720
Contour Grading

General

Contour grading directs water to a desired point, prevents erosion, provides noise deflection, provides visual fit of the facility into the landscape, and protects desirable vegetation. Examples of locations where contour grading is used are wetland mitigation sites and noise berms.

Contour grading plans detail the blending of the constructed landform with the surrounding earth forms. Blending the facility into adjacent landforms is Washington State Department of Transportation (WSDOT) policy, as stated in the *Roadside Classification Plan*.

References

Construction Manual M 41-01, WSDOT

Design Manual M 22-01, WSDOT

Highway Runoff Manual M 31-16, WSDOT

Hydraulics Manual M 23-03, WSDOT

Roadside Classification Plan M 25-31, WSDOT

WSDOT Soil Bioengineering website:
http://www.wsdot.wa.gov/eesc/cae/design/roadside/SBwebsite/mainpage/Index.html

Resources

The region's Landscape Architect Office

The region's Materials Engineer

HQ Hydraulics Office

HQ Roadside and Site Development Unit

HQ Geotechnical Branch

Definitions

angle of repose The angle between the horizontal and the maximum slope that a soil assumes through natural processes.

berm The continuous artificial contouring of a slope or water-channel bank.[1]

contour An imaginary line on the surface of the earth connecting points of the same elevation.

contour interval The difference in elevation between two contours.[2]

cross section The representation of a landform as it would appear if cut by an intersecting plane.

cut That part of the ground surface that, when graded, is lower than the original ground.[3]

datum In surveying, a reference point, line, or surface for computing or correlating the results of surveys. In surveying, there are two principal types of datums: vertical and horizontal.

elevation Vertical distance of a point above or below a reference surface or datum.[4]

fill That part of the ground surface that, when graded, is higher than the original ground.[5]

finish grading Minor changes to finalize a prepared earth surface to its desired grade.

grading Modification of the ground surface by cuts and/or fills.

interpolation The determination of the elevation of a location between two known points. Done by calculating the slope between known points and using the horizontal distance from the known point to the intermediate point to calculate the elevation of the intermediate point.

profile The representation of a landform seen from the side.

section See *cross-section*.

Contour Grading Plans

WSDOT grading for roadways is represented on plans using cross-sections. Landforms other than the roadway prism are usually represented using contours. Contour grading plans are required for landforms that have irregular variations between cross-sections. They

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[1] Hugo Schiechtl, *Bioengineering for Land Reclamation and Conservation*, University of Alberta Press, 1980.
[2] Morris M. Thompson, *Maps for America*, U.S. Department of Interior, Geological Survey National Center, Reston, Virginia, 1987.
[3] Steven Strom and Kurt Nathan, *Site Engineering for Landscape Architects*, Van Nostrand Reinhold, New York, 1992.
[4] Thompson, 1987
[5] Strom and Nathan, 1992.

are also used to show fine grading where profiles or cross-sections do not show enough detail. Examples include wetland mitigation sites, retention and detention ponds, noise abatement berms, and interchanges. Cross-sections or grids for additional clarification often accompany contour grading plans. These elements, work together for an improved finished product that reduces the need for interpretation during construction. In addition, minor landform changes can affect sensitive plant and animal ecosystems. For example, providing for amphibian habitat requires grading plans to be accurate to within a few millimeters (inches) because these species need shallow water depths.

Contour lines graphically connect points of the same elevation in plan view. Contours are separated by a *contour* interval, which is the vertical separation between the contour lines. Each contour is separated from the next by that number of vertical units. In the figure below, the contour interval is 10 meters. Depending upon where the lines are drawn, the cross sections appear very different.

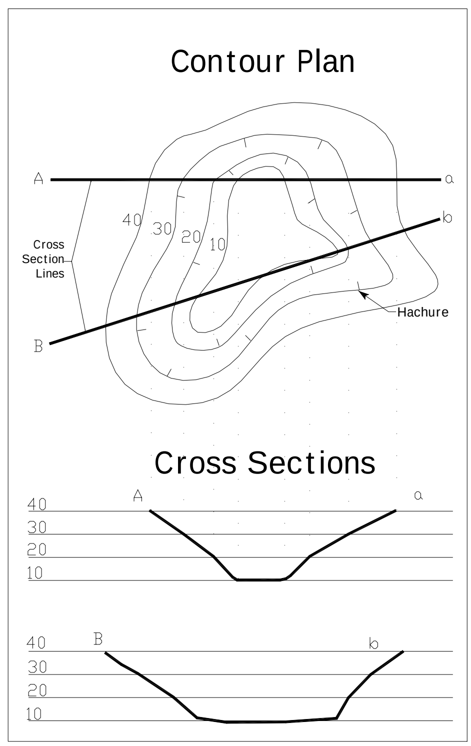

Figure 720.1 Contours

In Figure 720.1, the contour line labeled "40" is exactly 40 units above a known point called a *datum*. Assume that every point on that line is exactly 40 meters above the datum. If this basin was filled with water to the 40 meter contour, the edge of the water would follow the contour line when viewed from above.

On any given plan sheet, contours that are spaced far apart have a gradual degree of slope. In contrast, contours that are spaced close together indicate steeper slopes. It is necessary to read the numbers along the contour lines to determine which direction the ground is sloped. Hachures are used on the down slope side of contours to depict enclosed concave forms.

The Rules of Contours:

- Existing contours are drawn with dashed lines. Proposed contours are drawn with solid lines.
- Contours never cross.
- Contour lines depict connected points of equal vertical position.
- All contour lines close on themselves (this may be either on or off the plan sheet or map).
- The steepest slope is along a line perpendicular to the contour lines. Water will always flow downhill in a line perpendicular to contour lines.
- Contour lines never merge into one another. However, on a vertical face, such as a retaining wall, they may appear to merge on the plan sheet.
- The greater the detail of the plan, the smaller the contour interval.

Use interpolation to determine the approximate elevation of any point between contour lines. A point half way between the 30 m and 40 m contours, would have an elevation of 35 meters. A point four-tenths of the distance between the 27 m and 28 m contours would have an elevation of 27.4 meters.

A contour plan conveys grading information that would otherwise require many cross-sections to convey. For complex roadside grading, cross-sections used alone do not provide adequate information to ensure that the design intent is being met. It is for this reason that most roadside grading is depicted in a contour grading plan format. When cross-sections are used in conjunction with a contour grading plan they represent the condition only at the location of the cross-section line.

Cross-sections are used differently when they are intended to show a typical condition. For example, on a linear facility with a centerline (such as a roadway), cross-sections are often used to represent a typical condition between two stations. Make the intention clear on the plan sheet.

Contour Design

There are many, often competing elements that require consideration in the design phase. Routes that are designated scenic highways might have a Corridor Management Plan. Review and consider the Corridor Management Plan to identify any considerations, such as visual appearance or buffers that might need to be factored in to the design.

Consider the following factors when developing a contour grading plan and associated cross-sections:

- The intent of the plan when choosing contour intervals.
- Drainage (including detention and retention functions).
- Balancing of cut and fill within project limits, if possible. It might be possible to create a berm to use excavated material from that project.
- Maximum allowable cut or fill next to a structure (minimum cover over a footing, maximum fill behind a wall or next to a pier).
- Vehicle recovery areas.
- Sight distance.
- Pedestrian safety and security.
- Impacts to groundwater and surface water both on and off the right of way, including wetlands.
- Preservation of existing desirable vegetation.
- Preservation of existing topsoil.
- Slope angle and potential soil erosion.
- Soil properties and angle of repose.
- Fence detention and retention ponds if banks are equal to, or steeper than 3H to 1V

Slope rounding. For design details on slope rounding, see *Standard Plans*, number H8.

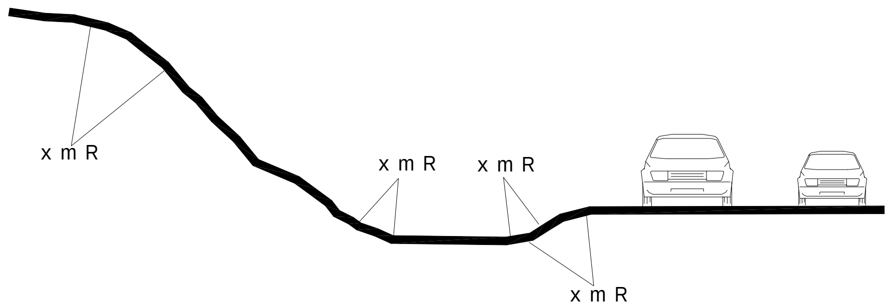

Figure 720.2 Slope Rounding

- Fit of the graded area into the surrounding landscape for corridor continuity.
- Visual factors (a form that blends with the adjacent landforms).
- Cost of grading.
- Slopes steeper than 2H to 1V may be difficult to stabilize and establish vegetation on.
- Maintenance access to drainage and traffic operational features.
- Access along fence line or noise walls, if necessary.
- For areas that are to be mowed, design slopes to be no steeper than 3H to 1V.

The region's Materials Engineer or HQ Geotechnical Branch can evaluate the stability of cut and fill slopes, help determine the groundwater regime, and determine the permeability of soils. Contact the region's Materials Engineer early in the design phase to allow for groundwater and soil engineering properties testing, as appropriate. See the *Design Manual* for guidelines.

Construction

The use of the grid method or station and offset method is useful in transferring grading information from the plans to locations in the field.

Grids

To simplify staking during construction, a grid can be laid over the contour grading plan as seen in the simplified figure below.

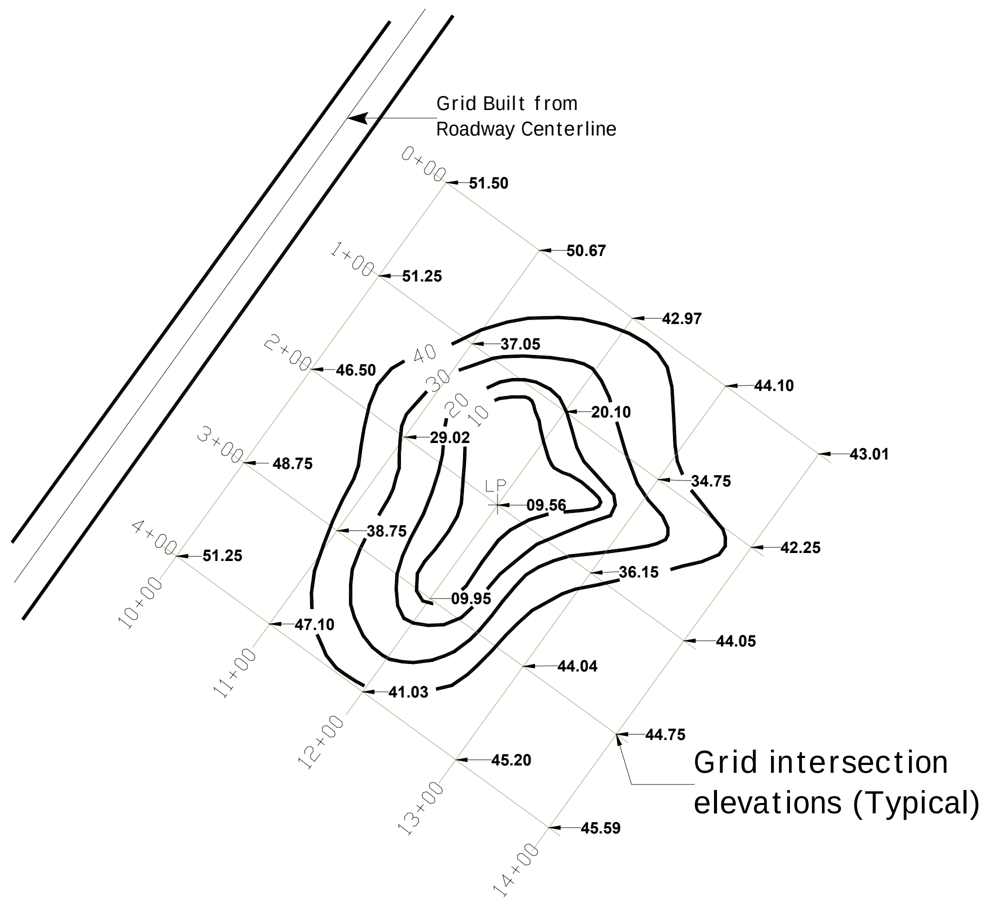

Figure 720.3 The Grid

The grid size will be related to the size of the site and the complexity of the design contours. Make sure that enough grid points are used to reflect the contours as shown on the plan. Ensure that high and low spot elevations are located.

The grid is tied to a known base line and station point such as a roadway centerline, a fence, or a right of way line. Elevations at the grid intersections can then be determined by interpolation. Mark the elevation at all grid intersections. Contours and spot elevations can then be staked in the field using the elevations shown on the plans.

Station & Offset Method

The station and offset method is an alternative to the grid method for locating contours in the field.

- Define the base line either by extending a known center line or by drawing a line between two known survey points.

- Identify lines perpendicular to the base line at station points to measure the distance of control points from the base line.
- If available, use a data collector with a "Roading" module to set stakes in the field. With proper survey techniques, elevations will be determined at the location of the station and the offset. By comparing the elevation with the contour, a cut or fill can be marked on the stake.

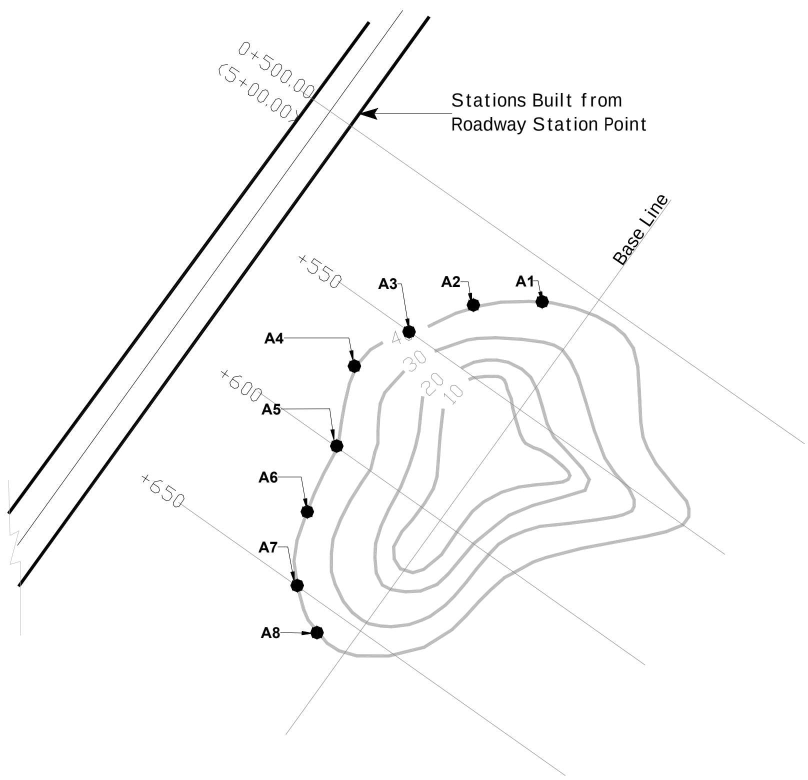

Figure 720.4 Baseline, Stations, and Offset Points

A table showing the location of the control points, as in Tables 720.1 and 720.2, is an integral part of this method. Right or left direction of offset is determined by the direction of increasing stations.

Station	Station Point	Offset (m)
A1	0+511.80	15.70 Rt
A2	0+527.90	35.27 Rt
A3	0+550.00	49.35 Rt
A4	0+570.82	57.46 Rt
A5	0+600.00	45.23 Rt
A6	0+626.47	40.77 Rt
A7	0+700.00	29.00 Rt
A8	0+719.24	12.00 Rt

Table 720.1 Metric Station & Offset Table

Station	Station Point	Offset (ft)
A1	5+11.80	51.51 Rt
A2	5+27.90	115.72 Rt
A3	5+50.00	161.91 Rt
A4	5+70.82	188.52 Rt
A5	6+00.00	148.39 Rt
A6	6+26.47	133.76 Rt
A7	7+00.00	95.14 Rt
A8	7+19.24	39.37 Rt

Table 720.2 English Station & Offset Table

As with all contour grading plans, the plan sheet is accompanied by cross-sections. Include notes stating that grading between cross-sections will be as shown on the plan. Discuss this with the contractor at the preconstruction meeting. The slope can also be labeled on the cross-section.

Cross-Sections

When cross-sections are included in a contract set, it is important to confirm whether they represent a typical condition or the condition only at a specific location. Generally, when cross-sections are used in conjunction with a contour grading plan they represent the condition only at the location of the cross-section line. Cross-sections that represent a typical condition are usually labeled as "Typical" or are labeled for "Sta ___ to Sta ___."

Compaction

Soil compaction hinders plant growth and infiltration of water. The possibility of soil compaction exists when large equipment is grading a site. Soil compaction can be minimized by:

- Working when soils are not saturated.
- Ensuring vehicles have wide tracks or wide wheels (low ground pressure equipment [LGP]).
- Minimizing the passes a vehicle makes over any one area.

Refer to Chapter 700 of this manual, "Soil and Soil Amendments" for more information.

In some cases, such as in detention pond berms, compaction is desirable. They will fail if not compacted. Slopes can be compacted to prevent surface sloughing. See the soil bioengineering chapter for information on using plants in combination with other materials, such as logs or rock, to stabilize slopes.

Earth Berms

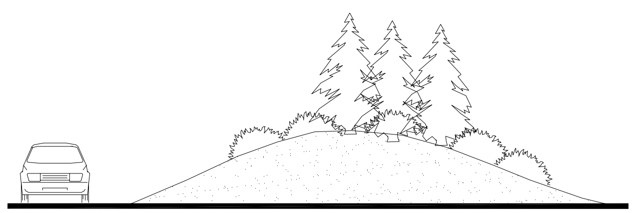

Figure 720.5 Roadside berm example

Berms are used to:

- Visually screen distracting views.
- Provide and enhance corridor continuity.
- Mitigate safety hazards.
- Provide noise abatement either alone or in conjunction with noise walls.
- Waste material from other sites.
- Retain or detain surface water flow.

Materials

Berms can be used to balance cut and fill. However, materials used in the berm must facilitate plant establishment and continued growth. Materials used in berms must allow for the stability of the berm.

The materials used in the berm will determine the angle of the slope. Finer grained materials, such as clays and silts, require a flatter slope for stability.

The use of recycled materials, such as asphalt, has environmental and legal implications. Consult the HQ Construction Materials Engineer when recycled materials are considered.

For details on topsoil and compost see the Soil and Soil Amendments chapter in this manual, Chapter 700.

When noise walls are constructed on a berm, the materials must be able to support the weight of the noise wall. Consult the Technical Services Unit and the region's Materials Engineer for all berms that are used as a base for noise walls and when deciding whether material is suitable for a berm, as directed in the *Design Manual*.

For any berm over 3 m (10 ft) high and any berm in conjunction with a detention/retention pond, consult the region's Materials Engineer. For detention/retention pond berms, consult with the Hydraulics engineer. These berms have specific engineering requirements and must meet dam design standards per the Washington State Department of Ecology.

For information on planting on berms within the highway right of way, see the vegetation chapter in this manual.

Berm Design

Berms can have variations in grades. When the slope, or grade, changes, the distance between contours on the plan changes as shown in the Figure below.

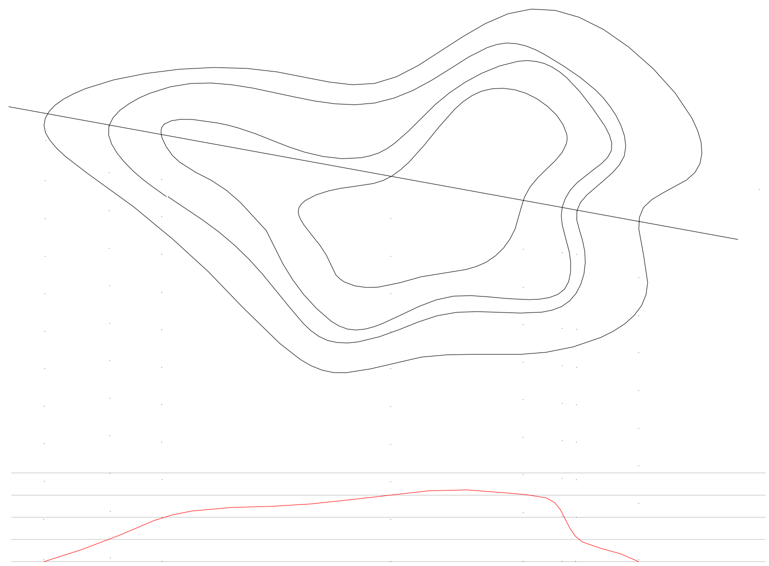

Figure 720.6 Varying Distances Between Contours

Variations in the distance between contours can make berms appear more natural and blend them into their surroundings.