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February 17, 2022

Mr. David De Angelis
Village Manager
Village of Elm Grove
13600 Juneau Boulevard
Elm Grove, WI 53122-0906

Re: Gebhardt Road and Highland Drive Improvements
Highland Drive Sight Distance Analysis

Dear Mr. De Angelis:

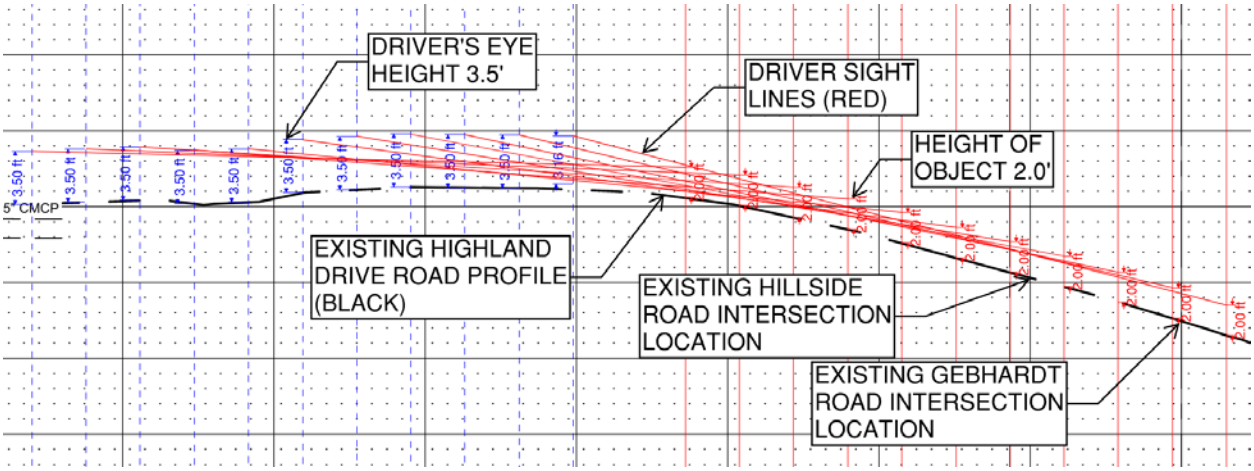
As requested at the January 10, 2022 Public Works Utilities Committee Meeting, we have reviewed the existing sight distance at the intersection of Highland Drive and Gebhardt Road as well as Highland Drive and Hillside Road. Our review consisted of the analysis of both the Stopping Sight Distance (SSD) on Highland Drive and the Intersection Sight Distance (ISD) from both Gebhardt Road and Hillside Road. Parameters identified in the 2018 AASHTO "A Policy on Geometric Design of Highways and Streets" (The Green Book) were used in the analysis for both SSD and ISD. The Wisconsin Department of Transportation Facilities Development Manual (FDM) references the parameters found in The Green Book.

Stopping Sight Distance

Stopping Sight Distance is the distance that the driver of a traveling vehicle needs to see a stationary obstruction in their path and be able to react and safely come to a complete stop. The SSD for any roadway is based on the vehicle traveling at or slightly above the posted speed for that respective roadway. The posted speed limit for Highland Drive is 25 mph. The design speed analyzed for SSD was 30 mph based on the assumption that vehicles tend to travel an average of 5 mph over the posted speed limit. SSD on a level roadway for a vehicle traveling at 30 mph is 200-feet.

SSD consists of two components: the distance traveled after a driver recognizes an obstruction in the roadway prior to applying the brakes (brake reaction time), and the distance to come to a complete stop after applying the brakes (braking distance). On upgrades or downgrades, the braking distance decreases or increases, respectively. In the areas where brake reaction time would end and braking distance would begin, there is an average grade of approximately 6%. Vehicles traveling southbound would experience a 6% upgrade while braking and vehicles traveling northbound would experience a 6% downgrade while braking. A downgrade of 6% increases the braking distance by 15-feet and an upgrade of 6% decreases the braking distance by 16-feet. A SSD of 215-feet (braking distance for level roadway, plus increase due to downgrade) was used in the analysis for vehicles traveling northbound and a SSD of 184-feet was used in the analysis for vehicles traveling southbound on Highland Drive. The SSD due to the downgrade headed in the northbound direction on Highland Drive is larger and therefore governs the required SSD needed for any vehicle traveling on Highland Drive. In other words, if there is a need to cut down the hill on Highland Drive to improve stopping sight distance, then the cut would be greater for a vehicle traveling northbound.

The average height of a driver's eye above the pavement is 3.5-feet and the smallest height of objects statistically involved in crashes is 2-feet above the pavement. Using existing centerline survey data for the roadway profile on Highland Drive, we laid out a 215-feet long sight line between a driver at 3.5-feet above the pavement and an obstruction at 2-feet above the pavement at various intervals over the hill on Highland Drive. The screenshot image below was taken from the attached Figure 1 and shows the sight lines (red lines) that were analyzed at the various intervals along Highland Drive.



Screenshot From Figure 1 - SSD

As can be seen in the screenshot above, the results of the analysis yields that there is adequate SSD for vehicles traveling on Highland Drive. An example of a hazard for a northbound traveling vehicle as they crest the hill on Highland Drive might be a vehicle that pulls out from Gebhardt Road or Hillside Road, or vehicles queued to turn at either of the intersections. However, based on standard design parameters, the SSD for vehicles traveling along Highland Drive is sufficient in these cases.

Intersection Sight Distance

Intersection Sight Distance is the distance that needs to be provided at intersections to allow drivers to perceive the presence of potentially conflicting vehicles. In the cases of the intersections at Gebhardt Road and Highland Drive and at Hillside Road and Highland Drive, the ISD is the uninterrupted line of sight needed for a vehicle stopped on Hillside Road or Gebhardt Road to perceive the presence of an approaching vehicle on Highland Drive to decide if it is safe to proceed onto Highland Drive. In The Green Book, this is referenced as “Intersection Control Case ‘B’: Stop Control on Minor Road”.

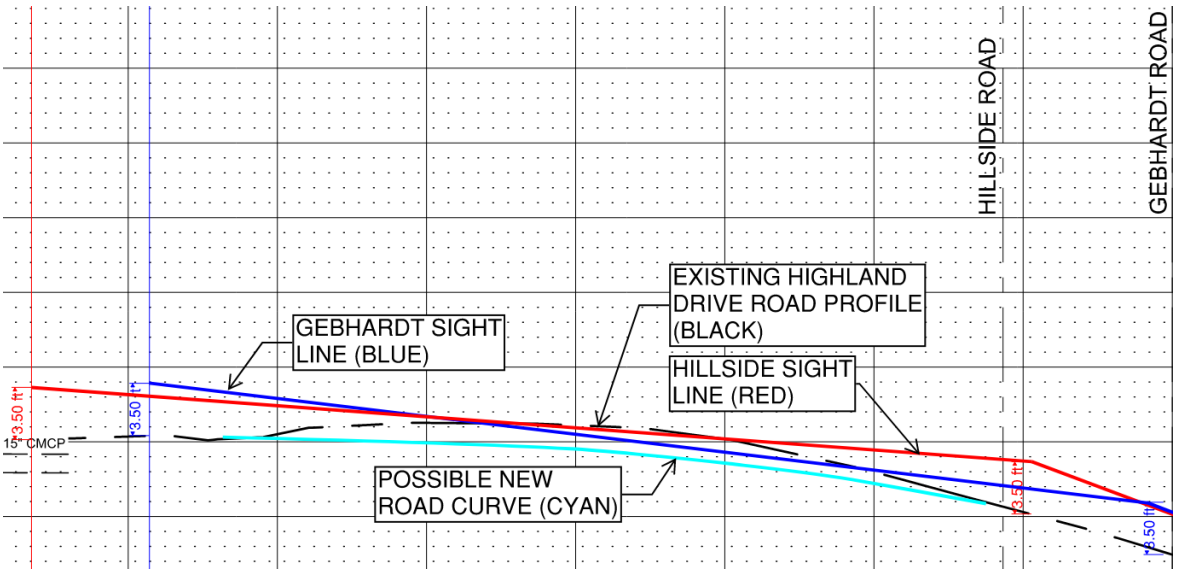
The line of sight needs to be clear of any obstructions on the side of the road such as trees, signs or hills that wouldn’t allow a driver to be able to see for the recommended distance. The uninterrupted line of sight needs to be far enough for a driver on the minor road (Hillside or Gebhardt) to allow the driver to react and proceed into the intersection or wait. If the driver decides to proceed, the line of sight needs to allow the turning vehicle to safely complete the turning movement onto the major road (Highland Drive).

The intersection sight distance varies based on the time needed to safely complete the turning movement. If a vehicle on a minor road is looking to turn right onto the major road, the minor road vehicle only needs to enter the lane closest to them and then proceed. If a vehicle on the minor road is looking to turn left onto the major road, the minor road vehicle needs to pass through the lane closest to them and then into the lane furthest away from them and proceed on their way. The sight distance for a left-hand turn is greater than the sight distance for a right-hand turn. For this reason, the ISD needed to make a left turn onto a roadway governs the required ISD needed for any stopped vehicle on Gebhardt or Hillside. According to The Green Book, this sight distance is 335-feet.

The ISD analysis was performed based on a few different factors compared to the SSD analysis. First, the elevation on Highland Drive is the existing centerline profile of the roadway as surveyed by our staff

last year. Second, the Village has not yet fully determined the extent in which Gebhardt will be moved to the south, during the reconstruction. For this reason, the reconstruction of Gebhardt has not yet been fully designed and therefore, proposed elevations of a relocated Gebhardt Road do not currently exist. Recognizing that there is a need for drainage improvements on the north side of Gebhardt that will require some minimum amount of Gebhardt Road relocation at this intersection, the ISD was analyzed assuming Gebhardt Road is moved about 5-feetouth of where it exists today. Third, the height of the vertical obstruction for the ISD analysis is raised from 2-feet to 3.5-feet because the obstruction is another vehicle. Contrary to SSD, in the case of ISD, the stopped vehicle is attempting to see another vehicle on the roadway, not a stationary object. Lastly, the height of the driver's eye for a vehicle stopped on Gebhardt is slightly lower than the center of the road on Highland Drive because the stopped vehicle is headed uphill as it approaches the intersection. Therefore, the height of the driver's eye on Gebhardt is set slightly below the existing road profile shown on the drawing.

In the screenshot from the attached Figure 2, shown below, you will see that the height of the hill on Highland Drive obstructs the line of sight for a vehicle stopped on Gebhardt and on Hillside. Depending upon final design of the elevation of the intersection, which is not anticipated to change much, the hill on Highland Drive would need to be cut down approximately 1-feet to provide the recommended ISD. It is likely that the modifications to the intersection would need to include a combination of slightly raising the intersection at Gebhardt and slightly lowering the hill on Highland.



Screenshot From Figure 1 - SSD

In the analysis of horizontal obstructions for ISD, also known as "sight" or "vision triangles" three different stop sign setback distance scenarios were analyzed. Assuming that a driver is making their decision to stay at the stop sign or proceed, while stopped at the location of the stop sign on Hillside or Gebhardt, we analyzed their vision triangles in both directions for existing setback conditions, "minimum" setback conditions, and "desired" setback conditions. The figure below, taken from The Green Book, shows what those vision triangles look like for a vehicle stopped on a minor road.

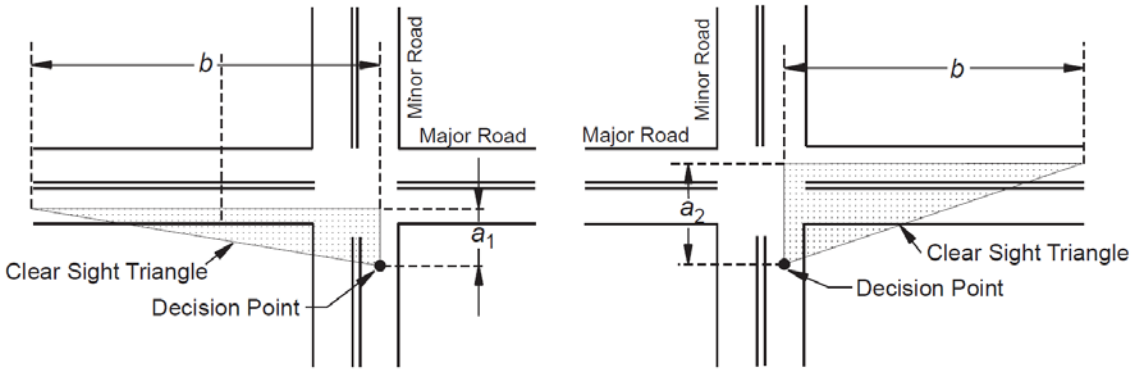
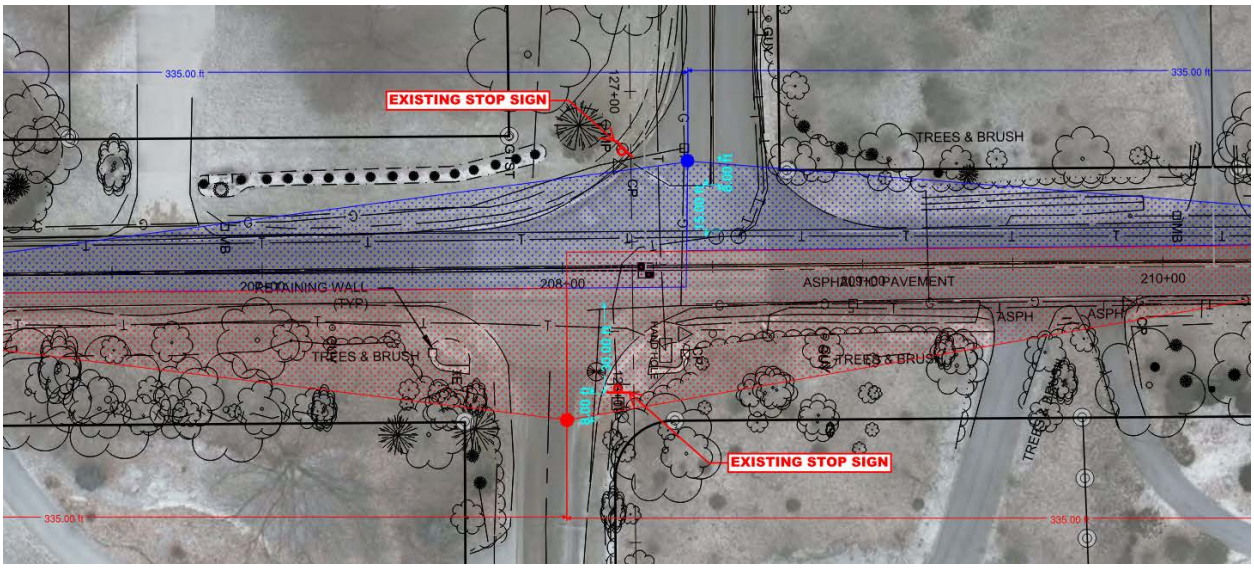


Figure 9-17 From AASHTO "A Policy on Geometric Design of Highways and Streets, 7th Edition, 2018" (The Green Book)

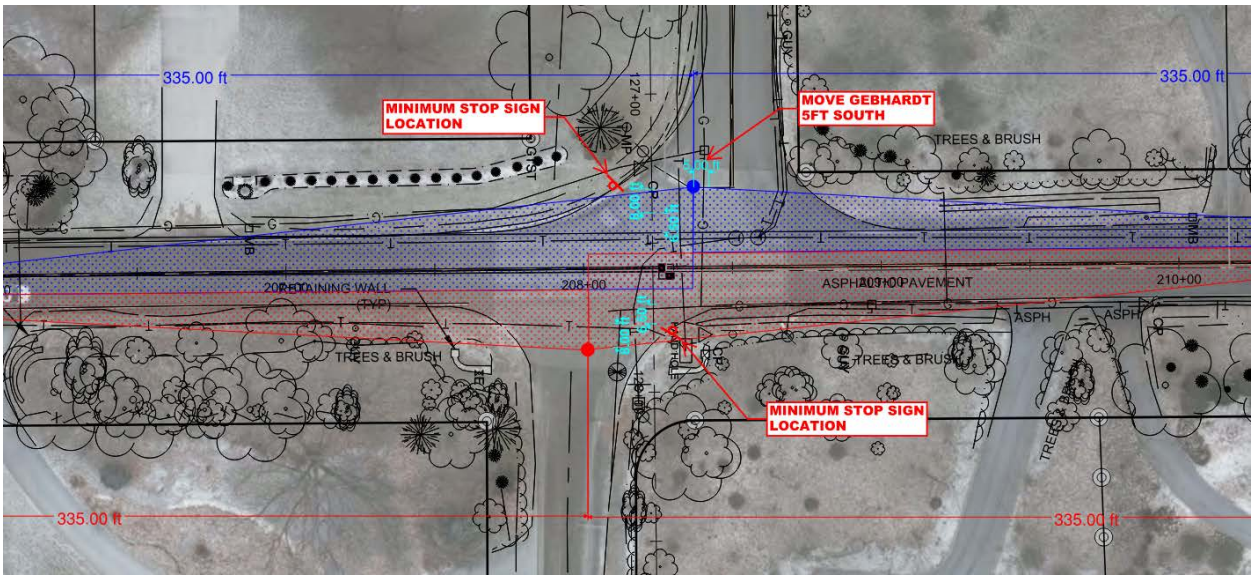
The distance labeled as letter "b" in the figure is the 335-feet that was discussed above. The distance labeled as "a1" and "a2" is the distance of the driver's eye set back from the edge of pavement of the major road, plus ½-lane width or 1 ½-lane widths, respectively. The distance of the driver's eye set back from the edge of pavement of the major road (Highland) will vary based on where the stop sign (and sometimes a stop bar) is located on the minor road (Hillside or Gebhardt). The driver's eye, on average, is approximately 8-feet behind the front of the vehicle. The front of the vehicle is presumed to be even with the location of the stop sign.

The screenshot from the attached Figure 2, shown below, shows that the existing stop sign on Hillside is set back 30-feet from the edge of pavement and the stop sign on Gebhardt is set back 15-feet from the edge of pavement of Highland Drive. The driver's eye location, shown as the large red and blue dots, is set back another 8-feet from those distances, as previously discussed. The corresponding vision triangles can be seen for Hillside and Gebhardt, in the red and blue hatched areas, respectively.



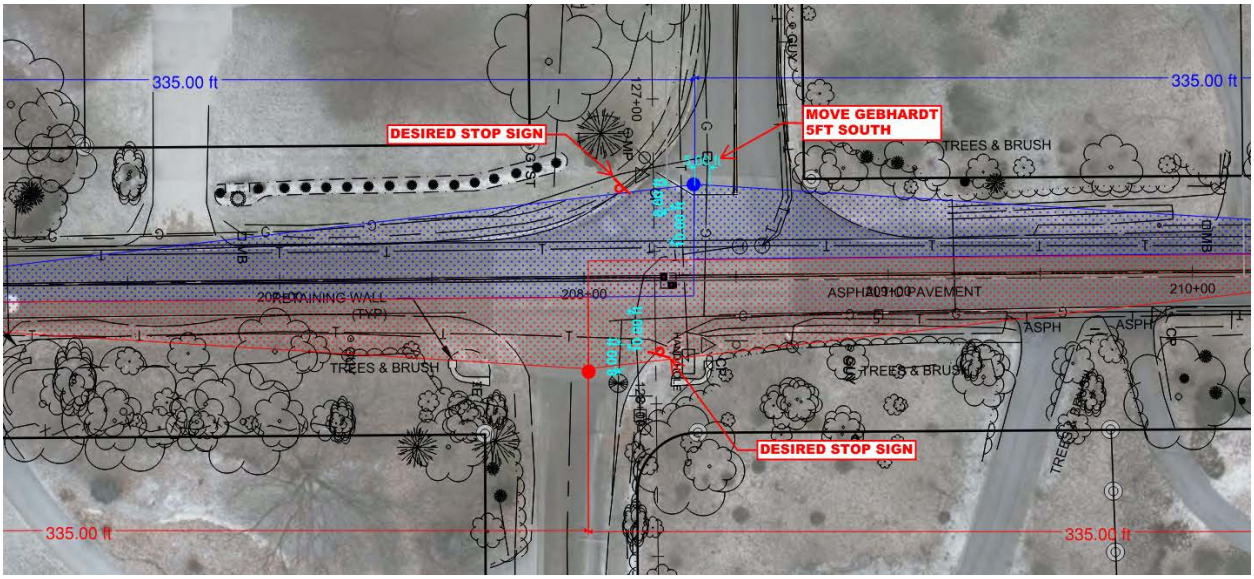
Screenshot From Figure 2 - Existing ISD

The Green Book states that, on average, drivers stop approximately 6.5-feet from the edge of pavement of the major road. Taking this into account, the screenshot from Figure 3 below shows the minimum distance away from the edge of pavement on Highland that the stop sign should be placed on Hillside and Gebhardt. The driver's eye is again shown as the large red and blue dots, set back an additional 8-feet from the stop sign location. The corresponding vision triangles are shown.



Screenshot From Figure 3 - Minimum ISD

According to The Green Book, the desired distance to place a stop sign from the edge of pavement of the major road is 10-feet. The area provided between where a vehicle is supposed to stop and the edge of pavement of the major road allows for safer turning movements for vehicles turning from Highland onto Gebhardt or Hillside. The screenshot from Figure 4 below shows the desired location for the stop sign to be set back from the edge of pavement of Highland Drive. The large red and blue dots again show the location of the driver's eye on Hillside or Gebhardt, set back 8-feet from the stop sign location. The corresponding vision triangles are shown.



Screenshot From Figure 4 - Desired ISD

Based on the analysis of the vision triangles in all three scenarios, the "desired" stop sign location is optimal for the configuration of this intersection. The existing stop sign location on Hillside appears to be set too far back and causes drivers to creep forward to be able to see around the obstructions located within the vision triangles. A stop sign located at the "minimum" distance back from the edge of pavement for both roadways appear to be too close to Highland Drive because the stopped vehicle will likely conflict with the turning movement of another vehicle turning off of Highland Drive. Additionally, the stop sign at the "minimum" distance on Gebhardt does not allow enough room for a crosswalk for the future Highland Drive Pedestrian Pathway that is planned to be installed at a future date. The "desired" stop sign location for both roadways allow for the most optimum vision triangles in both directions with minimal clearing of roadside obstructions such as existing trees and brush. The "desired" stop sign location on Hillside also avoids the new subdivision monument signs from being located within the vision triangles.

Conclusion

We have reviewed the existing conditions for SSD and ISD at the Highland Drive intersection with Gebhardt Road and with Hillside Road. Based on existing conditions, the SSD in both directions appears to be adequate for a vehicle traveling on Highland Drive and encountering an object in the travel way. The ISD at both Hillside Road and Gebhardt road is inadequate in both the vertical and horizontal directions. The vertical crest hill on Highland Drive impedes the line of sight needed for a driver at Hillside or Gebhardt to safely decide to proceed from a stopped position on either roadway. The vision triangles that currently exist are inadequate unless a vehicle stops beyond the posted stop sign on either roadway.

After reviewing the different scenarios, we are recommending relocating Gebhardt Road a minimum of 5-feet south from its current location. This will lessen the cut depth in the hill on Highland, will improve the vision triangle looking north from a stopped position on Gebhardt, and will allow for necessary drainage improvements on the north side of the roadway.

Based on the information that we have readily available, we've estimated that the additional project cost to improve the sight distance on Highland Drive would cost approximately $70,000 which is similar to the

cost that was included with the cost estimates dated January 10, 2022. This cost includes necessary excavation and grading to cut down the hill on Highland Drive and additional cost to clear obstructions within the vision triangles as seen in the above screenshots.

If you or others from the Village should have any questions regarding this, please feel free to contact our office at (262) 542-5733. Thank you for allowing us to be of service to the Village of Elm Grove.

Respectfully,

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Respectfully,

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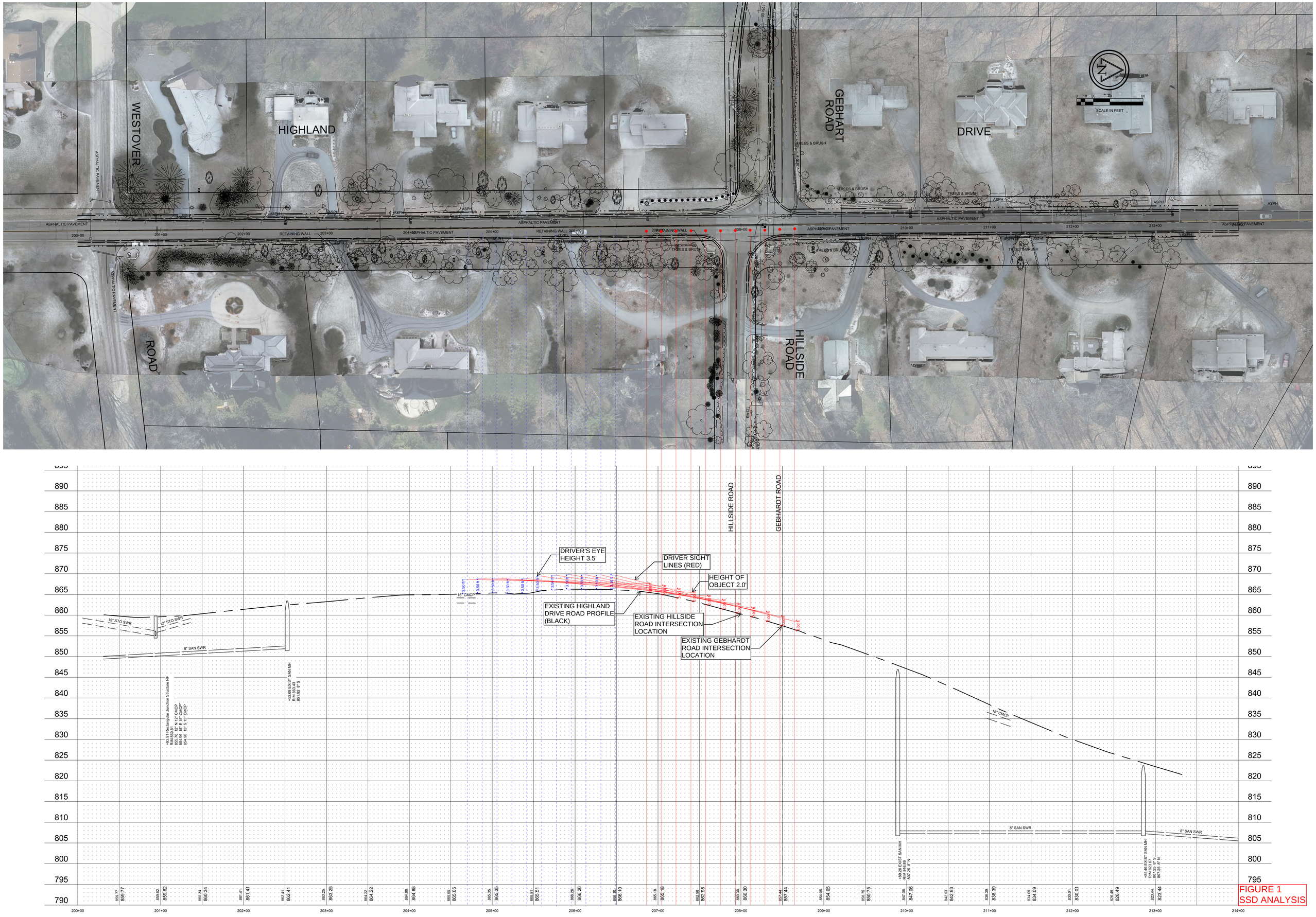

FIGURE 1
SSD ANALYSIS

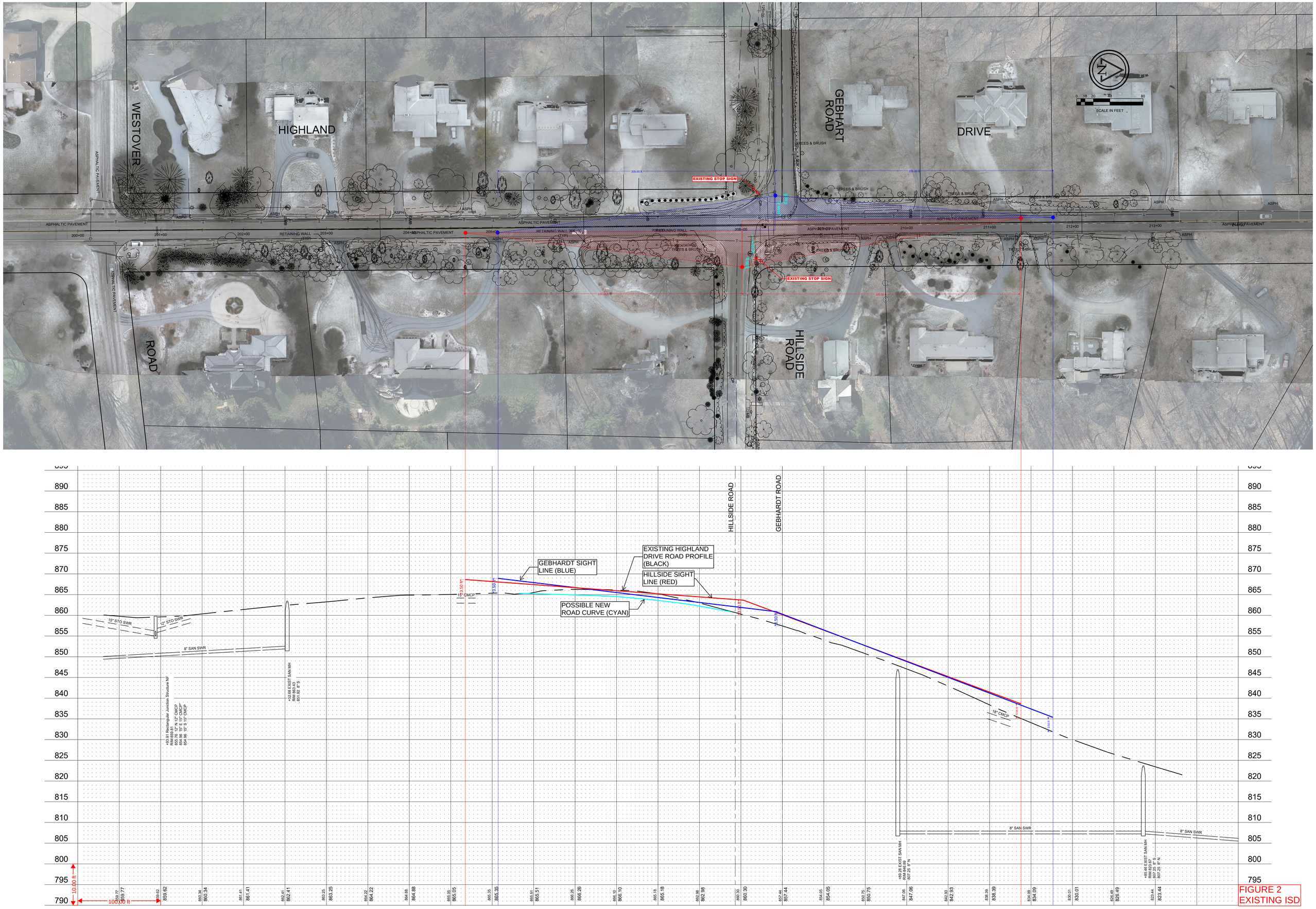

FIGURE 2
EXISTING ISD

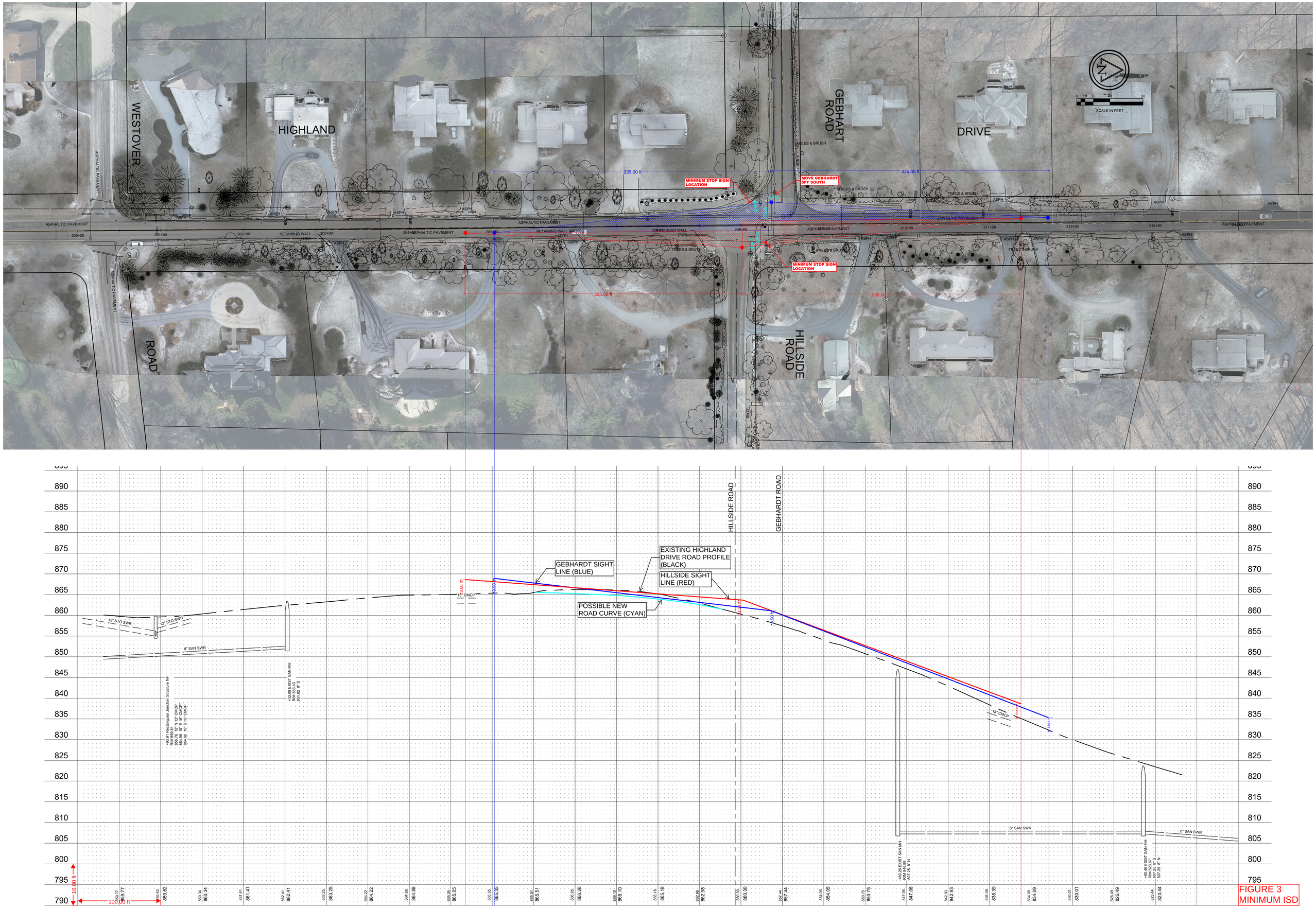

FIGURE 3
MINIMUM ISD

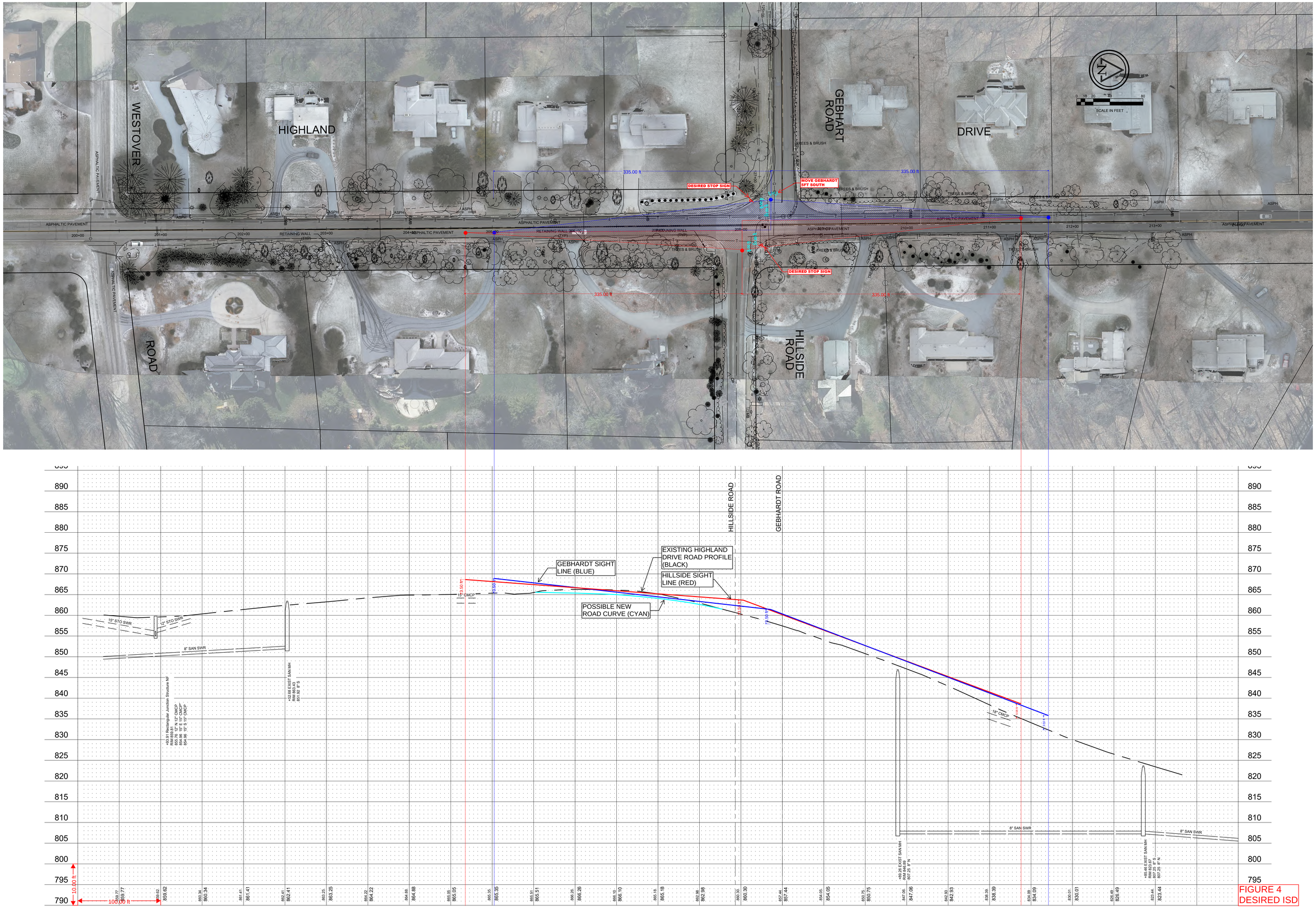

FIGURE 4
DESIRED ISD