Pathways to the Future

SCENARIO PLANNING PROCESS FOR THE RICHMOND REGION

PROCESS DOCUMENTATION REPORT

SEPTEMBER 2024

Richmond Regional
Transportation
Planning
Organization

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Where the region comes
together to look ahead.

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PATHWAYS TO THE FUTURE PROJECT TEAM

PLAN RVA TEAM

Sulabh Aryal – *Project Manager*
Chet Parsons, *CVTA Executive Director*
Sarah Stewart, *REME Program Director*
Nicole Keller, *Resilience Planner*
Holly Gordon, *Community Engagement Manager*
Dan Motta, *Planner*
Elizabeth Greenwell, *Data Analyst*
Rishabh Singh, *Data Analyst*

CONSULTANT TEAM

THE CORRADINO GROUP

Srin Varanasi – *Project Manager*
Parag Gupta
Ken Kaltenbach
Nizamul Mojumder

EPR, PC

Vlad Gavrilovic
Matthew Rehnborg

MICHAEL BAKER INTERNATIONAL

Lorna Parkins
Josh Mallow
Alan Cunningham

EBP

Adam Blair
Brandon Irvine
Jess Wilson

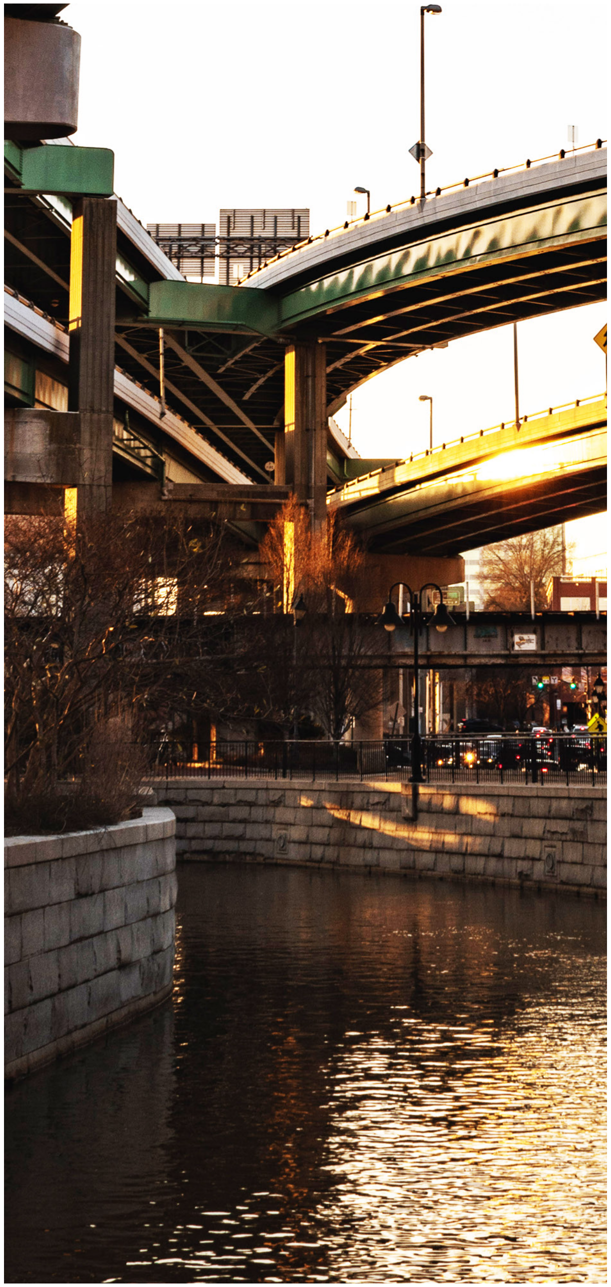
ACKNOWLEDGEMENTS

Pathways to the Future
Scenario Planning Advisory Committee (SPAC)

FIELD OF EXPERTISE	NAME	AFFILIATION(S)
Transportation	Joe Vidunas	RRTPO Technical Advisory Committee/Hanover County
	Chessa Walker	RRTPO Technical Advisory Committee/ Chesterfield County
	John Leonard	RRTPO Community Transportation Advisory Committee / Virginia Commonwealth University
	Tiffany Dubinsky	RRTPO Policy Board/ Virginia Department of Rail and Public Transportation
	Jeremy Raw	Federal Highway Administration
	John Miller	Virginia Transportation Research Council
	Peter Ohlms	
Land use/ Community Development	Seth Humphreys	Henrico County
	Nora Amos	RRTPO Technical Advisory Committee/ Town of Ashland
	Matthew Ebinger	City of Richmond
Environment	Jonah Fogel	Resilient Virginia/University of Virginia
	Kristin Owen	Henrico County
Emergency Management	Eric Seymour	National Weather Service
Housing	Jovan Burton	Partnership for Housing Affordability
Energy	Damian Pitt	Virginia Commonwealth University
Economic Development	Chuck Peterson	Greater Richmond Partnership
Community Health	Louise Lockett Gordon	Virginia Department of Health

PLANRVA STAFF

Martha Shickle, *Executive Director*
Myles Busching, *Director of Transportation*
Barbara Jacocks, *Director of Community Development*
Sarin Adhikari, *Principal Data Manager*
Kenneth Lantz Jr., *Mobility Coordinator*
Phil Riggan, *Planner*
Sidd Kumar, *Digital Media Specialist*



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FOR THE RICHMOND REGION

INTRODUCTION

Pathways to the Future (P2F) is an effort to have ***meaningful conversations*** about the future drivers of change and how to manage risk while embracing opportunities to pursue the Richmond region's vision for change. Future changes and uncertainties are inevitable. Scenario planning is a way to plan for the future under various circumstances and expected drivers of change. While predicting and evaluating the future for all drivers of change is an understandably impossible task, P2F focuses on testing the region's future under significant drivers of change.

Evaluating the future under various drivers of change involves gathering and analyzing the data for multiple scenarios. More scenarios and drivers will provide more information into the future with the expense of increased complexity of the data analysis. Exploratory Scenario Planning requires an agile approach to complex data and measures to provide a meaningful and differentiated analysis.

PlanRVA seeks to address many social and environmental questions within the exploratory scenario planning framework. The primary approach is to identify the drivers of change, group them into plausible scenarios and evaluate the Richmond region's different future with the help of performance measures. Predictive modeling tools were developed to measure key performance measures.

Exhibit 1 shows the P2F Process Flow, which outlines the different phases and steps involved in the process. The process is divided into four main phases:

- **Phase 1** **Development of Baseline Data & Models/Tools,**
- **Phase 2** **Scenario Development,**
- **Phase 3** **Scenario Testing, Analysis and Communication, and**
- **Phase 4** **Application within different program areas of areas of PlanRVA.**

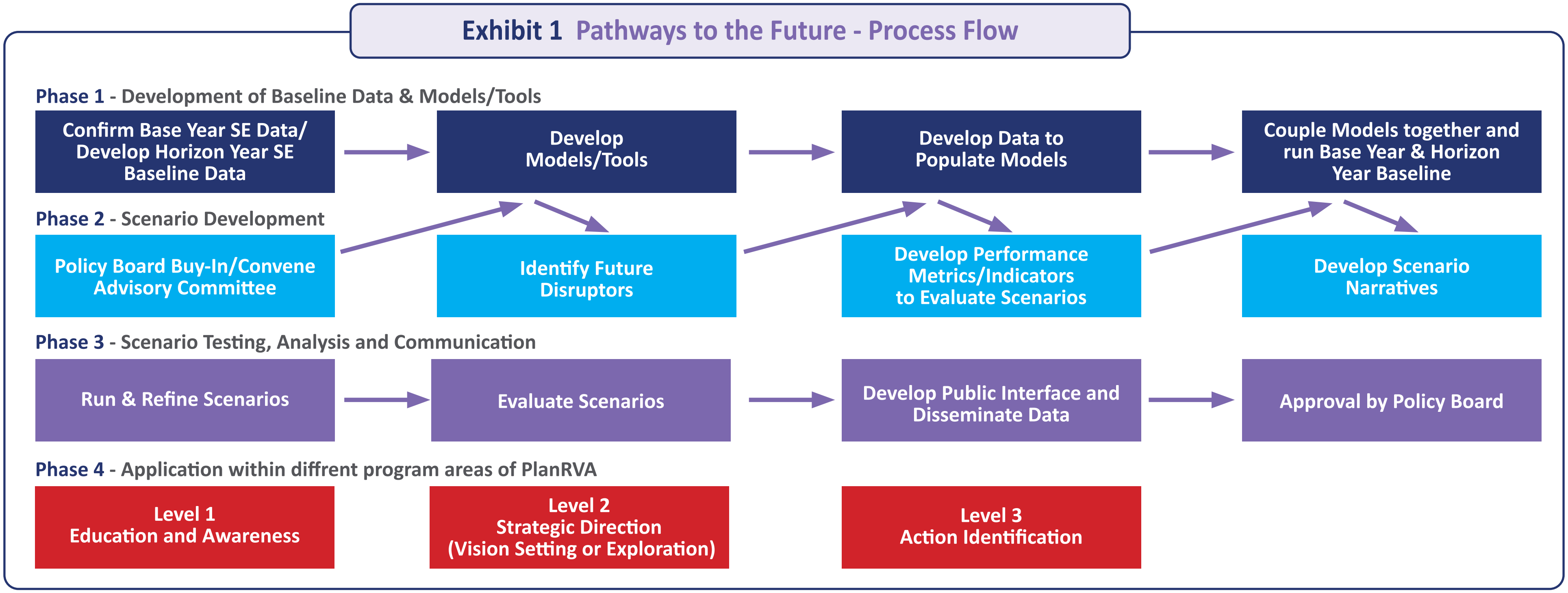

Exhibit 1 Pathways to the Future - Process Flow

Phase 1 - Development of Baseline Data & Models/Tools

Confirm Base Year SE Data/ Develop Horizon Year SE Baseline Data

Develop Models/Tools

Develop Data to Populate Models

Couple Models together and run Base Year & Horizon Year Baseline

Phase 2 - Scenario Development

Policy Board Buy-In/Convene Advisory Committee

Identify Future Disruptors

Develop Performance Metrics/Indicators to Evaluate Scenarios

Develop Scenario Narratives

Phase 3 - Scenario Testing, Analysis and Communication

Run & Refine Scenarios

Evaluate Scenarios

Develop Public Interface and Disseminate Data

Approval by Policy Board

Phase 4 - Application within diffrent program areas of PlanRVA

Level 1
Education and Awareness

Level 2
Strategic Direction
(Vision Setting or Exploration)

Level 3
Action Identification

PHASE 1
DEVELOPMENT OF BASELINE DATA & MODELS/TOOLS

Phase 1 of the P2F process primarily involves identifying data sources, compiling data, and conducting final checks on them to ensure the credibility and usefulness of each data source. This phase lays the groundwork for the project, providing the data collected is accurate and comprehensive. Once the data are developed, various models and tools are then created to test the relationships between different variables and validate the model created. This process is crucial for understanding the dynamics of the Richmond region and predicting future scenarios. By thoroughly vetting the data and developing robust models, Phase 1 sets the stage for subsequent project phases, providing a solid foundation for informed decision-making and planning.

1.1 Baseline Data

The 2017 base year existing conditions data and 2050 horizon year baseline data was developed by staff, vetted by the localities, and approved by the RRTPO Policy Board. The 2050 baseline data serves as the foundation for the P2F process. Exhibits 2 and 3 presents the Jurisdiction-level population and employment control totals. Various demographic data were developed at the geographic precision of a Transportation Analysis Zone (TAZ), ensuring the data, when aggregated, matches the jurisdiction control totals. For more details please review the [Socioeconomic Data Report for the 2017 Base Year and 2050 Forecast Year.]

Exhibit 2
Locality Approved Control Totals for Population

JURISDICTION	POPULATION			
	BASE YEAR 2017	HORIZON YEAR BASELINE 2050	GROWTH (2050 - 2017)	TOTAL GROWTH RATE (2017 - 2050)
Ashland [1]	7,785	8,822	1,037	13.3%
Charles city	7,126	6,552	-574	-8.1%
Chesterfield	340,848	504,814	163,966	48.1%
Goochland	23,536	34,742	11,206	47.6%
Hanover [2]	109,595	142,156	32,561	29.7%
Henrico	335,283	422,954	87,671	26.1%
New Kent	21,347	36,081	14,734	69.0%
Powhatan	29,147	39,576	10,429	35.8%
Richmond	224,798	278,538	53,740	23.9%
Region Total	**1,099,465**	**1,474,235**	**374,770**	**34.1%**

Exhibit 3
Locality Approved Control Totals for Employment

JURISDICTION	EMPLOYMENT			
	BASE YEAR 2017	HORIZON YEAR BASELINE 2050	GROWTH (2050 - 2017)	TOTAL GROWTH RATE (2017 - 2050)
Ashland [1]	8,636	13,408	4,772	55.3%
Charles city	1,668	1,850	182	10.9%
Chesterfield	131,120	186,051	54,931	41.9%
Goochland	13,966	21,704	7,738	55.4%
Hanover [2]	50,625	68,361	17,736	35.0%
Henrico	191,240	246,718	55,478	29.0%
New Kent	3,956	6,299	2,343	59.2%
Powhatan	6,092	7,704	1,612	26.5%
Richmond	152,044	178,256	26,212	17.2%
Region Total	**559,347**	**730,351**	**171,004**	**30.6%**

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[1] *Ashland displayed here separetely, but also includes as a part of Hanover County*
[2] *Hanover County Includes Town of Ashland*

Other datasets beyond the socioeconomic data, were also developed for the P2F process. These datasets were developed as input for the various predictive models (discussed in the next section) used in the P2F process. Datasets included safety data (motorized and non-motorized crash and injury), location of different destinations (grocery stores, healthcare facilities, parks, etc.), air pollutants, carbon greenhouse emissions, water quality (nutrient loading) etc. for the Richmond region. These datasets provided insights into air quality, water quality, safety, and accessibility to services within the Richmond region. This collaborative approach ensured that the P2F process incorporated various relevant data sources, enabling a more holistic understanding of the Richmond region and its needs.

1.2 P2F Suite of Predictive Models

Various predictive models help in quantifying the performance outcome of the future scenarios. The detailed documentation of the predictive models used in the P2F process is documented in the technical report. The following predictive models were developed/customized for the P2F process.

1.2.1 Richmond Tri-Cities (RTC) Travel Demand Model

RTC travel demand model was used in the scenario planning to forecast future travel patterns and demand for transportation services within the Richmond region. The model helps in understanding how people travel, where they go when they travel, and what modes of transportation they use. In addition to the traditional components of trip generation, trip distribution, mode choice, and trip assignment, a Connected and Autonomous Vehicles (CAV) component was also integrated into the model. This addition accounts for the evolving landscape of transportation, where CAVs are expected to play a significant role in the future. The CAV component incorporates factors such as the penetration rate of the autonomous vehicles, their impact on travel behavior, and the overall increase in traffic and their trip lengths.

1.2.2 Richmond Simplified Land Use Allocation Model (RSLAM)

RSLAM is an allocation model. It allocates control totals specified for the region and jurisdictions to individual TAZs. Each jurisdiction has its own control totals, so growth is allocated separately within each jurisdiction.

The primary constraint of RSLAM is that growth can be allocated only where there is vacant, developable land, or where the holding capacity or density is increased. Allocation to a given zone will cease when it is full of holding capacity. Generally, holding capacity will be estimated based on the amount of vacant, developable land and user-specified densities for the zone. A "vertical" measure was added to allow certain TAZs to become denser and to recognize high rise development. A vertical index was also included to represent the attractiveness of TAZs where higher densities are permitted. Additionally, since all development requires land, growth is allocated according to the type of development that can pay the most for the land. While the order is user-specified, the usual allocation order is retail employment, non-retail employment, and residential. Land use allocation scores are calculated based on – Market Scores as determined by local knowledge, Accessibility Scores as derived from the regional transportation network, and compatibility of each land use category based on the existing land use. RSLAM's output is used an input by the various downstream models.

1.2.3 Transportation Accessibility Model

The accessibility model quantifies the accessibility of each TAZ by estimating the number of destinations like grocery stores, healthcare facilities, schools, parks, and jobs that are accessible within specified travel time thresholds. The accessibility benefit is quantified by measuring the change (delta) in average accessibility between the Baseline and other future scenarios.

If there are improvements in travel times, more destinations can be reached within the given time thresholds, increasing accessibility. However, a distance decay factor is applied that gives higher weight to closer destinations when computing accessibility, reflecting that the nearer amenities are more valuable. The time threshold criteria vary by destination type and transportation mode (highway, transit, bicycle and pedestrians) to account for typical travel patterns in the region. Accessibility is calculated using congested travel times from the travel demand model, filtered by the time thresholds, weighted by the decay factor, and divided by the total population.

1.2.4 System Resiliency Model

The System Resiliency Model predicts the potential impacts of natural hazards in the Richmond region. This model measures sea level rise, flooding, dam breach and wildfire risk areas to report the acreage, population, housing units, jobs, and impacted transportation networks at risk for a given scenario. Sea level rise, flooding, and dam breach; and wildfire risk are modeled separately, but both utilize the RSLAM output as the input.

1.2.5 Economic Model

The Economic model uses demographic, travel, and land use inputs and provides economic outputs related to housing, transportation, energy, etc. The model also estimates the change in Gross Regional Product (GRP) between the Baseline scenario and a future scenario.

1.2.6 Buildings Emission and Energy Model

The building emissions and energy model captures the effects of different growth patterns and policy changes. The model applies energy use and emissions factors based on land use types. It also differentiates grid-generated energy use from locally generated energy (such as natural gas, propane, etc.) to facilitate capturing different assumptions regarding the carbon neutrality of the region's electricity supply in 2050. Outputs include both energy use and carbon greenhouse gas emissions.

1.2.7 Mobile Emissions Model

While the building emissions model estimates emissions/carbon footprint from the static places such as buildings, the mobile emissions model focuses on assessing the emissions from the mobile sources (autos and trucks) and trip/tour types in the Richmond region. The model is based on Environmental Protection Agency (EPA) emission factors to estimate the carbon greenhouse gas emissions (carbon dioxide) and, pollutants like nitrogen-oxide compounds, volatile organic compounds, and particulate matter 2.5.

1.2.8 Water Consumption Model

The water consumption model is a simplified model to estimate water consumption at regional, jurisdictional, and sub-jurisdictional levels. Growth dynamics like Industry mix, land use patterns, agricultural trends, regulatory trends, and societal trends influence water consumption in various ways. The model uses a simplified approach to calculate the difference in water consumption for different scenarios by using national research/data that relate land use categories and densities to water consumption, trends in water consumption, and local data on water consumption over time, gathered from state and regional data sources. The RSLAM outputs are the primary drivers of changes in water consumption, along with the coefficients of water consumption by land use type, which can be modified to reflect assumptions regarding future conservation practices.

1.2.9 Land Cover Model

Land cover refers to the surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil or other. The Land Cover model estimates the change in percentages of different Land cover categories at the TAZ level in future scenarios based on the output provided by the RSLAM. The model uses the Chesapeake Bay Program Land Use-Land Cover data set and its 12 land cover categories. The model outputs are used to calculate the change in the overall impervious surface percentage in each TAZ. Impervious surface percentage calculation is also needed to develop the polluting loading impact (discussed later in the Pollutant/Runoff Loading Model).

1.2.10 Pollutant/Runoff Loading Model

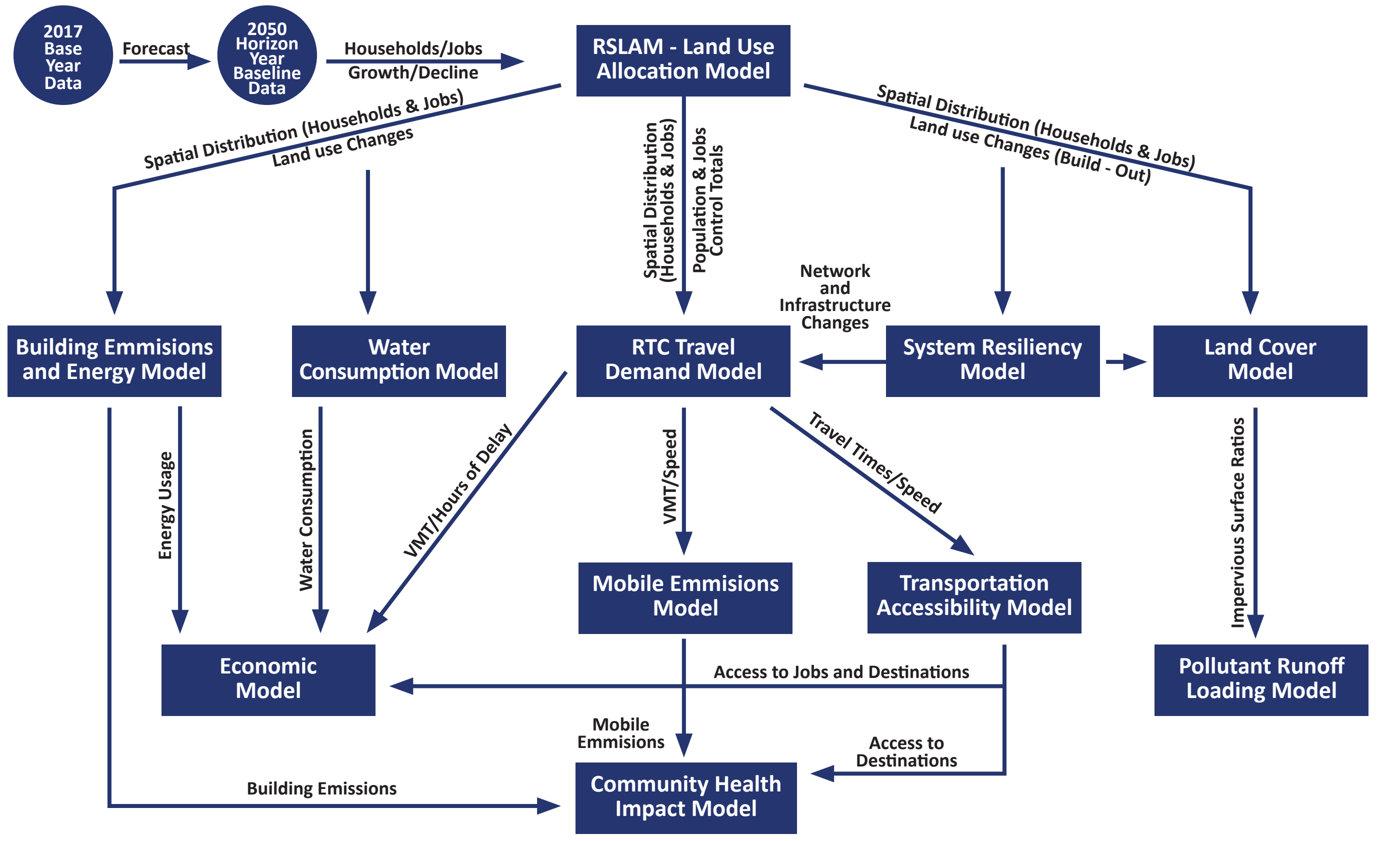
The Pollutant/Runoff loading model estimates Nitrogen, Phosphorus and Sediments loads in runoffs for the Richmond region. This model determines the Runoff Quantity for each TAZ, and then applies a development runoff coefficient for the land use mix (RSLAM output) and percentage of imperious surface (Land Cover Model output) within each TAZ. Planning for a sustainable future involves the protection and/or restoration of our water resources while supporting population growth and associated land use changes. The increase in impervious surfaces associated with urbanization and related development results in the rise of pollutant discharge to receiving waters. This model provides a means to evaluate various future scenarios to understand the impacts associated with the land use changes fully.

1.2.11 Community Health Impact Model

The Community Health Impact model assesses the impacts of various drivers of change on health outcomes in the Richmond region. It has several components that aim to capture the health impacts due to changes in transportation patterns, accessibility to amenities, green space availability, and air quality by leveraging well-established relationships between the input variables and various health outputs and outcomes. The inputs for the community health model comes from other models i.e. the travel demand model, RSLAM, building emissions and energy model, the mobile emissions model, the water consumption model, and the accessibility model, which are then translated into predicted social, mental, and physiological community health effects. These include projected transportation fatalities and injuries related to the change in vehicle miles travel, changes in life expectancy related to change in accessibility to grocery stores and health care facilities, changes in mortality rates, psychological distress and depression rates based on increased green space and tree canopy coverage, and Chronic Obstructive Pulmonary Disease (COPD) hospitalization and asthma-related emergency room visits due to the change in the air quality.

Exhibit 4 presents the flowchart illustrating the interconnected modeling tools and critical outputs of the P2F process. The flow chart highlights the models' dependencies and the flow of information between them.

Exhibit 4 Pathways to the Future - Organization of Predictive Modeling tools and Key Outputs



PHASE 2
SCENARIO DEVELOPMENT

The Pathways to the Future examines the risks and opportunities posed by future uncertainty. The process included a robust engagement of the public and regional stakeholders. Benchmarks in the engagement process included:

- The formation of a stakeholder committee called the Scenario Planning Advisory Committee (SPAC) that met periodically throughout the process to shape and guide the development of the scenarios and the modeling of the results. The SPAC was comprised of 17 regional and national experts in the fields of transportation, community development, environment, emergency management, housing, energy, economic development, and community health.
- Surveys of the general public that asked for their input on the potential drivers of future change in the region and their ideas or thoughts on the scenario modeling results.
- Participatory charettes that brought together a cross-section of stakeholders and influencers in the region to help affirm the scenario narratives and review the results of the modeling.

In the project's first phase, a series of scenario narratives was developed based on public and stakeholder input. This report summarizes the process for developing those scenario narratives and describes the narratives in detail.

2.1 Initial Discussions on Drivers of Change

In March of 2023, the SPAC met to discuss the initial drivers of change that could be used to inform potential scenario narratives for the process. The following drivers of change as shown in Exhibit 5 were finalized as a potential framework to categorize the forces of change that could have an impact on the Richmond region in the next 25 years.

Exhibit 5 Categories of Drivers of Change for the future

COMMUNITY	TECHNOLOGY	ECONOMY	RESILIENCY
POPULATION DYNAMICS Overall Growth, Age, HH Size, HH Composition, Eucation, Migration & Inmigration, Climate Migration	**TRANSPORTATION TECHNOLOGY DYNAMICS** CAV, E-Vehicles, MAAS, Automated Freight, Parking Managment Tech	**GLOBAL/NATIONAL ECONOMY DYNAMICS** Economic Growth/Decline, Sector Growth, Retail & Freight Dynamics, Govt. Investment, Material Costs, Interest Rate	**CLIMATE/PLANET DYNAMICS** Climate, Sea Level, Flooding, Pandemic
SETTLEMENT DEMAND DYNAMICS Locational Preferences, Housing Preferences, School Preferences	**TRANSPORTATION MODE SHIFT DYNAMICS** Micro Mobility, High Speed Rail, Active Transportation	**REGIONAL ECONOMY DYNAMICS** Economic Growth/Decline, Sector Growth, Retail Dynamics, Tourism	**ENVIRONMENTAL POLICY DYNAMICS** Clean Energy, Clean Transportation, Utilities, Ag. Technology
SETTLEMENT SUPPLY DYNAMICS Housing Stock	**OTHER TECHNOLOGY DYNAMICS** Broadband, Solar farms, Automtion, Robotics, 3D Printing, Artificial Intelligence, ChatGPT	**EMPLOYMENT/ WORKFORCE DYNAMICS** Workforce Dev't./Supply, Telework, Corp. Culture	**LOCAL/INDIVIDUAL RESPONSE DYNAMICS** Local Food, Local Resilience, Recycling, Water Consumption
POLITICAL DYNAMICS State/Federal Economic Directives, Interest Rates, Environmental Mandates, Local Land Use Policy			

Based on the four buckets of driver (Exhibit 5) categories – Community, Technology, Economy and Resiliency, the SPAC was polled on their opinions on each driver's relative importance and certainty. Exhibit 6 shows the results of the SPAC survey on the drivers.

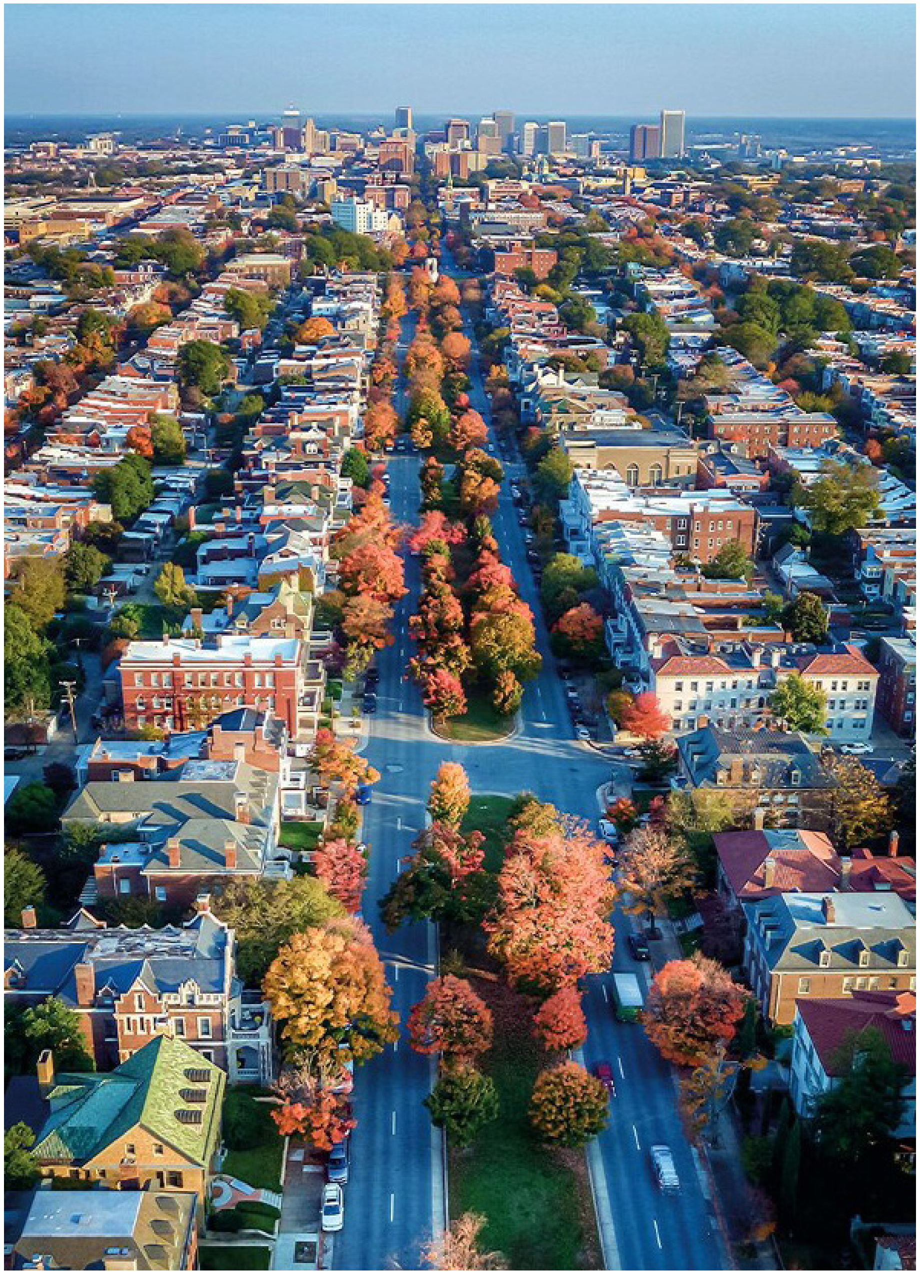
Exhibit 6

SPAC Survey Results of the Ranking of Importance and Certainty for each Driver

SCENARIO DRIVERS	Importance	Certainty
	Average Importance	Average Certainty
Community: Population Dynamics	4.4	3.9
Community: Settlement Demand Dynamics	3.7	3.1
Community: Settlement Supply Dynamics	4	3.9
Community: Political Dynamics	3.6	3
Technology: Transportation Technology Dynamics	3.2	3.1
Technology: Transportation Mode Shift Dynamics	3.4	3.2
Technology: Other Technology Dynamies	2.7	2.9
Economy: Global/National Economy Dynamics	3.4	2.6
Economy: Regional Economy Dynamics	3.9	2.8
Economy: Employment/Workforce Dynamics	4	3.6
Resilience: Climate/Planet Dynamics	3.3	3.4
Resilience: Environmental Policy Dynamics	3.2	3.3
Resilience: Local/Individual Response Dynamics	3.5	2.7

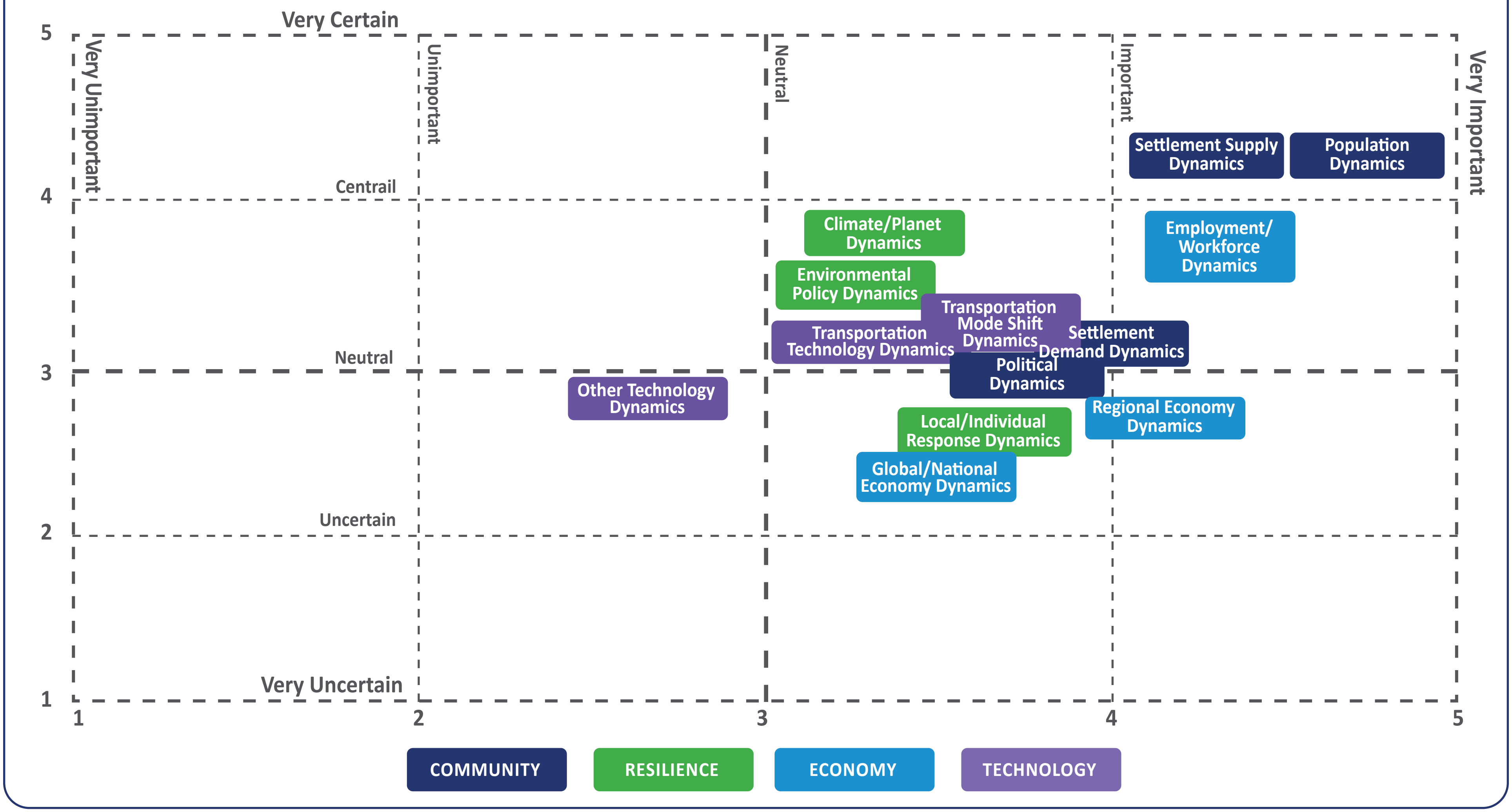
Very Important	5
Important	4
Neutral	3
Unimportant	2
Very Unimportant	1

Very Certain	5
Certain	4
Neutral	3
Uncertain	2
Very Uncertain	1



This data was then assimilated into a frequency chart (Exhibit 7) that showed how each of the driver categories ranked in terms of certainty and importance. Note in the chart that the highest importance and certainty drivers were in the Community category, particularly Population Dynamics and Settlement Demand Dynamics. In addition, Employment Demand Dynamics also ranked high in the SPAC review.

Exhibit 7 Frequency Chart of Importance and Certainty Ranking of Drivers



2.2 Public Survey

Based on these same four buckets of potential drivers, a public survey was conducted to gather input on the importance of the trends in these areas of change and the greatest concerns and hopes that the region's residents have for the future. The survey was active from April 21, 2023, to June 1, 2023. The survey had 474 participants and 1,043 visitors. Participants were asked to indicate how great an impact each **Driver of Change** will have on the region's future. This exercise prompted them to rate each **Driver of Change** on a scale from one to five, with five indicating a significant impact. Participants could also leave comments to support their selection.

The drivers that were considered the most important for the public in the Richmond region correlated well with those that the SPAC considered important, with community drivers, such as housing demand, and economic drivers, such as the local economy, receiving the most votes on importance.

2.3 Initial Draft Scenario Narratives

Based on the SPAC discussions and initial round of responses, following initial scenario narratives were developed:

- Scenario A. Diverse & Adaptive Growth
- Scenario B. Conventional Growth
- Scenario C. Local & Resilient Balance

These initial scenarios were fleshed out in terms of each driver of change in the following charts (Exhibit 8 and Exhibit 9):

Exhibit 8 Charts of Initial Scenario Narratives Showing Descriptions of Change in each Driver Category

DRIVER DYNAMICS	Potential Scenario Narrative: DIVERSE & ADAPTIVE GROWTH	Potential Scenario Narrative: CONVENTIONAL GROWTH
COMMUNITY		
Population Dynamics	Population grows - climate migration to region - new immigrants - lower Household size - diverse demographics - rising educational attainment	Population grows - natural birth rate increase - economic migration to region - educational attainment and demographics hold steady
Settlement Demand Dynamics	Preference for urban lifestyles - new mixed use centers in suburbs - denser growth in city - improved community-based schools - less rural growth	Preference for suburban lifestyles - large lot single family homes and rural growth - less growth in urban areas - growth follows school dynamics
Settlement Supply Dynamics	Redevelopment of urban neighborhoods - growth in multifamily housing - more compact housing types in all areas	All housing types increase, especially single family detached homes - townhouse and condo growth in suburban areas - infrastructure expansion costs for new growth areas
Political Dynamics	State legislation and federal economic support for affordable housing - local ordinances favor compact development and protect against sprawl	Federal support for home ownership - low interest rates and tax breaks for homeowners - local ordinances favor new growth over redevelopment or compact growth

Continue next page

Exhibit 8 Charts of Initial Scenario Narratives Showing Descriptions of Change in each Driver Category

DRIVER DYNAMICS	Potential Scenario Narrative: DIVERSE & ADAPTIVE GROWTH	Potential Scenario Narrative: CONVENTIONAL GROWTH
TECHNOLOGY		
Transportation Technology Dynamics	Very high adoption of Electric Vehicles (EVs) and Connected Autonomous Vehicles (CAVs) - high adoption of automated freight - reduced and automated parking	Low adoption of CAVs and automated freight - low EV adoption - larger vehicles and parking needs
Transportation Mode Shift Dynamics	Major shifts to transit and active transportation modes - investments in bike/ped and transit infrastructure - intercity high speed rail	Continued dominance of automobiles and Single Occupancy Vehicles (SOVs) - moderate investment in transit and active transportation - low growth in high speed rail
Other Technology Dynamics	Broadband allows work from home - robotics and 3D printing adoption - solar and wind farms in rural areas	Conventional growth in manufacturing and traditional industry sectors - large scale agribusiness - less reliance on clean energy
ECONOMY		
Global/National Economy Dynamics	Overall economic growth - clean industry sector growth - national investments in green technology and resilience	Overall economic growth - traditional industry sector growth - tax incentives to grow business and tax policy favors middle class
Regional Economy Dynamics	Regional economic growth - shifts away from manufacturing & service sector to knowledge and tech sectors - e-retail growth	Regional growth in service, construction and manufacturing - new retail and office growth fueled by economic migration and strong local economies in all localities
Employment/Workforce Dynamics	Growth in telework - less work in offices - workers free to move based on lifestyle preferences	Return to traditional office environments - “drive to qualify” commuting to employment centers - less mobile workforce regionally
RESILIENCY		
Climate/Planet Dynamics	Reduced climate and flooding impacts due to global adaptive resiliency measures - more tree cover and cleaner industry globally leads to mitigation of climate change	Increased climate and flooding impacts due to global extractive industries - less tree cover and more heavy industry industry globally leads to more intense climate change
Environmental Policy Dynamics	Clean energy and clean transportation technology adoption at national level - sustainable agriculture trends	Support for traditional industry growth - some rollback of environmental regulations - subsidies for agribusiness
Local/Individual Response Dynamics	Societal adoption of resiliency measures - recycling - local foods initiatives - water and land conservation practices - solar & wind power adoption	Limited resilience and recycling locally - lifestyle and housing preferences lead to sprawl and higher resource and water use

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Exhibit 9 Charts of Initial Scenario Narratives Showing Descriptions of Change in each Driver Category

DRIVER DYNAMICS	Potential Scenario Narrative: LOCAL & RESILIENT BALANCE
COMMUNITY	
Population Dynamics	Moderate population growth - low migration to region - increasing demographic diversity and educational attainment
Settlement Demand Dynamics	Preference for diverse lifestyles - growth in place for all settlement types - revitalizing of existing communities - focus on local communities and schools
Settlement Supply Dynamics	Expansion of new housing types - missing middle housing growth - revitalized urban housing - suburban town centers - rural villages
Political Dynamics	Diverse policy dynamics - support local community revitalization programs - support for new compact communities in urban, suburban and rural areas
TECHNOLOGY	
Transportation Technology Dynamics	High EVs adoption & moderate CAVs adoption - low automated parking adoption
Transportation Mode Shift Dynamics	Balance of auto and non auto modes - expansion of active transportation for recreation - more demand response / microtransit in suburban areas & fixed route in urban areas
Other Technology Dynamics	Broadband expansion - some new industries - gradual and localized adoption of clean energy
ECONOMY	
Global/National Economy Dynamics	Growth is more localized with mature areas seeing less growth than emerging areas. More State than Federal economic support & incentives
Regional Economy Dynamics	Growth is more limited - growth in both urban and suburban centers and some new rural economic initiatives.
Employment/Workforce Dynamics	Balance of telework in suburban communities and commuting into urban offices and service - more localized employment opportunities
RESILIENCY	
Climate/Planet Dynamics	Climate and flooding impacts become more localized based on local resilience initiatives - urban areas adopt resilience initiatives while suburban and rural areas are slower to adopt
Environmental Policy Dynamics	Economic support for smaller localized environmental measures - urban areas achieve greater deployment of environmental policies
Local/Individual Response Dynamics	Significant local recycling and resilience programs but only in selected local communities - communities with local support become more resilient - local solar & wind power adoption

2.4 Input from Charrette

On April 21st, 2023, Plan RVA hosted a "Regional Futures Charrette," inviting stakeholders, and subject matter experts throughout the region to give their input on these potential scenario narratives. Over 60 people attended the charette. They were distributed in a series of 11 small groups with facilitators that asked them questions including:

- Strengths and Weaknesses of the Region today
- Opportunities and Risks/Threats in the Region for the next 25 years
- What would you most like to be modeled quantitatively in the future (if possible)?

In general, stakeholders provided lively and robust input on the scenarios and potential drivers of change. The results of the facilitated responses from each of the groups were summarized into a series of themes under each category of driver, as shown in Exhibit 10 and 11.

Exhibit 10 Summaries of Charrette Participants' Input on Opportunities for the Future

COMMUNITY

CO1 Growth
There is room for growth and growth potential in the region

CO2 Diversity
Increasing diversity of population, economic diversity leading to a more mixed income, equitable future

CO3 Connectivity
More freedom of transportation options, multimodal connections & political connectivity across region

CO4 Complete Communities
New and revitalized communities with diversity of housing options, mix of uses and access to services

ECONOMY

EO1 Changing Work Dynamics
Locational flexibility for employment

EO2 New Economy
New economic sectors (Renewable energy, logistics, etc.)

EO3 Regional Attractiveness
State government, economic migration & strategic location

EO4 Local Ecosystem
Emphasis on local economic cooperation & new local industry clusters

TECHNOLOGY

TO1 Social Isolation
Technology that minimizes personal contact leads to more isolation

TO2 Inequitable Adoption
Rapid tech advances leave some populations behind and increase disparities through lack of educational opportunities

TO3 System Fragility
Overdependence on some technologies can lead to lack of resilience to economic or environmental shocks

RESILIENCY

RO1 Resilient Infrastructure
Reimagine new infrastructure to resist flooding and environmental/climate shocks

RO2 Sustainable Growth
Green design and compact, sustainable development practices

RO3 Resilient Practices
Political and societal transition to more sustainable and resilient use of resources, industries and investments

Exhibit 11 Summaries of Charrette Participants' Input on Threats for the Future

COMMUNITY

CT1 Fragmentation
Lack of community and cooperation in the world, nation and region

CT2 Affordability
Crisis of affordability of housing and cost of living impacts on economically challenged people

CT3 Disparity
Further disparities in wealth, inequitable distribution of investments and urban/suburban/rural divide

CT4 Decline
Population & economic decline, aging infrastructure, declining health and access to good healthcare

ECONOMY

ET1 Economic Polarization
Lack of wage diversity through polarization of high and low wage jobs

ET2 Under Employment
Remote work, automation, AI and Work from Home reduce local employment opportunities

ET3 Workforce Mismatch
Housing costs and untrained workforce leads to mismatch between available jobs and available workforce

TECHNOLOGY

ET1 New Vehicle Technology
More travel flexibility and safety from driverless cars / trucks, high speed rail, drones, e-bikes, etc.

ET2 Green Technology
Green energy and more sustainable industries

ET3 Automation Benefits
Benefits from increased automation in terms of better connections and more free time

RESILIENCY

RT1 Climate Impacts
Increasing and cumulative impacts of extreme weather, sea level rise, global warming, etc.

RT2 Unresilient Responses
Local and national responses to environmental threats don’t respond adequately and don’t build a resilient future

RT3 Systemic Failures
Cumulative effects of global trends on human health and environmental health create severe impacts on local community health and wellbeing

2.5 SPAC Refinement of Scenario Narratives

In the SPAC meeting on June 28th, 2023, the results of the charette input were shared with the SPAC. The SPAC members were asked to refine the input from the charette on the initial three scenarios into a more finished set of scenario narratives, including the baseline scenario and a doomsday scenario that would test the potential for very low growth. They were divided into groups and asked to define each scenario narrative in terms of a brief and succinct "elevator speech" as 40 words or less that embody the core idea in the scenario plus a catchy name to remember the scenario and any ideas for a logo (extra credit).

Exhibits 12 and 13 shows the results of that scenario narrative refinement and naming process:

Exhibit 12 Refined Scenario Narratives From SPAC Input

1. BASELINE ("TRENDLINE GROWTH")	2. RVA SINKS (DOOMSDAY)	3. ECOTOPIA (RESILIENT GROWTH)	4. SO 20TH CENTURY (NEW TRADITIONAL GROWTH)	5. MEH AND SAFE (BALANCE OF RESILIENT & CONVENTIONAL GROWTH)
There is significant regional grow in the suburban areas, densifying urban cores and rural growth. Health care dominates employment sectors withstrong professional growth as well.Clean energy and technology are adopted based on notional trends and settlement is based on adopted Comprehensive Plans.	Through a consecutive series of man-made and natural disasters the region does not hove time to recover fully,and due to o lock of affordable housing, safe areas and jobs, both residents and businesses begin to leave the region.	The Richmond region attracts new residents including climate refugees and digital nomads in search of quality community that provides transportation choices, diversity of housing, o no/low carbon footprint lifestyle,in a technology based and entrepreneurial economy.	The region begins a return to earlier decades, with growth fueled primarily by suburban and rural areas,a more professional/service economy, single income families with larger car-centric households and reactive rather than proactive regional responses ta the global winds of change.	Responses to change are hyperlocol, with some localities adopting proactive resilient strategies and some staying the course and reacting as needed. Growth is in line with the 2050 Baseline but transportation and housing choices, technology adoption and lifestyles vary widely and reflect eachlocality's preferred approach.
Medium Growth	*Low Growth*	*High Growth*	*Medium Growth*	*Low Growth*

The scenario Narrative were further refined and finalized as shown in the below Exhibit 13

Exhibit 13 Final Scenario Narratives Presented to the Public

MEDIUM GROWTH

BASELINE

The Baseline Scenario is built on the idea that currently projected growth patterns will continue into the future. This means that there will be significant regional growth in suburban areas, more dense development in urban cores, and growth in rural areas as well. In the Baseline Scenario, Health care dominates employment sectors, and the share of professional service jobs grows. Clean energy and technology would be adopted based on national trends. Settlement patterns would be guided by the currently adopted Comprehensive Plans of our jurisdictions.

Continue next page

Exhibit 13 Final Scenario Narratives Presented to the Public

HIGH GROWTH

ECOTOPIA

This scenario depicts a region that is actively mitigating the impacts of climate change. Under the Ecotopia Scenario, the region would experience considerable growth – attracting climate refugees and digital nomads seeking high-quality communities. Ecotopia's future is multimodal, meaning people can travel throughout the region without relying solely on automobiles. Lifestyle shifts in this scenario lead to no/low carbon footprints. The economy shifts to one based on technology and entrepreneurialism.

HIGH GROWTH

BACK TO THE FUTURE

The Back to the Future Scenario sees a return to lower density development patterns. In this scenario, growth mainly occurs in the suburbs and rural areas. Professional and service industry jobs take a larger share of employment. Single-income families become more common, and most households are car-centric. The region does not attempt to mitigate the impacts of climate change and instead reacts to climate events and disasters after they occur.

MEDIUM GROWTH

MEH & SAFE

The Meh and Safe Scenario depicts a future that matches the growth levels of the Baseline Scenario but with widely varied development patterns based on each locality's preference. Meh and Safe would adopt some proactive strategies for climate resilience but also react to climate events and disasters after they occur. The Meh and Safe Scenario incorporates more varied technology adoption and a shift towards a more transit-oriented culture.

LOW GROWTH

RVA SINKS

This scenario represents the doomsday alternative – a sort of worst-case scenario. For RVA Sinks to become a reality, both man-made and natural disasters would result in a slow recovery. These disasters are worsened by a lack of affordable housing and jobs. The result of the RVA Sinks scenario is low population and economic growth, with businesses and residents leaving the region in favor of better working and living conditions elsewhere.

2.6 Development of Control Totals

Once the scenario narratives had been affirmed by the SPAC, the methodology for modeling these scenario narratives through the suite of integrated scenario models was developed. Since all of the models rely on RSLAM as the initial driver model, this methodology started with the ways in which RSLAM could be used to allocate future growth to match each of the scenario narratives.

A series of explorations of a range of potential growth profiles to inform control totals for the modeling was conducted first. From the range of growth profiles, a series of numerical scenario profiles were explored. These were not intended to reflect the Scenario Narratives but only to understand the full universe of possible permutations of scenarios from a modeling standpoint.

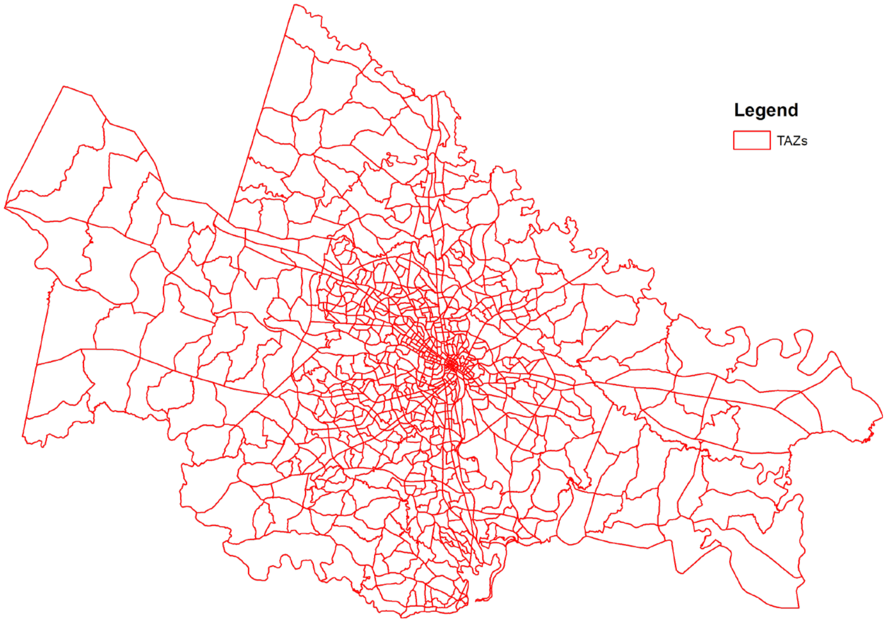
Assumptions about the growth profiles of each of the scenarios, with Meh and Safe at the Baseline projected (medium) growth rate, RVA Sinks at a lower growth rate, and Ecotopia and Back to the future at a higher growth rate were developed.

The development of regional growth totals for these scenarios was based partly on the analysis of a cross-section of plausible scenarios. Specifically, growth rates for 2017-2050 were developed as follows:

- The Baseline Growth rates in the regional baseline forecast are 34% growth for population and 31% growth for employment. These regional rates also apply to "Meh and Safe"
- The high population growth rates are based on doubling the regional in-migration and increasing the natural growth rate by 20-25%. This calculation was rounded to 60% growth from 2017 to 2050. The high employment growth rates match the 60% growth rate of the population, a slightly higher relative growth rate that reflects a slightly higher share of workers in the region's population from the focus on in-migration.
- The low growth rate is 16% for both population and employment, roughly half of the Baseline Growth rates.

The next step was to model this growth in spatial terms. A series of maps (Exhibit 14) showing the spatial geography of different factors that could be used to target growth in the model to match the narratives in each scenario were developed. Below exhibits shows the maps of the Transportation Analysis Zones (TAZ) – the building block for all spatial distribution and some examples of spatial distribution which could be used.

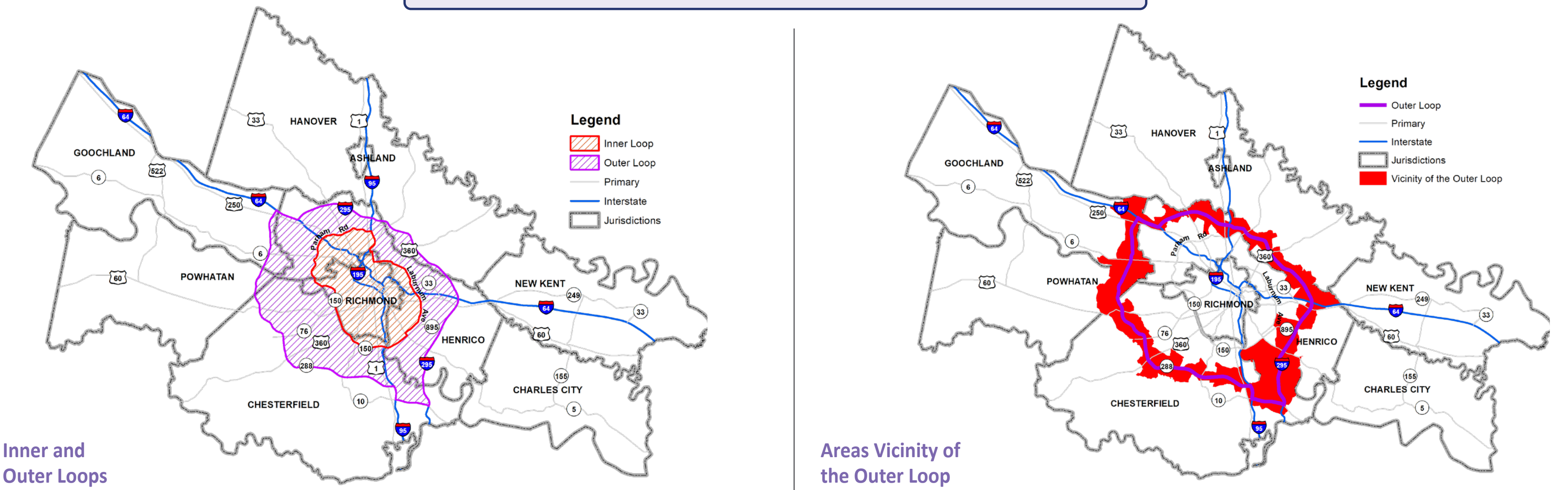
Exhibit 14
Spatial Distribution Alternatives for the Region



Transportation Analysis Zone (TAZs)
Building Block For All Spatial Distribution

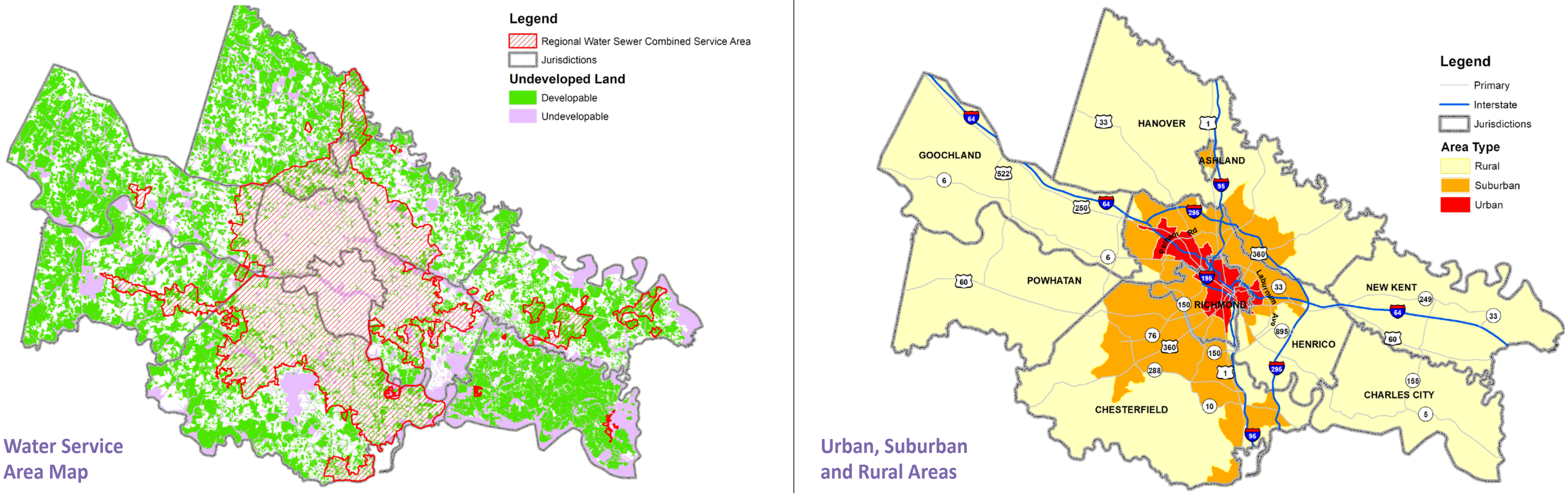
Continue next page

Exhibit 14
Spatial Distribution Alternatives for the Region



Inner and Outer Loops

Areas Vicinity of the Outer Loop

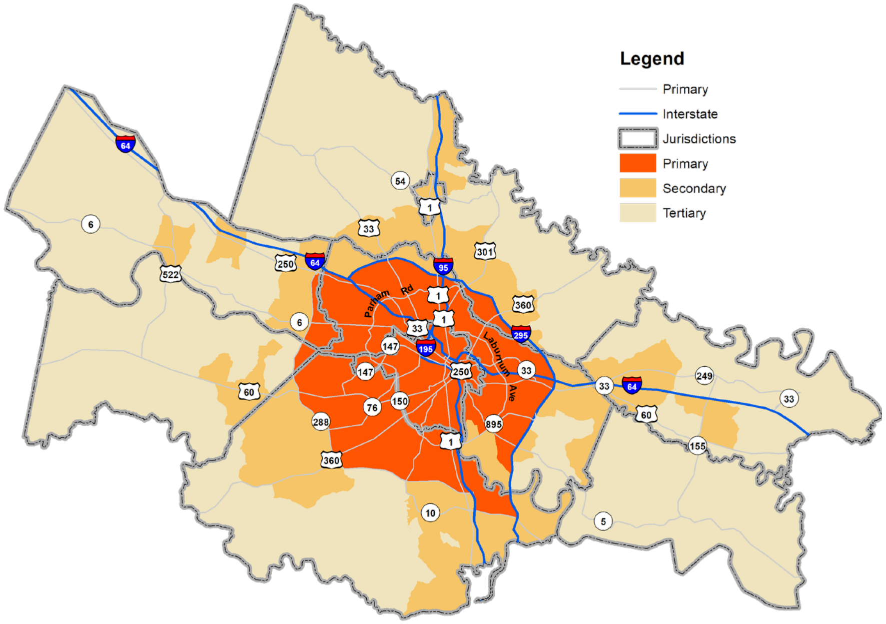


Water Service Area Map

Urban, Suburban and Rural Areas

Based on the different spatial distribution maps, a series of areas were developed to allocate growth to match the scenario narratives. Ultimately, these were assimilated into a series of three zones for allocation of growth, primary, secondary, and tertiary, as shown in the Exhibit 15.

Exhibit 15
Primary, Secondary, and Tertiary Allocation Areas for Growth Allocation



To make the scenarios comparable, the same sets of primary, secondary, and tertiary areas are used for each scenario. The boundary between the primary and secondary areas roughly coincides with the outer loop centered around Richmond along I-295 and VA- 288. The boundary between the secondary and the tertiary areas coincides roughly with the edge of the water service areas in the Richmond region. The tertiary areas are the remaining areas in the Richmond region. The consistency of these areas is key to comparing the scenarios. Exhibit 16 reflects the overall approach to differentiating the emphasis/de-emphasis of growth by scenario among the growth areas based on the scenario narratives.

- For the high-growth scenarios, Ecotopia emphasizes primary growth areas, while Back to the Future emphasizes secondary growth areas.
- Meh and Safe is similar in emphasis across growth areas to Ecotopia but with baseline growth levels.
- RVA Sinks has a lower overall growth level, allocated across growth areas proportionally like the baseline scenario.

Exhibit 16
Overall Primary, Secondary, and Tertiary Growth Allocation Emphasis by Scenario

	SCENARIO ALLOCATION APPROACH				
	 **BASELINE**	 **ECOTOPIA**	 **BACK TO THE FUTURE**	 **MEH & SAFE**	 **RVA SINKS**
	BASELINE GROWTH	HIGH GROWTH	HIGH GROWTH	BASELINE GROWTH	LOW GROWTH
PRIMARY AREA Areas inside of the I-295/VA-288 Ring	⚪	🔴	🟡	🟡	🔵
SECONDARY AREA Areas outside of the I-295/VA-288 Ring connected to public water utilities	⚪	🟡	🔴	🟡	🔵
TERTIARY AREA Areas outside of the I-295/VA-288 Ring not connected to public water utilities	⚪	⚪	🟡	🔵	🔵

BASELINE GROWTH	GROWTH SIGNIFICANTLY LOWER THAN BASELINE	GROWTH SOMEWHAT HIGHER THAN BASELINE	GROWTH SIGNIFICANTLY HIGHER THAN BASELINE
⚪	🔵	🟡	🔴

PHASE 3
SCENARIO TESTING, ANALYSIS AND COMMUNICATION

Scenario planning helps guide policymakers, planners, and community members by considering various future conditions and how to respond to and plan for them effectively. Pathways to the Future scenarios are a set of reasonably possible but structurally different futures. The analysis of scenarios provides insight into what could happen in the future as a way to consider possible outcomes and better prepare for future uncertainties. Phase 3 of the project analyzes and discusses the Pathways to the Future scenarios. It begins a discussion and the foundation for an additional planning process that can further test alternative policies and investments in the Pathways to the Future scenario framework.

3.1 Scenario Testing and Analysis

Scenario planning is not just a set of "what if" questions. Rather, the "what ifs" are supported with data analysis. When we try to predict what might happen in the future based on changes to individual elements, it is called "modeling." Phases 1 and 2 of the projects provided the modeling tools, growth assumptions, and the basis for scenario testing. The scenario testing includes feeding the alternative land use scenarios from RSLAM to the downstream models and preparing modifications to the baseline assumptions in each model. This process began with the land use control total modifications which was presented to the SPAC. The SPAC recommendations were to amplify the land use density assumptions in RSLAM and further enhance the scenario driver impacts by adjusting assumptions in the individual models. The final adjustments to the scenario model inputs are provided in Exhibits 17 and 18.

Exhibit 17

Model Adjustments/Assumptions by Scenario For Land Use, Transportation ans Other Models

MODEL	BASELINE	ECOTOPIA	BACK2FUTURE	MEH & SAFE	RVA SINKS
RSLAM - Household Distribution Model	Did not Use Household Distribution Model	Added Household Density > 10 vertical index < 5 = 5 to distribution model	Default Distribution Model	Added Household Density > 10, vertical index < 5 = 5 to distribution model	Default Distribution Model
Travel Demand Model (CAVs - Penetration Rate)	0.35	0.6	0.25	0.45	0.15
Travel D emand Model (CAV Trip Factors)	Longer trips	Encouraged shorter trips	Longer trips	Encouraged shorter trips	Longer trips
Accessibility Model	No Changes	Destinations increase by employment factor	Destinations increase by employment factor	Destinations increase by employment factor	Destinations decrease by employment factor
Mobile Emissions Model	No Changes	No Changes	No Changes	No Changes	No Changes

Exhibit 18 Model Adjustments/Assumptions by Scenario for other Models

MODEL	BASELINE	ECOTOPIA	BACK2FUTURE	MEH & SAFE	RVA SINKS
Pollutant Loading Model		10% reduction in runoff; more efficient behavior per job/per household		10% reduction in runoff; more efficient behavior per job/per household	Higher rainfall/hour
Water Consumption Model		10% reduction in water use		10% reduction in water use	
Building Emissions & Energy Use Model	Carbon-neutral electricity generation and trend-based improvement in combustible energy efficiency	Adds more efficient behavior per job/ per household	Electric emissions counted as carbon-producing	Adds more efficient behavior per job/per household	Electric emissions counted as carbon-producing; no improvement in combustible energy efficiency
Resiliency Model	3-foot sea-level rise	2-foot sea-level rise	3-foot sea-level rise	2-foot sea-level rise	5-foot sea-level rise

The SPAC also requested that the models' assumptions that drive the performance measure outcomes be made as clear as possible in presenting results. The summary 'model levers' shown below represents the modeling assumptions detailed above.

Exhibit 19 Summary of Scenario Levers in the Scenario Models

LEVERS	ASSUMPTIONS
Regional Growth	Regional growth is set at high, medium or low population and employment.
Location	The region is divided into three types of areas (primary, secondary, tertiary) as an overlay on the jurisdictions. RSLAM allocates growth to these areas.
Density	RSLAM assigns density based on location and on scenario assumptions.
Sea Level Rise	The Resiliency Model assigned different sea level rise assumptions by scenario.
Decarbonization	The Building Energy/Emissions Model and Travel Demand Model vary assumptions by scenario for carbon reduction.
Conservation	The water consumption, pollutant loading, and energy models vary conservation assumptions by scenario.
Technology	The technology assumptions for connected & autonomous vehicles (CAV) vary by scenario in the travel demand model.
Travel/Trip Making	The Travel Demand and Accessibility Models apply trip making assumptions, such as shorter trip lengths, to reflect scenario narratives.

3.2 Performance Measures

Performance measures in modeling are quantitative metrics used to assess the accuracy, reliability, and overall effectiveness of predictive models and to report the unique results of each set of assumptions applied in the models. These measures are used to objectively compare different scenarios, identify strengths and weaknesses, and make informed decisions about scenario selection and improvement. The significance of performance measures lies in their ability to ensure that models are not only accurate but also robust and generalizable, thereby enhancing their applicability in scenarios and driving better decision-making.

For reporting scenario results in Phase 3, the model results are simplified to present each performance measure per scenario relative to the baseline outcomes.

3.2.1 Richmond Simplified Land Allocation Model (RSLAM)

- **Total Land Consumed -** Total land consumed is a critical Performance Measure (PM) derived from RSLAM, used to evaluate the spatial distribution and extent of land development. This measure assesses areas where land consumption is high versus areas where it is low, providing insights into land use patterns and efficiency. High land consumption in densely populated areas can indicate effective use of space, supporting urban growth and infrastructure development. Conversely, high land consumption in low-density areas often signals inefficient land use, which can be detrimental as it encroaches on valuable resources like wildlife habitats, agricultural land, and open spaces essential for ecological balance and food production. By analyzing total land consumed, one can identify trends, promote sustainable scenarios, and make informed decisions that balance development needs with environmental conservation and productivity.

- **Types of households** - This PM categorize residential areas into low density, medium density, high density, and mixed-use households. High-density and mixed-use households are often considered more advantageous than low-density households due to their ability to foster vibrant communities with enhanced walkability and mobility. These areas typically feature a blend of residential, commercial, and recreational spaces, creating dynamic neighborhoods where residents can live, work, and play without traveling long distances. This proximity reduces reliance on automobiles, lowers greenhouse gas emissions, and encourages physical activity. Moreover, high-density and mixed-use developments tend to support better public transportation systems, offer more diverse housing options, and promote social interactions, contributing to overall community well-being. When evaluating different urban development scenarios, the distribution and types of households provide valuable insights into the potential social, economic, and environmental impacts. By analyzing these household types, one can weigh scenarios based on their ability to promote sustainable growth, enhance quality of life, and maximize resource efficiency. Scenarios with higher proportions of mixed-use and high-density households might be favored for their potential to create more resilient and adaptable urban environments. Conversely, scenarios dominated by low-density households could be scrutinized for their possible drawbacks, such as increased urban sprawl, higher infrastructure costs, and reduced environmental sustainability. Using these household types as a PM helps to prioritize scenarios that align with long-term planning goals.

3.2.2 Richmond Tri-Cities (RTC) Travel Demand Model

Vehicle miles traveled (VMT) is a crucial PM derived from Richmond travel demand model, representing the total distance traveled by all vehicles within a specific area and time period. VMT is an important indicator of a city's transportation efficiency and environmental impact. Lower VMT is beneficial for several reasons. Firstly, it leads to a reduction in mobile emissions, thereby improving air quality and public health by decreasing pollutants such as carbon dioxide, nitrogen oxides, and particulate matter. Secondly, less VMT translates to reduced gasoline consumption, which not only conserves finite natural resources but also lowers household transportation costs and enhances energy security. Additionally, decreasing VMT helps to alleviate traffic congestion, which can significantly cut down the time commuters spend traveling, leading to increased productivity and quality of life. By reducing VMT, PlanRVA can focus on scenarios promoting more sustainable transportation practices, such as public transit, biking, and walking, contributing to a healthier, more efficient, and environmentally friendly urban environment.

3.2.3 Transportation Accessibility Model

Accessibility, as a PM, refers to the ease with which people can reach essential services and destinations such as jobs, hospitals, grocery stores, schools, and recreational facilities. Accessibility is crucial because it directly impacts quality of life, economic opportunities, and social equity. High accessibility ensures that all residents, regardless of their socioeconomic status, have convenient access to essential services and employment opportunities. For instance, easy access to jobs can help improve employment rates and increase economic mobility, while proximity to hospitals and healthcare facilities is vital for maintaining public health and responding to emergencies. Additionally, accessible grocery stores are essential for ensuring food security and promoting healthy eating habits. Prioritizing accessibility can create more livable, equitable, and resilient communities where resources are within reach for everyone, leading to more sustainable and balanced urban development.

3.2.4 Mobile Emissions Model

Mobile emissions, another key PM, encompasses pollutants released from vehicles, including carbon dioxide (CO2), nitrogen oxides (NOx), and volatile organic compounds (VOCs). These emissions have significant detrimental effects on both human health and the environment. CO2 is a major greenhouse gas contributing to global warming and climate change. NOx can cause respiratory problems, smog formation, and acid rain, while VOCs are precursors to ozone formation and can lead to serious health issues such as cancer and respiratory diseases. Reducing these emissions is critical for improving air quality, mitigating climate change, and protecting public health.

Technology advancements, such as autonomous vehicles, are pivotal in this effort. Autonomous vehicles can optimize driving patterns and reduce idling time, leading to lower emissions. Most autonomous vehicles are also designed to be electric, reducing fossil fuel use and emissions. Prioritizing mobile emissions as a key PM can help in creating healthier and pollutant-free communities.

3.2.5 Pollutant Loading Model

The pollutant loading model processes the differences in land use distribution from RSLAM, the differences in land cover and impervious surface from the Land Cover model, and assumptions regarding future pollutant conservation policies and rainfall intensity to produce performance measures of Nitrogen, Phosphorus, and Sediment runoff. The amount of growth and geographic distribution of the land use and the differences in land use types (density in particular) alter the pollutant loading results for each scenario. As indicated in the scenario testing discussion, the assumptions within the pollutant loading model were modified to reflect greater conservation policies/behavior in the future via the runoff per-household ratios in the more environmentally resilient scenarios; for the direst climate change scenario, the rainfall intensity was increased above the baseline forecast. To facilitate comparisons between scenarios, pollutant loading model outputs are reported in tons per capita per pollutant relative to the Baseline for each scenario.

3.2.6 Land Cover Model

The Land Cover model estimates the change in percentages of different Land cover categories. The major PM from the model is the change in the coverage of the impervious surface at the TAZ, jurisdiction or at the regional level. impervious surfaces are an environmental concern because they initiate a chain of events that can cause urban flooding, increase “heat islands” and increase pollutant runoff which may have negative effects on animals, fish plants and people.

3.2.7 Building Emissions Model

The building emissions model has two important PMs. It captures the effects of alternative land use and growth patterns on residential and job-related (commercial) energy use, and it also translates the building-related energy use into carbon emissions. The energy use and carbon emissions calculated by the model divide the energy produced by the electric grid from the energy produced by other sources, such as natural gas, at the building level. Based on current policy, the baseline assumption for 2050 is that regional electricity generation will be carbon neutral. Two ways that the model can capture the scenario drivers in addition to interpreting the land use changes is 1) to alter the assumption regarding carbon-neutral electricity generation (i.e., decarbonization) and 2) to alter the baseline projection of improved energy efficiency per household and per job across the region. These levers facilitate greater differentiation between the scenarios in keeping with the scenario narratives. The building emissions model PM are reported in kilowatts (kWH) per year per capita and metric tons of CO2 per capita.

3.2.8 Water Consumption Model

Water consumption is a relatively simple PM that translates the forecast of jobs and households by land use type to project the gallons per day of water use. This PM is primarily affected by the amount and distribution of growth, but it does include a lever to reflect the assumptions regarding water conservation. Thus, the more environmentally resilient scenarios reflect a greater reduction in water use per job and household than the baseline scenario assumptions, supporting the scenario narratives and increasing the differentiation between scenario performance results. This PMis reported by scenario regarding gallons per day per capita.

3.2.9 Community Health Model

The community health impact model has several model outputs that serve as PMs to evaluate the impacts of changes in land use, transportation, the environment, and medical and food accessibility in the Richmond region. These outputs are grouped into the following categories:

- **Green Space:** The model calculates the percent change in mortality rate (deaths per 100,000 people per year), the percent change in psychological distress prevalence, and the percent change in depression prevalence due to changes in green space area (park and forest acres).
- **Emissions:** The model estimates the percent change in Chronic obstructive pulmonary disease (COPD) hospitalization rate, the percent change in mortality rate (deaths per 100,000 people per year), and the percent change in asthma-associated emergency room visit risk resulting from changes in emissions of nitrogen oxides (NOx), particulate matter (PM2.5), and volatile organic compounds (VOCs).
- **Accessibility:** The model calculates the percent change in food insecurity likelihood and the percent change in life expectancy due to changes in the number of grocery stores per capita and the number of primary care physicians per capita, respectively.
- **VMT-Related Crashes:** The model predicts the percent change in fatalities and injuries per 100 million vehicle miles traveled (VMT) for passenger cars and heavy trucks separately, based on changes in their respective VMT.

These model outputs serve as performance measures to quantify the potential health impacts of different scenarios related to land use, transportation, environmental factors, and healthcare and food access in the Richmond region.

3.2.10 Economic Model

The Economic Model includes estimates and analyses that serve as PMs to evaluate the economic impacts of different scenarios. Here's a summary of these performance measures:

- **Water Cost Estimate:** This component estimates the variable costs for the marginal gallons of water used by households and firms based on municipal water rates. It serves as a performance measure to assess the water costs associated with different land use and development scenarios for each household.
- **Electricity Cost Estimate:** This component calculates the electricity costs for different land use types based on estimated electricity usage and average kilowatt-hour (kWh) costs for residential, commercial, and industrial uses. It provides a performance measure to evaluate the electricity costs under different scenarios for each household.
- **Housing Cost Estimate:** This component estimates the housing costs (mortgage or rent) for single-family and multi-family housing units based on data from the American Housing Survey. It serves as a performance measure to assess the housing costs associated with different housing mixes in various scenarios for each household.
- **Social Cost of Travel Estimate:** This component calculates the social costs of travel, including the value of time, vehicle wear-and-tear, fuel costs, and the costs of fatalities and injuries associated with travel. It provides performance measures to evaluate the social costs of transportation under different scenarios.

- **Economic Impact of Travel Estimate:** This component estimates the economic impacts of travel changes, such as changes in output, value-added, earnings, and employment, based on travel cost data and Regional Input-Output Modeling System (RIMS II) multipliers. It is a performance measure to assess the economic impacts of transportation improvements or changes across different scenarios.

- Market Access Analysis: **It assesses the accessibility to markets or economic** opportunities under different scenarios and outputs the total population and households that are within 45 minutes of travel time.

3.2.11 System Resiliency Model

The System Resiliency Model predicts the potential impacts of natural hazards on the region. The Flood Risk Model predicts sea level rise, flooding and dam breach for each scenario and provides information of total acreage, households, population, and jobs affected by flooding. It also provided the number of road centerline miles affected by flooding in each scenario. The Wildfire Risk Model predicts wildfire risk areas for each scenario and provides information of total acreage, households, population and jobs affected by wildfire.

3.3 Scenario Evaluation Framework

Based on the SPAC and the public input on the most desired performance measures and outcomes to compare in the scenario analysis within the modeling framework eight indices (singular: index) that combine various direct PM of the individual models were developed. The indices can best describe the results of the scenarios in relation to the baseline results in a simplified dashboard. The eight indices (Illustrated in Exhibit 20 as well) are as follow:

1. **Healthy Living Index:** This index measures factors related to human health, food insecurity, and transportation safety within a region or community.
2. **Smart Growth Index:** This index evaluates the total area (in acres) utilized for housing and job opportunities, as well as the extent to which households are located in areas with high-density land use. It assesses the efficiency and sustainability of urban growth patterns.
3. **Environmental Protection Index:** This index considers various pollution measures, such as air and water quality, as well as the potential for wildfires and water inundation or flooding in the area. It evaluates the environmental risks and resilience of a region.
4. **Access to Markets Index:** This index measures the proximity and accessibility of markets or commercial centers within a 45-minute travel time from residential areas. It assesses the convenience and ease of access to essential goods and services.
5. **Business Impacts Index:** This index quantifies regional productivity by measuring the Gross Regional Product (GRP), which is a measure of the total economic output or value added within a specific geographic region.
6. **Technology Index:** This index evaluates the amount of vehicle miles traveled by connected and automated vehicles (CAVs), as well as changes in energy use and emissions associated with transportation and other technological advancements.
7. **Cost of Living Index:** This index assesses the overall affordability of living in a particular area by considering factors such as household costs and travel expenses.
8. **Accessibility for Equity Emphasis Areas Index:** This index evaluates access to key destinations and employment opportunities for specific population groups or communities, likely focusing on traditionally underserved or disadvantaged areas.

These indices collectively provide a comprehensive assessment of various aspects of urban development, sustainability, economic productivity, environmental quality, and equity, enabling data-driven decision-making and policy formation.

Exhibit 20 Scenario Evaluation Frameworks

Healthy Living Index	Human health measures, food insecurity, transportation safety.
Smart Growth Index	Total area (acres) In use for housing and jobs, households in high density land use.
Environmental Protection Index	The Resiliency Model assigned different sea level rise assumptions by scenario.
Access to Markets Index	Access to central Business District (CBD) within 45 minutes.
Business Impacts Index	Regional productivity (Gross Regional Product)
Technology Index	Amount of vehlcle miles traveled by CAV, changes in energy use and emissions.
Cost of Living Index	Household cost, travel cost.
Accesibility for Equity Emphasis Areas Index	Access to key destinations, access to employment

3.4 Scenario Evaluation

After each model was run, the key individual model results were summarized briefly for the regional stakeholders and experts in the second Pathways to the Future Charrette held on April 15, 2024, and discussed in greater detail with the SPAC in its meeting on May 15, 2024.

The scenario index results are portrayed as a "dashboard," which is a way to show multiple data points in relation to each other, as shown in the Exhibit 21. The scenario results dashboard presents each scenario's results as a percent difference from the Baseline 2050 scenario results. For example, in Healthy Living, Back to the Future is 44% lower than the Baseline, and Meh & Safe is 64% higher. For all of the indices, including Cost of Living, a higher result is a better outcome, and a lower result is a less desirable outcome.

Exhibit 21
Pathways to the Future Scenario Results Dashboard

	ECOTOPIA	BACK TO THE FUTURE	MEH & SAFE	RVA SINKS
Healthy Living	146	-44	64	-115
Smart Growth	21	16	10	-2
Equitable Access	17	-14	12	3
Environmental Protection	17	-10	9	-20
Cost of Living	25	-7	12	-15
Business Impacts	94	-68	160	15
Access to Markets	16	-3	2	-11
Technology	27	-9	10	-25

All numbers are expressed in the percent difference from the Baseline Scenario

- **Healthy Living Index:** This index shows the best results in Ecotopia, positive results in Meh & Safe, and negative results for Back to the Future and RVA Sinks, which rates the lowest. Some of the assumptions driving these results are more connected/autonomous electric vehicles in Ecotopia and Meh & Safe, improving air quality, and more compact development patterns, improving the outcomes for food security measures.

- **Smart Growth Index:** The Smart Growth results show improvements over the Baseline for all scenarios except RVA sinks, and with Ecotopia rated the highest. Ecotopia and Meh & Safe show improvements due to more compact development patterns. Back to the future's higher rating results from a greater amount of higher-density development with this scenario's higher growth rate, despite the overall greater land use consumption in acres.

- **Accessibility for Equity Emphasis Areas Index:** Accessibility for Equity Emphasis Areas is improved over the Baseline in all but the Back to the Future scenario. The Ecotopia and Meh & Safe scenarios rate best largely due to their more compact development patterns.

- **Environmental Protection Index:** Ecotopia and Meh & Safe score better than the Baseline for this measure, largely because these scenarios assume improved household and commercial conservation of electricity, water, and water pollutants. The Back to the Future and RVA Sinks scenarios have worse-than-baseline results partly due to reduced measures to mitigate climate change and sea-level rise.

- **Cost of Living Index:** The household conservation assumptions and travel cost efficiencies in Ecotopia and Meh & Safe drive the improved cost of living. RVA Sinks and the Back to The Future scenarios have negative impacts on the cost of living.

- **Business Impacts Index:** The Meh & Safe scenario scores the highest in business impacts, representing overall regional productivity. This is partly because this scenario has improved efficiency in development patterns without the impacts of higher traffic congestion in the two high-growth scenarios (Ecotopia and Back to the Future). Ecotopia scenario scores the second highest in this category due to the efficiencies in travel automation and subsequent reductions in travel costs, fuel costs, and costs associated with accidents/fatalities/injuries.

- **Access to Markets Index:** Due to high efficiency in travel time/cost measures resulting from assumed high CAV implementation, the Ecotopia and the Meh & Safe scenarios show positive accessibility to the CBD. RVA Sinks and Back to the Future scenarios show negative impacts. The growth in population is also a contributing factor in this measure, leading to relatively higher accessibility when compared to the RVA Sinks scenario.

- **Technology Index:** The two scenarios with higher connected and autonomous vehicle use assumptions, Ecotopia and Meh & Safe, rate best in the technology measure.The less environmentally favorable scenarios Back to the Future and RVA Sinks rate poorly, on the basis of having higher per capita energy use than the Baseline and other scenarios.

The initial scenario results were discussed in small groups in Charrette #2 and in the final SPAC meeting. Feedback on the overall P2F process and the scenario results are highlighted below.

▶ Scenario Dashboard

In the second Charrette, the participants engaged in a small group exercise to explore the dashboard results by discussing the relative importance of the indices and testing out alternative weighting of the indices' component measures. The indices of greatest interest across the six breakout groups included Land Use, Accessibility, and Healthy Living. In exploring the variations

in the weighting of the measures in each index, the groups' recommendations varied, but some common themes emerged:

- **Accessibility for Equity Emphasis Areas Index:** consider balancing the accessibility components between work (employment) and non-work destinations.
- **Healthy Living:** consider an even balance between mental and physical health components.
- **Technology Index:** consider more emphasis on transit and less on drive-alone and CAV Vehicle Miles Traveled (VMT) measures.

The key takeaway from taking a deeper dive into the dashboard was that the information is engaging, and participants indicated that in using the models for regional planning, some additional data would be interesting to see, such as:

- Details of the Baseline Scenario results.
- Mapped results or summaries by the three growth areas (primary, secondary, tertiary) and/or by jurisdiction
- Accessibility measured for all people in addition to the Equity Emphasis Areas
- Accessibility for other regional activity centers (as opposed to the primary regional business district center as currently measured)
- More insight into alternative transportation modes

The SPAC also discussed the indices and component measures. They pointed out some key assumptions, such as the assumption that CAV emissions are carbon neutral, which may or may not correspond to the building emissions scenario assumptions regarding the decarbonization of the electric grid.

Scenario Implications

In the Charrette, small groups discussed the following aspects of each scenario, looking at the dashboard results both vertically (by scenario) and horizontally (comparing scenarios): strengths/positive outcomes, risks/negative outcomes, investments to support more positive outcomes or avert negative ones, and policies to do the same. The themes in each area emerging from the small group discussions are summarized below.

ECOTOPIA	BACK TO THE FUTURE
• Positive for the environment and multimodal travel • Risks for housing affordability • Invest in transit, affordable housing, green infrastructure. • **Policies –** rent control, complete streets.	• Something for everyone (less opposition) • **Risks –** car dependence, obstacles to affordable & accessible housing, high cost of living, exacerbating climate change. • Invest in land preservation and equitable transportation. • **Policies –** inclusive zoning, mixed-use centers
MEH & SAFE	**RVA SINKS**
• **Balanced outcomes, positive for quality of life –** congestion, accessibility, health • Risks from concentrated development patterns (market access, growth have/have-nots) • Invest in transit and neighborhood resiliency grants. • **Policies –** inclusive zoning, ADUs, revenue-sharing, investment hubs.	• Less congestion & more economic efficiency • **Risks –** health and environment • Invest less in infrastructure, more in environmental resiliency, and reinvest in existing housing. • **Policies –** resiliency requirements for development, green space and social distancing, normalize green transportation.

These findings illustrate how the scenarios can be used in regional planning to prepare for the future by identifying risks and opportunities, tracking trends that mark turning points requiring intervention, and proactively identifying policies and investments supporting preferred outcomes for the region.

▶ Scenario Planning Framework

Both the SPAC and the Charrette participants reflected on the scenario framework as it may be applied in future planning studies, observing the extent of flexibility in the framework and tools:

- Adjustment of the relative weights of the dashboard components with this or any other set of model outputs.
- Addition or enhancement of the reported indices with additional information generated by the scenario models.
- Adjustment of the assumptions in the models via the scenario levers, including different policy assumptions for land use, conservation, resiliency, etc., and the future investment assumptions, such as the transportation network applied in the travel demand model.

Through polling and exit surveys in the Charrette, participants indicated that most are interested in scenario planning and found the scenario framework plausible and useful for various planning purposes. The SPAC echoed these assessments and noted that the initial scenario planning in Phases 1 through 3 has built an understanding of the scenario planning tools and performance measures that will enable regional stakeholders to refine and apply the tools effectively in upcoming planning projects.

PHASE 4
APPLICATION WITHIN DIFFERENT PROGRAM AREAS OF AREAS OF PLANRVA

PlanRVA intends to use the outcomes of the P2F process (the four scenarios, the predictive modeling analytical toolset and the performance measures and indices) in its ongoing and future planning processes with different level of applicability.

1 **Education and Awareness –** providing early warning signs or shared understandings of the potential impacts of different regional, national or global trends and their impact on each program area

2 **Strategic Direction (Vision setting or exploration) –** providing a benchmark for ongoing strategic planning for areas such as transportation (Long Range Transportation Plan), housing (Regional Housing Plan), emergency management (Hazard Mitigation Plan), economic development (Comprehensive Economic Development Strategy) or environment (Regional Environmental Framework) to help inform their visions or strategic direction.

3 **Action Implementation (policy and project identification and selection) –** providing specific policy guidance by being able to forecast potential impacts (for example, from climate, technology or economic futures) and get ahead of these impacts with mitigation policies or projects (LRTP).

Pathways to the Future

PlanRVA
Where the region comes together to look ahead.

424 Hull Street,
Suite 300
Richmond, VA 23224
WWW.PLANRVA.ORG