REGIONAL CONNECTORS STUDY

Scenario Planning White Paper

December 9, 2019

Contents

Introduction

This White Paper describes the approach to scenario planning to be applied in the Regional Connectors Study. It describes the overall framework for scenario planning and gives particular attention to the methods for analyzing and allocating regional land use for the scenarios.

Scenario planning can be defined as the process of planning for the future by analyzing existing trends and organizing them into a series of plausible future scenarios to explore their consequences. Scenario planning is useful in understanding the potential impacts of current and proposed policies in the face of these potential futures. With respect to land use planning, scenario planning provides a method for exploring potential future land development patterns and alternative forecasts of population and jobs in a locality or region. This exploration is done through the development of multiple future land use scenarios in which growth is driven by distinct sets of "drivers." The drivers represent forces such as demographic change, economic trends or technological advances, which can all affect land use patterns in different ways. After the scenarios are developed, their impacts can be quantified and used as evaluation measures against which to test the viability of policies and investments in the long-term.

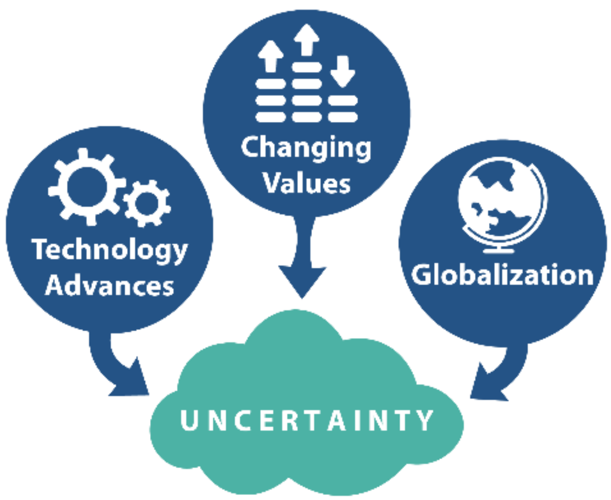


Figure 1. Conceptual Diagram of Scenario Planning Approach

Scenario Planning in the Regional Connectors Study

For the Hampton Roads Regional Connectors Study (RCS), scenario planning is being used to test potential future land use and growth scenarios as a basis for further analyzing potential future transportation alternatives. Normally, transportation alternative testing is done against a single future land use scenario that is built into the regional transportation planning assumptions, typically within a regional Travel Demand Model (TDM). This land use scenario is usually developed in consultation with each locality and represents their collective vision for how much population and employment growth will be distributed across their jurisdictions and where that growth will be located.

In the Regional Connectors Study, however, a series of land use scenarios is being developed for the Hampton Roads region, and the regional transportation alternatives will then be tested against each of these potential future land use patterns. The purpose of this approach is to give a more sophisticated "resilience test" of each of the transportation alternatives. It will yield information about how each transportation improvement package would perform under very different future land use conditions. As an example, proposed improvements that rely on transit investments require compatible and supportive densities of land uses to make extensive transit mode share viable. Alternately, future expansion of marine-related employment growth may show better performance for some types of transportation investments that support freight movement near the water. Therefore, the exploration of different land use growth patterns allows a much deeper analysis of the resilience of future transportation investments in the face of uncertainty. Using scenario analysis to test the outcomes of investments will reveal how beneficial and robust potential transportation investments will likely be; in other words, how resilient the investments are. The ultimate goal is to make the wisest possible transportation investments, ones that will stand up optimally in light of several potential growth futures and will be most resilient to change and uncertainty.

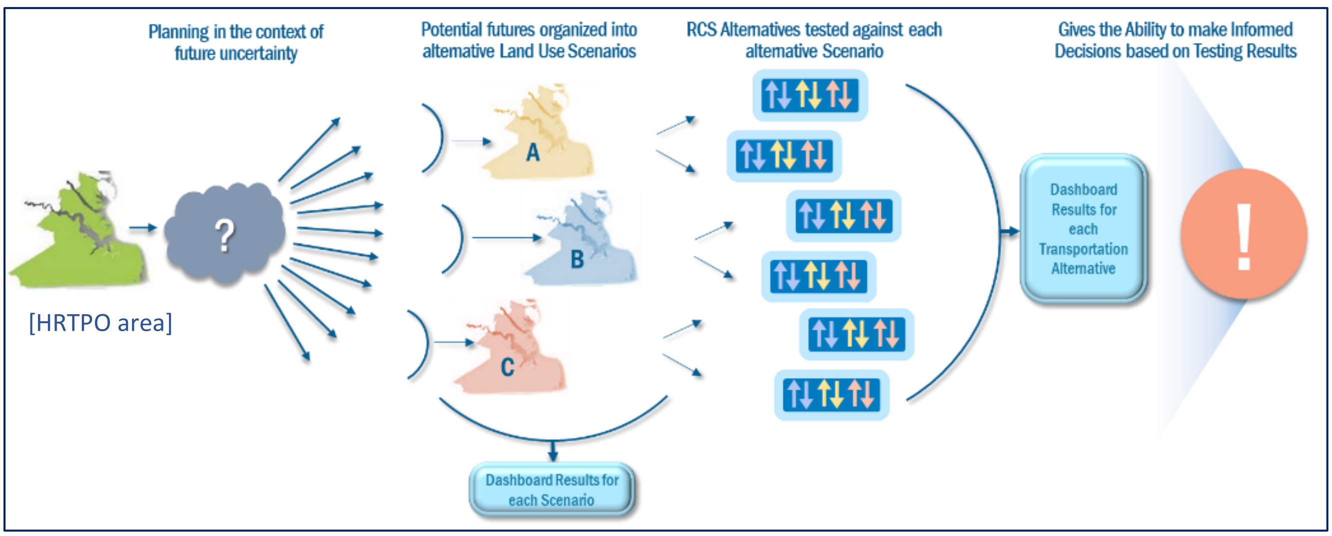


Figure 2. Diagram of the Process of Testing Transportation Alternatives Against Potential Future Land Use Scenarios Used in the Regional Connectors Study Process

The timeframe to conduct scenario planning includes initial planning and scoping (July to December 2018), developing the scenarios and modeling tools (January 2019 to January 2020), and conducting the scenario analysis (January to April 2020 for scenarios with E+C network, and late 2020 for modeling candidate RCS alternatives).

Scenario Development

Baseline Growth Assumptions

Through an interactive process with the RCS Working Group, the study team began by developing assumptions about the amount of population and employment growth that would be used as the basis for the development of the land use scenarios. The starting point for these assumptions is the growth totals that were approved by the HRTPO Policy Board and built into the 2045 regional Travel Demand Model (TDM). These totals and the 2015 base year totals (the latest approved for the HRTPO TDM) are summarized in Table 1.

Table 1. Approved 2015 and 2045 Regional Control Totals

Year	Employment	Population
2015	1,027,006	1,725,777
2045	1,108,274	2,024,085

The RCS Working Group, with approval by the RCS Steering Committee, decided to use these assumptions as the "2045 Baseline" scenario and to develop three other scenarios that would assume an additional amount of "greater growth" above the 2045 baseline level. The 2045 employment growth represents an increase of 8 percent over the 2015 employment total. The RCS Working Group and the study team reviewed alternative forecasting assumptions and related trends and scenarios, as documented in the RCS *Economic Trends and Opportunities Memorandum* (forthcoming) to develop a recommended change in employment growth control total for the three greater growth scenarios. The RCS Working Group recommended, and RCS Steering Committee approved, an employment increase of 16 percent over the 2015 employment total. The Steering Committee's approval allows up to 21 percent growth to be modeled if the initial modeling of 16 percent growth does not produce adequate differentiation between scenarios. The HRPDC staff used their REMI© regional economic model to derive population growth totals from the 16 percent employment growth assumption. The scenario planning control totals for population and employment for the three "greater growth" scenarios are as follows:

Table 2. Control Totals for the "Greater Growth" Scenarios Using 16 Percent Employment Growth 2015-2045

	Greater Growth Total	2015 - 2045 Growth	Greater Growth amount over 2045 Baseline
Employment	1,187,532	163,798	82,972
Population	2,127,172	408,214	110,460

Based on these assumptions, the three Greater Growth land use scenarios use these growth control totals. The amount of growth to be allocated by the land use model is the increment of employment and population growth *over the 2045 Baseline* (i.e., 83,053 jobs and 110,569 population). The land use model does not re-allocate any of the 2015 to 2045 Baseline forecast growth. The land use scenario testing also uses the existing plus committed project (E+C) transportation network from the regional TDM as an assumed network in all scenarios.

Baseline Scenario

The Baseline Scenario uses the forecasted growth for the region in the 2045 regional Travel Demand Model. It consists of the 2045 socioeconomic forecast that was approved for the region by the HRTPO Board allocated into a total of over 1,500 Transportation Analysis Zones

(TAZs). For the purposes of scenario planning, the 2045 Baseline Scenario is used to compare against the three Greater Growth scenarios.

Greater Growth Scenarios

The three Greater Growth scenarios are the alternative future land use scenarios that were developed interactively by the Working Group and approved by the Steering Committee. They represent the alternative future land use patterns against which the transportation investment alternatives will be tested. Figure 3 depicts the scenario narratives, including the key drivers for each scenario that were agreed upon for this study. Each scenario has a distinct set of drivers that inform different patterns of economic and population growth in the region as well as technology that will affect transportation demand and performance. The drivers represent external forces that can influence growth and transportation dynamics in the region. The scenario planning process uses a set of computer models to translate the drivers into variable input measures that yield variable outcomes to be studied under each scenario. Specifically, the Land Use Allocation model uses GIS data and the techniques described in the remainder of this White Paper to modify the distribution of land use in each scenario, and the TDM uses a combination of built-in levers and modified travel behavior and network performance assumptions to represent the impact of technology drivers. The scenario drivers are documented in detail in the *Technical Memorandum on Scenario Drivers* (forthcoming).

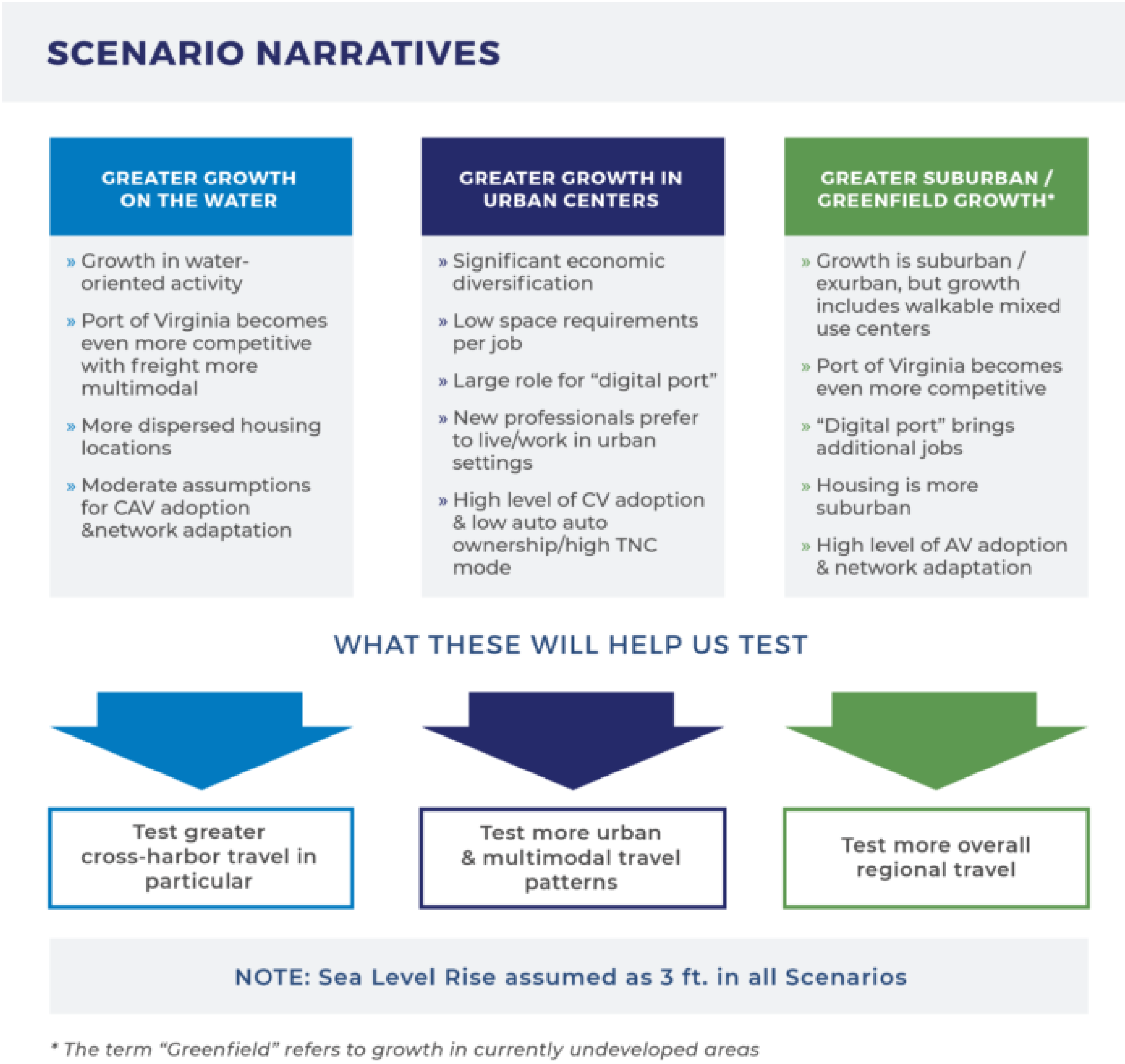


Figure 3. Greater Growth Scenario Narratives

Building the GIS Base for Scenario Planning

A regional base map created in GIS serves as a starting point for scenario analysis. The base map for the scenario analysis is based on the HRTPO Regional Land Use Map. First developed in 2011 and updated since then, the map synthesizes the existing and future land use maps from the comprehensive plans of the region's sixteen jurisdictions into a single set of land use categories that was agreed to and adopted by the HRTPO Board. This unified existing and future land use map provides a common language for analyzing, planning and envisioning land use patterns and growth across the region. The land use categories from the regional land use map were adopted as the place types for the computer modeling in the scenario planning process.

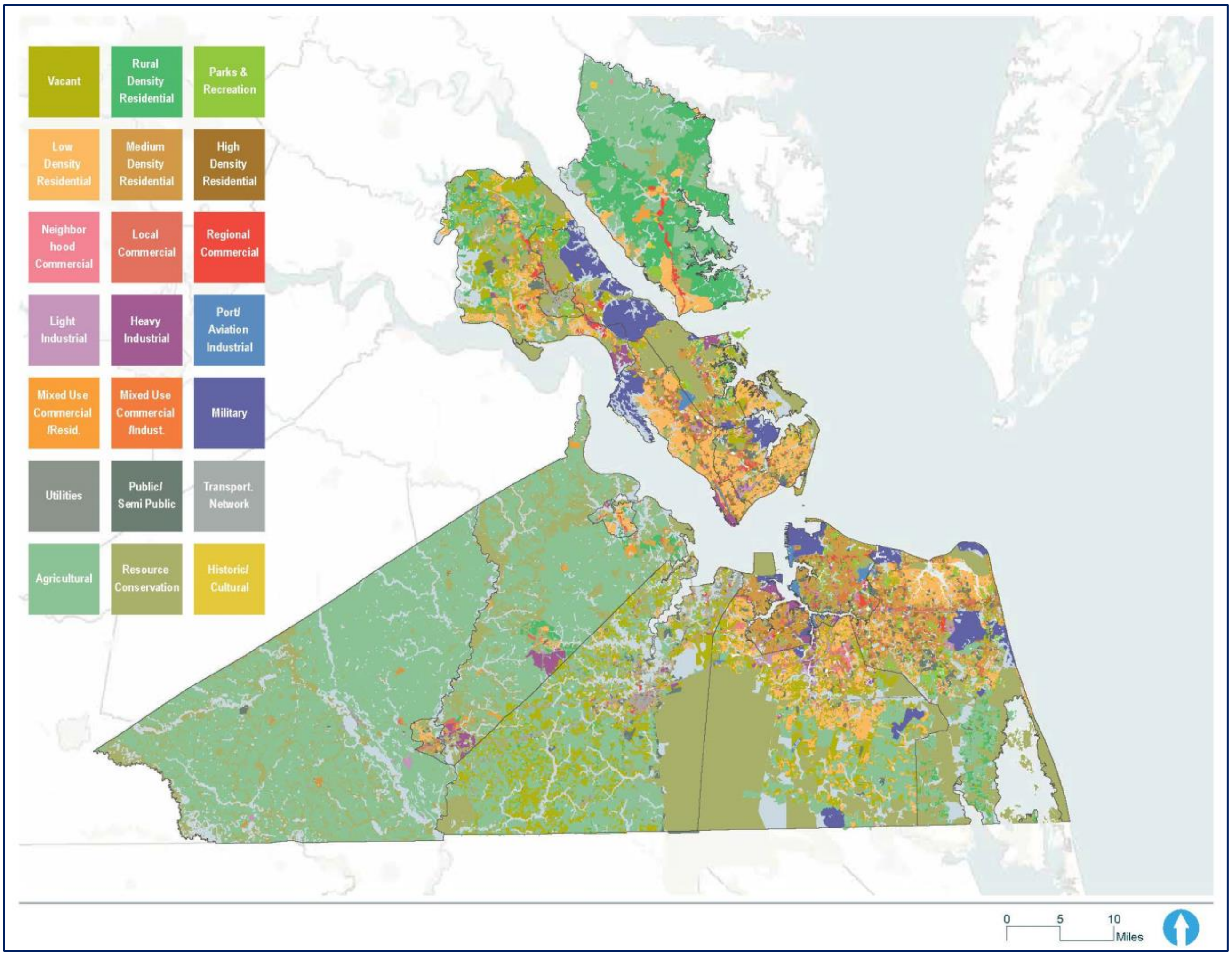


Figure 4. The Regional Land Use Map with the 2015 (Existing) Place Type Geography

Simplifying the Parcel Based Land Use Map

Given that the Regional Land Use Map was developed at the parcel level, it consists of several hundred thousand polygons. This number of polygons is too many to allow the Land Use Allocation computer model to function, so the parcel geography has been somewhat simplified.

A translational layer with a smaller number of polygons was created and combined with the regional land use map to provide a simpler geography, but still with an accurate reflection of the 2015 and 2045 regional land uses. A grid comprised of 80-acre cells was intersected with the parcel-based map to reduce the total number of features in the base map. The grid layer reduces the total number of features in the base map to around fifty thousand features which allows computer modeling of the scenarios.

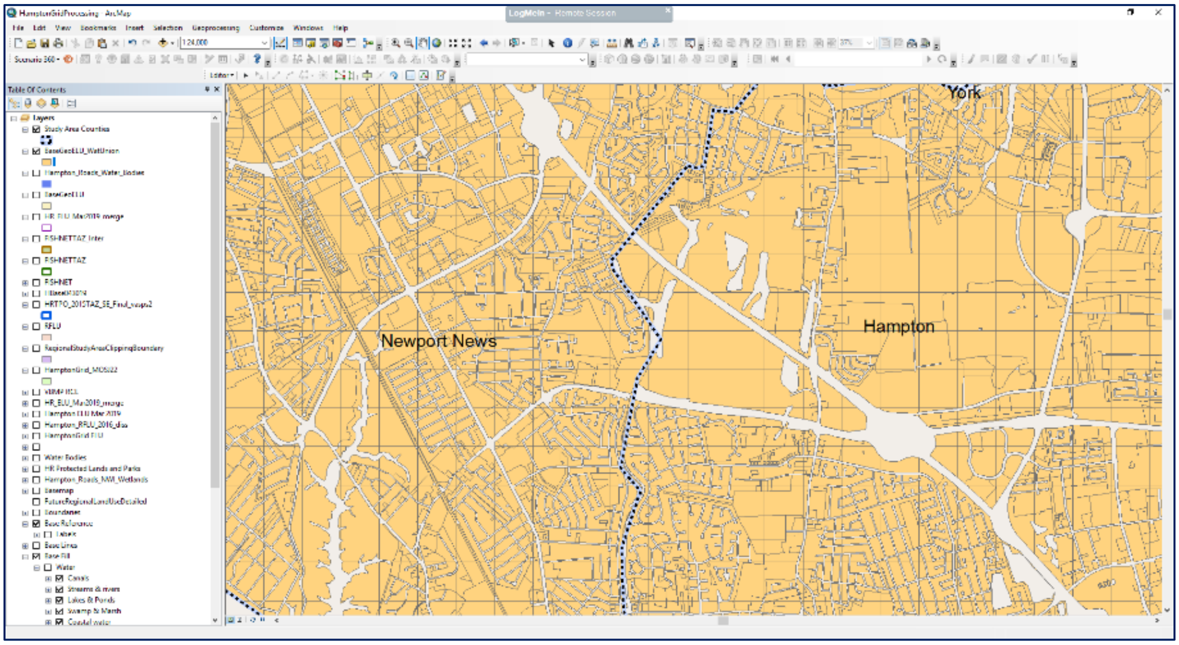


Figure 5. Example of Simplifying the Parcel Geography with an Overlaid Grid

Associating the Place Types to TAZs

This simplified base map is then associated with the TAZ geography from the regional Travel Demand Model, which ties the land use mapping to the TDM. Since the grid cells in the translational layer are larger than the parcels used in the Regional Land Use Map but smaller than the TAZs, the place type data can be aggregated up to the grid cells, and then associated to each of the larger TAZs. This exercise results in a unified base map where the socioeconomic data in each place type is exactly correlated with the socioeconomic data in each TAZ. This allows the place type base map to be used in scenario planning with the confidence that its data “matches” the data in the travel demand model.

Developing the No Build Layer

After the place types are associated with the TAZs, any areas of nondevelopable land are identified to create a “no build’ layer that is removed from the base map. The nondevelopable land or No Build layer is made up of the following data features derived from available HRTPO datasets:

- Water
- Wetlands
- Parks
- Other Protected Areas, e.g., wildlife refuges and management areas
- Roadways
- Chesapeake Bay Resource Protection Areas

This refined base map, minus the no build areas becomes the base for allocating population and growth in each place type in the scenario planning. Potential sea level rise was accommodated in the scenario planning process through incorporating a data layer for a potential three-foot sea level rise and assigning it to have no capacity for any allocation of population or employment in the Greater Growth scenarios. The Working Group agreed to use the three-foot sea level rise benchmark in this process since it represented the midpoint of the PDC's regional sea level rise scenarios for the year 2050.

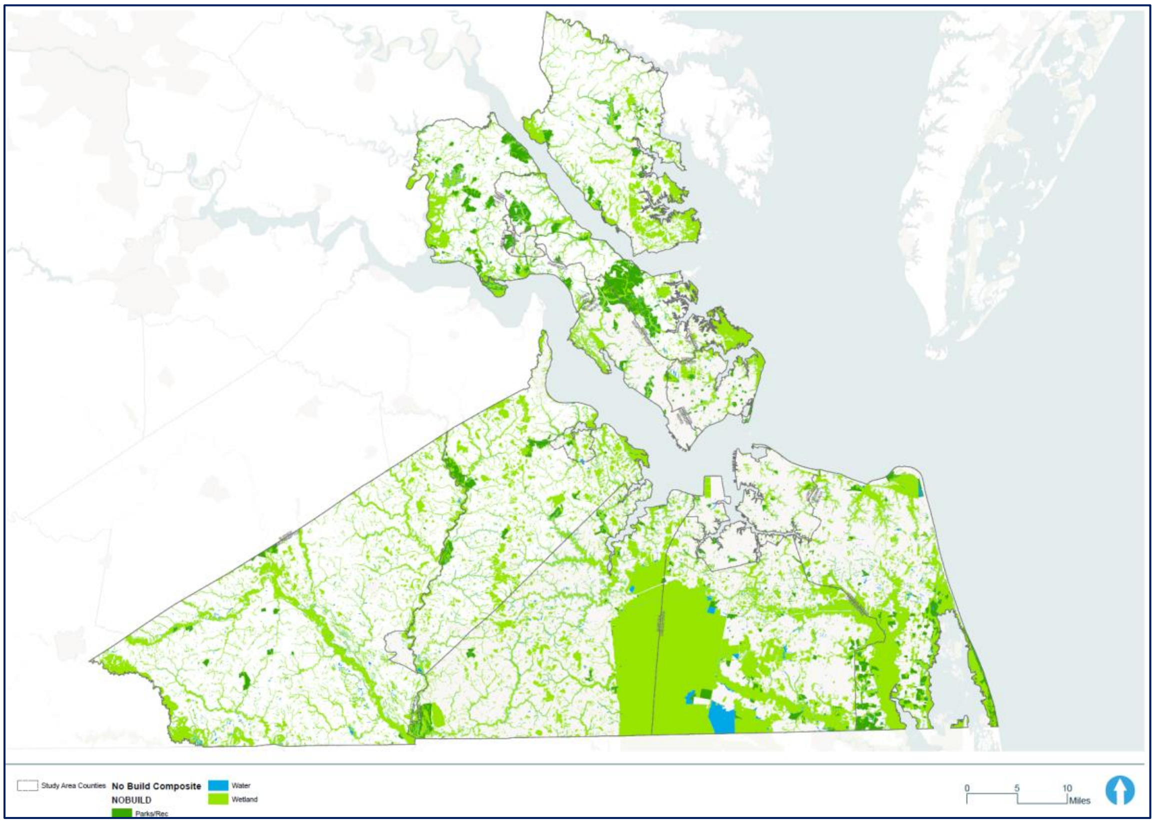


Figure 6. Sample No Build mapping for the region

Building Land Use Data for the Place Types

Maintaining Local Land Use Policies for Growth

For the purposes of scenario planning, the base maps containing the 2015 and 2045 place types are called the "Virtual Present" and "Virtual Future" maps. As described above, these Virtual Present and Virtual Future maps are derived directly from the existing and future land use mapping of each locality that was done for the development of the Regional Land Use Map. One of the key principles in this scenario planning process agreed upon by the Working Group is to maintain the future land use plans and policies of each jurisdiction, rather than to try and change them. This meant preserving the basic geography and locations of future land uses that each jurisdiction has adopted, as affirmed in the Regional Land Use Map and the 2045 regional TDM.

Therefore, the Greater Growth scenarios all use the same distribution of land uses in each jurisdiction (i.e. place types) as the 2045 Regional Land Use Map and the TDM. The spatial variations of growth in each scenario are accomplished by allocating more or less growth to various place types throughout the region rather than changing the location or spatial pattern of regional place types. In other words, the scenarios vary by how much growth is allocated to each place type cell, rather than by rearranging the place type cells on the map.

Figure 7. The 21 Basic Place Types Used in the Regional Land Use Map

Assigning Capacity to Place Types

Since the capacity of each place type to accommodate additional growth is central to the scenario planning process, the place types must be assigned both an existing level of growth and a capacity for future growth. The Regional Land Use Map only assigns different land uses to parcels; it does not have data about the density or intensity of those land uses. Therefore, each place type must be populated with a certain amount of population and employment and a capacity for future growth.

The first step in quantifying growth in the place types entails profiling the existing and future land use types in the region to determine the existing employment and population characteristics. Based on sampling of existing densities and intensities of place types across the region (through available census data), quantitative summaries of each place type are developed that summarized land uses and socioeconomic data for each place type. Additionally, 3-D visualizations of each place type are developed in order to explain their characteristics to stakeholders and the public.

The result of the sampling is a standardized maximum capacity of population and employment density for each place type. The place type density data are used to generate the quantitative summaries of the place types, which include a description of the land use along with the ranges of dwelling units per acre, floor-to-area ration (FAR), people per acre, and jobs per acre for each place type. The Land Use Allocation Model uses this place type capacity data to determine how much additional growth can be placed in each place type polygon when it runs the allocations. The amount of growth that each place type polygon can accommodate is the difference between its capacity (how much growth it can accommodate) and how much growth it already has (its existing density).

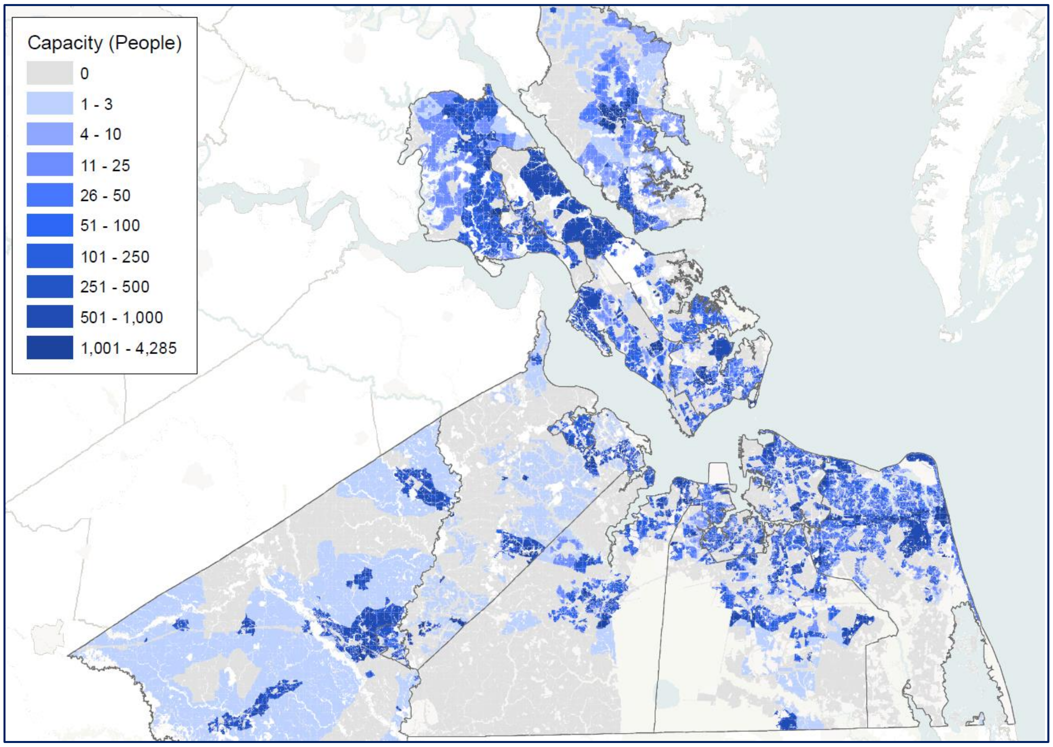


Figure 8. Sample Mapping of Capacities Across the Region

Calibrating the Place Type Data to TAZ Control Totals

The Virtual Present map represents a picture of where development is currently located in the region. Building the Virtual Present map of the region starts with allocating the typical densities associated with each place type (from the prior sampling exercise) into all of the place type polygons. However, since these densities were based on a regional sampling exercise, the totals for people and jobs do not necessarily match the respective numbers for the TAZs in any given location. Therefore, a second step in the process is to adjust the jobs and population totals in each place type polygon so that they match the control totals in their respective TAZs. Since the scenario analysis outputs are to be used in conjunction with the TDM, the population and job totals in the Virtual Present map needs to exactly match the control totals for the distribution of jobs and people throughout the region in the TAZs from the TDM.

In order to calibrate the land use data in the place types to the socioeconomic data in the TAZs, a ratio is developed and applied to the place type allocations in order to correlate them with the TAZ control totals. The ratio, called the development factor, is applied to the polygons in the Virtual Present map to remedy the disparity between the TAZ numbers and the place type allocation numbers. The development factor for each polygon is derived by dividing the TAZ control total numbers by the place type allocation numbers for jobs and for people. The development factor is then applied to the place type allocation numbers to correlate them to the TAZ control numbers. This basic process of reconciling the place type densities and intensities with the TAZ numbers through the use of development factors represents the process of calibrating the Virtual Present to the TDM's TAZ control totals. The same process used to create the Virtual Present map is also used to create the Virtual Future map, using the 2045 control totals from the TDM, as opposed to the 2015 control totals.

The output of this calibration process is a GIS map of the Virtual Present and Virtual Future of the region that shows the existing and future place types that is correlated both to each locality's existing and future land use maps and to the socioeconomic data in the regional TDM.

Figure 9. Slide from a Presentation Explaining the Use of Development Factors in Calibrating Place Type Totals to TAZ Totals

Modeling the Greater Growth Scenario Land Use

The modeling of potential future growth in the Land Use model is conducted using the CommunityViz Scenario 360 software. CommunityViz is a GIS software developed by City Explained, Inc. that provides a range of quantitative analysis and visualization tools that facilitate geodesign and scenario planning. CommunityViz has been used to model growth in numerous regional transportation planning efforts across the country. The Allocator 4 tool available in CommunityViz is used to model the spatial pattern of the Greater Growth scenarios in this project.

Suitability and Capacity

CommunityViz uses two basic frameworks to model future growth in scenarios; suitability and capacity. In the simplest terms, suitability controls where growth will be allocated first (i.e., where growth is most desirable), while capacity controls how much growth can be allocated in a given location. However, the allocation process can consider both of these factors together as explained in the paragraphs that follow.

Capacity is simply the capacity to accommodate future growth and is controlled by the available capacity for additional density in each place type polygon. It is the difference between the maximum density allowed in a place type polygon and the actual density already accounted for by existing development in the polygon. A vacant parcel, for example, would have a development capacity equal to the maximum density of the place type for that parcel since it has no existing development. Similarly, a parcel developed at 25 percent of its maximum density would have an additional 75 percent of capacity available to accommodate future growth.

Suitability is essentially a way of characterizing site suitability or desirability for growth across the region. The suitability feature of CommunityViz allows users to specify the factors that should be considered for attracting or repelling growth, such as proximity to roads or overlap with floodplains. The program uses these factors to determine where growth should be allocated. These factors can be extensively customized using data provided by the user, with factors such as “waterfront proximity” based on a user-defined GIS data layer. Once the suitability factors for a given scenario have been determined, the program allows users to change the weighting of each factor to better match the characteristics of a particular scenario.

The Allocator Tool

The Allocator 4 tool available in CommunityViz is used to model the distribution of growth in the three alternative Greater Growth scenarios. The allocator requires three inputs: the forecasted growth amount (or growth control total), a capacity map and a suitability map. The capacity map represents the capacity for development and the suitability represents the desirability for development. The allocator tool then uses these to allocate growth to each place type polygon based on its capacity for employment and its capacity for population, along with its associated set of suitability scores.

The allocator assigns the forecasted growth amount among the polygons in the base map in order of higher suitability to lower suitability according to the polygons’ suitability scores. In essence, the allocator distributes growth to the polygons with the highest suitability scores until their capacity is used up and then moves on to the next highest sets of polygons, with some additional adjustment through a randomization feature included in CommunityViz.

To avoid an oversimplified allocation based rigidly on the suitability scores, the tool allows for some amount of randomness to be set. The randomization feature allows the allocation to deviate from the suitability as determined by the suitability analysis. The randomness feature incorporates a level of uncertainty into the allocation process, mirroring the real world, where market and other forces may steer development away from occurring only in the most suitable locations. A basic randomization feature available in the allocator tool is used in all of the scenario allocations in this project.

Capacity Mapping

As described above, the capacity is the difference between the Virtual Present/Future development numbers, i.e., the place type numbers of jobs and people calibrated to the TAZs, against the buildout potential of each polygon. The buildout potential is the product of the acres and the maximum density of a place type polygon. The outcome of the capacity calculation was two maps, one for population capacity and one for employment capacity. The allocator tool used these maps to assign available growth to each polygon, based on its relative suitability.

Suitability Mapping

Suitability mapping for each scenario is prepared to geographically represent the suitability factors that guide the Allocator. The suitability analysis assigns a specific suitability score to each polygon that measures its desirability for development given its spatial relationship to the set of suitability factors. For each Greater Growth scenario, a set of suitability factors is developed that matches the basic narrative description of each scenario. For example, for the Greater Growth on the Water scenario, suitability factors such as proximity to ports and shipbuilding are used. Similarly, for the Greater Growth in Urban Centers scenario, suitability factors such as proximity to transit stops or to city centers are used. The suitability factors for each scenario represent the spatial aspects of drivers that inform the varying growth patterns in each scenario. Collectively, the suitability factors are combined and a suitability score is assigned to each place type polygon.

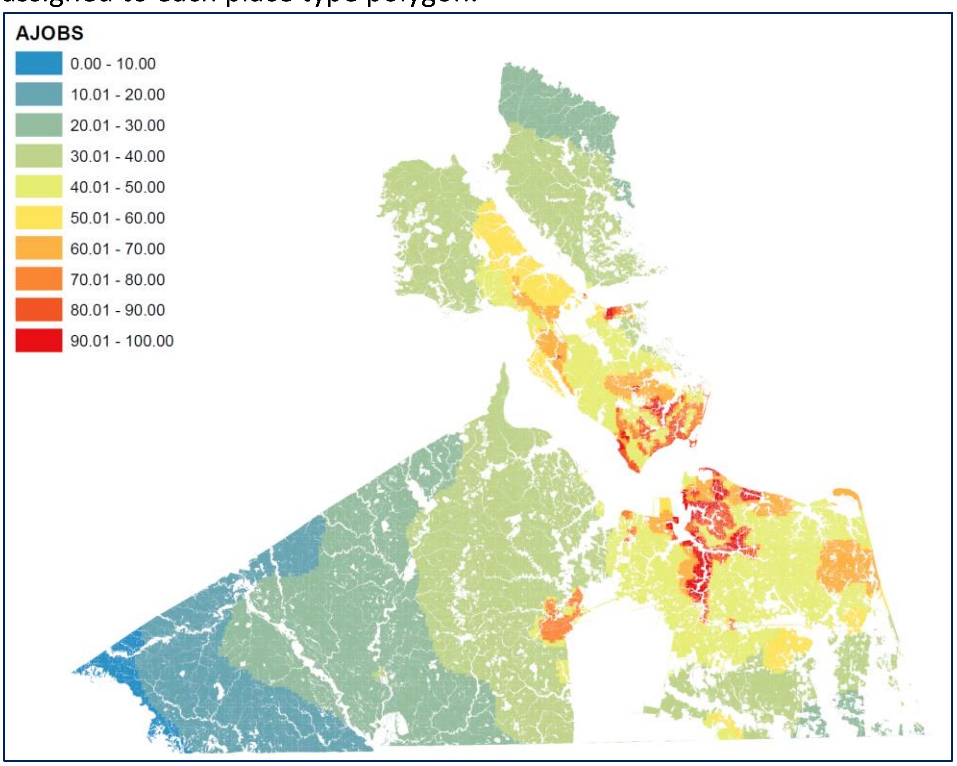


Figure 10. Sample Mapping of Suitability for Employment Across the Region

To identify relevant suitability factors for each scenario, two types of suitability factors are used: place type suitability factors and spatial attractor suitability factors. Place type factors consist of place types on the base map that are considered as growth attractors for a given scenario. For example, the High Density Residential place type is used as a suitability factor selected to attract population growth in the Greater Growth in Urban Centers scenario.

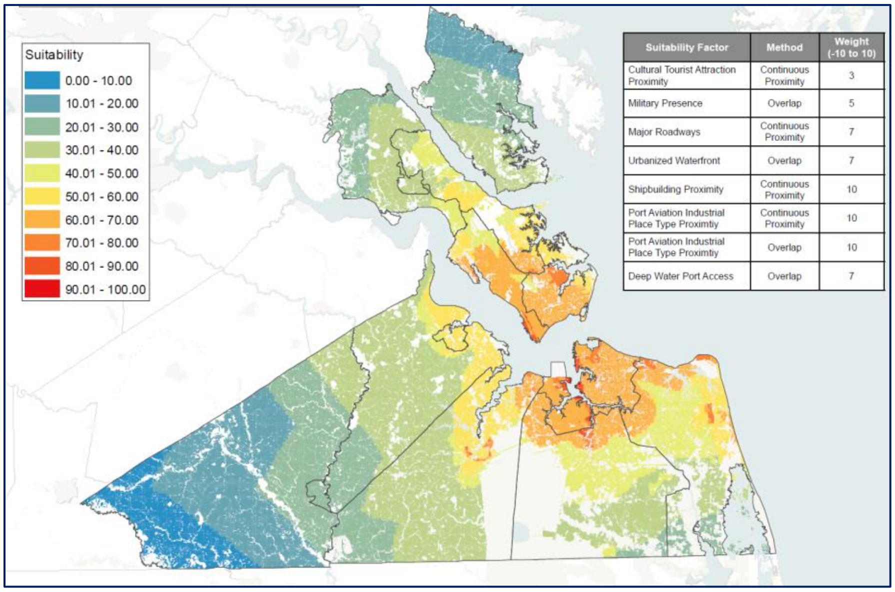
By contrast, the spatial attractors are specific places, objects, boundaries or systems that attract growth toward them or repel growth away from them. For example, the locations of large undeveloped parcels are used as a factor that increases the suitability for employment growth in the Greater Growth in Suburban Centers scenario, while close proximity to major transportation corridors is used as a repulsor of population growth in the same scenario. Separate maps are created for each scenario for employment and for population suitability, so that there are six suitability maps in total.

Setting Suitability Weights

The Suitability Wizard tool in CommunityViz also allows the specific weighting of each suitability factor to be varied by the user. The suitability factors each receive a relative weight that is set by the user to amplify or mitigate their spatial effect. The weights range from negative ten (for detractors) to positive ten (for attractors.)

In each scenario, the methods and weights of relevant suitability factors are determined based on their role in influencing the scenario drivers. In other words, the suitability weights are carefully calibrated to match each scenario narrative as closely as possible, based in part on iterative review of results. For example, while two scenarios may have the same suitability factor, such as proximity to water and sewer service areas, the weights of that factor could be set differently according to the scenario factors (e.g. high weighting for the “Urban” scenario and relatively low weighting for the “Suburban” scenario). The sum of suitability factors for each polygon are further normalized onto a 1-100 scale wherein each polygon had a relative score of 0 to 100, where 100 was the highest suitability score.

The output of the suitability analysis consists of six maps – one for each scenario for both population and employment.



Suitability Factor	Method	Weight (-10 to 10)
Cultural Tourist Attraction Proximity	Continuous Proximity	3
Military Presence	Overlap	5
Major Roadways	Continuous Proximity	7
Urbanized Waterfront	Overlap	7
Shipbuilding Proximity	Continuous Proximity	10
Port Aviation Industrial Place Type Proximtiy	Continuous Proximity	10
Port Aviation Industrial Place Type Proximtiy	Overlap	10
Deep Water Port Access	Overlap	7

Figure 11. Sample Suitability Mapping with Associated Weighting of Suitability Factors

Running the Allocations

Once the capacity and suitability maps are completed, the Allocator is allowed to run for each scenario to create a pattern of future growth according to each scenario narrative. A final step in the process is to conduct a series of iterative runs of each scenario while slightly adjusting the suitability factor weighting for each scenario so that the pattern of growth more closely matched the intended narrative of each scenario. In some cases, this included identifying additional suitability factors to differentiate the scenario based on geographic features, such as existing urban density. The goal of this process is to produce three distinctively different patterns of growth, each keyed to a respective set of drivers described in the scenario narratives.

Upon completion of this task, the scenario results are output into the types of socioeconomic data needed to run the Travel Demand Model for each scenario.

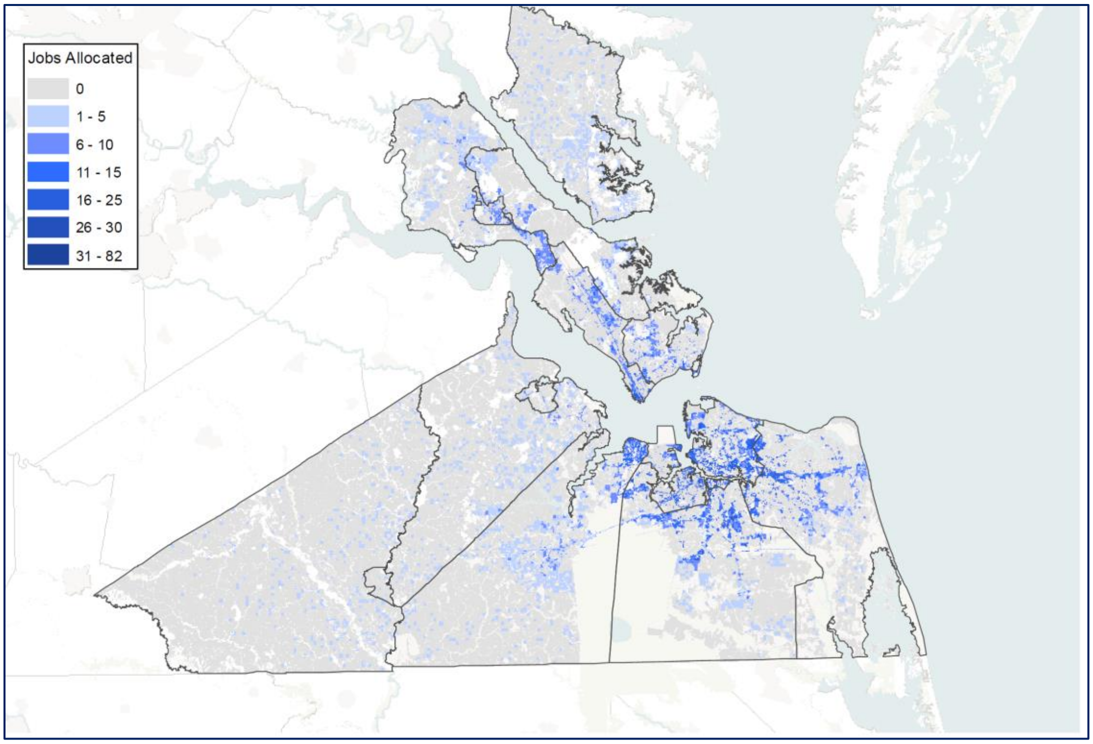


Figure 12. Sample Final Employment Allocation Across the Region

Completing the Greater Growth Scenario Planning

After preparation of the land use allocation for each Greater Growth scenario, the scenario planning process is completed in the Travel Demand Model. In addition to applying a unique set of socioeconomic data by TAZ from the land use model, the TDM is used to apply the technology drivers of each scenario. The TDM was developed with some levers incorporated to allow assumptions relating to technology, such as the growth of transportation demand in response to people having the ability to operate autonomous cars without a driver's license (i.e., youth, elderly, blind, etc.). These levers can be adjusted for each scenario to reflect the technology driver assumptions. In addition to the levers, the TDM can be adjusted to reflect alternative performance assumptions in the transportation network, such as dedicated lanes for connected vehicles in platoons.

The full set of TDM adjustments and assumptions, along with the detailed spatial assumptions for the three Greater Growth Scenarios, will be provided in the Technical Memorandum on Control Totals, Aggregate Spatial Assumptions, and Travel Parameters (forthcoming).

Once the TDM interpretation of the scenarios is complete, TDM outputs are provided to the economic model (TREDIS), where economically-based performance measures are calculated. The performance measure outputs of all three models will be provided in a dashboard that will summarize, and graphically represent, the performance measures for each scenario, as illustrated in Figure 13. The details of the performance measures approved by the RCS Working

Group and Steering Committee are provided in the *Technical Memorandum on Performance Measures (forthcoming)*.

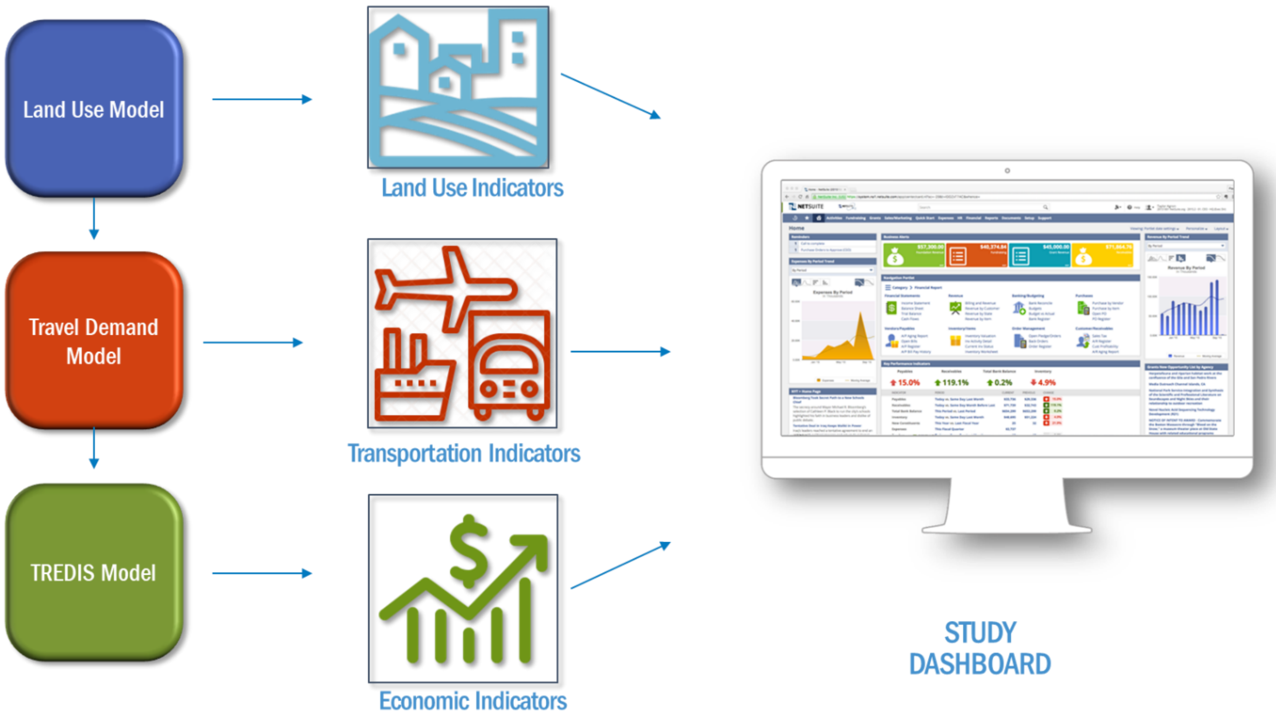


Figure 13. Illustration of the Three Scenario Models and Performance Dashboard

Initially, the results of the three Greater Growth Scenarios with the E+C network will be prepared and reviewed with the RCS Working Group and Steering Committee. Once the candidate alternatives for the Regional Connectors Study are sufficiently defined, they will be run in the TDM using all four sets of socioeconomic data (or land use allocations): the 2045 Baseline and the three Greater Growth scenarios. The HRTPO staff will also run these results through the HRTPO regional prioritization tool to determine the projects that score best across all future scenarios. These results will inform selection and prioritization of RCS alternatives to move forward into project development.