SITE AND LAYOUT DESIGN GUIDANCE 2

This chapter discusses comprehensive architectural and engineering design considerations (mitigation measures) for the school site, from the property line to the school building, including: land use, site planning, stand-off distance, controlled access zones, entry control and vehicular access, signage, parking, loading docks and service access, physical security lighting, and site utilities. The intent of this guidance is to provide concepts for integrating mitigation strategies to the design basis threats as identified during the risk assessment. Integrating security requirements into a larger, more comprehensive approach necessitates achieving a balance among many objectives such as reducing risk; facilitating proper school building function; aesthetics and matching architecture; creating a school environment conducive to learning; and hardening of physical structures beyond required building codes and standards for added security.

The design community must work closely with school districts and school administrators to ensure that the optimal balance of all these considerations is achieved; thus, coordination within the design team is critical. Many school asset protection objectives can be achieved during the early stages of the design process when mitigation measures are the least costly and most easily implemented. Planners, architects, and landscape designers play an important role in identifying and implementing crucial asset protection measures while considering land use; site selection; the orientation of buildings on the site; and the integration of vehicle access, control points, physical barriers, landscaping, parking, and protection of utilities to mitigate threats.

It is important to remember that the nature of any threat is always changing. Although indications of potential future threats may be scarce during the design stage, consideration should be given to accommodating enhanced protection measures in response to future threats that may emerge. School protection objectives must be balanced with other design objectives, such as the efficient use

of land and resources, and must also take into account existing physical, programmatic, and fiscal constraints.

2.1 LAND USE CONSIDERATIONS

Land use is a broad planning process that encompasses zoning ordinances, subdivision regulations, and master planning. Regulating land use development has been a common practice in the United States for many years, with numerous regulations and other tools in use by state and local governments to influence the configuration of urban sites. Comprehensive planning can encourage certain types of development, incentives, allocation of resources, and capital improvement programs oriented to improve the security of areas vulnerable to manmade disasters. In most cases, sound site planning will increase the land area needed for individual school buildings and maximize the protection measures to be adopted. Other potential terrorist targets in the surrounding area should also be considered. Students and teachers might be killed or injured by collateral damage from a terrorist attack directed at another nearby facility. When designing a school, the designer should consider external and internal land use design concerns, including the characteristics of the surrounding area (e.g., construction type, occupancies, and the nature and intensity of adjacent activities), as well as the implications of these characteristics for the protection of the students, faculty, and staff on the school site under consideration. The amount of land available on the site for stand-off and the inherent ability of the school site to accommodate the implementation of natural and manmade antiterrorism and security design features could help the designers to determine if other measures such as hardening the school building should also be considered.

It is important to recognize that conflicts sometimes arise between security-oriented site design and conventional site design. For example, open circulation and common spaces (which are desirable for conventional design) may be detrimental to certain aspects of security.

When designing new school buildings or evaluating existing schools, the designer should evaluate key protection measures to ensure they are appropriate, desirable, and cost-effective in terms of mitigating the risk of potential terrorist attacks. Security measures must be evaluated carefully to understand which measures are truly beneficial and which are not practical.

When making decisions about site antiterrorism and security, designers should consider the following:

- Adjacent land use and zoning plans for potential development that would impact security within the school (assess by using land use maps and Geographic Information Systems [GISs])
- Building footprint(s) relative to total land available
- Building location(s) or, if undeveloped, suitable building location(s) relative to the site perimeter and adjacent land uses; distance between the perimeter fence and improved areas off site
- Access via foot, road, rail, water, and air; suitability to support a secure perimeter
- Current and planned infrastructure and its vulnerabilities, including easements, tunnels, pipes, and rights-of-way
- Infrastructure nodes that constitute single-point vulnerabilities
- Adjacent land uses and occupancies that could enable or facilitate attacks or that are potential targets themselves and thus present collateral damage or cascading failure hazards
- Proximity to fire and police stations, hospitals, shelters, and other critical facilities that could be of use in an attack
- Presence of natural physical barriers such as water features, dense vegetation, and terrain that could provide access control and/or shielding, or suitability of the site for the incorporation of such features
- Topographic and climatic characteristics that could affect the performance of chemical agents and other weapons

- Observability from outside site boundaries; ability of vegetation in proximity to building or site to screen covert activity

2.2 SITE PLANNING

The single most important goal in planning a site to resist terrorism and security threats is the protection of life, property, and operations. Decision-making in support of this purpose should be based first and foremost on a comprehensive assessment of the manmade threats and hazards so that planning and design countermeasures are appropriate and effective in the reduction of vulnerability and risk as described in Chapter 1. It is important to recognize that a given countermeasure can mitigate one or more vulnerabilities, but may be detrimental to other important design goals. This section will highlight several aspects of site design and will present some of the unique characteristics arising from their application to antiterrorism and security.

2.2.1 Site Design

Because the economics of development dictate the construction of schools, security concerns should be evaluated carefully. Conflicts sometimes arise between security site design and conventional site design. For example, open circulation and common spaces, which are desirable for conventional school design, are often undesirable for security design. To maximize safety, security, and sustainability, designers should implement a holistic approach to site design that integrates form and function to achieve a balance among the various design elements and objectives. Even if resources are limited, significant value can be added to a project by integrating security considerations into the more traditional design tasks in such a way that they complement, rather than compete with, the other elements.

2.2.2 Layout and Form

The overall layout of a school site (e.g., the placement and form of its buildings, infrastructures, and amenities) is the starting point for development. Choices made during this stage of the design

process will steer decision-making for the other elements of the site. A number of aspects of site layout and building type present security considerations and are discussed below.

- **Clustered versus dispersed functions.** There is a strong correlation between building functions and building layout and forms. Typically, the former dictates the other two. Depending on the site characteristics, the occupancy requirements, and other factors, school buildings may cluster key functions in one particular area or have these functions designed in a more dispersed manner. Both patterns have compelling strengths and weaknesses in terms of security.

  Concentrating key functions in one place may create a target-rich environment and increase the risk of collateral impacts. Additionally, it increases the potential for the establishment of more single-point vulnerabilities, such as indicated in Figure 2-1. This figure shows several key functions grouped in a particular area of the building (i.e., the mechanical rooms, stairs, telephone switch room, and loading docks). If these areas become a target, the school may be closed for a substantial period of time, even if the attack is not severe and the rest of the school remains unharmed. However, grouping high-risk activities, concentrations of personnel, and critical functions into a cluster can help maximize stand-off from the perimeter and create a "defensible space." This also helps to reduce the number of access and surveillance points, and minimize the size of the perimeter needed to protect the school areas.

  In contrast, the dispersal of key functions reduces the risk that an attack on any one part of the site will impact the other parts. However, this could also have an isolating effect and reduce the effectiveness of on-site surveillance, increase the complexity of security systems and emergency response, and create a less defensible space.

  To the extent that site, economic, and other factors allow, the designer should consolidate school designs that are functionally

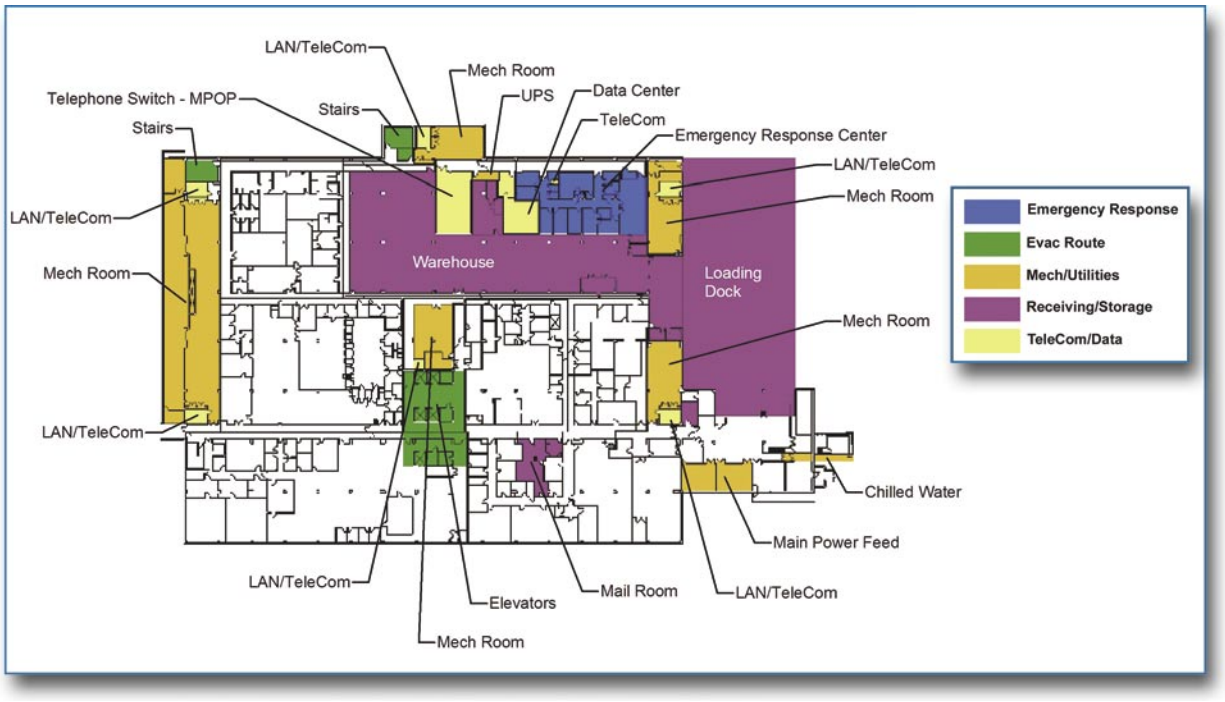


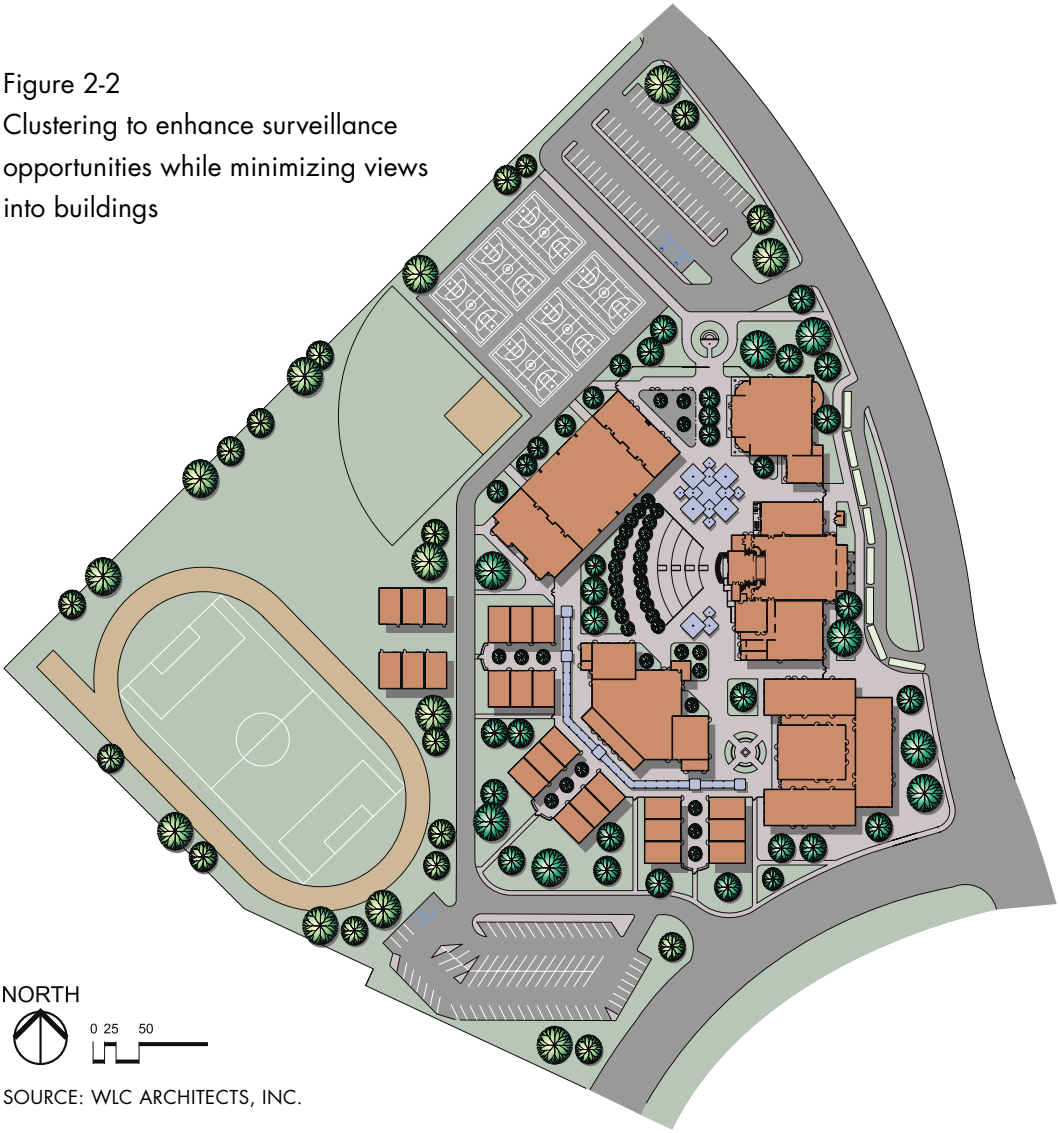
Figure 2-1 Non-redundant critical functions collocated near loading dock

compatible and have similar threat levels. For example, visitor areas and receiving/loading areas constitute a school's innermost line of defense, because they are the first places where people and materials enter the school building. Logically, they should be physically separated from other key functions such as the main operational areas or where people concentrate.

- **School building orientation.** The orientation of a school building can have significant impact on its performance, not only in terms of energy efficiency, but also the ability to protect occupants (see Figure 2-2). A school building's orientation relative to its surroundings defines its relationship to that area. In aesthetic terms, a school building can open up to the area or turn its back; it can be inviting to those outside, or it can "hunker down" defensively. The physical positioning of a building relative to its surroundings may seem more subtle, but can be a greater determinant of this intangible quality than exterior aesthetics. Nevertheless, the proximity of a vulnerable

façade to a parking area, street, adjacent site, or other area that is accessible to vehicles and/or difficult to observe can greatly contribute to its vulnerability. This illustrates one way in which protective requirements can be at odds with otherwise good design. A strong, blank wall with no glazing will help to protect students, faculty, staff, property, and operations within from a blast, but the lack of windows removes virtually all opportunity for the faculty and staff to monitor activities outside and take appropriate protective actions in a timely manner. Designers should consider such trade-offs early in the design process, in an effort to determine an acceptable level of risk.

Figure 2-2
Clustering to enhance surveillance opportunities while minimizing views into buildings



SOURCE: WLC ARCHITECTS, INC.

- **Open space.** The incorporation of open space into school site design presents a number of benefits. First and foremost is the ability to easily monitor an area and detect intruders, vehicles, and weapons. Closely related to this benefit is the stand-off value of open space; as discussed in Chapter 4, blast energy decreases as the inverse of the cube of the distance from the seat of the explosion, so every additional increment of distance provides increasingly more protection. In addition, pervious open space allows stormwater to percolate back into the ground, reducing the need for culverts, drainage pipes, manholes, and other covert site access and weapon concealment opportunities. Also, if the open space is impassible for vehicles (as in the case of a wetland or densely vegetated area), it can provide not only environmental and aesthetic amenities, but prevent vehicle intrusion as well.

- **Infrastructure and lifelines.** Providing power, gas, water, wastewater, and communications services is one of the most basic requirements of any school development. At the site scale, all critical lifelines should have at least one layer of redundancy, or backup. By eliminating single-point vulnerabilities, designers will reduce the chance that service will be interrupted if an attack damages or destroys a lifeline either outside the school perimeter or on site. It is important to note that collocating a backup lifeline with its primary lifeline does not eliminate single-point vulnerability; only physical separation can substantially increase the likelihood of continuity of service.

  Additionally, all controls, interconnections, exposed lines, and other vulnerable elements of school infrastructure systems should be protected from access and exploitation by surveillance and/or physical countermeasures. Service entrances and other secondary access points should be monitored and access-controlled; special attention should also be paid to any locations where multiple systems or primary and backup systems come together, such as control rooms and mechanical spaces. Again, these facilities should be designed

for maximum observability, including the use of opportunity reduction and target hardening strategies where appropriate, and should be equipped with adequate lighting and emergency communications capabilities wherever possible. For additional information, see Sections 2.9 and 2.10.

2.2.3 Vehicular and Pedestrian Circulation

The movement of people and materials into, through, and out of a school facility is determined by the design of its access, circulation, and parking systems. Such systems should be designed to maximize efficiency while minimizing conflicts between vehicle and pedestrian modes. Designers should begin with an understanding of the school's transportation requirements based on an analysis of how the school will be used. This includes studying the number and types of access points that are required, bus requirements, the parking volume needed, where users need to go to and from, and the modes of transportation they will use. Several aspects of transportation planning can impact security and are discussed below.

- **Roadway network design.** Streets are generally designed to minimize travel time and maximize safety, with the end result typically being a straight path between two or more endpoints. Although a straight line may be the most efficient course, designers should use caution when orienting streets relative to school buildings requiring high protection. Designers should design a roadway system to minimize vehicle velocity, thus using the roadway itself as a protective measure. This is accomplished through the use of several strategies.

  First, straight-line or perpendicular approaches to school buildings should not be used in a school at high risk, because these give vehicles the opportunity to gather the speed necessary to ram through protective barriers and crash into or penetrate buildings. Instead, approaches should be parallel to the façade, with berms, high curbs, appropriate trees, or other measures used to prevent vehicles from departing the roadway. A related technique for reducing vehicle speeds is the construction of serpentine (curving) roadways with tight-

radius corners. Existing streets can be retrofitted with barriers, bollards, swing gates, or other measures to force vehicles to travel in a serpentine path. Again, high curbs and other measures should be installed to keep vehicles from departing the roadway in an effort to avoid these countermeasures.

Less radical than these techniques are traffic calming strategies, which seek to use design measures to cue drivers as to the acceptable speed for an area. These include raised crosswalks, speed humps and speed tables, pavement treatments, bulbouts, and traffic circles. In addition to creating a more pedestrian-friendly environment, which increases "eyes on the street" surveillance, designing roadways to physically limit speeds can have the added benefits of increasing safety and, subsequently, lowering liability. Designers should be aware, however, that many of these techniques can have detrimental effects for emergency response, including slowing response time, interfering with en route emergency medical treatment, and increasing the difficulty of maneuvering fire apparatus. They also may present problems for snow removal, and their outer ends should remain flat so that bicycles can proceed unimpeded.

- **Parking.** Surface lots can be designed and placed to keep vehicles away from school buildings, but they can consume large amounts of land and, if constructed of impervious materials, can contribute greatly to stormwater runoff. They can also be hazardous for pedestrians if dedicated pedestrian pathways are not provided. For additional information, see Section 2.7.

2.2.4 Landscape and Urban Design

Designing to meet user needs while maintaining stewardship of the natural and built environments becomes increasingly more challenging when security requirements are factored in. Design principles at the school site should include an emphasis on selection of low-impact development techniques and environmental stewardship; compatibility of context and relationship with adjacent uses, forms, and styles; establishment of scale and identity

through aesthetic design; connectivity among buildings, uses, activities, and transportation modes; resource conservation; cultural responsiveness; and the creation of appealing public spaces. These objectives are generally achieved through the work of two closely related disciplines, landscape design and urban design. For the purposes of this document, these two disciplines are virtually overlapping and will, therefore, be addressed together.

- **Landscape design.** Many landscape features can be used in school design to enhance security. Landscape design features should be used to create the level of protection without turning the school into a fortress. Elements such as landforms, water features, and vegetation are among the building blocks of attractive and welcoming spaces, and they can also be powerful tools for enhancing security. These features can be used not only to define or designate a space, but also to deter or prevent hostile surveillance or unauthorized access. Vegetative groupings and landforms can even provide some level of blast shielding. Stands of trees, earthen berms, and similar countermeasures generally cannot replace setbacks, but they can offer supplementary protection. However, landscaping can also have detrimental impacts for safety and security, and designers should consider the unique requirements of the school project to ensure that the landscape design elements they choose will be appropriate and effective.

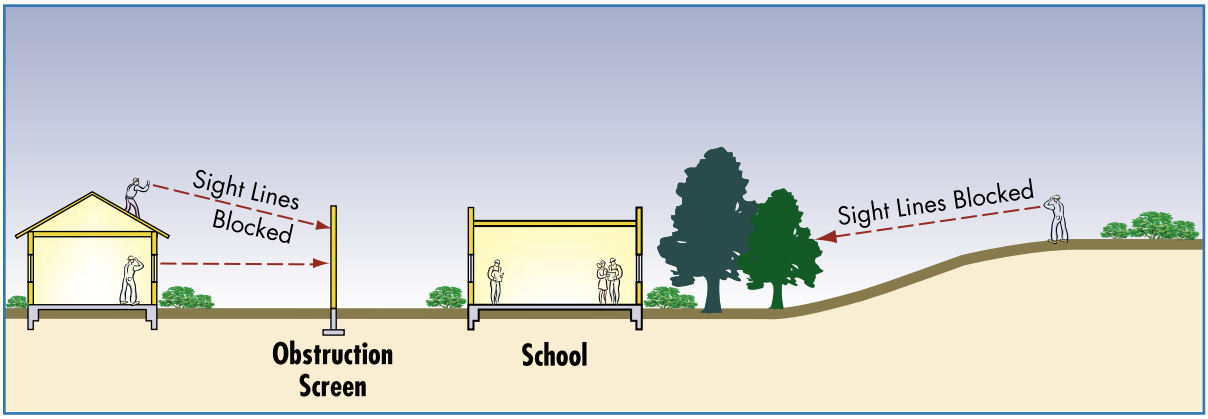
  With careful selection, placement, and maintenance, landscape elements can provide visual screening that protects school gathering areas and other activities from surveillance without creating concealment for covert activity. However, dense vegetation in close proximity to a school building can screen illicit activity and should be avoided. Additionally, thick ground cover such as English ivy or vegetation over 4 inches tall such as monkey grass can be used to conceal bombs and other weapons; in setback clear zones, vegetation should be selected and maintained with eliminating concealment opportunities in mind. Similarly, measures to screen visually detractive components such as transformers, trash compactors, and condensing units should be designed to minimize concealment opportunities for people and weapons.

- **Urban design.** Numerous urban design elements present opportunities to provide school security. The scale of the streetscape should be appropriate to its primary users, and it can be manipulated to increase the comfort level of desired users while creating a less inviting atmosphere for users with malicious intent. However, even at the pedestrian scale, certain operational requirements must be accommodated. For example, although efficient pedestrian and vehicle circulation systems are important for school functions and operations, they are also critical for emergency response, evacuation, and egress, and must be able to accommodate vehicles up to the largest fire apparatus in the community. Furthermore, despite an emphasis on downsizing the scale of the streetscape, it is critical to maintain the maximum stand-off distance possible between vehicles and structures.

  At the school perimeter, walls and fences used for space definition may be hardened to resist the impact of a weapon-laden truck; however, planters, bollards, or decorative boulders could accomplish the same objective in a much more aesthetically pleasing manner. Such an approach also creates permeability, which would allow pedestrians and cyclists to more easily move through the space.

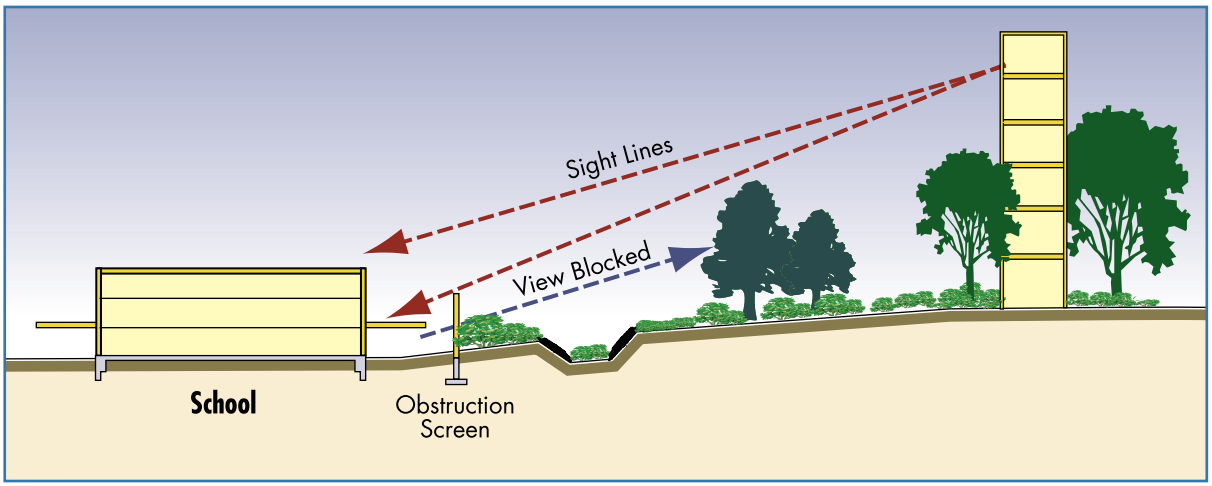
  Landscape and urban design inherently define the "lines of sight" in a space. These techniques seek to deny aggressors a "line of sight" to a potential target, either from on or off site. This increases the protection of sensitive information and operations by using stand-off weapons (see Figures 2-3 and 2-4). In addition to the use of various types of screening options, anti-surveillance measures (e.g., using building orientation, landscaping, screening, and landforms) to block sight lines can also be used.

Depending on the circumstances, landforms can be either beneficial or detrimental to anti-surveillance. Elevated sites may enhance surveillance of the surrounding area from inside the facility, but may also allow observation of on-site areas by adversaries. School buildings should not be sited immediately adjacent



SOURCE: U.S. AIR FORCE, *INSTALLATION FORCE PROTECTION GUIDE*

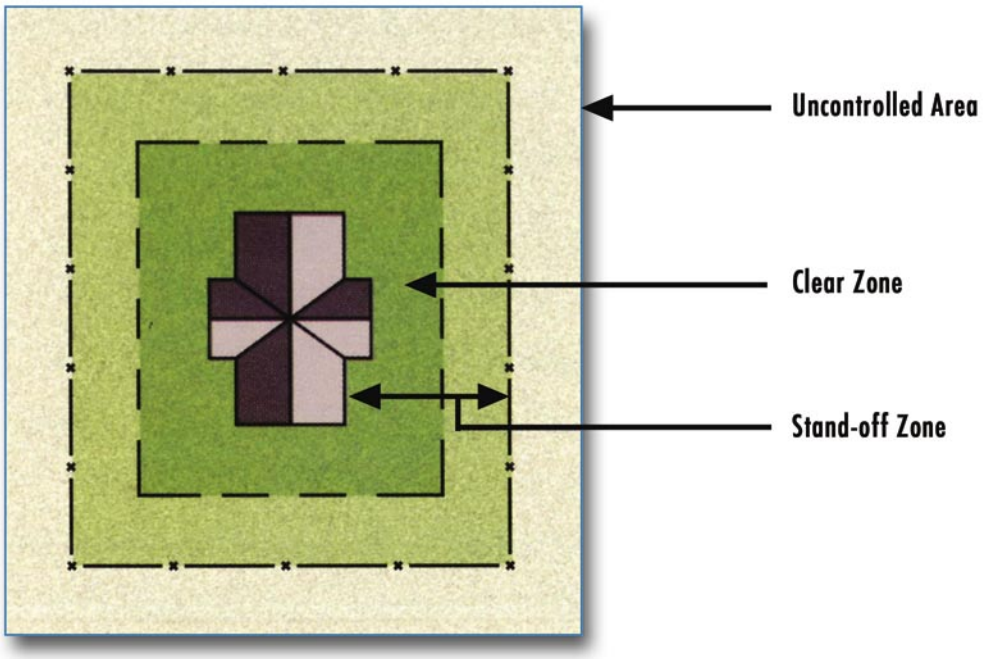
Figure 2-3 Blocking of sight lines



SOURCE: U.S. AIR FORCE, *INSTALLATION FORCE PROTECTION GUIDE*

Figure 2-4 Improper school siting and view relationships

to higher surrounding terrain, unsecured buildings owned by unfamiliar parties, and vegetation, drainage channels, ditches, ridges, or culverts that can provide concealment. For high-risk school buildings, it may be necessary to provide additional protection by creating a clear zone immediately adjacent to the structure that is free of all visual obstructions or landscaping (see Figure 2-5). The clear zone facilitates monitoring of the immediate vicinity and visual detection of attacks. Walkways and other circulation features within a clear zone should be located so that buildings do not block views of pedestrians and vehicles. If clear zones are implemented, it may be necessary to implement other anti-surveillance measures.

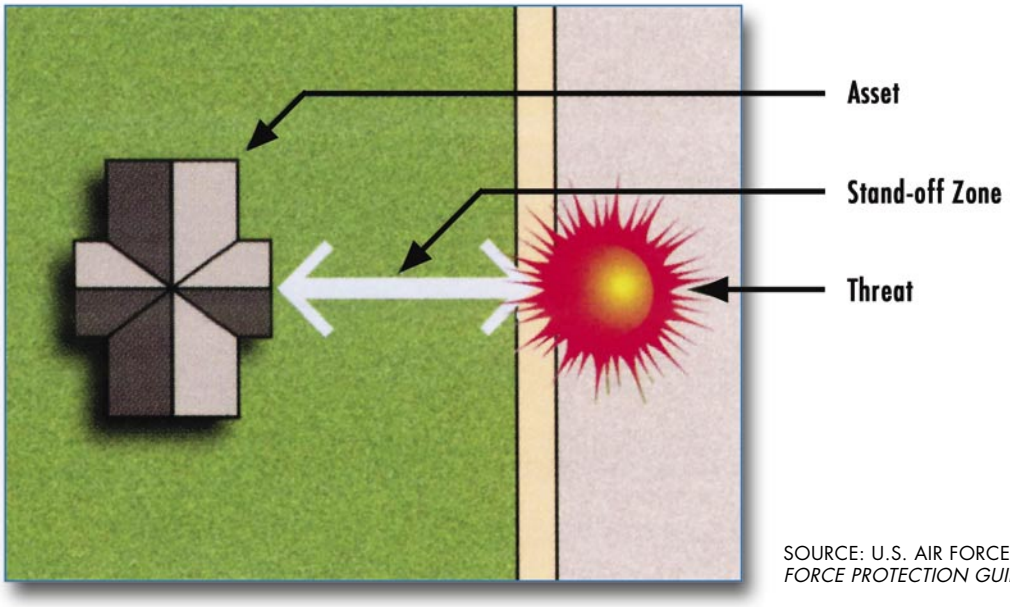


SOURCE: U.S. AIR FORCE, *INSTALLATION FORCE PROTECTION GUIDE*

Figure 2-5 Clear zone with unobstructed views

2.3 STAND-OFF DISTANCE

The most cost-effective solution for mitigating explosive effects on school buildings is to keep explosives as far away from them as possible. The distance between an asset and a threat is referred to as the stand-off distance as shown in Figure 2-6. There is no ideal stand-off distance; it is determined by the type of threat, the type of construction, and desired level of protection. The easiest and least costly opportunity for achieving appropriate levels of protection against terrorist threats is to incorporate sufficient stand-off distance into school designs. Maximizing stand-off distance also ensures that there is opportunity in the future to upgrade school buildings to meet increased threats or to accommodate higher levels of protection. Stand-off distance must be coupled with appropriate building hardening as discussed in Chapter 3, to provide the necessary level of protection to the school.



SOURCE: U.S. AIR FORCE, *INSTALLATION FORCE PROTECTION GUIDE*

Figure 2-6 Concept of stand-off distance

For schools located in high-risk areas, additional considerations follow:

- The first mode of site protection is to create "keep out zones" that can ensure a minimum guaranteed distance between an explosion (i.e., from a vehicle) and the school structure.

- The perimeter line is the outermost line that can be protected by the security measures incorporated during the school design process. It is recommended that the perimeter line be located as far as is practical from the building exterior. Many vulnerable school buildings are located in urban areas where only the exterior wall of the building stands between the outside world and the building occupants. In this case, the options are obviously limited. Often, the perimeter line can be pushed out to the edge of the sidewalk by means of bollards, planters, and other obstacles. To push this line even further outward, restricting or eliminating parking along the curb often can be arranged with local authorities. In some extreme cases, elimination of loading zones and the closure of streets are an option.

- "Keep out zones" can be achieved with perimeter barriers that cannot be compromised by vehicular ramming. A continuous line of security should be installed along the perimeter of the site to protect it from unscreened vehicles and to keep all vehicles as far away from the school as possible.

- The following critical building components should be located away from main entrances, vehicle circulation, parking, and maintenance areas. If this is not possible, harden as appropriate:

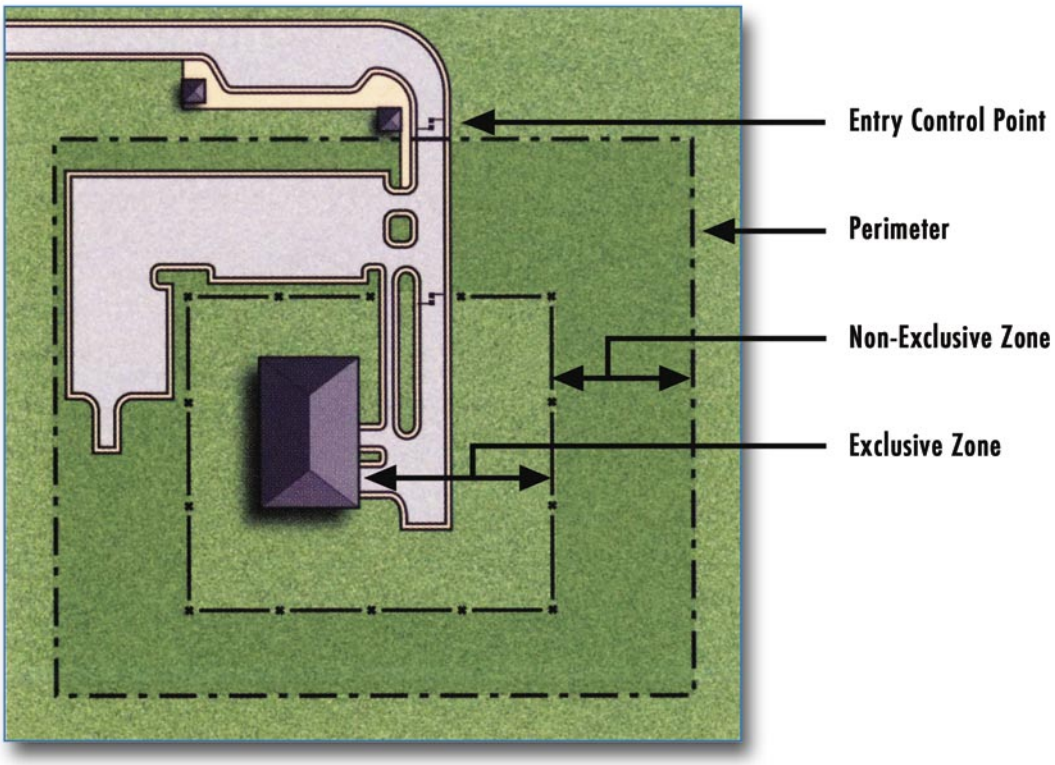
  - Emergency generator, including fuel systems, day tank, fire sprinkler, and water supply
  - Normal fuel storage
  - Telephone distribution and main switchgear
  - Fire pumps
  - Building control centers
  - Uninterrupted power supply (UPS) systems controlling critical functions
  - Main refrigeration systems if critical to building operation
  - Elevator machinery and controls
  - Shafts for stairs, elevators, and utilities
  - Critical distribution feeders for emergency power

2.4 CONTROLLED ACCESS ZONES

For a school at high risk, one method to attain the appropriate protection is with the creation of a controlled access zone. These zones define minimum distances between a school building and potential threats through the installation of barriers (such as bollards, planters, fountains, walls, and fences). The barriers are designed to withstand assaults by terrorist vehicles; however, their placement must be designed to allow for access by fire and rescue vehicles in the event of an emergency. Selection of barriers is

based on operational considerations related to vehicle access and parking. Good design principles for high-risk schools endorse the complete surround of a school building with a stand-off zone that has perimeters set at distances that consider threat levels, desired level of protection, building construction, and land availability. Entry into the controlled area should only be through an entry control point.

When designing schools at high risk, controlled access zones may be exclusive or non-exclusive, as shown in Figure 2-7. An exclusive zone is the area surrounding a school building within the exclusive control of the building. Anyone entering an exclusive zone must have a purpose related to the building. A non-exclusive zone is either a public right-of-way or a particular area related to the main school building.



SOURCE: U.S. AIR FORCE, *INSTALLATION FORCE PROTECTION GUIDE*

Figure 2-7 Exclusive and non-exclusive zones

The following are some security considerations applicable to controlled access zones and enforcement:

- Design and select barriers based on threat capabilities.
- If the limited availability of land precludes the creation of an exclusive zone, the use of screening surrounding the school building is an alternative.
- Design and locate security devices to establish consistent rhythm patterns within the site. Incorporate subtle and aesthetically pleasing security measures to reach the desired level of protection.
- Locate security measures so that they do not impede the free access to school public entrances or internal pedestrian flow. Miscellaneous decorative elements (e.g., flag poles, fountains, pools, gardens, and similar features) may be located within access ways to slow movement or restrict access.
- Use a combination of barriers. Some barriers are fixed and obvious (fences and gates), while others are passive (sidewalks far away from buildings, curbs with grassy areas, etc.). See Figure 2-8.

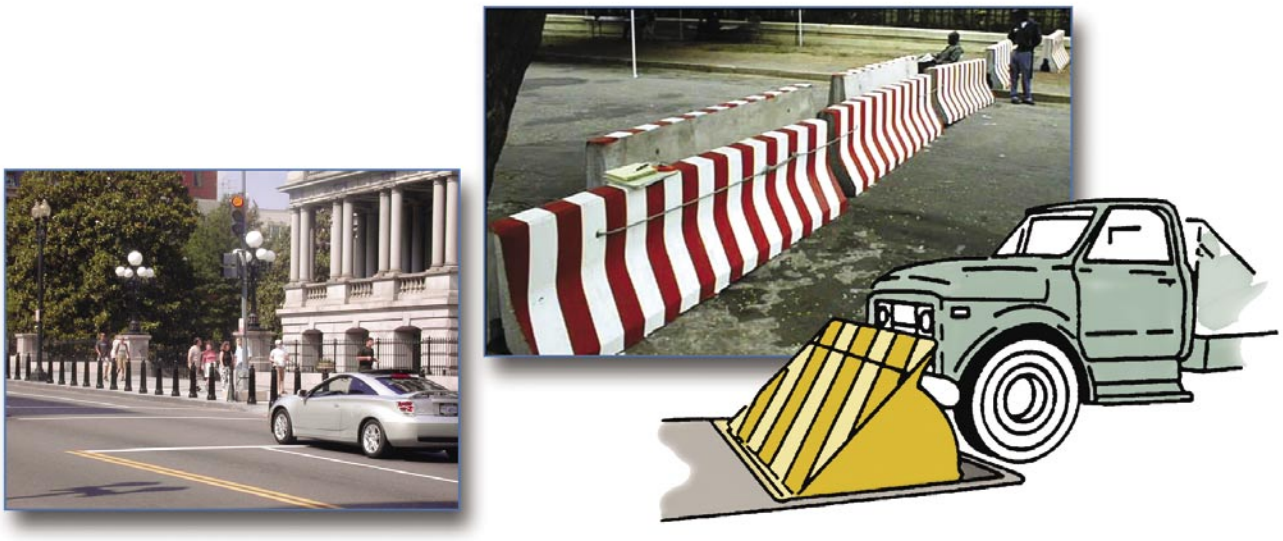


Figure 2-8 Sample bollard applications

- Consider using landscape materials to create barriers that are soft and natural rather than manmade where physical barriers are required.
- Use vehicles as temporary physical barriers by placing them in front of buildings or across access roads.
- Maintain as much stand-off distance as possible between potential vehicular bombs and the school building.
  - Provide traffic obstacles near entry control points to slow down traffic.
  - Consider vehicle barriers at building entries and drives.
  - Offset vehicle entrances from the direction of a vehicle's approach to force a reduction in speed.
  - Position gates and perimeter boundary fences outside the blast vulnerability envelope, when possible.
  - Provide a vehicle crash resistance system in the form of a low wall or earth berm, if the threat level warrants it.
- Design entry control points (if provided) to screen the building from vehicles entering it.
- Provide passive vehicle barriers to keep stationary vehicle bombs at a distance from the school building.
  - Use high curbs, low berms, shallow ditches, trees, shrubs, and other physical separations to keep stationary bombs at a distance.
  - Do not allow vehicles to park next to perimeter walls of the secured area. Consider using bollards or other devices to keep vehicles away.
- Provide adequate lighting to aid in threat detection in controlled access zones.
- Use CCTV to control entry points, the site perimeter, and exclusive and non-exclusive zones.

2.5 ENTRY CONTROL AND VEHICULAR ACCESS

In the case of a school, the objective of the design professional is to save lives by mitigating building damages and reducing the chances of a catastrophic collapse of the building at least until it is fully evacuated. Although there are many forms of attacks against a school, from the standpoint of school structural design, the vehicle bomb governs design because historically it has been used on multiple occasions by terrorists. Where a school perimeter barrier is required for security, it will be necessary to provide points of access through the perimeter for school users (i.e., students, faculty, staff, visitors, and service providers). An entry control point or guard building serves as the designated point of entry for site access. It provides a point for implementation of desired/required levels of screening and access control. The objective of the entry control point is to prevent unauthorized access to school grounds while maximizing the rate of authorized access by foot or vehicle. These measures will not be required for all schools; they may only be appropriate for schools considered at high risk. Designs should be flexible to allow implementation of increased security controls when schools are placed in high alert and easing of controls at lower threat levels. For a school considered to be at high risk, the following should be considered in the design of entry control points:

- Design entry roads to schools so that they do not provide direct or straight-line vehicular access to the main building. Route major corridors away from key school areas and functions.
- Design access points at an angle to oncoming streets so that is difficult for a vehicle to gain enough speed to break through them.
- Minimize the number of access roads and entrances into a school.
- Provide a drop-off/pick-up lane for buses only.

- Minimize the number of driveways or parking lots that students will have to walk across to get to the school building.
- Designate an entry to the school for commercial, service, and delivery vehicles, preferably away from key school areas and functions, whenever possible.
- Design the entry control point and guard building so that the authorization of approaching vehicles and occupants can be adequately assessed, and the safety of both gate guards and approaching vehicles can be maintained when a school is placed at high alert).
- Design (if they are required) traffic calming strategies and barriers (road alignment, retractable bollards, swing gates, or speed bumps) to control vehicle speed and slow incoming vehicles before they reach the gate so that entry control personnel have adequate time to respond to unauthorized activities.
- Provide inspection areas that are not visible to the public. Place appropriate landscape plantings to accomplish screening.
- Provide pull-over lanes at site entry gates to check suspect vehicles. Also, provide a visitor/site personnel inspection area to inspect vehicles prior to allowing access to the school site.
- Consider providing a walkway and turnstile for pedestrians and a dedicated bicycle lane.

2.6 SIGNAGE

Signs are an important element of school security. They are meant to keep intruders out of restricted areas. Confusion over site circulation, parking, and entrance locations can contribute to a loss of site security. Signs should be provided off site and at school entrances; there should be on-site directional, parking, and cautionary signs for students, faculty, staff, visitors, service vehicles, and pedestrians. Unless required, signs should not identify

sensitive areas. A comprehensive signage plan should include the following:

- Prepare entry control procedures signs that explain current entry procedures for drivers and pedestrians.
- Prepare traffic regulatory and directional signs that control traffic flow and direct vehicles to specific appropriate points.
- Consider using street addresses or building numbers instead of detailed descriptive information inside the school grounds.
- Minimize the number of signs identifying high-risk areas; however, a significant number of warning signs should be erected to ensure that possible intruders are aware of entry into restricted areas.
- Minimize signs identifying critical utility complexes (e.g., power stations and significant gas, water, and sewer). Post easily understandable signs to minimize accidental entry by unauthorized visitors into critical areas.
- In areas where English is one of two or more languages commonly spoken, warning signs must contain the other language(s) in addition to English. The signs should be posted at intervals of no more than 100 feet and should not be mounted on fences equipped with intrusion-detection equipment.
- Locate variable message signs, which give information on site/organization special events and visitors, far inside site perimeters.

2.7 PARKING

Parking restrictions can help to keep potential threats away from a school building. In urban settings, however, curbside or underground parking is often necessary and sometimes difficult to control. Mitigating the risks associated with parking requires creative design measures, including parking restrictions, perimeter buffer zones, barriers, structural hardening, and other architectural

and engineering solutions. The following considerations may help designers to implement parking measures for schools that may be at high risk:

- Locate vehicle parking areas away from school buildings to minimize blast effects from potential vehicle bombs.
- Provide separate parking areas for students, faculty, staff, and visitors who may be going in and out during the school day. (This allows the main student parking lot to be closed off during the school day.)
- If possible, locate visitor or general public parking near, but not on, the site itself.
- Locate general parking in areas that provide the fewest security risks to school personnel.
- Consider one-way circulation within a school parking lot to facilitate monitoring for potential aggressors.
- Locate parking within view of occupied school buildings while maintaining stand-off.
- Prohibit parking within the stand-off zone.
- Request appropriate permits to restrict parking in the curb lane for school vehicles or key employee parking only where distance from the building to the nearest curb provides insufficient setback, and compensating design measures do not sufficiently protect the building from the assessed threat. If necessary, use structural features to prevent parking.
- Provide appropriate setback from parking on adjacent properties, if possible. Structural hardening may be required if the setback is insufficient. In new designs, it may be possible to adjust the location of the school building on the site to provide adequate setback from adjacent properties.
- When establishing parking areas, provide emergency communications systems (e.g., intercom, telephones, etc.) at readily identified, well-lighted, CCTV monitored locations to permit direct contact with security personnel.

- Provide parking lots with CCTV cameras connected to the security system and adequate lighting capable of displaying and videotaping lot activity.
- If possible, prohibit parking beneath or within a school building.
- If parking beneath a building is unavoidable, limit access to the parking areas and ensure they are secure, well-lighted, and free of places of concealment.
- Apply the following restrictions If parking within a school building is required:
  - Public parking with identification (ID) check
  - School vehicles and school employees and students only
  - Selected school employees only, or those requiring security

2.8 LOADING DOCKS AND SERVICE ACCESS

Loading docks and service access areas are commonly required for a school building and are typically desired to be kept as invisible as possible. For this reason, special attention should be devoted to these service areas in order to avoid intruders. Design criteria for school loading docks and service access include the following:

- Separate by at least 50 feet, loading docks and shipping and receiving areas in any direction from utility rooms, utility mains, and service entrances, including electrical, telephone/data, fire detection/alarm systems, fire suppression water mains, cooling and heating mains, etc.
- Locate loading docks so that vehicles will not be allowed under the building. If this is not possible, the service area should be hardened for blast. Loading dock design should limit damage to adjacent areas and vent explosive forces to the exterior of the building.
- If loading zones or drive-through areas are necessary, monitor them and restrict height to keep out large vehicles.

- Avoid having driveways within or under school buildings.
- Provide adequate design to prevent extreme damage to loading docks. The floor of the loading dock does not need to be designed for blast resistance if the area below is not occupied and or does not contain critical utilities. In certain cases, significant structural damage to the walls and ceiling of the loading dock may be acceptable; however, the areas adjacent to the loading dock should not experience severe structural damage or collapse.
- Provide signage to clearly mark separate entrances for deliveries.

2.9 PHYSICAL SECURITY LIGHTING

Security lighting can be provided for overall school ground/building illumination and the perimeter to allow security personnel to maintain visual-assessment during darkness. It may provide both a real and psychological deterrent for continuous or periodic observation. Lighting is relatively inexpensive to maintain and may reduce the need for security personnel while enhancing personal protection by reducing opportunities for concealment and surprise by potential attackers.

Provide sufficient lighting at entry control points to ensure adequate lighting for the area. Where practical, place lighting elements as high as possible to give a broader, more natural light distribution. This requires fewer poles (less hazardous to drivers) and is more aesthetically pleasing than standard lighting.

The type of site lighting system used depends on the school's overall security requirements. Four types of lighting are used for security lighting systems:

- **Continuous lighting** is the most common security lighting system. It consists of a series of fixed lights arranged to flood a given area continuously during darkness with overlapping cones of light.

- **Standby lighting** has a layout similar to continuous lighting; however, the lights are not continuously lit, but are either automatically or manually turned on when suspicious activity is detected or suspected by the security personnel or alarm systems.
- **Movable lighting** consists of manually operated, movable searchlights that may be lit during hours of darkness or only as needed. The system normally is used to supplement continuous or standby lighting.
- **Emergency lighting** is a backup power system of lighting that may duplicate any or all of the above systems. Its use is limited to times of power failure or other emergencies that render the normal system inoperative. It depends on an alternative power source such as installed or portable generators or batteries. Consider emergency/backup power for security lighting as determined to be appropriate.

2.10 SITE UTILITIES

Utility systems can suffer significant damage when subjected to the shock of an explosion. Some of these utilities may be critical for safely evacuating people from the school building. Their destruction could cause damage that is disproportionate to other building damage resulting from an explosion. To minimize the possibility of such hazards, apply the following measures:

- Where possible, provide underground, concealed, and protected utilities.
- Provide redundant utility systems (particularly electrical services) to support school security, life safety, and rescue functions.
- Consider quick connects for portable utility backup systems if redundant sources are not available.
- Prepare vulnerability assessments for all utility services to the school, including all utility lines, storm sewers, gas transmission lines, electricity transmission lines, and other utilities that may cross the site perimeter.

- Protect drinking water supplies from waterborne contaminants by securing access points, such as manholes. If warranted, maintain routine water testing to help detect waterborne contaminants.
- Minimize signs identifying critical utilities. Provide fencing to prevent unauthorized access and use landscape planting to conceal aboveground systems.
- Locate petroleum, oil, and lubricants storage tanks and operations buildings downslope from all other occupied school buildings. Locate fuel storage tanks at least 100 feet from buildings.
- Consider providing utility systems with redundant or loop service, particularly in the case of electrical systems. Where more than one source or service is not currently available, provisions should be made for future connections. In the interim, consider "quick connects" at the building for portable backup systems.
- Decentralize a school's communications resources, when possible; the use of multiple communication networks will strengthen the communications system's ability to withstand the effects of a terrorist attack.
- Place trash receptacles as far away from the building as possible; trash receptacles should not be placed within 30 feet of a building.
- Provide a school-wide public address system that extends from the interior to the exterior of buildings.
- Conceal and harden incoming utility systems within schools to provide blast protection, including burial or proper encasement wherever possible.
- Locate utility systems at least 50 feet from loading docks, front entrances, and parking areas.
- Route critical or fragile utilities so that they are not on exterior walls or on walls shared with mailrooms.

- Ensure that the redundant utilities are not collocated or do not run in the same chases. This minimizes the possibility that both sets of utilities will be adversely affected by a single event.
- Ensure backup systems are located away from the systems components for which they provide backup.
- Mount all overhead utilities and other fixtures weighing 31 pounds (14 kilograms) or more to minimize the likelihood that they will fall and injure school occupants. Design all equipment mountings to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction. This standard does not preclude the need to design equipment mountings for forces required by other criteria such as seismic standards.
- Ensure that access to crawl spaces, utility tunnels, and other means of under school building access is controlled to limit opportunities for aggressors placing explosives underneath buildings.
- Screen, seal, or secure all utility penetrations of the site's perimeter to prevent their use as access points for unauthorized entry into the school site. If access is required for maintenance of utilities, secure all penetrations with screening, grating, latticework, or other similar devices.

2.11 SUMMARY OF SITE MITIGATION MEASURES

A general spectrum of site mitigation measures ranging from the least protection, cost, and effort going to the greatest protection, cost, and effort for a school site is presented below. Detailed discussions of individual measures can be found earlier in the chapter. This is a nominal ranking of mitigation measures. In practice, the effectiveness and cost of individual mitigation measures may be different for specific applications. Table 2-1 can be used by designers and school administrators to correlate the mitigation measures described in this chapter to specific terrorist threats and tactics.

Less Protection
Less Cost
Less Effort

- Place trash receptacles as far away from the school building as possible.
- Remove any dense vegetation that may screen covert activity.
- Use thorn-bearing plant materials to create natural barriers.
- Identify all critical resources in the school area (fire and police stations, hospitals, etc.) for design consideration.
- Identify all potentially hazardous facilities in the area (nuclear plants, chemical labs, etc.).
- Use temporary passive barriers to eliminate straight-line vehicular access to areas of limited access.
- Use vehicles as temporary physical barriers during elevated threat conditions.
- Make proper use of signs for traffic control, building entry control, etc. Minimize signs identifying high-risk areas.
- Identify, secure, and control access to all utility services to the school.
- Limit and control access to all school crawl spaces, utility tunnels, and other means of under building access to prevent the planting of explosives.
- Utilize GIS to assess adjacent land use.
- Provide open space inside the fence along the school perimeter.
- Locate fuel storage tanks at least 100 feet from all occupied school buildings.
- Block sight lines through building orientation, landscaping, screening, and landforms.
- Use temporary and procedural measures to restrict parking and increase stand-off.
- Locate and consolidate high-risk land uses in the interior of the school site.
- Select and design barriers based on threat levels.
- Maintain as much stand-off distance as possible from potential vehicle bombs.
- Separate backup utility systems.
- Conduct periodic water testing to detect waterborne contaminants.
- Enclose the perimeter of the school. Create a single controlled entrance for vehicles (entry control point).
- Establish law enforcement or security force presence for schools facing high threats.
- Install quick connects for portable utility backup systems.
- Install security lighting in areas where needed.
- Install CCTV cameras in areas where needed.
- Mount all equipment to resist forces in any direction.
- Include security and protection measures in the calculation of school land area requirements.
- Redesign and construct parking to provide adequate stand-off for vehicle bombs.
- Position buildings to permit occupants and security personnel to monitor the site.
- Do not site the school building adjacent to potential threats or hazards.
- Locate critical school building components away from the main entrance, vehicle circulation, parking, or maintenance area. Harden as appropriate.
- Provide a site-wide public address system and emergency call boxes at readily identified locations.
- Prohibit parking beneath or within a school building.
- Redesign and construct access points at an angle to oncoming streets.
- Designate entry points for commercial and delivery vehicles away from high-risk areas.
- In urban areas, push the perimeter out to the edge of the sidewalk by means of bollards, planters, and other obstacles. For even better stand-off, push the line even farther outward by restricting or eliminating parking along the curb, eliminating loading zones, or through street closings.
- Provide intrusion detection sensors for all utility services to the school.
- Provide backup utility systems to support school security, life safety, and rescue functions.
- Conceal and/or harden incoming utility systems.
- Install active vehicle crash barriers.

Greater Protection
Greater Cost
Greater Effort

Table 2-1 Correlation of Mitigation Measures to Threats*

■ The symbols indicate which of the protective measures shown in the left-hand column can be effective in countering the types of threats indicated across the top of the chart.

	Moving Vehicle Bomb	Stationary Vehicle Bomb	Exterior Attack	Stand-off Weapons Attack	Armed Attack	Covert Entry	Mail and Supplies Bombs	Airborne Contamination	Waterborne Contamination
LAND USE CONSIDERATIONS									
Locate high-risk land uses in the interior of the school site	■	■	■	■	■				
Consolidate high-risk land uses	■	■	■	■	■				
Include stand-off areas in land area requirements	■	■		■	■				
Consider effects of development off-property development	■	■	■		■				
SITE PLANNING									
Maximize distance from perimeter fence and developed areas	■	■	■	■	■			■	
Site critical school facilities on higher ground	■	■	■	■	■			■	■
Avoid areas with adjacent high terrain or structures			■	■	■			■	■
Avoid areas with adjacent dense vegetation			■	■	■				
Avoiding low-lying topographic areas			■	■	■			■	■
Site school facilities within view of other occupied facilities						■			
Create complexes to enhance surveillance opportunities	■	■	■	■	■				
Eliminate vehicle parking from interior of building complexes	■	■							
High surrounding terrain			■	■	■				
Distance from non-school facilities	■	■	■	■	■	■		■	■
Areas that provide concealment		■	■	■	■	■			
Earth berms		■	■	■	■				
Bodies of water	■	■	■	■	■	■			
Depressions			■	■	■				
Vehicle access	■	■							
Dense thorn-bearing vegetation			■			■			
Vegetation screens		■	■	■	■	■			
Location of trash receptacles							■		

Table 2-1: Correlation of Mitigation Measures to Threats* (continued)

	Moving Vehicle Bomb	Stationary Vehicle Bomb	Exterior Attack	Stand-off Weapons Attack	Armed Attack	Covert Entry	Mail and Supplies Bombs	Airborne Contamination	Waterborne Contamination
STAND-OFF DISTANCE									
Stand-off zone	■	■		■	■	■			
CONTROLLED ACCESS ZONES									
Exclusive zone/Non-exclusive zone	■	■				■			
Clear zone	■	■				■			
Fencing and physical barriers	■	■	■	■	■	■			
Active barriers	■	■	■	■	■	■			
Passive barriers	■	■	■			■			
ENTRY CONTROL AND VEHICULAR ACCESS									
Minimize access roads	■	■				■	■		
Control points	■	■	■	■	■	■			
Active monitoring	■	■	■	■	■	■	■	■	■
Provide enhanced protection at school entrances	■	■	■	■	■	■			
Include pull-over lanes at checkpoints to inspect vehicles	■	■	■	■	■	■			
Avoid straight-line vehicular access to high-risk areas	■	■							
Avoid straight-line entry approach roads	■	■							
Locate vehicle parking areas far from high-risk areas	■	■							
Provide separate service and delivery access	■	■							
Route major corridors away from high-risk areas	■	■		■	■				
Locate high-risk resources remote from primary roads	■	■		■	■				
Minimize directional identification signs	■	■	■	■	■	■			
Limit vehicular access to high-risk areas	■	■	■	■	■	■			
SIGNAGE									
Minimize signage	■	■	■	■	■	■	■	■	■

Table 2-1: Correlation of Mitigation Measures to Threats* (continued)

	Moving Vehicle Bomb	Stationary Vehicle Bomb	Exterior Attack	Stand-off Weapons Attack	Armed Attack	Covert Entry	Mail and Supplies Bombs	Airborne Contamination	Waterborne Contamination
PARKING									
View of parking		■							
Parking under a building		■							
Parking at interior of facility		■							
Parking near high-risk areas		■							
Parking in exclusive zone		■							
One-way circulation	■	■	■			■			
LOADING DOCKS AND SERVICE ACCESS									
Loading/unloading docks		■					■		
Driveways under facilities	■	■							
PHYSICAL SECURITY LIGHTING									
Lighting		■	■			■			
SITE UTILITIES									
Provide protection at culverts, sewers, and pipelines					■	■			■
Provide protection at concrete trenches, storm drains, and duct systems					■	■			■
Provide and check locks on manhole covers					■	■			■
Minimize signs identifying utility systems					■	■			■
Provide fencing at critical utility complexes						■			■
Use landscape planting to conceal aboveground systems						■			■
Install utilities underground	■	■	■	■	■	■	■		
Locate fuel/lube storage downslope and away from facilities	■	■	■	■	■	■	■		
Provide redundant utility systems and loop service	■	■	■	■	■	■	■		
Provide utility “quick disconnects” for portable backup systems	■	■	■	■	■	■	■		

Table 2-1: Correlation of Mitigation Measures to Threats* (continued)

	Moving Vehicle Bomb	Stationary Vehicle Bomb	Exterior Attack	Stand-off Weapons Attack	Armed Attack	Covert Entry	Mail and Supplies Bombs	Airborne Contamination	Waterborne Contamination
Decentralize communications resources	■	■	■	■	■	■	■		
Use multiple communications networks	■	■	■	■	■	■	■		
Conceal and protect network control centers	■	■	■	■	■	■	■		
Public address system			■		■			■	■
Underground utilities	■	■	■	■					■
Redundant utilities	■	■	■	■	■				■
Quick disconnects	■	■	■	■	■				
Remote fuel storage	■	■	■	■	■				

* ADAPTED FROM U.S. AIR FORCE *INSTALLATION FORCE PROTECTION GUIDE*.

2.12 CRIME PREVENTION THROUGH ENVIRONMENTAL DESIGN (CPTED)

CPTED is a crime reduction technique that has several key elements applicable to the analysis of building function and site design against physical attack. It is used by architects, city planners, landscape and interior designers, and law enforcement with the objective of creating a climate of safety in a community by designing a physical environment that positively influences human behavior. Although CPTED principles are not incorporated into the assessment process presented in this primer, it is useful to briefly discuss CPTED because it is often entwined with terrorism protection measures.

CPTED concepts have been successfully applied in a wide variety of applications, including streets, parks, museums, government

buildings, houses, and commercial complexes. The approach is particularly applicable to schools, where outdated facilities are common. Most schools in the United States were built 30 to 60 or more years ago. Security issues were almost nonexistent at the time, and technology was dramatically different. As a result, building designs are not always compatible with today's more security-conscious environment.

According to CPTED principles, depending upon purely conventional physical security measures (e.g., security guards and metal detectors) to correct objectionable student behavior may have its limitations. Although employing physical security measures will no doubt increase the level of physical security, in some cases physical security measures employed as stand-alone measures may lead to a more negative environment, thereby enhancing violence. In short, employing stand-alone physical security measures may fail to address the underlying behavioral patterns that adversely affect the school environment. CPTED analysis focuses on creating changes to the physical and social environment that will reinforce positive behavior.

CPTED builds on three strategies:

- Territoriality (using buildings, fences, pavement, sign, and landscaping to express ownership)
- Natural surveillance (placing physical features, activities, and people to maximize visibility)
- Access control (the judicial placement of entrances, exits, fencing, landscaping, and lighting)

A CPTED analysis of a school evaluates crime rates, office-referral data, and school cohesiveness and stability, as well as core design shortcomings of the physical environment (e.g., blind hallways, uncontrolled entries, or abandoned areas that attract problem behavior). The application of CPTED principles starts with a threat and vulnerability analysis to determine the potential for attack and what needs to be protected. Protecting a school from physical

attack by criminal behavior or terrorist activity, in many cases, only reflects a change in the level and types of threats. The CPTED process asks questions about territoriality, natural surveillance, and access control that can:

- Increase the effort to commit crime or terrorism
- Increase the risks associated with crime or terrorism
- Reduce the rewards associated with crime or terrorism
- Remove the excuses as to why people do not comply with the rules and behave inappropriately

The CPTED process provides direction to solve the challenges of crime and terrorism with organizational (people), mechanical (technology and hardware), and natural design (architecture and circulation flow) methods.

CPTED concepts can be integrated into expansion or reconstruction plans for existing buildings as well as new buildings. Applying CPTED concepts from the beginning usually has minimal impact on costs, and the result is a safer school. Each school, district, and community should institute measures appropriate for their own circumstances because there is no a single solution that will fit all schools.

Many CPTED crime prevention techniques for a school complement conventional terrorism and physical attack prevention measures. For example, as part of the CPTED strategy of improving territoriality, schools are encouraged to direct all visitors through one entrance that offers contact with a receptionist who can determine the purpose of the visit and the destination, and provide sign-in/sign-out and an ID tag prior to building access. These CPTED measures are similar to and complement physical security entry control point stations.

However, in some cases, CPTED techniques can conflict with basic physical security principles. The CPTED strategy of natural surveillance calls for locating student parking in areas that allow ease

of monitoring. A design that locates student parking close to the principal's office also reduces vehicle stand-off and could create a vulnerability of the school structure to a vehicle bomb. In cases where CPTED techniques conflict with security principles, designers and school administrators should seek innovative solutions tailored to their unique situation.