Final Report

Hillen Road & 33rd Street Intersection Analysis

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Introduction: The Study Location

The intersection of 33rd St. and Hillen Rd. is adjacent to Lake Montebello and serves as a key interface among a major north–south corridor (Hillen Rd.), an east–west neighborhood connection (E 33rd St.), and the park-access roadway system (Whitman Dr. and the E 32nd St. connection). This context can generate frequent pedestrian movements, bicycling and scooter activity, and complex interactions between vehicles and non-vehicle users. Figure 1 depicts the intersection's crosswalks, sidewalks, and bicycle facilities. This road geometry underscores the importance of understanding (i) multimodal exposure (how many users are present), (ii) vehicle operating speeds, and (iii) the frequency and location of vehicle–vehicle and vehicle–pedestrian/bicycle interaction events.

The intersection includes marked crosswalks on multiple legs, including a marked crossing associated with the Whitman Dr./park entrance. However, pedestrian connectivity is not continuous on the east side of the intersection. Specifically, the sidewalk on the east side of Whitman Dr. does not extend beyond the park-adjacent crosswalk, and a marked crosswalk that directly connects the north and south sides along the east leg of the intersection is absent (Figure 1, green box).

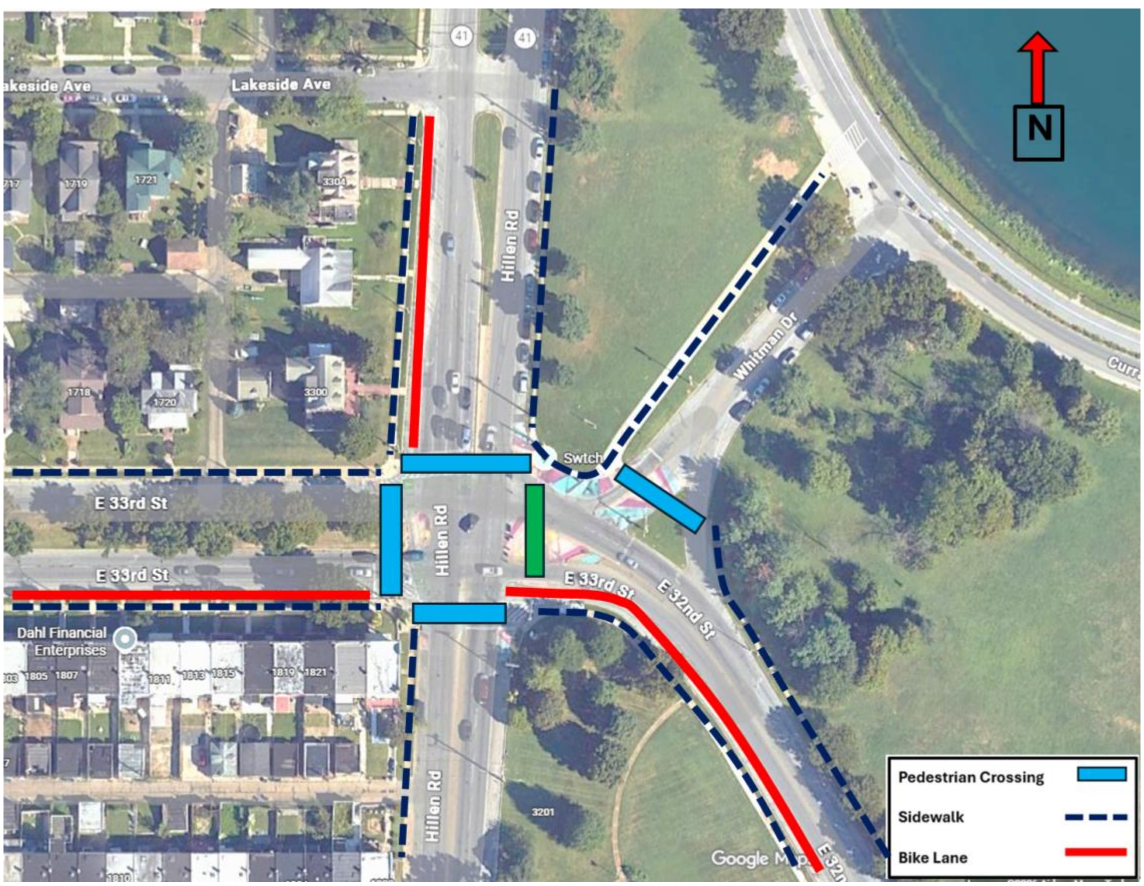

Figure 1. Hillen Rd. & 33rd St. Intersection

As shown in Figure 1, there are three bicycle lanes and seven sidewalks around the intersection. Marked pedestrian crossings exist across the north and south sides of Hillen Rd., across E 33rd St. on the west leg, and at the Whitman Dr. park entrance. However, there is no marked crosswalk that directly connects the north and south sides on the east leg. Field review indicates that geometric features near the southeast corner, such as a median opening and an ADA-accessible curb ramp that leads to the street, may unintentionally encourage pedestrians to initiate crossings from this location despite the lack of a complete crosswalk connection. The decorative pavement markings may further reduce clarity for pedestrians unfamiliar with the intersection because the colored patterns do not always align with the physical sidewalk edges and barrier boundaries. These conditions help explain why some pedestrians may choose informal routes rather than use marked crossings (Figures 2, 3, and 4).

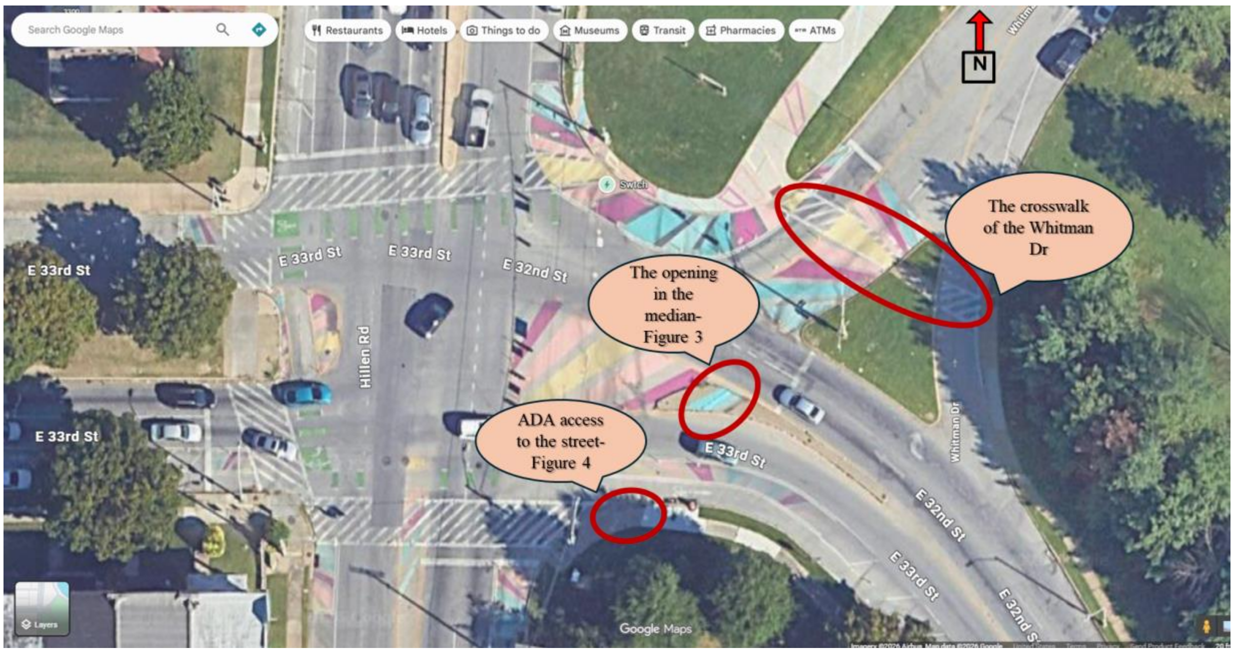

Figure 2. Southeast corner features that may influence pedestrian path choice (median opening and ramp-to-street condition) and the Whitman Dr. crosswalk context

Figure 3. Median opening near the southeast area of the intersection (potential informal crossing staging point)

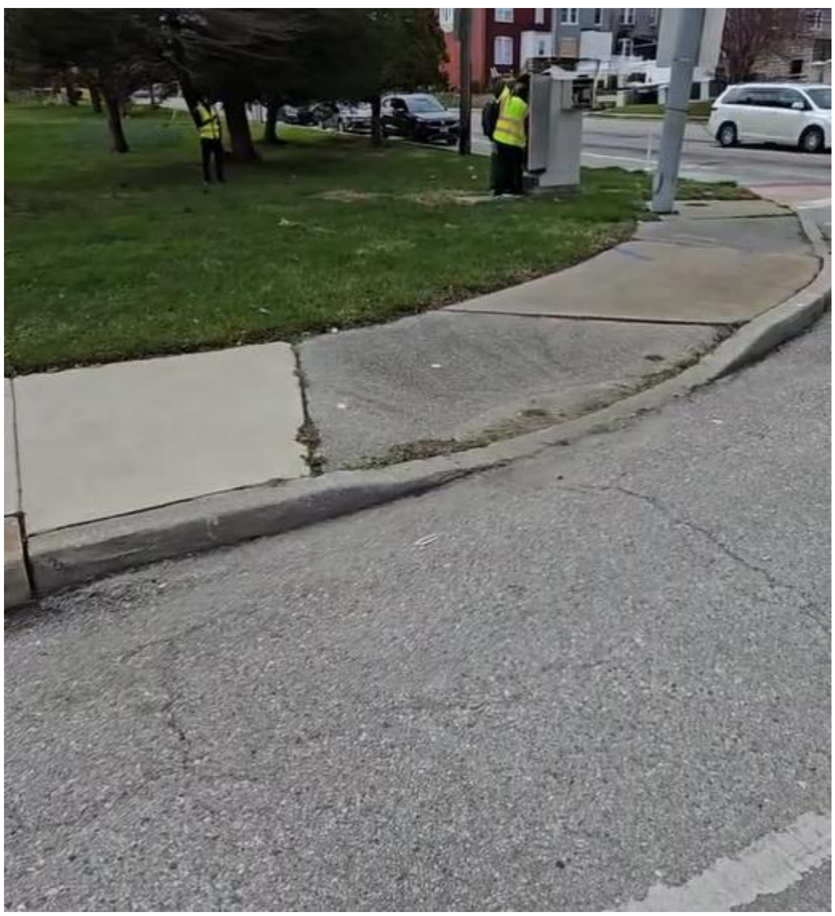

Figure 4. ADA-accessible ramp/curb transition leading to the street near the southeast area (may encourage informal crossing initiation)

Motorized traffic at the intersection approaches from four directions: Hillen Rd. northbound, Hillen Rd. southbound, 33rd St. eastbound, and 33rd St. westbound. These movements are distributed into through, left-turn, and right-turn flows at the intersection. Figure 5 indicates the traffic into and out of the intersection.

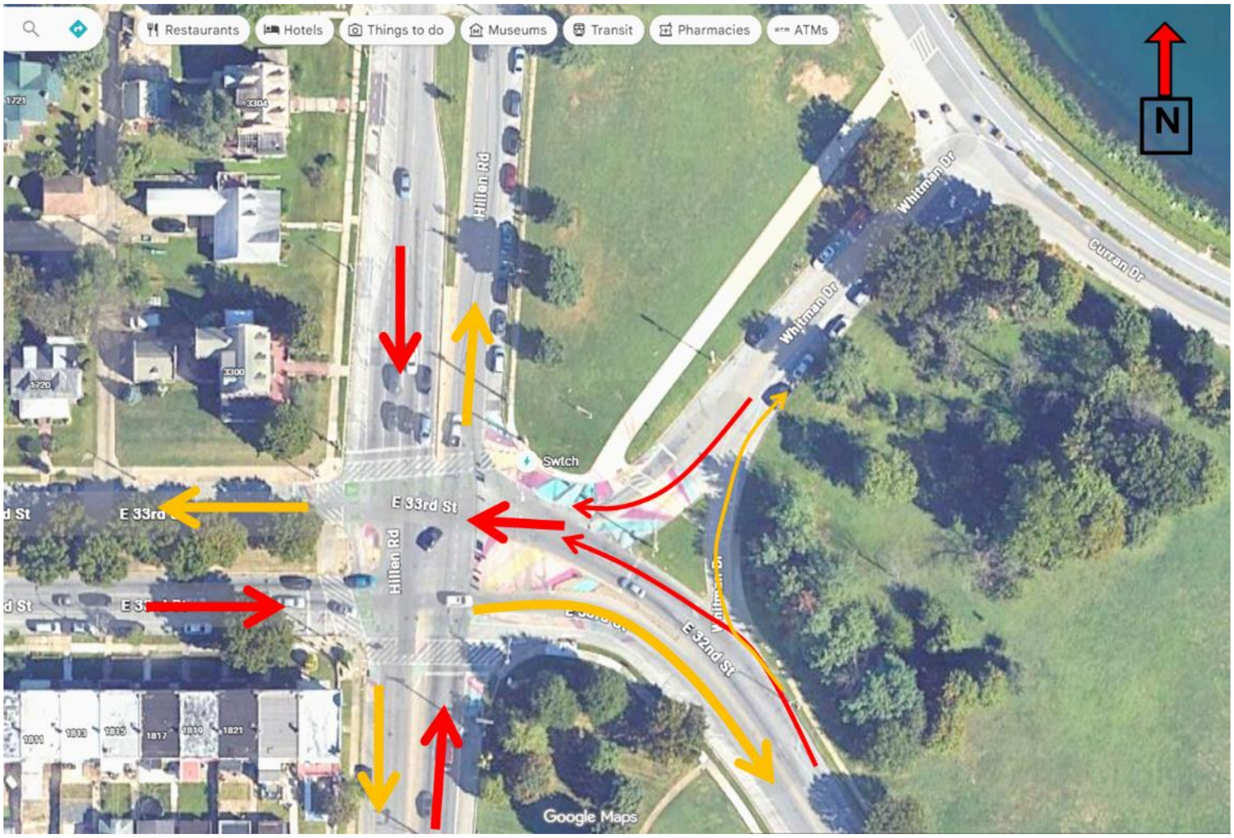

Figure 5. Motorized Traffic at Hillen Rd. & 33^rd St. Intersection

To avoid confusion caused by the non-standard east-side geometry and the LiDAR export structure, this report uses the following conventions:

- *East-side entry (Westbound approach):* vehicles entering from the east are counted as a single combined stream (E 32nd St + Whitman Dr). LiDAR does not provide separate counts for these two sources. The combined stream then splits into through (E→W), right-turn (E→N), and left-turn (E→S) movements (Figure 6).

- *West-side entry (Eastbound approach):* the physical left-turn has two destinations (LT1 to Hillen Rd. northbound and LT2 to Whitman Dr.), but LiDAR reports a single combined left-turn total (LT = LT1 + LT2) (Figure 7). Although park-related traffic volumes are lower than those on the major approaches, they are included because they affect turning paths and pedestrian activity near the park entrance.

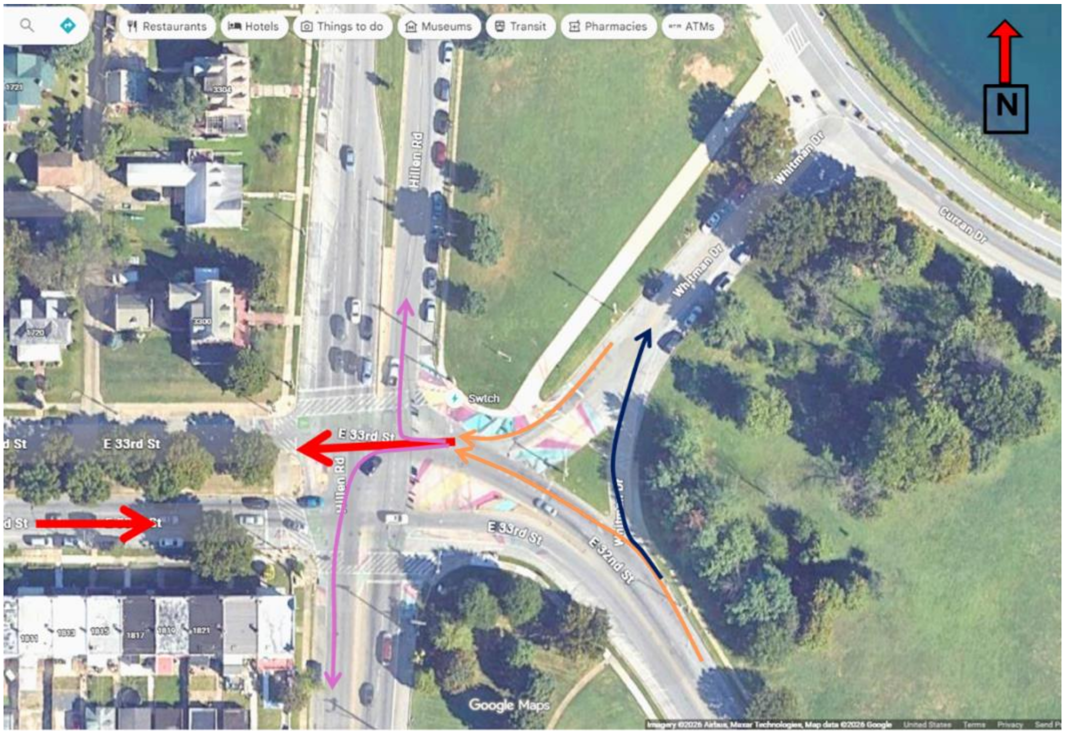

Figure 6. East-side entry (combined E 32nd St. + Whitman Dr. stream) and its distribution into through (E→W), right (E→N), and left (E→S) movements

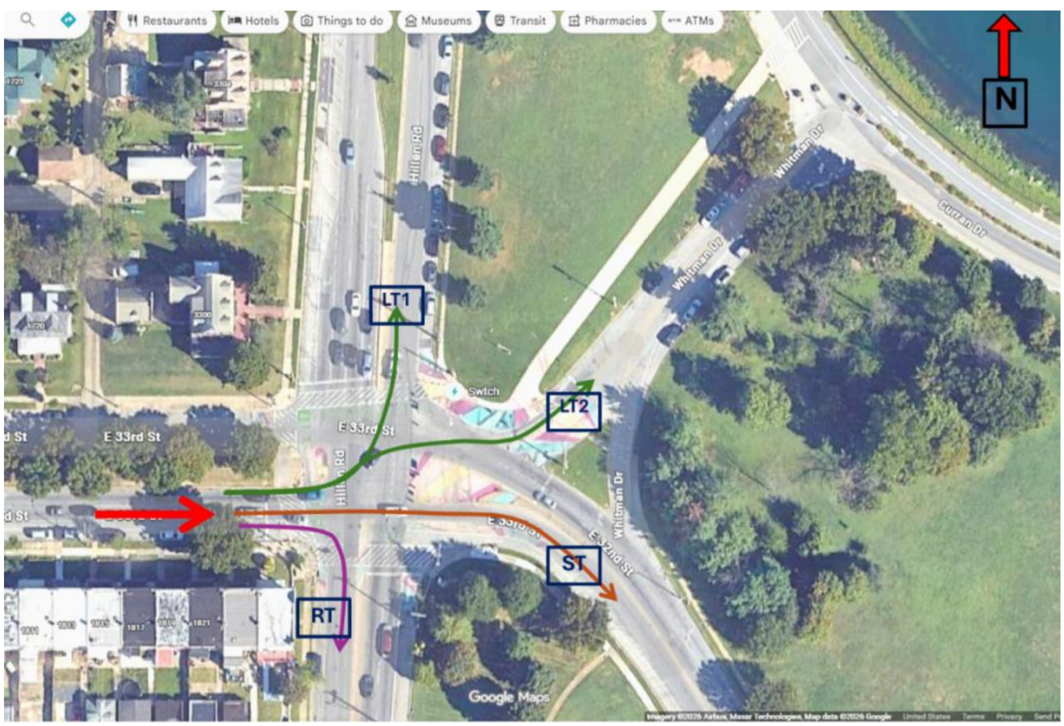

Figure 7. West-side entry movement structure; left-turn consists of LT1 (to Hillen Rd. northbound) and LT2 (to Whitman Dr.), but LiDAR reports one combined LT count (LT1+LT2)

This report summarizes observed multimodal activity and safety-relevant operational conditions at the intersection using *infrastructure-based LiDAR sensing*. The objective is to provide quantitative, location-specific evidence on:

1. ***Multimodal volumes*** (vehicles, pedestrians, and bicycles/scooters),
2. ***Vehicle operating speeds*** by approach,
3. ***Surrogate safety outcomes*** based on near-conflict indicators (PET-based events), and
4. ***Pedestrian crossing behavior***, including ***out-of-crosswalk (OCW)*** crossings.

Because severe crashes are relatively rare at a single intersection over short time windows, this study emphasizes both exposure and surrogate safety measures (e.g., PET-based conflicts) to represent day-to-day operational safety risk and to help identify specific movement patterns and locations that may benefit from targeted countermeasures.

Intersection Geometry, Traffic Approaches, and Multimodal Facilities

Intersection layout

The study intersection is a four-leg signalized junction with a geometric nuance on the east side: E 33rd St. continues east and transitions into the curved approach associated with E 32nd St., Whitman Dr., and park-access movements. For this analysis, the east-side inflow is treated as a combined approach to match the structure of the available data. Moreover, the Eastbound left-turn includes two movements: 33rd St. to Hillen Rd. (northbound) and 33rd St. to Whitman Dr. (park access).

Definition of traffic approaches (analysis convention)

To ensure consistent interpretation of counts, speeds, and conflict measures, traffic is summarized across four primary inbound approaches:

- NB (Northbound) Hillen Rd.: inbound vehicles traveling north toward the intersection.
- SB (Southbound) Hillen Rd.: inbound vehicles traveling south toward the intersection.
- EB (Eastbound) E 33rd St.: inbound vehicles traveling east from the west (neighborhood) side toward the intersection.
- WB (Westbound) Combined east-side approach: a combined stream of traffic entering the intersection from the east-side roadway system, including:
  - vehicles traveling westbound from E 32nd St., and
  - vehicles exiting the park/Whitman Dr. side.
    These movements are collectively treated as the WB (East → West) approach traffic for volume, speed, and conflict summaries.

Vehicles from each inbound approach may proceed straight, turn left, or turn right. Where feasible within the dataset structure, results will be interpreted to determine whether observed issues are more consistent with through movements or turning movements.

Pedestrian crossings (existing marked crossings)

Based on the field context reflected in the site map, marked pedestrian crossings exist at:

- Across Hillen Rd. (north side of the intersection),
- Across Hillen Rd. (south side of the intersection),
- Across E 33rd St. on the west leg, and
- Across Whitman Dr. on the Lake Montebello connection.

Bike lanes and bicycle/scooter context

- Bike facilities are present near the intersection, including segments along:
- Hillen Rd. (north of the intersection),
- E 33rd St. (west approach), and
- The east/southeast curved connection associated with the E 32nd St. side.

Data Source and Study Period

Data for this analysis were collected from an infrastructure-mounted LiDAR sensor positioned to observe movement at and near the intersection. The dataset spans from October 10, 2025, through November 26, 2025, and includes:

- Count data for vehicles, pedestrians, and bikes (including bicycles, motorbikes, and scooters),
- Average vehicle speeds for the four primary approaches (NB, SB, EB, and WB, as defined above),
- Conflict indicators for Vehicle-to-Vehicle (V2V) and Vehicle-to-Non-Vehicle interactions, based on the Post-Encroachment Time (PET) surrogate safety metric, with conflicts flagged when PET < 5 seconds, and
- Out-of-Crosswalk (OCW) events, representing pedestrian crossings outside marked crosswalk areas.

Count Data Analysis

Data screening and aggregation

Count data were available for Oct 10–Nov 28, 2025; however, to align with the speed, conflict, and OCW datasets (which end on Nov 26), the count summaries in this report focus on Oct 10–Nov 26. Consistent with the study-wide screening protocol, Oct 18 and Oct 31 were excluded due to atypical conditions. A data-completeness check also indicated that Nov 27–28 had partial-day recording and were therefore excluded from the count dataset. After exclusions, the count analysis yields 46 complete days (33 weekdays and 13 weekend days).

Daily totals were computed for motorized vehicles (MV) and non-motorized users (pedestrians and cyclists). MV volumes are reported by approach (SB, NB, EB, WB) and by turning movement (left, through, right). Non-motorized (NM) volumes are reported by crossing side (North, East, South, West) and include both travel directions (clockwise and counterclockwise) for each side.

Motorized-vehicle volumes and approach distribution

Daily MV totals show a stable weekly cycle, with systematically lower weekend demand (Figure 8). Across the screened period, the intersection processed an average of ~25,693 vehicles per day. Weekday demand consistently exceeded weekend demand (Figure 9):

- Weekdays: ~27,252 veh/day (mean)
- Weekends: ~21,736 veh/day (mean)
- Weekend reduction: ~20% relative to weekdays

Approach-level volumes were unbalanced, indicating directional dominance. Average daily volumes and approximate shares of total MV demand were as follows (Figure 10):

- SB: ~8,000 veh/day (31.1%)
- EB: ~7,034 veh/day (27.4%)
- WB: ~6,407 veh/day (24.9%)
- NB: ~4,252 veh/day (16.5%)

These approach differences provide essential context for interpreting interaction frequency and safety conditions (e.g., higher SB and EB demand implies higher exposure to conflicts involving those streams).

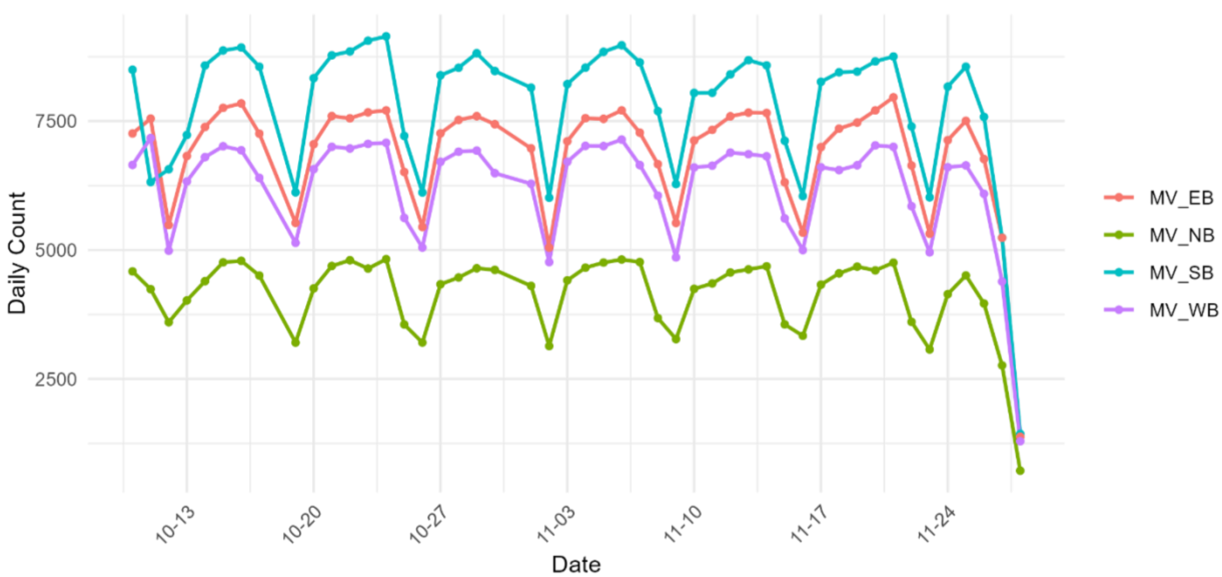

Figure 8. Daily MV Volumes by Approach (SB/NB/EB/WB)

Figure 9. MV Total Daily Volume Distribution: Weekday vs. Weekend

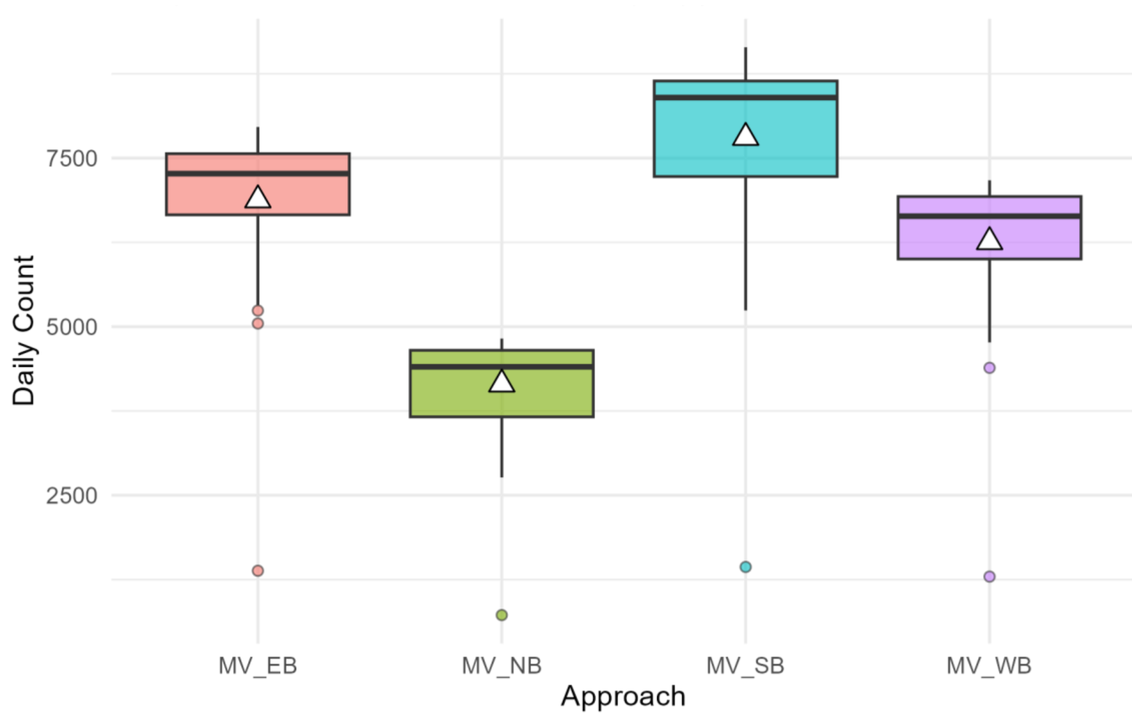

Figure 10. MV Daily Volume Distribution by Approach

Turning-movement composition (MV)

Across all approaches combined, MV demand is dominated by through movements:

- Through: ~63.9%
- Right-turn: ~19.2%
- Left-turn: ~17.0%

Approach-specific shares (computed from the screened dataset) are summarized below and provide a clearer view of how traffic is distributed across conflict-relevant movement types:

- Southbound (SB): LT ~23.8%, Through ~45.4%, RT ~30.7%
- Northbound (NB): LT ~3.3%, Through ~94.8%, RT ~2.0%
- Eastbound (EB): LT ~31.4%, Through ~65.4%, RT ~3.1%
- Westbound (WB): LT ~1.6%, Through ~64.7%, RT ~33.7%

For transparency, the daily time series of SB/NB/EB/WB turning movements (LT/Through/RT) are presented in Appendix Figure A1 (one panel per approach). These plots allow the reader to verify day-to-day stability and identify localized spikes by movement type.

Diurnal patterns (15-minute averages) – MV

Average 15-minute MV profiles show clear weekday commuter peaks and a flatter weekend profile (Figure 11).

<u>*Weekdays (MV):*</u>

- AM peak period: 07:45–08:00 (peak bin at 07:45), ~529 veh/15-min
- PM peak period: 16:15–16:30 (peak bin at 16:15), ~553 veh/15-min *(highest weekday peak)*

<u>*Weekends (MV):*</u>

- AM peak period: 09:45–10:00 (peak bin at 09:45), ~279 veh/15-min
- PM peak period: 15:15–15:30 (peak bin at 15:15), ~377 veh/15-min
- Weekend demand also shows a broad midday plateau (overall maximum near 14:15, ~380 veh/15-min), consistent with non-commute travel.

These profiles are directly relevant to interpreting time-of-day exposure and the expected timing of elevated interaction opportunities.

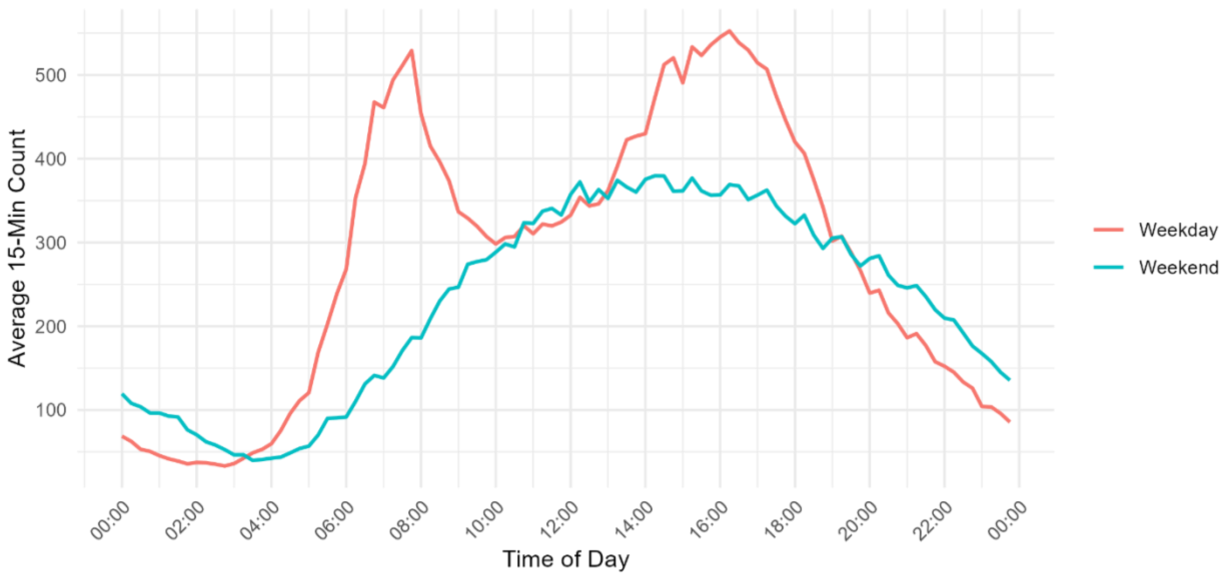

Figure 11. MV Diurnal Profile (Average 15-minute Volumes): Weekday vs. Weekend

Non-motorized (NM) volumes – pedestrians and two-wheelers ***combined***

Non-motorized demand (pedestrians + two-wheelers) is substantially lower than MV volumes but shows meaningful variability and a weekend increase (Figure 12). Non-motorized (NM) volumes are reported by crossing side/zone (North, South, and West-marked crossings, and an East-side crossing zone that captures observed movements on the east side, even though a marked N–S crossing is missing). Across the screened dataset:

- Overall mean: ~331 NM crossings/day
- Weekdays: ~316/day (mean)
- Weekends: ~369/day (mean; ~16.8% higher than weekdays)

On average, pedestrians account for ~211/day and bicycles for ~120/day, indicating that bicycles represent approximately 36% of total NM crossings over the study period.

Spatial distribution by crosswalk/crossing zone

Daily NM crossings are concentrated on the north and west sides of the intersection (Figure 13). Average daily counts and approximate shares are shown below:

- North: ~122.5/day (37.0%)
- West: ~103.5/day (31.3%)
- East: ~61.0/day (18.4%)
- South: ~43.8/day (13.2%)

Although the east leg lacks a marked pedestrian crossing in the field inventory, an east-side crossing zone was still included in the count summaries to capture observed movements within the detection area, including informal crossings and edge movements.

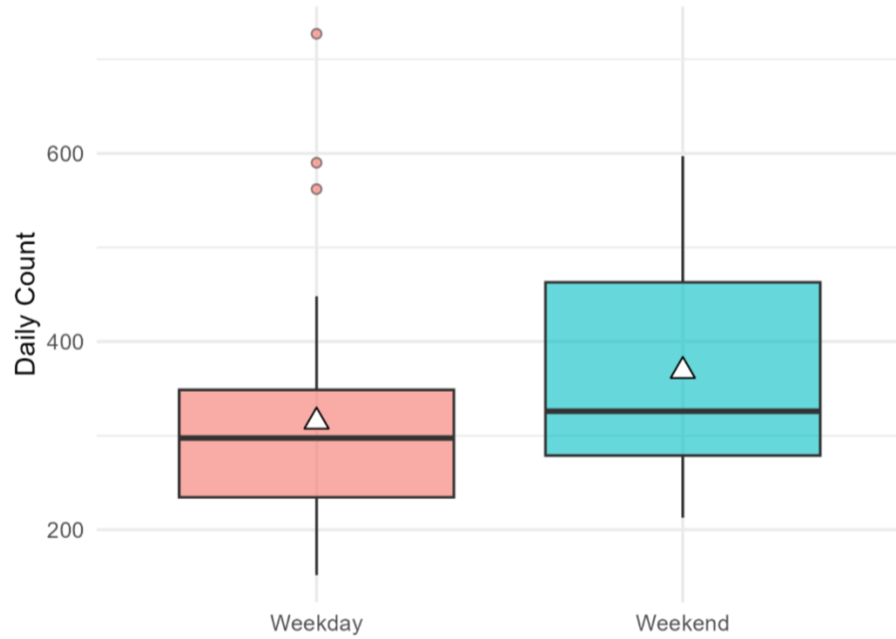

Figure 12. NM (Ped + Two-wheelers*) total daily distribution (Weekday vs Weekend)*

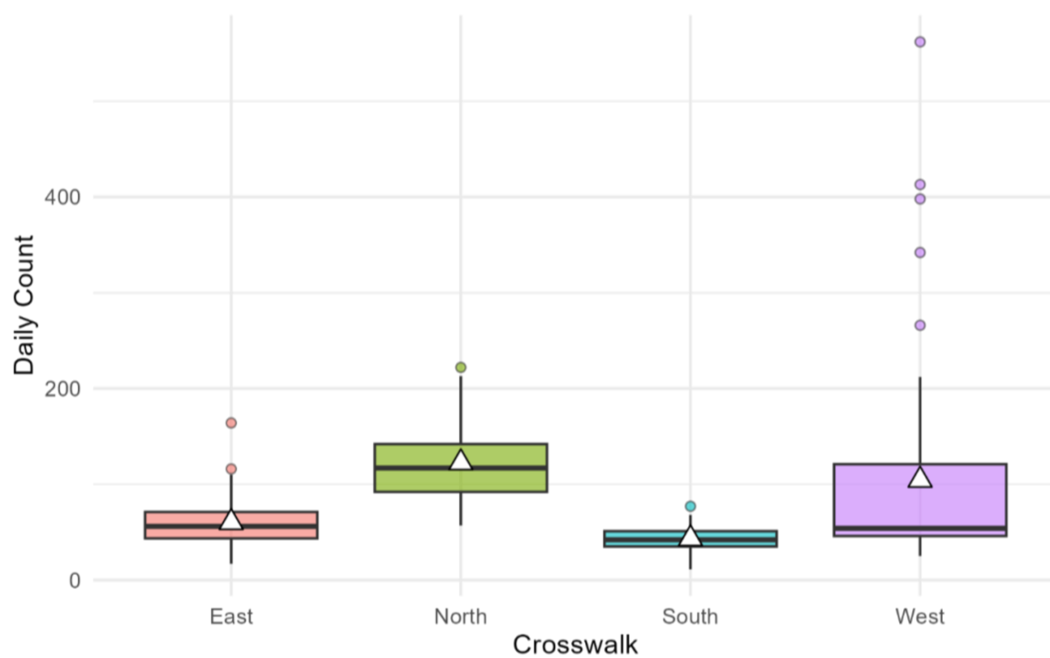

Figure 13. NM (Ped + Two-wheelers) daily distribution by crosswalk/side

Diurnal patterns (15-minute averages) – Non-motorized (Ped + Two-wheelers)

Average 15-minute NM volumes are low at night and increase during daytime hours. The peak periods below summarize the highest average 15-minute crossing intensities (Ped + Bike combined):

Weekdays (NM):

- AM peak period: 07:00–07:15, ~5.5 crossings/15-min
- PM peak period: 18:15–18:30, ~10.6 crossings/15-min *(weekday maximum)*

Weekends (NM):

- AM peak period: 09:15–09:30, ~8.8 crossings/15-min
- PM peak period: 16:15–16:30, ~6.3 crossings/15-min
- The weekend profile also shows occasional elevated evening activity (notably around ~19:00), suggesting episodic surges on some days rather than a uniform shift across all weekend days.

Directional NM movements (clockwise vs. counterclockwise)

Directional summaries were computed from the combined Ped + Two-wheelers crossings (after all exclusions). Clockwise movements exceed counterclockwise movements on all sides, with the largest imbalance on the south and east sides:

- North: Clockwise ~73.8/day (60.3%) vs Counterclockwise ~48.7/day (39.7%)
- East: Clockwise ~40.0/day (65.6%) vs Counterclockwise ~21.0/day (34.4%)
- South: Clockwise ~31.3/day (71.5%) vs Counterclockwise ~12.5/day (28.5%)
- West: Clockwise ~54.3/day (52.4%) vs Counterclockwise ~49.2/day (47.6%)

For readers who want the full day-by-day directional time series, the following additional plots are included in the appendix:

- Appendix Figure A2: Daily pedestrian crossings by crosswalk/side (North/East/South/West), including directional patterns.
- Appendix Figure A3: Daily bicycle crossings by crosswalk/side (North/East/South/West), including directional patterns.

Speed Analysis (Straight-Through Movements)

Vehicle speeds for straight-through movements on each approach—SBST (NS), NBST (SN), EBST (WE), and WBST (EW)—were evaluated from October 10 to November 26, 2025. To ensure results reflect typical operating conditions, October 18, 2025 (Baltimore Running Festival) and October 31, 2025 (unexplained anomaly) were excluded from the speed summaries, consistent with the study-wide screening. In addition, November 27–28 were flagged as data-quality outliers in the count workbook (missing/abnormal records) and are excluded from the overall study dataset; these dates do not appear in the speed dataset (which ends on Nov 26). The final speed dataset used in this section contains 46 valid days. It should be noted that EB straight-through represents travel continuing on E 33rd St; WB straight-through represents the combined east-side inbound stream entering the intersection (E 32nd St. + Whitman Dr.).

Temporal stability of daily speeds

Daily average speeds are stable throughout the screened period, with only modest day-to-day variation across approaches (Figure 14). SBST (NS) remains the highest, followed by NBST (SN), while EBST (WE) and WBST (EW) have lower average speeds.

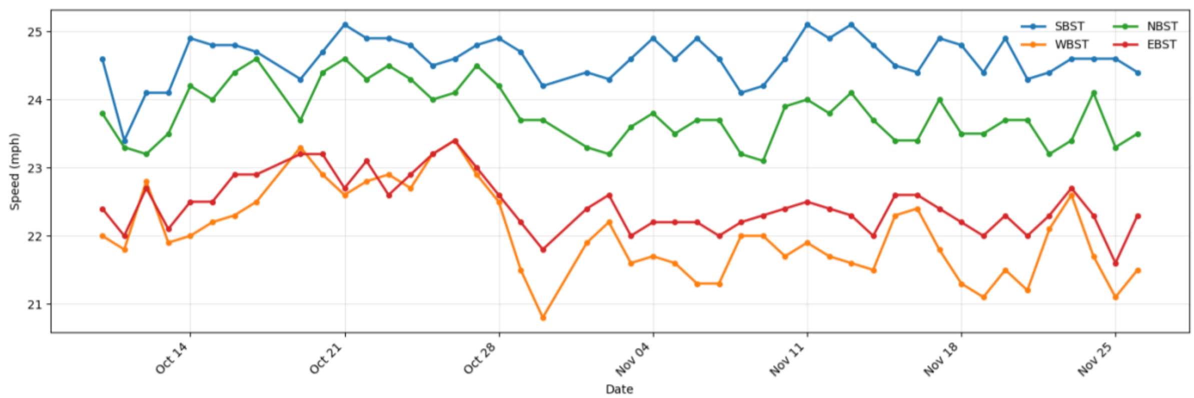

Figure 14. Daily Average Speed by Approach

Speed distributions by approach

Approach-level speed distributions (Figure 15) show clear differences in both typical speeds and variability:

- SBST (NS): mean 24.60 mph
- NBST (SN): mean 23.79 mph
- EBST (WE): mean 22.45 mph
- WBST (EW): mean 22.03 mph

Overall, WBST (EW) has the most variable operating speeds, whereas SBST (NS) is both the fastest and the most stable.

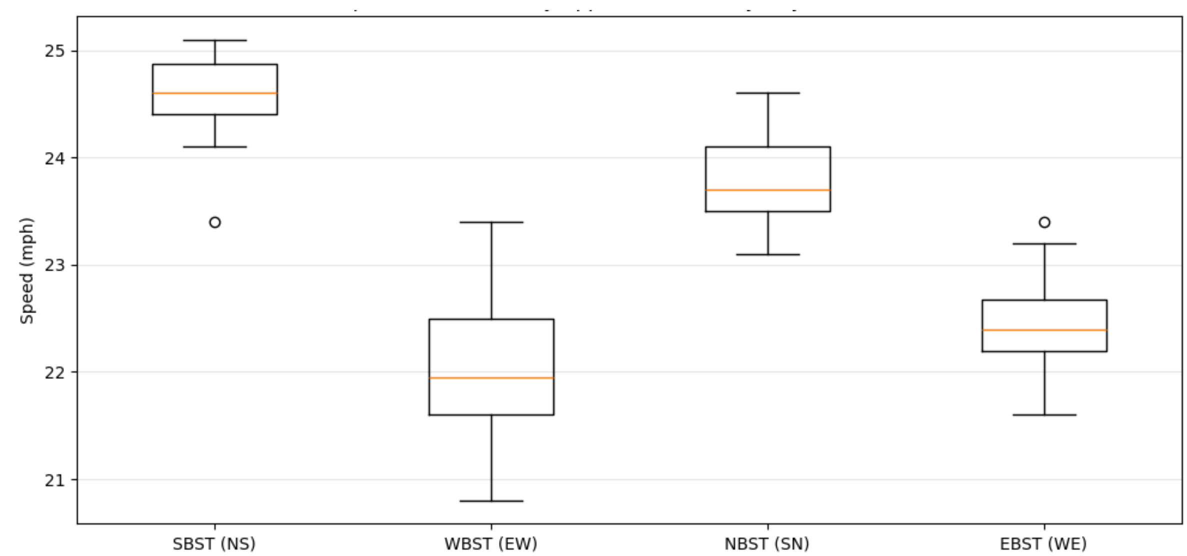

Figure 15. Speed Distribution by Approach

Interpretation relative to posted speed limits

Posted speed limits vary by roadway segment: on Hillen Rd. north of the intersection (both northbound and southbound), the posted limit is 35 mph, whereas on all other segments, including Hillen Rd. south of the intersection, the limit is 30 mph. In this context, the observed straight-through mean speeds on Hillen Rd. movements (~24.6 mph (SBST) and ~23.8 mph (NBST)) are well below both posted limits. This indicates that traffic typically operates under signal control, intersection approach effects, and platooning/queue discharge conditions, which constrain speeds to the mid-20 mph range even on the higher-limit segment.

A practical way to summarize compliance context is via "buffer to limit":

- Relative to 35 mph, SBST and NBST averages are about 10–11 mph below the posted limit.
- Relative to 30 mph, the same averages are about 5–6 mph below the posted limit.

Similarly, the lower average speeds observed for straight-through movements on 33rd St. (~22.5 mph (EBST) and ~22.0 mph (WBST)) are below the posted 30 mph speed limit, consistent with an urban, signalized intersection.

Safety/exposure implication

Because straight-through speeds consistently fall below posted limits and show limited variability over time (Figures 14–15), speed is best treated as a relatively stable background operating condition during the study period rather than a primary driver of day-to-day variability in interactions. However, the higher variability on WBST (EW) suggests occasional operational friction (e.g., progression, queuing, and turning interference) that may influence interaction opportunities and should be considered when interpreting approach-specific safety results.

Conflict Analysis (PET-Based)

Conflicts were evaluated using Post Encroachment Time (PET), defined as the time gap between two road users passing through a common conflict area. Smaller PET values indicate more critical interactions. Two severity thresholds were used: PET < 2s (critical conflicts) and PET 2s to 5s (general conflicts). Consistent with the study-wide screening, October 18, 2025 (Baltimore Running Festival) and October 31, 2025 (unexplained anomaly) were excluded. The final conflict analysis includes 46 valid days.

Conflict type definition and PET severity bands

Conflicts were categorized using participant class types:

- Vehicle-to-vehicle (V2V): both participants are motor vehicles, including cars, buses, and trucks.
- Vehicle-to-non-vehicle (V2NonV): one participant is a motor vehicle, and the other is a Pedestrian/Bicycle.

Conflict severity was summarized using two PET bands:

- Critical: PET < 2 s
- General: 2 ≤ PET < 5 s

Across the screened period (PET < 5 s only), a total of 38,054 conflicts were observed:

- V2V: 30,913 (≈81.2%)
- V2NonV: 7,141 (≈18.8%)

Within each conflict type, general conflicts dominate:

- V2V: 13.8% critical vs 86.2% general
- V2NonV: 17.4% critical vs 82.6% general

When normalized by total motorized volume (from the MV count summary), overall conflict rates were:

- V2V: ~36.2 critical and ~225.3 general conflicts per 10,000 vehicles
- V2NonV: ~10.5 critical and ~49.9 general conflicts per 10,000 vehicles

Temporal variability (daily time series)

Daily conflict rates per 10,000 vehicles show:

- Higher weekday levels relative to weekends for both V2V and V2NonV are consistent with higher exposure (traffic volumes) and more complex interaction conditions.
- General conflicts (2–5 s) dominate the daily profile; critical conflicts (<2 s) are smaller in magnitude but exhibit similar temporal fluctuations.

Figures 16 and 17 show the time series of V2V and V2NonV conflict rates per 10,000 vehicles.

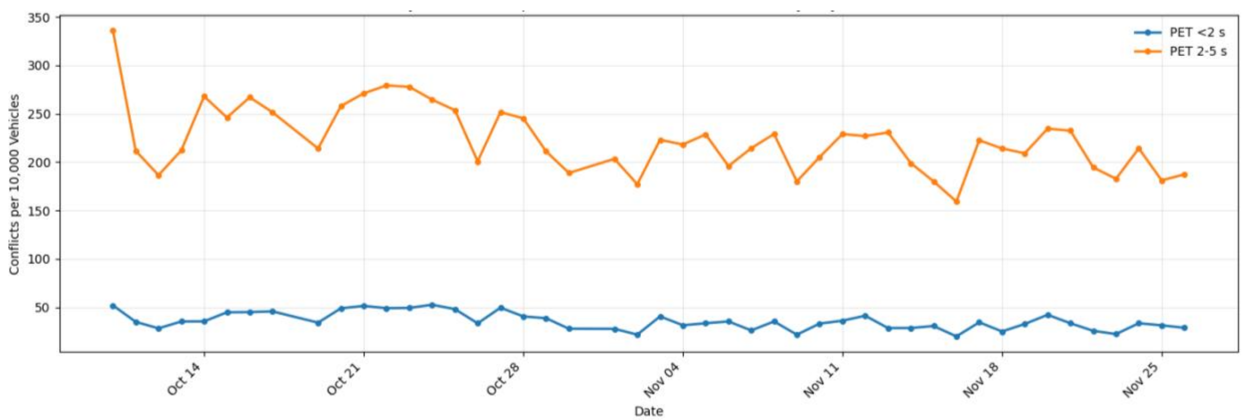

Figure 16. Daily V2V Conflict Rate Per 10,000 Vehicles

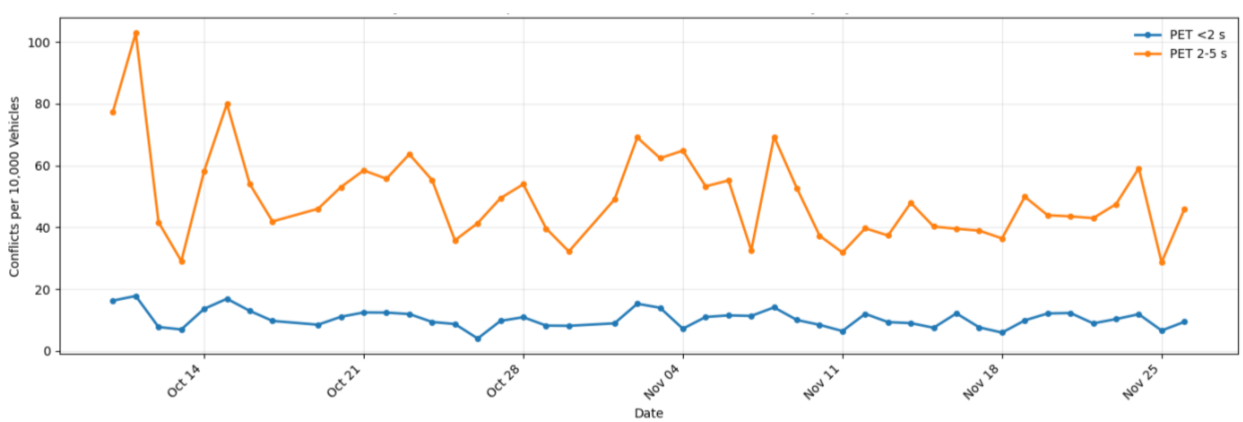

Figure 17. Daily V2NonV Conflict Rate Per 10,000 Vehicles

Approach-level distribution (most conflicted approaches)

Approach attribution was performed as follows:

- Approach definition:
  - EBLT, EBST, EBRT → EB approach
  - NBRT, NBLT, NBST → NB approach
  - SBLT, SBST, SBRT → SB approach
  - WBLT, WBST, WBRT → WB approach

- For V2V, conflicts were assigned to the leading vehicle movement approach.
- For V2NonV, conflicts were assigned to the vehicle's approach (in conflict with pedestrians/bicyclists).

Tables 1 and 2 present the V2V and V2NonV counts and percentages for PET<2s and PET 2-5s across four main approaches.

Table 1. V2V conflict counts and percentages in main approaches

Approach	PET<2 (count)	PET<2 (%)	2≤PET<5 (count)	2≤PET<5 (%)
NB	2,361	55.2%	12,062	45.3%
SB	1,167	27.3%	11,658	43.8%
EB	575	13.4%	1,196	4.5%
WB	177	4.1%	1,717	6.4%

Table 2. V2NonV conflict counts and percentages in main approaches

Approach	PET<2 (count)	PET<2 (%)	2≤PET<5 (count)	2≤PET<5 (%)
NB	177	14.2%	848	14.4%
SB	252	20.3%	1,244	21.1%
EB	535	43.0%	2,062	35.0%
WB	279	22.4%	1,744	29.6%

Results show distinct concentration patterns:

- V2V conflicts are dominated by NB and SB approaches, accounting for ~82% of critical and ~89% of general conflicts.
- V2NonV conflicts are dominated by EB and WB approaches, together accounting for ~65% of both critical and general conflicts.

These distributions indicate that vehicle–vehicle interaction exposure is most pronounced in the north–south streams, whereas vehicle–nonvehicle interaction exposure is more pronounced in east–west movements within this dataset.

Critical conflicts (PET < 2 s): distribution and interpretation

Critical conflicts (PET < 2 s) represent the smallest temporal separation between road users and therefore warrant special attention. For V2V, critical conflicts are concentrated on the northbound (55.2%) and southbound (27.3%) approaches, with smaller shares on EB (13.4%) and WB (4.1%). This pattern indicates that the most severe vehicle–vehicle interaction risk is primarily associated with the north–south stream on Hillen Rd., where higher exposure and closely spaced vehicle interactions are most likely.

For V2NonV, critical conflicts follow a distinct pattern: the largest share occurs on the eastbound approach (43.0%), followed by westbound (22.4%) and southbound (20.3%), with the smallest share on northbound (14.2%). This distribution aligns with the intersection's geometry and pedestrian environment, where non-vehicle exposure is influenced by east–west movements, the west-side median area, and the missing north–south pedestrian connection on the east side. In other words, the most severe vehicle–pedestrian/two-wheeler interactions tend to occur where pedestrian crossing demand intersects the east–west traffic stream and where the built environment may encourage informal crossings.

Out-of-Crosswalk (OCW) Events (Jaywalking)

Out-of-crosswalk (OCW) events were extracted from the pedestrian trajectory dataset for the period from October 10 to November 26, 2025. OCW records capture pedestrian movements that crossed the roadway outside marked crosswalks. To maintain consistency with the study-wide screening for atypical conditions, October 18 and 31, 2025, were excluded from the OCW analysis. After screening, the OCW dataset contained 896 events across 46 valid days, with an average of 19.48 OCW events per day (median: 16/day; range: 6–82/day).

OCW frequency was similar on weekdays and weekends when summarized at the daily level. Weekdays (33 days) accounted for 627 OCW events (19.00 events/day; median: 16/day), while weekends (13 days) accounted for 269 OCW events (20.69 events/day; median: 15/day). The slightly higher weekend mean is largely attributable to a single high-activity Sunday (November 16: 82 events), while typical weekday and weekend levels (as reflected by the medians) were comparable.

OCW events showed a strong time-of-day pattern. Hourly aggregation indicates that the highest OCW activity occurs in the late afternoon, with the peak hour at 16:00–16:59 (116 events), followed by 15:00–15:59 (102 events) and 17:00–17:59 (87 events). At a finer temporal resolution, the peak 15-minute bin was 16:45 (37 events), followed by 15:00 (35 events) and 16:30 (34 events). Overall, approximately 54% of OCW events occurred between 12:00 and 17:59, and approximately 34% between 15:00 and 17:59, indicating a pronounced afternoon concentration.

Trajectory-density heatmaps indicate that OCW activity is spatially concentrated rather than uniformly distributed. Figures 18 and 19 present OCW heatmaps for two time periods. Two locations are particularly important. First, a substantial share of OCW activity clusters near the west-side median, suggesting that pedestrians may use the median as a staging point and complete crossings outside marked crosswalks. Second, OCW activity clusters along the east-side north–south connection, consistent with the documented absence of a marked crossing on the east leg that would otherwise provide a direct north–south pedestrian connection.

Field observations also suggest a "false continuity" effect: although the east side lacks a continuous sidewalk and a marked N–S crossing, the combination of a median opening, an ADA ramp that leads to the street edge, and decorative/colored pavement markings that do not always align with physical sidewalk or barrier boundaries may unintentionally encourage pedestrians, particularly unfamiliar users, to initiate crossings from the southeast or east side.

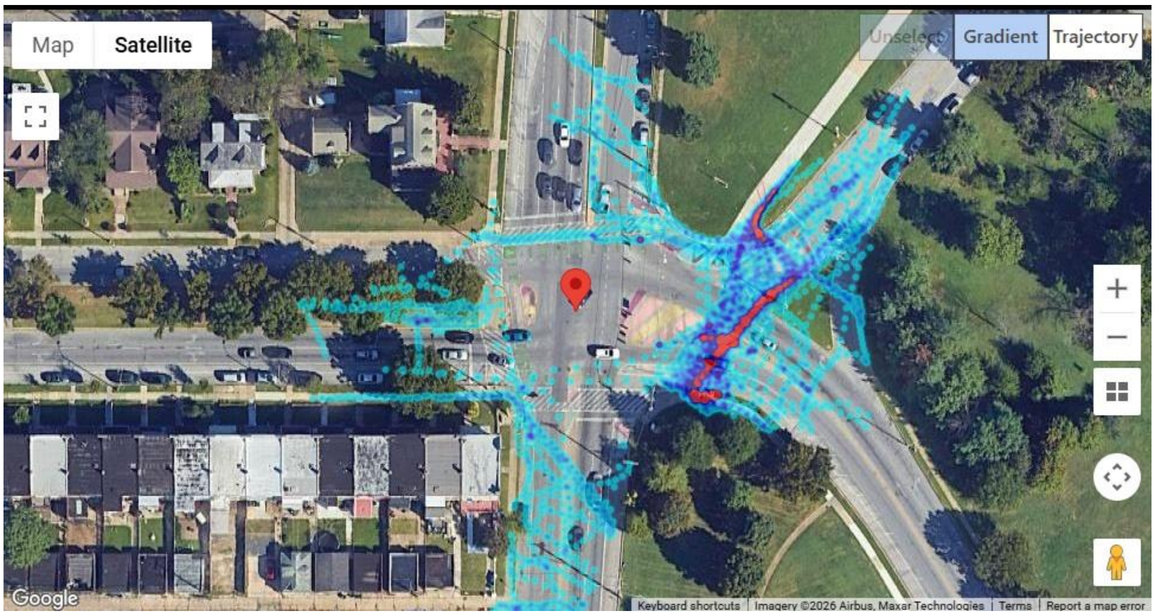

Figure 18. OCW Heatmap Between Oct 10 and Oct 17

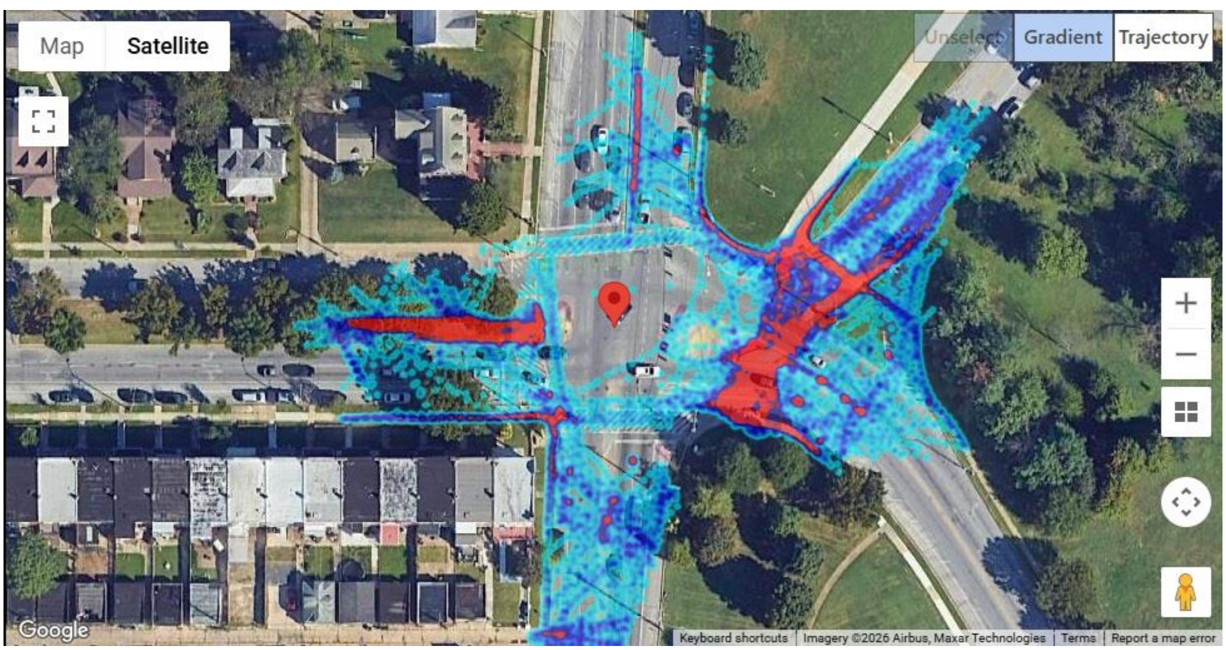

Figure 19. OCW Heatmap Between Oct 19 and Nov 26

Conclusion

This report used infrastructure-based LiDAR data to characterize multimodal activity, operating speeds, surrogate safety conflicts (PET), and out-of-crosswalk (OCW) behavior at Hillen Rd. & E 33rd St. intersection for Oct 10–Nov 26, 2025, excluding anomaly days. The intersection experiences high motor-vehicle demand alongside sustained pedestrian and bicycle activity, creating frequent opportunities for interaction. Straight-through speeds are stable and generally below posted limits (35 mph on Hillen Rd. north of the intersection; 30 mph elsewhere), indicating that safety conditions are shaped primarily by intersection operations, turning interactions, and pedestrian connectivity rather than by high-speed free-flow conditions.

PET-based analysis shows that vehicle–vehicle conflicts dominate overall; however, critical conflicts (PET < 2 s) reveal distinct concentration patterns by interaction type. Critical V2V conflicts are concentrated on the Hillen Rd. north–south stream, whereas critical V2NonV conflicts are most strongly associated with the east–west stream, where pedestrian exposure intersects vehicle paths. OCW results provide a geometry-consistent explanation: although a marked crosswalk exists at the Whitman Dr./park entrance, pedestrian connectivity remains incomplete on the east side (the Whitman Dr. east-side sidewalk terminates at the park crosswalk, and the east leg lacks a marked N–S pedestrian connection). OCW heatmaps and field observations indicate repeated desire-line crossings near the west-side median and along the east-side missing-connection area, consistent with “false continuity” cues created by the median opening, the ADA ramp-to-street condition, and decorative pavement markings that do not consistently align with physical boundaries.

Safety implications

1. PET < 2 s events identify the most urgent interaction mechanisms. Critical PET conflicts are distributed differently for V2V versus V2NonV, implying that countermeasures should be tailored by conflict type rather than applied uniformly across the intersection.
2. Connectivity gaps and misleading cues can lead to unpredictable pedestrian behavior. The missing east-leg N–S pedestrian connection and sidewalk discontinuity can encourage informal crossings, particularly when geometric cues (median opening and ADA ramp) imply a continuous route where one is not formally provided.
3. The west-side median functions as a recurrent exposure node. OCW clustering near the west-side median suggests staged or informal crossings that increase exposure to through and turning movements during high-demand periods.
4. Legibility matters in multimodal settings. Decorative or colored pavement patterns that do not align with physical curb/sidewalk/barrier boundaries can reduce pedestrian and driver expectancy, increasing the likelihood of unexpected pedestrian movements.

Recommendations to Improve Safety

Recommendations are organized into near-term, low-cost actions and medium- to long-term improvements that are more capital-intensive.

Near-term (operational + low-cost engineering)

- Refresh high-visibility crosswalk markings and stop bars to reinforce pedestrian priority areas, especially where pavement color treatments may reduce legibility.
- Add/enhance "Yield to Pedestrians" signage and advance warning at conflict-prone turning locations and near pedestrian-priority areas.
- Improve lighting and visibility during afternoon/evening periods to match OCW peak timing and enhance detection near corners and median areas.
- Discourage unsafe shortcuts using selective barriers/delineators/landscaping at the west-side median and the east-side missing-connection area while maintaining a convenient, intuitive safe path (avoid long detours that increase noncompliance).

Medium- to long-term (geometric + accessibility upgrades)

- Provide a formal east-side north–south pedestrian connection (marked/controlled crossing + continuous sidewalk/ADA connectivity) so the built cues (ramp/median opening) align with a safe, predictable route.
- Add pedestrian refuge where exposure is highto reduce exposure time and support staged crossings in a controlled manner, especially near the west-side median area where OCW activity concentrates.

Appendix A

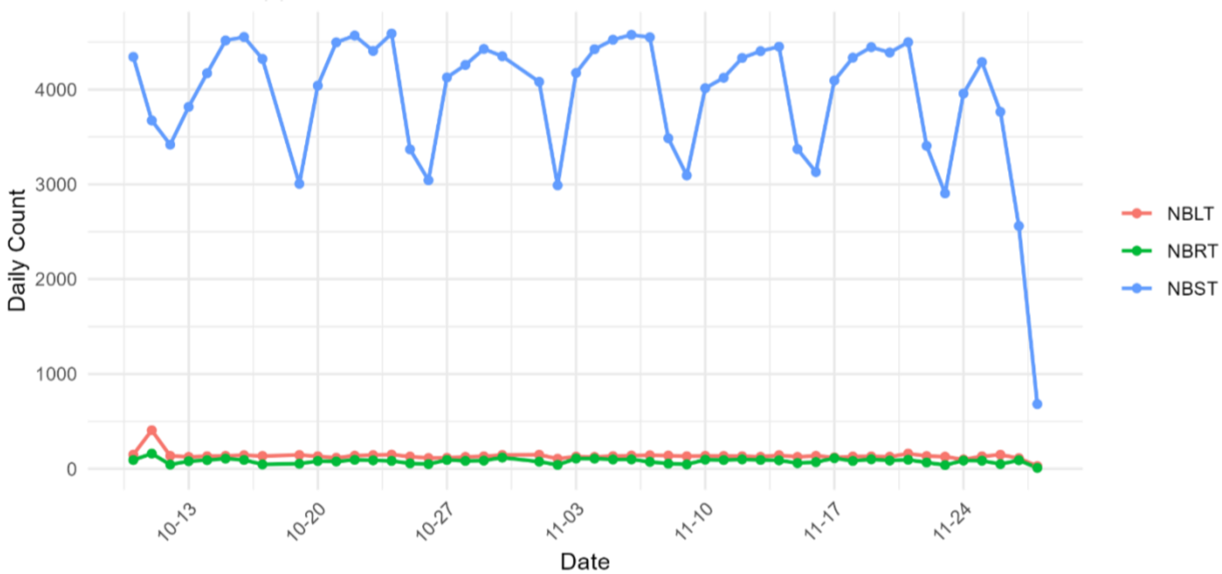

Figure A1a. MV Daily Volume Distribution by Northbound Approach

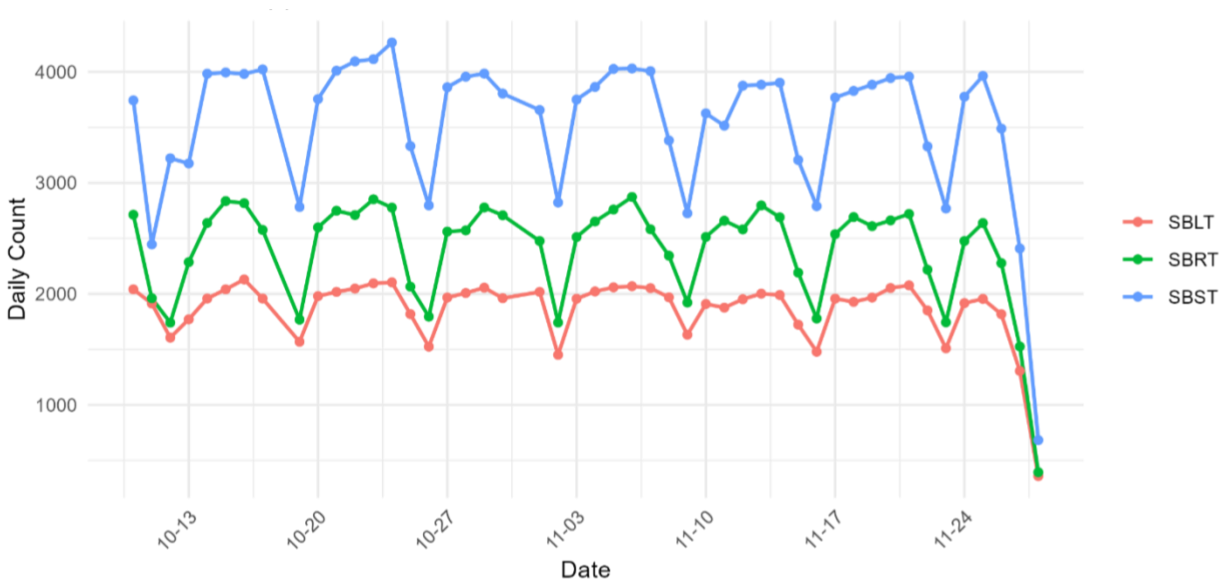

Figure A1b. MV Daily Volume Distribution by Southbound Approach

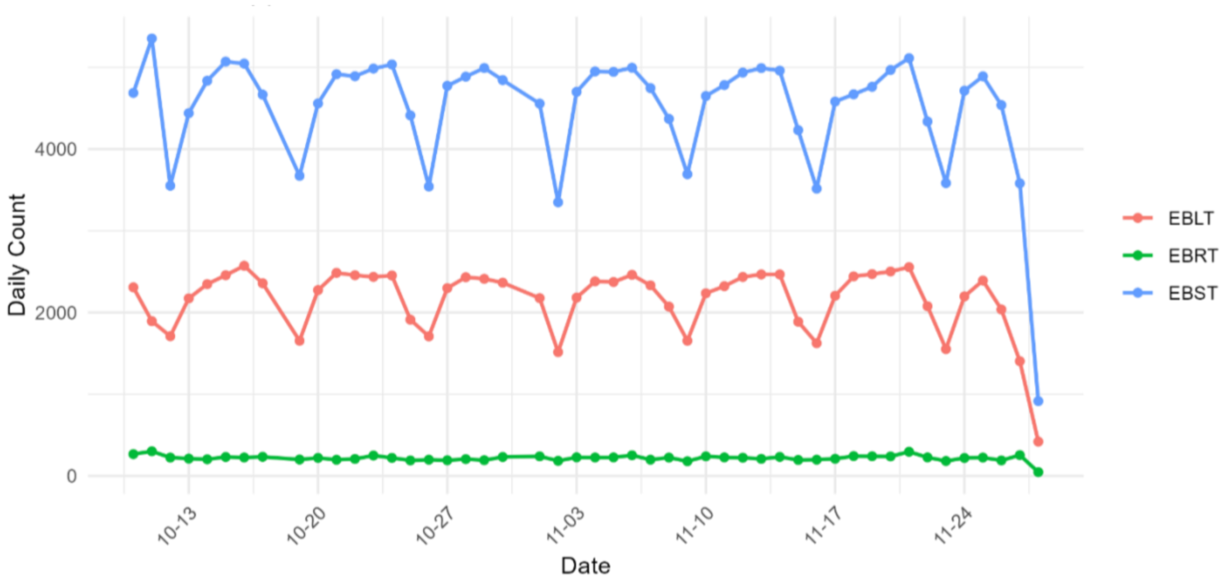

Figure A1c. MV Daily Volume Distribution by Eastbound Approach

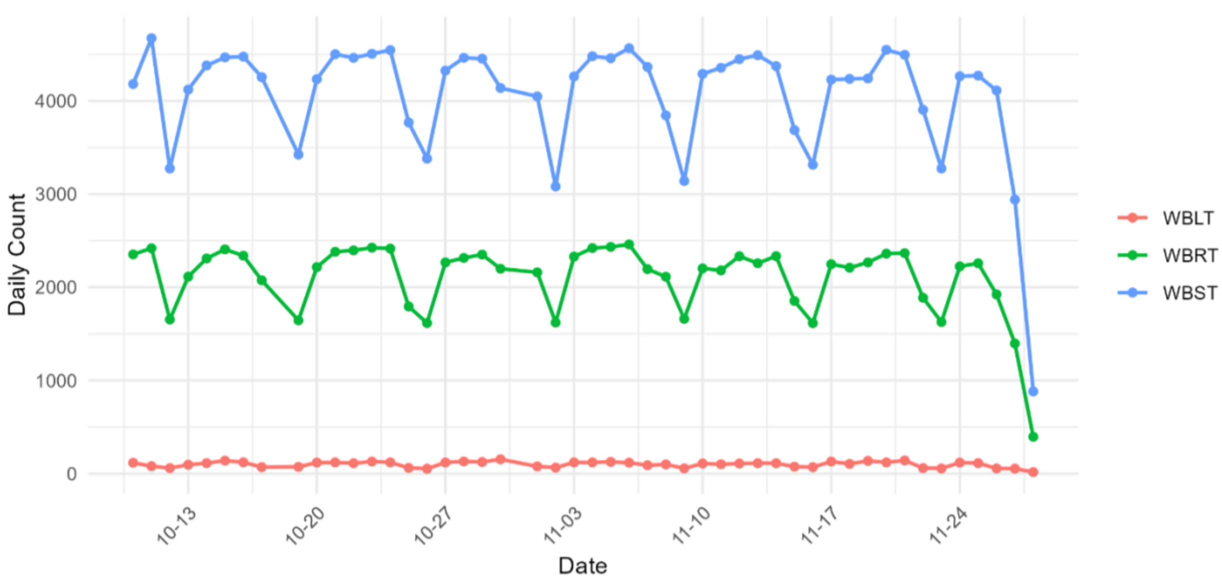

Figure A1d. MV Daily Volume Distribution by Westbound Approach

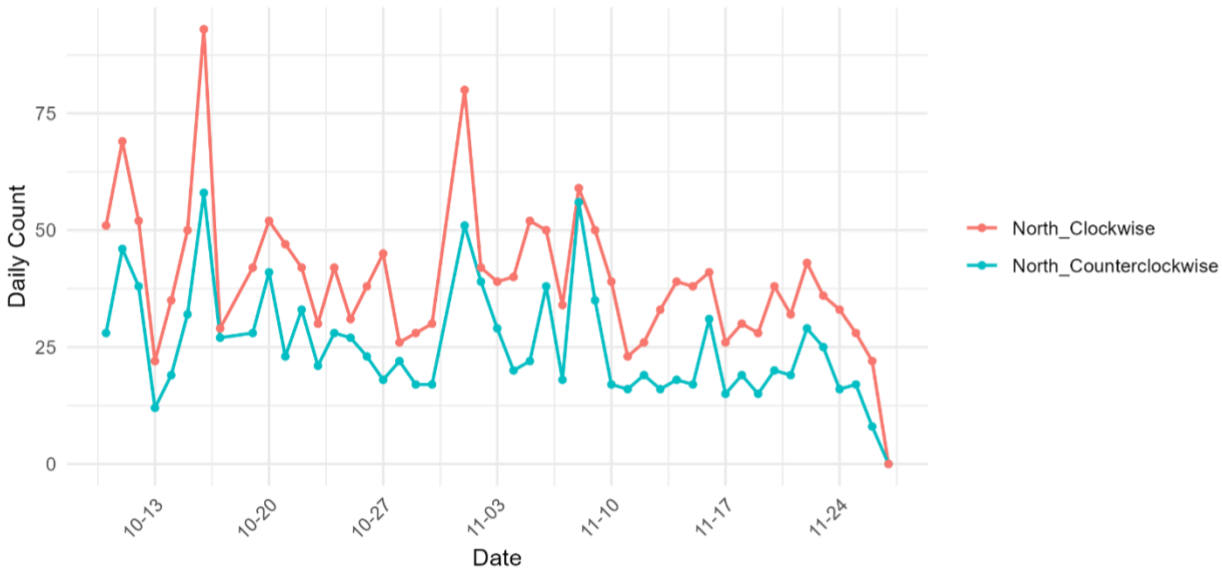

Figure A2a. Pedestrian Daily Volume Distribution by North-leg Crosswalk

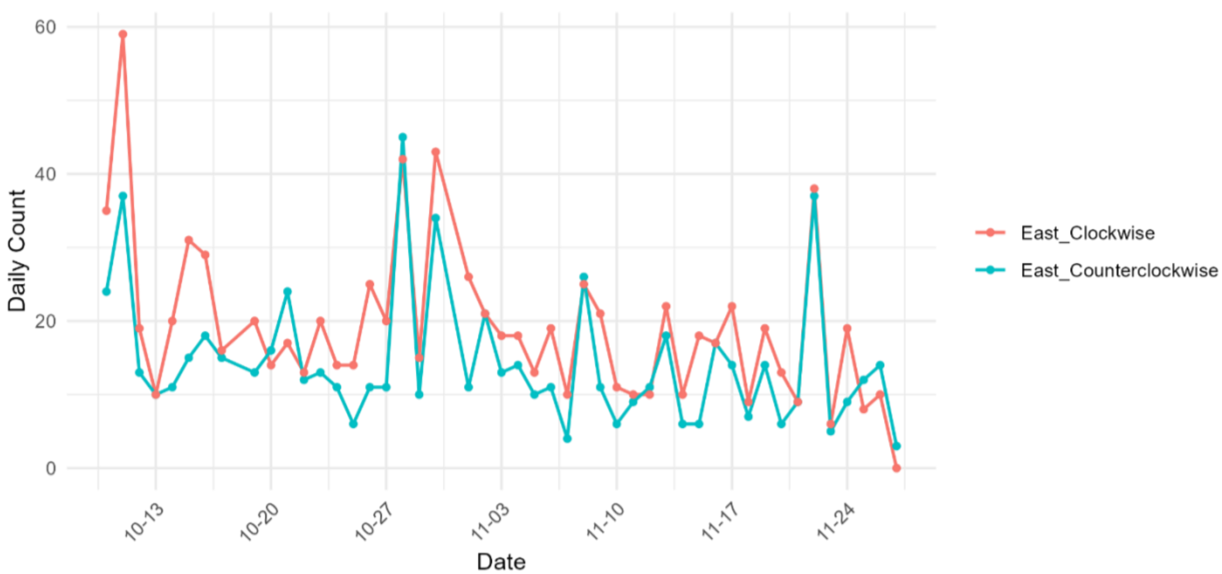

Figure A2b. Pedestrian Daily Volume Distribution by East-leg Crosswalk

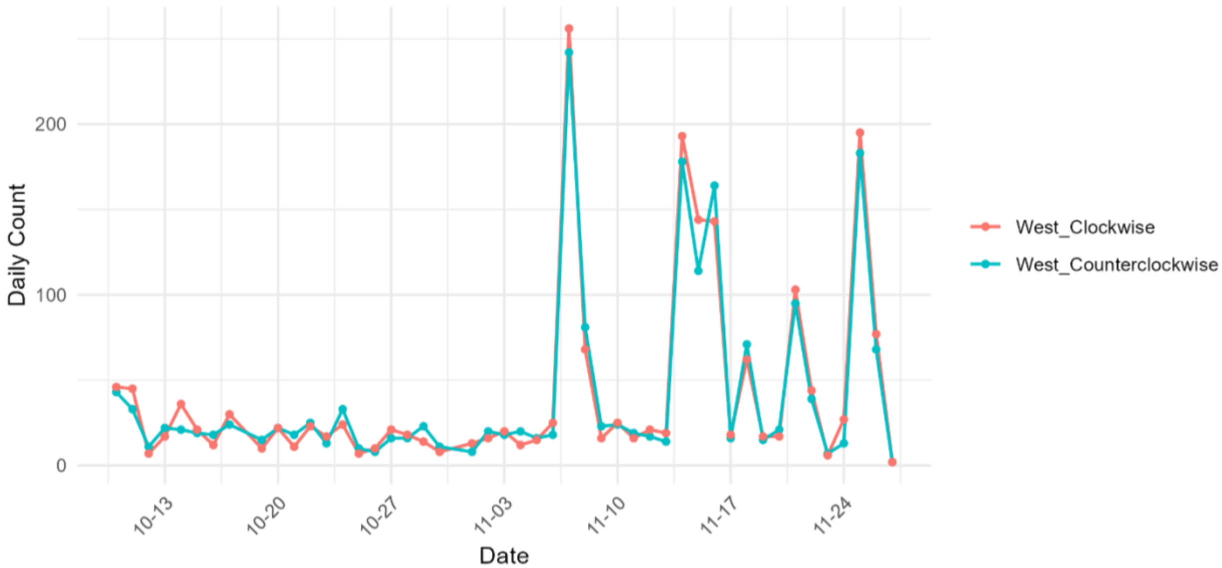

Figure A2c. Pedestrian Daily Volume Distribution by West-leg Crosswalk

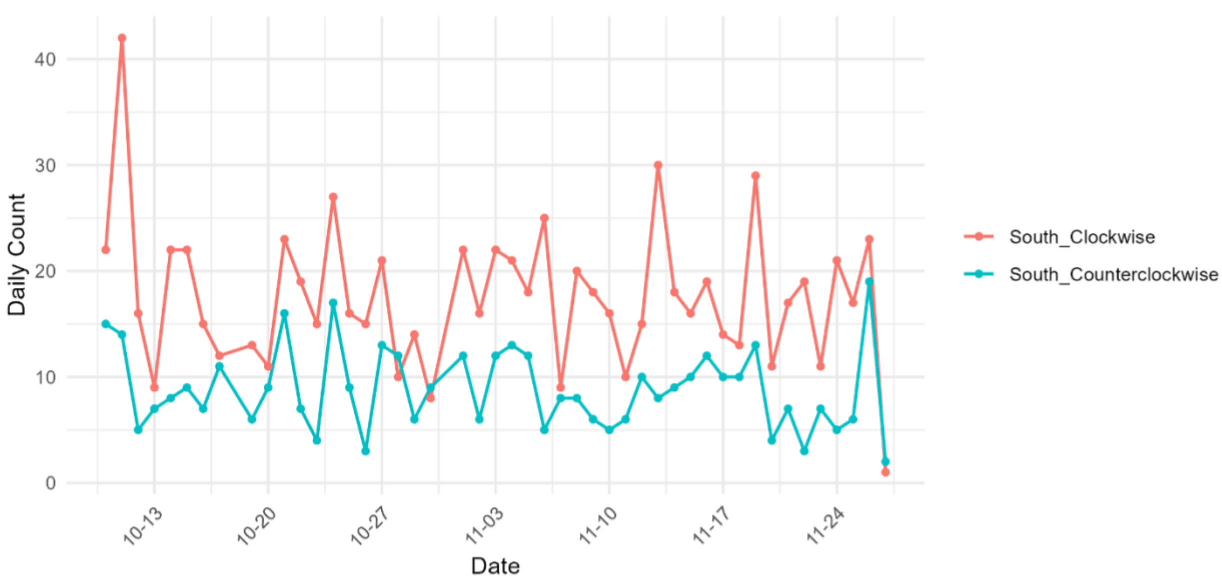

Figure A2d. Pedestrian Daily Volume Distribution by South-leg Crosswalk

Figure A3a. Bicycle Daily Volume Distribution by North-leg Crosswalk

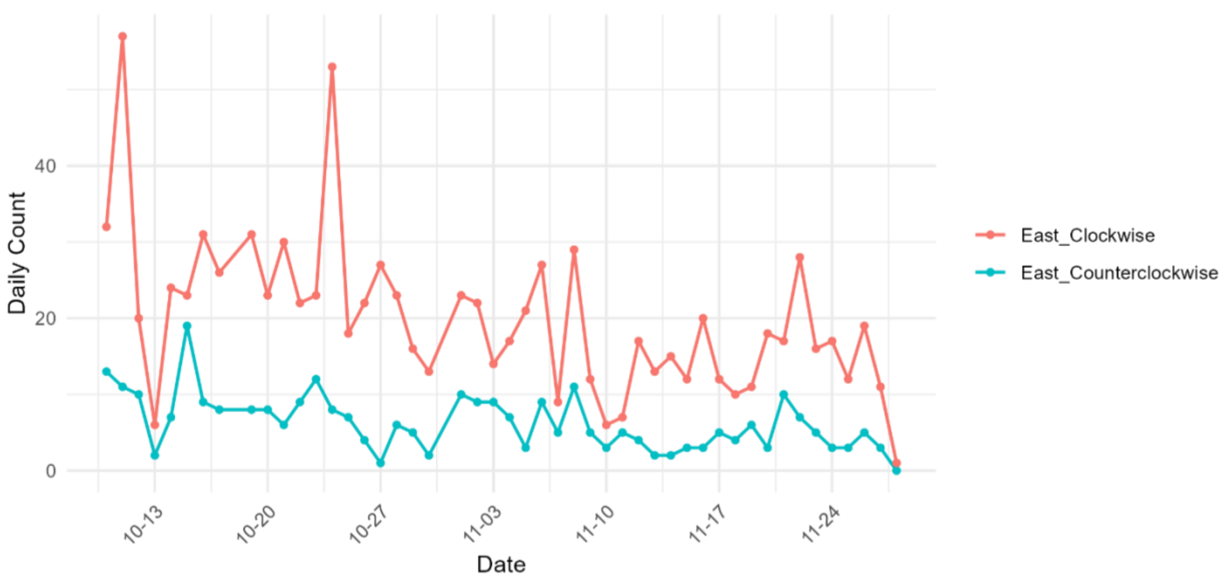

Figure A3b- Bicycle Daily Volume Distribution by East-leg Crosswalk

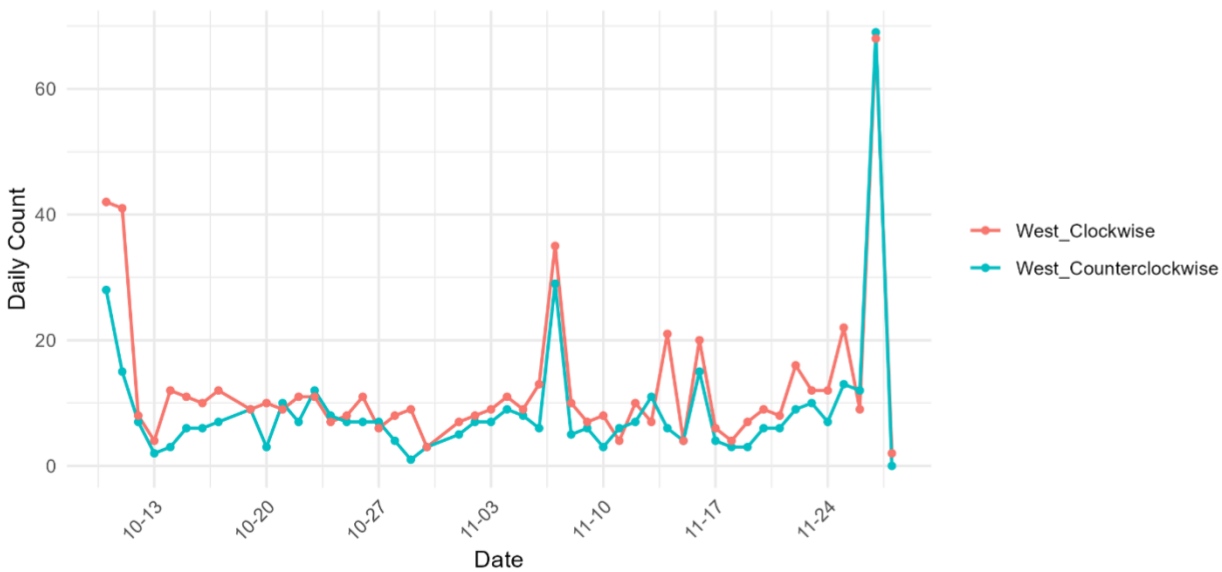

Figure A3c. Bicycle Daily Volume Distribution by West-leg Crosswalk

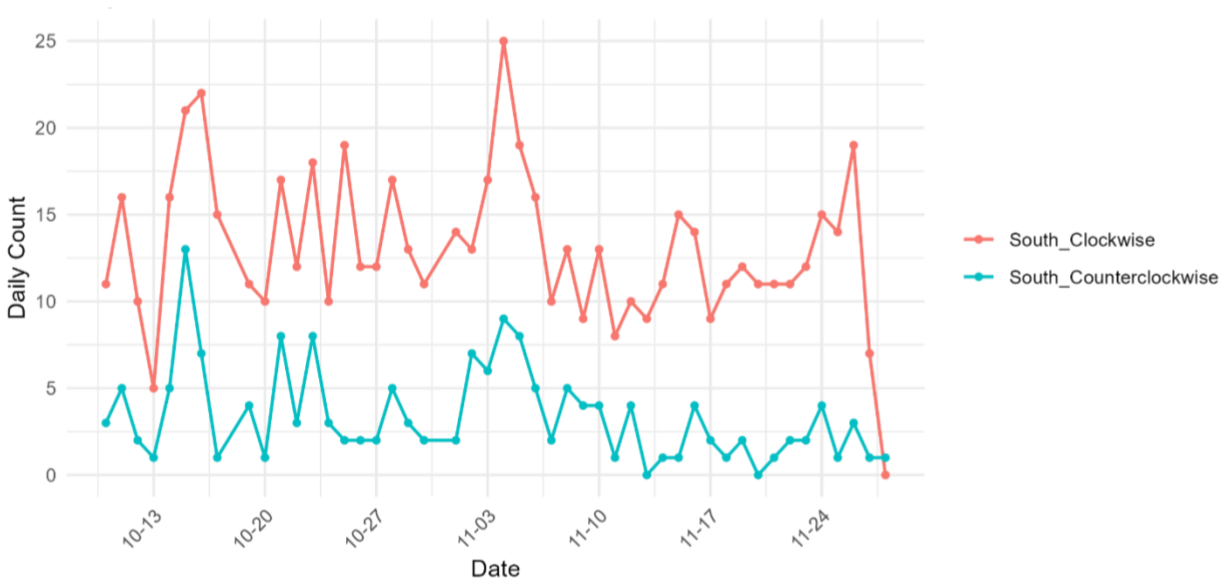

Figure A3d. Bicycle Daily Volume Distribution by South-leg Crosswalk