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Third-Party Evaluation of the Ontario Power Generation's Development of Evacuation Time Estimates for Pickering NGS

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ABSTRACT

Ontario Power Generation, operating with license from the Canadian Nuclear Safety Commission (CNSC) contracted with a U.S. based company to conduct a traffic engineering evacuation time estimate (ETE) study for the Planning Zones (PZs), and various subset of the PZ around the Pickering Nuclear Generation Station (PNGS). The commissioned ETE report describes the analysis undertaken and the results obtained by a study for the Pickering NGS, located in the City of Pickering (Durham Region), Ontario, Canada. The simulation model used reflects the NRC guidance provided in U.S. NUREG/CR-7002, "Criteria for Development of Evacuation Time Estimate Studies". Due to the complexity of a large scale evacuation and modeling thereof, a third party independent review of the Pickering NGS Development of Evacuation Time Estimates, P-REP-03490-00080 R000, is being conducted. This document summarizes the third-party review and provides insight, comments, and recommendations on the licensee's study.

Among the many factors evaluated as part of the third-party review are population groups, trip generation times, and combinations of distributions for various evacuation time components, evacuation times for special facilities, use of traffic simulation models, and assessment of shadow evacuations. The review finds the initial conditions, assumptions, modeling methodology, scenarios, and analysis conducted did not substantively deviate from similar studies which utilized NUREG/CR-7002 and have been accepted by the U.S. Nuclear Regulatory Commission. The ETE provided by PNGS are validated against ETE times from 58 NPP sites in the U.S. The analysis found that while PNGS is among one of the highest populated sites reviewed, the ETEs are consistent with NPP sites with similar demographics. However, the review also shows deficiencies related to transit dependent facilities and individuals who need assistance to evacuate.

DISCLAIMER

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EXECUTIVE SUMMARY

Ontario Power Generation, operating with license from the Canadian Nuclear Safety Commission (CNSC) contracted with a U.S. based company to conduct a traffic engineering evacuation time estimate (ETE) study for the Planning Zones (PZs), and various subsets of the PZ around the Pickering Nuclear Generation Station (PNGS). The commissioned ETE report describes the analysis undertaken and the results obtained by a study for the Pickering NGS, located in the City of Pickering (Durham Region), Ontario, Canada. The simulation model used reflects the NRC guidance provided in U.S. NUREG/CR-7002, "Criteria for Development of Evacuation Time Estimate Studies". Due to the complexity of a large scale evacuation and modeling thereof, a third party independent review of the Pickering NGS Development of Evacuation Time Estimates, P-REP-03490-00080 R000, is being conducted. This document summarizes the third-party review and provides insight, comments, and recommendations on the licensee's study.

The objective of the independent, third-party evaluation is to provide insights, observations, and recommendations as well as review compliance with the guidance provided in NUREG/CR-7002. Among the many factors evaluated as part of the third-party review are population groups, trip generation times, and combinations of distributions for various evacuation time components, evacuation times for special facilities, use of traffic simulation models, and assessment of shadow evacuations. In general, the results of the third-party evaluation shows the PNGS ETE study adhered to the guidance provided in NUREG/CR-7002. The results of the review show that the initial conditions and assumptions are consistent with the guidance provided as well as the state-of-the-practice in ETE development and traffic simulation modeling. Based on these findings the evacuation model is determined to be properly supported. Furthermore, the review shows the initial conditions, assumptions, modeling methodology, scenarios, and analysis conducted as part of the PNGS ETE study did not substantively deviate from similar studies accepted by the U.S. Nuclear Regulatory Commission.

The review finds that while consistent with prior ETE studies conducted in the U.S., several shortcomings exist within the report. In general, these deficiencies relate to transit dependent facilities and individuals who need assistance to evacuate. The review found that the report did not provide an inventory of the number buses, wheelchair buses, and ambulances that could be made available during the evacuation. Without this information, it is unknown if special facilities would require a second-wave evacuation. Therefore the ETE for this population cannot be definitively estimated. The report also omitted the number and time required to evacuate special needs individuals who do not reside at medical facilities. These are individuals who live independently, but cannot evacuate by themselves. Without an accurate estimate of the number of these individuals, their mobilization time, or resources required to facilitate their evacuation, an ETE cannot be determined for this population.

A review of recent ETE studies developed to the guidelines prescribed in NUREG/CR-7002 and accepted by the U.S. Nuclear Regulatory Commission found 58 U.S. NPP sites with comparable scenarios to those used in the PNGS ETE study. These 58 U.S. based NPP ETE studies, are used to validate the 90 percent and 100 percent PZ ETEs for 14 unique; time of day, day of week, season of year, weather, special event, and roadway impact scenarios. The analysis finds that while PNGS is among one of the highest populated sites reviewed, the ETEs are consistent with NPP sites with similar demographics. A similar analysis is also conducted for the 3 km ring and 6 km ring, both subsets of the PZ, and found similar results.

ABBREVIATIONS AND ACRONYM

CNSC	Canadian Nuclear Safety Commission
EPZ	Emergency Planning Zone
ETE	Evacuation Time Estimate
NGS	Nuclear Generation Station
NPP	Nuclear Power Plant
PAR	Protective Action Recommendation
PNGS	Pickering Nuclear Generation Station
PZ	Planning Zone
DPZ	Detailed Planning Zone
CPZ	Contingency Planning Zone
VPK	Vehicles Per Kilometer

1.0 INTRODUCTION

The evacuation time estimate (ETE) is a calculation of the time to evacuate the plume exposure pathway Planning Zone (PZ), which is an area surrounding a nuclear power plant (NPP) [1]. The benefit of an ETE study is found in the methodology required to perform the analysis, as well as the calculated times [2] [3]. In the United States, NPP licensees and applicants develop ETEs following the guidance provided in NUREG/CR-7002, "Criteria for Development of Evacuation Time Estimates," [4]. The development of an ETE study includes obtaining site-specific demographic data, reviewing the transportation network, gathering data on special facilities and transit-dependent residents to determine the number of ambulances, wheelchair vans, buses, and other vehicles needed to support evacuation, identifying the number of schoolchildren and corresponding buses to facilitate an evacuation, and obtaining information related to many other site-specific considerations [4].

In the U.S., Section IV of Appendix E to 10 CFR Part 50 requires nuclear power reactor licensees[1] to develop ETE analyses using United States Census Bureau decennial data [1]. Licensees are required to submit the ETE analysis to the NRC before using it to form protective action recommendations (PARs) and before providing it to State and local governmental authorities for use in developing offsite protective action strategies. During the years between decennial censuses, Section IV of Appendix E to 10 CFR Part 50 also requires licensees to estimate PZ permanent resident population changes once a year. If at any time during the decennial period the PZ permanent resident population increases, such that it exceeds specified criteria, the licensee is required to update the ETE analysis to reflect the impact of that population increase.

Ontario Power Generation, operating with license from the Canadian Nuclear Safety Commission (CNSC) contracted with a U.S. based company to conduct a traffic engineering ETE study for the Detailed Planning Zone (DPZ), a 10 km ring and the Contingency Planning Zone (CPZ) a 20 km ring around the Pickering Nuclear Generation Station (PNGS). The commissioned ETE report describes the analysis undertaken and the results obtained by a study to develop evacuation time estimates for the Pickering NGS, located in the City of Pickering (Durham Region), Ontario, Canada. The simulation model used reflects the NRC guidance that evacuees will seek to travel away from the location of the hazardous event. The ETEs provide all levels of government with site-specific information needed for protective action decision making.

Pickering NGS is located in a high population density area in which a large scale evacuation would be required in the event of a severe accident at the station. Due to the complexity of a large scale evacuation and modeling thereof, a third party independent review of the Pickering NGS Development of Evacuation Time Estimates, P-REP-03490-00080 R000, is being conducted. The review, documented in the following chapters of this report, provides insight, comments, and recommendations on the licensee's study. Among the many factors evaluated as part of the third-party review are population groups, trip generation times, and combinations of distributions for various evacuation time components, evacuation times for special facilities, use of traffic simulation models, and assessment of shadow evacuations.

Conclusions and recommendations of the third-party review are based on the evaluation of the document "Pickering NGS Development of Evacuation Time Estimates, P-REP-03490-00080

[1] The term "licensees" refers to licensees of NPPs under 10 CFR Parts 50 and 52.

R000" and considerations of conditions and assumptions, the appropriateness of the simulation model and development, and a validation of evacuation time predictions through a comparison of similar NPP sites. The following section of this chapter identifies the objectives and scope of the third-party evaluation.

1.1 Objectives and Scope

The overall project objective is to conduct an independent, third-party evaluation of the Ontario Power Generation's Development of Evacuation Time Estimates for Pickering NGS. The evaluations, insights, observations, and recommendations are identified and completed following the guidance provided in U.S. NUREG/CR-7002, "Criteria for Development of Evacuation Time Estimate Studies" and include a comparison of the simulation result from other NPP sites. In addition to the overall project objective, the scope of the evaluation includes the validation of the evacuation time predictions as well as comments and conclusions related to:

- Whether the simulation model used to analyze evacuation scenarios is properly supported
- Whether the estimates of times to evacuate the Planning Zone and various subsets of the Planning Zone are conducted properly
- Whether the initial conditions and assumptions are comprehensive and correct
- Any gaps to be addressed in the modeling

The following chapters document the methodology, findings, insights, and recommendations of the third-party review. Utilizing the Review Criteria Checklist provided in NUREG/CR-7002, Chapter 2 explores the simulation model development, inclusive of initial conditions and assumptions. Chapter 2 also investigates the suitability of the data collection and model inputs and assumptions. Chapter 3 provides a validation of the times to evacuate the DPZ, CPZ, and various subsets through a comparison of other NPP sites. Finally, recommendations and conclusions are provided in Chapter 4.

2.0 EVALUATION OF INITIAL CONDITIONS AND ASSUMPTIONS

This Chapter discusses the simulation model development, inclusive of initial conditions and assumptions as well as explores the suitability of the data collection and model inputs and assumptions. Specifically, this section speaks to whether the simulation model used to analyze the evacuation scenarios is properly supported, whether the initial conditions and assumptions are comprehensive and correct, and identifies any gaps in the modeling approach. NUREG/CR-7002, Appendix B "ETE Review Criteria Checklist is used to help facilitate this evaluation. The next section presents the ETE Review Checklist table followed by a summary of significant findings.

2.1 ETE Review Checklist

Table 1 shows the ETE Review Checklist provided by NUREG/CR-7002. This check list is used to assist in the review of ETE studies. The Review Section column shows the relative location where information should be located within the report. The Criterion Addressed column is a "yes" or "no" statement indicating whether the criterion under review has been explicitly addressed, per guidance provided in NUREG/CR-7002. The Comments column provides a third-party evaluation of the criterion and whether the criterion is met or not. Comments are given to elaborate on where this information can be found in the report or what information is missing. The PNGS report submitted by the licensee has a similar table in Appendix N based on an evaluation conducted by the licensee.

Table 1: ETE Review Checklist

Review Sections	Criterion Addressed (Yes/No)	Comments
1.0 Introduction		
a. The emergency planning zone (EPZ) and surrounding area should be described.	Yes	Response to CNSC Comments has added an additional discussion to include topographic features that would impact highway grades and subsequently capacity.
b. A map should be included that identifies primary features of the site, including major roadways, significant topographical features, boundaries of counties, and population centers within the EPZ.	Yes	Response to CNSC Comments states Figure 1-1 has been updated to show topographic features.
c. A comparison of the current and previous ETE should be provided and includes similar information as identified in Table 1-1, "ETE Comparison," of NUREG/CR-7002.	Yes	Section 1.4 and Table 1-3 provide a comparison between the ETE study and the one submitted in 2015. Several differences are evident. However, based on the population considered in the 2015 study and the transportation infrastructure improvements which took place since then, these differences appear to be appropriate.
1.1 Approach		

a. A discussion of the approach and level of detail obtained during the field survey of the roadway network should be provided.	Yes	Section 1.3 describes the data collection and general assumptions made during the field visit and roadway survey. It appears lane widths are estimated (not measured). This is an appropriate approximation because minor changes in lane widths are not expected to have a significant impact on ETE. Signal timing at actuated controllers are approximated and not directly observed. Therefore, actuated signal controller timing must be approximated within the traffic model. The signal timing is likely based on a reasonable approximation of a representative actuated controller. This approach is suitable for a macroscopic simulation model such as DYNEV II and is not likely to significantly impact ETE estimates.
b. Sources of demographic data for schools, special facilities, large employers, and special events should be identified.	Yes	Section 1.3 provides an overview of data collection sources for the various populations. Demographic data for schools is provided by the local school boards and special facilities data gathered from phone calls to individual facilities. Large employers and the special event demographics are collected by contacting these facilities directly or estimated from the Durham Region, Open Data - City of Toronto.
c. Discussion should be presented on use of traffic control plans in the analysis.	Yes	The Nuclear Emergency - Annex "B2" Traffic Control/Sector Book Pickering Guide (or the Region Traffic Control/Sector Book Plan) for the PZ, provided by Durham Region is used as the basis for modeling. This is discussed in section 2.3, 9, and appendix G.
d. Traffic simulation models used for the analyses should be identified by name and version.	Yes	The DYNEV II System and its associated models are used for the analysis. Sections 1.3 list the simulation model and version while Appendix C provides an overview of the model, and Appendix B provides and overview of the dynamic traffic assignment algorithm.

e. Methods used to address data uncertainties should be described.	Yes	In general, the method used to address data uncertainties throughout the report is to provide conservative estimates which may (but not necessarily) lead to higher ETE predictions. Sample procedures are employed, where possible and some sensitivity analysis have been conducted on input parameters. Guidance provided by NUREG/CR-7002 is limited on this issue and the ETE report takes an engineering approach to address uncertainty, where possible.
1.2 Assumptions		
a. The planning basis for the ETE includes the assumption that the evacuation is ordered promptly and no early protective actions have been implemented.	Yes	This assumption is used during the simulated scenarios as stated in Section 2.3 and Section 5.1.
b. Assumptions consistent with Table 1-2, "General Assumptions," of NUREG/CR-7002 should be provided and include the basis to support their use.	Yes	Section 2 documents the study assumptions, inclusive of those provided in Table 1-2 of NUREG/CR-7002
1.3 Scenario Development		
a. The ten scenarios in Table 1-3, Evacuation Scenarios, should be developed for the ETE analysis, or a reason should be provided for use of other scenarios.	Yes	Table 2-1 list 14 scenarios evaluated, inclusive of the scenarios required by Table 1-3 of NUREG/CR-7002.
1.3.1 Staged Evacuation		
a. A discussion should be provided on the approach used in development of a staged evacuation.	Yes	Section 5.4.2 discusses how the phased evacuation is modeled. It is worth noting, however, the following populations are excluded from the "staged" order: 1. 20 percent of the population downwind of the contiguous zone 2. Transient populations 3. Employees
1.4 Evacuation Planning Areas		

a. A map of the EPZ with emergency response planning areas (ERPAs) should be included.	Yes	This map is provided in Figure 3-1.
b. A table should be provided identifying the ERPAs considered for each ETE calculation by downwind direction in each sector.	Yes	This is provided in Table 7-5 and 7-6.
c. A table similar to Table 1-4, "Evacuation Areas for a Staged Evacuation Keyhole," of NUREG/CR-7002 should be provided and includes the complete evacuation of the 2, 5, and 10 mile areas and for the 2 mile area/5 mile keyhole evacuations.	Yes	This is provided in Table 7-6.
2.0 Demand Estimation		
a. Demand estimation should be developed for the four population groups, including permanent residents of the EPZ, transients, special facilities, and schools.	Yes	Section 3.1 discusses permanent residents, Section 3.2 discusses shadow evacuees, Section 3.3 discusses transients, Section 3.4 discusses employees, Section 3.5 discusses medical facilities, Section 3.6 discusses correctional facilities, and Section 3.7 discusses transit dependent populations, Section 3.8 discuss school demand, Section 3.9 discusses day camps, and Section 3.10 discusses special event demand.
2.1 Permanent Residents and Transient Population		
a. The US Census should be the source of the population values, or another credible source should be provided.	Yes	The primary source of demand information is provided by the 2016 Statistics Canada Census data.
b. Population values should be adjusted as necessary for growth to reflect population estimates to the year of the ETE.	Yes	The year of the ETE is taken to be 2018 and population growth factors ranged from 1.17 percent to 1.86 percent. Table 3-1 uses population data from 2011 - 2014 to estimate a population growth factor and then estimates the ETE populations for future years, 2018, 2024, and 2028.

c. A sector diagram should be included, similar to Figure 2-1, "Population by Sector," of NUREG/CR-7002, showing the population distribution for permanent residents.	Yes	These are used throughout Section 3 to show the various population cohorts and number of vehicles.
2.1.1 Permanent Residents with Vehicles		
a. The persons per vehicle value should be between 1 and 2 or a justification should be provided for other values.	Yes	A per person vehicle rate of 2.35 is used. This is done based on ride-share proportions estimated from the 2016 Census and telephone survey results. The census estimated 2.89 person/household and the telephone survey estimated 1.23 evacuating vehicles/household. Dividing these two numbers results in an estimated 2.35 persons per evacuating vehicle.
b. Major employers should be listed.	Yes	This is provided in Appendix E, Table E-5.
2.1.2 Transient Population		
a. A list of facilities which attract transient populations should be included, and peak and average attendance for these facilities should be listed. The source of information used to develop attendance values should be provided.	Yes	The transient population is divided into non-employee transients and employee transients. The facilities and their attendance are described in Sections 3.3 and 3.4. The attendance data is obtained from the Durham Region, Open Data – City of Toronto and complemented with phone calls to individual facilities within the PZ.
b. The average population during the season should be used, itemized and totaled for each scenario.	Yes	Table 3-5 shows the total transient population and vehicles within each Response Sector (i.e. 100 percent of the transient population). Table 6-4 provides scenario specific presentation for transients evacuation participation.
c. The percent of permanent residents assumed to be at facilities should be estimated.	Yes	Response to CNSC's Comments has added details for calculating the percent of permanent residents at facilities when the evacuation is ordered.
d. The number of people per vehicle should be provided. Numbers may vary by scenario, and if so, discussions on why values vary should be provided.	Yes	This information is provided throughout Section 3 for each population cohort and in Tables 3-3 through 3-7.

e. A sector diagram should be included, similar to Figure 2-1 of NUREG/CR-7002, showing the population distribution for the transient population.	Yes	This has been done for each population cohort in Section 3.
2.2 Transit Dependent Permanent Residents		
a. The methodology used to determine the number of transit dependent residents should be discussed.	Yes	The number of transit dependent residents is estimated via telephone survey of PZ residents. The method is described in Section 3.7 and the results provided in Table 3-9.
b. Transportation resources needed to evacuate this group should be quantified.	Yes	The ETE study estimated 2,607 people could require transit service and further estimates 87 bus runs would be required. This results in approximately 30 people per bus. This is described in Section 3.7.
c. The county/local evacuation plans for transit dependent residents should be used in the analysis.	Yes	Discussions were held with Durham Region Transit, Toronto Transit Commission, and Go Transit. It can be assumed, although not explicitly stated in the ETE study that any evacuation plans these agencies have are implemented into the simulation model.
d. The methodology used to determine the number of people with disabilities and those with access and functional needs who may need assistance and do not reside in special facilities should be provided. Data from local/county registration programs should be used in the estimate, but should not be the only set of data.	No	Data is not provided for the number of people with disabilities and those with access and functional needs. It is assumed that people with access and functional needs who may need assistance and do not reside in special facilities are included in the transit dependent permanent resident population. It is also assumed, based on conversations with the local transit providers that these people would call their local emergency management organization and arrange for special vehicles to be sent to their homes on an on-demand basis.
e. Capacities should be provided for all types of transportation resources. Bus seating capacity of 50% should be used or justification should be provided for higher values.	Yes	Response to CNSC comments has added discussion and distinction between bus capacity and loading with additional detail and clarity.

f. An estimate of this population should be provided and information should be provided that the existing registration programs were used in developing the estimate.	No	There is no discussion of pre-registration programs for disabled, transit dependent populations.
g. A summary table of the total number of buses, ambulances, or other transport needed to support evacuation should be provided and the quantification of resources should be detailed enough to assure double counting has not occurred.	Yes	Tables 3-8, 3-9, and 3-10 provides a summary of the transportation resources required. Section 8 provided a detailed account of the methods for estimating the transit resources required to a level of detail which minimized double counting.
2.3 Special Facility Residents		
a. A list of special facilities, including the type of facility, location, and average population should be provided. Special facility staff should be included in the total special facility population.	Yes	This is provided in Appendix E in Tables E-1, E-2, E-3, and E-4.
b. A discussion should be provided on how special facility data was obtained.	Yes	Data is collected from the local school board as well as phone calls to individual facilities. This is detailed in Section 8.
c. The number of wheelchair and bed-bound individuals should be provided.	Yes	This data is provided in Table 8-8.
d. An estimate of the number and capacity of vehicles needed to support the evacuation of the facility should be provided.	Yes	This is discussed in Section 8.
e. The logistics for mobilizing specially trained staff (e.g., medical support or security support for prisons, jails, and other correctional facilities) should be discussed when appropriate.	Yes	Medical facilities are discussed in Section 8.1 and correctional facilities in Section 8.2.
2.4 Schools		

a. A list of schools including name, location, student population, and transportation resources required to support the evacuation, should be provided. The source of this information should be provided.	Yes	School names, locations, enrolment, and required buses are provided in Table E-1. The same information for day-camps is provided in table E-2. Data is obtained from the local school board and from phone calls to individual facilities.
b. Transportation resources for elementary and middle schools are based on 100% of the school capacity.	Yes	The absentee rate is assumed to be zero percent and discussed in Section 3.8.
c. The estimate of high school students who will use their personal vehicle to evacuate should be provided and a basis for the values used should be provided.	Yes	The ETE study assumes zero percent of high school students would evacuate using personal vehicles. Thus, 100 percent would require bus transportation, Section 3.8.
d. The need for return trips should be identified if necessary.	Yes	The required resources are provided in Table 3-10. However, no account for available resources are given. Section 3.8 states that schools will be evacuated first using all necessary resources. “Second wave” ETEs are provided for all schools and special facilities.
2.5.1 Special Events		
a. A complete list of special events should be provided and includes information on the population, estimated duration, and season of the event.	Yes	One special event at the Toronto Zoo is considered with an estimated population of 18,000 which typically occurs during Summer days and weekends, Section 3.10.
b. The special event that encompasses the peak transient population should be analyzed in the ETE.	Yes	The special event results in 3,116 additional transient vehicles and 77 more bus runs.
c. The percent of permanent residents attending the event should be estimated.	Yes	15 percent of special event attendees are assumed to be permanent residents of the PZ.
2.5.2 Shadow Evacuation		
a. A shadow evacuation of 20 percent should be included for areas outside the evacuation area extending to 15 miles from the NPP.	Yes	Section 3.2 describes the shadow population.
b. Population estimates for the shadow evacuation in the 10 to 15 mile area beyond the EPZ are provided by sector.	Yes	Table 3-3 provides the shadow population and vehicles, by sector.

c. The loading of the shadow evacuation onto the roadway network should be consistent with the trip generation time generated for the permanent resident population.	Yes	The shadow population characteristics such as household size, evacuating vehicles per household, and mobilization times, are assumed to be the same as the PZ permanent resident population.
2.5.3 Background and Pass Through Traffic		
a. The volume of background traffic and pass-through traffic should be based on the average daytime traffic. Values may be reduced for nighttime scenarios.	Yes	Response to CNSC Comments as added a discussion on a 30-minute seeding period to model background traffic. Pass-through traffic is discussed in section 3.6 and modeled appropriately using AADT, k-factors, and D-factors obtained from the Ministry of Transportation of Ontario.
b. Pass-through traffic should be assumed to have stopped entering the EPZ about two hours after the initial notification.	Yes	120 minutes after the advisory to evacuate the pass-through traffic is prevented from entering the PZ.
2.6 Summary of Demand Estimation		
a. A summary table should be provided that identifies the total populations and total vehicles used in the analysis for permanent residents, transients, transit dependent residents, special facilities, schools, shadow population, and pass-through demand used in each scenario.	Yes	These values are presented in Tables 3-7 and 3-8.
3.0 Roadway Capacity		
a. The method(s) used to assess roadway capacity should be discussed.	Yes	The approached described in Section 4 to assess roadway capacity is consistent with the Highway Capacity Manual, 2010 and the principles of traffic engineering. However, assessing capacity for large, congested networks is not simple or a straight-forward process, relying, in part, on engineering judgment.
3.1 Roadway Characteristics		
a. A field survey of key routes within the EPZ has been conducted.	Yes	Section 1.3 discusses the process used to survey the road network.

b. Information should be provided describing the extent of the survey, and types of information gathered and used in the analysis.	Yes	Table 1-2 describes the types of data collected during the survey. The survey is a visual inspection conducted while driving the entire road network.
c. A table similar to that in Appendix A, "Roadway Characteristics," of NUREG/CR-7002 should be provided.	Yes	This table is provided in Appendix K, Table K-1.
d. Calculations for a representative roadway segment should be provided.	No	This is not a practical requirement for ETE studies which utilize traffic simulation.
e. A legible map of the roadway system that identifies node numbers and segments used to develop the ETE should be provided and should be similar to Figure 3-1, "Roadway Network Identifying Nodes and Segments," of NUREG/CR-7002.	Yes	A legible map of the roadway system, identifying node numbers and segments is provided in Appendix K, Figures K-1 through K-48 .
3.2 Capacity Analysis		
a. The approach used to calculate the roadway capacity for the transportation network should be described in detail and identifies factors that are expressly used in the modeling	Yes	Traffic models are a reasonable representation of real-world systems and therefore can only represent, through approximation actual roadway capacity. The ETE study follows the Highway Capacity Manual, 2010 procedures and therefore follows the state-of-the-practice in estimating and modeling capacity. This is described in Section 4.
b. The capacity analysis identifies where field information should be used in the ETE calculation.	Yes	The field data collection included the approximate free-flow speed, number of lanes, and types of roadway facilities and any pre-timed signal timing. However, the number and timing of pre-timed signals is not reported.
3.3 Intersection Control		
a. A list of intersections should be provided that includes the total numbers of intersections modeled that are unsignalized, signalized, or manned by response personnel.	No	The ETE study, Table N-1 on page N-9 states "Table redacted at OPG's request".

b. Characteristics for the 10 highest volume intersections within the EPZ are provided including the location, signal cycle length, and turn lane queue capacity.	Yes	This information is provided in Appendix J, Table J-1.
c. Discussion should be provided on how timed signal cycle is used in the calculations.	Yes	Cycle and phase length is used, in part, to calculate the capacity of signalized intersections, in Section 4.1. However, actuated signals, which likely make up the vast majority of signalized intersections in the model are not taken from individual field observations, but estimated based on a sample of representative intersections and engineering judgement.
3.4 Adverse Weather		
a. The adverse weather condition should be identified and the effect of adverse weather on mobilization should be considered.	Yes	Table 2-1 describes the weather conditions (adverse or otherwise) modeled in each of the 14 scenarios. Assumption 13 in section 2.3 and Table 2-2 described the impact of adverse weather on mobilization time for both rain and snow. The impact on mobilization time is estimated via the telephone survey of PZ permanent residents and is represented by a distribution shown in Figure F-10.
b. The speed and capacity reduction factors identified in Table 3-1, "Weather Capacity Factors," of NUREG/CR-7002 should be used or a basis should be provided for other values.	Yes	Table 2-2 describes the free-flow speed and capacity reduction for rain and snow scenarios. These values differ from Table 3-1 in NUREG/CR-7002. The ETE study uses a 90 percent reduction for both free-flow speed and capacity in rain scenarios and an 80 percent reduction for free-flow speed and capacity in snow scenarios. The ETE study sited Agarwal et al., 2005 as justification for using these reduced values instead of the ones reported in NUREG/CR-7002.
c. The study identifies assumptions for snow removal on streets and driveways, when applicable.	Yes	The telephone survey is used to estimate the added mobilization time needed to account for snow removal. This distribution is accounted for in the mobilization time distributions for the snow scenarios.

4.0 Development of Evacuation Times		
4.1 Trip Generation Time		
a. The process used to develop trip generation times should be identified.	Yes	Section 5 discusses the trip generation time development. In short, telephone surveys are used to generate distributions of the time required to receive notification, prepare to leave work, travel home, prepare to leave to evacuate, and clear snow. These distributions are combined to create the various generation times for each population cohort and scenario, as needed.
b. When telephone surveys are used, the scope of the survey, area of the survey, number of participants, and statistical relevance should be provided.	Yes	Appendix F discusses the telephone survey design, procedure, and results. The survey was conducted in 2015 on 500 permanent residents of the PZ. The survey has a sampling error of 4.4 percent at a 95 percent confidence level. The survey collected information including travel patterns, car ownership, household size, and demographic information as well as response times.
c. Data obtained from telephone surveys should be summarized.	Yes	The survey results are summarized in Appendix F in figures F-1 through F-10.
d. The trip generation time for each population group should be developed from site specific information.	Yes	Cohort trip generation times and loading curves are generated by combining the various distributions from each surveyed activity (i.e. receiving notification, and preparing to leave to evacuate for permanent residents at home when the evacuation is ordered). To combine distributions requires generating hundreds (or more) simulated notifications and adding those to hundreds of simulating to preparing to leave times, to generate a new distribution that incorporates the two activities.
4.1.1 Permanent Residents and Transient Population		
a. Permanent residents are assumed to evacuate from their homes but are not assumed to be at home at all times. Trip generation time includes the assumption that	Yes	Table 6-4 shows daytime, weekday scenarios are modeled with 32 percent of homes with returning commuters and 68 percent of homes without. Weekend and evening scenarios had 3 percent of homes with

a percentage of residents will need to return home prior to evacuating.		returning commuters. Appendix F shows that trip generation times are consistent with the associated activities of these groups.
b. Discussion should be provided on the time and method used to notify transients. The trip generation time discusses any difficulties notifying persons in hard to reach areas such as on lakes or in campgrounds.	Yes	Section 5.3 states sirens and automated telephone messages would notify the entire PZ population to the evacuation. Section 5.4.3 states the Provincial Emergency Operations Center will issue operational directives to clear boat traffic from Lake Ontario and the Canadian Coast Guard will control entry into the lake during the evacuation. The ETE study assumed that 2.5 hours is sufficient for campers, boaters, and other transients to return to their vehicles and begin their evacuation trips.
c. The trip generation time accounts for transients potentially returning to hotels prior to evacuating.	Yes	Figure 5-1 shows residents and transients away from residents, returning home (or to hotel) before evacuating.
d. Effect of public transportation resources used during special events where a large number of transients are expected should be considered.	Yes	Section 3.10 discusses the impact of a special event at the Toronto Zoo. The impact to public transportation is estimated to be an additional 2,295 transient-transit passengers, requiring an additional 77 bus runs.
e. The trip generation time for the transient population should be integrated and loaded onto the transportation network with the general public.	Yes	Figure 5-4 shows the trip generation distributions for transient and employees being loaded onto the network along with the general public.
4.1.2 Transit Dependent Residents		
a. If available, existing plans and bus routes are used in the ETE analysis. If new plans are developed with the ETE, they should have been agreed upon by the responsible authorities.	Yes	Section 8.1 states "buses will be assigned to their normal routes to evacuate the transit-dependent population". No new plans are developed as part of the ETE study.
b. Discussion should be included on the means of evacuating ambulatory and non-ambulatory residents.	No	Section 8 discusses the evacuation of medical facilities. Telephone interviews with individual facilities estimate a need for 53 bus runs, 81 wheelchair bus runs, and 215

		ambulatory runs within the DPZ. No discussion is provided on the availability of these resources.
c. The number, location and availability of buses, and other resources needed to support the demand estimation are provided.	No	Response to CNSC Comments has added that a subset of the DPZ can be evacuated with 87 buses and discussion held by the licensee and local providers estimated an ample number of buses to evacuate a subset. However, there is not a definitive estimate on the number of buses which could be made available in the unlikely event the entire DPZ is evacuated.
d. Logistical details, such as the time to obtain buses, brief drivers and initiate the bus route are provided.	Yes	Section 8.1 discusses the pre-evacuation activities required for a transit based evacuation. Figure 8-1 provides a diagram, inclusive of driver mobilization and travel to facility/route time required.
e. Discussion should identify the time estimated for transit dependent residents to prepare and then travel to a bus pickup point, and describes the expected means of travel to the pickup point.	Yes	Section 10.0 states “It is assumed that residents will walk to and congregate at bus stops along these (pre-established) routes, and that they can arrive at these routes within the 120-minute bus mobilization time (good weather).
f. The number of bus stops and time needed to load passengers should be discussed.	Yes	Response to CNSC Comments has added the location of bus stops to Figures 10-1 through 10-7.
g. A map of bus routes should be included.	Yes	This is provided in Figures 10-1 through 10-7.
h. The trip generation time for non-ambulatory persons includes the time to mobilize ambulances or special vehicles, time to drive to the home of residents, loading time, and time to drive out of the EPZ should be provided.	No	It is assumed that special needs persons who do not reside at special facilities will either evacuate as a transit dependent person or “will call their local emergency management organization and arrange for a special vehicle to be sent to their home on an on-demand basis.”
i. Information should be provided to support analysis of return trips, if necessary.	Yes	8.1 discusses the need for and time requirements of second-wave evacuation trips.
4.1.3 Special Facilities		
a. Information on evacuation logistics and mobilization times should be provided.	Yes	Section 8.1 discusses the mobilization and evacuation of medical facilities and Section 8.2 discusses the mobilization and evacuation of correctional facilities.

b. Discussion should be provided on the inbound and outbound speeds.	Yes	The simulation model is used to compute outbound speeds for links likely to be used by the evacuating vehicles to the PZ boundary. From the PZ boundary an average speed is assumed to calculate the time required to travel from the PZ boundary to the nearest Reception Center. Second wave inbound trips are based on general averages and no direct travel speeds from the simulation model are used.
c. The number of wheelchair and bed-bound individuals should be provided, and the logistics of evacuating these residents should be discussed.	Yes	Table 8-1 estimates the number of wheelchair individuals to be 324 and the number of bed-bound individuals to be 215. Section 8.1 discusses the use of wheelchair accessible buses and ambulances to evacuate these individuals.
d. Time for loading of residents should be provided.	Yes	Section 8.1 states "loading times of 1 minute, 5 minutes, and 10 minutes per patient are assumed for ambulatory patients, wheelchair bound patients, and bedridden patients, respectively."
e. Information should be provided that indicates whether the evacuation can be completed in a single trip or if additional trips are needed.	No	ETEs are provided for single-wave and second-wave evacuations, but no discussion on the number of available resources is provided. It is therefore unknown if a second-wave evacuation will be needed.
f. If return trips are needed, the destination of vehicles should be provided.	No	Section 8.1 states patients will be dropped off at Reception Centers, but the location and description of these centers is redacted from the report at the request of OPG.
g. Discussion should be provided on whether special facility residents are expected to pass through the reception center prior to being evacuated to their final destination.	No	The ETE study did not discuss what will happen to patients after leaving the bus at the unidentified Reception Center.
h. Supporting information should be provided to quantify the time elements for the return trips.	Yes	Section 8.1 estimates unloading of the buses and ambulances will require 5 minutes, then the drivers will take a 10-minute break. Return trip time is estimated by

		assuming an average speed of travel between the Reception Center and the special facility.
4.1.4 Schools		
a. Information on evacuation logistics and mobilization times should be provided.	Yes	Section 8.1 discusses the school population and transit demand. It lists several assumptions on page 8-4, which likely overestimates the number of school bus trips that will be required. Section 8.1 discusses the mobilization time and states "[schools and Day-Camps] are ready to begin their evacuation trips at 105 minutes after the advisory to evacuate – 90 minutes mobilization time plus 15 minutes loading time – in good weather.".
b. Discussion should be provided on the inbound and outbound speeds.	Yes	The simulation model is used to compute outbound speeds for a representative bus route from each response sector to the PZ boundary (representing all schools within the Response Sector). From the PZ boundary an average speed is assumed to calculate the time required to travel from the PZ boundary to the Reception Center or THC. Second wave inbound trips are based on general averages and no direct travel speeds from the simulation model are used. It is estimated that a second wave would require an additional 1:35 after the completion for the first wave ETE for schools and Day-Camps. It is also assumed the 90-minute mobilization time is inclusive of the travel time between the bus depot and any school being evacuated.
c. Time for loading of students should be provided.	Yes	Section 8.1 states a student loading time of 15 minutes is assumed.
d. Information should be provided that indicates whether the evacuation can be completed in a single trip or if additional trips are needed.	No	There is no discussion on the number of available buses, only calculations on the number of buses required and their ETE. A second wave ETE is calculated, but the ETE study, as written, cannot be used to estimate if this second wave is needed.

e. If return trips are needed, the destination of school buses should be provided.	No	Section 8.1 states student will be dropped off at Temporary Holding Centers (THC), but the location and description of these centers is redacted from the report at the request of OPG.
f. If used, reception centers should be identified. Discussion should be provided on whether students are expected to pass through the reception center prior to being evacuated to their final destination.	No	Reception Centers and/or THC locations are redacted at the request of OPG. The ETE report states that students will be picked up at the THC by their parents.
g. Supporting information should be provided to quantify the time elements for the return trips.	Yes	Schools and Day-Camps are assumed to have a second wave ETE that is 1:35 longer than the first wave ETE. This is inclusive of a 5-minute unloading time, 10 minute break for the bus driver, and travel time.
4.2 ETE Modeling		
a. General information about the model should be provided and demonstrates its use in ETE studies.	Yes	Appendix C document the model and Appendix D demonstrate its use on ETE studies.
b. If a traffic simulation model is not used to conduct the ETE calculation, sufficient detail should be provided to validate the analytical approach used. All criteria elements should have been met, as appropriate.	Yes	The tool used to calculate the ETE is a traffic simulation model.
4.2.1 Traffic Simulation Model Input		
a. Traffic simulation model assumptions and a representative set of model inputs should be provided.	Yes	Appendix C discusses the simulation model, Appendix B discusses the dynamic traffic assignment model, and Appendix J provides representative model inputs and outputs.
b. A glossary of terms should be provided for the key performance measures and parameters used in the analysis.	Yes	Appendix A provides a glossary of traffic engineering terms. Table C-1 provides the measure of effectiveness

		used in the model, their units, and the network element the measure quantifies.
4.2.2 Traffic Simulation Model Output		
a. A discussion regarding whether the traffic simulation model used must be in equilibration prior to calculating the ETE should be provided.	Yes	Appendix B discusses the dynamic assignment algorithm used to route vehicles during the evacuation. The algorithm dynamically reassigns drivers based on time dependent conditions until volumes and travel times on links do not significantly change between assignment iterations. Therefore, the algorithm needs to be in equilibrium prior to calculating the ETE. However, this may not be considered a true "Network Equilibrium" dynamic traffic assignment model because modifications for the representation of evacuation conditions (i.e. travel toward the NPP is prohibited, etc.) are made.
b. The minimum following model outputs should be provided to support review:	Yes	See comments below
b.1. Total volume and percent by hour at each EPZ exit mode.	Yes	This is provided in Table J-5 for Scenario 1 only.
b.2. Network wide average travel time.	Yes	This is provided in Table J-3 for all 14 scenarios.
b.3. Longest Queue length for the 10 intersections with the highest traffic volume.	Yes	This is provided in Table J-1. However, it does not distinguish by scenario.
b.4. Total vehicles exiting the network.	Yes	This is provided in Table J-3 for all 14 scenarios.
b.5. A plot that provides both the mobilization curve and evacuation curve identifying the cumulative percentage of evacuees who have mobilized and exited the EPZ.	Yes	This is provided for each scenario in Figures J-1 through J-14.
b.6. Average speed for each major evacuation route that exits the EPZ.	Yes	This is provided in Table J-4 for Scenario 1 only.

c. Color coded roadway maps should be provided for various times (i.e., at 2, 4, 6 hrs., etc.) during a full EPZ evacuation scenario, identifying areas where long queues exist including level of service (LOS) "E" and LOS "F" conditions,	Yes	This is provided in Figures 7-3 through 7-14 at various times into the simulation model.
4.3 Evacuation Time Estimates for the General Public		
a. The ETE should include the time to evacuate 90% and 100% of the total permanent resident and transient population.	Yes	This is provided in Tables 7-1 and 7-2.
b. The ETE for 100% of the general public should include all members of the general public. Any reductions or truncated data should be explained.	Yes	A 100 percent ETE truncation is generally necessary when trip generation distributions have significantly longer evacuation tails. Section 5.4.1 discussed how statistical outliers in the survey responses are excluded from consideration. This process prevented excessively long evacuation tails, in the generation phase. Therefore, no truncating of the 100% ETE is needed because these outliers are removed before the trip generation distributions are loaded into the simulation model. A truncation of the 100 percent ETE can also be necessary in some cases when microsimulation modeling is used, if vehicles are lost or otherwise "stuck" inside the model.
c. Tables should be provided for the 90 and 100 percent ETEs similar to Table 4-3, "ETEs for Staged Evacuation Keyhole," of NUREG/CR-7002.	Yes	This is provided in Tables 7-1 and 7-2.
d. ETEs should be provided for the 100 percent evacuation of special facilities, transit dependent, and school populations.	No	Tables 8-2 through 8-4 provide the single wave ETE times for schools and state a second wave ETE would require an additional 1:35. However, there is no way of knowing if a one-wave, two-waves, or even three-waves evacuation is required. Therefore, these is no means of determining what the 100 percent ETE time is, without knowing how many waves are needed. The only way to

		determine the number of ETE waves is to have a reasonably accurate assessment of the number of buses available, which is not addressed in the ETE study. Likewise, the single-wave and second-wave ETE times are provided for transit dependent and special facilities populations in Tables 8-5 through 8-11.
5.0 Other Considerations		
5.1 Development of Traffic Control Plans		
a. Information that responsible authorities have approved the traffic control plan used in the analysis should be provided.	Yes	Response to CNSC Comments states changes to the traffic management plan made during the 2015 and 2018 studies have been discussed with the Durham Region Police Service Emergency Management personnel.
b. A discussion of adjustments or additions to the traffic control plan that affect the ETE should be provided.	Yes	These adjustments are discussed in section 9.0 and Appendix G as well as illustrated in Figures G-1 through G-9.
5.2 Enhancements in Evacuation Time		
a. The results of assessments for improvement of evacuation time should be provided.	Yes	Appendix M documents the results of several sensitivity analyses. Section M.4 summarizes the overall findings and provides suggestions to enhance the ETE for the region.
b. A statement or discussion regarding presentation of enhancements to local authorities should be provided.	Yes	The ETE study states "The report was reviewed by the offsite response organizations. Enhancements were presented to local authorities during the final meeting."
5.3 State and Local Review		
a. A list of agencies contacted and the extent of interaction with these agencies should be discussed.	Yes	This is provided in Table 1-1.
b. Information should be provided on any unresolved issues that may affect the ETE.	Yes	The ETE study states "No issues were determined after review with the offsite agencies."
5.4 Reviews and Updates		

a. A discussion of when an updated ETE analysis is required to be performed and submitted to the NRC.	Yes	The ETE reports are conducted in accordance with CNSC REGDOC-2.10.1 regarding future year ETE [5].
5.5 Reception Centers and Congregate Care Center		
a. A map of congregate care centers and reception centers should be provided.	No	The location information for congregate care centers, reception centers, or temporary holding centers is redacted upon request from OPG.
b. If return trips are required, assumptions used to estimate return times for buses should be provided.	Yes	Section 8.4 discusses calculations for second-wave ETEs. Schools and Day-Camps are found to have second-wave ETEs that are 1:35 longer than first-wave ETE provided in Tables 8-2 through 8-11.
c. It should be clearly stated if it is assumed that passengers are left at the reception center and are taken by separate buses to the congregate care center.	Yes	Section 10.0 states that transit dependent evacuees will be loaded onto busses and dropped off at reception centers. From there it is assumed, although not explicitly stated in the ETE study, evacuees will make any additional travel arrangements on their own. School children will be taken to THC where they will be picked up by their parents.

2.2 Significant Findings

This chapter uses the Review Criteria Checklist provided in NUREG/CR-7002, Appendix B to evaluate the PNGS ETE study. In general, the review suggest the licensee adheres to a strict following of NUREG/CR-7002 in the development of the ETE study and report. Overall, the review shows the initial conditions and assumptions to be consistent with NUREG/CR-7002 and the state-of-the-practice in ETE modeling. The simulation model used to analyze the evacuation scenarios is DYNEV-II. Of the 64 ETE studies accepted by the U.S. Nuclear Regulatory Commission following the 2010 U.S. census, 59 are conducted with DYNEV-II using a nearly identical methodology, process, and set of assumptions as those described in the PNGS ETE study. The initial conditions, assumptions, modeling methodology, scenarios, and analysis conducted as part of the PNGS ETE study did not substantively deviate from similar studies accepted by the U.S. Nuclear Regulatory Commission. However, the review did determine several items to be missing or otherwise deficient in meeting the guidance provided by NUREG/CR-7002. The majority of these have been resolved through discussions with the PNGS licensee and documented in prior versions of this report.

The remaining deficiencies are related to the inventories of buses, wheelchair buses, and ambulances available to facilitate the evacuation of special facilities and special needs individuals. The section of the report detailing special needs facilities does not provide an inventory for buses, wheelchair buses, and ambulances available to facilitate the evacuation. The report details the number of required resources, but is silent regarding their availability. As the report is currently written, it is not possible to determine if the evacuation could be completed in a single-wave or if a second-wave would be necessary. Similarly, there is no estimate for the number of individuals who require assistance to evacuate, but do not reside at a special facility. The ETE study states "based on discussions with local transportation providers, it is assumed that these people [special needs individuals, not residing at a special facility] will call their local emergency management organization and arrange for a special vehicle to be sent to their home on an on-demand basis." The licensee assumes that these individuals will evacuate with the transit dependent population. However, this assumption ignores the fact that these individuals need assistance to do so. Estimates of this population are needed and a separate ETE calculation for this population is required according to NUREG/CR-7002. Based on the current reading of the report, it is unknown how long it would take to mobilize and evacuate this population. Furthermore, the number of available resources (buses, vans, drivers, etc.) to carry out this on-demand service is not provided.

3.0 VALIDATION OF EVACUATION TIME PREDICTIONS

This chapter discusses the process developed to validate the evacuation estimates for the Planning Zone (PZ) and various subsets of the PZ. Broadly, this is accomplished by comparing the ETEs provided by the PNGS licensee and those of 58 NPP licensees in the U.S. following the 2010 census. All ETE reports submitted by licensees and used in the evaluation of the PNGS follow the guidance provided in NUREG/CR-7002. However, a significant factor impacting the comparison of Canadian NPP sites and those in the U.S. is the size of the PZ. Canadian NPP have DPZ radii of 10 km and CPZ radii of 20 km, whereas sites in the U.S. have PZ radii of 16.09 kilometers (10 miles). Therefore, to compare any NPP site located in Canada to those in the U.S., evaluations are conducted on a per kilometer basis. For example, the number of PZ vehicles per radial length in kilometer is compared to the U.S. sites giving a PZ vehicle population in vehicles per km (veh/km). Likewise, 90 percent and 100 percent ETE values are also divided by the radial length in kilometers to evaluate ETE per kilometer evacuated (min/km).

A series of three comparisons are conducted to validate PNGS ETEs. The first investigates the number of vehicles within the PZ to provide context to the ETE values. Fundamentally, evacuation times are functions of supply and demand. NPPs located in high population areas are typically expected to have longer ETEs. By first understanding the number of vehicles evacuating the PZ, a better contextual understanding of the ETE is established. The second comparison evaluated the 90 percent and 100 percent ETE per radial kilometer evacuated to those reported by other NPP in the U.S. The third evaluation seeks to control for both PZ size and population to facilitate an “apples-to-apples” comparison of the PNGS ETEs and U.S. sites. For this third analysis, the ETE times are converted to seconds and divided by the number of vehicles exiting the PZ and the radius of the PZ (sec/veh/km). This value is heretofore referred to as the P – factor in the following text, tables, and figures. Equation 1 shows the calculation of the P – factor developed to evaluate the PNGS ETE times against ETEs studies conducted in the U.S.

$$\boldsymbol{P_i = \frac{ETE_i * 3600}{N * r}} \qquad \textbf{Equation 1}$$

Where,
P is the number of seconds required to evacuate 1000 vehicles, one kilometer within the PZ (seconds/vehicle/kilometer)
ETE_i is the evacuation time estimate in hours corresponding to a clearance of 90 percent or 100 percent of the Planning Zone population
N is the number of vehicles, in thousands located within the Planning Zone
r is the radius of the Planning Zone in kilometers

The P – factor can be seen as a general measure of network efficiency. A high P – factor indicates the evacuation process tends to require more time to evacuate the same number of vehicles. A low P – factor may suggest a network is better capable of moving large numbers of vehicles, quickly through the network. As such, the P – factor tends to favor large, diverse road networks with many high capacity exit/evacuation routes. Furthermore, regions that mobilize more quickly are likely to have lower P – factor values, indicating a more efficient evacuation response. A PZ with a relatively low roadway capacity and small resident and transient population is likely to have a higher P – factor when compared to a higher capacity network, even if the population of the higher capacity network is significantly larger.

3.1 Validation Procedure

A review of recent ETE studies developed to the guidelines prescribed in NUREG/CR-7002 and accepted by the U.S. Nuclear Regulatory Commission found 58 U.S. NPP sites with comparable scenarios to those used in the PNGS ETE study. These 58 U.S. based NPP ETE studies, are used to validate the ETE provided by the PNGS. To facilitate the validation, ETEs and vehicle evacuating the PZ and subsets of the PZ are collected from the 58 prior ETE studies. From these values, cumulative distribution functions are developed to identify the percentile ranking ETE. The ETE values reported by PNGS are superimposed and the relative percentile estimated. This procedure allows for a general comparison between the ETEs provided by the PNGS licensee and those values reported and accepted by the U.S. Nuclear Regulatory Commission, following the guidelines provided in NUREG/CR-7002. The analysis and validation of PNGS ETE is provided for the DPZ, CPZ, and subsets of the PZ.

3.2 Detailed and Contingency Planning Zone Analysis

The Detailed Planning Zone (DPZ) is a 10 km ring surrounding PNGS. The Contingency Planning Zone (CPZ) is a 20 km ring, centered at PNGS and encompasses the DPZ. The PNGS ETE study estimates the 90 percent and 100 percent DPZ and CPZ ETE for 14 unique; time of day, day of week, season of year, weather, special event, and roadway impact scenarios. The scenarios evaluated as part of the third-party review for the PZ are shown in Table 2.

Table 2: Evacuation Scenario Descriptions

Scenario	Season	Day of the Week	Time of Day	Weather	Special Event
Scenario 1	Summer	Midweek	Midday	Good	None
Scenario 2	Summer	Midweek	Midday	Rain	None
Scenario 3	Summer	Weekend	Midday	Good	None
Scenario 4	Summer	Weekend	Midday	Rain	None
Scenario 5	Summer	Midweek, Weekend	Evening	Good	None
Scenario 6	Winter	Midweek	Midday	Good	None
Scenario 7	Winter	Midweek	Midday	Rain	None
Scenario 8	Winter	Midweek	Midday	Snow	None
Scenario 9	Winter	Weekend	Midday	Good	None
Scenario 10	Winter	Weekend	Midday	Rain	None
Scenario 11	Winter	Weekend	Midday	Snow	None
Scenario 12	Winter	Midweek, Weekend	Evening	Good	None
Scenario 13	Summer	Weekend	Midday	Good	Large event
Scenario 14	Summer	Midweek	Midday	Good	Highway Single Lane Closure

Figure 1 shows the vehicles per kilometer exiting the 16.09 km (10 mile) PZ for Scenario 1 for the 58 NPP sites in the U.S. as well as PNGS's 2015 DPZ (10 km), 2018 DPZ (10 km), and 2018 CPZ (20 km). The *x-axis* provides the range of PZ vehicles per kilometer (vpk). The *y-axis* provides the percentage of sites with vehicles per kilometer at the shown levels or lower. The PNGS 2015 ETE study reported that Scenario 1 has 18,834 vpk evacuating from the DPZ. The 2018 PNGS ETE study reports 24,180 vkp exiting the DPZ and 36,256 vph exiting the CPZ. From the figure, it is determined that, per kilometer, PNGS has the highest number of vehicles exiting the PZ than any NPP reviewed (in the 99th percentile). While the number of vehicles evacuating the DPZ is high, PNGS is comparable to Indian Point (18,353 vpk), Catawba (16,058 vpk) and Three Mile Island (15,465 vpk). However, the number of vehicles exiting the CPZ is nearly twice that of highest U.S. based site. This is because the PNGS CPZ extends into the suburbs of Toronto and unlike U.S. sites which only consider 16.09 km, the CPZ encompasses a radius of 20 km. It is likely that U.S. NPP sites that are situated near major cities, would likely see a similar, precipitous increase in population density as the evacuation radius increases.

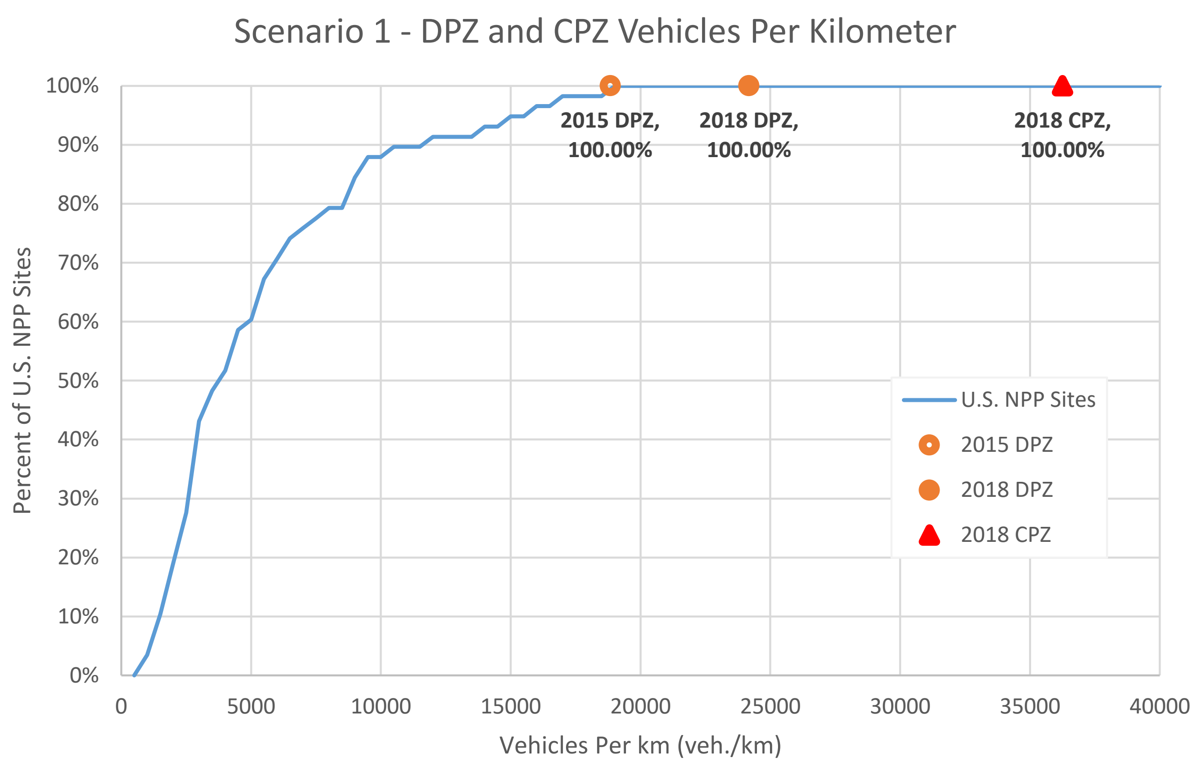

Figure 1: Vehicles Exiting the Planning Zone (per kilometer) for Scenario 1

Similarly, Figure 2 and Figure 3 show the 90 percent and 100 percent ETE times per kilometer for the 58 NPP sites in the U.S. as well as PNGS's 2015 DPZ, 2018 DPZ, and 2018 CPZ. The *x-axis* provides the range of PZ ETE times and the *y-axis* provides the percentage of sites with ETEs at the shown levels or lower. The 2015 DPZ shows that Scenario 1 has a 90 percent ETE time of 26.5 min/km, placing 2015 DPZ's 90 percent ETE in the 98th percentile of reviewed sites. The 2018 DPZ 90 percent ETE per kilometer is also in the 98th percentile at 27 min/km, while the 2018 CPZ value is significantly higher than any of the reviewed U.S. based sites at 54 min/km. The 100 percent ETE value for the 2015 DPZ is reported as 40.5 minutes per kilometer, placing it in the 99th percentile. However, the 2018 DPZ is lower, at 37.5 min/km, resulting in the site residing in the 98th percentile. Comparable U.S. sites are Three Mile Island and Turkey Point each having 100 percent ETE times of 36.04 minutes per kilometer, and Diablo Canyon's 100 percent ETE time per kilometer of 38.22 minutes. The 2018 CPZ is reported at 71.5 min/km, again the highest of any reviewed sites (99th percentile).

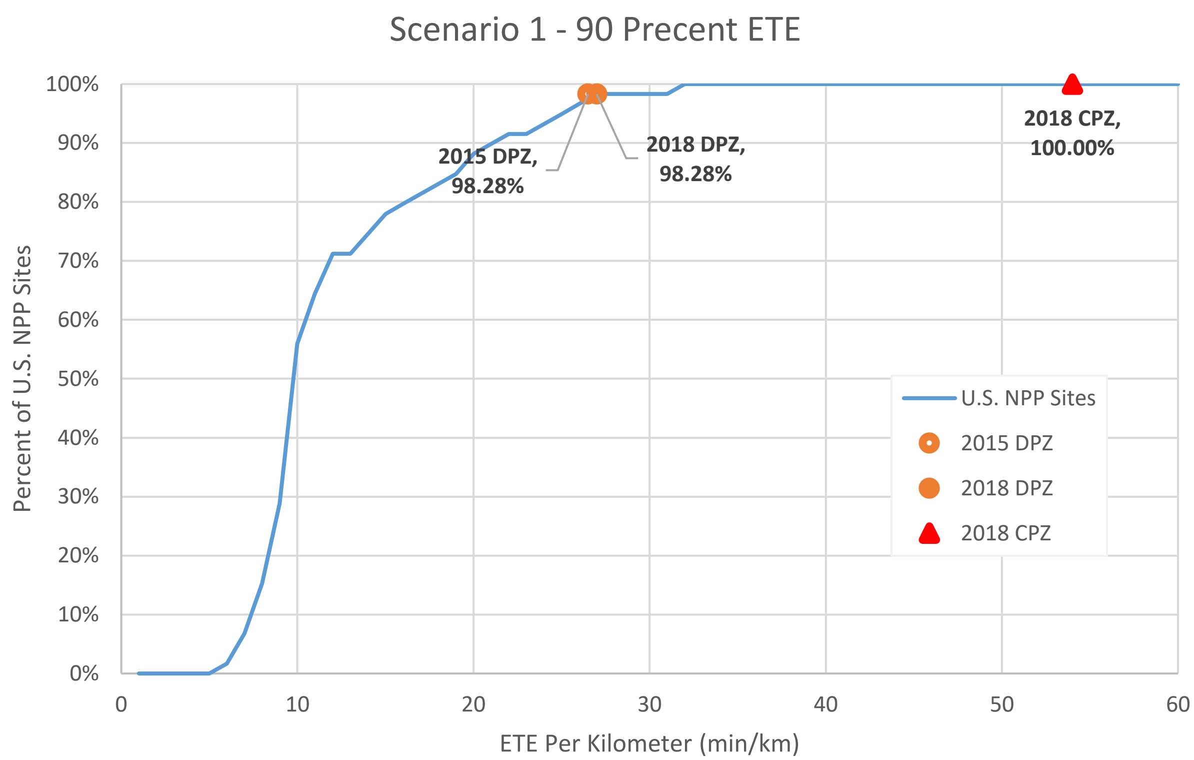

Figure 2: 90 Percent ETE (per kilometer) for Scenario 1

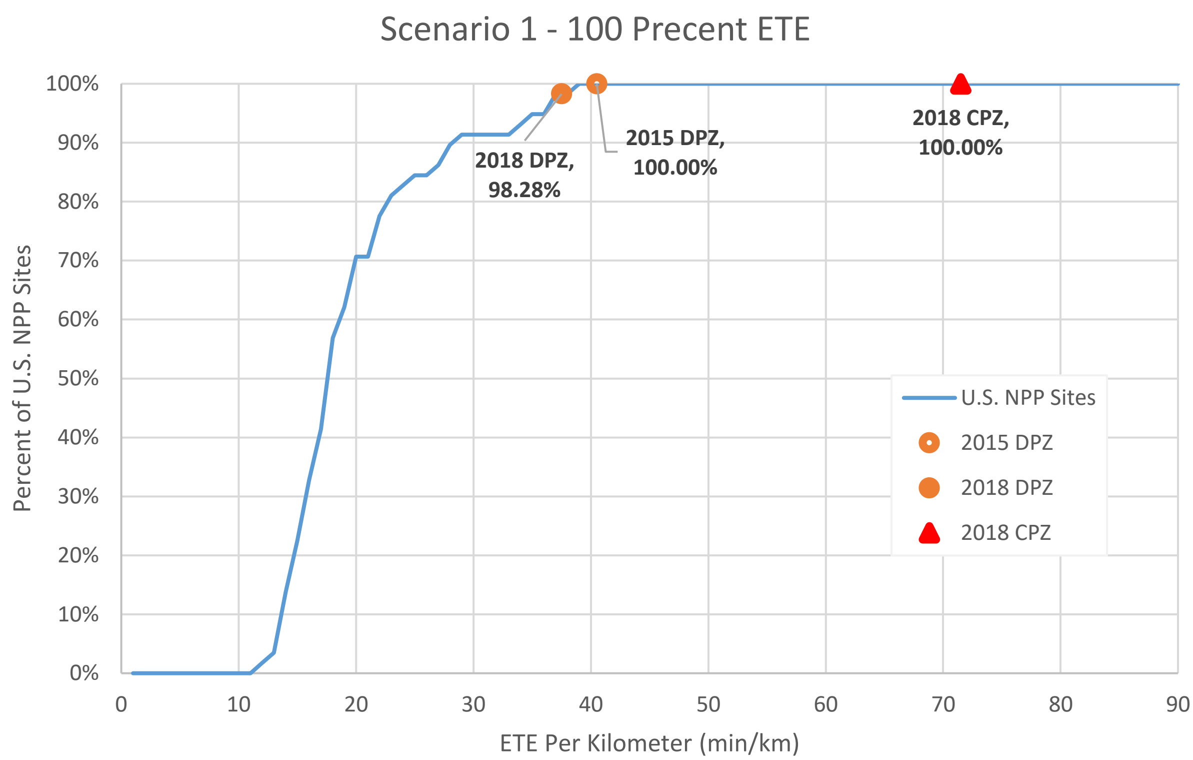

Figure 3: 100 Percent ETE (per kilometer) for Scenario 1

Figure 4 and Figure 5 show the 90 percent and 100 percent *P*-factor for the 58 NPP sites in the U.S. as well as PNGS's 2015 DPZ, 2018 DPZ, and 2018 CPZ. The *x-axis* provides a range of *P*-factor and the *y-axis* provided the percentage of sites with *P*-factors at the shown levels or lower. The 90 percent ETE *P*-factor for Scenario 1 for the 2015 DPZ is 8.44 sec/veh/km (31st percentile), the 2018 DPZ is 6.70 sec/veh/km (17th percentile), and the 2018 CPZ is 2.23 sec/veh/km (1st percentile). The 100 percent *P*-factor for Scenario 1 is reported for the 2015 DPZ as 12.90 (31st percentile), the 2018 DPZ as 9.31 sec/veh/km (12th percentile), and 2018 CPZ as 2.96 sec/veh/km (2nd percentile). When looking at the DPZ from either the 2015 or 2018 ETE studies, the *P*-factor values reported by the licensee are well within the range of other North American NPP sites. The analysis finds that an increase in the population between the 2015 study and the 2018 actually resulted in a lower *P*-factor. This is because while the 2018 study had a higher number of evacuating vehicles, the ETE values reported are generally the same or lower. The cause of this decrease is the completion of several transportation infrastructure improvements projects after the 2015 study took place. Therefore, more vehicles are loaded onto the road network due to population growth, but subsequently evacuated more quickly as a result of the increased network capacity. This suggest a more efficient evacuation causing the lower *P* –factor.

This *P*-Factor analysis attempts to control for geographic size and population of the PZ. When the evacuation radius is extended out to 20 km for the CPZ, the *P*-Factor decreases significantly. This suggest that as the network extends into the Toronto suburbs, the roadway network becomes more diverse, allowing for increased efficiencies in the evacuation processe i.e. more, high capacity exit/evacuation routes. This is typical for an economically developed area without major hindrances to transportation development (bridges, rivers, geopolitical boundaries). The *P*-factor for the PNGS is comparable to other large population sites located within close proximity to major population centers, such as Indian Point near New York, NY (2.27 sec/veh/km) and Catawba near Charlotte SC (4.47 sec/veh/km).

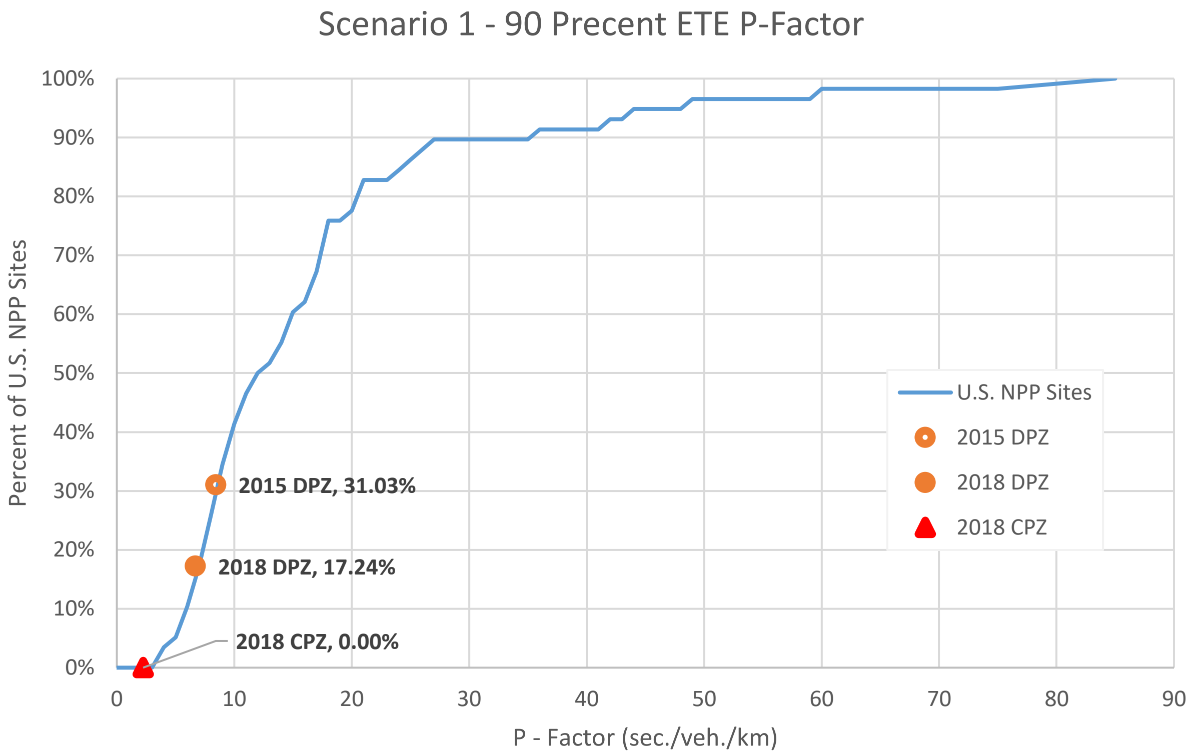

Figure 4: 90 Percent ETE *P*-Factor for Scenario 1

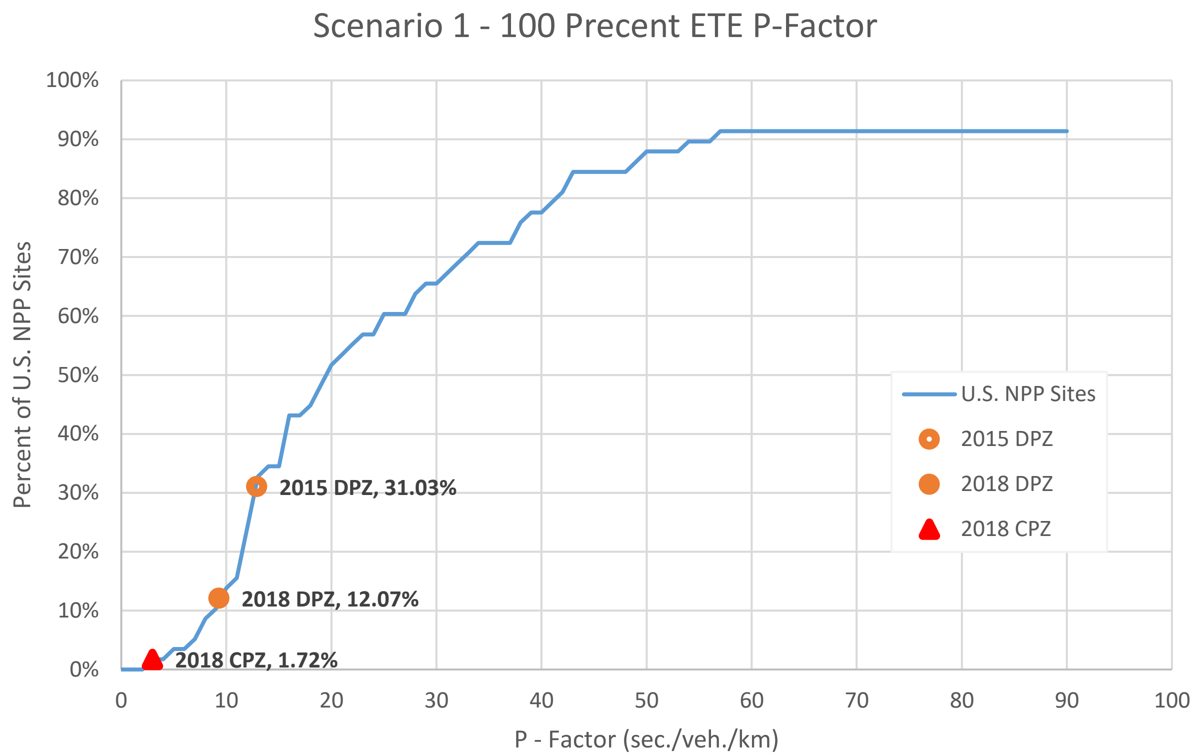

Figure 5: 100 Percent ETE *P*-Factor for Scenario 1

Appendix A provides the cumulative distribution functions for the PZ vehicles (per kilometer), 90 percent and 100 percent ETE (per kilometer), and *P*-factors for all 14 scenarios reported in Table 2. Table 3 and Table 4 summarize the results from the validation of the PZ ETE and *P*-factor analysis. The results suggest that PNGS consistently shows the highest number of evacuating vehicles, per kilometer of any NPP site reviewed, regardless of scenario. This is likely because the zoning requirements in the U.S. differ from those in Canada. The 90 percent and 100 percent ETE times are consistently ranked among some of the highest reported. This is an expected finding because of the higher populations evacuating the PZ. Comparable ETE times are seen for other high population U.S. sites such as Indian Point, Diablo Canyon, and Catawba. When controlling for the geographic size and population of PZ, the *P*-factor analysis suggest the ETE times reported by the PNGS licensee are appropriate. As a whole, the ETE times are consistent to other high population density NPP sites in North America.

Table 3: PNGS ETE Percentile Ranking Comparison to U.S. NPP Sites

Scenario	Vehicles (per km)	90% ETE (per km)			100% ETE (per km)		
		2015 DPZ	2018 DPZ	2018 CPZ	2015 DPZ	2018 DPZ	2018 CPZ
Scenario 1	99%	98%	98%	99%	99%	98%	99%
Scenario 2	99%	98%	98%	99%	99%	98%	99%
Scenario 3	99%	96%	96%	99%	99%	98%	99%
Scenario 4	99%	96%	94%	99%	99%	93%	99%
Scenario 5	99%	98%	94%	99%	99%	96%	99%
Scenario 6	99%	98%	98%	99%	99%	96%	99%
Scenario 7	99%	98%	98%	99%	99%	96%	99%
Scenario 8	99%	99%	99%	99%	99%	99%	99%
Scenario 9	99%	98%	98%	99%	99%	98%	99%
Scenario 10	99%	98%	98%	99%	99%	98%	99%
Scenario 11	99%	99%	99%	99%	99%	99%	99%
Scenario 12	99%	98%	98%	99%	99%	99%	99%
Scenario 13	99%	94%	93%	99%	94%	91%	98%
Scenario 14	99%	96%	96%	99%	98%	96%	99%

Table 4: PNGS *P*-Factor Comparison to U.S. NPP Sites

Scenario	90% P-Factor			100% P-Factor		
	2015 DPZ	2018 DPZ	2018 CPZ	2015 DPZ	2018 DPZ	2018 CPZ
Scenario 1	31%	17%	0%	31%	12%	1%
Scenario 2	29%	15%	0%	34%	12%	1%
Scenario 3	27%	15%	0%	32%	12%	1%
Scenario 4	29%	15%	0%	32%	12%	1%
Scenario 5	29%	18%	0%	25%	15%	1%
Scenario 6	27%	17%	0%	31%	10%	1%
Scenario 7	27%	17%	0%	32%	10%	1%
Scenario 8	32%	15%	0%	36%	13%	2%
Scenario 9	27%	17%	0%	29%	12%	1%
Scenario 10	27%	17%	0%	32%	12%	1%
Scenario 11	30%	21%	0%	30%	13%	2%
Scenario 12	29%	18%	0%	24%	15%	1%
Scenario 13	25%	13%	0%	25%	8%	1%
Scenario 14	22%	12%	0%	25%	10%	1%

3.3 Subsets of the Planning Zones Analysis

A similar analysis to the one conducted on the CPZ and DPZ, is provided for the 3 km ring and 6 km ring, both subsets of the DPZ. Because vehicle populations per scenarios are not as readily available for all 58 comparative NPP sites, permanent resident population is used in its place. This prevented a scenario-by-scenario comparison, like the one conducted for the other PZ. Instead, the analysis of the PZ subset only investigates ETE times corresponding to Scenario 1 (summer, midweek, mid-day, good weather, no special event). The cumulative distribution functions for the three kilometer ring are provided in Appendix B. Likewise, the cumulative distributions functions for the six kilometer ring are provided in Appendix C.

Table 5 and Table 6 show a summary of the validation results for the three kilometer and six kilometer rings. Table 5 provides the a comparisons of the resident populations within each ring and the 90 percent and 100 percent ETE comparisons. Table 6 show the results of the *P*-factor comparison. A review of ETE studies found high variations in the resident populations of the smaller ring subsets. Some sites with lower than average PZ population have relatively high three kilometer ring populations and vise-versa. A number of sites also have zero permanent residents residing within the three kilometer ring. Therefore, the population results shown here, and by extension the *P*-factor results, may not be as insightful as those for the larger PZs. The 90 percent and 100 percent ETE per kilometer results suggest the subset of the PZ performed similar to the larger ringed DPZ and CPZ (showing ETE values ranging from the 86th percentile to the 99th percentile). This is an expected finding and consistent with other NPP sites in North America.

Table 5: PNGS PZ Subset Percentile Ranking Comparison to U.S. NPP Sites

PZ Ring	Resident Population		90% ETE (per km)		100% ETE (per km)	
	2015 PZ	2018 PZ	2015 PZ	2018 PZ	2015 PZ	2018 PZ
3 km	94%	94%	86%	91%	96%	96%
6 km	99%	99%	90%	91%	91%	91%

Table 6: PNGS PZ Subset P-Factor Comparison to U.S. NPP Sites

PZ Ring	90% P-Factor		100% P-Factor	
	2015 PZ	2018 PZ	2015 PZ	2018 PZ
3 km	6%	6%	9%	9%
6 km	1%	1%	1%	1%

4.0 RECOMMENDATIONS AND CONCLUSIONS

NUREG/CR-7002 provides guidance and a consistent methodology toward the development of ETE studies for U.S. based NPP sites. The current state-of-the-practice in the development of ETE studies relies heavily on traffic simulation modeling. The development of a reliable model is in turn based on a variety of data collection procedures, assumptions, and in many cases, expert judgment. The objective of this report is to present the results of an independent, third-party evaluation of the PNGS ETE study, conducted in compliance with NUREG/CR-7002.

In general, the results of the third-party evaluation showed the PNGS ETE study adhered to the guidance provided in NUREG/CR-7002. The results of the review show that the initial conditions and assumptions are consistent with the guidance provided as well as the state-of-the-practice in ETE development and traffic simulation modeling. Based on these findings the evacuation model is determined to be properly supported. Furthermore, the review shows the initial conditions, assumptions, modeling methodology, scenarios, and analysis conducted as part of the PNGS ETE study did not substantively deviate from similar studies accepted by the U.S. Nuclear Regulatory Commission.

The review found that while consistent with prior ETE studies conducted in the U.S., several shortcomings were initially present in the report. The majority of these have been resolved through discussions with the licensee. The remaining discrepancies, in general, relate to the inventories of buses, wheelchair buses, and ambulances available to facilitate the evacuation of special facilities and special needs individuals. The review found that the report did not provide an inventory on the number buses, wheelchair buses, and ambulances that could be made available during the evacuation. Without this information, it is unknown if transit dependent evacuees and special facilities would require a second-wave evacuation and therefore the ETE for this population cannot be definitively estimated. Although unlikely, depending on the availability of resources a third-wave evacuation could possibly be needed. The report also omitted the number and time required to evacuate special needs individuals who do not reside at medical facilities. These are individuals who live independently, but cannot evacuate themselves. It is unlikely that the evacuation of special needs individuals would extend the overall ETE time. However, without an accurate estimate of the number of individuals, mobilization time, or required resources, an ETE cannot be determined for this population.

The third-party evaluation of the PNGS ETE study also sought to validate the evacuation times required for the PZ and subsets of the PZ. To accomplish this, the ETE times provided by the PNGS are systematically compared with those from 58 NPP sites in the U.S. The analysis found that while PNGS showed the highest number of vehicles evacuating, per kilometer, the ETEs are consistent with other high population sites in North America. Furthermore, the results show that when controlling for geographical size and population, the PNGS ETEs are consistent with prior ETE studies accepted by the U.S. Nuclear Regulatory Commission.

4.1 Recommendations

Based on the findings the third-party review, several recommendations are identified which could enhance the PNGS ETE study and report. The majority of these recommendations have been incorporated into the report or otherwise resolved though discussion with the licensee. These recommendations are labeled *Resolved* under the *Status* column. The remaining recommendations yet to be addressed are labeled either *Missing* or *Deficient*. The recommendations are provide in Table 7.

Table 7: Review Recommendations

Review Section	Status	Recommendations
Modeling		
Description of the regions topography and map	Resolved	Response to CNSC Comments has added an additional discussion to include topographic feature that would impact highway grades and subsequently capacity. Figure 1-1 has been modified to show topographic features.
Heavy vehicles in the simulation model	Resolved	The model assumed a three percent heavy vehicle factor and added section to describe the modeling thereof.
Background traffic in the simulation model	Resolved	The model included a 30-minute seeding period before the state of the simulation. A section has been added to background traffic and model seeding.
Transit Dependent Population		
The use of a 68 percent bus capacity	Resolved	The discussion and distraction between bus capacity and loading have described with additional detail and clarity.
Identify the location of bus stops that will be serviced during the evacuation	Resolved	Bus stop locations have been added to Figures 10-2 through 10-7.
Inventory of buses available to service transit dependent population.	Resolved	The licensee has shown that adequate buses can be available in the event that a subset of the DPZ is evacuated. No information is provided in the event of an evacuation of the entire DPZ.
Special Facilities		
Location, description, and capacity of Reception Centers outside the PZ.	Resolved	Locations of the reception centers is redacted from both of the ETE reports upon request from OPG.
Second-wave ETE calculation for correction facilities	Resolved	A second-wave evacuation for correction facilities is included.

Inventory of buses, wheelchair buses, and ambulances available to service special facilities.	Missing	No inventory of buses, wheelchair buses, and ambulances has been conducted. Insufficient resources could lead to a major delay in evacuating these populations.
Special Needs Individuals		
Estimate of the number of people needing evacuation assistance, but do not reside at special facilities.	Missing	The ETE study incorporates the people needing evacuation assistance, but do not reside at special facilities into the transit dependent population. This ignores their need for assistance. This is what disguises this population from the transit dependent population as a whole. These individuals need assistance to evacuate, without it, they are stranded. For this reason, NUREG/CR-7002 separates this population from other transit evacuees.
ETE for the people needing evacuation assistance, but do not reside at special facilities.	Missing	Because these individuals are included in with other transit dependent populations, no ETE is specifically provided.
Inventory of buses, wheelchair buses, and ambulances available to service special facilities.	Missing	No inventory of buses, wheelchair buses, and ambulances has been conducted. Insufficient resources could lead to a major delay in evacuating these populations.
Other		
An estimate of the permanent resident population at identified facilities when the evacuation is ordered The percent of permanent residents assumed to be at facilities.	Resolved	The licensee provided additional details for calculating the percent of permanent residents at facilities when the evacuation order is given.
Calculations for a representative roadway segment should be provided	Resolved	NUREG/CR-7002 states this calculation as a requirement. However, this is not a practical requirement for ETE studies which utilize traffic simulations.
A list of intersections and their control type should be provided	Resolved	The table is redacted upon request from OPG.
The traffic management plan for intersection EVA07 and EVA50ai modified	Resolved	Changes to the traffic management plan made during the 2015 and 2018 study have been discussed with the Durham Region Police Service Emergency Management personnel.

When an updated ETE analysis is required?	Resolved	The ETE reports are conducted in accordance with CNSC REGDOC-2.10.1 regarding future year ETE [5].

5.0 REFERENCES

[1] Appendix E to 10 CFR Part 50—Emergency Planning and Preparedness for Production and Utilization Facilities.

[2] NUREG/CR-4831, "State of the Art in Evacuation Time Estimate Studies for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, D.C., 1992.

[3] NUREG/CR-6863, "Development of Evacuation Time Estimate Studies for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC, January 2005.

[4] NUREG/CR-7002, "Criteria for Development of Evacuation Time Estimate Studies," U.S. Nuclear Regulatory Commission, Washington, DC, November 2011.

[5] REGDOC-2.10.1, Version 2, "Emergency Management and Fire Protection Nuclear Emergency Preparedness and Response," Canadian Nuclear Safety Commission, Ottawa, CA, 2016.

APPENDIX A – PLANNING ZONE (PZ) ETE ANALYSIS

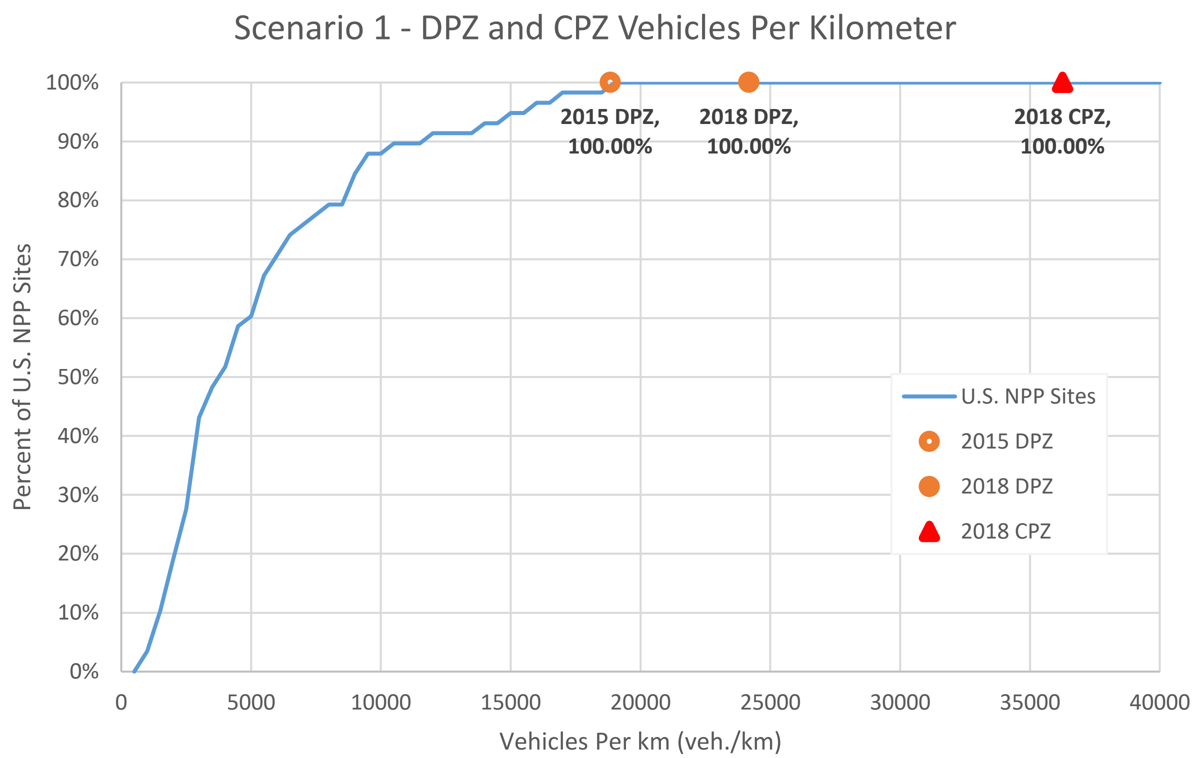

Figure A **- 6: Scenario 1 – Planning Zone Vehicles Per Kilometer**

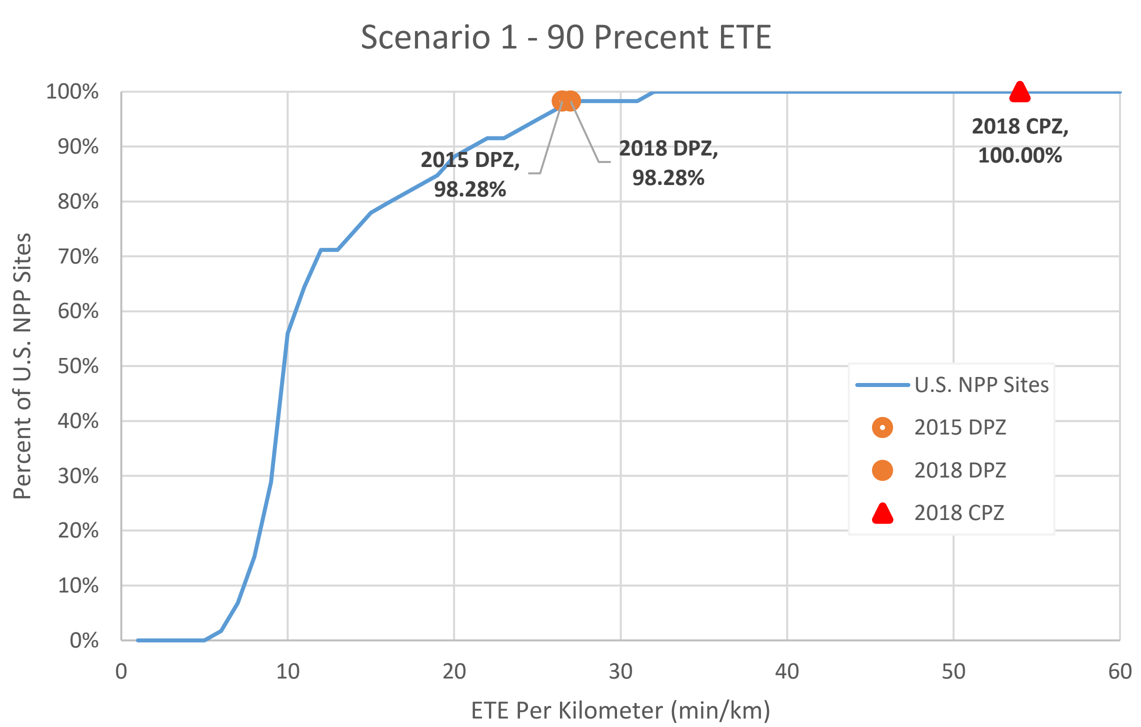

Figure A **- 7: Scenario 1 – Planning Zone 90 Percent ETE Per Kilometer**

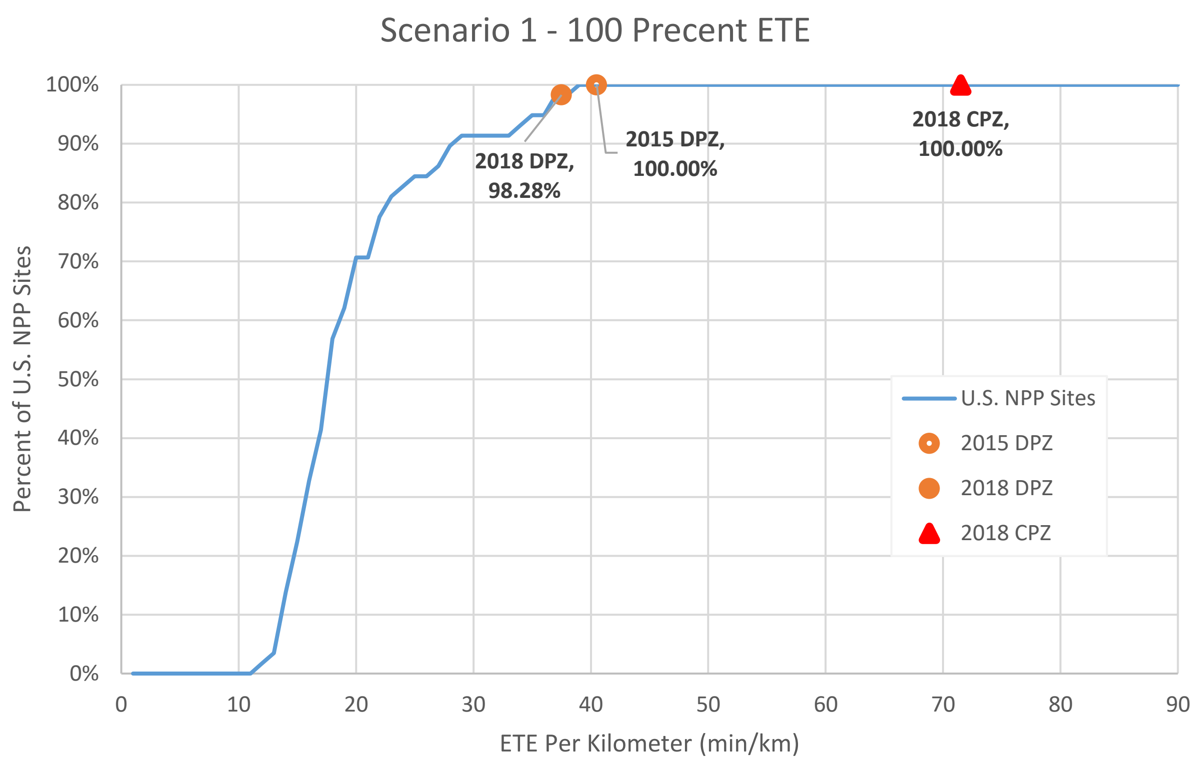

***Figure A* - 8: Scenario 1 – Planning Zone 100 Percent ETE Per Kilometer**

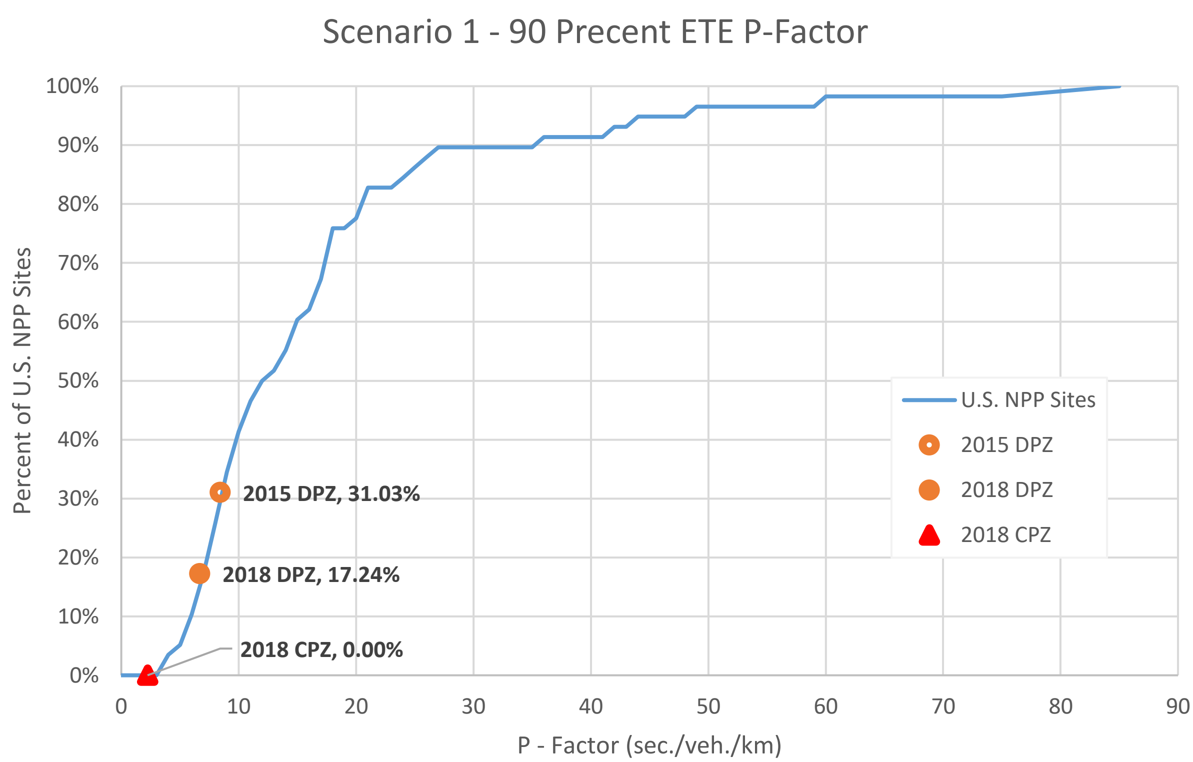

***Figure A* - 9: Scenario 1 – Planning Zone 90 Percent ETE *P* - Factor**

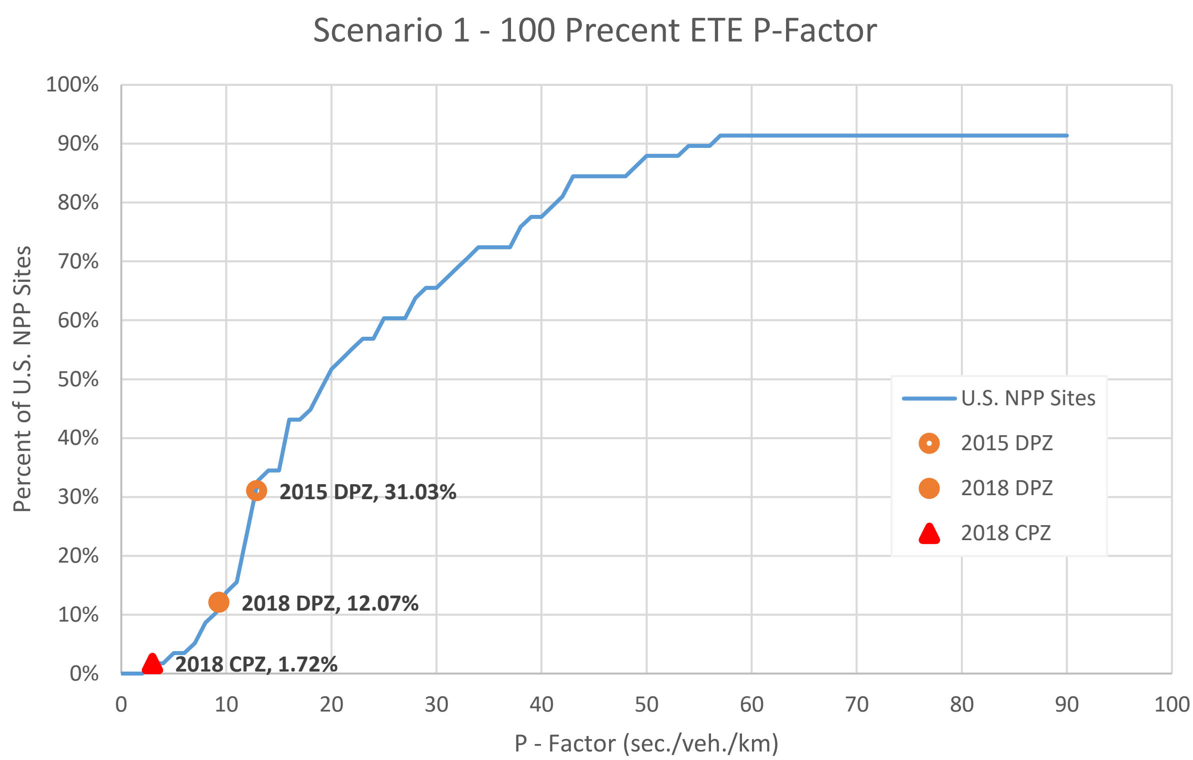

Figure A **- 10: Scenario 1 – Planning Zone 100 Percent ETE *P* - Factor**

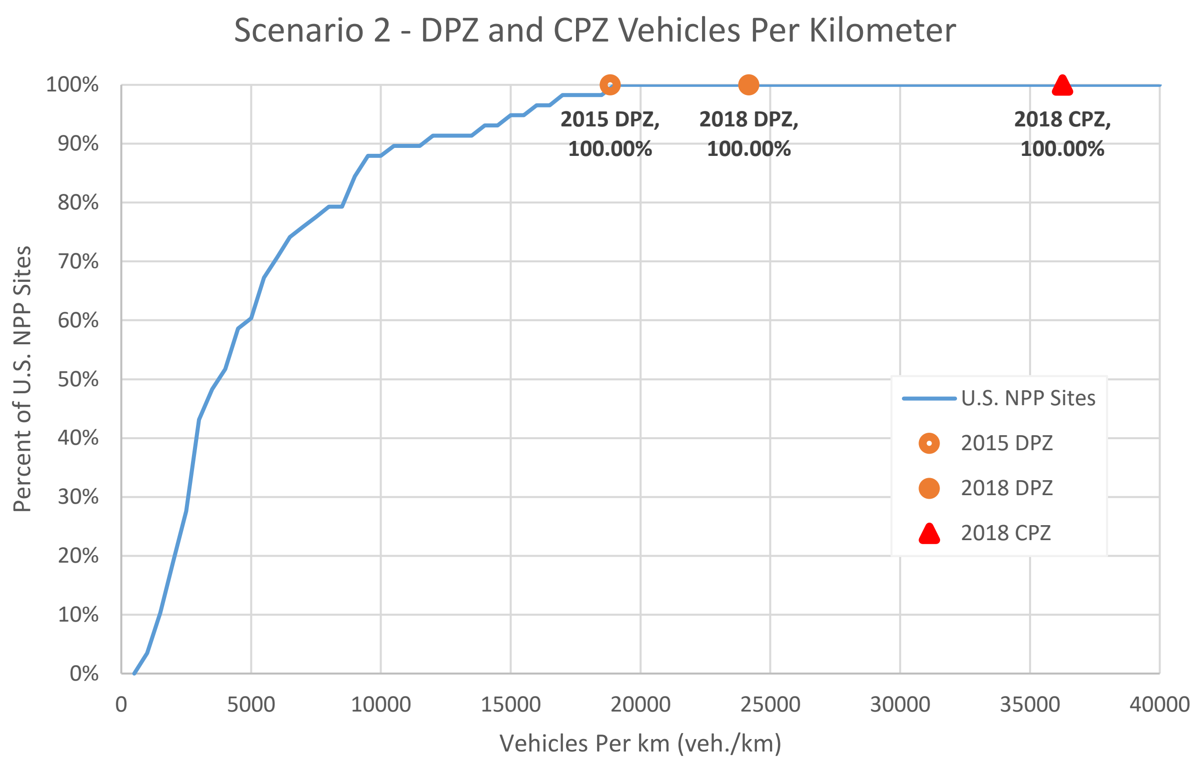

Figure A **- 11: Scenario 2 – Planning Zone Vehicles Per Kilometer**

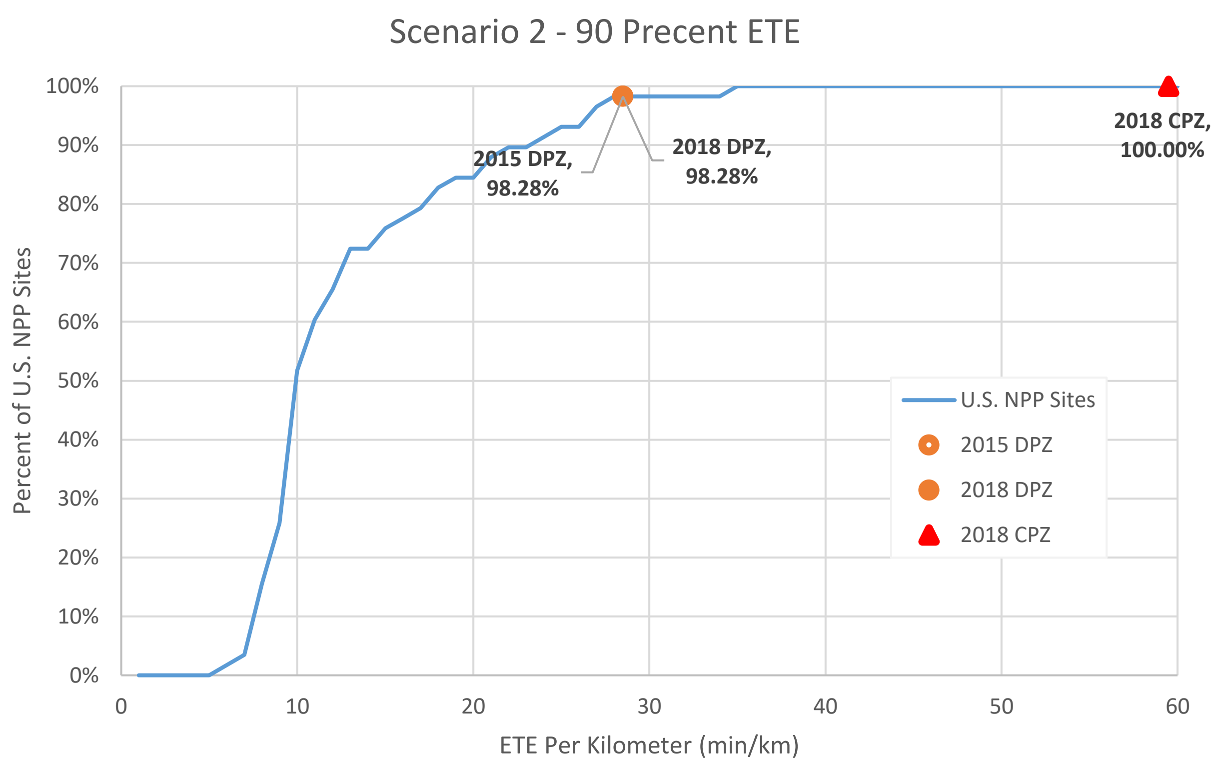

Figure A **- 12: Scenario 2 – Planning Zone 90 Percent ETE Per Kilometer**

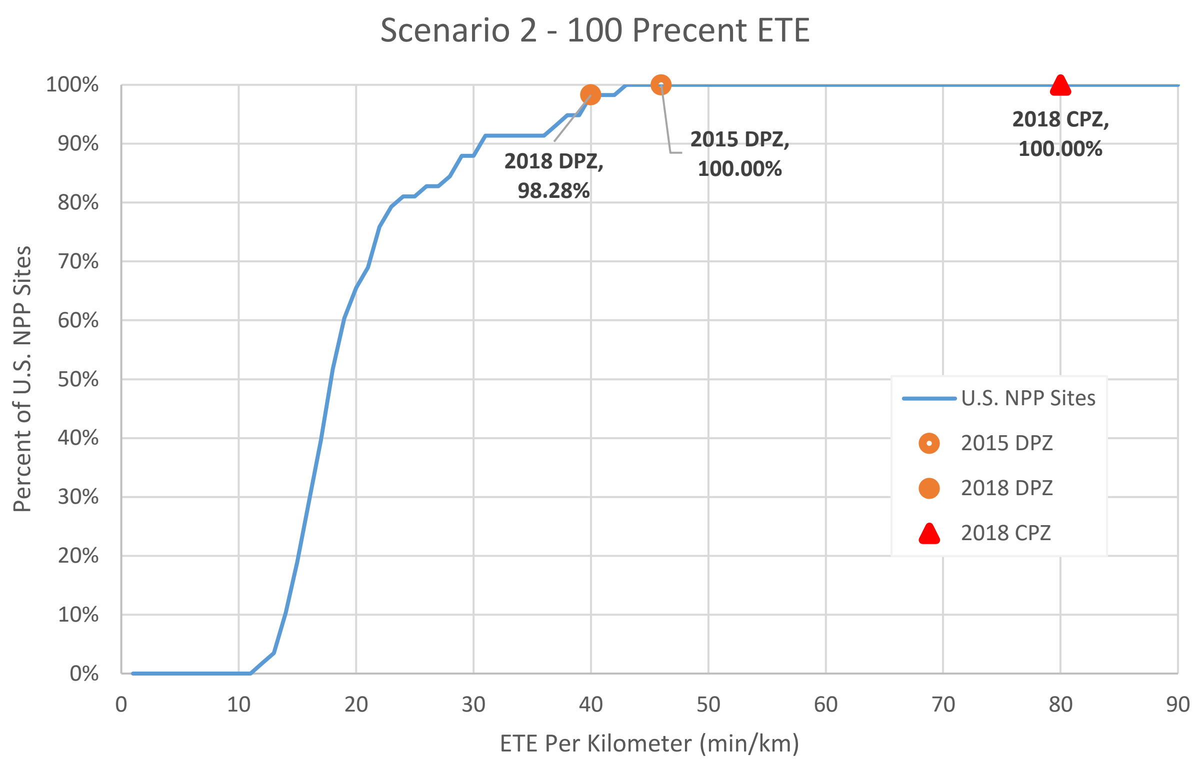

Figure A **- 13: Scenario 2 – Planning Zone 100 Percent ETE Per Kilometer**

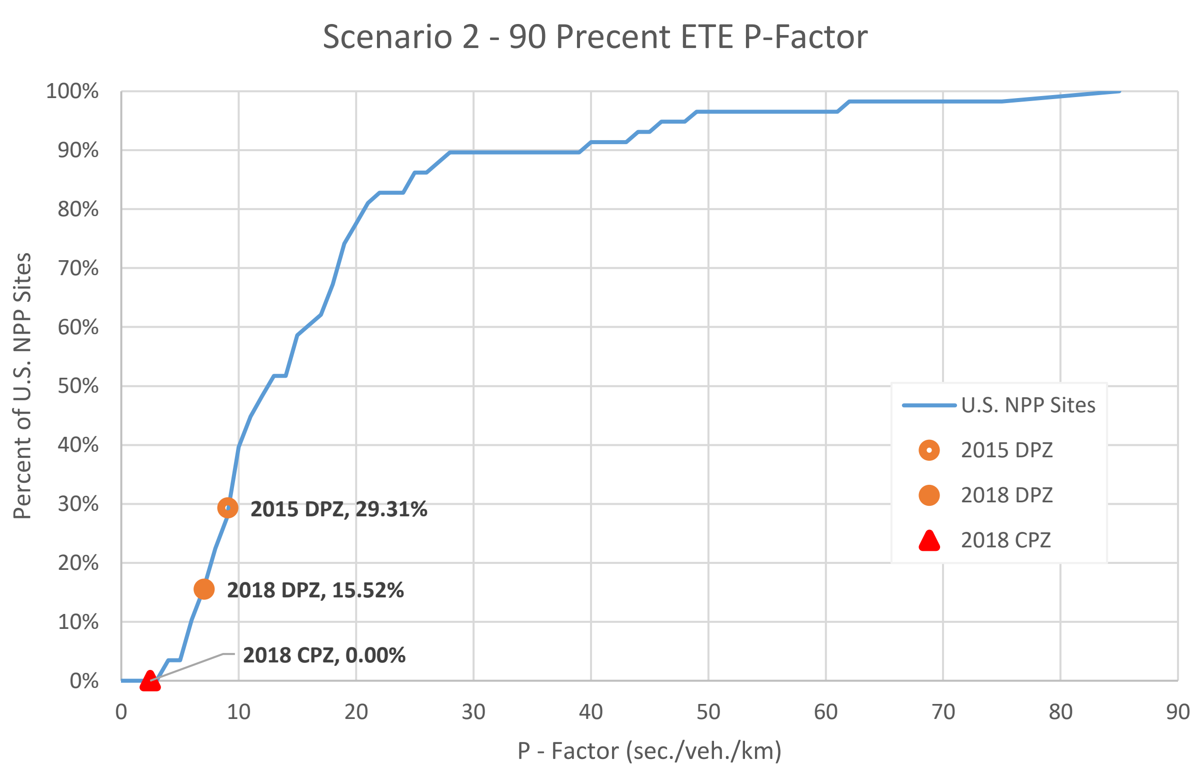

Figure A **- 14: Scenario 2 – Planning Zone 90 Percent ETE *P* - Factor**

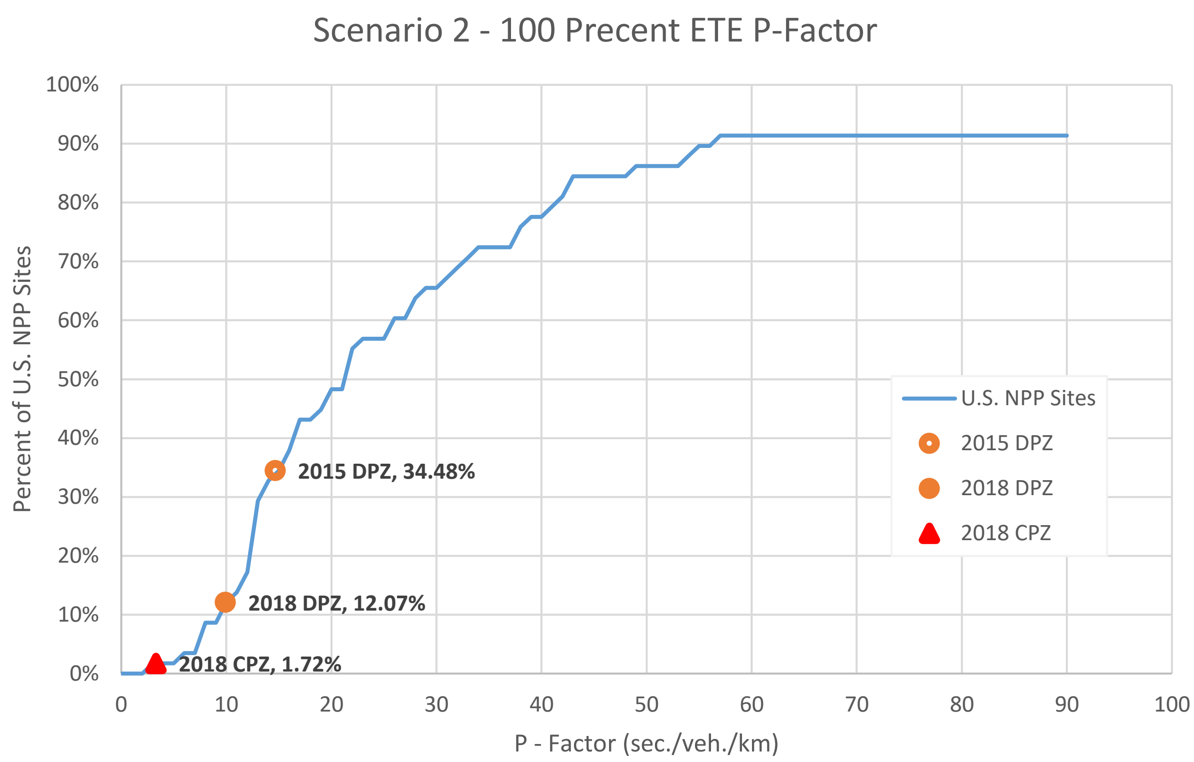

Figure A **- 15: Scenario 2 – Planning Zone 100 Percent ETE *P* - Factor**

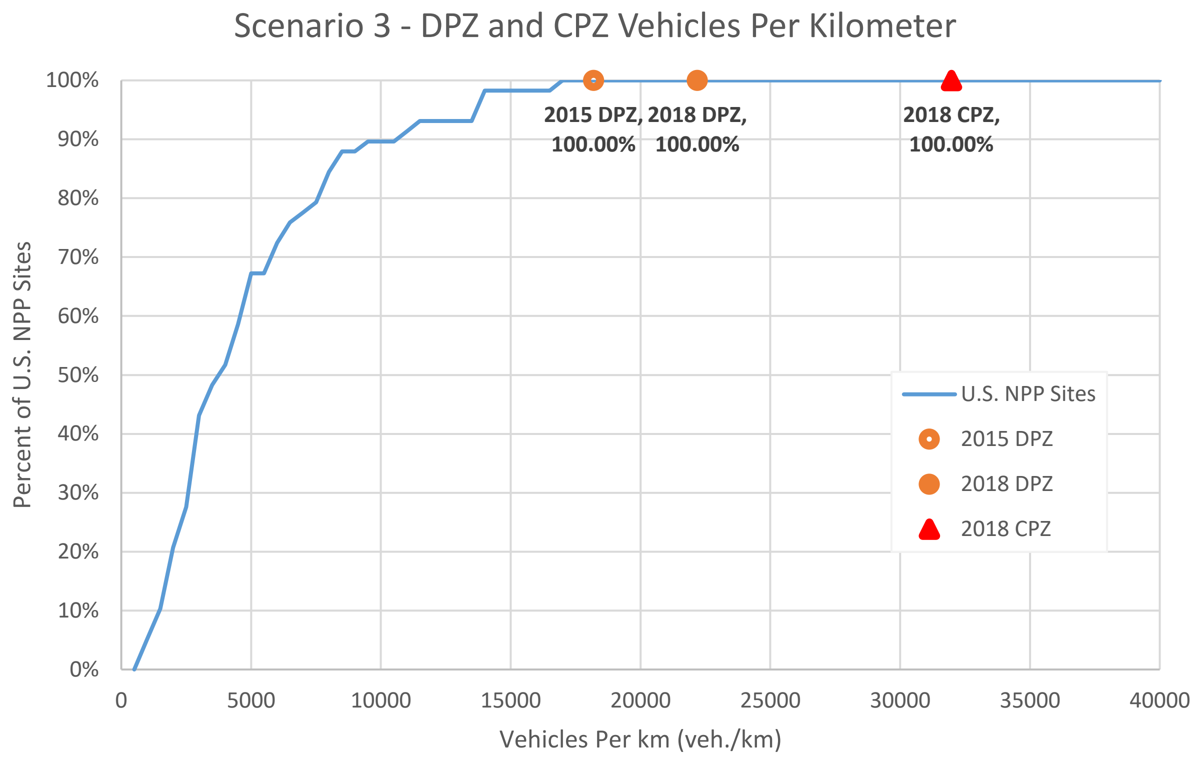

Figure A **- 16: Scenario 3 – Planning Zone Vehicles Per Kilometer**

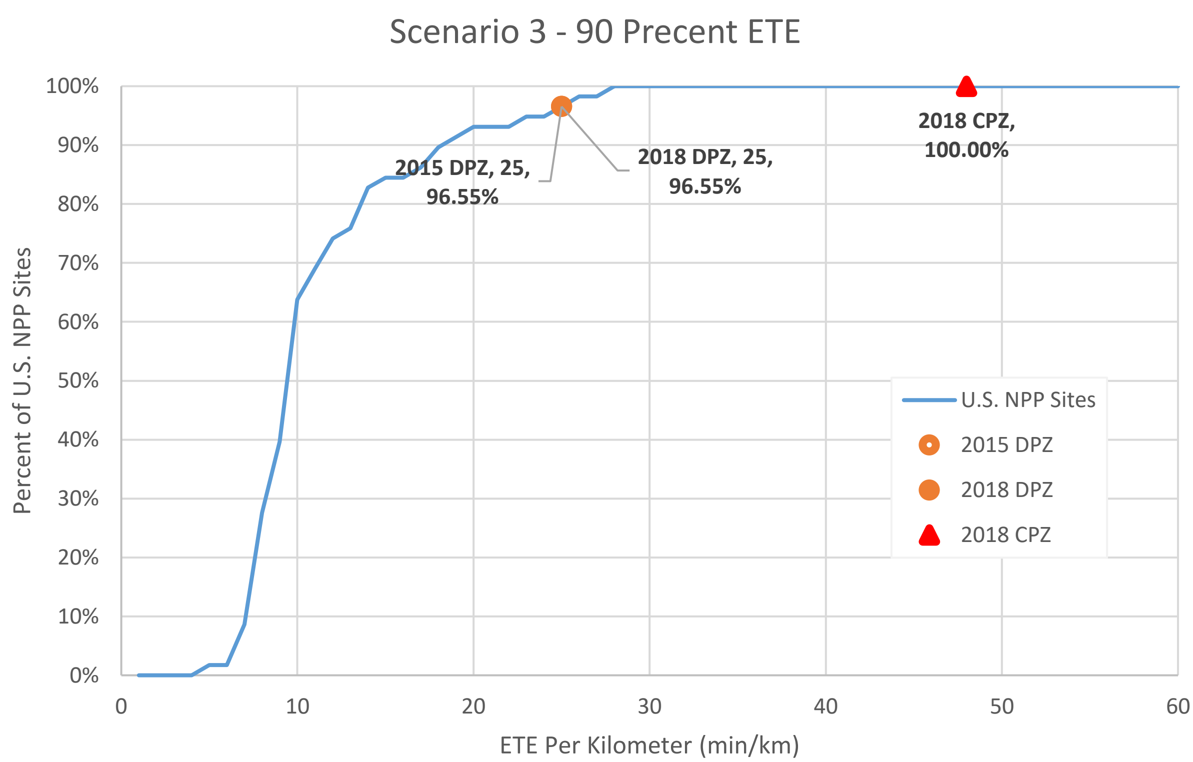

Figure A **- 17: Scenario 3 – Planning Zone 90 Percent ETE Per Kilometer**

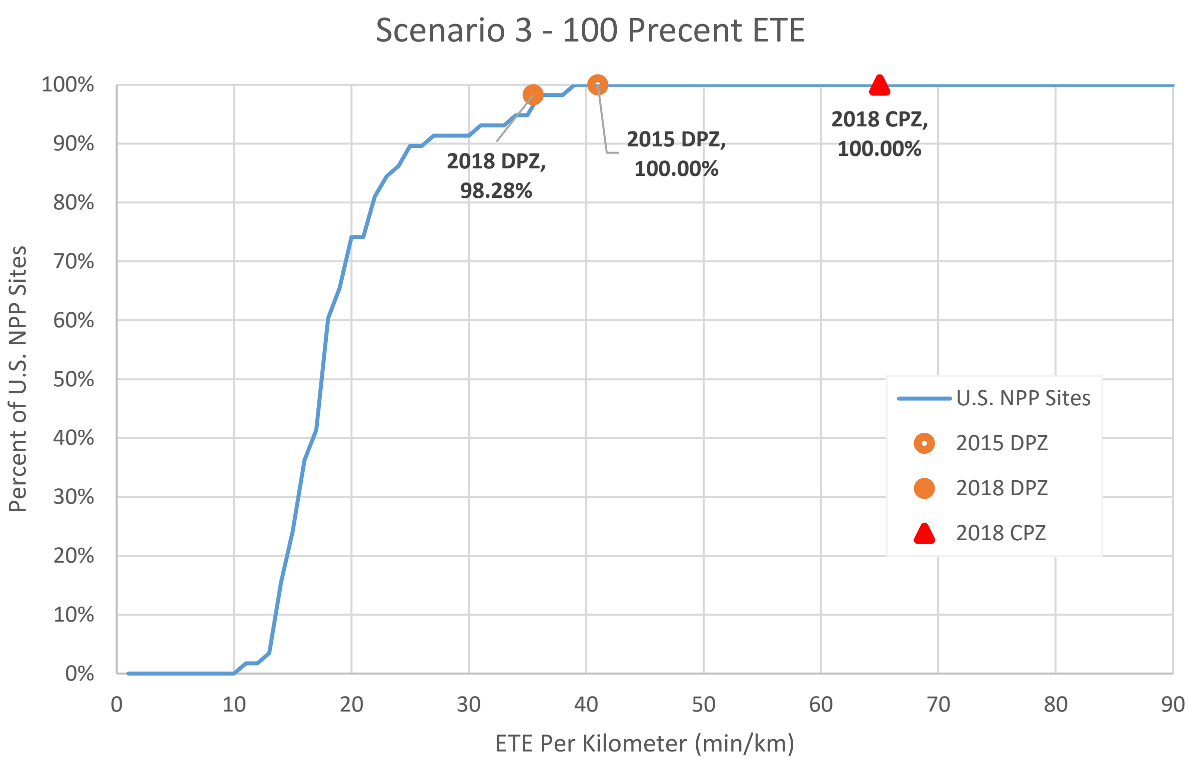

Figure A **- 18: Scenario 3 – Planning Zone 100 Percent ETE Per Kilometer**

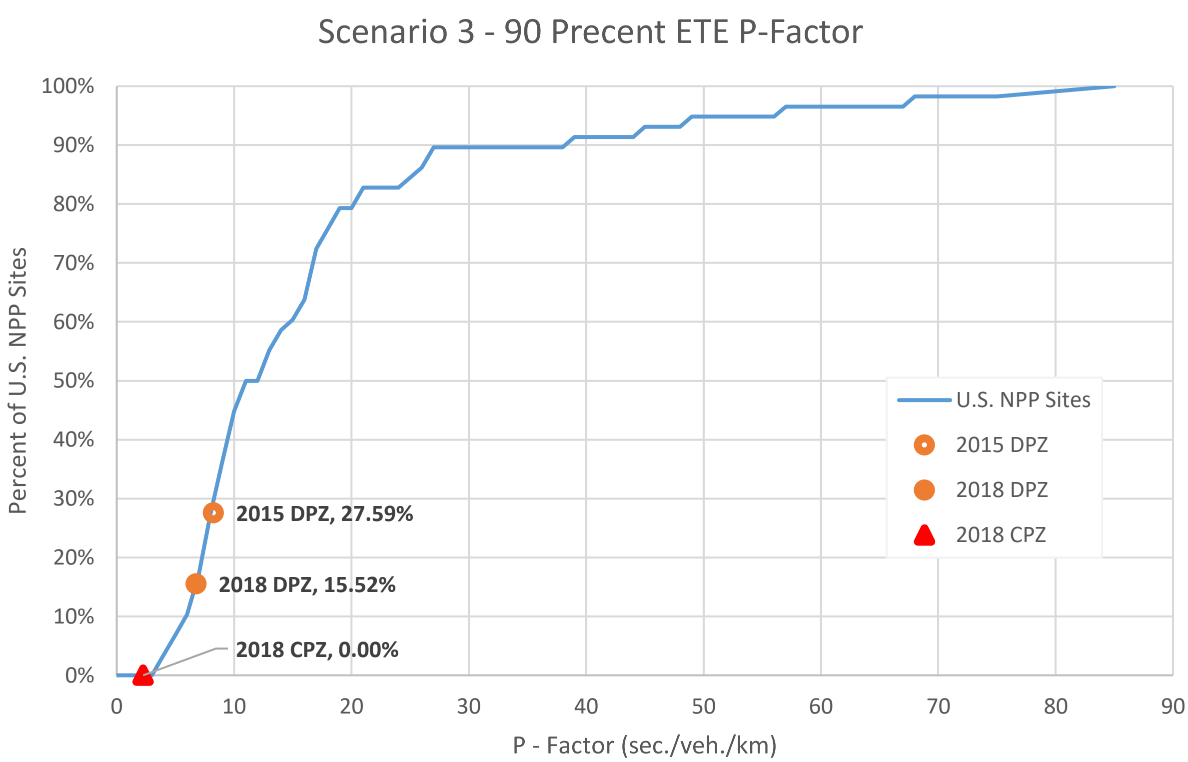

Figure A **- 19: Scenario 3 – Planning Zone 90 Percent ETE** ***P*** **- Factor**

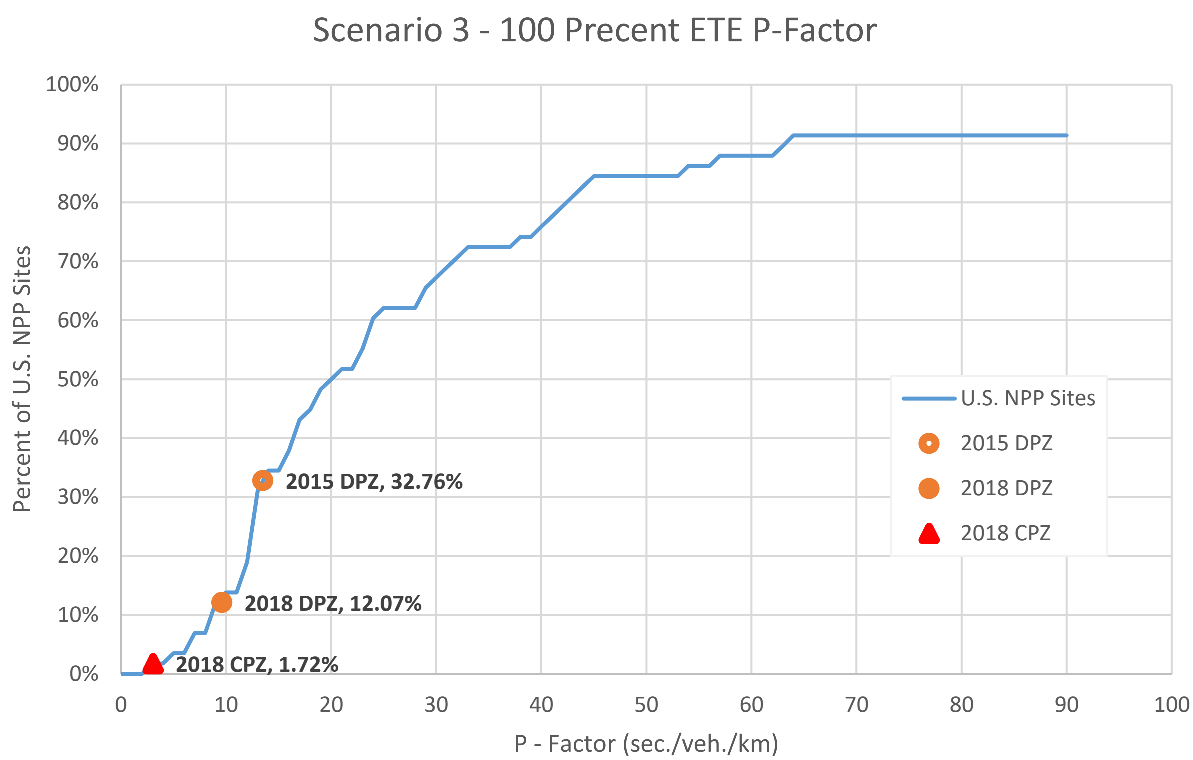

Figure A **- 20: Scenario 3 – Planning Zone 100 Percent ETE *P* - Factor**

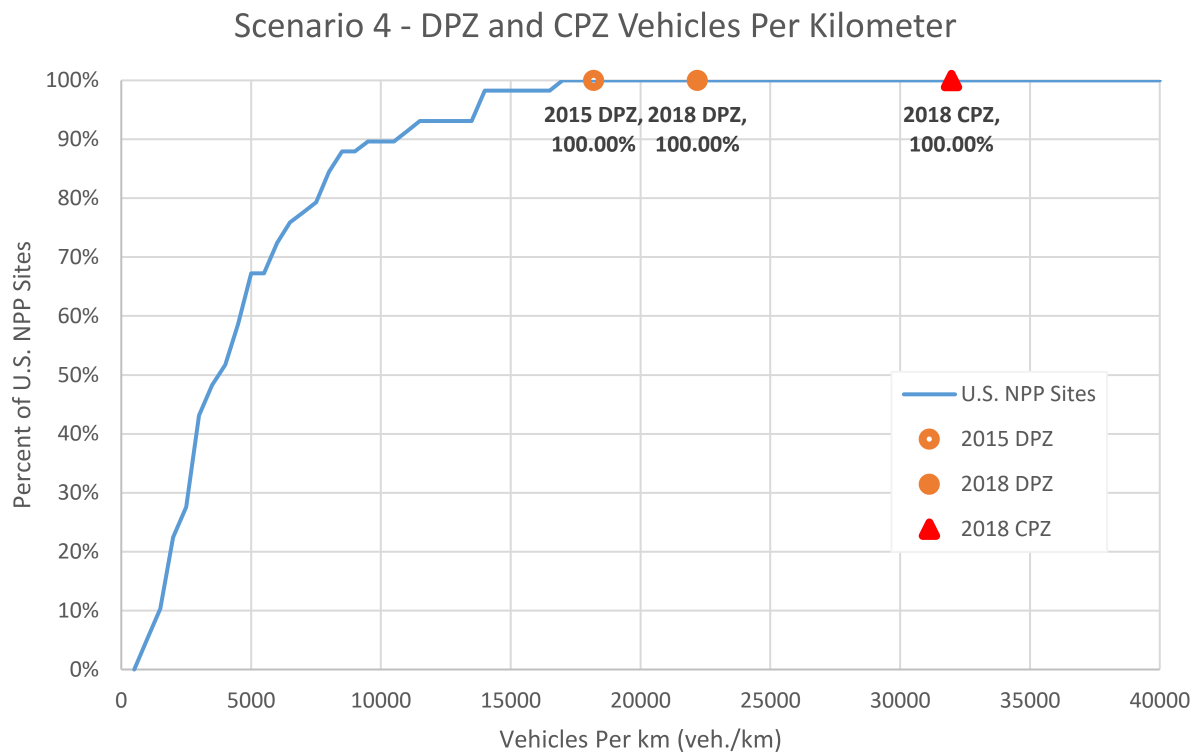

Figure A **- 21: Scenario 4 – Planning Zone Vehicles Per Kilometer**

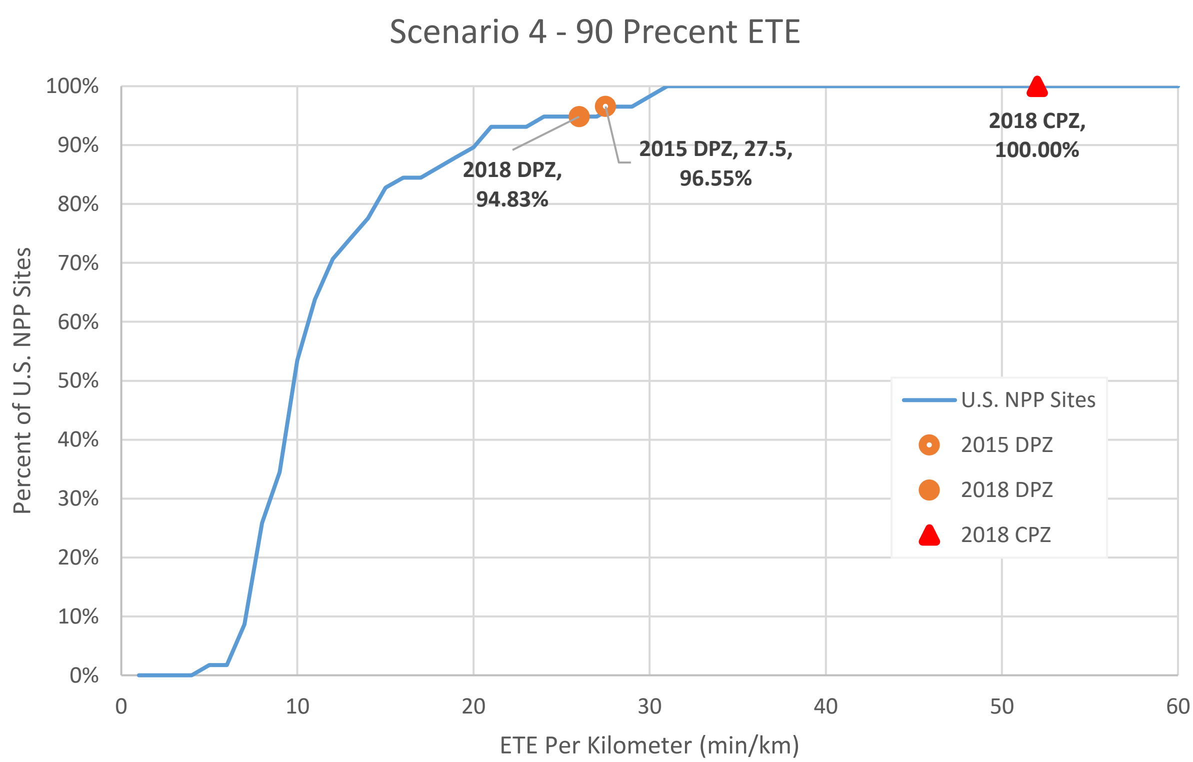

Figure A **- 22: Scenario 4 – Planning Zone 90 Percent ETE Per Kilometer**

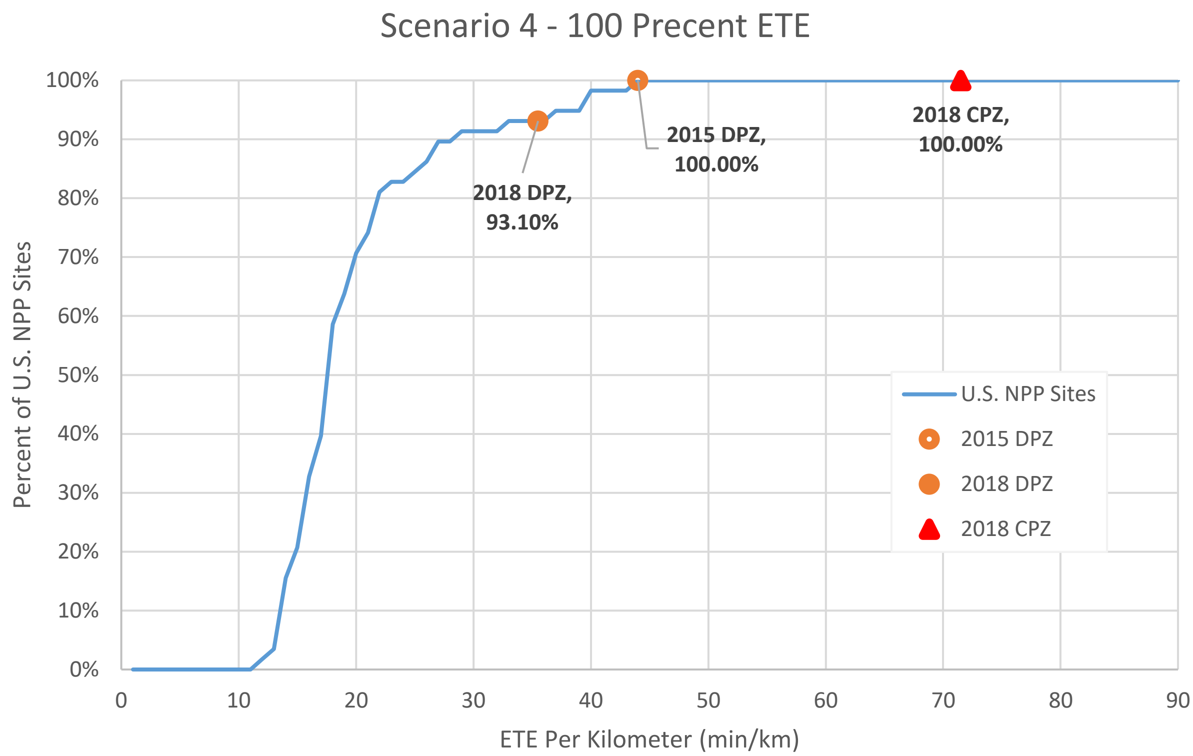

Figure A **- 23: Scenario 4 – Planning Zone 100 Percent ETE Per Kilometer**

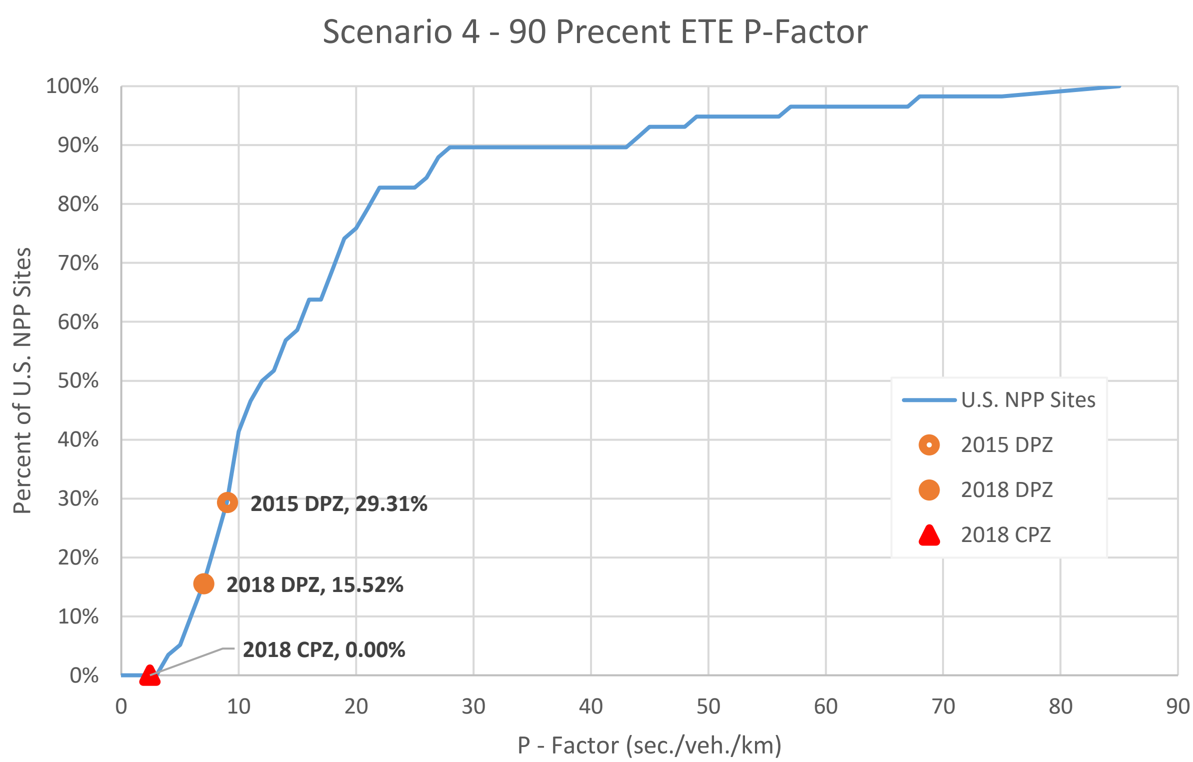

Figure A **- 24: Scenario 4 – Planning Zone 90 Percent ETE *P* - Factor**

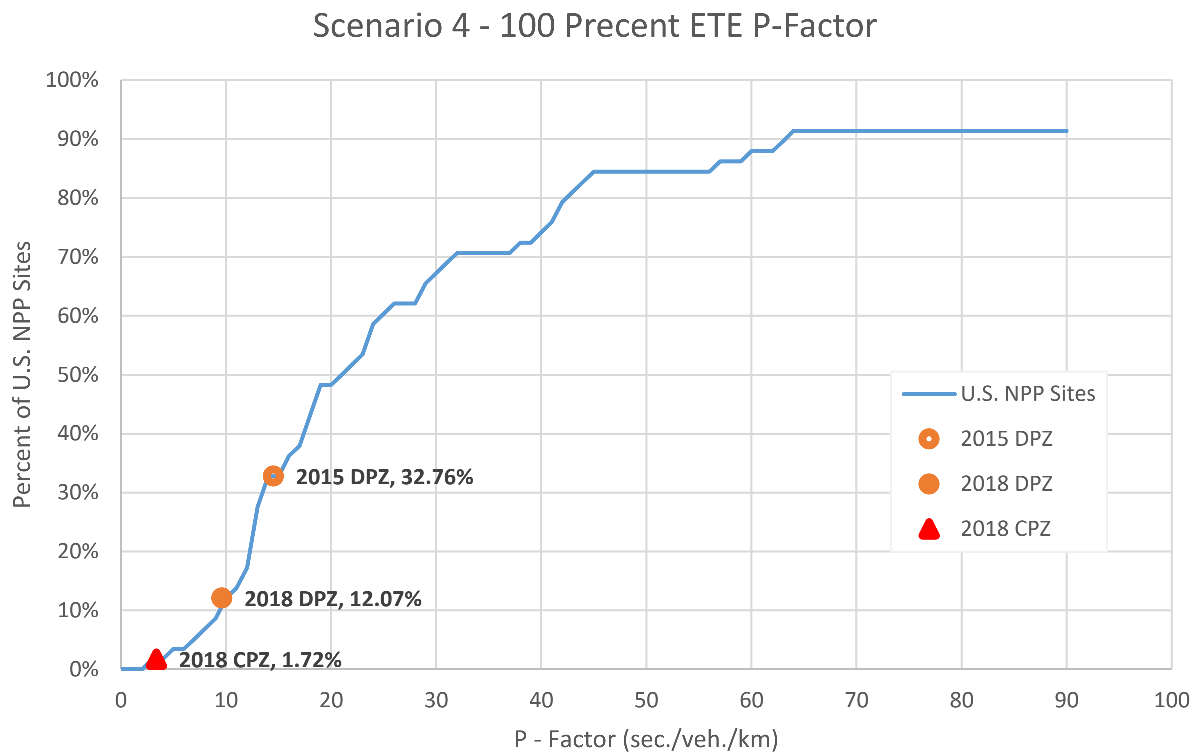

***Figure A* - 25: Scenario 4 – Planning Zone 100 Percent ETE *P* - Factor**

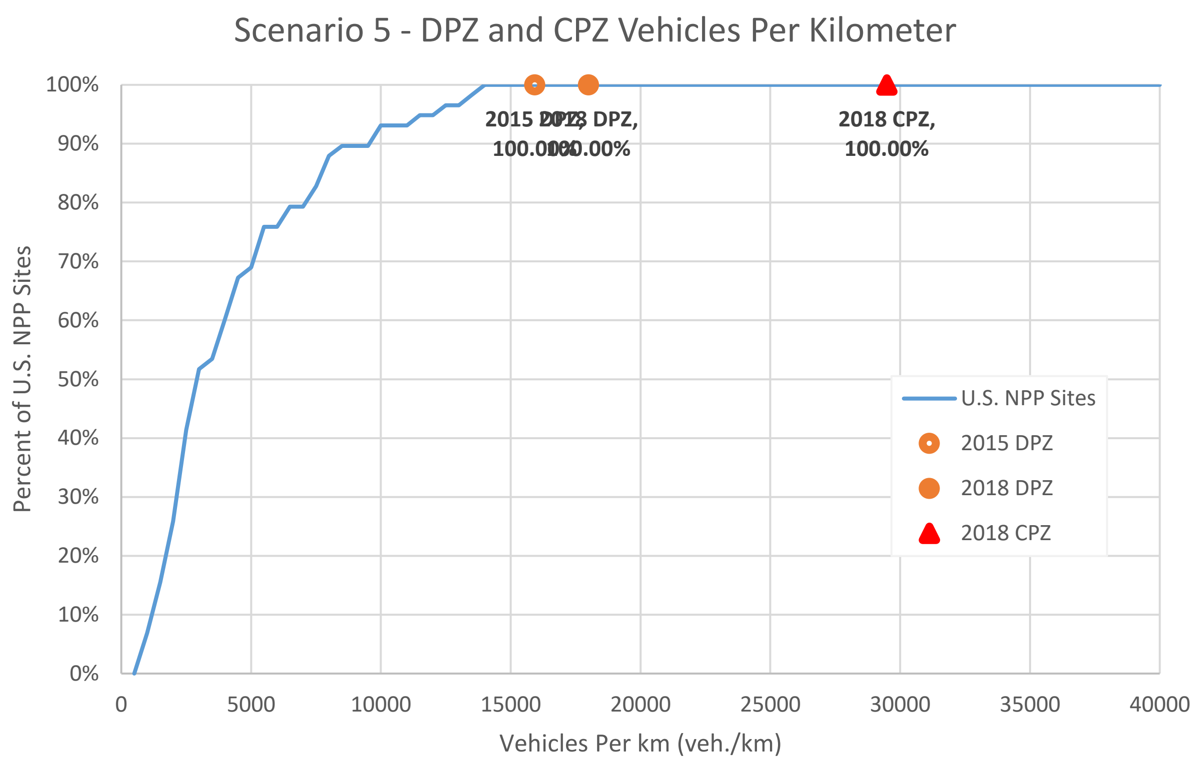

Figure A **- 26: Scenario 5 – Planning Zone Vehicles Per Kilometer**

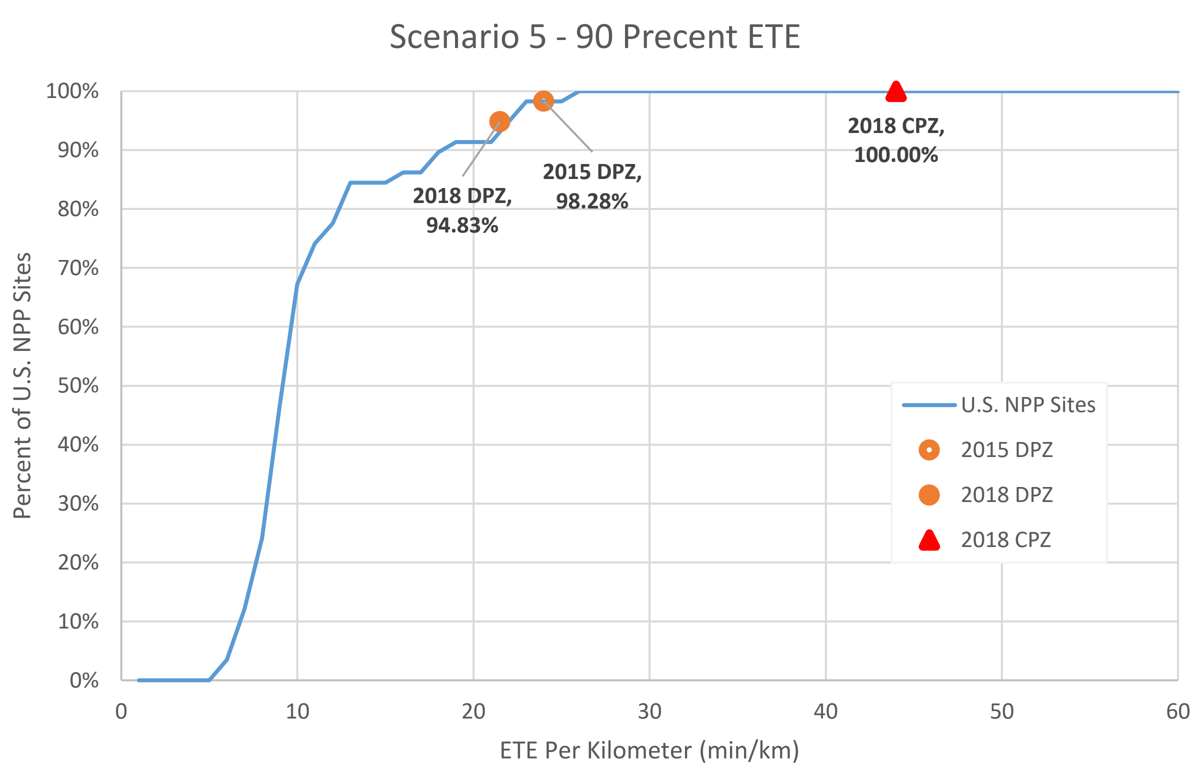

Figure A **- 27: Scenario 5 – Planning Zone 90 Percent ETE Per Kilometer**

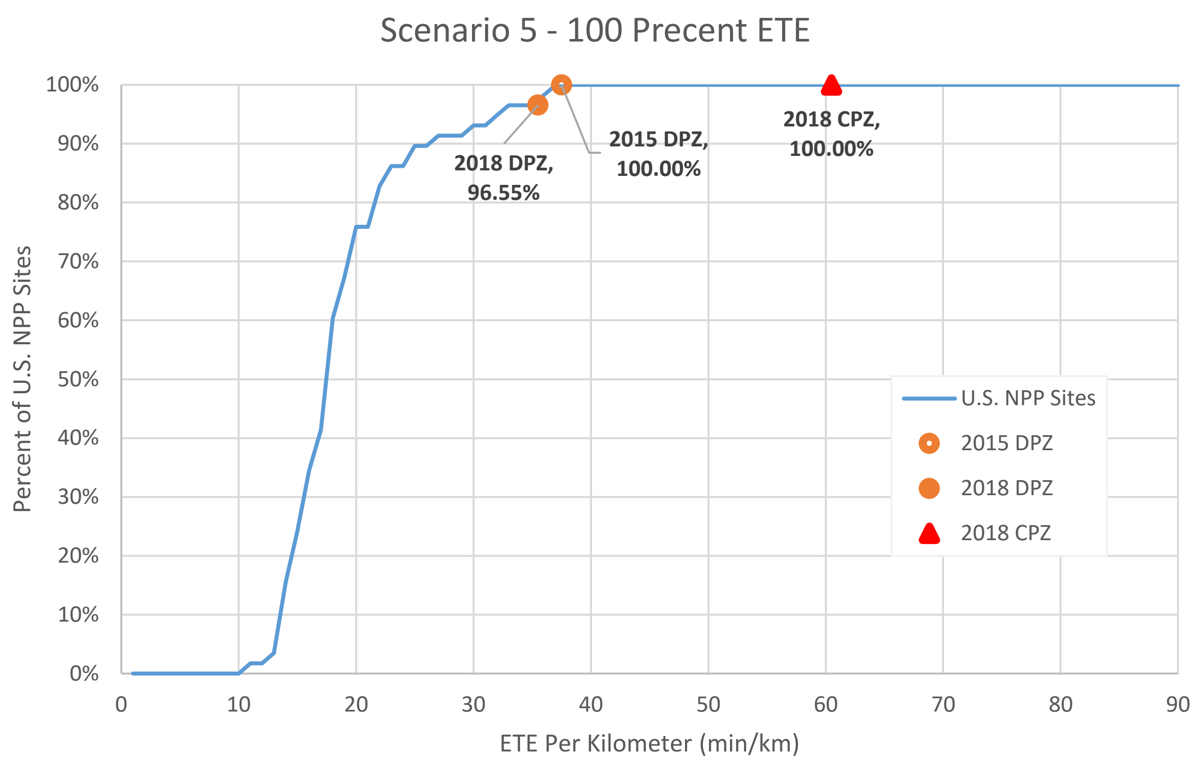

***Figure A* - 28: Scenario 5 – Planning Zone 100 Percent ETE Per Kilometer**

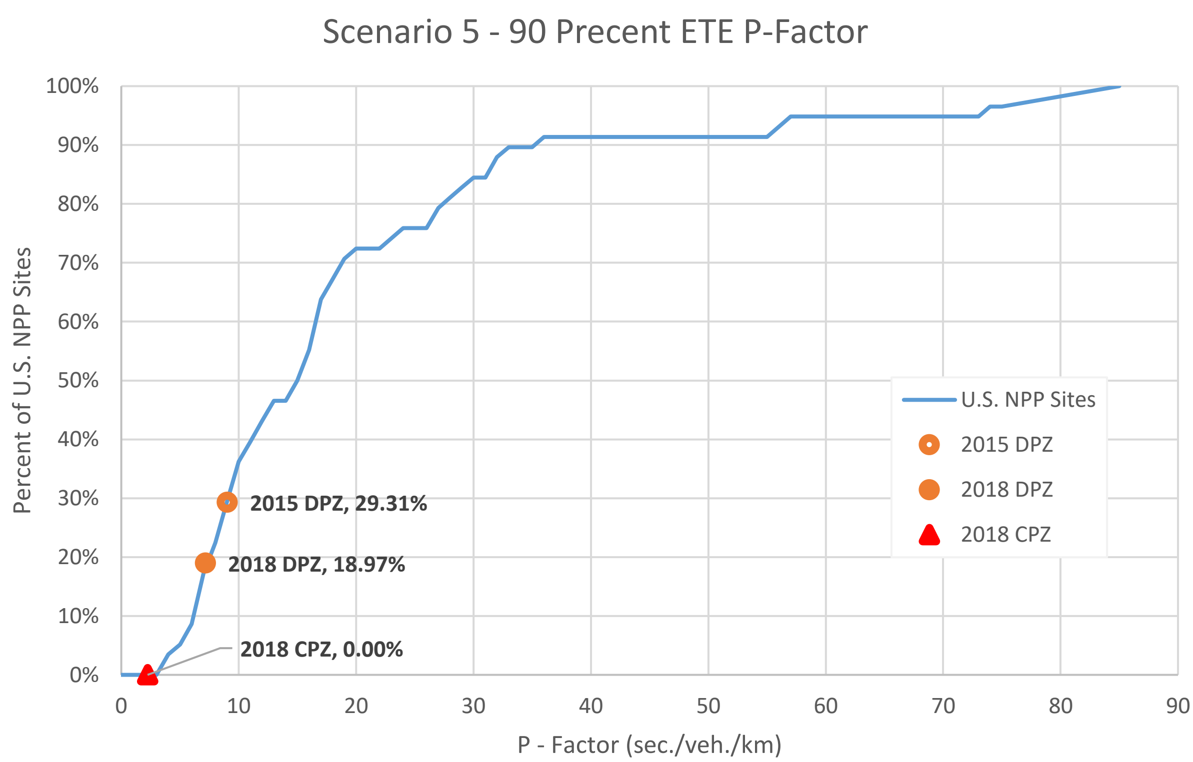

***Figure A* - 29: Scenario 5 – Planning Zone 90 Percent ETE *P* - Factor**

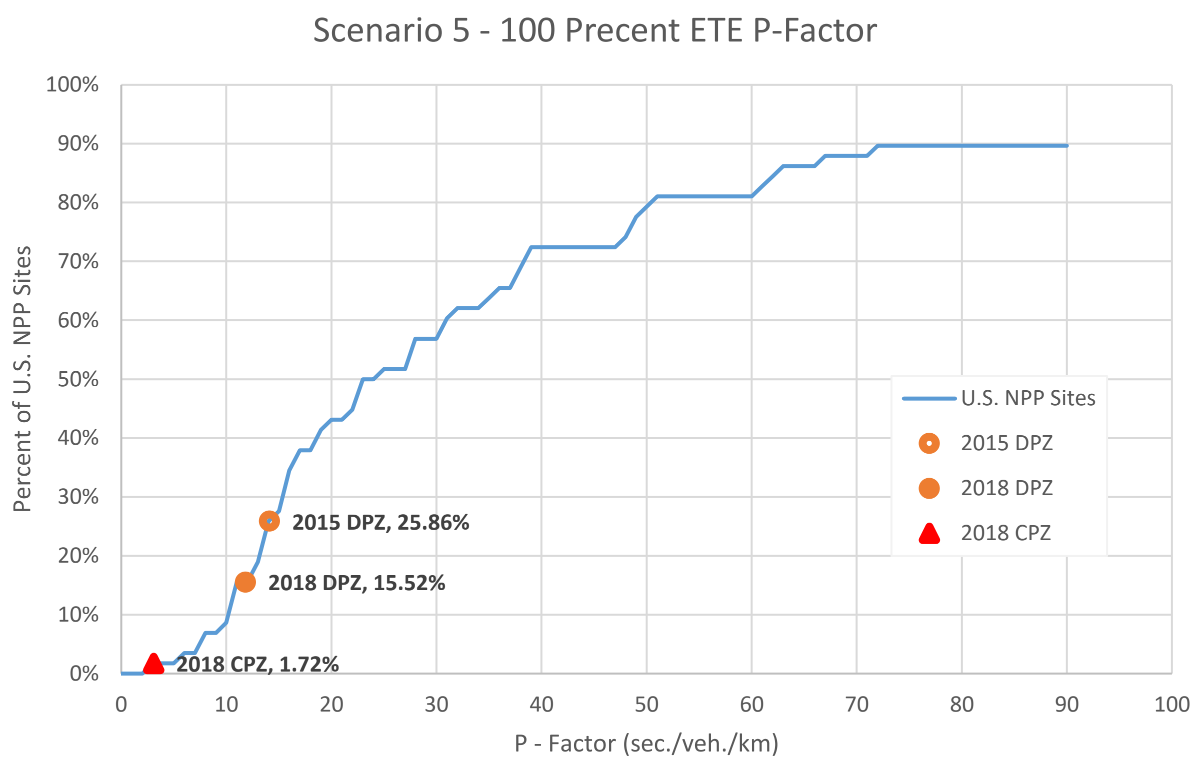

Figure A **- 30: Scenario 5 – Planning Zone 100 Percent ETE *P* - Factor**

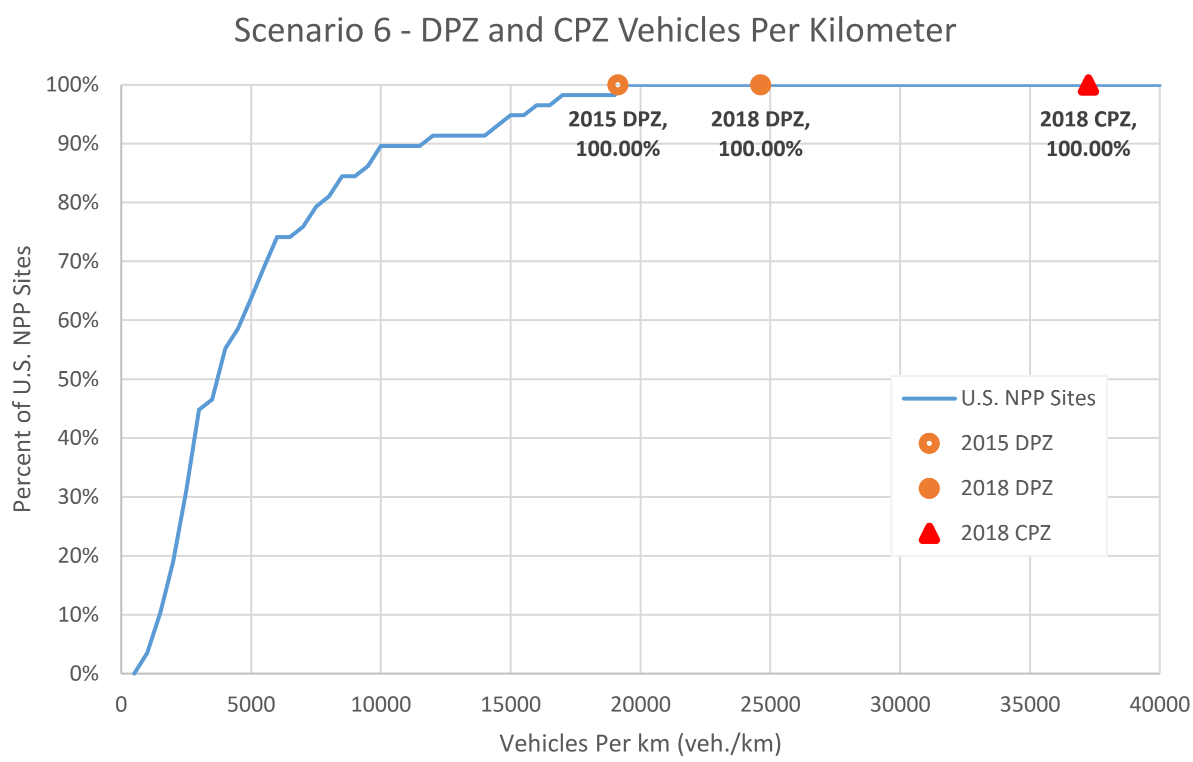

Figure A **- 31: Scenario 6 – Planning Zone Vehicles Per Kilometer**

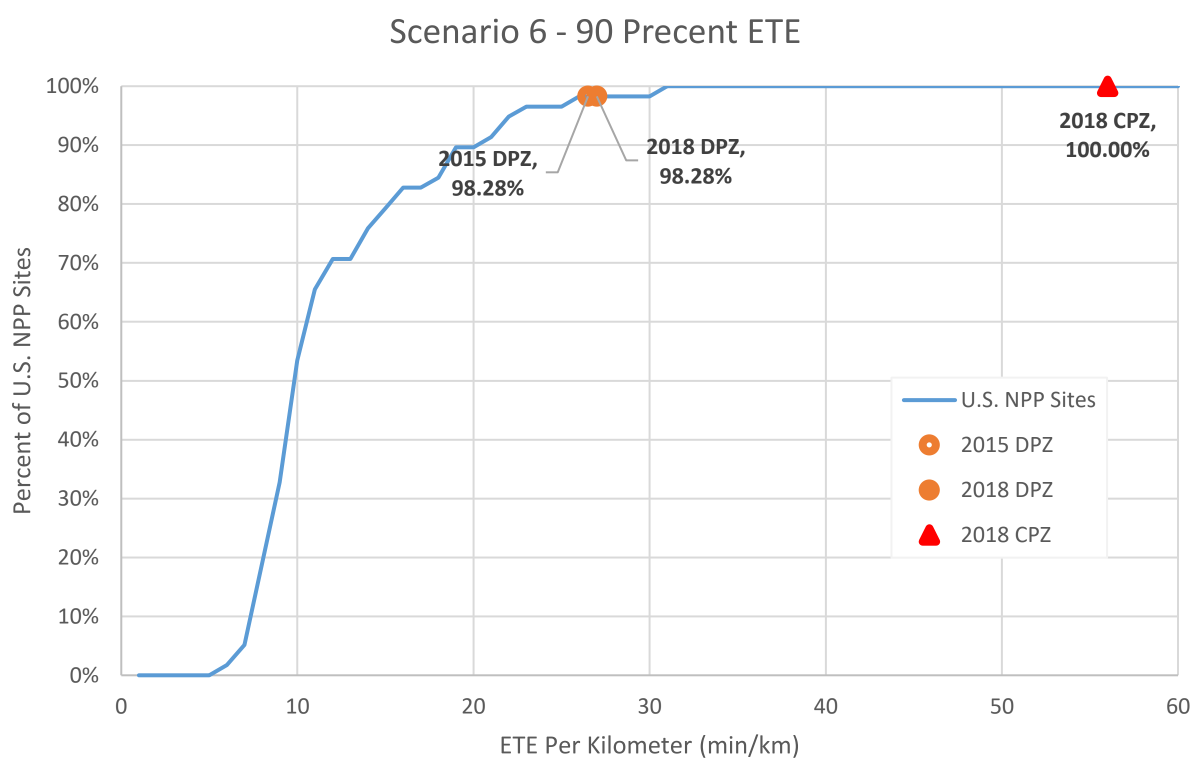

Figure A **- 32: : Scenario 6 – Planning Zone 90 Percent ETE Per Kilometer**

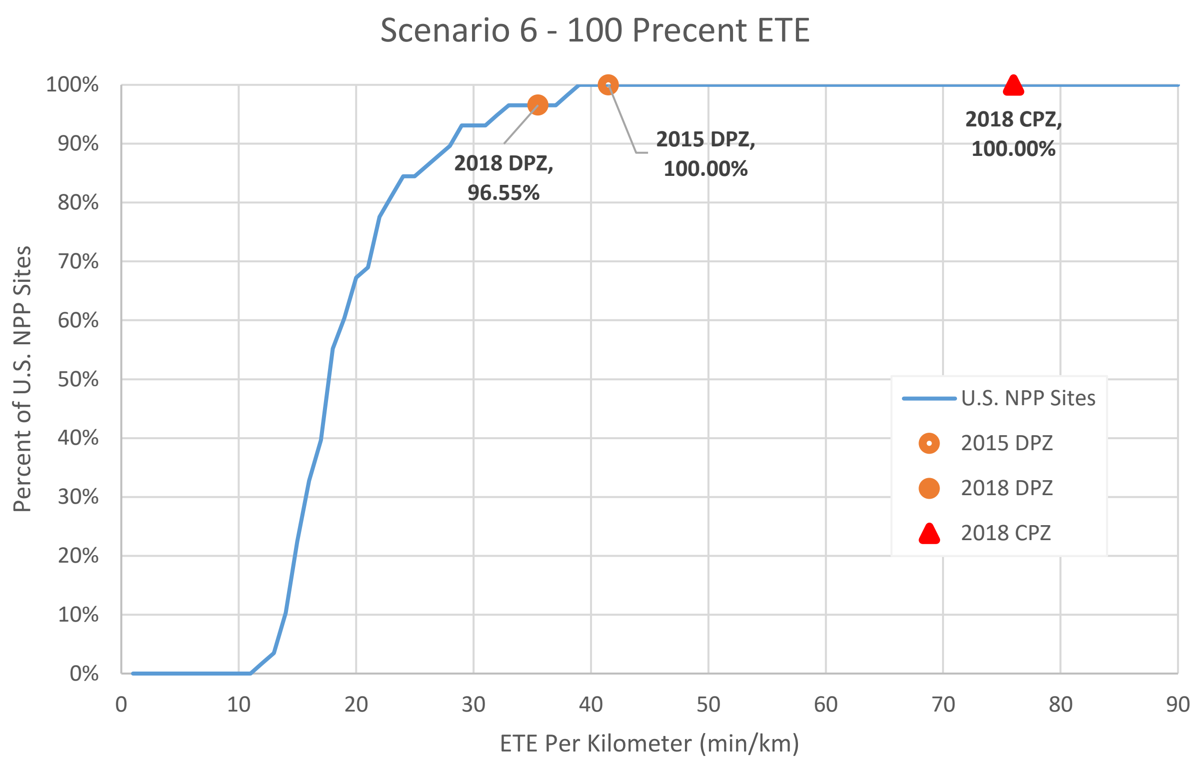

Figure A **- 33: Scenario 6 – Planning Zone 100 Percent ETE Per Kilometer**

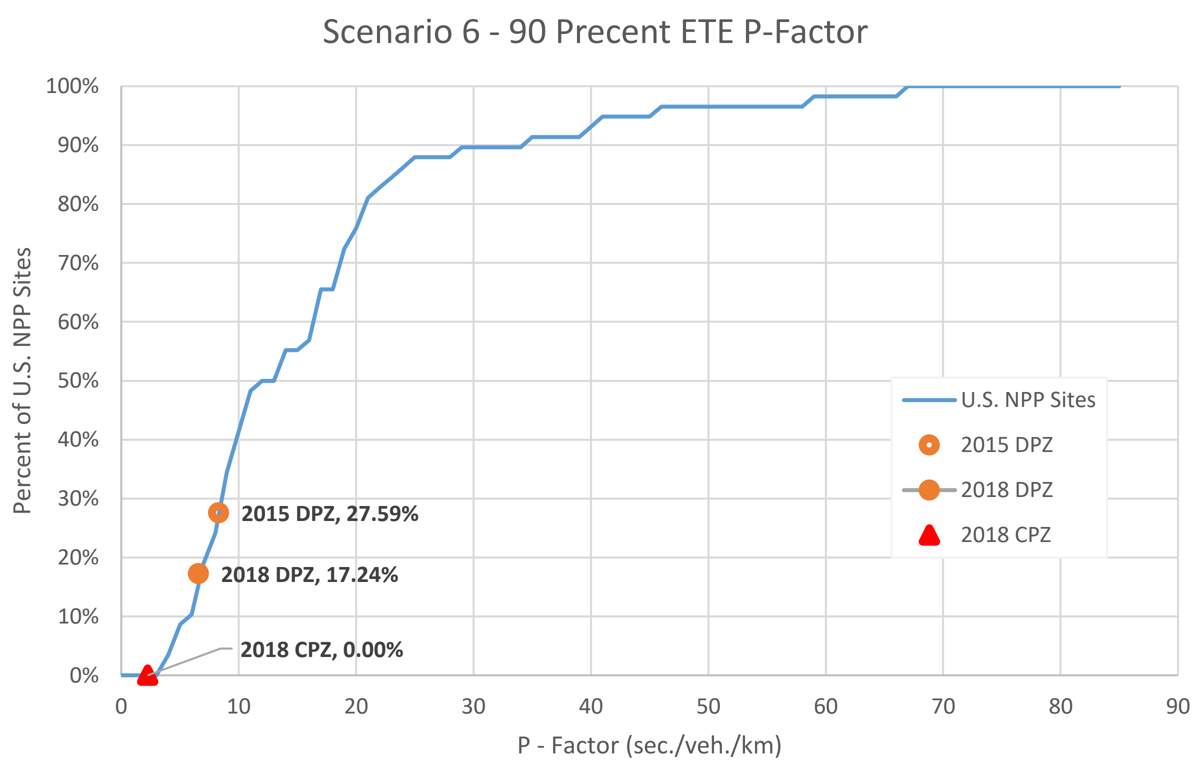

Figure A **- 34: Scenario 6 – Planning Zone 90 Percent ETE *P* - Factor**

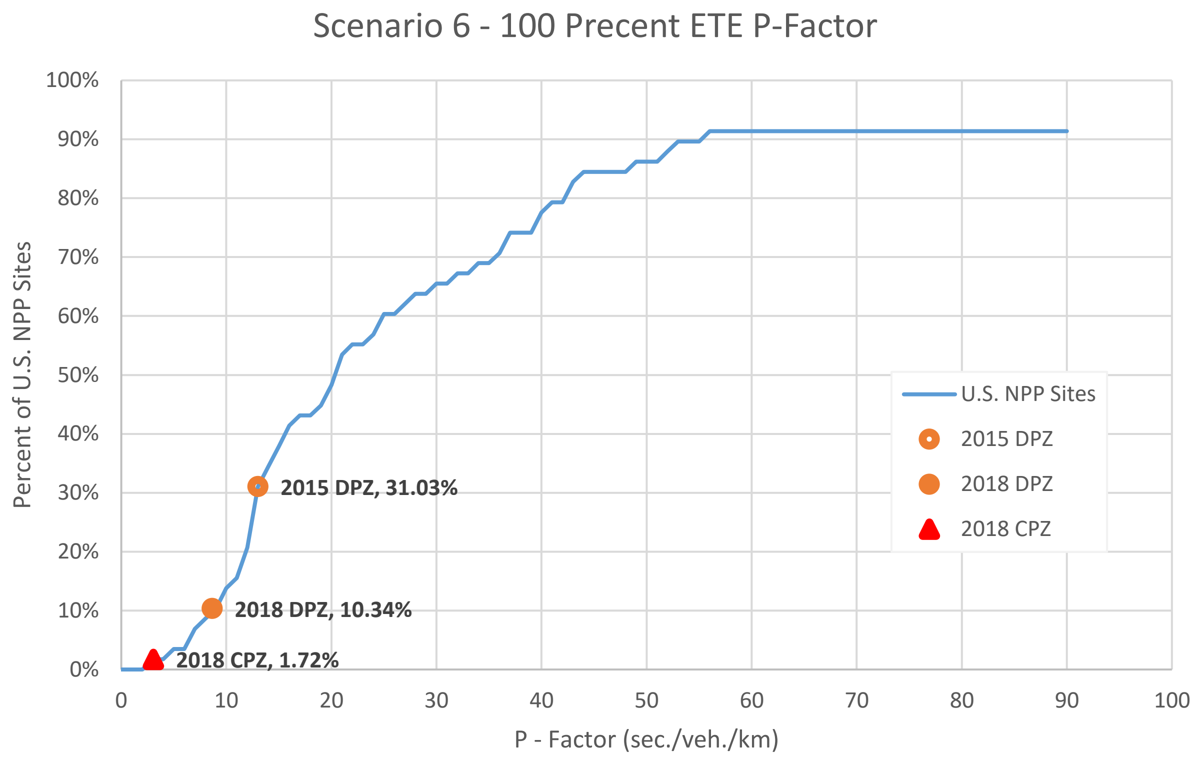

Figure A **- 35: Scenario 6 – Planning Zone 100 Percent ETE *P* - Factor**

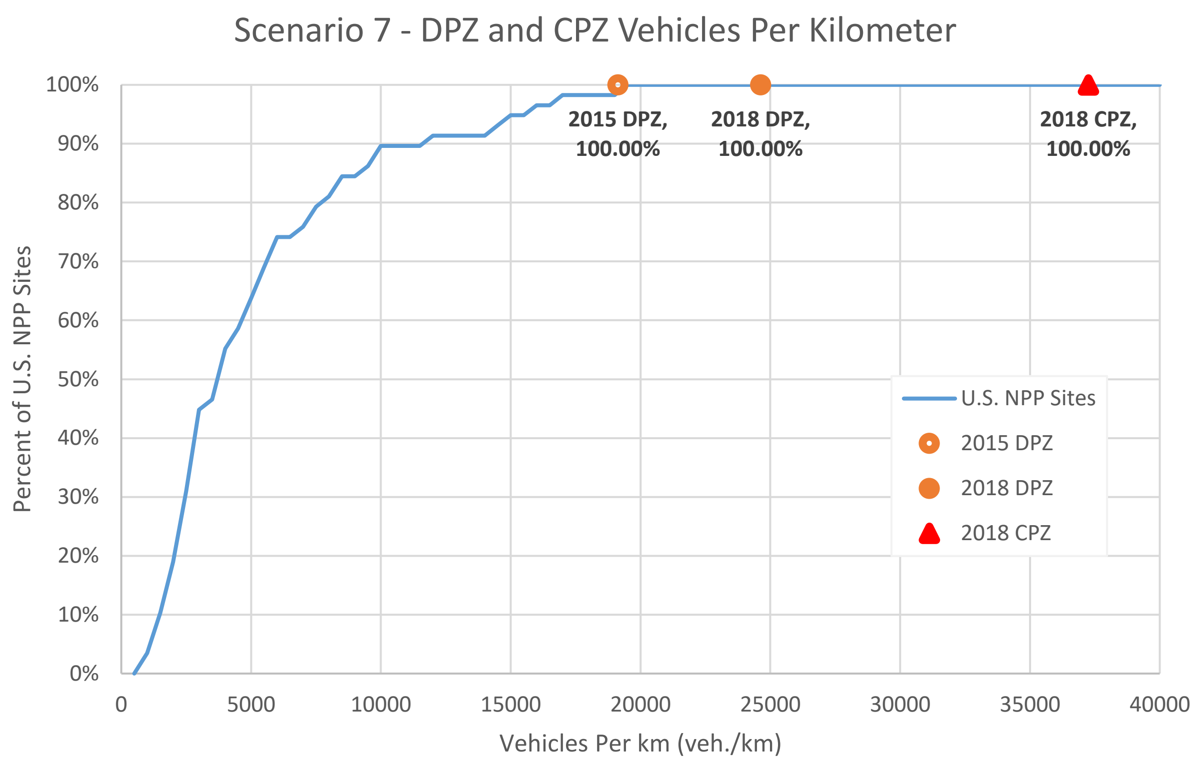

Figure A **- 36: Scenario 7 – Planning Zone Vehicles Per Kilometer**

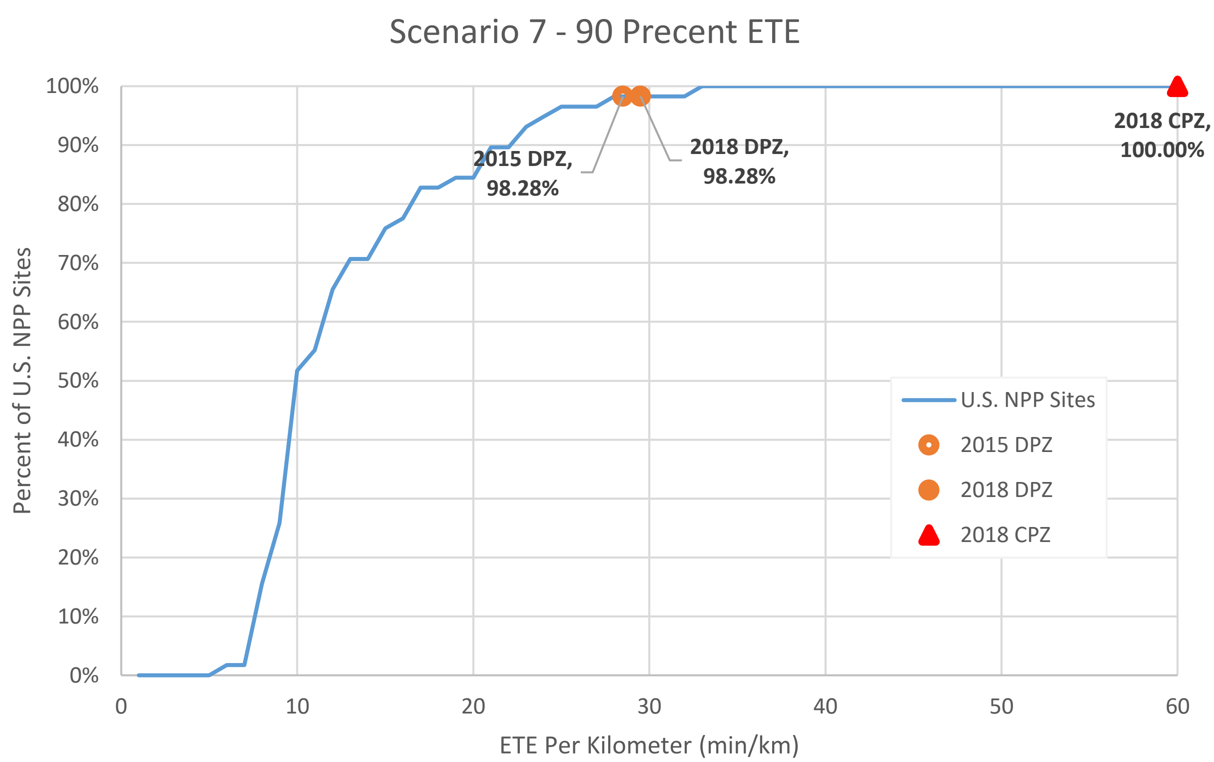

Figure A **- 37: : Scenario 7 – Planning Zone 90 Percent ETE Per Kilometer**

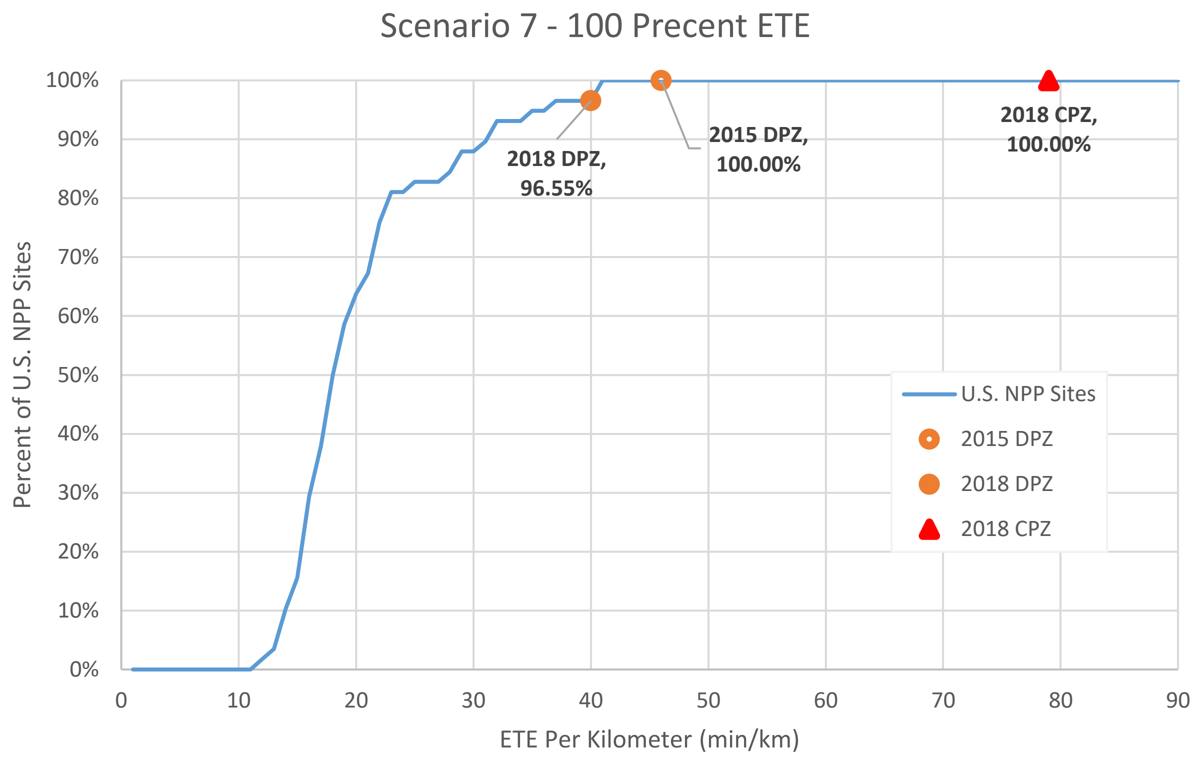

Figure A **- 38: Scenario 7 – Planning Zone 100 Percent ETE Per Kilometer**

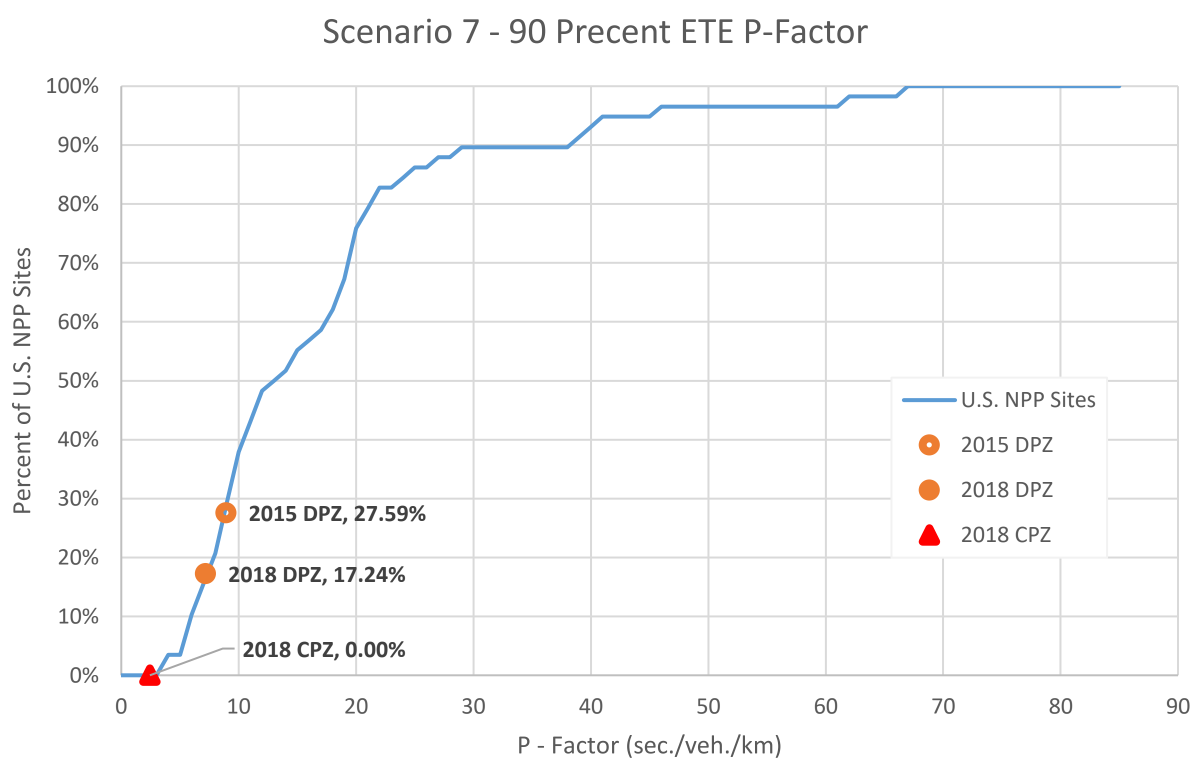

Figure A **- 39: Scenario 7 – Planning Zone 90 Percent ETE** ***P*** **- Factor**

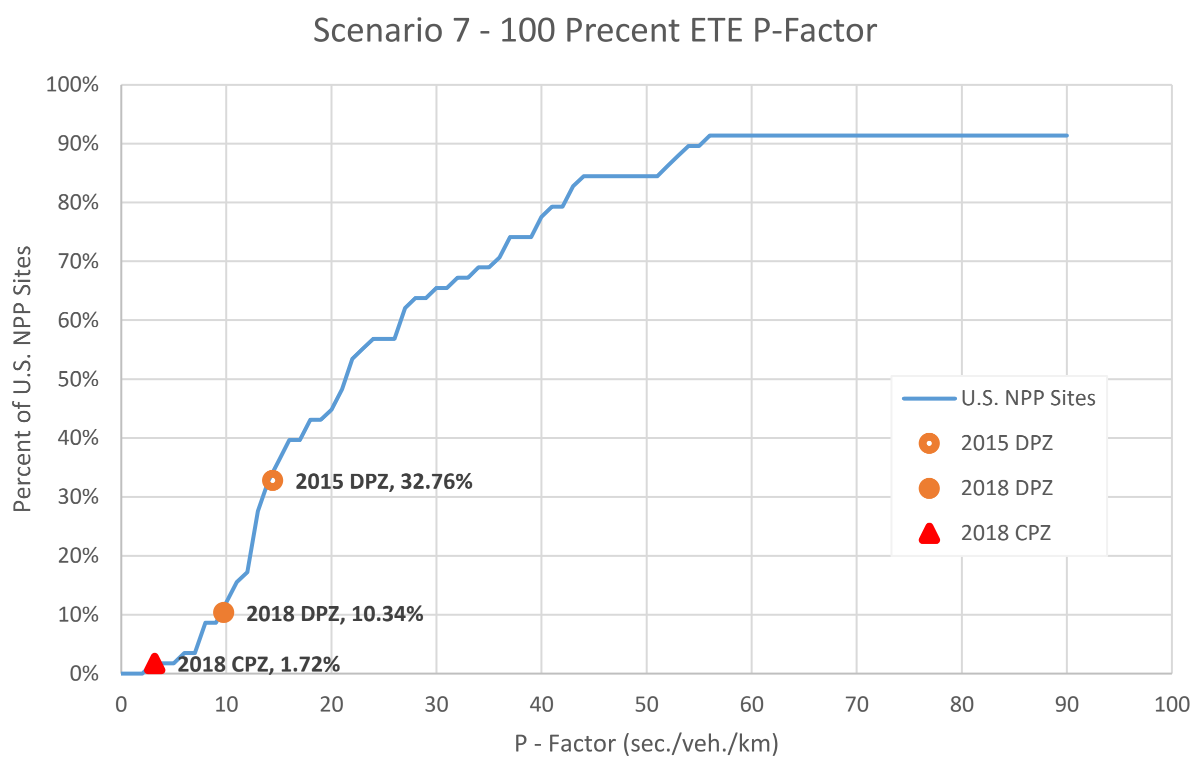

***Figure A* - 40: Scenario 7 – Planning Zone 10 Percent ETE *P* - Factor**

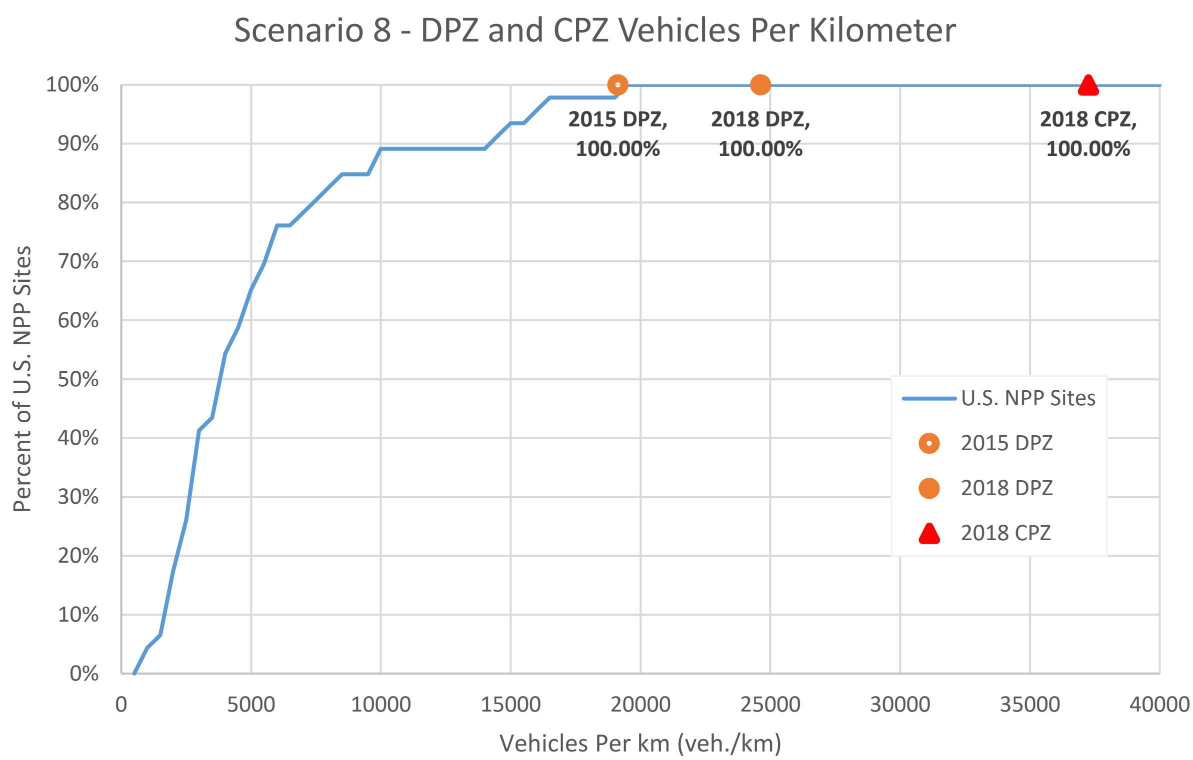

Figure A **- 41: Scenario 8 – Planning Zone Vehicles Per Kilometer**

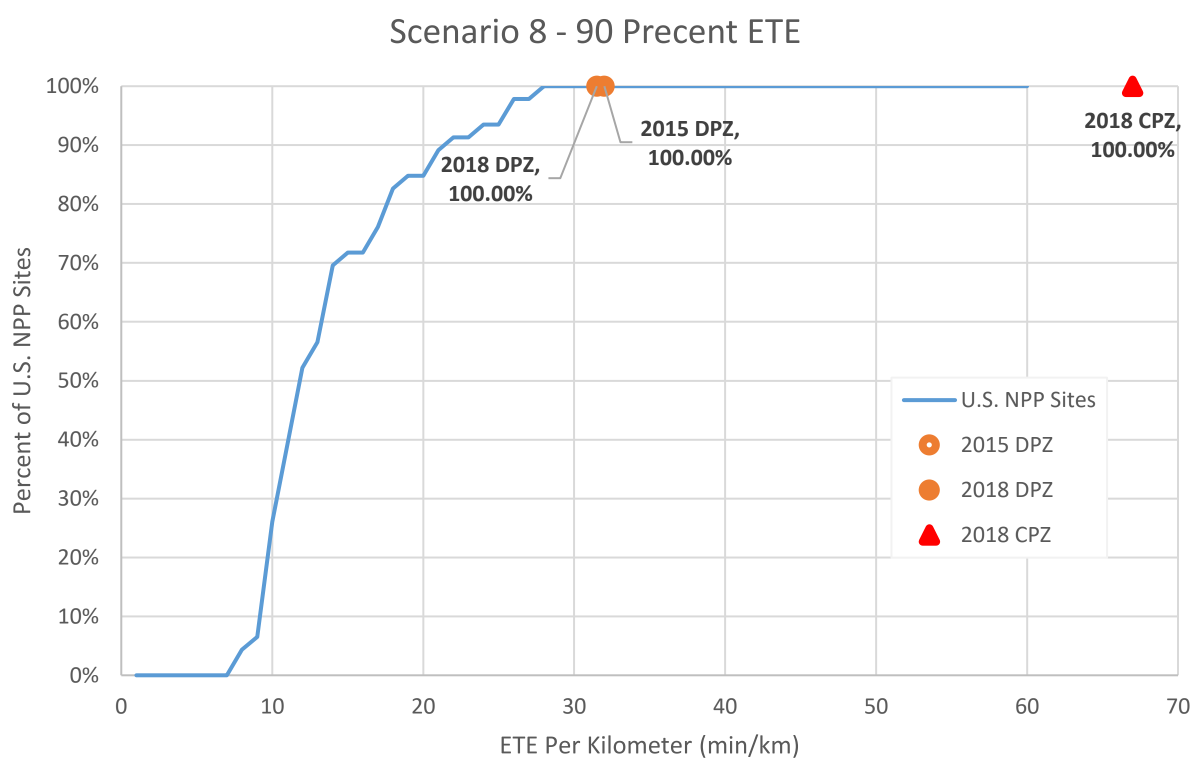

Figure A **- 42: Scenario 8 – Planning Zone 90 Percent ETE Per Kilometer**

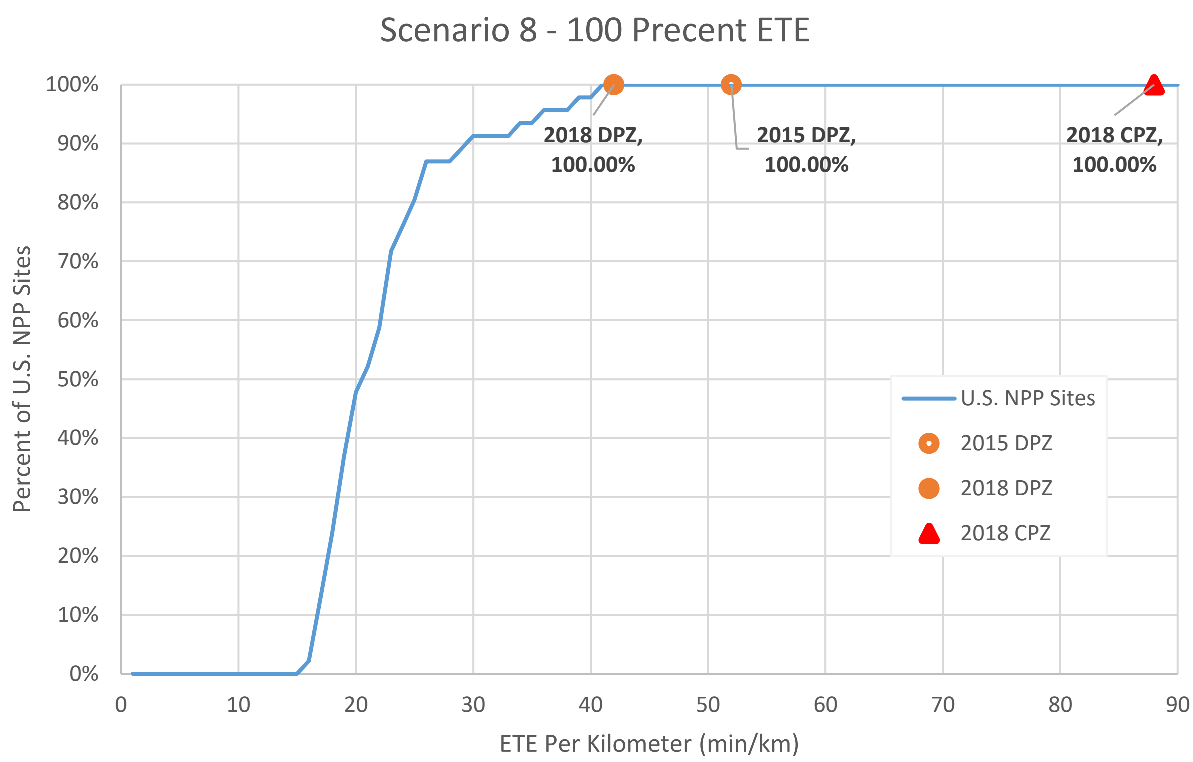

***Figure A* - 43: Scenario 8 – Planning Zone 100 Percent ETE Per Kilometer**

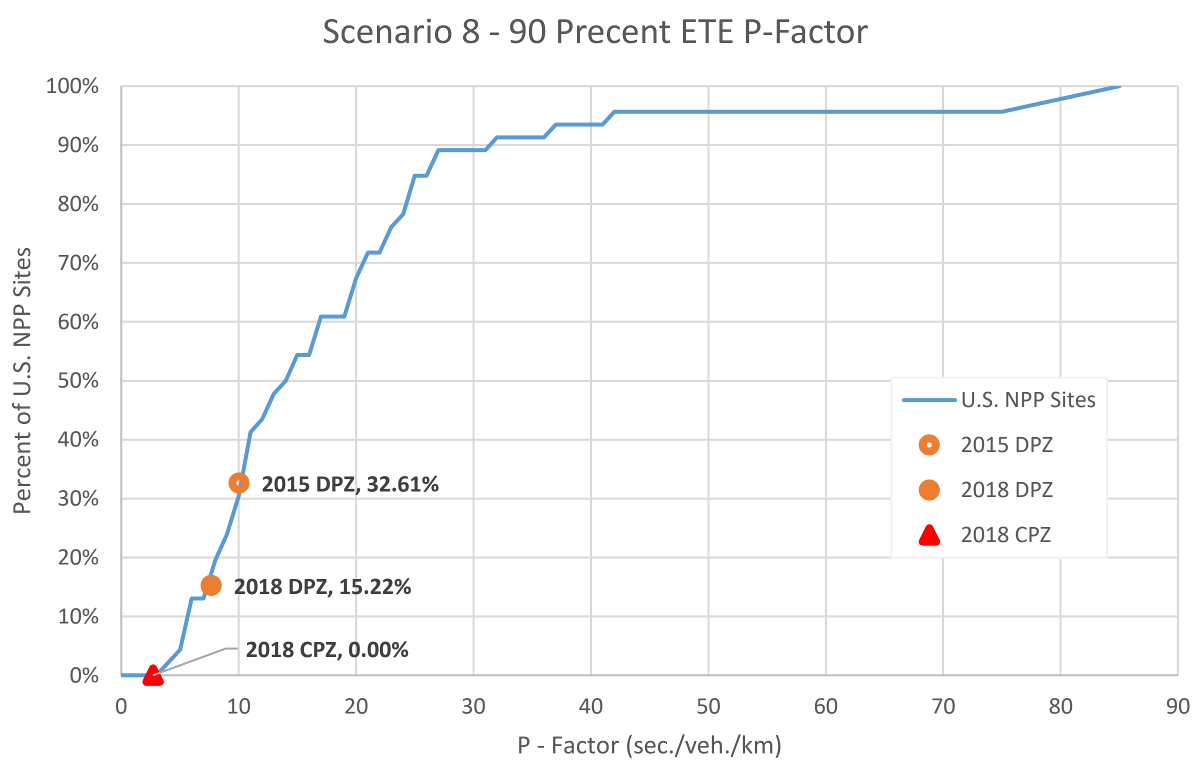

***Figure A* - 44: Scenario 8 – Planning Zone 90 Percent ETE *P* - Factor**

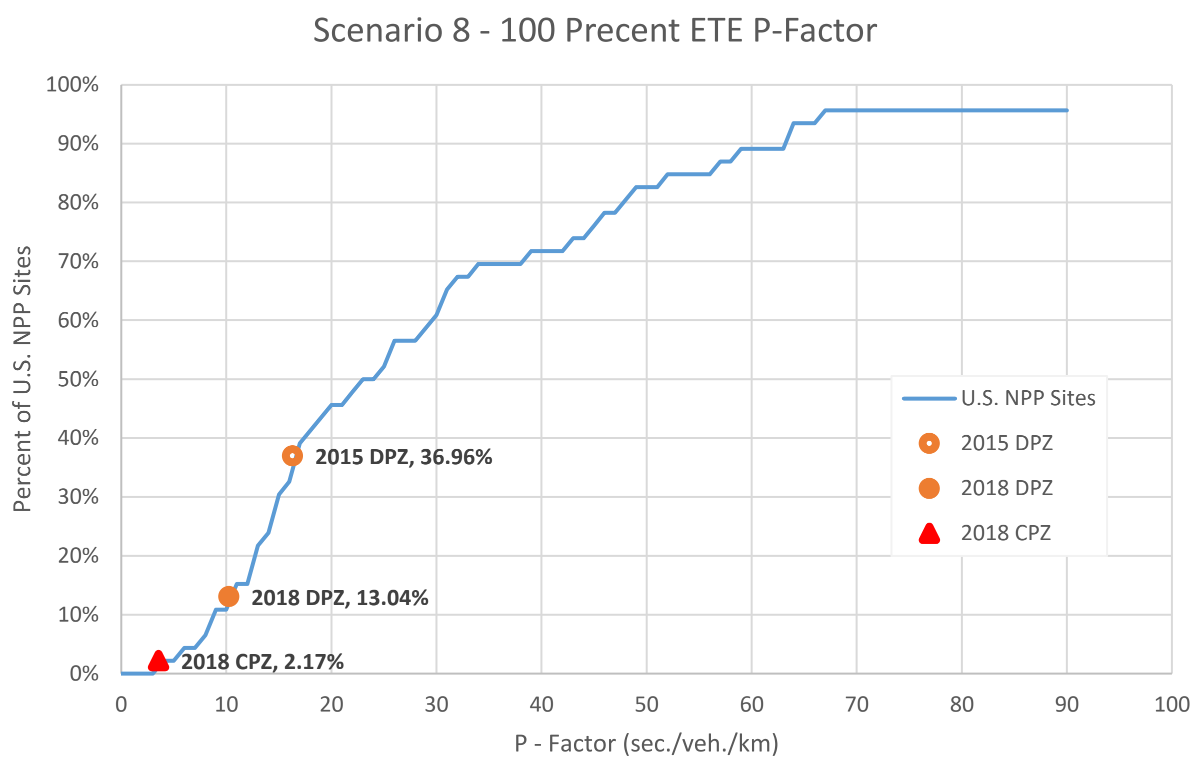

***Figure A* - 45: Scenario 8 – Planning Zone 100 Percent ETE *P* - Factor**

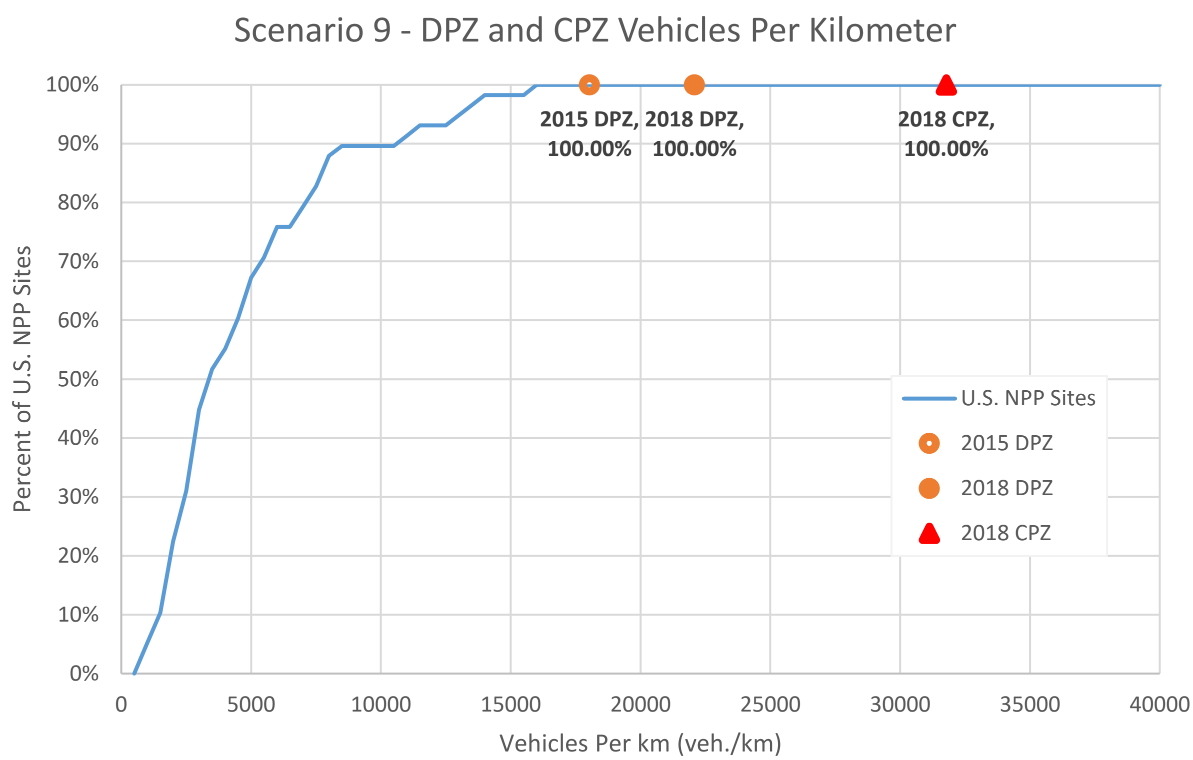

Figure A **- 46: Scenario 9 – Planning Zone Vehicles Per Kilometer**

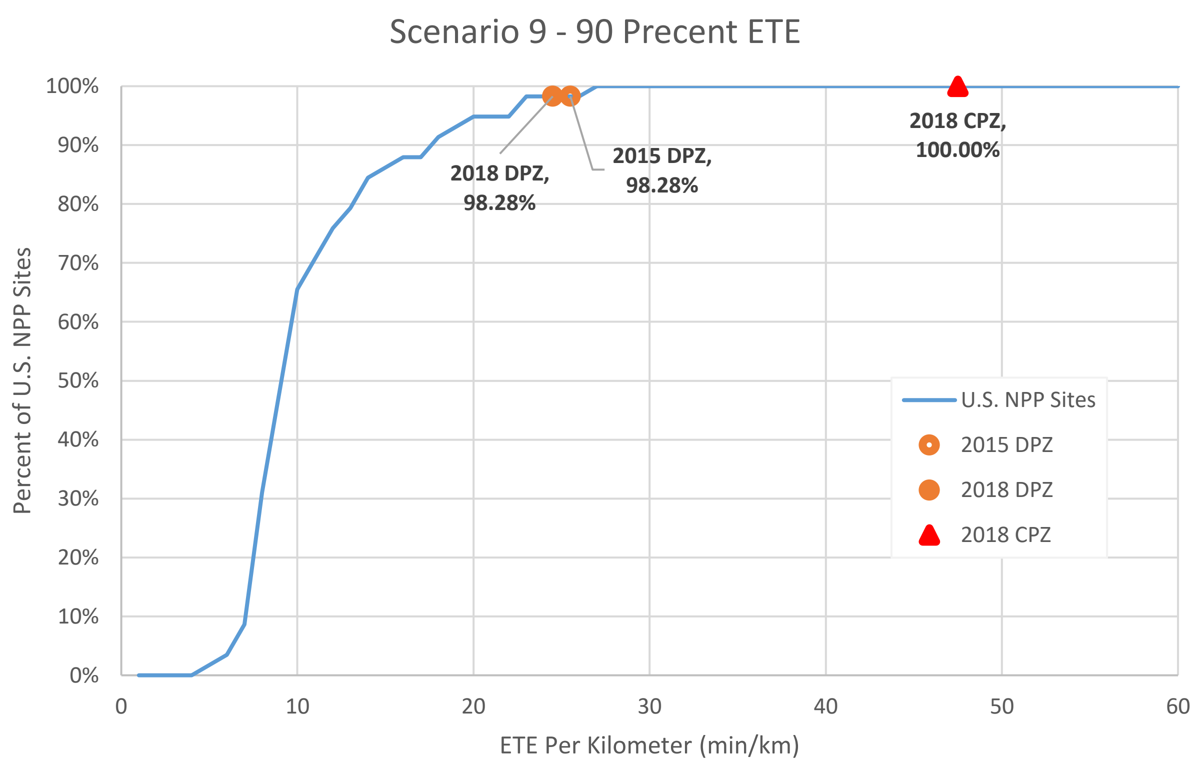

Figure A **- 47: Scenario 9 – Planning Zone 90 Percent ETE Per Kilometer**

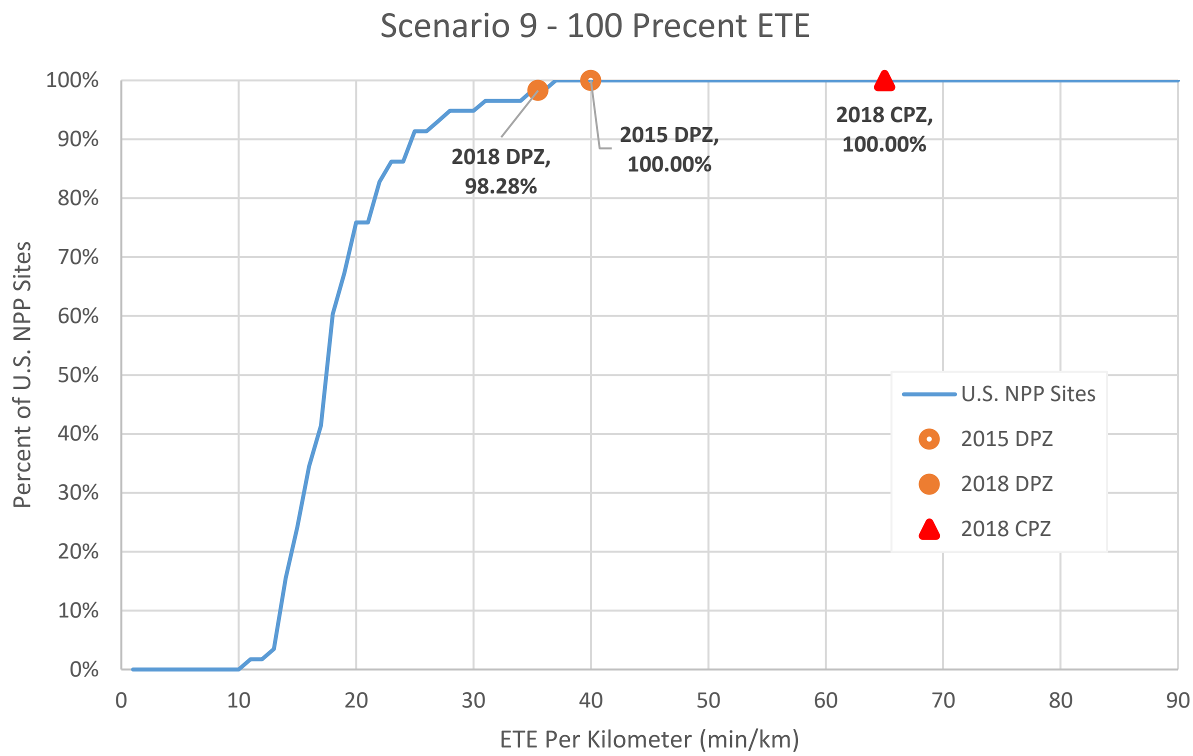

***Figure A* - 48: Scenario 9 – Planning Zone 100 Percent ETE Per Kilometer**

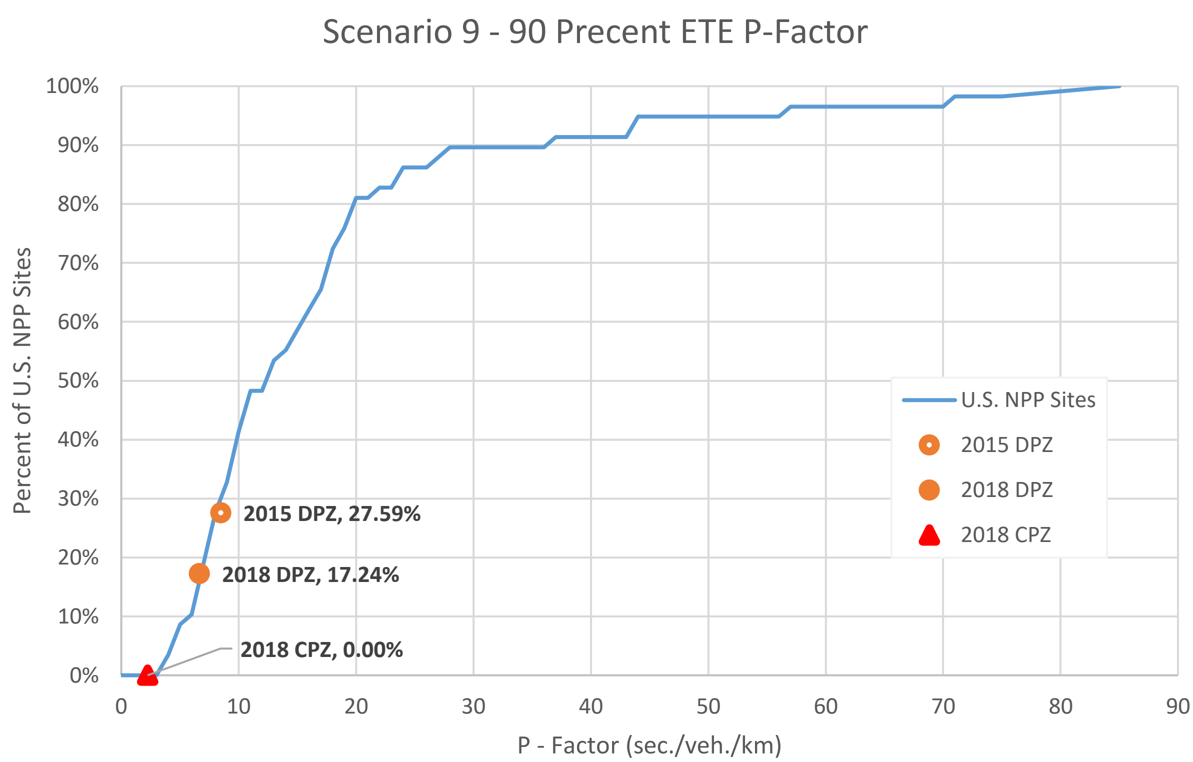

***Figure A* - 49: Scenario 9 – Planning Zone 90 Percent ETE *P* - Factor**

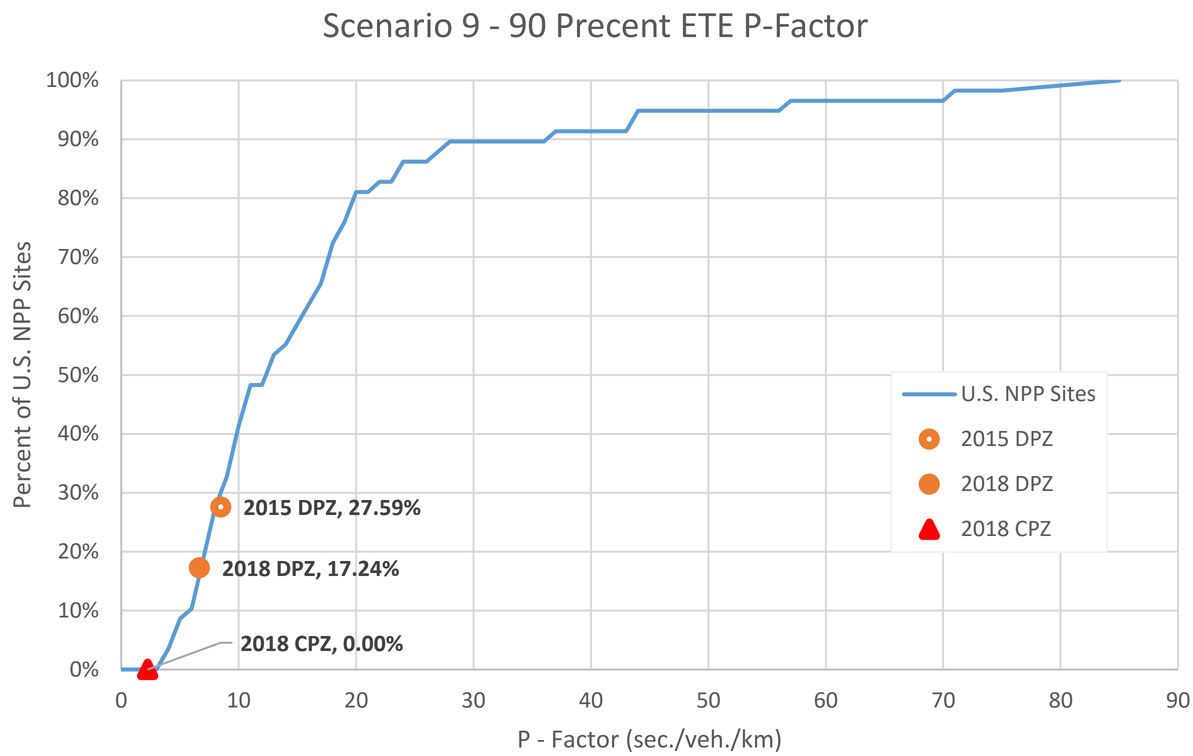

Figure A **- 50: Scenario 9 – Planning Zone 100 Percent ETE *P* - Factor**

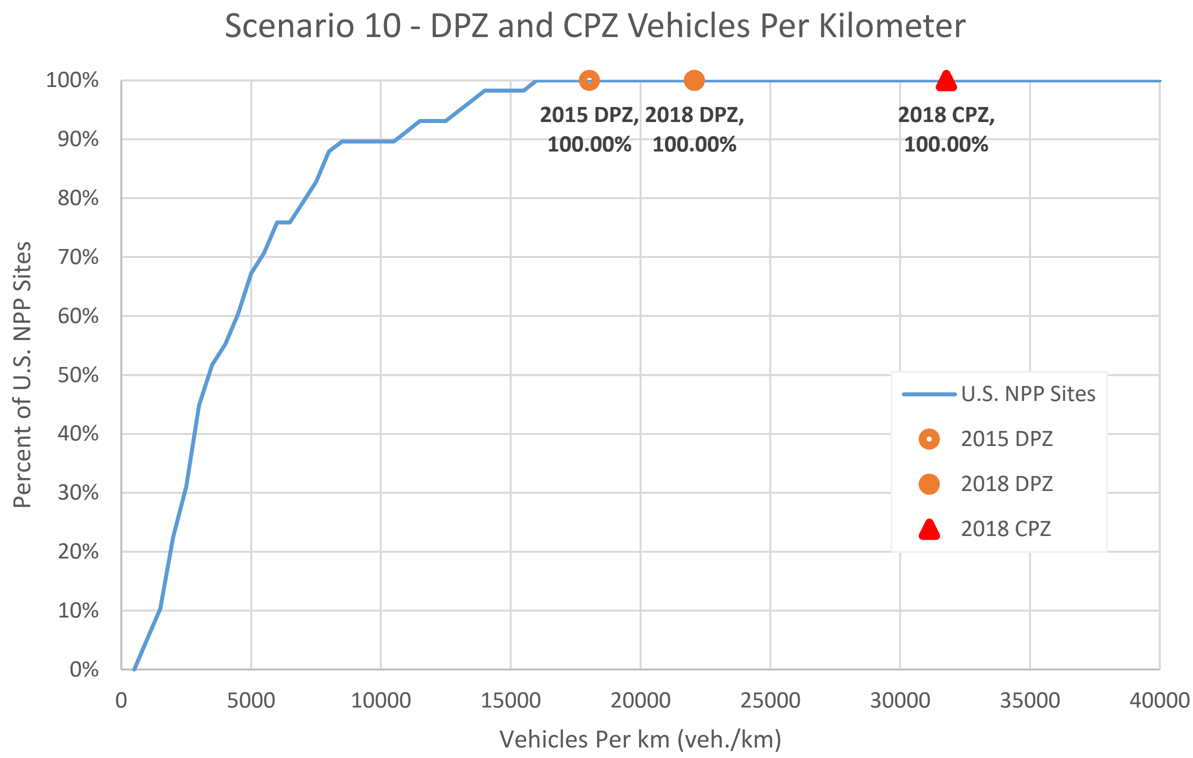

***Figure A* - 51: Scenario 10 – Planning Zone Vehicles Per Kilometer**

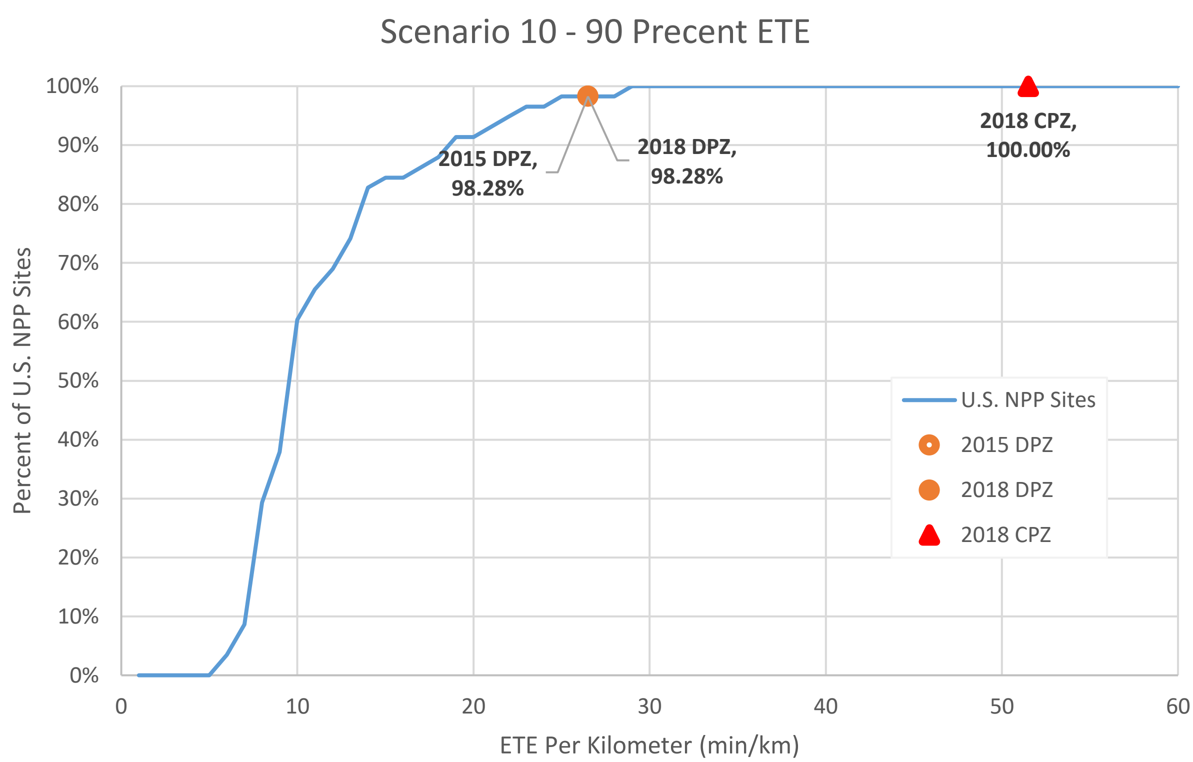

***Figure A* - 52: Scenario 10 – Planning Zone 90 Percent ETE Per Kilometer**

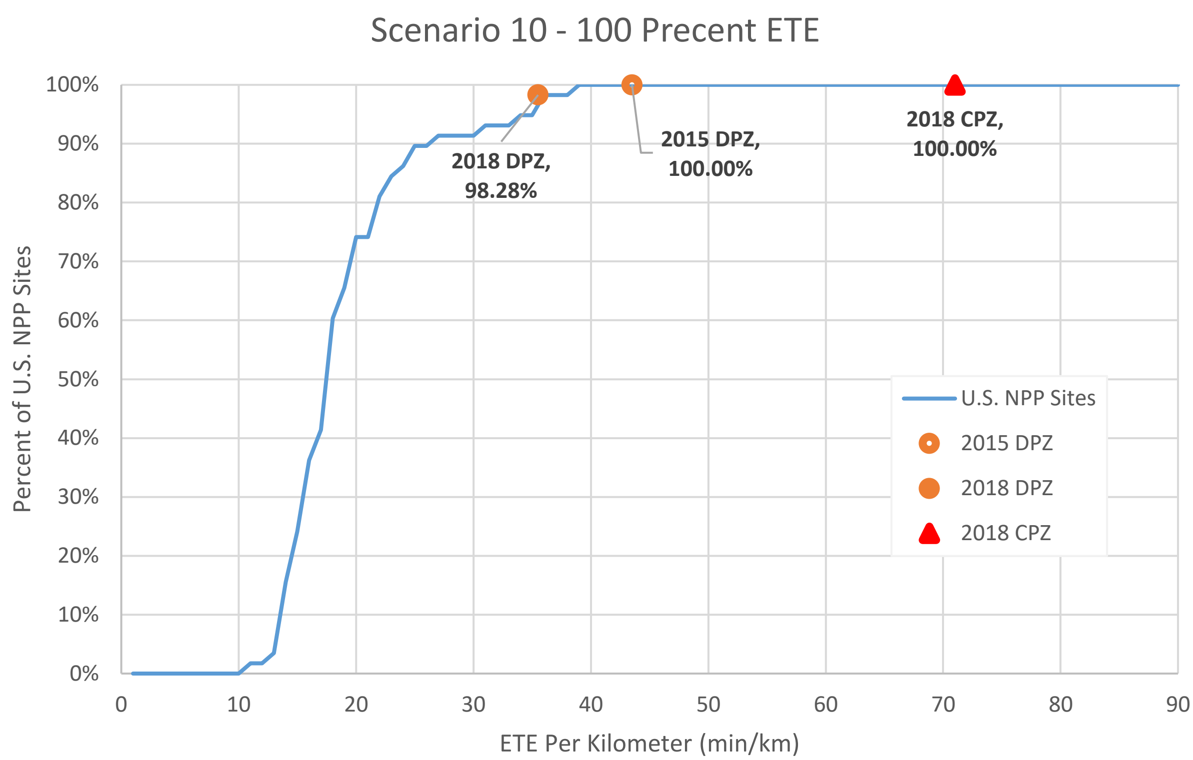

Figure A **- 53: Scenario 10 – Planning Zone 100 Percent ETE Per Kilometer**

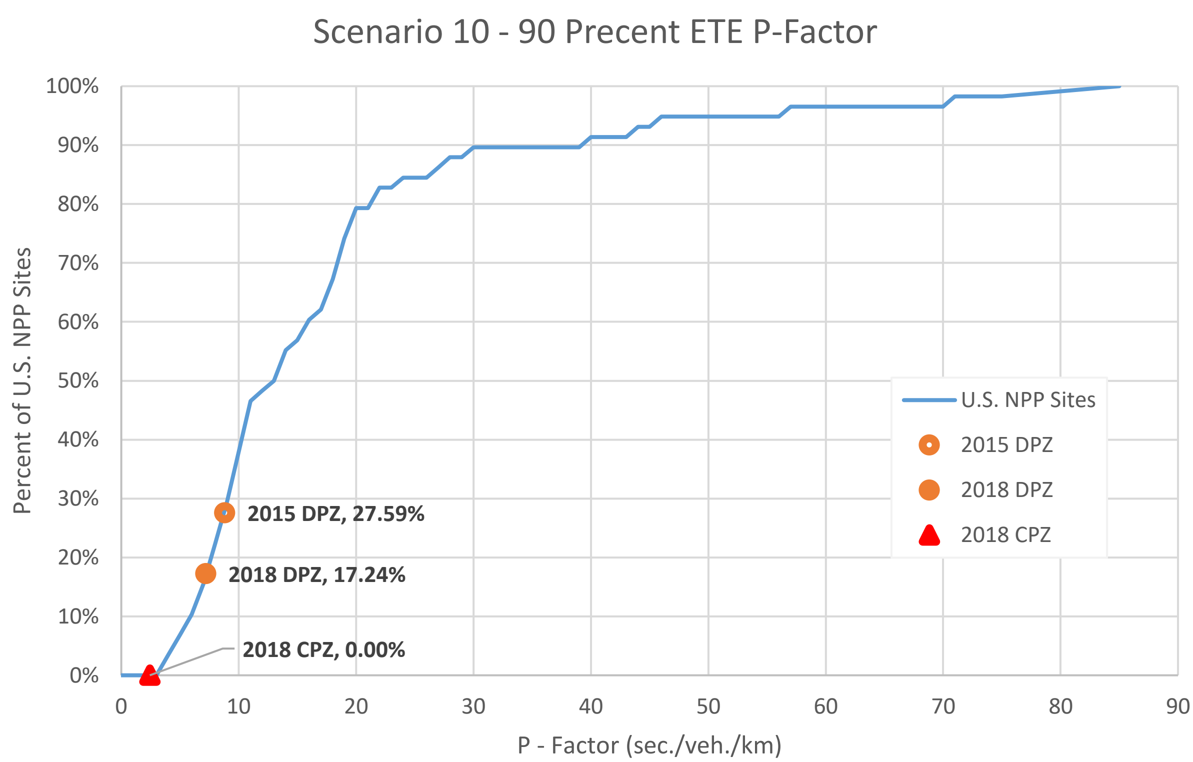

Figure A **- 54: Scenario 10 – Planning Zone 90 Percent ETE** ***P*** **- Factor**

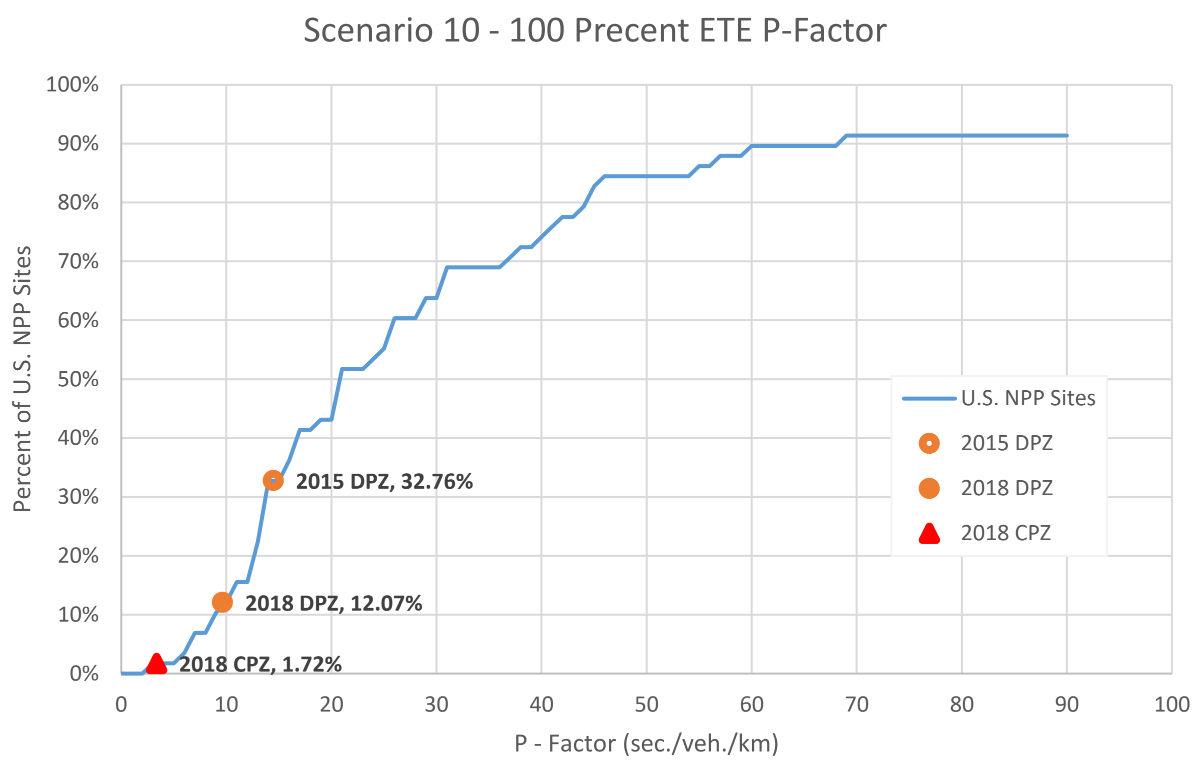

Figure A **- 55: Scenario 10 – Planning Zone 100 Percent ETE *P* - Factor**

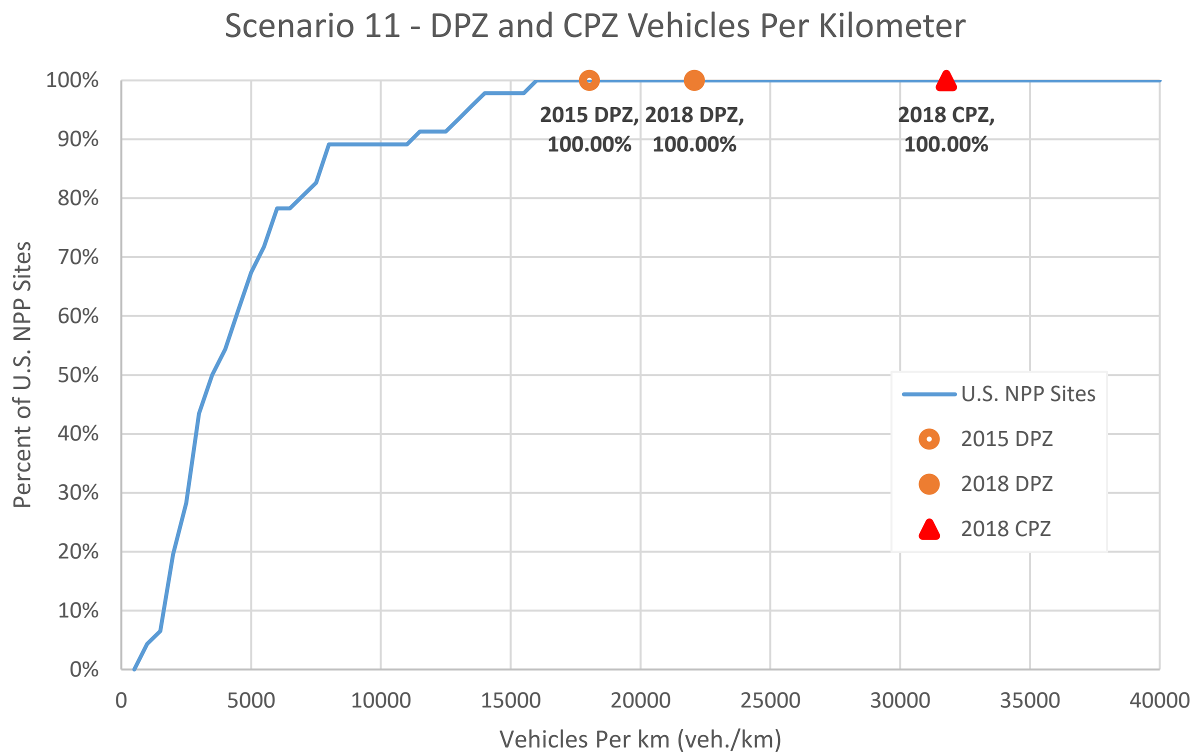

***Figure A* - 56: Scenario 11 – Planning Zone Vehicles Per Kilometer**

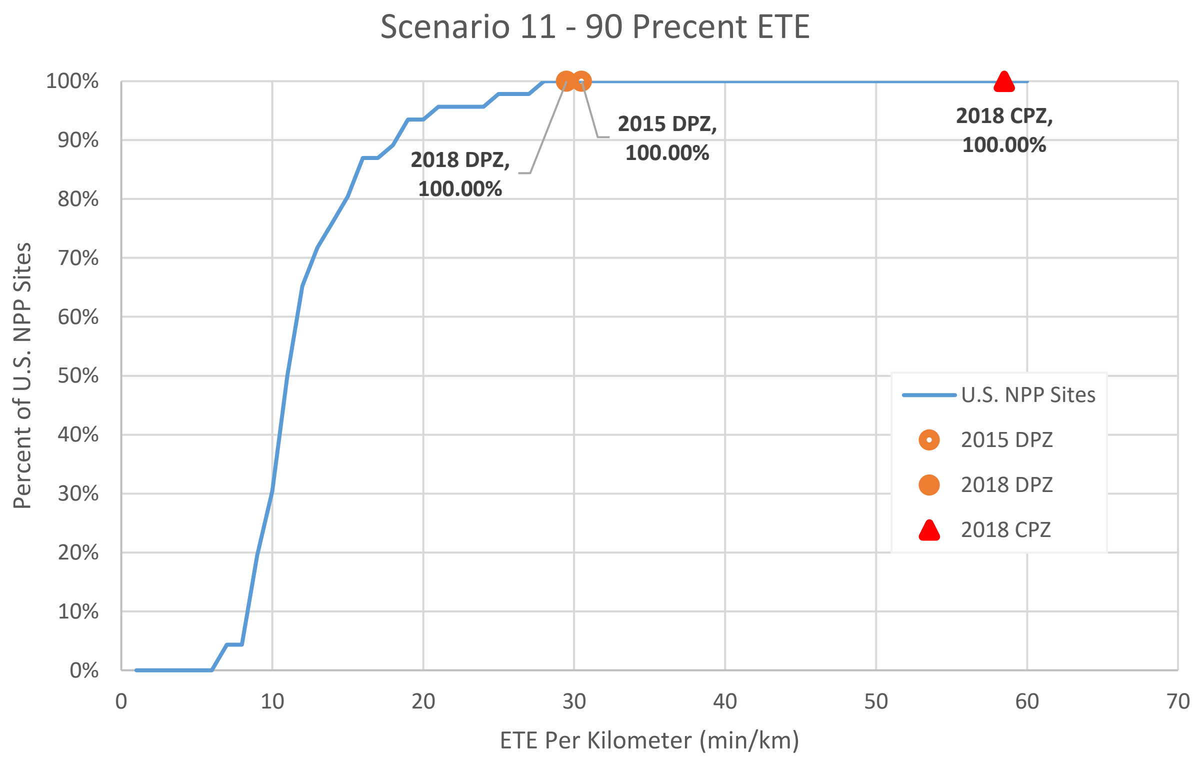

***Figure A* - 57: Scenario 11 – Planning Zone 90 Percent ETE Per Kilometer**

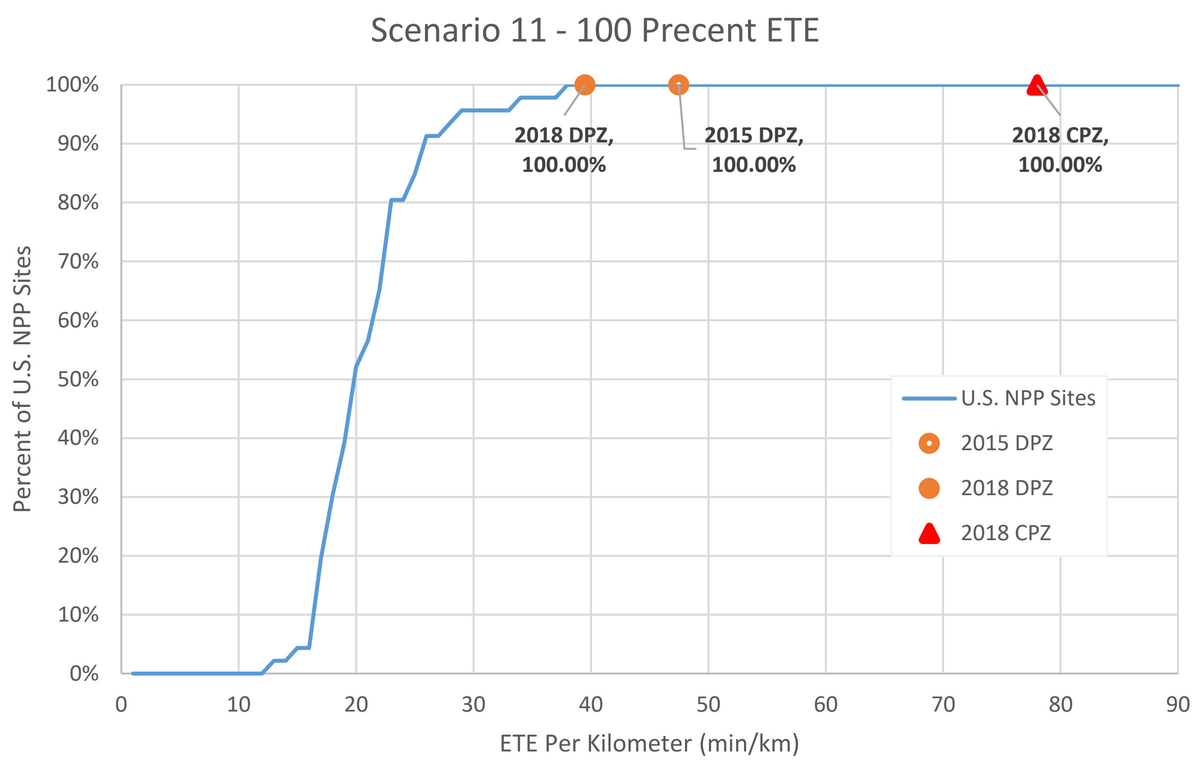

Figure A **- 58: Scenario 11 – Planning Zone 100 Percent ETE Per Kilometer**

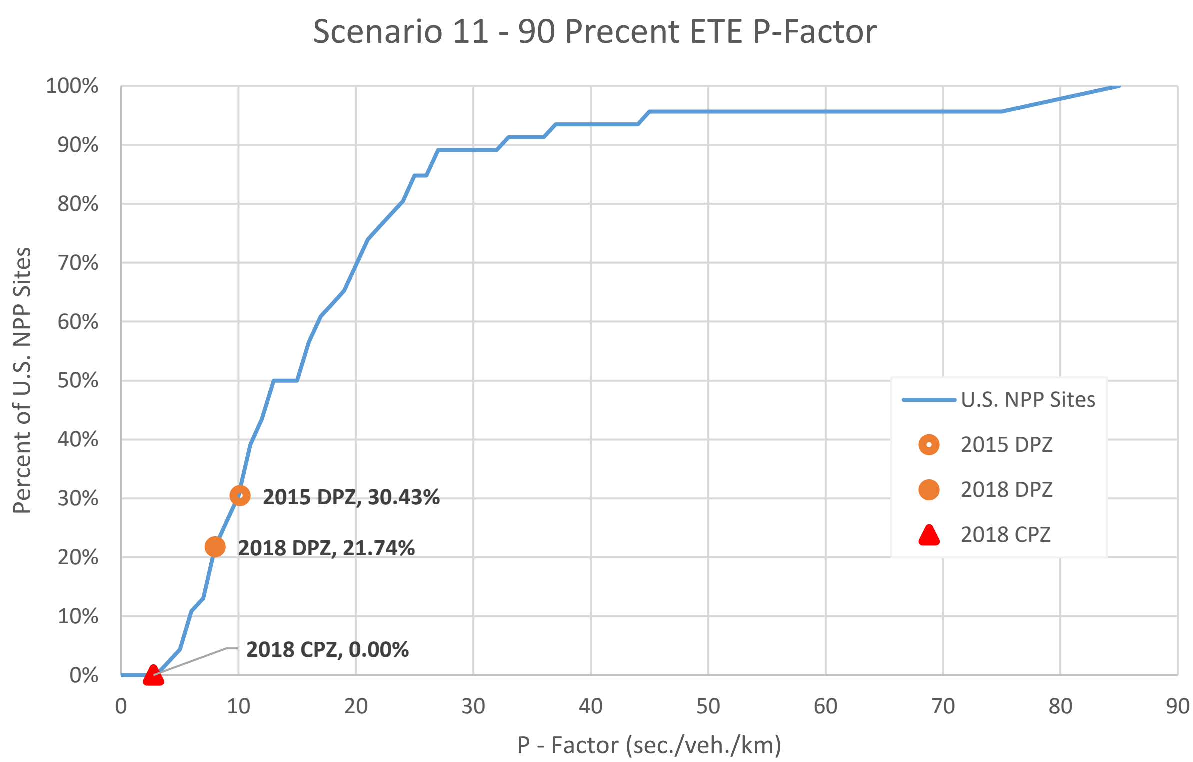

Figure A **- 59: Scenario 11 – Planning Zone 90 Percent ETE *P* - Factor**

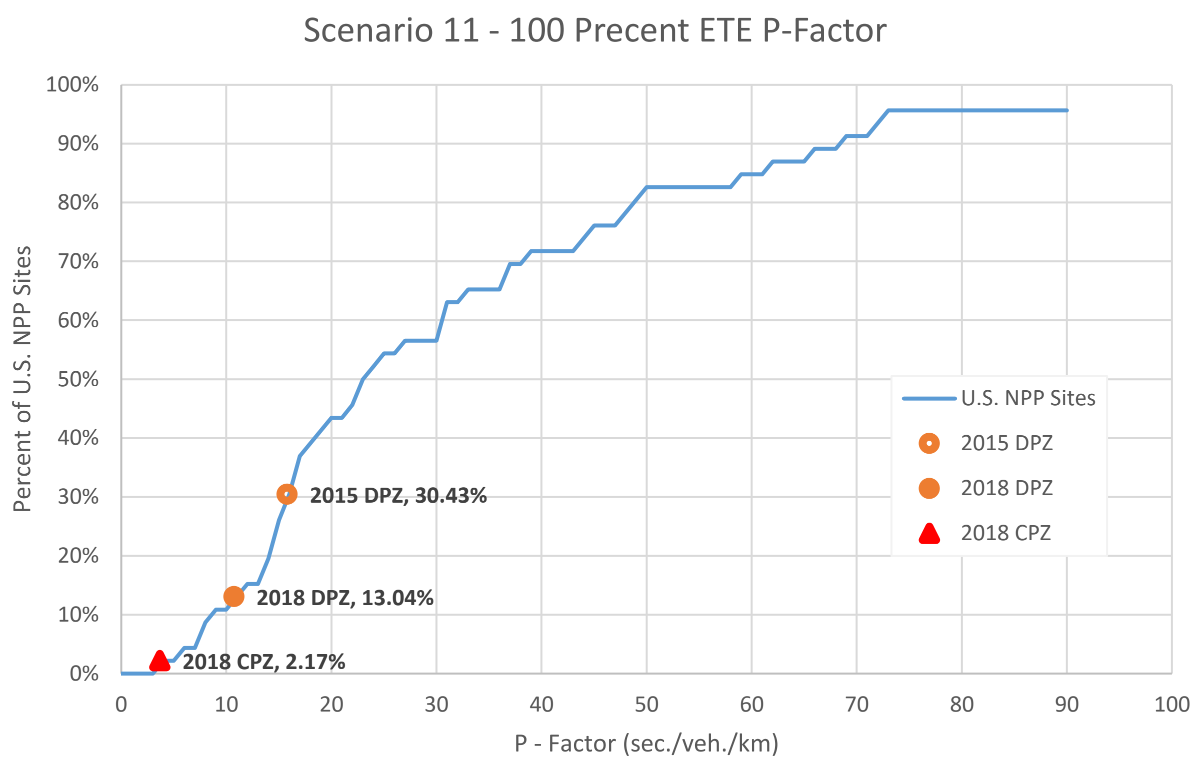

***Figure A* - 60: Scenario 11 – Planning Zone 100 Percent ETE *P* - Factor**

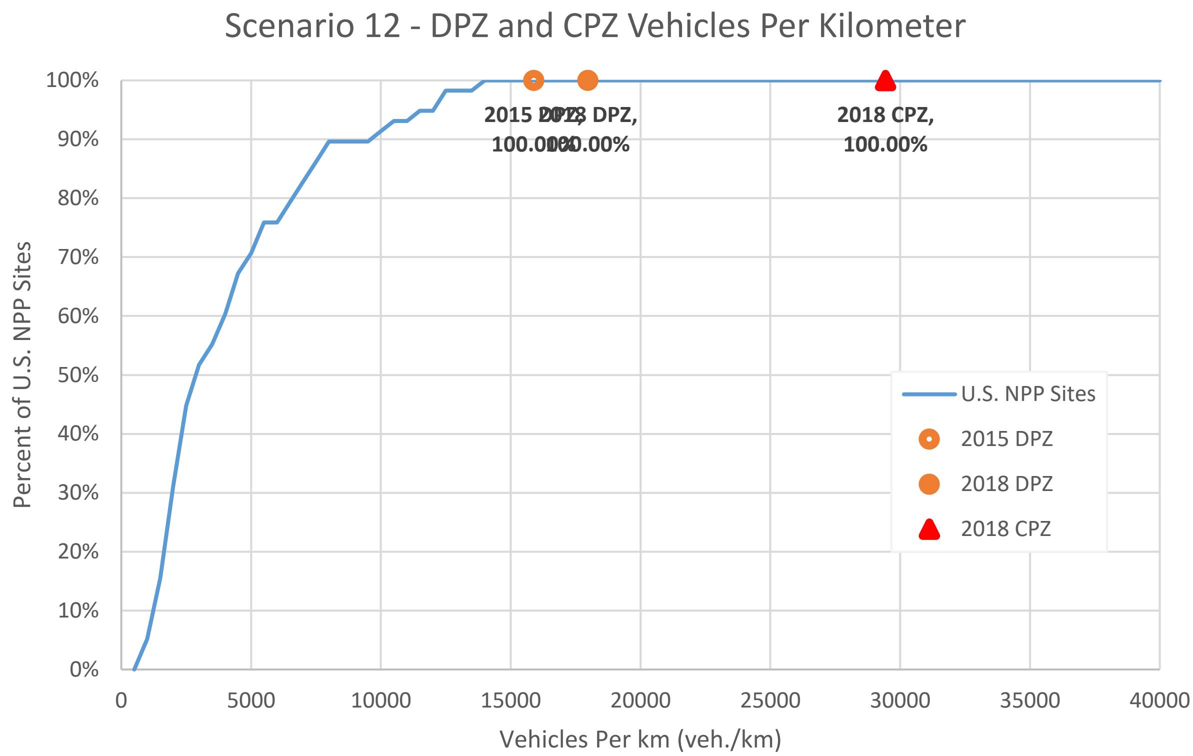

Figure A **- 61: Scenario 12 – Planning Zone Vehicles Per Kilometer**

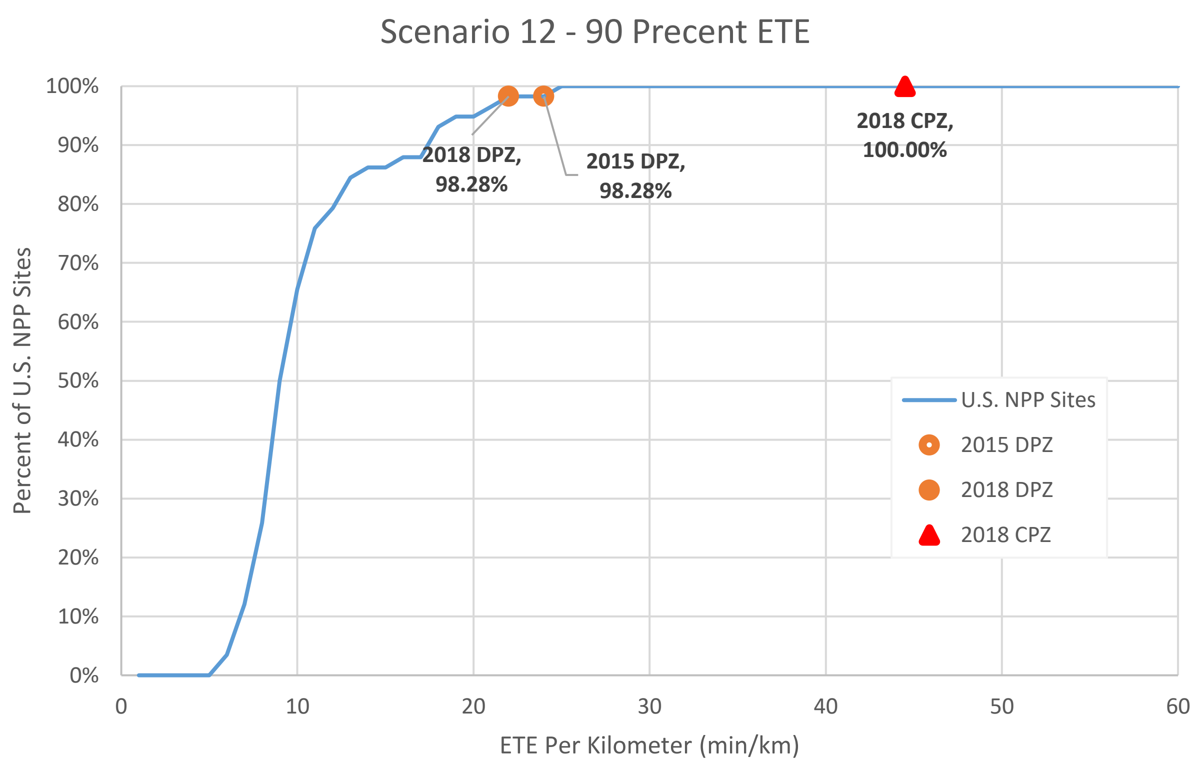

Figure A **- 62: Scenario 12 – Planning Zone 90 Percent ETE Per Kilometer**

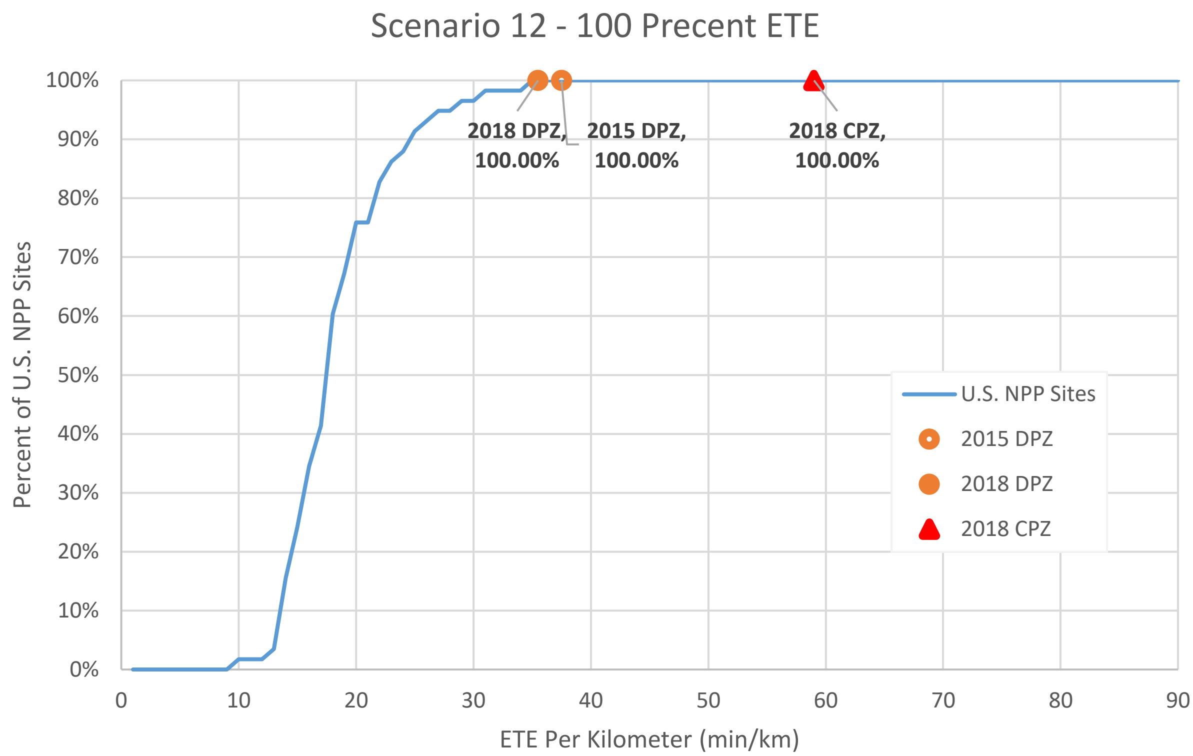

Figure A **- 63: Scenario 12 – Planning Zone 100 Percent ETE Per Kilometer**

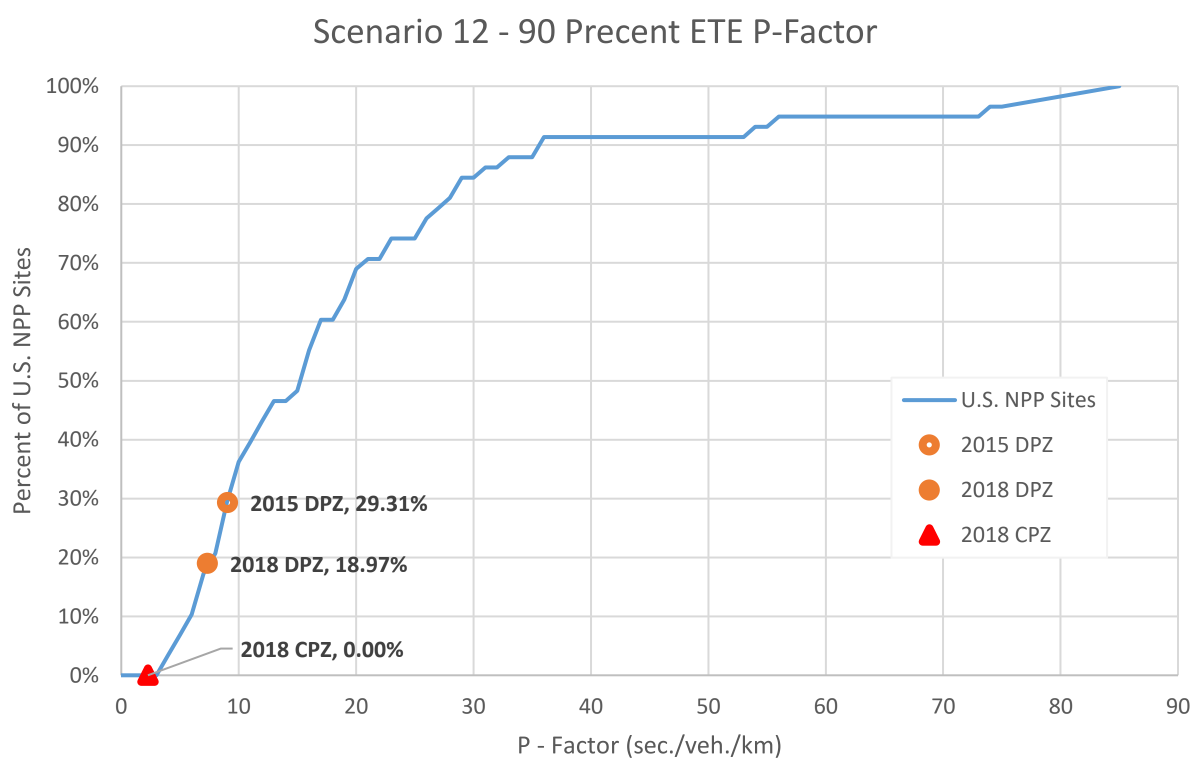

Figure A **- 64: Scenario 12 – Planning Zone 90 Percent ETE *P* - Factor**

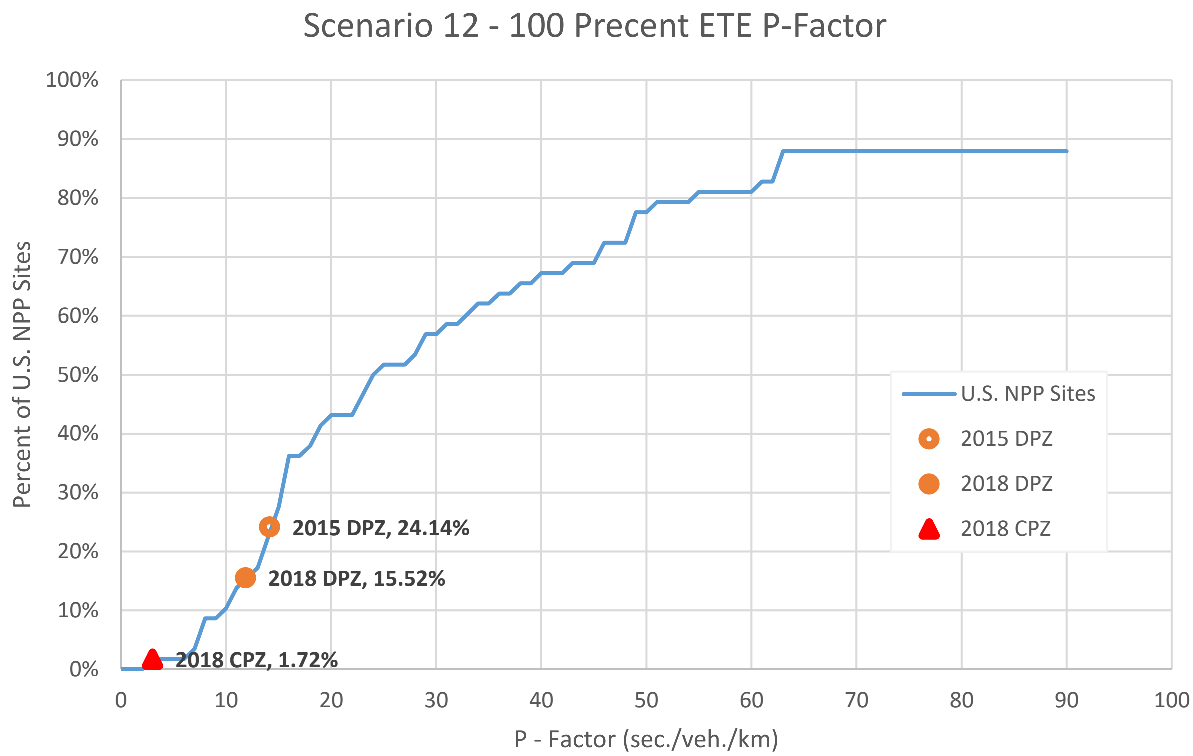

Figure A **- 65: Scenario 12 – Planning Zone 100 Percent ETE *P* - Factor**

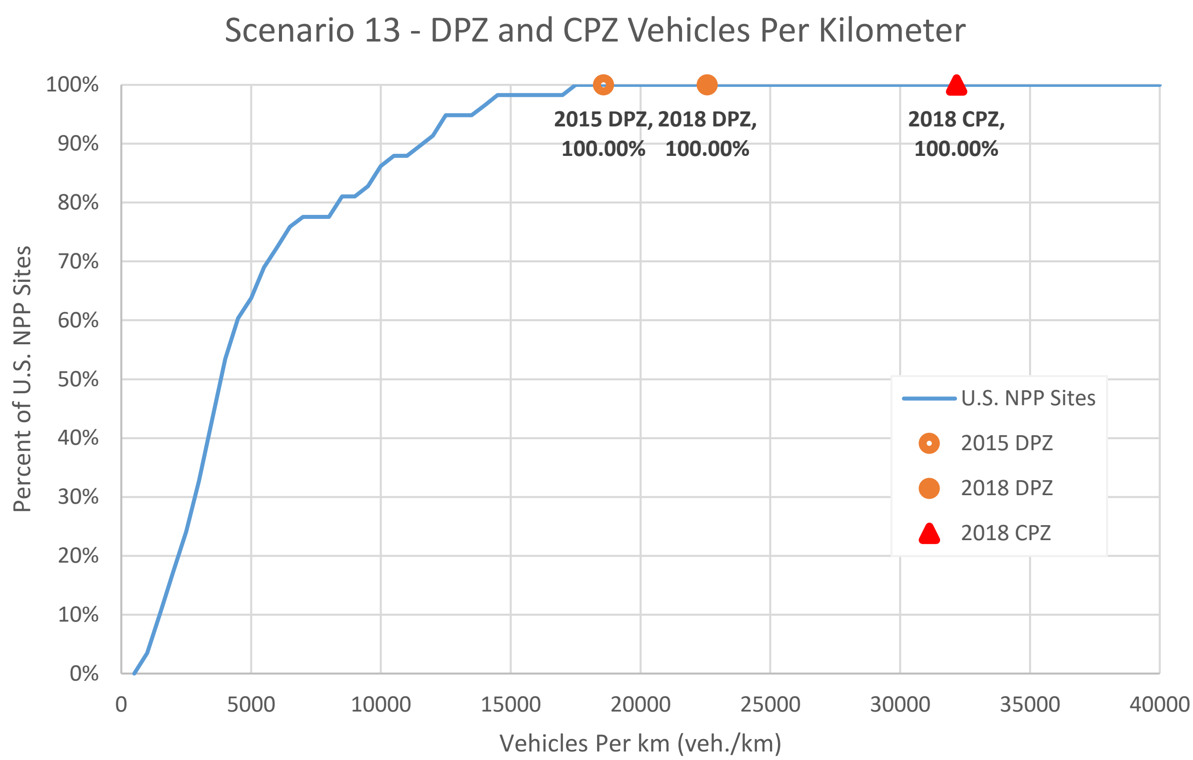

***Figure A* - 66: Scenario 13 – Planning Zone Vehicles Per Kilometer**

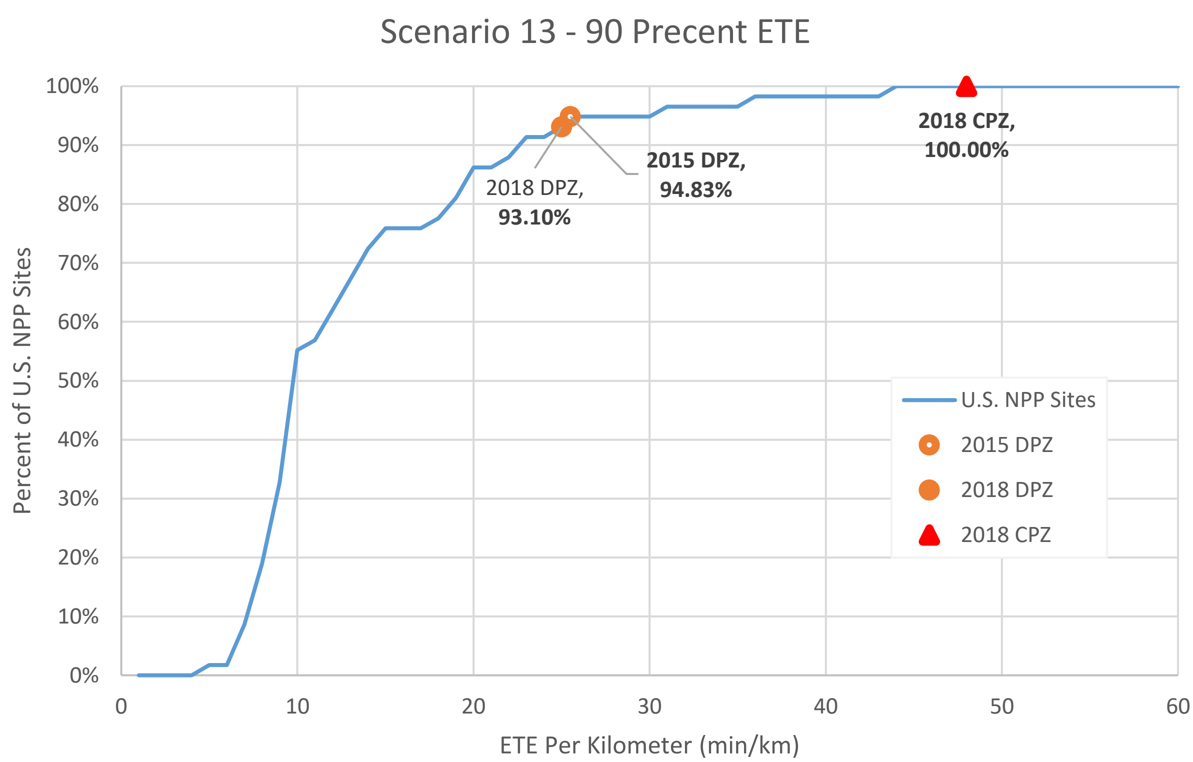

***Figure A* - 67: Scenario 13 – Planning Zone 90 Percent ETE Per Kilometer**

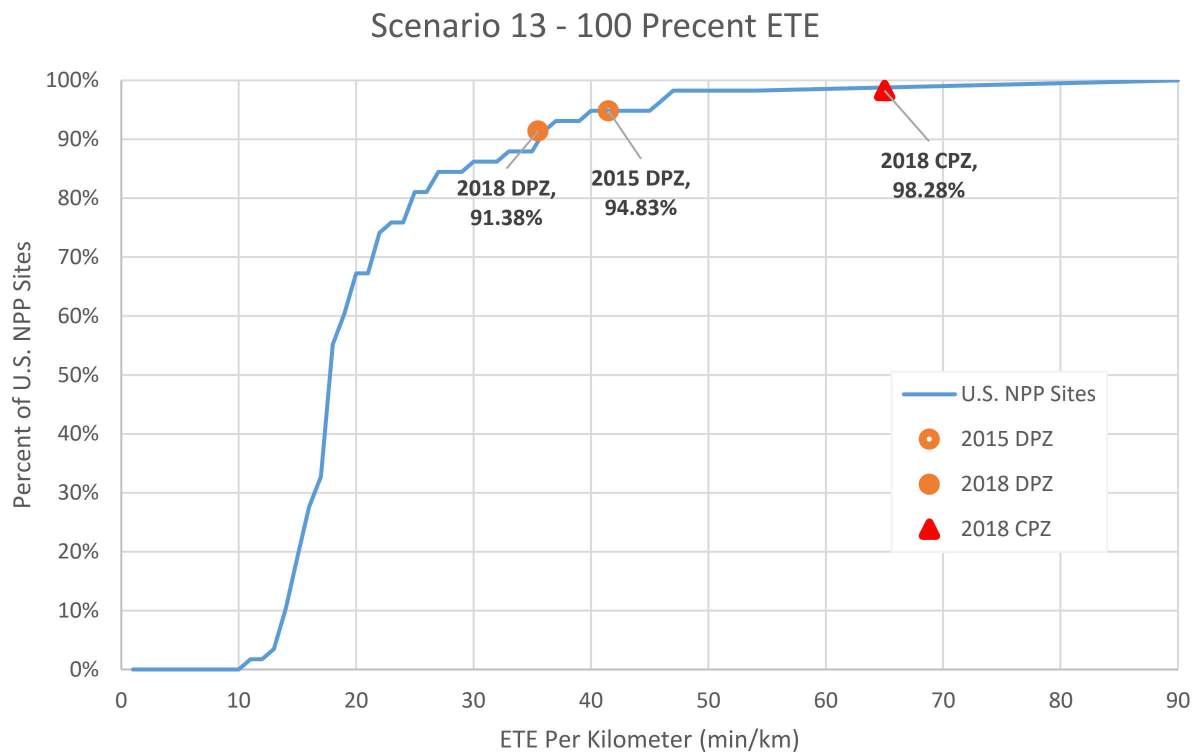

Figure A **- 68: Scenario 13 – Planning Zone 100 Percent ETE Per Kilometer**

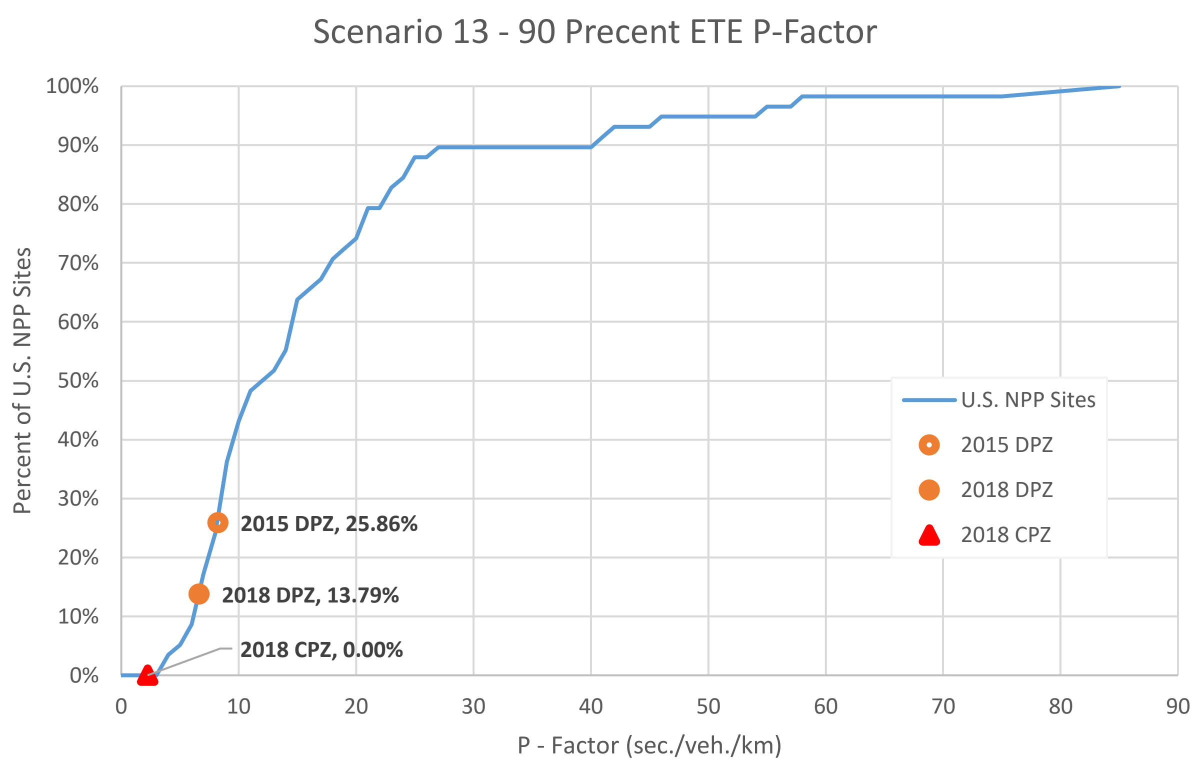

Figure A **- 69: Scenario 13 – Planning Zone 90 Percent ETE *P* - Factor**

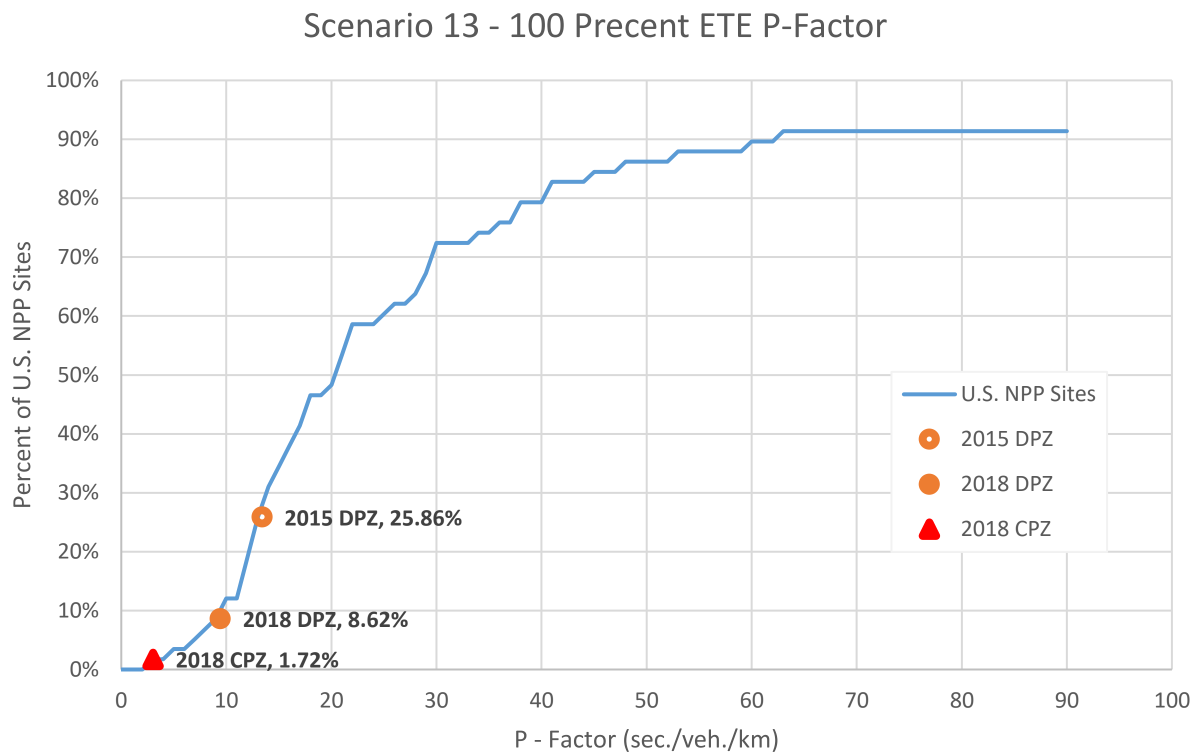

***Figure A* - 70: Scenario 13 – Planning Zone 100 Percent ETE *P* - Factor**

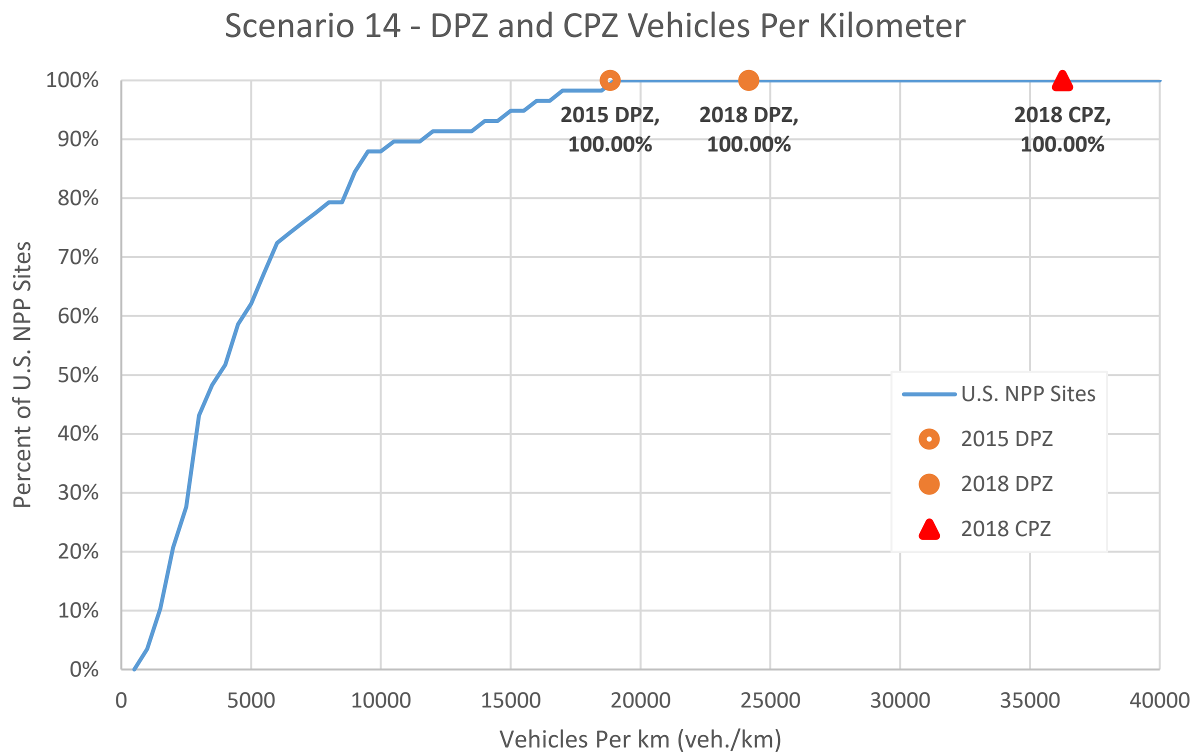

Figure A **- 71: Scenario 14 – Planning Zone Vehicles Per Kilometer**

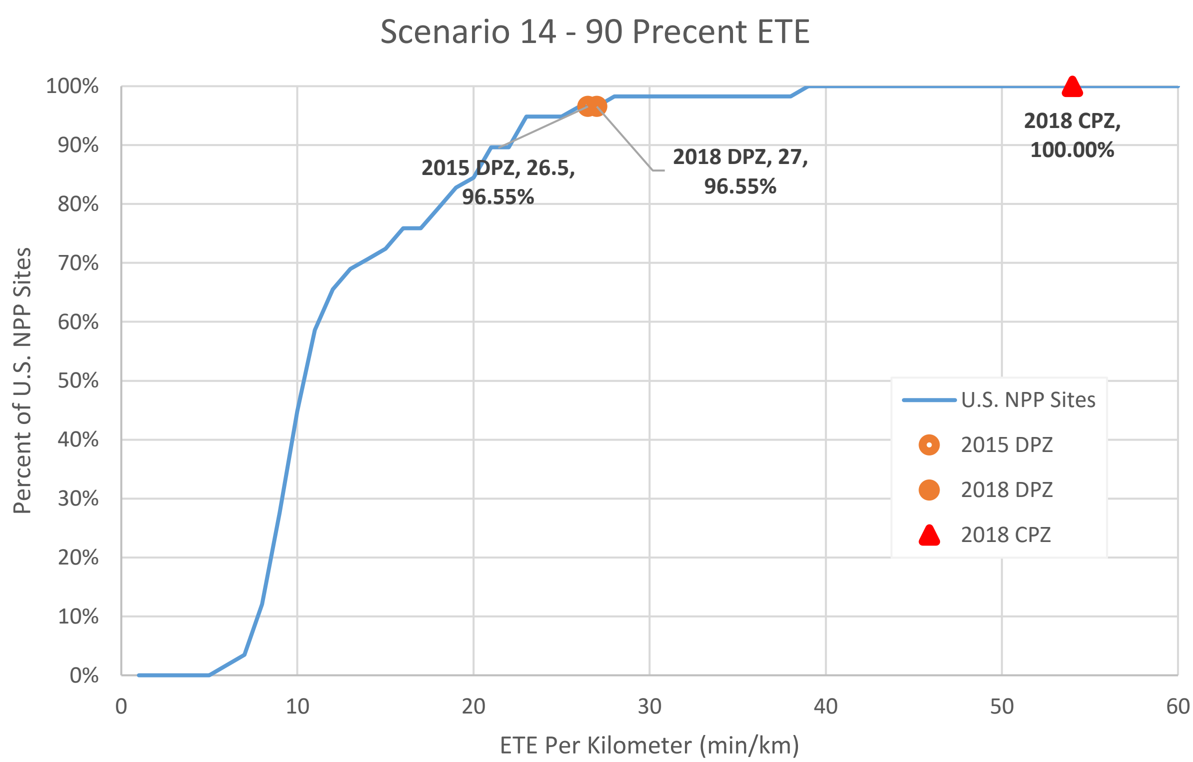

Figure A **- 72: Scenario 14 – Planning Zone 90 Percent ETE Per Kilometer**

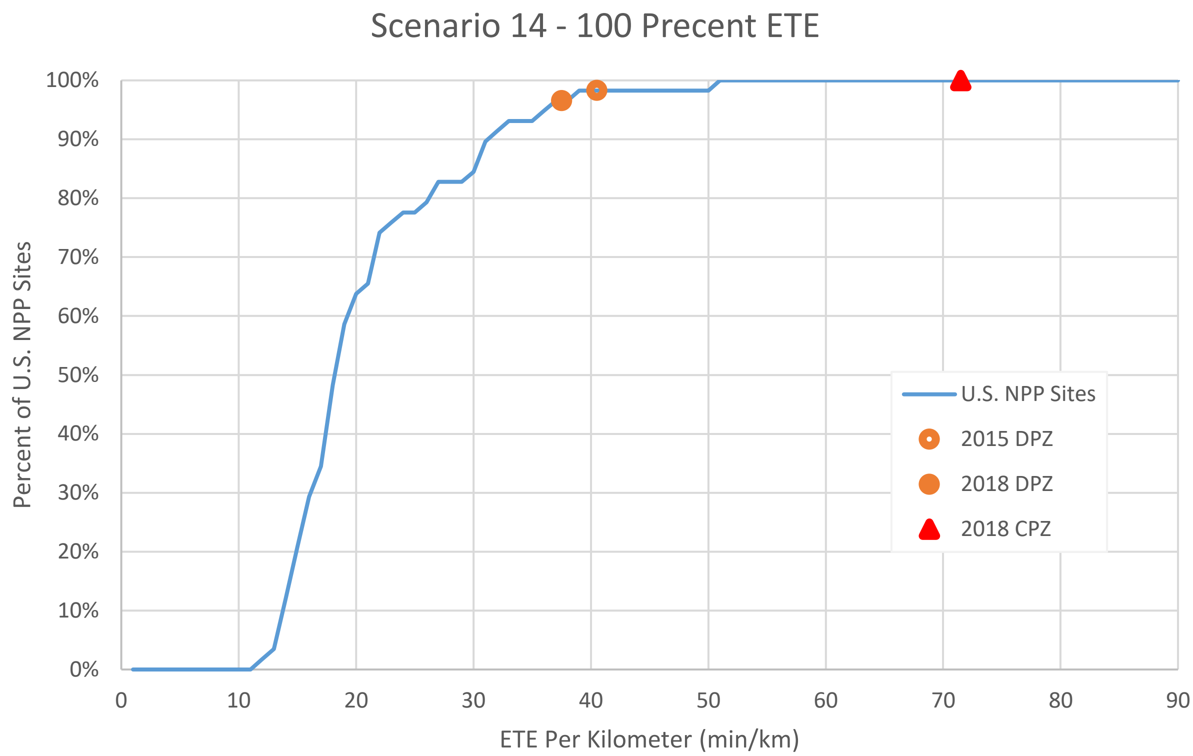

***Figure A* - 73: Scenario 14 – Planning Zone 100 Percent ETE Per Kilometer**

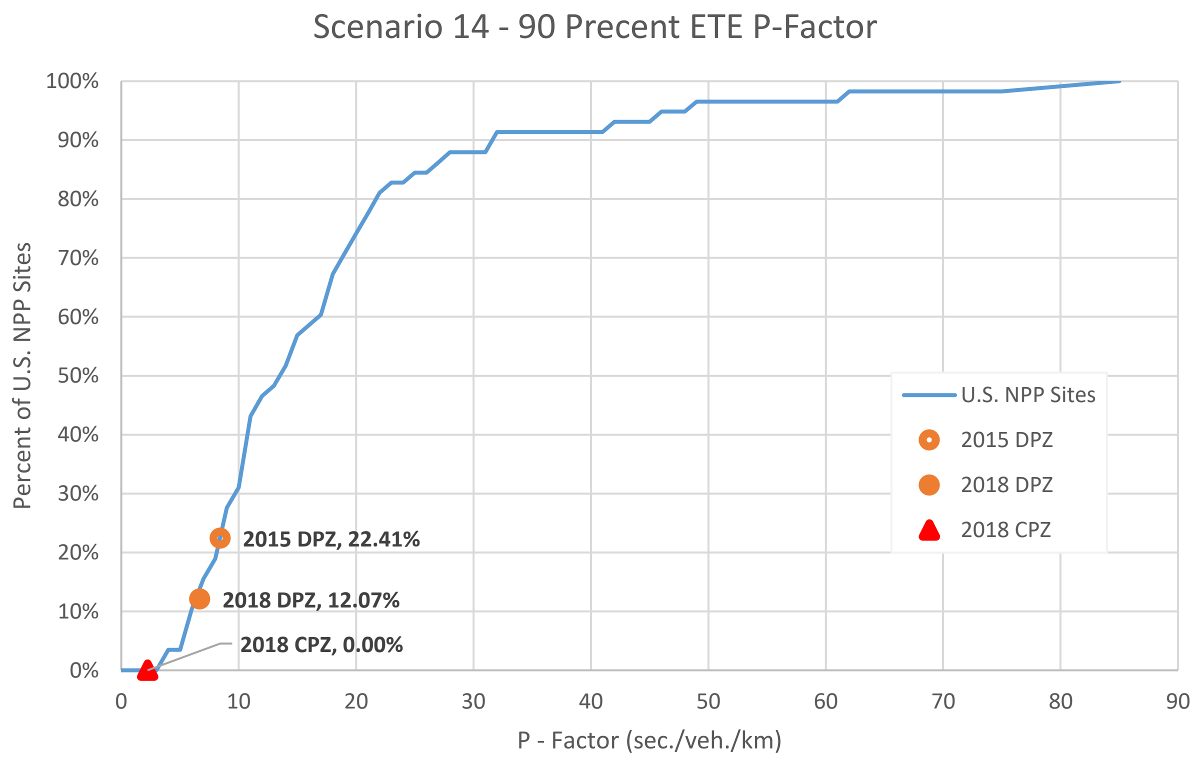

***Figure A* - 74: Scenario 14 – Planning Zone 90 Percent ETE *P* - Factor**

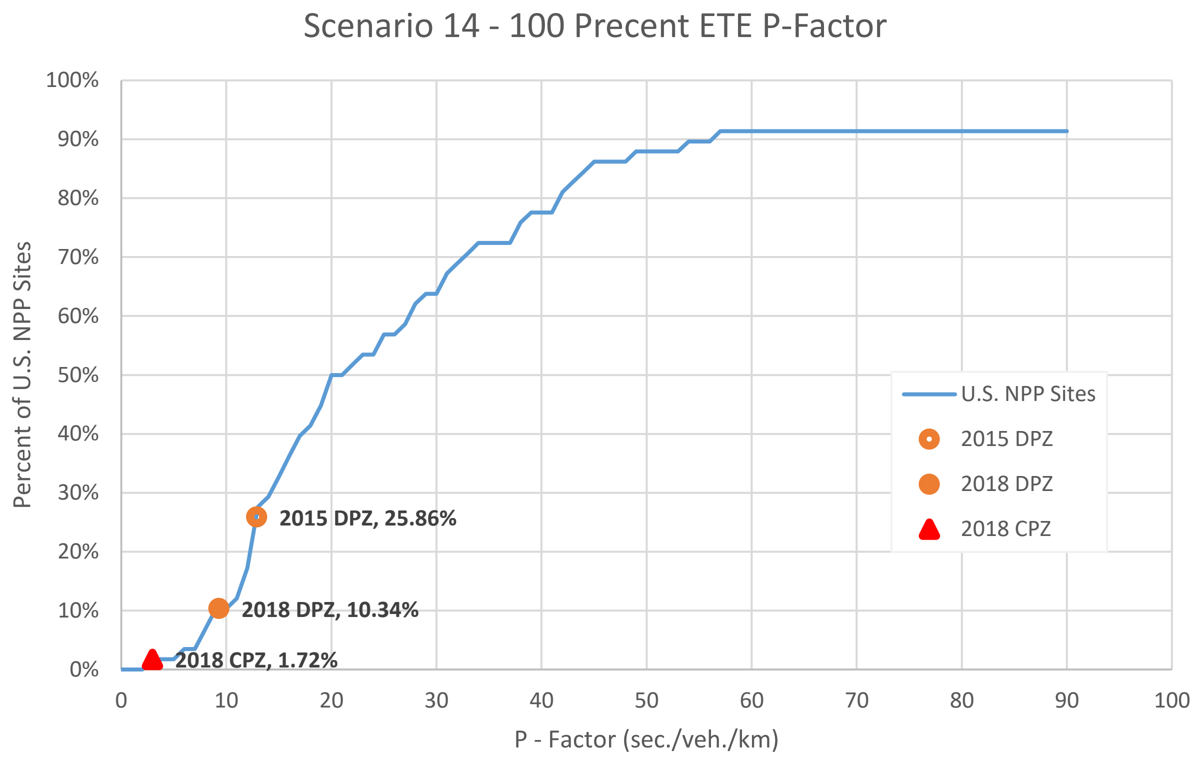

Figure A - 75: Scenario 14 – Planning Zone 100 Percent ETE *P* - Factor

APPENDIX B – THREE KILOMETER RING ETE ANALYSIS

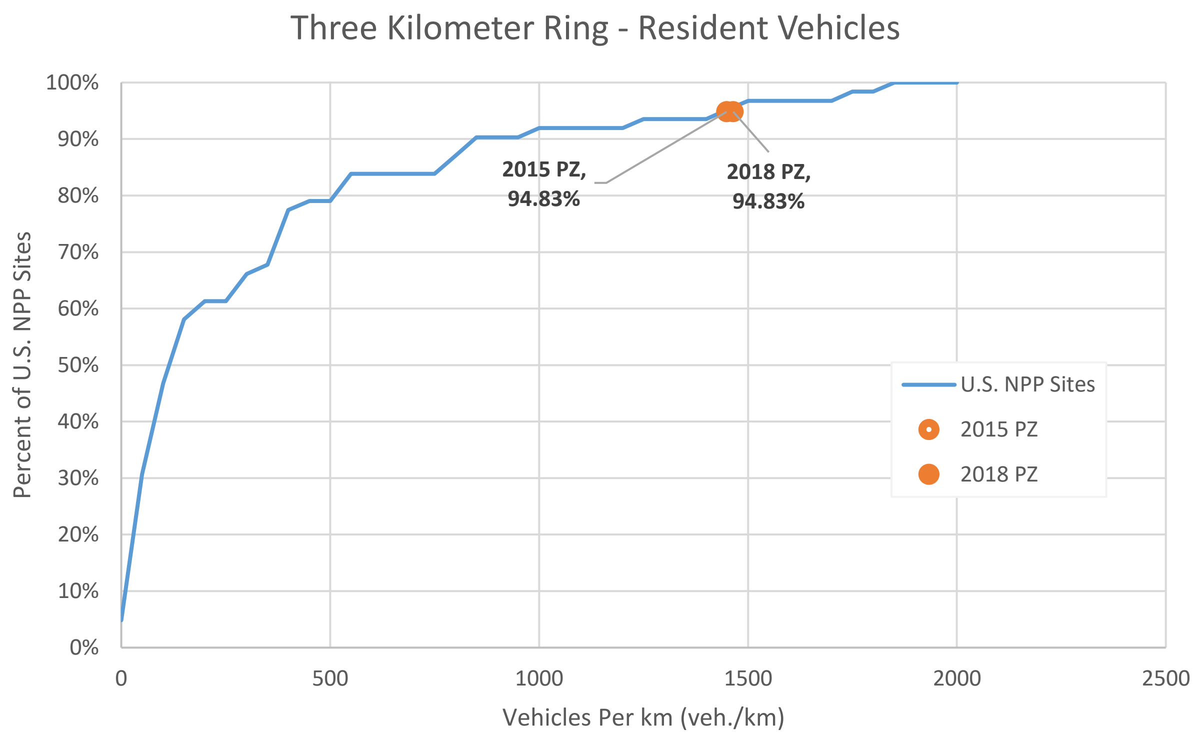

Figure B - 76: Three Kilometer Ring Resident Population Per Kilometer

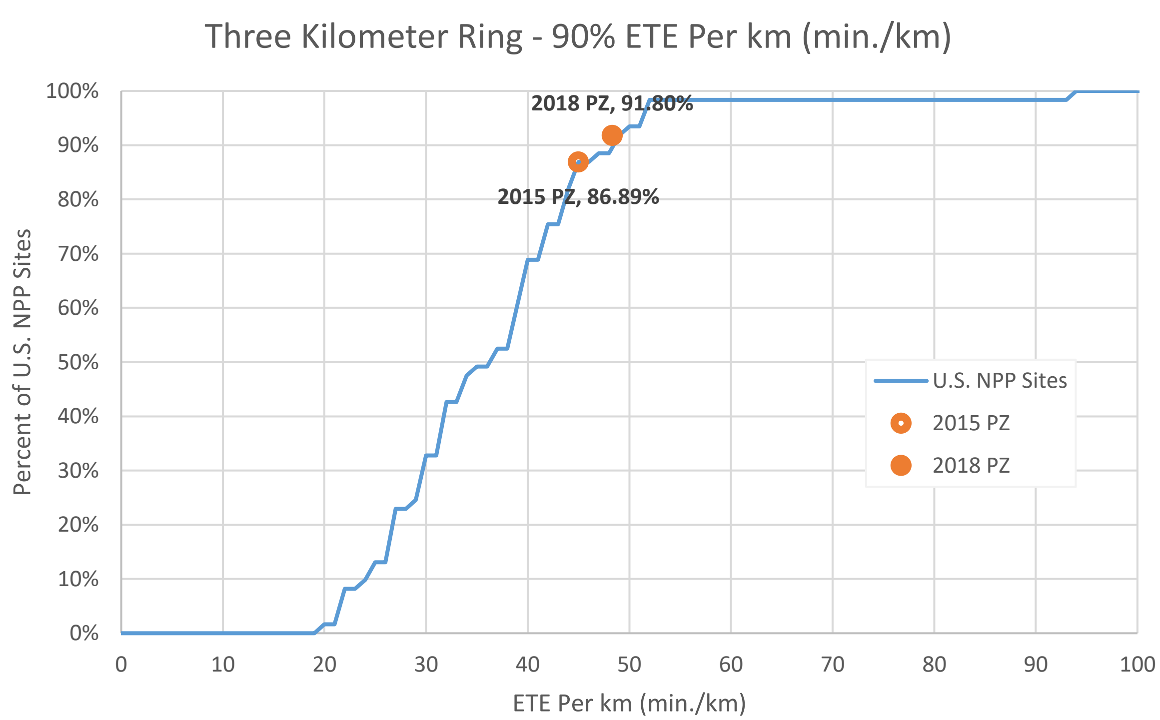

Figure B - 77: Three Kilometer Ring 90 Percent ETE Per Kilometer

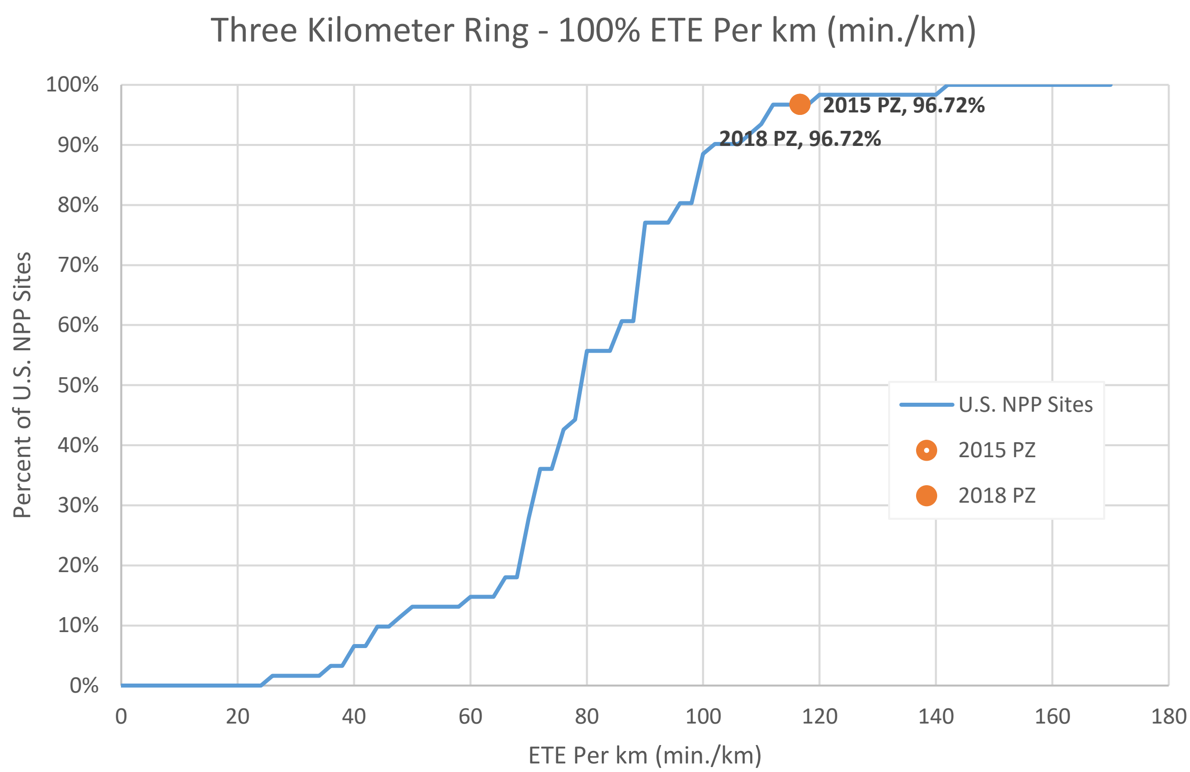

Figure B - 78: Three Kilometer Ring 100 Percent ETE Per Kilometer

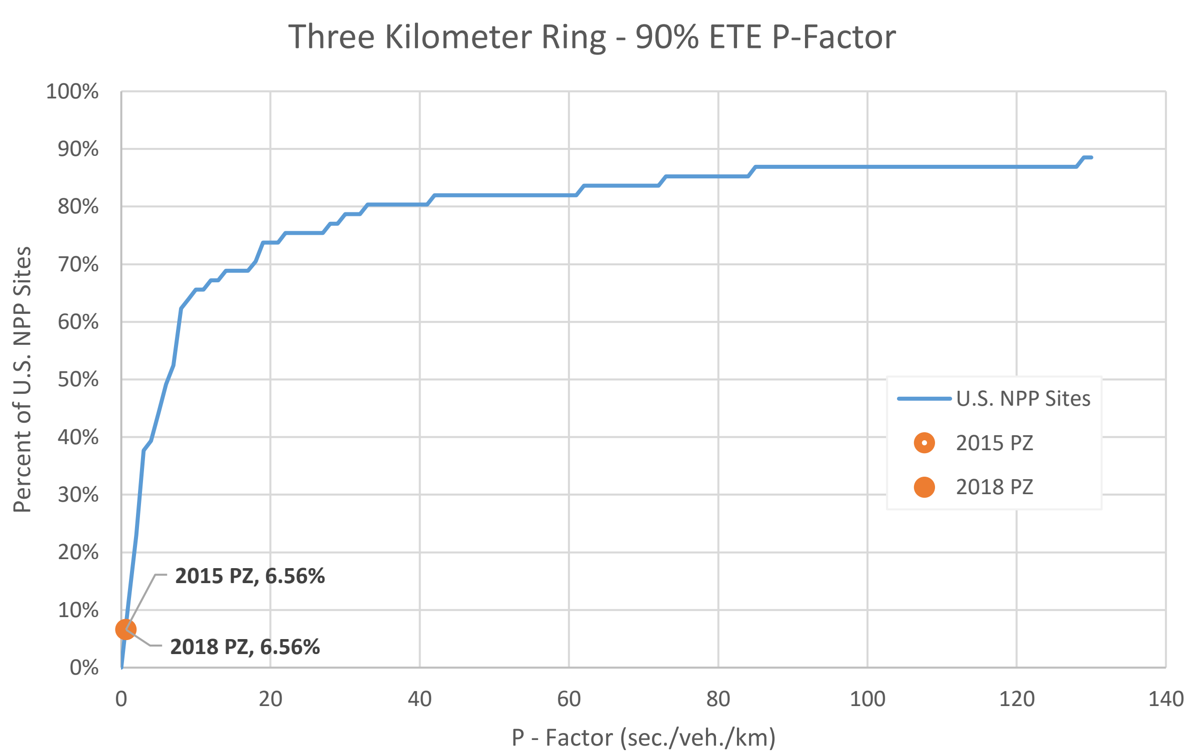

Figure B - 79: Three Kilometer Ring 90 Percent *P* - Factor

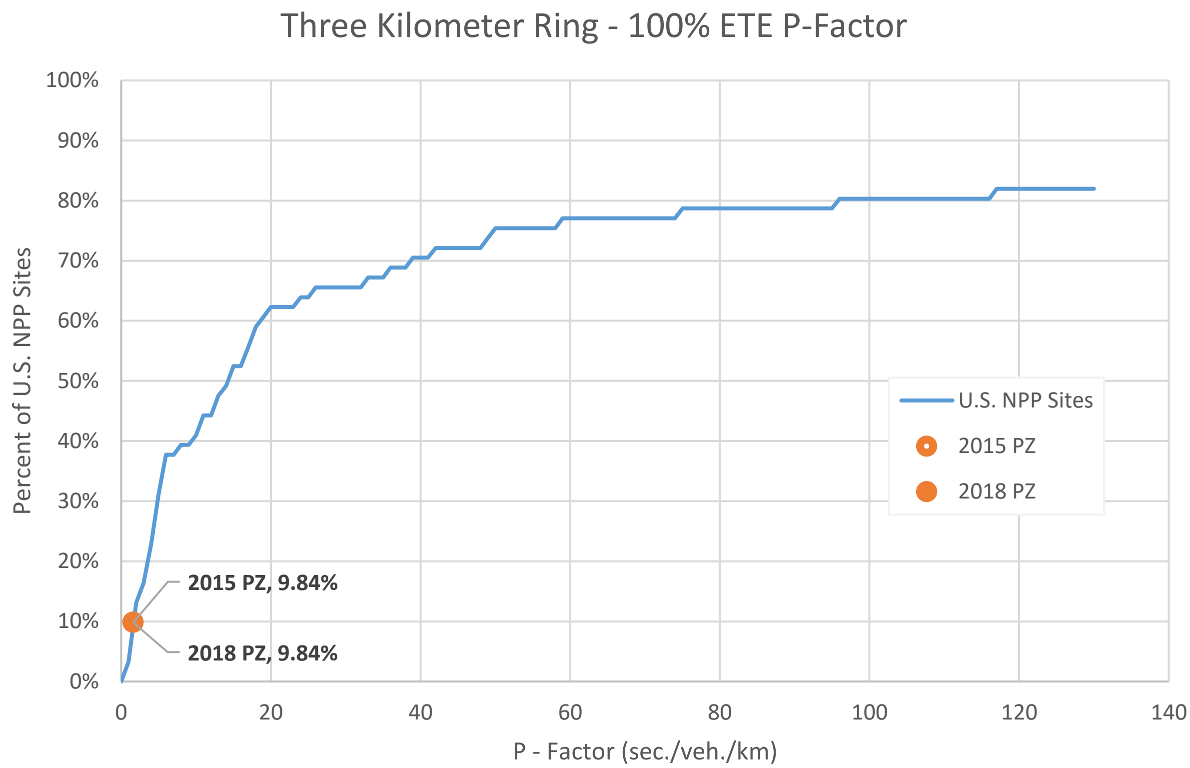

Figure B - 80: Three Kilometer Ring 100 Percent *P* - Factor

APPENDIX C – SIX KILOMETER RING ETE ANALYSIS

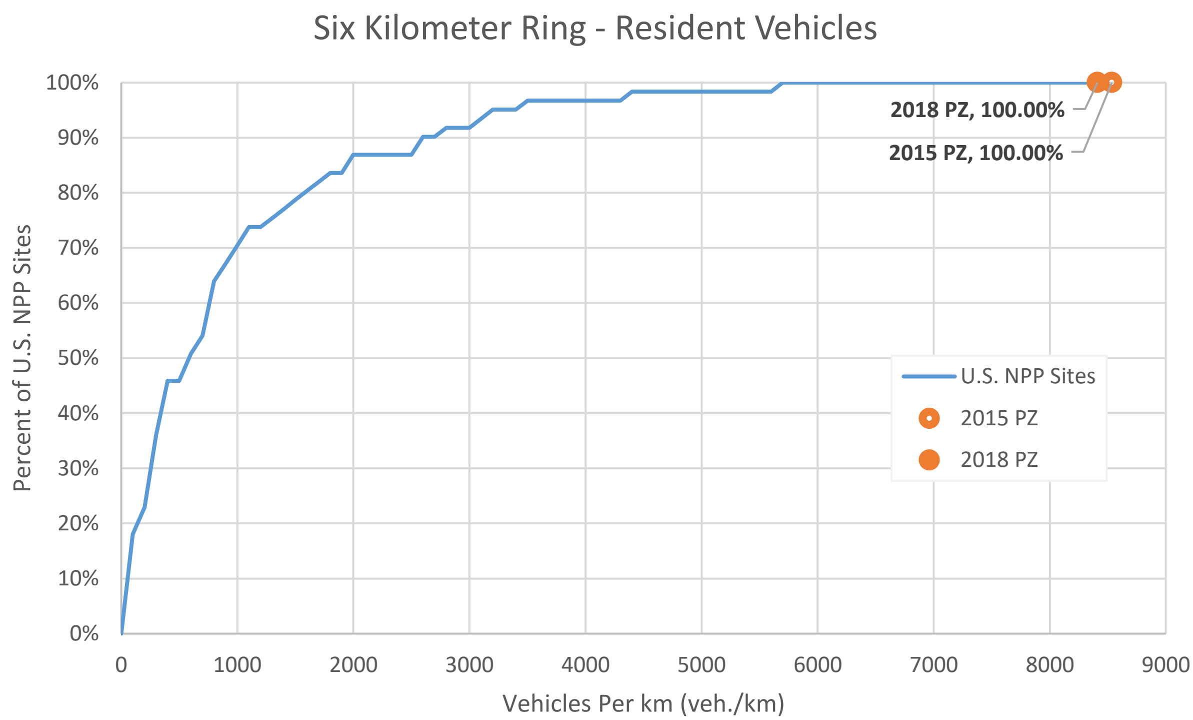

Figure C - 81 Six Kilometer Ring Resident Population Per Kilometer

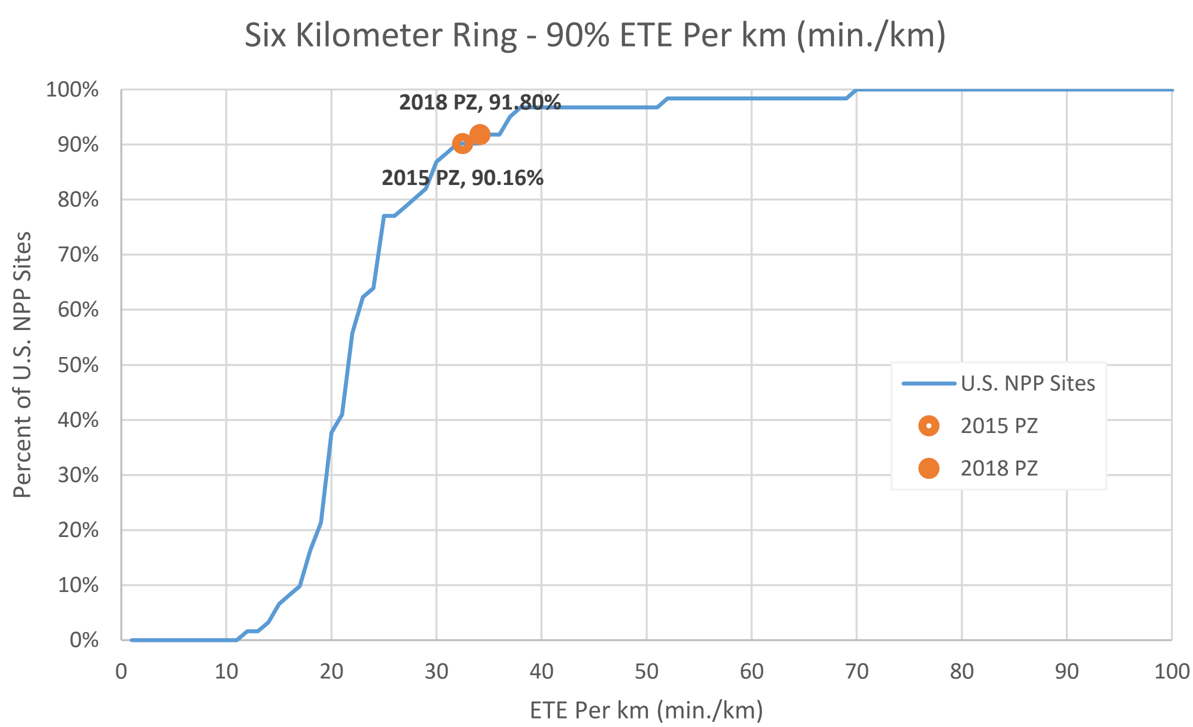

Figure C - 82: Six Kilometer Ring 90 Percent ETE Per Kilometer

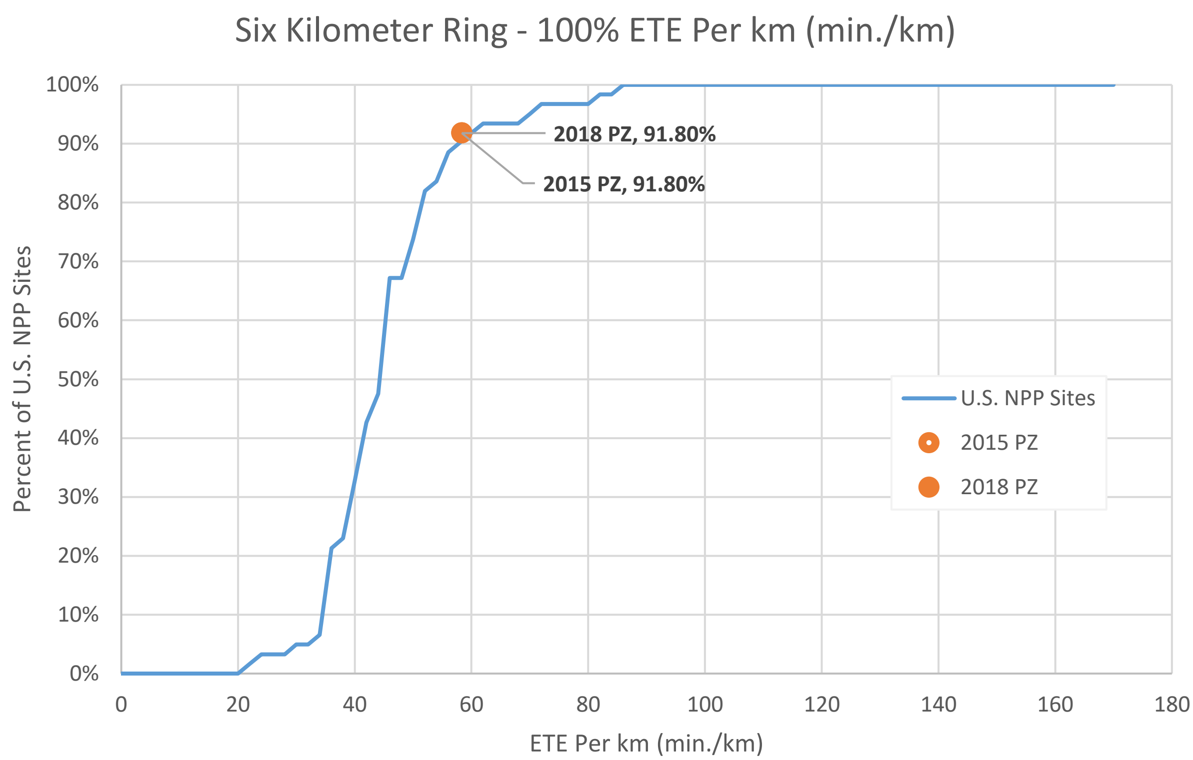

Figure C - 83: Six Kilometer Ring 100 Percent ETE Per Kilometer

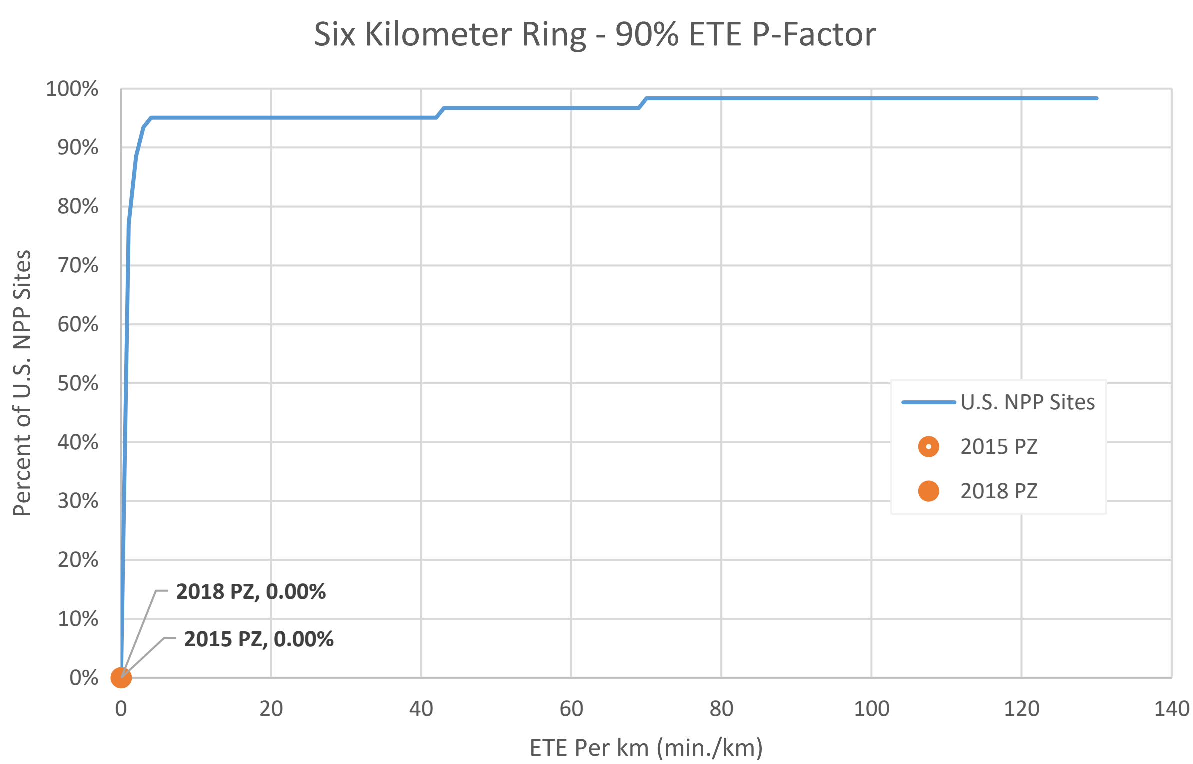

Figure C - 84: Six Kilometer Ring 90 Percent *P* - Factor

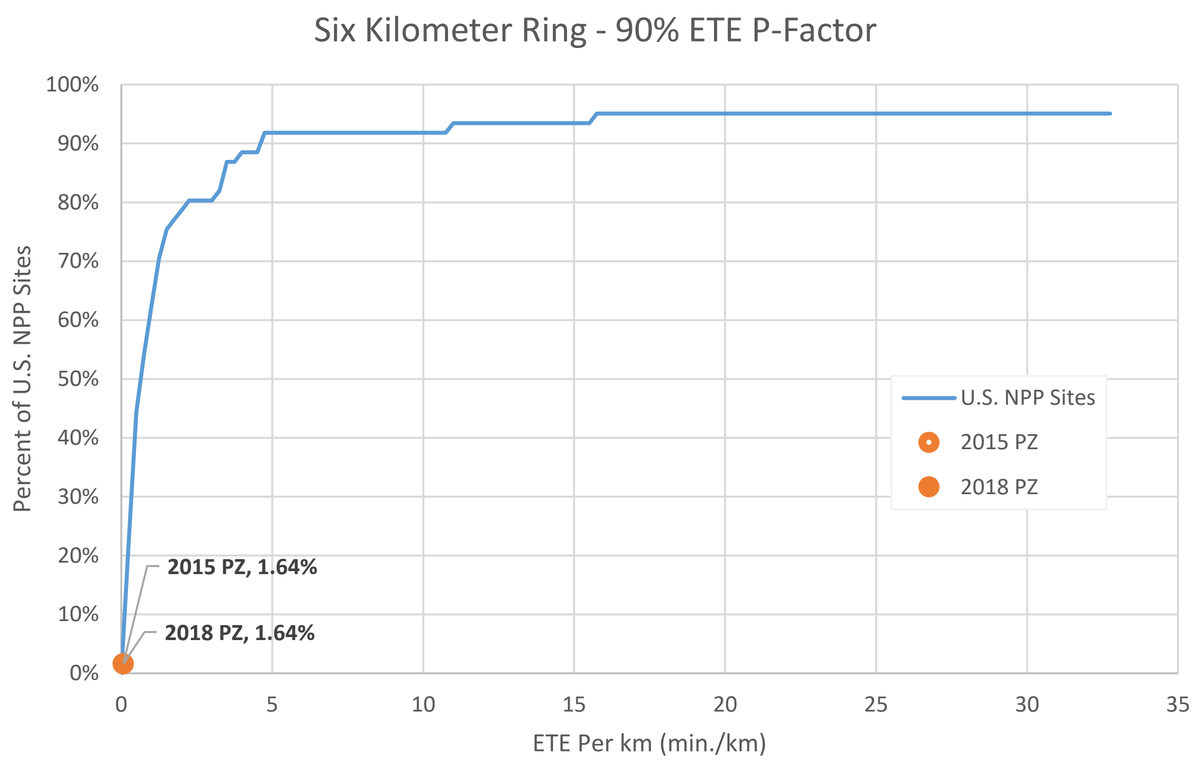

Figure C - 85: Six Kilometer Ring 100 Percent *P* - Factor