CHAPTER 1

Site Engineering IS Design

WHY IS AN UNDERSTANDING OF THIS MATERIAL IMPORTANT?

Simply put, grading is design.

With regard to the relationship between grading and design, three points must be emphasized: First, grading and site design are two highly related and dependent processes. To achieve an appropriate as well as successful final product, both must be integrated in a holistic manner at the outset of the project. Second, before manipulating contours on a grading plan, it is important to have a clear understanding of the form of the desired final product. Without this knowledge, the manipulation of contours is aimless and futile. To reinforce this point, any appropriate three-dimensional form can be expressed by contours on a grading plan. However, without a preconception of what that form should be, it can never be attained. Finally, a change in grade must be purposeful, whether for functional or aesthetic reasons, and not arbitrary. The intent to change a grade 2 in. is no less important than the intent to change a grade 20 ft.

THE DESIGN LANGUAGE OF SITE ENGINEERING

It is important to realize that grading is one of the primary design tools available to the landscape architect. Every site design project requires some change in grade. How these grade changes are integrated into the overall design concept will influence the success of the project functionally, visually, and experientially. The necessity for grade changes creates opportunities for site engineering to play a role in the aesthetic, perceptual, spatial, and environmental considerations of a design.

Figure 1.1. (a) Geomorphic: A stream restoration is carved in a floodplain to appear as if created by natural processes *(Photo: The Watershed Company)*. (b) Architectonic: Terraces define the central lawn of the Leventritt Garden at the Arnold Arboretum. (c) Sculptural: The playful mounds of vegetation interact with the curvilinear benches, providing seating in the Jacob Javits Federal Courthouse Plaza *(Photo: Michael Cluer)*. (d) Naturalistic: In Prospect Park, the land was manipulated to create a meadow within a valley-like space.

Aesthetics

The visual form of grading may be broadly categorized into four types. The selection of a particular type is appropriate within a given landscape or design context, but it is possible to combine types within the same project. The four categories are geomorphic, architectonic, sculptural, and naturalistic (Figure 1.1).

Geomorphic

The proposed grading blends ecologically and visually with the character of the existing natural

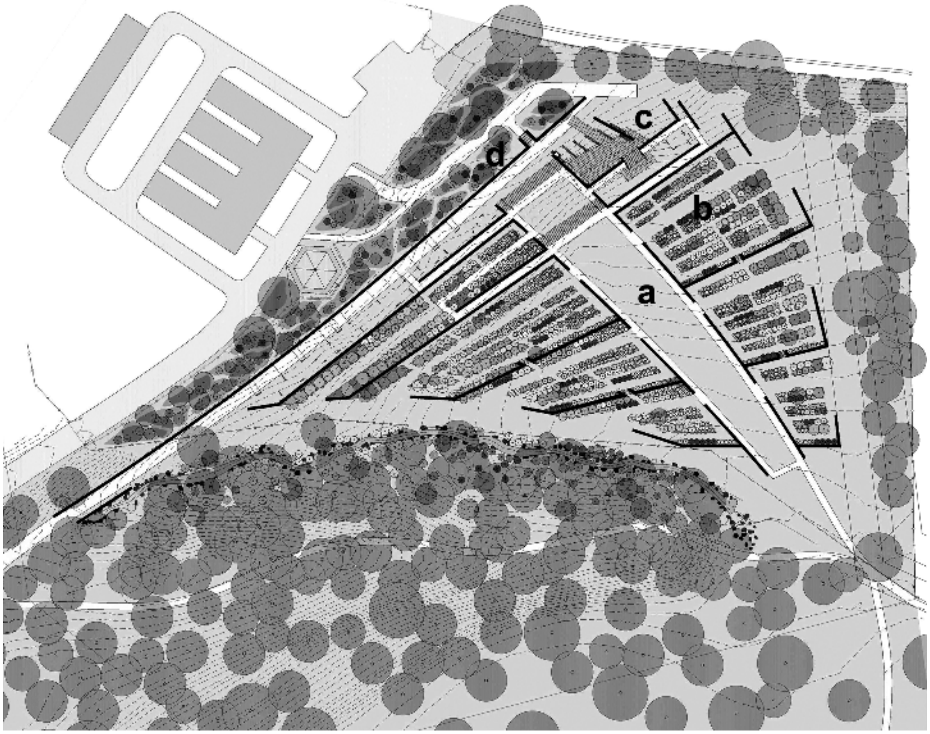

Figure 1.2. Plan of the Leventritt Garden at the Arnold Arboretum. (a) Central lawn panel. (b) Terraces. (c) Garden pavilion. (d) Great wall. *(Plan: Reed Hilderbrand)*

landscape. It reflects the geologic forces and natural patterns that shape the landscape by repeating similar landforms and physiographic structure. The intent of this category is to minimize the amount of regrading necessary in order to preserve the existing landscape character, though in some cases it is used to restore character and ecological function that have been lost.

A discussion of the range of environmental factors this aesthetic type is employed to integrate with can be found later in this chapter.

Architectonic

The proposed grading creates uniform slopes and forms, which usually are crisply defined geometric shapes. The lines along which planes intersect are clearly articulated rather than softened by rounded edges. This type of grading is appropriate where the overall impact is human-dominated or where a strong contrast is desired between built and natural landscapes.

Leventritt Garden at the Arnold Arboretum.[1] This language can be used to reinforce the geometry of an associated building or provide a legible organization system, as in the Leventritt Garden, Boston, Massachusetts, at the Arnold Arboretum (Figure 1.2). The design for the garden draws on the long, rich tradition of terracing the landscape to create

[1]Landscape Architect: Reed Hilderbrand
Architect: Mary Thompson
Engineers: Green Associates

usable and dramatic spaces, whether for agriculture, habitation, or gardens. The area selected for the garden was a nearly triangular open space with an east-facing slope that rose more steeply along its western edge. The designers reworked this form to create a more constant grade change.

The constant slope established an opportunity to develop a series of terraces that are arranged in a fan-like manner, described by the designers as an *organic parterre* (Figure 1.3). The terraces provide order and organization to the collection, while the terrace walls frame the displays. A central lawn (Figure 1.1b) establishes an axis that divides the terraces into manageably sized spaces and creates the main approach to the garden. Stairs at the uphill end of the lawn, together with the great wall and pavilion, form a structured terminus to the space and a focal point for the garden (Figures 1.4 and 1.5).

This garden is an example of a strong concept translated into a cohesive composition. The structure and beautiful craftsmanship of the fieldstone walls recall the New England agricultural landscape and provide a timeless framework to display the plant collection. Of particular note is the approach to providing accessibility, which is so well integrated into the design that it could easily be overlooked.

Sculptural

This category is a bridge between the architectonic and naturalistic categories. There is a range of forms that fall between the sharp, crisp planar architectonic forms and the fluid curves of the natural forms. On a continuum of landscape forms between these two categories, Earthworks Park, a landscape of abstract forms and few hard lines, would be considered sculptural and yet still closely related to the architectonic category. At the other end of that spectrum is Waterworks Gardens, with fluid forms that directly reference nature but would not have been formed by nature. A brief discussion of these two landscapes follows.

Figure 1.3. Walls delineate the fan-like arrangement of terraces.

Figure 1.4. Great wall and steel trellises for vine collection.

Figure 1.5. View of the central lawn, terraces, and garden pavilion.

Earthworks Park.[2] Earthworks Park in Kent, Washington, demonstrates how grading can be used to solve a pragmatic storm runoff and erosion problem while creating sculptural landforms and a park area for passive recreation. The design and reclamation of the Mill Creek Canyon site were undertaken to alleviate erosion and flooding problems as part of a public art project titled "Earthworks: Land Reclamation as Sculpture," sponsored by the King County Arts Commission and King County Department of Public Works during the 1970s.

The park is located at the lower end of a 1,500-ac drainage basin. Approximately 460 $ft.^3/s$ of storm runoff would flow through the site during a 100-year storm. The goal of the storm water management project was to reduce the discharge so that it would not exceed 100 $ft.^3/s$ for a 100-year storm. To meet this goal, a large detention basin was created by constructing an earth dam across the steeply walled valley formed by Mill Creek. The resulting detention basin has a water storage capacity of 652,000 $ft.^3$ (approximately 15 ac-ft.).

A series of abstract circular forms consisting of ring-shaped and cone-shaped mounds were created on the upstream side of the dam. The sculptural landforms establish the overall spatial and visual character of the park (Figure 1.6). These landforms reflect an earlier earth sculpture work by Bayer, titled "The Grass Mound," in Aspen, Colorado. The role of the park as a storm water management facility is visually reinforced by a number of design elements. A circular pond containing an inner grass ring (Figure 1.7) retains water most of the year, thus providing a sense of the storm water-detention function of the larger park landscape. A small stream passes under the bridge, shown in Figure 1.8, during dry periods; however, the

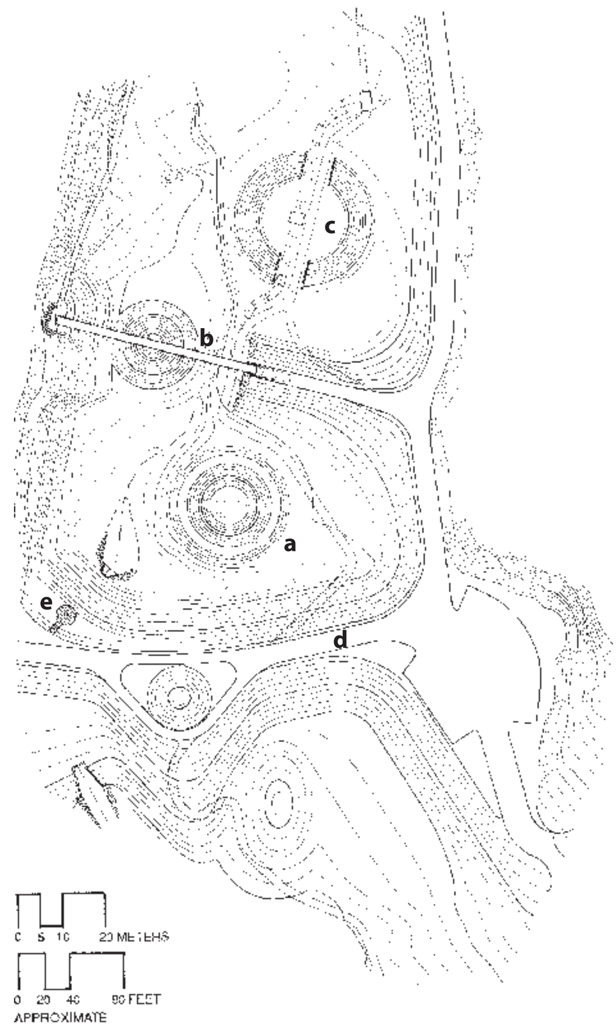

Figure 1.6. Site plan of Earthworks Park. (a) Circular pond. (b) Bridge structure. (c) Ring-shaped mound. (d) Embankment. (e) Spillway structure.

capacity to accommodate much greater volumes of water is readily apparent to the park user by the scale of the bridge structure. A ring-shaped mound provides a more enclosed space within the larger landscape. Retaining walls are used to define the entry into this smaller space (Figure 1.9). The three primary sculptural elements (ring, bridge, and

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[2] Designer: Herbert Bayer
Engineers: URS Engineers

Figure 1.7. Circular pond contains an inner grass ring.

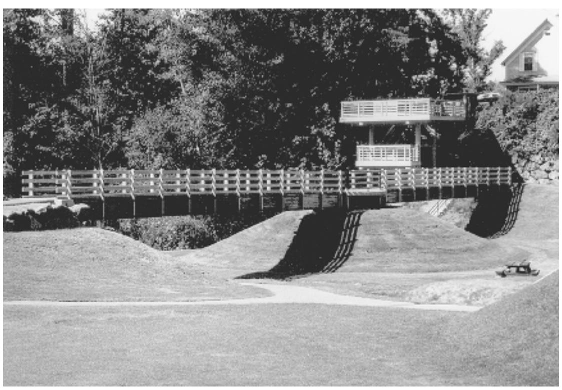

Figure 1.8. Bridge structure allows for greater water flow.

Figure 1.9. Ring-shaped mound with retaining walls define the entry.

circular pond) are physically and visually linked by the stream running through the park.

A set of access stairs at one of the valley walls is an interesting detail. Rather than switchback or scissor-type stairs, which would appear to reduce the height of the valley wall, the stairs directly ascend the slope (Figure 1.10). This technique accentuates the steepness of the landform. A small platform provides a resting and vantage point approximately halfway up the stairs. The placement of the platform next to the stairs is important to note, since it does not interrupt the steep character created by the line of the stair structure (Figure 1.11).

Figure 1.10. Access stairs at valley wall directly ascend the slope.

Figure 1.11. Overlook platform at access stair does not interrupt the line of the stair structure.

Waterworks Gardens.[3] Waterworks Gardens is 8 ac (3.2 ha) of land located on the northern edge of the Renton, Washington, wastewater treatment facility. Initially, the design of the treatment facility called for the storm water runoff to be treated along with the sewage, which would have been a clear case of treatment overkill. It also would have set a precedent for the plant that was undesirable because it did not already treat storm water from other sources. The municipality decided that the storm water should drain into Springbrook Creek to the north of the site treated instead of into the Green River, where drainage for the 50 ac (20.2 ha) of roads and other impervious surfaces was already directed. To do this, a vault and pump had to be installed to redirect the runoff. This provided the opportunity to create what eventually became Waterworks Gardens.

The initial design proposed three featureless square detention ponds to be sandwiched between two already environmentally degraded wetlands. After successful advocacy by Lorna Jordan, the design team's artist, an alternative design was developed that incorporated a natural storm water treatment system and enhanced wetlands accessible to the public through a series of paths (Figure 1.12). Realization of this design required merging the art and storm water budgets, as well as additional funding to enhance the wetlands.

The gardens start at the top of the hill and cascade downslope to the wetlands below. The storm water being pumped from the south end of the treatment plant flows under metal grates on its way to the first of 11 settlement ponds (Figure 1.13). From the top of the hill, views extend across the site to the treatment plant and Springbrook Creek. The pedestrian path proceeds downhill, weaving between seven leaf-shaped pools, edged with native vegetation, which are connected through a series of standpipes. The top two pools are graded to allow vehicular access to the pool bottom to periodically remove sediment buildup. The series of seven pools leads into a shotcrete, a grotto with a tumbled stone mosaic. This grotto appears as a dissected seed pod emerging from an earthen mound, damp and seeping with water. From this room, the path meanders between three circular pools to arrive at the final egg-shaped pool on the edge of the wetlands that forms the rest of the composition. This final pool is also graded for vehicular access. The pools range between 4 and 7 ft. (1.2 and 2.1 m) deep, with a total volume of 102,081 ft.^{3} (2,889 m^3), with 16,215 ft.^{3} (459 m^3) being designed as sediment storage. The treatment process is completed in the wetlands shown in Figure 1.14, where the water winds its way through islands, some with human access and others strictly for animal habitat, to its connection with Springbrook Creek.

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[3] Artist and Lead Designer: Lorna Jordan
Landscape Architects: Jones + Jones Architects and Landscape Architects
Consulting Engineer: Brown & Caldwell Engineering
Wetland Science and Geotechnical Engineering: Shannon & Wilson
Irrigation Design: Dragonfly Irrigation

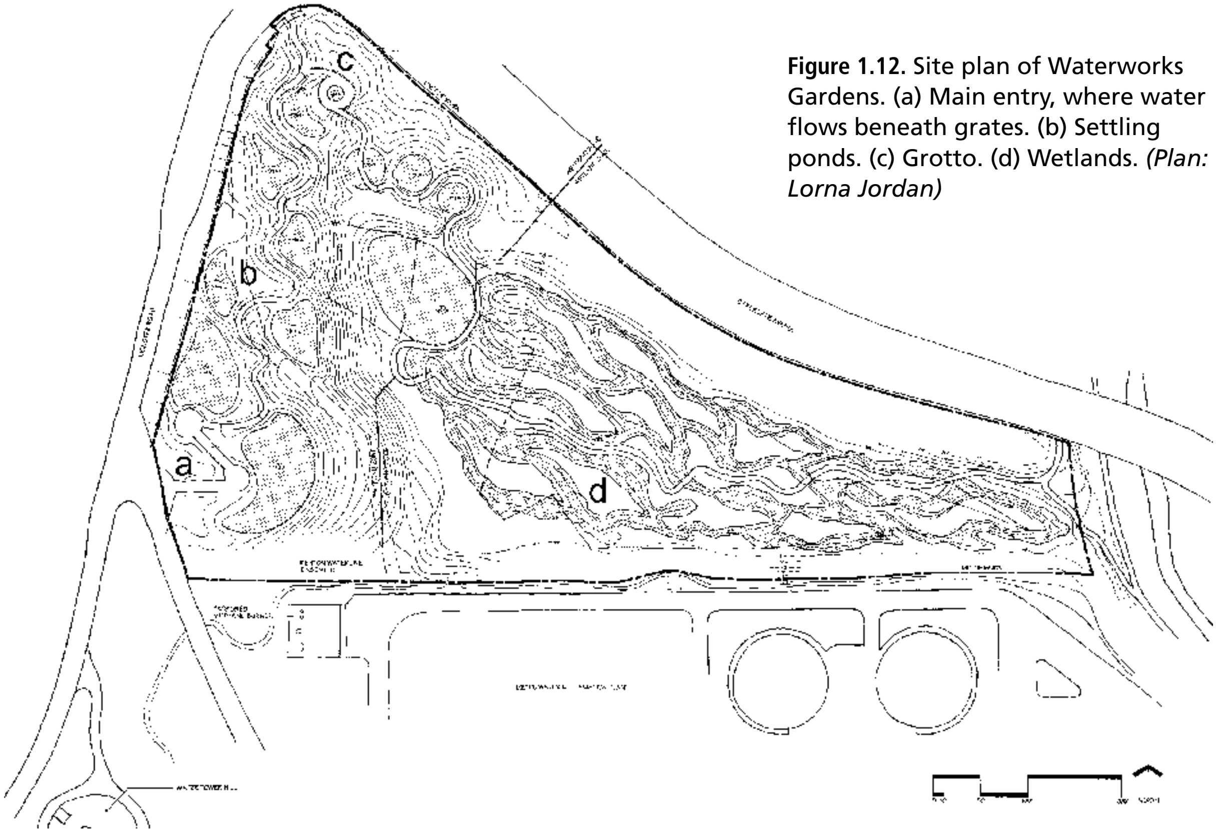

Figure 1.12. Site plan of Waterworks Gardens. (a) Main entry, where water flows beneath grates. (b) Settling ponds. (c) Grotto. (d) Wetlands. *(Plan: Lorna Jordan)*

Figure 1.13. View of the metal grates where the water starts its journey toward the first settlement pond, visible just beyond the railing in the distance. *(Photo: Lorna Jordan)*

Figure 1.14. View across the wetlands shows the treatment plant in the background on the right. *(Photo: Lorna Jordan)*

Created through collaboration between an artist, landscape architects, and engineers, this set of garden rooms is a dramatic alternative to the original landscape proposal that would have surrounded the site with a fence of trees and treated water in three square pools. Not only is the infrastructure revealed, but a place of wonder is created where humans can trace the purification and habitat functions of storm water or simply walk and enjoy the vibrant plant and animal life that surrounds them.

Figure 1.15. Landform is sculpted to look as if it is draped from bedrock outcrops. *(Photo: Michael Cluer)*

Naturalistic

Central Park.[4] This last category is perhaps the most common type of grading, particularly in suburban and rural settings, but has also been used to great effect in the urban work of Frederick Law Olmsted, as in Central Park in New York City. It is a stylized approach in which abstract (or organic) landforms are used to represent or imitate the natural landscape. The design is so successful that the landscape is believed to be a product of natural forces. The way the landforms respond to the remaining bedrock leads many to the conclusion that the landforms are natural (Figure 1.15). That misconception may also result from the great range of environmental experiences that are possible within the park's boundaries and the attention paid to the design of thresholds into the park, truly separating the experience of the park from the city beyond (Figure 1.16). There are wild-feeling places (Figure 1.17) adjacent to rolling manicured lawns (Figure 1.18). These experiences are deftly sewn together with a multilayered circulation system (Figure 1.19).

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[4] Landscape Architect: Frederick Law Olmsted
Architect: Calvert Vaux

Figure 1.16. Boating in a constructed lake. The city emerges above the tree line. *(Photo: Michael Cluer)*

Figure 1.18. Expansive rolling lawns juxtapose with the skyline. *(Photo: Michael Cluer)*

Figure 1.17. Rough-hewn rock corridors feel like undiscovered country in the midst of the city. *(Photo: Michael Cluer)*

Figure 1.19. Bridges and tunnels are found throughout the park, often separating pedestrians from automobile or other traffic, but in this case separating two pedestrian pathways. *(Photo: Michael Cluer)*

Perception

Slope

The perception of slope is influenced by the texture of the surface material and the relationship to surrounding grades. The coarser the texture, the less noticeable the slope. For example, the slope of smooth pavement, such as troweled concrete, is more noticeable than coarse pavement, such as cobblestone. Generally, slopes of 2 percent or greater on pavements can easily be perceived. See Chapter 4 for a definition of slopes and how to calculate them. However, horizontal reference lines, such as brick coursing or the top of a wall, increase the awareness of slope even in unpaved situations (Figure 1.20).

The relationship of one slope to another will also influence the perception of steepness. For example, when one travels along a walk with an 8 percent slope, which then changes to a 4 percent slope, the 4 percent slope will visually appear to be less than half the original slope.

Topography, landform, and changes in grade break the landscape into comprehensible units, which establish a sense of scale and sequence. The manner in which these grade changes occur affects the spatial and visual perception and image of a place.

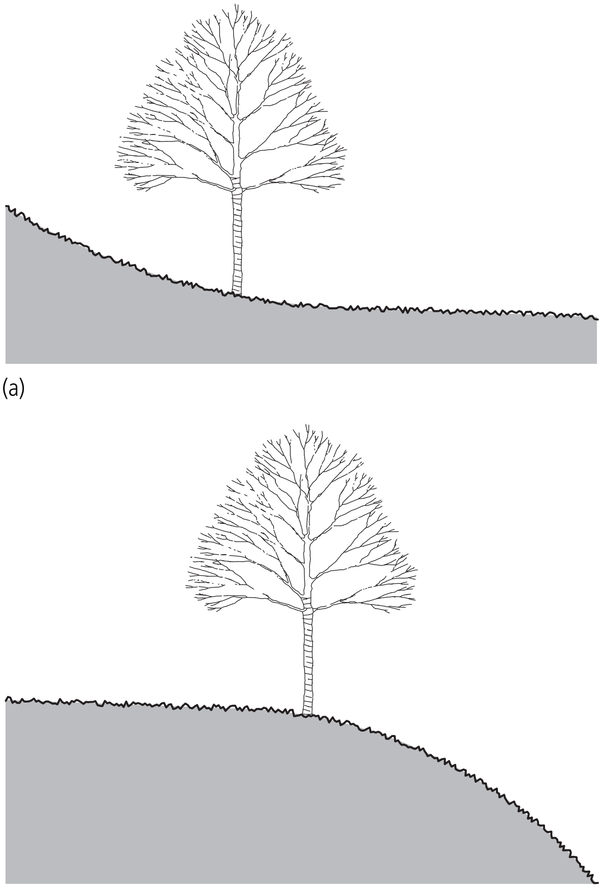
Elevation Change

Being at a higher elevation relative to the surrounding landscape is potentially dramatic for a variety of reasons. First, a rise in grade may provide a feeling of expansiveness by extending views and the overall field of vision. Also, being at a higher elevation may provide a sense of superiority, which may contribute to a feeling of control or dominance of a place. In addition, an upward change in elevation can provide an opportunity to contrast or exaggerate the steepness or flatness of the surrounding landscape. The abruptness of an elevation change will affect how space is perceived. The more gradual the ascent, the more subtle the experience. The steeper the grade, the greater the sense of enclosure at the lower elevations, while the opportunity for drama and excitement is increased at the higher elevations.

Figure 1.20. The clean, square edges of the planter walls exaggerate an already-steep slope running adjacent to them.

Convex and Concave Slopes

Generally, a plane is visually less pleasing than a convex or concave landform, although this depends on scale and contrast (Figure 1.21). In comparing



(a)

(b)

Figure 1.21. Rounded slopes. (a) Concave. (b) Convex.

the two rounded forms, the concave one appears more graceful from the downhill side, since it exhibits an uplifting quality. From the downhill side both forms foreshorten the view, with the foreshortening being much more abrupt with the convex slope. From the uphill side of a convex slope the sense of height is accentuated. Also, the sense of distance appears compressed, since the middle ground is foreshortened. The following quote from Arthur Raistrick's *The Pennine Dales*, illustrates the influence landform can have on experience:

> The most impressive approach to a view of one of the dales is to come upon it from the high moors—what the dalesfolk call, so expressively, from off the "tops". One has spent the day . . . with wide views of moorland cut by faint runnels and gullies, many of which are, in fact, the gaps of the dale lip seen in foreshortened perspective. The high ground begins to decline and one may come to the edge of the heather and peat and enter a world of benty grass and occasional stream heads. Then comes the moment when one looks "over the edge"—the convexity of the hill has reached the point where one can look back up the gentler slope of moorland, or forward down what often appears to be an almost precipitous slope into the valley.[5]

Enhancement

By analyzing existing topography and landscape character, proposed landforms, grade changes, and design elements may be constructed or placed to emphasize, negate, or have little impact on the visual structure of the landscape. The basic considerations when proposing design alternatives are whether they will enhance, complement, contrast with, or conflict with that particular landscape context. In Figure 1.22a, the steepness of the slope is exaggerated by planting taller vegetation at the top of the slope. The prominence of the house in the landscape of Figure 1.22b is heightened by the lack of surrounding vegetation that would give the structure scale. The plantings in the valley also provide a picturesque view from the house.

Spatial Considerations

Proposed grade changes may perform a variety of spatial functions. The appropriateness of the application of these functions is determined by a careful analysis of the potentials of the site and the demands of the design program. Several grading design applications are discussed and illustrated in this section.

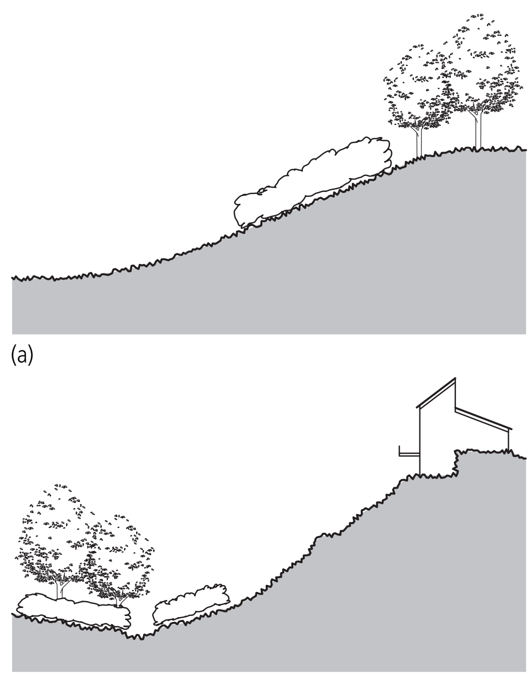

(a)
(b)

Figure 1.22. Enhancing topography with design elements. (a) Planting. (b) Architecture.

[5] Arthur Raistrick, The Pennine Dales (London: Eyre & Spottiswoode, 1968), p. 29.

Enclosure

Enclosure may be used to perform several tasks, including containment, protection, privacy, and screening. Seclusion, intimacy, and privacy may be achieved through the use of containment, as in the section of the sitting area illustrated in Figure 1.23. Screening is a form of visual containment, since it terminates sight lines and eliminates undesirable views (Figure 1.24).

Enclosure, possibly in the form of a berm, as illustrated in Figure 1.25, also may be used to provide safety and protection, such as restraining children from running into the street from a playground or serving as a backstop for various types of athletic activities. However, this type of application should be used with caution. The enclosure reduces visibility into the area, creating a potentially unsafe condition. Properly designed and placed landforms can themselves be an excellent outlet for creative play.

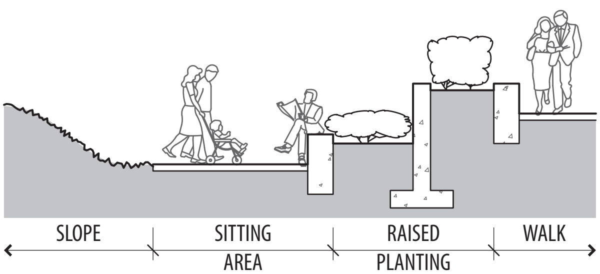


Figure 1.23. Level changes for privacy. Raised planting separates and visually screens the sunken sitting area from the sidewalk. The slope is used to add to the spatial enclosure of the sitting area.

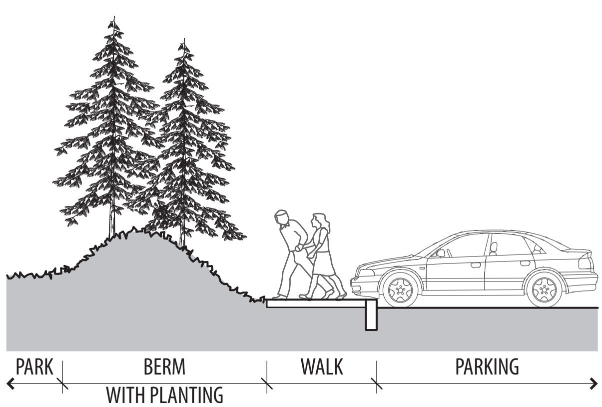


Figure 1.24. Visual screen. Topography, particularly in conjunction with planting, can be used to screen or block undesired views. In the illustration, a planted berm is used to screen the view of a parking lot from a park area.

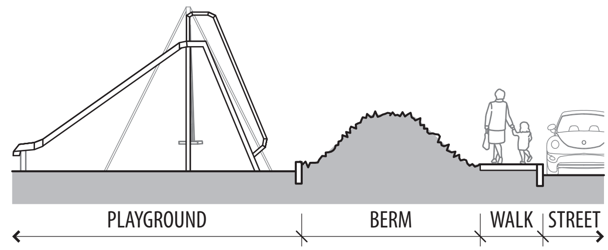


Figure 1.25. In this section, a berm is used to separate a playground from a street.

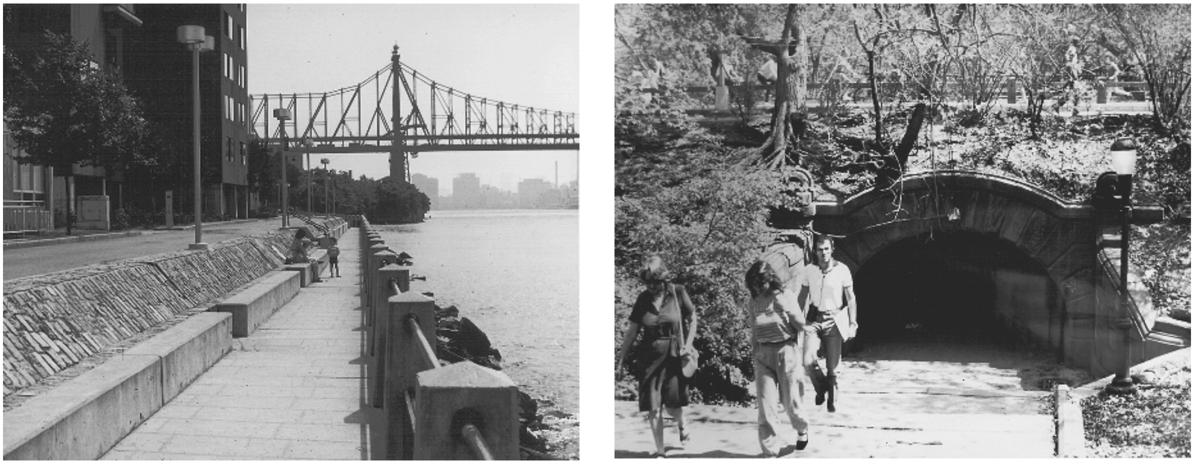
Berms are vegetated or paved embankments commonly used by landscape architects for enclosure and separation purposes. However, the use of these devices must be carefully evaluated, to ensure the scale and proportion of berms are not insignificant or inappropriate with regard to the surrounding context.

Separation

A very basic application of grading is the separation of activities to reduce potential conflicts, such as separating auto traffic from pedestrians and bicyclists, bicyclists from pedestrians, and sitting areas from walkways. In the design of New York's Central Park, Olmsted and Vaux showed great vision in using grade changes and overpasses to separate the traffic on the transverse roads from the park. Grade changes in the park were also often designed for the dual purposes of separation and enclosure, as shown in Figure 1.26. Even a change in grade of only a few inches may sufficiently define the territory in which an activity may occur (Figure 1.27). Separation may be accomplished by a variety of techniques, two of which are illustrated in Figure 1.28.

Figure 1.26. The low wall at the edge of some portions of Central Park in New York City provides both enclosure and separation while allowing the park and the city beyond to benefit from views in and out. *(Photo: Michael Cluer)*

Figure 1.27. A small grade change is enough, when supported by planting, to make this space feel very separate from the Great Lawn in Central Park. *(Photo: Michael Cluer)*



(a)

(b)

Figure 1.28. Separation of activities. (a) Along a riverfront promenade, a grade change, which incorporates seating, is used to separate the pedestrian walk from the bicycle and service lane. (b) An underpass is used to separate pedestrian and vehicular circulation in Central Park.

Channeling

Landform may be used to direct, funnel, or channel auto and pedestrian circulation. It may also be used to direct and control viewing angles and vistas as well as wind and cold air drainage. An amphitheater is a special use of landform to both focus attention and enclose space (Figure 1.29).

It must be realized that, in all the applications just listed, the functions of landform and grade


(a)

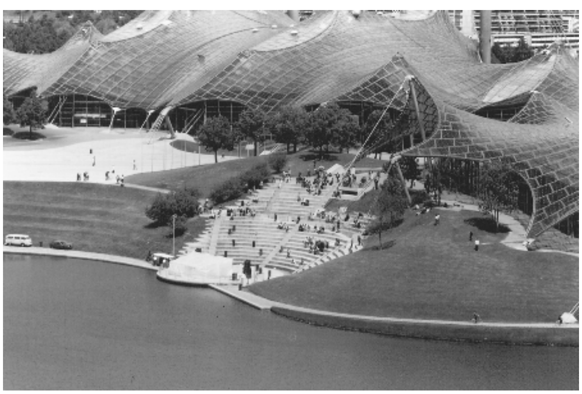

(b)

Figure 1.29. Amphitheaters. There are many good examples of places where topography has been used effectively to create a theater setting, two of which are presented here. (a) A Roman amphitheater built in Caesarea, Israel, about 25 BCE. The theater has been reconstructed and is in use today. (b) An amphitheater was constructed for the 1972 Olympics in Munich. Note how the edge of the theater has been blended into the surrounding earth form.

changes are reinforced and strengthened by the use of plantings and structural elements, such as walls and fences.

Environmental

Storm Water Management

The acts of grading and controlling and managing storm water runoff are inextricably linked. Almost all site development projects result in the remolding and sculpting of the earth's surface as well as changes in surface character. The complexity of this topic, as well as its prevalence across all scales of design, merits detailed discussion, which will be undertaken in Chapter 9.

Wildlife Habitat Enhancement

Landforming can play a large role in wildlife habitat enhancement. One of the best examples of this concerns the listing of the Pacific salmon on the endangered species list and the resultant effort to improve their habitat in the Pacific Northwest.

In many parts of the United States, waterways have been channelized because the conventional wisdom at the time dictated that moving water away faster was the goal of storm water management. This has caused great stress to river-dwelling wildlife populations. It is among many stresses that caused the Pacific salmon to be put on the endangered species list. As a result, a great deal of effort has gone into understanding how best to improve conditions for their health and survival. One way to improve conditions for the salmon directly involves the use of landform to re-create meandering stream conditions, replacing channelized streams to mimic the original dynamic natural environment. The images in Figure 1.30 (see Figure C1 in the Color Plates)

Figure 1.30. Beebe Springs Creek Restoration, Chelan, Washington. (a) The channelized stream. (b) Oblique view of the project shows the channelized stream still flowing in the upper-right corner and the new channel still under construction below and to the left. (c) Heavy machinery was used to carve the new channel into the floodplain. (d) The resulting stream has a great deal of complexity and offers a much more habitable environment to salmon making the journey upstream. *(Photos: The Watershed Company)*

chronicle the stream's transformation from a fast-flowing straight channel to a meandering and complex stream.

Landforms may also be involved in habitat enhancement by providing cues to help guide animals toward underpasses or bridges over highways designed especially for them.

Microclimate Modification

Enclosures mentioned earlier in the chapter can provide protection from climatic elements (Figure 1.31). Properly placed landforms can control drifting snow and significantly reduce the impact of wind on structures and even over large areas such as playfields and parking lots.

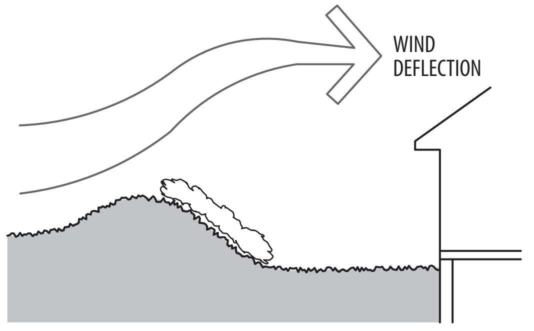


Figure 1.31. Microclimate modification. Topography can be used to channel or deflect winds, capture solar radiation, and create cold or warm pockets.

SUMMARY

Landforms and site engineering are at the heart of high-quality design of all types. Mastering the concepts laid out in the chapters ahead will build a foundation for the capacity to create high-quality designs that are responsive to the benefits and constraints of site engineering.