US 29 / Cherry Hill Transit-Oriented Development Scenario Planning Report

Montgomery County, Maryland

Prepared for:
Montgomery County Planning Department
Maryland-National Capital Park and Planning Commission
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Silver Spring, MD 20910

With funding from:
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Prepared by:
MARTIN ALEXIOU BRYSON

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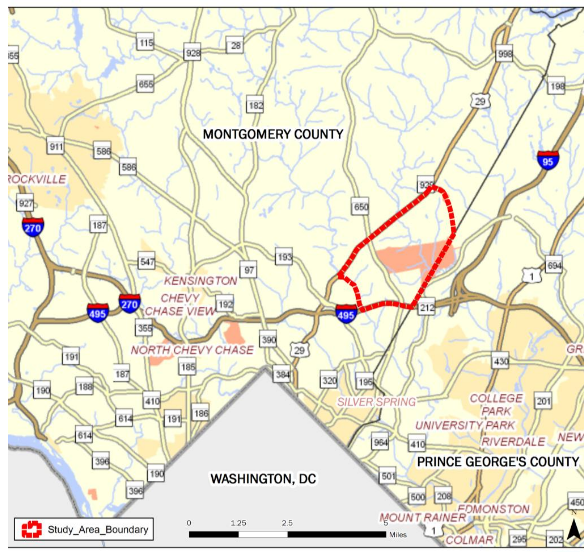
4000 WESTCHASE BLVD, SUITE 530, RALEIGH, NC 27607

EXECUTIVE SUMMARY

This report examines the results of a transit-oriented development (TOD) scenario planning exercise in Montgomery County, Maryland. This report is funded through the National Capital Region Transportation Planning Board's Transportation/Land-Use Connection (TLC) program. The primary Study Area for the project is the Cherry Hill Employment Area, located east of US 29 and south of Cherry Hill Road, adjacent to the White Oak neighborhood. In particular, the focus was the two vacant parcels south of the existing office, shopping center, and light industrial development. These parcels are generally referred to as the Percontee Sand and Gravel lot and the County's Site II. A key feature of this area is the Federal Research Center (FRC) that currently houses roughly 5,500 employees of the Food and Drug Administration (FDA), but has plans for expansion.

The work done as part of this project will help feed into an update of the Master Plan for the East County Science Center which contains the study area for this project. The ultimate vision and goals for the area will be further refined during the master planning process, but this analysis provides some initial guidance on the types and intensities of land use required to support different transit options to the area. While traffic conditions within the area vary substantially today, future conditions are expected to be substantially degraded so the impact of additional development in the area is a concern for both the neighborhood and for its impacts to regional mobility



REGIONAL CONTEXT MAP

MONTGOMERY COUNTY LAND-USE AND TRANSPORTATION STUDY

The planning exercise had three main components: 1) a literature review examining TOD best practices, particularly in relation to a large federal campus; 2) a transit sketch-planning analysis; and 3) a land-use scenario testing analysis. Highlights of each are provided below.

Case Studies

For this study, relevant research on transit-oriented development (TOD) was examined, with a particular focus on how to provide transit to a large secured federal complex. TOD strategies yield a number of positive results, particularly with respect to the transportation network, including increased number of transit riders and significantly reduced vehicle trips. The five D's of TOD guide the development process – density, diversity, design, destinations, and distance.

The Metropolitan Washington region provides plentiful examples of successful TOD with Montgomery County and Arlington County, VA leading the way. Unfortunately, TOD on a federal campus is not common and is increasingly difficult to implement due to heightened security concerns at federal facilities. However, TOD can still be successful by clustering development to a station at the edge of a federal property and working with the agency to ensure access to transit.

Transit Sketch-Planning Analysis

The first phase of the analysis was a transit sketch planning exercise. As this work is largely aimed to support the East County Science Center Master Plan, the goal of the exercise was to produce a series of analyses exploring the relationship between transit mode, alignment and future development within the study area. The key output was a determination of the minimum ridership necessary to satisfy basic cost-effectiveness criteria for each identified transit alignment. This process identified transit costs, new rider targets, total development, peak-hour traffic volumes, and potential roadway capacity constraints.

M/A/B summarized and presented the results of model runs to the interagency working group. While this exercise was largely exploratory in nature, there are some key takeaways:

- Fully-tunneled Metrorail is generally cost-prohibitive.
- Metrorail – tunnel, cut-and-cover, or above ground – is not feasible without substantial growth along the entirety of the corridors examined. Given existing forecast development, ridership requirements at a Site II/Percontee/Cherry Hill station could range from 32,000 to 85,000 boardings a day compared with the roughly 35,000 boardings at day at Union Station, the busiest Metro station today. Even if the development were spread out along a corridor, the required development is enormous – potentially exceeding 100 million GSF of additional development – and generally out of character for the study area and its environs.
- Without very high transit mode splits (i.e. the percentage of travelers using transit), the level of development necessary to support transit the Metrorail alternatives studied would stress the road network to a degree that the cost of the roadway improvements would be prohibitive (and the improvements themselves generally impractical).
- Both bus rapid transit (BRT) and light rail transit (LRT) are promising in that ridership goals seem achievable and additional development is in line with a potential higher-density vision that would typically accompany such an investment in transit BRT offers similar service quality as LRT with lower cost; it can also be constructed more quickly and has a smaller impact on adjacent properties.
- Given current land use forecasts (which reflect current zoning) alignments serving New Hampshire Ave (between Takoma-Langley and the study area) are more likely to achieve ridership goals than those serving US 29 to Silver Spring.
- An extension to Konterra and Muirkirk is likely more cost-effective (as it will capture more ridership) than to Briggs-Chaney.

Land-Use Scenario Planning Analysis

INDEX Alternatives Modeling

M/A/B created three main scenarios using INDEX software:

- Scenario 1 – Existing Conditions
- Scenario 2 – Mixed-Use Build-Out at Floor Area Ratio of 1
- Scenario 3 – Existing Conditions Plus Percontee and Site II Development

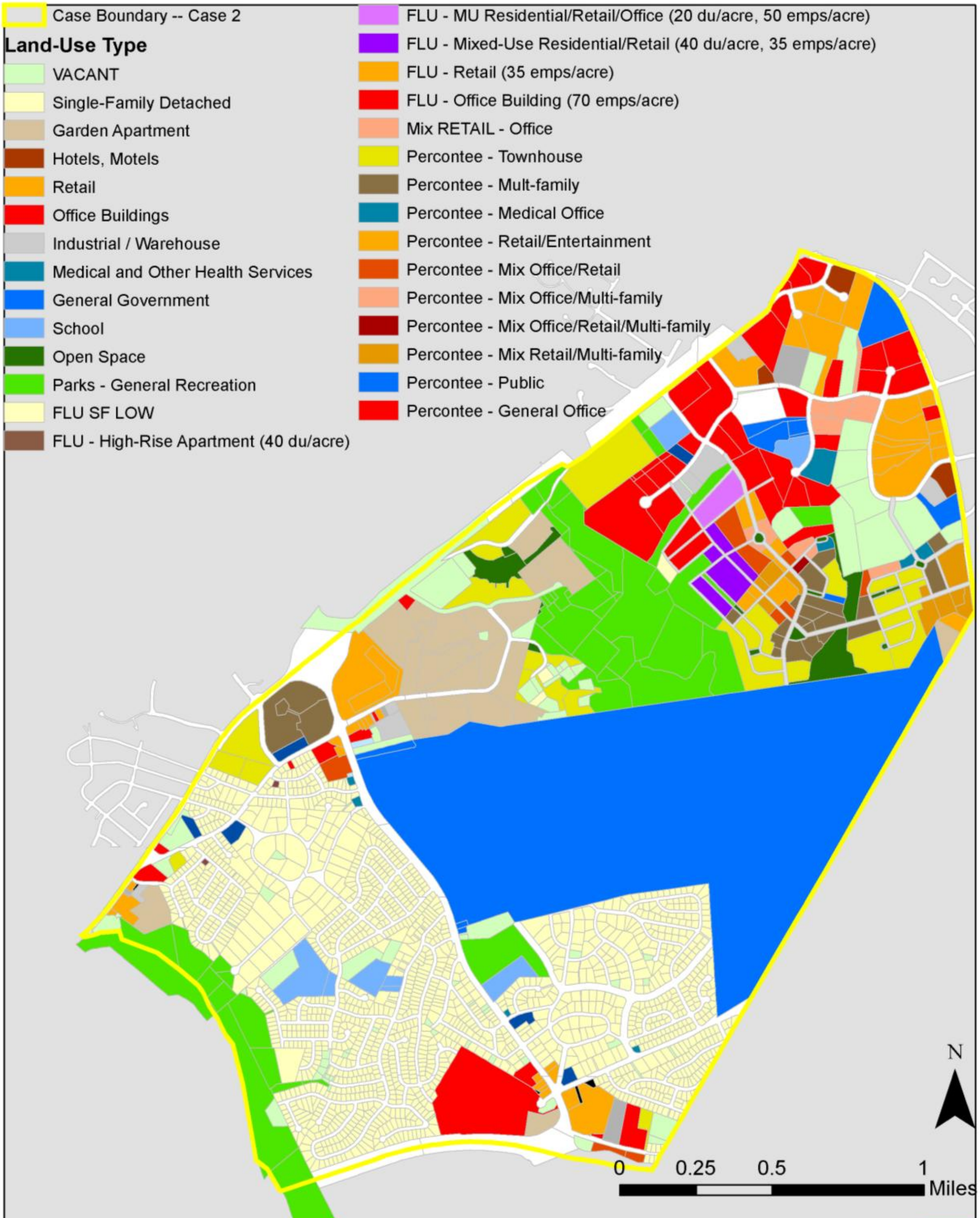
INDEX is an ArcGIS add-on which allows users to tie together land use, transportation, and environmental planning to assess over 90 different indicators from scenarios including population, employment, transit ridership, and greenhouse gas emissions. INDEX adds a quantitative element to comparing and ranking different development possibilities.

The three scenarios were designed to understand the impacts of different land-use options in the area. The goal of Scenario 1 was to accurately model current conditions, which serves as a benchmark for comparisons of future alternative scenarios. Scenario 2 applied higher density, multi-use land-uses throughout the majority of the portion of the study area north of the FRC in order to determine a maximum load or maximum impact to the transportation network as a result of redevelopment in the area. Scenario 3 modeled the impacts of mixed-use development of the Percontee and Site II properties, and is shown in the figure below.

M/A/B tested these three cases on a variety of indicators to determine what current conditions look like, and what the area may look like under the two future scenarios. Scenario 2 increases population, employees, and vehicle trips significantly over Scenario 1. Population increases 125%, dwelling units increase 163%, and employees increase 125%. Although per capita home based trips decrease slightly, total trips are significantly higher vs. Scenario 1 (existing conditions) due to the population increase. The existing conditions level of trips is roughly 165,000 daily trips in the Study Area. Under Scenario 2, trips would roughly double to 335,000 per day.

The development impacts of Scenario 3 are much lower than those from Scenario 2. As compared to Scenario 1, population in Scenario 3 would increase roughly 22%, employees would increase about 15%, and dwelling units would increase about 40%. Daily vehicle trips would increase roughly 18% over the Scenario 1 baseline to a total of about 195,000. Scenario 3 increases the development in the Study Area, adding residents and workers, but does so in a way which has significantly lower impacts than Scenario 2. The table below shows the basic output for the three scenarios.

Indicator	Scenario 1	Scenario 2	Scenario 3
Residential Population	20,451	45,961	24,965
Employment	24,254	39,215	27,799
Gross Square Feet of Development (millions)	20.997	48.044	22.831
Total Daily Trips	165,459	335,137	195,685



SCENARIO 3 CASE STUDY AREA MAP

MONTGOMERY COUNTY LAND USE AND TRANSPORTATION STUDY
MAY 2011

Lessons Learned

This project has provided a number of lessons learned and best practices for repeating a similar study in the future. Many of the lessons learned stem from the fact that using INDEX frontloads a lot of data work; because of this, having a clear vision, an understanding of desired final products, and agreement on study parameters at the beginning of a project can save significant time and effort later. Some of the main items to consider when working in INDEX are:

- Have a plan before starting data cleaning – desired indicators, goals of the study.
- Base the existing conditions map on existing land-use not zoning.
- Group similar land-uses to simplify creation of "paints" and organize paints prior to creating them. INDEX uses paints which represent land-use types and contain dwelling, employment, and environmental attributes; these paints can be applied to a parcel in one action which imbues that parcel with the unique characteristics of that paint.
- If multiple datasets are needed, code them similarly then append the data sets during the load into INDEX rather than combining them before loading.
- Make any changes to the existing conditions case in INDEX before creating new alternative scenarios.
- Create an alternative scenario that can be used as a test case to "play around" in the program.

INDEX Pros and Cons

INDEX is a powerful and versatile tool which can be useful in many different applications; however, it is not always the best tool. It is important to consider the goals of a study and the strengths and weaknesses of INDEX before deciding to utilize the software for a project. Below are some of the items to consider before starting a project.

- INDEX requires certain types of data which may require significant upfront data cleaning work.
- INDEX is designed for small-area projects, not regional analyses.
- One of the main strengths of INDEX is the ability to tie together land-use, environmental, and transportation planning which are often left in silos in practice.
- INDEX is a good tool for assessing environmental impacts such as greenhouse gas emissions or water runoff.
- Because data preparation work is frontloaded, the software can be a powerful tool for digital charrettes and public meetings, allowing for real-time feedback on citizen ideas.
- INDEX has extensive and specific data requirements, although all types of data will not be needed for all types of studies, emphasizing the importance of forethought and planning before undertaking a project.
- INDEX is sometimes opaque in how calculations work and making changes to formulas to account for local knowledge or technical expertise is not always an option.

Conclusions

The Study Area is a good candidate for increased bus service and potentially LRT or BRT in the future with some higher-density development around station areas. Heavy-rail transit is likely cost-prohibitive. The land-use analysis shows that, absent transit enhancements, major redevelopment of the area will significantly stress the transportation network, potentially doubling baseline vehicle trips per day. Moderate redevelopment, which accompanies the expansion at the Federal Research Campus, is likely to have manageable impacts in the short term. Coupled with increased transit access in the future, a smart and moderate redevelopment of key areas with TOD principles seems feasible.

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MARTIN ALEXIOU BRYSON

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1. INTRODUCTION

This report examines the results of a transit-oriented development (TOD) scenario planning exercise in Montgomery County, Maryland. This report is funded through the National Capital Region Transportation Planning Board's Transportation/Land-Use Connection (TLC) program. This study is a sketch-level analysis meant to inform the Master Plan update for the East County Science Center. The primary Study Area for the project is the Cherry Hill Employment Area, located east of US 29 and south of Cherry Hill Road, adjacent to the White Oak neighborhood. In particular, the focus was the two vacant parcels south of the existing office, shopping center and light industrial development. These parcels are generally referred to as the Percontee Sand and Gravel lot and the WSSC Site II. Not only is there the potential for substantial change to the area with the redevelopment of these parcels, the Federal Research Center, immediately to the south, will continue to grow. This TOD planning process used iterative scenario testing to evaluate how several different land use types and densities affected the feasibility of a range of transit services to the area, including heavy-rail, light-rail, and bus rapid transit. This analysis also evaluated the different growth and development scenarios for preliminary environmental and greenhouse gas impacts.

One of the key features of this area is the Federal Research Center (FRC) that currently houses roughly 5,500 employees of the Food and Drug Administration (FDA). The FDA currently has plans to greatly expand their usage of this site to up to nearly 9,000 employees and has a desire for additional consolidation in the future. The adjacent Percontee and Site II properties offer a prime opportunity to create developments that would eventually support transit in an area of the County attractively situated for businesses and residents alike. Figure 1.1 shows where the site is situated in the region, and Figure 1.2 shows the existing conditions in the site at the parcel level.

Figure 1.1: Study Area Context

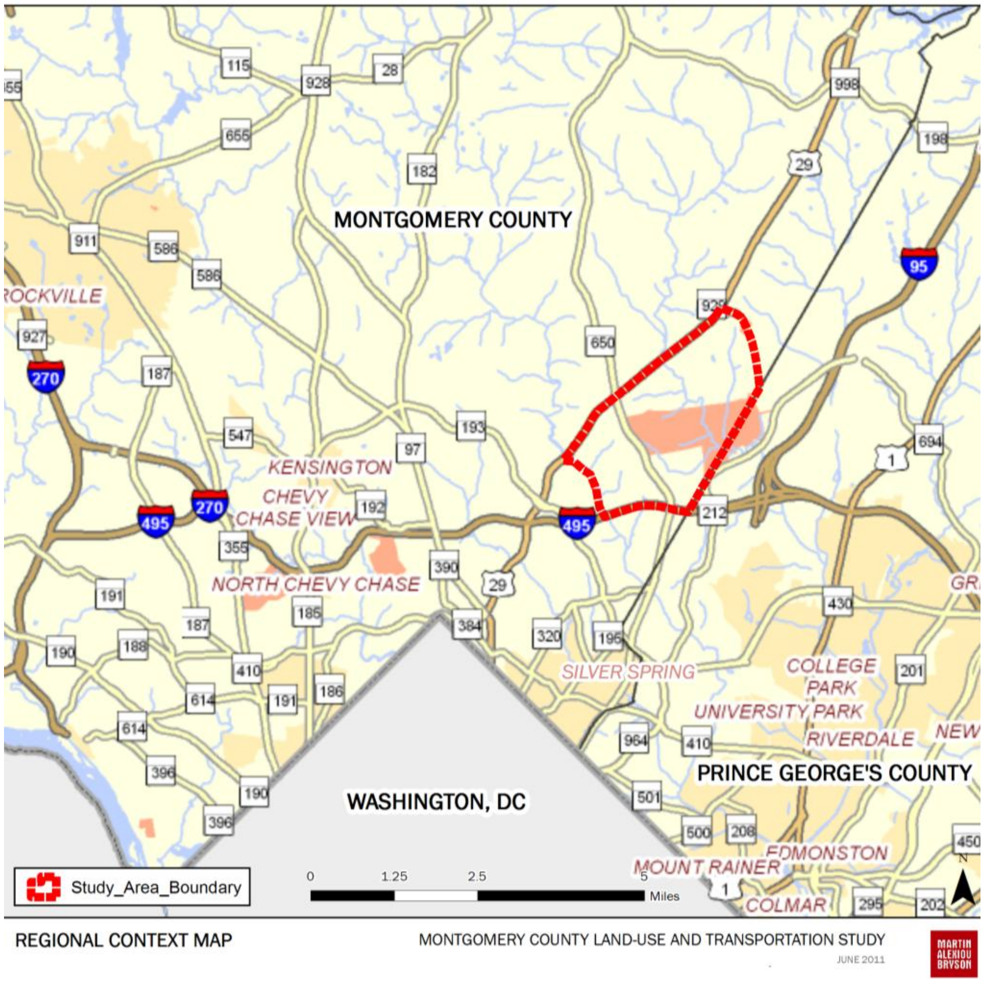
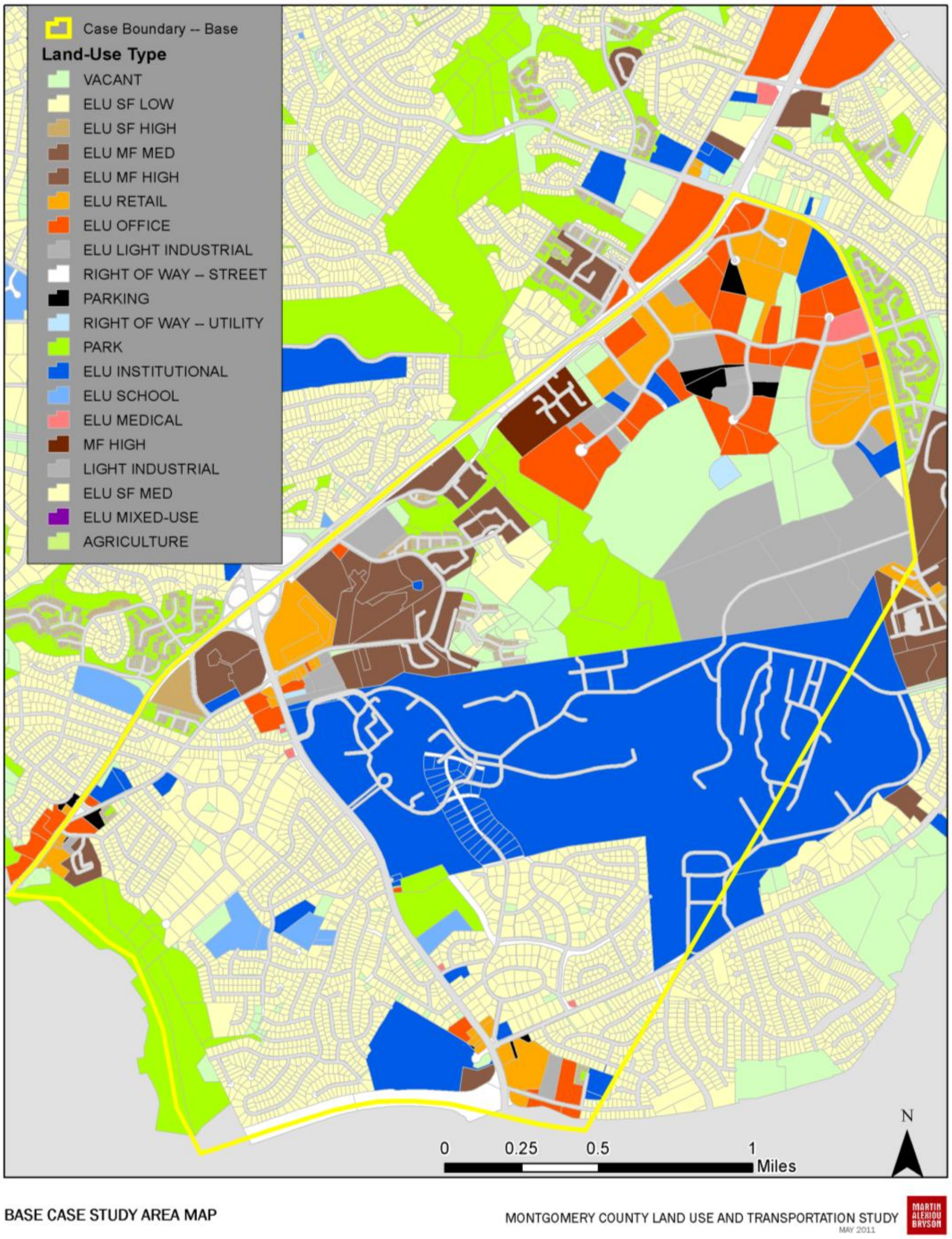


Figure 1.2: Study Area Existing Conditions



This project involved three key stages – 1) a literature review of Transit Oriented-Development research, 2) a sketch level analysis of the transit options that could serve the site in the future, and 3) a land-use scenario testing process. The transit sketch planning phase, which explored various transit options, used a spreadsheet-based tool to produce a series of analyses exploring the relationship between transit mode, alignment, and future development within the study area. This phase provided a reasonable order-of-magnitude analysis of the benefits and costs of a number of transit options for the area. The analysis provides an estimate of the minimum ridership necessary to satisfy basic cost-effectiveness criteria for each transit alignment, net new gross square feet (GSF) that would be required, and an order of magnitude level of impact on the transportation network.

M/A/B tested three land-use scenarios using INDEX software, which is an add-on to ArcGIS and allows for the creation and comparison of different configurations of land-uses and transportation networks. INDEX also allows planners to tie together environmental, transportation, and land-use to objectively compare outcomes in these different areas. This project looked at both theoretical scenarios and more likely development scenarios. Scenario 1 documented existing conditions to provide a baseline for comparison. Scenario 2 is a hypothetical mixed-use build-out scenario which was created to understand the impacts to the area at the upper bound of development possibilities. Scenario 3 added possible development at two sites (Percontee and Site II) to baseline existing conditions.

The work done as part of this project will feed into an update of the Master Plan for the East County Science Center, which has the same study area as this project. The ultimate vision and goals for the area will be further refined during the master planning process, but this analysis provides some initial guidance on the types and intensities of land use required to support different transit options to the area. The future development of the area assumed for this study was based on smart growth techniques and transit-oriented development principles to create a vibrant, walkable, transit rich urban environment.

1.1. Existing Conditions

The Study Area is slightly less than 3,200 acres located in eastern Montgomery County near the border with Prince George's County and the I-95 and I-495 interchange. The Percontee property is about 185 acres, and the Site II parcel is roughly 115 acres. Site II is vacant, and Percontee only has some limited operations ongoing at this time. The large Federal Research Campus (FRC) property is about 660 acres and has secure access requirements due to the sensitive nature of the work being performed on the site and the generally higher security level at federal offices nationwide. Many of the adjacent parcels between US 29 and Cherry Hill Road are occupied by office and retail uses; most of these parcels are zoned for light industrial with an overlay zone. There are also some single-family detached, townhouses, and multi-family housing units in the surrounding area.

The FRC is a large parcel that includes the consolidated headquarters of the Food and Drug Administration (FDA). Currently, this site has roughly 5,500 FDA employees and full build-out of the campus will include nearly 9,000 employees.

The existing transit options are focused on the corridors bordering the site: US 29 and New Hampshire Avenue (MD 650). There is limited service that penetrates the area. Existing transit service is a mix of both Washington Metropolitan Area Transit Authority (WMATA) and Montgomery County RideOn bus services. A total of 16 routes provide service adjacent to or within the study area (RideOn routes 10, 20a, 20b, 21, and 22; and WMATA routes C8, K6, R2, R5, Z2, Z6, Z8, Z9, Z11, Z13, and Z29); eight of these routes only have peak hour service. Service north of the site is limited though there are several commuter express bus routes which travel along US 29, some of which stop at the park and ride lot at Tech Road (adjacent to Old Columbia Pike). Most routes have buses every 30 minutes, though the K6 route offers 10-minute headways in the peak direction along New Hampshire Avenue with 20-minute service in the off-peak period.

Overall, while the specific sites analyzed in this study have moderate to limited transit availability, they are situated in a transit rich region making this area ripe for new transit development.

Studies over the past 20 years have examined transit options in the Study Area's US 29 corridor including the recent MCDOT Countywide Bus Rapid Transit Study which recently released draft findings. The countywide BRT study has also identified New Hampshire Avenue as a candidate for BRT, and a series of near-term improvements have been proposed to the K6 line as part of WMATA's Priority Corridor Network (PCN) project.

Traffic conditions in the peak vary dramatically throughout the area. While some intersections are failing and many are bad, some have a level of service (LOS) of B in the peak period. There are a number of bottlenecks and hotspots in the area which result in recurring congestion. Traffic volumes are generally high, evidenced by the fact that most of the roads in the study area have volume over capacity (VOC) ratios in excess of 0.8 in the peak direction and some are at or above capacity. The impact of new development must be carefully analyzed in order to avoid any degradation of traffic conditions, including regional mobility, and the negative impacts on the surrounding community. Without additional improvements, it is likely that future conditions will exacerbate existing congestion.

2. CASE STUDIES

Transit-oriented development (TOD) is a land-use and transportation strategy to focus and cluster development around transit stations in order to address traffic congestion through increased transit ridership, encourage private investment, and take advantage of the often large public investment in transit facilities. TODs have been successfully implemented in a number of areas around the country including Montgomery County and the greater Washington metropolitan area. This section discusses some of the components and best practices of TOD and successful national examples in addition to the Montgomery County experience. One unique aspect of the study area is the presence of a large federal campus (the FRC). Unfortunately, while the literature is robust on TOD in general, the specific experience of TOD around a federal complex with heightened security requirements is largely absent from the literature. However, this section attempts to discuss previous experiences and outcomes for this type of TOD environment.

2.1. Components of Successful Transit-Oriented Development

A mandatory requirement in the formation of a TOD is the provision of transit. Nationally, most TODs are constructed around rail stations (either light-rail transit (LRT) or heavy-rail transit (HRT)), but can also be based around commuter rail, bus rapid transit (BRT), or high-frequency regular bus service. There are many factors that determine a successful TOD, which are succinctly captured in the five D's of successful transit-oriented development: density, diversity, destinations, distance to transit, and design. Each are described below:

Density

Increased density of development amplifies the benefits associated with a TOD project, including higher transit ridership, higher transit mode choice, and lower per capita auto usage (both trips and vehicle miles). Density brings more people into the area around a transit station which supports retail businesses and fills office buildings and residences with less auto traffic than conventional suburban, car-oriented places. TOD developments often include density bonuses to encourage developers to build at higher densities. It is important to create transit-oriented developments with higher densities to increase the number of people, offices, and retail businesses that are served by the transit station.

Diversity

The diversity of the development increases the number of activities (origins and destinations) that can be conducted in close proximity to the center of the development. Most TODs have a mixture of residential, office, retail and public spaces to encourage more trips to be taken by walking, cycling or transit. Diversity also spreads out users of the services and amenities so that different types of businesses are supported throughout the day and public facilities like the transportation network are not overburdened by heavy peak travel and light usage the rest of the day. It is also critical in creating a mixed use place that has a round-the-clock, lively, walkable environment. Diversity of uses also creates the potential for shared parking because different users access the site at different times of day.

Destinations

Location decisions on the part of public and private sector decision-makers contribute greatly to the success of a TOD. The locational advantages of being in close proximity to customers, clients, vendors and others was a leading factor contributing to the formation of villages, towns and cities throughout history. The accessibility of destinations to the people who live, work, and patronize the TOD is therefore very important. The ability to access destinations (such as homes, restaurants, and shops) within the station area or within a reasonable travel time from the transit station is a key to reducing auto mode share at a station.

Distance

The benefits of TOD decrease as the distance of residences and work locations from the station increases. In a study of TOD in Washington, DC, conducted by the Washington Metropolitan Area Mass Transit Authority (WMATA), "distance between station and site was the only variable among the ones tested that showed a significant correlation with the worker commute and visitor mode choice." The study looked at riders at a site adjacent to the transit station and compared them to riders ½ mile away from a station. The study found that for commuters, the percentage of workers arriving by Metrorail decreased by 0.96% for every 100-foot increase in the distance from the station entrance. Typically, TOD has the greatest effect on the area within the first ¼ mile of the transit station. A second ring of reduced influence usually extends ½ mile from the station.

Design

The final main component of TOD is high-quality design to create a safe and pleasant environment to attract pedestrian activity. One of the goals of TOD is to reduce per capita auto usage which is significantly hampered if the space is not designed in a way that is safe and accommodating to pedestrians. Most TODs seek to have the resident or visitor arrive by transit or car initially, but then travel around the development on foot to accomplish the necessary or desired activities. Building form is an important part of the design equation; including buildings that line the edge of sidewalks with non-opaque windows at pedestrian eye-level, and interesting streetscapes that include appropriate lighting, trash receptacles, benches, and walking surfaces.

In addition to the five D's of TOD, there are often factors beyond the control of a developer, local agency or transit agency that also affect the success of a TOD. These factors include the relative travel time of transit vs. auto, regional context, and the extensiveness of the transit system. Transit Cooperative Research Program (TCRP) Report 128 notes that relative travel time is more important than density, diversity, and design in determining transit use for workers and residents of a TOD.

2.2. Best Practices

Some of the general best practices identified by research that analyzed national examples of TOD are:

- Limit parking, and avoid too much free or low-cost parking
- Make transit service fast, frequent, and comfortable, with headways of 15 minutes or less
- Design a pedestrian-friendly environment
- Employ traffic calming measures
- Provide a mixture of land uses

- Create compact development within the first ½ mile of the transit station and particularly within the first ¼ mile
- Flexible, but predictable, development controls

2.3. Transit-Oriented Development in Montgomery County, MD

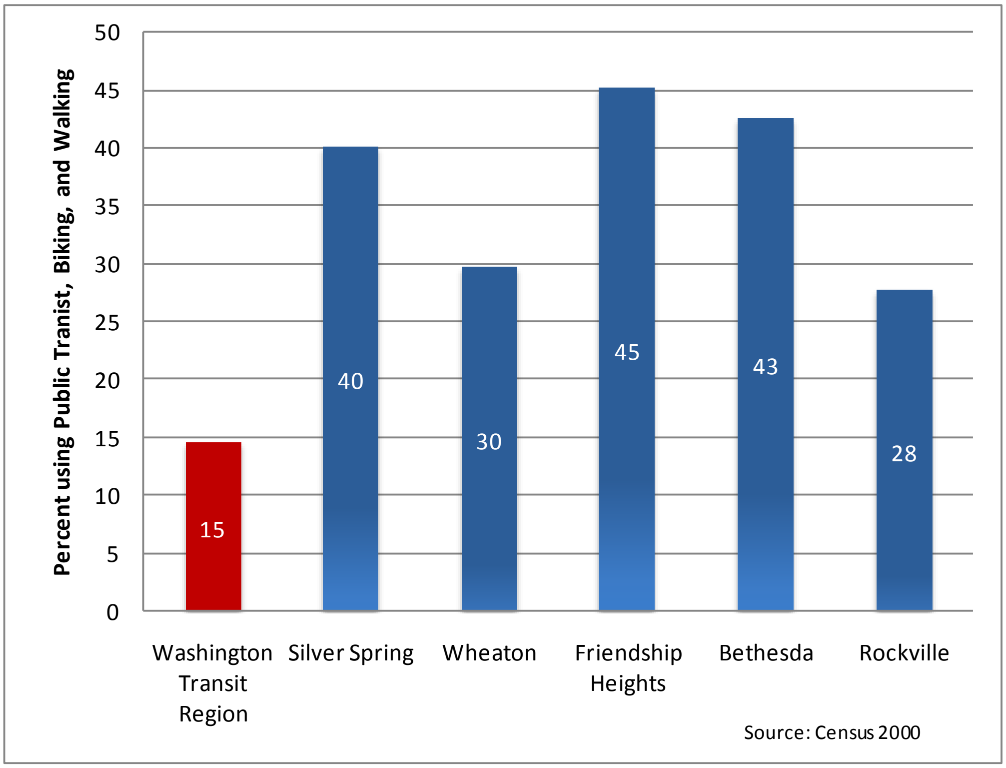
Montgomery County, MD, was an early adopter of TOD and has many of the best examples of successful TODs in the country including Bethesda, Silver Spring, and Friendship Heights. Montgomery County has a variety of zoning codes (such as the CBD zone) and land-use control regulations designed to foster successful transit-oriented development. Although the particulars of different zoning classifications varies, the density requirements are generally in line with guidance from organizations like Leadership in Energy and Environmental Design (LEED)

In Montgomery County, residents of TODs have very different mode choice, transportation cost, and car ownership rates than residents of the wider Washington, DC, metropolitan area. Using the Transit-Oriented Development Database provided by the Center for Transit-Oriented Development, it is possible to examine areas within ½ mile of a transit stop and compare these populations with the wider region (utilizing Census 2000 Journey to Work data). Table 2.3 compares some of Montgomery County's main TOD developments to the greater Washington area (using the U.S. Census Bureau's definition of the Metropolitan Statistical Area for Washington, DC). TOD residents use transit, walk, and bike much more than average residents of the region. TOD residents also own fewer cars and spend less on transportation as a percent of income. Figure 2.1 shows the percent of workers 16 and over who use public transportation, walk, or bike to work.

Table 2.1: TOD Development Characteristics (First ½-Mile from Station)

	Population Density (Pop/Acre)	Typical Transportation Costs (% of Income)	% Workers Who Use Public Transportation	% Workers Who Use Public Transportation, Bike, or Walk	Vehicles Per Household	Percent of Households with 0 or 1 Car
Washington Transit Region	1.2	17.5	11.2	14.5	1.7	45.0
Silver Spring	22.9	13.9	35.0	40.2	1.0	78.7
Wheaton	10.6	16.2	26.5	29.7	1.4	57.2
Friendship Heights	17.6	14.2	39.1	45.1	1.2	71.6
Bethesda	13.2	14.4	28.6	42.6	1.1	75.5
Rockville	7.6	15.9	23.5	27.7	1.3	62.4

Figure 2.1: Percent of Workers Who Use Public Transportation, Walk, or Bike to Work



2.4. *General Transit-Oriented Development Case Studies*

Arlington County, VA (WMATA)

The WMATA stations in Arlington, VA, are other examples of successful TODs. Like Montgomery County, officials in Arlington County planned for regional rail early and instituted policies to create successful developments. Planners decided to bring the rail line into the heart of existing activity centers and multi-family housing areas as a subway rather than push the line north into freeway right-of-way. The County also established policies to create mixed-use developments with a tax base that was 50/50 residential and commercial as well as seeking to concentrate the majority of development in the first ¼ mile around station areas. The policies have proven to be very successful. Between 1969 and 2000, the County increased its commercial space from 4.5 million square feet to 18.4 million square feet and high-density residential units from 2,600 to 14,300. Most of this increased development has occurred around the County's 11 Metro stations, in particular the Rosslyn, Ballston, and Court House station areas. Transit ridership also increased in Arlington, up 28.5% for the Rosslyn, Ballston, and Courthouse stations between 1990 and 2006. In 2000, 67% of all jobs in the County were within walking distance of a Metro station.

San Francisco, CA (BART)

Ridership impacts have been extensively studied in the San Francisco Bay Area and results show that shoppers, workers, and residents all are more likely to use transit when living close to transit. Residents living within one mile of the 129 rail stations in the Bay area took transit for 12.6% of commuting trips in 2000 as compared to 9.7% for the whole region. A separate study based on travel diary data showed TOD residents to be five times more likely to take transit to work than non-TOD residents. Another finding of Bay Area ridership studies is that having a work destination that is accessible by rail (BART in this case) increased the likelihood of taking transit by 35% to 60% among residents of suburban TOD developments.

Portland, OR (TriMet)

Portland has fairly extensive growth policies aimed at encouraging transit use. The city has an urban growth boundary and implemented parking supply management policies in the CBD. The Metro Region's 2040 Plan of 1995 aims to have 2/3 of new employment development and 1/3 of new residential development occur in transit station areas and corridors. The value of new development occurring in the LRT corridor was tallied to be $1.31 billion in 1996 after only ten years of LRT operation. The Transit Cooperative Research Program (TCRP) noted "Portland appears to have replaced Toronto, Canada, as a regional model for transit-focused development" in its *Synthesis 20* Report published in 1997. Portland has seen rates of transit use and non-motorized transportation increase in TOD areas.

2.5. Transit-Oriented Development and Federal Campuses

Planning for TOD around a secure, federal campus has added challenges not present in a typical TODs. There are few examples of TOD being built around secure federal office buildings, particularly in the suburban context. Washington, DC, has a number of federal offices that could be considered TOD based on distance to the station, but are not generally considered to be TOD because the transit was added to existing development (for example, the U.S. House of Representatives office buildings are located within a ½ mile of the Capitol South Metrorail Station, but not considered generally TOD). Many of the best examples are either not fully developed at this point or only in the planning stages. Finally, older examples may not be as pertinent as the newer examples discussed below as the security environment has changed so dramatically over the last decade for federal facilities.

Federal Center in Lakewood, CO

This development is in suburban Denver, about a 15-minute drive from downtown Denver, and currently being developed. The station is on the Regional Transportation District (RTD) West light-rail line. Figure 2.2 shows the West line alignment (the edge of downtown Denver is on the eastern side of the map). The site is a 640-acre site with approximately 4.1 million square feet of office space in 50 active buildings which is used by 26 federal agencies to house approximately 6,000 workers. Current plans are for a light-rail station to be built on the western part of the site near where a hospital will also be relocated. The area around the station will be redeveloped using TOD principles to create a vibrant community that also supports federal offices. The development will be focused around a main federal quad. The development includes a mixture of uses, community facilities, and graduated densities focused on the RTD light-rail station.

Figure 2.2: RTD West Line Alignment

An important consideration in this process has been to maintain the security of federal facilities. As shown in the site plan (Figure 2.3), one solution has been to group the office buildings by security classification and separate them by their security needs. The agencies and offices that only need building level security will be generally accessible by pedestrians in an open arrangement around the federal quad. Uses with heightened security needs are grouped together in the southwestern corner of the development and will have additional security enhancements to ensure safety, including the possibility of perimeter fencing. These buildings are still within walking distance of the planned RTD station, however. Another security feature is to have the station located at the western part of the development with no transit line through the heart of the Federal Center property.

Figure 2.3: Federal Center Site Plan

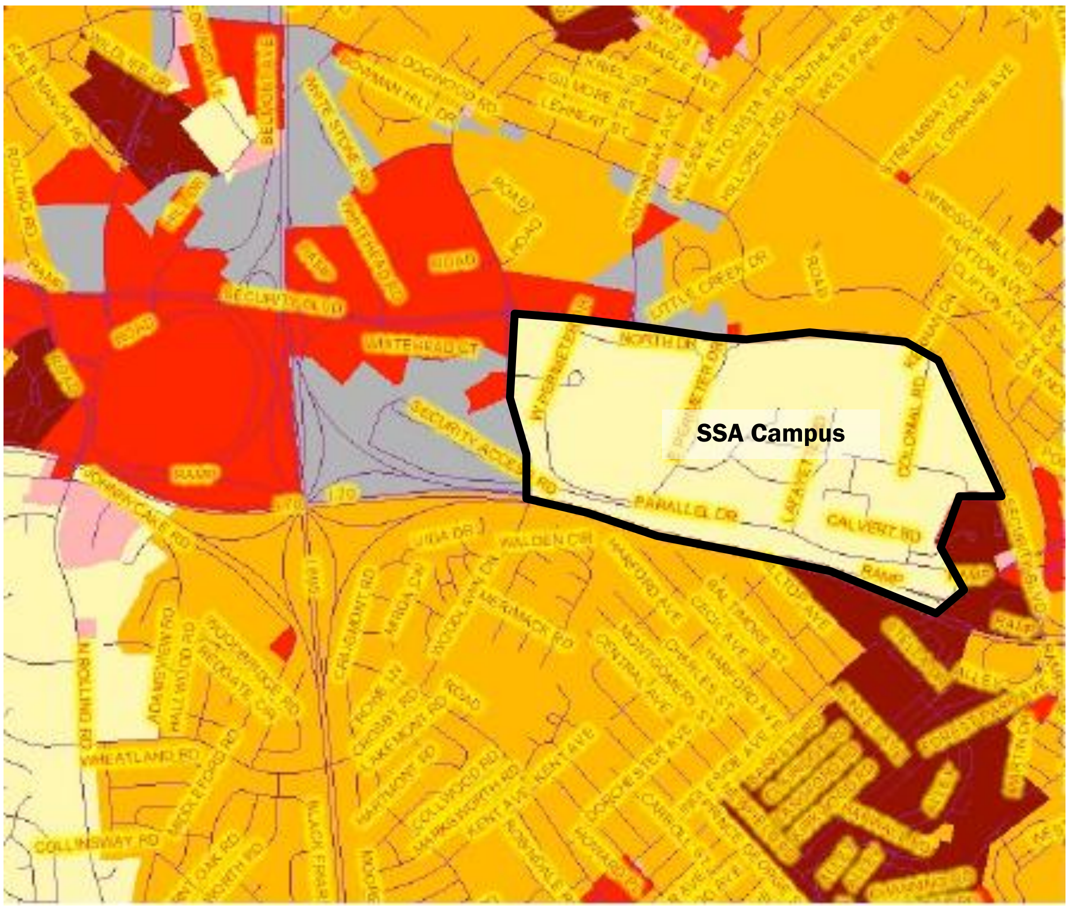
The development has a mixed use and office core immediately adjacent to the RTD station on the western edge of the site. The federal buildings are located more centrally in the site (including the secure federal campus for research and development in the southwest corner). The development seeks to balance security concerns with transportation accessibility, community engagement, and quality of life.

The TOD is also being coordinated across jurisdictional boundaries between the General Services Administration (GSA) at the federal level and the City of Lakewood at the local level. Both entities have plans for TOD near the station. The City of Lakewood created Transit Mixed-Use (TMU) zones to facilitate the development of TOD areas around the planned RTD light-rail stations. These zones are designed to create an environment for high density, efficient and attractive transit and pedestrian-oriented development around transit stations with higher rates of transit, walking, and bicycling mode choice while also providing flexibility in building design and use mixture.

Social Security in Baltimore, MD

The Social Security Administration (SSA) has a couple of TOD projects on the horizon. The first is the Red Line of the Baltimore Light-Rail, which would extend from the medical campuses of Johns Hopkins in downtown to the 140-acre SSA campus in Woodlawn, just outside of Baltimore. The current nature of Woodlawn is suburban, and despite bus service, the SSA campus is primarily accessed by auto. The campus houses approximately 10,000 workers. The Baltimore Red Line extension would provide light rail transit connections between Woodlawn and downtown Baltimore.

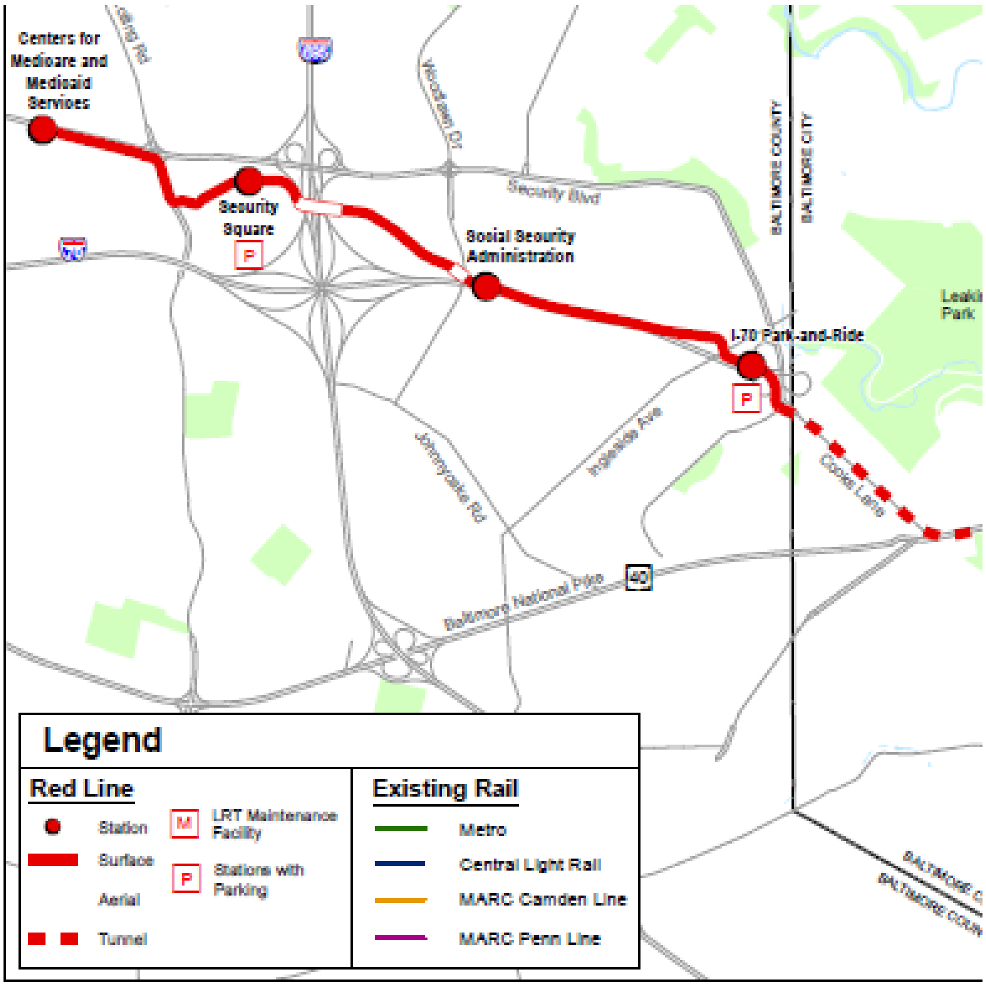
Figure 2.4: Baltimore County General Land-Use Zones



The zoning for the area around the SSA campus is shown in Figure 2.4. The Social Security Headquarters is zoned R-3.5 (light yellow area in the center of the map), which is a moderate density zoning; however, the federal government is exempt from zoning requirements meaning they are free to design their campus as they choose. Areas adjacent to the campus have higher density major business centers (red), and high density residential (orange areas and dark red-brown in southeastern corner). There is also light industrial zoning (gray). These higher density areas correspond to areas under Baltimore County jurisdiction near the SSA campus and potential light-rail stations.

A final alignment of the Red Line around the SSA campus has recently been selected, but station area planning and engineering has not been completed. At least one of the initial proposed alignments went into the heart of the campus, potentially through a tunnel, but the final alignment skirts the campus with a station right on the edge (see Figure 2.5). This alignment uses the I-70 right-of-way to get close to the campus but not enter the campus. The Social Security Administration did not want the light-rail line to come onto their campus. The Red Line project is scheduled to have engineering work done in 2011 and construction begin in 2013.

Figure 2.5: Red Line Route Alternatives Near Social Security Administration

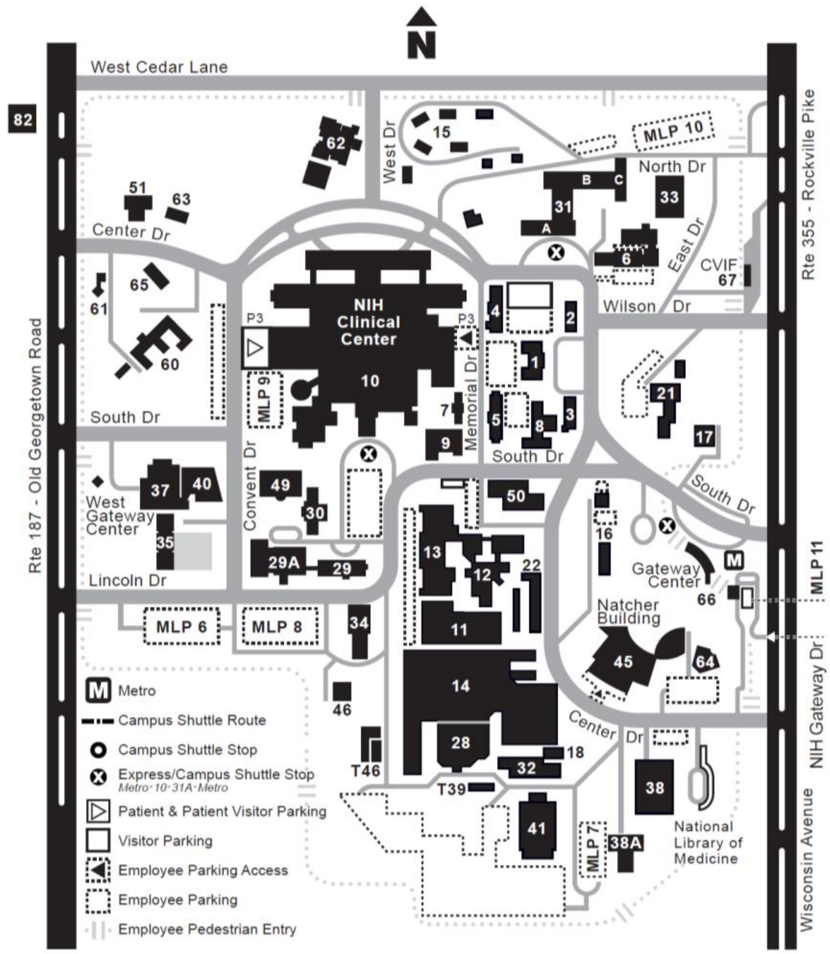


National Institutes of Health in Bethesda, MD

The National Institutes of Health (NIH) has a secure, 320-acre campus in Bethesda, MD, which has transit access through the WMATA Metrorail system. There is a stop (Medical Center) on the edge of the NIH campus. The campus is not a traditional TOD in some ways because it is a single-use site with no retail or residential. All buildings on the site are for NIH offices.

Those needing access to the site can walk from the Metrorail station into the NIH campus via the Gateway Center (the only access point for visitors) where security personnel can perform an individual security screening. After passing the security check, individuals may enter the campus and board a shuttle bus that provides internal circulation on the site to access buildings. Most buildings can then be accessed without any additional security screening. However, there are some buildings which require additional security measures which are performed at the building level. The campus is a unit to itself with controlled access and internal circulation shuttles and paths. Figure 2.6 shows the campus with the Metrorail station and Gateway Center (eastern side) and the secure perimeter with additional employee pedestrian access points (in addition to the main entrance).

Figure 2.6: National Institutes of Health Campus Map



Secure Shuttle Buses

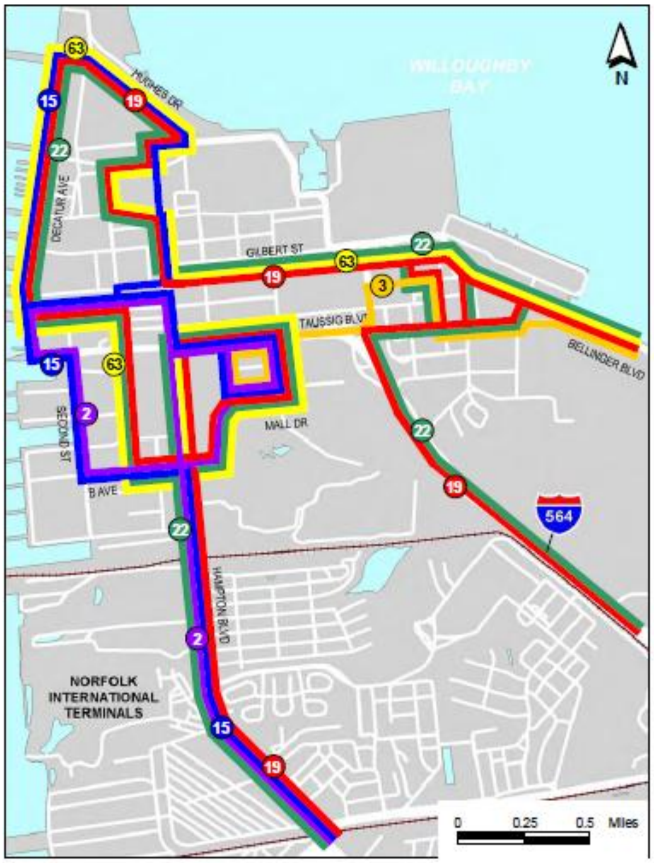
Some federal agencies offer secure shuttle buses into secure areas as a way to provide transit service in hard to serve areas. These shuttle buses can connect to existing transit service but provide door-to-door access because of their secure nature where other transit providers may only be able to offer door-to-security perimeter service. The Washington, DC, region offers several examples of this sort of arrangement.

The Department of Defense (DoD) offers shuttles from the Pentagon to other DoD locations. These shuttles are secure and require showing one of several acceptable forms of identification in order to access the shuttle. Similarly, the Department of State (DoS) has shuttle service between their main office and other locations which also requires users to show one of several types of identification to access the shuttle. Both DoD and DoS state that their shuttles may be used only for official business. The Department of State explicitly states that the shuttle bus may not be used for any portion of an individual's trip between home and office.

Norfolk Naval Station

Finally, Norfolk Naval Station receives daily bus service from Hampton Roads Transit. There are a number of bus routes which go directly onto the Norfolk Naval Station base (see Figure 2.7). The buses provide access to areas inside the base's gates where vehicles must pass a security inspection. However, these areas are still publicly accessible, once clearing the security procedure. The base also provides a circulator shuttle around the base area.

Figure 2.7: Norfolk Naval Air Station Bus Service



In all of the examples of transit on secure facilities, the common theme is that the transit vehicles stop outside of the security perimeter of the campus (with the exception of Norfolk which is still a publicly accessible area). The stop outside of the necessary security perimeter could still be within walking distance of the buildings but it provides an opportunity for security personnel to perform a security check. The other option seems to be to have secure transit vehicles (which would likely be shuttle buses) that could enter a secure campus to provide door-to-door service.

2.6. Conclusion

Transit-Oriented Development offers many benefits to a region including lower auto usage, increased transit and non-motorized transportation travel, less congestion, and the creation of thriving activity centers. To create a successful TOD it is important to allow higher density development, design the development in a pedestrian friendly way, cluster development around the transit station, connect a variety of destinations, and provide a diverse set of uses at the station. Successful TODs around the country show the potential of TODs to affect travel patterns while also spurring development. According to the Transit Research Cooperative Program Report 128 on TOD Travel Characteristics, residents of TODs use transit for work and non-work trips two to five times more than non-residents in the area. These case studies also show the importance of proactive leadership and policies which can enable TOD.

The literature is much less robust when looking at the specific challenges of accommodating a secure campus in a TOD. The relevant examples point to the importance of assessing the security needs of various users of the site and grouping them by security classification. Those uses that need little to no security can be clustered around the station while those sites which need higher levels of security including a secure perimeter can be located a little ways away from the station but connected with walking paths. The examples studied also had stations on the periphery of the campus and tracks which skirted the development. Secure access could be provided by special shuttle buses that would be security-controlled at the point of entry onto the shuttles. Otherwise, transit is typically provided only to the point of the security perimeter whereupon visitors and employees must pass a security screening before being permitted entrance to the secure portion of the site. In many cases, the secure campus is outside the jurisdiction of the local planning agency. In these cases TOD is often clustered adjacent to the campus property with pedestrian access into the secure campus.

These conclusions are reflected in subsequent input from the GSA. While the GSA is very supportive of transit service to the site, a transit line crossing the site is fraught with complications, primarily based on security concerns. Also of concern would be any infrastructure that potentially hampers future uses of the site. Though less desirable, transit in a completely sealed tunnel traveling beneath the site at sufficient depth would likely be acceptable. Therefore, the study did not look at any alternatives that would cross the FDA site in order to better align the study with the national findings on TOD near federal campuses.

3. TRANSIT SKETCH PLANNING

The first phase of the analysis was a transit sketch planning exercise. The goal of the exercise was to produce a series of analyses exploring the relationship between transit mode, alignment, and the level of development needed to support each type of transit, and to provide a reasonable order-of-magnitude analysis of the benefits and costs of a number of transit options for the area.

The spreadsheet-based tool is modular and allows for easy addition and modification of alternatives. The key output of the analysis is a broad determination of the minimum ridership necessary to satisfy basic cost-effectiveness criteria for each identified transit alignment. The analysis provides an estimate of the net new GSF that would be required as well as an order of magnitude level of impact on the road network.

3.1. Potential Transit Alignments

The first step in the exercise was to develop potential transit alignments, for each of the three modes that could serve the study area: heavy rail (Metrorail); light rail (LRT); and bus rapid transit (BRT). Based on the literature review of transit interactions with federal campuses, and comments from the GSA, alignments were assumed to avoid the FRC campus site (though could travel adjacent or beneath it). M/A/B and the Planning Department staff developed the initial alignments, which were refined and augmented based on feedback from the working group. The figures below show the final sixteen routes analyzed as part of this effort.

Figure 3.1: Metrorail Extension Alignments Analyzed

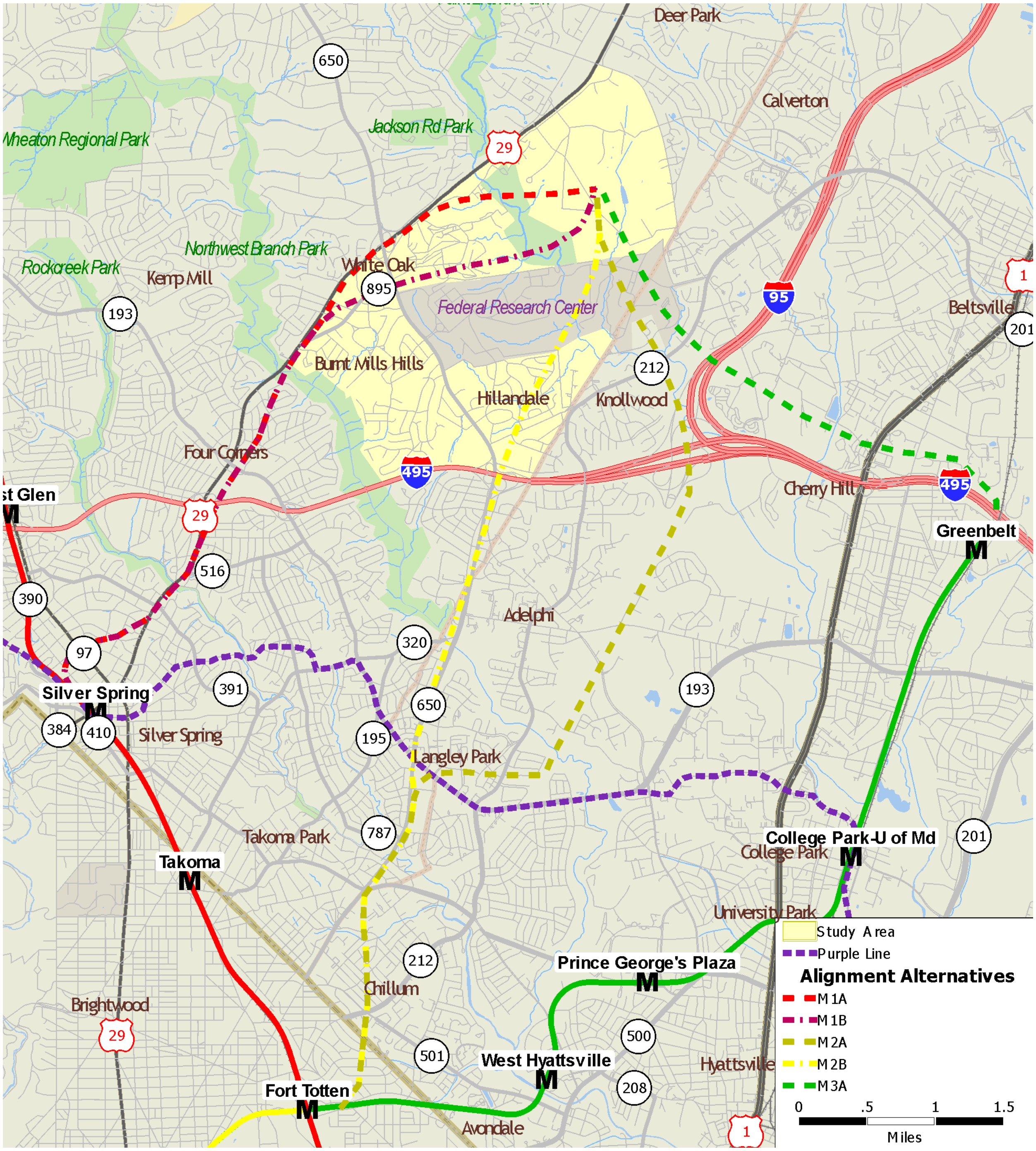
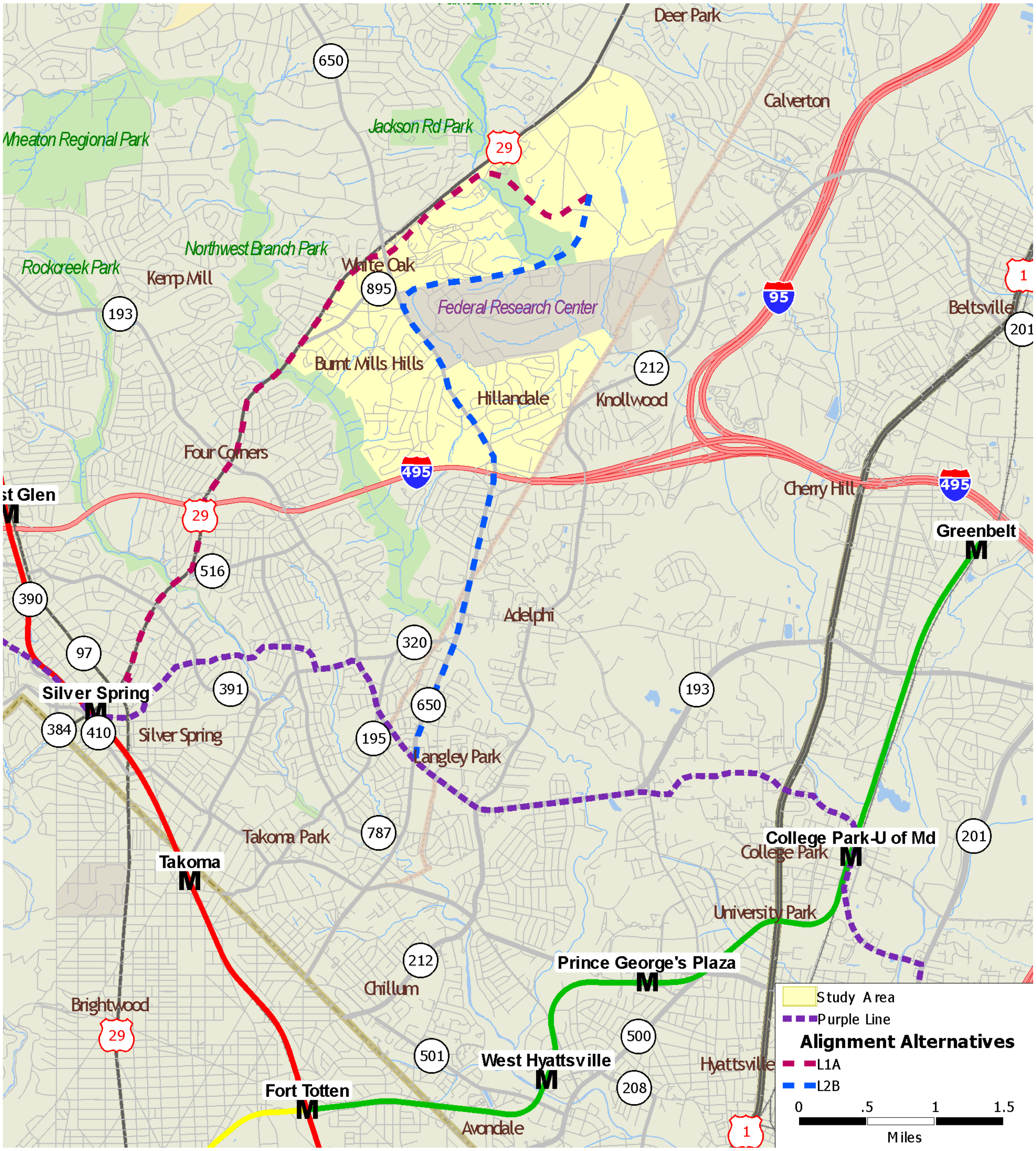
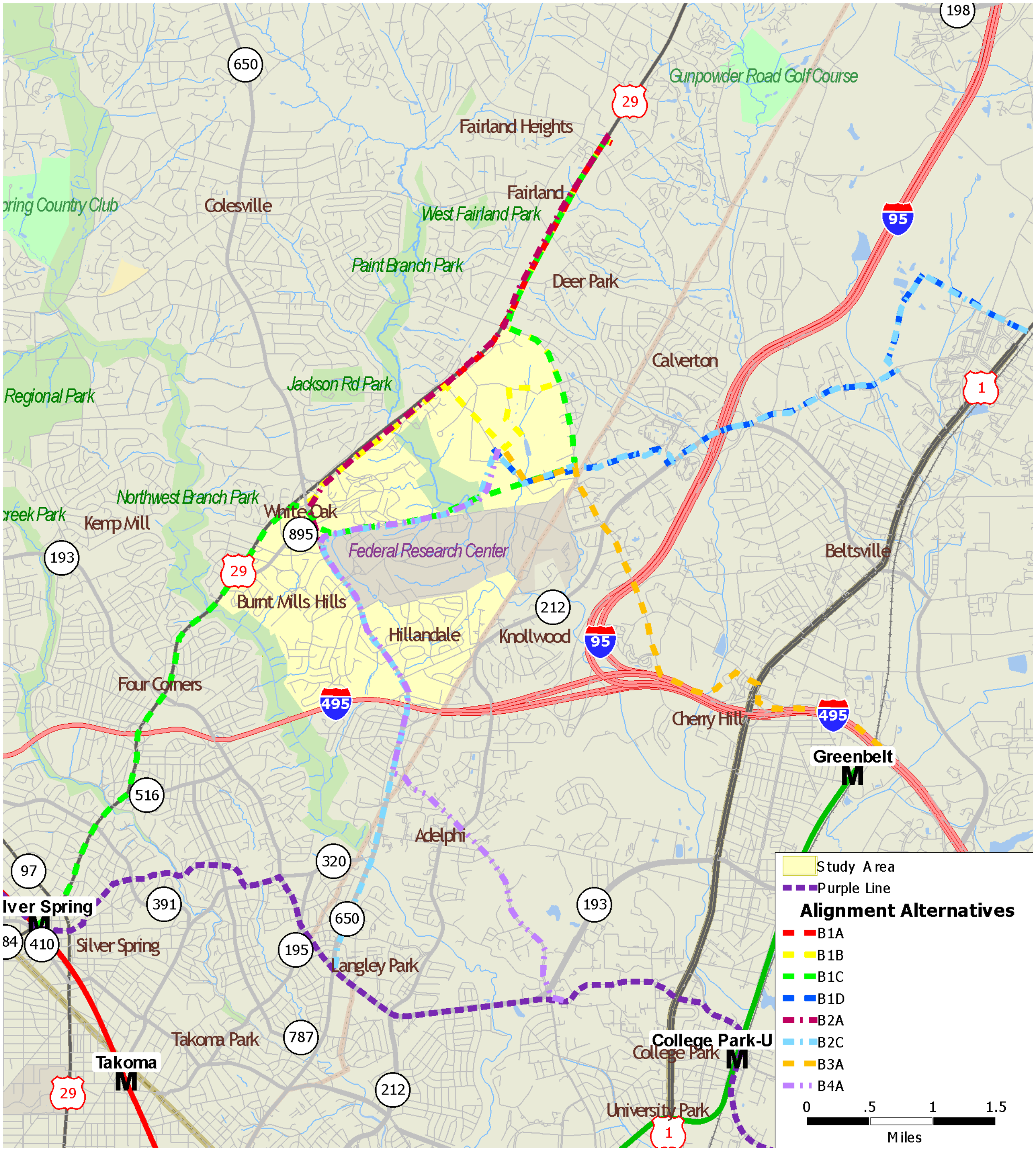


Figure 3.2: LRT Alignments Analyzed



![MARTIN ALEXIOU BRYSON]

Figure 3.3: BRT Alignments Analyzed



3.2. Sketch Planning Methodology

While the sketch planning tool has a large number of inputs and outputs (and intermediate steps), the basic approach can be distilled to a few steps.

1. Identify Transit Costs

The consultants mapped each potential alignment and made an approximate determination of vertical alignment: surface, aerial, shallow tunnel/cut and cover, and deep tunnel (bored). Based on a survey from active transit projects across the country an approximate per-mile cost was developed for each segment type for each mode. The values used are shown in the table below:

Table 3.1: Summary of Unit Construction Costs

Unit Costs ($M/mi)			
	Guideway Type		
	Surface	Aerial/C&C	Tunnel
Metrorail	200	500	800
LRT	100	250	500
BRT	40	100	350

2. Identify New Rider Target

A key measure for Federal Transit Administration (FTA) New Starts projects is the project cost-effectiveness, a key metric of which is the capital cost per hour user benefit (CCPHUB). This is difficult to calculate at a sketch level as it includes benefits for a range of users and trips. There is evidence, though, that the capital cost per weekday passenger (CCPWP) tends to be positively correlated with the CCPHUB. Based on analysis of current and proposed projects, threshold values of CCPWP were identified with the intention that as long as the future projects were similar in overall cost-effectiveness to representative projects, the CCPHUB would hopefully be similar in subsequent analysis. Simple division of the total capital cost and the CCPWP yields the estimate of total needed average weekday ridership (boardings). As part of this step, the number of park and ride spaces along the station was estimated, with each space assumed to generate two trips per day (one boarding and one alighting).

3. Identify Total Development

In order to estimate the total amount of development needed to generate the minimum ridership (minimum from the point of transit cost-effectiveness), we have to identify the relationship between jobs and developed floor space. This is a three-step process. First, we collected regional averages for the number of employees per square foot, by employment category, as well as the average dwelling unit size. For each mode, the transit (line) specific mode share was estimated. These two items, coupled with a daily trip expansion factor generated average transit trip generation per square foot of development.

Next, based on these rates, we estimated the number of trips generated by existing and forecast development within the corridor (based on the County's Round 8 2040 forecasts for Transportation Analysis Zones (TAZs) adjacent to the transit lines). The employment and dwelling unit forecasts were converted to GSF of development, which was then used to estimate transit ridership from the forecast development. After subtracting off ridership from the forecast development, the balance was treated as new ridership needed within the study area needed to support the transit line. Using the above-discussed rates, this ridership was converted back into GSF to estimate the total amount of additional development needed to satisfy the cost-effectiveness criteria.

4. Identify Peak Hour Traffic Volumes

The total GSF needed to support each alternative was converted to GSF by development type and number of dwelling units. Using the County trip generation rates – adjusted for predicted mode split – the peak hour traffic was estimated from the study area. This was then reduced to account for internal capture and displacement of travel using a relationship identified as part of the Great Seneca Science Corridor Master Plan work. The ratio of non-auto-drive mode to transit was assumed to be 3:1

5. Identify Cordon Line Constraints

Using LOS D capacities, M/A/B estimated volumes at the study area boundary. Existing volumes were grown based on 2040 model runs using the Round 8 2040 COG forecast data. Trip distribution was based on the County's LATR/PAMR guidelines. Park and ride trips were removed from the background traffic volumes. Based on the predicted demand, the lanes needed to bring the segment volume to capacity (v/c) ratio below 1.0 were estimated for each direction. The cost of widening varied linearly with capacity of the roadway to reflect that widening to a wider facility would be more expensive as: a) right-of-way and construction costs would likely be higher; and b) the length of the widening would be greater.

A sample sheet detailing these calculations is shown in Figure 3.1.

Figure 3.4: Sample Detail Sheet from Model

East County Science Center
MWCOG TLC Project

Transit Feasibility and Reserve Capacity Analysis
First-Level Screening

DRAFT Analysis Template - Hypothetical Information - for agency discussion

Mode:	BRT	**Scenario:**	1A	Silver Spring / Tech Rd / Briggs Chaney

1. Identify Transit Costs
(From capital/O&M assumption summary sheet)

Capital Cost	8 miles @	$44 $M / mi	$350 $M

2. Identify New Rider Target
(From cost effectiveness assumption summary sheet)

Target CCPWP	$100
Targeted daily boardings	13,889
Park and Ride	1,000
Daily boardings generated by corridor + site	**12,889**

3. Identify Total Development
(From site development summary sheet)

	Office	Retail	Industrial	Other	Residential	TOTAL
Commuters / KGSF	4.00	2.50	2.22	2.00	1.60	
Assumed commute mode share (line specific)	5%	2%	2%	2%	15%	
Assumed expansion factor - JTW to daily	2.5	2.5	2.5	2.5	2.5	
Daily Passengers / KGSF	0.50	0.13	0.11	0.10	0.60	
Existing (2040) Corridor Development	4,094	6,313	1,271	773	8,172	20,623
Ridership from corridor						7,988
Ridership from site						4,901
Assumed FAR breakdown for Site	10%	7%	11%	22%	50%	
GSF needed to meet ridership goal (Million)						**12.515**

4. Identify Peak Hour Traffic Volumes
(From INDEX trip generation summary sheet)

	Office	Retail	Industrial	Other	Residential	TOTAL
GSF (Million)	1.203	0.842	1.404	2.808	6.257	12.514
Commercial GSF (Million)	1.203	0.842	1.404	2.808		6.257
DU					6,260	6,260
Internal Capture	24%	24%	24%	24%	24%	
Latent Demand / Redistribution Percentage	0%	0%	0%	0%	0%	
Assumed Auto Driver Mode Split	85%	94%	94%	94%	100%	
Net PM Peak Hour Inbound	175	956	131	367	2,032	**3,660**
Net PM Peak Hour Outbound	854	883	958	1,790	1,094	**5,579**

5. Identify Cordon Line Constraints
(From cordon line summary sheet)

	Base Volume		P&R Volume		Site Volume		Total Volume		Capacity		VOC		Capacity Needed		Additional Lanes		
Cordon Analysis	PM In	PM Out	PM In	PM Out	PM In	PM Out	PM In	PM Out	PM In	PM Out	PM In	PM Out	PM In	PM Out	PM In	PM Out	Cost ($M)
101 Old Columbia Pike N of Fairland	440	804	-5		37	56	472	860	850	850	0.55	1.01	0	0	0	0	$0
102 US 29 N of Fairland	2,899	4,155	-80		586	893	3,404	5,048	3,825	3,825	0.89	1.32	0	1,200	0	1	$383
103 Briggs Chaney Road N of Fairland	644	828	-5		37	56	675	884	850	850	0.79	1.04	0	0	0	0	$0
104 Old Gunpowder Rd N of Briggs Chai	435	980	-5		37	56	466	1,036	1,700	1,700	0.27	0.61	0	0	0	0	$0
105 Old Gunpowder Rd S of Briggs Char	493	635	-5		37	56	525	691	1,700	1,700	0.31	0.41	0	0	0	0	$0
106 Powder Mill Road W of I-95	1,023	1,183	-40		293	446	1,276	1,629	2,550	2,550	0.50	0.64	0	0	0	0	$0
107 Cherry Hill Road S of Powder Mill	1,684	1,944	-20		146	223	1,810	2,167	2,550	2,550	0.71	0.85	0	0	0	0	$0
108 Riggs Road S of Powder Mill	1,148	712	-15		110	167	1,243	879	850	850	1.46	1.03	400	0	1	0	$85
109 New Hampshire Avenue S of Elton	3,188	3,157	-40		293	446	3,441	3,603	3,825	3,825	0.90	0.94	0	0	0	0	$0
110 University Blvd E of Williamsburg	2,606	2,313	-5		37	56	2,638	2,369	3,825	3,825	0.69	0.62	0	0	0	0	$0
111 US 29 S of University	4,103	2,079	-157.5		1,153	1,757	5,098	3,836	5,100	5,100	1.00	0.75	0	0	0	0	$0
112 University Blvd W of US 29	1,880	1,848	-10		73	112	1,943	1,960	3,825	3,825	0.51	0.51	0	0	0	0	$0
113 Southwood Road W of US 29	167	279	-5		37	56	199	335	425	425	0.47	0.79	0	0	0	0	$0
114 New Hampshire Avenue N of Jacks	1,379	2,793	-25		183	279	1,537	3,072	3,825	3,825	0.40	0.80	0	0	0	0	$0
115 East Randolph Road E of Tamarack	1,566	1,066	-35		256	391	1,787	1,457	2,550	2,550	0.70	0.57	0	0	0	0	$0
116 Fairland Road E of Tamarack	783	622	-15		110	167	878	789	850	850	1.03	0.93	0	0	0	0	$0
TOTAL	24,436	25,399	-468	0	3,422	5,216	27,391	30,615	39,100	39,100	0.70	0.78	400	1,200	1	1	**$468**

3.3. *Results of the Exercise*

M/A/B presented the results of the model runs and analyses to the interagency working group. These results are presented in the tables below. Table 3.2 summarizes the results while Table 3.3 summarizes the key inputs and assumptions used to generate the results.

The results in the table merit some explanation. First, as discussed above, this was a sketch planning exercise: a more detailed analysis would examine the inputs and assumptions for each alternative more carefully and might result in some modifications of such. Second, as the primary output of the exercise was the amount of development needed to support a particular alignment, no constraint was placed on this output. In particular, some alignments indicate a need for a negative amount of growth. This simply indicates that the model estimates that the housing and jobs in the Round 8 2040 forecasts exceeds the amount needed to meet the cost effectiveness criteria. This, in turn, results in a prediction of "negative trips" for these alternatives, a mathematical abstraction which can be ignored as, in reality, the trips will not decrease below the level forecast from the land use forecasts. Similarly, the cost of highway improvements for these alternatives should be viewed with caution as the cost of improvements would not decrease below the background level.

Lastly, it is important to remember that the costs of roadway improvements reported should in no way be construed as detailed cost estimates. They are valid only for order of magnitude comparisons of the alternatives to one another and for having a general understanding of the general range of roadway costs that might be incurred as a result of the selected alternative.

While this exercise was largely exploratory in nature, there are some key takeaways:

- Fully-tunneled Metrorail is generally cost-prohibitive.
- Metrorail – tunnel, cut-and-cover, or above ground – is not feasible without substantial growth along the entirety of the corridors examined. Given existing forecast development, ridership requirements at a Site II/Percontee/Cherry Hill station could range from 32,000 to 85,000 boardings a day compared with the roughly 35,000 boardings at day at Union Station, the busiest Metro station today. Even if the development were spread out along a corridor, the required development is enormous – potentially exceeding 100 million GSF of additional development – and generally out of character for the study area and its environs.
- Without very high mode splits, the level of development necessary to support the Metrorail alternatives studied would stress the road network to a degree that the cost of the roadway improvements would be prohibitive (and the improvements themselves generally impractical).
- Both BRT and LRT are promising in that ridership goals seem achievable and additional development is in line with a potential higher-density vision that would typically accompany such an investment in transit. BRT offers similar service quality as LRT with lower cost; it can also be constructed more quickly and has a smaller impact on adjacent properties.[1]
- Given current land use forecasts (which reflect current zoning) alignments serving New Hampshire Ave (between Takoma-Langley and the study area) are more likely to achieve ridership goals than those serving US 29 to Silver Spring.
- An extension to Konterra and Muirkirk is likely more cost-effective (as it will capture more ridership) than to Briggs-Chaney

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[1] Although generally outside the scope of this study, there are other issues which may affect mode, such as constructability, availability of a suitable maintenance facility, financing and the availability of funding. In most cases, BRT rates higher than LRT in these criteria.

Table 3.2: Summary of Sketch Planning Analysis

Option	Description	Mode	Guideway/ROW Surface	Aerial/C&C	Tunnel	Total	Total Cost ($M)	Ridership Needed	S/E Corridor	Site MGSF Needed	PM Vehicle Trips In	Out	Cost of Hwy Impr ($M)
M1A	Silver Spring / Site 2 / P&R	Metrorail			5.8	5.8	$ 4,640	**69,651**	Silver Spring - US 29	**118.9**	**19,981**	**29,089**	**$9,988**
M1B	Silver Spring / FDA West / Site 2 / P&R	Metrorail			5.8	5.8	$ 4,640	**69,651**	Silver Spring - US 29	**118.9**	**19,981**	**29,089**	**$9,988**
M2A	Fort Totten / TLC / FDA Circle / Site 2 / P&R	Metrorail	1.5		6.6	8.1	$ 5,580	**84,571**	Fort Totten - MD 650	**143.3**	**21,601**	**31,447**	**$11,475**
M2B	Fort Totten / TLC / FDA Circle / Site 2 / P&R	Metrorail		1.8	5.3	7.1	$ 5,140	**77,587**	Fort Totten - MD 650	**129.4**	**20,784**	**30,257**	**$10,965**
M3A	Greenbelt / Site 2 / FDA North	Metrorail	0.5	2	1.5	4	$ 2,300	**32,508**	Greenbelt - Cherry Hill	**34.7**	**7,911**	**11,517**	**$2,678**
L1A	Silver Spring / Site 2 / P&R	LRT	5.2	0.7		5.9	$ 695	**13,960**	Silver Spring - US 29	**12.0**	**3,456**	**5,120**	**$468**
L2B	TLC / FDA Circle / Site 2 / P&R	LRT	4.9	0.5		5.4	$ 615	**12,146**	Fort Totten - MD 650	**2.4**	**844**	**1,253**	**$468**
B1A	Silver Spring / Tech Rd / Briggs Chaney	BRT	7.5	0.5		8	$ 350	**12,889**	Silver Spring - US 29 - B	**12.5**	**3,660**	**5,579**	**$468**
B1B	Silver Spring / Site 2 / Briggs Chaney	BRT	9.2	0.5		9.7	$ 418	**15,587**	Silver Spring - US 29 - B	**19.4**	**4,854**	**7,400**	**$1,615**
B1C	Silver Spring / FDA West / Site 2 / Briggs Chaney	BRT	8.7	0.8		9.5	$ 428	**15,984**	Silver Spring - US 29 - B	**20.4**	**5,093**	**7,763**	**$1,615**
B1D	Silver Spring / FDA West / Site 2 / Konterra / Muirkirk	BRT	10.5	0.8		11.3	$ 500	**18,341**	Silver Spring - US 29 - K	**18.1**	**4,545**	**6,927**	**$1,445**
B2A	TLC / FDA Circle / Tech Rd / Briggs Chaney	BRT	7.8			7.8	$ 312	**11,381**	Fort Totten - MD 650 - E	**1.7**	**628**	**956**	**$468**
B2B	TLC / FDA Circle / Site 2 / P&R	BRT	4.9	0.5		5.4	$ 246	**8,762**	Fort Totten - MD 650	**(0.6)**	**(215)**	**(327)**	**$468**
B2C	TLC / FDA Circle / Site 2 / Konterra / Muirkirk	BRT	10.2	0.5		10.7	$ 458	**16,675**	Fort Totten - MD 650 - K	**6.8**	**2,293**	**3,496**	**$468**
B3A	Greenbelt / Site 2 / FDA North	BRT	4.7			4.7	$ 188	**6,460**	Greenbelt - Cherry Hill	**(7.0)**	**(2,712)**	**(4,132)**	**$85**
B4A	UM / FDA Circle / Site 2 / P&R	BRT	6.3			6.3	$ 252	**9,000**	UM - Adelphi Rd - MD 6	**6.0**	**2,060**	**3,140**	**$468**

Table 3.3: Summary of Key Inputs and Assumptions for Sketch Planning Analysis

Option	Description	Target CCPWP	Daily Boardin	Transit-Specific Mode Split Office	Retail	Industria	Other	Residential	Internal Capture Office	Retail	Industrial	Other	Residential
M1A	Silver Spring / Site 2 / P&R	$250	4,000	10%	5%	5%	5%	15%	54%	54%	54%	54%	54%
M1B	Silver Spring / FDA West / Site 2 / P&R	$250	4,000	10%	5%	5%	5%	15%	54%	54%	54%	54%	54%
M2A	Fort Totten / TLC / FDA Circle / Site 2 / P&R	$250	4,000	10%	5%	5%	5%	15%	59%	59%	59%	59%	59%
M2B	Fort Totten / TLC / FDA Circle / Site 2 / P&R	$250	4,000	10%	5%	5%	5%	15%	56%	56%	56%	56%	56%
M3A	Greenbelt / Site 2 / FDA North	$250	4,000	10%	5%	5%	5%	15%	38%	38%	38%	38%	38%
L1A	Silver Spring / Site 2 / P&R	$175	1,800	8%	4%	4%	4%	15%	23%	23%	23%	23%	23%
L2B	TLC / FDA Circle / Site 2 / P&R	$175	1,800	8%	4%	4%	4%	15%	5%	5%	5%	5%	5%
B1A	Silver Spring / Tech Rd / Briggs Chaney	$100	1,000	5%	2%	2%	2%	15%	24%	24%	24%	24%	24%
B1B	Silver Spring / Site 2 / Briggs Chaney	$100	1,000	5%	2%	2%	2%	15%	35%	35%	35%	35%	35%
B1C	Silver Spring / FDA West / Site 2 / Briggs Chaney	$100	1,000	5%	2%	2%	2%	15%	35%	35%	35%	35%	35%
B1D	Silver Spring / FDA West / Site 2 / Konterra / Muirkirk	$100	1,500	5%	2%	2%	2%	15%	35%	35%	35%	35%	35%
B2A	TLC / FDA Circle / Tech Rd / Briggs Chaney	$100	1,000	5%	2%	2%	2%	15%	3%	3%	3%	3%	3%
B2B	TLC / FDA Circle / Site 2 / P&R	$100	1,000	5%	2%	2%	2%	15%	0%	0%	0%	0%	0%
B2C	TLC / FDA Circle / Site 2 / Konterra / Muirkirk	$100	1,500	5%	2%	2%	2%	15%	13%	13%	13%	13%	13%
B3A	Greenbelt / Site 2 / FDA North	$100	1,000	5%	2%	2%	2%	15%	0%	0%	0%	0%	0%
B4A	UM / FDA Circle / Site 2 / P&R	$100	1,000	5%	2%	2%	2%	15%	12%	12%	12%	12%	12%

4. INDEX SCENARIOS

M/A/B employed INDEX software to create and test different land use configurations and intensities. INDEX is an add-on to ArcGIS software, which works within the existing framework of GIS but allows for some additional calculations, provides an easier way to test alternative scenarios, and generates quantitative results and rankings of scenarios to aid in alternative evaluation and selection. It also allows users to tie together land use, transportation, and environmental planning to assess over 90 different indicators including population, employment, transit ridership, and greenhouse gas emissions. Through this scenario creation and testing process, INDEX allows users to objectively compare different future options on a variety of criteria in order to select optimum development strategies.

4.1. Scenario Creation

M/A/B created three main scenarios for Montgomery County using INDEX software:

- Scenario 1 – Existing Conditions
- Scenario 2 – Mixed-Use Build-Out at Floor Area Ratio of 1
- Scenario 3 – Existing Conditions Plus Percontee and Site II Development

The Planning Department also retained Criterion Planners, the creators of INDEX, who created several scenarios independently, including an existing conditions scenario, a zoning build-out scenario, and a Percontee Site development scenario.

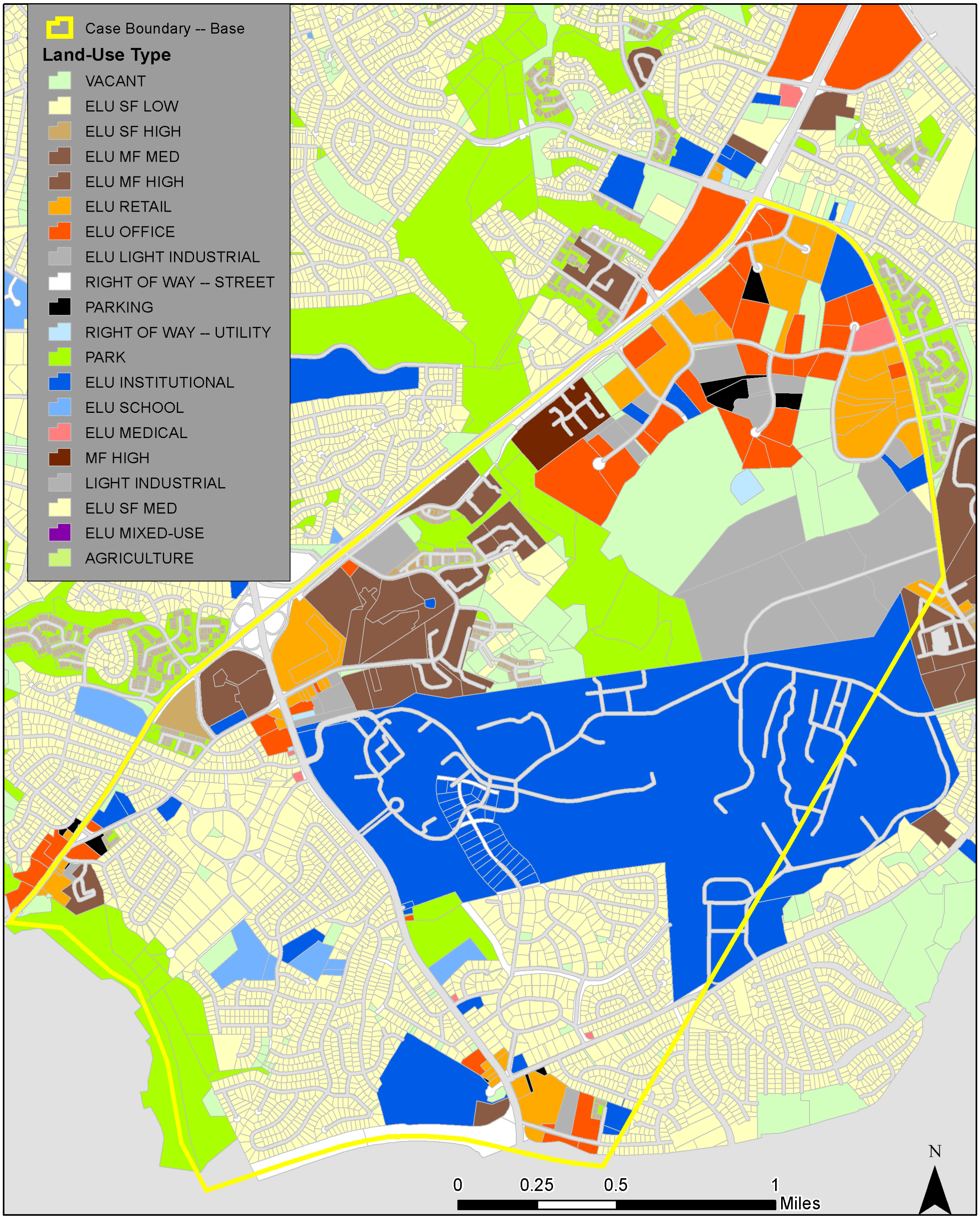
The most important outputs of the scenarios were how they would affect vehicle trips and gross square feet of development. These indicators help demonstrate what the additional impact to the existing road network would be. The gross square footage calculation can help tie in the transit sketch analysis to the INDEX modeling to show how each development scenario could potentially support transit. Table 4.1 shows these basic outputs along with population and employment for the three scenarios. A longer discussion of the three scenarios and their creation follows.

Table 4.1: Scenario Outputs Summary

Indicator	Scenario 1	Scenario 2	Scenario 3
Residential Population	20,451	45,961	24,965
Employment	24,254	39,215	27,799
Gross Square Feet of Development (millions)	20.997	48.044	22.831
Total Daily Trips	165,459	335,137	195,685

The scenarios created by M/A/B were intended to measure the conditions as they exist today and compare them to a theoretical, future maximum build-out scenario and a more plausible limited redevelopment scenario. The existing conditions scenario was based on information provided from Montgomery County and Prince George's County, publicly available information, and a site visit. The goal of this scenario was to accurately model what current conditions are, which will serve as a benchmark for comparisons of future alternative scenarios. Figure 4.1 shows Scenario 1.

Figure 4.1: Scenario 1

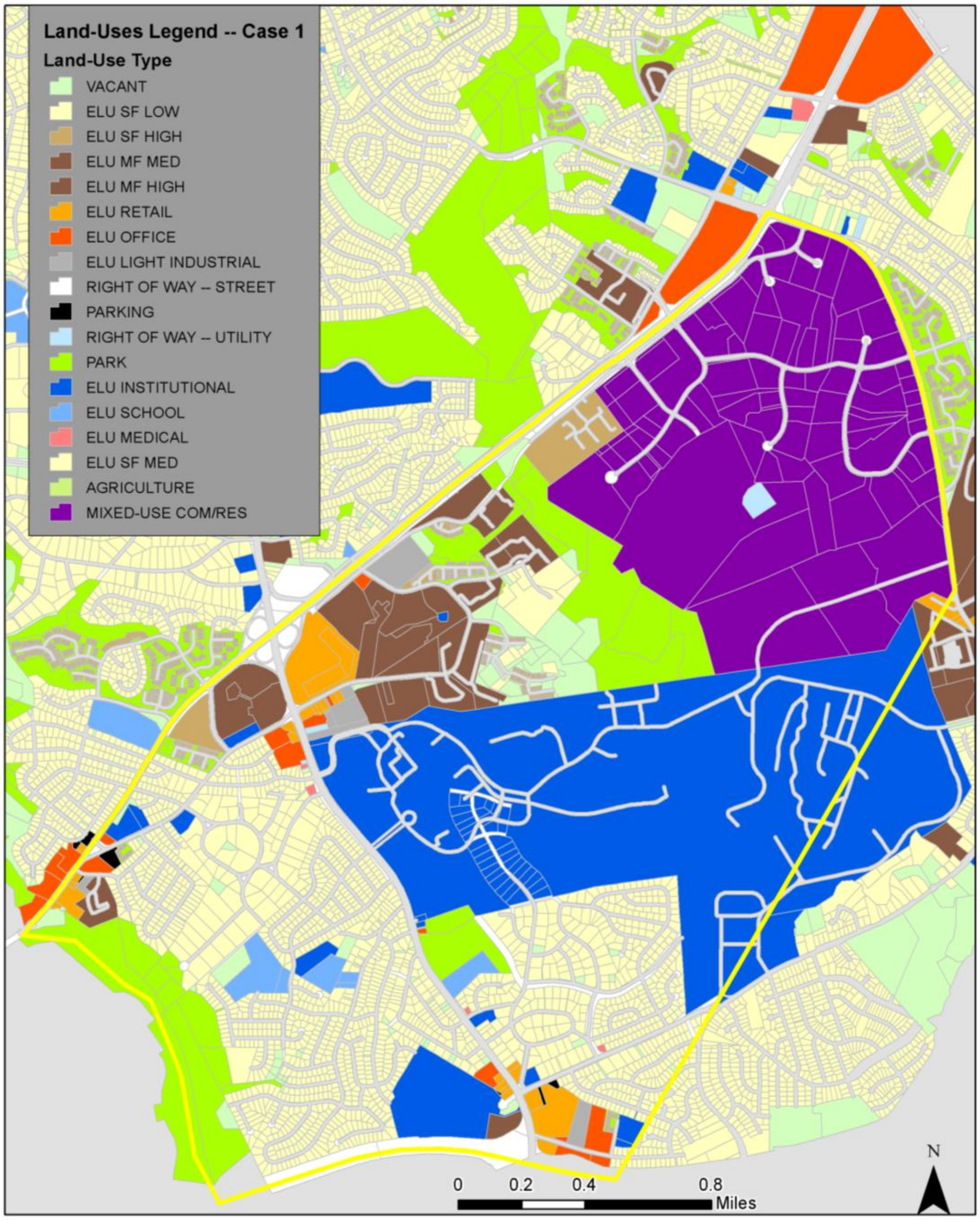


SCENARIO 1 CASE STUDY AREA MAP

MONTGOMERY COUNTY LAND USE AND TRANSPORTATION STUDY
MAY 2011

Scenario 2 was more of a thought exercise than a practical land-use scenario. This scenario applied higher density, mixed land-uses throughout the majority of the study area which is north of the FRC at a Floor Area Ratio of roughly one with slightly more than 50% of the land-use being commercial. The density and jobs-housing balance selected to apply to these parcels were based on levels that were thought to be at the upper bound of possible development for the site. The goal of this scenario was to determine a maximum load or maximum impact that the transportation network in the region may face as a result of redevelopment in this area. Figure 4.2 shows Scenario 2.

Figure 4.2: Scenario 2



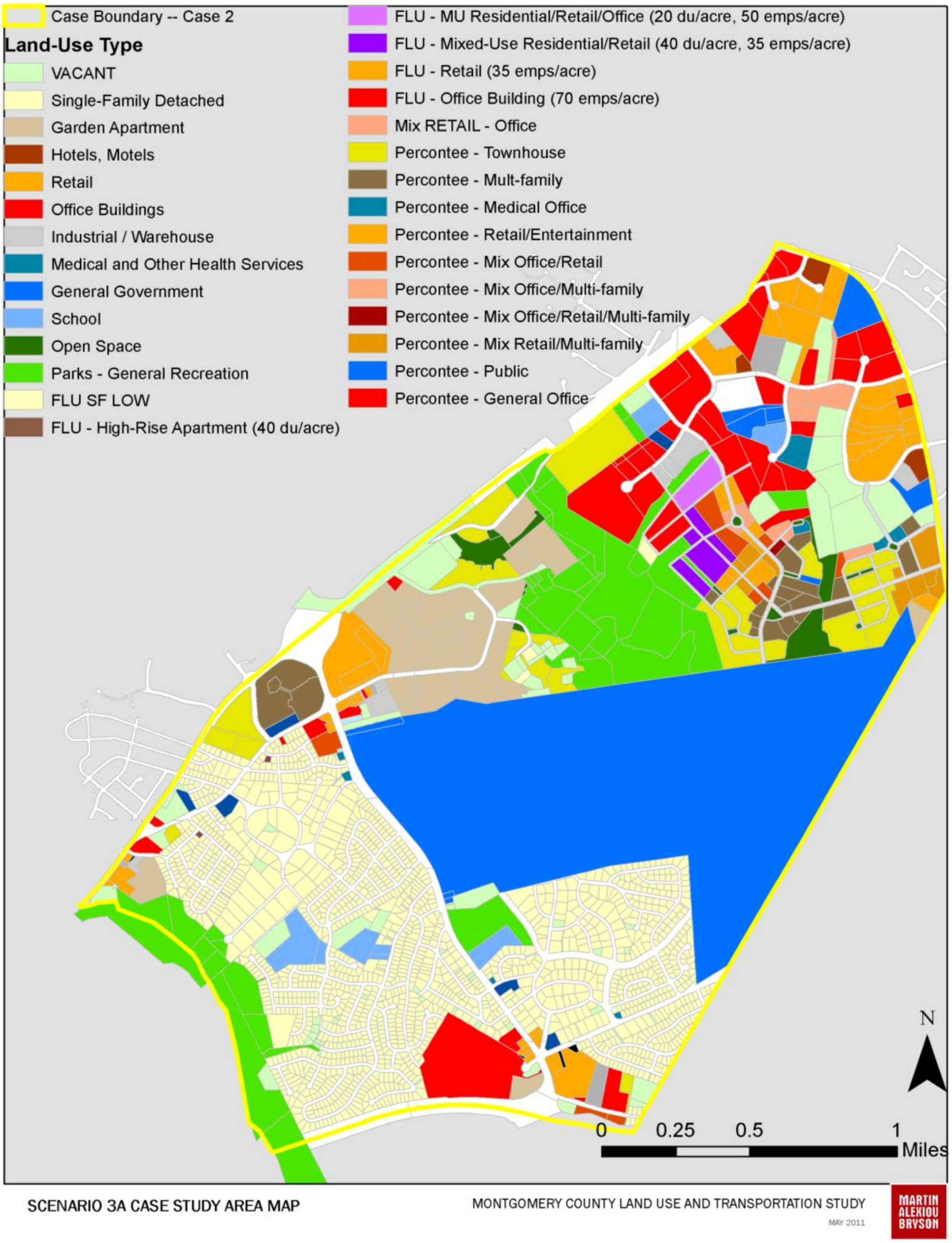
SCENARIO 2 CASE STUDY AREA MAP

MONTGOMERY COUNTY LAND USE AND TRANSPORTATION STUDY
MAY 2011

MARTIN ALEXIOU BRYSON

The final scenario was an estimate of a potential redevelopment of the Site II and Percontee parcels. Both the Percontee and Site II redevelopment plans were based on land uses that would create a walkable, mixed-use, small urban area. The goal of this scenario was to create a future development alternative for the parcels with the most potential to redevelop in the future (see Figure 4.3). Development was planned to have between 20 and 40 dwelling units per acre and 35 to 70 employees per acre depending on different land-use types. This would redevelop the area with higher intensity land-uses, but still fit the character of the area.

Figure 4.3: Scenario 3



These three cases were tested on a variety of indicators to determine what existing conditions look like (Scenario 1) or what the area may look like under future scenarios (Scenario 2 and Scenario 3). M/A/B's main task was to identify impacts to the transportation network under future scenarios, although other factors were considered. Table 4.2 shows the output for the three M/A/B created scenarios on a variety of indicators.

Table 4.2: Scenario Indicator Outputs

Indicator	Units	Scenario 1	Scenario 2	Scenario 3
Demographics				
Population	residents	20,451	45,961	24,965
Employment	employees	24,254	39,215	27,799
Population Density	residents/gross acre	6.41	14.41	7.97
Gross Square Feet of Development	Total Sq. Ft. (millions)	20.998	48.044	22.831
Land-Use				
Study Area Acreage	total acres	3,188.9	3,188.9	3,130.5
Use Mix	0-1 scale (1=highest mix)	0.13	0.98	0.18
Use Balance	0-1 scale (1=perfect balance)	0.81	0.73	0.81
Housing				
Dwelling Density	DU/gross acre	2.43	6.41	3.48
Dwelling Unit Count	total DU	7,750	20,439	10,888
Single-Family Dwelling Share	% total DU	27.4	12.6	15.3
Multi-Family Dwelling Share	% total DU	72.6	87.4	83.6
Transit Adjacency to Housing	% pop w/i 1/4 mi buffer	94.7	77.9	87.5
Employment				
Jobs to Housing Balance	jobs/DU	3.13	1.92	2.55
Employment Density	emps/net acre	19.14	25.99	23.32
Commercial Building Density	avg FAR	0.24	0.42	0.23
Transit Adjacency to Employment	% emps w/i 1/4 mi buffer	84.6	72.4	87.3
Travel				
Street Segment Density	centerline mi/sq mi	9.4	9.4	11.6
Transit Service Coverage	stops/sq mi	22.3	22.3	25.1
Transit Orientation Index	0-9 scale (9=highest)	2	4	2
Pedestrian Network Coverage	% of streets w/sidewalks	40.6	40.6	12.2
Home Based VMT Produced	mi/day/capita	25	24.2	14.9
Non-Home Based VMT Attracted	mi/day/emp	5	4.8	13.7
Home Based VT Produced	trips/day/capita	5.6	5.5	5.5
Non-Home Based VT Attracted	trips/day/emp	2.1	2.1	2.1
Total Vehicle Trips	total daily vehicle trips	165,459	335,137	195,685
Energy & Cliamte Change				
Residential Building Energy Use	MMBtu/yr/capita	36.12	38.31	46.7
Residential Vehicle Energy Use	MMBtu/yr/capita	41.47	40.21	24.66
Residential Total Energy Use	MMBtu/yr/capita	77.6	78.52	71.36
Non-Residential Building Energy Use	MMBtu/yr/emp	39.19	62.35	31.47
Non-Home Based Vehicle Energy Use	MMBtu/yr/emp	8.29	8.04	22.81
Non-Residential Total Energy Use	MMBtu/yr/emp	47.48	70.39	54.28
Residential Building CO2 Emissions	lbs/capita/yr	8,857	10,237	14,663
Residential Vehicle CO2 Emissions	lbs/capita/yr	6,334	6,142	3,766
Residential Total CO2 Emissions	lbs/capita/yr	15,191	16,378	18,429
Non-Residential Building CO2 Emissions	lbs/emp/yr	12,114	17,975	17,987
Non-Home Based Vehicle CO2 Emissions	lbs/emp/yr	1,267	1,228	3,483
Non-Residential Total CO2 Emissions	lbs/emp/yr	13,381	19,203	21,471

When examining the indicator results, it is important to remember that Scenario 3 was based on the existing conditions map created by Criterion Planners, not the one created by M/A/B. The differences between the two base cases are discussed more below, but it does make direct comparisons between the three cases more challenging. The key point is that Scenario 2 is a pretty radical increase over existing conditions, while the Scenario 3 is a more moderate development proposal.

Scenario 2 increases total square feet, population, employees, and vehicle trips significantly over Scenario 1. Under Scenario 2, total square feet of development increases 129% from 20.998 million GSF to 48.044 million GSF. Population increases 125%, dwelling units increase 163%, and employees increase 125%. Although per capita home based trips decrease slightly, total trips are significantly higher vs. the Scenario 1 due to the population increase. The base case level of trips is roughly 165,000 daily trips in the Study Area. Under Scenario 2 trips would roughly double to 335,000 per day. Greenhouse gas and energy consumption rise per capita under Scenario 2.

The impacts of Scenario 3 are much more reasonable compared to Scenario 2. As compared to Scenario 1, total square feet of development increases 9% from 20.998 million GSF to 22.831 million GSF. Residential population would increase roughly 22%, employees would increase about 15%, and dwelling units would increase about 40%. Daily vehicle trips would increase about 18% over Scenario 1 to a total of about 195,000. Scenario 3 increases the development in the Study Area, adding square footage, residents and workers, but does so in a way which has significantly lower impacts than Scenario 2.

Although M/A/B and Criterion Planners worked independently to create slightly different scenarios for the same area, the efforts of both companies resulted in reasonably similar outputs, although there are differences. Table 4.3 shows a comparison of similar outputs for the existing conditions case created by M/A/B (Scenario 1) and the existing conditions case created by Criterion. The strategies and methods to code the data were slightly different as were the goals of the work, but as is evident from the output, both companies arrived at similar conclusions, which adds strength to the findings.

Table 4.3: Base Case Comparison - M/A/B and Criterion

Indicator	Units	M/A/B Existing Conditions	Criterion Existing Conditions
Demographics			
Population	residents	20,451	17,840
Employment	employees	24,254	18,139
Population Density	residents/gross acre	6.41	5.70
Gross Square Feet of Development	Total Sq. Ft. (millions)	20.998	15.133
Land-Use			
Study Area Acreage	total acres	3,188.9	3,130.5
Use Mix	0-1 scale (1=highest mix)	0.13	0.12
Use Balance	0-1 scale (1=perfect balance)	0.81	0.78
Housing			
Dwelling Density	DU/gross acre	2.43	2.35
Dwelling Unit Count	total DU	7,750	7,351
Single-Family Dwelling Share	% total DU	27.4	22.7
Multi-Family Dwelling Share	% total DU	72.6	77.3
Transit Adjacency to Housing	% pop w/i 1/4 mi buffer	94.7	82.2
Employment			
Jobs to Housing Balance	jobs/DU	3.13	2.47
Employment Density	emps/net acre	19.14	15.23
Commercial Building Density	avg FAR	0.24	0.15
Transit Adjacency to Employment	% emps w/i 1/4 mi buffer	84.6	83.1
Travel			
Street Segment Density	centerline mi/sq mi	9.4	10.2
Transit Service Coverage	stops/sq mi	22.3	22.7
Transit Orientation Index	0-9 scale (9=highest)	2	2
Pedestrian Network Coverage	% of streets w/sidewalks	40.6	0.0
Home Based VMT Produced	mi/day/capita	25	15.3
Non-Home Based VMT Attracted	mi/day/emp	5	14.2
Home Based VT Produced	trips/day/capita	5.6	4.5
Non-Home Based VT Attracted	trips/day/emp	2.1	1.5
Total Vehicle Trips	total daily vehicle trips	165,459	107,489
Energy & Cliamte Change			
Residential Building Energy Use	MMBtu/yr/capita	36.12	48.79
Residential Vehicle Energy Use	MMBtu/yr/capita	41.47	25.38
Residential Total Energy Use	MMBtu/yr/capita	77.6	74.17
Non-Residential Building Energy Use	MMBtu/yr/emp	39.19	38.12
Non-Home Based Vehicle Energy Use	MMBtu/yr/emp	8.29	23.47
Non-Residential Total Energy Use	MMBtu/yr/emp	47.48	61.59
Residential Building CO2 Emissions	lbs/capita/yr	8,857	10,393
Residential Vehicle CO2 Emissions	lbs/capita/yr	6,334	3,876
Residential Total CO2 Emissions	lbs/capita/yr	15,191	14,270
Non-Residential Building CO2 Emissions	lbs/emp/yr	12,114	10,757
Non-Home Based Vehicle CO2 Emissions	lbs/emp/yr	1,267	3,585
Non-Residential Total CO2 Emissions	lbs/emp/yr	13,381	14,342

4.2. *Step By Step Scenario Creation Process*

Data Cleaning

The first step for a project in INDEX is to clean the input data to match the requirements of INDEX. Each municipality collects and maintains different data but INDEX requires and uses only certain data. In most cases, the required data is simple data which is most likely contained in the base data, but in some cases this must be calculated before the data can be loaded into INDEX. Examples of the types of data that might need to be created to ease the load into INDEX are population and employment numbers. Many counties and municipalities track things such as zoning, land use, parcel owners, etc., but very few municipalities also record the number of people living or working at a parcel; however, INDEX uses this information.

For this project, another challenge in data cleaning was using data from two different sources. Because the study area is at the border of Montgomery County, Prince George's County data also needed to be used in order to accurately represent and account for the influences of the surrounding area. However, this requires standardizing two different methods of zoning, coding streets, and tracking current land use. It is important to note here that INDEX can append data during the load process so the data for the two counties do not need to be combined into one dataset, just similarly coded so that similar information from the two datasets is loaded.

To load data into INDEX, it is also necessary to create individual shapefiles for each type of data you intend to load. The work done for this project examined only some aspects of land-use, transportation, and environmental planning, so all of the different shapefiles that INDEX can accept were not needed. Below is a brief discussion of each of the shapefiles that were loaded and the data cleaning and calculations that were performed in each shapefile to prepare it for loading into INDEX.

Parcel Shapefile

Both Montgomery County and Prince George's County provided parcel level data. M/A/B focused on land use, rather than zoning, to better approximate actual conditions. However, the two counties have different ways of tracking current land use. The first step was to create land-use coding that would correspond with a similar "paint" in INDEX. Land-use paints in INDEX are an easy way to change land-uses; a user creates a paint which has a number of underlying properties which can then be applied to a parcel with a single click in GIS. Land-uses were grouped together into similar categories (e.g., single-family low density, commercial retail, light industrial) with certain properties which corresponded to paints which were created in INDEX prior to the data load. Paints and land use codes could have been created for every existing land use, but we decided to group similar land-uses together to simplify understanding of the outputs and speed up the process.

We calculated the number of employees and residents in each parcel prior to the data load. There were several challenges to determining these levels. First, any inconsistencies in dwelling unit counts needed to be standardized. We manually set all non-residential parcels to zero dwelling units and all single-family parcels to one dwelling unit. Multi-family parcels were considered on an ad hoc basis. Once dwelling units were determined, the total residential population of each parcel was calculated by applying an average household size number from the US Census Bureau. Employment for a parcel was based on an average square footage per employee for each employment type and the building square footage, or when not available, parcel acreage.

The existing conditions land-use paints that were created in INDEX for the data load all contained "existing demographics" settings which instructs INDEX to use the information contained in the parcel data; future land-use paints contain estimates of variables like population and employment. It is also important to note that all parcels need to be single polygons for INDEX to function properly so any multi-part polygons must be eliminated.

Street Centerlines

Similar to how INDEX uses a land-use code which is tied to paints in order to properly match parcels with the appropriate land use types, street centerlines need to be classified by road type to match up with INDEX's classification scheme. Using existing data in the centerlines datasets for Montgomery County and Prince George's County, M/A/B classified each road by type. M/A/B also calculated street and right-of-way width where it was not present in the data based on Google Earth imaging and the street classification system. The sidewalk coverage percentage was also calculated, again based on street typologies where the information was not present. We also confirmed the connectivity of the Centerlines files by loading them into TransCAD and checking the connections.

Transit Routes and Transit Stops

Transit stops data were provided by Montgomery County and routes were digitized by looking up routes through WMATA and RideOn. The average frequency of service was an important component that was added to the data based on route timeline tables provided through WMATA and RideOn.

Pedestrian Network

The pedestrian network was created based on the parcel files and the street centerline files. Pedestrian access points were created from each parcel centroid to the nearest roadway (perpendicular) in TransCAD. Roadways that act as pedestrian barriers (e.g. expressways) and other barriers were excluded from the pedestrian network. Greenways and other off-road pedestrian paths were digitized in.

A more robust way to analyze pedestrian network would be to digitize in pedestrian connections to each parcel based on building footprints rather than parcel centroids. In this way, the distance a pedestrian has to walk to access a sidewalk is more accurately reflected. Also, if sidewalk data is available, that is preferable to centerline. The distance from the parcel centroid to the street centerline is likely a longer distance than a pedestrian would walk in real life (building edge to sidewalk). However, given the limitations of existing data and the difficulty and time involved in creating the required data, calculating at this level of detail was not deemed to be a good use of resources.

Study Area Boundary

The study area boundary is an important component to set up properly. The boundary is nothing fancy, but because most indicators in INDEX are calculated based on the study area (or at least a buffer of the study area), properly delineating the study area boundary is crucial. The study area should be only that area that will actually be changed for future land-use or transportation plans. A buffer of additional parcels and roads should be maintained since they are used for some calculations. However, using a study area that is too large will result in "noise" from the parcels and transportation elements that go unchanged in future scenarios, potentially obscuring some of the effects of future alternatives. A smaller study area restricted to the parcels most directly impacted in future scenarios allows the differences in each scenario to shine through. Creating the Study Area Boundary shapefile is easy – it is simply a polygon representing all areas intended to be studied. The study area boundary file also contains base case vehicle trip and vehicle miles traveled data, which can be changed by the user. M/A/B used data from the National Capital Region Transportation Planning Board's Travel Forecasting Report to estimate this information for the base case (INDEX calculates it for alternative cases).

4.3. Lessons Learned

This project has provided a number of lessons learned and best practices for repeating a similar study in the future. Many of the lessons learned stem from the fact that using INDEX frontloads a lot of data work which means having a clear vision, an understanding of desired final products, and agreement on several points can save a lot of backtracking and reworking once the project is well underway. Below is a list of the primary lessons learned followed by a discussion of each point.

- Have a plan before starting data cleaning – desired indicators, goals of the study.
- Base the existing conditions map on existing land-use not zoning.
- Group similar land-uses to simplify creation of paints and organize paints prior to creating them.
- If multiple datasets are needed, code them similarly then append the data sets during the load into INDEX rather than combining them before loading.
- Make any changes to the existing conditions case in INDEX before creating new alternative scenarios.
- Create an alternative scenario that can be used as a test case to "play around" in the program.

One of the primary inputs is the land-use, and therefore the decisions involving how to code in different land-uses are crucial. The first concern is whether to use land-use or zoning. Both are certainly possible, but show different outputs – current conditions vs. existing zoning build-out. For an existing conditions base case scenario, the current conditions are obviously more valuable and this is the preferred starting point. A zoning build-out scenario can show useful information, but it should not be the base case that is created initially.

An issue connected with the land use vs. zoning issue is whether to create paints, or new land use classifications in INDEX, for each land use and zoning type, or to group similar ones into general categories. For instance, we identified 14 types of residential land uses in the Montgomery County parcels in the study area. To simplify the study and create easier to read materials, we condensed these into five different types (single family -low, -medium, and -high density, and multi-family medium and -high density). We treated other categories, like Commercial – Retail, similarly. This means a loss of some detail, but it creates a more readable and understandable output. A decision on how to handle the zoning and land-use classifications should be made prior to doing any work in ArcGIS or INDEX to save time later.

A final issue that pertains primarily to land-use (although was an issue with street centerlines) is the difficulty of combining two different datasets, in this case Montgomery County and Prince George's County. With land-use, the two counties have different systems for classifying land-use and different zoning categories. This creates issues of how to standardize these two datasets to make analogous comparisons between them. This difficulty is another reason to create more general land-use paints and classifications for INDEX, as we did, rather than to create one new paint for each land-use type and zoning classification. The general categories allow for easier combination of the two, often very different, datasets.

Another issue that should be decided early in the process is the desired outputs or indicators to measure. This will partially help determine which shapefiles need to be created, cleaned, and loaded at the beginning of the process. For instance, for a study that wants to examine water runoff, slope and hydrology shapefiles are necessary; however, for a study looking at how land use changes impact the transportation network may not need either of these files. Making the decision early on the desired study parameters can save unnecessary work and prevent problems of having to load in new data after scenario creation has already started. This also saves time running the indicator scores which can be a lengthy process if lots of indicators are used. It is also worth noting that selecting certain indicators may require selecting others in order for INDEX to properly complete the calculations. For example, calculating Vehicle Trips also requires calculating other variables as well like Pedestrian Network Coverage and Street Network Extent). These variables also must be selected for the base case in addition to the desired alternative case(s).

A final issue that should be resolved prior to creation of the base case scenario in INDEX is what land-use paints to create. INDEX uses these paints to change the land use quickly so that alternative land-use scenarios can be tested. Creating a system for organizing paints and the basic paints that are anticipated being needed can save time on the back end. Also, it is important to remember that INDEX contains assumptions about the characteristics of different land-use types based on empirical research, but to the extent that this information can be replaced, updated, or modified to reflect better and more accurate local information that is desirable. An example of this is population per dwelling unit – INDEX has an assumption, but if reliable local information can be found then using the local data is preferable. An example of how to group and organize paints is shown below. A simple scheme differentiates between existing land-uses and future planned land-uses (existing land-uses contain "no demographics" and utilize underlying information whereas future land-uses make assumptions about the characteristics of that land-use) and groups similar land-uses together reserving unused paint IDs to add any additional paints that may need to be created in the future. Paint IDs run from 1 to 250 (in the table ELU means Existing Land Use).

Table 4.4: Sample INDEX Paint Organization

INDEX PAINT ID	NAME
1	VACANT
20	ELU SF Low
21	ELU SF MED
22	ELU SF HIGH
25	ELU MF MED
26	ELU MF HIGH
30	ELU COM RETAIL

31	ELU COM OFFICE
32	ELU MIXED
35	ELU LIGHT INDUSTRIAL
36	ELU HEAVY INDUSTRIAL
40	ELU ROW - STREET
41	ELU ROW - PARKING
42	ELU ROW - UTILITIES
50	ELU PARK
51	ELU AGRICULTURAL
60	ELU INSTITUTION
61	ELU SCHOOL
62	ELU HOSPITAL
100	SF LOW
101	SF MED
102	SF HIGH
105	MF MED
106	MF HIGH
110	COM RETAIL
111	COM OFFICE
112	MIXED
115	LIGHT INDUSTRIAL
116	HEAVY INDUSTRIAL
120	INSTITUTION
121	SCHOOL
122	HOSPITAL

These recommendations and lessons learned primarily deal with the importance of having a game plan in place prior to starting anything in INDEX. This is all for good reason, however, because each new alternative scenario in INDEX will be copied from the Base Case Scenario and compared to this scenario, meaning that the Base Case must be completely correct before any new scenarios should be created. Making changes to the Base Case after creating four or five new scenarios will lead to inaccurate results and require significant work to recreate all new scenarios again. Also, because INDEX is a powerful software with wide capabilities, having a plan and strategy at the beginning will save time later in the process. INDEX makes creating and testing new scenarios and ideas for development very easy, but it requires that the starting point be correct and complete first.

Finally, another useful practice is to "play around" in INDEX once the base case is set up by testing some theoretical maximums in different configurations of transportation or land-use. By informally pulling different levers in INDEX and creating some "worst-case" scenarios, it is possible to understand better what drives various indicators and outputs in INDEX. This can lead to more rigorous results and a better understanding of results when the true scenario testing process begins.

It also can be used as a check on the set-up of future land-use paints and transportation treatments to make sure they are creating outcomes which are logical.

4.4. The Utility of INDEX in Planning Processes

INDEX is a powerful and versatile tool which can be useful in many different applications; however, it is not always the best tool. First, INDEX is designed for small-area plans as opposed to a county-wide plan (at least not without significant technical support and project design assistance). Comparing land-use and/or transportation changes within a few square miles is the preferred application of the software. Second, INDEX does involve a fair amount of upfront work to prepare data and ensure accuracy. This means that quick projects should perhaps only be analyzed using traditional GIS or another tool, and reserving INDEX use for longer-term planning projects or projects where the data is already in a mostly prepared state. Often the biggest hurdle is simply acquiring the GIS layers in a suitable and clean format for use in INDEX. If the layers are readily available, many of the fields in these layers may be estimated (or not necessary) to conduct a basic analysis.

One of the main strengths of INDEX is the ability to tie together different types of planning which have often been left in silos. INDEX allows land-use, transportation, and environmental factors to interact and shows how changes in one of these components affect the others. In this way, INDEX can be a great tool for a comprehensive study of an area, particularly where environmental goals like greenhouse gas reduction come into play.

INDEX can also be a powerful tool for interacting with the public through some of the digital charretting abilities. Because complex computational work is done on the front-end, planners can allow members of the public to make real-time changes to land-use for an area and see the impacts of those decisions. This opens up the planning process to the public and can help build support for the eventual plans that result from these processes.

It is for such public forums that a larger-scale implementation of INDEX may be desirable. One application would be the evaluation of broad scale changes such as wholesale redefinition of zoning densities. Another use would be to take a large-scale model (such as at the county level) and define multiple study area boundaries, thus being able to engage in charrette activity at neighborhood meetings but incorporate it into the larger model and, if desirable, simultaneously answer how local changes would (or would not) have large-scale impacts. While the model is not as responsive in certain areas (such as a travel demand model), it does provide a rapid evaluation that would be next-to-impossible with traditional sketch planning tools (which are often spreadsheet-based).

INDEX does have some limitations which should be considered before using it for a project. The first is the data requirements. These can be extensive and are often slightly different from what a municipality or organization already has, like parcel level population and employment. In order to load data into INDEX, certain measurements will need to be calculated and certain attributes will have to be coded to comply with the needs of INDEX. This can be a lot of work if the data is not ready. The need for data can be mitigated to some degree with a careful evaluation of the documentation for each indicator. By ascertaining the focus of the study, you can determine how extensive the input dataset must be. While some indicators require nearly all of the possible data INDEX can use, others require only the most basic inputs – though even these can be time-consuming. It is also important to understand how you will use the indicators. In some instances, it may be acceptable to provide generic values or make simplifying assumptions as you will still be able to gauge the relative merits of the different scenarios.

Just as it is important to get the right base geographic data, it is also important to have certainty in other factors. The greenhouse gas indicators, for example, are primarily driven by assumptions about typical households. While the default values are reasonable, one must be confident that they are representative for the study area or else the results will be meaningless. Similarly, much of the trip calculations are pivot-point based. This allows for estimation of response when tweaking existing conditions, but requires reliable trip information for the base year: INDEX will not calculate existing trips.

Another weakness of INDEX is that it can operate as a "black box" sometimes, meaning that the program performs various calculations behind the scenes in hard to know ways. The program comes with documentation of how calculations are performed, but these descriptions can be difficult to penetrate for more complex calculations. For instance, vehicle trips are calculated based on a user-defined baseline and scores and elasticities for the five D's (density, diversity, design, destinations, and distance); this methodology seems rigorous, sound, and based on the best available research, but it is also very difficult to understand. Additionally, if a local user wants any tweaks to a methodology based on local knowledge or specific technical expertise, this is not possible.

INDEX also provides only a fixed set of indicators. This will obviously be a problem with any program, but users should make sure that the outputs of INDEX are going to be the best indicators for the information desired. For example, INDEX will calculate vehicle trips and vehicle miles travelled in different scenarios, but a more thorough transportation model would have to be performed in another program if more indicators and outputs were desired.

Connected with this issue of opacity in calculations is understanding how various measurements fed into the model. When calculating Light-Rail Transit ridership, the stated formula is based primarily on densities, station characteristics, and the light-rail network's characteristics (the full formula is shown below in Figure 4.4). However, each light-rail station has its own attributes, including distance to CBD, distance to nearest station, and boardings. It is not immediately clear from the documentation whether these attributes are user input or if they are calculated when INDEX calculates the indicator "Light-Rail Transit Boardings?" If INDEX calculates them, how does it determine distance to next station (i.e., does it use a straight line measurement or a path along a light-rail transit line)? It can be difficult to determine what needs user intervention and what is calculated by the program. In this case, INDEX calculates the appropriate LRT boardings but needs a two-mile buffer around the stations in question to pull the needed demographic data for the model.

Figure 4.4: Light-Rail Transit Boardings Methodology

Indicator Name:	Light Rail Transit Boardings [63]
Definition and Units:	Average daily number of persons boarding light rail transit (LRT).
Illustrative Scores:	Varies by case boundary area composition and size.
General formula:	$\frac{\sum\left(e^{5.48} * e^{0.8T_s} * e^{-0.15P_s} * M_{ns}^{\ 0.65} * M_{cbds}^{\ 0.27} * D_{ps}^{\ 0.24} * D_{es}^{\ 0.49}\right)}{N}$ T_s = is rail stop *s* a terminal (yes=1, no=0)? P_s = does LRT stop *s* have parking (yes=1, no=0)? M_{ns} = distance in miles from LRT stop *s* to nearest stop. M_{cbds} = distance in miles from LRT stop *s* to nearest CBD. D_{ps} = population density per acre within two miles of LRT stop *s*. D_{es} = employment density per acre within a half mile of LRT stop *s*. e = base of natural logarithms (2.71828). N = number of rail stops in the case boundary area.
Map Type:	Dynamic.
ESRI License Restrictions:	None.
Note:	This indicator requires a case boundary that extends in a 2-mile radius from the LRT station(s) in question.

5. CONCLUSIONS

This study provides a starting point for the East County Science Center Master Plan update by providing some initial guidance on the ability of the existing transportation network to handle new development. This study also provides a sketch-level analysis of the requirements and impacts for different transit modes and alignments in the area to assess the feasibility of different transit options and the necessary land-use changes. The area is in a transit-rich region and a portion of the county ideally suited for smart redevelopment.

The Study Area is a good candidate for increased bus service and potentially LRT or BRT in the future with some higher-density development around station areas. Heavy-rail transit is cost-prohibitive. The land-use analysis shows that, absent transit enhancements, major redevelopment of the area will significantly stress the transportation network, potentially doubling baseline vehicle trips per day. Moderate redevelopment which accompanies the expansion at the Federal Research Campus is likely to have manageable impacts in the short term. Coupled with increased transit access in the future, a smart and moderate redevelopment of key areas with TOD principles seems feasible.