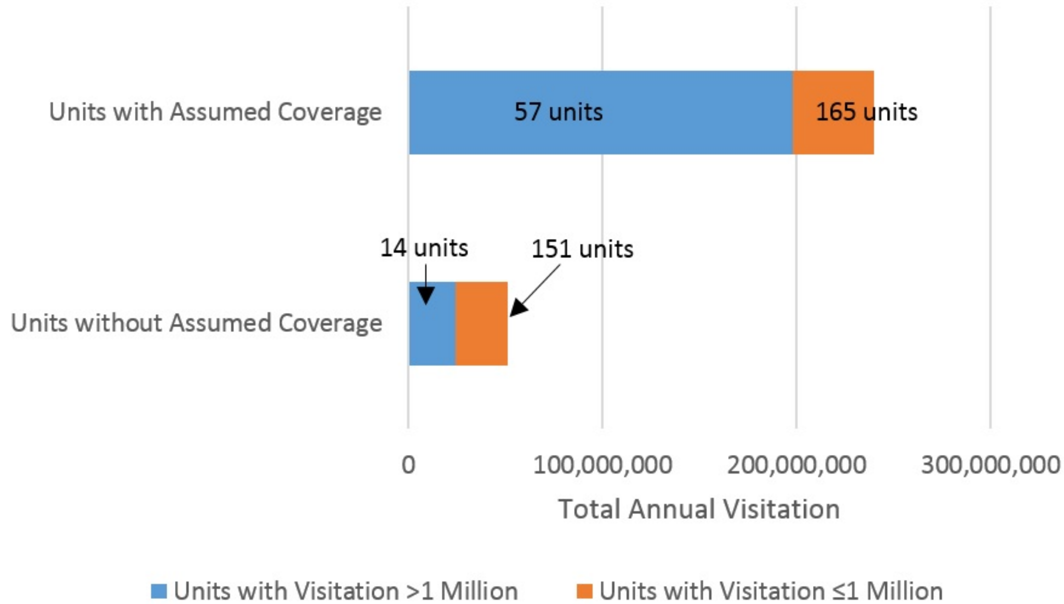
Annual Visitation	Number of Units	Total Annual Visitation for Category
> 3,000,000	26	142,415,945
1,000,000 – 3,000,000	31	55,814,671
250,000 – 1,000,000	60	33,081,432
≤ 250,000	105	8,458,131
No Visitation Data	22	
Grand Total	**244**	**239,770,179**

Table 3

Summary statistics for units assumed to be without coverage (not EV-accessible)

Annual Visitation	Number of Units	Total Annual Visitation for Category
> 3,000,000	1	4,710,712
1,000,000 – 3,000,000	13	19,642,878
250,000 – 1,000,000	35	17,643,586
≤ 250,000	116	9,164,981
No Visitation Data	10	
Grand Total	**175**	**51,162,157**

Figure 6
Assumed EV access by total annual visitation



Four Corners Analysis

The nationwide screening exercise, as described in the preceding section, determined that the largest remaining gap for EV access for NPS (as measured by visitation) is in the four corners area of the Intermountain Region (as of 2019). In light of that, the team used the semi-automated tool to conduct a final gap analysis in the four corners area. The analysis identified two primary corridors that, if fully EV-accessible, could provide access or near access to the major park units in the area from the major cities of Salt Lake City, Denver, Phoenix, and Las Vegas. Figure 9 shows the resulting overview map, including: identified gaps, the FHWA Alternative Fuel EV Corridors, and the property boundaries of major federal land management agencies. Much of the remaining gaps along these corridors abut property owned by either the Bureau of Land Management (BLM) or the Forest Service (FS), suggesting that there may be opportunities to partner with those agencies to close the gaps. Figure 10 and Figure 11 show the resulting linear diagrams. The route from Las Vegas to Denver includes segments of Interstate 15 (I-15) and I-70. The route from Phoenix to Salt Lake City includes segments of I-17, State Route 89, I-70 and I-15.

Figure 7
Overview map of four corners gap analysis

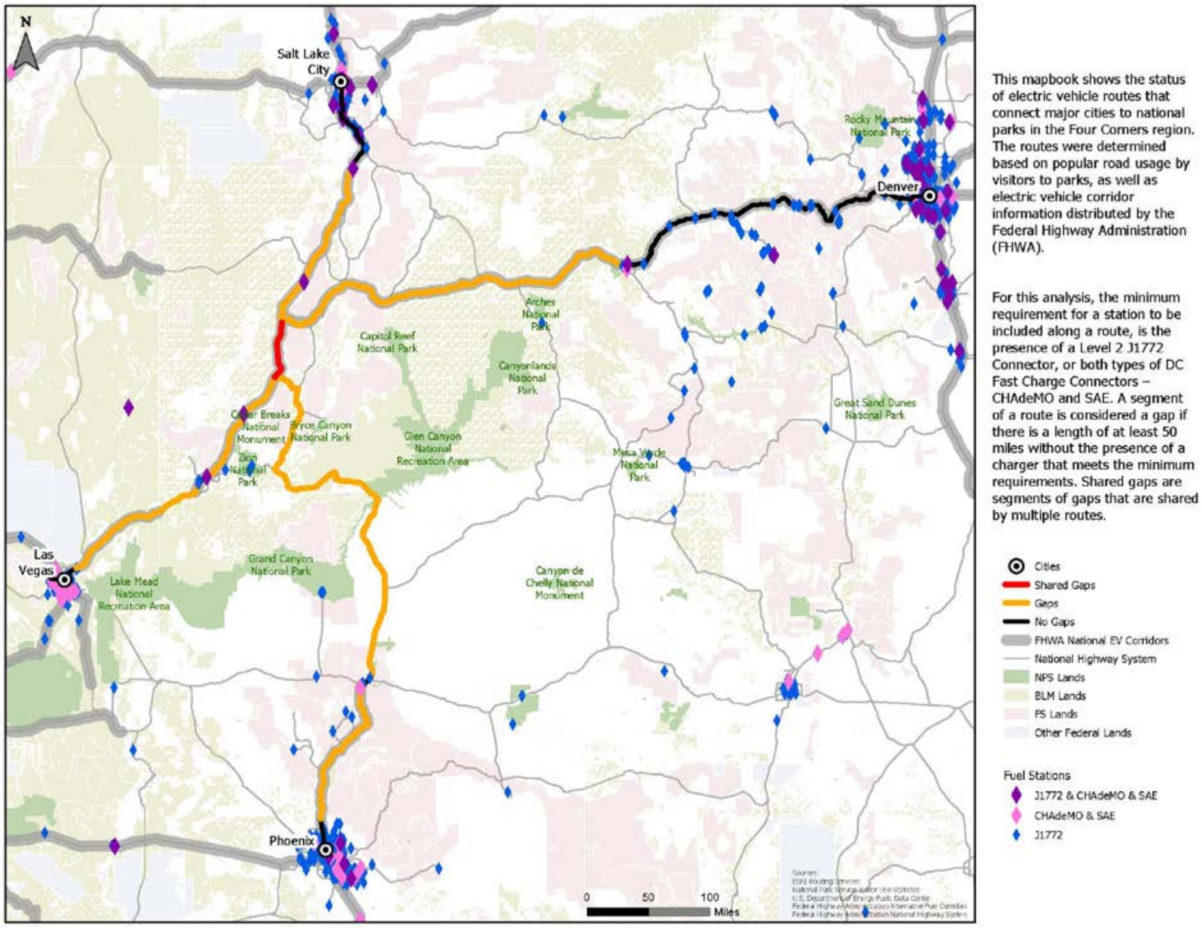


Figure 8
First linear diagram from four corners analysis

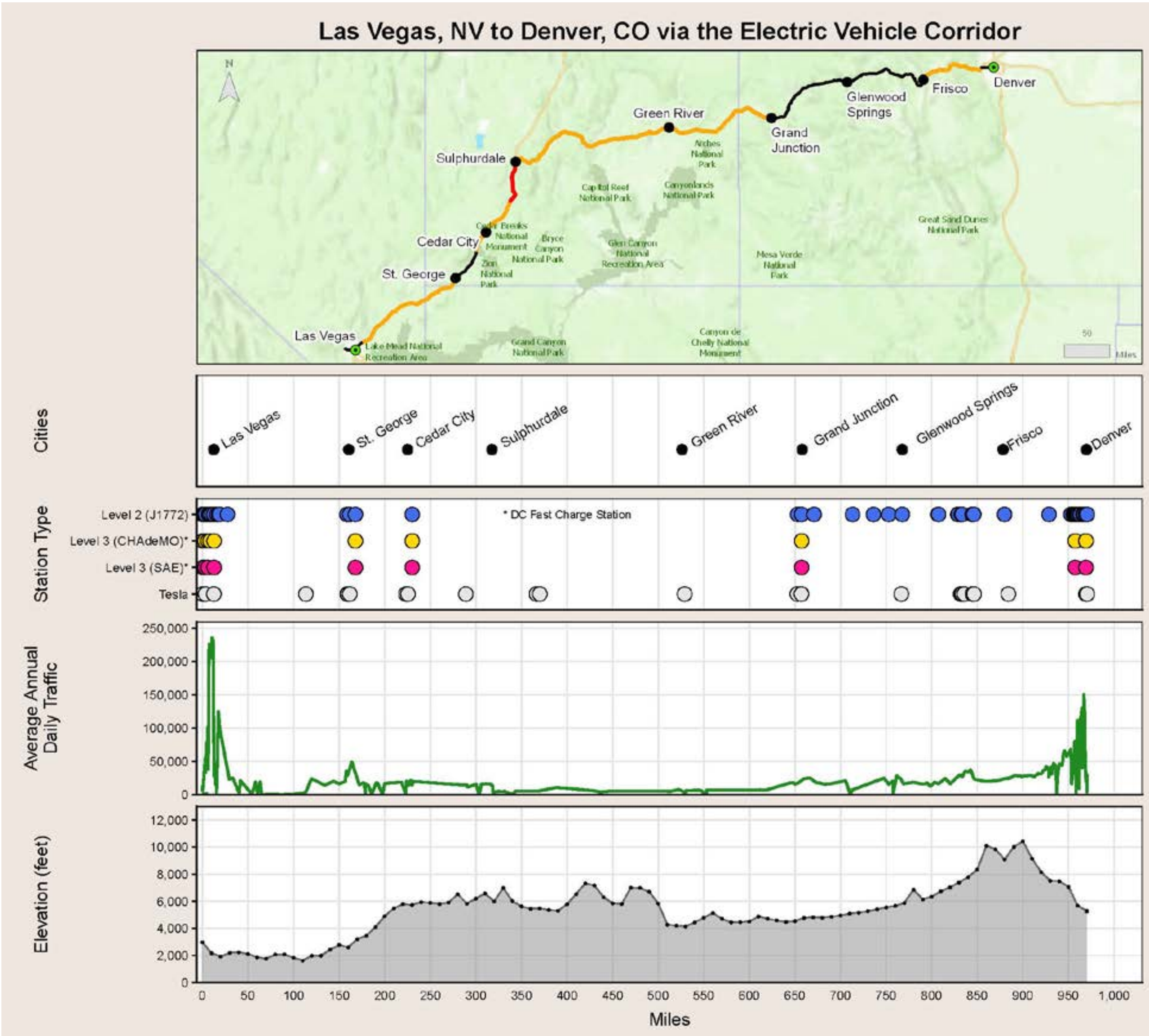
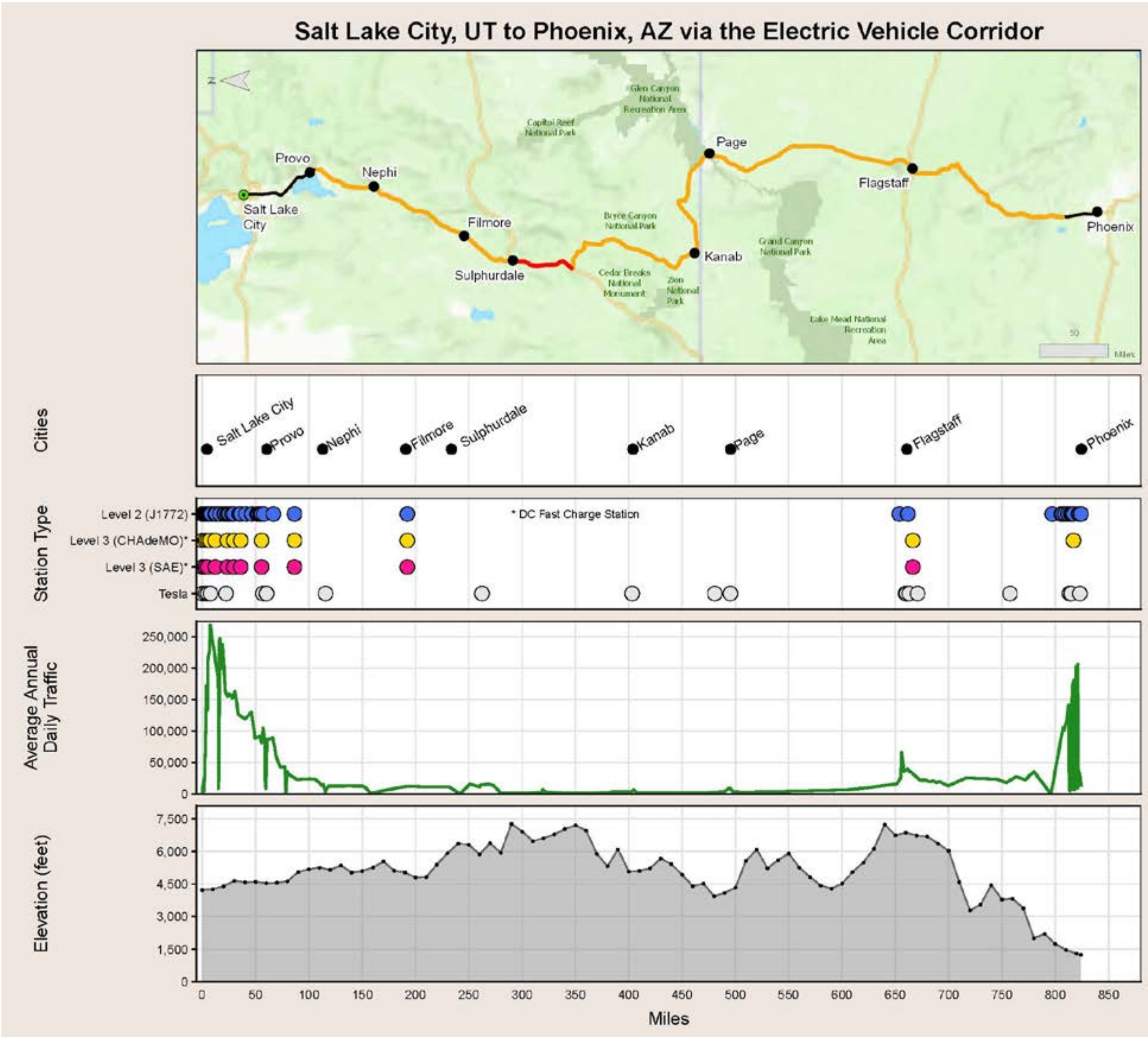


Figure 9
Second linear diagram from four corners analysis



Next Steps and Areas for Further Analysis

The Task 1 analytical framework can help NPS to visualize and understand key gaps in EV access on a park-by-park basis, or for clusters of co-located park units. As a semi-automated tool, it enables NPS to perform future analyses efficiently and adaptively on an ongoing basis. Task 3 began to explore nationwide prioritization, but did not complete a full prioritization framework. Suggested next steps include the following:

- Consider how to weight the relative importance of various potential policy priorities (e.g. maximizing station usage, providing access to a diverse range of unit types, facilitating larger network connections, etc.) in order to prioritize nationwide efforts.
- Identify other areas of the country in which to use the semi-automated tool to identify and analyze gaps.
- Engage with federal partners in the four corners area, where there is a concentration of high-visitation parks with no assumed coverage (not EV-accessible), and where BLM and FS own most of the real estate abutting the corridors.
- Contact state and regional partners, such as stakeholders supporting the Regional Electric Vehicle Plan for the West (REV West) partnership. They may be able to help by nominating corridors in the region and advancing EV infrastructure deployment to address gaps. For example, route 89 connects interstate 40 in Arizona to interstate 15 in Utah. It is not currently a FHWA National Alternative Fuel Corridor for EVs, but it connects other designated corridors and is important for connecting EV drivers to the parks, based on the findings of this project.

Appendix: Instructions for Running Automated Tool

As described above in the main body of the report, the Volpe Center developed a semi-automated tool to help NPS identify and analyze gaps in the EV-accessible road network connecting visitors to parks. The following sections describe how to configure and execute the tool to analyze gaps between any set of origins and destinations. The automated tool produces data tables and shapefiles that a user can then use to create visualizations such as maps and other diagrams. The project team used this tool to produce the data, and then manually created the maps and linear diagrams (e.g. Figure 2, Figure 8, and Figure 9).

Software

Necessary software include the following:

- Some kind of plain text editor (i.e. not Word);
- Environmental System Research Institute (Esri) ArcGIS Pro;
- Esri Online Routing Service (with access to Esri credits*);
- Python version 3.x (installed with ArcGIS Pro); and,
- Python modules/libraries.

Additionally, the user will need credits in order to consume Esri's ArcGIS Online Routing Services.

Setting Up Your Environment

Data Collection

In order run the tool you will need to procure the input data. The tool requires three input data tables, as follows:

- EV stations;
- Origin locations of each route with their associated coordinates (in decimal degrees); and,
- Destinations of each route with their associated coordinates (in decimal degrees).

All of the input files should be in one folder, which the rest of this document refers to as your *\program directory*.

EV Stations

The EV Station data are downloadable via the DOE AFDC (https://afdc.energy.gov/data_download) using the parameters below:

- Step 1. Choose data to download
    - Dataset = Alternative Fuels
    - File Format = .csv (opens in Excel)
    - Fuel Type = Electric
    - Access = All
    - Status = All (or, if desired, select only existing stations to filter out planned stations)

* An annual subscription to ArcGIS online includes a certain number of credits. Subscribers can also purchase additional credits, if needed, by logging into their account at esri.com.

- Enter your contact information in Step 2, read the terms and conditions and check to agree, and click *DOWNLOAD*.

Origin-Destinations Pairs

Create two Excel files, one for origin locations and one for destination locations, and include the coordinates for these locations (latitude (LAT) and longitude (LON)) in decimal degrees. The tool is set up so that each origin location will route to each destination location; so if there are 5 origins and 5 destinations then the tool will create and analyze 25 routes.

Table 4
Example of the origin/destination table that the user must create in Excel

NAME	LAT	LON
Las Vegas	36.1699	-115.1398
Salt Lake City	40.7608	-111.8910

Running the Tool

Inputs

The first step to running the tool is to adjust the input variables, so that the tool will locate files correctly based on your directory settings. Using your text editor, open the Python script, *nps_ev_gap_analysis.py*, and adjust lines 18-23.

Figure 10
Variables and their values located in the python script

```
16  # UPDATE USER ARGUMENTS
17  # --------------------
18  PROGRAM_DIR = r"H:\nps_ev\program"
19  ALT_FUEL_CSV_NAME = "alt_fuel_stations (Jun 14 2019).csv"
20  ORIGINS_XLS_NAME = "origins.xls"
21  DESTINATION_XLS_NAME = "destinations.xls"
22  GAP_SIZE = 50  # Minimum distance between stations in Miles
23  MAX_STATION_DIST_FROM_ROAD = 3  #max distance station can be from road in Miles
24
25  # ---------------------------------------------------------------------------
```

Table 5
Explanation of the input variables

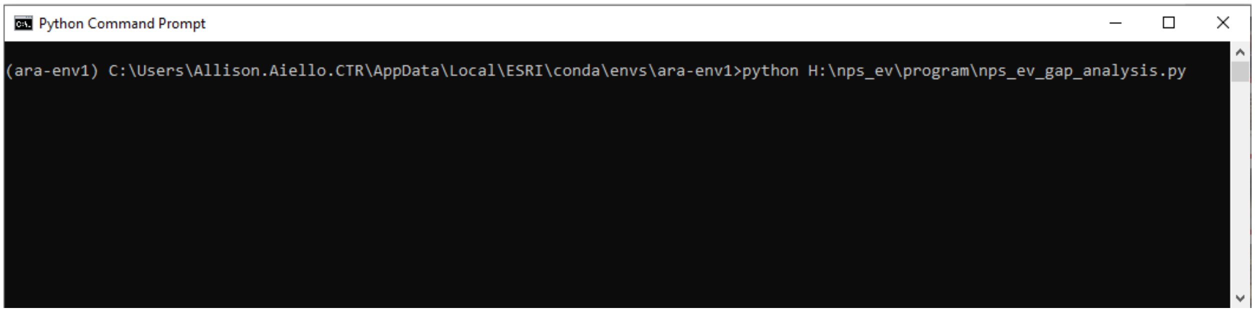
Line in Script	Variable Name	Variable Description
Line 18	PROGRAM_DIR	The location of your *\program* directory where all of the input data tables should be stored (Fuel Station .csv file, Origins Excel sheet, Destinations Excel Sheet)
Line 19	ALT_FUEL_CSV_NAME	The name of the .csv file downloaded from the AFDC
Line 20	ORIGINS_XLS_NAME	The name of the Excel workbook that includes the name of the origin location(s) and the coordinates (in decimal degrees)
Line 21	DESTINATIONS_XLS_NAME	The name of the Excel workbook that includes the name of the destination location(s) and the coordinates (in decimal degrees)
Line 22	GAP_SIZE	The minimum distance, in miles, between stations that would determine a road segment as a gap. For example, if the distance between two stations was 50 miles or greater, then that road segment between those two stations would be considered a gap. If the distance was less than 50 miles, than that segment would not be considered a gap.
Line 23	MAX_STATION_DIST_FROM_ROAD	The maximum distance, in miles, that a station can be located from the route in order for it to be considered a viable option for a driver to use.

After adjusting these variables, you are now ready to run the script. If you do not have a standard way of running your Python scripts, you can run this program out of the Python command prompt that comes with ArcGIS Pro. At the Python command line prompt, enter the following:

python <file path of script>

Example: *python C:\nps_ev\program\nps_ev_gap_analysis.py*

Figure 11
Python command prompt to run the script, with example script file path



Outputs

The tool creates two file geodatabases in the *program* directory: *program.gdb* and *routes.gdb*. The *program.gdb* includes *routes_with_gaps* and *shared_gap_segments*, while *routes.gdb* will have the original origin route geometries for every origin-destination pair.

Program.gdb is the main geodatabase which contains the gap analysis feature classes and tables. Table 6 summarizes them.

Table 6
Explanation of output feature classes and tables located in *program.gdb*

Feature Class/Table Name	Description
all_routes_with_station_data	A feature class containing all of the routes from each origin to each destination. These routes are segmented by stations that are within three miles of the road. The attribute data in this feature class has the station name, street address, and connector type of the stations that segment this route, along with the length of the gap between the stations.
alt_fuel_stations	A geodatabase table of the fuel station data downloaded from the Alternative Fuels Data Center. A column has been added to this data called CONNECTOR_TYPES, which has combined the station types into more generalized and consistent categories (ex. CHAdeMO, CHAdeMO and J1772, etc.).
destinations	A geodatabase table of the destination Excel sheet
origins	A geodatabase table of the origins Excel Sheet
routes_with_gaps	A feature class that only contains road segments that are gaps, road segments that are longer than the gap threshold set by the user.
shared_gap_segments	A feature class that only contains road segments of gaps that are shared by multiple routes.

Route.gdb is the file geodatabase with the original route geometries for every origin-destination pair. It contains a feature class for each individual route, named after the origin-destination pair. For example, if the route connects Salt Lake City to the Grand Canyon, the route would be named *Salt_Lake_City_to_Grand_Canyon*.

Using the Outputs

The output of this analysis provides the necessary feature classes to create maps and tables displaying gaps that do not have EV charging stations. One can overlay the feature classes to create a map like the one below, with *all_routes_with_station_data* on the bottom, *routes_with_gaps* next, and *shared_gap_segments* as the top layer. The shared_gap_segments layer highlights gaps that one or more routes share.

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14. ABSTRACT
This document summarizes the methodology and major deliverables resulting from the National Park Service (NPS) Electric Vehicle (EV) Charging Stations Gap Analysis project. The project created a semi-automated geospatial tool that can help NPS to visualize and understand key gaps in EV access on a park-by-park basis, or for clusters of co-located park units. It will enable NPS to perform future analyses efficiently and adaptively on an ongoing basis. The project also performed a nationwide screening exercise, which determined that the largest remaining gap for EV access for NPS (as measured by visitation) is in the four corners area of the NPS Intermountain Region (as of 2019). In light of that, the project used the semi-automated tool to conduct a final gap analysis in the four corners area. The appendix of the document includes instructions for using the semi-automated tool.

15. SUBJECT TERMS
national park service, electric vehicle, geospatial, analysis, charging station, electric vehicle supply equipment

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