KYTC TRAFFIC FORECAST REPORT DEVELOPMENT GUIDE

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Prepared for:

Kentucky Transportation Cabinet

Prepared by:

Stantec Consulting Services Inc.

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Abbreviations

AADT	Annual Average Daily Traffic
ADT	Average Daily Traffic
ADTT	Average Daily Truck Traffic
CAGR	Compound Annual Growth Rate
DHV	Design Hour Volume
LRTP	Long Range Transportation Plan
MPO	Metropolitan Planning Organization
PHF	Peak Hour Factor
SUA	Small Urban Area
TIS	Traffic Impact Statement
TMC	Turning Movement Count
VPD	Vehicles Per Day

1.0 INTRODUCTION

This *KYTC Traffic Forecast Development Guide* (development guide) is the second phase of KYTC Division of Planning's initiative to provide policy guidance and practical instruction for the preparation and development of traffic forecasts for use in KYTC's planning efforts. The first phase of this effort was the *KYTC Traffic Forecasting Guidance Manual* (guidance manual), prepared in December 2022. The guidance manual provides the context and rationale behind KYTC's forecasting efforts and describes the many foundational elements and concepts involved with developing forecasts. The guidance manual, which serves as the technical foundation for traffic forecast development, also discusses best practices and identifies data and other resources related to different elements of traffic forecasting. In addition to the report development guide and guidance manual, the Kentucky Transportation Center's **PL 43 Traffic Forecasting Report 2023** for KYTC provides relevant traffic data summaries, metrics, and factors for you use in forecast development. These three documents serve as primary resources for KYTC's forecasting methodologies, parameters, and practices.

This report development guide supplements the manual by providing practical instruction for the development of a traffic forecast report for KYTC. The guide provides step-by-step instructions for each phase and element of the forecast development process and is intended to be an introductory guide for new practitioners. In particular, this guide is intended to provide a step-by-step tutorial that can be followed to develop a forecast and report for a "typical" KYTC highway project requiring a design level forecast. **Chapter 1** summarizes the distinctions between the two primary levels of forecasting, their role in KYTC's project development process, and the typical process for completing a KYTC forecast. **Chapter 2** discusses the KYTC process for initiating and scoping a forecast. **Chapter 3** describes the process of acquiring and processing count data. **Chapter 4** provides instructions for estimating and determining the growth rates that will be used to develop future year forecast volumes. **Chapter 5** supplies instructions and sample templates for creating turn movement diagrams. **Chapter 6** provides tips for truck forecasting, and **Chapter 7** describes how to effectively present all elements of the forecasting process in a forecast report, an example of which is provided as **Appendix A.**

Both this development guide and the guidance manual are intended to support each other. While they have different roles, inevitably there is overlap between the two documents. This guide will summarize topics discussed in the guidance manual and refer readers to it for more detailed information. For those unfamiliar with forecasts in general, please review **Chapter 1 – Introduction** of the Guidance Manual for a more detailed understanding of the types of forecasts and how they are used for various projects and purposes. A summary is provided here.

1.1 LEVELS OF TRAFFIC FORECASTS

Traffic forecasts are informed estimates of future travel demand that are used to aid decision making for any number of purposes, from the general and conceptual to the highly detailed and specific. They are used by every level of government, from city planning departments, regional Metropolitan Planning Organizations (MPOs) and Area Development Districts (ADDs), and state and federal agencies. Traffic forecasts typically have time horizons between 20 to 25 years into the future but can be much shorter depending on the project purpose for which it is developed. While there are a variety of technical or specialty forecasts that have distinct purposes and requirements, there are two primary levels of forecasts used in transportation projects: ***planning level forecasts and design level forecasts***.

Planning level forecasts represent the general and conceptual range of traffic forecasts, most often used to identify potential issues or problems, analyze solutions, and prioritize project plans. These forecasts are often associated with Long-Range Transportation Plans (LRTP), transportation feasibility and programming studies, small urban area plans, and corridors studies where no design phases or budgets are included. Planning level forecasts may also serve to provide required inputs for environmental studies, such as air quality and noise studies, and toll and revenue studies. Planning level forecasts can even be used in larger highway projects for the identification and preliminary evaluation of conceptual alternatives.

Planning level forecasts are generally limited to a level of detail associated with Average Daily Traffic (ADT) volumes at the highway segment level, although depending on their purpose, they may include volumes for peak hour, travel mode and/or vehicle class. The method for forecasting growth may be as simple as the application of a single growth rate to current count data or involve the application of advanced planning processes and tools, such as a travel demand model. Planning forecasts may also include a range of values intended to represent various forecast scenarios (low growth versus high growth; with or without a proposed development, etc.) or to apply sensitivity tests, such as determining the level of traffic growth when an additional through lane or specific interchange concept become necessary.

Consider minimum ADT thresholds when deciding where planning forecast values are necessary. Roads or side approaches with historically consistent ADT's less than 1,000 vehicles per day typically do not warrant new design considerations unless a plan scenario substantially changes the traffic pattern for that corridor or location.

As projects progress beyond the planning stages, ***design level forecasts*** are needed to properly size, design, and evaluate project alternatives and components, including the operation of interchanges and intersections. Beyond the segment level estimates included in a planning level forecast, design level forecasts are distinguished by peak hour turning movement estimates at intersections and interchanges. Final construction plans require detailed truck forecasts by truck class. The time horizon for design forecasts generally ranges from 20-25 years for most projects involving significant construction, to 5-10 years for smaller scale operational improvements to existing facilities. Short-term horizons may also be necessary for projects in congested settings currently experiencing explosive growth that cannot be

accurately forecast for a longer period, or where a proposed improvement is tailored to serve an immediate transportation need. Design level forecasts are an integral part of KYTC highway design projects and the Traffic Impact Statements (TIS) required from developers who must demonstrate the impacts a new development will likely have on the surrounding roadway system[1].

Ultimately, the level of forecast required is determined by the proposed transportation improvement project purpose. The following rules of thumb, also illustrated in **Figure 1**, should help determine whether a planning level or design level forecast is appropriate:

- Planning studies, including corridor studies or small urban area (SUA) studies, generally need only planning level forecasts. If the study purpose is solely focused on identifying issues and potential solutions, or evaluating environmental, social, or financial impacts, a planning level forecast is most likely sufficient.
- If the proposed project does not intend to address or change capacity, such as a safety project or a small bridge replacement, traffic forecasts are not necessary, although a basic ADT (planning level) forecast may be valuable for reference.
- If the project scope includes specific design tasks, a design level forecast is most likely wanted, although not necessarily, if design decisions are unrelated to traffic (see previous bullet point).
- If the project includes the design of intersections or interchanges, a design level forecast is desirable.

Beyond the major distinction between planning level and design level forecasts, ***technical forecasts*** refer to a specific analytical purpose for forecasts, such as air quality and noise analyses. Transit and toll forecasts are another form of technical forecast that require significant advanced modeling to produce. The required forecast elements will vary according to the specific purpose and are usually well documented according to the state or federal protocols for the respective technical analysis. While these analyses may not require turning movement forecasts, they often need significant data beyond daily or hourly traffic volumes.

[1] KYTC provides specific policy guidance regarding the project analyses included in Traffic Impact Statements and specifies analysis for the open-to-traffic year and 10 years beyond open-to-traffic.

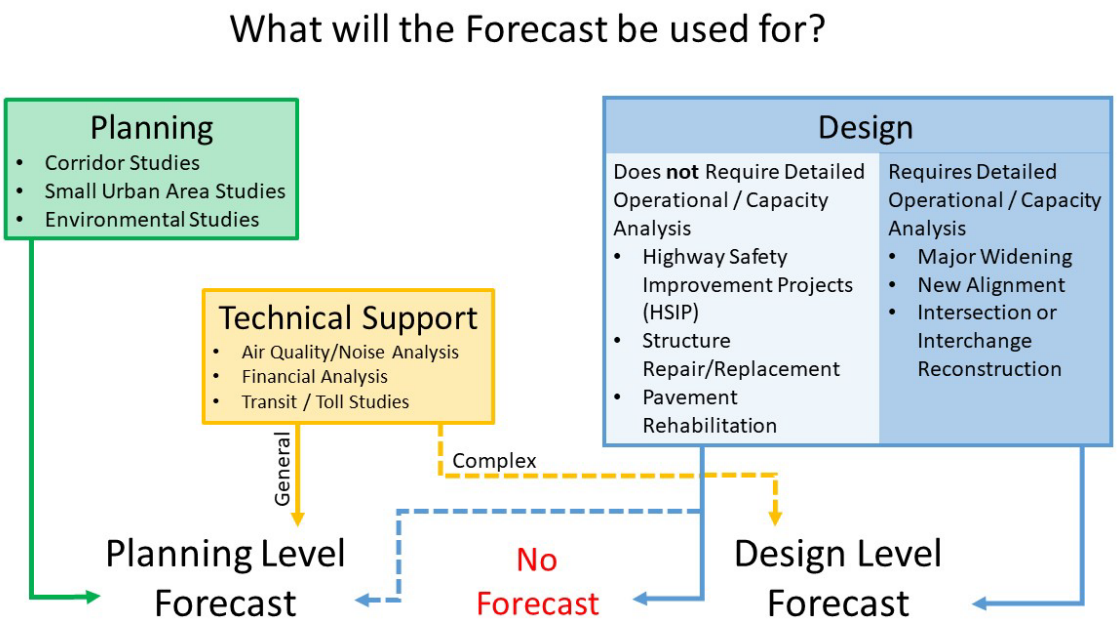


Figure 1: Forecast Type Decision Tree

1.2 THE KYTC FORECAST DEVELOPMENT PROCESS

The specific purpose and type of a traffic forecast often determines how the development of that forecast will proceed. Most planning level forecasts prepared for studies and transportation plans with no design component are often included as a specific task in the scope of the study for which it is to be used. These forecasts are likely defined and developed internally by the study team and documented within the larger study report. In contrast, design level forecasts should be integrated and scoped consistent with KYTC's five-stage project development process, as described in **Figure 2**. Whether a design forecast is scoped as a task within a design project scope or scoped and prepared separately from the larger project, the parameters of any forecast prepared for a KYTC project or study should be discussed and reviewed with the Modal Programs Branch during project scoping and throughout the development of the methodology and final forecast. The focus of this guide is the development of design level forecast reports that are prepared as part of KYTC's project development process.

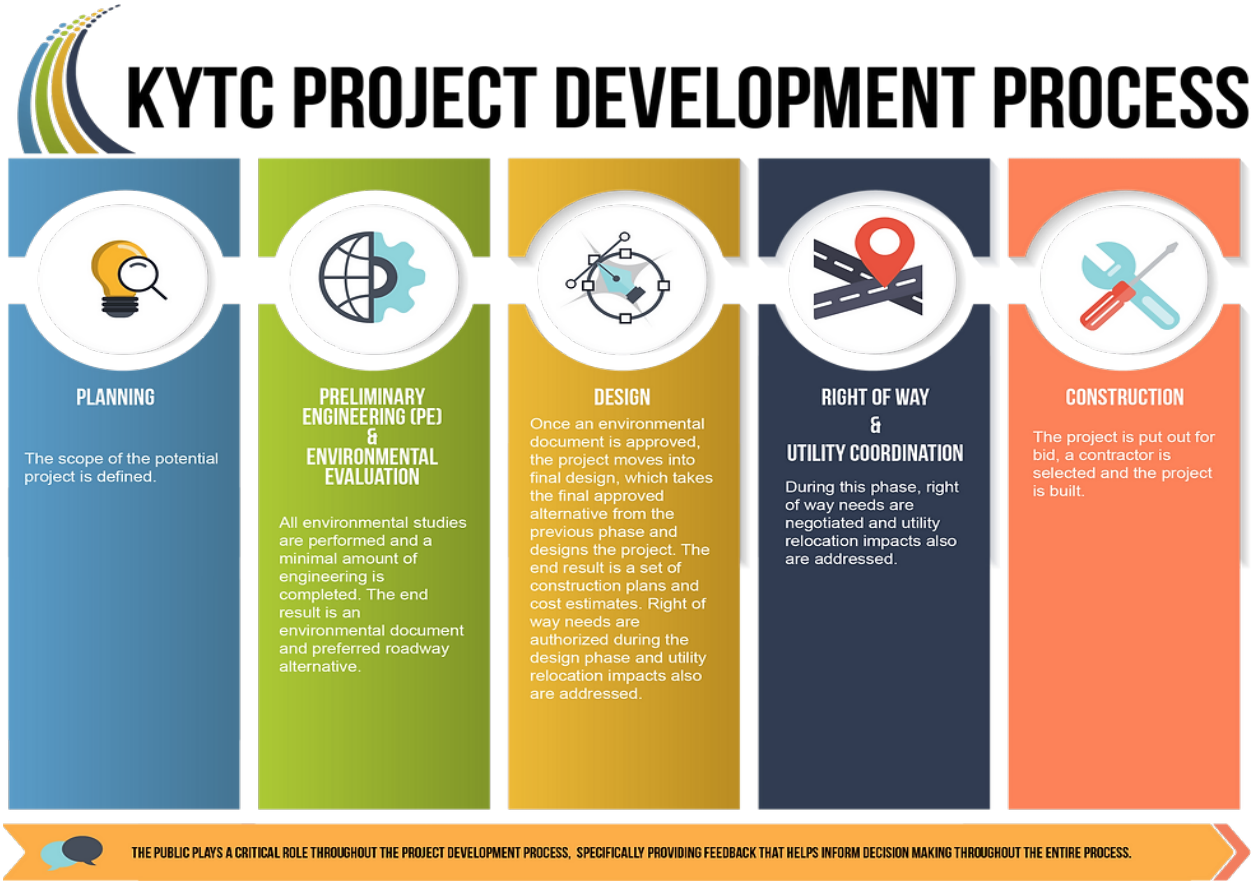


Figure 2. KYTC Project Development Process

Figure 3 on the next page presents the general steps involved in the development of a typical forecast report for KYTC, beginning with the initiation of a traffic forecast request to the KYTC Division of Planning's Modal Programs Branch. Regardless of whether KYTC or an assigned consultant performs the forecast, these steps, which will be expanded upon in the proceeding chapters of this guide, should be followed to ensure efficient and coordinated progress through the fundamental elements of forecast development.

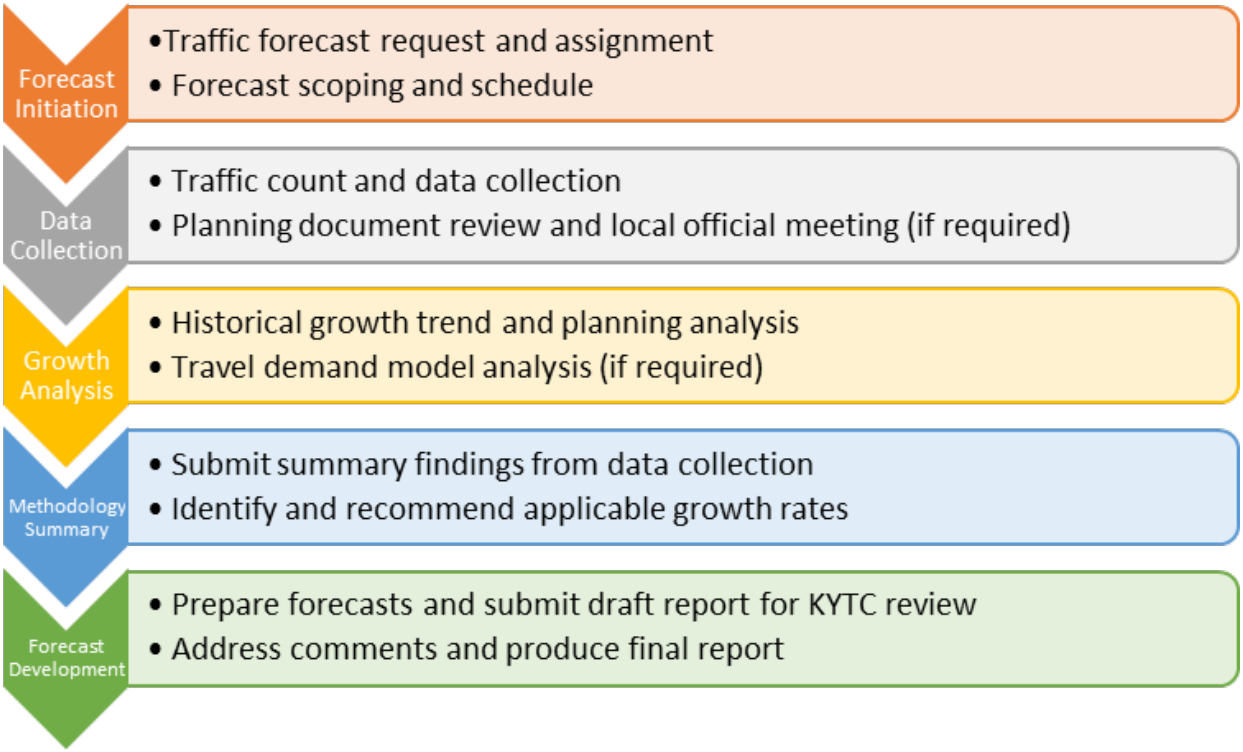


Figure 3. KYTC Traffic Forecast Development Steps

1.3 FORECAST LIMITATIONS

Before proceeding further with discussing the practical steps for developing forecast reports, it is important to remember the limitations of traffic forecasts. Traffic forecasts are simply estimates of future demand for travel. As such, all users, irrespective of their intended use, must consider the potential for variability and deviations between forecast traffic volumes and actual traffic volumes over time. Data variability, especially when forecasts rely on a small sample of counts taken over a few days, can skew existing traffic patterns and amplify an anomalous event into the future. The introduction or alteration of neighboring land uses or competing transportation facilities will also affect how traffic in the area develops. Changing growth conditions in the study area can significantly alter the pace and timing of traffic growth.

Transportation improvement projects may take a decade or more to progress from concept to construction, and in some cases more than one traffic forecast may be required to support the project implementation as it progresses. Traffic forecasts certainly have a “shelf-life”, but there is no universal time threshold for determining how long a forecast remains valid. As the project development process proceeds, forecast users should stay alert to new data, including variation in traffic counts and population growth. Always consider whether the assumptions upon which a forecast is based remain valid, or whether new data, policy, or development changes warrant updates or revisions to the forecast.

2.0 INITIATING A FORECAST

2.1 FORECAST REQUEST FORM

KYTC's form ***TC 59-5: Traffic Forecast Request***, included as **Appendix A**, is required for all forecasts used in the KYTC project development process. Submitting this request form ensures that coordination with the Modal Branch staff occurs at the beginning of forecast development, regardless of how or who ultimately prepares it. The form is organized in four sections:

Section 1 addresses the overall level of complexity expected for the forecast. Understanding at the outset of the process what is needed from the forecast will help KYTC determine the appropriate level of effort and schedule for the forecast.

- A **Simple** forecast requires no new data and no turning movement forecasts and is intended for projects with low existing volumes and low expected growth. A forecast report for simple forecast can be correspondingly brief, with no explicit requirements for unessential elements, such as maps, tables, or extensive narrative analysis.
- A **Moderate** forecast reflects a reasonable level of new data and overall effort, typically involving four or less turning movement forecasts and minimal travel demand modeling support.
- A **Complex** forecast is required for a large project area or new alignment, with five or more intersections and substantial demand model work, such as changes to model network or zonal geographies requiring new model calibration.

Section 2 is where project details are provided. This includes the type of project and the purposes for which the forecasts will be used. While several types and purposes are provided as options, the requestor should use the available extra space provided in Section 4 to describe specific project details or needs.

Section 3 addresses the forecast deliverables requested, including forecast year, scenarios, volume types, and a list of all intersections requiring turning movement forecasts.

Section 4 is intended to identify other relevant circumstances, data sources, and plans or projects that will inform or affect the forecast, including the date by which the forecast is required with recognition of the level of effort expected. Additional space is provided for written comments, as well for a list of reference materials attached to the request.

2.2 FORECAST SCOPE OF WORK

Once the Division of Planning has received the forecast request and selected the forecast developer, an official forecast scope of work ("scope") is prepared. For forecasts prepared internally by the Division of Planning, the scope may be informally documented via an internal email or notes related to the details conveyed in the forecast request. For externally prepared forecasts, a scoping meeting with the forecaster and the Modal Branch serves as the initial opportunity to clarify any questions regarding the

information provided in the request, identify existing data sources and additional data needs (particularly traffic counts), and set the schedule for deliverables. Depending on the complexity of the project, it may be beneficial for the project manager/forecast requester to participate in this meeting to ensure that all relevant project details and insights have been provided, and that the goals and expectations for the forecast are understood by all.

A defined scope serves multiple purposes, including its most important function as the established work plan for project delivery. It also serves as an outline of the final forecast report, as it formally addresses each element that will be included in the final document. In fact, the scope document should begin with an **introductory project summary** that can serve as the general introduction for the proceeding forecast report. This project summary should reiterate the information provided in the traffic forecast request form, including:

- Project description with project limits and/or mile points
- The forecast elements to be prepared, including a list of count locations and intersections with turning movements
- A corresponding road map of the study area/corridor with project limits, count locations, intersections where turning movements will be forecast, and any other notable points of interest to the forecast, such as major trip generators or developments
- A brief summary of the population and possibly employment trends of the area (city/county) to provide context regarding future traffic expectations.

For more details on the other elements included in a conventional forecast scope, review **Chapter 3.2** of the Guidance Manual.

2.3 FORECAST STUDY AREA

The forecast request should provide the basis for determining an appropriate forecast study area, and the study area should be explicitly defined during the scoping meeting and in the subsequent scope of work. Primary considerations include:

- All areas of the corridor and intersections identified in the underlying project description, including mile points and specified geographic boundaries
- Road segments or intersections specifically identified for project design
- Project objectives, such as improved connectivity, or congestion mitigation on adjacent facilities
- Major traffic generators and planned developments
- Specific traffic patterns, such as connections to adjacent freeway interchanges
- Data availability and budget

A suitable forecast study area should, at a minimum, include the project under design as well as enough of the surrounding area to reflect the future trip pattern through the project area whether it occurs within or feeds traffic to the project corridor. A forecast for a small corridor improvement may only require future directional and turning movement volumes for segments and intersections directly on the corridor, but larger projects may require a study area that extends beyond the project itself, to include adjacent intersections, parallel routes, and trip generators.

2.4 FORECAST SCHEDULE AND EFFORT

Figure 4 presents an example project schedule for a typical design forecast. This example assumes a relatively compact study area or corridor with multiple intersections identified for turning movement forecasts. Traffic counts should occur as soon as possible, which could still take several weeks to schedule. It may also be desirable to delay the collection of Turning Movement Counts (TMC) to coincide with when public schools are in session, should a school(s) be a source of traffic within or adjacent to the study area.

Other data collection including modeling work can begin while waiting for the count data. The first major milestone will occur approximately halfway through the schedule with the submission of a methodology memorandum to KYTC presenting the existing count data and growth analysis, along with a recommendation for growth rates to employ in the development of forecasts. Upon KYTC review and approval of the memorandum, which may involve discussion with the project team, the forecast can be completed, and a draft report submitted for review. Once KYTC returns its comments on the draft report, a final draft of the forecast report can be prepared and submitted for final review and acceptance.

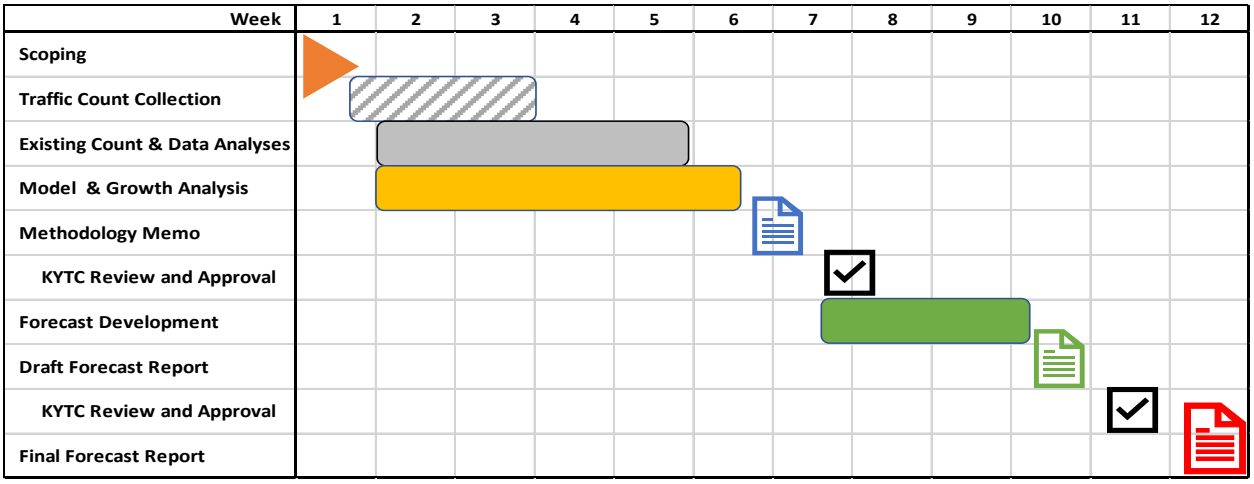


Figure 4. Example Forecast Schedule

This schedule illustrates the rough proportion of the work effort for a typical forecast of moderate to complex size and scope. A larger forecast study area with many defined segments and intersections will increase the overall project timeline. The collection of traffic counts can affect project schedules as traffic counts may be postponed to avoid collection during holidays, school and road closures, and inclement weather. Forecast tasks involving travel demand modeling, particularly if model revisions and calibration are necessary, will also affect the schedule. KYTC specifies that the expected time to complete forecasts by type are:

- **Simple**: Low volume; low expected growth; no turning movements; no new counts ≈ 2-4 weeks;
- **Moderate**: 1-4 turning movements; new counts; minimal demand modeling ≈ 6-8 weeks;
- **Complex:** 5+ turning movements; new routes; substantial demand modeling ≈ 3-6 months.

The work effort in terms of hours to prepare forecast components varies according to many factors, including the experience of the forecaster, the complexity of the project, the quality or consistency of data, required modeling tasks, and specific coordinating activities. The estimates of work effort on any given project will be discussed and negotiated by the forecaster and the KYTC project manager.

3.0 ACQUIRING AND PROCESSING COUNT DATA

The typical KYTC design forecast uses several types of traffic count data. Ideally, current and high-quality data would be available for all segments and turning movements in the study area, but realistically, budgetary and other constraints require a practical acquisition and prioritization strategy. Before collecting new counts, determine what count data are already available. Most count data can be sourced directly from KYTC's website and KYTC's Traffic Data Collections and Processing Team in the Traffic and Equipment Management Branch of the Division of Planning. Other count data may be available from other sources, such as MPOs or local government departments.

3.1 IDENTIFY AVAILABLE COUNTS AND NEW COUNT LOCATIONS

During forecast scoping, consider the following steps regarding the acquisition of available counts and identifying where new counts will be needed.

1. Compare the forecast study area to the KYTC Statewide Traffic Counts Map (https://maps.kytc.ky.gov/trafficcounts/) to determine the location of KYTC count stations within and adjacent to the study area.
2. **Historical Average Annual Daily Traffic (AADT)** counts for KYTC count stations can be downloaded from KYTC's web site CTS - Query Page (ky.gov). In addition to a range of AADT volumes by year, the CTS query page provides the most recent truck percentages, K-factors, and D-factors associated with each count station. If the most recent count in CTS is over three years old, inquire about more recent counts to KYTC's Traffic Data Collections team.

3. Request the most recent "**15 Minute Volume Report**" count files from the KYTC's Traffic Data Collections team. These are available for most count stations. Typically covering a period of 48 hours, these hourly counts include KYTC's seasonal and daily adjustment factors to calculate the associated AADT for the count station. Depending on the size of the facility, they may or may not distinguish directional volumes. In the cases that fifteen-minute reports do not exist, request the most recent **Short-term Hourly Volume** count files unless the Traffic Data Collections team gave them already as an alternative.
4. Request "**Fifteen Minute Class Reports**" from the KYTC's Traffic Data Collections team**.** While available for fewer count station locations than AADT and hourly counts, these counts provide a distribution of vehicles for each of FHWA's 13 vehicle types. In the cases that fifteen-minute reports do not exist, request the most recent **Daily Classification Counts** unless the Traffic Data Collections team gave them already as an alternative.
5. KYTC also collects peak hour TMCs on a project basis and these counts may be available for select locations. Consult with both the KTC Modal Branch and Data Collections team as well as the District project manager to identify relevant counts.
6. Contact MPO or local government staff to inquire about the count data they may have available, particularly TMCs.

   Consider the age of the available counts. KYTC station counts are typically counted on a three-year cycle. Counts between three and five years may still be valid for areas with mild to moderate traffic growth and no substantial new development or other discernable changes to traffic patterns. Under most circumstances, counts older than five years should not be used for primary study locations, but may still have value to reflect volumes peripheral to the study area. Extraordinary circumstances, such as the recent COVID-19 pandemic, may make counts collected during a specific period atypical and either unusable or subject to specific adjustment.
7. Cross-check the list of available and suitable counts with the intersections or other locations specifically identified in the forecast request. Prioritize the locations for which counts are not available for new count collection. TMCs are essential for any intersection for which turning movement forecasts are requested, although Streetlight data has been used to estimate turns on specific occasions.
8. Intersection TMCs are generally recommended for all signalized intersections and for interstate ramp terminals. For other intersections with approach volumes of at least 1,000 VPD, prioritize those that are on the corridor or roadway segments where design is planned.
9. Consider the impacts of adjacent and connected roadways and traffic generators and determine whether updated hourly or ADT count data is necessary to properly account for their impact on the study corridor or area.
10. 15-minute spot TMCs during peak hours may be collected to get a broader sample of low volume approaches and commercial driveways.

11. For new counts, be sure to specify the vehicle and truck classifications to be counted, for both directional counts and TMCs.
12. Consider available daily classification counts from adjacent count stations to serve as a proxy for the study corridor. A new classification count is only warranted if there is a consensus that the distribution of sub-classes of heavy trucks varies substantially from the local area (for example, the presence of a coal haul route or major industrial facility).

3.2 COUNT COLLECTION TECHNOLOGIES AND BEST PRACTICES

All new count collections should be coordinated through KYTC. Counts may be collected by KYTC or by a data collection firm prequalified by KYTC to perform this task. There are four primary technologies for collecting count data on a temporary basis:

- **Manual counts** using electronic counting boards provide great flexibility and adaptability in the field but are labor intensive and subject to human error. It may also be difficult to find a suitable or safe location to observe all locations, especially for large intersections or relatively complex interchanges. Manual counts are especially useful for short spot counts at low volume locations, for sampling purposes.
- **Pneumatic tube counters** are laid across the roadway to count both total vehicles and vehicles by class and by lane. It is an economical method for collecting all 13 FHWA vehicle classes. As installation occurs on active roadways, proper safety protocols are essential. It is good practice to validate tube counts with manual counts to ensure they recorded data accurately.
- Specialized **video cameras** are secured on utility posts to record intersections and roadway segments. A third-party processer typically processes the videos and returns directional and turning movement count data in standard count file formats, such as Petra Pro (.ppd), pdf, and Microsoft Excel. One advantage of video collection is that cameras can record for multiple days, but count processing can be limited to specific periods, reducing costs. The video can also be used to observe traffic operations and validate data. However, video count providers often compress the number of classes in which vehicle and truck classes are counted, with typically only five bins of vehicles types reported.
- **Online data vendors**, such as StreetLight, Inrix, and Replica are new sources for estimated count data collected via GPS and other mobile device capture technologies. These data are higher customizable by time and location and can be acquired relatively quickly. However, as these data are not actual observed counts but estimates based on sampling algorithms, they must be validated with other collected counts to confirm feasibility for use.

Consider the following best practices for collecting new traffic counts.

- Unless required for specific reasons, counts should be collected during the middle of the work week (Tuesday through Thursday).

- Counts should be collected while schools are in regular session and in fair weather conditions. Avoid holiday periods such as late December or spring break.
- Do not collect counts near where road work or other temporary traffic control is occurring. Monitor traffic reports to ensure traffic incidents do not affect count collection. Avoid counts during special events, such as a large sporting event or concert.
- Optimally, hourly directional counts should be collected for 24 to 48 hours to provide a sufficient sample for estimating ADTs and diurnal factors. At a minimum, hourly counts should cover all hours comprising the AM and PM peak periods, in order to effectively identify the 60-minute AM and PM peak hours. The peak periods for data collection may be affected by adjacent land uses, such as factories with unique shift changes or schools with start or dismissal times that may fall outside the “traditional” peak hours for travel.
- TMCs should be collected for the highest two-hour peak period for AM and PM peaks, as assessed by nearby fifteen-minute (or hourly) traffic station counts or local input. Counts should be collected in fifteen-minute increments. The time period for traffic turning movement data collection can include a continuous twelve hours (typically 6:00 AM to 6:00 PM) or can be tailored to capture only the AM and PM peak periods of travel. In rare occasions, it may also be desirable to account for a mid-day peak period if a continues twelve hours of data will not be collected. In such cases, this will be discussed during the scoping meeting.
- For most forecasts, collect counts separately for light passenger vehicles (cars, pickup trucks, and vans), medium sized/single unit trucks, and heavy/combination trucks. Note if motorcycles and buses are collected separately. Consult with KYTC to determine if new FHWA 13-vehicle class counts are required, or if class counts from an adjacent count station can serve as a proxy distribution for additional truck sub-classes.

3.3 COUNT TEMPLATES AND PROCESSING TOOLS

Hourly directional and classification counts are saved as text, .csv, or pdf files and should be easy to transfer to Microsoft Excel for further formatting. Examples of KYTC hourly directional and daily classification count reports are included in **Appendix A**. TMCs recorded using manual count boards can be downloaded, viewed, and edited via software provided by the vendor. The predominant software used in Kentucky is Jamar’s Petra Pro. Petra Pro can save count files in its own file format (.ppd), as a pdf or Microsoft Excel (.xlsx) file, and in other formats. Video counts processed by third party vendors such as MioVision are also initially processed and returned in these same formats.

The standard Petra Pro file output will present the count data in tables with rows representing time increments (typically fifteen minutes) and columns representing turning movements for each movement at every intersection approach. Petra Pro can export customizable pdf reports. The default templates include turning movement tables and diagrams for each peak period and each peak hour. Default reports also include percentage breakouts of vehicle classes by turning movement and approach. An example of a Petra Pro pdf report is included in **Appendix A**.

KYTC, like many state Departments of Transportation and other professional forecasters, has developed its own Microsoft Excel tools for entering count data for further processing and forecast preparation. These multi-tabbed templates use formulas and functions, and factor look up tables to calculate count statistics and parameters, identify peak hours, populate turning movement diagrams, and prepare the count data for further forecast tasks. **Chapter 5** will go into greater detail about the methodologies used in these tools.

3.4 COMMON COUNT PARAMETERS

Various count statistics are often requested as part of traffic forecasts or required for other parts of the traffic forecasting process, including the following common statistics:

- **K-factors** represent the relationship between the **Design Hour Volume (DHV)** and the **AADT** for a given count location. The KYTC provides default K-factors for each of its count stations on its count web site. The ***PL 43 Traffic Forecasting Report 2023*** from the Kentucky Transportation Center (Research Report: KYTC-24-22) provides average K-Factors by functional class in **Table 3.2** and **3.3.** In practice, a K-factor for an individual count location can be estimated by dividing the ADT by the highest sixty-minute volume factored by its respective adjustment factor from **Table A.9** or **A.10** of the PL 43 Forecast Report. For more information, see **Section 3.4.1** of the *Guidance Manual*. As noted previously, the typical KYTC process is to estimate independent DHVs for the AM and PM peak (as opposed to peak hours); should a singular DHV be required for project purposes, it is generally estimated as the PM DHV.
- **D-factors** represent the percentage of traffic in the higher volume direction during the DHV. KYTC also provides default D-factors for each count station on its count web site. In practice, a D-factor can be calculated from dividing the highest hourly directional volume by the total hour directional volume for a count location.
- **Peak Hour Factors** (PHF) are often calculated to demonstrate the degree of traffic peaking characteristics occurring within the peak hour. It is calculated by dividing the total hourly volume by the highest single fifteen-minute period volume and then multiplying by four. A PHF of 1.0 means that volume is evenly distributed throughout the hour. On the opposite end of the spectrum, a PHF of 0.25 means that all traffic occurs in a single fifteen-minute period.
- **Truck percentages** are calculated for both hourly counts and TMCs by dividing the number of single-unit and combination-unit trucks by the total traffic volume. Truck percentages are calculated for both daily and hourly volumes, but not typically for individual turning movements. The KYTC count web site includes default single-unit and combination-unit truck percentages for each of its count stations.

It is common for many intersection count locations to have counts of less than a full day even though an **ADT** is needed for each approach to apply growth rates for future forecast volumes. The partial day count should include the highest peak hour volume, which could be adjusted by a design hour factor and then a K-factor to estimate an AADT. Alternatively, the proportion of hourly volumes for an adjacent 24-hour hourly count can be calculated and applied to factor up the respective hours available in the partial count

to create an ADT. For example, if a turning movement count has a total of six hours of counts (three in the AM period and three in the PM period), the reciprocal of the proportion of those same hours from an adjacent hourly count can be applied to the partial count hours to estimate a representative ADT. By expanding the number of individual hours to factor to an ADT (one DHV versus six total peak hours), this approach deemphasizes the concentrated peaking and directionality that is more likely to exist in a single hour.

4.0 ESTABLISHING GROWTH RATES

Growth rates are the developmental element of a traffic forecast that connects existing traffic volumes to their respective future year forecast values. They are informed by the following sources:

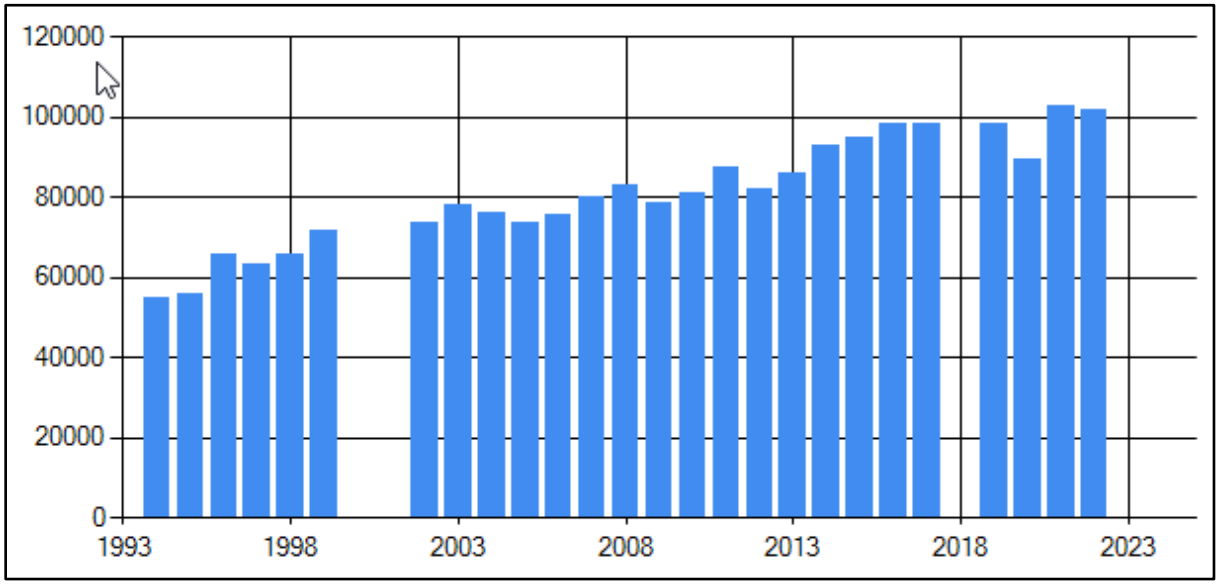
- Historical traffic counts
- Travel demand model assignments
- Population (and possibly employment) trends and forecasts
- Other planning documents, including development plans, transportation plans, or comprehensive plans, and
- Previous or adjacent traffic forecast reports

Trends estimated from historical traffic counts and travel demand model assignments are the most common and transparent sources for establishing growth rates. Historical counts, by definition, reflect what has occurred and a well informed and well calibrated travel demand model is designed to reflect what will occur. However, it is important that a forecast reflect all relevant factors, especially if they are not evident in those two sources alone. While population and employment trends should be incorporated into the travel demand model's zonal data, comparing the model's rate of traffic growth to the area-wide growth of the community is a good reasonableness check. A review of planning documents will alert the forecast developer to critical developments and adjacent projects that should be accounted for and may also provide applicable growth rates as well. Finally, new forecasts should recognize the growth assumptions of other relevant forecasts, even if only to demonstrate how new information necessitates a change in course.

The acquisition and analysis of all these data sources can begin immediately upon the approved scope, in parallel with the collection of new project-specific count data. In practical terms, individual growth rates can be developed from each of the various sources and offer a common metric of comparison between each source.

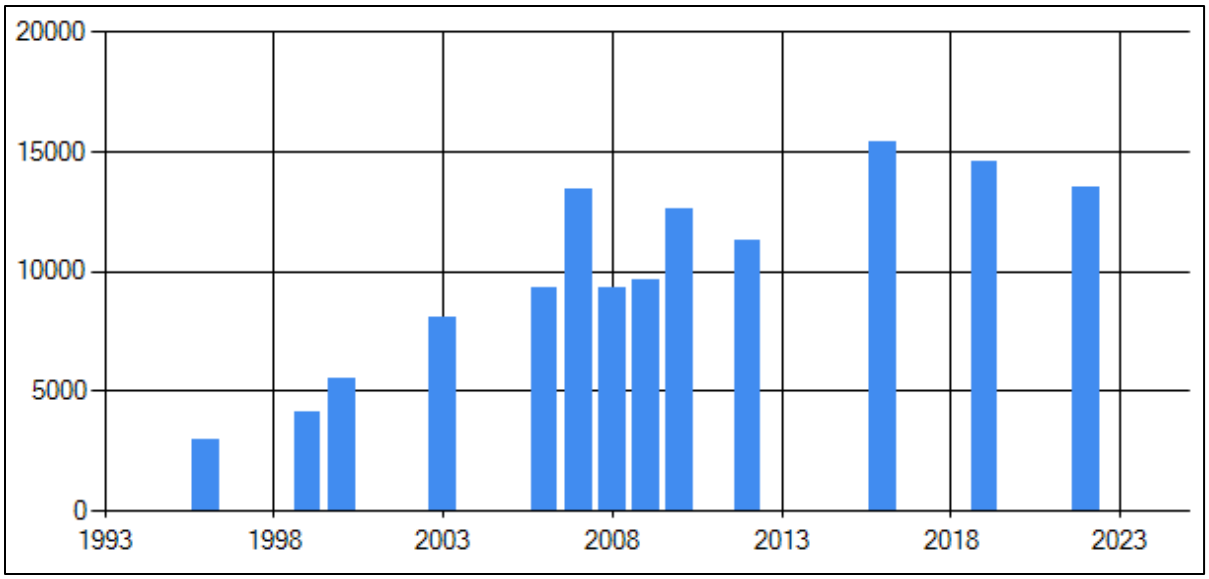
4.1 HISTORICAL COUNT TRENDS AND THE COMPOUND ANNUAL GROWTH RATE (CAGR)

KYTC's online CTS database is the best source for historical count data. It includes AADTs for multiple years within the most recent 30-year period, in both table and chart form. **Figure 5 and 6** depict the individual count station volume charts from KYTC's CTS database for I-75 in Fayette County and KY 237 in Boone County. **Figure 5** shows the consistent linear growth of traffic on I-75 near Lexington, as well as the COVID effect recorded in 2020. **Figure 6** reflects the exponential growth curve of a corridor serving a rapidly developing area north of the Cincinnati/Northern Kentucky International Airport (CVG). It also shows the downward effect on demand resulting from a recently completed roadway and interchange project on an adjacent corridor. Both graphs show the fluctuations in recorded volumes that can occur between adjacent years.



Source: https://maps.kytc.ky.gov/trafficcounts/

Figure 5. I-75 Historical Count AADT, Fayette County (Station 034049)



Source: https://maps.kytc.ky.gov/trafficcounts/

Figure 6. KY 237 Historical Count AADT, Boone County (Station 008054)

Almost every forecast project incorporates multiple historical counts that will differ in relative volume, growth, and consistency. From a practical perspective, it is most efficient to depict the data from these count locations in a single table and chart. **Table 1** and **Figure 7** present the table and chart created for a forecast project in Bullitt County. The chart in **Figure 7** includes both individual data points for counts and a linear regression line estimated from each count data set.

Table 1. Historical AADT Volumes by KYTC Count Station

Year	Sta 015803 (KY 1450)	Sta 056587 (KY 1450)	Sta 015804 (KY 1450)	Sta 015805 (KY 1526)	Sta 015790 (KY 1526)	Sta 015836 (CS 5036)	Sta 015767 (KY 61)	Sta 056590 (I-65)
1998	6,520	8,130	2,160	21,700				82,900
1999								
2000							20,100	
2001						6,970		79,600
2002		9,780	2,580	18,700	13,600		17,100	86,800
2003								
2004	6,940	10,300				5,280	15,800	96,400
2005					13,200			
2006			2,170	23,600				
2007	10,200	10,400				5,060	18,000	84,100
2008	10,500				13,400			85,500
2009	10,400		2,550	25,300				
2010	10,800	10,200				6,570	16,100	97,900
2011					14,200			98,100
2012			2,053	24,542				97,625
2013	9,697	10,391				4,318	14,828	99,865
2014					14,783			89,264
2015								102,398
2016	9,842	8,227				4,153	16,468	
2017					14,441			105,898
2018			2,266	26,145				110,103
2019	10,412	10,353				5,341	18,451	
2020[1]					14,176			93,983
2021			2,377	25,135				104,574
Long-term (1998-2021) % CAGR	**1.9%**	0.3%	0.0%	1.0%	0.1%	-1.7%	-0.4%	1.3%
Medium-term (2011 - 2021) % CAGR	**1.2%**	-0.1%	1.7%	0.4%	0.3%	3.8%	3.8%	1.2%

Source: https://maps.kytc.ky.gov/trafficcounts/
[1]Counts taken during 2020 may reflect depressed volumes due to the the COVID pandemic.

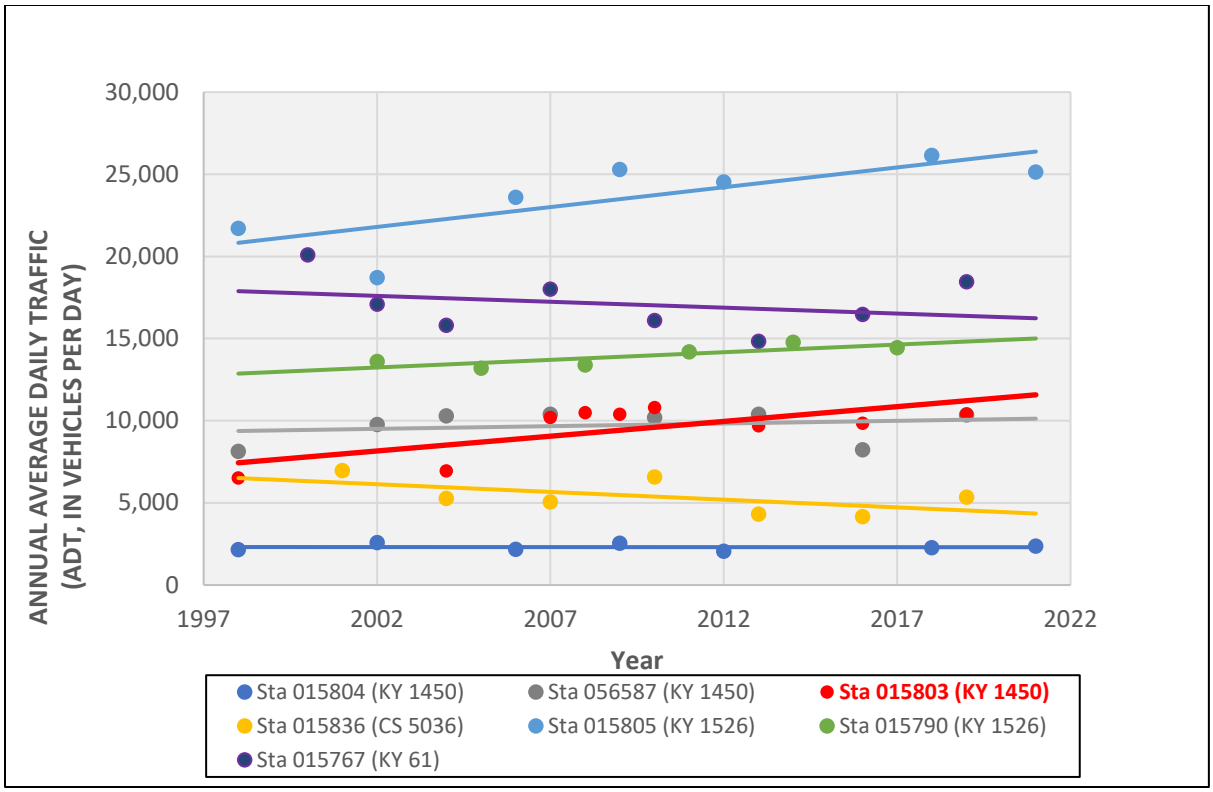


Figure 7. Historical AADT Volumes by KYTC Count Station

As shown at the bottom of **Table 1**, estimating a Compound Annual Growth Rate (CAGR) is an effective method for creating and comparing the growth rates of individual trend lines to each other. The equation for a CAGR, which is most often converted to a percentage:

$$CAGR = \left(\frac{V_n}{V_1}\right)^{1/(y_n - y_1)} - 1$$

Where: V_n = Volume for final year in series
V_1 = Volume for first year in series
y_n = Final year in series
y_1 = First year in series

As an example, the 20-year CAGR equation for I-75 traffic recorded for KYTC count station 034049 and presented in **Figure 5** is:

$$\%CAGR = \left(\frac{102{,}098}{73{,}900}\right)^{1/(2022-2002)} - 1 = 1.6\%$$

Some important aspects regarding the estimation of CAGRs from traffic counts include the following:

- As depicted in **Figure 5 and 6** and discussed in section 3.4.5 of the guidance manual, traffic counts can reflect both linear and exponential growth trends. While the CAGR equation is technically an exponential equation, a low CAGR value behaves similarly to a linear trend line, making it possible to use CAGRs as a common metric for comparison.
- Consider estimating separate 10-year and 20-year CAGRs for each count location. This allows the forecaster the opportunity to see if early, higher growth rates that occur when volumes are relatively low taper over the more recent 10-year period. The comparison of these rates will serve as an important point of consideration for establishing the recommended long-term growth rates to be used in the forecast.
- Identify and discard outliers, such as construction events or COVID when estimating a CAGR. Further, a substantial change in the network and traffic pattern may signal the beginning of the relevant growth pattern to consider.
- As **Table 1** illustrates, missing or sparse data points can make estimating CAGRs for comparable times periods across multiple counts difficult. One suggestion is to use the Microsoft Excel regression tools in its chart function to create linear regression lines for each count as shown in **Figure 7**. In addition to smoothing out the natural fluctuation from year to year, it will provide a proxy value for any year in the time series to use in that count's CAGR equation.
- While the CAGRs for adjacent roadway facilities or segments provide insight into overall growth in the study area or in a particular location, the growth rates directly on the corridor should be weighted higher in importance than those for peripheral locations.

4.2 TRAVEL DEMAND MODEL ASSIGNMENTS

It is tempting to assume that model assignments for a future year scenario can be used directly in forecasts. However, even the most well calibrated and validated models are still approximations derived from a long series of assumptions and calculations far removed from the foundation of observed count data. In situations involving a new alignment, model assignments may be the best option, but for forecasts involving existing facilities, it is best to convert model assignment volumes to CAGRs, which can then be compared directly with the CAGRs from historical counts. This approach allows the forecast developer to incorporate the primary value of the model's synthesis of various data points, particularly related to future conditions, while reducing the impact of model error - the difference between observed volumes and assigned volumes.

Section 3.7 in the guidance manual discusses the use of models in forecasting in detail. Some practical notes regarding working with models and model assignments include the following:

- While a forecaster does not need to be an expert in demand modeling to estimate CAGRs from base year and future year model assignments, performing a model run and making changes to model files, whether to make corrections or create new scenarios, requires specific software and experience with the model. Work with KYTC's Modal Branch staff to assist with or direct specific

modeling tasks as necessary. Do not use or make changes to a KYTC model without receiving specific authorization from the Modal Branch.

- To recall the adage, “garbage in, garbage out,” A model is only as reliable as the data inputs used to inform and calibrate it. Before using model assignments, review the model networks for both the base and future year scenarios, including important attributes such as lane configurations and speeds. If important elements are missing or wrong, correct them. Similarly, review the zonal data corresponding to the model’s Traffic Analysis Zones (TAZs) to ensure that population and employment estimates are accurate for the scenario.
- It is important to note that demand models are “macro” in scale and typically do not include low volume local roads and driveways. Focus on major network facilities but ensure that all essential network connections for which unique growth rates will be required are included.
- It is less common but forecast scenarios sometimes necessitate a model adjustment or split TAZ boundaries to reflect important growth and traffic patterns. This is a relatively more advanced procedure than basic network or TAZ editing and will require specific knowledge of the model’s script and associated matrix files.
- Document all identifying elements of the model in the forecast report, including its name, version/update data, base year and future forecast years, and the number of TAZs. This allows reviewers and future forecast users to understand the source of the underlying assumptions such that they can be repeated or updated, if necessary.
- Section 3.7.2 of the guidance manual discusses the Root Mean Square Error (RMSE) validation statistic, which should be used to assess the accuracy of the model specifically in the project area. Report the validation statistics for the overall model for the project study area, including RMSE and summary Volume to Count (V/C) ratios.
- Include maps of the model network and TAZ boundaries for the project area. These maps should include relevant model assignments (example shown on **Figure 8**) and population and employment in the study area TAZs (example shown on **Figure 9**).
- Review and receive approval for all model adjustments and output assignments from KYTC Modal Branch staff before proceeding with using model assignments.

Once approved for use, model assignments from the base year and future year of the model can be used to estimate CAGRs that can be compared to the CAGRs estimated from historical count data. Because they are forward looking, it should not be expected that they will necessarily match the CAGRs of their count counterparts. However, there should be a clear rationale for why they are different. Similar to the count CAGRs, the estimates on the most critical corridors should be weighted higher.

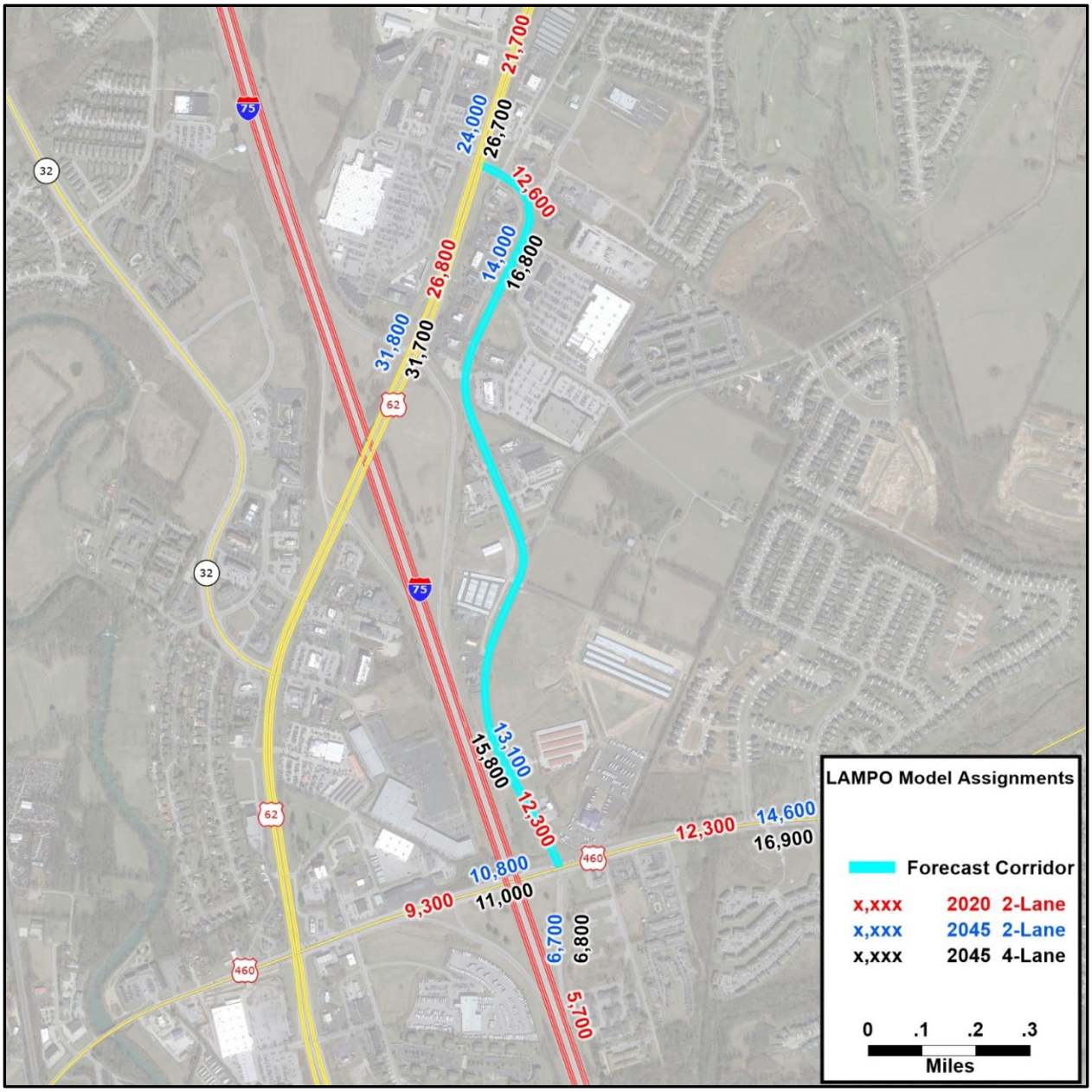


Figure 8. Example Model Assignment Map

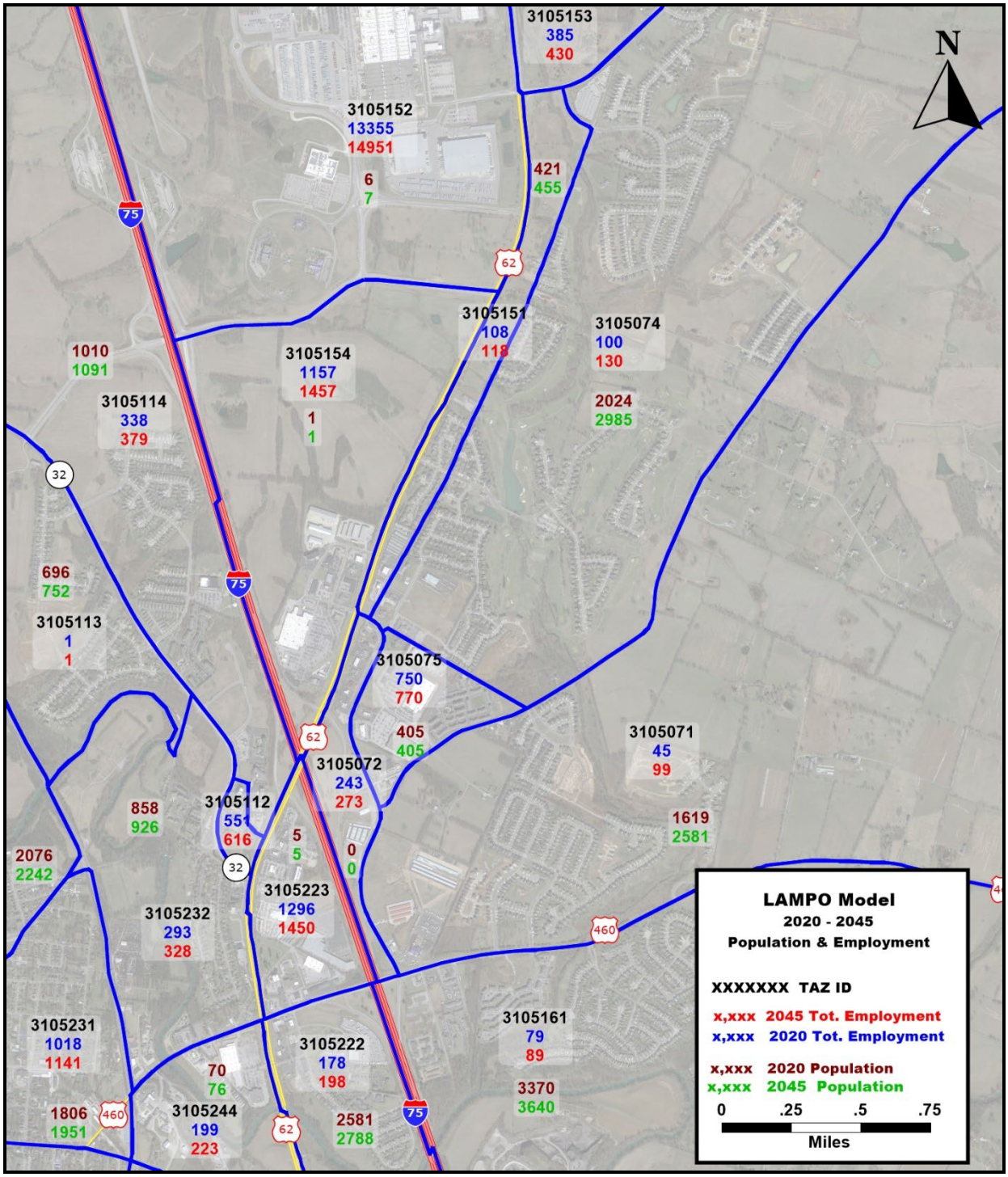


Figure 9. Example Model TAZ Map

4.3 POPULATION AND EMPLOYMENT TRENDS

Population trends, and to a lesser extent, employment trends, provide important context when establishing growth rates to use in developing traffic forecasts. Below are the most relevant sources for such data:

- US Census (www.census.gov/data.html) - Historical population and household statistics to the block level.
- Kentucky State Data Center (KSDC) (ksdc.louisville.edu/) - Census summaries and county level household and population projections to the year 2050.
- The US Bureau of Labor Statistics (www.bls.gov/data/) provides historical country level employment data based on employer payroll records and the US Bureau of Economic Analysis (www.bea.gov/data/employment) provides similar data based on worker surveys.
- Regional or Local Comprehensive/Land-use Plans – Population and employment data at multiple levels, and potentially specific details regarding the location of future development
- Travel demand model TAZ files can serve as another source for small area future population and employment, although it is important to acknowledge the employment projections are more speculative in nature.

The level of analysis of population statistics is dependent on the relative level of growth in the project area. In mature areas with mild to moderate population growth, a table presenting the past 20 years of population statistics at the state and county level, as well as projections from the KSDC may be sufficient. Table 2 presents an example for an area in southern Kentucky with low growth. In addition to the population statistics, it reports the corresponding CAGRs for both historical and projected population growth. For areas experiencing more rapid growth, it is recommended to include data from relevant census tracts or block groups, and possibly TAZ data. Include employment data when significant shifts in employment, such substantial new commercial development, is expected to be a primary driver of traffic growth in the county and project area.

Table 2. Example Population Statistics

Area	Census Estimates			CAGR	2040 Projection	CAGR
	2000	2010	2020	2000 - 2020		2020 - 2040
Kentucky	**4,041,769**	**4,339,367**	**4,505,836**	**0.54%**	**4,886,381**	**0.41%**
Logan County	26,573	26,835	27,423	0.16%	25,618	-0.34%
Todd County	11,971	12,460	12,243	0.11%	13,092	0.34%
Russellville	7,149	6,960	7,164	0.01%	--	--
Guthrie	1,469	1,419	1,330	-0.50%		
Logan & Todd	**38,544**	**39,295**	**39,666**	**0.14%**	**38,710**	**-0.12%**

Source: 2020 U.S. Census; Kentucky State Data Center

Again, it is not to be expected that CAGRs estimated from population and employment data would directly match CAGRs estimated from counts or model assignments, but there should be a contextual relationship between them. For example, traffic in counties with slow to no projected population or job growth should not be expected to grow at a significantly higher rate without a clear explanation, such as the identified growth in external through traffic.

4.4 OTHER PLANNING DOCUMENTS AND FORECASTS

While historical count data, model assignments, and basic population data are the primary data sources for establishing growth rates, other sources for forecasts and growth assumptions, when available, are also relevant. As with all data sources, their age, level of detail, and supporting data are all factors when considering their value. Identify sources and document what information is relevant to the forecast.

Comprehensive land-use plans, whether prepared by a local or regional planning agency, have the benefit of local knowledge and may include their own expected growth rates along with comparable statistics. These plans are particularly useful in areas transitioning from rural or exurban land uses to suburban and urban uses, as they may provide explicit details about development expectations not found elsewhere.

Transportation plans, prepared at the local or regional level, or on behalf of KYTC, may have some form of forecast or potential project information, including growth assumptions and possibly planning level forecast volumes.

Previously prepared traffic forecasts, whether from an earlier phase or legacy project, or for an adjacent project should be identified and briefly documented. Include all comparable growth rates and specifically address why these rates are or are no longer relevant, given new observed data. It is particularly important that adjacent forecasts that are the primary source for active KYTC projects under development do not have unaddressed conflicting growth assumptions or growth rates.

4.5 SUMMARIZING AND RECOMMENDING GROWTH RATES

Once all the various sources for growth rates and assumptions are analyzed, they should all be included in the Methodology Memorandum developed for submission to KYTC for approval before a specific set of recommended growth rates is adopted. As a part of that documentation, a narrative summary should directly consider the relationship of the various rates and relative weight of each of the sources. If there is an explicit conflict between sources and growth rates, provide an explanation and recommendation for how the competing rates can or cannot be reconciled.

Through the course of the growth analysis, multiple growth rates will be generated for various network links and locations within a project area. In contrast, the recommended growth rates for use in the final forecast should be limited to as few as possible to facilitate a smooth balance of forecast link volumes across a corridor and turning movements between approaches. For a small to moderately sized forecast area, the total number or recommended growth rates should be three to four or less. Growth rates should be the same or relatively close for locations along the same primary corridors, with minor approaches

assigned uniform rates where possible. Recommended growth rates serve as a conclusion for the methodology memorandum to KYTC and reflect the primary consensus metric to be considered and accepted by the KYTC project team before final forecasts are developed.

5.0 FORECASTING TURNING MOVEMENTS

Almost all traffic forecasts involve the distribution of vehicular turn movements through at least one or more intersections or interchanges. Turning movements are integral within an overall traffic forecast as the individual movements (left, right, and through) entering and exiting an intersection add up to the approach volumes that become the directional link volumes for the larger forecast network. Assuming no unaccounted intermediate driveways or breaks in the network, the approach volumes of adjacent intersections become the directional link volumes between each intersection. **Figure 10** shows two adjacent ramp terminal intersections at an interstate diamond interchange with an arterial highway, illustrating how the adjacent approach volumes equate to the directional volumes for the network link connecting the two intersections.

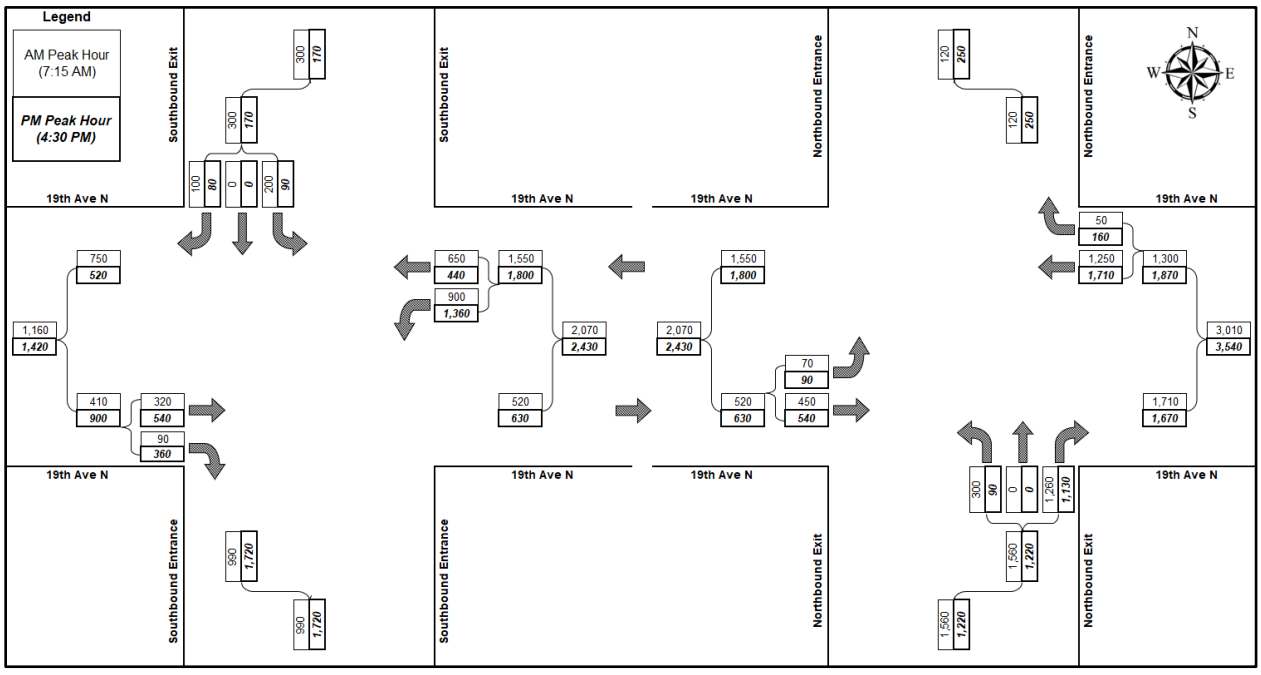


Figure 10. Turning Movement Diagram with Adjacent Intersections

Forecasting turning movements through an intersection is the most computationally complex aspect of a forecast project, as it involves the distribution and balancing of multiple movements. For that reason, most practitioners, including KYTC, develop a customized spreadsheet tool with templates, look-up tables, and formulas to perform this work. In addition to establishing a consistent process for streamlining the process, these tools also provide a transparent and organized record of the forecast process for future review and reference.

5.1 PRIMARY TOOL ELEMENTS

While different tools vary in design and included features, a complete tool will include the following fundamental elements, often organized within individual tabs in the tool's spreadsheet file.

- **Documentation**. Most tools begin with a "Documentation" or "Start" tab that describes the tool's steps and organization. It will include instructions and often color-code keys to indicate how tabs, sections, or cells are identified and used throughout the tool. For example, tabs with input fields may be shaded in yellow while tabs with self-populating calculation fields are shaded in red. Additional instructions, warnings, or notes will likely occur throughout the tool, and all should be carefully heeded, as even small alterations in formulas or cell references can produce downstream consequences.
- **Project data and inputs**. Prominently identified input fields for project details, such as count dates, forecast years, street names, and functional classes, allow for the consistent propagation of these data for use in the tool's many calculations and labels. Many of these fields may be on the first introductory tab or in a dedicated tab. Other important data inputs, such as target ADT values by approach and forecast growth rates by approach, may be imbedded within the specific steps for which they are used.
- **Input TMCs**. TMCs are typically input into a specific tab or table area that is formatted to easily accept the count data from the output files provided by the count collection. This format includes rows for each 15-minute increment counted and columns for each approach's turning movements. **Figure 11** presents an example section of the KYTC count input table for a PM peak period. There may be additional input areas for multiple vehicle classes and output fields for count summaries and other statistics, such as highest peak hour volumes and peak hour factors.

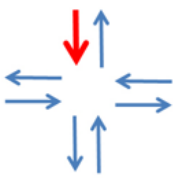
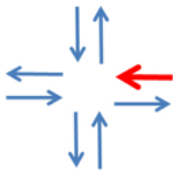
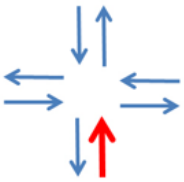
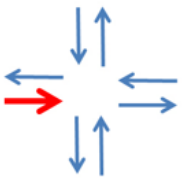
DATE & TIME													
		RIGHT	STRAIGHT	LEFT	RIGHT	STRAIGHT	LEFT	RIGHT	STRAIGHT	LEFT	RIGHT	STRAIGHT	LEFT
4/12/23 3:30 PM	Wednesday	3	5	0	0	277	19	39	13	74	0	0	0
4/12/23 3:45 PM	Wednesday	0	8	1	1	308	24	79	30	102	0	6	7
4/12/23 4:00 PM	Wednesday	7	11	6	0	357	29	90	40	139	68	470	5
4/12/23 4:15 PM	Wednesday	9	18	3	2	366	34	72	35	116	70	544	6
4/12/23 4:30 PM	Wednesday	4	9	5	2	345	25	105	59	173	57	509	11
4/12/23 4:45 PM	Wednesday	3	8	2	2	412	33	78	55	130	66	468	2
4/12/23 5:00 PM	Wednesday	5	11	1	7	427	31	76	39	133	53	503	10
4/12/23 5:15 PM	Wednesday	5	19	6	1	379	30	76	53	124	71	489	7
4/12/23 5:30 PM	Wednesday	5	12	1	1	339	26	84	36	125	41	494	9
4/12/23 5:45 PM	Wednesday	3	6	1	2	346	27	45	24	100	53	578	6

Figure 11. KYTC Turning Movement Forecasting Tool: Count Data Input Table

- **Reference tables**. Look up tables for seasonal adjustment factors by functional class may be referenced to convert raw count data to DHV and AADT values. It is important that the date of the counts used in the forecasts is explicitly stated along with any assumptions concerning roadway characteristics (e.g., roadway functional class) so that reviewers can verify any adjustments.
- **Calculation Fields**. The essential core of the tool is the formula fields and tables performing the various calculations that occur as part of each step of the forecasting process. As noted, these fields and tables will often be color coded to suggest caution concerning user edits and provide notes describing the purpose of each calculation.
- **Turning Movement Diagrams**. Templates for diagramming the turning movements entering and exiting the intersection are valuable visual aids for both the observed base year estimates and for final forecasts. These templates can also serve as output exhibits for use in forecast reports, so it is important that they effectively communicate the flow of movements and all descriptive information (year, time period, road names, etc.) related to each diagram.

5.2 TURNING MOVEMENT FORECASTING STEPS

A typical tool like the one used by KYTC proceeds through multiple steps to process and diagram both the observed and forecast turning movements through an intersection. Again, while process designs can differ, the following general steps for forecasting turning movements are common.

1. Turning movement count data for the intersection, delineated in 15-minute increments, are input into the tool. The length of the period for which data are input may vary but should include at least two to three hours for each peak period to ensure that the highest peak hour within each period is captured.
2. The base year peak hour turning volumes for all hours available are organized in a table of entering and exiting turning movements, as shown in the example in **Figure 12**. Entering volumes for each approach are presented in rows and exiting volumes for each approach are presented in columns. This organization will serve as the basis for employing the Fratar Method balancing procedure used to grow and balance all turn movements to match higher ADT and future year approach volumes. The Fratar Method will be discussed in **Section 5.3**.

Observed		1	2	3	4		
		Example Dr. (N)	Textbook Pkwy. (W)	Example Dr. (S)	Textbook Pkwy. (E)	Totals	Desired
1	Example Dr. (N)		118	467	389	974	2,458
2	Textbook Pkwy. (W)	73		1043	9139	10255	22,591
3	Example Dr. (S)	486	942		1736	3164	7,351
4	Textbook Pkwy. (E)	485	7561	1629		9675	25,158
Totals		1044	8621	3139	11264	**24068**	
Desired		2,458	22,591	7,351	25,158		

Figure 12. KYTC Turning Movement Forecasting Tool: Example Turning Movement Fratar Table

3. The tool identifies and extracts the highest four consecutive 15-minute periods, representing the peak 60-minute peak hour volume for each period. Additional calculations for identifying the respective Peak Hour Factor may also be performed during this step.
4. If appropriate, DHV adjustment factors may be applied to the peak hour turn movements, using a look-up table of monthly and daily factors for each roadway functional class. These seasonal factors should be the published factors for Kentucky provided by KYTC.
5. The base year peak hour movements are rounded to increments of five or ten and populated within a turning movement diagram similar to the examples in **Figure 10**. When rounding, all allowable movements should be presented with a minimum positive value (five or ten).
6. Identify the base year ADT for each approach. If a full ADT or AADT count is not available for an approach, use an appropriate K Factor and D Factor to estimate an ADT based on the highest peak hour volume. Alternatively, if 24-hour count data are available for a similar count station nearby, apply the ratio of comparable hours to 24 hours from that segment.
7. The base year ADTs for each approach, divided evenly between entering and exiting traffic unless specific circumstances such as one-way approaches dictate otherwise, are input for use in the Fratar Method balancing process to produce daily turning movements that sum to match those desired daily approach volumes. These ADT values are included in the example Fratar table as “Desired” volumes in the shaded cells in **Figure 12**.
8. The recommended annual growth rates for each approach (**Section 4.5**) are applied to the base year ADT to estimate the forecast year ADT volumes for each approach.
9. The Fratar Method balancing process is applied a second time (using the same turning movements from Step 2) to produce the future year turning movements that sum to match the forecast year ADT approach volumes, which are now the desired approach volumes.
10. The final, base year peak hour turning movement volumes are factored by the ratio of the ADT turning movement volumes for the forecast year to the base year to create the forecast year peak hour turning movement volumes.
11. The forecast year peak hour movements are rounded to increments of five or ten and populated within a turning movement diagram similar to the examples in **Figure 10**. When rounding, all allowable movements should be presented with a minimum positive value (five or ten).

5.3 THE FRATAR BALANCING PROCEDURE

If ADTs for all intersection approaches are assumed to grow at the same rate, turning movements would grow by the same proportion and estimating future turning movements simply requires the application of a single factor to each movement. Where approach volumes are expected to grow at different rates, growing future turning movements to match future approach volume targets while maintaining the proportionality of observed movements requires a more advanced technique.

The Fratar method is a balancing process for iteratively extrapolating a trip table, typically from an observed base year to a future year, or from a smaller time period to a larger time period. It follows an algorithmic process of applying adjustment factors to the trip table until it converges on a solution that satisfies the input conditions, in this case the desired approach volumes. Each repetition of the algorithm will yield smaller differences in cell values for each successive trip table iteration until the differences between successive tables are considered negligible.

In the context of a turning movement forecasting tool, the Fratar balancing procedure includes the following steps:

1. The individual rows (entering approach volumes) and columns (exiting approach volumes) from the base trip table (**Figure 12**) are summed.
2. These base sums are compared to the desired sums (base year or forecast year ADT approach volumes) for each row and column, with a ratio calculated between the base and desired sums for each row and column.
3. Each resulting row and column ratio is applied to each corresponding cell in the trip table, generating a new iteration of the trip table with adjusted turning movement values.
4. The sums of the adjusted cell values for each row and column from the new trip table are now compared to the respective desired row and column sums, and new ratios are calculated for the next iteration of the trip table.
5. This iterative process continues until the ratios, which will decline in each iteration, are sufficiently small enough as to be considered negligible. In practice, a sufficiently high number of iterations is typically set to ensure this condition is met.
6. The final iteration trip table's rows and columns will sum to totals very close to matching the desired approach totals entered at the beginning of the process.

5.4 BALANCING VOLUMES BETWEEN ADJACENT INTERSECTIONS

Most forecasts include multiple intersection turning movement forecasts. As shown in **Figure 10**, when no network interruptions exist between adjacent intersection approaches, continuity between intersection volumes is recommended. However, it is common for a final refinement or balancing of these adjacent volumes to be necessary, as minor differences due to count date collection, rounding, and adjustment factors affect final base year volumes. When forecasted volumes are generated through the growth and balancing procedures discussed in sections 5.2 and 5.3, minor differences in the base year volumes can compound significantly.

Professional judgment is the primary lens to perform volume balancing. As has been reiterated throughout this manual, traffic counts can and do differ greatly from one day to the next. The goal is to achieve volume balance with adjustments slight enough to preserve relative accuracy. Below are general suggestions for achieving this.

- Review and compare base year count data between intersections before beginning the balancing process to identify and address any significant disparities or outliers between adjacent intersections.
- Identify any intermediate local streets or driveways that reasonably justify differences between forecast intersections. Note these sources and sinks on the final forecast maps to explain reasonable differences between forecast intersection volumes. If a significant traffic generator(s) exists between adjacent intersections for which forecasts are being developed, balancing may be impractical and unnecessary. This should be discussed with the KYTC project manager before proceeding.
- Identify and note primary intersections and/or corridors, presumably with the higher volumes and (ideally) recent count dates. Prioritize the preservation of the approach volumes of these intersections.
- Make balanced adjustments outward from the primary intersection or corridor.
- Rebalance through movements where adjustments reflect a lower percentage of total traffic.
- Avoid excessive changes to left turn movement volumes, where small changes in quantity have a greater effect to traffic operation.
- After making initial changes through the network, compare these changes to the original unadjusted volumes and mitigate the most altered volumes where appropriate.

6.0 FORECASTING TRUCKS

Truck forecasts are a common element included in traffic forecasts and KYTC requires the submission of the ***Pavement Design Factors Form*** for most forecasts. The following best practices are recommended to provide the appropriate truck forecast detail.

- Address the role that truck forecasts will have in the overall project forecast during the scoping process as truck data are less likely to be readily available and may require specific count instructions.
- Determine if the study corridor is identified in KYTC's list of **Coal Haul Highway System**, which include public highways on which coal was reported transported by truck in the previous year. Consult with KYTC to determine if special instructions for specific counts are required. Indicate the corridor's coal haul route status in the ***Pavement Design Factors Form*** spreadsheet tool on the 'Data Entry' tab and enter the corresponding coal tonnage from the 'Coul Routes' tab.
- In most cases, a basic segmentation of medium (FHWA Classes 4-6) and heavy trucks (Classes 7-13) is sufficient for the purposes of new count collection, which enables more options for count collection than full 13-class counts.

- As with all specific traffic generators, new or expanding truck traffic generators should be quantified and documented as part of the forecast methodology and growth rate recommendations and approval.
- For projects or corridors with significant truck traffic, specific growth rates for truck volumes independent from ADT growth rates should be considered for the subject corridors. While truck-specific intersection turning movement diagrams are not typically required in forecast reports, a turning movement forecasting tool may be the best method to forecast truck link volumes if trucks require different growth rates than total traffic.
- While truck percentages are commonly reported as part of the descriptive statistics for count data, base year and future year forecast traffic maps should include actual truck volumes rather than just percentages. Specify if medium and heavy truck volumes should be reported separately.
- Recent KYTC classification counts for nearby segments of the same roadway with the same functional class are generally accepted as a proxy for use in the ***Pavement Design Factors Form*** look-up table. Where new medium and heavy truck counts are taken, the redistribution of the sub-class percentages within these basic categories (Classes 4-6 and 7-13) is an option with KYTC approval.
- The ***Pavement Design Factors Form*** spreadsheet tool includes count station and project look-up data that will populate default count volumes and estimate future year volumes. However, specific forecast values, including updated count data, growth rates, and forecast volumes can and should override these data with KYTC approval.

7.0 THE FORECAST REPORT

The forecast report serves as the documentation of the forecast process and presentation of the final forecasts. While a technical document, it should be accessible to a wide audience of users and reviewers, allowing the reader to follow how actual data, assumptions, and the forecasting process resulted in the final forecast volumes. The document should be concise but should also serve as a standalone resource. The main report will include introductory elements from the project scope and methodology memorandum previously submitted to KYTC, along with directional volume graphics / tables for the base year and all requested forecast years. Additional data and forms, such as turning movement diagrams and ***Pavement Design Factors Form***, should be included as appendices. Below are recommended guidelines for preparing the report.

- The report should include a **Title Page** and **Table of Contents** with a list of tables and figures. The report date and associated KYTC Item Number, location, and project name should be included on the title page and on all headers.
- The report introduction should include a description of the project and project area and an inventory of the forecast elements included in the forecast, including a list of roadway sections and intersections for which forecasts have been requested and the forecast years requested. A

corresponding study area map is recommended. These items should be similar to those included in the previously submitted scoping document and methodology memorandum.

- All maps should include a legend, scale, and north arrow. Relevant roadways, mileposts, and intersection locations should be labeled, along with the location of referenced count stations or count locations. Identify specific traffic generators or landmarks and political boundaries, such as county or state boundaries. **Figure 13** presents an example study map.
- Include a summary table of relevant statistics related to the analysis of current count data, such as peak hours and peak hour factors, K and D factors, and truck percentages. Cite the count dates and locations or stations that inform these statistics.
- Historical count data should be presented in tables similar to **Table 1**. Line graphs similar to **Figure 7** are useful for demonstrating historical volume trends. Multiple graphics may be necessary if large volume disparities or numbers of counts make distinguishing values difficult. Highlight or bold specific counts of importance.

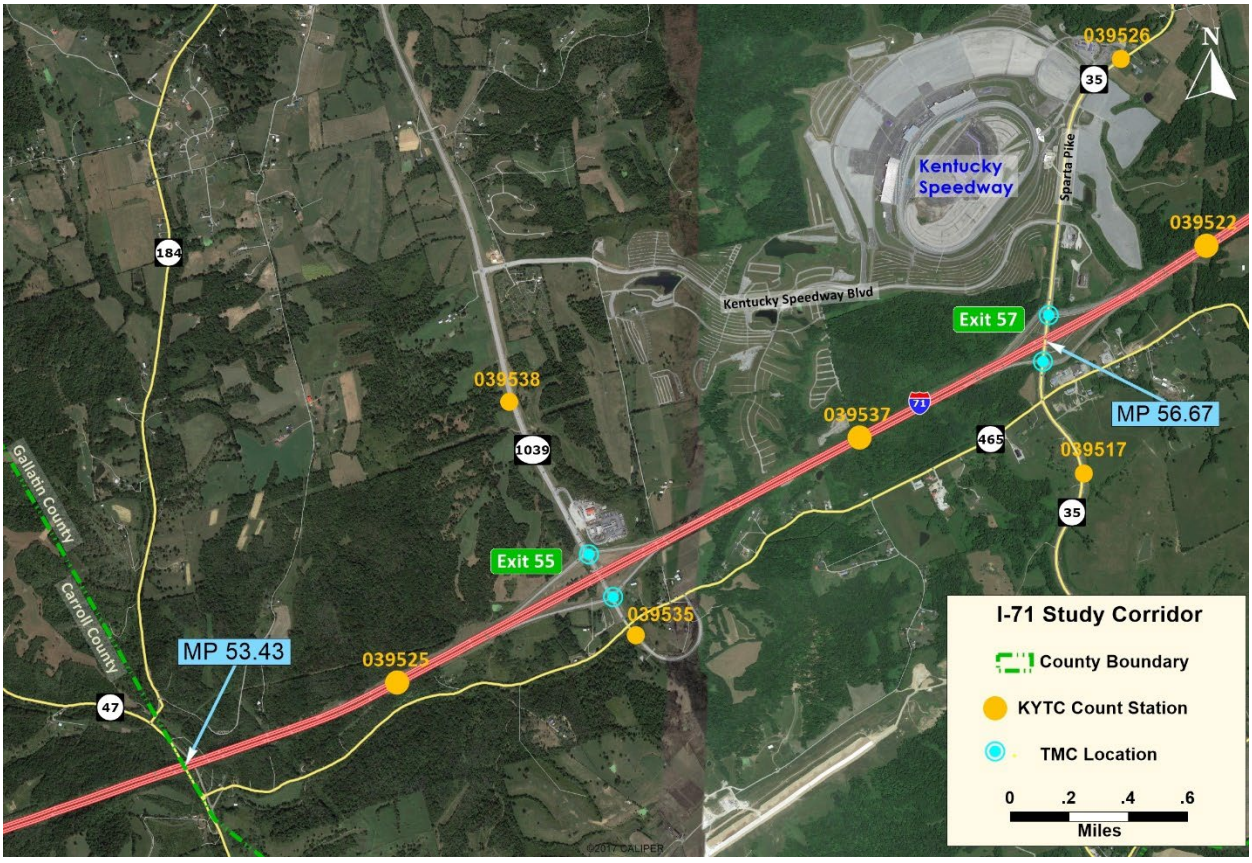


Figure 13. Example Project Area Map

- Document all socioeconomic data used in the growth analysis in a table like Table 2.

- If a travel demand model is used for growth analysis, provide all model version and scenario details such that a future reviewer can verify the source. Also provide basic validation statistics of the base year volume assignments compared to counts within or adjacent to the project area. If model refinements are necessary, these should be thoroughly documented to provide a brief explanation supporting the need and outcome of the revisions. Provide maps from the demand model of significant geographic edits, such as TAZ splits or new roadway or centroid connector alignments.
- Include a summary of all elements, including historical traffic and socioeconomic trends; model analysis; and other relevant plans, projects, or forecasts that inform the growth rate recommendations used. Provide a succinct rationale for the recommended rates.
- For roadway forecast volumes, provide a table or tables that compare base estimates to forecast year scenario volumes. Include maps with rounded forecast volumes labeled on all relevant roadway segments. Consider the use of call-out tables, such as those depicted in **Figure 14**.
- Turning movement diagrams should be limited in the number of data series included on each diagram to ensure clarity. Use templates that only depict the explicit movements through each intersection.
- It is often necessary to discuss development and growth potential with local professionals who have firsthand knowledge of land use changes anticipated within the project area. Documentation from any meetings held with local project stakeholders or local officials should be included in the appendices.

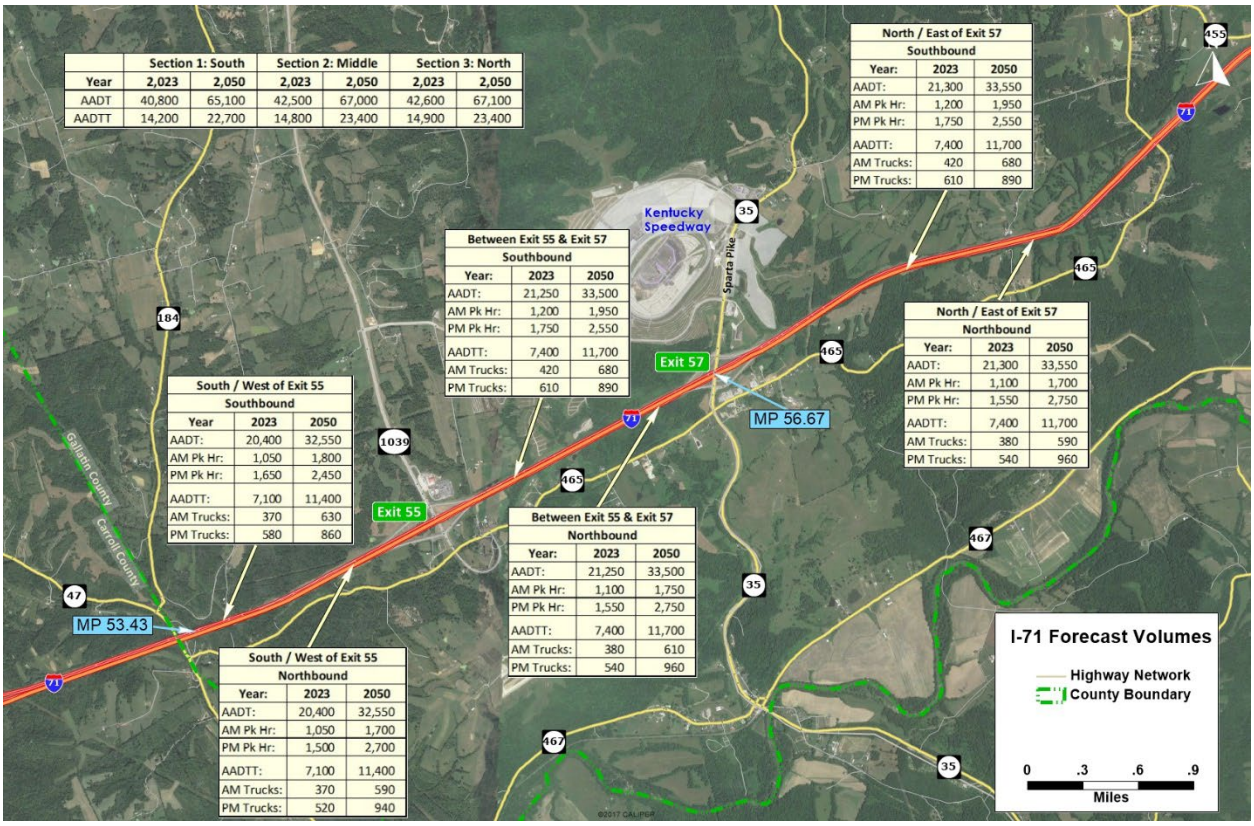


Figure 14. Example Forecast Map with Segment Tables

Appendix B includes examples of recent forecasts prepared either by or for KYTC, including a simple forecast.

APPENDIX A

TC 59-5: Traffic Forecast Request

TRAFFIC FORECAST REQUEST

INSTRUCTIONS: *Complete each section below. Use Section 4 for any additional details, as well as a list all attachments including the required Project Area Map. Email the completed form to the Modal Programs Branch Manager, KYTC Division of Planning.*

SECTION 1: FORECAST TYPE REQUESTED

- ☐ **SIMPLE**: Low volume; low expected growth; no turning movements; no new counts. (≈ 2-4 weeks)
- ☐ **MODERATE**: 1-4 turning movements; new counts; minimal demand modeling. (≈ 6-8 weeks)
- ☐ **COMPLEX**: 5+ turning movements; new routes; substantial demand modeling. (≈ 3-6 months)

SECTION 2: FORECAST PROJECT INFORMATION

REQUESTER *(first name)* *(last name)*	**DISTRICT**	**COUNTY**
PROJECT NAME *(Map required)*	**ITEM #**	**eMARS PROJECT #**

PRIMARY ROUTES *(Include beginning and ending milepoints.)*

PROJECT TYPE *(Check all that apply.)*

☐ Major widening ☐ Minor widening ☐ New alignment/route
☐ New intersection/access control ☐ Reconstruction ☐ Other *(Describe in Section 4.)*

PURPOSE OF FORECAST *(Check all that apply.)*

☐ Phase 1 Design ☐ Phase 2 Design ☐ Air Quality Analysis ☐ Noise Analysis
☐ Environmental Report *(Such as EA, EIS, CA. Describe in Section 4.)* ☐ Other *(Describe in Section 4.)*

SECTION 3: FORECAST DELIVERABLES

TRAFFIC FORECAST YEARS *(List all that apply.)*

Current: _____ Open/Interim: _____ Design: _____ ☐ Other *(Describe in Section 4.)*

FUTURE TRAFFIC FORECAST SCENARIOS

☐ No Build ☐ Build ☐ Other *(Describe in Section 4.)*

FORECAST ELEMENTS

☐ ADT ☐ TRUCKS/ADTT ☐ AM/PM DHVs

KYTC PAVEMENT DESIGN FACTORS REQUESTED

☐ Design Year ☐ Other *(Describe in Section 4.)*

INTERSECTIONS REQUIRING TURNING MOVEMENTS *(List intersections. Check here ☐ if unsure/unknown. Minor forecast is 1,000 ADT for minor approach; explain below if otherwise required. Text limited. Attach additional pages, as necessary.*

TRAFFIC FORECAST REQUEST

SECTION 4: ADDITIONAL PROJECT DESCRIPTION & FORECAST DETAILS *(If yes, identify or describe below.)*

	YES	NO	Unknown
1. Prior forecasts for this or adjacent project	☐	☐	☐
2. Existing or planned traffic/truck generators for consideration	☐	☐	☐
3. Relevant development plans or land-use changes for consideration	☐	☐	☐
4. Relevant traffic studies or road projects for consideration	☐	☐	☐
5. Available recent project-specific counts	☐	☐	☐
6. Available Pre-Design Conference Minutes	☐	☐	☐
7. Available design files (CADD) for the project	☐	☐	☐
8. Other special circumstances for consideration	☐	☐	☐

DATE COMPLETED FORECAST IS REQUIRED: _____

(Include all additional information identified in other sections here, as well as any other project details or special requests, including critical project schedule dates. Text limited. Attach additional pages, as necessary.)

ATTACHMENTS *(Identify each attachment.)*

	Description
☐ Project Area Map **(REQUIRED)**	
☐ Other Forecast Reports	
☐ Other Plans/Reports	
☐ Project Design Files	
☐ Count Files	

KYTC Project File Directory *(if available)*:

FORECAST DISTRIBUTION *(List names of those to receive completed forecast.)*

FOR INTERNAL USE ONLY **TF#** _____ **FORECASTER:** _____

APPENDIX B

Example Forecast Reports

Traffic Forecast Executive Summary
Jackson County: KY 290 Corridor Study
Item No. 11-80202.00

FORECAST SUMMARY

The purpose of the study was to assess existing conditions and develop improvement concepts for KY 290 in Jackson County from McKee to KY 30. The purpose of this forecast was to analyze the future traffic of the corridor using 2022 as the current year and 2045 as the design year.

FORECAST TYPE

The following types of forecasts were developed:

- 2022 and 2045 ADT values

CURRENT-YEAR VOLUME

There are two traffic counting stations along the corridor: Station 055750 and Station 055527. Station 055750's most recent traffic count in 2020 was significantly lower than its second-most recent count due to the economic effects of the COVID-19 pandemic. Therefore, the current-year total volume for the project was developed based on Station 055527's most recent traffic count in 2022 of about 2,300.

DESIGN-YEAR/GROWTH FACTOR

A total volume growth rate of zero percent was used for the purpose of this forecast, which was consistent with the historical growth rate of Station 055527, meaning that the project corridor had an estimated 2045 ADT of 2,300.

DESIGN HOURLY FACTORS

Design hourly factors were not requested and therefore not included.

TRUCK VOLUMES AND PERCENTAGES

Truck volumes and percentages were not requested and therefore not included.

TURN MOVEMENTS

Turn movements were not requested and therefore not included.

I-71 Improvements - Gallatin County
Forecast Report

KYTC Item #06-20021

Traffic Forecast Report

Revised January 23, 2024

Prepared for:

Kentucky Transportation Cabinet,
Division of Planning

Prepared by:

Stantec Consulting Services Inc.
Louisville, Kentucky

Table of Contents

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

This traffic forecast report was prepared in support of Kentucky Transportation Cabinet (KYTC) project 06-20021.00, *I-71 Improvements - Gallatin County*, which is intended to identify and consider potential roadway improvements on 3.24 miles of I-71 from milepost 53.4 to milepost 56.7 in Gallatin County, including the widening of this section from two to three lanes in each direction. This report includes forecasts for Average Daily Traffic (ADT), Average Daily Truck Traffic (ADTT), and AM and PM peak hour volumes for total vehicles and trucks for the current year (2023) and the forecast design year (2050). The report also includes design hour intersection turning movement forecasts for each of the four ramp terminal intersections at exits 55 (KY 1039) and 57 (KY 35).

Figure 1 presents the project corridor and study area, including the location of KYTC count stations and the locations of turning movement counts collected for this forecast.

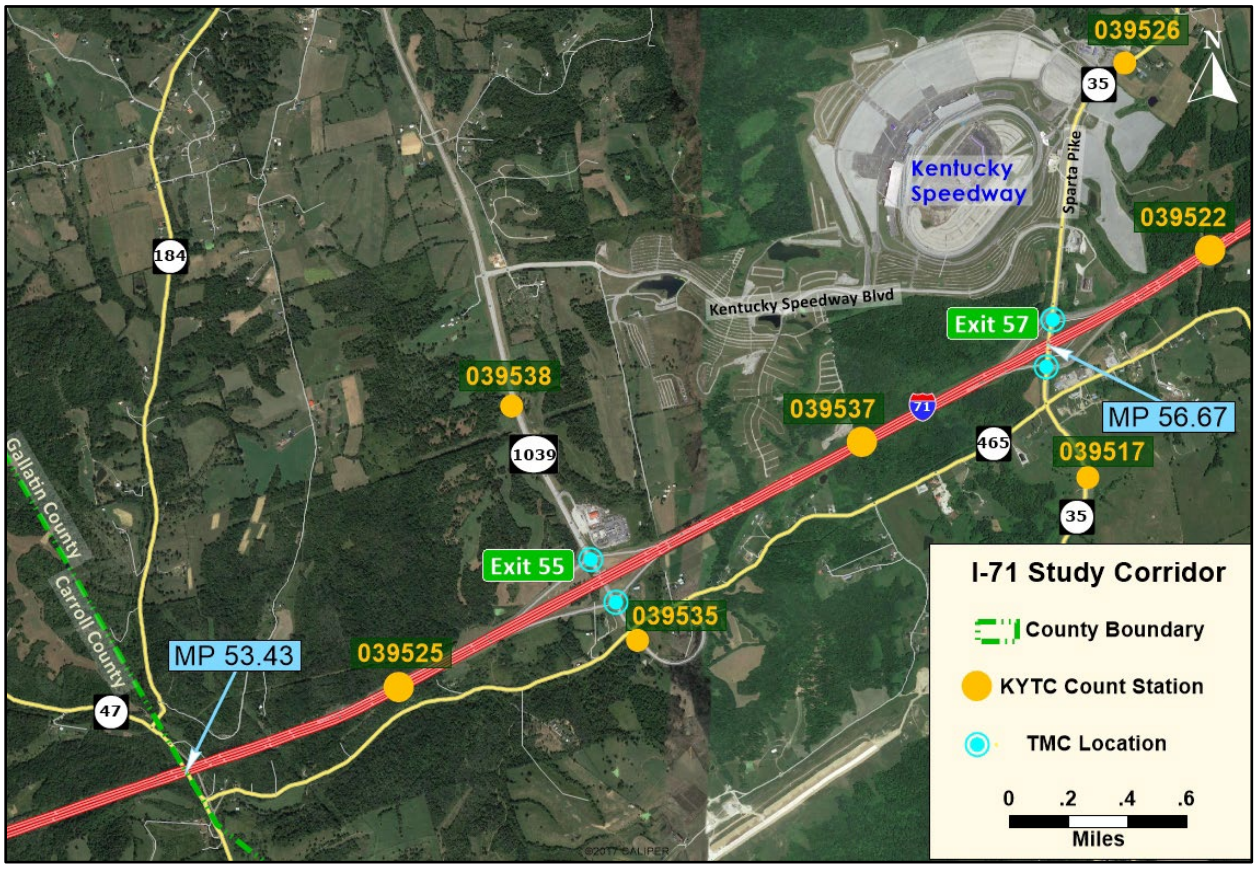


Figure 1. Project Corridor and Study Area

This report presents the methodology and assumptions used in the development of the traffic forecasts for the corridor and the directional forecasts for the three sections of I-71 south of, in between, and north

of exits 55 and 57. The attached **Appendices A** through **C** provide the turning movement diagrams for the four ramp terminal intersections on KY 1039 and KY 35. **Appendix A** presents the seasonally adjusted existing year (2023) AM and PM peak hour turning movement volumes. **Appendix B** presents the seasonally adjusted forecast year (2050) AM and PM peak hour turning movement volumes. **Appendix C** presents the total volume ADT for 2023 and 2050. Turning movement volumes in the diagrams have been balanced to ensure that the volumes of adjacent intersection approaches match. **Appendix D** contains the **Pavement Design Factors Forms** for the three sections of the I-71 study corridor.

1.1 STUDY CORRIDOR

I-71 is a federal interstate highway which begins in Louisville, Kentucky and terminates in Cleveland, Ohio. It traverses approximately 15 miles in Gallatin County, Kentucky, approximately halfway between the Louisville and Cincinnati, Ohio metropolitan areas. The 3.24-mile study corridor runs through a rural area with rolling terrain. I-71 serves as a primary freight corridor, connecting the major manufacturing hubs in Ohio and Michigan along I-75 with manufacturing hubs located near I-65 in Kentucky, Tennessee, and Alabama.

Two interchanges, exit 55 at KY 1039, and exit 57 at KY 35, are located within the study corridor. Both exits serve as primary entry routes to the Kentucky Speedway, a major special events facility located directly north of I-71 and between the two exits. Exit 55 also provides direct access to the Markland Dam, the only crossing of the Ohio River for 25 miles downstream and 37 miles upstream. A truck stop is located at Exit 55 and a gas station and travel hotel are located at Exit 57.

The typical section of the 3.24-mile study corridor includes two 12-foot directional lanes and 10-foot shoulders in each direction. There is a 0.75-mile taper where the two-lane southbound entrance ramp for Exit 55 merges with the mainline, and a third lane added northbound immediately before the two-lane northbound entrance ramp for Exit 57 merges with the mainline. These high-capacity entrance ramps are designed for the special event traffic associated with the Kentucky Speedway, which is typically inactive.

2.0 GROWTH ANALYSIS

2.1 HISTORICAL TRAFFIC GROWTH

Table 1 presents the historical Annual Average Daily Traffic (AADT) count data for the three KYTC count stations on I-71 located south, between, and north of Exits 55 and 57, and for the count stations on KY 1039 and KY 35 directly north and south of Exits 55 and 57 respectively. Count data for the years 2003 through 2021 were taken from KYTC's online Traffic Count Reporting System. AADT counts from 2022 and 2023, highlighted in yellow, are taken from the most recent KYTC AADT count files for each station. A new AADT count taken at station 039537 was collected for this forecast in September 2023 and is highlighted in green. This count is a daily average of a 48-hour count factored to represent an AADT value using the September seasonal adjustment factor (1.01) from Table D2 from KYTC's *Traffic Forecasting Report - 2008.*

Table 1. Historical Traffic Counts

Year	I-71			KY 1039		KY 35	
	Sta 039525 (mp 53)	Sta 039537 (mp 56)	Sta 039522 (mp 57)	Sta 039538 (north)	Sta 039535 (south)	Sta 039526 (north)	Sta 039517 (south)
2003	24,500	25,400	26,100		238	3,480	3,840
2004	24,500		26,600				4,030
2005	24,800	24,200	26,900		209		
2006	27,300	23,900			207	2,840	
2007	28,100	28,100	26,700	4,810	271		3,950
2008	25,600	28,900	27,200	5,950	212		
2009	29,100	31,500	28,600			2,840	
2010			29,500	5,990			3,580
2011	27,200	29,500	29,400		292		
2012	29,272		30,954	6,333		2,163	
2013	30,202	32,833	31,739				3,302
2014	32,216	33,781	36,378		318		
2015	29,923	33,465				2,502	
2016	33,464	36,556	34,373	6,212			3,503
2017	37,987	38,282	38,491		362		
2018	33,188	37,320	34,809			1,443	
2019	34,714	38,715	37,278	5,287			3,237
2020	37,288	41,099	37,703		334		
2021	33,859		35,794			1,344	
2022	33,918	38,970	35,777	5,962			3,789
2023		42,500			308		
CAGR: 2004-2023	**2.1%**	**2.9%**	**2.1%**	**0.3%**	**2.4%**	**-5.5%**	**-0.7%**

Figure 2 provides a chart of the I-71 count values by year along with the linear regression line associated with each station. **Figure 3** provides a similar chart for the lower volume counts at the count stations on KY 1039 and KY 35. A 20-year and a 10-year Compound Annual Growth Rate (CAGR) were calculated for each count station based the linear regression lines presented in **Figures 2** and **3**. These rates indicate that traffic growth on I-71 has been robust over the past 20 years, although it has tapered within the past ten years, particularly in 2021 and 2022. However, the count taken at Station 039537 for this study is a record high count volume.

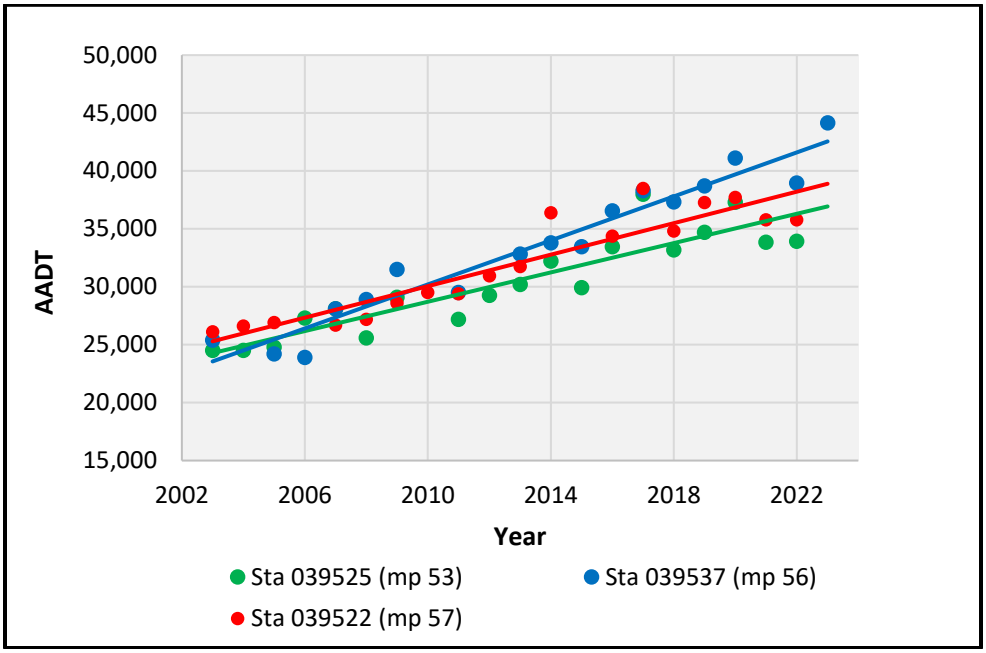


Figure 2. I-71 Historical Traffic Counts

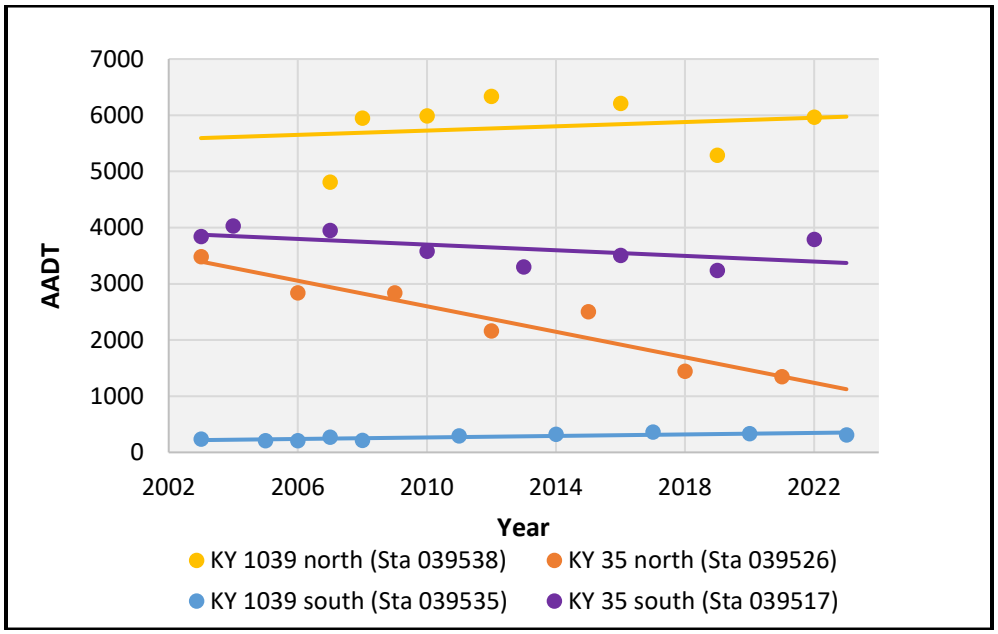


Figure 3. KY 1039 and KY 35 Historical Traffic Counts

2.2 POPULATION AND EMPLOYMENT TRENDS

Table 2 presents population trends for Kentucky and the Kentucky counties through which the I-71 corridor travels. The population of Gallatin County, where the project is located, is very small with no growth expected through 2050. The populations of the most adjacent counties along the I-71 corridor (Carroll, Trimble and Henry Counties) are also small and not projected to grow. At the southwestern end of the Kentucky section of I-71, the combined populations of Jefferson County and Oldham Counties are projected to grow at 0.3% annually, while the combined populations of Boone and Kenton Counties on the northeastern end of the corridor are projected to grow at 0.6% annually. While these two regional rates are mild to moderate, they exceed the projected annual growth rate of 0.2% for Kentucky.

Table 2. Population Trends

Area	Census Estimates			CAGR 2000-2020	2050 Projection	CAGR 2020-2050
	2000	2010	2020			
Kentucky	**4,041,769**	**4,339,367**	**4,505,836**	**0.5%**	**4,785,233**	**0.2%**
Gallatin County	**7,870**	**8,589**	**8,690**	**0.5%**	**8,546**	**-0.1%**
Carroll County	10,155	10,811	10,810	0.3%	10,407	-0.1%
Trimble	8,125	8,809	8,474	0.2%	6,545	-0.9%
Henry	15,060	15,416	15,678	0.2%	15,800	0.0%
Oldham	46,178	60,316	67,607	1.9%	99,779	1.3%
Jefferson	693,604	741,096	782,969	0.6%	838,210	0.2%
Boone	85,991	118,811	135,968	2.3%	181,733	1.0%
Kenton	151,464	159,720	169,064	0.6%	180,023	0.2%

Source: 2020, 2010, 2000 U.S. Census; Kentucky State Data Center

Table 3 presents statistics for total employment in Gallatin County and the three local surrounding counties. Reflecting these counties' population, employment is small and stable, with a combined 0.5% annual growth rate since 2001.

Table 3. Total Employment

County	2001	2010	2020	2022	CAGR 2001 - 2022
Gallatin County	**2,841**	**2,932**	**3,535**	**3,655**	**1.2%**
Carroll County	7,683	6,994	8,253	9,401	1.0%
Henry County	6,396	6,040	5,331	5,671	-0.6%
Trimble County	2,296	2,824	2,320	2,399	0.2%
Total	**19,216**	**18,790**	**19,439**	**21,126**	**0.5%**

Source: U.S. Bureau of Economic Analysis

2.3 DEMAND MODEL ANALYSIS

Base year (2019) and future year (2045) traffic assignments from the Kentucky Statewide Traffic Model version 19[1] (KYSTMv19) were analyzed to estimate growth rates that may be applicable to the study corridor. A cursory validation check of the model base year assignments was performed. Counts from 18 KYTC count locations, including each of the KYTC count stations included in **Table 1** as well as counts for each individual ramp for Exits 55 and 57 were compared to model assignments. Base year 2019 model assignments throughout the study area were generally 20 percent lower than equivalent 2018 or 2019 counts, well outside the Volume-to-Count (V/C) target range of five percent (0.95-1.05). The Percent Root Mean Square Error (%RMSE), which reflects the model's relative error in matching counts, was 48.9%, which is above the 35% threshold target for model validation.

Table 4 presents model statistics, including the model assignments for the three count stations located on I-71 in the study area. **Table 4** also presents the 2045 model forecast year assignments for the study area as whole and for the three I-71 count station locations. Based on these assignments, annual growth rates were calcuated for each location.

Table 4. KYSTM Model Statistics

	Model Volume to Count Ratio (Target: 0.95 - 1.05)			%RMSE (Target: <35%)	2045 Forecast Volume	Forecast CAGR
	Model Volume	Count (2018/19)	V/C			
Study Area (18 Counts)	107,445	137,839	0.78	48.9%	137,273	0.9%
Station 39525	27,717	33,476	0.83		36,135	1.0%
Station 39537	27,616	36,584	0.75		32,288	0.6%
Station 39522	27,264	34,494	0.79		32,396	0.7%

2.4 ADJACENT FORECASTS

Three recent KYTC project forecasts are relevant to this section of I-71. In 2017, a forecast was prepared for the *I-MOVE Kentucky* project (KYTC Item number 05-537.00), which includes the widening of I-71 from the interchange with I-265 in Jefferson County to the KY 329 interchange in Oldham County. The 2045 ADT from the I-MOVE forecast is 119,000, up from the 72,000 ADT in 2017, which implies an annual growth rate of 1.8% for total traffic on this section of I-71.

A separate forecast was prepared in 2019 for the widening of I-71 in Oldham County (KYTC Item number 05-483.10) between mile points 14.1 and 19.0, approximately 35 miles southwest of the project study area. The annual growth rate used to forecast I-71 traffic for the year 2045 was 1.7%. The 2041 forecast ADT for the most northern section of I-71 covered in this forecast was 96,000 with an ADTT of 24,000.

[1] KYSTMv19 - Build 20220912, TAZ 6003

In 2019, a traffic forecast was prepared for KYTC Item number 06-8910, a I-71 reconstruction project between mile points 61.77 and 64.00, which is approximately four miles northeast of the project study area in Gallatin County. The annual growth rate used to forecast I-71 traffic for the year 2041 was also 1.7%. The 2041 forecast ADT for this section was 51,000, with an ADTT of 20,300.

Table 5 summarizes the statistics from these three KYTC project forecasts.

Table 5. Adjacent KYTC I-71 Forecasts

Item #	County	Mile Points	Base Year	Forecast Year	Base ADT	Forecast ADT	CAGR
5-537.00	Oldham	9.0 - 14.5	2017	2045	72,000	119,000	1.8%
5-483.10	Oldham	14.1 - 19.0	2019	2045	50,000	77,000	1.7%
6-8910.00	Gallatin	61.7 - 64.0	2019	2041	35,000	51,000	1.7%

GROWTH RATE ANALYSIS AND RECOMMENTATION

A comparison of the historical growth rates from traffic counts on I-71 with the rates of traffic growth on KY 1039 and KY 35 (**Table 1**), as well as the growth rates of local population (**Table 2**) and employment (**Table 3**) illustrate a contrast between the low expected local traffic growth and the strong growth in long-distance through traffic on I-71. Although the KYSTM has relatively poor validation statistics for the study area, the CAGR estimates its assignments produce (**Table 4**) do fall within the range of the respective CAGRs estimated for interstate traffic and local traffic and population.

A growth rate over 2.0 percent is aggressive and should be reserved for areas where sustained high development growth is expected. Such conditions are not present in the study area or surrounding counties. However, the high historical growth on I-71, as well as its high proportion of truck traffic, indicate that its growth will continue to reflect the growth of long-distance through traffic. Given that the primary focus of this study is on the operation of the interstate mainline facility and recent forecasts for adjacent sections of I-71 have recommended an annual growth rate of 1.7%, a similar annual growth rate of 1.7% for mainline I-71 traffic growth is used for this forecast. Based on low local population growth projections and recent historical traffic trends on KY 1039 and KY 35, a 0.3% annual growth rate is appropriate for the KY 1039 and KY 35 approaches of the I-71 ramp terminal intersections.

3.0 FORECAST PARAMETERS

3.1 PEAK HOURS

Figure 4 presents the 24-hour distribution of weekday traffic volume from KYTC's March 2022 counts for the three I-71 count stations (039525, 039537, and 039522) shown in **Figure 1**. It also shows the distribution of the new 48-hour count collected at the location of station 039537 in September 2023.

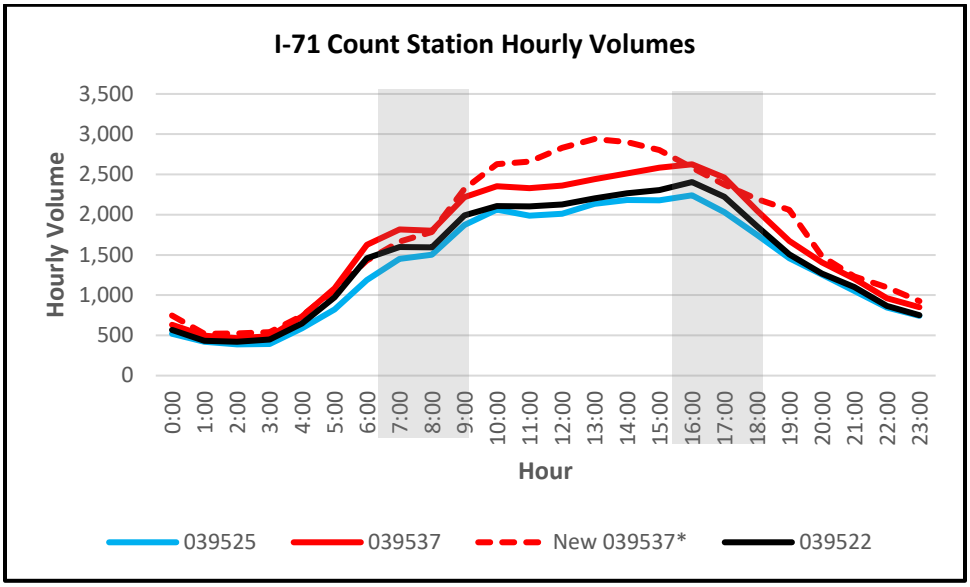


Figure 4. 24-hour Distribution of I-71 Traffic

The Monday-Thursday distributions of the three 2022 counts reflect the pattern presented in Table D1 of the *KYTC Traffic Forecast Report* for rural interstates (FC 1). That pattern shows a sharp increase beginning in the AM peak period, with traffic volumes steadily increasing until they peak around the 4:00 PM hour. The volumes and patterns of overnight, AM and PM peak periods in the September 2023 count are similar. However, in contrast to the March 2022 counts, the September 2023 counts have a sharper mid-day peak, with the highest peak hour beginning at 1:30 PM.

Given that the mid-day peak pattern from the September 2023 count is dissimilar to the pattern of the 2022 counts at the same location and the average pattern presented for rural interstates in the *KYTC Traffic Forecast Report*, design hour volumes for the AM and PM peak periods were used for this forecast. The design hour factor (1.26) for September weekdays (Mon.-Thur.) for rural interstates (FC 1), as provided by KYTC, was used to calculate the AM and PM design hour volumes. **Table 6** presents the 2023 count and design hour volumes for the AM and PM peak hours of 8:00 AM and 4:00 PM at KYTC Station 039537, located on I-71 between Exits 55 and 57. **Table 6** also presents the directional factors calculated for each peak hour, and the 2050 design year AM and PM peak hour forecast volumes, based on the application of the recommended CAGR of 1.70%

Table 6. I-71 Peak Hour Count and Volume Parameters

	AM Peak	PM Peak
Hour	8:00 AM	4:00 PM
Count Volume[1]	1,800	2,600
Design Hour Factor[2]	1.26	1.26
2023 DHV	2,300	3,300
Directional Factor[3]	0.53 (SB)	0.52 (NB)
Recommended CAGR	1.70%	1.70%
2050 DHV	3,700	5,300

[1]Average hourly volume (rounded), 48-Hour count at Station 039537, Sep. 2023
[2]Table D3, FC1; KYTC Traffic Forecast Report, 2008
[3]Peak hour average directional factor, 48-Hour count at Station 039537, Sep. 2023

Intersection turning movement counts were taken at the four ramps terminals at Exits 55 and 57. **Table 7** presents the 60-minute traffic volumes proceeding from each 15-minute increment start time for each intersection and for all intersections combined. The highest 60-minute interval for each intersection are shaded in grey. Intersection volumes are generally low and the difference between total hourly volumes by start times is relatively insignificant from a traffic operations perspective. Therefore, to maintain continuity with the peak hours of the I-71 mainline forecasts, 8:00 AM and 4:00 PM were also selected for the turning movement forecasts.

Table 7. Peak Hour Intersection Volumes, Exits 55 and 57

Start Time	KY 1039 @ I-71 SB ramps	KY 1039 @ I-71 NB ramps	KY 35 @ I-71 SB ramps	KY 35 @ I-71 NB ramps	All Intersections
7:00 AM	525	224	258	285	1,292
7:15 AM	497	200	257	281	1,235
7:30 AM	497	214	257	277	1,245
7:45 AM	471	231	292	294	1,288
8:00 AM	**436**	**213**	**315**	**327**	**1,291**
3:00 PM	600	310	318	349	1,577
3:15 PM	626	345	311	363	1,645
3:30 PM	654	366	328	389	1,737
3:45 PM	688	379	380	411	1,858
4:00 PM	**685**	**363**	**396**	**404**	**1,848**
4:15 PM	683	348	423	402	1,856
4:30 PM	695	366	429	399	1,889
4:45 PM	680	354	375	383	1,792
5:00 PM	690	351	366	380	1,787

3.2 TRUCK PERCENTAGES

Table 8 presents the average daily truck percentages collected by KYTC for each of the three I-71 count stations. **Table 8** also includes the truck percentage estimated from the September 2023 count collected at Station 039537 for this forecast. As it represents the most recent count and it falls centrally within the range of the truck percentages recorded at the other stations, **34.9%** is recommended for this forecast.

Table 8. I-71 Truck Percentages

Station	Year	Truck Pct.
039525	2019	33.6%
039537*	2018 (NB only)	32.7%
039522	2018	36.4%
039537	**2023**	**34.9%**

4.0 FORECAST VOLUMES

Figure 5 presents the 2023 and 2050 forecast ADT and ADTT volumes for the study corridor's three sections for both southbound and northbound directions. Directional volumes for AM and PM peak hour total vehicles and trucks are also presented. Volumes have been rounded to the nearest 50, except for peak hour truck volumes, which have been rounded to the nearest ten.

Appendices A through **C** provide the associated intersection turn movements for the four ramp identified intersections on the study corridor. Volumes between the southbound and northbound ramp terminals at the exits for both KY 1039 and KY 35 have been respectively balanced to match at their adjacent approaches. Given the low volumes in some turn movements, volumes have been rounded to the nearest 5. Turn movements for the interstate ramp approaches have been adjusted so that aggregate ramp volumes are rounded to the nearest 50.

Appendix D presents the KYTC Pavement Design Factors Forms for the three sections of I-71 in the study corridor. The 24-hour time distribution for truck volumes were taken from the September 2023 48-hour directional count taken at Station 039537 for this study. The percent distribution of truck classifications was taken from the March 2019 KYTC weeklong classification count taken at Station 039525, south of Exit 55.

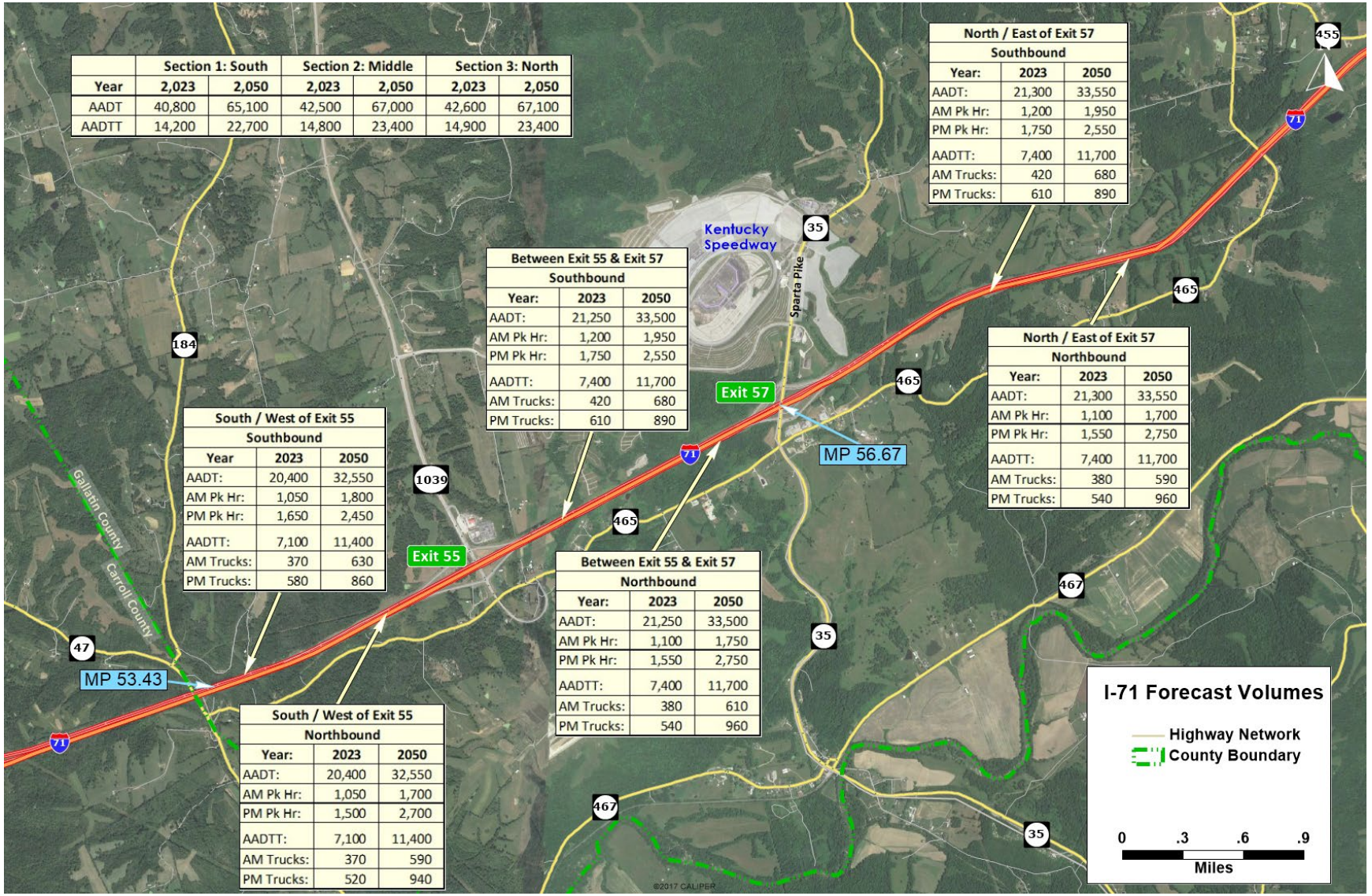
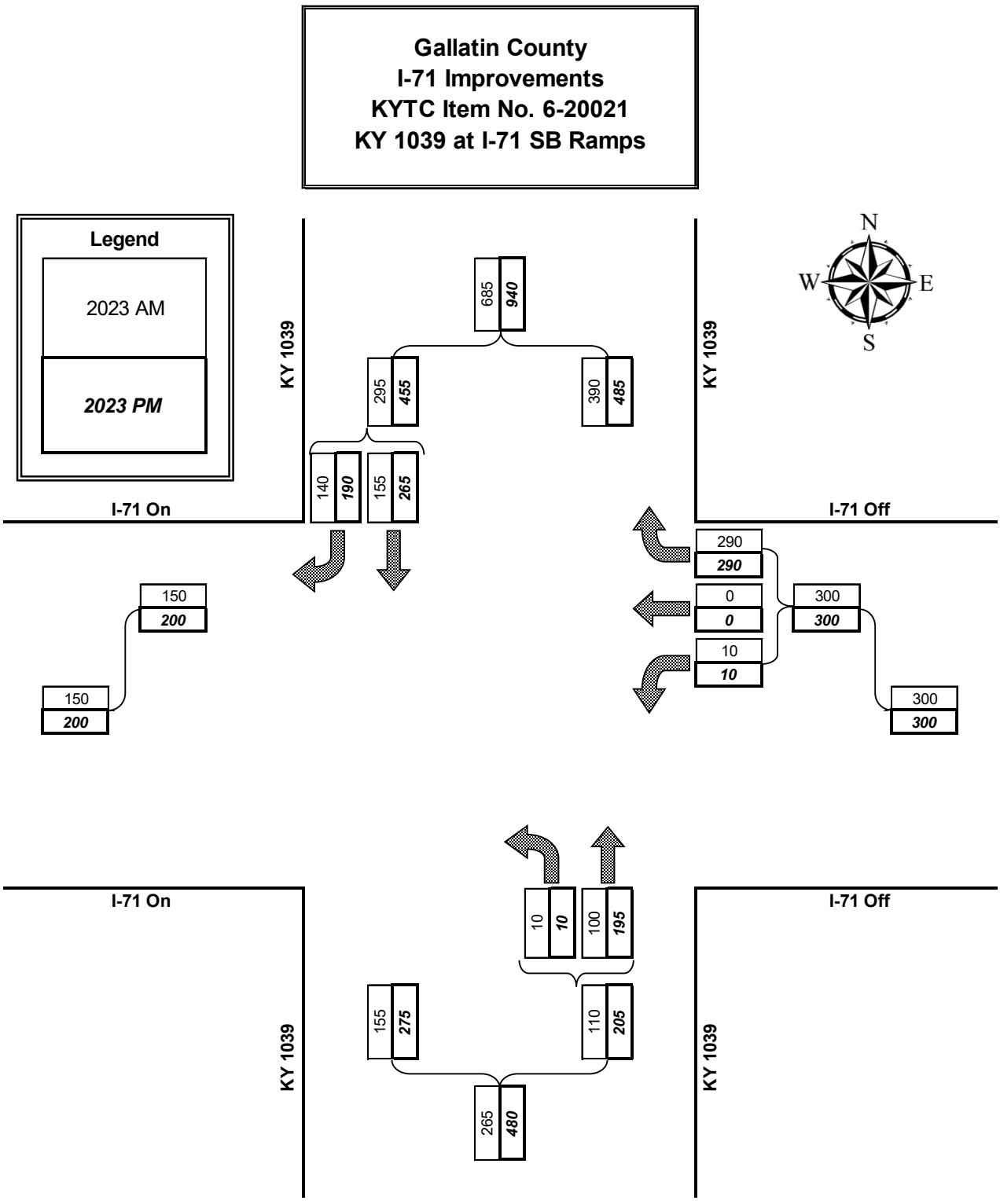


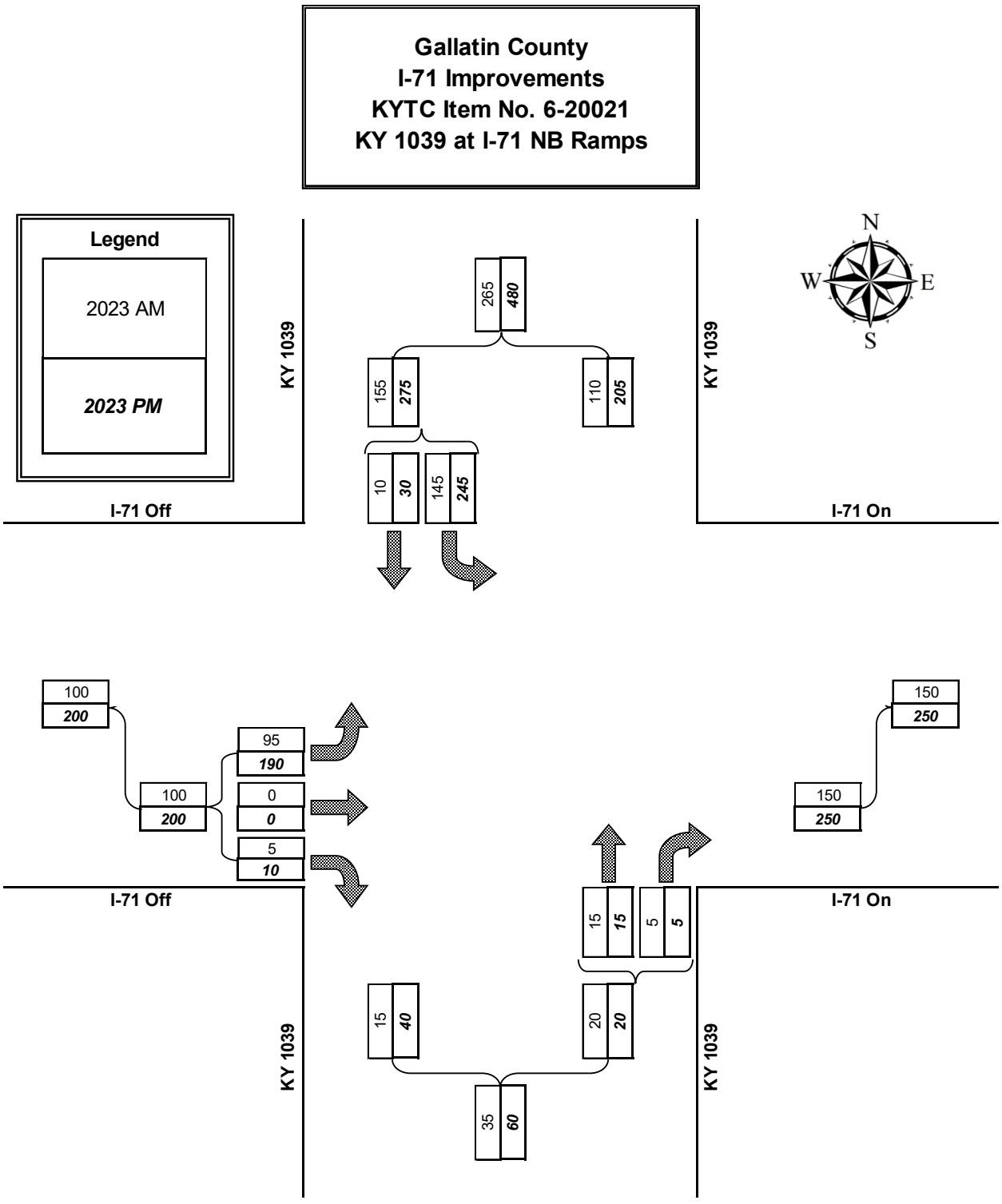
Figure 5. 2023 and 2050 Directional Forecast Volumes

Appendix A

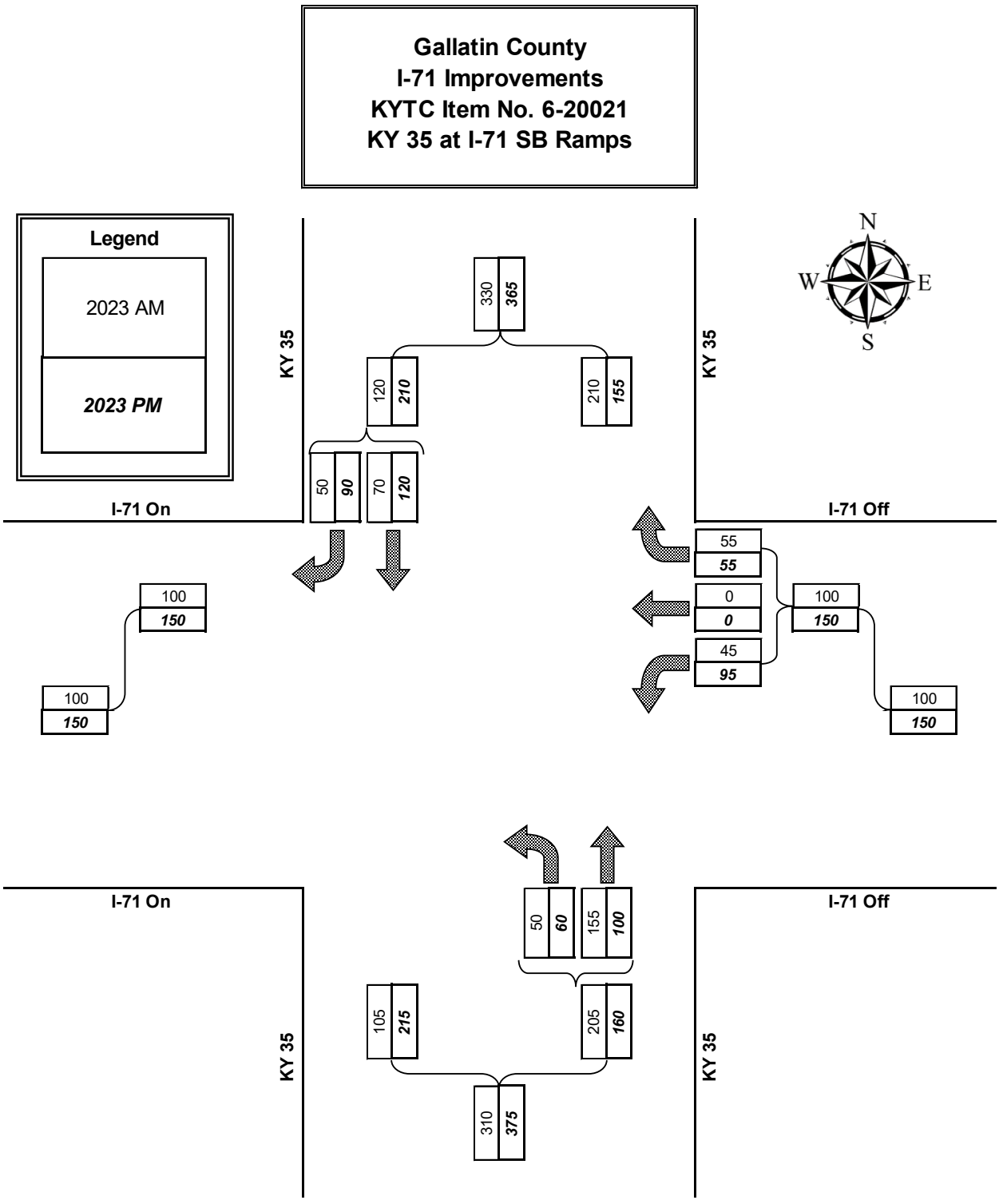
2023 AM and PM Design Hour Turning Movements



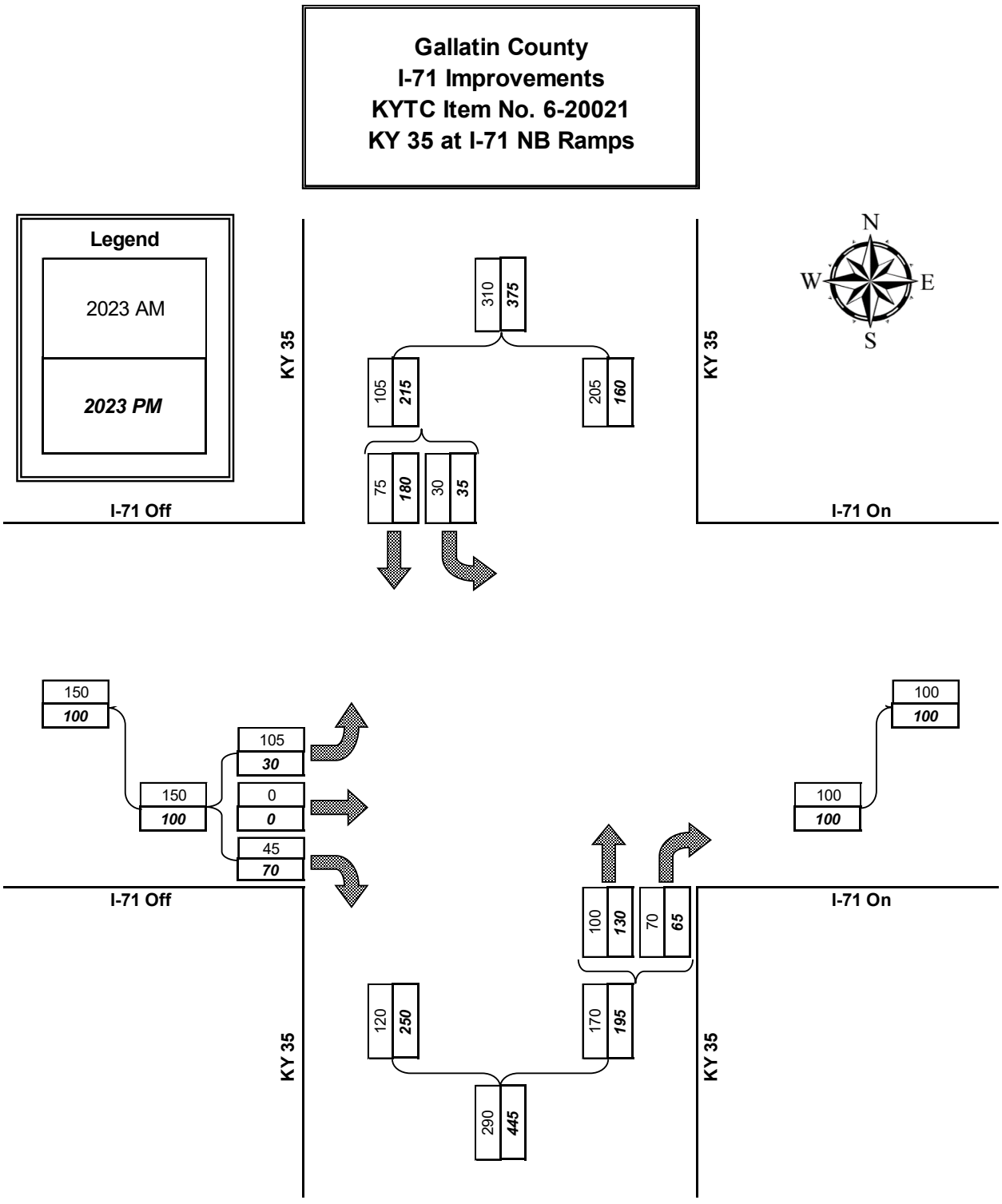
PERIOD: Existing (2023) Design Hour Volumes (DHV's)	AM PEAK HOUR: 8:00 AM to 9:00 AM
PREPARED BY: Mark Butler	AM PHF: 0.92
DATE PREPARED: 12/10/2023	PM PEAK HOUR: 4:00 PM to 5:00 PM
	PM PHF: 0.93



PERIOD: Existing (2023) Design Hour Volumes (DHV's)	AM PEAK HOUR: 8:00 AM to 9:00 AM
PREPARED BY: Mark Butler	AM PHF: 0.89
DATE PREPARED: 12/10/2023	PM PEAK HOUR: 4:00 PM to 5:00 PM
	PM PHF: 0.93

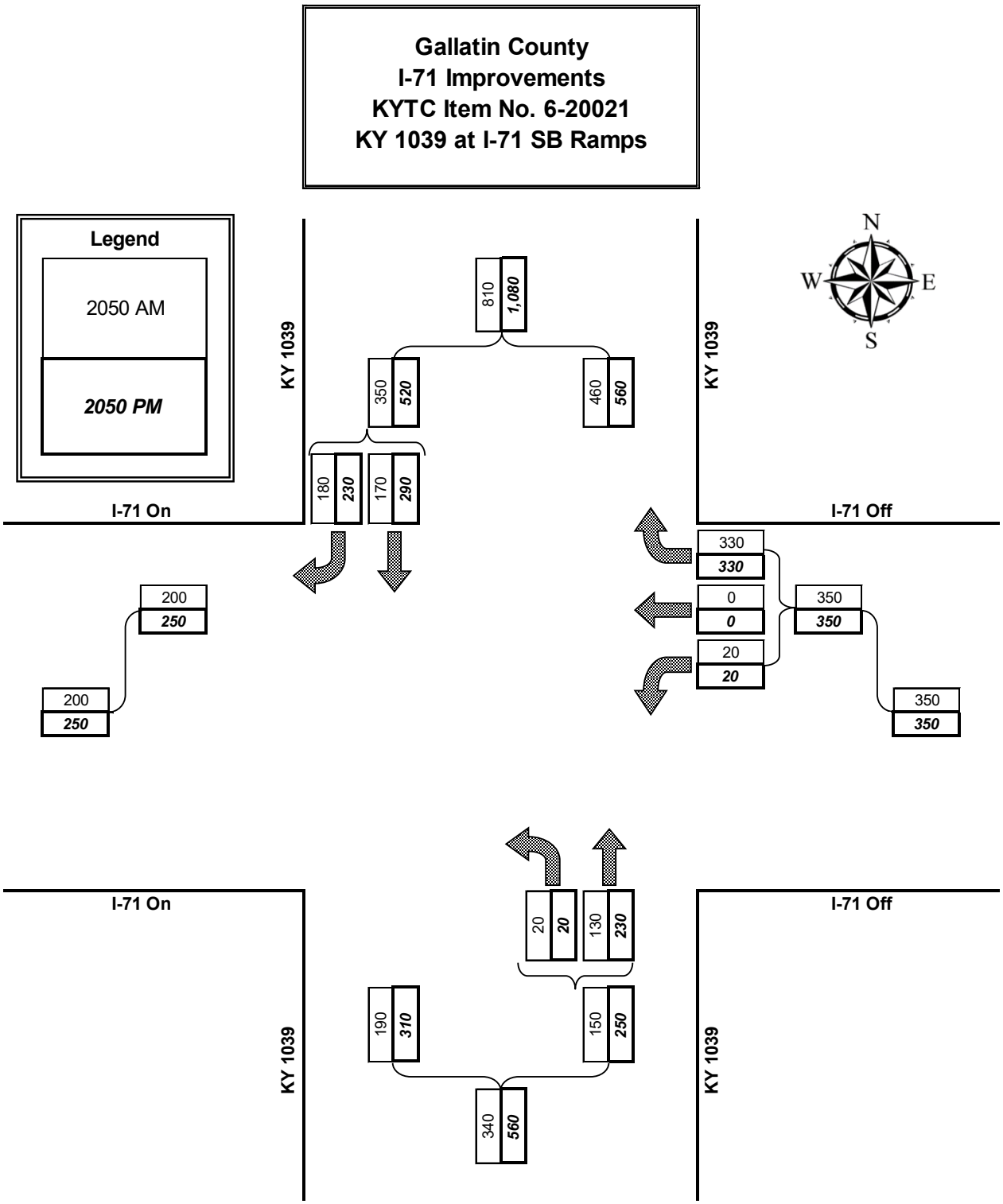


PERIOD: Existing (2023) Design Hour Volumes (DHV's)	AM PEAK HOUR: 8:00 AM to 9:00 AM
PREPARED BY: Mark Butler	AM PHF: 0.82
DATE PREPARED: 12/10/2023	PM PEAK HOUR: 4:00 PM to 5:00 PM
	PM PHF: 0.81

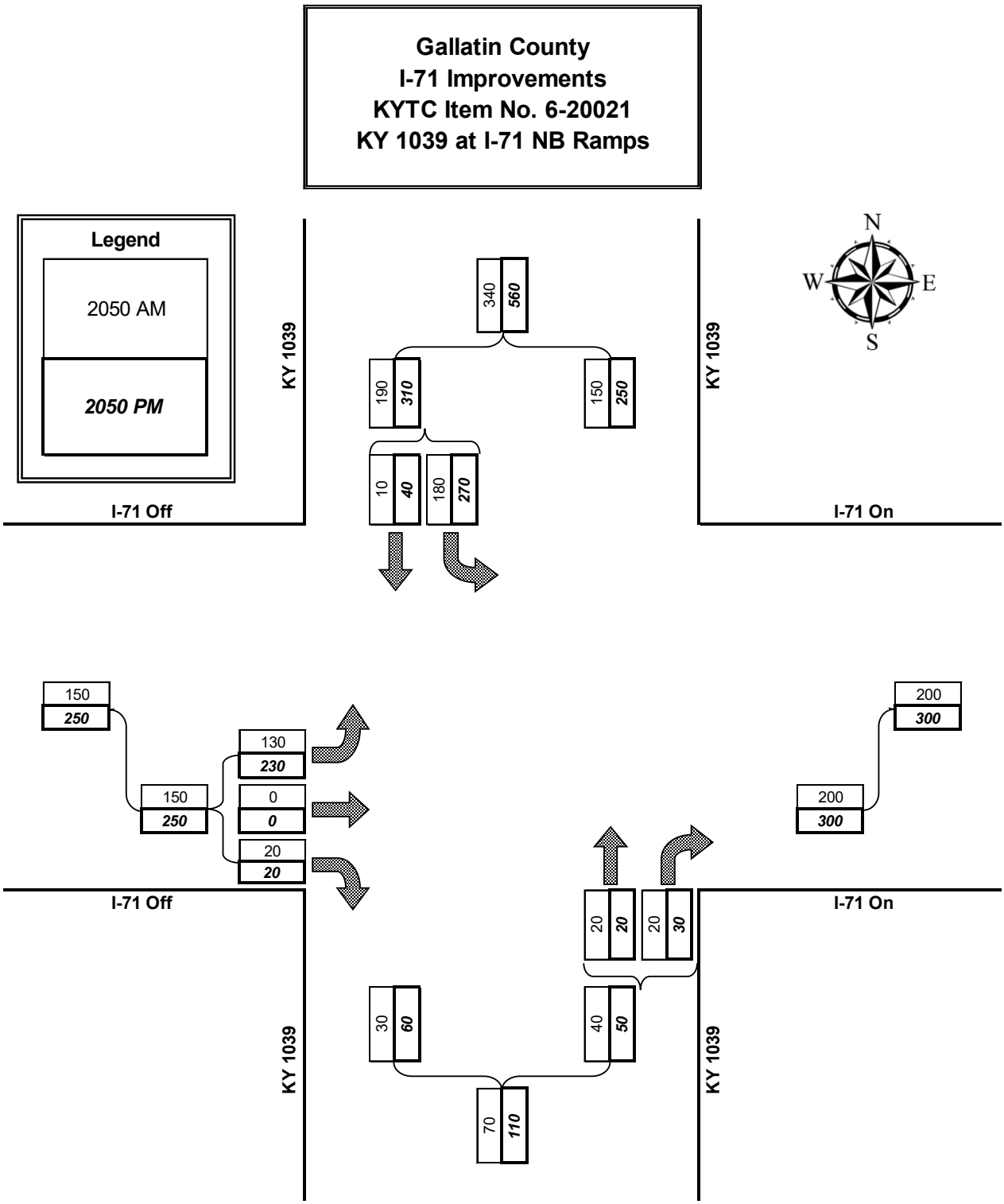


PERIOD: Existing (2023) Design Hour Volumes (DHV's)	AM PEAK HOUR: 8:00 AM to 9:00 AM
PREPARED BY: Mark Butler	AM PHF: 0.83
DATE PREPARED: 12/10/2023	PM PEAK HOUR: 4:00 PM to 5:00 PM
	PM PHF: 0.93

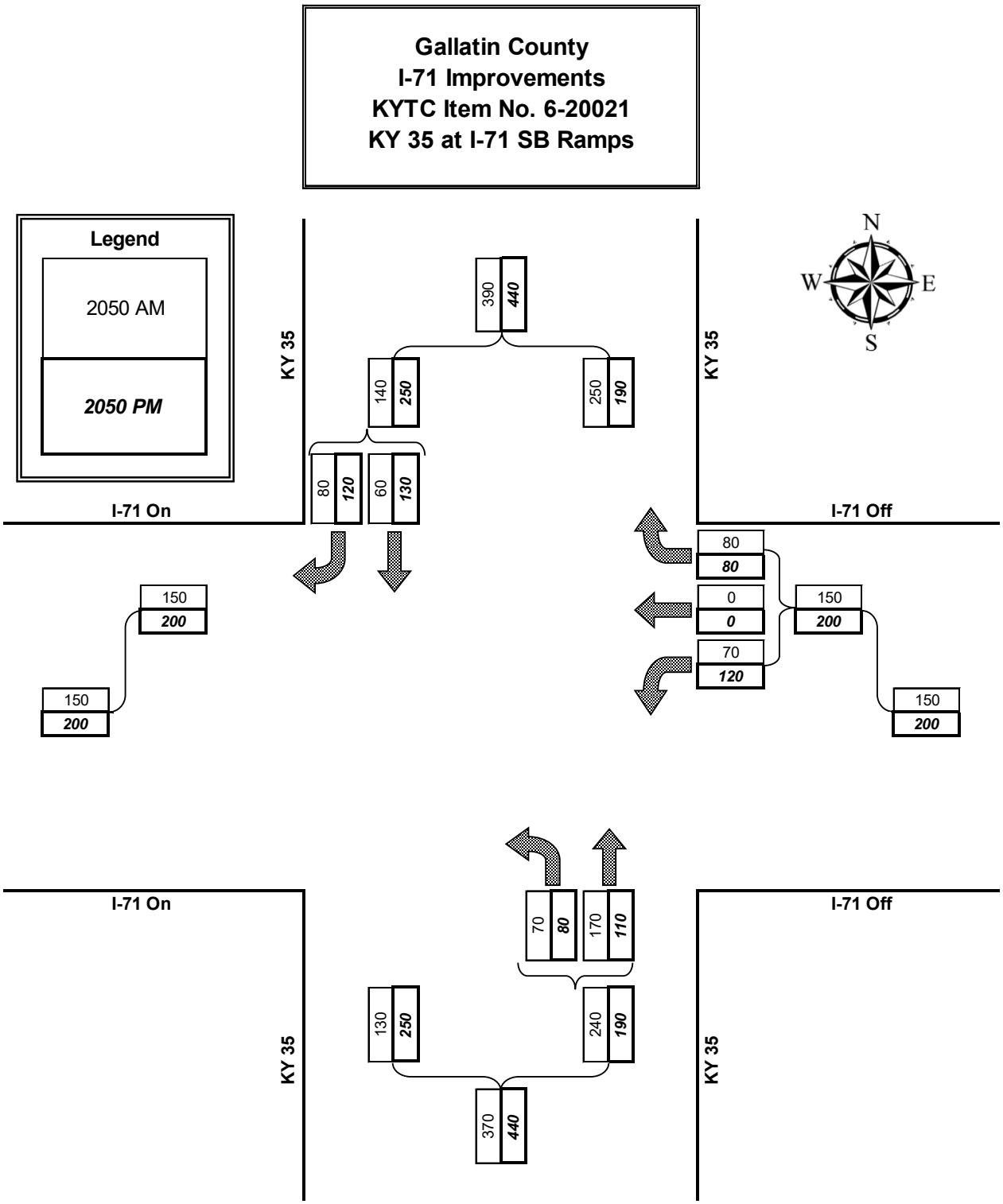
Appendix B
2050 AM and PM Design Hour Turning Movements



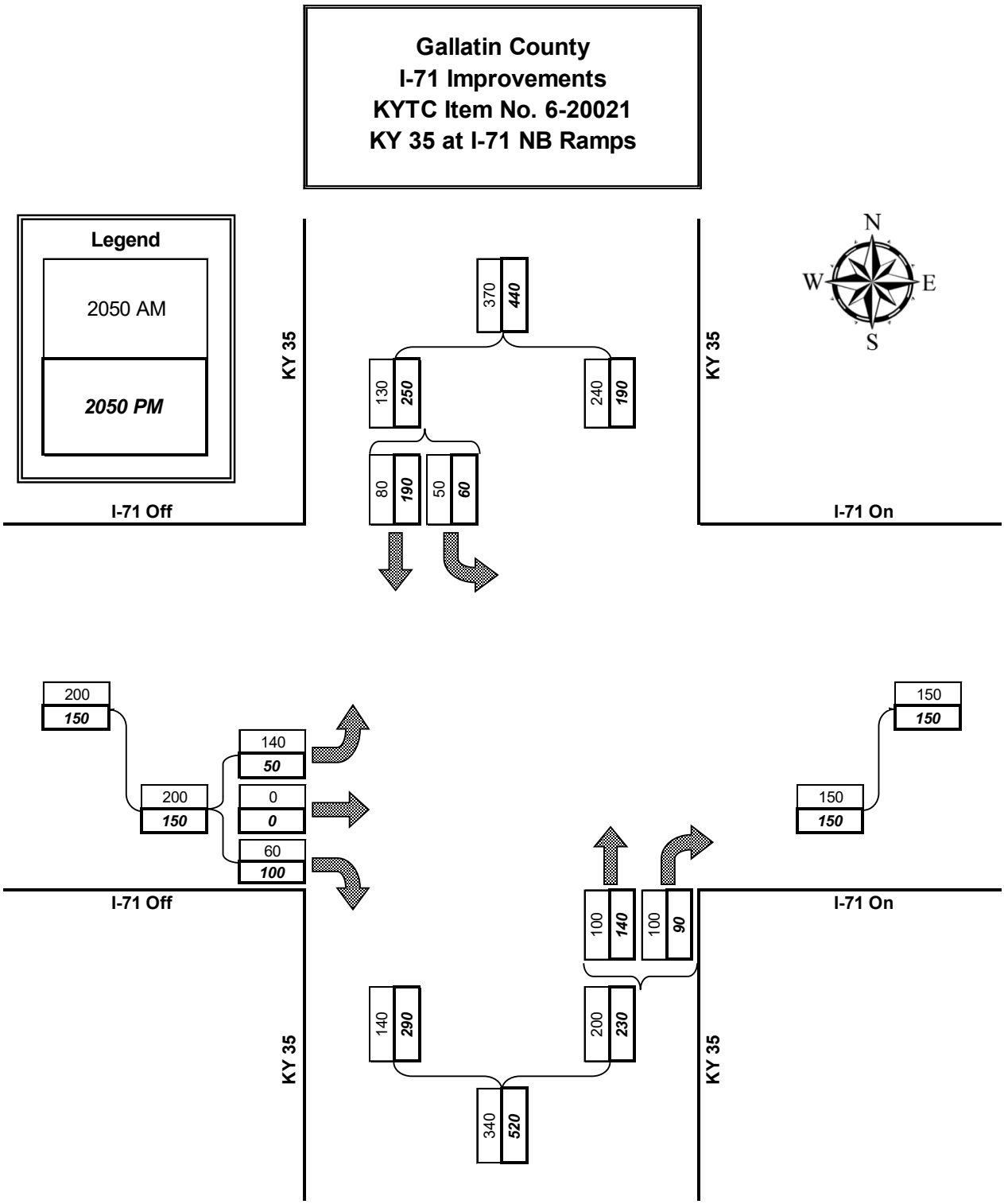
PERIOD: 2035 Design Hour Volumes (DHV's) PREPARED BY: Mark Butler DATE PREPARED: 12/10/2023	



PERIOD: 2050 Design Hour Volumes (DHV's) PREPARED BY: Mark Butler DATE PREPARED: 12/10/2023	

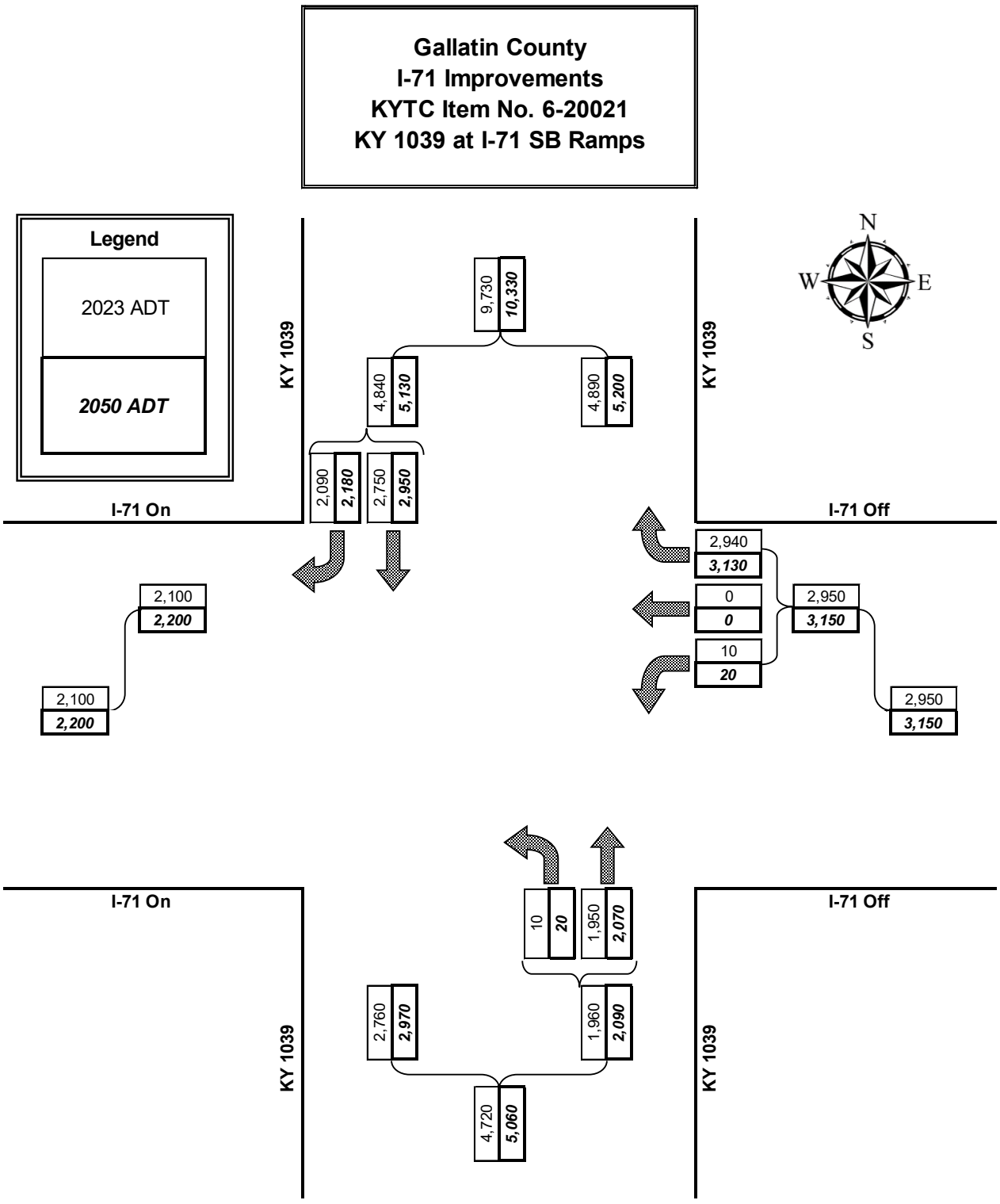


PERIOD: 2035 Design Hour Volumes (DHV's) PREPARED BY: Mark Butler DATE PREPARED: 12/10/2023	

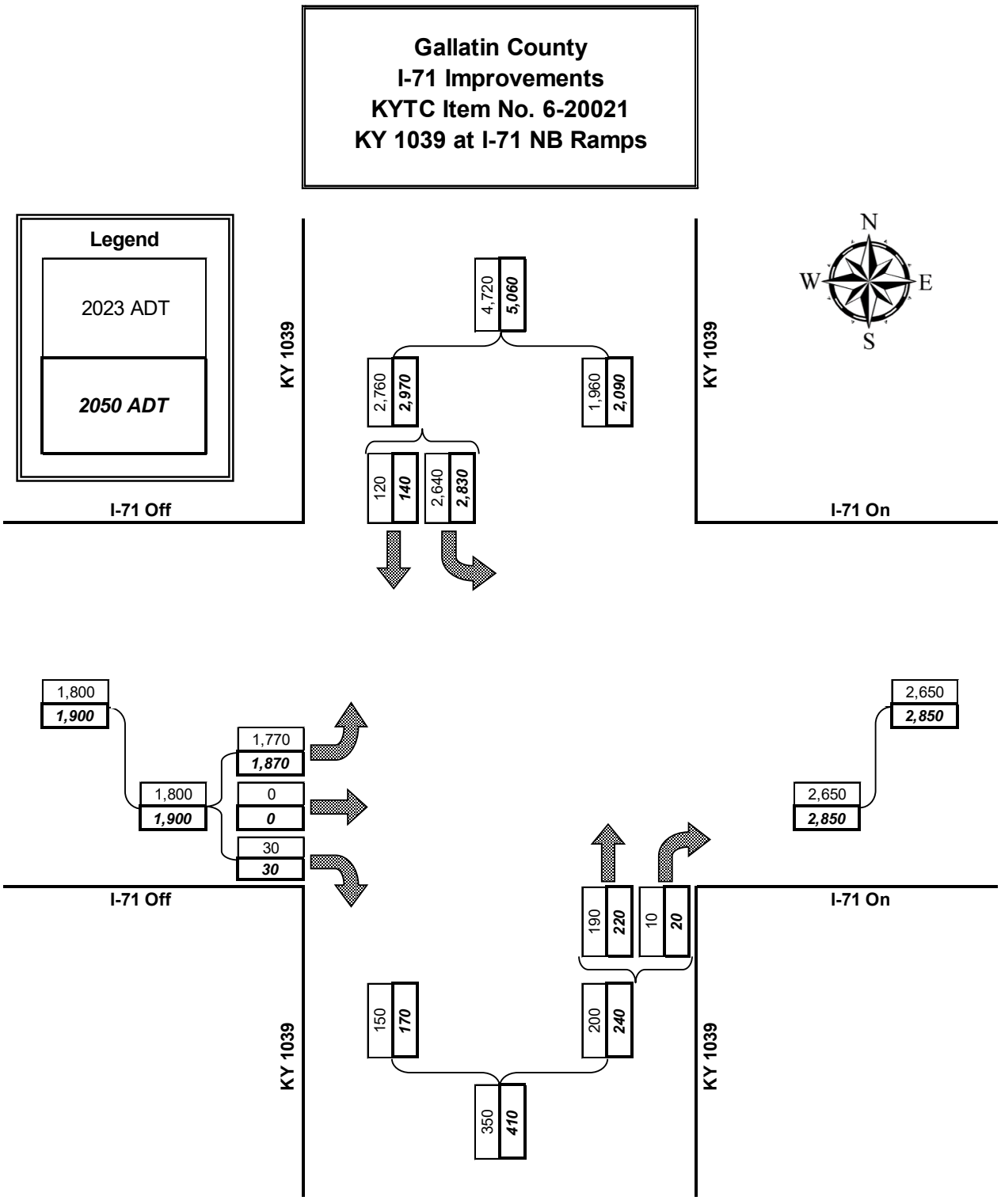


PERIOD: 2050 Design Hour Volumes (DHV's) PREPARED BY: Mark Butler DATE PREPARED: 12/10/2023	

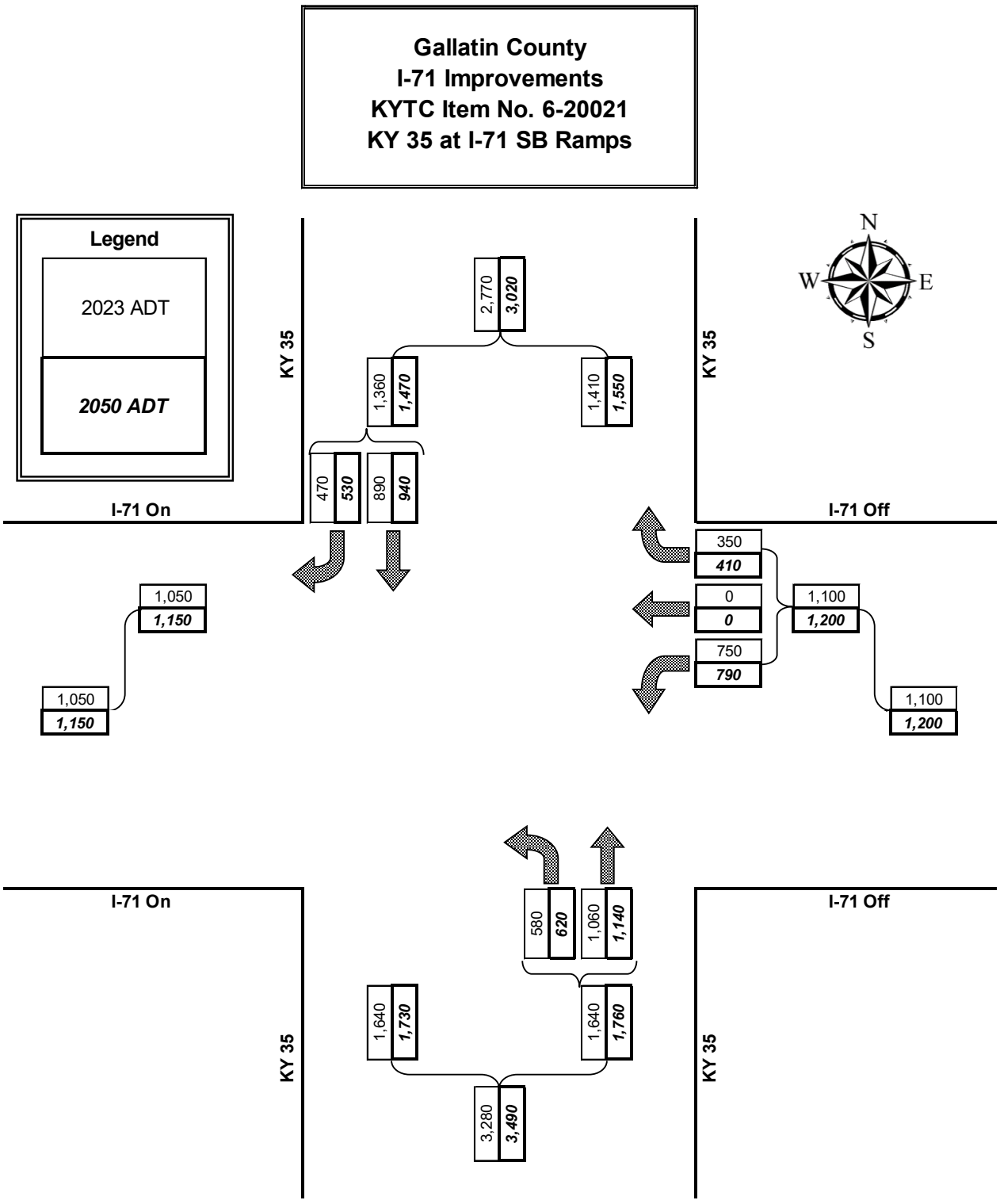
Appendix C
2023 and 2050 ADT Turning Movements



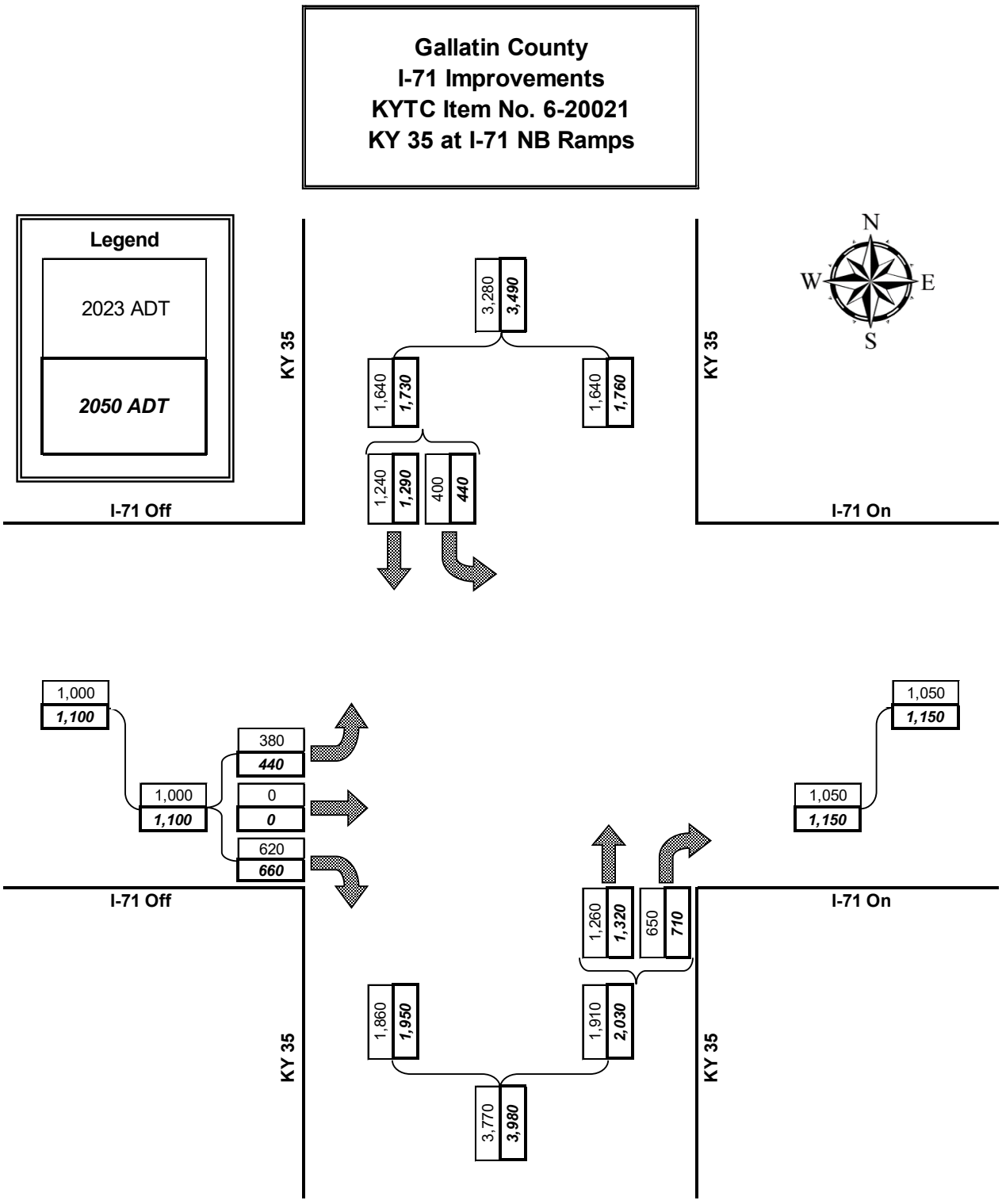
PREPARED BY: Mark Butler DATE PREPARED: 12/10/2023	Notes: Existing (2023) & Design Year (2050) Average Daily Traffic Volumes



PREPARED BY: Mark Butler DATE PREPARED: 12/10/2023	Notes: Existing (2023) & Design Year (2050) Average Daily Traffic Volumes



PREPARED BY: Mark Butler DATE PREPARED: 12/10/2023	Notes: Existing (2023) & Design Year (2050) Average Daily Traffic Volumes



PREPARED BY: Mark Butler DATE PREPARED: 12/10/2023	Notes: Existing (2023) & Design Year (2050) Average Daily Traffic Volumes

Appendix D
Pavement Design Factors Forms

Pavement Design Factors for I-71 Improvements - Gallatin County

Project Information:

Date of Forecast	11/22/2022
Name of Forecaster	Mark Butler
Item Number	6-20021.00
County Name	Gallatin
County Number	39
District	6
eMARS Number	0
Function	
Fund	
Project Type	Major Widening
Current Year	2023
Letting Year	2023
Construction Year	2024
Design Year	2050

Project Description: ADDRESS CONDITION OF I-71 FROM MILEPOINT 53.433 TO MILEPOINT 56.673 (2022CCR)

Route Information:

Route ID	039-I -0071 -000
Road Name	I-71
BMP	53.400
EMP	56.700
Functional Class	1 - Interstate
Total Lanes (Both Ways)	4
One or Two Ways	Two Ways
Pavement Type	Asphault
Are Trucks Prohibited in a Lane?	No

Volume Information:

Volume ADT Station	039525
Current-Year Volume	40,800
Design-Year Volume	65,100

Truck Count and Truck Volume Information:

Truck Count Station	039525	Truck % of ADT	34.9%
Truck Volume in Design Direction	7,400	FC Average Truck %	25.3%
Truck Volume in Design Lane of Design Direction	6,700	% of Trucks in Design Direction	52.0%
Current-Year AADTT	**14,200**	% of Trucks in Design Lane of Design Direction	90.0%
Design-Year AADTT	**22,700**	**Truck Volume Growth Rate**	**1.7%**

Distribution Factors for Functional Class:

1 - Interstate

Truck Percent Year: 2019

Daily Volume Distribution Factors by Vehicle Class

	Vehicle Class	Truck Volume	Truck Percent
Bus	4	411	2.89%
2 Axles, 6 Tires Single Unit	5	923	6.50%
3 Axles Single Unit	6	907	6.38%
4 or More Axles, Single Unit	7	44	0.31%
3-4 Axles, Single Trailer	8	841	5.93%
5 Axles Single Trailer	9	8,812	62.06%
6 or More Axles, Single Trailer	10	1,322	9.31%
5 or Less Axles, Multi-Trailer	11	293	2.06%
6 Axles, Multi-Trailer	12	238	1.68%
7 or More Axles, Multi-Trailer	13	409	2.88%
All Vehicle Classes		14,200	100.00%

Coal Haul Information:

Annual Coal Tonnage for 2021:	
Coal Trucks per Day:	
Percentage of Trucks that Are Coal:	
Percentage of All Vehicles that Are Coal:	

TEAM KENTUCKY TRANSPORTATION CABINET

Hourly Volume Distribution Factors

0	12 AM to 1 AM	373	2.62%
1	1 AM to 2 AM	302	2.13%
2	2 AM to 3 AM	318	2.24%
3	3 AM to 4 AM	311	2.19%
4	4 AM to 5 AM	414	2.92%
5	5 AM to 6 AM	498	3.51%
6	6 AM to 7 AM	539	3.79%
7	7 AM to 8 AM	595	4.19%
8	8 AM to 9 AM	616	4.34%
9	9 AM to 10 AM	808	5.69%
10	10 AM to 11 AM	830	5.84%
11	11 AM to 12 PM	781	5.50%
12	12 PM to 1 PM	828	5.83%
13	1 PM to 2 PM	804	5.66%
14	2 PM to 3 PM	745	5.25%
15	3 PM to 4 PM	659	4.64%
16	4 PM to 5 PM	677	4.77%
17	5 PM to 6 PM	649	4.57%
18	6 PM to 7 PM	719	5.06%
19	7 PM to 8 PM	795	5.60%
20	8 PM to 9 PM	578	4.07%
21	9 PM to 10 PM	482	3.40%
22	10 PM to 11 PM	448	3.16%
23	11 PM to 12 AM	433	3.05%
	All Hours	14,200	100.00%

Pavement Design Factors for I-71 Improvements - Gallatin County

Project Information:

Date of Forecast	11/22/2022
Name of Forecaster	Mark Butler
Item Number	6-20021.00
County Name	Gallatin
County Number	39
District	6
eMARS Number	0
Function	
Fund	
Project Type	Major Widening
Current Year	2023
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Construction Year	2024
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Project Description: ADDRESS CONDITION OF I-71 FROM MILEPOINT 53.433 TO MILEPOINT 56.673 (2022CCR)

Route Information:

Route ID	039-I -0071 -000
Road Name	I-71
BMP	53.400
EMP	56.700
Functional Class	1 - Interstate
Total Lanes (Both Ways)	4
One or Two Ways	Two Ways
Pavement Type	Asphault
Are Trucks Prohibited in a Lane?	No

Volume Information:

Volume ADT Station	039537
Current-Year Volume	42,500
Design-Year Volume	67,000

Truck Count and Truck Volume Information:

Truck Count Station	039537	Truck % of ADT	34.9%
Truck Volume in Design Direction	7,700	FC Average Truck %	25.3%
Truck Volume in Design Lane of Design Direction	6,900	% of Trucks in Design Direction	52.0%
Current-Year AADTT	**14,800**	% of Trucks in Design Lane of Design Direction	90.0%
Design-Year AADTT	**23,400**	**Truck Volume Growth Rate**	**1.7%**

Distribution Factors for Functional Class:

1 - Interstate

Truck Percent Year: 2019

Daily Volume Distribution Factors by Vehicle Class

	Vehicle Class	Truck Volume	Truck Percent
Bus	4	428	2.89%
2 Axles, 6 Tires Single Unit	5	962	6.50%
3 Axles Single Unit	6	945	6.38%
4 or More Axles, Single Unit	7	46	0.31%
3-4 Axles, Single Trailer	8	877	5.93%
5 Axles Single Trailer	9	9,185	62.06%
6 or More Axles, Single Trailer	10	1,378	9.31%
5 or Less Axles, Multi-Trailer	11	305	2.06%
6 Axles, Multi-Trailer	12	248	1.68%
7 or More Axles, Multi-Trailer	13	426	2.88%
All Vehicle Classes		14,800	100.00%

Coal Haul Information:

Annual Coal Tonnage for 2021:	
Coal Trucks per Day:	
Percentage of Trucks that Are Coal:	
Percentage of All Vehicles that Are Coal:	

TEAM KENTUCKY TRANSPORTATION CABINET

Hourly Volume Distribution Factors

0	12 AM to 1 AM	388	2.62%
1	1 AM to 2 AM	315	2.13%
2	2 AM to 3 AM	331	2.24%
3	3 AM to 4 AM	324	2.19%
4	4 AM to 5 AM	432	2.92%
5	5 AM to 6 AM	519	3.51%
6	6 AM to 7 AM	561	3.79%
7	7 AM to 8 AM	621	4.19%
8	8 AM to 9 AM	642	4.34%
9	9 AM to 10 AM	842	5.69%
10	10 AM to 11 AM	865	5.84%
11	11 AM to 12 PM	814	5.50%
12	12 PM to 1 PM	863	5.83%
13	1 PM to 2 PM	838	5.66%
14	2 PM to 3 PM	777	5.25%
15	3 PM to 4 PM	686	4.64%
16	4 PM to 5 PM	705	4.77%
17	5 PM to 6 PM	676	4.57%
18	6 PM to 7 PM	749	5.06%
19	7 PM to 8 PM	828	5.60%
20	8 PM to 9 PM	602	4.07%
21	9 PM to 10 PM	503	3.40%
22	10 PM to 11 PM	467	3.16%
23	11 PM to 12 AM	451	3.05%
	All Hours	14,800	100.00%

Pavement Design Factors for I-71 Improvements - Gallatin County

Project Information:

Date of Forecast	11/22/2022
Name of Forecaster	Mark Butler
Item Number	6-20021.00
County Name	Gallatin
County Number	39
District	6
eMARS Number	0
Function	
Fund	
Project Type	Major Widening
Current Year	2023
Letting Year	2023
Construction Year	2024
Design Year	2050

Project Description: ADDRESS CONDITION OF I-71 FROM MILEPOINT 53.433 TO MILEPOINT 56.673 (2022CCR)

Route Information:

Route ID	039-I -0071 -000
Road Name	I-71
BMP	53.400
EMP	56.700
Functional Class	1 - Interstate
Total Lanes (Both Ways)	4
One or Two Ways	Two Ways
Pavement Type	Asphault
Are Trucks Prohibited in a Lane?	No

Volume Information:

Volume ADT Station	039522
Current-Year Volume	42,600
Design-Year Volume	67,100

Truck Count and Truck Volume Information:

Truck Count Station	039522	Truck % of ADT	34.9%
Truck Volume in Design Direction	7,700	FC Average Truck %	25.3%
Truck Volume in Design Lane of Design Direction	6,900	% of Trucks in Design Direction	52.0%
Current-Year AADTT	**14,900**	% of Trucks in Design Lane of Design Direction	90.0%
Design-Year AADTT	**23,400**	**Truck Volume Growth Rate**	**1.7%**

Distribution Factors for Functional Class:

1 - Interstate

Truck Percent Year: 2019

Daily Volume Distribution Factors by Vehicle Class

	Vehicle Class	Truck Volume	Truck Percent
Bus	4	431	2.89%
2 Axles, 6 Tires Single Unit	5	968	6.50%
3 Axles Single Unit	6	951	6.38%
4 or More Axles, Single Unit	7	46	0.31%
3-4 Axles, Single Trailer	8	883	5.93%
5 Axles Single Trailer	9	9,247	62.06%
6 or More Axles, Single Trailer	10	1,387	9.31%
5 or Less Axles, Multi-Trailer	11	307	2.06%
6 Axles, Multi-Trailer	12	250	1.68%
7 or More Axles, Multi-Trailer	13	429	2.88%
All Vehicle Classes		14,900	100.00%

Coal Haul Information:

Annual Coal Tonnage for 2021:	
Coal Trucks per Day:	
Percentage of Trucks that Are Coal:	
Percentage of All Vehicles that Are Coal:	

TEAM KENTUCKY TRANSPORTATION CABINET

Hourly Volume Distribution Factors

0	12 AM to 1 AM	391	2.62%
1	1 AM to 2 AM	317	2.13%
2	2 AM to 3 AM	333	2.24%
3	3 AM to 4 AM	326	2.19%
4	4 AM to 5 AM	435	2.92%
5	5 AM to 6 AM	522	3.51%
6	6 AM to 7 AM	565	3.79%
7	7 AM to 8 AM	625	4.19%
8	8 AM to 9 AM	646	4.34%
9	9 AM to 10 AM	848	5.69%
10	10 AM to 11 AM	871	5.84%
11	11 AM to 12 PM	820	5.50%
12	12 PM to 1 PM	869	5.83%
13	1 PM to 2 PM	844	5.66%
14	2 PM to 3 PM	782	5.25%
15	3 PM to 4 PM	691	4.64%
16	4 PM to 5 PM	710	4.77%
17	5 PM to 6 PM	681	4.57%
18	6 PM to 7 PM	754	5.06%
19	7 PM to 8 PM	834	5.60%
20	8 PM to 9 PM	606	4.07%
21	9 PM to 10 PM	506	3.40%
22	10 PM to 11 PM	470	3.16%
23	11 PM to 12 AM	454	3.05%
	All Hours	14,900	100.00%

Andy Beshear
GOVERNOR

TRANSPORTATION CABINET
200 Mero Street
Frankfort, Kentucky 40601

Jim Gray
SECRETARY

MEMORANDUM

TO: Joe Plunk, P.E.
Chief District Engineer
District 3 – Bowling Green

ATTN: Stewart Lich, P.E.

FROM: Mikael Pelfrey, P.E. MBP
Director
Division of Planning

DATE: July 25, 2023

SUBJECT: Warren County Traffic Forecast
Improve KY 234 from Roger Porter Road to Fountain Trace Drive
Item No. 3-8854.00

In response to your March 7, 2023, request, we are providing the following forecasts on the attached report:

- 2023 and 2050 Build Average Daily Traffic
- 2023 and 2050 Build Average Daily Truck Traffic
- 2023 and 2050 Build Turning Movements and Design Hourly Volume

If you have any questions, please contact Connor Schurman, P.E., of this Division at (502) 782-5553.

Attachments

c/att: Kenny Carrico, P.E.
Andy Stewart, P.E.
Ben Hunt, P.E.
Isidro Delgado Herrera, P.E.

Executive Summary

Traffic Forecast Report
Warren County
KY 234 Widening
Item No. 3-8854.00

Prepared for:

TEAM KENTUCKY®
TRANSPORTATION CABINET

Prepared by:
Connor Schurman
Division of Planning
Kentucky Transportation Cabinet
July 25, 2023

Table of Contents

Commonly Used Abbreviations and their Descriptions

ADT	Average Daily Traffic	Without any adjustment
AADT	Annual Average Daily Traffic	The total volume of traffic for one year/365
AADTT	Annual Average Daily Truck Traffic	The total volume of truck traffic for a year/365
DHV	Design Hour Volume	30th highest hour of a year
%T	Truck Percentage	The percentage of trucks to total volume
FC	Functional Class	Refers to a road's importance
GR	Growth Rate	A value normally compounded annually
PHF	Peak Hour Factor	Considers a 15-minute spike in an hourly count
K-Factor	K-30th hour Factor	DHV divided by ADT (DHV/ADT)
D-Factor	Directional Factor	Percentage of dominant flow to total
MP	Mile Point	Miles increase easterly and northerly
ATR	Automatic Traffic Recorder	A permanent & continuous recording station
KYSTM	Kentucky Statewide Model	A computerized representation of KY roads
BCI	Bicycle Comfort Index	Rating of bicyclists' comfort level

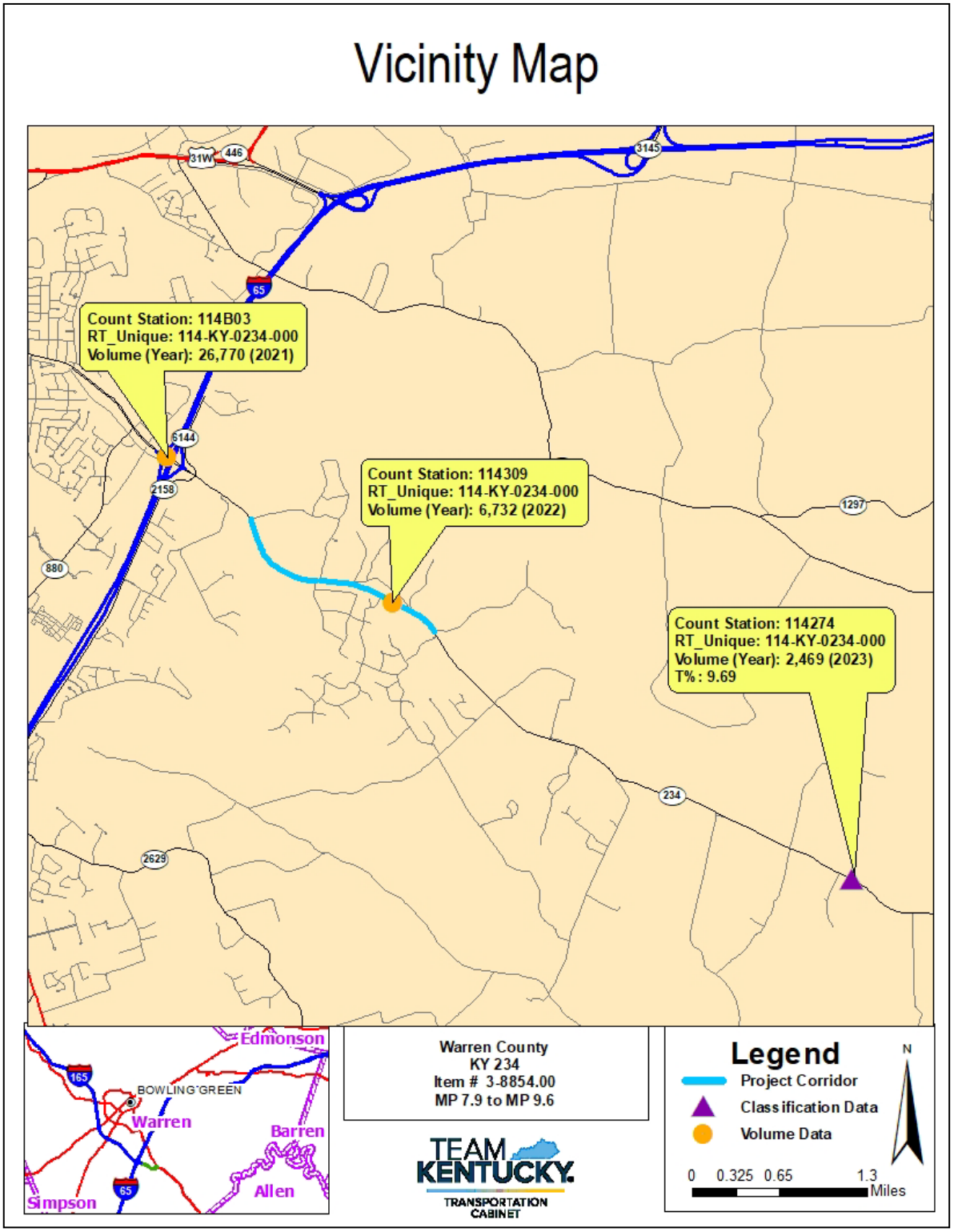

Vicinity Map
Count Station: 114B03
RT_Unique: 114-KY-0234-000
Volume (Year): 26,770 (2021)
Count Station: 114309
RT_Unique: 114-KY-0234-000
Volume (Year): 6,732 (2022)
Count Station: 114274
RT_Unique: 114-KY-0234-000
Volume (Year): 2,469 (2023)
T%: 9.69
31W
446
3145
65
6144
2158
880
1297
234
2629
Edmonson
BOWLING GREEN
Warren
Barren
Allen
Simpson
165
65
Warren County
KY 234
Item # 3-8854.00
MP 7.9 to MP 9.6
TEAM KENTUCKY
TRANSPORTATION CABINET
Legend
Project Corridor
Classification Data
Volume Data
N
0 0.325 0.65 1.3
Miles

Figure 1

Traffic Forecast Executive Summary
Warren County: KY 234 Widening
Item No. 3-8854.00

FORECAST SUMMARY

This project proposed widening of Cemetery Road (KY 234) from Fountain Trace Drive (MP 7.878) to Roger Porter Road (MP 9.625). Therefore, KYTC District 3 requested this forecast report to analyze traffic volumes in the base-year and future-year scenarios.

FORECAST TYPE

The following types of forecasts were developed:

- 2023 and 2050 ADT values
- 2023 and 2050 DHV values
- 2023 and 2050 AADTT and Truck DHV values
- 2023 and 2050 daily and design hour turn movements

CURRENT-YEAR VOLUMES

The current-year ADT volumes came from traffic volume and classification counts on KY 234 using KYTC's CTS database. The locations of these stations and their respective ADT values can be seen on the vicinity map on Page 2.

DESIGN-YEAR/GROWTH FACTORS

Design-year growth rates were determined based on the population projections for Warren County, the historical growth rates for surrounding traffic count stations, and the model runs from the Warren County TDM. The population data was gathered from the Kentucky State Data Center and suggested an annual growth rate of 1.47% from 2020 to 2045 for Warren County. The population information is depicted in Figure 3 on the following page.

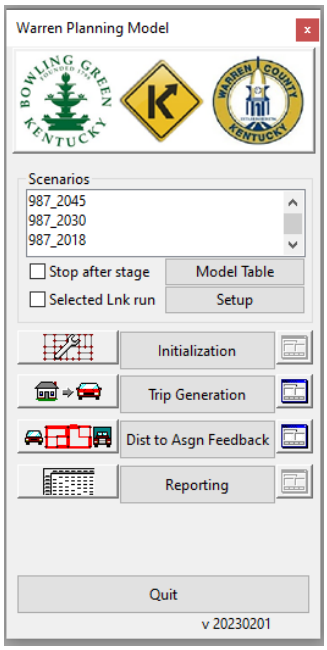


Figure 2

Place	2010 Census	2020 Census	Annual Growth 2010-2020	2045 Projection	Annual Growth 2020-2045
Kentucky	4,339,367	4,505,836	0.38%	4,750,369	0.22%
Warren County	113,792	134,554	1.69%	194,531	1.47%

Figure 3

Growth analyses performed on traffic count stations surrounding the project area helped find a historical growth rate. The count stations evaluated for this forecast can be seen on the vicinity map on Page 2. The growth trends for each count station are depicted in Figure 4 below. All three count stations surrounding the project limits had a positive trend with the station closest to I-65 having the largest positive trend.

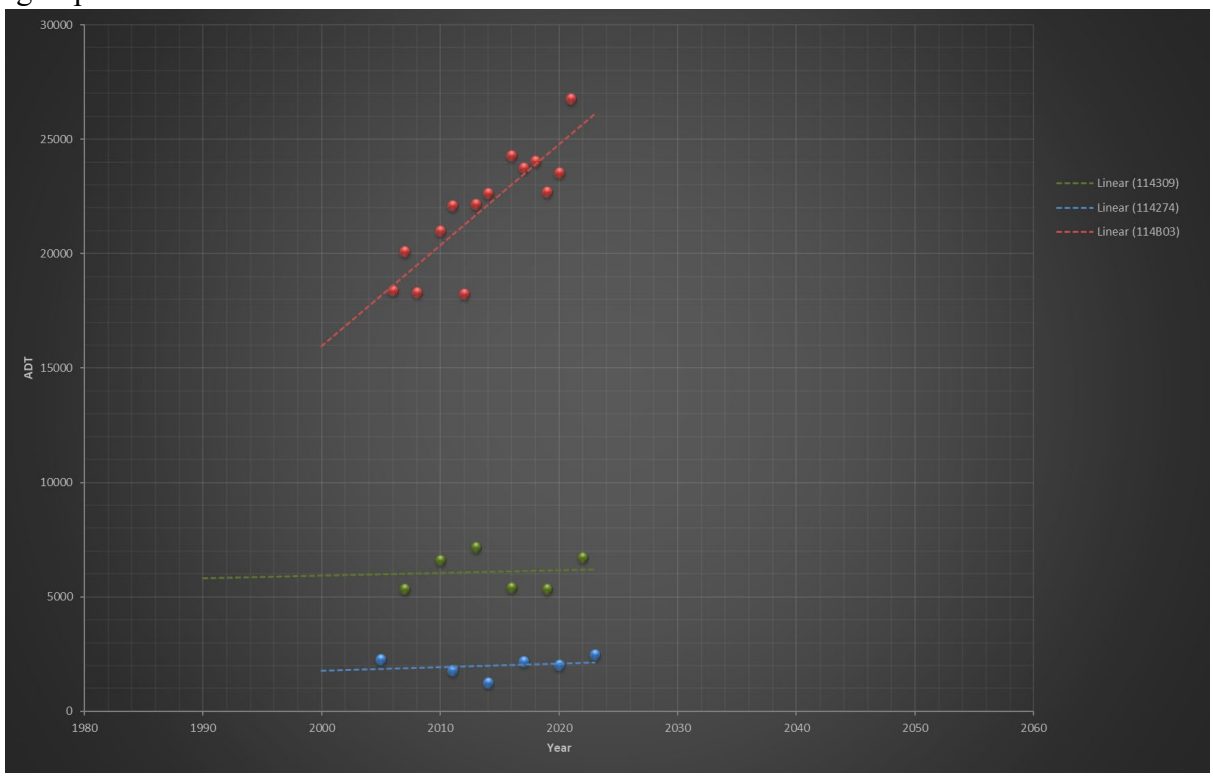


Figure 4

The Warren County TDM suggested an annual growth rate of 1.3% for Warren County and 2.1% for the project area on average. Using the information mentioned in this section a 1.5% annual growth rate was used for the purpose of this forecast.

DESIGN HOURLY FACTORS FOR 2050

The project corridor had a 2023 K-factor of 10.6% which came from the calculated base-year turning movements. The 2050 K-factor was kept consistent with the 2023 K-factor, and the design hour volumes were grown using the same growth rates discussed in the growth factors section.

TRUCK VOLUMES AND PERCENTAGES FOR 2050

Truck growth rate and volumes were based on the most recent classification count at station 114274. A 1.5% annual growth rate was used for trucks. The base and future-year AADTT can be seen on the pavement design spreadsheet on Page 6.

TURN MOVEMENTS

Turning movements were collected at three intersections along KY 234 in March of 2023. The resulting current-year and future-year volumes are shown in the turn movement spreadsheets starting on Page 9. The summary map on page 7 includes the locations of the three intersection counts, which are:

1. KY 234 @ Fountain Trace Drive
2. KY 234 @ Drakesborough Drive
3. KY 234 @ Rivergreen Lane
4. KY 234 @ Barrington Drive

PAVEMENT DESIGN SPREADSHEET

Pavement Design Factors for KY 234 Widening

Project Information:

Date of Forecast	3/13/2023
Name of Forecaster	Connor Schurman
Item Number	3-8854.00
County Name	Warren
County Number	114
District	3
eMARS Number	1444301D
Function	FD04
Fund	1100
Project Type	Major Widening
Current Year	2023
Letting Year	
Construction Year	2027
Design Year	2050

Project Description: MAJOR WIDENING/RECONSTRUCTION OF CEMETERY ROAD (KY-234) FROM FOUNTAIN TRACE TO ROGER PORTER ROAD (MP 7.878 TO MP 9.625).(14CCN)

Route Information:

Route ID	114-KY-0234 -000
Road Name	Cemetery RD
BMP	7.878
EMP	9.625
Functional Class	5 - Major Collector
Total Lanes (Both Ways)	2
One or Two Ways	Two Ways
Pavement Type	Asphault
Are Trucks Prohibited in a Lane?	No

Volume Information:

Volume ADT Station	114309
Current-Year Volume	6,600
Design-Year Volume	9,900

Truck Count and Truck Volume Information:

Truck Count Station	114274
Truck Volume in Design Direction	390
Truck Volume in Design Lane of Design Direction	390
Current-Year AADTT	680
Design-Year AADTT	960

Truck % of ADT	9.7%
FC Average Truck %	10.0%
% of Trucks in Design Direction	57.5%
% of Trucks in Design Lane of Design Direction	100.0%
Truck Volume Growth Rate	1.5%

Distribution Factors for Functional Class: 5 - Major Collector

Truck Percent Year: 2023

Daily Volume Distribution Factors by Vehicle Class

Vehicle Class		Truck Volume	Truck Percent
Bus	4	29	4.26%
2 Axles, 6 Tires Single Unit	5	425	62.55%
3 Axles Single Unit	6	23	3.40%
4 or More Axles, Single Unit	7	12	1.70%
3-4 Axles, Single Trailer	8	162	23.83%
5 Axles Single Trailer	9	20	2.98%
6 or More Axles, Single Trailer	10	3	0.43%
5 or Less Axles, Multi-Trailer	11	0	0.00%
6 Axles, Multi-Trailer	12	0	0.00%
7 or More Axles, Multi-Trailer	13	6	0.85%
All Vehicle Classes		680	100.00%

Coal Haul Information:

Annual Coal Tonnage for 2021:	
Coal Trucks per Day:	
Percentage of Trucks that Are Coal:	
Percentage of All Vehicles that Are Coal:	

TEAM KENTUCKY TRANSPORTATION CABINET

Hourly Volume Distribution Factors

0	12 AM to 1 AM	6	0.85%
1	1 AM to 2 AM	0	0.00%
2	2 AM to 3 AM	0	0.00%
3	3 AM to 4 AM	0	0.00%
4	4 AM to 5 AM	6	0.85%
5	5 AM to 6 AM	14	2.13%
6	6 AM to 7 AM	32	4.68%
7	7 AM to 8 AM	41	5.96%
8	8 AM to 9 AM	49	7.23%
9	9 AM to 10 AM	38	5.53%
10	10 AM to 11 AM	35	5.11%
11	11 AM to 12 PM	41	5.96%
12	12 PM to 1 PM	41	5.96%
13	1 PM to 2 PM	46	6.81%
14	2 PM to 3 PM	32	4.68%
15	3 PM to 4 PM	72	10.64%
16	4 PM to 5 PM	58	8.51%
17	5 PM to 6 PM	61	8.94%
18	6 PM to 7 PM	43	6.38%
19	7 PM to 8 PM	41	5.96%
20	8 PM to 9 PM	17	2.55%
21	9 PM to 10 PM	6	0.85%
22	10 PM to 11 PM	0	0.00%
23	11 PM to 12 AM	3	0.43%
	All Hours	680	100.00%

Figure 5

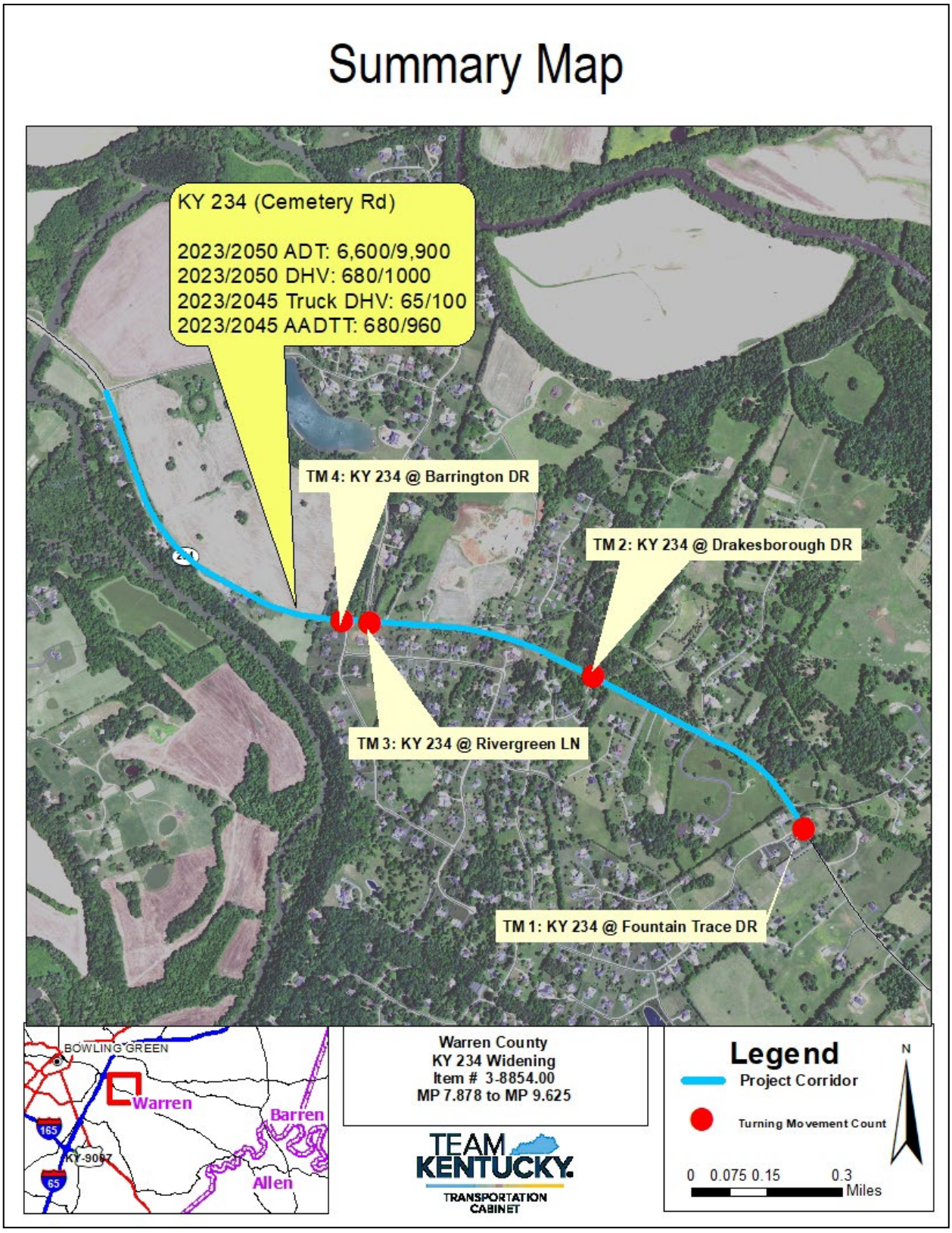

Summary Map
KY 234 (Cemetery Rd)
2023/2050 ADT: 6,600/9,900
2023/2050 DHV: 680/1000
2023/2045 Truck DHV: 65/100
2023/2045 AADTT: 680/960
TM 4: KY 234 @ Barrington DR
TM 2: KY 234 @ Drakesborough DR
TM 3: KY 234 @ Rivergreen LN
TM 1: KY 234 @ Fountain Trace DR
BOWLING GREEN
Warren
Barren
Allen
165
KY-9067
65
Warren County
KY 234 Widening
Item # 3-8854.00
MP 7.878 to MP 9.625
TEAM KENTUCKY
TRANSPORTATION CABINET
Legend
Project Corridor
Turning Movement Count
N
0 0.075 0.15 0.3
Miles

Figure 6

2023 TURNING MOVEMENTS AND DHVs

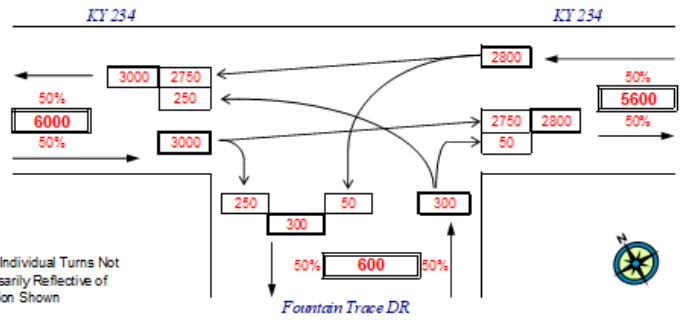
PROJECT: KY234 Widening
ITEM NUMBER: 3-8854.00
MARS NUMBER: 1444301D
REQUEST DATE: 3/732023
ANALYST: Connor Schurman
YEAR: **2023** **ADT and Design Hour Volumes**
INTERSECTION: KY234 and Fountain Trace Drive

NOTE: Directional distributions were determined from a 2023 turning movement count.

TURN MOVEMENT 1 (2023)

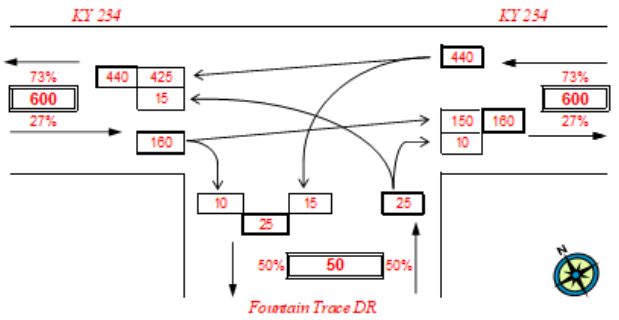
****DHV TURN MOVEMENT FORECASTS SHOULD NOT BE USED FOR SIGNAL TIMING OR WARRANT ANALYSIS**

2023 ADT



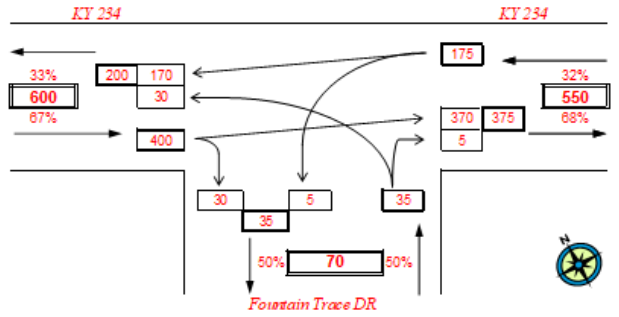
Note : Individual Turns Not Necessarily Reflective of Precision Shown

2023 AM Design Hour



Location Map

2023 PM Design Hour



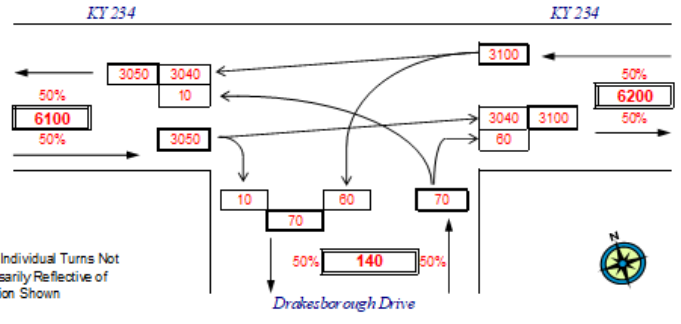
PROJECT: KY234 Widening
ITEM NUMBER: 3-8854.00
MARS NUMBER: 1444301D
REQUEST DATE: Saturday, January 0, 1900
ANALYST: Connor Schurman
YEAR: 2023 ADT and Design Hour Volumes
INTERSECTION: KY234 and Drakesborough Drive

NOTE: Directional distributions were determined from a 2023 turning movement count.

TURN MOVEMENT 2 (2023)

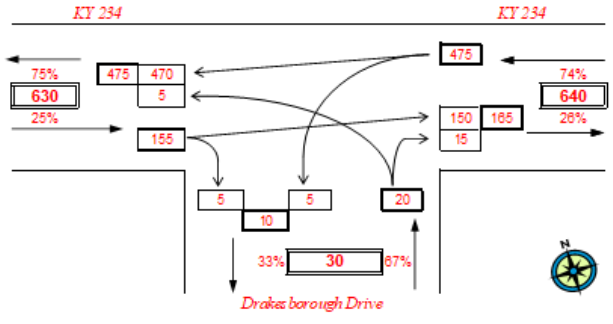
**DHV TURN MOVEMENT FORECASTS SHOULD NOT BE USED FOR SIGNAL TIMING OR WARRANT ANALYSIS

2023 ADT



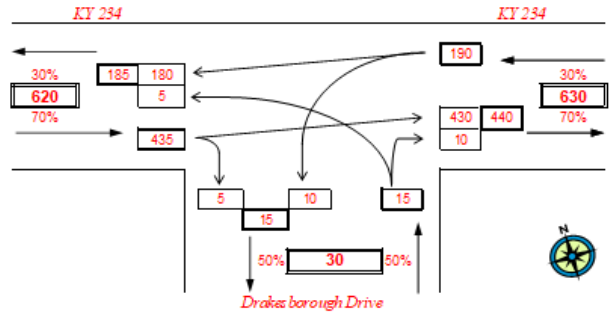
Note : Individual Turns Not Necessarily Reflective of Precision Shown

2023 AM Design Hour



Location Map

2023 PM Design Hour

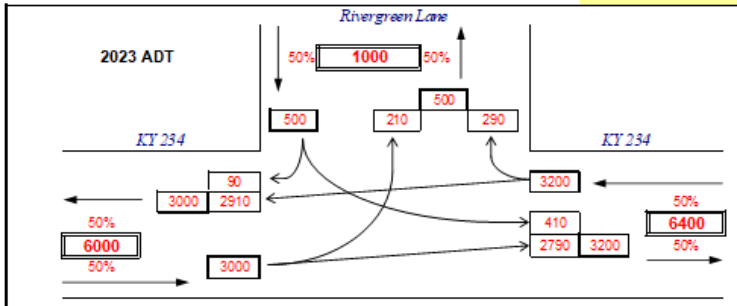


PROJECT: KY234 Widening
ITEM NUMBER: 3-8854.00
MARS NUMBER: 1444301D
REQUEST DATE: Saturday, January 0, 1900
ANALYST: Connor Schurman
YEAR: 2023 ADT and Design Hour Volumes
INTERSECTION: KY234 and Rivergreen Lane

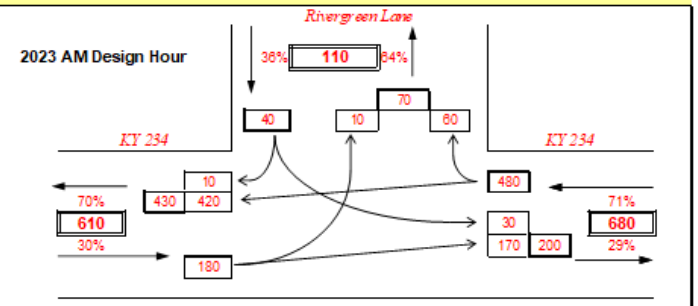
NOTE: Directional distributions were determined from a 2023 turning movement count.

TURN MOVEMENT 3 (2023)

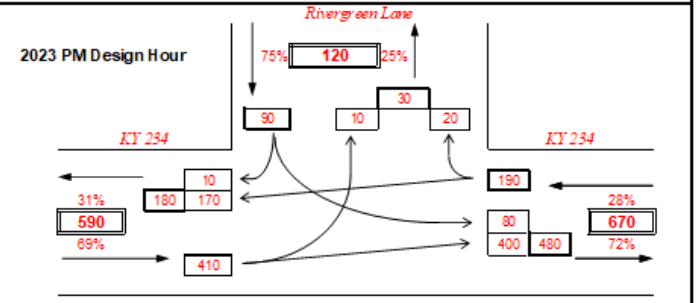
**DHV TURN MOVEMENT FORECASTS SHOULD NOT BE USED FOR SIGNAL TIMING OR WARRANT ANALYSIS



Note : Individual Turns Not Necessarily Reflective of Precision Shown



Location Map



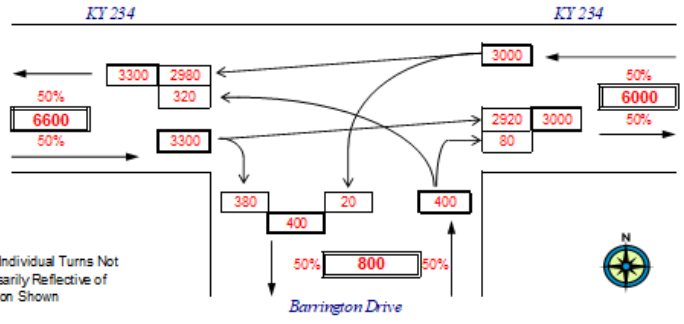
PROJECT: KY234
ITEM NUMBER: 3-8854.00
MARS NUMBER: 1444301D
REQUEST DATE: Saturday, January 0, 1900
ANALYST: Connor Schurman
YEAR: 2023 ADT and Design Hour Volumes
INTERSECTION: KY234 and Barrington Drive

NOTE: Directional distributions were determined from a 2023 turning movement count.

TURN MOVEMENT 4 (2023)

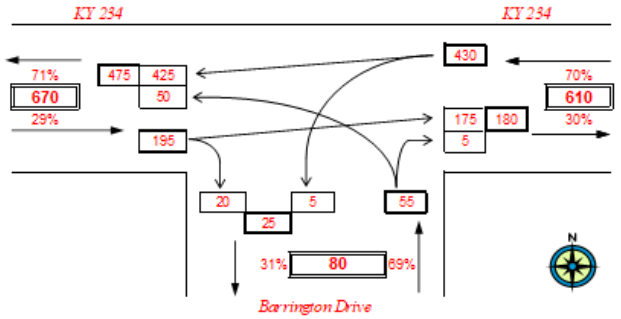
**DHV TURN MOVEMENT FORECASTS SHOULD NOT BE USED FOR SIGNAL TIMING OR WARRANT ANALYSIS

2023 ADT



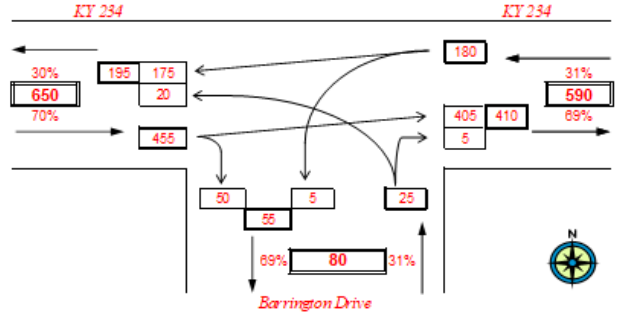
Note : Individual Turns Not Necessarily Reflective of Precision Shown

2023 AM Design Hour



Location Map

2023 PM Design Hour



2050 TURNING MOVEMENTS AND DHVs

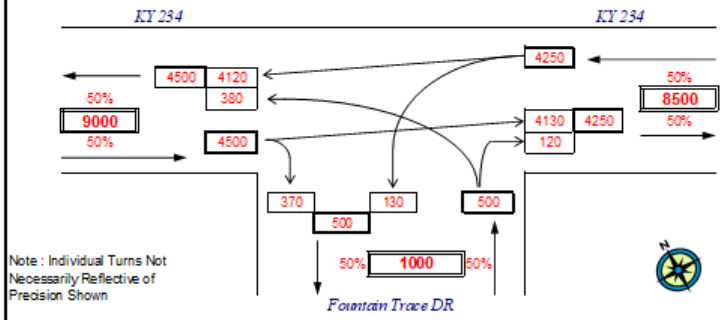
PROJECT: KY234 Widening
ITEM NUMBER: 3-8854.00
MARS NUMBER: 1444301D
REQUEST DATE: 3/732023
ANALYST: Connor Schurman
YEAR: 2050 ADT and Design Hour Volumes
INTERSECTION: KY234 and Fountain Trace Drive

NOTE: Directional distributions were determined from a calculated turning movement count.

TURN MOVEMENT 1 (2050)

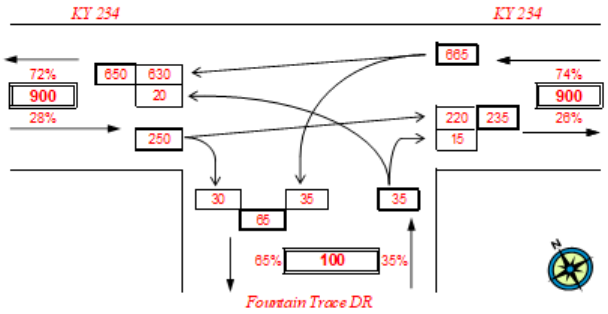
**DHV TURN MOVEMENT FORECASTS SHOULD NOT BE USED FOR SIGNAL TIMING OR WARRANT ANALYSIS

2050 ADT



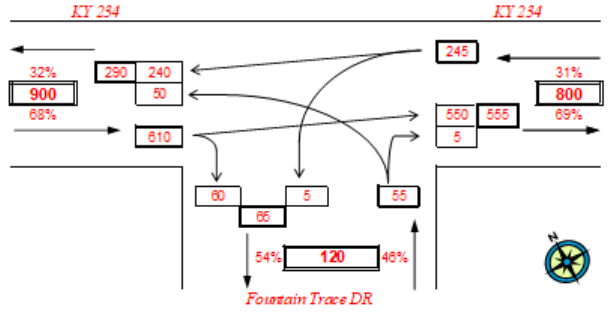
Note : Individual Turns Not Necessarily Reflective of Precision Shown

2050 AM Design Hour



Location Map

2050 PM Design Hour



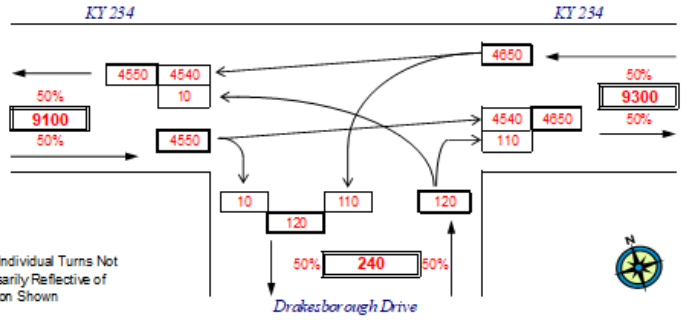
PROJECT: KY234 Widening
ITEM NUMBER: 3-8854.00
MARS NUMBER: 1444301D
REQUEST DATE: Saturday, January 0, 1900
ANALYST: Connor Schurman
YEAR: 2050 ADT and Design Hour Volumes
INTERSECTION: KY234 and Drakesborough Drive

NOTE: Directional distributions were determined from a calculated turning movement count.

TURN MOVEMENT 2 (2050)

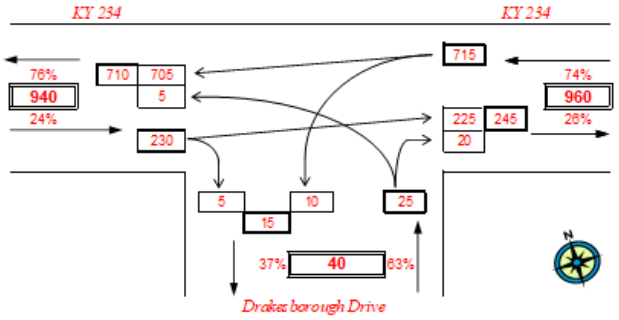
**DHV TURN MOVEMENT FORECASTS SHOULD NOT BE USED FOR SIGNAL TIMING OR WARRANT ANALYSIS

2050 ADT



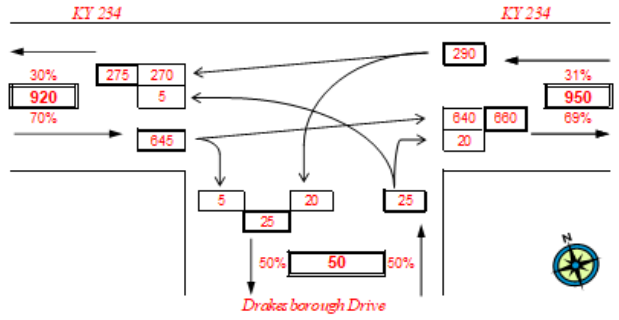
Note : Individual Turns Not Necessarily Reflective of Precision Shown

2050 AM Design Hour



Location Map

2050 PM Design Hour

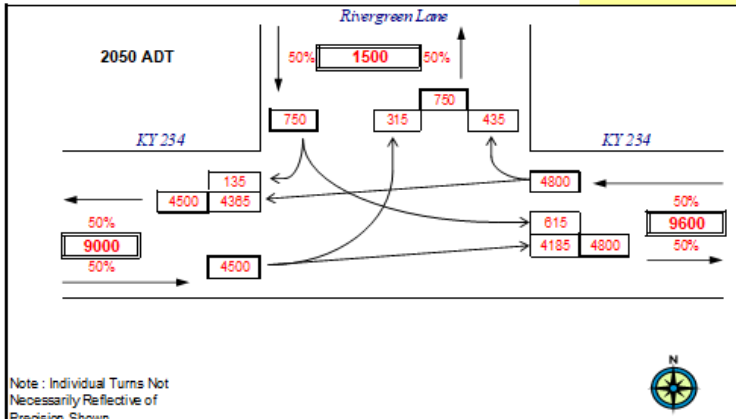


PROJECT: KY234 Widening
ITEM NUMBER: 3-8854.00
MARS NUMBER: 1444301D
REQUEST DATE: Saturday, January 0, 1900
ANALYST: Connor Schurman
YEAR: 2050 ADT and Design Hour Volumes
INTERSECTION: KY234 and Rivergreen Lane

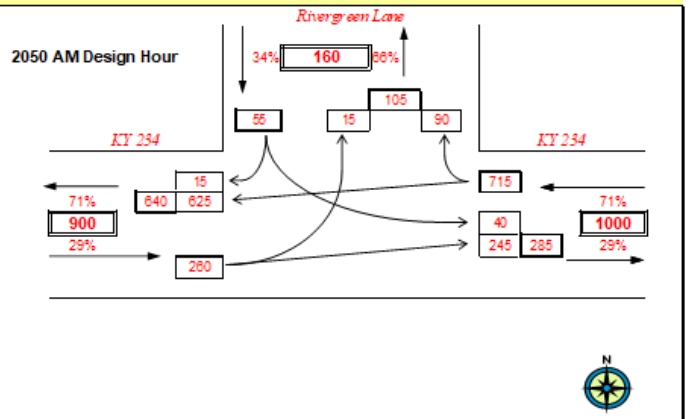
NOTE: Directional distributions were determined from a calculated turning movement count.

TURN MOVEMENT 3 (2050)

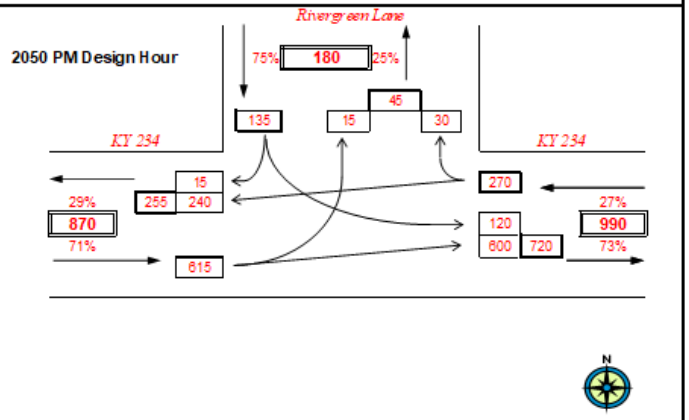
**DHV TURN MOVEMENT FORECASTS SHOULD NOT BE USED FOR SIGNAL TIMING OR WARRANT ANALYSIS



Note : Individual Turns Not Necessarily Reflective of Precision Shown



Location Map



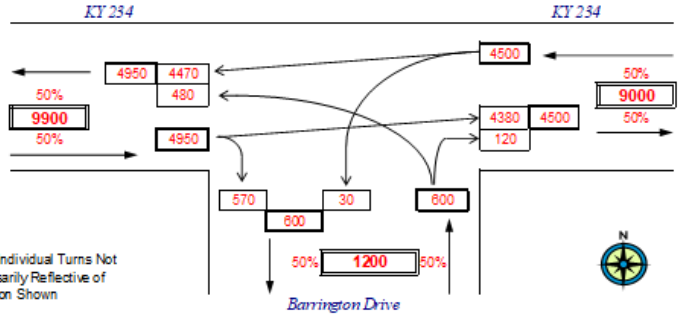
PROJECT: KY234
ITEM NUMBER: 3-8854.00
MARS NUMBER: 1444301D
REQUEST DATE: Saturday, January 0, 1900
ANALYST: Connor Schurman
YEAR: 2050 ADT and Design Hour Volumes
INTERSECTION: KY234 and Barrington Drive

NOTE: Directional distributions were determined from a calculated turning movement count.

TURN MOVEMENT 4 (2050)

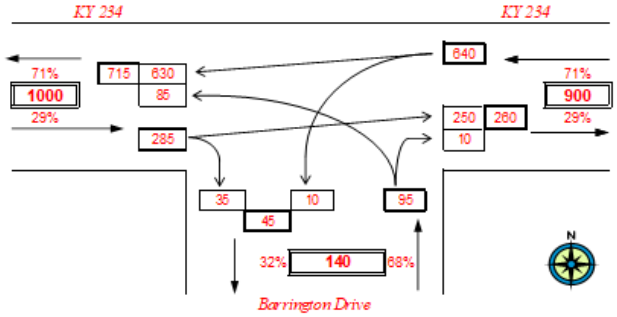
**DHV TURN MOVEMENT FORECASTS SHOULD NOT BE USED FOR SIGNAL TIMING OR WARRANT ANALYSIS

2050 ADT



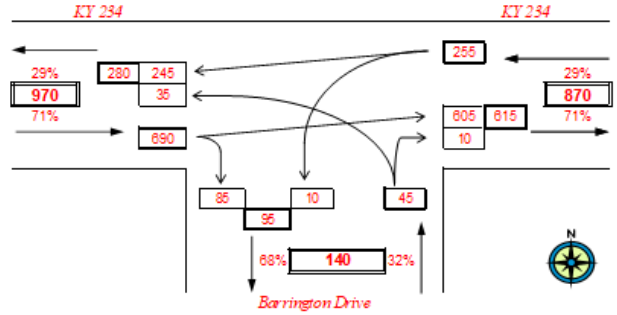
Note : Individual Turns Not Necessarily Reflective of Precision Shown

2050 AM Design Hour



Location Map

2050 PM Design Hour



Pedestrian & Bicycle Consideration Review

Warren County
Item #03-8854.00
KY 234

Prepared for: Stewart Lich

Requested by:
District 3

Bicycle and Pedestrian Consideration Review
Item No. 03-8854.00

Project Overview:

Major widening/reconstruction of Cemetery Road (KY 234) from Roger Porter Road (MP 9.6) to Fountain Trace Drive (MP 7.9) in Warren County.

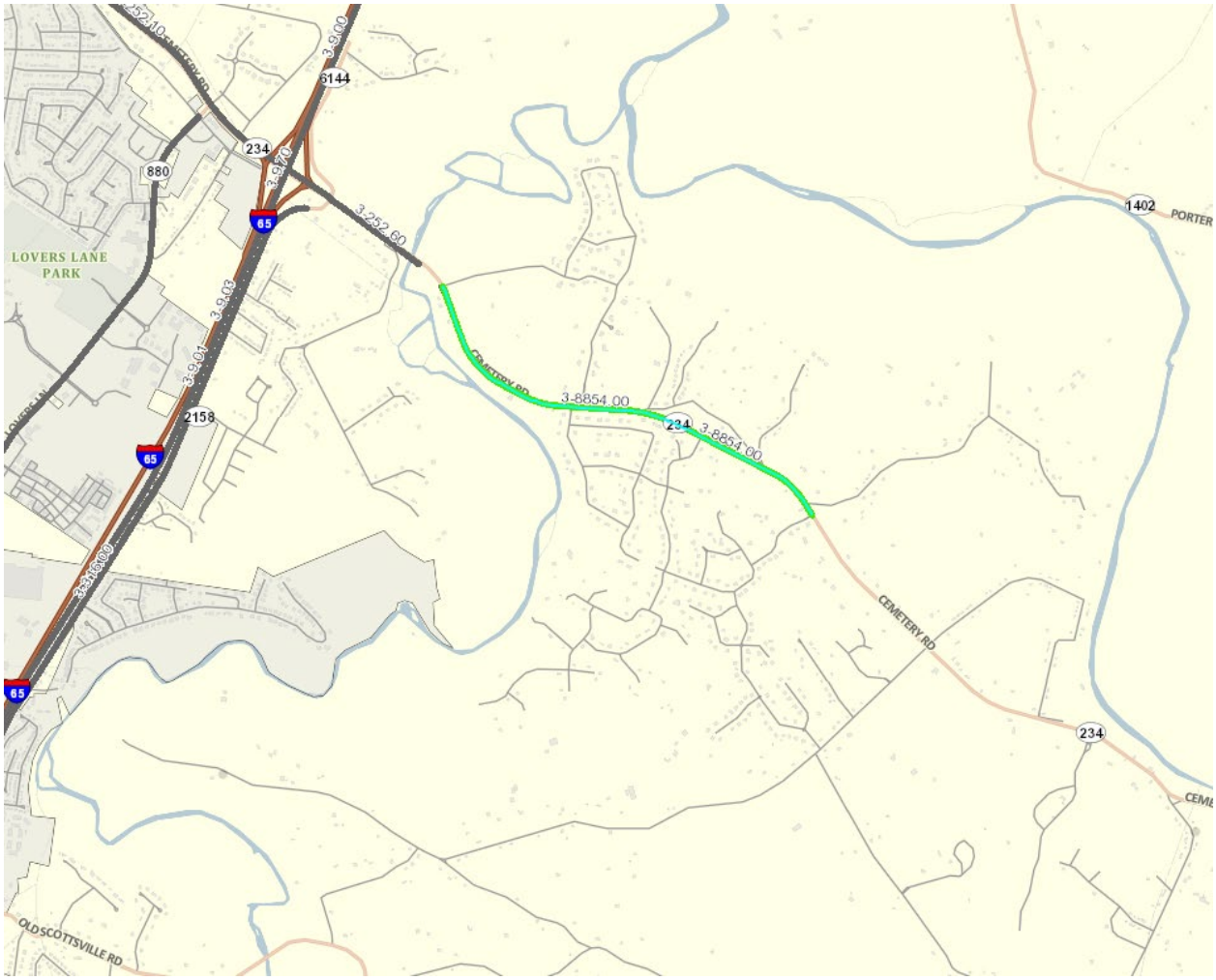
Local/regional Bicycle & Pedestrian Planning:

Bowling Green-Warren County does have a Bicycle and Pedestrian Master Plan and it was updated in 2022. This project is not identified in the Master Plan.

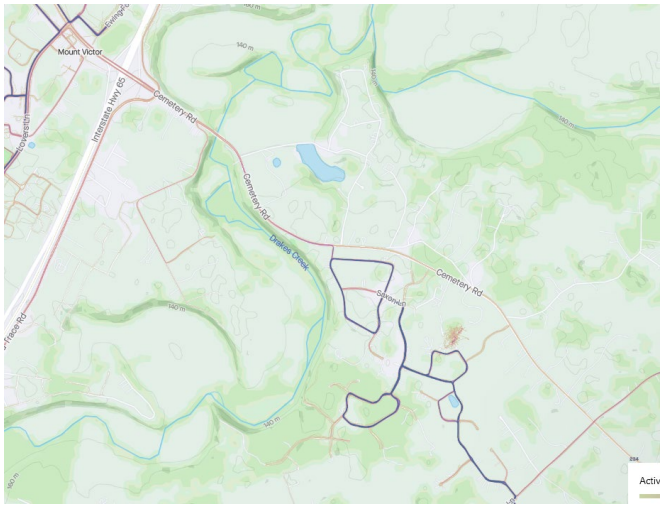
Existing Conditions:

114-KY-0234-000

a. **ADT:** 6,600 (2023)
b. **Heavy Truck Percentage:** 9.7%
c. **Posted Speed Limit** is 55 mph
d. Rural Area
e. **Functional Class**: Major Collector
f. Bicycle Comfort Index average rating is a Level E
g. Pedestrian Comfort Index average rating is a Level E
h. Strava Heat Map indicates heavy bicycle activity in the project area (Figure 2)
i. Strava Heat Map indicates heavy pedestrian activity in the project area. (Figure 3)



(Figure 1) Project Area



(Figure 2) Strava Heat Map showing minimum bicycle activity in project area and significant bicycle traffic in the adjacent area

(Figure 3) Strava Heat Map showing no pedestrian activity in project area but significant traffic adjacent to project area

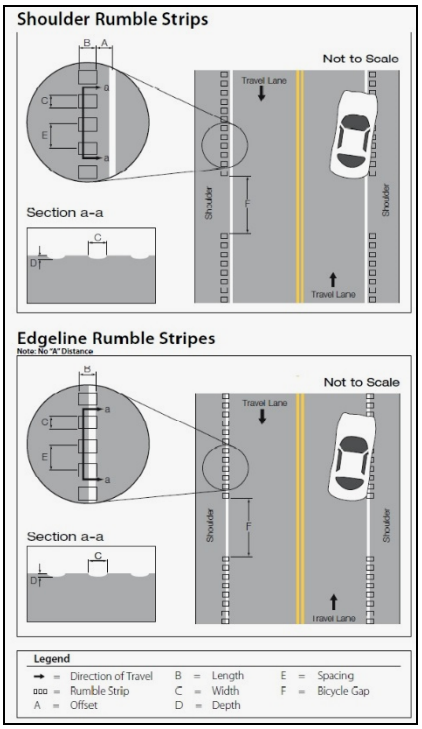
The KYTC Bicycle and Pedestrian program team recommendations are:

Best: Reconstruct the road as a complete street meeting the needs of all modes of travel including bicycle and pedestrian modes as appropriate. Project should look at other opportunities to provide improved enhanced crossings as appropriate.

These improvements could include a shared-use path (10' or wider) along the roadway (entire project area) to create pedestrian and bicycle network connections along the project area. Portions of KY 234 have a shared use path in place currently. Coordinate with the local government for opportunities to accommodate future pedestrian access along this roadway. This would serve the current and future local planning and residential/commercial development for both bicycle and pedestrian travel (including ADA access). Create an agreement or update an existing agreement with the local government regarding the pedestrian and bicycle facility maintenance responsibilities. The BCI average would improve to a level A, and the PCI average would improve to a level A (for the project area).

Good: Construct buffered/protected bike lanes and sidewalk along the corridor connecting to the existing sidewalks along roadway. This would better accommodate the bike and pedestrian travel in the area, as well as providing better ADA compliance. Place or replace marked crosswalks at all appropriate signalized intersections. The Bicycle Comfort Index would elevate to a level B and Pedestrian Comfort Index would increase to a Level A.

Fair: Construct paved shoulders (8' or wider) on both sides of the roadway to better accommodate pedestrian and bicycle travel along this roadway corridor. Place 10' gaps every 40-50' in the rumbles strips to better accommodate bicycle travel (Figure 4). The BCI average would maintain a level C, and the PCI average would remain a level C (for the project area).



(Figure 4) Bicycle Gap Sapce in Rumble Strips

1 KY Complete Streets Policy:
https://transportation.ky.gov/BikeWalk/Documents/Complete%20Streets%20Policy.pdf

2 BCI:
https://transportation.ky.gov/BikeWalk/Documents/BCI%20Metadata%20Page%20Updated%202018.pdf

3 PCI:
https://transportation.ky.gov/BikeWalk/Documents/Metadata%20Page%20PCI%202019.pdf

4 Rumble Strips:
https://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips/bike_fs/

Prepared by:
Keith Lovan, Bicycle & Pedestrian Coordinator
Division of Planning, Kentucky Transportation Cabinet
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