List of Meeting Materials
Complete Streets Implementation Team
Meeting #19

Wednesday, July 7, 2021, 3:00 pm

Microsoft Teams

Agenda..................................................................................................................................... page 2
Draft minutes of June 2 CSIT meeting .................................................................................. 3
Comment log............................................................................................................................ 9
Revised drafts of Chapters 3 with changes tracked ............................................................... 34
Revised draft of Chapter 3 without changes tracked.............................................................. 90
Introduction, roll call, agenda review, consideration of minutes from June 2 meeting................................................................. 3:00

Updated Chapter 3 (structures)................................................................................................................................. 3:05

Review of comments received on Chapter 4 (adequate public facilities test requirements) and Chapter 5 (traffic studies).................................................................................................................. 3:30

Overview of schedule through October .................................................................................................................. 4:30

Next steps......................................................................................................................................................... 4:55
  • Second part of this CSIT meeting: Friday, July 9, 2021 at 1:00 pm
  • Action items from this meeting

Adjourn ...................................................................................................................................................... 5:00
Date: June 18, 2021

Date of Meeting: June 2, 2021
Meeting Location: Video conference

Work Order Number: 32189-005
Project: Howard County Complete Streets

Meeting Description: Complete Streets Implementation Team Meeting #18

Participants:

<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>Phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tom Auyeung</td>
<td>Howard County DPW, Trans. &amp; Special Projects</td>
<td>410.313.6142</td>
<td><a href="mailto:tauyeung@howardcountymd.gov">tauyeung@howardcountymd.gov</a></td>
</tr>
<tr>
<td>Jennifer Biddle</td>
<td>Howard County DPW, Traffic Engineering</td>
<td>410.313.2430</td>
<td><a href="mailto:jbiddle@howardcountymd.gov">jbiddle@howardcountymd.gov</a></td>
</tr>
<tr>
<td>David Cookson</td>
<td>Howard County Office of Transportation</td>
<td>410.313.3842</td>
<td><a href="mailto:dcookson@howardcountymd.gov">dcookson@howardcountymd.gov</a></td>
</tr>
<tr>
<td>Chris Eatough</td>
<td>Howard County Office of Transportation</td>
<td>410.313.0567</td>
<td><a href="mailto:ceatough@howardcountymd.gov">ceatough@howardcountymd.gov</a></td>
</tr>
<tr>
<td>Chad Edmondson</td>
<td>Howard County Department of Planning &amp; Zoning</td>
<td>410.313.2350</td>
<td><a href="mailto:cedmondson@howardcounty.gov">cedmondson@howardcounty.gov</a></td>
</tr>
<tr>
<td>Felix Facchine</td>
<td>County Council, on behalf of Christiana Rigby</td>
<td>410.313.3108</td>
<td><a href="mailto:ffacchine@howardcounty.gov">ffacchine@howardcounty.gov</a></td>
</tr>
<tr>
<td>Carl Gutschick</td>
<td>Gutschick, Little and Weber, P.A.</td>
<td>410.880.1820</td>
<td><a href="mailto:cgutschick@glwpa.com">cgutschick@glwpa.com</a></td>
</tr>
<tr>
<td>Kris Jagarapu</td>
<td>Howard County DPW, Highways</td>
<td>410.313.7470</td>
<td><a href="mailto:kjagarapu@howardcountymd.gov">kjagarapu@howardcountymd.gov</a></td>
</tr>
<tr>
<td>David Nitkin</td>
<td>Howard County General Hospital</td>
<td>410.740.7740</td>
<td><a href="mailto:dnitkin1@jhmi.edu">dnitkin1@jhmi.edu</a></td>
</tr>
<tr>
<td>David Ramsay</td>
<td>Howard County Public School System</td>
<td>410.313.6726</td>
<td><a href="mailto:david.ramsay@hcpss.org">david.ramsay@hcpss.org</a></td>
</tr>
<tr>
<td>Christiana Rigby</td>
<td>Howard County Council</td>
<td>410.313.3108</td>
<td><a href="mailto:crigby@howardcountymd.gov">crigby@howardcountymd.gov</a></td>
</tr>
<tr>
<td>Kristin Russell</td>
<td>Columbia Association</td>
<td>410.715.3107</td>
<td><a href="mailto:kristin.russell@columbiaassociation.org">kristin.russell@columbiaassociation.org</a></td>
</tr>
<tr>
<td>Larry Schoen</td>
<td>Multimodal Transportation Board</td>
<td>410.730.9797</td>
<td><a href="mailto:larryschoen@gmail.com">larryschoen@gmail.com</a></td>
</tr>
<tr>
<td>John Seefried</td>
<td>Howard County DPW</td>
<td>410.313.5712</td>
<td><a href="mailto:jseefried@howardcountymd.gov">jseefried@howardcountymd.gov</a></td>
</tr>
<tr>
<td>Sam Sidh</td>
<td>Howard County Office of the County Executive</td>
<td>410.313.2013</td>
<td><a href="mailto:ssidh@howardcountymd.gov">ssidh@howardcountymd.gov</a></td>
</tr>
<tr>
<td>Cory Summerson</td>
<td>Public Works Board</td>
<td></td>
<td><a href="mailto:cory.j.summerson@bge.com">cory.j.summerson@bge.com</a></td>
</tr>
<tr>
<td>Paul Walsky</td>
<td>Howard County Recreation and Parks</td>
<td>410.313.1695</td>
<td><a href="mailto:pwalsky@howardcountymd.gov">pwalsky@howardcountymd.gov</a></td>
</tr>
<tr>
<td>Jennifer White</td>
<td>Horizon Foundation</td>
<td>248.345.3030</td>
<td><a href="mailto:jwhite@thehorizonfoundation.org">jwhite@thehorizonfoundation.org</a></td>
</tr>
<tr>
<td>Jeff Riegner</td>
<td>WRA</td>
<td>302.571.9001</td>
<td><a href="mailto:jriegner@wrallp.com">jriegner@wrallp.com</a></td>
</tr>
<tr>
<td>Leah Kacanda</td>
<td>WRA</td>
<td>302.571.9001</td>
<td><a href="mailto:lkacanda@wrallp.com">lkacanda@wrallp.com</a></td>
</tr>
<tr>
<td>Mayra Filippone</td>
<td>Mahan Rykiel Associates</td>
<td>410.235.6001</td>
<td><a href="mailto:mfilippone@mahanrykiel.com">mfilippone@mahanrykiel.com</a></td>
</tr>
</tbody>
</table>
Introduction

The purpose of the meeting was to review updated Chapter 3 (structures), updated Chapter 4 (adequate public facilities test requirements), updated Chapter 5 (traffic studies), and the revised list of remaining Design Manual edits.

Jeff Riegner welcomed all attendees and reviewed the agenda. Jeff led the group through the materials attached to these minutes.

Members of the CSIT were provided with a copy of the draft minutes from the April 7, April 9, May 5, and May 7, meetings in advance. Jennifer White made a motion to approve the minutes, and Christiana Rigby seconded the motion. The CSIT approved the minutes unanimously.

Jeff noted that the distributed versions of Chapter 3, 4, and 5 did not include track changes. He noted that the track-changes version of each chapter will be distributed to the CSIT following the meeting to aid in their review of the documents.

Updated Chapter 3 (structures)

Jeff reviewed the substantive changes made to Chapter 3, Design of Bridges, Retaining Walls, and Small Structures. The only new section is 3.7 Shared Use Path Underpasses. The organization of the remainder of the chapter is the same. Changes are specified in the attached meeting materials. Questions and comments from members of the CSIT on proposed changes are included in these minutes.

Chris Eatough noted that there is no mention of bridge height in Section 3.2 I, Clearances. Jeff clarified that section only applies to bridges over roadways, and the vertical clearance for the road beneath the bridge will govern the bridge height. The section on shared use path underpasses will require a 10-foot minimum vertical clearance.

Christiana asked where the height minimum is mentioned, noting that all bridges should allow for transit. Jeff responded that bridge height is addressed in subsection I.3 Vertical Clearance. Kris observed that the section on clearances is split into a horizontal and vertical section which sufficiently covers the issues raised by the group.

In Subsection 3.2 J, the AASHTO Bike Guide is added as reference for railings and fences. Jennifer asked how updates to AASHTO would be handled, and whether the Design Manual will need to be updated each time changes occur. Jeff noted that the revised version of the AASHTO Bike Guide that was supposed to be published in 2017 has still not been released. It would be appropriate to note that the current edition will apply in the references section. Jennifer responded that “current edition” language should be included for all referenced guidance.

John Seefried noted that the Department of Public Works (DPW) is not familiar with every reference included in the Design Manual revisions. Sometimes, DPW likes the flexibility to decide when a new manual is adopted because the changes can be contentious, and it is helpful to allow time to see how the new guidance works out in other jurisdictions. Instead of using the current edition for all guidance, it should be looked at comprehensively. Jeff asked if the current edition could be referenced for all AASHTO references in this chapter. John agreed.

Jeff provided an update on bridge widths which are part of section 3.2 I, which requires shoulders be incorporated to accommodate bicyclists and pedestrians even in areas where there are no planned bicycle or pedestrian facilities. Larry asked what happens if the rehabilitation does not allow for widening. Jeff replied the way it is written, a rehabilitation would be required that consists of a full superstructure replacement. Jeff asked for feedback from DPW, suggesting adding the language “to the extent practical given the extent of the project.” Kris replied that it is important to define what a rehabilitation is, for example, if DPW is just working on a bridge deck repair, it may not be feasible to modify the structure. Larry referenced the Old Columbia Road bridge adjacent to SR 29 which is a one-lane bridge. He noted a structural issue would take years to address, but the current configuration could be improved for bicyclists if the bridge had two bike lanes and one vehicular lane, requiring cars to yield. Jeff suggested including the language “to the extent practical. If the scope of the project does not allow for the full width of those facilities,
consideration should be given to retrofits to accommodate pedestrians and bicyclists.” Larry responded that he would review the section after the meeting to provide additional feedback.

The rehabilitation section also includes language about maintaining a bridge deck surface smooth and free of irregularities. Larry noted that there are often missing covers on bridge joints, and it would be helpful to be more qualitative about what constitutes smooth. Jeff responded that it depends on what is practical in terms of construction tolerances and maintenance. It is important to not create an unfunded mandate. Larry asked about standard practice when resurfacing, such as adding collars to utility access points to maintain a level surface during repaving projects. Kris replied that typically new collars are added and adjusted. Since the plow also catches those locations the County would know about any major irregularities. John noted that DPW only inspects developer projects and occasional work by utility companies. Although a trip hazard standard has been discussed, nothing has been published. John offered to follow up on the trip hazard provision, and Jeff noted that although ADA addresses sidewalks, it does not address surface irregularities for bicyclists.

Carl asked about the ADA clause, and whether it includes a generalized exception for facilities that follow the road grade. He observed there are not a lot of bridges that will be built at a grade higher than five percent. Jeff replied that an exception is not necessary since the ADA accessibility guidelines state that sidewalks may follow the existing road grade, including roads passing over a bridge.

Larry asked for clarification on why there are landing areas along the shared use path bridge on Little Patuxent Parkway. Chris replied that he was not sure whether that was required for ADA. Jeff replied that typically, a running slope of five percent maximum is acceptable before triggering a ramp requirement, which has a 1:12 or 8.33% grade and requires landings. Chris noted that Toole Design Group designed the pathway and they may have input on why landings were provided. Kris noted that the length of the slope was an issue. Larry commented that the landings are less than ideal for cyclists. Kris replied that the landings provide a place where wheelchair users can slow their speed.

**Updated Chapter 4 (adequate public facilities test requirements)**

Jeff noted that there are only minor changes to Chapter 4, as noted in the track changes version of the document. Last year it was determined that this chapter will remain intact except for a few housekeeping measures since changes will also impact the Adequate Public Facility Ordinance (APFO) portion of the County Code.

Jeff commented that the biggest potential change has to do with background growth rate. There are three types of traffic growth that need to be considered: growth based on the development in question, growth based on other committed development in the vicinity, and background growth associated with growth beyond the study area. Over time there has generally been an increase in vehicular traffic. The current language incorporates background traffic growth of three percent per year, and an increased rate of six percent per year after the third year of the study, which is an extraordinarily high percentage. Jeff shared that based on preliminary analysis, something closer to 1.5 percent or two percent is likely, but the analysis is not yet complete. Although this seems like a traffic issue, it is very relevant to walking and bicycling since when additional lanes are added to accommodate estimated motor vehicle traffic, there is less room available for people walking and bicycling. More information will be provided at the next meeting.

Jeff noted that there is currently a Pedestrian and Bicycle Level of Service test (PLOS and BLOS) required for Downtown Columbia. There is nothing wrong with PLOS and BLOS tests, but Design Manual revisions specify Level of Traffic Stress (LTS) as the appropriate methodology for the design of bicycle facilities in Howard County. LTS has a bias toward separate bicycle facilities, which are not explicitly noted in BLOS. Jeff asked the CSIT if there was concern that the two methods are different, clarifying that both methods provide for better bicycle facilities.

Larry acknowledged that limited updates are being done to Chapter 4 because it is related to the APFO. He asked whether it is possible to state that APFO creates certain minimum requirements, but that other sections of the Design Manual and the Complete Streets policy go beyond those minimum requirements.
Jeff responded that the question is whether there is a difference between what can legally be required of developers based on the Code, and what could be provided in excess those requirements by a willing participant based on the Design Manual. There is nothing that prevents a developer from doing more, but Chapter 4 sets forth the minimum requirement. Larry replied that during the development of the Complete Streets policy, there was some discussion about whether the policy should be an ordinance with more mandatory language, but there was an acknowledgement that it was important to get into the details of the Design Manual. He expressed concern that the older system will be maintained since the Complete Streets policy does not have any teeth. For example, the Complete Streets policy says if existing facilities are being degraded or not provided something must be done.

Chris noted that the County was initially reluctant to make changes to Chapter 4 because APFO was recently updated by a committee. The few housekeeping items that Jeff has raised are transportation related and were not addressed the last time APFO was updated. Some changes in the measures used for analysis, like the use of LTS instead of BLOS, have occurred since those updates were made. He noted that, in his opinion, transportation related changes to APFO could happen, and that this group is comprised of transportation experts qualified to make recommendations. The previous APFO committee was not focused on transportation elements and did not make substantive changes to transportation aspects of APFO.

Larry asked whether this chapter should speak to LTS. Jeff replied that the street types were developed based on LTS. The text shown on BLOS is what is currently in Chapter 4. The question is which test are developers in Downtown Columbia required to use to determine the bicycle facilities that are provided for their development.

Carl shared that he has done a lot of work in Downtown Columbia, and generally, the design of transportation facilities has been much more progressive then elsewhere in the County. There was a lot of legislation implemented that only applies to the 350 acres of Downtown Columbia. If changes to those regulations are going to be made, it is important to involve those engaged in Downtown development, since substantial investments in planning have already been made that reflect the Downtown standards. Carl noted that he does not think it would be appropriate to apply standards for the rest of the County to Downtown, since it has been viewed as a separate entity subject to more rigorous standards. Jeff noted that if these standards have resulted in the facilities that have been developed recently, the Downtown requirements are working well, but if they are due to the largess of downtown developers, there may be more standards required. What is being built appears to be high quality infrastructure. Carl replied that transportation facilities in Downtown are the results of past planning efforts and current Downtown standards. Developers agreed to the standards as part of the negotiated package for Downtown revitalization, which included a lot of give and take. Making changes to those standards is much more complicated than just applying the new regulations to Downtown.

Jennifer noted that it is important to maintain the same high standard of bicycle and pedestrian facilities in Downtown Columbia as elsewhere in the County. Christiana commented that the Law Office should be included in any conversations about changes to the Downtown Columbia regulations.

Jeff suggested that BLOS and PLOS studies may provide a high enough design standard. He noted that the current tests are working well, and because of the level of complexity and number of stakeholders it may be best to leave this section untouched. It will not shortchange walking and bicycling in the Downtown Columbia area. Carl agreed and clarified that Downtown Columbia does not include the broader Columbia area. It is an area with an extremely high design standard that exceeds what is in place for the rest of the County and the rest of Columbia. If it has already been determined that an area needs to be handled differently, the County should be cautious about applying a countywide regulation.

Larry observed that there are places Downtown where the transportation network works very well, especially for pedestrians. It is difficult to judge the Merriweather District because occupancy is lower due to the pandemic, but there are gaps in the bike network. He cited a 2021 Transportation Research Board paper that acknowledges that BLOS does not account for traffic exposure and delay. There are issues at intersections for both bicyclists and pedestrians. Everyone agrees that stakeholders need to be involved, and the Complete Streets policy should apply to Downtown Columbia.
Chris noted that many good walking and bicycling facilities are not the result of BLOS or PLOS but because there was a specific requirement in a plan to connect points A and B with a shared use pathway. Outside of new facilities that were required by a plan, there are a lot of gaps and there is room for improvement. Jeff noted that there will be opportunity to further review and discussion of this section.

**Updated Chapter 5 (traffic studies)**

Jeff only reviewed the key items for Chapter 5, traffic studies. He noted that there are more significant changes in this chapter than Chapters 3 and 4. One big change in organization is separating pedestrian and bicycle studies. This chapter includes six different types of studies: traffic level of service (LOS) studies, safety evaluations, pedestrian crossing studies, bicycle LTS, parking and access studies, and noise studies.

Jeff provided information about pedestrian studies and midblock crossings. Christiana noted that from a land use perspective, the County has a growing push to reinvest in incremental development. For example, instead of redeveloping large swaths of land, slowly convert single family homes to duplexes and eventually to fourplexes. She asked how to account for that incremental development when planning for multimodal facilities. Jeff responded that many communities reference future land use in their general plan or comprehensive plan. Facilities should accommodate future land use not current land use. Christiana asked how the Design Manual would support that approach, and how facilities designed now can adapt for the future. Jeff replied that where land use is noted in Chapter 1, future land use should also be referenced. The Design Manual has to guide requirements for developers and County capital projects.

Larry noted that there are analogous issues in the western part of the County, where a development of ten homes may not have a significant impact now, but if there are a series of ten unit developments, a road that used to be walkable or bikeable may no longer be so. He agreed that it is important that the Design Manual address incremental development.

Jeff replied that if the County wants to undertake a future update to APFO, there is a policy called fair share contributions or Transportation Investment Districts (TIDs) where a transportation plan is used to identify future facilities with build-out scenarios. Each trip is required to pay their fair share into those improvements, then the County builds the improvements via the capital project process. Larry asked about concurrency. Jeff replied that the County addresses that now. Redeveloping a single family home would not trigger contributions.

Larry asked about mode share, and whether there should be a requirement in Downtown Columbia for trip reduction. There are ways that developers can enable short motor vehicle trip replacement. He asked how that could be addressed in the traffic studies section. Jeff replied that there are not specific trip reduction requirements. The traffic studies section addresses how studies are done and makes sure that those studies properly address multimodal travel. Larry speculated that a developer who invests in multimodal facilities that enable people to get to local schools or shopping destinations may not need to invest money in expanding vehicular capacity. Chris replied that kind of analysis is done by the APFO process, but he was not sure of the kinds of credits or reductions a developer can request. Jeff replied that APFO guidance around trip generation is very general and based on formulas and guidance from the Institute of Transportation Engineers (ITE), which is commonly used. Adjustments need to be made where there are good walking and bicycling facilities. Proximity to transit also tends to result in a deduction in motor vehicle trip generation. Although there has been research, nothing has been synthesized into practice.

Jeff introduced the safety evaluations section. Larry noted that the focus is on crash history, and although there is language that addresses midblock crossings, some issues of safety for bicyclists and pedestrians are not quantifiable. Jeff replied that those issues are addressed by the LTS section. There are similar criteria for intersection approaches, unsignalized crossings, and roundabouts. If the goal is LTS 2 in most areas and LTS 1 for certain destinations, this guidance can be used to evaluate what the comfort level is for bicyclists. LTS makes these issues quantifiable.

**List of New Content**
Jeff noted that the list of new content for the Design Manual was updated based on comments from the CSIT. New items are shown highlighted in yellow. Jeff walked through additions to the list. Chris noted that pedestrian crossings at unsignalized locations were added. He said that unsignalized crossings could be midblock or at intersections, which are different circumstances that require distinct guidance.

Jeff provided information on leading bicycle and pedestrian intervals. Bicycle signals could be used, or bicyclists could be allowed to use pedestrian signals to get a head start. He asked whether there are intersections that are set to recall instead of using pedestrian push buttons. Chris noted that national guidance would be helpful to determine when signals should be set to recall. Jeff replied he was only aware of location specific guidance. Determining whether a signal should be set to recall requires examining the volume of pedestrians at the intersection and the motor vehicle level of service. The decision tends to be a judgement call since guidance is not specific in terms of numbers. The goal is that both methods are included in the Design Manual so they are available to the designer. Jeff added that a note could be provided stating that “no turn on red” can be beneficial in locations where there are conflicts between vehicular traffic and bicycles and pedestrians. There is MUTCD guidance for those locations.

Jeff noted that a comment was received about using street design demonstration projects to pilot changes. He asked whether that concept should be housed in the Design Manual. Larry replied that some demonstration projects are more incremental pilot changes as opposed to temporary pop-ups. This type of pilot seems like it should go into the Design Manual, even if it just a cross reference to an external document or a sentence opening the door. Jeff replied that agencies should not be afraid to experiment, especially if changes are small and inexpensive. Jennifer mentioned tactical urbanism, which is a quick and affordable way to pilot changes. Chris agreed that this could require a lot of guidance that may need to be a standalone document. Larry asked if Chris was comfortable with a brief mention of pilot projects in the Design Manual and Chris agreed.

Larry asked if there were any significant suggestions from CSIT members that were not included in the list. Chris replied that bike dots were not included since they are not MUTCD approved and there is not much guidance available. Chris explained that bike dots are wayfinding pavement markings that guide where a bike should be positioned in the right of way and direction of travel.

Chris noted that OoT is working on a countywide bicycle wayfinding system using signs which are compliant with the MUTCD. The Design Manual should include things that are included in national guidance.

**Next Steps**

Jeff provided the CSIT with an update on the other sections of the Design Manual. The team is incorporating edits into Chapter 1 and Chapter 2 is under development. There is no new content to review on Friday. He asked whether CSIT members would prefer an informal meeting on Friday or to use that time to review the draft of Chapters 3, 4, and 5. Larry replied that he would prefer to use that time to review the draft documents. Chris agreed.

Jeff asked that comments be provided with a week. Jennifer asked whether the review period could be extended to Friday, June 11. The team agreed with the proposed timeline. Chris asked that a notice be sent out regarding the change of plans for the Friday meeting, as well as a homework reminder.

Action items from this meeting include:

- Review Chapters 3, 4, and 5 of the Design Manual by Friday, June 11

The next CSIT meeting is scheduled for Wednesday, July 7 at 1:00 pm.

Leah Kacanda, AICP
<table>
<thead>
<tr>
<th>#</th>
<th>Chapter</th>
<th>Section</th>
<th>Date</th>
<th>Comment by</th>
<th>Comment</th>
<th>Status</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 (Introduction)</td>
<td>-</td>
<td>11/12/2020</td>
<td>White</td>
<td>Thank you for sharing this. Because we are in the early stages of the design manual review it is a perfect time for CSIT to discuss the review process. Is it possible for us to add this to the agenda for December, if time allows? I highly encourage us to start off creating a master comment sheet early in this process. The design manual is a critical document and providing an opportunity for CSIT to provide input on how to standardize the review may be helpful. Plus, this may assist stakeholders in sharing their feedback. For us, having the process flushed out concretely will be helpful as we prepare feedback.</td>
<td>Resolved</td>
<td>Process and schedule presented at December 2020 CSIT meeting</td>
</tr>
<tr>
<td>2</td>
<td>1 (Introduction)</td>
<td>-</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>Change &quot;will&quot; to &quot;shall&quot; throughout</td>
<td>Resolved</td>
<td>Changed &quot;will&quot; to &quot;shall&quot; in all cases except where (1) the distinction is not important or (2) &quot;will&quot; is consistent with other approved documents</td>
</tr>
<tr>
<td>3</td>
<td>1 (Introduction)</td>
<td>1.1</td>
<td>11/10/2020</td>
<td>Russell</td>
<td>The map graphic in the introduction section 1.1 (pg. 4) is too small to read.</td>
<td>Resolved</td>
<td>The graphic has been rotated and enlarged, and a caption has been added to clarify that this is simply an illustration rather than the map that will be used to identify specific project locations</td>
</tr>
<tr>
<td>4</td>
<td>1 (Introduction)</td>
<td>1.1 A</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>I've seen other manuals include NACTO. I've also seen others give a complete list. Should we?</td>
<td>Parked</td>
<td>To consider as the CSIT works through subsequent chapters</td>
</tr>
<tr>
<td>5</td>
<td>1 (Introduction)</td>
<td>1.1 A</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>3rd paragraph, last sentence: What about places where they contradict, or where one is stricter than another. In accordance with CS policy, priority should always be given to vulnerable users.</td>
<td>Resolved</td>
<td>Text has been modified</td>
</tr>
<tr>
<td>6</td>
<td>1 (Introduction)</td>
<td>1.1 A</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>4th paragraph, &quot;intended to guide&quot;: Are minimum requirements for.... Also, add a sentence, perhaps in the next paragraph with the &quot;restrict&quot; concept, that designers are encouraged to go beyond the minimum requirements to reflect current best practices that achieve safe, efficient, etc. (see first paragraph).</td>
<td>Resolved</td>
<td>In some cases the Manual is a standard, and in others it is guidance, so changing this text to &quot;minimum requirements&quot; is not necessarily accurate. The recommended sentence has been provided in the following paragraph.</td>
</tr>
<tr>
<td>7</td>
<td>1 (Introduction)</td>
<td>1.1 A</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>&quot;Howard County Complete Streets Design Manual&quot; should be the title of the document.</td>
<td>Resolved</td>
<td>The title has been modified</td>
</tr>
<tr>
<td>8</td>
<td>1 (Introduction)</td>
<td>1.1 A</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>5th paragraph: What does &quot;economical&quot; mean? I wouldn't want this to mean cutting scope.</td>
<td>Resolved</td>
<td>Removed the word economical; it now reads &quot;innovative and practical designs&quot;</td>
</tr>
<tr>
<td>9</td>
<td>1 (Introduction)</td>
<td>1.1 C</td>
<td>11/4/2020</td>
<td>CSIT</td>
<td>Consolidate benefits, potentially combining with 1.1 D</td>
<td>Resolved</td>
<td>Benefit text has been compressed and moved to the policy section</td>
</tr>
<tr>
<td>10</td>
<td>1 (Introduction)</td>
<td>1.1 E</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>Last paragraph: Does the VPI system apply to developers? If so, clarify how and where applicability will be described.</td>
<td>Resolved</td>
<td>The VPI system does not apply to developers.</td>
</tr>
<tr>
<td>11</td>
<td>1 (Introduction)</td>
<td>1.1 F</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>&quot;enacted November 24, 1975&quot;: Weren't there later revisions? If so, at least mention. Won't this version be adopted by the Council? If so, leave a placeholder here.</td>
<td>In process</td>
<td>DPW will verify dates of DM updates and appropriate legal language to use here.</td>
</tr>
<tr>
<td>12</td>
<td>1 (Introduction)</td>
<td>1.2</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>&quot;Transportation projects&quot; should be &quot;All projects that impact transportation shall be developed in accordance with the Complete Streets Policy and developed in accordance with processes outlined therein. Such projects...&quot;</td>
<td>Parked</td>
<td>Text will be added to the Design Manual that notes that coordination occurs internally without going into specifics.</td>
</tr>
<tr>
<td>13</td>
<td>1 (Introduction)</td>
<td>1.2 -</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>&quot;are divided into&quot; should be &quot;consist of&quot;</td>
<td>Resolved</td>
<td>Changed text.</td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment by</td>
<td>Comment</td>
<td>Status</td>
<td>Resolution</td>
</tr>
<tr>
<td>----</td>
<td>---------</td>
<td>---------</td>
<td>------------</td>
<td>------------</td>
<td>-------------------------------------------------------------------------</td>
<td>------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>14</td>
<td>1 (Introduction)</td>
<td>1.2 -</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>&quot;privately funded&quot; should be “funded by the developer, which is often a private entity” LS: Wanting to include federal, state and local govt. projects.</td>
<td>Resolved</td>
<td>Changed text.</td>
</tr>
<tr>
<td>15</td>
<td>1 (Introduction)</td>
<td>1.2 C</td>
<td>11/10/2020</td>
<td>Russell</td>
<td>If there is ever a time when a capital project needs to be pursued outside of the capital budget project, does it also undergo the scoring process? If so does that set off a new priority ranking of previously ranked projects? Some capital projects are budgeted across multiple years. Do they need to be scored again against new projects every budget cycle? If so is it possible for a low scoring project to be continuously bumped as a result?</td>
<td>Resolved</td>
<td>Capital projects are never pursued outside of the capital budget process except in case of emergency. Proposed projects will always go through the TIPS scoring process. Once a high-scoring proposed improvement is included in the budget as a capital project, it generally stays in the budget through design and construction and is not re-scored. Emergency projects do not go through the capital projects but they are also exempt from the TIPS scoring process.</td>
</tr>
<tr>
<td>16</td>
<td>1 (Introduction)</td>
<td>1.2 C</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>&quot;Project Prioritization&quot; should be &quot;Project Prioritization for Capital Projects&quot;</td>
<td>Resolved</td>
<td>Changed text.</td>
</tr>
<tr>
<td>17</td>
<td>1 (Introduction)</td>
<td>1.2 C</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>&quot;capital transportation projects&quot; should be &quot;capital projects&quot;; all projects should be included.</td>
<td>Resolved</td>
<td>Changed text.</td>
</tr>
<tr>
<td>18</td>
<td>1 (Introduction)</td>
<td>1.2 C</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>&quot;transportation projects when funding is available to do so&quot; should be &quot;transportation goals&quot;; LS: I believe this more accurately reflects the Policy. The Policy doesn’t limit it to transportation projects, and doesn’t discuss funding limitations at all - simply gives sources of funding.</td>
<td>Resolved</td>
<td>The TIPS process will be utilized based on funding availability, and the TIPS process only applies to capital transportation projects; all text here is consistent with the TIPS process approved by the CSIT.</td>
</tr>
<tr>
<td>19</td>
<td>1 (Introduction)</td>
<td>1.2 C</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>Second paragraph, second sentence: strike &quot;transportation&quot;</td>
<td>Resolved</td>
<td>The TIPS process only applies to capital transportation projects all text here is consistent with the TIPS process approved by the CSIT.</td>
</tr>
<tr>
<td>20</td>
<td>1 (Introduction)</td>
<td>1.2 C</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>Second paragraph, third sentence: strike &quot;transportation&quot;</td>
<td>Resolved</td>
<td>The TIPS process only applies to capital transportation projects all text here is consistent with the TIPS process approved by the CSIT.</td>
</tr>
<tr>
<td>21</td>
<td>1 (Introduction)</td>
<td>1.2 E</td>
<td>11/11/2020</td>
<td>Rigby</td>
<td>Thank you! I really appreciate that the Office of Transportation and MMTB are involved in the decision-making process for exceptions to the Complete Streets policy.</td>
<td>Resolved</td>
<td>Noted.</td>
</tr>
<tr>
<td>22</td>
<td>1 (Introduction)</td>
<td>1.3 -</td>
<td>11/10/2020</td>
<td>Russell</td>
<td>Section 1.3 Street Types would be an appropriate place to include a section for street cross sections rather than in chapter two or in the Volume IV of the design manual. They should at least be presented here in concept to identify all the items that should be considered for the various street types and conceptually where they should be located. Perhaps the numerous and specific cross section types could be in the specific design sections but their introduction should be in 1.3.</td>
<td>Resolved</td>
<td>Typical sections will be included in one location (Design Manual Volume IV) and will be cross-referenced in Volume III.</td>
</tr>
<tr>
<td>23</td>
<td>1 (Introduction)</td>
<td>1.3 -</td>
<td>11/10/2020</td>
<td>Russell</td>
<td>Section 1.3 should also include a section of intersection elements and transitions to those intersection elements, at least to identify the elements that need to be considered for complete street intersections. Currently, the whole design manual has intersection design based on Level of Service but complete streets pulls in other competing elements and weights the importance of those competing elements with a renewed emphasis.</td>
<td>In process</td>
<td>Intersections will be addressed in the Street Design chapter. During the April CSIT meeting, there was a discussion about the need to address transitions between different street types as well as transitions at intersections. This issue was also discussed at the May 5 CSIT meeting.</td>
</tr>
<tr>
<td>24</td>
<td>1 (Introduction)</td>
<td>1.3 A</td>
<td>11/10/2020</td>
<td>Russell</td>
<td>Land Use Context - a reference or example should be included with a reference and description of where you can find the latest land use map so that you don’t have to revise the manual every time the land use map changes.</td>
<td>In process</td>
<td>The team is working with DPZ to advance this issue.</td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment by</td>
<td>Comment</td>
<td>Status</td>
<td>Resolution</td>
</tr>
<tr>
<td>----</td>
<td>---------</td>
<td>---------</td>
<td>------------</td>
<td>------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>25</td>
<td>1</td>
<td>1.3 A</td>
<td>11/11/2020</td>
<td>Rigby</td>
<td>Considering the push for a Code rewrite and the anticipated updates to the Code, zoning regulations, and General Plan, how will we ensure that the design manual is adaptable to future changes?</td>
<td>In process</td>
<td>The team is working with DPZ to advance this issue.</td>
</tr>
<tr>
<td>26</td>
<td>1</td>
<td>1.3 B</td>
<td>11/4/2020</td>
<td>CSIT</td>
<td>Split collectors into major and minor</td>
<td>Resolved</td>
<td>Revised.</td>
</tr>
<tr>
<td>27</td>
<td>1</td>
<td>1.3 B</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>Add to first paragraph: &quot;The classifications are historically based on a hierarchy from the Federal Highway Administration and are primarily focused on motor vehicle throughput. Requirements that facilitate multi-modal access on each type of street are covered in later chapters of this Manual.&quot;</td>
<td>In process</td>
<td>The team is developing language to clarify that functional classification is about mobility and access for all road users.</td>
</tr>
<tr>
<td>28</td>
<td>1</td>
<td>1.3 C</td>
<td>11/10/2020</td>
<td>Schoen</td>
<td>Add to first paragraph: &quot;The classifications are historically based on a hierarchy from the Federal Highway Administration and are primarily focused on motor vehicle throughput. Requirements that facilitate multi-modal access on each type of street are covered in later chapters of this Manual.&quot;</td>
<td>In process</td>
<td>This was resolved through development of the new street typology.</td>
</tr>
<tr>
<td>29</td>
<td>1</td>
<td>1.3 D</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>Please address requirements for land developments when there is an opportunity for projects to create a connection NOT shown on the current Bike Howard plan. This was discussed in the 11/4/20 meeting.</td>
<td>In process</td>
<td>Being addressed through &quot;network considerations&quot; section.</td>
</tr>
<tr>
<td>30</td>
<td>1</td>
<td>1.3 E</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>&quot;low traffic volumes&quot; should be &quot;low motor vehicle traffic volumes and often have no facilities for pedestrians or bicycles&quot;</td>
<td>In process</td>
<td>This quote is from Section 16.1404, which speaks to alterations to scenic road rights-of-way. As stated by Councilwoman Rigby, Section 16.125(c)(4) allow for multi-use pathways (not exceeding 15 feet of disturbance) within a vegetated buffer. Revisit the cross references in this section after the section is fully developed and proposed typologies are applied to areas with a scenic overlay.</td>
</tr>
<tr>
<td>31</td>
<td>1</td>
<td>1.3 E</td>
<td>11/12/2020</td>
<td>Schoen</td>
<td>Point 1: Here is what it says: Protecting scenic character. Scenic roads may be altered to make necessary safety, access, drainage, or road capacity improvements, including improvements to meet the requirements of the adequate public facilities act (title 16, subtitle 11) or to install pull-offs or utility, water or sewage systems. Projects which alter the appearance of a scenic road, including maintenance, capital projects and improvements required through the subdivision or development process, shall be designed to protect to the maximum extent possible the features of the road right-of-way that contribute to the scenic character of the road.</td>
<td>In process</td>
<td>Current draft mentions Section 16.1403 which gives Council the power to designate scenic roads. Section 16.125(c)(4) references the design standards and &quot;protection of scenic roads.&quot; Revisit the cross references in this section after the section is fully developed and proposed typologies are applied to areas with a scenic overlay.</td>
</tr>
<tr>
<td>32</td>
<td>1</td>
<td>1.3 E</td>
<td>11/11/2020</td>
<td>Rigby</td>
<td>Would it be helpful to also reference Section 16.125 of the County Code, which pertains to protection of scenic roads? Section 16.125(c)(4) permits limited use of multi-purpose pathways within scenic roads buffers, which may be relevant to any complete streets improvements along scenic roads.</td>
<td>In process</td>
<td>This quote is from Section 16.1404, which speaks to alterations to scenic road rights-of-way. As stated by Councilwoman Rigby, Section 16.125(c)(4) allow for multi-use pathways (not exceeding 15 feet of disturbance) within a vegetated buffer. Revisit the cross references in this section after the section is fully developed and proposed typologies are applied to areas with a scenic overlay.</td>
</tr>
<tr>
<td>33</td>
<td>1</td>
<td>1.4 B</td>
<td>11/10/2020</td>
<td>Russell</td>
<td>4th bullet wording is confusing. That &quot;were studied?&quot; That &quot;are to be studied?&quot; Does not make sense.</td>
<td>Resolved</td>
<td>Changed to &quot;that were studied.&quot;</td>
</tr>
<tr>
<td>34</td>
<td>1</td>
<td>1.1 C-D</td>
<td>12/21/2020</td>
<td>White</td>
<td>Benefits of Complete Streets &amp; Complete Streets Policy. This section should quote Howard County's Complete Streets Policy. It references the resolution, number and then a short list of benefits. While we understand the intent may be to incorporate the policy into individual chapters, it would be helpful to include it here at the beginning of the Guide, such as Section 1: Vision, and Section 2: Scope. This would be a helpful foundation to have at the beginning of the Design Manual.</td>
<td>In process</td>
<td>Will be addressed as part of Introduction chapter.</td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment</td>
<td>Comment</td>
<td>Status</td>
<td>Resolution</td>
</tr>
<tr>
<td>----</td>
<td>---------</td>
<td>---------</td>
<td>------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>------------</td>
</tr>
<tr>
<td>35</td>
<td>1 (Introduction)</td>
<td>1.2 D</td>
<td>12/21/2020</td>
<td>White</td>
<td>Community Engagement Plan</td>
<td>In process</td>
<td>Will be addressed as part of Introduction chapter.</td>
</tr>
<tr>
<td>36</td>
<td>1 (Introduction)</td>
<td>1.3 B</td>
<td>12/21/2020</td>
<td>White</td>
<td>Transportation Classification</td>
<td>Resolved</td>
<td>New street types have been developed.</td>
</tr>
<tr>
<td>37</td>
<td>1 (Introduction)</td>
<td>1.4 B</td>
<td>12/21/2020</td>
<td>White</td>
<td>Content of Report</td>
<td>In process</td>
<td>Will be addressed as part of Introduction chapter.</td>
</tr>
<tr>
<td>38</td>
<td>Street Types</td>
<td>General</td>
<td>2/8/2021</td>
<td>White</td>
<td>The cross sections should match the street types. It is difficult to review since we have yet to settle on street types. While we are considering a hybrid of functional and descriptive, grouping Commercial, Industrial and Lower Density Residential are different types of land uses and should not be in one category.</td>
<td>Resolved</td>
<td>Updated for March CSIT meeting. Proposed street types are now descriptive and better tied to land use.</td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment by</td>
<td>Comment</td>
<td>Status</td>
<td>Resolution</td>
</tr>
<tr>
<td>---</td>
<td>---------</td>
<td>---------</td>
<td>------------</td>
<td>------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>39</td>
<td>Street Types</td>
<td>Intermediate Arterial</td>
<td>2/8/2021</td>
<td>White</td>
<td>For any wider road like the Intermediate Arterial, people riding bicycles need separation from high speed traffic. These are four lane roads and traffic will undoubtedly be higher. One option should show separated bike lanes. The other option should show shared use paths and no bike lanes (shared use paths + bike lanes is too much). The decision between these two options is mainly based on frequency of pedestrian use. For example, in a residential area where pedestrian use is more frequent, separation is needed between pedestrians and bicyclists. The separated bike lane can either be two-way on one side, or one way on each side depending on site conditions and other constraints.</td>
<td>Resolved</td>
<td>Typical sections have been revised to show shared use paths in suburban areas (with lower pedestrian volumes) and separated bike lanes in mixed use areas (where higher pedestrian volumes can be expected).</td>
</tr>
<tr>
<td>40</td>
<td>Street Types</td>
<td>Mixed Use (Intermediate Arterial, Minor Arterial, Collector), Higher-Density Residential (Intermediate Arterial, Minor Arterial, Collector)</td>
<td>2/8/2021</td>
<td>White</td>
<td>The cross sections for these categories show bike lanes directly adjacent to travel lanes. This design should not be an option, as it will require bicyclists to operate adjacent to fast traffic. These bike lanes are not likely to be used because they will be uncomfortable for anyone other than experienced bicyclists. For that reason, this design is no longer recommended in the AASHTO Bike Guide. Both cross section options in each category should include separated bike lanes. One should be a two-way separated bike lane on one side of the street, and the other should be separated bike lanes on both sides of the street.</td>
<td>Resolved</td>
<td>The current AASHTO Bike Guide, FHWA Bikeway Selection Guide, and LTS guidance all incorporate bike lanes adjacent to travel lanes where speeds are lower. Street types where higher speeds are expected have been revised to include shared use paths or separated bike lanes.</td>
</tr>
<tr>
<td>41</td>
<td>Street Types</td>
<td>Mixed Use (Local Street), Higher-Density Residential (Local Street)</td>
<td>2/8/2021</td>
<td>White</td>
<td>Unless these streets are designed for an operating speed of 20 mph or less, a separated bike lane will be needed. If an option without a bicycle facility is provided, it should be made clear that geometric design measures must be taken to ensure operating speeds are low.</td>
<td>Resolved</td>
<td>The FHWA Bikeway Selection Guide and LTS guidance permit conventional or buffered (not separated) bike lanes at speeds higher than 20 mph.</td>
</tr>
<tr>
<td>42</td>
<td>Street Types</td>
<td>General</td>
<td>2/11/2021</td>
<td>Russell</td>
<td>I don’t see a typical section for when you have a shared use pathway on only one side of the road in the different land use contexts. I would imagine such a configuration could require a wider pathway than a section that shares volume on both sides of the roadway.</td>
<td>Resolved</td>
<td>The current sections are designed for new construction. In retrofit situations, provisions will be made in the Design Manual for a single shared use path where land use or constraints dictate.</td>
</tr>
<tr>
<td>43</td>
<td>Street Types</td>
<td>General</td>
<td>2/11/2021</td>
<td>Russell</td>
<td>Also related to the potential need for wider sidewalk scenarios: the inclusion of street furniture (post office boxes, benches, bike parking, cafe/outdoor seating), areas where you want a double row of trees/promenade, etc.</td>
<td>Resolved</td>
<td>Mixed use street types provide very wide space between the building face and the curb to allow for a variety of uses. At the April CSIT meeting, a suggestion was made to show things like street furniture in graphical representations of this street type.</td>
</tr>
<tr>
<td>44</td>
<td>Street Types</td>
<td>General</td>
<td>2/11/2021</td>
<td>Russell</td>
<td>No typical sections that put bikes/peds/or transit in a wide median or central promenade (either as a wide park-like boulevard or retrofit of wider median) That is a fairly typical design for providing open space in urbanizing mixed use areas, especially given that HoCO has really wide existing roads.</td>
<td>Resolved</td>
<td>This is a good topic for discussion. The principal concern with shared use paths in medians is the fact that drivers don’t expect people walking or bicycling in the median at intersections. This may be incorporated as an option for retrofits.</td>
</tr>
<tr>
<td>45</td>
<td>Street Types</td>
<td>General</td>
<td>2/11/2021</td>
<td>Russell</td>
<td>I'm not sure if the typical sections is the appropriate place to put this but I think the design manual needs to address implementation/construction that on construction plans a note needs to be added to the effect that: stripping of lanes shall begin with the bike lane and bike lane buffer to ensure striped widths match the plan then move towards vehicular traffic lanes. Reason being that I find contractors often start with the inside vehicular lanes and every lane they are ever so slightly off the mark and those inches add up to squeeze the bike lane from the designed width to instead be too skinny. Any room for error or variance should not come at the expense of the bike facilities.</td>
<td>Parked</td>
<td></td>
</tr>
</tbody>
</table>

Page 5 of 25
<table>
<thead>
<tr>
<th>#</th>
<th>Chapter</th>
<th>Section</th>
<th>Date</th>
<th>Comment by</th>
<th>Comment</th>
<th>Status</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>46</td>
<td>Street Types</td>
<td>General</td>
<td>2/11/2021</td>
<td>Russell</td>
<td>The utility zone is variable in these sections. The consultant should study exactly what is permitted and expected in the utility zone, the clearances needed between utilities and see what width utility zone is necessary. Also, is it OK to plant trees and light pole and foundations in the same zone over the utilities? Has consideration been made to allow the “utility zone” under the Shared use Path in addition to the Tree zone?</td>
<td>Resolved</td>
<td>Howard County standards have essentially no utilities within the buffer between the sidewalk (or shared use path) and the curb. Sufficient room should be provided to allow for maintenance of utilities under curbs and sidewalks.</td>
</tr>
<tr>
<td>47</td>
<td>Street Types</td>
<td>General</td>
<td>2/11/2021</td>
<td>Russell</td>
<td>Intersections are critical for bikeways. The cross sections are good for the linear part of the road but transitioning to the intersections where turning movements are introduced, multiple turning lanes, free right turns, additional capacity lanes, possible lane width changes and the like need to be considered. Perhaps typical sections at intersections and how the standard cross section transitions to the intersection cross section should be considered</td>
<td>Parked</td>
<td>This relates to comment 23 and will be addressed in the Street Design chapter.</td>
</tr>
<tr>
<td>48</td>
<td>Street Types</td>
<td>General</td>
<td>2/11/2021</td>
<td>Russell</td>
<td>There are no dimensions on any of the cross sections. - Please ensure that “tree/utility zone” is a min 6’ width. - Median/turn lanes should show width so that we can plan for the total ROW required. - Total minimum ROW width for typical sections should be shown in cross section. Are sidewalks considered in the public ROW or private? Building setbacks are measured from ROW line so important to know ROW width to plan for setbacks.</td>
<td>Resolved</td>
<td>Dimensions have been added. Tree zones are at least 6 feet wide. Sidewalks are in the public right of way.</td>
</tr>
<tr>
<td>49</td>
<td>Street Types</td>
<td>General</td>
<td>2/11/2021</td>
<td>Russell</td>
<td>Are there any considerations for SWM in the roadways? If yes, they should be incorporated in the sections</td>
<td>In process</td>
<td>For new construction, SWM is assumed to be outside the right of way or in microscale facilities in the tree zone or curb extensions (where provided). SWM will be mentioned in Volume III, but SWM criteria are discussed in detail in Volume I, which will not be updated as part of this effort. This issue was discussed at the May 5 CSIT meeting.</td>
</tr>
<tr>
<td>50</td>
<td>Street Types</td>
<td>General</td>
<td>2/11/2021</td>
<td>Russell</td>
<td>It appears from some of the photo examples that buses pull into the bike lanes when they stop at a bus stop? Can this be avoided?</td>
<td>Parked</td>
<td>Bus stop design will be addressed as part of the Street Design chapter.</td>
</tr>
<tr>
<td>51</td>
<td>Street Types</td>
<td>Lower-Density Residential Area</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>35 mph will only be achieved in suburban areas with curves. Many, not all, of our lower density roads are straighter and thus have FFS greater than 35.</td>
<td>Resolved</td>
<td>Sections have been revised to provide separated bicycle facilities at higher speeds. Retrofits will be addressed in the Street Design chapter.</td>
</tr>
<tr>
<td>52</td>
<td>Street Types</td>
<td>Commercial Area</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>Again, 35 mph is not likely to be the case for much of our commercial, which I interpret as office and retail. We tend to have wider roads and higher speed traffic like LPP, roads in Gateway, Stanford Blvd, etc. The only ones 35 mph or less are in old E.C., inside the Mall, inside Gateway Overlook, inside Dobbin Center, inside Columbia Crossing, etc.</td>
<td>Resolved</td>
<td>Sections have been revised to provide separated bicycle facilities at higher speeds. Retrofits will be addressed in the Street Design chapter.</td>
</tr>
<tr>
<td>53</td>
<td>Street Types</td>
<td>Low-Density/Commercial/Industrial (Intermediate Arterial)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>Bicyclist goes on shared use path for LTS 1</td>
<td>Resolved</td>
<td>The applicable sections have been revised.</td>
</tr>
<tr>
<td>54</td>
<td>Street Types</td>
<td>Low-Density/Commercial/Industrial (Intermediate Arterial)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>For bike lanes, clarify what happens with turn lanes to avoid right hook and other crashes</td>
<td>Parked</td>
<td>Will be addressed as part of the Street Design chapter.</td>
</tr>
<tr>
<td>55</td>
<td>Street Types</td>
<td>Low-Density/Commercial/Industrial (Intermediate Arterial)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>Enhance bike lanes with physical separation, which can achieve LTS 1</td>
<td>Resolved</td>
<td>Sections have been revised to provide separated bicycle facilities at higher speeds.</td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment by</td>
<td>Comment</td>
<td>Status</td>
<td>Resolution</td>
</tr>
<tr>
<td>----</td>
<td>---------</td>
<td>---------</td>
<td>------------</td>
<td>------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>56</td>
<td>Street Types</td>
<td>Low-Density/Commercial/Industrial (Intermediate Arterial)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>Conventional bike lanes could work for many of our roads, provided that there is an alternate LTS1 that provides access, though perhaps by a more indirect route. <strong>Follow-up comment</strong>: Design manual must state the default, with exceptions granted based on network considerations. Commercial areas need to be reachable by all, which means there must be an LTS 1 method of access concurrent with the road being built or upgraded, not based on some future network facility. The meaning of industrial is changing, so access should apply to this use as well. A maker space is one example of industrial that is community and educational oriented. (We subsequently discussed using the language in the CS Policy, which would resolve my comment.) If there is coordinating language that goes in Regs and master Plans, let’s put placeholders for them now.</td>
<td>In process</td>
<td>This is a network planning consideration that is more appropriately addressed by BikeHoward than by the Design Manual. This issue was discussed at the May 5 CSIT meeting. The Street Design Chapter will cross reference BikeHoward which will include maps of priority low-stress connections.</td>
</tr>
<tr>
<td>57</td>
<td>Street Types</td>
<td>Low-Density/Commercial/Industrial (Intermediate Arterial)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>Curb is a problem for bikers when adjacent to bike lanes. Eliminate the curb, add a foot and create a separation between the biker and the cars. Clarify how the turn lanes will work and intersection treatment.</td>
<td>Resolved</td>
<td>Curbs are needed for drainage. Bike lanes of sufficient width are commonly provided adjacent to curbs.</td>
</tr>
<tr>
<td>58</td>
<td>Street Types</td>
<td>Low-Density/Commercial/Industrial (Minor Arterial)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>Repeat comments from previous slides U.O.N. It’s really hard to get the “feel” for the road and its use from just the classification w/o the context, driveway interruptions, setbacks, etc. There are many roads that straddle categories and change significantly over short distances. I think we need a whole bunch of arrows in the quiver and individual judgements may need to be made by planners, engineers, development staff, transportation specialists.</td>
<td>In process</td>
<td>Transitions between different street types will be addressed in the Street Design chapter. This issue was discussed at the May 5 CSIT meeting.</td>
</tr>
<tr>
<td>59</td>
<td>Street Types</td>
<td>Low-Density/Commercial/Industrial (Minor Collector)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>If it’s really a minor collector, with speeds at 25 mph this is ok, otherwise need physical protection or sidepath.</td>
<td>Resolved</td>
<td>Noted. Sections have been revised.</td>
</tr>
<tr>
<td>60</td>
<td>Street Types</td>
<td>Low-Density/Commercial/Industrial (Collector, Local Street)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>Can we eliminate the yellow line? Our roads don’t look like this - the yellow lines go all over the road surface as turn lanes come and go, bike lanes end, etc.</td>
<td>Resolved</td>
<td>Sections have been revised.</td>
</tr>
<tr>
<td>61</td>
<td>Street Types</td>
<td>Low-Density/Commercial (Collector)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>Will never be 30 mph until density and volume are much higher, so this doesn’t work.</td>
<td>Resolved</td>
<td>Sections have been revised to provide separated bicycle facilities at higher speeds.</td>
</tr>
<tr>
<td>62</td>
<td>Street Types</td>
<td>Mixed-use (Intermediate Arterial Option 2)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>It would be good to see the ROW width. This looks comparable to Option 1, and it’s less comfortable for bikers and cars. Maybe more comfortable for peds, since they don’t share w/bikes. I don’t see how it will ever be 25 mph, so this really doesn’t work.</td>
<td>Resolved</td>
<td>Right of way widths are now shown.</td>
</tr>
<tr>
<td>63</td>
<td>Street Types</td>
<td>Mixed-use (Minor Arterial Option 2)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>It would be good to see the ROW width. This looks comparable to Option 1, and it’s less comfortable for bikers and cars. Maybe more comfortable for peds, since they don’t share w/bikes. I don’t see how it will ever be 30 mph, so this really doesn’t work.</td>
<td>Resolved</td>
<td>Right of way widths are now shown.</td>
</tr>
<tr>
<td>64</td>
<td>Street Types</td>
<td>Mixed-Use (Collector Option 2)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>I don’t see how we would ever get 30 mph unless traffic volume is very high.</td>
<td>Resolved</td>
<td>Sections have been revised.</td>
</tr>
<tr>
<td>65</td>
<td>Street Types</td>
<td>Mixed-Use (Local Street)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>LTS 1-3 is a wide range. We need a method to guide decision making.</td>
<td>Resolved</td>
<td>Sections have been revised.</td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment by</td>
<td>Comment</td>
<td>Status</td>
<td>Resolution</td>
</tr>
<tr>
<td>----</td>
<td>---------</td>
<td>---------</td>
<td>------------</td>
<td>------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>66</td>
<td>Street Types</td>
<td>Higher-Density Residential (Intermediate Arterial)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>I don’t see how it will ever be 25 mph, so this really doesn’t work.</td>
<td>Resolved</td>
<td>Sections have been revised.</td>
</tr>
<tr>
<td>67</td>
<td>Street Types</td>
<td>Higher-Density Residential (Minor Arterial Option 2)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>It would be good to see the ROW width. This looks comparable to Option 1, and it’s less comfortable for bikers and cars. Maybe more comfortable for pets, since they don’t share w/bikes. I don’t see how it will ever be 30 mph, so this really doesn’t work.</td>
<td>Resolved</td>
<td>Right of way widths are now shown.</td>
</tr>
<tr>
<td>68</td>
<td>Street Types</td>
<td>Higher-Density Residential (Collector Option 2)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>This strikes me as similar to Great Star Drive, but w/o the parking. It is not a complete street, safe for all uses. Speeds are well over 30 mph and there is no protection at intersections. Bike lane ends completely at the most dangerous spots x-ing 32 and at each end 32 @ N and Guilford @ S. We could fix it with physical protection at dangerous spots, slowing speeds with narrower lanes, coloring the bike lane in some spots. Need to draw attention to motorists that they are sharing the road.</td>
<td>Resolved Right of way widths are now shown</td>
<td>Resolved Sections have been revised. Yellow center lines are used on streets classified collector and above. Center lines are only used local streets in select situations such as intersections when they are used to define where cars should be positioned when they turn into a community.</td>
</tr>
<tr>
<td>69</td>
<td>Street Types</td>
<td>Higher-Density Residential (Local Street)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>At what speed and volume is the yellow line needed? LTS 1 - 3 is a big difference and should be a driver for the type of bike facility needed.</td>
<td>Resolved</td>
<td>Sections have been revised. Yellow center lines are used on streets classified collector and above. Center lines are only used local streets in select situations such as intersections when they are used to define where cars should be positioned when they turn into a community.</td>
</tr>
<tr>
<td>70</td>
<td>Street Types</td>
<td>Outside PSA</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>I question whether we have anything left in the County that is rural. Roads that were previously rural now have multi-unit developments or houses dotted on 2 acre lots. Even if they don’t have continuous development, many of them have now become collectors or more. Follow-up comment: This does not resolve my comment. See also comment 75. The General plan definition may not be applicable to road design. See the prototypical rural road photo from FHWA 2013 Functional Classification. Outside the PSA is a very bold line and by itself means something related to water and sewer and does not mean a road is rural. Since we are not likely to be building new rural roads, this may apply more to our discussion of retrofit.</td>
<td>In process</td>
<td>As defined by the General Plan, many parts of the County remain rural. This issue was discussed at the May 5 CSIT meeting. The road designer will decide what street type makes sense based on the anticipated surrounding land use and transportation function. PSA will not be used to determine street type.</td>
</tr>
<tr>
<td>71</td>
<td>Street Types</td>
<td>Rural (Intermediate Arterial Option 2)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>This does not work. From the Bicycle Facility Design Course, “A shoulder is not a bikeway because it is not designated or maintained for bicycle use and may not meet the design standards for safe bicycle operation, such as minimum width. It does not provide physical separation from motor vehicle traffic, and bicyclists may have to exit the shoulder into the adjacent motor vehicle travel lane to avoid obstructions, drainage grates that are not designed to be compatible with bicycle travel, or pavement imperfections.” At these higher speeds, which are almost always going to be the case, provide a buffer. Follow-up comment: This does not resolve my comment without inclusion of additional design and maintenance information ... for when a shoulder serves as a bikeway. As with many open items, this may apply more to retrofit.</td>
<td>In process</td>
<td>The FHWA Bikeway Selection Guide on which the course is based does, in fact, suggest the use of shoulders as bikeways in rural contexts. “Shared lanes, paved shoulders, and shared use paths are appropriate bikeway types on rural roadways.” (pages 24 and 25). This issue was discussed at the May 5 CSIT meeting. Design and maintenance provisions for shoulders as a bikeway will be included in the Street Design chapter.</td>
</tr>
<tr>
<td>72</td>
<td>Street Types</td>
<td>Rural (Intermediate Arterial Option 2)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>At these higher speeds, which are almost always going to be the case, provide a buffer. Also, the protection of the bike facility is going to be very important with the TWLTL and it should be colored different from the roadway.</td>
<td>Resolved</td>
<td>Sections have been revised.</td>
</tr>
<tr>
<td>73</td>
<td>Street Types</td>
<td>Rural (Minor Arterial Option 2)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>At these higher speeds, which are almost always going to be the case, provide a buffer. Also, the protection of the bike facility is going to be very important with the TWLTL and it should be colored different from the roadway.</td>
<td>Resolved</td>
<td>Sections have been revised.</td>
</tr>
<tr>
<td>74</td>
<td>Street Types</td>
<td>Rural (Collector Option 2)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>At these higher speeds, which are almost always going to be the case, provide a buffer.</td>
<td>Resolved</td>
<td>Sections have been revised.</td>
</tr>
</tbody>
</table>
### Chapter Resolution Status

#### 75 Street Types v2

<table>
<thead>
<tr>
<th>#</th>
<th>Chapter</th>
<th>Section</th>
<th>Date</th>
<th>Comment by</th>
<th>Comment</th>
<th>Status</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>Street Types</td>
<td>Rural (Local Street)</td>
<td>2/11/2021</td>
<td>Schoen</td>
<td>I'm having trouble understanding what a rural local street is. If it has a yellow line, no bike lane and now shoulder, how could it ever be less than LTS 3 or 4? From the Bicycle Facility Design Course, &quot;...shared lanes and bicycle boulevards may be viable options on roadways with lower motor vehicle speeds and volumes, generally up to around 20 or 25 miles per hour and below around 2,000 vehicles per day. In the rural context, the only one I can think of is Manor Lane, which is a dead end. Follow-up comment: This does not resolve my comment. See also comment 70. I believe it is now called a Rural Development Street. If it is inside a development, then it's residential and no longer rural, regardless of whether it is outside the PSA. So if no parking, then the roadway width can be 20', no center line, and similar to a neighborhood yield street. I wouldn't want this to be applied to a road like Guilford Road east of Hall Shop where the road narrows to no shoulder, or even roads with lower AADT, that often have higher speeds and no shoulder. Previous comments with clarifications: Is this street type restricted to residential? Is rural local street any different from residential local street? Is it more or less permissive?</td>
<td>In process</td>
<td>A rural local street is a narrow street in a rural development. It does not have a yellow centerline and typically has low speeds and volumes. The 24-foot width is consistent with a narrow neighborhood street as discussed in detail and approved by the CSIT. This issue was discussed at the May 5 CSIT meeting. The Street Design Chapter will note that long, straight roadways without the benefit of frequent intersections are not desirable.</td>
</tr>
<tr>
<td>76</td>
<td>Street Types v2</td>
<td>Neighborhood Yield Street</td>
<td>2/28/2021</td>
<td>Edmondson</td>
<td>Shared a photo of a typical subdivision street, usually short looked or Cul de sac. Because these streets are low volume, slow speeds we require sidewalk on one side only. Peds walk down their driveway and cross the street at all points. Jurisdictions are mandated to reduce impervious area where possible. To limit clearing for additional SWM. A half mile long road with sidewalks on both sides is about a half-acre of impervious material requiring substantial area for SWM. I suggest on these low speed roads continue current design of one side walk but meeting the current wider request. This also provides space to park cars in the driveway. Otherwise cars would hang over the walk in some cases.</td>
<td>Resolved</td>
<td>Discussed at the April 9 CSIT meeting. It was determined that cul-de-sacs with 10 homes or less should have a sidewalk on one side of the street, replacing the current regulation that does not require a sidewalk on those streets.</td>
</tr>
<tr>
<td>77</td>
<td>Street Types v2</td>
<td>Neighborhood Yield Street</td>
<td>2/28/2021</td>
<td>Edmondson</td>
<td>In response to question from WRA about whether driveway aprons are designed to accommodate a future sidewalk on the other side of the street: There is no plans for future sidewalk. As stated, Howard County requires sidewalk on one side of the road. Engineers have to make driveways longer on the side of the street to accommodate cars parked within the driveway where side walk exists. Parking in your driveway is a plus in any neighborhood, makes the lots more desirable, and increases safety. Cars not parked in the road makes maintenance easier, allows roads to be fully cleared of snow and increases sight distance. Sure we can continue this conversation.</td>
<td>Resolved</td>
<td>Discussed at the April 9 CSIT meeting. The only streets that will have a sidewalk on one side is a cul-de-sac with 10 homes or less (see comment 76). That sidewalk will be accessible by driveway aprons. A ramp is also specified at the end of the sidewalk to provide an additional point of access.</td>
</tr>
<tr>
<td>78</td>
<td>Street Types v2</td>
<td>General</td>
<td>3/2/2021</td>
<td>Gutschick</td>
<td>Current sections don’t have shoulders in curbed situations and I would not be in favor of adding them now. Takes up real estate, costs more to build, and creates more runoff. Unless the shoulder is wide enough for a vehicle in distress, it doesn’t do much good anyway.</td>
<td>Resolved</td>
<td>Sections have been revised.</td>
</tr>
<tr>
<td>79</td>
<td>Street Types v2</td>
<td>General</td>
<td>3/2/2021</td>
<td>Gutschick</td>
<td>The Tree zone should be 6’ across the board. I surveyed a large number of developers and the dry utilities rarely go in the tree zone.</td>
<td>Resolved</td>
<td>Sections have been revised.</td>
</tr>
<tr>
<td>80</td>
<td>Street Types v2</td>
<td>General</td>
<td>3/2/2021</td>
<td>Gutschick</td>
<td>What are the &quot;Buffers&quot; for? Conventional cross-sections use 1’ behind the SW to set the R/W. I don’t see any reason to use more real estate.</td>
<td>Resolved</td>
<td>Sections have been revised.</td>
</tr>
<tr>
<td>81</td>
<td>Street Types v2</td>
<td>General</td>
<td>3/2/2021</td>
<td>Gutschick</td>
<td>I think we should consider SUP on one side with a 5’ SW on the other. Having SUPs on both sides seems extravagant.</td>
<td>Resolved</td>
<td>One SUP and one sidewalk are specified for Industrial Streets and Neighborhood Streets 2 where low volumes or walkers and cyclists are anticipated. Two SUPs are provided for higher classification streets in order to provide better connectivity and handle higher volumes.</td>
</tr>
<tr>
<td>82</td>
<td>Street Types v2</td>
<td>General</td>
<td>3/2/2021</td>
<td>Gutschick</td>
<td>I think the need for both a separated bike lane and a sidewalk is rare. A SUP is much more likely to serve the need, as it does along LPP.</td>
<td>Resolved</td>
<td>Discussed at March 3 CSIT meeting. The circumstance is rare, which is why it is only being proposed in Mixed-Use areas where there are likely to be higher volumes of pedestrian and cyclists.</td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment by</td>
<td>Comment</td>
<td>Status</td>
<td>Resolution</td>
</tr>
<tr>
<td>----</td>
<td>-------------------------------</td>
<td>--------------------------------</td>
<td>----------</td>
<td>------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>83</td>
<td>Street Types v2</td>
<td>General</td>
<td>3/2/2021</td>
<td>Gutschick</td>
<td>All sidewalks should be 5’. For the mixed use areas, just indicate an extension of the pedestrian zone &quot;as shown on the SDP&quot;. That's what we did for Maple Lawn in the commercial areas.</td>
<td>Resolved</td>
<td>Discussed at March 3 CSIT meeting. Sections to be revised to show narrower sidewalks.</td>
</tr>
<tr>
<td>84</td>
<td>Street Types v2</td>
<td>General</td>
<td>3/2/2021</td>
<td>Gutschick</td>
<td>Aren’t buffered bike lanes to guard against car doors opening? Should not need the extra width when there are no parked cars.</td>
<td>Resolved</td>
<td>Buffered bike lanes also increase the amount of separation between the rider and vehicular traffic, resulting in improved safety and a lower Level of Traffic Stress.</td>
</tr>
<tr>
<td>85</td>
<td>Street Types v2</td>
<td>Level of Traffic Stress</td>
<td>3/2/2021</td>
<td>Gutschick</td>
<td>I have been thinking more about the presentation last month regarding bicyclist safety. The LTS categories seem very subjective, depending on the individual. For instance, I am not an accomplished rider, but I have ridden bikes since childhood, including to my elementary school (about a mile). We rode along the side of what was probably a major collector and never felt unsafe. Are the LTS measures standardized? How do you factor in variations in individuals? After categorizing the LTS, we then populate the table, which then results in decisions on separated bike facilities. Seems like it may start with too subjective of a foundation.</td>
<td>Resolved</td>
<td>The LTS methodology is intended to capture this difference between individuals. It is understood that some percentage of the bicycling population will be comfortable on streets that are ranked as high stress, but the vast majority of the bicycling population are comfortable on streets that are ranked as low stress.</td>
</tr>
<tr>
<td>86</td>
<td>Street Types v2</td>
<td>Neighborhood Yield Street</td>
<td>3/3/2021</td>
<td>White</td>
<td>In response to the question &quot;Do we need a wider section with designated parking on both sides of the street for high density areas?&quot;, Neighborhood Yield Streets do not work well in high density areas. They only work where parking is less than 80% occupied, because drivers must pull into the unoccupied parking spots to enable other drivers to pass. If there are insufficient opportunities to pass, then the street ceases to function. Another option might be to intentionally create no parking/passing zones on a high density street, but this is not a common practice. Neighborhood Yield Streets are best used in neighborhoods where there is a mix of on-street and off street parking options. They can work in denser neighborhoods, but not in neighborhoods with a lot of apartment buildings and no off street parking spaces. None of this is to say that Yield Streets aren’t a great street type, they are.</td>
<td>Resolved</td>
<td>Discussed at March 3 CSIT meeting.</td>
</tr>
<tr>
<td>87</td>
<td>Street Types v2</td>
<td>Neighborhood Yield Street</td>
<td>3/3/2021</td>
<td>White</td>
<td>Clarify this is a two-way street.</td>
<td>Resolved</td>
<td>Discussed at March 3 CSIT meeting. A note was added to the street section.</td>
</tr>
<tr>
<td>88</td>
<td>Street Types v2</td>
<td>Neighborhood Yield Street</td>
<td>3/3/2021</td>
<td>White</td>
<td>Transit is the key determining factor in using 26’ instead of 24’. Use 26’ for transit.</td>
<td>Resolved</td>
<td>Discussed at March 3 CSIT meeting. Neighborhood Yield Street width is determined based on the density of the surrounding housing.</td>
</tr>
<tr>
<td>89</td>
<td>Street Types v2</td>
<td>Neighborhood Connectors and Town Center Connectors</td>
<td>3/3/2021</td>
<td>White</td>
<td>Regarding two-way left turn lanes: Use caution with applying them across the board, along the entire length of streets. While they are needed at intersections, they are often not needed at midblock, particularly when the only entrances onto the road are residential driveways or other low volume entrances. Where they are needed are for higher volume generators, like parking garages, major shopping centers, etc. When they are continuous at midblock locations (e.g. the entire length of the road between intersections) they create a wide street that results in higher speeds.</td>
<td>Resolved</td>
<td>Discussed at the March 9 CSIT meeting. It was acknowledged that a painted or landscaped median could be provided in between areas where 2-way left turn lanes are needed.</td>
</tr>
<tr>
<td>90</td>
<td>Street Types v2</td>
<td>Neighborhood Connector Options 1 &amp; 2</td>
<td>3/3/2021</td>
<td>White</td>
<td>We would like to see the threshold lowered from 35 mph to 30 mph and clarify that this is the operating speed, not the speed limit. Otherwise, if it was intended to be the speed limit, this cross section would result in streets with 45 mph operating speeds, which would need separated bike lanes. The chart from the new AASHTO Bike Guide (under publication) is below.</td>
<td>Ready for discussion</td>
<td>Discussed at the March 9 CSIT meeting. The Neighborhood Connector Street type now shows a shared use path.</td>
</tr>
<tr>
<td>91</td>
<td>Street Types v2</td>
<td>Neighborhood Streets</td>
<td>3/3/2021</td>
<td>White</td>
<td>Depending on operating speed, see comment above, it may be preferable to use separated bike lanes instead of conventional bike lanes. This can be done in the same cross section, at street level to save ROW if necessary.</td>
<td>Resolved</td>
<td>Discussed at the March 9 CSIT meeting. Neighborhood Street 1 shows an on-road buffered bike lane and Neighborhood Street 2 shows a shared use path.</td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment by</td>
<td>Comment</td>
<td>Status</td>
<td>Resolution</td>
</tr>
<tr>
<td>----</td>
<td>--------------------------</td>
<td>--------------------------</td>
<td>----------</td>
<td>------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>92</td>
<td>Street Types v2</td>
<td>Country Road and Rural Development Street</td>
<td>3/3/2021</td>
<td>White</td>
<td>These streets may in some cases require adjacent shared use paths if they are part of a connected network of pathways.</td>
<td>In process</td>
<td>Is it appropriate to address this in the shared use path section of the Street Design chapter? This issue was discussed at length at the May 5 CSIT meeting. If the existing road does not have shoulders but does have an existing shared use path, a pathway could be provided in lieu of shoulders (shoulders being the standard for the Country Road street type). This only applies in &quot;missing link&quot; situations.</td>
</tr>
<tr>
<td>93</td>
<td>Street Types v2</td>
<td>Rural Development Street</td>
<td>3/3/2021</td>
<td>White</td>
<td>We question why this is the only street with 12’ wide lanes? Would 10’ wide lanes suffice here, to save some ROW costs? Ideally these would be very low speed streets.</td>
<td>In process</td>
<td>This is really the rural equivalent of a Neighborhood Yield Street rather than a street with two defined 12-foot lanes. This issue was discussed at the May 5 CSIT meeting. See resolution for comment 75.</td>
</tr>
<tr>
<td>94a</td>
<td>Street Types v2</td>
<td>Street Type Comparison Table</td>
<td>3/3/2021</td>
<td>White</td>
<td>Consider adding operating speeds to this table to make it clear to designers that measures should be taken to design these streets to achieve lower speeds.</td>
<td>In process</td>
<td>Speeds will be noted in the table.</td>
</tr>
<tr>
<td>94b</td>
<td>Street Types v2</td>
<td>General</td>
<td>3/3/2021</td>
<td>Jagarapu</td>
<td>Provided an image of Cedar Lane. IMG_8015 is on Cedar Lane with 10’ lane widths. RTA mobility bus appeared to be trying to stay in the lane but is shying away from the face of the curb. The vehicle next to the RTA bus is a compact Ford Focus. Please see IMG_8032 to notice the gutter pan at the same location taken on a sunny day. Gutter pan appears to be failing, possibly due to vehicles driving on the joint.</td>
<td>Resolved</td>
<td>Discussed at March 3 CSIT meeting. No proposed sections show a 10-foot outside lane that includes a gutter pan, which is what is present on Cedar Lane.</td>
</tr>
<tr>
<td>95</td>
<td>Street Types v2</td>
<td>Neighborhood Yield Street</td>
<td>3/3/2021</td>
<td>Jagarapu</td>
<td>Provided an image of a 28’ wide neighborhood street. IMG_7944 is on a County local road 28 feet wide with vehicles parked on both sides and a County snow plow. I cannot recommend parking on both sides of the streets with anything less than this width.</td>
<td>Resolved</td>
<td>Discussed at March 3 CSIT meeting. CSIT agreed to maintain the yield street widths that are currently in the Design Manual, ranging from 24 to 28 feet depending on land use and traffic volume.</td>
</tr>
<tr>
<td>96</td>
<td>3 (Structures) General</td>
<td>General</td>
<td>4/14/2021</td>
<td>White</td>
<td>While this may not be a part of the budget, but this chapter would benefit greatly from having some illustrations and photographs.</td>
<td>In process</td>
<td>Illustrations are under development.</td>
</tr>
<tr>
<td>97</td>
<td>3 (Structures) General</td>
<td>General</td>
<td>4/14/2021</td>
<td>White</td>
<td>The outline of this chapter does not appear to have a section on railings on bridges. This is an important topic that shouldn't only be covered under the section on Shared Use Pathway Bridges. As &quot;regular&quot; roadway bridges must consider the appropriate railing height for pedestrians and bicyclists. The recommended height of a railing adjacent to a bikeway is 42 in. (this is based on research and is the new standard in the upcoming AASHTO Bike Guide) with a 48 in. high railing in locations where bicycle speeds are expected to be high (such as on a downgrade), where high winds are typical, or where a bicyclist could impact a railing at a 25-degree angle or greater. There should also be a discussion of placement of crashworthy barriers between the motor vehicle lanes and a separated bikeway (if one is provided).</td>
<td>In process</td>
<td>Additional information will be provided for railings.</td>
</tr>
<tr>
<td>98</td>
<td>3 (Structures) General</td>
<td>General</td>
<td>4/14/2021</td>
<td>White</td>
<td>It may be helpful to add a statement under &quot;General Features of Design&quot;. Consider the following: For bridges that afford scenic views, consideration should be given to providing periodic locations where pedestrians and bicyclists can stop for a respite or to enjoy the view from the bridge. The viewing area platforms should be located outside the operating space of the pathway and be of sufficient size to accommodate the expected volume of users that may stop so they do not block the adjacent through travel on the facility.</td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
<tr>
<td>99</td>
<td>3 (Structures) 3.2 A.</td>
<td>Coordination with Road and Street Planning</td>
<td>4/14/2021</td>
<td>White</td>
<td>Coordination with Road and Street Planning: Last sentence of this paragraph (starting &quot;For structures in historic districts,...&quot;) needs to be revised. It is not grammatically correct.</td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
<tr>
<td>100</td>
<td>3 (Structures) 3.2 B.</td>
<td>Design Specifications:</td>
<td>4/14/2021</td>
<td>White</td>
<td>Design Specifications: in first item, AASHTO, change to &quot;For highway and pedestrian/bicycle bridges...&quot;</td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
</tbody>
</table>

Page 11 of 25
<table>
<thead>
<tr>
<th>#</th>
<th>Chapter</th>
<th>Section</th>
<th>Date</th>
<th>Comment by</th>
<th>Comment</th>
<th>Status</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>3 (Structures)</td>
<td>3.2 B.</td>
<td>4/14/2021</td>
<td>White</td>
<td>Design Specifications: In first item referring to AASHTO, both the AASHTO Ped Guide and AASHTO Bike Guides should be referenced, both have chapters on structures</td>
<td>Resolved</td>
<td>AASHTO Pedestrian Guide is out of date; current guidance is referenced.</td>
</tr>
<tr>
<td>102</td>
<td>3 (Structures)</td>
<td>3.2 E.1.c</td>
<td>4/14/2021</td>
<td>White</td>
<td>Selection of Retaining Wall Type, Proprietary Walls, Gabions: A statement is needed that gabion retaining walls are not the appropriate choice immediately adjacent to pedestrian and bicycle facilities. Because walking or riding a bike next to a vertical gabion wall is unpleasant and unsafe.</td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
<tr>
<td>103</td>
<td>3 (Structures)</td>
<td>3.2 F.4</td>
<td>4/14/2021</td>
<td>White</td>
<td>Selection of Bridge Type, Safety and Aesthetics: paragraph 3 needs to be rewritten. Sidewalks and bicycle lanes are not &quot;embellishments.&quot; This section should make a strong statement, similar to Federal policies (see <a href="https://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/policy_accom.cfm">https://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/policy_accom.cfm</a>), that pedestrian and bicycle accommodations should be a part of every bridge project, including projects on limited access freeways. As we discussed on our call, bridges have a 75-100 year lifespan. Even if there is no current pedestrian and bicycle activity, we must assume that there will be a need in the future. Let's be forward looking. For any bridges built in urban and suburban areas, it should be expected that a pedestrian and bicycle facility will be provided. Accommodations are needed on both sides of bridges to avoid exposing pedestrians and bicyclists to a crossing at the two ends of the bridge. The absence of a sidewalk or bikeway on the approach roadways to a structure should not prevent the provision of a bikeway on a bridge or in a tunnel. The constrained conditions on the structure have a profound effect on the safety of pedestrians and bicyclists. Even on roadways where pedestrian and bicycle access is prohibited, consideration should be given to providing a nonmotorized component to the structure if it provides a potential link to a sidewalk or bicycle network.</td>
<td>Resolved</td>
<td>Text has been revised. 8’ shoulders shall be provided on bridges unless sidewalks and separated bike lanes (or shared use paths) are planned in the area.</td>
</tr>
<tr>
<td>104</td>
<td>3 (Structures)</td>
<td>3.2 i.1.a</td>
<td>4/14/2021</td>
<td>White</td>
<td>Selection of Bridge Type, Clearances, Bridge Roadway Width: First sentence under Bridge Roadway Width should say &quot;The roadway width of bridges shall preferably be the full width of the approach roadway section including the shoulders. Sidewalks and bicycle facilities shall be provided on both sides of the bridge even if they don't exist on the approaches.&quot; Then, remove the last two sentences of that section. Those statements are weak and are not aligned with federal policy, which requires the provision of bicycle facilities on the bridge if bicyclists are permitted to operate on the approaches. See 23 U.S.C. 217(e)</td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
<tr>
<td>105</td>
<td>3 (Structures)</td>
<td>3.2 i.1.e</td>
<td>4/14/2021</td>
<td>White</td>
<td>Selection of Bridge Type, Clearances, Underpass Clearance: this section should discuss the inclusion of pedestrian and bicycle facilities in the clearance width.</td>
<td>In process</td>
<td>A new section on underpasses will be provided.</td>
</tr>
<tr>
<td>106</td>
<td>3 (Structures)</td>
<td>3.2 i.3.c</td>
<td>4/14/2021</td>
<td>White</td>
<td>Selection of Bridge Type, Clearances, Vertical Clearance, Pedestrian: should be expanded, title should be Pedestrian/Bike</td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
<tr>
<td>107</td>
<td>3 (Structures)</td>
<td>3.2 J.1</td>
<td>4/14/2021</td>
<td>White</td>
<td>Bridge Roadway Section, Curbed (Closed) Section: this section should be revised to assume sidewalks/bikeways will be provided regardless of whether they exist on the approaches per the discussion above and Federal policy.</td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
<tr>
<td>108</td>
<td>3 (Structures)</td>
<td>3.2 J.3</td>
<td>4/14/2021</td>
<td>White</td>
<td>Bridge Roadway Section, Barriers: about 2/3 of the way down in the first paragraph: There is a statement that implies that the designer should determine if pedestrians and/or bicyclists are expected to use the bridge. As stated in the comment above, even in rural areas, bridges are expected to last for 75 years and the assumption should be that they will accommodate pedestrians and bicyclists. Revise to make this clear.</td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
<tr>
<td>109</td>
<td>3 (Structures)</td>
<td>3.2 J.3</td>
<td>4/14/2021</td>
<td>White</td>
<td>Bridge Roadway Section, Barriers: second paragraph, this discussion should include a mention that the placement and design of sidewalks/bike facilities and approaches should be considered in the design of bridge ends, to afford maximum protection for those users.</td>
<td>In process</td>
<td>Will be addressed.</td>
</tr>
</tbody>
</table>
Substructures and Retaining Walls: Somewhere in this section there should be a discussion about the design of retaining walls adjacent to pedestrian facilities. It is very uncomfortable to walk on a narrow sidewalk adjacent to a tall retaining wall. Either the wall should be constructed in shorter sections and stepped back from the sidewalk edge. Or, the sidewalk needs to be wider than normal.

Substructures and Retaining Walls: Page number in this section is incorrect and the structure/subsection numbering in this chapter is unclear.

Substructures and Retaining Walls: This entire section would benefit from some illustrations. In process Illustrations are under development.

Bridge Superstructure, Expansion Joints: Need to make a statement about bicyclists being particularly susceptible to surface irregularities, and that expansion joints in locations where bicyclists may be operating should be smooth, slip resistant, and free of gaps or irregularities.

Shared Use Pathway Bridges: Overall comments on this chapter: A section is needed on underpass design for pedestrians and bicyclists, and this should cover lighting, which should be required. It would also be a good idea to address prefab bridges, since they are commonly used on shared use paths.

Shared Use Pathway Bridges, General, Design Specifications, A.A.S.H.T.O: Include the AASHTO Ped and Bike Guides as references.

Shared Use Pathway Bridges, General, Design Specifications, A.D.A: This should be a simple statement that "all designs such meet or exceed those recommended in current accessibility guidelines to the extent that it is not structurally impracticable to do so" rather than referring to a specific document that may become outdated.

Shared Use Pathway Bridges, Clearances, Horizontal Clearances: Per the AASHTO Bike Guide, the minimum width of a shared use path on a structure must account for the shy distance required to the railing on each side. The minimum width of a shared use path is 10', therefore the minimum clear width of a path across a structure should be 14' (preferably) and 12' minimum.

Shared Use Pathway Bridges, Clearances, Vertical Clearances: Do you mean the minimum vertical clearance from the surface of a path? This should acknowledge the need for a greater clearance if the path will need to accommodate emergency vehicles.

Shared Use Pathway Bridges, Profile and Grade: Need to acknowledge that the cross slope should not exceed 2% to meet accessibility guidelines.
<table>
<thead>
<tr>
<th>#</th>
<th>Chapter</th>
<th>Section</th>
<th>Date</th>
<th>Comment by</th>
<th>Comment</th>
<th>Status</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>122</td>
<td>3</td>
<td>3.6 E</td>
<td>4/14/2021</td>
<td>White</td>
<td>Shared Use Pathway Bridges, Railings and Fencing: This section needs to be revised to provide more detail, rather than referring to MDOT or AASHTO standards. Depending on which standards they refer to, they may not be the right standards. Assuming you are only talking about shared use pathway bridges here, they can and should have different standards than roadway bridges. For example, railings on shared use pathways (independent from roads) typically do not need to be crashworthy. Also, it is common for shared use paths to be in natural areas and some are very low bridges over a small gully or wetland area. If they are less than 30 in. off the ground, they don't need a railing. A toeboard along the edge of the pathway will suffice. This section should also mention that the railing or fencing should begin prior to and extend beyond, the area of need. This should also mention that it is not desirable to place a shared use path between two fences for a long distance, as this creates a personal security issue.</td>
<td>In process</td>
<td>Additional information will be provided for railings.</td>
</tr>
<tr>
<td>123</td>
<td>3</td>
<td>3.9 A</td>
<td>4/14/2021</td>
<td>White</td>
<td>Utilities on Bridges, Telephone Lines &amp; Cable: Need to make clear that these should not interfere with the surface quality or ADA compliance of the sidewalk slab.</td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
<tr>
<td>124</td>
<td>3</td>
<td>3.10 A</td>
<td>4/14/2021</td>
<td>White</td>
<td>Rehabilitation of Existing Structures, Introduction: Make this section stronger. Rehabilitation is an opportunity to accommodate pedestrians and bicyclists on bridges where they were not accommodated before. This is an important opportunity and every effort should be made to provide separated bike lanes and sidewalks for example by reallocating roadway space (narrowing or reconfiguring travel lanes).</td>
<td>In process</td>
<td>Text has been revised.</td>
</tr>
<tr>
<td>125</td>
<td>3</td>
<td>3.10 B.1</td>
<td>4/14/2021</td>
<td>White</td>
<td>Rehabilitation of Existing Structures, Superstructure Repairs, Bridge Decks.: Need to make a statement about bicyclists being particularly susceptible to surface irregularities, and that bridge decks particularly where bicyclists may be operating, should be smooth, slip resistant, and free of gaps or irregularities.</td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
<tr>
<td>126</td>
<td>3</td>
<td>3.2 F.1</td>
<td>4/14/2021</td>
<td>Schoen</td>
<td>General Features of Design, Selection of Bridge Type, Site Conditions: Shall be designed to preserve and should be designed to enhance... Views from the bridge and to provide pedestrian bicycle facilities as specified in other chapters of this Manual.</td>
<td>Resolved</td>
<td>Addressed in other sections.</td>
</tr>
<tr>
<td>127</td>
<td>3</td>
<td>3.2 F.4</td>
<td>4/14/2021</td>
<td>Schoen</td>
<td>General Features of Design, Selection of Bridge Type, Safety and Aesthetics: A sidewalk or bike lane in accordance with other chapters is not an embellishment but a minimum requirement. Embellishment might describe enhancing a view (as in F.1), making a wide pedestrian mall with benches, decorative lighting, etc.</td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
<tr>
<td>128</td>
<td>3</td>
<td>3.2 H</td>
<td>4/14/2021</td>
<td>Schoen</td>
<td>General Features of Design, Structures over Waterways: Consideration shall be given to provision for walking and bicycling paths under structures over waterways. These could be goat paths or future planned path. Regarding walkable watersheds and walking paths, see <a href="https://www.communityecologyinstitute.org/walkable-watershed.html">https://www.communityecologyinstitute.org/walkable-watershed.html</a> and <a href="https://www.nfwf.org/sites/default/files/2020-12/five-star-urban-waters-2020-grant-slate.pdf">https://www.nfwf.org/sites/default/files/2020-12/five-star-urban-waters-2020-grant-slate.pdf</a></td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment by</td>
<td>Comment</td>
<td>Status</td>
<td>Resolution</td>
</tr>
<tr>
<td>------</td>
<td>---------------</td>
<td>---------</td>
<td>-----------</td>
<td>------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>129</td>
<td>3 (Structures)</td>
<td>3.2 H.I.1.a</td>
<td>4/14/2021</td>
<td>Schoen</td>
<td>General Features of Design, Structures over Waterways, Clearances and Bridge Roadway Section: As discussed in the meeting, in this and all similar sections, provide something for peds and bikes. I believe it should be the minimum of 1) existing approach, 2) what is required by Ch. 3 for the road type, or 3) existing or planned facility on the road within some distance (2 miles or the nearest intersection?), As Kris said, it could be a shoulder, but it should be wide enough to be convertible to mixed use pathway or sidewalk and bicycle facility. Some narrowing is acceptable for limited distance (see references).</td>
<td>Resolved</td>
<td>Text has been revised. 8’ shoulders shall be provided on bridges unless sidewalks and separated bike lanes (or shared use paths) are planned in the area.</td>
</tr>
<tr>
<td>130</td>
<td>3 (Structures)</td>
<td>3.2 I.3</td>
<td>4/14/2021</td>
<td>Schoen</td>
<td>General Features of Design, Bridge Roadway Section, Barriers: highlighted “whether pedestrians and/or cyclists are expected to use the bridge;” Bicyclist used elsewhere; use consistent terms. Given the Complete Streets policy, ped/bike use is expected anywhere it is not specifically prohibited. As discussed in the meeting, some facility must be provided, whether a shoulder, mixed use path, or sidewalk and bicycle facility.</td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
<tr>
<td>131</td>
<td>3 (Structures)</td>
<td>4.6 A.1.a</td>
<td>4/14/2021</td>
<td>Schoen</td>
<td>Shared Use Pathway Bridges, General, Design Specifications, A.A.S.H.T.O: highlighted “Shared use pathway shields shall also be in accordance with the “Guide for the Development of Bicycle Facilities” of the Association of State Highway and Transportation Officials (A.A.S.H.T.O, Ref. 23), including subsequent interim specifications.” Good!!!</td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
<tr>
<td>132</td>
<td>3 (Structures)</td>
<td>3.10 A</td>
<td>4/14/2021</td>
<td>Schoen</td>
<td>Rehabilitation of Existing Structures, Introduction: highlighted &quot;As part of any rehabilitation design of an existing structure, consideration should be given to retrofits to accommodate pedestrians and bicyclists via sidewalk or shared use pathway, for immediate or future use.&quot; New facilities shall be provided to a mode not already covered prior to enhancing other modes (mimic language from Complete Streets Policy).</td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
<tr>
<td>133</td>
<td>3 (Structures)</td>
<td>3.10 B.1</td>
<td>4/14/2021</td>
<td>Schoen</td>
<td>Rehabilitation of Existing Structures, Superstructure Repairs, Bridge Decks: highlighted “maintain pedestrian and/or bicycle traffic.” Good!!!</td>
<td>Resolved</td>
<td>Noted.</td>
</tr>
<tr>
<td>134</td>
<td>3 (Structures)</td>
<td>General</td>
<td>4/26/2021</td>
<td>Rigby</td>
<td>Not sure if it belongs in the introduction, but AASHTO and the Manual of Uniform Traffic Control Devices should be the minimum safety standards. Can we use “meet or exceed standards” language in this section, similar to how it is used elsewhere?</td>
<td>Parked</td>
<td>This would benefit from further discussion when the Introduction chapter is revised.</td>
</tr>
<tr>
<td>135</td>
<td>3 (Structures)</td>
<td>General</td>
<td>4/26/2021</td>
<td>Rigby</td>
<td>Throughout this chapter, language pertaining to vehicle transportation is active and uses “shall,” while language for multimodal transportation is more passive and uses “consideration should be given to.” Can we consider changing this language to “shall” to reflect importance of incorporating bike and pedestrian facilities in design?</td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
<tr>
<td>136</td>
<td>3 (Structures)</td>
<td>General</td>
<td>4/26/2021</td>
<td>Rigby</td>
<td>Agree with points made on Chapter 4 by Schoen and White regarding: railings on bridges, removing/changing the phrasing of “embellishments’ to describe bike and pedestrian facilities, addressing underpass design of Shared Use Pathways, especially where waterways are present, acknowledging that shared use pathway cross slope not to exceed 2%, addressing surface irregularities for bicyclists.</td>
<td>Resolved</td>
<td>Noted. Revisions will be made as described under those comments.</td>
</tr>
<tr>
<td>137</td>
<td>3 (Structures)</td>
<td>3.2 I</td>
<td>4/26/2021</td>
<td>Rigby</td>
<td>Clearances: If there are no existing bike/ped facilities approaching the bridge, can we include a requirement for the bridge to include a shoulder lane wide enough for future bike/ped improvements? Is there b, c, and d missing after this section, or is e “a listing typo?</td>
<td>Resolved</td>
<td>Text has been revised. 8’ shoulders shall be provided on bridges unless sidewalks and separated bike lanes (or shared use paths) are planned in the area.</td>
</tr>
<tr>
<td>138</td>
<td>3 (Structures)</td>
<td>3.2 I.1.e</td>
<td>4/26/2021</td>
<td>Rigby</td>
<td>Underpass Clearance: How do we ensure there is enough space when a bridge is built to accommodate bike and pedestrian access in the future?</td>
<td>In process</td>
<td>A new section on underpasses will be provided.</td>
</tr>
<tr>
<td>139</td>
<td>3 (Structures)</td>
<td>3.10 B.1</td>
<td>4/26/2021</td>
<td>Rigby</td>
<td>Bridge Decks (paragraph 5, line 6): Recommend changing language to “need to maintain and enhance pedestrian and/or bicycle traffic.”</td>
<td>Resolved</td>
<td>Improvements to properly accommodate walking and bicycling in accordance with the Complete Streets policy are in other sections of this chapter.</td>
</tr>
<tr>
<td>140</td>
<td>3 (Structures)</td>
<td>3.10 B.2</td>
<td>4/26/2021</td>
<td>Rigby</td>
<td>Barriers: Are there barrier requirements that we should be considering for pedestrian and cyclist safety in this section?</td>
<td>In process</td>
<td>Additional information will be provided for railings and barriers.</td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment by</td>
<td>Comment</td>
<td>Status</td>
<td>Resolution</td>
</tr>
<tr>
<td>------</td>
<td>---------</td>
<td>---------</td>
<td>------------</td>
<td>------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-----------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>141</td>
<td>3 (Structures)</td>
<td>3.11.A</td>
<td>6/14/2021</td>
<td>White</td>
<td>Change last paragraph to &quot;Bridge widths, including travel lanes, shoulders, and pedestrian and bicycle facilities, shall conform to Section 3.2.I to the extent practical. If the scope of the project does not allow for the full width of those facilities, consideration should be given to retrofits that provide additional space for pedestrian and bicycle travel. In constrained conditions on bridges with inadequate pedestrian and bicycle facilities, consideration should be given to narrowing or reconfiguring motor vehicle lanes or medians to provide additional space for pedestrians and bicyclists. Consideration should also be given to adding some separation (if feasible) between the travel lanes and the adjacent pedestrian/bicycle facility, such as a curb, a concrete barrier, or flexposts. Separation is a particular need on bridges with motor vehicle operating speeds over 35 mph that are more than 100’ long.&quot;</td>
<td>Resolved</td>
<td>Text has been revised.</td>
</tr>
</tbody>
</table>
| 142  | 3 (Structures) | 3.11.A  | 6/14/2021  | Schoen     | Regarding comment 141, "I'd make it even stronger, as follows, to make it consistent with the CS policy that calls for prioritizing modes that are currently underserved: 'Bridge widths, including travel lanes, shoulders, and pedestrian and bicycle facilities, shall conform to Section 3.2.I to the extent practical. If the scope of the project does not allow for the full width of those facilities, priority shall be given to retrofits that provide additional space for pedestrian and bicycle travel. In constrained conditions on bridges with inadequate pedestrian and bicycle facilities, narrowing or reconfiguring motor vehicle lanes or medians shall be prioritized to provide additional space for pedestrians and bicyclists. Separation shall be provided (if feasible) between the travel lanes and the adjacent pedestrian/bicycle facility, such as a curb, a concrete barrier, or flexposts. Separation is a particular need on bridges with motor vehicle operating speeds over 35 mph that are more than 100’ long."
<p>| Resolved | Text has been revised in accordance with comment 141. |
| 143  | 4 (APFO) | 4.1. Purpose | 6/11/2021 | White      | Purpose: The result of this is that new development is built further away from other destinations, creating longer walking and bicycling distances. By using LOS to determine mitigation, the result is faster motor vehicle traffic and streets that are unpleasant to walk along and difficult to cross. Fundamentally, this framework is incompatible with complete streets. | Discuss with CSIT | Chapter 4 was discussed in detail by staff. Requirements for traffic studies to be conducted by developers extend beyond the Design Manual, including updates to the Subdivision and Land Development Regulations and possibly other regulations and documents. These comments will be considered, but not in the timeframe of the current Design Manual updates. |
| 144  | 4 (APFO) | 4.1  | 6/15/2021  | Schoen     | Purpose: The purpose of this Chapter needs to match the effort we are expending on the rest of this Design Manual. All the stakeholders are represented on the CSIT and I think we need to include a re-write that reflects the new multimodal imperatives in the new Complete Streets Policy. I have made limited comments on this chapter pending such re-write. | Discuss with CSIT | See response to comment 143. |
| 145  | 4 (APFO) | 4.2 A  | 6/11/2021  | Schoen     | Projects Requiring Evaluation/Traffic Study Outside of the Downtown Columbia Area: highlighted &quot;approved mitigation plan&quot; and commented, mitigation should allow for mode shift to bike / ped / transit. | Discuss with CSIT | See response to comment 143. |
| 146  | 4 (APFO) | 4.2 C  | 6/11/2021  | Schoen     | Study Area: highlighted &quot;not beyond the intersection of a major collector,&quot; &quot;first intersection in all directions,&quot; and &quot;not beyond the intersection of a minor collector&quot; and commented, This is too limiting according to my review of The General Plan Road Map. There are developments that could degrade connectivity and safety of bike and ped even on the major and minor collectors and beyond. | Discuss with CSIT | See response to comment 143. |
| 147  | 4 (APFO) | 4.3  | 6/11/2021  | Schoen     | Traffic Volumes: Highlighted &quot;in accordance with the procedures and technical standards identified in Chapter 5&quot; and commented, it's really difficult to understand the relationship between Chapters 4 &amp; 5. If I interpret this statement strictly, then everything in 5 applies, and Chapter 4 has additional requirements. I realize this is a bigger editing task, but for clarity, should 4 &amp; 5 be integrated? | Discuss with CSIT | See response to comment 143. |</p>
<table>
<thead>
<tr>
<th>#</th>
<th>Chapter</th>
<th>Section</th>
<th>Date</th>
<th>Comment by</th>
<th>Comment</th>
<th>Status</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>148</td>
<td>4 (APFO)</td>
<td>4.3.C.3</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Background Traffic Growth Rate: If we're going to relax this requirement, let's not make it unilateral, and require some trip reduction, complete street actions, trip modeling showing that the development can reduce existing cart trips, etc.</td>
<td>Discuss with CSIT</td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>149</td>
<td>4 (APFO)</td>
<td>4.5.C.</td>
<td>6/11/2021</td>
<td>White</td>
<td>Roadway/Intersection Mitigation Plan: Mitigation plans mean that intersections must be made wider and turn lanes added. As a result, crossing distances increase for pedestrians. This section says nothing about mitigation measures for the pedestrian and bicycle safety issues that these projects introduce.</td>
<td>Discuss with CSIT</td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>150</td>
<td>4 (APFO)</td>
<td>4.6</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Transitional Requirements: highlighted &quot;may&quot; and commented &quot;shall.&quot;</td>
<td>Discuss with CSIT</td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>151</td>
<td>4 (APFO)</td>
<td>4.9.B.5</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Roadway/Intersection Mitigation Plan: Mitigation plans mean that intersections must be made wider and turn lanes added. As a result, crossing distances increase for pedestrians. This section says nothing about mitigation measures for the pedestrian and bicycle safety issues that these projects introduce.</td>
<td>Discuss with CSIT</td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>152</td>
<td>4 (APFO)</td>
<td>4.9.C.</td>
<td>6/11/2021</td>
<td>White</td>
<td>Pedestrian and Bicycle Level of Service Tests: These aren't compatible with the LTS goals that were established previously in chapter 4. This needs to be reconciled.</td>
<td>Discuss with CSIT</td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>153</td>
<td>4 (APFO)</td>
<td>4.9.C</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Pedestrian and Bicycle Level of Service Tests: What LOS measure are we using? From a 2021 TRB paper: &quot;Bicycle Level of Service: Accounting for Protected Lanes, Traffic Exposure, and Delay&quot; Motorized traffic exposure and delay are two critical factors for bicycle level of service (LOS). Unfortunately, the current Highway Capacity Manual's methodology for bicycle LOS fully accounts for neither. At the intersection level, motorized traffic speed and bicycle delay are not considered at all; and at the link level there is no account for one of the most effective traffic-exposure mitigating infrastructure types, separated bicycle lanes. This creates a systemic problem, enabling the design of roadways that ignore bicycle exposure and delay (i.e., comfort and safety), while giving approving LOS grades to otherwise poor roads and intersections.&quot;</td>
<td>Discuss with CSIT</td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>156</td>
<td>4 (APFO)</td>
<td>4.9.D</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Transportation Demand Management Statement: Highlighted &quot;alternative means of mobility through&quot; and commented, First goal IMHO should be promoting walkability. The planning world has come a long way in describing and valuing walkability, which includes things like safe, comfortable, interesting, somewhere to get to, etc. I believe it is sorely needed in Town Center and many other locations.</td>
<td>Discuss with CSIT</td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>157</td>
<td>4 (APFO)</td>
<td>4.9.2.2</td>
<td>6/11/2021</td>
<td>White</td>
<td>Non-Automobile Trip Credits: This needs to be built out more. This should apply to the whole County, not just Downtown Columbia.</td>
<td>Discuss with CSIT</td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>158</td>
<td>4 (APFO)</td>
<td>4.9.2.2</td>
<td>6/11/2021</td>
<td>White</td>
<td>Non-Automobile Trip Credits - Table 2: There are many things that should be added to this list: leading pedestrian intervals, separated bike lanes, protected intersections, uncontrolled intersection improvements, intersection crossing reduction measures (tight corner radii), traffic calming, the list goes on. These shouldn't be an afterthought to get &quot;credits&quot;, they should be required as key metrics of success.</td>
<td>Discuss with CSIT</td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment by</td>
<td>Comment</td>
<td>Status</td>
<td>Resolution</td>
</tr>
<tr>
<td>-----</td>
<td>---------</td>
<td>---------</td>
<td>------------</td>
<td>------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>159</td>
<td>4 (APFO)</td>
<td>Table 2</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Non-Automobile Trip Credits: See Jeff Speck's requirements for walkability:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1. A reason to walk</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. A safe walk</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. A comfortable walk</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4. An interesting walk</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>and specifically to make mobile safer:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1. Needed driving lanes only</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. Proper width</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. Few one-way</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4. Continuous on street parking</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5. Useful bike network</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6. Fewer centerlines, more parking stripes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7. Few swooping geometries</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8. Few sidewalk curb cuts</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9. No traffic signals that could be all way stops</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10. Proper crosswalks and beacons.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>All the facilities listed in this table need to be safe, comfortable, interesting and get you somewhere. There is a whole field of current research and practice in travel demand modeling for our changing landscape of mobility.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Why set a maximum? Perhaps a developer who really &quot;gets&quot; complete streets makes it work, why shouldn’t they get credit?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>4 (APFO)</td>
<td>Appendix</td>
<td>6/11/2021</td>
<td>White</td>
<td>Free Right: This rewards the developer for designing intersections with free-flowing traffic at faster speeds, since slip lanes typically have a wider turn radii, and is an example of how this manual favors fast movement of motor vehicles over pedestrian and bicyclist safety. Allowing free-flowing traffic at slip lanes does not follow complete street principles.</td>
<td></td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>161</td>
<td>4 (APFO)</td>
<td>Appendix</td>
<td>6/11/2021</td>
<td>White</td>
<td>Right Turn on Red: This should not be encouraged as it conflicts with pedestrian movements and favors motor vehicle through-put.</td>
<td></td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>162</td>
<td>4 (APFO)</td>
<td>Appendix</td>
<td>6/11/2021</td>
<td>White</td>
<td>Double Left Turn Lanes: These are particularly bad for pedestrians and contribute to extremely wide crossing distances at intersections. For older adults who often rely on walking, they increase the chances that a pedestrian who can’t walk quickly will get “caught” in the intersection after the light changes.</td>
<td></td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>163</td>
<td>4 (APFO)</td>
<td>Appendix</td>
<td>6/11/2021</td>
<td>White</td>
<td>Lane Use Factors A. Signalized Intersections and Land Use Factors B. Unsignalized Intersections: Need to include pedestrians or bicyclists here.</td>
<td></td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>164</td>
<td>4 (APFO)</td>
<td>Appendix</td>
<td>6/11/2021</td>
<td>White</td>
<td>(III) Pedestrian and Bicycle Impact Test: This need to be reconciled with LTS. This appears to only apply to Downtown Columbia. It should apply to the whole county.</td>
<td></td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>165</td>
<td>4 (APFO)</td>
<td>Appendix</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Signalized Intersections: highlighted &quot;where it is felt&quot; and commented &quot;not good mandatory language.&quot;</td>
<td></td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>166</td>
<td>4 (APFO)</td>
<td>Appendix</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Unsignalized Intersections: highlighted &quot;if there is any chance&quot; and commented &quot;not good mandatory language.&quot;</td>
<td></td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>167</td>
<td>5 (Traffic</td>
<td>S.2 A.</td>
<td>6/11/2021</td>
<td>White</td>
<td>General: This is not clear. Are there two types of pedestrian studies, one for crossings and one for connectivity? This would be better stated as: Pedestrian access studies, including: 1. pedestrian crossing studies to determine location and need for pedestrian crossing measures at intersections and midblock locations; 2. pedestrian connectivity studies to determine the need and location of pathways that connect between destinations and to/from transit stops; and 3. ADA accessibility studies to evaluate the accessibility of the pedestrian network for pedestrians with disabilities.</td>
<td></td>
<td>See response to comment 143.</td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment by</td>
<td>Comment</td>
<td>Status</td>
<td>Resolution</td>
</tr>
<tr>
<td>-----</td>
<td>-----------</td>
<td>---------</td>
<td>---------</td>
<td>------------</td>
<td>------------------------------------------------------------------------</td>
<td>-------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>168</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A</td>
<td>6/11/2021</td>
<td>White</td>
<td>General: Needs to be more than LTS. This also needs to include connectivity analysis.</td>
<td>Discussed with CSIT</td>
<td></td>
</tr>
<tr>
<td>169</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A</td>
<td>6/11/2021</td>
<td>White</td>
<td>General: Parking studies should address both motor vehicle and bicycle parking.</td>
<td>Discussed with CSIT</td>
<td></td>
</tr>
<tr>
<td>170</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>General: Highlighted &quot;six types of traffic studies&quot; and commented, Add walkability study at the neighborhood level. From VTPI: Walkability takes into account the quality of pedestrian facilities, roadway conditions, land use patterns, community support, security and comfort for walking. Walkability can be evaluated at various scales. At a site scale, walkability is affected by the quality of pathways, building accessways and related facilities. At a street or neighborhood level, it is affected by the existence of sidewalks and crosswalks, and roadway conditions (road widths, traffic volumes and speeds).</td>
<td>Discussed with CSIT</td>
<td></td>
</tr>
<tr>
<td>171</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>General: Comment on first bullet, Motorized vehicle traffic. That seems to be what is meant here.</td>
<td>Discussed with CSIT</td>
<td></td>
</tr>
<tr>
<td>172</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>General: Comment on first bullet, Trip reduction or shortening measures by providing local destinations (e.g. the 20 minute city Eugene, OR) that reduce traffic. Facilities that shift travel to other modes, resulting in vehicle trip reduction.</td>
<td>Discussed with CSIT</td>
<td></td>
</tr>
<tr>
<td>173</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>General: Comment on second bullet, Evaluate safety issues that prevent the use of facilities by vulnerable users. Add a sentence that describes safety of highest priority to bike and ped as VRU (vulnerable road users).</td>
<td>Discussed with CSIT</td>
<td></td>
</tr>
<tr>
<td>174</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>General: Comment on fifth bullet, Include identifying the real cost of parking facilities provided, even if they are provided without charge. Analysis of parking fee structure that achieves a target parking vacancy rate for on-street parking. 85% load factor has been proposed by some investigators and planners.</td>
<td>Discussed with CSIT</td>
<td></td>
</tr>
<tr>
<td>175</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>General: Comment on sixth bullet, I know this is off the subject, but if we are serious about noise impacts, we need to include landscaping noise impacts in our noise ordinance.</td>
<td>Discussed with CSIT</td>
<td></td>
</tr>
<tr>
<td>176</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>General: Highlighted &quot;proposed roadways and intersections&quot; and commented it should be &quot;existing and proposed.&quot;</td>
<td>Discussed with CSIT</td>
<td></td>
</tr>
<tr>
<td>177</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Scope of Studies: Resurfacing always triggers the need for an ADA accessibility study and the addition of curb ramps and accessible driveway crossings.</td>
<td>Discussed with CSIT</td>
<td></td>
</tr>
<tr>
<td>178</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.1</td>
<td>6/11/2021</td>
<td>White</td>
<td>In the third paragraph, this fundamentally reflects an auto-centric approach and is a large part of the reason why Howard County streets are unsafe for pedestrians and bicyclists. The criteria for triggering a traffic study is traffic congestion, with the ultimate result that the developer will be required to make capacity &quot;improvements&quot; that move traffic faster, which ultimately degrades the safety of pedestrians and bicyclists.</td>
<td>Discussed with CSIT</td>
<td></td>
</tr>
<tr>
<td>179</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.1</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Scope of Studies: first paragraph, struck &quot;new developments will not generally be concerned with safety evaluations because the roads are proposed rather than existing, so there will be no crash history to study&quot; and comments, This is too narrow and contradicts the Safety evaluations bullet.</td>
<td>Discussed with CSIT</td>
<td></td>
</tr>
<tr>
<td>180</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.1</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Scope of Studies: second paragraph, struck &quot;However&quot; and replaced it with &quot;Thus.&quot;</td>
<td>Discussed with CSIT</td>
<td></td>
</tr>
<tr>
<td>181</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.1</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Scope of Studies: second paragraph, highlighted &quot;Department&quot; and commented, Which department? Does it depend on whether it is developer or capital? Add &quot;... based on consultation with the Office of Transportation...&quot;</td>
<td>Discussed with CSIT</td>
<td></td>
</tr>
<tr>
<td>182</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.1</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Scope of Studies: third paragraph, highlighted &quot;All projects, regardless of size...&quot; and commented, This is good. Should reference complete streets policy. Conduct a walkability and bikeability audit?</td>
<td>Discussed with CSIT</td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment by</td>
<td>Comment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>--------------</td>
<td>---------</td>
<td>---------</td>
<td>------------</td>
<td>-------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>183</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.1</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Scope of Studies: third paragraph, highlighted “...pedestrian and parking studies are not required to be submitted” and commented, This seems to be moving us backwards rather than forwards as the CS policy requires. The regs are not yet updated, so in the interim we need requirements consistent with the current policy. I would delete the sentence.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>184</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.1</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Scope of Studies: third paragraph, highlighted “where appropriate” and commented, Who gets to decide what is appropriate? If we really mean our policy, then I believe it’s always appropriate to evaluate the impact on multimodal and not just car trips. Safety, at the beginning of this sentence, is paramount, according to the Policy.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>185</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.1</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Scope of Studies: third paragraph, highlighted “significant impact on existing facilities” and commented, whose judgement? what is significant? how do we handle death by a thousand cuts on roads in western county?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>186</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.1</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Scope of Studies: third paragraph, highlighted “100 peak hour trips in the morning or evening” and commented, Add some examples of other criteria, such as “where LTS exceeds 1 in semi-urbanized areas; or lower than LTS 2 in other areas. How can we address or areas where a significant number of trips will be 2 miles or less so there is an opportunity for mode shift by achieving LTS 1.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>187</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.1</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Scope of Studies: fourth paragraph, highlighted “if the study approved with the original subdivision is still valid” and commented, CS requirements are new so old studies are no longer valid. Nevertheless, I understand the reluctance to impose new requirements for a project already approved. Perhaps require a new study when 3 years have passed? Even if we can’t place responsibility for more improvements on the developer, it will help the County to know of deficiencies.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>188</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.1</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Scope of Studies: fourth paragraph, highlighted “intersections” and commented, cover road segments as well.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>189</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.1</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Scope of Studies: fourth paragraph, highlighted “known operational problems exist...” and commented Known to whom? Better to refer to a database, Plans, Tell HoCo reports.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>190</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.2</td>
<td>6/11/2021</td>
<td>White</td>
<td>Study Report Format/Presentation/Content: In the fourth paragraph, are five copies of the report still needed? Or, is the submission electronic?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>191</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.2</td>
<td>6/11/2021</td>
<td>White</td>
<td>Study Report Format/Presentation/Content: The listing in the sixth paragraph is heavily weighted towards through-put and does not reflect a Safe Systems approach.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>193</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.2</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Study Report Format/Presentation/Content: highlighted “Pedestrian Study” and commented, Describe the location with regard to Walk Howard and how the proposed work will contribute to plan implementation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>194</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.2</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Study Report Format/Presentation/Content: highlighted “Bicycle Study” and commented, Describe the location with regard to Bike Howard and how the proposed work will contribute to plan implementation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>196</td>
<td>5 (Traffic Studies)</td>
<td>5.2 A.2</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Study Report Format/Presentation/Content: highlighted report requirements and commented, Update to electronic submission. Digitally signed now acceptable to County?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Discuss with CSIT
<table>
<thead>
<tr>
<th>#</th>
<th>Chapter</th>
<th>Section</th>
<th>Date</th>
<th>Comment by</th>
<th>Comment</th>
<th>Status</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>197</td>
<td>5 (Traffic</td>
<td>5.2 A.2</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Study Report Format/Presentation/Content: highlighted bulleted list of items for developer consideration and commented, This list is car-centered, with multimodal as a last bullet afterthought. I would like to see each bullet be multimodal. Furthermore, acceleration, deceleration lanes and right turn lanes create problems for cyclists and I would like to see their use curtailed. E even FHWA says, &quot;Pedestrian and bicyclist safety and convenience should also be considered when adding turn lanes at an intersection.&quot; <a href="https://safety.fhwa.dot.gov/provencountermeasures/left_right_turn_lanes/">https://safety.fhwa.dot.gov/provencountermeasures/left_right_turn_lanes/</a></td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>198</td>
<td>Studies)</td>
<td>5.2 A.3</td>
<td>6/11/2021</td>
<td>White</td>
<td>Design Year and Ultimate Development Year: These projections in the first paragraph are often inaccurate and result in oversized roads that are unsafe for walking and biking. This is another example of how this chapter reflects an auto-centric approach.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>199</td>
<td>5 (Traffic</td>
<td>5.2 A.3</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Design Year and Ultimate Development Year: highlighted &quot;traffic demand&quot; and commented, Change to demand for multimodal transportation. We need contingency plans for mode shift that may occur in the future due to demands of population growth, climate change, the epidemic of inactivity we face and other global trends. We can't assume the transportation world is going to remain on the same track.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>Studies)</td>
<td>5.2 B</td>
<td>6/11/2021</td>
<td>White</td>
<td>Level of Service Studies: In the second paragraph, the use of level of service as a foundational performance metric for Howard County streets needs to be reconsidered. This discourages infill development by making it difficult and expensive to develop where traffic is already busy. In turn, this encourages sprawl and development in the more rural areas of the county. The result is a transportation system that is dangerous to our health by perpetuating reliance on motor vehicles, and is unsafe for people on foot, bicycle, or accessing transit because road designs are difficult to navigate or cross safely if you are not in a car. We need new thinking in Howard County that does not rely on LOS as the driving force behind roadway design. Howard County should be a leader in Maryland in tackling this issue, following the lead of other forward-thinking agencies that have adopted Vehicle-Miles-Travelled (VMT) as a key transportation metric for new development, thereby rewarding measures that reduce reliance on cars and supporting access via transit, carpool, walking and bicycling. This will also reduce the environmental impact of new development in Howard County.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>201</td>
<td>5 (Traffic</td>
<td>5.2 B.1</td>
<td>6/11/2021</td>
<td>White</td>
<td>General Requirements: In reference to paragraph two, all of this results in faster speeds on Howard County roads, which degrades the safety of pedestrians, bicyclists and even motorists, and is one reason why transit has struggled to take hold in Howard County, because it is difficult and unsafe to reach transit stops on foot.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>202</td>
<td>Studies)</td>
<td>5.2 B.2</td>
<td>6/11/2021</td>
<td>White</td>
<td>Collection of Existing Data: In the first paragraph, we appreciate that bicyclists and pedestrians were added, but how does this information inform a LOS analysis? Is the intent to perform a Bicycle LOS analysis and a pedestrian LOS analysis, per the Highway Capacity Manual?</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>203</td>
<td>5 (Traffic</td>
<td>5.2 B.3</td>
<td>6/11/2021</td>
<td>White</td>
<td>Projection of Future Traffic Volumes: For paragraph six, instead of relying on vague statements like this, the manual should define VMT reduction as a metric by which future development will be assessed.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>204</td>
<td>Studies)</td>
<td>5.2 B.3</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Projection of Future Traffic Volumes: paragraph five, highlighted &quot;Use of higher than necessary growth rates&quot; and commented, And the use of excessively high peak period design factors for motor vehicles. If we are serious about creating a multimodal system that is used, then we may need to increase the cost of time that motorized users of the roads experience. I believe we need a fundamental shift from laying down more asphalt to serve the development patterns to a new paradigm of incentives for development that needs fewer car trips.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment by</td>
<td>Comment</td>
<td>Status</td>
<td>Resolution</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------</td>
<td>---------</td>
<td>------------</td>
<td>------------</td>
<td>-------------------------------------------------------------------------</td>
<td>---------------------</td>
<td>------------</td>
</tr>
<tr>
<td>205</td>
<td>5 (Traffic Studies)</td>
<td>5.2 B.3</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Projection of Future Traffic Volumes: paragraph six and seven, commented, We can’t have our cake and eat it. The first paragraph says design for cars and the second says design for multimodal. It’s crunch time. We need to decide what we want the County to be in a generation.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>206</td>
<td>5 (Traffic Studies)</td>
<td>5.2 B.3</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Projection of Future Traffic Volumes: paragraph nine, highlighted “traffic” and commented, There’s that word again. Maybe the solution is to more broadly define the word, or put the word “multimodal” in front of every use of the word “traffic”.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>207</td>
<td>5 (Traffic Studies)</td>
<td>5.2 B.4</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Level of Service Analysis: Mimic all this language in LTS and pedestrian travel. Another alternative is to fall back to an activity based model of transportation demand and figure out how the development, in the context of the General Plan, will generate trips and mode share that foster the quality of life we want in the County. Some jurisdictions (Eugene, OR) are utilizing the paradigm of the 20 minute city to foster quality of life.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>208</td>
<td>5 (Traffic Studies)</td>
<td>5.2 B.4.c</td>
<td>6/11/2021</td>
<td>White</td>
<td>Level of Service Study Results: Again, this is the reason why intersections are wide and difficult to cross in Howard County. They are designed to flow without delay at peak hour. This means faster motor vehicle speeds and reduced safety for all users.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>209</td>
<td>5 (Traffic Studies)</td>
<td>5.2 C</td>
<td>6/11/2021</td>
<td>White</td>
<td>Pedestrian Studies: Strike the first sentence of the second paragraph. All curved roads should have sidewalks on both sides, even short cul-de-sacs. This corrects a flaw in the original design of residential areas in Howard County, which required sidewalks on only one side of cul-de-sacs.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>210</td>
<td>5 (Traffic Studies)</td>
<td>5.2 C</td>
<td>6/11/2021</td>
<td>White</td>
<td>Pedestrian Studies: The point of the sixth paragraph appears to be that inter-parcel pathway connections are beneficial and encouraged, so that people can walk between adjacent parcels without having to access the street. This is not clearly stated, recommend to revise.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>211</td>
<td>5 (Traffic Studies)</td>
<td>5.2 C</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Pedestrian Studies: Highlighted, &quot;Safety and general community well-being...&quot; and commented, Add a sentence like, &quot;The best scenario of our future is a built environment that makes walking safe, comfortable and useful for access.&quot;</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>212</td>
<td>5 (Traffic Studies)</td>
<td>5.2 C</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Pedestrian Studies: paragraph four, Neighborhood commerce, food stores, dance studios, restaurants, etc. See my later comments for other destinations.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>213</td>
<td>5 (Traffic Studies)</td>
<td>5.2 C</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Pedestrian Studies: paragraph five, highlighted and commented, Does the CS Policy not affect this at all? Worthy of at least a mention?</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>214</td>
<td>5 (Traffic Studies)</td>
<td>5.2 C</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Pedestrian Studies: Highlighted, Safety and general community well-being...&quot; and commented, The best scenario of our future is a built environment that makes walking safe, comfortable and useful for access.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>215</td>
<td>5 (Traffic Studies)</td>
<td>5.2 C.1</td>
<td>6/11/2021</td>
<td>White</td>
<td>Midblock Crosswalks: The third paragraph in this section should be rewritten with a Safe Systems approach in mind. The decision to provide a pedestrian crossing should be based on safety, not on the volume of pedestrians. This sets up an unreasonable threshold of minimum pedestrian volumes within a transportation system that is inherently unsafe for people on foot, which is the reason why people aren't out walking in the first place. Furthermore, warrants are not appropriate at midblock trail crossings, where the only option is to cross at that location.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>216</td>
<td>5 (Traffic Studies)</td>
<td>5.2 C.1</td>
<td>6/11/2021</td>
<td>White</td>
<td>Midblock Crosswalks: Paragraph three and four should not be stated as &quot;must&quot; requirements, as there have been examples of successful midblock crossings that solve a safety issue that would not meet these criteria.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>217</td>
<td>5 (Traffic Studies)</td>
<td>5.2 C.1</td>
<td>6/15/2021</td>
<td>Schoen</td>
<td>Midblock Crosswalks: paragraph one, add &quot;...crossing locations connecting a multi-use trail on each side of a roadway are not subject to minimum pedestrian volume criteria for installation of crossings.&quot; This is from Brentwood, TN - see link 2 paragraphs down.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment by</td>
<td>Comment</td>
<td>Status</td>
<td>Resolution</td>
</tr>
<tr>
<td>-----</td>
<td>----------------</td>
<td>---------</td>
<td>-----------</td>
<td>------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>218</td>
<td>5 (Traffic Studies)</td>
<td>S.2.C.1</td>
<td>6/15/2021</td>
<td>Schoen</td>
<td>Midblock Crosswalks: paragraph three, highlighted 20 pedestrians or bicyclists an hour, commented Count children and students as double, as does Brentwood, TN <a href="https://www.brentwoodtn.gov/Home/ShowDocument?id=4865">https://www.brentwoodtn.gov/Home/ShowDocument?id=4865</a>. What about elderly, or impaired counting double?</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>219</td>
<td>5 (Traffic Studies)</td>
<td>S.2.C.1</td>
<td>6/15/2021</td>
<td>Schoen</td>
<td>Midblock Crosswalks: paragraph six, highlighted &quot;Crosswalk illumination shall be provided at all midblock or uncontrolled approach crosswalks&quot; and commented, Good!!! Should we specify illumination level or is this given elsewhere?</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>220</td>
<td>5 (Traffic Studies)</td>
<td>S.2.C.1</td>
<td>6/15/2021</td>
<td>Schoen</td>
<td>Midblock Crosswalks: paragraph seven, added at the end of the paragraph, &quot;Provided that it does not narrow a bicycling facility or otherwise reduce safety.&quot;</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>221</td>
<td>5 (Traffic Studies)</td>
<td>S.2.C.1</td>
<td>6/15/2021</td>
<td>Schoen</td>
<td>Bulleted list: Good! Thank you.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>222</td>
<td>5 (Traffic Studies)</td>
<td>S.2.D.1</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Bicyclist Studies Overview: highlighted &quot;These higher stress-corridors prevent people who ride bikes...&quot; and commented, This and the material preceding is great! Thank you. While I like seeing all the LTS material, are we better referring to an outside source? This would also help if there are updates to the LTS methodology or its application to special situations.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>223</td>
<td>5 (Traffic Studies)</td>
<td>S.2.D.2</td>
<td>6/15/2021</td>
<td>Schoen</td>
<td>Bicyclist Studies Definitions: highlighted &quot;LTS 2 or better” and commented I believe the best way to handle this is to put the burden on the designer. Make LTS 1 the required default, with exceptions granted when it can be demonstrated that the link is not required for children or impaired adults because either (1) it serves no destinations to which they are expected to travel, or (2) there is an acceptable alternate route meeting LTS 1.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>224</td>
<td>5 (Traffic Studies)</td>
<td>S.2.D.2</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Bicyclist Studies Definitions: struck 'schools or libraries, LTS 1 is preferred' and commented, greatly expand the list; see my previous comments. Strip centers now have dance studios, children s/o able to make shopping errands, go to neighborhood pools, religious facilities, farmers markets, basketball courts, and so much more. We want to encourage an active, healthy lifestyle from a young age. Change preferred to required.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>225</td>
<td>5 (Traffic Studies)</td>
<td>S.2.D.3</td>
<td>6/11/2021</td>
<td>White</td>
<td>Criteria: LTS is a good tool for evaluating a network to determine where improvements are needed and this is appropriate for a traffic analysis because it helps to identify connectivity issues beyond the immediate vicinity of a project. However, LTS is not a great tool for determining facility type, as it is described here. The cross sections provided in Chapter 1 should be used to determine facility type. That is not made clear in this section. Also, if this is intended to help the designer choose a cross section at intersections, then it is flawed because none of the tables address protected intersection designs (as those were not available for study by the researchers who developed LTS). This is another reason why LTS isn't a great tool for this purpose. In general, we should rethink this section.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>226</td>
<td>5 (Traffic Studies)</td>
<td>S.2.D.3</td>
<td>6/11/2021</td>
<td>White</td>
<td>Criteria: Signalized intersections with no conflicting turning movements (RTOR or permissive left turns) can be relatively low stress. But, we should not make a blanket statement that all signalized intersections are low stress, as this is where most bike crashes occur in urban areas. Conflicting turning movements are a particular problem.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>227</td>
<td>5 (Traffic Studies)</td>
<td>S.2.D.3</td>
<td>6/11/2021</td>
<td>White</td>
<td>Criteria: Pocket lanes should be avoided as they are uncomfortable and less safe for bicyclists than protected intersections. Chart d. should be deleted.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment by</td>
<td>Comment</td>
<td>Status</td>
<td>Resolution</td>
</tr>
<tr>
<td>-----</td>
<td>-------------</td>
<td>---------</td>
<td>------------</td>
<td>------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>228</td>
<td>5 (Traffic</td>
<td>S.2 D.3</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Bicyclist Studies Criteria: highlighted &quot;After determining the appropriate LTS for a given street&quot; and commented, Text above discussed the high stress link that prevents travel. In the same way that under the old paradigm we would not allow additional car traffic on a dysfunctional intersection for cars, we need to require that the actual routes be provided, not just one street in front of the development. This may require a PPP to accomplish.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>229</td>
<td>Studies</td>
<td>S.2 D.3</td>
<td>6/15/2021</td>
<td>Schoen</td>
<td>Bicyclist Studies Criteria: highlighted &quot;Signalized intersections are also Considered LTS 1&quot; and commented, 1. Only IF they have no right turn lanes. If they do, they require further analysis. 2. Only if signal design incorporates all the features needed for bike and ped safety, including, but not limited to, LPI, no turn on red where conflicts will be created, no sweeping geometry for turns, bicycle boxes where needed to avoid conflicts. We probably need a section for signal design for bikes and peds or to find a good external reference.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>230</td>
<td>5 (Traffic</td>
<td>S.2 E</td>
<td>6/15/2021</td>
<td>Schoen</td>
<td>Safety Evaluations: paragraph one, Broaden this paragraph and those that follow to indicate conflicts, potential conflicts, other safety concerns, and lack of use by a mode due to perceived or actual lack of safe facilities for bike, peds and transit users that are NOT reflected in crash history. We need some guidance on what we mean by studies that go beyond crash data. One source and I think we should look for others, is the material on pp. 32-37 Roadway/Sidewalk Inventories of <a href="https://safety.fhwa.dot.gov/ped_bike/ped_focus/docs/fhwas0512.pdf">https://safety.fhwa.dot.gov/ped_bike/ped_focus/docs/fhwas0512.pdf</a> that starts, &quot;Not all pedestrian deficiencies can be identified by crash data.&quot;</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>231</td>
<td>5 (Traffic</td>
<td>S.2 E</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Safety Evaluations: paragraph four, highlighted &quot;pedestrian and bicycle crashes&quot; and commented, As indicated in other sections, you can't rely only on crash data for peds and bikes when even marginal facilities do not exist for them, since the majority of peds and bikes won't even go where it feels unsafe.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>232</td>
<td>5 (Traffic</td>
<td>S.2 E</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Safety Evaluations: paragraph five, highlighted &quot;County may decide to build a left-turn lane&quot; and commented, or it may decide to acquire land to construct multimodal facilities, install a bike / ped link to an adjacent development, complete a link described in Walk Howard or Bike Howard, change the location of a transit stop, etc. etc. Avoid giving one example that is car-centric.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>233</td>
<td>5 (Traffic</td>
<td>S.2 F</td>
<td>6/11/2021</td>
<td>White</td>
<td>Parking/Access Studies: Revise to include bicycle parking.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>234</td>
<td>5 (Traffic</td>
<td>S.2 F</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Parking/Access Studies: paragraph one, commented, Allocating true cost of providing parking to those using it also creates a more functional and fair network. See Donald Shoup's &quot;The High Cost of Free Parking.&quot;</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>235</td>
<td>5 (Traffic</td>
<td>S.2 F</td>
<td>6/11/2021</td>
<td>Schoen</td>
<td>Parking/Access Studies: paragraph four, highlighted &quot;Potential parking impacts should be...&quot; and commented Mitigation measures may include charging all or certain users for parking in order to achieve a target parking utilization factor. 85% has been suggested as optimal by some investigators.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>236</td>
<td>5 (Traffic</td>
<td>S.2 G</td>
<td>6/15/2021</td>
<td>Schoen</td>
<td>Noise Studies: I know this is out of scope, but if we really believe this, the County needs noise restrictions for landscape maintenance equipment.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>Chapter</td>
<td>Section</td>
<td>Date</td>
<td>Comment by</td>
<td>Comment</td>
<td>Status</td>
<td>Resolution</td>
</tr>
<tr>
<td>----</td>
<td>------------------</td>
<td>---------</td>
<td>-------------</td>
<td>------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------</td>
<td>------------------</td>
</tr>
<tr>
<td>237</td>
<td>5 (Traffic Studies)</td>
<td>5.3</td>
<td>6/11/2021</td>
<td>White</td>
<td>Roundabouts: Revise to clearly communicate that single-lane roundabouts are preferable to multilane roundabouts, which result in higher speeds and reduced safety and accommodation for pedestrians and bicyclists. Pedestrian and bicycle pathways within roundabouts should be clearly defined and crossing measures should be enhanced to encourage motorists to yield the right of way. Separated bike lanes are preferred rather than requiring bicyclists to merge with traffic in roundabouts.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>238</td>
<td>5 (Traffic Studies)</td>
<td>5.3</td>
<td>6/15/2021</td>
<td>Schoen</td>
<td>Intersection Traffic Control Devices: Signal timing, LPI, ped and bike heads, pushbuttons, sensing, signal prioritization and more are critically important to the comfort, safety and speed of ped, bike and transit travel. The main user cost for non-auto modes in Ho Co is time. If we want to achieve a more balanced user cost structure, I don't see how a CS design guide can fail to have a section covering signalized intersection design. Perhaps a good external reference exists; I could not find one. Best I found was a course <a href="https://registration.techtransfer.berkeley.edu/CourseStatus.awp?&amp;course=0500TE410000">https://registration.techtransfer.berkeley.edu/CourseStatus.awp?&amp;course=0500TE410000</a></td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>239</td>
<td>5 (Traffic Studies)</td>
<td>5.3 B</td>
<td>6/15/2021</td>
<td>Schoen</td>
<td>Roundabouts: Many of our roundabouts do not provide comfort and safety for cyclists and pedestrians; this is especially true for multi-lane roundabouts w/o separated paths. We need multimodal consideration in this section. Is there an external reference?</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>240</td>
<td>5 (Traffic Studies)</td>
<td>5.4 A</td>
<td>6/15/2021</td>
<td>Schoen</td>
<td>General: highlighted &quot;MUTCD&quot; and commented, ... including Interim Approvals. In addition, requests for experimentation with applications not in the MUTCD, &quot;...that will improve road user safety or operation...&quot; particularly those already demonstrated in other jurisdictions, may be submitted to DPW for consideration. See <a href="https://mutcd.fhwa.dot.gov/condexper.htm">https://mutcd.fhwa.dot.gov/condexper.htm</a></td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>241</td>
<td>5 (Traffic Studies)</td>
<td>5.5</td>
<td>6/15/2021</td>
<td>Schoen</td>
<td>Maintenance of Traffic During Construction: paragraph two and three, commented Add examples of diverting bicycle, pedestrian traffic and/or transit stop to automobile travel lane, to alternate temporary pedestrian crossings.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>242</td>
<td>5 (Traffic Studies)</td>
<td>5.5</td>
<td>6/15/2021</td>
<td>Schoen</td>
<td>Maintenance of Traffic During Construction: paragraph four, highlighted &quot;This situation would...&quot; and commented, Consideration shall be given to the length of detours, especially taking into account the slower speed of bicycles and pedestrian traffic.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>243</td>
<td>5 (Traffic Studies)</td>
<td>5.5</td>
<td>6/15/2021</td>
<td>Schoen</td>
<td>Maintenance of Traffic During Construction: paragraph six, highlighted &quot;Traffic&quot; and commented, Vehicle, bicycle, pedestrian and transit traffic volumes:...</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
<tr>
<td>244</td>
<td>5 (Traffic Studies)</td>
<td>5.5</td>
<td>6/15/2021</td>
<td>Schoen</td>
<td>Maintenance of Traffic During Construction: paragraph nine, highlighted &quot;Placement of signs...&quot; and commented, Please include construction equipment, vehicles, material staging, etc. I see this very often.</td>
<td>Discuss with CSIT</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 3
Design of Bridges, Retaining Walls and Small Structures

3.1 INTRODUCTION
A. Responsibility of the Designer .......................... 3-X
B. Limitation of Topics Presented in the Design Manual ............ 3-X
C. Abbreviations ............................................ 3-X
D. Definitions .............................................. 3-X

3.2 GENERAL FEATURES OF DESIGN
A. Coordination with Road and Street Planning .......................... 3-X
B. Design Specifications ....................................... 3-X
C. Technical Reference for Design .................................. 3-X
D. Basic Information Required for Design .......................... 3-X
E. Selection of Retaining Wall Type .................................. 3-X
F. Selection of Bridge Type ....................................... 3-X
G. Selection of Culverts ......................................... 3-X
H. Structures Over Waterways ...................................... 3-X
I. Clearances .................................................. 3-X
J. Bridge Roadway Section ........................................ 3-X
K. Horizontal and Vertical Alignment .............................. 3-X
L. Subsurface Investigations ....................................... 3-X
M. Foundation Reports .......................................... 3-X
N. Scour Reports ............................................... 3-X
O. Bridge Inspection ........................................... 3-X

3.3 DESIGN LOADING – HIGHWAY STRUCTURES
A. General ................................................... 3-X
B. Dead Load ................................................... 3-X
C. Live Load ................................................... 3-X
D. Wind Loads .................................................. 3-X
E. Thermal Forces .............................................. 3-X
F. Force of Stream Flow ........................................ 3-X
G. Earth Pressure .............................................. 3-X
H. Earthquake Forces .......................................... 3-X
I. Distribution of Loads ......................................... 3-X
J. Constructability ............................................ 3-X

3.4 SUBSTRUCTURES AND RETAINING WALLS
A. Retaining Walls ............................................ 3-X
B. Abutments .................................................. 3-X
C. Piers ....................................................... 3-X
D. Foundations .................................................. 3-X
E. Substructure Protection ....................................... 3-X
F. Slope and Bank Protection .................................... 3-X

3.5 BRIDGE SUPERSTRUCTURE
A. Slab on Beams and Girders .................................. 3-X
B. Beams and Girders .......................................... 3-X
C. Steel Beams and Girders .................................... 3-X
D. Prestressed Concrete Beams .................................. 3-X
E. Bridge Drainage ............................................ 3-X
F. Expansion Joints ........................................... 3-X
G. Bearings ..................................................... 3-X
H. Drainage Troughs ........................................... 3-X
I. Elevations ................................................... 3-X
J. Sidewalks ..................................................... 3-X

3.6 SHARED USE PATH BRIDGES
A. General ................................................... 3-X
B. Loading ..................................................... 3-X
C. Clearances .................................................. 3-X
D. Profile and Grade .......................................... 3-X
E. Railings and Fencing ........................................ 3-X
F. Lighting ..................................................... 3-X
G. Aesthetics/Structure Type .................................... 3-X
H. Hydraulics .................................................. 3-X

3.7 SHARED USE PATH UNDERPASSES .................................. 3-X
A. General ................................................... 3-X
B. Clearances .................................................. 3-X
C. Profile and Grade .......................................... 3-X
D. Lighting ..................................................... 3-X
E. Aesthetics ................................................... 3-X
F. Drainage ..................................................... 3-X

3.8 BOX CULVERTS
A. Analysis .................................................. 3-X
B. Design Guidelines .......................................... 3-X
C. Bottomless Box Culverts (Rigid Frames) ....................... 3-X

3.9 PIPE CULVERTS
A. Geometry ................................................... 3-X
B. End Treatment ............................................. 3-X
C. Foundation Requirements .................................... 3-X

3.10 UTILITIES ON BRIDGES
A. Telephone Lines & Cable .................................... 3-X
B. All Other Utilities .......................................... 3-X

3.11 REHABILITATION OF EXISTING STRUCTURES
A. Introduction ............................................... 3-X
B. Superstructure Repairs ..................................... 3-X
C. Substructure Repairs ...................................... 3-X
D. Retaining Walls ............................................ 3-X
E. Maintenance of Traffic ..................................... 3-X

3.12 LOAD RATINGS
A. Introduction ............................................... 3-X
3.13 PLAN PREPARATION GUIDELINES
A. Introduction............................................. 3-X
B. Sheet Layout and Order.............................. 3-X

3.14 REFERENCES.......................................... 3-X
3.1 Introduction

A. Responsibility of the Designer

This chapter addresses the selection and use of design and evaluation criteria and practices applicable to the design and maintenance of Public Works structures including bridges, retaining walls and small structures in Howard County. The subject matter presented herein includes specifications and guidelines for the selection, analysis and design of Public Works structures and their individual subcomponents. While the requirements described for the various aspects of design will include and cover the majority of conditions encountered, there is no intention to relieve the Designer of the responsibility to recognize when conditions are not favorable for the application of these design guidelines. The Designer shall be continually alert to those conditions that cannot be satisfied by the application of these design guidelines.

The design specifications to be used for various types of Public Works structures are identified and referenced herein. Guidance and interpretations of the design specifications and specific standard design requirements of the Bureau of Engineering are also presented in this Chapter.

B. Limitations of Topics Presented in the Design Manual

It is not possible to include in this manual all features and topics of design and drafting necessary to accomplish the development of structure designs and construction documents for all projects incorporating bridges, retaining walls and small structures. The topics addressed herein are limited to those that will assist the Designer in performing most engineering design tasks in an efficient manner and comply with currently accepted engineering practice as well as Howard County practice. Although it is the Designer’s responsibility to exercise professional judgment in the acceptance and/or use of the design guidelines included herein, the Designer shall recognize that they are being provided to assist in the development of the project in the manner preferred by Howard County. However, projects that are funded by Federal and/or State Aid may require compliance with the design criteria and standards set forth by the funding agency. Projects may also be subject to current, future and evolving regulations set forth by various local state and federal regulatory and resource agencies which may require deviation with or expansion of the criteria and standards herein. Any deviations from these design guidelines shall be brought to the attention of Howard County immediately. Any waivers of this design manual shall be justified to Howard County in writing, from an engineering evaluation, and shall include relevant considerations of life cycle costs and maintenance requirements. Approval or denial of the waiver requests will be by return letter signed by the Chief of the Bureau of Engineering.

C. Abbreviations

For standard abbreviations, refer to Section 1.2, “Abbreviations,” of this design manual.

D. Definitions

Bridge: A structure designed to carry vehicular, pedestrian and/or bicycle traffic having a roadway surface comprised of a structural element such as reinforced concrete or timber.

Culvert: A structure designed to carry vehicular, pedestrian and/or bicycle traffic having a roadway surface placed atop earthen fill and/or a structure designed as a continuous unit between the superstructure and substructure.

Small Structure: Any bridge or culvert structure that measures less than 20' clear between abutments (measured parallel to the roadway centerline).

Retaining Wall: Any structure that is built to retain a fill section or a roadway as a means to eliminate or minimize impacts to adjacent properties or structures, with greater than 3'-0" exposed. For retaining walls with less than 3'-0" exposed, refer to the Subdivision and Land Development Regulations.
3.2 General Features of Design

A. Coordination with Road and Street Planning

Bridges, small structures and retaining walls are required for grade separations, stream crossings and earth retention usually as elements of a road or street facility. Planning and design of these structures must be coordinated with the road or street planning for overall project purpose as well as agreement in alignment, grade and typical section. For structures in historic districts and along scenic roads, aesthetics are also important.

B. Design Specifications

1. AASHTO

For bridges, retaining walls and small structures, the basic design specifications to be used are those of the latest edition of the "LRFD Bridge Design Specifications" of the Association of State Highway and Transportation Officials (AASHTO, Ref. 1), including subsequent interim specifications. Shared use path bridges and shared use path underpasses shall be designed in accordance with the AASHTO "Guide for the Development of Bicycle Facilities" (Ref. 23) and the AASHTO "Guide for Planning, Design and Operation of Pedestrian Facilities" (Ref. 27).

2. AREMA

The basic specifications to be followed in the design of railroad bridges or walls retaining railroad embankments are the current specifications of the American Railway Engineering and Maintenance-of Way Association (AREMA, Ref. 2).

3. Howard County Storm Drainage Design Manual

Hydrologic and hydraulic design of structures shall be in accordance with the "Howard County Storm Drainage Design Manual Volume I" (Ref. 7).

4. Maryland Department of Transportation, State Highway Administration, Office of Structures (MDOT SHA OOS) Manual for Hydrologic and Hydraulic Design

Scour analyses and countermeasure design shall also be in accordance with the MDOT SHA OOS "Manual for Hydrologic and Hydraulic Design" (Ref. 12).

C. Technical References for Design

1. Capital Projects

Capital projects will be designed using Maryland Department of Transportation State Highway Administration Office of Structures Structural Guidelines and Procedure Memorandums (Ref. 10) Structural Details Manual (Ref. 11), and the Aesthetic Bridges - Users Guide (Ref. 26).

2. Other Projects

Other projects, such as Developer Projects, shall be designed similarly as Capital Projects unless written authorization is granted by the Chief of the Bureau of Engineering.

D. Basic Information Required for Design

1. General Information

To determine the overall configuration of a structure, the Designer must obtain or establish the project alignment, profile and typical section and impose them on the existing physical topography.

2. Studies and Reports

Previous studies, engineering reports and preliminary plans, if any, shall be reviewed before beginning any new work on the project.

3. Record Plans

Records of utilities, existing structures, stream flow, and subsurface investigations at or near the proposed structure must be obtained.

4. Topography

Existing topographic maps such as those available from the United States Coast and Geodetic Survey and the Howard County Department of Public Works may be used for preliminary studies. Hydrologic studies shall be based upon the best available topographic maps.
mapping. Existing mapping must be supplemented by aerial photogrammetry and/or ground surveys to provide adequate detailed topography at the project site.

E. Selection of Retaining Wall Type

The type of retaining wall to be constructed usually is determined by the cost of construction. However, some other factors such as critical clearances or right-of-way cost may affect the decision. The most economical type of wall to construct is primarily a function of the height of the wall. A gravity type wall is the most economical for low walls, a cantilever type wall for intermediate heights and a counterfort type for high walls. Other factors that shall be considered in the comparison of alternate wall types are the lateral earth pressure, the type of foundation, the depth of piles, and the allowable bearing pressure. The simplicity of construction and the durability of a gravity wall must also be considered in the final decision. See Section 3.4.A.1 for a description of retaining wall types.

In the historic districts and on scenic roads the aesthetics of a stone facing, colored and impressed concrete brick or wood trim may merit consideration. The approval of aesthetic amenities and/or special landscaping shall be subject to the review and approval by Chief of the Bureau of Engineering.

1. Proprietary Walls

Proprietary walls are patented systems for retaining soil. Depending on conditions, they can be more economical when compared to conventional retaining wall types. These walls are often more economical for long abutments and where high wall heights are dictated by field conditions. This type of wall construction can also save on bridge superstructure costs by reducing span lengths.

The detailed design and associated drawings are the responsibility of the proprietary wall firm, and wall products are typically provided through licensed regional manufacturers. The Maryland State Highway Administration requires that proprietary walls considered for use on capital projects must be on the list of Approved Proprietary Retaining Walls provided in the MDOT SHA Structural Guidelines and Procedure Memorandums (Ref. 10).

a. MSE

Mechanically stabilized earth (MSE) walls are comprised of a reinforced soil mass and modular precast concrete facing panels which are vertical or near vertical. MSE walls may be used where conventional gravity, cantilever, or counterforted walls are considered, and are well suited for supporting fills and where substantial total and differential settlements are anticipated. The precast facing panels are adaptable to a variety of architectural finishes. MSE walls should not be used where utilities other than highway drainage would be constructed in the reinforced soil zone, where erosion or scour may undermine the reinforced soil zone, or where galvanized reinforcements may be exposed to surface or ground water contaminated by pollutants characterized by low pH and high chlorides or sulfates.

b. Precast Gravity

Precast gravity walls, also known as segmental or modular retaining walls, consist of interlocking, soil-filled concrete units, and depend on dead weight for stability. The precast units can also be used with soil reinforcements to construct taller walls than those that resist loads by gravity alone. The stacked prefabricated units offer fast, easy installation, with the flexibility of curved and corner alignments and terraced walls. The concrete units may be colored and the wall face fabricated in a variety of shapes and textures.

Precast gravity walls should not be used on curves with a radius of less than 800 ft unless the curve can be substituted as a series of chords, or where the longitudinal differential settlement along the face of the wall is greater than 1/200.

c. Gabions

Gabions are stacked, stone-filled wire baskets that are interconnected to form gravity-type walls. Gabion walls are simple to install and are well suited for use as slope
protection, low-height retaining walls and, in some cases, channel linings. They are permeable, which allows for backfill drainage and also permits the growth of natural vegetation. Once vegetation has been established, these walls blend well into the natural environment. Gabion walls are inherently flexible and are able to tolerate differential settlement that may result from unstable foundation soils. Consideration as a stream channel lining or stream bank stabilization technique shall only be made after considering the potential for debris lodging which can damage and accelerate failure of gabions. Due to their rough surface, gabions are not to be used where people may be walking or bicycling adjacent to the face of the wall.

F. Selection of Bridge Type

1. Site Conditions

Since no two bridge sites are exactly equivalent, the Designer must develop a particular span arrangement and bridge type for each individual site. Conditions at the proposed site such as existing grading, type of crossing and subsurface conditions must be taken into consideration. The constraints of limited right-of-way are relevant to some sites. Bridges in historic districts and on scenic roads should be designed to preserve or enhance the appearance of the road and to afford views from the bridge.

2. Materials

The type of material to be used in construction will depend on a variety of factors including suitability of material to load requirements, availability of material, construction procedures, maintenance of traffic, construction time, unusual site conditions and relative life cycle cost of the various types of materials. The County precludes the use of prestressed concrete box beams and planks without the expressed written permission of the Chief of the Bureau of Engineering due to the difficulty in maintaining these types of structures. Wooden bridges in County park property may be acceptable subject to the review and approval by both the Chief of the Bureau of Engineering and Director of the Department of Recreation and Parks.

3. Cost

Since the relative economy of structure types cannot be generalized, it will be necessary to prepare economic comparisons of alternate bridge types suitable for a given situation in order to determine which type is most suitable from a cost standpoint. Future maintenance costs should be considered in addition to initial costs to ensure that the structure with the lowest life cycle cost is used.

To prepare these economic comparisons, it is first necessary to determine the structure quantities that are associated with each type of bridge. These may be obtained from preliminary designs, from quantity charts, from historical data, or by a combination of these methods.

Unit prices for application to the estimated quantities should be determined based on recent bids tabulations for comparable projects in the Howard County area. These unit prices must be adjusted by judgment on the basis of project size, location and construction difficulties.

4. Safety and Aesthetics

Important considerations are safety and aesthetics. Maximum traffic safety is provided by deck type overpass structures with adequately designed safety barriers and open span underpass structures without piers or other structural elements adjacent to the roadway.

Bridges on scenic roads or in historic districts merit special design consideration. The width of the deck should be consistent with the adjacent roadway. Barrier parapet walls should incorporate open railings at passenger eye level to permit views of the river crossing and adjacent scenery. Abutment embankments/slopes and piers shall be positioned to retain the natural stream channel adjacent to the bridge. If erosion is of concern, consider bio-engineering rather than riprap, gabions or a concrete channel.

Wider sidewalks for pedestrian use or scenic views, wider bicycle facilities, open railings, architectural treatments, and special lighting
should be considered where it is appropriate to improve the utility and appearance of the bridge to make it more compatible with the other elements of the surrounding community, especially in historic districts along a scenic road. Modest use of special treatments can be done without a significant increase in cost, but such aesthetic requirements as an increase in span lengths, special finishes and special structural shapes can result in significant cost increases. The added cost resulting from special treatments must be evaluated to determine that the improved aesthetics are worthy of the increased cost.

5. Maintenance Requirements

Future maintenance is another important consideration in the design of new bridges and existing bridge rehabilitations. All bridge components must be accessible for routine biennial inspection as well as maintenance, either by a snapper or some other means. Designs should provide for superstructure jacking to facilitate servicing, repair, or replacement of bridge bearings.

Key items to minimize future maintenance include:

- Protect stream channels from erosion and piers and abutments from scour.
- Provide roadway drainage at abutments and wing walls to prevent erosion.
- Provide adequate vertical and horizontal clearances to prevent vehicle damage.
- Consider the feasibility of painting structural steel and evaluate the suitability of weathering steel.
- Consider using precast prestressed concrete structural members.
- Investigate the feasibility of using integral or semi-integral abutment construction.

G. Selection of Culverts

1. General

Culverts are generally cost-effective solutions for relatively small stream crossings. A single culvert can be used for the smallest crossing. Larger stream crossings can utilize multiple cell box culverts or a battery of pipe culverts. In each case, all factors of hydraulics, topography, economics and environmental factors must be considered before a culvert alternative is selected. It will be necessary to comply with the policies of all permitting agencies concerning the need for permits and the maintenance of the natural environment. Design of culverts shall meet all the requirements of bridges, including those for foundation design and scour design. For small culverts with invert, subsurface borings taken for the roadway will usually be sufficient for the foundation design.

Box culverts are generally made of concrete with mild reinforcing. These can be cast in the field or precast at a factory in units which are then shipped and placed in the field. When precast concrete box culverts are used, the box culvert ends and all wing walls, headwalls and toe walls shall be cast in place; refer to Volume IV Design Manual.

Pipe culverts are available in a large range of shapes, sizes and materials. Steel pipes can consist of pipes rolled at the mill such as corrugated metal pipes (CMP’s, etc.) or pipes made from steel plates assembled at the job site such as structural steel plate pipes (SPP’s, etc.). Steel pipes less than 4’ in diameter may be either the CMP or the SPP type. Steel pipes larger than
4" in diameter must be of the SPP type.

Culverts without paved inverts, such as structural plate pipe arches and precast concrete arches, are also commonly available. These types of structures are very dependent on the foundation conditions and their use may require extensive foundation and scour investigation work.

Refer to Volume I Design Manual for additional information concerning culverts.

2. Advantages

For streams of a size within the hydraulic capacity of a culvert, the culvert is usually less costly to design, construct and maintain than a bridge. A culvert structure is less susceptible than a bridge to structural defects due to differential settlement, undermining and scour.

3. Disadvantages

In most cases, culverts tend to have the following disadvantages:

- The design opening is wider than the existing channel requiring undesirable channel modifications.
- Siltting occurs during low flow.
- Multiple cells tend to obstruct flow and accumulate debris during flood flow.
- Water velocity increases in the culvert cause downstream scour.

H. Structures over Waterways

1. Hydrologic Studies

Hydrologic studies shall be performed for all structures crossing waterways. Flow rates and hydrographs associated with these studies shall be developed in accordance with procedures described in the “Howard County Storm Drainage Design Manual,” Vol. I (Ref. 7) for typical roadway culverts or the MDOT SHA “Manual for Hydrologic and Hydraulic Design” (Ref. 12) for Small Structures or Bridges. Existing stream gauging data, observed high water marks and observations of local residents shall be used to check and calibrate hydrologic calculations based on empirical methods, including those noted in Reference 12.

2. Hydraulic Studies

a. Bridges

Analysis of the effect of bridges on the stream flow and establishment of the design high water at the bridge site or at other critical points shall be in accordance with the procedures described in the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12).

A freeboard of one (1) foot from the design high water to the underside of the superstructure shall be maintained. Refer to the “Howard County Storm Drainage Design Manual” (Ref. 7) for specific freeboard requirements.

b. Box Culverts

The effects and characteristics of flow in box culverts shall be analyzed in accordance with the procedures described in the Federal Highway Administration Circular “Hydraulic Design of Highway Culverts” (HDS–5) (Ref. 8) or similar publications. Due consideration shall be given to both inlet control and outlet control.

3. Hydraulic Design Criteria

a. Highwater Elevation

A stream crossing structure shall be designed to interfere as little as possible with the natural stream channel and shall conform to the “Howard County Storm Drainage Design Manual”, Vol. I (Ref. 7) and other State and Federal requirements.

b. Maximum Velocities

Discharge velocity shall be consistent with channel materials. For maximum and minimum velocities, refer to the “Howard County Storm Drainage Design Manual”, Vol I (Ref. 7), the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12)
and applicable environmental regulations.

4. Walking and Bicycling Use

Consideration shall be given to making provisions for walking and bicycling under structures placed over waterways. Where feasible, provide sufficient clearance for walking and bicycling use in these circumstance in accordance with the relevant sections of this chapter. In these locations, the Designer shall consider the pavement section and subgrade if they could be subjected to flooding and/or erosion.

I. Clearances

1. Horizontal Clearances - Highways

a. Bridge Roadway Width

The roadway width of bridges shall preferably be the full width of the approach roadway section including the shoulders. Minimum bridge roadway widths are discussed in the MDOT SHA "Structural Guidelines and Procedure Memorandums" (Ref. 10) for various classifications of highways. These minimum widths shall be adhered to unless written authorization is provided by the Chief of the Bureau of Engineering.

If sidewalks and/or bicycle facilities exist on either approach roadway section, or are anticipated within the bridge's service life, those sidewalks and/or bicycle facilities shall be carried across the bridge. If sidewalks and/or bicycle facilities are not anticipated within the bridge's service life, an eight-foot shoulder shall be provided on each side of the bridge to provide accommodation for people walking and bicycling.

b. Underpass Clearance

For an open section roadway or a bridge, the piers or abutments shall be set to provide clearance for the full shoulder plus a guardrail or concrete barrier. The roadway face of the guardrail shall be at least 5'-0" from the face of the pier or abutment. The face of the guardrail or barrier shall be at least 2'-0" outside of the normal shoulder line. For closed section roadways, the face of pier or abutment shall be set a minimum of 8'-0" back of the curb line. Piers and abutments shall be protected by guardrail or crash walls.

If sidewalks and/or bicycle facilities exist on either approach roadway section, or are anticipated within the bridge's service life, piers or abutments shall be set to provide sufficient horizontal clearance to allow for accommodation of those facilities. If sidewalks and/or bicycle facilities are not anticipated within the bridge's service life, piers or abutments shall be set to accommodate a minimum eight-foot shoulder on each side of roadway under the bridge to provide accommodation for people walking and bicycling.

2. Horizontal Clearances - Railroads

Horizontal clearances from railroad tracks to piers, abutments or walls of an overpass structure shall be in accordance with the requirements of AREMA (Ref. 2) and the policy of the particular railroad for the class of track involved. In the case of privately owned spurs, the clearances shall be at least equal to the requirements of the Maryland Public Safety Laws and meet the approval of the railroad operating over the spur.

3. Vertical Clearance

a. Highways

Vertical clearance to highway or railroad structures over highways shall be 16'-9", which provides for 16'-0" minimum over any usable portion of the roadway and shoulder and 9" of future surfacing.

b. Railroad

Vertical clearance over railroads shall be 24'-3" (top of rail to underclearance) for electrified railroads, and 23'-0" for all others. Clearance shall be approved by the railroad.
Chapter 3: Design of Bridges, Retaining Walls and Small Structures

3. Bridge Roadway Section

1. Curbed (Closed) Section

The flow line of a curbed roadway section shall be continuous across the bridge.

2. Rural (Open) Section

The shoulder of a rural section shall be carried across the bridge. The cross slope configuration shall conform to that of the approach roadway except that the cross slope in the shoulder area on the bridge shall be an extension of the adjacent traffic lane (i.e., no shoulder breaks on bridge). The approach roadway shoulder slope shall be transitioned to meet the shoulder slope of the structure beginning at a minimum distance of fifty (50) feet from the ends of the structure.

3. Barriers

All barriers on bridges and approaches, including transitions, shall meet or exceed MDOT SHA and AASHTO specifications, including crash testing requirements based on the roadway classification. The MDOT SHA “Bridge Railing Manual” (Ref. 25) provides guidance on railing selection and shall be adhered to for capital projects unless written authorization is provided by the Chief of the Bureau of Engineering. Selection of the appropriate barrier, with or without metal railing, should be made with consideration given to the type of roadway facility (controlled access or non-controlled access) and type of pedestrian and bicycle facilities on the bridge. The Designer shall use care in selecting railing systems to ensure serviceability. Safety fence shall be provided in accordance with MDOT SHA requirements. Decorative barriers/railings or bridge lighting appurtenances shall be subject to the approval of the Chief of the Bureau of Engineering.

In accordance with the AASHTO “Guide for the Development of Bicycle Facilities” (Ref. 23), the minimum recommended distance between a shared use path and the roadway curb (i.e., face of curb) or edge of traveled way (where there is no curb) on a vehicular bridge is 5 feet. Where the separation is less than 5 feet a physical barrier or railing should be provided between the path and the roadway. The barrier or railing shall be in accordance with the provisions of AASHTO (Ref. 1 and Ref. 23) for a pedestrian, bicycle, or combination railing. A barrier or railing between a shared use path and adjacent roadway should not impair sight distance at intersections and should be designed to limit the potential for injury to errant motorists and bicyclists.

Careful attention shall be given to the treatment of railings at bridge ends. Exposed rail ends, posts and sharp changes in the geometry of the railing shall be avoided. A smooth transition by means of a continuation of the bridge barrier, flared end posts, roadway guardrail anchored to the bridge barrier, continuation of bridge guardrail, or other effective means shall be provided to protect the traffic from direct collision with the bridge rail ends and to afford protection for people walking and bicycling. Guidelines for these transitions are specified in the MDOT SHA “Book of Standards for Highway and Incidental Structures” (Ref. 15).

K. Horizontal and Vertical Alignment

1. Bridges

The horizontal and vertical alignment of the bridge must be coordinated with the overall plan and profile of the approach roadway. Geometric design requirements concerning sight distances, minimum curve radii, superelevation, etc., shall be in accordance with Chapter 2, “Road and Street Design.” Methods and criteria for maintenance of traffic are contained in Chapter 5, “Traffic Studies.”

2. Horizontal Alignment of Box Culverts
a. Alignment with Waterway and Road

Culverts shall generally be located and aligned as closely as possible to the natural drainage course for which they are being designed. The skew angle shall be kept as close to 0 degrees as possible, while providing a minimum stream relocation, if any.

b. Maintenance of Flow

The Designer must consider the requirements for maintaining stream flow during construction. It may be necessary to provide a temporary channel in order to provide for maintenance of flow. Maintenance of stream flow plans shall be prepared in accordance with the latest edition of the MDE “Maryland Waterway Construction Guidelines” (Ref. 9).

L. Subsurface Investigations

In order to determine the type of foundation and allowable bearing pressures, borings will be required at the proposed locations of walls, culverts and bridge foundations. The information obtained should include elevation of the existing ground at the boring, a description and depth of the material encountered, number of blows per six (6) inches on the sampling spoon, recovery of cored rock, total depth of boring, the water table level and the time of observation. For small culverts with inverts, subsurface borings taken for the roadway will usually suffice for the foundation design.

Standard penetration borings through soil are required to be performed in accordance with AASHTO T206 and ASTM D1586. The number of blows required for each 6 inches of penetration or fraction thereof shall be recorded. The first 6-inch penetration is considered to be a seating drive. The number of blows required for the second and third six inches of penetration added together is considered the penetration resistance, N.

Split spoon samples shall be taken at every change in material at intervals not exceeding five (5) feet. All borings should be drilled to refusal and cored a minimum of 5 feet into rock. Refusal is defined as 50 blows or more per inch or less of penetration.

Foundation borings shall generally be located as follows: one boring at each end of each substructure unit for multibeam bridges; one boring at each end minimum with intermediate borings as required to maintain 100’ maximum c/c spacing for culvert type structures and retaining walls.

All the boring log information must be shown on the plans.

M. Foundation Reports

A formal Foundation Report is required for all retaining walls 4’ or greater in height measured from the top of wall to the ground line at the front face of wall; all box culverts; all pipe culverts with individual spans greater than 8’ measured perpendicular to the pipe; all hydraulic structures without inverts; and all bridges. For structures not meeting these requirements the Designer shall perform sufficient subsurface investigations and analysis to ensure the stability of the structure. The depth and number of borings shall be in accordance with AASHTO LRFD Bridge Design Specifications requirements.

The formal foundation report shall provide all information and calculations documenting that the subsurface investigations and foundation design have been made in accordance with the requirements of this Volume III Design Manual and AASHTO LRFD Bridge Design Specifications. In addition, the foundation report shall address the impact of settlement of approach fill embankment on bridge foundation design as well as pertinent foundation construction control and construction considerations. The Foundation Report shall be accompanied by boring logs plotted on a plan sheet and preliminary structure plans.

For all new or replacement bridges, detailed Foundation Reports shall be prepared for review and approval by the Chief of the Bureau of Engineering. Foundation Reports shall include copies of all boring and laboratory testing information including a project map noting the location of all test borings. For Capital Projects, Foundation Reports shall be prepared in accordance with applicable sections of the MDOT SHA “Structural Guidelines and Procedure Memorandums” (Ref. 10).

N. Scour Reports
Current regulations require that the construction, replacement or rehabilitation of any bridge structure which uses either full or partial funding from the Federal Government be accompanied by an approved Scour Analysis Report. Reports for such projects will be reviewed by the Maryland State Highway Administration Office of Structures (OOS). All scour reports shall be developed in accordance with the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12), in particular Chapter 11.

All scour reports shall be prepared and sealed by a registered professional engineer in the state of Maryland. Personnel involved in the evaluation of scour need to possess the technical qualifications, including practical experience, education and professional judgment, to perform the individual tasks assigned. Interpretation of results and conclusions of scour analyses shall be accomplished by registered engineers qualified in the appropriate disciplines. Because of the complexity of bridge scour, the evaluations shall be performed by an interdisciplinary team of engineers with the requisite knowledge in structural, hydraulic, river mechanics and geotechnical engineering.

For non-federally funded projects, scour reports may not be required if any of the following criteria applies:

- The project scope is limited to the rehabilitation of the bridge superstructure and/or minor rehabilitation of the substructure. Minor rehabilitation of the substructure shall be limited to abutment (or pier) repair and shall not include any changes to the overall geometry of the substructure units, with the exception of minor fascia treatments that do not reduce the total waterway opening by more than 10%.

- The project is a replacement or rehabilitation of a bridge or bottomless culvert where evidence of scour is minimal either through inspection or previous inspection reports and where the proposed abutment footings, or deep foundations such as piles, are founded in non-erodible rock. Rock where borings indicate a Rock Quality Designation (RQD) less than 50% shall be assumed to be erodible (FHWA Memorandum on Scourability of Rock – June 19, 1991).

- The project is a new, replacement or rehabilitated bridge or culvert along a private road or drive not governed by any county, state or local municipality easements, right-of-way or right-of-entry.

The county reserves the right to request that a formal Scour Report be prepared in accordance with MDOT SHA standards for any project within county right-of-way or along a roadway maintained by the county by virtue of easement, right-of-entry or prior agreement. A formal Scour Report shall be required for all bridges and small structures without integral paved inverts and which carry waterways. A formal Scour Report shall also be required for retaining walls which could be subject to stream action and which require a formal Foundation Report. The Scour Report shall be submitted in conjunction with the Foundation Report. The county may also request that a Scour Report be prepared for a structure for the purpose of re-evaluating the Structure Inventory and Appraisal Item 113. If a Scour Report is not requested by the county, the engineer of record shall still have the responsibility of ensuring that the bridge or culvert is designed in adequate consideration of the effects of scour.

Contraction, abutment and pier scour depths/elevations developed by scour analyses shall be used in the assessment of the bridge stability in accordance with Chapter 11 of the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12). For the Design Flood for scour, the material in the resulting scour prism shall be assumed to be removed, and the bridge shall be analyzed with stability factors as dictated by the AASHTO “LRFD Bridge Design Specifications” (Ref. 1). For the Check Flood for scour, the material in the resulting scour prism shall be assumed to be removed and the bridge shall be analyzed with a stability factor of 1.0.

0. Bridge Inspection

Howard County maintains an inventory of bridges and small structures. To assist the County, Designers are required to provide the following information for culverts with spans greater than 10’ and for all bridges:

- Design Storm Year
- Runoff Q in cfs
- Drainage area in acres
- High Water Elevation for the Design Storm
- Year of Maryland State Highway Specification used
- Year of AASHTO Specification used
P. Design Life

All bridges must be designed to achieve a minimum service life of 75 years or a longer period (e.g., 100 years), if so directed by the Chief of the Bureau of Engineering, for applicable capital projects.
3.3 Design Loading – Highway Structures

A. General

Loads and loading combinations shall be in accordance with the provisions of AASHTO (Ref. 1). The limit states described in the AASHTO specifications (Ref. 1) shall be investigated for the design and analysis of bridge components.

B. Dead Load

1. Future Wearing Surface

In addition to the dead load of the structure, an allowance shall be made in the design analysis for a future wearing surface. This shall be 25 lbs./sq. ft. for all except moveable spans and exceptionally long spans. The additional deck load for these spans shall be determined on an individual basis depending on the type of construction.

2. Unit Loads on Culverts

The dead load on culverts shall include the dead load of the box and the weight of earth above the box. Loads shall be calculated in accordance with AASHTO Specifications, (Ref. 1). Except for box culverts on piles, the dead load of the bottom slab and water within the box should be neglected in design of slabs and walls. These dead loads shall, however, be included when determining foundation pressures. In the absence of more exact information, the density of the soil shall be taken as 120 lbs./cu. ft. and 150 lbs./cu. ft. shall be used for the weight of the concrete.

3. SIP Forms

An additional allowance shall be made in the design analysis when the use of steel stay in place forms is required. This loading shall be 15 lbs./sq. ft. of deck form plan area. This value includes the weight of the forms plus concrete in the corrugation valleys of the forms.

C. Live Load

1. Design Loadings

For vehicular bridges and all other structures, an HL-93 loading shall be used. For additional information concerning Design Loadings, see the MDOT SHA “Structural Guidelines and Procedure Memorandums” (Ref. 10). Permanent deformations under overloads, live load deflections, and fatigue characteristics under service loadings shall be investigated, as specified in the AASHTO Specifications (Ref. 1). The loading for temporary structures will be determined by the Department of Public Works on the basis of the duration of time the temporary structure is expected to be in place and the anticipated traffic characteristics during that period. It shall not be less than HS-20 with standard over-load provisions, as specified in the AASHTO Specifications (Ref. 1).

D. Wind Loads

Wind loads calculated in accordance with AASHTO Specifications (Ref. 1) shall be applied to the bridge substructure and superstructure as indicated therein.

E. Thermal Forces

Thermal forces shall be as specified by AASHTO (Ref.1) for moderate climate.

F. Force of Stream Flow

The effect of flowing water on piers shall be calculated in accordance with AASHTO (Ref. 1).

No static or dynamic pressures shall be applied for ice floes, ice sheets or ice jams except under special circumstances for public structures such as pedestrian bridges in public parks. The consideration of occasional cost and safety must be considered in the structure’s life cycle cost and this determination shall be made by the Chief of the Bureau of Engineering.

G. Earth Pressure

Structures which retain earth shall be proportioned to withstand pressure as given by Rankine’s formula. In the absence of more specific information, an equivalent fluid pressure of 35 lbs./cu. ft. shall be...
used. This pressure is based on the assumption that a layer of porous backfill and a drainage system with weep holes will be provided to insure a low ground water elevation at the rear face of the structure.

If conditions are such that it is not possible to control the water table behind the structure, the structure shall be designed taking into account, below the water level, the full hydraulic pressure in conjunction with pressures of the submerged soil.

A sloping finished grade line behind the structure may be accounted for by computing the pressure on the basis of the depth of earth in a vertical plane at the heel of the footing.

1. Water Pressure

   If conditions are such that it is not possible to control the water table behind the structure, the structure shall be designed taking into account, below the water table, the full hydraulic pressure in conjunction with pressures of the submerged soil. Below the water table the unit weight of the retained soil is reduced to its submerged or buoyant value. As a result, the lateral earth pressure below the water table is reduced, while the retained water exerts a horizontal hydrostatic pressure.

   When ground water levels differ on opposite sides of a retaining wall, the upward buoyant force beneath the wall foundation tends to overturn the wall. Unequal ground water levels also result in seepage beneath the wall. The effect of seepage forces is to increase the load on the back of the wall (and decrease any passive resistance in front of the wall). Pore pressures in the backfill soil can be approximated through the development of a flow net or other analytical methods, and then added to the horizontal earth pressures acting on the wall.

J. Constructability

Constructability checks shall be completed in accordance with the provisions of the AASHTO Specifications (Ref. 1). The wind load provisions specified in the "Guide Specifications for Wind Loads on Bridges During Construction" of the Association of State Highway and Transportation Officials (AASHTO, Ref. 22), including subsequent interim specifications shall be used for wind loading on steel and concrete superstructures before the deck has been placed.

The load factors for construction loads shall be taken as the minimum specified in AASHTO (Ref. 1).
3.4 Substructures and Retaining Walls

A. Retaining Walls

The primary structural function of a retaining wall is to counteract the lateral forces caused by earth pressure. These forces have two principal effects on the wall. First, they tend to overturn the wall and secondly, these forces tend to push or slide the wall. Before designing specific parts of the wall, such as the footing, stem, etc., overall stability of the wall and the earth mass must be satisfied. The total earth mass containing the wall and its foundation must be in equilibrium. A subsurface investigation should be made to determine the possibility of a slip plane failure that would affect the global stability of the entire installation. The overturning moment about the toe of the footing, caused by the earth pressure and surcharge, must be resisted by the stabilizing moments of the dead load forces. Unless a structure is keyed into rock or is restrained by an adjacent structure, the horizontal earth pressure force must be resisted by friction between the footing and the foundation. Retaining walls used in subdivisions and site development plans shall use the retaining wall checklist when submitting designs.

Reinforced fills and proprietary retaining walls will be considered on a case by case basis. No consideration for use shall be given unless the system has been approved for use by the MDOT State Highway Administration.

Retaining walls are primarily either fill walls or cut walls. Fill walls are typically constructed from the bottom up and consist of placing material behind the face of the wall. Cut walls are typically constructed from the top down and consist of removing material in front of the face of the wall.

1. Fill Retaining Wall Types

There are six principal types of fill retaining walls: gravity walls, semi-gravity walls, cantilever walls, counterfort walls, buttress walls and MSE walls. Table 1 provides general guidelines for fill retaining wall selection.

a. Gravity Walls

Gravity Walls resist sliding and overturning by means of their mass, the resultant of all forces being within the middle third of any horizontal section through the wall. Reinforcing is required only to resist shrinkage and temperature forces and shall be the minimum required by the governing design specification.

As a guide for initial design, the width of the base of the wall should be approximately 0.45 times the total height. The final size used varies with the type of material, the slope of the backfill surface, the surcharge and the allowable bearing pressure.

### TABLE 1 – FILL RETAINING WALL TYPES

<table>
<thead>
<tr>
<th>Retaining Wall Type</th>
<th>Cost Effective Height Range (ft)</th>
<th>Typical Required Right-of-Way</th>
<th>Tolerable Differential Settlement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Gravity Wall</td>
<td>Up to 10 feet</td>
<td>0.5 – 0.7H</td>
<td>1/500</td>
</tr>
<tr>
<td>Concrete Cantilever Wall</td>
<td>Up to 20 feet</td>
<td>0.4 to 0.7H</td>
<td>1/500</td>
</tr>
<tr>
<td>Concrete Counterfort Wall</td>
<td>30 feet to 60 feet</td>
<td>0.4 – 0.7 H</td>
<td>1/500</td>
</tr>
<tr>
<td>Gabion Wall</td>
<td>5 feet to 20 feet</td>
<td>0.5 – 0.7H</td>
<td>1/50</td>
</tr>
<tr>
<td>MSE wall with precast facing</td>
<td>10 feet to 40 feet</td>
<td>0.7 to 1.0H</td>
<td>1/100</td>
</tr>
<tr>
<td>MSE wall (modular block facing)</td>
<td>5 feet to 20 feet</td>
<td>0.7 to 1.0H</td>
<td>1/200</td>
</tr>
<tr>
<td>MSE wall (geotextile/ geogrid/ welded wire facing)</td>
<td>5 feet to 40 feet</td>
<td>0.7 to 1.0H</td>
<td>1/50</td>
</tr>
</tbody>
</table>
Gravity walls may be used under any condition where foundation material is reasonably good and are often the most economical type for use where the wall is quite low. Because of its massive construction, this type of wall is more resistant to destructive agents and partial disintegration of the concrete is not as serious as for the heavily reinforced types.

b. Semi-Gravity Walls

By introducing a relatively small amount of reinforcing steel in the back face of a gravity wall, a slenderer stem can be used. This type of wall is commonly known as a semi-gravity wall. The semi-gravity wall is more economical than the solid gravity wall and has the same advantage of durability due to massive construction, although to a lesser extent.

c. Cantilever Walls

Cantilever walls consist of a continuous stem supported on a continuous footing. Resistance to overturning results from the stabilizing action of the weight of concrete in the wall and the block of earth supported directly over the heel of the footing. The stem, the heel of the footing and the toe of the footing act as cantilever slabs resisting the applied loads.

The stem shall be designed to resist the moments and shears caused by the earth pressure above the top of footing and the surcharge applied to it. The weight of the stem itself shall be considered and the critical sections designed for direct stress and bending.

The heel of the footing shall be designed to resist its own weight and the total weight of the earth supported directly on it, with or without a reduction for upward foundation pressures.

The toe shall be designed to resist the foundation pressure acting on it, less its own weight, but no reduction is to be made for backfill over the toe.

Cantilever walls are the most widely used type and can be used in heights to approximately 30 feet. This type of wall is by nature more flexible than the other types, and considerable deflection can be expected at the top of the higher walls. Consequently, cantilever walls should not be tied to other types of walls with shear keys. Rather, architectural offsets or plasters should be incorporated into the design at such junctures so that differential deflection will not be noticeable.

For the most economical arrangement, a cantilever wall stem should be located over the point where the resultant of the loads pierces the plane of the footing. This means the toe of the footing for the typical wall should be about one-third the total width of the footing. However, the stem may be located anywhere on the footing as required by right-of-way requirements, conflict with structures and utilities, or for other reasons.

As a guide for initial design, the footing width normally ranges between 0.5 and 0.7 the total height of the wall, depending on allowable bearing pressures, desirable bearing differentials and superimposed loads.

d. Counterfort Walls

Counterfort walls consist of a face wall spanning continuously between counterforts which extend into the backfill. Counterforts are spaced at some constant interval, usually in the range of from 8 feet to 16 feet and are supported on either individual or continuous footings.

The face wall may be either full height or, in the case of deep footings, extend only 2 ± feet below finished grade at the front of the wall.

Face walls shall be designed as continuous slabs in increments of height. Each increment shall have the proper thickness and/or reinforcement to resist the average earth pressure over that increment. If the face wall is tied to the footing, the bottom
increment can be designed for vertical and horizontal bending.

The heel portion of continuous footings shall also be designed as continuous slabs. The toe, which commonly is rather short, shall be designed as a cantilever as previously described. Counterforts shall be designed as tee-beams to resist the overturning forces for the full counterfort interval.

Counterfort walls are usually most economical for heights over 30 feet and in instances where the footing must be placed very deep.

Widths of counterfort footings to satisfy stability requirements are usually at least 0.5 the height of the wall. The heel dimension is normally governed by the counterfort design.

It is necessary that counterforts be of sufficient size to permit proper placing and vibrating of the concrete and to permit proper cleaning prior to placing the concrete. They should not be less than 2 feet in thickness.

e. Buttress Walls

A variation of the counterfort wall is the buttress wall. This type of wall resembles the counterfort wall except that the members supporting the face slab are on the exposed face of the wall and are called buttresses rather than counterforts. The face slab is designed in the same manner as a counterfort wall and the buttresses are designed as rectangular beams. Since the buttresses are exposed and therefore reduce the clearance in front of the wall, the buttress wall is rarely used.

f. MSE

Mechanically stabilized earth (MSE) walls consist of facing elements connected to layers of soil reinforcement that are embedded within a select backfill. These walls resist lateral loads through the dead weight of the reinforced soil mass behind the wall facing. Wall heights of up to 40 ft can be constructed. MSE walls are often used at bridge abutments, with a stub abutment supported on piles behind the wall.

MSE wall systems are designed to meet the requirements for overall stability (global stability), external stability including overturning and sliding, bearing capacity, and settlement, as well as the internal stability requirements including the strength of the reinforcement element, pullout resistance and connection strength. Lateral pressures are determined from active earth pressure acting on the back of the reinforced soil mass. The analysis of the overall and external stability is the responsibility of the design consultant. The analysis of the internal stability is the responsibility of a proprietary retaining wall company.

The reinforced soil mass consists of select granular backfill placed in layers between reinforcement, which is comprised of either inextensible (deformation of the reinforcement at failure is less than deformability of soil – includes steel strip and bar mat reinforcement) or extensible (deformation of reinforcement at failure is comparable to or greater than deformability of soil – includes geogrid, geotextile and woven steel mesh reinforcement) reinforcement. Metallic reinforcement typically consists of mild steel and nonmetallic reinforcements typically consist of polymeric materials consisting of polyester or polyethylene. Steel soil reinforcements and connection hardware shall be galvanized. The soil reinforcement length is a minimum of 70 percent of the overall wall height and is uniform throughout the entire height of the wall.

Facing elements are designed to resist the horizontal force of the reinforcement. Facing materials consist of precast concrete panels, full height panels, modular block wall units, and welded wire mesh facing. Segmental, precast concrete panels are typically between 5 inches and 8 inches thick, 5 feet high and have a front face width that is 5 feet or 10 feet. Panels are typically square or rectangular; however, cruciform, diamond and hexagonal face geometry are also available. Typical dimensions of full-height
concrete panels are 6 inches to 8 inches thick, 8 feet to 10 feet wide. Modular block wall face units (also known as segmental retaining wall units) are typically 4 inches to 15 inches high, 8 inches to 18 inches in exposed face length and 8 inches to 24 inches in depth. Welded wire mesh facing is typically used for temporary walls. Galvanized steel is used for permanent walls with welded wire facing. Hot dip galvanizing of at least 2 oz/ft² is expected to protect the steel in atmospheric conditions for up to 50 years. A corrosion rate of 1.0 mil/year should be considered for temporary, non-galvanized steel facings.

Internal drainage must be provided to prevent saturation of the reinforced backfill and infiltration of damaging elements from the surface. In cut areas, drainage blankets are provided behind and below the reinforced soil mass. For roadways subject to chemical dicing agents, an impervious membrane above the first layer of reinforcement may be necessary.

General design guidelines for MSE retaining walls are as follows:

- Publication No. FHWA-NHI-10-024, Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, Volumes I and II, 2009
- AASHTO LRFD Bridge Design Specifications, Volume II

h. Gabions

Gabion walls are constructed from stone filled wire mesh boxes, which are stacked and wired together. The backfill can be placed behind the wall as each level of boxes is installed. Gabion walls can be economically constructed to about 30 feet in height. Gabions can also be used as a wall facing with soil reinforcements, typically galvanized wire mesh, for wall heights up to 45 feet.
Gabion boxes are constructed from hexagonal mesh woven from soft galvanized wire. The wire may be PVC coated to protect from acidic soils or marine environments. The nominal size of the mesh openings is three to four inches. The boxes are usually constructed with internal wire mesh diaphragms or wire cross-ties for increased strength. Standard gabions are available with the following dimensions:

- Nominal Length – 6, 9, or 12 feet
- Nominal Width – 3 feet
- Nominal Height – 1, 1.5, or 3 feet

The stone used to fill the gabion baskets should be non-friable, weather resistant, and preferably high density. Gabions may be filled by hand or machinery, but in either case it is important that they be filled carefully to maintain the box shape to ensure proper alignment of the wall.

Gabion walls are designed to resist lateral earth loads as a mass gravity structure, in which the additional tensile resistance of the wire mesh is ignored. Gabion structures are permeable, allowing for free drainage, and are not designed for water pressure loads. While gabion walls are self-draining, it is advisable to provide a backfill drain above footing level to collect drainage and protect the wall foundation. Smaller height gabions are used at the base of walls, and the boxes are arranged such that the longest dimension is perpendicular to the wall to reduce shear deformation. The front wall face may be either stepped of flush, but a stepped front face is preferable, especially for taller walls. Gabion walls are constructed tilted back toward the retained soil at about a 6-degree angle for stability.

i. Noise Abatement Walls

Noise Abatement Walls shall be designed and constructed in accordance with the MDOT SHA Noise Abatement Planning and Engineering Guidelines and Chapter 15 of the MDOT SHA OOS Design Guides for Capital Projects. All components shall meet or exceed the requirements set forth in these policies and guidelines and will be subject to the same level of review and design standard. Refer to Section 5.2.F of this Design Manual for additional requirements. General design guidelines and references for noise abatement walls are as follows:

**FHWA Guidelines for Noise Abatement Walls:**
- FHWA Highway Noise Fundamentals, 1980
- FHWA Highway Traffic Noise Sources, 1980
- FHWA Measurement of Highway-Related Noise, 1996
- FHWA Highway Construction Noise: Measurement, Prediction; and Mitigation, 1977
- AASHTO Guide on Evaluation and Abatement of Traffic Noise, 1993
- FHWA Noise Barrier Design Handbook, 1975
- LPILE by Ensoft, Inc., Latest Version
- AASHTO Guide Specifications for Structural Design of Sound Barriers
- AASHTO LRFD Bridge Design Specifications
- FHWA Traffic Noise Model (TNM), Latest Version

**MDOT SHA Guidelines for Noise Abatement Walls:**
- MDOT SHA Standard Specifications for Construction and Materials, July 2020
- MDOT SHA Highway Noise Abatement Planning and Engineering Guidelines – April 2020
- MDOT SHA Noise Barrier Standards
- MDOT SHA Pavement & Geotechnical Design Guide
Guidance contained in any memos and letters published by the FHWA/MDOT SHA?

Refer to the Subdivision and Land Development Regulations for residential noise abatement wall guidelines.

2. Cut Type Retaining Walls

There are four principle types of cut retaining walls: sheet pile walls, pile and lagging retaining walls, soil nail walls and permanent tieback retaining walls.

Table 2 provides general guidelines for cut retaining wall selection.

TABLE 2 – CUT RETAINING WALL TYPES

<table>
<thead>
<tr>
<th>Wall Type</th>
<th>Cost Effective Height Range (feet)</th>
<th>Required Right-of-Way</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheet Pile Wall</td>
<td>Up to 16 feet</td>
<td>Minimal</td>
</tr>
<tr>
<td>Soldier Pile and Lagging Wall</td>
<td>Up to 18 feet</td>
<td>Minimal</td>
</tr>
<tr>
<td>Tieback Wall</td>
<td>15 feet minimum unbonded length + anchor bond length</td>
<td></td>
</tr>
<tr>
<td>Soil Nail Wall</td>
<td>10 feet to 40 feet</td>
<td>0.6 to 1.0H</td>
</tr>
</tbody>
</table>

a. Sheet Pile Walls

Sheet pile walls are often used for support of excavation systems. These walls are constructed in one phase in which interlocking sheet piles are driven to the required depth below the final grade. These walls may not be feasible for construction in hard ground conditions or where obstructions exist due to potential difficulty obtaining the required embedment depth or potential problems maintaining proper alignment during installation.

Sheet pile walls act as both vertical and horizontal wall elements. Because these walls are relatively continuous, water pressure behind the wall must be considered in the design.
b. Soldier Pile and Lagging Walls

Soldier pile and lagging walls use discrete vertical wall elements that are spanned by lagging, which typically consists of timber. This wall system can typically be constructed in most subsurface conditions; however, cohesionless soils and soft clays may cause construction problems due to limited stand-up time for lagging installation.

Vertical soldier beams may either be installed into predrilled holes or driven to their required depth. After installation of the soldier beams, the soil in front of the wall is excavated in lifts (typically 4 feet to 5 feet), followed by the installation of horizontal lagging. Once the lagging reaches the final depth, prefabricated drainage elements may be placed at predetermined spacings and connected to a collector at the base of the wall.

Support is provided through the shear and bending stiffness of the vertical wall element and passive resistance of the soil below the finished grade elevation.

c. Tieback Wall (Anchored Wall System)

Tieback walls are retaining walls that utilize top down construction methods that consist of nongravity cantilevered walls with one or more levels of tiebacks (ground anchors) anchored to the ground to aid in stability.

Nongravity cantilevered walls consist of either discrete (soldier beam, typically piles or drilled shafts) or continuous (sheet piles) vertical wall elements that can be either driven or drilled to depths below finished grade. Support is provided through the shear and bending stiffness of the vertical wall element and passive resistance of the soil below the finished grade elevation.

Tiebacks consist of a steel rod, wire or tendons that are anchored in the ground by drilling a hole into the soil or rock behind the wall face and encasing a portion of the rod or tendons in a grout mixture that forms a bond with the surrounding soil or rock to provide lateral resistance to resist horizontal pressures acting on the wall. If a tendon is used, the wire is typically prestressed to a desired tension. The rod or tendon are typically inclined at an angle. The installation of tiebacks requires specialized equipment and construction methods and post-installation testing.

Tieback walls have the following advantages:
- Potential incorporation of temporary excavation support in the permanent retaining wall;
- Reduction of construction disturbance and right-of-way acquisition required;
- Reduction of excavation needed when compared to other retaining wall systems;
- Adaptability to various site and subsurface conditions.

The following are some disadvantages of the wall system:
- Permanent underground easements are required;
- Groundwater drainage systems may be difficult to construct;
- Creep can affect long-term performance and displacements in clayey soils;
- Pull-out capacity may not be able to be economically mobilized in soft soils.

All production anchors shall be subjected to load testing and stressing in accordance with the provisions of AASHTO LRFD Bridge Construction Specifications.

Additional information on Tieback (Anchored) Retaining Walls can be found in:
- AASHTO LRFD Bridge Design Specifications, Volumes I and II (Ref. 1).

d. Soil Nail Walls

Soil nail walls are constructed using top down construction methods. In soil nail construction, the ground is excavated in 3 foot to 5 foot lifts. Soil nails and an initial
shotcrete construction facing are placed at each lift to provide support prior to progressing to the next lift. A final cast-in-place (CIP) concrete facing is installed when the lifts are complete. Typical vertical and horizontal nail spacings are 3 feet to 6 feet. The vertical spacing is dependent on the height that the site soils can temporarily remain stable after excavation of each lift.

Typically, dense to very dense granular soils with apparent cohesion, weathered rock (depending on orientation of weakness planes), stiff to hard fine grain soils, engineered fill and residual soils that are above groundwater are ideal for soil nailing. Non-engineered fill and residual soils that contain mica or shale may pose difficult soil conditions for soil nailing. Poorly graded cohesionless soils, areas with high groundwater, soils with cobbles and boulders, soft fine-grained soils, corrosive soils or groundwater, expansive soils and karst conditions are generally not suitable for soil nail walls.

In general, the soil nails support the soil and transfer loads behind the wall. The construction shotcrete and final CIP facings support the soil between the nails.

A drainage system is installed behind the soil nail walls to direct groundwater away from the wall and collect perched groundwater and/or infiltrated surface water that is present behind the facing.

The following failure modes should be evaluated for the design of soil nail walls: internal stability, global stability (temporary at each lift and final stability), lateral sliding, nail pullout, nail tensile strength, and facing bending, punching shear and headed stud in tension. Design procedures and requirements are provided in the following reference:


Verification and proof load testing are performed during construction. Verification load tests are conducted on sacrificial nails to verify the pullout resistance resulting from the Contractor’s installation methods are consistent with the values of pullout resistance and bond strengths used in design. Proof tests are conducted on a minimum of 5% of the total production nails that are installed to verify that there are no significant variations in soil nail performance throughout wall construction.

3. Retaining Wall Design Guidelines

a. General Items

The purpose of these guidelines is to establish the minimum requirements necessary to provide plans and details for the construction of retaining walls in Howard County.

These guidelines shall be adhered to when practical and applicable, but the responsibility of providing a complete design ultimately belongs to the design engineer. Innovative designs are not meant to be discouraged by these guidelines. Common sense and good engineering judgment are essential elements of any good design.

In order to facilitate the review process, these guidelines are intended to promote consistency and expediency by standardizing the requirements that are necessary in order to provide acceptable retaining wall construction documents.

For new construction, the first preference is to revise grading so a retaining wall is not needed. To the extent feasible, if a wall is required, any pedestrian or bicycle facility at its base shall be widened by at least one foot to maintain an offset between facility users and the face of the wall.

If a retaining wall exceeds three feet in height at any point, the following criteria will apply, otherwise it is exempt from review by the Development Engineering Division and only the Department of Inspections, Licenses, and Permits (DILP) and the Division of Land Development (DLD) regulations apply. The height of a retaining
wall for this purpose is measured from the finished grade at the front of the wall to the top of the wall. Grades above or below the wall shall not exceed a 2:1 slope.

All horizontal dimensions in the plan view shall be taken from the bottom face of the wall at the proposed grade.

Retaining walls shall not be constructed upon fill materials. Exceptions may be granted via the Design Manual Waiver Request process.

All retaining walls, regardless of height, shall not be constructed within a Howard County Right of Way or Easement. The only exception is if written permission has been granted by the Director of Public Works.

All construction documents for retaining walls three feet in height or higher shall be designed, signed, and sealed by a Registered Professional Engineer.

b. Construction Drawings – Plan Views

All retaining walls shall be shown in plan view showing all of the proposed conditions at a maximum scale of 1" = 50'.

Show enough grading around the retaining wall to clearly demonstrate all flow patterns in the vicinity of the retaining wall. Provide spot elevations every 50 feet along the length of the wall at the top and bottom of the wall.

Provide flow arrows along the top of the wall to indicate flow paths along the length of the wall. It is not desirable for run-off to be allowed to cascade over the top of retaining walls. This will be permitted if run-off approaching the wall is sheet flow and adequate scour protection is provided.

For all walls, a minimum ten-foot-wide construction easement/setback shall be required from the face of the wall. If the wall is greater than ten feet in height the width of the easement shall be equivalent to the height of the wall. This easement shall be clear of floodplains, buffers, wetlands, property boundaries, structures and/or other environmentally sensitive areas. 4:1 is the maximum slope allowed within this easement in front of the wall.

A permanent wall maintenance easement shall be provided behind each wall that is equivalent in width to the height of the wall plus the length of the geogrid. No structures may be placed within this easement.

For “CRITICAL” walls ten feet or more in height, the design engineer shall appropriately address the issue of global stability for the slope and provide an acceptable maintenance easement based upon the conclusions of the analysis.

For all block and timber retaining walls, a ten-foot-wide "NO TREE" planting zone shall be delineated behind the top of the wall.

Under no circumstances shall the maintenance easement for any wall encroach upon the building envelope of any residential lot.

c. Construction Drawings – Elevations

The elevation, or front view, of the proposed retaining wall is considered to be the most important detail for the purposes of constructing the wall.

The following scales are recommended, but good judgment is necessary to ensure that this detail is readable and reasonably drawn.

- VERTICAL: 1" = 1' to 1" = 5'; 1" = 2' preferred
- HORIZONTAL: 1" = 5' for lengths up to 50'
- 1" = 10' or as appropriate over 50' in length

Provide a vertical scale bar and horizontal stationing across the bottom of the elevation.

For the purpose of constructability, the front view shall have each typical section identified by a letter or a number. Provide
section breaks shown as heavy vertical lines indicating where each section begins and ends. Variation from one section to the next should be minimized in order to reduce the number of typical sections.

Essential elements of the elevation are as follows:

- A complete outline of the wall
- Show the finished grade line superimposed over the wall at the top and at the bottom
- Show the locations of the weep holes (40’ on center) and other utilities in proximity to the wall
- The vertical placement of the geogrid must be identified by which block layers the geogrid is to be inserted between
- Indicate the required allowable bearing strength for each typical section or as it varies
- Show with a dimension the maximum height allowed by design for each typical section

**d. Construction Drawings – Cross Sections**

Show a typical cross-sectional detail for each section of the wall as it varies by height and geogrid placement and/or other significant design features. The maximum vertical scale is 1” = 5’; 1” = 2’ is preferred.

Show the maximum height of the wall for each typical section.

For block or timber walls, show the number of blocks or timbers, vertically placed, graphically.

For reinforced concrete walls, show the typical reinforcement design including notes to indicate proper horizontal spacing along the length of the wall.

Indicate the maximum slope above or below allowed by the design. The maximum slope allowed is 2:1.

For each typical section show the allowable bearing strength that is required for the soil beneath the base of the wall.

Show the drain placement behind the base of the wall, entrenched in stone for at least one foot of depth, then covered with filter fabric to prevent clogging. More stone should then be placed in a one foot wide vertical layer to 90% of the walls height to facilitate water flow to the drain. Weep holes must daylight through the wall every 40 feet.

Geogrid placement by layers and length for manufactured block walls must be shown in the cross sectional detail.

**e. Construction Details – Fences/Guardrails**

Retaining walls that exceed thirty inches in height at any point and present an inherent falling hazard require a fence along the entire length of the wall.

The fence must be a minimum of thirty-six inches in height, and the openings in the fence or rail must be small enough to prevent the passage of a four-inch sphere. Fences adjacent to bicycle facilities have additional requirements and shall be designed in accordance with the AASHTO “Guide for the Development of Bicycle Facilities” (Ref. 23).

Fences must be stable enough to withstand 200 lbs. of concentrated loading applied horizontally at any point.

A typical footing detail shall be provided.

If the fence is set back from the face of the wall, the fence shall be tapered at the ends of the wall to prevent children from accessing the ledge.

If the fence is not directly above the wall, show its location in the plan view.
For walls in proximity to vehicular traffic, guardrails, per the Howard County standard guardrail details are required.

For roadways and parking lots, the face of the curb must be a minimum of two feet in front of the face of the guardrail or the retaining wall. The Howard County standard 7” curb is required.

The location of a guardrail, if required shall be three feet from the face at the top of the wall to the side of the guardrail facing the wall.

f. Design Calculations / Failure Analysis

All retaining walls shall be designed to resist the possible modes of failure, including sliding, overturning, and bearing failure. Sufficient analysis shall be provided to confirm that the resistance factors have been applied and that the design of the retaining wall meets AASHTO design specifications (Ref. 1).

Any likely or anticipated surcharge loads shall be included in the failure analysis. If none are included in the design, add a note to the cross-sectional details stating, “this wall is not designed for surcharge loads”.

For manufactured block walls, supplemental design booklets may be submitted to satisfy the failure analysis requirement, but they may not be considered as part of the construction drawings. The plans shall contain all of the relevant information required to construct the wall.

For reinforced concrete walls, provide a complete set of design calculations for the wall, including the placement and spacing of steel reinforcement.

g. Construction Drawings – Required Notes

“Retaining walls shall only be constructed under the observation of a Registered Professional Engineer and a (NICET, W ACEL or equivalent) certified soils technician.”

“The required bearing resistance beneath the footing of the wall shall be verified in the field by a certified soils technician. Testing documentation must be provided to the Howard County Inspector prior to the start of construction.” The required test procedure shall be the Dynamic Cone Penetrometer Test ASTM STP-399.”

“The suitability of fill material shall be confirmed by the on-site soils technician. Each eight-inch lift must be compacted to a minimum of 95% Standard Proctor Density and the testing report shall be made available to the Howard County Inspector upon completion of construction.”

“For “CRITICAL” walls, one soil boring is required every 100 feet along the length of the wall, copies of the boring reports shall be provided to the Howard County Inspector upon completion of construction.”

All other miscellaneous information required for the construction of the retaining wall shall be included somewhere on the construction drawings. Items may include material specifications, recommendations from the manufacturer of block wall systems, notes from the design engineer, specific instructions for non-typical designs, etc.

Each design package shall include the Designer’s seal and signature on the cover page along with the name, address, and telephone number of the consulting firm he represents. Also provide the name, address, and telephone number of the owner/developer.

h. Policy on Retaining Walls in Stormwater Management Facilities

The Howard County Design Manual Volume I requires under section 5.2.5.A.1. that “A pond buffer shall be provided for all stormwater management facilities in accordance with the criteria set forth in the MDE Design Manual. The minimum distance from the end of the outlet structure, including the riprap exit channel, or the edge of an underground facility, to the downstream
property line shall not be less than 25 feet. Along other parts of the facility, the minimum distance from the toe of the embankment or top of cut to the property lines, public easements, rights-of-way, and structures shall be 25'. For structures adjacent to the facility where the top of cut cannot be defined and the grading condition encroaches onto a residential lot, the distance from the 100-year water surface elevation within the facility or edge of underground facility shall be 25 feet minimum horizontal and two feet minimum vertical to the lowest floor elevation of a habitable structure."

This specification applies for all new retaining wall construction plans to be submitted for review. Through the Alternative Compliance request procedure, the following provisions will govern.

In general, the Department of Public Works discourages the use of retaining walls in stormwater management facilities due to the increased maintenance costs and long-term liability of the structures. The Department recognizes, however, that in some instances retaining walls may be required as other viable alternatives may not be available. If the Department or its designee deems that retaining walls are the only viable solution within a stormwater management facility, the following criteria shall govern:

1) For all facilities, both public and private, retaining walls shall not be allowed within the embankment area, either inside or outside the facility, unless the toe of the retaining wall and any tie-backs are beyond the phreatic line of the facility. These walls shall have a height not to exceed three feet. Tiered walls shall not be allowed unless they are designed so that the influences of the upper walls do not impact the lower walls.

2) For publicly owned and maintained facilities or privately owned and jointly maintained facilities, minor retaining walls, less than three feet in height, measured form the top of the wall to the ground along the face, shall be allowed on cut slopes above the uppermost maintenance bench of any stormwater management facility. These walls shall not be located in the ponding area of the facility. These walls shall be privately owned and maintained. The construction and maintenance of these walls shall be made part of a developer agreement for the facility.

3) For privately owned and maintained facilities, the maximum height of any wall, whether single or tiered, shall not exceed ten feet. These walls may be located in or adjacent to pooling areas provided the walls are reinforced concrete and shall be designed to withstand the hydrostatic pressure and saturated ground conditions on the footing of a flooded condition.

4) All retaining walls in excess of thirty inches in height shall have an appropriate safety railing or fence.

i. Tiered Walls

For tiered walls where the total cumulative height of the tiers is ten feet in height or greater, the provisions for "CRITICAL" walls apply.

The set back from one wall to the next in a series of tiers shall be equivalent to the height of the lower wall or greater.

The slope between tiered walls shall not exceed 4:1.

3. Wall Thickness

The thickness of the top of a wall shall be sufficient to accommodate any railing or appurtenance to be placed on it. However, for ease in placing concrete, it shall not be less than 1 foot.
4. Passive Pressure

Passive pressures on the front face of a wall are unpredictable and shall be neglected for normal wall footing depths. Shear keys shall be similarly avoided. Passive earth pressure shall not be considered in any case if the cover in front of the wall may be subject to scour or if the ground slopes at more than 4:1 rate.

5. Wall Elevations

Top of wall elevations shall be computed at joints and alignment breaks and at vertical curve control points. The elevation shall be tied to Howard County control where available within one mile.

6. Batter

For walls over 15 feet in height, consideration shall be given to provide a batter on the front face of the wall. The back face of the wall shall be battered if required for the stem design.

7. Joints

Walls shall be detailed with expansion points through the portion above the footing at approximately 90 ft. intervals. Gravity, semigravity and cantilever walls shall have two equally spaced contraction joints located between the expansion joints. The face walls of counterfort and buttress walls are designed as continuous beams and they cannot have contraction joints within a continuous unit. Counterfort and buttress walls shall be designed in continuous units not over 60 feet in length with expansion joints between units.

8. Drainage and Weep Holes

Drainage systems should be provided behind retaining walls to reduce hydraulic pressures, which could result in failure of the wall. Retaining walls are typically drained by means of either continuous back drains or weep holes, along with porous backfill, which allows water to flow behind the wall. Weep holes extending through the wall stem with a pocket of gravel backfill on the back are inexpensive, but often become clogged. Continuous back drains are preferable to weep holes and may be outlet into nearby storm drainage systems, if available, to minimize aesthetic impacts.

For retaining walls and larger wing walls, sloped perforated PVC pipe drains shall be placed along the back face of walls. The perforated pipe drains are placed below a full height porous backfill blanket and are supported on a continuous concrete ledge extending from the back of the wall. Drain outlets, consisting of 4 in. non-perforated PVC pipe, spaced at no more than 15 ft along the wall, are located 1 ft above the finished groundline at the front of wall. Outlet drain pipes are to be extended 3 in. from the face of wall, where visible to the public, to minimize staining. Where pedestrian or bicycle facilities are located along the front of walls, outlet drain pipes are to be placed below the facility and outlet into the adjacent gutter.

For box culvert wing walls and wing walls less than 30 ft. long and 16 ft. tall, use weep drains with 2 cu. ft. of porous backfill behind each drain. The requirements for outlet drain pipes are the same as for the continuous back drains.

B. Abutments

Abutments support the ends of the bridge beams and provide for the transition from the bridge structure to the approach roadway pavement. All abutments retain the earth of the adjacent roadway and are subject to live load surcharge. Some types of abutments retain substantial amounts of fill. The abutment design must satisfy the requirements of a retaining wall. In addition, the overall stability and the foundation loads must be checked both with and without the dead and live loads from the superstructure. Provision shall be made for surcharge due to construction loads.

1. Types of Abutments

a. Gravity Abutments

As with gravity retaining walls, gravity abutments resist loads imposed on them by means of their mass. The resultant of forces must be within the middle third of any horizontal section through the abutment, both with and without the loads imposed by the superstructure.
b. Spill-Through Abutments

This type of abutment is designed with openings between the supporting legs to allow the embankment material to spill through and form a slope in front of the abutment. The abutment must be designed for the earth pressure on the backwall and cap and on the fill face of the supporting legs. The area of the legs shall be multiplied by a shape factor, usually 2.0, to allow for arching of the soil. If the embankment slope in front of the abutment is not subject to scour, passive earth pressure may be considered on the front face of the legs. The legs and cap shall be designed as a frame to support the loads imposed by the superstructure.

c. Stub Abutment on Piles

This type of abutment is similar to a spill-through abutment except that the piles are very flexible compared to the stiffness of the concrete stub. The piles shall be considered pinned at the footing and shall be designed for axial load only. Batter piles shall be provided to resist horizontal forces. The lateral resistance of the soil surrounding the piles will provide lateral stability and can resist an unbalanced shear which will depend on the nature of the soil.

d. Cantilever and Counterfort Abutments

Cantilever and counterfort abutments resist loads in a manner similar to their retaining wall counterparts.

e. Integral and Semi-Integral Abutments

Integral abutments eliminate the need for abutment roadway joints and hence provide a structure that will require minimal, if any, maintenance to the abutments and associated bearings. Integral abutments should be considered for new bridges when the project site conditions and geometry are suitable for these types of elements. Key considerations to be evaluated include soil type and profile, span alignment, length and skew, superstructure type and the presence of utilities on the bridge. In general, for integral abutment design to be considered, the soil type shall be a reasonably graded cohesionless soil with no defined rock line. Soil profiles suitable for driven pile foundations are also suitable for the installation of integral abutments. Integral abutments shall not be used when there is the possibility of pile downdrag forces. Integral abutments shall only be considered for use on tangent superstructure alignment with a change in vertical grade less than 5% between abutments. Maximum span length for use with integral abutments is 200‘ and maximum skew (measured as the angle between the centerline of beam and a line normal to the centerline of bearing) is 30 degrees. Superstructure types that may be used with integral abutments include concrete slab supported by a redundant steel beam system or adjacent or spread prestressed concrete I-beams, box beams or slab beams. The use of timber superstructure components shall not be used with integral abutments. Normally, integral abutments are discouraged when the bridge carries utilities due to the required opening in the abutment stem to facilitate utility conduit expansion. This opening is a potential source of future deterioration and should be avoided, if possible.

Only cast-in-place concrete piles or steel H-piles shall be considered for use with integral abutments. If steel H-piles are selected, they shall be installed with the weak axis parallel to the centerline of bearing (i.e., driven to allow bending from thermal movements to be about the weak axis). Depending on the soil type and profile, consideration shall be given to pre-auguring a hole that extends a minimum of 10 feet below the bottom of abutment. The pre-augured hole shall be at least two times the pile diameter and filled with well-graded sand or a bentonite slurry mix. Piles shall extend to a sufficient depth to provide adequate structural stability (i.e., no “stilling” effect) and end firly even when the adverse effects of scour are considered. A minimum of one pile per steel girder or spread prestressed concrete beam member shall be used.
Bearings shall be selected to resist the temporary loading imposed by the superstructure prior to encapsulating the ends of the beams and bearings with the deck closure pour. Minimalist bearings such as plain elastomeric pads should be considered.

Concrete approach slabs shall be used with all integral abutment designs and shall be structurally tied to the bridge deck slab and abutment stem via hinge reinforcement. If the end of the approach slab abuts rigid roadway approach pavement, provisions for expansion shall be implemented at this location. If the roadway approach pavement is flexible, the ends of the approach slabs may butt up against the section without expansion provisions being provided. The ends of approach slabs adjacent to flexible pavement shall be protected by steel angle armoring embedded in the slab with studs. Approach slabs shall be poured atop well graded aggregate and dual layers of polyethylene curing sheeting.

Semi-integral abutments also eliminate the need for abutment roadway joints, but since they are founded on a rigid foundation (e.g., spread footing, multiple rows of piles, etc.), expansion bearings will be required. Criteria for the use of semi-integral abutments are similar for that specified for integral abutments. Semi-integral abutments should be considered when the soil profile is not favorable (i.e., presence of rock, clayey soils, etc.) or if span lengths, geometry or alignment issues preclude the use of integral abutments.

2. Design Guidelines
   a. Lateral Earth Pressure
      The lateral earth pressure shall be computed in the same manner as for a retaining wall.
   b. Other Loads
      In addition to lateral earth pressure, the abutment shall be designed to withstand the dead load of the abutment and superstructure, live load over any portion of the superstructure or approach fill, wind forces, longitudinal forces from the superstructure when the bearings are fixed and longitudinal forces due to friction or shear resistance of the bearings when the bearings are not fixed. The design shall be investigated for all combinations of these forces which may produce the most severe loading case.

   c. Drainage
      It is not necessary to provide drainage behind the stems of perched abutments when they are placed atop granular fill.

C. Piers
   1. Types of Piers
      a. Rigid Frame Piers
         Rigid frame piers consist of a continuous pier cap, columns and a continuous footing or independent footings. Rigid frame piers are generally used on bridges spanning highways and railroads.
      b. Single Column Piers
         Single column piers, or hammer head piers, consist of a pier cap supported by a single column. Single column piers are generally used for bridges spanning rivers or streams or where they are necessitated by space requirements.
      c. Solid Stem Piers
         The cap and column of a solid stem pier is a single unit supported by a continuous footing. They are used for short or narrow piers.
      d. Pile Bents
         Pile bent type piers consist of a single or double row of piles driven to act as both foundation and substructure elements. Superstructure loads are distributed to the piles via a rigid structural pile cap. Pile types normally considered in a pile bent type pier include timber, steel H-pile and cast-in-place
concrete. A structural cap, normally constructed of reinforced concrete, encases the top portion of the piles to distribute superstructure loads. Pile bent piers shall be designed to account for the adverse effects of scour as it may create a longer unbraced pile length. Pile bents shall be checked against the ultimate scour condition. Both structural stability and pile stresses should be investigated.

Pile bent piers are normally utilized for stream crossings to minimize the impacts to the waterway during and after construction as well as minimize the reduction in the available hydraulic opening. Appropriate scour countermeasures shall be incorporated into the detailing of this pier type as required by the existing or proposed conditions.

2. Design Guidelines
   a. Loads

      Piers shall be designed to withstand the dead and live loads super-imposed thereon; wind pressures acting on the pier, the superstructure and on the moving live loads; shrinkage and temperature forces; forces due to stream current; and longitudinal traffic traction forces. These various forces shall be divided into components that are normal to and parallel to the centerline of the pier.

   b. Application of Loads

      Longitudinal forces are transferred to the substructure mainly through the fixed bearings acting at the hinge of the bearing. However, some longitudinal force will be transferred through the expansion bearings by virtue of friction. The maximum longitudinal force, due to superimposed loads or temperature effect, which is transferred to the pier at an expansion bearing, is equal to the bearing friction.

      Transverse force may also be assumed to act at the hinge of the bearing. The total transverse force on the superstructure will be transferred to the piers and abutments in proportion to the length of the adjacent spans.

   c. Columns

      Rigid frame column spacing shall be in the range of from 12 feet to 20 feet. The spacing shall be set so that positive and negative movements in the pier cap are approximately equal. Circular pier columns whose diameter is 5'-0" or less shall be designed using spiral reinforcing.

D. Foundations

1. Depth

   Footings of all piers in the floodplain shall be founded on rock or on piles driven to rock, except as approved by the Chief of the Bureau of Engineering.

   All other footings in the floodplains, including those for abutments, wing walls, and culverts shall be founded below the estimated depths of scour, or 3' below the thalwag, whichever is lower.

   Footings outside the floodplain shall be founded on a suitable uniform foundation below the frost line and not less than 3'-0" below finish grade. Refer to the AASHTO LRFD Bridge Design Specifications (Ref. 1) for footings on slopes.

   Footings on rock shall be keyed into the bedrock a depth of 12 inches when they are designed to transfer lateral forces. When a bedrock foundation is required for scour protection or design bearing pressure, footings shall be carried into bedrock a minimum of six inches. Spread footings on soil shall have the lower 1' in depth poured against undisturbed earth.

   Plan sheets on which footings are shown shall include a note giving the allowable soil pressure or pile loads.

2. Loads

   Footings shall be designed to transmit to underlying stratum all forces transmitted to and acting on the substructure component.
3. Pile Foundations

a. Types

Available pile types that may be considered for use include timber, cast-in-place concrete, steel H-pile, and steel pipe pile. Each pile shall be evaluated for the project site conditions based on the available soil information, drivability, loading and structure location.

4. Drilled Shafts

Design of concrete drilled shaft foundations shall be done in accordance with AASHTO “LRFD Bridge Design Specifications” (Ref. 1) and utilizing LPILE by Ensoft, Inc. or another industry acceptable drilled shaft design program.

5. Design Guidelines

a. Location of Resultant Loads on Spread Footings

Footings founded on materials other than bedrock shall be proportioned so that the resultant intersects the bottom of the footing within the middle third. The resultant force on footings founded in bedrock may be outside of the middle third provided that the maximum allowable bearing pressure is not exceeded.

b. Pile Foundations

Pile foundations shall be so proportioned that no pile receives more than the maximum allowable pile load and no pile is subjected to uplift under any combination of design loads. All pile foundations shall have batter piles to resist horizontal forces transmitted to the foundation and to increase the rigidity of the entire structure. Plumb piles may be assumed to resist 2 kips of lateral load per pile.

Resistance factors used to determine the nominal pile bearing resistance shall be selected based on the method used for determining the pile driving criteria in accordance with AASHTO LRFD Bridge Design Specifications.

E. Substructure Protection

The selection and design of substructure protection to resist the effects of scour shall be in accordance with MDOT SHA guidelines and FHWA circulars and memorandums associated with scour countermeasure design. FHWA Hydraulic Engineering Circular 23 (HEC-23) (Ref. 18) shall be used in the design of countermeasures at piers and abutments.

Class II riprap is the preferred material for scour countermeasures. The $D_{50}$ of the riprap shall be confirmed in accordance with HEC-23. Velocities used in the design of countermeasures shall be based upon the 100-year or incipient overtopping storm event, whichever yields a higher velocity, and shall be derived by using the hydraulic modeling techniques described in the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12). Configuration of the riprap blankets, including depth, distance from abutments/piers, toe dimensions, etc., shall be in accordance with MDOT SHA memorandum “Scour Countermeasures at Bridges” (November 25, 1992).

F. Slope and Bank Protection

Slope and bank protection (revetments) for roadway approach embankments, retaining walls and stream channel banks shall be selected and designed in accordance with FHWA Hydraulic Engineering Circular 23 (HEC-23) (Ref. 18). Class II riprap is the preferred material for revetments.

Where applicable, revetments shall be designed to accommodate wave interaction as described in HEC-23. For the purpose of determining the total height of the revetment, the engineer should assume that the maximum wave height occurs coincidentally with the maximum water surface elevation generated by the design storm.
Chapter 3: Design of Bridges, Retaining Walls and Small Structures

3.5 Bridge Superstructure

The bridge superstructure includes the slab, beams or girders and bearings. The function of the superstructure is to distribute and transmit loads to the substructure. Bridge superstructure shall be designed in accordance with AASHTO Specifications (Ref. 1).

A. Slab on Beams and Girders

1. Concrete

   All superstructure concrete including parapets, abutment backwalls and parapet portion of wingwalls but excluding concrete overlay shall be air entrained concrete with a minimum 28-day compressive strength of 4500 psi. Slab concrete shall be low slump concrete.

2. Wearing Surface

   Concrete slabs shall have an extra 1/2-inch concrete which will serve as a wearing surface. This wearing surface shall be considered sacrificial and shall not be included when determining member strength.

3. Reinforcing

   Epoxy coated reinforcing bars shall be used for the entire superstructure, including top and bottom mats of slabs, abutment backwalls and parapet portion of wingwalls.

4. Forms

   Concrete slabs shall be poured on stay-in-place metal forms.

5. Concrete Cover

   Slabs shall have 2 1/2 inches of cover over the top reinforcing mat (which includes a 1/2-inch concrete wearing surface) or 1 inch of cover between the bottom reinforcing mat and the stay-in-place forms. Parapets and backwalls shall have 2 inches of cover.

6. Slab Thickness

   Slabs shall be designed to carry the dead and live load loading in accordance with the AASHTO Specifications (Ref. 1). The minimum slab thickness including the concrete overlay shall be 7-1/2 inches.

7. Deck Pour Sequence

   Construction plans shall include a suggested pouring sequence including the order and limits of each pour. For conventional superstructures (i.e., non-integral or non-jointless), positive moment regions of the superstructure shall be poured first followed by the pours in the negative moment region(s). For integral abutment bridges, the pouring sequence shall be configured to minimize dead load rotation at the abutment to prevent unwanted transverse deck cracking.

   In developing the pour sequence, consideration shall be given to accounting for the temporary stresses on the in-place portions of the structure that may not have been considered such as lateral flange buckling of the longitudinal girders supporting the wet concrete. Individual concrete pours shall not exceed 100 cubic yards per day without written authorization of the Chief of the Bureau of Engineering.

B. Beams and Girders

1. Composite and Non-Composite Design

   In superstructures consisting of concrete slabs supported on prestressed concrete beams or steel beams or girders, composite designs shall be used for simple spans exceeding 35 feet, and generally for continuous spans exceeding 50 feet. Because of the effect of span ratios, no specific limits for composite design can be established for continuous construction.

   Continuous steel beam or girder spans shall be designed as composite for positive movement regions only; however, shear connectors shall be provided at maximum allowable spacing through the negative movement regions even though composite action is not considered.

2. Camber

   a. Spans Less than 50 Feet

      Steel beams with a span of less than 50 feet shall not be cambered for dead load deflection or vertical curve corrections. If the
beams are not rolled exactly true, they shall be fabricated and erected with their natural camber up.

b. Spans 50 Feet or More

Steel beams and girders with spans of 50 feet or more shall be cambered to compensate for dead load deflection and vertical curve correction. Camber tolerance shall be zero (0) inches under to one-half (1/2) inch over.

3. Bearing Stiffeners

Stiffeners shall be placed at all bearings. The stiffeners shall be designed to carry the total reaction acting as a column.

C. Steel Beams and Girders

Steel plate girders shall be designed, where economically feasible, to eliminate transverse and longitudinal web stiffeners. The use of AASHTO M270 Grade 50W steel must be approved on a case by case basis by the Chief of the Bureau of Engineering.

D. Prestressed Concrete Beams

In lieu of steel beams or girders, precast prestressed concrete beams may be used for simple spans. The length and weight of any prestressed concrete member shall not exceed the State of Maryland limitations for highway shipment without permits.

E. Bridge Drainage

Scuppers on bridges shall be avoided if possible. On closed systems inlets shall be placed immediately off the bridge at the upgrade end of the bridge to prevent accumulated gutter flow from entering the structure. On open section roadways inlets shall be placed immediately off the bridge at the downgrade end to control water accumulated on the bridge. On closed section roadways, inlets shall be placed downgrade from the bridge as required by the gutter flow design.

Scuppers shall be placed on the bridge only if the ponding encroachment exceeds the limit permitted by the Howard County Storm Drain Design Manual, (Ref. 7). Where required, scuppers shall be MDOT SHA standard scuppers. Scuppers shall be a minimum of 10' from any substructure unit. Downspouts shall extend 8” below adjacent stringers and shall outlet into streams, slope protection or splash blocks.

F. Expansion Joints

Watertight roadway expansion joints shall be provided at all abutments and at all piers supporting simple spans. These joints shall provide for the total thermal movement for a temperature range of 0 F to 120 F.

Abutments integral with the superstructure should be considered where appropriate in lieu of expansion joints. Where feasible, joints shall be eliminated at intermediate pier locations via use of continuous spans, link slabs, or simple spans made continuous. If joints are required, they shall be selected to provide minimal irregularities and/or gaps to facilitate safe operation of motorcyclists and bicyclists.

Because bicyclists are particularly susceptible to surface irregularities, expansion joints in locations where bicyclists may be operating should be smooth, slip resistant, and free of gaps or irregularities.

G. Bearings

The selection of bearings shall consider length of span contributing to expansion, superstructure material type, applied loading, bridge skew and degree of curvature (if applicable). Consideration should be given to selecting bearings that require minimal maintenance including plain and steel laminated elastomeric pad bearings with or without polytetrafluoroethylene (PTFE) – stainless steel sliding surfaces. Bronze sliding bearings shall be considered for steel structures. Refer to the MDOT SHA “Structural Details Manual” (Ref. 11) for suggested bronze sliding bearings. The use of steel rocker bearings is prohibited.

Elastomeric bearings are generally used to support precast prestressed concrete slabs or beams. Plain pads are preferred unless structure rotation and thermal translation require steel laminated bearings. Elastomeric bearing shall be adequately attached to the bearing seat via an appropriate epoxy bonding compound. Provisions shall also be considered to prevent the elastomeric pads from "walking" by using reclaimer bars, plates or angles or by inserting an anchor dowel through the ends of the precast prestressed concrete member and embedded into the beam seat.

Commented [CL1]: If a bridge needs a joint (even one with an integral abutment with approach slab at the end, which has a joint at the approach roadway end), not sure we can design a joint that is smooth and free of gaps. A joint has a gap with a seal in it. Making them slip resistant involves adding sand grit, etc. to the steel armoring surface, so that is doable. Added additional statement above.
H. Drainage Troughs

Drainage troughs shall be investigated for use on new structures or rehabilitated structures where open joints (e.g., finger joints) are located in the bridge deck. Troughs shall also be considered as a way of providing a redundant system to protect specific bridge elements if the roadway joints begin leaking. Fiberglass drainage troughs shall be used underneath all open joint systems and shall be installed using a cross slope no less than 1" per foot. Adequately sized catch basins shall be incorporated into the system to collect all drainage water and efficiently disperse it away from the structure by means of downspout piping. Suitable caulking material shall be used along the interface between the structure and the trough to prevent water seepage.

Neoprene drainage trough material may be used in other locales assuming that the anticipated drainage flow will not exceed the capacity of the trough. Troughs placed underneath closed joint systems shall be installed at a cross slope of no less than ¼" per foot. Stiffening bars shall be incorporated into the system to keep the neoprene material flush up against the structure to prevent water seepage.

Stainless steel hardware shall be used to affix the drainage trough to the structure. Downspout piping shall be incorporated into the drainage trough systems when necessary to convey drainage away from the structure. PVC conduit shall be used for the piping material and it shall be adequate attached/braced against the structure to maintain the integrity of the system. Stainless steel hardware shall also be used to brace the downspout piping. Discharge from any downspout piping shall be directed away from structure foundations and/or adjacent roadway surfaces. Refer to the MDOT SHA Structural Details Manual (Ref. 11) for suggested drainage trough details.

I. Elevations

Bridge deck elevations shall be computed and indicated on the plans at each girder centerline, PG/L of the roadway, at any roadway break lines and along the gutter flow lines. Elevations shall be provided in accordance with MDOT SHA Structural Guidelines and Procedure Memorandums (Ref. 10).

J. Sidewalks

Any surface features in the sidewalk shall be smooth, slip-resistant, and level with the sidewalk to maintain ADA compliance.
3.6 Shared Use Path Bridges

A. General

Shared use path bridges carry users such as bicyclists, pedestrians, equestrian riders and light maintenance vehicles.

1. Design Specifications

   a. AASHTO

      The design of shared use path bridges shall be in accordance with the “LRFD Bridge Design Specifications” (AASHTO, Ref. 1), including subsequent interim specifications, except as modified by the “LRFD Guide Specifications for the Design of Pedestrian Bridges” of the Association of State Highway and Transportation Officials (AASHTO, Ref. 21), including subsequent interim specifications.

      Shared use path bridges shall also be in accordance with the “Guide for the Development of Bicycle Facilities” of the Association of State Highway and Transportation Officials (AASHTO, Ref. 23), including subsequent interim specifications.

   b. ADA

      All designs shall meet or exceed Americans with Disabilities Act (ADA) guidelines to the extent that it is not structurally impractical to do so.

      **Design Life**

      Unless otherwise directed, shared use path bridges shall be designed to achieve a minimum 75-year service life.

B. Loading

1. Live Load

   Live load shall be in accordance with AASHTO (Ref. 21). Whenever vehicle access is not prevented by permanent physical methods, shared use path bridges shall be designed for H5 vehicle live load, or a different vehicle depending on the needs of the owner or jurisdiction.

   **Commented [CL2]:** This is referenced in Section 3.2.P (for all bridges) and is redundant.

C. Clearances

1. Horizontal Clearance

   In accordance with the AASHTO “Guide for the Development of Bicycle Facilities” (Ref. 23), a shared use path bridge shall have a 14' preferred clear width (12' minimum clear width) unless written authorization is provided by the Chief of the Bureau of Engineering.

2. Vertical Clearance

   The minimum vertical clearance from the surface of path to an overhead obstruction shall be 10 feet. Greater vertical clearance should be considered where maintenance vehicles or emergency vehicles may use the path.

D. Profile and Grade

   The deck of the bridge should maintain the cross slope of the approach path. Where pedestrians are present, this cross slope should not exceed 2% to meet accessibility guidelines. Refer to Chapter 2, and the provisions given by AASHTO (Ref. 23) for profile and grade requirements.

E. Railings and Fencing

   All railings on bridges and approaches, including transitions, shall meet or exceed MDOT SHA and AASHTO specifications, including crash testing requirements. Pedestrian and bicycle railings shall conform to the “Bridge Railing Manual” by MDOT SHA (Ref. 25) and the AASHTO “Guide for the Development of Bicycle Facilities” (Ref. 23), unless written authorization is provided by the Chief of the Bureau of Engineering. However—If a railing type is selected that is not included in those references it shall meet all geometric criteria of the AASHTO specifications. Rub rails should be considered as specified in the AASHTO specifications (Ref. 23) where a bicyclist's handlebar may come into contact with a railing or barrier. Railings should not impede stormwater runoff. Refer to Section 3.2.J.3 for additional information on barriers.

   If the shared use path bridge crosses a high volume or high-speed roadway, or objects are likely to be thrown from the structure, fencing shall be
considered. Fencing shall meet MDOT SHA “Structural Details Manual” (Ref. 11). Fencing installed on structures crossing over railroads shall meet the minimum requirements of the respective railroad.

F. Lighting

Refer to the “Guide for the Development of Bicycle Facilities” (AASHTO, Ref 23) for lighting requirements.

When lighting for shared use path bridges is provided on poles, it should be independent of the bridge structure where possible.

G. Aesthetics/Structure Type

The Aesthetic Bridges - Users Guide (Ref. 26) provides recommendations for design suggestions and considerations.

H. Hydraulics

Refer to Appendix D in Chapter 10 of the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12).
3.7 Shared Use Path Underpasses

A. General

Shared use path underpasses carry users such as bicyclists, pedestrians, equestrian riders, and maintenance vehicles. Shared use path underpasses include tunnels and openings under bridge structures.

1. Design Specifications

   a. AASHTO

      The design of shared use path underpasses shall be in accordance with the "LRFD Bridge Design Specifications" (AASHTO, Ref. 1), including subsequent interim specifications.

      Shared use path underpasses shall also be in accordance with the "Guide for the Development of Bicycle Facilities" of the Association of State Highway and Transportation Officials (AASHTO, Ref. 23), including subsequent interim specifications, the "Guide for the Planning, Design and Operation of Pedestrian Facilities" (AASHTO, Ref. 27), including subsequent interim specifications, and the "Roadway Lighting Design Guide" (AASHTO, Ref. 28), including subsequent interim specifications.

   b. ADA

      All designs shall meet or exceed Americans with Disabilities Act (ADA) guidelines to the extent that it is not structurally impractical to do so.

B. Clearances

1. Horizontal Clearance

   In accordance with the AASHTO "Guide for the Planning, Design and Operation of Pedestrian Facilities" (Ref. 28), a shared use path underpass shall have a 14' preferred clear width (12' minimum clear width), unless written authorization is provided by the Chief of the Bureau of Engineering. Wider widths should be considered for lengths over 60 feet. Consideration shall be given for longer underpasses to enhance visibility, security, and safety via wider openings or flared ends.

2. Vertical Clearance

   The minimum vertical clearance from the surface of the path to an overhead obstruction shall be 10 feet, 12 feet if equestrian accommodation is required. Greater vertical clearance should be considered where maintenance vehicles or emergency vehicles may use the path, or for longer underpass lengths to maintain openness and security for pedestrians.

C. Profile and Grade

   The surface of the shared use path should maintain the cross slope of the approach path. Where pedestrians are present, this cross slope should not exceed 2% to meet accessibility guidelines. Approaches and grades should be evaluated to provide the maximum possible field of vision towards the underpass. Refer to Chapter 2, Section 2.32 and the provisions given by AASHTO (Ref. 23) for profile and grade requirements.

D. Fencing

   Refer to Section 3.2.J.3 for fencing requirements.

E. Lighting

   All shared use path underpasses where pedestrians, bicyclists, equestrians, or maintenance vehicles may be present require lighting. Luminaires shall be mounted to the underpass walls. Vandal resistant lighting should be installed and maintained. Refer to the "Guide for the Development of Bicycle Facilities" (AASHTO, Ref. 23) and the "Roadway Lighting Design Guide" (AASHTO, Ref. 28) for lighting requirements.

F. Aesthetics

   The Aesthetic Bridges - Users Guide (Ref. 26) provides recommendations for design suggestions and considerations.

G. Drainage

   Drainage shall be carefully considered for shared use pathway underpasses to prevent flooding. Underpasses shall be designed to avoid sumps in vertical alignments and configurations where non-free-draining systems (e.g. pump stations) are
required to prevent flooding. Underpasses shall not be located in areas of known flooding or floodplains where pedestrian egress may be restricted during storm events.
3.8 Box Culverts

A. Analysis

Box culverts shall be analyzed as closed rigid frames. The dead and superimposed earth loads, the lateral earth pressures and the live and impact loads are to be analyzed separately. The results of these separate loading conditions shall be assembled in various combinations to give maximum moments and shears at the critical points, i.e., the corners, and the positive moment areas. Appropriate live load positions shall be used to produce maximum positive or negative moments. A maximum of one-half of the moment caused by lateral earth pressure, including any live load surcharge, may be used to reduce the positive moment in the top and bottom slabs. The weight of the bottom slab of a box culvert will be resisted by an equal and opposite soil pressure and the weight of the slab will cause no bending in the structure. The structure should therefore be analyzed for a net soil reaction, excluding the reaction to the weight of the bottom slab.

B. Design Guidelines

1. Minimum Thickness

   The thickness of walls and slabs of a box culvert shall be not less than 8 inches for members with single reinforcing and not less than 12 inches for members with reinforcing in both faces.

2. Minimum Reinforcing Cover

   The minimum cover shall be as follows:

   a) Bottom of bottom slab - 3 inches
   b) Top slab used as riding surface - 2 1/2 inches (including 1/2-inch concrete wearing surface)
   c) All other faces — 2 inches

   a. Epoxy Coated Reinforcing

      When the distance from the riding surface to the top slab is less than 2", all reinforcing in, or extending in, the top mat of reinforcing steel for the entire length of the culvert shall be epoxy coated.

3. Wearing Surface

   If the top slab is to be used as a roadway riding surface, it shall have a 1/2" integral concrete wearing surface. This wearing surface shall be considered sacrificial and shall not be included when determining member strength. When the top slab is not the riding surface, the earth cover provided shall be no less than 9 inches (in addition to paving) at the minimum point.

4. Contraction and Expansion Joints

   Contraction joints shall be provided at a spacing of approximately thirty (30) feet. Expansion joints shall be provided at approximately ninety (90) foot intervals. Reinforcement shall be stopped two (2) inches clear of joints.

5. Headwalls

   Headwalls shall be provided at the exposed ends of box culverts, to retain the earth cover and to act as edge distribution beams on skewed alignments. The headwall shall be constant height.

6. Cut-Off Walls

   In order to provide for effects of scour, cut-off walls, a minimum of three (3) feet deep, shall be provided at the exposed ends of the culverts. Wing wall footings shall be set at the elevations of the bottom of the cut-off walls and securely tied to them with reinforcement.

7. Provisions for Future Extension

   If the culvert is to be placed under a roadway which could be widened in the foreseeable future, provisions shall be made for extension of the culvert by placement of appropriate joint keys on the exposed inlet and outlet faces.

C. Bottomless Box Culverts (Rigid Frames)

   Bottomless culverts may be considered when it is desirable from a permitting standpoint to put in a culvert with a natural channel and the span length is such that using a structural plate pipe arch is uneconomical. Since the foundation loads on a bottomless culvert are relatively higher than a four-sided box, the existing subsurface information must be closely analyzed to determine if the culvert can be supported by spread footings. If the resultant bearing
pressure is too high when compared to the allowable, or the adverse effects of settlement is a possibility, placing the structure on piles should be considered. Regardless of the foundation system, the bottom of footing for any rigid frame shall be placed a minimum of 3 feet below proposed groundline.

Bottomless culverts shall be analyzed for scour in accordance with current MDOT SHA guidelines. The Designer should consult with the MDOT SHA Office of Structures for guidance on the selection of bottomless culverts and the preferred scour analysis and countermeasure design procedures.
3.9 Pipe Culverts

The hydraulic design and analysis of roadway cross culverts should be performed in accordance with the guidelines contained in the Howard County Storm Drainage Design Manual, FHWA HDS-5, MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12) and applicable MDE and USACE regulations. This section deals specifically with larger culvert crossings of waterways with base flow.

A. Geometry

Pipe culverts shall be designed to carry the full ultimate roadway section including safety grading, guardrail backing, etc.

The layout of any pipe culvert shall be configured primarily to preserve existing drainage patterns and watercourses, while integrating the overall geometry of the roadway embankment. Significant guidance is available in Chapter 13 of the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12) and in HDS-5 regarding the optimal configuration of the culvert to accommodate different channel types.

When culverts are used singularly at crossings, the pipe invert shall be set 1' below the planned bottom of stream bed. When multiple pipe culverts are used in a single crossing, one pipe shall be considered the low flow cell and have its invert set 1' below the planned bottom of stream bed; the remaining pipes shall have their inverts set 1' above the low flow invert. Natural siltation will fill the bottom of the pipe to the planned stream bed level.

For pipe culvert crossings of Non-Tidal Wetlands and Waterways, including Water of the U.S., the Designer shall be thoroughly familiar with the regulations of COMAR Section 26.17.04.06, Bridges and Culverts. The engineer should be aware that, for any such crossing, culvert lengths are typically limited to 150 feet by COMAR 26.17.04.06.B.3. In addition, this section of COMAR also requires that culverts conveying such waters have inverts buried by at least 1 foot. For any such crossing, the Designer shall coordinate with regulating agencies at the concept stage in order to confirm the basic type, size and location of the culvert prior to proceeding with final design.

B. End Treatment

Steel pipe culverts derive their strength from the interaction of the soil with the pipe. At pipe ends, this interaction no longer applies and the end treatment must be detailed to stiffen the pipe as well as to protect against hydraulic and erosion forces.

1. Headwalls

For culverts with greater than 5' of fill measured at the start of the fill slope, headwalls shall generally be the minimum height possible. There shall be 9' of cover from the top of the pipe to the ground line at the back face of headwall and there shall be 9' freeboard from the ground line to the top of headwall at the back face of wall. Regardless of whether the headwall is perpendicular to the culvert or parallel to the roadway, the top of the headwall shall be level.

For culverts with less than 5' of fill measured at the start of the fill slope, the headwall shall generally be placed so that the barrier on the headwall lines up with the traffic barrier on the approach roadway.

The front and back faces of the headwall shall extend a minimum of 1' horizontally beyond the pipe prior to the start of the wingwall. The portion of the headwall over the pipe shall be designed as a horizontal beam carrying the horizontal loads to either side of the pipe. The portions of the headwall immediately beside the pipe shall be designed as a cantilever, fixed at the footing, and shall carry the horizontal loads from the area over the pipe as well as loads placed on it directly. The pipe shall be attached to the headwall by J bolts at 18” c/c around the perimeter. No load from the headwall shall be assumed to be carried by the pipe.

Details of the headwall shall include a plan view drawn to a scale of 3/8” = 1'-0” or larger depicting placement of the headwall reinforcing.

The bottom of the headwall and wing wall footings shall be a minimum of 3' below the low flow pipe invert elevation. A toe wall may be placed below this if required but a bottom of footing less than 3' below the low flow pipe invert in conjunction with a toe wall shall not be acceptable. Shear keys and/or passive pressure
to increase the sliding resistance shall not be considered.

Headwalls on large pipe culverts should generally be oriented parallel with the roadway embankment. For smaller culverts and headwalls not visible from the roadway, headwalls may be oriented perpendicular to the centerline of the pipe.

Headwalls for large culverts should have the edges beveled at a minimum angle of 45 degrees around the entire pipe circumference. The use of flared wingwalls may be required to reduce erosion at culvert inlets and outlets. In general, upstream wingwalls should be flared at 1:1 from parallel with the direction of flow. A 4:1 flare is recommended for downstream wingwalls (4 in the direction of flow to 1 perpendicular to the direction of flow).

Culvert headwalls that are to be used for earth retaining in excess of standard dimensions (i.e. greater than 6 inches above the top of the pipe) will require special design. The concept of using a standard headwall in conjunction with a smaller diameter pipe, such as a 36-inch pipe used with a standard headwall for a 48-inch pipe, will not be acceptable. The Designer shall have the responsibility of designing such retaining-type headwalls in accordance with the AASHTO “LRFD Bridge Design Specifications” (Ref. 1).

2. Other End Treatments

End treatments other than head walls are generally allowed if they conform to the pipe manufacturer’s recommendations. Step beveled ends are preferred over fully beveled ends for their added stiffness; however, both require concrete collars/slope protection with J bolts at 18” c/c and toewalls extending 3’ below the low flow pipe invert. Particular care must be taken with beveled ends for pipe arches due to their stiffness requirements.

It is structurally preferred for pipe ends to be on an axis perpendicular to the pipe centerline. For pipes not perpendicular to the centerline of the roadway, this may require warping the fill slopes. This structurally preferred solution may entail excessive cost for large culverts, may present aesthetic concerns for culverts with limited fill or may be impractical due to the right of way limitations. Each culvert site shall be examined in terms of end treatment.

Exposed square ends are not permitted except as temporary structures for aesthetic considerations.

Reinforced concrete or corrugated metal end sections are acceptable for use on single pipe culverts up to 36-inches in diameter, depending upon the application. When riprap is specified in conjunction with an end section, the riprap shall extend to the intersection of the end section and the pipe. End sections shall not be substituted for headwalls if the skew of the pipe is greater than 60 degrees to normal or if the pipe carries base flow.

Large-diameter culverts with extremely high outlet velocities (typically in excess of 20 feet per second) may require the design of specialty energy dissipaters. These dissipaters are typically cast-in-place or precast concrete. The methodologies presented in FHWA Hydraulic Engineering Circular 14 (HEC 14) (Ref. 19) shall be used in the design of any such dissipaters. The structural design of these units shall be in accordance with the AASHTO “LRFD Bridge Design Specifications” (Ref. 1).

3. Stream Protection

Where required due to high outlet velocities or stream instability, channel protection shall be designed in accordance with the methodologies of FHWA Hydraulic Engineering Circular HEC 20 (Ref. 20) and the guidance presented in Chapter 10 of the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12). Severe stream instability at culvert outlets should be assessed by qualified engineers experienced with fluvial geomorphology and Rosgen stream restoration techniques.

C. Foundation Requirements

Large culverts in excess of 48 inches in diameter shall be bedded in a concrete cradle which will support the pipe for at least 10 percent of its overall height.
Multiple-cell pipe culverts shall be spaced so that adjacent outside surfaces are as follows:

- Diameter less than 48 inches: Not less than 2 feet apart.
- Diameter greater than 48 inches: One-half the diameter or 3 feet apart, whichever is less.

This section applies to steel pipe culverts with spans greater than 8’ measured perpendicular to the pipe.

A normal foundation report shall be required, refer to Section 3.2.M.
3.10 Utilities on Bridges

A. Telephone Lines & Cable

Galvanized steel conduits will only be allowed to be placed in the sidewalk slab of the bridge. Any surface features in the sidewalk shall be smooth, slip-resistant, and level with the sidewalk to maintain ADA compliance.

B. All Other Utilities

No utilities other than telephone conduits will be permitted to be placed on a bridge. No conduit shall be placed closer than ten (10") inches from the face of the curb and three (3") inches from the inside face of the parapet or twelve (12") inches from the edge of the slab if no parapet is provided.

Commented [RJ3]: Moved to 3.5 Bridge Superstructure
### 3.11 Rehabilitation of Existing Structures

#### A. Introduction

This section addresses the rehabilitation of existing structures as part of an overall program to repair various Public Works structures. The goal of rehabilitation is to maintain the safety and structural integrity of the structure as well as extend its useful service life. The focus of any rehabilitation program is to effect repairs to key or critical structure elements in a timely manner to eliminate the need to replace the entire unit.

Structures designed per AASHTO LRFD (Ref. 1) shall be evaluated using AASHTO LRFD (Ref. 1). Structures designed by Load Factor Design (L.F.D.) or Allowable Stress Design (A.S.D) methods may be evaluated with either the AASHTO Standard Specifications (Ref. 24) or AASHTO LRFD (Ref. 1). It is appropriate and acceptable to analyze older structures with the AASHTO Standard Specifications (Ref. 24). However, in some cases, an LRFD analysis may yield more favorable results due to more refined methods of live load distribution or structural capacity. The intent of this provision is to not preclude the use of LRFD in these situations. A structure found to meet the minimum performance criteria when checked with either code should be considered acceptable. When projects in this category require the design of a new element or retrofit, it is preferred to use AASHTO LRFD (Ref. 1), when practical.

The design of temporary works (e.g., falsework) shall be performed in accordance with applicable sections of the latest edition of the AASHTO “Guide Design Specifications for Bridge Temporary Works” (Ref. 16) and the AASHTO “Construction Handbook for Bridge Temporary Works” (Ref. 17).

Bridge widths, including travel lanes, shoulders, and pedestrian and bicycle facilities, shall conform to Section 3.2.1 to the extent practical. If the scope of the project does not allow for the full width of those facilities, consideration should be given to retrofits that provide additional space for pedestrian and bicycle travel. In constrained conditions on bridges with inadequate pedestrian and bicycle facilities, consideration should be given to narrowing or reconfiguring motor vehicle lanes or medians to provide additional space for pedestrians and bicyclists. Consideration should also be given to adding some separation (if feasible) between the travel lanes and the adjacent pedestrian/bicycle facility, such as a curb, a concrete barrier, or flexible delineators. Separation is a particular need on bridges with motor vehicle operating speeds over 35 mph that are more than 100 feet long.

#### B. Superstructure Repairs

Superstructure repairs include rehabilitating those bridge elements located above the abutment or pier beam bearing seat. The elements to be addressed include decks, roadway barriers and sidewalks, roadway joints (transverse and longitudinal), drainage devices (including scuppers, troughs and downspout pipes), approach slabs, structural framing systems and bearings.

1. **Bridge Decks**

   In general, the rehabilitation of bridge decks will consist of maintenance repairs of the roadway surface (or soffit), removal of the top portion of the deck and placing a specialized concrete overlay or a complete deck replacement. The scope of rehabilitation should be based on the latest inspection information and all available testing data as appropriate. If inspection and testing information is unavailable, it is desirable to obtain this data through an in-depth inspection of the bridge deck and an adequate testing program. The in-depth inspection should focus on determining areas containing concrete defects that require repair including delaminations, spalling and cracking. All areas shall be thoroughly documented by defect type and location. The in-depth inspection shall include visual and tactile inspection methods including hammer tapping, chain drag and other nondestructive tests to evaluate the deck condition. Based on this information, concrete cores should be taken to evaluate, at a minimum, the compressive strength and chloride ion content of the deck concrete. Cores shall be taken in areas containing observed deterioration as well as areas in relatively good condition (as a control). A minimum of two (2) cores shall be taken for any bridge including a minimum of one (1) per span for multi-span structures. Cores shall not be taken directly over any main longitudinal or transverse structural members. Pending the results of the in-depth inspection and testing, a rehabilitation scheme can be...
recommended to repair the deck in place, install an overlay or replace the deck.

An estimate of the remaining service life should be made accounting for the current age of the deck, its current strength as compared to the original design strength, chloride ion content, location and extent of any observed structural cracking and the location and extent of concrete deterioration. The remaining service life estimate should be considered in the final decision to rehabilitate or replace the deck.

Concrete deck repairs involve placing an adequate concrete patching material in an area that has been first properly cleaned and prepared. Any area to be repaired shall have all deteriorated and loose concrete removed, exposed reinforcing steel cleaned of all rust (and replaced if it has lost more than 20% of its original section), and the area air blast or water-jet blast cleaned. Concrete patch material shall be chosen based on factors including durability, suitability of the material for the repair location, curing time (as it relates to opening lanes back to traffic) and cost.

If it is determined that the deck has adequate overall strength and some remaining service life left, a specialized concrete overlay may be considered. A concrete overlay will help to protect the remaining portions of the deck as well as extend the remaining service life of the bridge deck. Generally, only 1” to 2” of the existing concrete deck surface is removed (where the potential for delaminations or a high concentration of chloride ions exist) and the surface prepared to receive the overlay material. As part of the surface preparation process, localized concrete repairs may be required to ensure that the rehabilitated deck is a sound and integral element. Material(s) used in the patching process discussed previously are suitable for this repair. The overlay material shall be a dense cementitious type material suitable for placing in relatively thin applications. Materials such as latex modified concrete, micro-silica concrete and very early high strength latex concrete should be considered depending on the application needs. The structural capacity of the deck should be verified if more than 2” of concrete is removed from the top surface.

If the selected rehabilitation alternative is for complete replacement of the concrete deck, several issues shall be evaluated, including, but not limited to, studying and developing stages of construction for maintenance of traffic, need to maintain pedestrian and bicycle traffic, maintenance of utilities, checking the existing framing system for the new deck weight including the consideration of the effects of composite action and differential camber in adjacent beams (as a result of staged construction) and the rehabilitation needs for the substructure and those superstructure elements to remain.

Other rehabilitation work associated with the bridge deck will be the repair or replacement of existing roadway joint systems. The failure of transverse (and longitudinal) roadway joints may lead to substructure deterioration, bearing failure and section loss at the ends of the main superstructure supporting members. Depending on the severity of the joint deterioration, only the replacement of the seal may be required. Field measurements of the joint opening should be taken along with the ambient temperature to ensure that the correctly sized seal is installed. If the condition of the joint system is such that replacement is required, the existing joint configuration should be confirmed in the field and checked against available plans. If plans are unavailable, field measurements and details of the existing joint system shall be recorded for subsequent use in preparing joint replacement plans. As part of any joint modification scheme, consideration should be given to installing drainage troughs in accordance with Section 43.5.H of this Design Manual. The replacement joint system chosen (armored compression or strip seal, asphaltic plug, silicone, elastomeric, etc.) shall take into consideration such factors as cost, serviceability, durability (i.e., resistance to truck traffic) and constructability. Where feasible, the elimination of transverse joints should be investigated to extend the service life of bearings, beam ends, and other bridge components historically affected by failing joints. An appropriate structural analysis of the existing structure should be completed to determine the applicability and suitability of installing link slabs at intermediate pier roadway joints and/or a conventional deck-over system at each abutment. The ability of existing bearings to accommodate link slabs and/or deck-over details...
shall also be confirmed and the replacement of same evaluated to determine if their replacement is cost-effective in conjunction with the removal of transverse joints.

As part of a deck maintenance program, consideration should be given to eliminating bridge scuppers. If feasible, eliminating scuppers will minimize the deterioration of the deck from standing water/debris resulting from clogged scuppers. An analysis of the scupper(s) shall be performed and if the design spread for a ten-year storm event does not encroach more than 6 feet into the traveled way, Scuppers to be eliminated shall be filled with a lean concrete mix.

Because bicyclists are particularly susceptible to surface irregularities, bridge deck surfaces where bicyclists may be operating should be smooth, slip resistant, and free of gaps or irregularities.

2. Barriers

Traffic barriers include railings and parapet systems. Barriers inadequately attached to the superstructure (as a result of deterioration, accident damage or substandard design) shall be rigidly connected to the deck and/or fascia beams to provide sufficient strength to resist vehicular impacts.

3. Girders/Beams/Trusses

These repairs encompass many different types of repairs and will include all work to rehabilitate girders, beams and trusses.

There are many types of repairs that may be performed on steel beams/girders. Rusted webs can be repaired by welding or bolting plates across the deteriorated areas. Deteriorated flanges may be repaired by welding or bolting cover plates across the deteriorated or damaged areas. Care must be taken when welding to ensure that allowable fatigue stresses are not exceeded and that the weld quality can be obtained under field conditions.

For bridges with high volumes of truck traffic, repairs may involve the retrofitting of beams/girders at intermediate diaphragms or cross frame connections to prevent/mitigate problems at fatigue-sensitive connection details. Cracks in welds, as well as, cracks in the web and connection plates, have resulted from these fatigue-sensitive connection details. Retrofit details to consider include bolting angles or tees to the connection plates and flanges to prevent and/or mitigate out-of-plane bending or high-stress concentrations. In addition to this retrofit, welds may be repaired via grinding, drilling crack ends and replacing any cracked connection plates. Each situation must be carefully studied to ensure that the retrofit detail can be properly constructed in the field and that it will be achieving its intended purpose of eliminating and/or reducing out-of-plane bending or high-stress concentrations.

Although most projects will involve the repair and/or replacement of select members, in some cases, it may be desired to upgrade the load-carrying capacity of a structure. This can be accomplished by several methods, including applying more advanced analysis methods, rating the structure using load and resistance factor design, replacing the deck with lightweight concrete or a different type of lightweight deck (e.g. exodermic, etc.), making multiple simple spans continuous over the piers, post tensioning, or adding shear studs to make non-composite beams composite. When adding studs for the development of composite action, the type of steel being stud welded must be carefully evaluated. Older steels (e.g., A7) are not as ductile as current steel and special care must be utilized when attaching any element via welding.

Timber beams deteriorating as a result of decaying wood or insect attack can be rehabilitated by replacing individual members or
strengthening by thru-bolting galvanized steel channels to each side.

Rehabilitation of concrete tee-beam bridges typically involve beam repairs to address spalling, cracking and any exposed reinforcing steel that has lost cross sectional area. If the extent of deterioration does not compromise the ability of the member to safely carry load, cosmetic repairs using pneumatically applied mortar may be utilized to halt further deterioration. If the extent of corrosion adversely affects the load carrying capacity of the member, and the bridge cannot be load restricted, external reinforcement such as carbon fiber reinforced polymer sheets can be bonded to the sides and bottom of the beam to upgrade the live load capacity.

Prestressed members with concrete spalling can be repaired after cleaning of the strands. Some preloading of the beam may be necessary to prevent future cracking of the concrete patch. If prestressing strands are damaged or severed to a point where the load-carrying capacity of the member is inadequate, the member can be repaired by providing external post-tensioning. This method can also be used to increase the strength of under-designed prestressed beams. In addition, the use of external reinforcement such as carbon fiber reinforced polymer sheets can be bonded to the sides and bottom of the beam to upgrade the live load capacity in shear and/or bending.

4. Bearings

Deteriorated bearings may need to be cleaned and painted, reset or replaced with a similar or better functioning bearing device. To reset or replace bearings, the bearing load must be released through the use of hydraulic jacks and temporary jacking beams supported by the existing girders. Steel columns anchored to the face of the substructure may also support the jack(s). Or, if space allows, the jack(s) can be placed on the beam seat behind the end of a girder. The design plans shall clearly state the limits of the jacking system with respect to load, the amount of girder displacement that can be tolerated and whether traffic can be maintained on the bridge during the jacking operations. The existing structural components must also be checked to confirm their ability to withstand the jacking forces.

For bearings exhibiting extensive and advanced paint deterioration and base metal corrosion, complete cleaning and repainting may be necessary to restore full operational capacity to the bearings. In addition, these bearings may have to be jacked and temporarily supported to facilitate a more thorough cleaning. Reference the following section for the cleaning and painting of steel bearings.
5. Painting

The painting of steel superstructure elements (beams, girders, diaphragms, bearings, etc.) encompasses the cleaning and painting of all exposed surfaces as part of a maintenance or rehabilitation project. Depending on the condition of the paint system, either spot cleaning and painting or complete removal and replacement of the paint system may be required. However, if the paint system condition is relatively good, minor cleaning and overcoating may be a more economically viable alternative to full removal and coating. Spot cleaning shall extend a minimum of 10' from the beam ends on simple spans and 10' from the centerline of bearing on continuous spans. Steel bearings and associated end diaphragms should be included within these limits. Other areas of additional spot cleaning (e.g., exterior sides of fascia girders) shall be included as necessary.

The existing paint system should be evaluated for adhesion in accordance with ASTM D4541 as well the coating thickness and the compatibility of the existing coating with the new coating. Evaluation of the paint system shall be in accordance with the current edition of the “SSPC Painting Manual, Volume 2” (Ref. 13).

Prior to cleaning and painting, the existing paint system shall be evaluated for the presence of lead paint. If lead paint is present, contract specifications shall be prepared for proper and adequate lead paint removal and containment and worker protection (reference Volume 4 – Specifications for more information). 100 percent containment of blast by-products shall be contained. The design of the containment system shall be borne by the Contractor performing the work.

The new paint system(s) shall be in conformance with the Volume 4 Specifications assuming that it is compatible with the existing paint system.

C. Substructure Repairs

Substructure repairs include rehabilitating those bridge elements located at or below the abutment or pier beam bearing seat. The elements to be addresses include beam seats (and pedestals), abutments and wing walls, piers, slopes and foundation elements.

1. Concrete Repairs

The repair of concrete substructures generally involves both cosmetic and structural rehabilitation. Cosmetic repairs include superficial concrete deterioration such as shallow spalling (defined by no exposed reinforcement) and delaminating concrete (i.e., incipient spalling). Structural repairs include flexural or shear cracking, cracks wider than 1/16" and deep spalling where reinforcement is exposed (regardless of the condition of the reinforcement).

Concrete repair limits shall be based on the latest field inspection documentation. This information shall be field verified if it is older than one year or if the limits of concrete deterioration are not well defined. When determining the limits of repair for both shallow and deep spalling, the outside dimensions of the defect shall be increased by a minimum of 6" on all sides to ensure that the deteriorated portion is encapsulated within the repair.

All concrete repairs shall include provisions to remove all loose and deteriorated concrete and thoroughly clean the remaining surfaces prior to placing the repair material. Any exposed reinforcement shall be blast cleaned and inspected for section loss. Any bar reinforcement that has sustained more than 20% section loss shall be replaced by reinforcement of equal size and adequately lapped/spliced to develop the full strength of the bar.

The material used to repair deteriorated concrete shall be selected based on the location, type and volume of the proposed repair.

2. Pile Repairs

Repairs to piles will consist of a combination of structural enhancement and/or protection. For existing steel piles with section loss resulting from corrosion, steel plates or rolled channel section shall be field bolted to increase the capacity of the pile. Unless the pile has significant section loss, the addition of these steel elements can be affixed under full traffic load. The length of these newly bolted members shall
extend well beyond the limits of the deteriorated portions so that the bolted connection is fully developed within the full original section of the pile. For concrete piles, additional concrete section may be added in a similar manner utilizing reinforcement dowelled into the existing pile and tremie concrete placed. Repairs to timber piles that have lost section can be accomplished using timber pile splices. Concrete and steel pilings shall be repaired by cleaning the exposed surfaces and placing fiberglass jackets from the channel bottom to up above the splash zone, or just in the vicinity of the splash zone if that distance is prohibitively long. Grout or a specialized concrete mix shall be placed between the existing pile and the jacket, with reinforcement added as needed to provide additional strength. Substantial cross-sectional losses can be strengthened by adding material to the pile and extending the concrete pile strut to the mudline. The foundation unit must be analyzed with this additional dead load to ensure that none of the piles are being overstressed by this additional weight.

3. Scour and Undermining

Channel degradation and/or scour can advance to the point of exposing the piles. In addition, strong waterway currents or wet/dry cycles can reduce the cross section of the piling at the channel bottom or mudline or water surface (common to timber piles and steel pipe piles). The foundation should be analyzed to determine the pile/soil interaction affects from lateral and vertical loadings and incorporate this information into a structural model to determine the overall structural integrity and/or stability of the foundation unit in question. Inspection observations and measurements or subsequent structural analyses will dictate if pile repairs should be performed in accordance with the previous section.

If scour countermeasures are deemed necessary, scour computations and evaluations shall be performed in accordance with the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12), in particular Chapter 7 and 11. In addition, an underwater inspection (including soundings) should be performed as well as a review of previous underwater inspection reports and other scour evaluation reports. Generally, scour countermeasures for bridges over streams, creeks and rivers will include riprap or grout bag blankets placed around piers and abutments. Stream instability countermeasures, if required, shall include riprap or gabion bank protection, spur dikes and check dams. Scour countermeasures for bridges over tidal waterways will include riprap aprons around pile bents and riprap revetments around abutments and approach roadways.

During the development of scour countermeasures, all permitting requirements shall be determined and applied for at the Preliminary Design phase.

4. Underpinning

In extreme cases of undermining, a substructure unit may lose sufficient bearing, which could result in the structure collapsing. In the case where a substructure unit has rotated or settled, it may be necessary to jack the substructure unit back into proper position prior to underpinning the foundation. The method used to underpin a foundation depends greatly upon the amount of undermining and whether the underpinning is required to provide structural support. For severely undermined foundations, the underpinning must be performed in such a manner as to provide bearing. This can be accomplished by placing either a temporary form or a permanent fiberglass jacket around the substructure footing and pumping concrete or grout in the void between the substructure footing and the form. Reinforcing steel shall be dowelled into the existing foundation or a rock foundation below. The form shall be high enough to provide sufficient head pressure so that the concrete or grout is forced into all voided areas and up against the bottom of the existing foundation. Constructing a cofferdam, dewatering the area, and constructing temporary forms is also another method which may be considered; however, this method results in considerable disturbance within the waterway and is generally more costly and sensitive to permitting regulations.

For foundations where the undermining is minor and it has been determined that the remaining bearing area provides sufficient bearing capacity, pumping grout behind placed grout bags can be performed. The grout bags will prevent future
undermining of the foundation while the grout pumped behind the grout bags will fill voids in which the bags could not fill.

D. Retaining Walls

The rehabilitation of retaining walls should consider the material and type of wall. For concrete retaining walls, repairs will generally only be made to the surface areas unless wall alignment is in question. Concrete repairs for retaining walls shall generally follow those stipulated for bridges under Section 3.11.C.1.

For the repair of MSE or other proprietary type precast walls, rehabilitation measures should be discussed with the wall manufacturer prior to implementing repairs. Typical problems involving MSE walls include the failure of the soil reinforcement strap attached to the wall facing panel. Grouted tie-back anchors may be considered to stabilize the wall panel and eliminate future local erosion of the fill.

Since gabion walls can tolerate substantial settlement and/or rotation prior to failure, repairs may only be necessary when the wire basket cages corrode or break. Retying the wires is an acceptable measure to repair the baskets. Gabion walls with substantial settlement and/or rotation shall be analyzed for stability to determine if the wall can remain or if reconstruction is required.

E. Maintenance of Traffic

Maintenance of Traffic (MOT) for the rehabilitation of existing structures shall conform to applicable portions of Chapter 5 as contained later within this volume.
3.12 Load Ratings

A. Introduction

This section addresses the calculation of load ratings for new or existing structures as part of a design project to rehabilitate or replace an existing bridge. Load ratings may also be required for existing structures that have incurred structural deterioration observed during routine biennial inspections. Load ratings shall be calculated for all bridges carrying traffic including culvert type structures covered with less than 8 feet of earthen fill. As part of the final design of new or replacement bridges, the Designer shall compute the load ratings for the structure and include these with the Final Plans submittal to the County.

B. Methodology

Load ratings shall be calculated in accordance with Chapter 6 of the latest edition of the AASHTO “Manual for Condition Evaluation of Bridges” (Ref. 14) and MDOT SHA Structural Guidelines and Procedure Memorandums” (Ref. 10). At a minimum, the four standard Maryland legal live load vehicles shall be rated, including the H-15 (15 tons), HS-20 (36 tons), Type T-4 (35 tons), and 3S-2 modified (40 tons) trucks. In addition, load ratings may be required for the eight (8) special vehicles (e.g., school buses, emergency vehicles, special permit vehicles, etc.) as directed by the County.

Both inventory and operating load rating values shall be computed for each truck considered. Material values shall be based on any available record plans or field testing, as applicable. If no plan or testing information is available, material properties shall be estimated based on the provisions contained within Chapter 6 of the latest edition of the AASHTO “Manual for Condition Evaluation of Bridges” (Ref. 14).

The inventory load rating value shall be considered as the load level that can safely cross the structure for an indefinite time period assuming that the structure remains in its current condition. The operating load rating value shall be considered as the maximum load level that can safely cross the bridge. Allowing this maximum load to cross the bridge indefinitely may compromise the structural integrity and limit the service life of the bridge.

Load ratings shall be computed based on the known section properties of each member accounting for any section loss or member deterioration that could adversely affect the load rating values. Load ratings may be hand-calculated or computed using appropriate computer software written specifically for structural load ratings. For rigid frames and box culvert type structures, structural models based on plane frame analysis methodologies shall be used. In addition to the application of dead and live loads, earth pressure loads (vertical and horizontal) shall be also be applied. Earth pressure loads shall be additive to the dead loads when computing the available member capacity to resist the applied live loads. For paved inverts that are structurally connected to the side walls (e.g., four-sided box culvert), the structural model shall incorporate the effects of the bottom slab loading on the subbase by utilizing spring constants in the model. These spring constants shall be based on an evaluation of the existing soil conditions to determine an appropriate coefficient of subgrade reaction. Each member within a four-sided culvert structure (i.e., walls, top slab and invert slab) shall be analyzed and load rated. Headwalls on rigid frame, four-sided culverts and pipes need not be load rated.

C. Posting

Structures that do not rate out for the minimum vehicle weight at the inventory level (i.e., the rating factor, RF < 1.0) shall be recommended for posting to the Chief of the Bureau of Engineering. All postings shall include both the Gross Vehicle Weight (GVW) for the H-15 and Type T-4 trucks and the Gross Combination Weight (GCW) for the HS-20 and Type 3S-2 modified trucks. The acceptance and implementation of the recommended load posting shall be at the discretion of the Chief of the Bureau of Engineering.
3.13 Plan Preparation Guidelines

A. Introduction

This section provides guidance on the proper manner to prepare plans for bridge replacement and/or rehabilitation projects. CADD guidelines related to the production of plan sheets using Microstation is covered under applicable sections of Chapter 1. Plan preparation guidelines for retaining wall projects are covered under Section 3.4.A.

B. Sheet Layout and Order

Bridge plan sheets shall be generated and prepared using commonly accepted engineering and drafting techniques and practices. In general, plan sheet layout shall be developed to include only those views, sections and details pertinent to a particular bridge component. Mixing of various details from different portions of the structure (e.g., substructure and superstructure) shall be avoided wherever possible.

The order of bridge plan sheets for new structures shall conform to the following:

- General Plan and Elevation
- Hydraulic and Hydrologic Data Sheet (if applicable)
- Geometric Layout (for substructure footings or piles)
- Substructure Unit Plan and Elevation (for abutments, wing walls and piers)
- Substructure Typical Sections (of abutments, wing walls and piers)
- Bridge Typical Section(s)
- Framing Plan Layout
- Beam/Girder Details (includes elevation, camber information, splice details, etc.)
- Diaphragm Details (end and intermediate)
- Bearings
- Deck Elevations
- Roadway Joint Details (includes plan layout, sections and any necessary details)
- Bridge Railing Details
- Approach Slab Layout and Sections (if applicable)
- Miscellaneous Details
- Boring Logs (including plan layout of locations)

The order of plan sheets for a rehabilitation project will follow this general order as applicable. Highway plan sheets and any necessary maintenance of traffic plan sheets shall be placed ahead of the bridge plans when they are made a part of the project.
3.14 References

(1) “LRFD Bridge Design Specifications,” American Association of State Highway and Transportation Officials (AASHTO)

(2) “Manual for Railway Engineering,” American Railway Engineering and Maintenance-of-Way Association (AREMA)

(3) “Manual of Steel Construction,” American Institute of Steel Construction (AISC)

(4) “ACI Manual of Concrete Practice,” American Concrete Institute (ACI)

(5) “Structural Welding Code,” AWS D1.1, American Welding Society (AWS)


(7) “Howard County Storm Drainage Design Manual,” Department of Public Works, Bureau of Engineering, Howard County, Maryland


(9) “Maryland Waterways Construction Guidelines,” Maryland Department of the Environment

(10) “Structural Guidelines and Procedure Memorandums,” Maryland Department of Transportation, State Highway Administration, Office of Structures

(11) “Structural Details Manual (Maryland Department of Transportation, State Highway Administration, Office of Structures

(12) “Manual for Hydrologic and Hydraulic Design,” Maryland Department of Transportation, State Highway Administration, Office of Structures


(14) “Manual for Condition Evaluation of Bridges,” American Association of State Highway and Transportation Officials (AASHTO)

(15) “Book of Standards for Highway and Incidental Structures,” Maryland Department of Transportation, State Highway Administration, Office of Highway Development


(21) “LRFD Guide Specifications for the Design of Pedestrian Bridges,” American Association of State Highway and Transportation Officials (AASHTO)

(22) “Guidelines for Wind Loads on Bridges During Construction,” American Association of State Highway and Transportation Officials (AASHTO)

(23) “Guide for the Development of Bicycle Facilities,” American Association of State Highway and Transportation Officials (AASHTO)

(24) “Standard Specifications for Highway Bridges,” American Association of State Highway and Transportation Officials (AASHTO)

(25) “Bridge Railings Manual,” Maryland Department of Transportation, State Highway Administration, Office of Structures

(26) “Aesthetic Bridges - User’s Guide,” Maryland Department of Transportation, State Highway Administration, Office of Structures

(28) "Roadway Lighting Design Guide," American Association of State Highway and Transportation Officials (AASHTO)
CHAPTER 3
Design of Bridges, Retaining Walls, and Small Structures

3.1 INTRODUCTION
A. Responsibility of the Designer ........................................... 3-1
B. Limitation of Topics Presented in the Design Manual ............... 3-1
C. Abbreviations .............................................................. 3-1
D. Definitions ........................................................................ 3-1

3.2 GENERAL FEATURES OF DESIGN
A. Coordination with Road and Street Planning ......................... 3-2
B. Design Specifications .......................................................... 3-2
C. Technical Reference for Design ........................................... 3-2
D. Basic Information Required for Design .................................. 3-2
E. Selection of Retaining Wall Type ........................................... 3-3
F. Selection of Bridge Type ..................................................... 3-4
G. Selection of Culverts ........................................................ 3-6
H. Structures Over Waterways ................................................ 3-7
I. Clearances ......................................................................... 3-8
J. Bridge Roadway Section ..................................................... 3-9
K. Horizontal and Vertical Alignment ....................................... 3-9
L. Subsurface Investigations .................................................... 3-10
M. Foundation Reports ........................................................ 3-10
N. Scour Reports ................................................................. 3-11
O. Bridge Inspection ........................................................... 3-11
P. Design Life .......................................................................... 3-11

3.3 DESIGN LOADING – HIGHWAY STRUCTURES
A. General .............................................................................. 3-12
B. Dead Load .......................................................................... 3-12
C. Live Load ............................................................................ 3-12
D. Wind Loads ......................................................................... 3-12
E. Thermal Forces ................................................................. 3-12
F. Force of Stream Flow ........................................................ 3-12
G. Earth Pressure ................................................................. 3-13
H. Earthquake Forces ............................................................ 3-13
I. Distribution of Loads .......................................................... 3-13
J. Constructability ................................................................. 3-13

3.4 SUBSTRUCTURES AND RETAINING WALLS
A. Retaining Walls ................................................................. 3-14
B. Abutments .......................................................................... 3-27
C. Piers .................................................................................. 3-29
D. Foundations ....................................................................... 3-30
E. Substructure Protection ....................................................... 3-31
F. Slope and Bank Protection ................................................... 3-31

3.5 BRIDGE SUPERSTRUCTURE
A. Slab on Beams and Girders .................................................. 3-32
B. Beams and Girders ............................................................. 3-32
C. Steel Beams and Girders ...................................................... 3-33
D. Prestressed Concrete Beams ................................................ 3-33
E. Bridge Drainage ................................................................. 3-33
F. Expansion Joints ................................................................. 3-33
G. Bearings ............................................................................. 3-33
H. Drainage Trenches ............................................................. 3-34
I. Epoxy ............................................................................... 3-34
J. Sidewalks ............................................................................ 3-34

3.6 SHARED USE PATH BRIDGES
A. General .............................................................................. 3-35
B. Loading .............................................................................. 3-35
C. Clearances ......................................................................... 3-35
D. Profile and Grade ............................................................. 3-35
E. Railings and Fencing .......................................................... 3-36
F. Lighting .............................................................................. 3-36
G. Aesthetics/Structure Type .................................................. 3-36
H. Hydraulics ......................................................................... 3-36

3.7 SHARED USE PATH UNDERPASSES
A. General .............................................................................. 3-37
B. Clearances ......................................................................... 3-37
C. Profile and Grade ............................................................. 3-37
D. Lighting .............................................................................. 3-37
E. Aesthetics .......................................................................... 3-37
F. Drainage ............................................................................ 3-37

3.8 BOX CULVERTS
A. Analysis ............................................................................. 3-38
B. Design Guidelines ............................................................ 3-38
C. Bottomless Box Culverts (Rigid Frames) ............................ 3-39

3.9 PIPE CULVERTS
A. Geometry .......................................................................... 3-40
B. End Treatment ................................................................. 3-40
C. Foundation Requirements ................................................. 3-42

3.10 UTILITIES ON BRIDGES
A. Telephone Lines & Cable .................................................. 3-43
B. All Other Utilities ............................................................ 3-43

3.11 REHABILITATION OF EXISTING STRUCTURES
A. Introduction ....................................................................... 3-44
B. Superstructure Repairs ....................................................... 3-44
C. Substructure Repairs ........................................................ 3-48
D. Retaining Walls ............................................................... 3-50
E. Maintenance of Traffic ....................................................... 3-50

3.12 LOAD RATINGS
A. Introduction ....................................................................... 3-51
B. Methodology ...................................................................... 3-51
C. Posting ............................................................................... 3-51

3.13 PLAN PREPARATION GUIDELINES
A. Introduction ....................................................................... 3-52
B. Sheet Layout and Order ..................................................... 3-52

3.14 REFERENCES ..................................................................... 3-53
3.1 Introduction

A. Responsibility of the Designer

This chapter addresses the selection and use of design and evaluation criteria and practices applicable to the design and maintenance of Public Works structures including bridges, retaining walls and small structures in Howard County. The subject matter presented herein includes specifications and guidelines for the selection, analysis and design of Public Works structures and their individual subcomponents. While the requirements described for the various aspects of design will include and cover the majority of conditions encountered, there is no intention to relieve the Designer of the responsibility to recognize when conditions are not favorable for the application of these design guidelines. The Designer shall be continually alert to those conditions that cannot be satisfied by the application of these design guidelines.

The design specifications to be used for various types of Public Works structures are identified and referenced herein. Guidance and interpretations of the design specifications and specific standard design requirements of the Bureau of Engineering are also presented in this Chapter.

B. Limitations of Topics Presented in the Design Manual

It is not possible to include in this manual all features and topics of design and drafting necessary to accomplish the development of structure designs and construction documents for all projects incorporating bridges, retaining walls and small structures. The topics addressed herein are limited to those that will assist the Designer in performing most engineering design tasks in an efficient manner and comply with currently accepted engineering practice as well as Howard County practice. Although it is the Designer's responsibility to exercise professional judgment in the acceptance and/or use of the design guidelines included herein, the Designer shall recognize that they are being provided to assist in the development of the project in the manner preferred by Howard County. However, projects that are funded by Federal and/or State Aid may require compliance with the design criteria and standards set forth by the funding agency.

Projects may also be subject to current, future and evolving regulations set forth by various local state and federal regulatory and resource agencies which may require deviation with or expansion of the criteria and standards herein. Any deviations from these design guidelines shall be brought to the attention of Howard County immediately. Any waivers of this design manual shall be justified to Howard County in writing, from an engineering evaluation, and shall include relevant considerations of life cycle costs and/or maintenance requirements. Approval or denial of the waiver requests will be by return letter signed by the Chief of the Bureau of Engineering.

C. Abbreviations

For standard abbreviations, refer to Section 1.2, "Abbreviations," of this design manual.

D. Definitions

Bridge: A structure designed to carry vehicular, pedestrian and/or bicycle traffic having a roadway surface comprised of a structural element such as reinforced concrete or timber.

Culvert: A structure designed to carry vehicular, pedestrian and/or bicycle traffic having a roadway surface placed atop earthen fill and/or a structure designed as a continuous unit between the superstructure and substructure.

Small Structure: Any bridge or culvert structure that measures less than 20’ clear between abutments (measured parallel to the roadway centerline).

Retaining Wall: Any structure that is built to retain a fill section or a roadway as a means to eliminate or minimize impacts to adjacent properties or structures, with greater than 3'-0" exposed. For retaining walls with less than 3'-0" exposed, refer to the Subdivision and Land Development Regulations.
3.2 General Features of Design

A. Coordination with Road and Street Planning

Bridges, small structures and retaining walls are required for grade separations, stream crossings and earth retention usually as elements of a road or street facility. Planning and design of these structures must be coordinated with the road or street planning for overall project purpose as well as agreement in alignment, grade and typical section. For structures in historic districts and along scenic roads, aesthetics are also important.

B. Design Specifications

1. AASHTO

For bridges, retaining walls and small structures, the basic design specifications to be used are those of the latest edition of the “LRFD Bridge Design Specifications” of the Association of State Highway and Transportation Officials (AASHTO, Ref. 1), including subsequent interim specifications. Shared use path bridges and shared use path underpasses shall be designed in accordance with the AASHTO “Guide for the Development of Bicycle Facilities.” (Ref. 23) and the AASHTO “Guide for Planning, Design and Operation of Pedestrian Facilities” (Ref. 27).

2. AREMA

The basic specifications to be followed in the design of railroad bridges or walls retaining railroad embankments are the current specifications of the American Railway Engineering and Maintenance-of-Way Association (AREMA, Ref. 2).

3. Howard County Storm Drainage Design Manual

Hydrologic and hydraulic design of structures shall be in accordance with the “Howard County Storm Drainage Design Manual Volume I” (Ref. 7).

4. Maryland Department of Transportation, State Highway Administration, Office of Structures (MDOT SHA OOS) Manual for Hydrologic and Hydraulic Design

Scour analyses and countermeasure design shall also be in accordance with the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12).

C. Technical References for Design

1. Capital Projects

Capital projects will be designed using Maryland Department of Transportation State Highway Administration Office of Structures Structural Guidelines and Procedure Memorandums (Ref. 10) Structural Details Manual (Ref. 11), and the Aesthetic Bridges - Users Guide (Ref. 26)

2. Other Projects

Other projects, such as Developer Projects, shall be designed similarly as Capital Projects unless written authorization is granted by the Chief of the Bureau of Engineering.

D. Basic Information Required for Design

1. General Information

To determine the overall configuration of a structure, the Designer must obtain or establish the project alignment, profile and typical section and impose them on the existing physical topography.

2. Studies and Reports

Previous studies, engineering reports and preliminary plans, if any, shall be reviewed before beginning any new work on the project.

3. Record Plans

Records of utilities, existing structures, stream flow, and subsurface investigations at or near the proposed structure must be obtained.
4. Topography

Existing topographic maps such as those available from the United States Coast and Geodetic Survey and the Howard County Department of Public Works may be used for preliminary studies. Hydrologic studies shall be based upon the best available topographic mapping. Existing mapping must be supplemented by aerial photogrammetry and/or ground surveys to provide adequate detailed topography at the project site.

E. Selection of Retaining Wall Type

The type of retaining wall to be constructed usually is determined by the cost of construction. However, some other factors such as critical clearances or right-of-way cost may affect the decision. The most economical type of wall to construct is primarily a function of the height of the wall. A gravity type wall is the most economical for low walls, a cantilever type wall for intermediate heights and a counterfort type for high walls. Other factors that shall be considered in the comparison of alternate wall types are the lateral earth pressure, the type of foundation, the depth of piles, and the allowable bearing pressure. The simplicity of construction and the durability of a gravity wall must also be considered in the final decision. See Section 3.4.A.1 for a description of retaining wall types.

In the historic districts and on scenic roads the aesthetics of a stone facing, colored and impressed concrete brick or wood trim may merit consideration. The approval of aesthetic amenities and/or special landscaping shall be subject to the review and approval by Chief of the Bureau of Engineering.

1. Proprietary Walls

Proprietary walls are patented systems for retaining soil. Depending on conditions, they can be more economical when compared to conventional retaining wall types. These walls are often more economical for long abutments and where high wall heights are dictated by field conditions. This type of wall construction can also save on bridge superstructure costs by reducing span lengths.

The detailed design and associated drawings are the responsibility of the proprietary wall firm, and wall products are typically provided through licensed regional manufacturers. The Maryland State Highway Administration requires that proprietary walls considered for use on capital projects must be on the list of Approved Proprietary Retaining Walls provided in the MDOT SHA Structural Guidelines and Procedure Memorandums (Ref. 10).

a. MSE

Mechanically stabilized earth (MSE) walls are comprised of a reinforced soil mass and modular precast concrete facing panels which are vertical or near vertical. MSE walls may be used where conventional gravity, cantilever, or counterforted walls are considered, and are well suited for supporting fills and where substantial total and differential settlements are anticipated. The precast facing panels are adaptable to a variety of architectural finishes. MSE walls should not be used where utilities other than highway drainage would be constructed in the reinforced soil zone, where erosion or scour may undermine the reinforced soil zone, or where galvanized reinforcements may be exposed to surface or ground water contaminated by pollutants characterized by low pH and high chlorides or sulfates.

b. Precast Gravity

Precast gravity walls, also known as segmental or modular retaining walls, consist of interlocking, soil-filled concrete units, and depend on dead weight for stability. The precast units can also be used with soil reinforcements to construct taller walls than those that resist loads by gravity alone. The stacked prefabricated units offer fast, easy installation, with the flexibility of curved and corner alignments and terraced walls. The concrete units may be colored and the wall face fabricated in a variety of shapes and textures.
Precast gravity walls should not be used on curves with a radius of less than 800 ft unless the curve can be substituted as a series of chords, or where the longitudinal differential settlement along the face of the wall is greater than 1/200.

c. Gabions

Gabions are stacked, stone-filled wire baskets that are interconnected to form gravity-type walls. Gabion walls are simple to install and are well suited for use as slope protection, low-height retaining walls and, in some cases, channel linings. They are permeable, which allows for backfill drainage and also permits the growth of natural vegetation. Once vegetation has been established, these walls blend well into the natural environment. Gabion walls are inherently flexible and are able to tolerate differential settlement that may result from unstable foundation soils. Consideration as a stream channel lining or stream bank stabilization technique shall only be made after considering the potential for debris lodging which can damage and accelerate failure of gabions. Due to their rough surface, gabions are not to be used where people may be walking or bicycling adjacent to the face of the wall.

F. Selection of Bridge Type

1. Site Conditions

Since no two bridge sites are exactly equivalent, the Designer must develop a particular span arrangement and bridge type for each individual site. Conditions at the proposed site such as existing grading, type of crossing and subsurface conditions must be taken into consideration. The constraints of limited right-of-way are relevant to some sites. Bridges in historic districts and on scenic roads should be designed to preserve or enhance the appearance of the road and to afford views from the bridge.

2. Materials

The type of material to be used in construction will depend on a variety of factors including suitability of material to load requirements, availability of material, construction procedures, maintenance of traffic, construction time, unusual site conditions and relative life cycle cost of the various types of materials. The County precludes the use of prestressed concrete voided box beams or slab beams/panels without the expressed written permission of the Chief of the Bureau of Engineering due to the difficulty in maintaining these types of structures. Wooden bridges in County park property may be acceptable subject to the review and approval by both the Chief of the Bureau of Engineering and Director of the Department of Recreation and Parks.

3. Cost

Since the relative economy of structure types cannot be generalized, it will be necessary to prepare economic comparisons of alternate bridge types suitable for a given situation in order to determine which type is most suitable from a cost standpoint. Future maintenance costs should be considered in addition to initial costs to ensure that the structure with the lowest life cycle cost is used.

To prepare these economic comparisons, it is first necessary to determine the structure quantities that are associated with each type of bridge. These may be obtained from preliminary designs, from quantity charts, from historical data, or by a combination of these methods.

Unit prices for application to the estimated quantities should be determined based on recent bid tabulations for comparable projects in the Howard County area. These unit prices must be adjusted by judgment on the basis of project size, location and construction difficulties.
4. Safety and Aesthetics

Important considerations are safety and aesthetics. Maximum traffic safety is provided by deck type overpass structures with adequately designed safety barriers and open span underpass structures without piers or other structural elements adjacent to the roadway.

Bridges on scenic roads or in historic districts merit special design consideration. The width of the deck should be consistent with the adjacent roadway. Barrier parapet walls should incorporate open railings at passenger eye level to permit views of the river crossing and adjacent scenery. Abutment embankments/slopes and piers shall be positioned to retain the natural stream channel adjacent to the bridge. If erosion is of concern, consider bio-engineering rather than riprap, gabions or a concrete channel.

Wider sidewalks for pedestrian use or scenic views, wider bicycle facilities, open railings, architectural treatments, and special lighting should be considered where it is appropriate to improve the utility and appearance of the bridge to make it more compatible with the other elements of the surrounding community, especially in historic districts along a scenic road. Modest use of special treatments can be done without a significant increase in cost, but such aesthetic requirements as an increase in span lengths, special finishes and special structural shapes can result in significant cost increases. The added cost resulting from special treatments must be evaluated to determine that the improved aesthetics are worthy of the increased cost.

5. Maintenance Requirements

Future maintenance is another important consideration in the design of new bridges and existing bridge rehabilitations. All bridge components must be accessible for routine biennial inspection as well as maintenance, either by a snooper or some other means. Designs should provide for superstructure jacking to facilitate servicing, repair, or replacement of bridge bearings.

Key items to minimize future maintenance include:
- Minimize the number of expansion joints.
- Design sealed joints to prevent deck runoff from draining onto the bearings and beam seats below.
- Provide joint components that can be maintained.
- Avoid unusual joint details.
- Avoid details that trap dirt in splices, joints or other components.
- Locate scupper outlets below the bottom flange of beams to prevent water damage from splash-back.
- Provide downspouts and/or splash blocks where scupper outlets would cause erosion or dump water on roadways from overpasses.
- Eliminate or minimize the existence of deck drainage systems. If required, design deck drainage systems with sufficient size and adequate slope to prevent clogging and ponding. Provide clean-outs and avoid sharp bends in piping.
- Protect stream channels from erosion and piers and abutments from scour.
- Provide roadway drainage at abutments and wing walls to prevent erosion.
- Provide adequate vertical and horizontal clearances to prevent vehicle damage.
- Consider the feasibility of painting structural steel and evaluate the suitability of weathering steel.
- Consider using precast prestressed concrete structural members.
- Investigate the feasibility of using integral or semi-integral abutment construction.
Chapter 3: Design of Bridges, Retaining Walls, and Small Structures

G. Selection of Culverts

1. General

Culverts are generally cost-effective solutions for relatively small stream crossings. A single culvert can be used for the smallest crossing. Larger stream crossings can utilize multiple cell box culverts or a battery of pipe culverts. In each case, all factors of hydraulics, topography, economics and environmental factors must be considered before a culvert alternative is selected. It will be necessary to comply with the policies of all permitting agencies concerning the need for permits and the maintenance of the natural environment. Design of culverts shall meet all the requirements of bridges, including those for foundation design and scour design. For small culverts with inverts, subsurface borings taken for the roadway will usually be sufficient for the foundation design.

Box culverts are generally made of concrete with mild reinforcing. These can be cast in the field or precast at a factory in units which are then shipped and placed in the field. When precast concrete box culverts are used, the box culvert ends and all wing walls, headwalls and toe walls shall be cast in place; refer to Volume IV Design Manual.

Pipe culverts are available in a large range of shapes, sizes and materials. Steel pipes can consist of pipes rolled at the mill such as corrugated metal pipes (CMP’s, etc.) or pipes made from steel plates assembled at the job site such as structural steel plate pipes (SPP’s, etc.). Steel pipes less than 4’ in diameter may be either the CMP or the SPP type. Steel pipes larger than 4’ in diameter must be of the SPP type.

Culverts without paved inverts, such as structural plate pipe arches and precast concrete arches, are also commonly available. These types of structures are very dependent on the foundation conditions and their use may require extensive foundation and scour investigation work.

Refer to Volume I Design Manual for additional information concerning culverts.

2. Advantages

For streams of a size within the hydraulic capacity of a culvert, the culvert is usually less costly to design, construct and maintain than a bridge. A culvert structure is less susceptible than a bridge to structural defects due to differential settlement, undermining and scour.

3. Disadvantages

In most cases, culverts tend to have the following disadvantages:

- The design opening is wider than the existing channel requiring undesirable channel modifications.
- Silting occurs during low flow.
- Multiple cells tend to obstruct flow and accumulate debris during flood flow.
- Water velocity increases in the culvert cause downstream scour.

H. Structures over Waterways

1. Hydrologic Studies

Hydrologic studies shall be performed for all structures crossing waterways. Flow rates and hydrographs associated with these studies shall be developed in accordance with procedures described in the “Howard County Storm Drainage Design Manual,” Vol. I (Ref. 7) for typical roadway culverts or the MDOT SHA “Manual for Hydrologic and Hydraulic Design” (Ref. 12) for Small Structures or Bridges. Existing stream gauging data, observed high water marks and observations of local residents shall be used to check and calibrate hydrologic calculations based on empirical methods, including those noted in Reference 12.

2. Hydraulic Studies

a. Bridges

Analysis of the effect of bridges on the stream flow and establishment of the design high water at the bridge site or at other critical points shall be in accordance with the procedures described in the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12).
A freeboard of one (1) foot from the design high water to the underside of the superstructure shall be maintained. Refer to the “Howard County Storm Drainage Design Manual” (Ref. 7) for specific freeboard requirements.

b. Box Culverts

The effects and characteristics of flow in box culverts shall be analyzed in accordance with the procedures described in the Federal Highway Administration Circular “Hydraulic Design of Highway Culverts” (HDS–5) (Ref. 8) or similar publications. Due consideration shall be given to both inlet control and outlet control.

3. Hydraulic Design Criteria

a. Highwater Elevation

A stream crossing structure shall be designed to interfere as little as possible with the natural stream channel and shall conform to the “Howard County Storm Drainage Design Manual”, Vol. I (Ref. 7) and other State and Federal requirements.

b. Maximum Velocities

Discharge velocity shall be consistent with channel materials. For maximum and minimum velocities, refer to the “Howard County Storm Drainage Design Manual,” Vol I (Ref. 7), the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12) and applicable environmental regulations.

4. Walking and Bicycling Use

Consideration shall be given to making provisions for walking and bicycling under structures placed over waterways. Where feasible, provide sufficient clearance for walking and bicycling use in these circumstance in accordance with the relevant sections of this chapter. In these locations, the Designer shall consider the pavement section and subgrade if they could be subjected to flooding and/or erosion.

I. Clearances

1. Horizontal Clearances - Highways

a. Bridge Roadway Width

The roadway width of bridges shall preferably be the full width of the approach roadway section including the shoulders. Minimum bridge roadway widths are discussed in the MDOT SHA “Structural Guidelines and Procedure Memorandums” (Ref. 10) for various classifications of highways. These minimum widths shall be adhered to unless written authorization is provided by the Chief of the Bureau of Engineering.

If sidewalks and/or bicycle facilities exist on either approach roadway section, or are anticipated within the bridge’s service life, those sidewalks and/or bicycle facilities shall be carried across the bridge. If sidewalks and/or bicycle facilities are not anticipated within the bridge’s service life, an eight-foot shoulder shall be provided on each side of the bridge to provide accommodation for people walking and bicycling.

b. Underpass Clearance

For an open section roadway or a bridge, the piers or abutments shall be set to provide clearance for the full shoulder plus a guardrail or concrete barrier. The roadway face of the guardrail shall be at least 5’-0” from the face of the pier or abutment. The face of the guardrail or barrier shall be at least 2’-0” outside of the normal shoulder line. For closed section roadways, the face of pier or abutment shall be set a minimum of 8’-0” back of the curb line. Piers and abutments shall be protected by guardrail or crash walls.
If sidewalks and/or bicycle facilities exist on either approach roadway section, or are anticipated within the bridge’s service life, piers or abutments shall be set to provide sufficient horizontal clearance to allow for accommodation of those facilities. If sidewalks and/or bicycle facilities are not anticipated within the bridge’s service life, piers or abutments shall be set to accommodate a minimum eight-foot shoulder on each side of roadway under the bridge to provide accommodation for people walking and bicycling.

2. Horizontal Clearances - Railroads

Horizontal clearances from railroad tracks to piers, abutments or walls of an overpass structure shall be in accordance with the requirements of AREMA (Ref. 2) and the policy of the particular railroad for the class of track involved. In the case of privately owned spurs, the clearances shall be at least equal to the requirements of the Maryland Public Safety Laws and meet the approval of the railroad operating over the spur.

3. Vertical Clearance

a. Highways

Vertical clearance to highway or railroad structures over highways shall be 16'-9", which provides for 16'-0" minimum over any usable portion of the roadway and shoulder and 9" of future surfacing.

b. Railroad

Vertical clearance over railroads shall be 24'-3" (top of rail to underclearance) for electrified railroads, and 23'-0" for all others. Clearance shall be approved by the railroad owner.

c. Shared Use Path Bridges

Vertical under clearances for shared use path bridges shall be: 24'-3" over electrified railroads and 23'-0" over other railroads. Vertical clearances for shared use path bridges over streets or highways shall be in accordance with the requirements of AASHTO (Ref. 1) and provide an additional 1'-0" clearance over that required for highway bridges.

J. Bridge Roadway Section

1. Curbed (Closed) Section

The flow line of a curbed roadway section shall be continuous across the bridge.

2. Rural (Open) Section

The shoulder of a rural section shall be carried across the bridge. The cross slope configuration shall conform to that of the approach roadway except that the cross slope in the shoulder area on the bridge shall be an extension of the adjacent traffic lane (i.e., no shoulder breaks on bridge). The approach roadway shoulder slope shall be transitioned to meet the shoulder slope of the structure beginning at a minimum distance of fifty (50) feet from the ends of the structure.

3. Barriers

All barriers on bridges and approaches, including transitions, shall meet or exceed MDOT SHA and AASHTO specifications, including crash testing requirements based on the roadway classification. The MDOT SHA “Bridge Railing Manual” (Ref. 25) provides guidance on railing selection and shall be adhered to for capital projects unless written authorization is provided by the Chief of the Bureau of Engineering. Selection of the appropriate barrier, with or without metal railing, should be made with consideration given to the type of roadway facility (controlled access or non-controlled access) and type of pedestrian and bicycle facilities on the bridge. The Designer shall use care in selecting railing systems to ensure serviceability.
Safety fence shall be provided in accordance with MDOT SHA requirements. Decorative barriers/railings or bridge lighting appurtenances shall be subject to the approval of the Chief of the Bureau of Engineering.

In accordance with the AASHTO “Guide for the Development of Bicycle Facilities” (Ref. 23), the minimum recommended distance between a shared use path and the roadway curb (i.e., face of curb) or edge of traveled way (where there is no curb) on a vehicular bridge is 5 feet. Where the separation is less than 5 feet a physical barrier or railing should be provided between the path and the roadway. The barrier or railing shall be in accordance with the provisions of AASHTO (Ref. 1 and Ref. 23) for a pedestrian, bicycle, or combination railing. A barrier or railing between a shared use path and adjacent roadway should not impair sight distance at intersections and should be designed to limit the potential for injury to errant motorists and bicyclists.

Careful attention shall be given to the treatment of railings at bridge ends. Exposed rail ends, posts and sharp changes in the geometry of the railing shall be avoided. A smooth transition by means of a continuation of the bridge barrier, flared end posts, roadway guardrail anchored to the bridge barrier, continuation of bridge guardrail, or other effective means shall be provided to protect the traffic from direct collision with the bridge rail ends and to afford protection for people walking and bicycling. Guidelines for these transitions are specified in the MDOT SHA “Book of Standards for Highway and Incidental Structures” (Ref. 15).

K. Horizontal and Vertical Alignment

1. Bridges

The horizontal and vertical alignment of the bridge must be coordinated with the overall plan and profile of the approach roadway. Geometric design requirements concerning sight distances, minimum curve radii, superelevation, etc., shall be in accordance with Chapter 2, “Road and Street Design.” Methods and criteria for maintenance of traffic are contained in Chapter 5, “Traffic Studies.”

2. Horizontal Alignment of Box Culverts

a. Alignment with Waterway and Road

Culverts shall generally be located and aligned as closely as possible to the natural drainage course for which they are being designed. The skew angle shall be kept as close to 0 degrees as possible, while providing a minimum stream relocation, if any.

b. Maintenance of Flow

The Designer must consider the requirements for maintaining stream flow during construction. It may be necessary to provide a temporary channel in order to provide for maintenance of flow. Maintenance of steam flow plans shall be prepared in accordance with the latest edition of the MDE “Maryland Waterway Construction Guidelines” (Ref. 9).

L. Subsurface Investigations

In order to determine the type of foundation and allowable bearing pressures, borings will be required at the proposed locations of walls, culverts and bridge foundations. The information obtained should include elevation of the existing ground at the boring, a description and depth of the material encountered, number of blows per six (6) inches on the sampling spoon, recovery of cored rock, total depth of boring, the water table level and the time of observation. For small culverts with inverts, subsurface borings taken for the roadway will usually suffice for the foundation design.

Standard penetration borings through soil are required to be performed in accordance with AASHTO T206 and ASTM D1586. The number of blows required for each 6 inches of penetration or fraction thereof shall be recorded. The first 6-inch penetration is considered to be a seating drive. The number of blows required for the second and third six inches of penetration added together is considered the penetration resistance, N.
Split spoon samples shall be taken at every change in material at intervals not exceeding five (5) feet. All borings should be drilled to refusal and cored a minimum of 5 feet into rock. Refusal is defined as 50 blows or more per inch or less of penetration.

Foundation borings shall generally be located as follows: one boring at each end of each substructure unit for multibeam bridges; one boring at each end minimum with intermediate borings as required to maintain 100’ maximum c/c spacing for culvert type structures and retaining walls.

All the boring log information must be shown on the plans.

M. Foundation Reports

A formal Foundation Report is required for all retaining walls 4’ or greater in height measured from the top of wall to the ground line at the front face of wall; all box culverts; all pipe culverts with individual spans greater than 8’ measured perpendicular to the pipe; all hydraulic structures without inverts; and all bridges. For structures not meeting these requirements the Designer shall perform sufficient subsurface investigations and analysis to ensure the stability of the structure. The depth and number of borings shall be in accordance with AASHTO LRFD Bridge Design Specifications requirements.

The formal foundation report shall provide all information and calculations documenting that the subsurface investigations and foundation design have been made in accordance with the requirements of this Volume III Design Manual and AASHTO LRFD Bridge Design Specifications. In addition, the foundation report shall address the impact of settlement of approach fill embankment on bridge foundation design as well as pertinent foundation construction control and construction considerations. The Foundation Report shall be accompanied by boring logs plotted on a plan sheet and preliminary structure plans.

For all new or replacement bridges, detailed Foundation Reports shall be prepared for review and approval by the Chief of the Bureau of Engineering. Foundation Reports shall include copies of all boring and laboratory testing information including a project map noting the location of all test borings. For Capital Projects, Foundation Reports shall be prepared in accordance with applicable sections of the MDOT SHA “Structural Guidelines and Procedure Memorandums” (Ref. 10).

N. Scour Reports

Current regulations require that the construction, replacement or rehabilitation of any bridge structure which uses either full or partial funding from the Federal Government be accompanied by an approved Scour Analysis Report. Reports for such projects will be reviewed by the Maryland State Highway Administration Office of Structures (OOS). All scour reports shall be developed in accordance with the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12), in particular Chapter 11.

All scour reports shall be prepared and sealed by a registered professional engineer in the state of Maryland. Personnel involved in the evaluation of scour need to possess the technical qualifications, including practical experience, education and professional judgment, to perform the individual tasks assigned. Interpretation of results and conclusions of scour analyses shall be accomplished by registered engineers qualified in the appropriate disciplines. Because of the complexity of bridge scour, the evaluations shall be performed by an interdisciplinary team of engineers with the requisite knowledge in structural, hydraulic, river mechanics and geotechnical engineering.

For non-federally funded projects, scour reports may not be required if any of the following criteria applies:

- The project scope is limited to the rehabilitation of the bridge superstructure and/or minor rehabilitation of the substructure. Minor rehabilitation of the substructure shall be limited to abutment (or pier) repair and shall not include any changes to the overall geometry of the substructure units, with the exception of minor fascia treatments that do not reduce the total waterway opening by more than 10%.
• The project is a replacement or rehabilitation of a bridge or bottomless culvert where evidence of scour is minimal either through inspection or previous inspection reports and where the proposed abutment footings, or deep foundations such as piles, are founded in non-erodible rock. Rock where borings indicate a Rock Quality Designation (RQD) less than 50% shall be assumed to be erodible (FHWA Memorandum on Scourability of Rock – June 19, 1991).

• The project is a new, replacement or rehabilitated bridge or culvert along a private road or drive not governed by any county, state or local municipality easements, right-of-way or right-of-entry.

The county reserves the right to request that a formal Scour Report be prepared in accordance with MDOT SHA standards for any project within county right-of-way or along a roadway maintained by the county by virtue of easement, right-of-entry or prior agreement. A formal Scour Report shall be required for all bridges and small structures without integral paved inverts and which carry waterways. A formal Scour Report shall also be required for retaining walls which could be subject to stream action and which require a formal Foundation Report. The Scour Report shall be submitted in conjunction with the Foundation Report. The county may also request that a Scour Report be prepared for a structure for the purpose of re-evaluating the Structure Inventory and Appraisal Item 113. If a Scour Report is not requested by the county, the engineer of record shall still have the responsibility of ensuring that the bridge or culvert is designed in adequate consideration of the effects of scour.

Contraction, abutment and pier scour depths/elevations developed by scour analyses shall be used in the assessment of the bridge stability in accordance with Chapter 11 of the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12). For the Design Flood for scour, the material in the resulting scour prism shall be assumed to be removed, and the bridge shall be analyzed with stability factors as dictated by the AASHTO “LRFD Bridge Design Specifications” (Ref. 1). For the Check Flood for scour, the material in the resulting scour prism shall be assumed to be removed and the bridge shall be analyzed with a stability factor of 1.0.

O. Bridge Inspection

Howard County maintains an inventory of bridges and small structures. To assist the County, Designers are required to provide the following information for culverts with spans greater than 10’ and for all bridges:

• Design Storm Year
• Runoff Q in cfs
• Drainage area in acres
• High Water Elevation for the Design Storm
• Year of Maryland State Highway Specification used
• Year of AASHTO Specification used

P. Design Life

All bridges must be designed to achieve a minimum service life of 75 years or a longer period (e.g., 100 years), if so directed by the Chief of the Bureau of Engineering, for applicable capital projects.
3.3 Design Loading – Highway Structures

A. General

Loads and loading combinations shall be in accordance with the provisions of AASHTO (Ref. 1). The limit states described in the AASHTO specifications (Ref. 1) shall be investigated for the design and analysis of bridge components.

B. Dead Load

1. Future Wearing Surface

In addition to the dead load of the structure, an allowance shall be made in the design analysis for a future wearing surface. This shall be 25 lbs./sq. ft. for all except moveable spans and exceptionally long spans. The additional deck load for these spans shall be determined on an individual basis depending on the type of construction.

2. Unit Loads on Culverts

The dead load on culverts shall include the dead load of the box and the weight of earth above the box. Loads shall be calculated in accordance with AASHTO Specifications, (Ref. 1). Except for box culverts on piles, the dead load of the bottom slab and water within the box should be neglected in design of slabs and walls. These dead loads shall, however, be included when determining foundation pressures. In the absence of more exact information, the density of the soil shall be taken as 120 lbs./cu. ft. and 150 lbs./cu. ft. shall be used for the weight of the concrete.

3. SIP Forms

An additional allowance shall be made in the design analysis when the use of steel stay in place forms is required. This loading shall be 15 lbs./sq. ft. of deck form plan area. This value includes the weight of the forms plus concrete in the corrugation valleys of the forms.

C. Live Load

1. Design Loadings

For vehicular bridges and all other structures, an HL-93 loading shall be used. For additional information concerning Design Loadings, see the MDOT SHA “Structural Guidelines and Procedure Memorandums” (Ref. 10). Permanent deformations under overloads, live load deflections, and fatigue characteristics under service loadings shall be investigated, as specified in the AASHTO Specifications (Ref. 1). The loading for temporary structures will be determined by the Department of Public Works on the basis of the duration of time the temporary structure is expected to be in place and the anticipated traffic characteristics during that period. It shall not be less than HS-20 with standard over-load provisions, as specified in the AASHTO Specifications (Ref. 1).

D. Wind Loads

Wind loads calculated in accordance with AASHTO Specifications (Ref. 1) shall be applied to the bridge substructure and superstructure as indicated therein.

E. Thermal Forces

Thermal forces shall be as specified by AASHTO (Ref.1) for moderate climate.

F. Force of Stream Flow

The effect of flowing water on piers shall be calculated in accordance with AASHTO (Ref. 1).

No static or dynamic pressures shall be applied for ice floes, ice sheets or ice jams except under special circumstances for public structures such as pedestrian bridges in public parks. The consideration of occasional cost and safety must be considered in the structure’s life cycle cost and this determination shall be made by the Chief of the Bureau of Engineering.
G. Earth Pressure

Structures which retain earth shall be proportioned to withstand pressure as given by Rankine's formula. In the absence of more specific information, an equivalent fluid pressure of 35 lbs./cu. ft. shall be used. This pressure is based on the assumption that a layer of porous backfill and a drainage system with weep holes will be provided to insure a low ground water elevation at the rear face of the structure.

If conditions are such that it is not possible to control the water table behind the structure, the structure shall be designed taking into account, below the water level, the full hydraulic pressure in conjunction with pressures of the submerged soil.

A sloping finished grade line behind the structure may be accounted for by computing the pressure on the basis of the depth of earth in a vertical plane at the heel of the footing.

1. Water Pressure

If conditions are such that it is not possible to control the water table behind the structure, the structure shall be designed taking into account, below the water table, the full hydraulic pressure in conjunction with pressures of the submerged soil. Below the water table the unit weight of the retained soil is reduced to its submerged or buoyant value. As a result, the lateral earth pressure below the water table is reduced, while the retained water exerts a horizontal hydrostatic pressure.

When ground water levels differ on opposite sides of a retaining wall, the upward buoyant force beneath the wall foundation tends to overturn the wall. Unequal ground water levels also result in seepage beneath the wall. The effect of seepage forces is to increase the load on the back of the wall (and decrease any passive resistance in front of the wall). Pore pressures in the backfill soil can be approximated through the development of a flow net or other analytical methods, and then added to the horizontal earth pressures acting on the wall.

H. Earthquake Forces

Structures shall not be designed to resist earthquake forces.

I. Distribution of Loads

For distribution of loads refer to AASHTO (Ref. 1).

J. Constructability

Constructability checks shall be completed in accordance with the provisions of the AASHTO Specifications (Ref. 1). The wind load provisions specified in the “Guide Specifications for Wind Loads on Bridges During Construction” of the Association of State Highway and Transportation Officials (AASHTO, Ref. 22), including subsequent interim specifications shall be used for wind loading on steel and concrete superstructures before the deck has been placed.

The load factors for construction loads shall be taken as the minimum specified in AASHTO (Ref. 1).
3.4 Substructures and Retaining Walls

A. Retaining Walls

The primary structural function of a retaining wall is to counteract the lateral forces caused by earth pressure. These forces have two principal effects on the wall. First, they tend to overturn the wall and secondly, these forces tend to push or slide the wall. Before designing specific parts of the wall, such as the footing, stem, etc., overall stability of the wall and the earth mass must be satisfied. The total earth mass containing the wall and its foundation must be in equilibrium. A subsurface investigation should be made to determine the possibility of a slip plane failure that would affect the global stability of the entire installation. The overturning moment about the toe of the footing, caused by the earth pressure and surcharge, must be resisted by the stabilizing moments of the dead load forces. Unless a structure is keyed into rock or is restrained by an adjacent structure, the horizontal earth pressure force must be resisted by friction between the footing and the foundation. Retaining walls used in subdivisions and site development plans shall use the retaining wall checklist when submitting designs.

Reinforced fills and proprietary retaining walls will be considered on a case by case basis. No consideration for use shall be given unless the system has been approved for use by the MDOT State Highway Administration.

Retaining walls are primarily either fill walls or cut walls. Fill walls are typically constructed from the bottom up and consist of placing material behind the face of the wall. Cut walls are typically constructed from the top down and consist of removing material in front of the face of the wall.

1. Fill Retaining Wall Types

There are six principal types of fill retaining walls: gravity walls, semi-gravity walls, cantilever walls, counterfort walls, buttress walls and MSE walls. Table 1 provides general guidelines for fill retaining wall selection.

a. Gravity Walls

Gravity Walls resist sliding and overturning by means of their mass, the resultant of all forces being within the middle third of any horizontal section through the wall. Reinforcing is required only to resist shrinkage and temperature forces and shall be the minimum required by the governing design specification.

As a guide for initial design, the width of the base of the wall should be approximately 0.45 times the total height. The final size used varies with the type of material, the slope of the backfill surface, the surcharge and the allowable bearing pressure.

<table>
<thead>
<tr>
<th>Retaining Wall Type</th>
<th>Cost Effective Height Range (ft)</th>
<th>Typical Required Right-of-Way</th>
<th>Tolerable Differential Settlement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Gravity Wall</td>
<td>Up to 10 feet</td>
<td>0.5 – 0.7H</td>
<td>1/500</td>
</tr>
<tr>
<td>Concrete Cantilever Wall</td>
<td>Up to 20 feet</td>
<td>0.4 to 0.7H</td>
<td>1/500</td>
</tr>
<tr>
<td>Concrete Counterfort Wall</td>
<td>30 feet to 60 feet</td>
<td>0.4 – 0.7 H</td>
<td>1/500</td>
</tr>
<tr>
<td>Gabion Wall</td>
<td>5 feet to 20 feet</td>
<td>0.5 – 0.7H</td>
<td>1/50</td>
</tr>
<tr>
<td>MSE wall with precast facing</td>
<td>10 feet to 40 feet</td>
<td>0.7 to 1.0H</td>
<td>1/100</td>
</tr>
<tr>
<td>MSE wall (modular block facing)</td>
<td>5 feet to 20 feet</td>
<td>0.7 to 1.0H</td>
<td>1/200</td>
</tr>
<tr>
<td>MSE wall (geotextile/ geogrid/ welded wire facing)</td>
<td>5 feet to 40 feet</td>
<td>0.7 to 1.0H</td>
<td>1/50</td>
</tr>
</tbody>
</table>
Gravity walls may be used under any condition where foundation material is reasonably good and are often the most economical type for use where the wall is quite low. Because of its massive construction, this type of wall is more resistant to destructive agents and partial disintegration of the concrete is not as serious as for the heavily reinforced types.

b. Semi-Gravity Walls

By introducing a relatively small amount of reinforcing steel in the back face of a gravity wall, a slenderer stem can be used. This type of wall is commonly known as a semi-gravity wall. The semi-gravity wall is more economical than the solid gravity wall and has the same advantage of durability due to massive construction, although to a lesser extent.

c. Cantilever Walls

Cantilever walls consist of a continuous stem supported on a continuous footing. Resistance to overturning results from the stabilizing action of the weight of concrete in the wall and the block of earth supported directly over the heel of the footing. The stem, the heel of the footing and the toe of the footing act as cantilever slabs resisting the applied loads.

The stem shall be designed to resist the moments and shears caused by the earth pressure above the top of footing and the surcharge applied to it. The weight of the stem itself shall be considered and the critical sections designed for direct stress and bending.

The heel of the footing shall be designed to resist its own weight and the total weight of the earth supported directly on it, with or without a reduction for upward foundation pressures.

The toe shall be designed to resist the foundation pressure acting on it, less its own weight, but no reduction is to be made for backfill over the toe.

Cantilever walls are the most widely used type and can be used in heights to approximately 30 feet. This type of wall is by nature more flexible than the other types, and considerable deflection can be expected at the top of the higher walls. Consequently, cantilever walls should not be tied to other types of walls with shear keys. Rather, architectural offsets or pilasters should be incorporated into the design at such junctures so that differential deflection will not be noticeable.

For the most economical arrangement, a cantilever wall stem should be located over the point where the resultant of the loads pierces the plane of the footing. This means the toe of the footing for the typical wall should be about one-third the total width of the footing. However, the stem may be located anywhere on the footing as required by right-of-way requirements, conflict with structures and utilities, or for other reasons.

As a guide for initial design, the footing width normally ranges between 0.5 and 0.7 the total height of the wall, depending on allowable bearing pressures, desirable bearing differentials and superimposed loads.

d. Counterfort Walls

Counterfort walls consist of a face wall spanning continuously between counterforts which extend into the backfill. Counterforts are spaced at some constant interval, usually in the range of from 8 feet to 16 feet and are supported on either individual or continuous footings.

The face wall may be either full height or, in the case of deep footings, extend only 2 ± feet below finished grade at the front of the wall.
Face walls shall be designed as continuous slabs in increments of height. Each increment shall have the proper thickness and/or reinforcement to resist the average earth pressure over that increment. If the face wall is tied to the footing, the bottom increment can be designed for vertical and horizontal bending.

The heel portion of continuous footings shall also be designed as continuous slabs. The toe, which commonly is rather short, shall be designed as a cantilever as previously described. Counterforts shall be designed as tee-beams to resist the overturning forces for the full counterfort interval.

Counterfort walls are usually most economical for heights over 30 feet and in instances where the footing must be placed very deep.

Widths of counterfort footings to satisfy stability requirements are usually at least 0.5 the height of the wall. The heel dimension is normally governed by the counterfort design.

It is necessary that counterforts be of sufficient size to permit proper placing and vibrating of the concrete and to permit proper cleaning prior to placing the concrete. They should not be less than 2 feet in thickness.

e. Buttress Walls

A variation of the counterfort wall is the buttress wall. This type of wall resembles the counterfort wall except that the members supporting the face slab are on the exposed face of the wall and are called buttresses rather than counterforts. The face slab is designed in the same manner as a counterfort wall and the buttresses are designed as rectangular beams. Since the buttresses are exposed and therefore reduce the clearance in front of the wall, the buttress wall is rarely used.

f. MSE

Mechanically stabilized earth (MSE) walls consist of facing elements connected to layers of soil reinforcement that are embedded within a select backfill. These walls resist lateral loads through the dead weight of the reinforced soil mass behind the wall facing. Wall heights of up to 40 ft can be constructed. MSE walls are often used at bridge abutments, with a stub abutment supported on piles behind the wall.

MSE wall systems are designed to meet the requirements for overall stability (global stability), external stability including overturning and sliding, bearing capacity, and settlement, as well as the internal stability requirements including the strength of the reinforcement element, pullout resistance and connection strength. Lateral pressures are determined from active earth pressure acting on the back of the reinforced soil mass. The analysis of the overall and external stability is the responsibility of the design consultant. The analysis of the internal stability is the responsibility of a proprietary retaining wall company.

The reinforced soil mass consists of select granular backfill placed in layers between reinforcement, which is comprised of either inextensible (deformation of the reinforcement at failure is less than deformability of soil – includes steel strip and bar mat reinforcement) or extensible (deformation of reinforcement at failure is comparable to or greater than deformability of soil – includes geogrid, geotextile and woven steel mesh reinforcement) reinforcement. Metallic reinforcement typically consists of mild steel and nonmetallic reinforcements typically consist of polymeric materials consisting of polyester or polyethylene. Steel soil reinforcements and connection hardware shall be galvanized. The soil reinforcement length is a minimum of 70 percent of the overall wall height and is uniform throughout the entire height of the wall.
Facing elements are designed to resist the horizontal force of the reinforcement. Facing materials consist of precast concrete panels, full height panels, modular block wall units, and welded wire mesh facing. Segmental, precast concrete panels are typically between 5 inches and 8 inches thick, 5 feet high and have a front face width that is 5 feet or 10 feet. Panels are typically square or rectangular; however, cruciform, diamond and hexagonal face geometry are also available. Typical dimensions of full-height concrete panels are 6 inches to 8 inches thick 8 feet to 10 feet wide. Modular block wall face units (also known as segmental retaining wall units) are typically 4 inches to 15 inches high, 8 inches to 18 inches in exposed face length and 8 inches to 24 inches in depth. Welded wire mesh facing is typically used for temporary walls. Galvanized steel is used for permanent walls with welded wire facing. Hot dip galvanizing of at least 2 oz/ft² is expected to protect the steel in atmospheric conditions for up to 50 years. A corrosion rate of 1.0 mil/year should be considered for temporary, non-galvanized steel facings.

Internal drainage must be provided to prevent saturation of the reinforced backfill and infiltration of damaging elements from the surface. In cut areas, drainage blankets are provided behind and below the reinforced soil mass. For roadways subject to chemical dicing agents, an impervious membrane above the first layer of reinforcement may be necessary.

General design guidelines for MSE retaining walls are as follows:

- Publication No. FHWA-NHI-10-024, Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, Volumes I and II, 2009
- AASHTO LRFD Bridge Design Specifications, Volume II

**g. Precast Gravity**

Prefabricated modular wall systems are designed to resist lateral earth loads as a gravity retaining wall. Two systems are generally used: interlocking soil filled concrete bins and segmental masonry concrete units. Soil filled bin systems can be used to construct walls up to 45 ft high. Segmental wall systems may be used to construct walls four to six feet high without soil reinforcements. They can also be used with soil reinforcements, typically metal or geosynthetic meshes, for wall heights up to 45 ft.

For overall stability against sliding and overturning, the modular units are considered to act as a rigid body. For overturning, 80 percent of the soil-fill unit weight within the modules is effective in resisting overturning moments, as not all of the soil can be expected to arch within the module. The full weight of the soil-fill may be considered to resist sliding. Stability shall be evaluated at every module level.

Modular units are installed on either concrete or gravel leveling pads, depending on soil conditions. Soil shall be sloped away from the wall base to prevent erosion and eliminate water from running along the wall base. Where groundwater behind the wall is expected, the backfill is typically drained with a continuous drainage blanket consisting of crushed stone immediately behind the wall and a continuous perforated drain pipe near the footing level. Additional subsurface drainage may be required behind reinforced soils. It is also important to provide adequate grading or drainage systems at the top of the wall to direct surface flows away from walls.
h. Gabions

Gabion walls are constructed from stone filled wire mesh boxes, which are stacked and wired together. The backfill can be placed behind the wall as each level of boxes is installed. Gabion walls can be economically constructed to about 30 feet in height. Gabions can also be used as a wall facing with soil reinforcements, typically galvanized wire mesh, for wall heights up to 45 feet.

Gabion boxes are constructed from hexagonal mesh woven from soft galvanized wire. The wire may be PVC coated to protect from acidic soils or marine environments. The nominal size of the mesh openings is three to four inches. The boxes are usually constructed with internal wire mesh diaphragms or wire cross-ties for increased strength. Standard gabions are available with the following dimensions:

- Nominal Length – 6, 9, or 12 feet
- Nominal Width – 3 feet
- Nominal Height – 1, 1.5, or 3 feet.

The stone used to fill the gabion baskets should be non-friable, weather resistant, and preferably high density. Gabions may be filled by hand or machinery, but in either case it is important that they be filled carefully to maintain the box shape to ensure proper alignment of the wall.

Gabion walls are designed to resist lateral earth loads as a mass gravity structure, in which the additional tensile resistance of the wire mesh is ignored. Gabion structures are permeable, allowing for free drainage, and are not designed for water pressure loads. While gabion walls are self-draining, it is advisable to provide a backfill drain above footing level to collect drainage and protect the wall foundation.

Smaller height gabions are used at the base of walls, and the boxes are arranged such that the longest dimension is perpendicular to the wall to reduce shear deformation. The front wall face may be either stepped or flush, but a stepped front face is preferable, especially for taller walls. Gabion walls are constructed tilted back toward the retained soil at about a 6-degree angle for stability.

i. Noise Abatement Walls

Noise Abatement Walls shall be designed and constructed in accordance with the MDOT SHA Noise Abatement Planning and Engineering Guidelines and Chapter 15 of the MDOT SHA OOS Design Guides for Capital Projects. All components shall meet or exceed the requirements set forth in these policies and guidelines and will be subject to the same level of review and design standard. Refer to Section 5.2.F of this Design Manual for additional requirements. General design guidelines and references for noise abatement walls are as follows:

**FHWA Guidelines for Noise Abatement Walls:**
- FHWA Highway Noise Fundamentals, 1980
- FHWA Highway Traffic Noise Sources, 1980
- FHWA Measurement of Highway-Related Noise, 1996
- FHWA Highway Construction Noise: Measurement, Prediction; and Mitigation, 1977
- AASHTO Guide on Evaluation and Abatement of Traffic Noise, 1993
- FHWA Noise Barrier Design Handbook, 1975
- LPILE by Ensoft, Inc., Latest Version
- AASHTO Guide Specifications for Structural Design of Sound Barriers
- AASHTO LRFD Bridge Design Specifications
2. Cut Type Retaining Walls

There are four principle types of cut retaining walls: sheet pile walls, pile and lagging retaining walls, soil nail walls and permanent tieback retaining walls.

Table 2 provides general guidelines for cut retaining wall selection.

**TABLE 2 – CUT RETAINING WALL TYPES**

<table>
<thead>
<tr>
<th>Wall Type</th>
<th>Cost Effective Height Range (feet)</th>
<th>Required Right-of-Way</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheet Pile Wall</td>
<td>Up to 16 feet</td>
<td>Minimal</td>
</tr>
<tr>
<td>Soldier Pile and Lagging Wall</td>
<td>Up to 18 feet</td>
<td>Minimal</td>
</tr>
<tr>
<td>Tieback Wall</td>
<td>15 feet to 45 feet</td>
<td>15 feet minimum unbonded length + anchor bond length</td>
</tr>
<tr>
<td>Soil Nail Wall</td>
<td>10 feet to 40 feet</td>
<td>0.6 to 1.0H</td>
</tr>
</tbody>
</table>

a. Sheet Pile Walls

Sheet pile walls are often used for support of excavation systems. These walls are constructed in one phase in which interlocking sheet piles are driven to the required depth below the final grade. These walls may not be feasible for construction in hard ground conditions or where obstructions exist due to potential difficulty obtaining the required embedment depth or potential problems maintaining proper alignment during installation.

Sheet pile walls act as both vertical and horizontal wall elements. Because these walls are relatively continuous, water pressure behind the wall must be considered in the design.

b. Soldier Pile and Lagging Walls

Soldier pile and lagging walls use discrete vertical wall elements that are spanned by lagging, which typically consists of timber. This wall system can typically be constructed in most subsurface conditions; however, cohesionless soils and soft clays may cause construction problems due to limited stand up time for lagging installation.

Vertical soldier beams may either be installed into predrilled holes or driven to their required depth. After installation of the soldier beams, the soil in front of the wall is excavated in lifts (typically 4 feet to 5 feet), followed by the installation of horizontal lagging. Once the lagging reaches the final depth, prefabricated drainage elements may be placed at predetermined spacings and connected to a collector at the base of the wall.

Support is provided through the shear and bending stiffness of the vertical wall element and passive resistance of the soil below the finished grade elevation.
c. Tieback Wall (Anchored Wall System)

Tieback walls are retaining walls that utilize top down construction methods that consist of nongravity cantilevered walls with one or more levels of tiebacks (ground anchors) anchored to the ground to aid in stability.

Nongravity cantilevered walls consist of either discrete (soldier beam, typically piles or drilled shafts) or continuous (sheet piles) vertical wall elements that can be either driven or drilled to depths below finished grade. Support is provided through the shear and bending stiffness of the vertical wall element and passive resistance of the soil below the finished grade elevation.

Tiebacks consist of a steel rod, wire or tendons that are anchored in the ground by drilling a hole into the soil or rock behind the wall face and encasing a portion of the rod or tendons in a grout mixture that forms a bond with the surrounding soil or rock to provide lateral resistance to resist horizontal pressures acting on the wall. If a tendon is used, the wire is typically prestressed to a desired tension. The rod or tendon are typically inclined at an angle. The installation of tiebacks requires specialized equipment and construction methods and post-installation testing.

Tieback walls have the following advantages:
- Potential incorporation of temporary excavation support in the permanent retaining wall;
- Reduction of construction disturbance and right-of-way acquisition required;
- Reduction of excavation needed when compared to other retaining wall systems;
- Adaptability to various site and subsurface conditions.

The following are some disadvantages of the wall system:
- Permanent underground easements are required;
- Groundwater drainage systems may be difficult to construct;
- Creep can affect long-term performance and displacements in clayey soils;
- Pull-out capacity may not be able to be economically mobilized in soft soils.

All production anchors shall be subjected to load testing and stressing in accordance with the provisions of AASHTO LRFD Bridge Construction Specifications.

Additional information on Tieback (Anchored) Retaining Walls can be found in:
- AASHTO LRFD Bridge Design Specifications, Volumes I and II (Ref. 1).

d. Soil Nail Walls

Soil nail walls are constructed using top down construction methods. In soil nail construction, the ground is excavated in 3 foot to 5 foot lifts. Soil nails and an initial shotcrete construction facing are placed at each lift to provide support prior to progressing to the next lift. A final cast-in-place (CIP) concrete facing is installed when the lifts are complete. Typical vertical and horizontal nail spacings are 3 feet to 6 feet. The vertical spacing is dependent on the height that the site soils can temporarily remain stable after excavation of each lift.
Typically, dense to very dense granular soils with apparent cohesion, weathered rock (depending on orientation of weakness planes), stiff to hard fine grain soils, engineered fill and residual soils that are above groundwater are ideal for soil nailing. Non-engineered fill and residual soils that contain mica or shale may pose difficult soil conditions for soil nailing. Poorly graded cohesionless soils, areas with high groundwater, soils with cobbles and boulders, soft fine-grained soils, corrosive soils or groundwater, expansive soils and karst conditions are generally not suitable for soil nail walls.

In general, the soil nails support the soil and transfer loads behind the wall. The construction shotcrete and final CIP facings support the soil between the nails.

A drainage system is installed behind the soil nail walls to direct groundwater away from the wall and collect perched groundwater and-or infiltrated surface water that is present behind the facing.

The following failure modes should be evaluated for the design of soil nail walls: internal stability, global stability (temporary at each lift and final stability), lateral sliding, nail pullout, nail tensile strength, and facing bending, punching shear and headed stud in tension.

Design procedures and requirements are provided in the following reference:


Verification and proof load testing are performed during construction. Verification load tests are conducted on sacrificial nails to verify the pullout resistance resulting from the Contractor’s installation methods are consistent with the values of pullout resistance and bond strengths used in design. Proof tests are conducted on a minimum of 5% of the total production nails that are installed to verify that there are no significant variations in soil nail performance throughout wall construction.

3. Retaining Wall Design Guidelines
   
a. General Items

   The purpose of these guidelines is to establish the minimum requirements necessary to provide plans and details for the construction of retaining walls in Howard County.

   These guidelines shall be adhered to when practical and applicable, but the responsibility of providing a complete design ultimately belongs to the design engineer. Innovative designs are not meant to be discouraged by these guidelines. Common sense and good engineering judgment are essential elements of any good design.

   In order to facilitate the review process, these guidelines are intended to promote consistency and expediency by standardizing the requirements that are necessary in order to provide acceptable retaining wall construction documents.

   For new construction, the first preference is to revise grading so a retaining wall is not needed. To the extent feasible, if a wall is required, any pedestrian or bicycle facility at its base shall be widened by at least one foot to maintain an offset between facility users and the face of the wall.

   If a retaining wall exceeds three feet in height at any point, the following criteria will apply, otherwise it is exempt from review by the Development Engineering Division and only the Department of Inspections, Licenses, and Permits (DILP) and the Division of Land Development (DLD) regulations apply. The height of a retaining wall for this purpose is measured from the finished grade at the front of the wall to the top of the wall. Grades above or below the wall shall not exceed a 2:1 slope.

   All horizontal dimensions in the plan view shall be taken from the bottom face of the wall at the proposed grade.
Retaining walls shall not be constructed upon fill materials. Exceptions may be granted via the Design Manual Waiver Request process.

All retaining walls, regardless of height, shall not be constructed within a Howard County Right of Way or Easement. The only exception is if written permission has been granted by the Director of Public Works.

All construction documents for retaining walls three feet in height or higher shall be designed, signed, and sealed by a Registered Professional Engineer.

b. Construction Drawings – Plan Views

All retaining walls shall be shown in plan view showing all of the proposed conditions at a maximum scale of 1" = 50'.

Show enough grading around the retaining wall to clearly demonstrate all flow patterns in the vicinity of the retaining wall. Provide spot elevations every 50 feet along the length of the wall at the top and bottom of the wall.

Provide flow arrows along the top of the wall to indicate flow paths along the length of the wall. It is not desirable for run-off to be allowed to cascade over the top of retaining walls. This will be permitted if run-off approaching the wall is sheet flow and adequate scour protection is provided.

For all walls, a minimum ten-foot-wide construction easement/setback shall be required from the face of the wall. If the wall is greater than ten feet in height the width of the easement shall be equivalent to the height of the wall. This easement shall be clear of floodplains, buffers, wetlands, property boundaries, structures and/or other environmentally sensitive areas. 4:1 is the maximum slope allowed within this easement in front of the wall.

A permanent wall maintenance easement shall be provided behind each wall that is equivalent in width to the height of the wall plus the length of the geogrid. No structures may be placed within this easement.

For "CRITICAL" walls ten feet or more in height, the design engineer shall appropriately address the issue of global stability for the slope and provide an acceptable maintenance easement based upon the conclusions of the analysis.

For all block and timber retaining walls, a ten-foot-wide "NO TREE" planting zone shall be delineated behind the top of the wall.

Under no circumstances shall the maintenance easement for any wall encroach upon the building envelope of any residential lot.

c. Construction Drawings – Elevations

The elevation, or front view, of the proposed retaining wall is considered to be the most important detail for the purposes of constructing the wall.

The following scales are recommended, but good judgment is necessary to ensure that this detail is readable and reasonably drawn.

- VERTICAL: 1" = l' to 1" = 5';
  1" = 2' preferred
- HORIZONTAL: 1" = 5' for lengths up to 50'
- 1" = 10' or as appropriate over 50' in length

Provide a vertical scale bar and horizontal stationing across the bottom of the elevation.

For the purpose of constructability, the front view shall have each typical section identified by a letter or a number. Provide section breaks shown as heavy vertical lines indicating where each section begins and ends. Variation from one section to the next should be minimized in order to reduce the number of typical sections.
Essential elements of the elevation are as follows:

- A complete outline of the wall
- Show the finished grade line superimposed over the wall at the top and at the bottom
- Show the locations of the weep holes (40’ on center) and other utilities in proximity to the wall
- The vertical placement of the geogrid must be identified by which block layers the geogrid is to be inserted between
- Indicate the required allowable bearing strength for each typical section or as it varies
- Show with a dimension the maximum height allowed by design for each typical section

**d. Construction Drawings – Cross Sections**

Show a typical cross-sectional detail for each section of the wall as it varies by height and geogrid placement and/or other significant design features. The maximum vertical scale is $1" = 5'$; $1" = 2'$ is preferred.

Show the maximum height of the wall for each typical section.

For block or timber walls, show the number of blocks or timbers, vertically placed, graphically.

For reinforced concrete walls, show the typical reinforcement design including notes to indicate proper horizontal spacing along the length of the wall.

Indicate the maximum slope above or below allowed by the design. The maximum slope allowed is $2:1$.

For each typical section show the allowable bearing strength that is required for the soil beneath the base of the wall.

Show the drain placement behind the base of the wall, entrenched in stone for at least one foot of depth, then covered with filter fabric to prevent clogging. More stone should then be placed in a one foot wide vertical layer to 90% of the walls height to facilitate water flow to the drain. Weep holes must daylight through the wall every 40 feet.

Geogrid placement by layers and length for manufactured block walls must be shown in the cross sectional detail.

**e. Construction Details – Fences/Guardrails**

Retaining walls that exceed thirty inches in height at any point and present an inherent falling hazard require a fence along the entire length of the wall.

The fence must be a minimum of thirty-six inches in height, and the openings in the fence or rail must be small enough to prevent the passage of a four-inch sphere. Fences adjacent to bicycle facilities have additional requirements and shall be designed in accordance with the AASHTO “Guide for the Development of Bicycle Facilities” (Ref. 23).

Fences must be stable enough to withstand 200 lbs. of concentrated loading applied horizontally at any point.

A typical footing detail shall be provided.

If the fence is set back from the face of the wall, the fence shall be tapered at the ends of the wall to prevent children from accessing the ledge.

If the fence is not directly above the wall, show its location in the plan view.

For walls in proximity to vehicular traffic, guardrails, per the Howard County standard guardrail details are required.
Chapter 3: Design of Bridges, Retaining Walls, and Small Structures

For roadways and parking lots, the face of the curb must be a minimum of two feet in front of the face of the guardrail or the retaining wall. The Howard County standard 7" curb is required.

The location of a guardrail, if required shall be three feet from the face at the top of the wall to the side of the guardrail facing the wall.

f. Design Calculations / Failure Analysis

All retaining walls shall be designed to resist the possible modes of failure, including sliding, overturning, and bearing failure. Sufficient analysis shall be provided to confirm that the resistance factors have been applied and that the design of the retaining wall meets AASHTO design specifications (Ref. 1).

Any likely or anticipated surcharge loads shall be included in the failure analysis. If none are included in the design, add a note to the cross-sectional details stating, "this wall is not designed for surcharge loads".

For manufactured block walls, supplemental design booklets may be submitted to satisfy the failure analysis requirement, but they may not be considered as part of the construction drawings. The plans shall contain all of the relevant information required to construct the wall.

For reinforced concrete walls, provide a complete set of design calculations for the wall, including the placement and spacing of steel reinforcement.

g. Construction Drawings – Required Notes

"Retaining walls shall only be constructed under the observation of a Registered Professional Engineer and a (NICET, W ACEL or equivalent) certified soils technician."

"The required bearing resistance beneath the footing of the wall shall be verified in the field by a certified soils technician. Testing documentation must be provided to the Howard County Inspector prior to the start of construction." The required test procedure shall be the Dynamic Cone Penetrometer Test ASTM STP-399."

"The suitability of fill material shall be confirmed by the on-site soils technician. Each eight-inch lift must be compacted to a minimum of 95% Standard Proctor Density and the testing report shall be made available to the Howard County Inspector upon completion of construction."

"For "CRITICAL" walls, one soil boring is required every 100 feet along the length of the wall, copies of the boring reports shall be provided to the Howard County Inspector upon completion of construction."

All other miscellaneous information required for the construction of the retaining wall shall be included somewhere on the construction drawings. Items may include material specifications, recommendations from the manufacturer of block wall systems, notes from the design engineer, specific instructions for non-typical designs, etc.

Each design package shall include the Designer's seal and signature on the cover page along with the name, address, and telephone number of the consulting firm he represents. Also provide the name, address, and telephone number of the owner/developer.
h. Policy on Retaining Walls in Stormwater Management Facilities

The Howard County Design Manual Volume I requires under section 5.2.5.A.1. that "A pond buffer shall be provided for all stormwater management facilities in accordance with the criteria set forth in the MDE Design Manual. The minimum distance from the end of the outlet structure, including the riprap exit channel, or the edge of an underground facility, to the downstream property line shall not be less than 25 feet. Along other parts of the facility, the minimum distance from the toe of the embankment or top of cut to the property lines, public easements, rights-of-way, and structures shall be 25'. For structures adjacent to the facility where the top of cut cannot be defined and the grading condition encroaches onto a residential lot, the distance from the 100-year water surface elevation within the facility or edge of underground facility shall be 25 feet minimum horizontal and two feet minimum vertical to the lowest floor elevation of a habitable structure."

This specification applies for all new retaining wall construction plans to be submitted for review. Through the Alternative Compliance request procedure, the following provisions will govern.

In general, the Department of Public Works discourages the use of retaining walls in stormwater management facilities due to the increased maintenance costs and long-term liability of the structures. The Department recognizes, however, that in some instances retaining walls may be required as other viable alternatives may not be available. If the Department or its designee deems that retaining walls are the only viable solution within a stormwater management facility, the following criteria shall govern:

1) For all facilities, both public and private, retaining walls shall not be allowed within the embankment area, either inside or outside the facility, unless the toe of the retaining wall and any tie-backs are beyond the phreatic line of the facility. These walls shall have a height not to exceed three feet. Tiered walls shall not be allowed unless they are designed so that the influences of the upper walls do not impact the lower walls.

2) For publicly owned and maintained facilities or privately owned and jointly maintained facilities, minor retaining walls, less than three feet in height, measured from the top of the wall to the ground along the face, shall be allowed on cut slopes above the uppermost maintenance bench of any stormwater management facility. These walls shall not be located in the ponding area of the facility. These walls shall be privately owned and maintained. The construction and maintenance of these walls shall be made part of a developer agreement for the facility.

3) For privately owned and maintained facilities, the maximum height of any wall, whether single or tiered, shall not exceed ten feet. These walls may be located in or adjacent to pooling areas provided the walls are reinforced concrete and shall be designed to withstand the hydrostatic pressure and saturated ground conditions on the footing of a flooded condition.
4) All retaining walls in excess of thirty inches in height shall have an appropriate safety railing or fence.

   i. Tiered Walls

   For tiered walls where the total cumulative height of the tiers is ten feet in height or greater, the provisions for "CRITICAL" walls apply.

   The set back from one wall to the next in a series of tiers shall be equivalent to the height of the lower wall or greater.

   The slope between tiered walls shall not exceed 4:1.

3. Wall Thickness

   The thickness of the top of a wall shall be sufficient to accommodate any railing or appurtenance to be placed on it. However, for ease in placing concrete, it shall not be less than 1 foot.

4. Passive Pressure

   Passive pressures on the front face of a wall are unpredictable and shall be neglected for normal wall footing depths. Shear keys shall be similarly avoided. Passive earth pressure shall not be considered in any case if the cover in front of the wall may be subject to scour or if the ground slopes at more than 4:1 rate.

5. Wall Elevations

   Top of wall elevations shall be computed at joints and alignment breaks and at vertical curve control points. The elevation shall be tied to Howard County control where available within one mile.

6. Batter

   For walls over 15 feet in height, consideration shall be given to provide a batter on the front face of wall. The back face of the wall shall be battered if required for the stem design.

7. Joints

   Walls shall be detailed with expansion points through the portion above the footing at approximately 90 ft. intervals. Gravity, semi-gravity and cantilever walls shall have two equally spaced contraction joints located between the expansion joints. The face walls of counterfort and buttress walls are designed as continuous beams and they cannot have contraction joints within a continuous unit. Counterfort and buttress walls shall be designed in continuous units not over 60 feet in length with expansion joints between units.

8. Drainage and Weep Holes

   Drainage systems should be provided behind retaining walls to reduce hydraulic pressures, which could result in failure of the wall. Retaining walls are typically drained by means of either continuous back drains or weep holes, along with porous backfill, which allows water to flow behind the wall. Weep holes extending through the wall stem with a pocket of gravel backfill on the back, are inexpensive, but often become clogged. Continuous back drains are preferable to weep holes and may be outlet into nearby storm drainage systems, if available, to minimize aesthetic impacts.

   For retaining walls and larger wing walls, sloped perforated PVC pipe drains shall be placed along the back face of walls. The perforated pipe drains are placed below a full height porous backfill blanket and are supported on a continuous concrete ledge extending from the back of the wall. Drain outlets, consisting of 4 in. non-perforated PVC pipe, spaced at no more than 15 ft along the wall, are located 1 ft above the finished groundline at the front of wall. Outlet drain pipes are to be extended 3 in. from the face of wall, where visible to the public, to minimize staining. Where pedestrian or bicycle facilities are located along the front of walls, outlet drain pipes are to be placed below the facility and outlet into the adjacent gutter.

   For box culvert wing walls and wing walls less than 30 ft. long and 16 ft. tall, use weep drains with 2 cu. ft. of porous backfill behind each drain. The requirements for outlet drain pipes are the same as for the continuous back drains.
B. Abutments

Abutments support the ends of the bridge beams and provide for the transition from the bridge structure to the approach roadway pavement. All abutments retain the earth of the adjacent roadway and are subject to live load surcharge. Some types of abutments retain substantial amounts of fill. The abutment design must satisfy the requirements of a retaining wall. In addition, the overall stability and the foundation loads must be checked both with and without the dead and live loads from the superstructure. Provision shall be made for surcharge due to construction loads.

1. Types of Abutments

a. Gravity Abutments

As with gravity retaining walls, gravity abutments resist loads imposed on them by means of their mass. The resultant of forces must be within the middle third of any horizontal section through the abutment, both with and without the loads imposed by the superstructure.

b. Spill-Through Abutments

This type of abutment is designed with openings between the supporting legs to allow the embankment material to spill through and form a slope in front of the abutment. The abutment must be designed for the earth pressure on the backwall and cap and on the fill face of the supporting legs. The area of the legs shall be multiplied by a shape factor, usually 2.0, to allow for arching of the soil. If the embankment slope in front of the abutment is not subject to scour, passive earth pressure may be considered on the front face of the legs. The legs and cap shall be designed as a frame to support the loads imposed by the superstructure.

c. Stub Abutment on Piles

This type of abutment is similar to a spill-through abutment except that the piles are very flexible compared to the stiffness of the concrete stub. The piles shall be considered pinned at the footing and shall be designed for axial load only. Batter piles shall be provided to resist horizontal forces. The lateral resistance of the soil surrounding the piles will provide lateral stability and can resist an unbalanced shear which will depend on the nature of the soil.

d. Cantilever and Counterfort Abutments

Cantilever and counterfort abutments resist loads in a manner similar to their retaining wall counterparts.

e. Integral and Semi-Integral Abutments

Integral abutments eliminate the need for abutment roadway joints and hence provide a structure that will require minimal, if any, maintenance to the abutments and associated bearings. Integral abutments should be considered for new bridges when the project site conditions and geometry are suitable for these types of elements. Key considerations to be evaluated include soil type and profile, span alignment, length and skew, superstructure type and the presence of utilities on the bridge. In general, for integral abutment design to be considered, the soil type shall be a reasonably graded cohesionless soil with no defined rock line. Soil profiles suitable for driven pile foundations are also suitable for the installation of integral abutments. Integral abutments shall not be used when there is the possibility of pile downdrag forces.
Integral abutments shall only be considered for use on tangent superstructure alignment with a change in vertical grade less than 5% between abutments. Maximum span length for use with integral abutments is 200’ and maximum skew (measured as the angle between the centerline of beam and a line normal to the centerline of bearing) is 30 degrees. Superstructure types that may be used with integral abutments include concrete slab supported by a redundant steel beam system or adjacent or spread prestressed concrete I-beams, box beams or slab beams. The use of timber superstructure components shall not be used with integral abutments. Normally, integral abutments are discouraged when the bridge carries utilities due to the required opening in the abutment stem to facilitate utility conduit expansion. This opening is a potential source of future deterioration and should be avoided, if possible.

Only cast-in-place concrete piles or steel H-piles shall be considered for use with integral abutments. If steel H-piles are selected, they shall be installed with the weak axis parallel to the centerline of bearing (i.e., driven to allow bending from thermal movements to be about the weak axis). Depending on the soil type and profile, consideration shall be given to pre-auguring a hole that extends a minimum of 10 feet below the bottom of abutment. The pre-augured hole shall be at least two times the pile diameter and filled with well-graded sand or a bentonite slurry mix. Piles shall extend to a sufficient depth to provide adequate structural stability (i.e., no “stilting” effect) and end fixity even when the adverse effects of scour are considered. A minimum of one pile per steel girder or spread prestressed concrete beam member shall be used.

Bearings shall be selected to resist the temporary loading imposed by the superstructure prior to encapsulating the ends of the beams and bearings with the deck closure pour. Minimalist bearings such as plain elastomeric pads should be considered.

Concrete approach slabs shall be used with all integral abutment designs and shall be structurally tied to the bridge deck slab and abutment stem via hinge reinforcement. If the end of the approach slab abuts rigid roadway approach pavement, provisions for expansion shall be implemented at this location. If the roadway approach pavement is flexible, the ends of the approach slabs may butt up against the section without expansion provisions being provided. The ends of approach slabs adjacent to flexible pavement shall be protected by steel angle armoring embedded in the slab with studs. Approach slabs shall be poured atop well graded aggregate and dual layers of polyethylene curing sheeting.

Semi-integral abutments also eliminate the need for abutment roadway joints, but since they are founded on a rigid foundation (e.g., spread footing, multiple rows of piles, etc.), expansion bearings will be required. Criteria for the use of semi-integral abutments are similar for that specified for integral abutments. Semi-integral abutments should be considered when the soil profile is not favorable (i.e., presence of rock, clayey soils, etc.) or if span lengths, geometry or alignment issues preclude the use of integral abutments.

2. Design Guidelines

   a. Lateral Earth Pressure

   The lateral earth pressure shall be computed in the same manner as for a retaining wall.
b. Other Loads

In addition to lateral earth pressure, the abutment shall be designed to withstand the dead load of the abutment and superstructure, live load over any portion of the superstructure or approach fill, wind forces, longitudinal forces from the superstructure when the bearings are fixed and longitudinal forces due to friction or shear resistance of the bearings when the bearings are not fixed. The design shall be investigated for all combinations of these forces which may produce the most severe loading case.

c. Drainage

It is not necessary to provide drainage behind the stems of perched abutments when they are placed atop granular fill.

C. Piers

1. Types of Piers

a. Rigid Frame Piers

Rigid frame piers consist of a continuous pier cap, columns and a continuous footing or independent footings. Rigid frame piers are generally used on bridges spanning highways and railroads.

b. Single Column Piers

Single column piers, or hammer head piers, consist of a pier cap supported by a single column. Single column piers are generally used for bridges spanning rivers or streams or where they are necessitated by space requirements.

c. Solid Stem Piers

The cap and column of a solid stem pier is a single unit supported by a continuous footing. They are used for short or narrow piers.

d. Pile Bents

Pile bent type piers consist of a single or double row of piles driven to act as both foundation and substructure elements. Superstructure loads are distributed to the piles via a rigid structural pile cap. Pile types normally considered in a pile bent type pier include timber, steel H-pile and cast-in-place concrete. A structural cap, normally constructed of reinforced concrete, encases the top portion of the piles to distribute superstructure loads. Pile bent piers shall be designed to account for the adverse effects of scour as it may create a longer unbraced pile length. Pile bents shall be checked against the ultimate scour condition. Both structural stability and pile stresses should be investigated.

Pile bent piers are normally utilized for stream crossings to minimize the impacts to the waterway during and after construction as well as minimize the reduction in the available hydraulic opening. Appropriate scour countermeasures shall be incorporated into the detailing of this pier type as required by the existing or proposed conditions.

2. Design Guidelines

a. Loads

Piers shall be designed to withstand the dead and live loads super-imposed thereon; wind pressures acting on the pier, the superstructure and on the moving live loads; shrinkage and temperature forces; forces due to stream current; and longitudinal traffic traction forces. These various forces shall be divided into components that are normal to and parallel to the centerline of the pier.
b. Application of Loads

Longitudinal forces are transferred to the substructure mainly through the fixed bearings acting at the hinge of the bearing. However, some longitudinal force will be transferred through the expansion bearings by virtue of friction. The maximum longitudinal force, due to superimposed loads or temperature effect, which is transferred to the pier at an expansion bearing, is equal to the bearing friction.

Transverse force may also be assumed to act at the hinge of the bearing. The total transverse force on the superstructure will be transferred to the piers and abutments in proportion to the length of the adjacent spans.

c. Columns

Rigid frame column spacing shall be in the range of from 12 feet to 20 feet. The spacing shall be set so that positive and negative movements in the pier cap are approximately equal. Circular pier columns whose diameter is 5'-0" or less shall be designed using spiral reinforcing.

D. Foundations

1. Depth

Footings of all piers in the floodplain shall be founded on rock or on piles driven to rock, except as approved by the Chief of the Bureau of Engineering.

All other footings in the floodplains, including those for abutments, wing walls, and culverts shall be founded below the estimated depths of scour, or 3’ below the thalwag, whichever is lower.

Footings outside the floodplain shall be founded on a suitable uniform foundation below the frost line and not less than 3'-0" below finish grade. Refer to the AASHTO LRFD Bridge Design Specifications (Ref. 1) for footings on slopes.

Footings on rock shall be keyed into the bedrock a depth of 12 inches when they are designed to transfer lateral forces. When a bedrock foundation is required for scour protection or design bearing pressure, footings shall be carried into bedrock a minimum of six inches. Spread footings on soil shall have the lower 1’ in depth poured against undisturbed earth.

Plan sheets on which footings are shown shall include a note giving the allowable soil pressure or pile loads.

2. Loads

Footings shall be designed to transmit to underlying stratum all forces transmitted to and acting on the substructure component.

3. Pile Foundations

Available pile types that may be considered for use include timber, cast-in-place concrete, steel H-pile, and steel pipe pile. Each pile shall be evaluated for the project site conditions based on the available soil information, drivability, loading and structure location.

4. Drilled Shafts

Design of concrete drilled shaft foundations shall be done in accordance with AASHTO “LRFD Bridge Design Specifications” (Ref. 1) and utilizing LPILE by Ensoft, Inc. or another industry acceptable drilled shaft design program.

5. Design Guidelines

a. Location of Resultant Loads on Spread Footings

Footings founded on materials other than bedrock shall be proportioned so that the resultant intersects the bottom of the footing within the middle third. The resultant force on footings founded in bedrock may be outside of the middle third provided that the maximum allowable bearing pressure is not exceeded.
b. Pile Foundations

Pile foundations shall be so proportioned that no pile receives more than the maximum allowable pile load and no pile is subjected to uplift under any combination of design loads. All pile foundations shall have batter piles to resist horizontal forces transmitted to the foundation and to increase the rigidity of the entire structure. Plumb piles may be assumed to resist 2 kips of lateral load per pile.

Resistance factors used to determine the nominal pile bearing resistance shall be selected based on the method used for determining the pile driving criteria in accordance with AASHTO LRFD Bridge Design Specifications.

E. Substructure Protection

The selection and design of substructure protection to resist the effects of scour shall be in accordance with MDOT SHA guidelines and FHWA circulars and memorandums associated with scour countermeasure design. FHWA Hydraulic Engineering Circular 23 (HEC-23) (Ref. 18) shall be used in the design of countermeasures at piers and abutments.

Class II riprap is the preferred material for scour countermeasures. The D_{50} of the riprap shall be confirmed in accordance with HEC-23. Velocities used in the design of countermeasures shall be based upon the 100-year or incipient overtopping storm event, whichever yields a higher velocity, and shall be derived by using the hydraulic modeling techniques described in the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12). Configuration of the riprap blankets, including depth, distance from abutments/piers, toe dimensions, etc., shall be in accordance with MDOT SHA memorandum “Scour Countermeasures at Bridges” (November 25, 1992).

F. Slope and Bank Protection

Slope and bank protection (revetments) for roadway approach embankments, retaining walls and stream channel banks shall be selected and designed in accordance with FHWA Hydraulic Engineering Circular 23 (HEC-23) (Ref. 18). Class II riprap is the preferred material for revetments.

Where applicable, revetments shall be designed to accommodate wave interaction as described in HEC-23. For the purpose of determining the total height of the revetment, the engineer should assume that the maximum wave height occurs coincidentally with the maximum water surface elevation generated by the design storm.
### 3.5 Bridge Superstructure

The bridge superstructure includes the slab, beams or girders and bearings. The function of the superstructure is to distribute and transmit loads to the substructure. Bridge superstructure shall be designed in accordance with AASHTO Specifications (Ref. 1).

#### A. Slab on Beams and Girders

1. **Concrete**

   All superstructure concrete including parapets, abutment backwalls and parapet portion of wingwalls but excluding concrete overlay shall be air entrained concrete with a minimum 28-day compressive strength of 4500 psi. Slab concrete shall be low slump concrete.

2. **Wearing Surface**

   Concrete slabs shall have an extra 1/2-inch concrete which will serve as a wearing surface. This wearing surface shall be considered sacrificial and shall not be included when determining member strength.

3. **Reinforcing**

   Epoxy coated reinforcing bars shall be used for the entire superstructure, including top and bottom mats of slabs, abutment backwalls and parapet portion of wingwalls.

4. **Forms**

   Concrete slabs shall be poured on stay-in-place metal forms.

5. **Concrete Cover**

   Slabs shall have 2 1/2 inches of cover over the top reinforcing mat (which includes a 1/2-inch concrete wearing surface) or 1 inch of cover between the bottom reinforcing mat and the stay-in-place forms. Parapets and backwalls shall have 2 inches of cover.

6. **Slab Thickness**

   Slabs shall be designed to carry the dead and live load loading in accordance with the AASHTO Specifications (Ref. 1). The minimum slab thickness including the concrete overlay shall be 7-1/2 inches.

7. **Deck Pour Sequence**

   Construction plans shall include a suggested pouring sequence including the order and limits of each pour. For conventional superstructures (i.e., non-integral or non-jointless), positive moment regions of the superstructure shall be poured first followed by the pours in the negative moment region(s). For integral abutment bridges, the pouring sequence shall be configured to minimize dead load rotation at the abutment to prevent unwanted transverse deck cracking.

   In developing the pour sequence, consideration shall be given to accounting for the temporary stresses on the in-place portions of the structure that may not have been considered such as lateral flange buckling of the longitudinal girders supporting the wet concrete. Individual concrete pours shall not exceed 100 cubic yards per day without written authorization of the Chief of the Bureau of Engineering.

#### B. Beams and Girders

1. **Composite and Non-Composite Design**

   In superstructures consisting of concrete slabs supported on prestressed concrete beams or steel beams or girders, composite designs shall be used for simple spans exceeding 35 feet, and generally for continuous spans exceeding 50 feet. Because of the effect of span ratios, no specific limits for composite design can be established for continuous construction.

   Continuous steel beam or girder spans shall be designed as composite for positive movement regions only; however, shear connectors shall be provided at maximum allowable spacing through the negative movement regions even though composite action is not considered.
2. Camber

a. Spans Less than 50 Feet

Steel beams with a span of less than 50 feet shall not be cambered for dead load deflection or vertical curve corrections. If the beams are not rolled exactly true, they shall be fabricated and erected with their natural camber up.

b. Spans 50 Feet or More

Steel beams and girders with spans of 50 feet or more shall be cambered to compensate for dead load deflection and vertical curve correction. Camber tolerance shall be zero (0) inches under to one-half (1/2) inch over.

3. Bearing Stiffeners

Stiffeners shall be placed at all bearings. The stiffeners shall be designed to carry the total reaction acting as a column.

C. Steel Beams and Girders

Steel plate girders shall be designed, where economically feasible, to eliminate transverse and longitudinal web stiffeners. The use of AASHTO M270 Grade 50W steel must be approved on a case by case basis by the Chief of the Bureau of Engineering.

D. Prestressed Concrete Beams

In lieu of steel beams or girders, precast prestressed concrete beams may be used for simple spans. The length and weight of any prestressed concrete member shall not exceed the State of Maryland limitations for highway shipment without permits.

E. Bridge Drainage

Scuppers on bridges shall be avoided if possible. On closed systems inlets shall be placed immediately off the bridge at the upgrade end of the bridge to prevent accumulated gutter flow from entering the structure. On open section roadways inlets shall be placed immediately off the bridge at the downgrade end to control water accumulated on the bridge. On closed section roadways, inlets shall be placed downgrade from the bridge as required by the gutter flow design.

Scuppers shall be placed on the bridge only if the ponding encroachment exceeds the limit permitted by the Howard County Storm Drain Design Manual, (Ref. 7). Where required, scuppers shall be MDOT SHA standard scuppers. Scuppers shall be a minimum of 10’ from any substructure unit. Downspouts shall extend 8” below adjacent stringers and shall outlet into streams, slope protection or splash blocks.

F. Expansion Joints

Watertight roadway expansion joints shall be provided at all abutments and at all piers supporting simple spans. These joints shall provide for the total thermal movement for a temperature range of 0 F to 120 F.

Abutments integral with the superstructure should be considered where appropriate in lieu of expansion joints. Where feasible, joints shall be eliminated at intermediate pier locations via use of continuous spans, link slabs, or simple spans made continuous. If joints are required, they shall be selected to provide minimal irregularities and/or gaps to facilitate safe operation of motorcyclists and bicyclists.

G. Bearings

The selection of bearings shall consider length of span contributing to expansion, superstructure material type, applied loading, bridge skew and degree of curvature (if applicable). Consideration should be given to selecting bearings that require minimal maintenance including plain and steel laminated elastomeric pad bearings with or without polytetrafluoroethylene (PTFE) – stainless steel sliding surfaces. Bronze sliding bearings shall be considered for steel structures. Refer to the MDOT SHA “Structural Details Manual” (Ref. 11) for suggested bronze sliding bearings. The use of steel rocker bearings is prohibited.
Elastomeric bearings are generally used to support precast prestressed concrete slabs or beams. Plain pads are preferred unless structure rotation and thermal translation require steel laminated bearings. Elastomeric bearing shall be adequately attached to the bearing seat via an appropriate epoxy bonding compound. Provisions shall also be considered to prevent the elastomeric pads from “walking” by using restrainer bars, plates or angles or by inserting an anchor dowel through the ends of the precast prestressed concrete member and embedded into the beam seat.

H. Drainage Troughs

Drainage troughs shall be investigated for use on new structures or rehabilitated structures where open joints (e.g., finger joints) are located in the bridge deck. Troughs shall also be considered as a way of providing a redundant system to protect specific bridge elements if the roadway joints begin leaking. Fiberglass drainage troughs shall be used underneath all open joint systems and shall be installed using a cross slope no less than 1” per foot. Adequately sized catch basins shall be incorporated into the system to collect all drainage water and efficiently disperse it away from the structure by means of downspout piping. Suitable caulking material shall be used along the interface between the structure and the trough to prevent water seepage.

Neoprene drainage trough material may be used in other locales assuming that the anticipated drainage flow will not exceed the capacity of the trough. Troughs placed underneath closed joint systems shall be installed at a cross slope of no less than ¼” per foot. Stiffening bars shall be incorporated into the system to keep the neoprene material flush up against the structure to prevent water seepage.

Stainless steel hardware shall be used to affix the drainage trough to the structure. Downspout piping shall be incorporated into the drainage trough systems when necessary to convey drainage away from the structure. PVC conduit shall be used for the piping material and it shall be adequate attached/braced against the structure to maintain the integrity of the system. Stainless steel hardware shall also be used to brace the downspout piping. Discharge from any downspout piping shall be directed away from structure foundations and/or adjacent roadway surfaces. Refer to the MDOT SHA Structural Details Manual (Ref. 11) for suggested drainage trough details.

I. Elevations

Bridge deck elevations shall be computed and indicated on the plans at each girder centerline, PG/L of the roadway, at any roadway break lines and along the gutter flow lines. Elevations shall be provided in accordance with MDOT SHA Structural Guidelines and Procedure Memorandums (Ref. 10).

J. Sidewalks

Any surface features in the sidewalk shall be smooth, slip-resistant, and level with the sidewalk to maintain ADA compliance.
3.6 Shared Use Path Bridges

A. General

Shared use path bridges carry users such as bicyclists, pedestrians, equestrian riders, and light maintenance vehicles.

1. Design Specifications
   
   a. AASHTO
      
      The design of shared use path bridges shall be in accordance with the “LRFD Bridge Design Specifications” (AASHTO, Ref. 1), including subsequent interim specifications, except as modified by the “LRFD Guide Specifications for the Design of Pedestrian Bridges” of the Association of State Highway and Transportation Officials (AASHTO, Ref. 21), including subsequent interim specifications.
      
      Shared use path bridges shall also be in accordance with the “Guide for the Development of Bicycle Facilities” of the Association of State Highway and Transportation Officials (AASHTO, Ref. 23), including subsequent interim specifications.

   b. ADA
      
      All designs shall meet or exceed Americans with Disabilities Act (ADA) guidelines to the extent that it is not structurally impractical to do so.

B. Loading

Live load shall be in accordance with AASHTO (Ref. 21). Whenever vehicle access is not prevented by permanent physical methods, shared use path bridges shall be designed for H5 vehicle live load, or a different vehicle depending on the needs of the owner or jurisdiction.

C. Clearances

1. Horizontal Clearance

   In accordance with the AASHTO “Guide for the Development of Bicycle Facilities” (Ref. 23), a shared use path bridge shall have a 14’ preferred clear width (12’ minimum clear width) unless written authorization is provided by the Chief of the Bureau of Engineering.

2. Vertical Clearance

   The minimum vertical clearance from the surface of path to an overhead obstruction shall be 10 feet. Greater vertical clearance should be considered where maintenance vehicles or emergency vehicles may use the path.

D. Profile and Grade

   The deck of the bridge should maintain the cross slope of the approach path. Where pedestrians are present, this cross slope should not exceed 2% to meet accessibility guidelines. Refer to Chapter 2, and the provisions given by AASHTO (Ref. 23) for profile and grade requirements.
E. Railings and Fencing

All railings on bridges and approaches, including transitions, shall meet or exceed MDOT SHA and AASHTO specifications, including crash testing requirements. Pedestrian and bicycle railings shall conform to the “Bridge Railing Manual” by MDOT SHA (Ref. 25) and the AASHTO “Guide for the Development of Bicycle Facilities” (Ref. 23). Unless written authorization is provided by the Chief of the Bureau of Engineering, if a railing type is selected that is not included in those references it shall meet all geometric criteria of the AASHTO specifications. Rub rails shall be considered as specified in the AASHTO specifications (Ref. 23) where a bicyclist’s handlebar may come into contact with a railing or barrier. Railings should not impede stormwater runoff. Refer to Section 3.2.J.3 for additional information on barriers.

If the shared use path bridge crosses a high volume or high-speed roadway, or objects are likely to be thrown from the structure, fencing shall be considered. Fencing shall meet MDOT SHA “Structural Details Manual” (Ref. 11). Fencing installed on structures crossing over railroads shall meet the minimum requirements of the respective railroad.

F. Lighting

Refer to the “Guide for the Development of Bicycle Facilities” (AASHTO, Ref. 23) for lighting requirements.

When lighting for shared use path bridges is provided on poles, it should be independent of the bridge structure where possible.

G. Aesthetics/Structure Type

The Aesthetic Bridges - Users Guide (Ref. 26) provides recommendations for design suggestions and considerations.

H. Hydraulics

Refer to Appendix D in Chapter 10 of the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12).
3.7 Shared Use Path Underpasses

A. General

Shared use path underpasses carry users such as bicyclists, pedestrians, equestrian riders, and maintenance vehicles. Shared use path underpasses include tunnels and openings under bridge structures.

1. AASHTO

The design of shared use path underpasses shall be in accordance with the “LRFD Bridge Design Specifications” (AASHTO, Ref. 1), including subsequent interim specifications.

Shared use path underpasses shall also be in accordance with the “Guide for the Development of Bicycle Facilities” of the Association of State Highway and Transportation Officials (AASHTO, Ref. 23), including subsequent interim specifications, the “Guide for the Planning, Design and Operation of Pedestrian Facilities” (AASHTO, Ref. 27), including subsequent interim specifications, and the “Roadway Lighting Design Guide” (AASHTO, Ref. 28), including subsequent interim specifications.

2. ADA

All designs shall meet or exceed Americans with Disabilities Act (ADA) guidelines to the extent that it is not structurally impractical to do so.

B. Clearances

1. Horizontal Clearance

In accordance with the AASHTO “Guide for the Planning, Design and Operation of Pedestrian Facilities” (Ref. 28), a shared use path underpass shall have a 14’ preferred clear width (12’ minimum clear width), unless written authorization is provided by the Chief of the Bureau of Engineering. Wider widths should be considered for lengths over 60 feet. Consideration shall be given for longer underpasses to enhance visibility, security, and safety via wider openings or flared ends.

2. Vertical Clearance

The minimum vertical clearance from the surface of the path to an overhead obstruction shall be 10 feet, 12 feet if equestrian accommodation is required. Greater vertical clearance should be considered where maintenance vehicles or emergency vehicles may use the path, or for longer underpass lengths to maintain openness and security for pedestrians.

C. Profile and Grade

The surface of the shared use path should maintain the cross slope of the approach path. Where pedestrians are present, this cross slope should not exceed 2% to meet accessibility guidelines. Approaches and grades should be evaluated to provide the maximum possible field of vision towards the underpass. Refer to Chapter 2 and the provisions given by AASHTO (Ref. 23) for profile and grade requirements.

D. Fencing

Refer to Section 3.2.J.3 for fencing requirements.

E. Lighting

All shared use path underpasses where pedestrians, bicyclists, equestrians, or maintenance vehicles may be present require lighting. Luminaires shall be mounted to the underpass walls. Vandal resistant lighting should be installed and maintained. Refer to the “Guide for the Development of Bicycle Facilities” (AASHTO, Ref. 23) and the “Roadway Lighting Design Guide” (AASHTO, Ref. 28) for lighting requirements.

F. Aesthetics

The Aesthetic Bridges - Users Guide (Ref. 26) provides recommendations for design suggestions and considerations.

G. Drainage

Drainage shall be carefully considered for shared use pathway underpasses to prevent flooding. Underpasses shall be designed to avoid sumps in vertical alignments and configurations where non-free-draining systems (e.g. pump stations) are required to prevent flooding. Underpasses shall not be located in areas of known flooding or floodplains where pedestrian egress may be restricted during storm events.
3.8 Box Culverts

A. Analysis

Box culverts shall be analyzed as closed rigid frames. The dead and superimposed earth loads, the lateral earth pressures and the live and impact loads are to be analyzed separately. The results of these separate loading conditions shall be assembled in various combinations to give maximum moments and shears at the critical points; i.e., the corners, and the positive moment areas. Appropriate live load positions shall be used to produce maximum positive or negative moments. A maximum of one-half of the moment caused by lateral earth pressure, including any live load surcharge, may be used to reduce the positive moment in the top and bottom slabs. The weight of the bottom slab of a box culvert will be resisted by an equal and opposite soil pressure and the weight of the slab will cause no bending in the structure. The structure should therefore be analyzed for a net soil reaction, excluding the reaction to the weight of the bottom slab.

B. Design Guidelines

1. Minimum Thickness

The thickness of walls and slabs of a box culvert shall be not less than 8 inches for members with single reinforcing and not less than 12 inches for members with reinforcing in both faces.

2. Minimum Reinforcing Cover

The minimum cover shall be as follows:

- Bottom of bottom slab - 3 inches
- Top slab used as riding surface - 2 1/2 inches (including 1/2-inch concrete wearing surface)
- All other faces — 2 inches

   a. Epoxy Coated Reinforcing

   When the distance from the riding surface to the top slab is less than 2', all reinforcing in, or extending in, the top mat of reinforcing steel for the entire length of the culvert shall be epoxy coated.

3. Wearing Surface

If the top slab is to be used as a roadway riding surface, it shall have a 1/2” integral concrete wearing surface. This wearing surface shall be considered sacrificial and shall not be included when determining member strength. When the top slab is not the riding surface, the earth cover provided shall be no less than 9 inches (in addition to paving) at the minimum point.

4. Contraction and Expansion Joints

Contraction joints shall be provided at a spacing of approximately thirty (30) feet. Expansion joints shall be provided at approximately ninety (90) foot intervals. Reinforcement shall be stopped two (2) inches clear of joints.

5. Headwalls

Headwalls shall be provided at the exposed ends of box culverts, to retain the earth cover and to act as edge distribution beams on skewed alignments. The headwall shall be constant height.

6. Cut-Off Walls

In order to provide for effects of scour, cut-off walls, a minimum of three (3) feet deep, shall be provided at the exposed ends of the culverts. Wing wall footings shall be set at the elevations of the bottom of the cut-off walls and securely tied to them with reinforcement.

7. Provisions for Future Extension

If the culvert is to be placed under a roadway which could be widened in the foreseeable future, provisions shall be made for extension of the culvert by placement of appropriate joint keys on the exposed inlet and outlet faces.
C. **Bottomless Box Culverts (Rigid Frames)**

Bottomless culverts may be considered when it is desirable from a permitting standpoint to put in a culvert with a natural channel and the span length is such that using a structural plate pipe arch is uneconomical. Since the foundation loads on a bottomless culvert are relatively higher than a four-sided box, the existing subsurface information must be closely analyzed to determine if the culvert can be supported by spread footings. If the resultant bearing pressure is too high when compared to the allowable, or the adverse effects of settlement is a possibility, placing the structure on piles should be considered. Regardless of the foundation system, the bottom of footing for any rigid frame shall be placed a minimum of 3 feet below proposed groundline.

Bottomless culverts shall be analyzed for scour in accordance with current MDOT SHA guidelines. The Designer should consult with the MDOT SHA Office of Structures for guidance on the selection of bottomless culverts and the preferred scour analysis and countermeasure design procedures.
3.9 Pipe Culverts

The hydraulic design and analysis of roadway cross culverts should be performed in accordance with the guidelines contained in the Howard County Storm Drainage Design Manual, FHWA HDS-5, MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12) and applicable MDE and USACE regulations. This section deals specifically with larger culvert crossings of waterways with base flow.

A. Geometry

Pipe culverts shall be designed to carry the full ultimate roadway section including safety grading, guardrail backing, etc.

The layout of any pipe culvert shall be configured primarily to preserve existing drainage patterns and watercourses, while integrating the overall geometry of the roadway embankment. Significant guidance is available in Chapter 13 of the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12) and in HDS-5 regarding the optimal configuration of the culvert to accommodate different channel types.

When culverts are used singularly at crossings, the pipe invert shall be set 1’ below the planned bottom of stream bed. When multiple pipe culverts are used in a single crossing, one pipe shall be considered the low flow cell and have its invert set 1’ below the planned bottom of stream bed; the remaining pipes shall have their inverts set 1’ above the low flow invert. Natural siltation will fill the bottom of the pipe to the planned stream bed level.

For pipe culvert crossings of Non-Tidal Wetlands and Waterways, including Water of the U.S., the Designer shall be thoroughly familiar with the regulations of COMAR Section 26.17.04.06, Bridges and Culverts. The engineer should be aware that, for any such crossing, culvert lengths are typically limited to 150 feet by COMAR 26.17.04.06.B.3. In addition, this section of COMAR also requires that culverts conveying such waters have inverts buried by at least 1 foot. For any such crossing, the Designer shall coordinate with regulating agencies at the concept stage in order to confirm the basic type, size and location of the culvert prior to proceeding with final design.

B. End Treatment

Steel pipe culverts derive their strength from the interaction of the soil with the pipe. At pipe ends, this interaction no longer applies and the end treatment must be detailed to stiffen the pipe as well as to protect against hydraulic and erosion forces.

1. Headwalls

For culverts with greater than 5’ of fill measured at the start of the fill slope, headwalls shall generally be the minimum height possible. There shall be 9” of cover from the top of the pipe to the ground line at the back face of headwall and there shall be 9” freeboard from the ground line to the top of headwall at the back face of wall. Regardless of whether the headwall is perpendicular to the culvert or parallel to the roadway, the top of the headwall shall be level.

For culverts with less than 5’ of fill measured at the start of the fill slope, the headwall shall generally be placed so that the barrier on the headwall lines up with the traffic barrier on the approach roadway.

The front and back faces of the headwall shall extend a minimum of 1’ horizontally beyond the pipe prior to the start of the wingwall. The portion of the headwall over the pipe shall be designed as a horizontal beam carrying the horizontal loads to either side of the pipe. The portions of the headwall immediately beside the pipe shall be designed as a cantilever, fixed at the footing, and shall carry the horizontal loads from the area over the pipe as well as loads placed on it directly. The pipe shall be attached to the headwall by J bolts at 18” c/c around the perimeter. No load from the headwall shall be assumed to be carried by the pipe.

Details of the headwall shall include a plan view drawn to a scale of 3/8” = 1'-0” or larger depicting placement of the headwall reinforcing.
The bottom of the headwall and wing wall footings shall be a minimum of 3' below the low flow pipe invert elevation. A toe wall may be placed below this if required but a bottom of footing less than 3' below the low flow pipe invert in conjunction with a toe wall shall not be acceptable. Shear keys and/or passive pressure to increase the sliding resistance shall not be considered.

Headwalls on large pipe culverts should generally be oriented parallel with the roadway embankment. For smaller culverts and headwalls not visible from the roadway, headwalls may be oriented perpendicular to the centerline of the pipe.

Headwalls for large culverts should have the edges beveled at a minimum angle of 45 degrees around the entire pipe circumference. The use of flared wingwalls may be required to reduce erosion at culvert inlets and outlets. In general, upstream wingwalls should be flared at 1:1 from parallel with the direction of flow. A 4:1 flare is recommended for downstream wingwalls (4 in the direction of flow to 1 perpendicular to the direction of flow).

Culvert headwalls that are to be used for earth retaining in excess of standard dimensions (i.e. greater than 6 inches above the top of the pipe) will require special design. The concept of using a standard headwall in conjunction with a smaller diameter pipe, such as a 36-inch pipe used with a standard headwall for a 48-inch pipe, will not be acceptable. The Designer shall have the responsibility of designing such retaining-type headwalls in accordance with the AASHTO “LRFD Bridge Design Specifications” (Ref. 1).

2. Other End Treatments

End treatments other than head walls are generally allowed if they conform to the pipe manufacturer’s recommendations. Step beveled ends are preferred over fully beveled ends for their added stiffness however both require concrete collars/slope protection with J bolts at 18” c/c and toe walls extending 3’ below the low flow pipe invert. Particular care must be taken with beveled ends for pipe arches due to their stiffness requirements.

It is structurally preferred for pipe ends to be on an axis perpendicular to the pipe centerline. For pipes not perpendicular to the centerline of the roadway, this may require warping the fill slopes. This structurally preferred solution may entail excessive cost for large culverts, may present aesthetic concerns for culverts with limited fill or may be impractical due to the right of way limitations. Each culvert site shall be examined in terms of end treatment.

Exposed square ends are not permitted except as temporary structures for aesthetic considerations.

Reinforced concrete or corrugated metal end sections are acceptable for use on single pipe culverts up to 36-inches in diameter, depending upon the application. When riprap is specified in conjunction with an end section, the riprap shall extend to the intersection of the end section and the pipe. End sections shall not be substituted for headwalls if the skew of the pipe is greater than 60 degrees to normal or if the pipe carries base flow.

Large-diameter culverts with extremely high outlet velocities (typically in excess of 20 feet per second) may require the design of specialty energy dissipaters. These dissipaters are typically cast-in-place or precast concrete. The methodologies presented in FHWA Hydraulic Engineering Circular 14 (HEC 14) (Ref. 19) shall be used in the design of any such dissipaters. The structural design of these units shall be in accordance with the AASHTO “LRFD Bridge Design Specifications” (Ref. 1).

3. Stream Protection

Where required due to high outlet velocities or stream instability, channel protection shall be designed in accordance with the methodologies of FHWA Hydraulic Engineering Circular HEC 20 (Ref. 20) and the guidance presented in Chapter 10 of the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12). Severe stream instability at culvert outlets should be assessed by qualified engineers experienced with fluvial geomorphology and Rosgen stream restoration techniques.
C. Foundation Requirements

Large culverts in excess of 48 inches in diameter shall be bedded in a concrete cradle which will support the pipe for at least 10 percent of its overall height.

Multiple-cell pipe culverts shall be spaced so that adjacent outside surfaces are as follows:

- Diameter less than 48 inches: Not less than 2 feet apart.
- Diameter greater than 48 inches: One-half the diameter or 3 feet apart, whichever is less.

This section applies to steel pipe culverts with spans greater than 8' measured perpendicular to the pipe.

A normal foundation report shall be required, refer to Section 3.2.M.
3.10 Utilities on Bridges

A. Telephone Lines & Cable

Galvanized steel conduits will only be allowed to be placed in the sidewalk slab of the bridge.

B. All Other Utilities

No utilities other than telephone conduits will be permitted to be placed on a bridge. No conduit shall be placed closer than ten (10") inches from the face of the curb and three (3") inches from the inside face of the parapet or twelve (12") inches from the edge of the slab if no parapet is provided.
3.11 Rehabilitation of Existing Structures

A. Introduction

This section addresses the rehabilitation of existing structures as part of an overall program to repair various Public Works structures. The goal of rehabilitation is to maintain the safety and structural integrity of the structure as well as extend its useful service life. The focus of any rehabilitation program is to effect repairs to key or critical structure elements in a timely manner to eliminate the need to replace the entire unit.

Structures designed per AASHTO LRFD (Ref. 1) shall be evaluated using AASHTO LRFD (Ref. 1). Structures designed by Load Factor Design (L.F.D.) or Allowable Stress Design (A.S.D) methods may be evaluated with either the AASHTO Standard Specifications (Ref. 24) or AASHTO LRFD (Ref. 1). It is appropriate and acceptable to analyze older structures with the AASHTO Standard Specifications (Ref. 24). However, in some cases, an LRFD analysis may yield more favorable results due to more refined methods of live load distribution or structural capacity. The intent of this provision is to not preclude the use of LRFD in these situations. A structure found to meet the minimum performance criteria when checked with either code should be considered acceptable. When projects in this category require the design of a new element or retrofit, it is preferred to use AASHTO LRFD (Ref. 1), when practical.

The design of temporary works (e.g., falsework) shall be performed in accordance with applicable sections of the latest edition of the AASHTO “Guide Design Specifications for Bridge Temporary Works” (Ref. 16) and the AASHTO “Construction Handbook for Bridge Temporary Works” (Ref. 17).

Bridge widths, including travel lanes, shoulders, and pedestrian and bicycle facilities, shall conform to Section 3.2.1 to the extent practical. If the scope of the project does not allow for the full width of those facilities, consideration should be given to retrofits that provide additional space for pedestrian and bicycle travel. In constrained conditions on bridges with inadequate pedestrian and bicycle facilities, consideration should be given to narrowing or reconfiguring motor vehicle lanes or medians to provide additional space for pedestrians and bicyclists. Consideration should also be given to adding some separation (if feasible) between the travel lanes and the adjacent pedestrian/bicycle facility, such as a curb, a concrete barrier, or flexible delineators. Separation is a particular need on bridges with motor vehicle operating speeds over 35 mph that are more than 100 feet long.

B. Superstructure Repairs

Superstructure repairs include rehabilitating those bridge elements located above the abutment or pier beam bearing seat. The elements to be addressed include decks, roadway barriers and sidewalks, roadway joints (transverse and longitudinal), drainage devices (including scuppers, troughs and downspout pipes), approach slabs, structural framing systems and bearings.

1. Bridge Decks

In general, the rehabilitation of bridge decks will consist of maintenance repairs of the roadway surface (or soffit), removal of the top portion of the deck and placing a specialized concrete overlay or a complete deck replacement. The scope of rehabilitation should be based on the latest inspection information and all available testing data as appropriate. If inspection and testing information is unavailable, it is desirable to obtain this data through an in-depth inspection of the bridge deck and an adequate testing program. The in-depth inspection should focus on determining areas containing concrete defects that require repair including delaminations, spalling and cracking. All areas shall be thoroughly documented by defect type and location.
The in-depth inspection shall include visual and tactile inspection methods including hammer tapping, chain drag and other nondestructive tests to evaluate the deck condition. Based on this information, concrete cores should be taken to evaluate, at a minimum, the compressive strength and chloride ion content of the deck concrete. Cores shall be taken in areas containing observed deterioration as well as areas in relatively good condition (as a control). A minimum of two (2) cores shall be taken for any bridge including a minimum of one (1) per span for multi-span structures. Cores shall not be taken directly over any main longitudinal or transverse structural members. Pending the results of the in-depth inspection and testing, a rehabilitation scheme can be recommended to repair the deck in place, install an overlay or replace the deck.

An estimate of the remaining service life should be made accounting for the current age of the deck, its current strength as compared to the original design strength, chloride ion content, location and extent of any observed structural cracking and the location and extent of concrete deterioration. The remaining service life estimate should be considered in the final decision to rehabilitate or replace the deck.

Concrete deck repairs involve placing an adequate concrete patching material in an area that has been first properly cleaned and prepared. Any area to be repaired shall have all deteriorated and loose concrete removed, exposed reinforcing steel cleaned of all rust (and replaced if it has lost more than 20% of its original section), and the area air blast or water-jet blast cleaned. Concrete patch material shall be chosen based on factors including durability, suitability of the material for the repair location, curing time (as it relates to opening lanes back to traffic) and cost.

If it is determined that the deck has adequate overall strength and some remaining service life left, a specialized concrete overlay may be considered. A concrete overlay will help to protect the remaining portions of the deck as well as extend the remaining service life of the bridge deck. Generally, only 1" to 2" of the existing concrete deck surface is removed (where the potential for delaminations or a high concentration of chloride ions exist) and the surface prepared to receive the overlay material. As part of the surface preparation process, localized concrete repairs may be required to ensure that the rehabilitated deck is a sound and integral element. Material(s) used in the patching process discussed previously are suitable for this repair. The overlay material shall be a dense cementitious type material suitable for placing in relatively thin applications. Materials such as latex modified concrete, micro-silica concrete and very early high strength latex concrete should be considered depending on the application needs. The structural capacity of the deck should be verified if more than 2" of concrete is removed from the top surface.

If the selected rehabilitation alternative is for complete replacement of the concrete deck, several issues shall be evaluated, including, but not limited to, studying and developing stages of construction for maintenance of traffic, need to maintain pedestrian and/or bicycle traffic, maintenance of utilities, checking the existing framing system for the new deck weight including the consideration of the effects of composite action and differential camber in adjacent beams (as a result of staged construction) and the rehabilitation needs for the substructure and those superstructure elements to remain.
Other rehabilitation work associated with the bridge deck will be the repair or replacement of existing roadway joint systems. The failure of transverse (and longitudinal) roadway joints may lead to substructure deterioration, bearing failure and section loss at the ends of the main superstructure supporting members. Depending on the severity of the joint deterioration, only the replacement of the seal may be required. Field measurements of the joint opening should be taken along with the ambient temperature to ensure that the correctly sized seal is installed. If the condition of the joint system is such that replacement is required, the existing joint configuration should be confirmed in the field and checked against available plans. If plans are unavailable, field measurements and details of the existing joint system shall be recorded for subsequent use in preparing joint replacement plans. As part of any joint modification scheme, consideration should be given to installing drainage troughs in accordance with Section 3.5.H of this Design Manual. The replacement joint system chosen (armored compression or strip seal, asphaltic plug, silicone, elastomeric, etc.) shall take into consideration such factors as cost, serviceability, durability (i.e., resistance to truck traffic) and constructability. Where feasible, the elimination of transverse joints should be investigated to extend the service life of bearings, beam ends, and other bridge components historically affected by failing joints. An appropriate structural analysis of the existing structure should be completed to determine the applicability and suitability of installing link slabs at intermediate pier roadway joints and/or a conventional deck-over system at each abutment. The ability of existing bearings to accommodate link slabs and/or deck-over details shall also be confirmed and the replacement of same evaluated to determine if their replacement is cost-effective in conjunction with the removal of transverse joints.

As part of a deck maintenance program, consideration should be given to eliminating bridge scuppers. If feasible, eliminating scuppers will minimize the deterioration of the deck from standing water/debris resulting from clogged scuppers. An analysis of the scupper(s) shall be performed and if the design spread for a ten-year storm event does not encroach more than 6 feet into the traveled way. Scuppers to be eliminated shall be filled with a lean concrete mix.

2. Barriers

Traffic barriers include railings and parapet systems. Barriers inadequately attached to the superstructure (as a result of deterioration, accident damage or substandard design) shall be rigidly connected to the deck and/or fascia beams to provide sufficient strength to resist vehicular impacts.

3. Girders/Beams/Trusses

These repairs encompass many different types of repairs and will include all work to rehabilitate girders, beams and trusses.

There are many types of repairs that may be performed on steel beams/girders. Rusted webs can be repaired by welding or bolting plates across the deteriorated areas. Deteriorated flanges may be repaired by welding or bolting cover plates across the deteriorated or damaged areas. Care must be taken when welding to ensure that allowable fatigue stresses are not exceeded and that weld quality can be obtained under field conditions.
For bridges with high volumes of truck traffic, repairs may involve the retrofitting of beams/girders at intermediate diaphragms or cross frame connections to prevent and/or mitigate problems at fatigue-sensitive connection details. Cracks in welds, as well as cracks in the web and connection plates, have resulted from these fatigue-sensitive connection details. Retrofit details to consider include bolting angles or tees to the connection plates and flanges to prevent and/or mitigate out-of-plane bending or high-stress concentrations. In addition to this retrofit, welds may be repaired via grinding, drilling crack ends and replacing any cracked connection plates. Each situation must be carefully studied to ensure that the retrofit detail can be properly constructed in the field and that it will be achieving its intended purpose of eliminating and/or reducing out-of-plane bending or high-stress concentrations.

Although most projects will involve the repair and/or replacement of select members, in some cases, it may be desired to upgrade the load-carrying capacity of a structure. This can be accomplished by several methods, including applying more advanced analysis methods, rating the structure using load and resistance factor design, replacing the deck with lightweight concrete or a different type of lightweight deck (e.g., exodermic, etc.), making multiple simple spans continuous over the piers, post tensioning, or adding shear studs to make non-composite beams composite. When adding studs for the development of composite action, the type of steel being stud welded must be carefully evaluated. Older steels (e.g., A7) are not as ductile as current steel and special care must be utilized when attaching any element via welding.

Trusses often need to be strengthened because of deterioration at the lower chord and connections. Strengthening can be accomplished by the addition of stressing cables or splicing of the chords themselves. Care must be taken in these repairs because of the lack of structural stability when a lower chord member is disconnected. On many trusses, the floorbeam/stringer framing system, including connections, may need rehabilitation and/or upgrading. Many of these repairs can be handled as stated above for steel beams/girders.

Timber beams deteriorating as a result of decaying wood or insect attack can be rehabilitated by replacing individual members or strengthening by thru-bolting galvanized steel channels to each side.

Rehabilitation of concrete tee-beam bridges typically involve beam repairs to address spalling, cracking and any exposed reinforcing steel that has lost cross sectional area. If the extent of deterioration does not compromise the ability of the member to safely carry load, cosmetic repairs using pneumatically applied mortar may be utilized to halt further deterioration. If the extent of corrosion adversely affects the load carrying capacity of the member, and the bridge cannot be load restricted, external reinforcement such as carbon fiber reinforced polymer sheets can be bonded to the sides and bottom of the beam to upgrade the live load capacity.

Prestressed members with concrete spalling can be repaired after cleaning of the strands. Some preloading of the beam may be necessary to prevent future cracking of the concrete patch. If prestressing strands are damaged or severed to a point where the load-carrying capacity of the member is inadequate, the member can be repaired by providing external post-tensioning. This method can also be used to increase the strength of under-designed prestressed beams. In addition, the use of external reinforcement such as carbon fiber reinforced polymer sheets can be bonded to the sides and bottom of the beam to upgrade the live load capacity in shear and/or bending.
4. **Bearings**

   Deteriorated bearings may need to be cleaned and painted, reset or replaced with a similar or better functioning bearing device. To reset or replace bearings, the bearing load must be released through the use of hydraulic jacks and temporary jacking beams supported by the existing girders. Steel columns anchored to the face of the substructure may also support the jack(s). Or, if space allows, the jack(s) can be placed on the beam seat behind the end of a girder. The design plans shall clearly state the limits of the jacking system with respect to load, the amount of girder displacement that can be tolerated and whether traffic can be maintained on the bridge during the jacking operations. The existing structural components must also be checked to confirm their ability to withstand the jacking forces.

   For bearings exhibiting extensive and advanced paint deterioration and base metal corrosion, complete cleaning and repainting may be necessary to restore full operational capacity to the bearings. In addition, these bearings may have to be jacked and temporarily supported to facilitate a more thorough cleaning. Reference the following section for the cleaning and painting of steel bearings.

5. **Painting**

   The painting of steel superstructure elements (beams, girders, diaphragms, bearings, etc.) encompasses the cleaning and painting of all exposed surfaces as part of a maintenance or rehabilitation project. Depending on the condition of the paint system, either spot cleaning and repainting may be required. However, if the paint system condition is relatively good, minor cleaning and overcoating may be a more economically viable alternative to full removal and coating. Spot cleaning shall extend a minimum of 10’ from the beam ends on simple spans and 10’ from the centerline of bearing on continuous spans. Steel bearings and associated end diaphragms should be included within these limits. Other areas of additional spot cleaning (e.g., exterior sides of fascia girders) shall be included as necessary.

   The existing paint system should be evaluated for adhesion in accordance with ASTM D4541 as well the coating thickness and the compatibility of the existing coating with the new coating. Evaluation of the paint system shall be in accordance with the current edition of the “SSPC Painting Manual, Volume 2” (Ref. 13).

   Prior to cleaning and painting, the existing paint system shall be evaluated for the presence of lead paint. If lead paint is present, contract specifications shall be prepared for proper and adequate lead paint removal and containment and worker protection (reference Volume 4 – Specifications for more information). 100 percent containment of blast by-products shall be contained. The design of the containment system shall be borne by the Contractor performing the work.

   The new paint system(s) shall be in conformance with the Volume 4 Specifications assuming that it is compatible with the existing paint system.

C. **Substructure Repairs**

   Substructure repairs include rehabilitating those bridge elements located at or below the abutment or pier beam bearing seat. The elements to be addressed include beam seats (and pedestals), abutments and wing walls, piers, slopes and foundation elements.

1. **Concrete Repairs**

   The repair of concrete substructures generally involves both cosmetic and structural rehabilitation. Cosmetic repairs include superficial concrete deterioration such as shallow spalling (defined by no exposed reinforcement) and delaminating concrete (i.e., incipient spalling). Structural repairs include flexural or shear cracking, cracks wider than 1/16” and deep spalling where reinforcement is exposed (regardless of the condition of the reinforcement).
Concrete repair limits shall be based on the latest field inspection documentation. This information shall be field verified if it is older than one year or if the limits of concrete deterioration are not well defined. When determining the limits of repair for both shallow and deep spalling, the outside dimensions of the defect shall be increased by a minimum of 6” on all sides to ensure that the deteriorated portion is encapsulated within the repair.

All concrete repairs shall include provisions to remove all loose and deteriorated concrete and thoroughly clean the remaining surfaces prior to placing the repair material. Any exposed reinforcement shall be blast cleaned and inspected for section loss. Any bar reinforcement that has sustained more than 20% section loss shall be replaced by reinforcement of equal size and adequately lapped/spliced to develop the full strength of the bar.

The material used to repair deteriorated concrete shall be selected based on the location, type and volume of the proposed repair.

2. Pile Repairs

Repairs to piles will consist of a combination of structural enhancement and/or protection. For existing steel piles with section loss resulting from corrosion, steel plates or rolled channel section shall be field bolted to increase the capacity of the pile. Unless the pile has significant section loss, the addition of these steel elements can be affixed under full traffic load. The length of these newly bolted members shall extend well beyond the limits of the deteriorated portions so that the bolted connection is fully developed within the full original section of the pile. For concrete piles, additional concrete section may be added in a similar manner utilizing reinforcement doweled into the existing pile and tremie concrete placed. Repairs to timber piles that have lost section can be accomplished using timber pile splices. Concrete and steel pilings shall be repaired by cleaning the exposed surfaces and placing fiberglass jackets from the channel bottom to up above the splash zone, or just in the vicinity of the splash zone if that distance is prohibitively long. Grout or a specialized concrete mix shall be placed between the existing pile and the jacket, with reinforcement added as needed to provide additional strength. Substantial cross-sectional losses can be strengthened by adding material to the pile and extending the concrete pile strut to the mudline. The foundation unit must be analyzed with this additional dead load to ensure that none of the piles are being overstressed by this additional weight.

3. Scour and Undermining

Channel degradation and/or scour can advance to the point of exposing the piles. In addition, strong waterway currents or wet/dry cycles can reduce the cross section of the piling at the channel bottom or mudline or water surface (common to timber piles and steel pipe piles). The foundation should be analyzed to determine the pile/soil interaction affects from lateral and vertical loadings and incorporate this information into a structural model to determine the overall structural integrity and/or stability of the foundation unit in question. Inspection observations and measurements or subsequent structural analyses will dictate if pile repairs should be performed in accordance with the previous section.

If scour countermeasures are deemed necessary, scour computations and evaluations shall be performed in accordance with the MDOT SHA OOS “Manual for Hydrologic and Hydraulic Design” (Ref. 12), in particular Chapter 7 and 11. In addition, an underwater inspection (including soundings) should be performed as well as a review of previous underwater inspection reports and other scour evaluation reports. Generally, scour countermeasures for bridges over streams, creeks and rivers will include riprap or grout bag blankets placed around piers and abutments. Stream instability countermeasures, if required, shall include riprap or gabion bank protection, spur dikes and check dams. Scour countermeasures for bridges over tidal waterways will include riprap aprons around pile bents and riprap revetments around abutments and approach roadways.

During the development of scour countermeasures, all permitting requirements shall be determined and applied for at the Preliminary Design phase.
4. Underpinning

In extreme cases of undermining, a substructure unit may lose sufficient bearing, which could result in the structure collapsing. In the case where a substructure unit has rotated or settled, it may be necessary to jack the substructure unit back into proper position prior to underpinning the foundation. The method used to underpin a foundation depends greatly upon the amount of undermining and whether the underpinning is required to provide structural support. For severely undermined foundations, the underpinning must be performed in such a manner as to provide bearing. This can be accomplished by placing either a temporary form or a permanent fiberglass jacket around the substructure footing and pumping concrete or grout in the void between the substructure footing and the form. Reinforcing steel shall be doweled into the existing foundation or a rock foundation below. The form shall be high enough to provide sufficient head pressure so that the concrete or grout is forced into all voided areas and up against the bottom of the existing foundation. Constructing a cofferdam, dewatering the area, and constructing temporary forms is also another method which may be considered; however, this method results in considerable disturbance within the waterway and is generally more costly and sensitive to permitting regulations.

For foundations where the undermining is minor and it has been determined that the remaining bearing area provides sufficient bearing capacity, pumping grout behind placed grout bags can be performed. The grout bags will prevent future undermining of the foundation while the grout pumped behind the grout bags will fill voids in which the bags could not fill.

D. Retaining Walls

The rehabilitation of retaining walls should consider the material and type of wall. For concrete retaining walls, repairs will generally only be made to the surface areas unless wall alignment is in question. Concrete repairs for retaining walls shall generally follow those stipulated for bridges under Section 3.11.C.1.

For the repair of MSE or other proprietary type precast walls, rehabilitation measures should be discussed with the wall manufacturer prior to implementing repairs. Typical problems involving MSE walls include the failure of the soil reinforcement strap attached to the wall facing panel. Grouted tie-back anchors may be considered to stabilize the wall panel and eliminate future local erosion of the fill.

Since gabion walls can tolerate substantial settlement and/or rotation prior to failure, repairs may only be necessary when the wire basket cages corrode or break. Retying the wires is an acceptable measure to repair the baskets. Gabion walls with substantial settlement and/or rotation shall be analyzed for stability to determine if the wall can remain or if reconstruction is required.

E. Maintenance of Traffic

Maintenance of Traffic (MOT) for the rehabilitation of existing structures shall conform to applicable portions of Chapter 5 as contained later within this volume.
3.12 Load Ratings

A. Introduction

This section addresses the calculation of load ratings for new or existing structures as part of a design project to rehabilitate or replace an existing bridge. Load ratings may also be required for existing structures that have incurred structural deterioration observed during routine biennial inspections. Load ratings shall be calculated for all bridges carrying traffic including culvert type structures covered with less than 8 feet of earthen fill. As part of the final design of new or replacement bridges, the Designer shall compute the load ratings for the structure and include these with the Final Plans submittal to the County.

B. Methodology

Load ratings shall be calculated in accordance with Chapter 6 of the latest edition of the AASHTO “Manual for Condition Evaluation of Bridges” (Ref. 14) and MDOT SHA Structural Guidelines and Procedure Memorandums” (Ref. 10). At a minimum, the four standard Maryland legal live load vehicles shall be rated, including the H-15 (15 tons), HS-20 (36 tons), Type T-4 (35 tons), and 3S-2 modified (40 tons) trucks. In addition, load ratings may be required for the eight (8) special vehicles (e.g., school buses, emergency vehicles, special permit vehicles, etc.) as directed by the County.

Both inventory and operating load rating values shall be computed for each truck considered. Material values shall be based on any available record plans or field testing, as applicable. If no plan or testing information is available, material properties shall be estimated based on the provisions contained within Chapter 6 of the latest edition of the AASHTO “Manual for Condition Evaluation of Bridges” (Ref. 14).

The inventory load rating value shall be considered as the load level that can safely cross the structure for an indefinite time period assuming that the structure remains in its current condition. The operating load rating value shall be considered as the maximum load level that can safely cross the bridge. Allowing this maximum load to cross the bridge indefinitely may compromise the structural integrity and limit the service life of the bridge.

Load ratings shall be computed based on the known section properties of each member accounting for any section loss or member deterioration that could adversely affect the load rating values. Load ratings may be hand-calculated or computed using appropriate computer software written specifically for structural load ratings. For rigid frames and box culvert type structures, structural models based on plane frame analysis methodologies shall be used. In addition to the application of dead and live loads, earth pressure loads (vertical and horizontal) shall be also be applied. Earth pressure loads shall be additive to the dead loads when computing the available member capacity to resist the applied live loads. For paved inverts that are structurally connected to the side walls (e.g., four-sided box culvert), the structural model shall incorporate the effects of the bottom slab loading on the subbase by utilizing spring constants in the model. These spring constants shall be based on an evaluation of the existing soil conditions to determine an appropriate coefficient of subgrade reaction. Each member within a four-sided culvert structure (i.e., walls, top slab and invert slab) shall be analyzed and load rated. Headwalls on rigid frame, four-sided culverts and pipes need not be load rated.

C. Posting

Structures that do not rate out for the minimum vehicle weight at the inventory level (i.e., the rating factor, RF < 1.0) shall be recommended for posting to the Chief of the Bureau of Engineering. All postings shall include both the Gross Vehicle Weight (GVW) for the H-15 and Type T-4 trucks and the Gross Combination Weight (GCW) for the HS-20 and Type 3S-2 modified trucks. The acceptance and implementation of the recommended load posting shall be at the discretion of the Chief of the Bureau of Engineering.
3.13 Plan Preparation Guidelines

A. Introduction

This section provides guidance on the proper manner to prepare plans for bridge replacement and/or rehabilitation projects. CADD guidelines related to the production of plan sheets using Microstation is covered under applicable sections of Chapter 1. Plan preparation guidelines for retaining wall projects are covered under Section 3.4.A.

B. Sheet Layout and Order

Bridge plan sheets shall be generated and prepared using commonly accepted engineering and drafting techniques and practices. In general, plan sheet layout shall be developed to include only those views, sections and details pertinent to a particular bridge component. Mixing of various details from different portions of the structure (e.g., substructure and superstructure) shall be avoided wherever possible.

The order of bridge plan sheets for new structures shall conform to the following:

- General Plan and Elevation
- Hydraulic and Hydrologic Data Sheet (if applicable)
- Geometric Layout (for substructure footings or piles)
- Substructure Unit Plan and Elevation (for abutments, wing walls and piers)
- Substructure Typical Sections (of abutments, wing walls and piers)
- Bridge Typical Section(s)
- Framing Plan Layout
- Beam/Girder Details (includes elevation, camber information, splice details, etc.)
- Diaphragm Details (end and intermediate)
- Bearings
- Deck Elevations
- Roadway Joint Details (includes plan layout, sections and any necessary details)
- Bridge Railing Details
- Approach Slab Layout and Sections (if applicable)
- Miscellaneous Details
- Boring Logs (including plan layout of locations)

The order of plan sheets for a rehabilitation project will follow this general order as applicable. Highway plan sheets and any necessary maintenance of traffic plan sheets shall be placed ahead of the bridge plans when they are made a part of the project.
3.14 References

(1) “LRFD Bridge Design Specifications,” American Association of State Highway and Transportation Officials (AASHTO)

(2) “Manual for Railway Engineering,” American Railway Engineering and Maintenance-of-Way Association (AREMA)

(3) “Manual of Steel Construction,” American Institute of Steel Construction (AISC)

(4) “ACI Manual of Concrete Practice,” American Concrete Institute (ACI)

(5) “Structural Welding Code,” AWS D1.1, American Welding Society (AWS)


(7) “Howard County Storm Drainage Design Manual,” Department of Public Works, Bureau of Engineering, Howard County, Maryland


(9) “Maryland Waterways Construction Guidelines,” Maryland Department of the Environment

(10) “Structural Guidelines and Procedure Memorandums,” Maryland Department of Transportation, State Highway Administration, Office of Structures

(11) “Structural Details Manual (Maryland Department of Transportation, State Highway Administration, Office of Structures

(12) “Manual for Hydrologic and Hydraulic Design,” Maryland Department of Transportation, State Highway Administration, Office of Structures


(14) “Manual for Condition Evaluation of Bridges,” American Association of State Highway and Transportation Officials (AASHTO)

(15) “Book of Standards for Highway and Incidental Structures,” Maryland Department of Transportation, State Highway Administration, Office of Highway Development


(21) “LRFD Guide Specifications for the Design of Pedestrian Bridges,” American Association of State Highway and Transportation Officials (AASHTO)

(22) “Guide Specifications for Wind Loads on Bridges During Construction,” American Association of State Highway and Transportation Officials (AASHTO)

(23) “Guide for the Development of Bicycle Facilities,” American Association of State Highway and Transportation Officials (AASHTO)

(24) “Standard Specifications for Highway Bridges,” American Association of State Highway and Transportation Officials (AASHTO)

(25) “Bridge Railing Manual,” Maryland Department of Transportation, State Highway Administration, Office of Structures

(26) “Aesthetic Bridges - User’s Guide,” Maryland Department of Transportation, State Highway Administration, Office of Structures
