ROAD DESIGN MANUAL

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MICHIGAN DESIGN MANUAL
ROAD DESIGN

CHAPTER 2 • GRADES & EARTHWORK

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2.01 REFERENCES

(revised 11-28-2022)

A. A Policy on Geometric Design of Highways and Streets, AASHTO, 2018 7th Edition

B. Roadside Design Guide, AASHTO, Current Edition

C. Standard Plan R-96-Series, Soil Erosion & Sedimentation Control Measures

D. Standard Plan R-100-Series, Seeding and Tree Planting

E. Standard Plan R-103-Series, Treatment of Peat Marshes

F. Standard Plan R-105-Series, Grading Cross Sections

G. Standard Plan R-107-Series, Superelevation and Pavement Crowns

H. Guidelines for Plan Preparation – Design Division

I. Geotechnical Manual, MDOT, Current Edition

2.02 VERTICAL ALIGNMENT – GENERAL

(revised 11-28-2011)

Vertical alignment establishes the profile gradeline of a proposed road construction project. The grade can be over virgin land as in the case of a relocation project or along an existing roadway, as in the case of a resurfacing project. In either case and in most proposed construction projects, a gradeline should be established.

Obviously a gradeline must always be established for new construction or relocation projects. Most reconstruction and rehabilitation projects will require new gradelines if improvements for sight distance, superelevation, and drainage are included. A simple resurfacing project can usually be constructed without establishing a new vertical alignment.

Establishing the vertical alignment is based on many factors, including terrain, existing conditions, soils, drainage, coordination with the horizontal alignment, location of bridges, culverts, crossroads, design speed, earthwork balance, etc. The Designer must work with other Divisions, mainly Construction Field Services Division and Traffic and Safety to provide the best possible vertical alignment. The final product should be safe, functional, aesthetically pleasing, and economical.

2.02.01 Grades

(revised 11-28-2011)

Terrain in Michigan is mostly level with some areas of rolling topography. Therefore, the Designer can usually achieve good vertical alignment, especially on new and reconstruction projects. Grades can be kept relatively flat with long vertical curves for long sight distances. In rolling terrain, more care is needed in establishing the vertical alignment.

Maximum grades depend on the functional classification of the roadway, location (urban or rural), design speed, terrain, and the scope of the construction project. MDOT generally uses a maximum grade of 3% for freeways and major trunklines and 4% for secondary and county roads. Steeper grades within AASHTO limits may be used when warranted.

Minimum grades depend more on drainage than on other factors. Uncurbed roads with ditch drainage can have a level longitudinal grade if the crown adequately drains the pavement. Independent ditches should be used when the grade is less than 0.3%. A desirable minimum is typically 0.5%, but grades of 0.3% may be used for paved roadways. See Section 3.03.02D.

If the grade is very flat, independent gutter grades may be necessary. (See Chapter 6 - Surfacing, Section 6.06 - Curb and Gutter.)

Gradelines for new construction are established by a series of tangents connected at their intersections (P.I.'s). The gradeline may be above or below the existing ground line depending on the type of soil, location of the water table, existing or proposed features such as bridges, crossroads, etc., and many other factors. The Region Soils Engineer can be helpful in establishing a new gradeline.

The series of tangent gradelines are smoothed out and refined by the use of parabolic vertical curves.

2.02.02 Deleted

Section deleted. Information incorporated into Chapter 3.

2.02.03 Principles and Procedures for Gradelines

(revised 8-26-2019)

2.02.03A General

The profile gradeline of a roadway construction project has a major impact on the facility's cost, aesthetics, safety and operation. The Designer must evaluate many factors when establishing the profile gradeline. These factors include but are not limited to:

1. Maximum and minimum grades.
2. Stopping, passing, decision, and intersection sight distance.
3. Earthwork balance.
4. Terrain, topography, and soil classification.
5. Bridges and culverts.
6. Railroad crossings.
7. Highway intersections and interchanges.
8. Highway safety.
9. Aesthetics, erosion control, and landscaping.
10. Snow and ice.

11. Coordination with other geometric features (horizontal alignment, design speed, etc.)
12. Utilities.
13. Drainage and water levels.
14. Highway location and classification.
15. Construction costs.
16. Airports.
17. Driver's View.
18. Presence of or future plans for bicycle or pedestrian infrastructure.

2.02.03B Earthwork Balance

When possible and without sacrificing safety and sight distance factors, the gradeline should be set to achieve an earthwork balance. Elimination of large quantities of borrow or excess excavation will help to keep costs down and lead to an economic design.

Mass diagrams, which illustrate the accumulated algebraic sum of excavation and embankment volume, were historically used in balancing earthwork. Current methods of payment have generally replaced the need for mass diagrams.

2.02.03C Bridges

Gradelines must be set to meet existing bridges and to provide adequate vertical clearance when going over or under existing highways, railroads, power lines or waterways.

Close coordination with Bridge Design is important when setting grades involving existing or proposed bridges. See Section 7.01.08 of the Bridge Design Manual for bridge underclearance requirements. When a facility will cross water, the underclearance and the waterway opening become important concerns. Coordination with MDOT Bureau of Planning and the Michigan Department of Environment, Great Lakes, and Energy (EGLE) may also be necessary.

2.02.03D Drainage

Grades should be set to provide adequate cover over culverts and to have minimum freeboard above the headwater levels at culverts, underdrain outlets and bridges. (See Chapter 4 - Drainage and the MDOT Drainage Manual.)

Drainage is also a concern when designing sag vertical curves, when flat grades are necessary and when vertical curves are on a bridge deck or under a bridge. To improve drainage on bridge decks, the high point of the vertical curve should be moved off the bridge deck, if possible. Similarly, the low point of a vertical curve under a bridge should be moved outside the shadow of the bridge, if possible.

2.02.03E Soils

Soils have a major impact on the location of a gradeline. Granular well drained soils can have the gradeline located anywhere, while poorly drained loamy soils may require a grade at least 4 ft.-0 in. above ground level. The Soils Manual and Construction Field Services Division can be used for guidance for establishing grade through the different soil classifications.

2.02.03F Erosion Control

Erosion controls will be necessary on any construction project, however careful planning in establishing a grade can minimize erosion effects. Some considerations follow:

1. Avoid steep longitudinal grades.
2. Avoid steep side slopes.
3. Minimize disturbed areas.
4. Make use of existing vegetation.
5. Conform to the existing contours and drainage of the area.

Refer to Section 2.05 for detailed information on this topic.

2.02.03G Airports

Grades need to be established that will not interfere with the glide paths for runways. The glide paths are obtained from the Aeronautics Division or Federal Aviation Administration.

2.02.03H Water Table

Areas with high water table may require review with the Region Soils/Material Engineer to determine the appropriate grade lines. In many soil series, the water table varies with the seasons and information relating to how the depth of water table may affect the roadway and structures should be collected and analyzed.

2.02.03I Multi-Modal

Grade should be a consideration in areas where multi-modal facilities are existing or planned. For example, larger grades are undesirable because ascents are difficult for some multi-modal users and descents can cause increases in speed that the user is either uncomfortable with or unable to manage safely. See Section 12.12.09 for grade limitations for shared use paths.

2.03 TYPICAL CROSS SECTIONS

(revised 8-26-2019)

A typical cross section shows, in elevation view, what is to be constructed. The proposed typical section can be superimposed on an existing road cross section as in the case of a resurfacing or widening project or be entirely new as in the case of a new or relocated roadway. Typical cross sections show all details of the proposed roadway including lane width (including bike lanes), shoulders, slopes, ditches, curb and gutters, sidewalks or pathways, subbase, and pavement. Typical cross sections are important and necessary for determining earthwork quantities. Some examples are shown in the Guidelines for Plan Preparation. Also, all the above design elements should meet AASHTO safety requirements.

2.03.01 Slopes

(revised 5-26-2026)

Slopes are measured as a ratio of vertical distance to horizontal distance, a *1:4 slope indicates 1 foot vertical drop in every 4 feet horizontally*. Slopes should be as flat as practical for existing conditions and type of roadway. 1:6 slopes are desirable for foreslopes or fill slopes for new trunkline construction. Slopes 1:3 or flatter are considered traversable if there are no other obstructions within the clear zone. See Section 7.01.30 for barrier warrants at embankments.

The following general criteria should be used for foreslopes, based on the fill height:

- Freeways and free access roads where Right-of-Way is adequate
    - Less than 10 ft. use 1:6 slope
    - 10 ft. to 25 ft. use 1:4 slope
    - Over 25 ft. use 1:2 slope
- Roadways where Right-of-Way is limited
    - Less than 10 ft. use 1:6 to 34 ft. from the edge of the through lane, then 1:3 slope
    - 10 ft. to 20 ft. use 1:4 slope
    - Over 20 ft. use 1:2 slope

In situations where ditch backslopes are involved and slopes must be steepened, for instance, to stay within the proposed or existing ROW, the ditch backslope should be steepened in preference to steepening the foreslope.

- The preferable traversable ditch cross sections are:
    - 1:6 foreslope use 1:3 backslope
    - 1:5 foreslope use 1:3.5 backslope
    - 1:4 foreslope use 1:4 backslope

Other combinations are less desirable and their use should be limited where high angle encroachments are expected, such as at the outside of curves. However, it is understood that in certain situations (high fills, deep cuts, limited ROW, physical obstructions, etc.) the use of 1:2 slopes may be necessary.

2.03.01A Fill Slopes

Fill slopes start at the shoulder point and go to existing ground. As fill heights increase, economy may dictate the need for steeper slopes. The Designer should attempt to minimize the use of slopes requiring guardrail or other barrier protection. A non-recoverable slope is defined as one which is traversable but from which most motorists will be unable to stop or return to the roadway. Vehicles on such slopes typically can be expected to reach the bottom, and generally slopes between 1:3 and 1:4 fall into this category. Fixed obstacles will normally not be constructed along such slopes and a clear runout area at the base is desirable.

2.03.01B Cut Slopes

Cut slopes can be foreslopes (from the shoulder point down to a ditch) or backslopes (from the ditch or a no ditch section up to existing ground.) Usually, cut foreslopes should be 1:4 or flatter. Backslopes should be as flat as right-of-way and existing conditions allow.

2.03.01C Barn Roof Section

Barn roof grading sections can be used under certain conditions to provide a section in high fills that provides the required clear recovery area and will not require guardrail or other protective barrier. Standard Plan R-105-Series shows the barn roof section. The section changes slope, i.e., flatter to steeper, beyond the normal clear zone. However, slopes steeper than 1:3 should not be used.

Barn roof sections are not appropriate in the following situations:

1. A crossroad over a freeway where guardrail is required at the structure.
2. Inside an interchange area where there is sufficient right-of-way to design using 1:4 slopes or flatter.
3. Locations where no runout area can be developed at the toe of slope, such as locations with large drainage ditches.

2.03.02 Drainage

(revised 8-26-2019)

Drainage is an important consideration in any highway construction project. Proposed drainage affects the establishment of the gradeline and the development of the typical cross section. Drainage is generally open drainage, using ditches and overland flow; closed drainage, using curb and gutter and enclosed sewers; or some combination of the two. For a complete discussion on drainage, refer to Chapter 4 - Drainage and the MDOT Drainage Manual.

2.03.02A Shoulder and Ditch Sections

Shoulder and ditch sections are the norm for open drainage projects. Storm water flows off the pavement, across the shoulder and foreslope, and into the ditch section. The ditch carries the water to a natural outlet. Ditch types include round bottom, valley, berm, toe of slope, “V” ditch and no ditch section. These are all shown on Standard Plan R-105-Series. The ditch section is often influenced by the location of the project, i.e., heavy snow areas would warrant a wider ditch section.

2.03.02B Curbed Sections

Curbed sections are most often used in urban situations. They may also be used when right-of-way is limited, where sidewalk or side paths may be present or planned, or in high fills where the curb is used for erosion control. Curbed sections generally drain to an enclosed sewer but sometimes outlet to a downspout or spillway.

Curbed sections are also used for roadside control and at intersections.

2.04 EARTHWORK - GENERAL

(revised 12-28-2020)

Earthwork is the term used to describe operations used in constructing the grading cross section for the proposed roadway. Earthwork has two main components, excavated (cut) and embankment (fill) material. Excavated materials, if suitable, can be moved and used to construct embankments. If on a project, excavated material is not sufficient to construct embankments, additional material or borrow must be brought in. Borrow material and sources are typically the responsibility of the contractor.

Granular materials, used for subbase and swamp backfill, must meet specifications and sources may not be readily available close to the project site. Topsoil is scarce in some areas and material for topsoil surface may have to be transported long distances to the project.

Excavation and embankment quantities are estimated electronically or manually as follows:

Electronically: Prismoidal Method

1. Use design software to model existing materials that are being removed and proposed design elements.
2. Use design software to extract prismoidal meshes between the existing ground Digital Terrain Model (DTM) and the modeled elements.

Electronically: End Area Volumes

1. Extract the existing ground cross sections from survey or photogrammetry Digital Terrain Models (DTM's) at suitable intervals.
2. Use design software to compute the proposed (design) cross sections. Modify them if necessary in special areas.
3. Use design software to compute the areas of cut and fill at each section and the resulting volumes (using the average end area method.)

Manually: End Area Volumes

1. Obtain the existing cross section from a manual survey or by extracting them from a DTM using design software.
2. Plot the original ground and proposed cross sections manually using MicroStation, automated using design software, or a combination of both.
3. Use design software to calculate end areas at each cross section.
4. Using the average end area method, calculate the desired volumes of cut and fill, utilizing spreadsheet software.
5. Sum the cut volumes and the fill volumes for the entire project or the specific project locations.

Some areas require special care in plotting sections. For example, ramp intersections with mainline (gore areas) need to have match lines to avoid double estimating of the overlapping cuts or fills. Alternately, export the mainline proposed cross section to the DTM, and create a composite of the proposed mainline and existing ground. Then, extract cross sections from the composite DTM surface, therefore taking into account the proposed mainline roadway.

2.04.01 Excavation

(revised 5-26-2026)

Excavation can be in other forms than regular roadway excavation. Following is a brief description of some of these special or project specific items.

2.04.01A Station Grading

This item is often used on projects where normal earthwork items are not practical, or when recommended by Region Construction.

Station grading is typically paid for by station and requires a special provision. The Designer should include an estimate of excavation and embankment requirements for the Contractor's information for bidding purposes.

2.04.01B Trenching

This item is used when a uniform section is to be excavated such as for a widening or reconstructing a shoulder. The excavation is typically a uniform width and depth.

Trenching is a standard specification pay item and because of uniformity an excavation quantity does not need to be estimated.

2.04.01C Topsoil Stripping

Topsoil removal shall be as follows:

- Peat and Muck Areas - Topsoil shall not be removed.
- Borrow and Clear Vision Areas - Topsoil shall be removed to the required depth and width. Topsoil may be stockpiled near its original location, unless otherwise specified.
- Roadway Cut Areas - Topsoil shall be removed within the slope stake lines.
- Roadway Embankment Areas - Topsoil shall be removed within the slope stake lines, unless otherwise specified.

Topsoil from the roadway shall be stockpiled within the right-of-way and outside the limits of construction or used in the slopes as specified. Temporary stockpiling of topsoil may be permitted on private property with the proper permits from the owner and as approved.

Topsoil Stripping in both cut and fill sections is paid for as earth excavation. The quantity is included in the earth excavation total, but is also presented separately for estimating purposes. Depth of stripping is determined by information from the Region Soils Engineer. It is shown on the plans as follows:

- Excavation, Earth [insert number] Cyd
- Embankment, CIP [insert number] Cyd

* Includes [insert number] Cyd of Topsoil Stripping

Designers are reminded that in fill areas, the volume removed by topsoil stripping, leaves a void that will require an equal additional volume of embankment to replace it. While the topsoil stripping in the fill section is added to the excavation quantities, an equal volume must also be added to the estimated quantity for embankment. Failure to account for this additional volume in fill areas can result in significant shortages for projects involving significant earthwork.

2.04.01D Rock Excavation

This item is fairly rare in Michigan, but when rock is encountered, the designer should contact the Region Soils Engineer to discuss options and decide the necessity for contacting the Geotechnical Services Unit of Construction Field Services Division to order rock cores to define the type and hardness of rock. This will give the contractor direction as to the appropriate method of excavation to be used (blasting, ripping, etc.). If cores are taken it is required that the rock core information be included on the soil boring plan sheets. A plan note should also be included on the soil boring plan sheet inviting the contractor to inspect the cores prior to bidding.

The standard pay item is “Excavation, Rock”.

2.04.01E Peat Excavation

Plans must show the limits and depth of peat areas and the method of treatment. Treatment methods are shown on Standard Plan R-103-Series. “Excavation, Peat” is a standard pay item.

Disposal of the excavated peat material is as specified in the current edition of the Standard Specifications for Construction, or disposal areas can be shown on plans.

Federal Executive Order 11990 for "Protection of Wetlands", May 24, 1977, and US DOT Implementing Internal Order 5660.1A for "Preservation of Wetlands", September 29, 1978, both stipulate that "...the proposed action includes all practical measures to minimize harm to wetlands which may result from such construction." FHWA interprets this to mean that, muck should not be stored permanently beyond the plan fill slope in wetlands.

The Department has revised Standard Plan R-103-Series to eliminate reference to permanent wasting of muck beyond the plan fill slope. This means that, usually, the excess material must be hauled to an upland waste site.

While FHWA has taken a firm stance in opposing the wasting of muck outside of plan fill slopes across wetland, Design must reach agreement with FHWA as to how each individual wetland area will be treated on a project. FHWA recognizes that there occasionally will be extenuating circumstances that could cause them to selectively relax their rigid adherence to their Wetland Policy.

The following is taken in part from a FHWA Lansing Office letter of January 4, 1984 to the Department.

In accordance with Executive Order 11990, new construction located in wetlands shall be avoided unless there is no practicable alternative to the construction and the proposed action includes all practicable measures to minimize harm to wetlands which may result from such construction. Practical measures to minimize harm include avoiding the permanent or temporary storage of muck in wetlands wherever possible. Some guidelines to further define this issue might be:

1. Permanent storage of excavated muck in wetlands or in the 100-year floodplain will not be allowed except in very extreme circumstances. Even then, the use of these areas will require FHWA approval and acquiring the required EGLE and Corps of Engineers permits.
2. The temporary or permanent storage of dry muck in wetlands should not be necessary.
3. The temporary storage of wet muck in a wetland may, at times, be justified for such time as is necessary to dry out prior to final shaping of the slope and/or hauling to an approved upland disposal area.
4. In our opinion, the temporary disposal areas in wetlands, from most desirable to least desirable, are:
    a. Between the one-on-one slope and the plan slope (also acceptable for permanent storage in fills less than 13 ft.-0 in. in height).
    b. In the median area (for dual lane roadway projects).
    c. On the side of the roadway where the remaining muck is the shallowest or the remainder of the wetland is the smallest.
    d. Adjacent area outside the highway Right-of-Way.

FHWA will permit permanent storage of waste muck, outside the plan fill slope, in an upland site without specific approval. An "upland" site is not to be interpreted as "offsite", i.e., another wetland area off the project.

FHWA appears to not favor temporary storage in a wetland area. They must specifically approve it and approve the limits at the same time as giving other wetland permissions.

The FHWA wetland review during the design stage must occur prior to submitting applications for EGLE and Corps of Engineers permits. FHWA may deny any extra use of a wetland even if a project has received EGLE and U.S. Fish and Wildlife Service approval, in an earlier environmental clearance, to use the wetland.

Wetlands are defined in Executive Order 11990 as "those areas that are inundated by surface or ground water with a frequency sufficient to support and under normal circumstances does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, natural depressions, wet meadows, river overflows, mud flats, and natural ponds.

No localized slope change will be permitted, to circumvent this federal edict, by showing a flatter plan fill slope than shown on the typical cross-section.

The plans should show estimated quantities of peat, marl, and soft clay, for each swamp area, that are to be hauled to upland disposal sites.

2.04.01F Subgrade Undercutting

This item is used to remove unsuitable and unstable soils and soils susceptible to frost action before constructing the final section. Subgrade undercut areas are backfilled with undercut excavated material, sound earth, or granular material depending on the type of undercut. Backfilling is included in the item "Subgrade Undercutting, Type [Insert Type]." The type of subgrade undercutting depends on the backfill. (Type I is backfilled with selected clay or other approved material; Type II is backfilled with granular material; Type III is backfilled with reworked material from subgrade undercut areas or other approved material and Type IV is backfilled with dense-graded aggregate or open-graded aggregate.). The Region Soils Engineer will generally provide subgrade undercut quantities.

2.04.02 Embankment

(revised 12-27-2022)

2.04.02A Regular Embankment

Regular Embankment is sound earth obtained from either roadway excavation or from borrow areas. Embankment is generally paid for as embankment compacted in place, therefore no shrinkage factor is applied to the volume.

2.04.02B Granular Embankments and Backfill

Granular materials are used as backfill in swamps and subgrade undercut areas. If granular material is plentiful from the roadway excavation, it can also be used as regular embankment.

Granular material used to backfill swamp excavation is paid for as ”Backfill, Swamp” and is generally measured in its original position. When granular material is used to backfill subgrade undercut areas it is not paid for separately.

2.04.02C Subbase

Subbases are constructed of granular material between the subgrade (constructed of regular embankment) and the pavement structure. The subbase layer provides structural support and good drainage beneath the pavement.

Payment can be either “Subbase, LM” (loose measure) or “Subbase, CIP” (compacted in place).

2.04.02D Topsoil Surface

There are two basic topsoil pay items: “Topsoil Surface, Furn” and “Topsoil Surface, Salv”.

The Designer should confer with the Region Soils Engineer to get a recommendation for topsoil. Other topsoil resource people are the Region Resource Specialist and the Roadside Development Unit.

Generally the quality of topsoil within the right of way is very poor on existing highways and it should not be recycled as topsoil. Nearly all resurfacing, rubblizing, safety and guardrail upgrading, lane widening as well as other types of upgrading work have unacceptable roadside topsoil for salvaging. On these types of projects “Topsoil Surface, Furn” should be used. Occasionally some salvaged topsoils may be acceptable but in insufficient quantity.

More than enough good quality salvaged topsoil is usually available on all new construction projects (new highway routes). Use the pay item “Topsoil Surface, Salv” on such projects. Excess topsoil can be used in fill slopes as shown on the plans or as directed by the Engineer.

Topsoil material is spread on exposed slopes that are to be seeded. “Topsoil Surface, Furn” or “Topsoil, Surface, Salv” should be estimated at a specific uniform depth but not less than 4". When topsoil is obtained from stockpiled topsoil or from any other source, the topsoil items include loading, hauling and placing the topsoil on site.

2.04.02E Adding Embankment to Existing Slopes (Widening Projects)

Widening projects often require placing embankment on an existing slope. If the existing slope is quite high and/or steep (1:6 or steeper), the Contractor must step the existing slope. Refer to Standard Plan R-105-Series.

2.05 EROSION & SEDIMENTATION CONTROL - GENERAL

(revised 4-22-2019)

The Michigan Department of Environment, Great Lakes, and Energy (EGLE) has designated MDOT an Authorized Public Agency (APA) under the authority of Act 451 of 1994, the Natural Resources and Environmental Protection Act.

EGLE regulates soil erosion and sedimentation control in Michigan under Part 91, *Soil Erosion and Sedimentation Control (SESC)* and Part 31, *Water Resources Protection*, of Act 451. These two programs are linked by way of state administrative rule 323.2190 (Rule 2190), promulgated under Part 31. Rule 2190 allows an APA to obtain storm water coverage without obtaining SESC permits.

As an APA, MDOT has established procedures to address SESC as required by Part 91. The procedures consist of a commitment to follow the department's design and construction manuals, standard plans, standard specifications, and project specific requirements shown in the plans and contract documents. This commitment is embodied in the MDOT Soil Erosion and Sedimentation Control Manual. Every designer needs to be familiar with the information contained in the SESC Manual.

The APA designation allows MDOT to undertake earth change activities without obtaining individual soil erosion and sedimentation control (SESC) permits. The APA designation carries with it an obligation to self-regulate efforts to remain in compliance with established procedures. Failure to remain in compliance will jeopardize MDOT's APA status.

Without APA status, an individual SESC permit would be required from the county or municipal enforcing agency whenever a project meets one or both of the following criteria.

- The project disturbs one or more acres.
- The disturbance, regardless of size, is within 500 feet of a lake or stream.

At a minimum, the plans must include enough information to satisfy the requirements of state administrative rule 323.1703 (Rule 1703). Many of these elements are present in any set of MDOT plans and no additional detail is necessary. The remaining elements, shown in italics below, are included in the contract documents by virtue of reference to the Standard Specifications for Construction and the SESC Manual. The twelve elements of a SESC plan are:

- Scaled Drawing
- Legal Description
- Site Location Sketch
- Proximity to Lakes and Streams
- Predominant Land Features
- Contour Interval or Slope Descriptions
- Description of Soil Types
- Physical Limits of Earth Change
- Drainage and/or Dewatering Features
- *Timing and Sequence of Earth Change*
- Description and Location of SESC Measures
- *Maintenance Plan for SESC Measures*

The inherent erosion potential of any area is determined by four interrelated principal factors: soil characteristics, climate, vegetative cover, and topography. In addition to these principal factors, the designer must also consider sensitive areas such as lakes, streams, or wetlands; vegetation to be retained; areas not to be used for materials or equipment storage; and critical areas such as highly erosive soils or slopes.

Due to the site specific nature of these factors, the region Soils/Material Engineer (or other designated region staff) is responsible for recommending quantities and locations for SESC measures. However, it is the designer's responsibility to seek this input early in the plan development process and incorporate the information into the project plans prior to requesting plan reviews by others. The goal is to include adequate pay items and quantities on the plans to allow the contractor, working with the construction staff, to minimize soil erosion and prevent the loss of sediment off the right-of-way or into the waters of the state.

Every designer must have a current SESC training certificate. In addition to the knowledge gained through the EGLE training, there are many sources of information available within the Department to help the designer during plan development. Designers should become familiar with and use each of these sources:

- Section 4.03.04 of this manual provides information on drainage design considerations to provide for post construction management of storm water.
- SESC Manual - Each of thirty seven standard controls is detailed in an Erosion & Sedimentation Control Detail (E&S) sheet in the SESC Manual. These E&S Details include information on the appropriate use, construction details, measurement and payment, and maintenance considerations.
- Standard Plan, R 96 Series, "Soil Erosion & Sedimentation Control Measures," summarizes all of the specific controls available to the designer for inclusion on the plans to minimize erosion and control sedimentation during construction.
- Drainage Manual - The Drainage Manual addresses all aspects of roadway drainage including temporary and permanent measures to minimize erosion and control sedimentation.
    - Section 4.4.3.2.3 Erosion Control in Ditches includes guidelines for permanent stabilization treatments for various ditch grades
    - Chapter 9 Stormwater Best Management Practices (BMPs) covers all aspects of designing for storm water management including a comprehensive discussion of the factors the designer must consider when evaluating the erosion potential at a site and the selection of SESC measures.
    - Table 9.1 lists the approved BMPs available to the designer to manage stormwater flows both during and after construction.
- Technical Training - All new design staff are encouraged to take the NHI Course "Design and Implementation of Erosion & Sedimentation Control." This two day class covers a range of topics related to the design and application of soil erosion and sedimentation controls on transportation projects. Contact the technical training coordinators at Construction Field Services Division to see when the course is available.

- MDOT Staff - Expert advice is available from region staff including the soils and drainage engineers, resource analyst, and environmental permit coordinator; and from Lansing staff in the Design Hydraulics Unit and Construction Field Services Division, Geotechnical Services Section.

2.05.01 General SESC Concepts

(revised 10-20-2008)

MDOT's SESC procedures require that the Department set up, install, and maintain adequate SESC measures to prevent sediment from entering the waters of the state or from leaving MDOT right of way. Temporary measures must be properly maintained until the disturbed areas can be permanently stabilized. Some SESC measures function as temporary controls and remain in place to ensure permanent stabilization of the area.

Three general principles guide the establishment of SESC measures:

- Preventing erosion is more effective than controlling sediment
- Controlling sediment is more cost effective than repairing damage caused by loss of sediment
- Specific control measures may be more effective than generalized procedures

2.05.01A Protect Exposed Soils

Protecting exposed soil will help minimize the amount that can be detached and transported as sediment. Calling for time or spatial limits on the exposed area is especially necessary adjacent to sensitive areas in order to minimize the potential for harmful impacts.

2.05.01B Manage Runoff

Runoff management tools are designed to utilize proper grading, diversions, barriers or intercepting ditches to minimize concentrated flows and divert runoff away from sensitive or critical areas during construction. This can be done by minimizing slope steepness and length by the use of benches and interceptor ditches. The concept is to divert clean runoff before it becomes sediment laden.

2.05.01C Minimize Concentrated Flows

Concentrated flows generate more energy and velocity than sheet flows. Greater depth and velocity can potentially generate more erosion and suspension of eroded materials. If concentrated flows develop, control measures such as check dams can be used to reduce the velocity. Level spreaders can be used to reestablish sheet flows. A level spreader is any control measure that disperses the concentrated flow reducing the depth of flow and energy. Level spreaders can also improve the efficiency of other measures such as vegetated swales, filter strips, or infiltration measures that are dependent on sheet flow to operate efficiently.

2.05.01D Reduce Velocity

Velocity reduction is a key component of many temporary and permanent SESC measures. Control measures such as check dams are placed perpendicular to the direction of flow whether it is concentrated or sheet flow to slow the velocity of the water by creating "speed bumps." The measures must be selected based on the anticipated depth and velocity of flows over the disturbed soils.

2.05.01E Capture Sediment

Effective sediment control measures are designed and implemented to slow the runoff velocity and retain the sediment-laden water to allow soil particles to fall from suspension and settle out of the runoff. This will facilitate transport reduction and thereby reduce the volume of sediment leaving the site.

2.05.02 Plan Preparation

(revised 5-26-2026)

Soil erosion and sedimentation control measures and locations are detailed on the plans for the areas within the limits of earth disturbance. Unless stated otherwise in the contract documents, the limits of earth disturbance will extend ten feet beyond the slope stake line except in areas adjacent to wetlands where the earth disturbance limits will be at the slope stake line. The extra ten feet is allowance for the movement of equipment and materials.

The SESC measures established for the project must provide adequate controls within the entire limits of earth disturbance. Noncontiguous clearing areas must also be considered when setting up SESC measures on the plans.

SESC measures must suit the specific construction project. Each of the following must be considered in preparation for selecting specific measures:

- Specific requirements included in environmental permits
- Environmental Classification/Certification (Supplied by Environmental Clearance Coordinator)
- Extent of earth disturbance on the project
- Soil types in the construction area
- Steepness and length of slopes
- Water resources on and adjacent to the project
- Staging and sequence of the construction activity
- Duration of the project
- Increase in impervious surface area
- Potential equipment egress points

By the preliminary plan review stage, the designer should have completed an analysis of the potential for soil erosion and sedimentation to occur during the construction phase. The soils engineer and others should have been contacted for suggestions. A combination of standard and site specific E&S measures should be incorporated and adequate pay item quantities included giving the contractor and construction staff the tools they will inevitably need to execute the project.

The following discussion is not intended to be all inclusive but rather to get the designer thinking about what must be considered and how they can be mitigated by the careful selection of SESC pay items.

2.05.02A Construction Staging

While the designer often does not know exactly when construction will begin on a project, it is necessary to consider how the progression of the work may impact the need for SESC. Refer to specific environmental permits and clearance documents for any seasonal limitations that may influence the selection and quantities of various SESC measures. In addition to providing a variety of pay items and miscellaneous quantities, it may be beneficial to include plan notes requiring placement of SESC measures prior to starting specific earth disturbing activities within the construction area.

2.05.02B Sensitive Areas

Minimize and clearly mark all clearing limits near sensitive areas on the plan and include quantities of silt fence (E&S-26) or protective fencing to protect sensitive areas and their buffers (E&S-6). Call for retaining existing vegetation in an undisturbed state in these areas to the maximum extent practicable. Call for permanent stabilization and installation of permanent SESC measures in these areas as early in the construction process as feasible.

2.05.02C Construction Related Activity

Consider all construction-related activity, including equipment staging and material storage areas. Call for gravel access approach (E&S-14) to prevent tracking sediment from the construction site. Aggregate cover (E&S-8) can be considered for stabilizing equipment storage areas and access points.

2.05.02D Flow Rates

Design to minimize increases in the volume, velocity, and peak flow rate of stormwater runoff from the site during and after construction in order to protect downstream properties and waterways from erosion. Call for energy dissipators when increased velocity cannot be avoided. Refer to Section 4.03.04 and the Drainage Manual for more information on designing to minimize non-point source pollution.

2.05.02E Sediment Traps and Check Dams

The proper placement and spacing of Sediment Traps (E&S-20) and Check Dams (E&S-37) is essential to SESC. This combination of measures is effective where ditch grades change from a steep to flat grade; when the ditch grade varies significantly over a short distance; and just prior to the point at which the ditch outlets to a watercourse or off of the right-of-way. In ditch cuts in sandy soils, the sediment trap/check dam pairs can be spaced further apart provided that the grades are consistent. In clay soils, the placement of these pairs will depend much more on the depth of ditch cut, length of cut and grade. In flat ditch cuts these pairs can be spaced at up to 500-foot intervals and still remain effective; they may however require more frequent sediment removal.

2.05.02F Temporary Detention

Include plan notes if necessary to require the installation of temporary detention facilities, such as Sediment Basin (E&S-21), Sediment Traps (E&S-20), or Detention Basins, prior to clearing and grading operations. These measures must be sized and located to account for both on-site storm water flow and also sheet flow or additional concentrated flow from off-site. Consider the need for Filter Bag (E&S-18) or Turbidity Curtain (E&S-1) to prevent the loss of sediment when these temporary measures are emptied in preparation for being brought online for permanent use at the end of the construction project.

2.05.02G Dewatering

Dewatering discharges must be controlled to protect downstream properties. When routing non-stormwater discharges the flow rate must be controlled to minimize scouring and flushing of sediment trapped in the system. Call for Filter Bag (E&S-18), Gravel Filter Berm (E&S-13), or Turbidity Curtain (E&S-1) to prevent the loss of sediment during this operation.

2.05.02H Soil Stabilization

Select soil stabilization measures to be appropriate for the time of year, site conditions, and estimated duration of use. Include a variety of temporary SESC pay items on the plans for specific locations and provide miscellaneous quantities for use as needed throughout the construction phase. Refer to Section 2.05.05 for a description of the designer's responsibilities regarding turf establishment measures.

2.05.02I Slope Protection

Design cut-and-fill slopes in a manner that will minimize erosion potential by:

- Reducing continuous length and steepness of slopes with terracing and diversions
- Avoiding steep longitudinal grades
- Avoiding steep side slopes
- Minimizing disturbed areas
- Retaining existing vegetation
- Conforming to the existing contours and drainage of the area
- Calling for Slope Roughening and Scarification (E&S-32)

2.05.02J Concentrated Flows

Protect disturbed areas from concentrated flows routed through temporary conveyances, such as Diversion Dike (E&S-10), Intercepting Ditch (E&S-11), Intercepting Ditch and Diversion Dike (E&S-12), or Pipe Drop (E&S-17). Consult the Hydraulics Unit for guidance on sizing the conveyance whenever runoff or groundwater must be intercepted and concentrated.

2.05.02K Riprap

When Riprap (E&S-7) is called for to stabilize a ditch or outlet, consider calling for Silt Fence (E&S-26) or Mulch Blanket (E&S-33) to be placed adjacent to the riprap. The will prevent sediment from adjacent unprotected areas from being deposited in the riprap and being carried into the receiving water or off the Right-of-Way during the next rainfall event.

2.05.02L Inlet Protection

Include inlet protection to protect all in-service storm drain inlets from sediment or construction related pollutants. Take into consideration inlets located down gradient on side streets and cross roads in addition to those on the mainline. Consider the location of the project in terms of soils, anticipated rainfall and urban/rural nature of the area and include adequate quantity of these measures to allow for replacement as they lose their effectiveness due to fine sediment accumulation.

2.05.02M Alterative Controls

New materials are continually being introduced to the construction market as a result of the expansion of the NPDES stormwater program. If a project warrants their use, contact Construction Field Services Division for assistance with the selection of a previously approved special provision or for assistance in preparing a project specific special provision to address a particular need. Refer to Chapter 11 for special provision preparation and approval guidelines.

2.05.03 Hydraulic Design Considerations

(revised 10-20-2008)

While many of the SESC measures typically included on plans require no formal hydraulic design, there are others that call for input from hydraulics, materials, or construction experts across the Department. Hydraulic design considerations are discussed in Chapter 9 of the Drainage Manual and may involve:

- Sizing or spacing for improved effectiveness
- Materials selection
- Dual-use temporary and permanent storm water management

2.05.04 Showing SESC Measures on Plans

(revised 8-18-2014)

Standard Plan R-96-Series shows standard SESC measures and their intended use. They are indicated on the plans by a legend at the location they are to be used. This legend must correspond to Standard Plan R-96-Series, which in turn corresponds to the individual E&S detail sheets in the SESC Manual.

Not all E&S measures are contract items (pay items) in and of themselves. Standard pay items may be required to complete the construction of the E&S measure as is the case with Diversion Dike (E&S-10) where the diversion dike is constructed using the pay item Embankment. Conversely, the E&S measure may require the omission of work as is the case with Vegetative Buffer at Watercourse (E&S-22), which calls for retaining vegetation adjacent to a watercourse.

Many of the E&S measures include optional work that may be included to increase the effectiveness of the measure or to address a specific site condition. The optional work often includes the addition of a sediment trap, check dam or silt fence. Since the need for the optional measures is not known at the time of design, these items of work are often included as miscellaneous quantities on the plans. The designer should always refer to the information on the E&S Detail sheets when placing E&S measures on the plans.

The success of the SESC measures selected during design depends in part on the ability of the contractor to translate the measures indicated by key numbers and notes on the plans to the most effective location and placement in the field. Suggestions on how best to accomplish this include:

- Show inlet protection, sediment traps, and check dams on the profile sheets to more clearly indicate location.
- Include control measures for use during the mobilization, clearing and removal process.
- Call for SESC measures at the break point of ditches.
- Call for intermediate measures within the construction area not just at the right of way line or at the edge of sensitive areas.
- Call for silt fence where it will function as intended - not at the top of backslope.
- Call for silt fence in all four quadrants of cross culvert outlets.
- Include miscellaneous quantities of the pay items such as the following for use as needed:
    - Temporary Seed
    - Silt Fence
    - Gravel Access Approach
    - Sediment Trap
    - Check Dam
    - Inlet Protection
- Identify erosion control measures on the construction sheet with the 'Erosion Control Number' cell. Pay for erosion control items in the main list of 'Quantities This Sheet'. Do not show key number next to pay item. See Road Sample Plans.
- Include plan notes to indicate required sequence of placement of SESC measures to maximize their effectiveness.
- Include an adequate quantity of the pay item "Erosion Control, Maintenance, Sediment Rem".
- Use special provisions for non-standard SESC measures when necessary and show these measures on the plans.
- Clearly identify sensitive areas such as lakes, streams, or wetlands, and include Vegetated Buffer at Watercourse (E&S-22);
- Delineate areas that are not to be used for materials or equipment storage and call for these areas to be clearly identified in the field.
- Clearly identify critical areas such as highly erosive soils or slopes.
- Show key numbers for E&S Details that do not have pay items associated with them such as Slope Roughening and Scarification (E&S-32), when these measures are critical for successful control of erosion and sediment control.

2.05.05 Turf Establishment

(revised 9-17-2012)

For all projects requiring turf establishment contact the Roadside Development Unit of the Design Division for procedures and materials recommendations four weeks before they are needed.