Road Safety Audit

City of Cleveland, Ohio

April 2013

Prepared By

NORTHEAST OHIO AREA WIDE COORDINATING AGENCY
1299 Superior Ave, Cleveland, Ohio 44114
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- Perform continuous water quality, transportation-related air quality and other environmental planning functions.
- Administer the area clearinghouse function, which includes providing local government with the opportunity to review a wide variety of local or state applications for federal funds.
- Conduct transportation and environmental planning and related demographic, economic and land use research.
- Serve as an information center for transportation and environmental and related planning.
- At NOACA Governing Board direction, provide transportation and environmental planning assistance to the 172 units of local, general purpose government.

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This report is for a Road Safety Audit conducted for the intersection of Chester Avenue and E.105th Street in the City of Cleveland. The purpose of the audit was to examine existing traffic, geometric and operational conditions with regards to safety, and to suggest short-term or long-term, low-cost or higher-cost safety improvements and opportunities.

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City of Cleveland
Ohio

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Executive Summary

The Road Safety Audit (RSA) for the intersection of Chester Avenue (US-322) and E. 105th Street in the City of Cleveland is one of several audits conducted by NOACA as part of Northeast Ohio Areawide Coordinating Agency’s (NOACA’s) safety studies program for fiscal year (FY) 2013. This intersection was identified as the fifth highest crash location based on NOACA’s 2009 Crash Report. The purpose of this RSA, conducted by an ad-hoc, independent audit team, was to examine the prevailing conditions at this location, identify deficiencies, and suggest short-term, low-cost safety improvements.

The RSA team recommends the following low-cost, short-term and low-cost, medium-term improvements to improve the level of safety at this intersection:

- Conduct a capacity analysis and reexamine the signal timing and phasing under the following geometric and traffic flow improvement conditions recommended in this study report
  - Converting Chester Avenue to five standard-width lanes marked such that it includes a median two-way left-turn lane and two through lanes for each direction, with the outermost lanes designated as shared through and right-turn lanes
  - Converting E. 105th Street to a 3-lane roadway consisting of a median two-way left-turn lane and one shared through and right-turn lane for each direction
- Add exclusive left-turn bays on both approaches of Chester Avenue, especially on the eastbound approach which appears to serve a higher volume of left-turn traffic movements
- Add exclusive left-turn bays on both approaches of the E.105th Street
- Upgrade the existing lanes by widening them to standard or near standard widths, especially at the approaches
- Improve the pavement surface condition
- Improve the pavement markings and place markings on better pavement surfaces
- Stagger the stop lines on the northbound and southbound approaches of E.105th Street by setting backward the stop line for the left-turn bays, and set forward the stop line for the through- and right-turn lanes
Background and Location of the Intersection

The intersection is located within the municipal boundaries of the City of Cleveland. Figure 1 shows the location of the intersection and surrounding area. Figure 2 shows the location of the intersection relative to Cleveland Public Square in the Central Business District. Based on NOACA’s 2009 Crash Report for high crash locations in the period 2007-2009, this intersection ranked 5th among the top 100 high crash locations. The ranking is based on a composite index derived from crash data obtained from the Ohio Department of Public Safety. The methodology NOACA used to rank the intersections is described in Appendix B.

Figure 1: Location Map
Team Members

The team for this audit included the City of Cleveland traffic engineer, NOACA transportation engineers, and the Ohio Department of Transportation (ODOT) District-12 office planning engineer.

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Organization</th>
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<tbody>
<tr>
<td>Andrew Cross, P.E.</td>
<td>City Traffic Engineer</td>
<td>City of Cleveland</td>
</tr>
<tr>
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<td>Traffic Planning Engineer</td>
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<td>Sahar Tawfiq</td>
<td>Transportation Engineer</td>
<td>NOACA</td>
</tr>
</tbody>
</table>
Pre-Audit and Post-Audit Meetings

Pre-audit and post-audit meetings among the team members were held on November 19 and 20, 2012 respectively at NOACA’s offices in Cleveland. The team shared their experiences and knowledge about the intersection. Lead members in the Audit Team presented the crash data analysis and a representative collision diagram. The crash information presented and discussed at the pre-audit meeting is shown in the next section titled “Crash History”. The field audit for the intersection was conducted in the interim between the two audit meetings and is presented in detail in the following section titled “The Audit”. Field observations were conducted for the midday and evening peak periods. An after-dark field review was also conducted to observe how traffic interacts with the prevailing environment under existing lighting conditions to determine whether the present lighting appears adequate and whether there are any visibility issues that might be contributing factors in the occurrence of crashes. The team returned to the site the following day to make observations regarding the operation of the intersection during the morning peak to see how the traffic patterns compare with the patterns observed during the other peak periods. The team convened a post-audit meeting to share and discuss its findings and observations and to prepare for writing a report.
Crash History

A review of the most recent three-year crash history for the period 2009-2011 within a radius of about 300 feet of the intersection was conducted to establish a profile for the types and patterns of crashes at this intersection. Crash reports for years 2009, 2010, and 2011 were obtained from the Ohio Department of Public Safety and studied to determine, among other things, the types, approximate locations, and severity of crashes at this intersection. Records show there were 80 crashes at or near the intersection in the three-year period for an average of 26.7 crashes per year. The intersection services about 34,870 vehicles per day (ADT). The crash rate at this intersection, therefore, is 2.1 crashes per million entering vehicles (MEV).

The predominant types of crashes are sideswipe-passing, rear end, and left-turn collisions followed by right angle collisions. The charts presented below show, among other statistics, the distribution of crashes by types, severity, hour-of-day, day-of-week, month-of-year, and road condition at the time of their occurrence. Presented also is a representative collision diagram that shows the type and approximate location of each crash in the three-year period.

The presence of a significant number of sideswipe-passing crashes indicate that there is a great deal of encroachment upon the paths of traveling vehicles notably aggravated by the narrow width of the lanes. Sideswipe-passing collisions often occur when drivers attempt to either avoid such encroachments or momentarily lose control over maintaining assured clear lateral distance. The lack of left-turn bays also contributes to the sideswipe crashes as drivers try to change lanes to avoid being blocked by awaiting left-turning vehicles. Rear end crashes are an indication of congestion and can also occur when conditions cause drivers to stop abruptly with little or no advance notice.

Chart 1 shows the various types and number of crashes at this intersection.

![Chart 1: Frequency of Crashes by Type of Crash](image)
Chart 2 shows the frequency of crashes by hour of day. The majority of the crashes are in the period between about noon to about 7 p.m. Heavy traffic movements on Chester Avenue are most noticeable between about 8 a.m. and 9:30 a.m. for the morning commute, and about 4 p.m. to about 6:30 p.m. for the evening peak.

Chart 3 shows the frequency of crashes by day of the week. Higher crash frequency is evident during regular weekdays, exacerbated by higher traffic volumes during work days.
Chart 4, ‘Frequency of Crashes by Month’, shows a remarkable variation in crash frequency by month of year. The increase in the number of crashes for the month of May is probably an abberation as there was not a recognizable reason found in the crash reports to explain it. The number of crashes during the months of November, December, January, and February are generally similar or relatively even, but higher in number than during other months, which is consistent with road conditions during the wintery season.

Chart 5, ‘Frequency of Crashes by Year’, shows that crash frequency is rather balanced although decreasing slightly from years 2009 through 2011. There were 80 crashes in the three-year period for an average of 26.7 crashes per year. The intersection serves about 34,870 vehicles per day (ADT). Therefore, the crash rate at this intersection is 2.1 crashes per million entering vehicles (MEV).
Chart 6 shows the percent of injury crashes and the percent of property damage crashes. Injury crashes represent 24 percent. No fatal crashes were reported for the three-year period studied. Chart 7 (Frequency of Crashes by Year and Severity) shows a slight decrease in both injury and property damage crashes.

Combined statistics from Charts 8 and 9 indicate that alcohol related and alcohol suspected crashes represent about 25 percent of all drivers involved in the crashes in the three-year period studied, regardless of which of the two drivers was cited for being at fault. Chart 8 shows that about 16 percent of the crashes involved drivers where alcohol was detected and the drivers were supposedly cited for being at fault (Driver1 Alcohol). Chart 9 shows that about 9 percent of the crashes involved drivers where alcohol was detected but the drivers may not have been cited for being at fault (Driver 2 Alcohol).
Environmental conditions such as road surface conditions and light conditions are important elements in the potential occurrence of crashes. Chart 10 shows that 34 percent of the crashes occurred on adverse road surface conditions, namely wet or snow-covered road surfaces. Chart 11 on the other hand shows that during the analysis period 79 percent of the crashes occurred during daylight. An examination of lighting conditions during non-daylight hours was made to ascertain whether adequate lighting conditions exist. It was determined that lighting conditions were adequate as street lights operated well, in addition to other lighting sources provided by adjacent businesses. Narrow travel lanes could exacerbate the occurrence of crashes on wet, snow-covered, or icy road surface conditions.

Collision Diagram

The collision diagram, Figure 3 below, shows the types, severity, and approximate locations of the reported crashes. The symbols in blue represent crashes involving injuries. The symbols in black represent property damage only. The diagram indicates that most of the sideswipe-passing crashes are lane-change or lane-encroachment related. Most of the crashes occurred on Chester Avenue, particularly near the approaches and on the E.105th Street southbound approach.
Figure 3: Collision Diagram for Crashes on Chester Avenue and E.105th Street in the 3-year Period 2009-2011
The Audit

The Road Safety Audit (RSA) for this intersection was conducted on November 19 and 21, 2012. It is part of the Northeast Ohio Areawide Coordinating Agency's (NOACA's) safety studies program for FY 2013.

A Road Safety Audit (RSA) is a formal on-site examination of the safety-related performance of an existing or future road or intersection by an independent, ad-hoc audit team. The RSA team usually considers the safety of all road users, qualitatively estimates and reports on road safety issues, and makes suggestions and recommendation regarding safety improvements. The steps for a road safety audit are:

1. Identify the project or the road-in-service to be audited.
2. Form an RSA team.
3. Conduct pre-audit and post audit meetings.
4. Perform field observations under various conditions.
5. Conduct an audit analysis.
6. Present the audit findings to the project owner/design team.
7. Project owner/design team prepares a formal response.
8. Incorporate the safety audit findings into the project when appropriate.

Figure 4A, below, is an aerial view of the intersection, prevailing landscape, geometry, and alignment. Figure 4B shows its lane configuration and year 2010 Average Daily Traffic (ADT)

Figure 4A: Prevailing Landscape, Geometry, and Alignment

1 FHWA Road Safety Audit Guidelines, FHWA-SA-06-06
The main characteristics of the roadways forming this intersection and prevailing conditions are:

- Chester Avenue is US 322, and classified as a principal arterial, with a posted speed limit of 35 miles per hour. East 105th Street, on the other hand, is classified as a minor urban arterial, with a posted speed limit of 25 miles per hour.
- According to 2010 vehicle count data by ODOT, Chester Avenue between E.97th Street and Euclid Avenue services about 23,720 vehicles per day (ADT 23,720 VPD)
- According to 2010 adjusted traffic count data by NOACA, E.105th Street between Martin Luther King Jr. Drive and Euclid Avenue services about 11,150 vehicles per day (ADT 11,150 VPD)
- All approaches of the intersection are relatively straight, and the terrain is level. Hence, there are no obstructions to the lines of sight due to any alignment issues.
- There were no fatal crashes. About 24 percent of all crashes were injury crashes, and the rest (76 percent) were property damage only.
Issues Identified and Remedial Actions Needed

The audit team made observations regarding many elements of the intersection and focused on the geometric configuration of the intersection, traffic movement, conflicting movements, signal operation, pedestrian movements, lighting conditions, and the road surface condition. The team made recommendations for measures to improve the overall safety conditions at this intersection based on observations in the field. The safety issues identified are listed under the following categories: traffic control signs and signals, lane geometry and configuration, signage, visibility, pavement surface conditions, pavement markings, pedestrian movement & amenities, access management, lane assignment and configuration, and the overall operation of the intersection.

Issues identified in this road safety audit and suggested remedial measures are presented in the following sections:

Traffic Control Signs and Signals

- The traffic control signal phasing and timing appear good for the most part, providing satisfactory traffic flow through the intersection with the following attributes:
  - Phase I is a leading left and through phase for the northbound movement on E.105\textsuperscript{th} Street,
  - phase II allows for the southbound movement to start after reverting the left-turn movements to permissive
  - Phase III is a leading left-turn and through movement for eastbound Chester Avenue
  - Phase IV permits the through movement to start after the leading left-turn movement reverts to permissive

- The cycle length of 100 seconds appears constant throughout the day
- Consider providing two through-lanes and one left-turn bay, and a two-way center-lane on both approaches of Chester Avenue based on capacity analysis to evaluate the operation of the intersection
- The eastbound 5-section traffic control signal head is positioned over the double yellow line; adjust its position and align it with the respective lanes it is intended to serve
- Use one signal head per lane
- No back-plates are available; consider adding back-plates as deemed appropriate
- The northbound protected leading left-turn phase and the eastbound protected leading left-turn phase for traffic utilizing shared through and left-turn lanes often fail to serve their purposes when through vehicles block the shared lanes during the service of the protected lead left-turn phases
• Exclusive left-turn bays are necessary for optimal operation, especially if the results of a capacity analysis study show a need
• Speed limit signs on Chester Avenue westbound were obscure or not available
• Check for the need to post additional 35-miles-per-hour speed-limit signs on Chester Avenue

Geometry and Lane Configuration/Lane Use Assignment

• The lanes on Chester Avenue in both directions are very narrow. They have a width of about nine feet. The width of this six-lane roadway from curb to curb is about 56 feet
• There are no lane markings on E.105th Street, allowing driver judgment to consider it and use it as a four-lane roadway (two lanes in each direction)
• East 105th Street, having a width of 40 feet curb-to-curb, is too wide to be only a two-lane roadway (one lane for each direction), and is somewhat too narrow for it to be lane-marked as a four-lane roadway (two lanes for each direction), which calls for conducting an arterial capacity analysis study to examine the viability of providing a through lane for each direction and a median, two-way left-turn lane for a three-lane roadway, if right of way is available or acquisition is possible, or to determine how to best delineate the pavement with appropriate lane markings to establish respective lane assignments with standard or near standard lane widths
• Figure 5 shows the existing lane configuration and lane-use
Figure 5: Existing Lane Configuration and Lane-Use
Signage

- There are no speed limit signs on Chester Avenue
- Street name signs, their location, orientation, and size appear to be adequate
- A ‘Hospital’ destination sign on the southeast corner of the intersection is blocking the pedestrian indication signal head for the crosswalk at the E.105th northbound approach (southern leg)
- There is too much clutter (banners on the northwest side of Chester Avenue and E. 105th Street) that distract from pertinent traffic signs
- Some signs are damaged, bent, or defaced by either vandalism or elements of inclement weather
Visibility

- Although mitigated by lead left-turn phasing, absence of exclusive left-turn bays on all approaches compromises visibility, especially when left-turning vehicles queue up or occupy the field of the intersection awaiting a gap to turn left on permissive phases, obstructing the line of sight for all opposing left turners.
- Obstruction to the line of sight is more acute for vehicles attempting to turn left onto E.105th Street from either approach during the permissive phase, or attempting to cross three lanes of through traffic on Chester Avenue.
- Light poles on the sidewalks are too close to the curb, especially those in front of the fire station, and those near the southeast and southwest corners, causing the lateral clearance to be less than desirable.
- A tree on the southeast corner is leaning toward and overarching Chester Avenue with low-hanging branches, causing visibility issues, obstruction to heavy trucks, and interference with the overhead cables and power lines (Figure 6).
- Line of sight is compromised when two opposing vehicles attempt to turn left on the permissive phase from E.105th Street onto Chester Avenue.

Figure 6: Existing Lane Geometry and Configuration
Trunk of felled tree, northeast corner

Tree still standing that should be felled, southeast corner
**Pavement Surface Condition**

- The pavement condition within the intersection is poor, particularly on the westbound approach (east leg) of the intersection. It is rutted, cracked, and uneven.
**Pavement Markings**

- Pavement lane lines, centerlines, and crosswalk markings are faded, jagged, and at some places unclear due to the unevenness of the surface of the pavement.
- There are no lane lines on E.105th Street, because the street has narrow lanes. Traffic uses the roadway as a two-lane roadway despite the absence of lane delineation.
Pedestrian Facilities

- The pedestrian signals operate on recall
- Pedestrian and bike activities are moderate
- The pedestrian signal head on the southeast corner for the crosswalk in front of the northbound approach of E.105th Street is obscured by the presence of a “Hospital” sign and a street pole

Access Management

- There is good access to and from the nearby business establishments; for example, driveway access to and from the newly built Key Bank branch are well designed to facilitate safe ingress and egress featuring streamlined curb curvature, right-in/right-out configuration, and signage
- Driveway locations are at a reasonable distance from the intersection

General Intersection Operation

- The primary causes of crashes are the narrow lanes, lack of visibility among opposing left-turning vehicles due to the lack of exclusive left-turn lanes and pertinent phasing -- especially on Chester Avenue, and heavy traffic volumes or congestion
- The RTA bus stops on E.105th Street are too close to the intersection. Buses stopping at these bus stops cause drivers to maneuver around them which increases the potential for crashes
- Turn radii are too short for larger trucks and semi-trailers. Large, heavy vehicles negotiating the turns encroach upon the curb and sidewalk when making turn movements
- There were construction activities on E.105th Street that entailed a traffic detour during the observation period. Hence, there were a number of uncommon truck turn movements and bus traffic on non-regular bus routes
Conclusion and Recommendations

The recommendations in this report are mostly low-cost, short-term measures to increase the level of safety at this intersection. The main recommendations are summarized and illustrated below. Crash reduction factors (CRF), for countermeasures for which such crash reduction factors are available, are shown in Table 1, below.

- **Capacity Analysis**
  - Perform a capacity analysis study to evaluate the operation of the intersection to:
    - Improve and optimize signal timing and phasing for better traffic flow, and to enable better utilization of lanes
    - Examine the viability of reapportioning the width of the roadways to convert the present lane configuration and assignment into median two-way left-turn lanes, and two through lanes in each direction for Chester Avenue and one through lane in each direction for E.105th Street, as shown in Figure 7
    - Reassign lanes to left-turn bays at all approaches
    - Increase the width of the lanes to near standard widths
    - Maintain the pedestrian recall phases
    - Reevaluate the length of the yellow and all-red clearance intervals

*Figure 7: Proposed Lane-Use Assignments*
• **Lane-Use and Pavement Markings**
  - Move the stop bar back on the E. 105th Street south leg
  - Add lane marking on E. 105th Street
  - Examine the feasibility of making Chester Avenue a five-lane section on both sides of the intersection up to Stokes Boulevard east of the intersection
  - A 2011 two-way traffic count on Chester Avenue between E.79th Street and Euclid Avenue is approximately 23,700 vehicles per day
  - Perform a brief study for an extended length of Chester Avenue (a short corridor) to provide lane balance throughout such extended length or corridor

• **Physical Obstructions**
  - Remove the tree located at the southeast corner of the intersection
  - Remove the stump of a felled tree in the northeast corner of the intersection
  - Relocate the poles that are very close to the edge of the curbs, especially on Chester Avenue near the fire station and on the southeast and southwest corners
  - Relocate the bus stop situated in the northwest corner farther away from the intersection
  - Relocate the sign for the ‘Hospital’ to avoid blocking the view of the pedestrian crossing signal

• **Signal Hardware**
  - Add back-plates
  - Move the pedestrian signal head, in the southeast corner, used for crossing the south leg to ensure its visibility
  - Reposition or move to the right the five-section signal heads for the eastbound approach because the five-head traffic control signal is almost over the double yellow line, affecting driver perception

• **Pavement Condition**
  - Perform a skid test
  - Resurface the pavement within the intersection and to about 250 feet on each approach because it is deteriorated

• **Overall Intersection Operation**
  - The primary causes of crashes are narrow lanes, lack of visibility due to opposing left-turning vehicles, the lack of exclusive left-turn lanes and pertinent phasing, especially on Chester Avenue, and heavy traffic volumes or congestion
## TABLE 1: IMPROVEMENT MEASURES AND CRASH REDUCTION FACTORS

<table>
<thead>
<tr>
<th>Description of Safety Measure</th>
<th>Cost Category¹</th>
<th>Time²</th>
<th>CRF³</th>
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<tbody>
<tr>
<td>Signal Timing</td>
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<tr>
<td>➢ Perform a capacity analysis study to evaluate the operation of the intersection to:</td>
<td></td>
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<td></td>
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<tr>
<td>• Improve the signal timing and phasing</td>
<td>Low</td>
<td>Short term</td>
<td>Unavailable</td>
</tr>
<tr>
<td>• Reassign lanes to left-turn bays at all approaches</td>
<td>Low</td>
<td>Short term</td>
<td>35% reduction for all types of crashes</td>
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<tr>
<td>• Increase the width of the lanes to standard or near standard widths</td>
<td>High</td>
<td>Long Term</td>
<td>44% reduction for left-turn crashes</td>
</tr>
<tr>
<td>• Maintain existing pedestrian recall phases</td>
<td>Low</td>
<td>Short term</td>
<td>13% reduction for all types of crashes (compared to 12-ft lane)</td>
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<tr>
<td>• Reevaluate the length of the yellow and all-red clearance intervals</td>
<td>Low</td>
<td>Long Term</td>
<td>Unavailable</td>
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<tr>
<td>➢ Install back-plates to improve visibility of the signals</td>
<td>Low</td>
<td>Short Term</td>
<td>Unavailable</td>
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<tr>
<td>➢ Realign the 5-section signal heads for the Chester Ave. eastbound approach with respective lanes</td>
<td>Low</td>
<td>Short term</td>
<td>13% reduction in all types of crashes</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>50% reduction in right-angle crashes</td>
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1 Appendix D
2 Implementation Time
3 Crash Reduction Factor: The percentage of crash reduction expected after implementing the recommended countermeasure. U.S. Department of Transportation, FHWA-SA-08-011
<table>
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<tr>
<th>Description of Safety Measure</th>
<th>Cost Category</th>
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<td><strong>Physical Obstructions</strong></td>
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<td></td>
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</tr>
<tr>
<td>➢ Remove the tree located at the southeast corner of the intersection</td>
<td>Low</td>
<td>Short term</td>
<td>Unavailable</td>
</tr>
<tr>
<td>➢ Remove the stump of a felled tree in the northeast corner of the intersection</td>
<td>Low</td>
<td>Short term</td>
<td>Unavailable</td>
</tr>
<tr>
<td>➢ Relocate the bus stop situated in the northwest corner farther away from the intersection</td>
<td>Low</td>
<td>Short term</td>
<td>Unavailable</td>
</tr>
<tr>
<td><strong>Pavement Condition</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>➢ Perform a skid test (to increase skid resistance)</td>
<td>Low</td>
<td>Short term</td>
<td>Unavailable</td>
</tr>
<tr>
<td>➢ Resurface the pavement within the intersection to about 250 feet on each approach because it is deteriorated</td>
<td>Low to Medium</td>
<td>Medium term</td>
<td>33% reduction for all types of crashes</td>
</tr>
<tr>
<td><strong>Lane and Pavement Markings</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>➢ Move the stop bar back on E. 105th St south leg</td>
<td>Low</td>
<td>Short term</td>
<td>Unavailable</td>
</tr>
<tr>
<td>➢ Add absent lane marking on E. 105th St.</td>
<td>Low</td>
<td>Short term</td>
<td>Unavailable</td>
</tr>
<tr>
<td>➢ Examine making Chester Avenue a 5-lane section on both sides of the intersection up to Stokes Boulevard east of the intersection</td>
<td>Low</td>
<td>Short term</td>
<td>Unavailable</td>
</tr>
</tbody>
</table>

1 Appendix D  
2 Implementation Time  
3 Crash Reduction Factor: The percentage of crash reduction expected after implementing the recommended countermeasure. U.S. Department of Transportation, FHWA-SA-08-011
Other Considerations and Information

Plans for Opportunity Corridor include proposals for six-lanes on Chester Ave. The Chester Avenue westbound approach will have a left-turn bay instead of the present shared thru and left lane. E. 105th Street will be widened to include a two-way left-turn center lane. E. 105th Street is currently a de-facto four-lane roadway but without lane markings. Next year, more traffic will be using E.105th Street and Chester Avenue due to the reconstruction of the E.105th roundabout.

These findings and recommendations are sent to the City of Cleveland for review, comments, and consideration. The city is asked to comment on all findings and recommendations, and provide a response to incorporate in this report. The City of Cleveland may wish to use this report to request safety funds through the Ohio Department of Transportation (ODOT) to address some or all of the safety improvement recommendations presented in this study report.

Exhibit A: Chester Avenue and E.105th Street Improvements via the Opportunity Corridor Project Plans
Appendix A:
Glossary

**An Actuated Traffic Control Signal:** A traffic control signal that operates based on actual, real time vehicular demand.

**Actuation:** Initiation of a change in or extension of a traffic signal phase through the operation of any type of detector.\(^1\)

**Adaptive Traffic Signal Control:** The process by which the timing of a traffic signal is continuously adjusted based on the changing arrival patterns of vehicles at an intersection, usually with the goal of optimizing a given measure of effectiveness. The characteristics of a traffic signal cycle are optimized at the conclusion of every phase based on the vehicle arrival times.

**Back-plate:** A thin strip of material that extends outward from and parallel to a signal face on all sides of the signal housing to provide a background for improved visibility of the signal indications.\(^1\)

**Capacity:** Traffic-carrying ability of a facility over a range of defined operational conditions. Capacity analysis provides tools to assess facilities and to plan and design improved facilities.\(^2\)

**Crash Reduction Factor:** The percentage of crash reduction expected after implementing the recommended countermeasure.

**Detector:** A device that detects the presence of a vehicle and actuates the demand for a green signal.

**Green Time:** The duration of the green indication for a given movement at a signalized intersection.

**Permitted Turn:** Left or right turn at a signalized intersection that is made against an opposing or conflicting vehicular or pedestrian flow.\(^2\)

**Protected Turn:** The left or right turns at a signalized intersection that are made with no opposing or conflicting vehicular or pedestrian flow allowed.\(^2\)

**Signal Phasing:** The way in which the right of way is allocated among conflicting traffic movements that seek to use the same space.

**Split Phasing:** A signal phasing where each two opposing traffic movements have a completely separate phase.

**Stop Line:** A solid white line extending across approach lanes to indicate the point behind which vehicles are required to stop.\(^1\)

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\(^1\) Manual on Uniform Traffic Control Devices  
\(^2\) Highway Capacity Manual
Appendix B: Methodology for Ranking High-Crash Locations

Crash locations are ranked based on a composite index derived from the four different ranking aspects, described below. The Composite Index for a location is the sum of the four ranks the location has according to crash frequency, equivalent property damage only, average equivalent property damage only and crash rate.

1. **Frequency of Crashes**
   
   Rank 1 means the location has the highest crash frequency.

2. **Equivalent Property Damage Only Index (EPDO)**
   
   This index uses a formula to convert crashes of all severities to the equivalent of property damage-only crashes. It is calculated by weighing crashes as follows, where the cost of property damage only (PDO) crash is given a weight of 1:
   
   - The number of fatal crashes multiplied by 122.75 (the cost of a fatal crash is $1,199,558).
   - The number of injury crashes multiplied by 7.30 (the cost of an injury crash is $71,343).
   - The number of property damage only (PDO) crashes multiplied by 1.0 (the cost of a PDO crash is $9,772).

   \[
   \text{EPDO} = (\text{# of fatal crashes} \times 122.75) + (\text{# of injury crashes} \times 7.30) + \text{property damage-only crashes}
   \]

   Rank 1 means the location has the highest EPDO.

3. **The Average Equivalent Property Damage Only (EPDO per crash)** is calculated for each intersection by taking the EPDO index calculated in step 2 above divided by the number of crashes occurring at the intersection.

   The highest EPDO per crash is ranked number 1.

4. **Crash Rate (Crashes per million entering vehicles):**

   \[
   \text{Crash Rate} = (\text{# of crashes} \times 1,000,000) / [(\text{years of data})^*(365)^*\text{(daily traffic volume entering the intersection)}]
   \]

   Rank 1 means the location has the highest crash rate

5. **Composite Index = Frequency Rank + EPDO rank + EPDO per crash rank + Crash rate rank**

   (Ranking of crash locations will be according to the value of the composite index in descending order: a location having the lowest composite index ranks at the top)
Appendix C: Cost-Range Categories

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Cost Range in Dollars</th>
<th>Time Range in Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Less than $100,000</td>
<td>One year or less</td>
</tr>
<tr>
<td>Medium</td>
<td>$100,000 - $5,000,000</td>
<td>One year - 5 years</td>
</tr>
<tr>
<td>High</td>
<td>Greater than $5,000,000</td>
<td>More than 5 years</td>
</tr>
</tbody>
</table>