Buildings and Infrastructure Protection Series

Primer

to Design Safe School Projects in Case of Terrorist Attacks and School Shootings

FEMA-428/BIPS-07/January 2012
Edition 2

Homeland Security
Science and Technology

Buildings and Infrastructure Protection Series

Primer

to Design Safe School Projects in Case of Terrorist Attacks and School Shootings

FEMA-428/BIPS-07/January 2012
Edition 2

Homeland Security
Science and Technology

FEMA

Foreword and Acknowledgments

Background

This publication, part of the new Building and Infrastructure Protection Series (BIPS) published by the DHS Science and Technology Directorate (S&T) Infrastructure Protection and Disaster Management Division (IDD), serves to advance high performance and integrated design for buildings and infrastructure. This manual was prepared as a component of the S&T program for infrastructure protection and disaster management; the overall goal of this program is to enhance the physical resistance of our Nation's buildings and infrastructure to manmade and natural hazards to meet specific performance requirements at the highest possible level.

This is the Second Edition of a publication developed by the Federal Emergency Management Agency (FEMA) as part of the Risk Management Series known as: FEMA 428, *Primer to Design Safe School Projects in Case of Terrorist Attacks*. This publication (hereafter primer) revises and expands the original 2003 edition with updated risk assessment techniques, protective measures, emerging technologies, and discussion of the threat of school shootings.

> The purpose of this primer is to provide the design community and school administrators with the basic principles and techniques to make a school safe from terrorist attacks and school shootings and at the same time ensure it is functional and aesthetically pleasing.

The purpose of this primer is to provide the design community and school administrators with the basic principles and techniques to make a school safe from terrorist attacks and school shootings and at the same time ensure it is functional and aesthetically pleasing, and meets the needs of the students, staff, administration, and general public. Protecting a school building and grounds from physical attack is a significant challenge because the design, construction, renovation, operation, and maintenance of a facility must consider numerous building users, infrastructure systems, and building design codes.

As of fall 2010, approximately 75.9 million people were projected as enrolled in public and private schools at all levels including elementary, secondary.

Schools are an integral part of every community in the United States. As of fall 2010, approximately 75.9 million people were projected as enrolled in public and private schools at all levels including elementary, secondary (See Figure 1), and postsecondary degree-granting. In addition, the number of professional, administrative, and support staff employed in educational institutions was projected at 5.4 million (U.S. Department of Education 2010). Additionally, schools serve as resources for their communities. Many schools are used as shelters, command centers, or meeting places in times of crisis. Schools are also used widely for polling and voting functions. In some communities, schools are places of health care delivery. Consequently, ensuring the safety of students, faculty, and staff in our schools, as well as the safety of the school buildings themselves, is critically important. Schools may or may not be the targets of terrorism, but they are certain to be affected by terrorism, whether directly or indirectly.

Figure 1:
An American high school

On September 11, 2001, four elementary schools and three high schools located within six blocks of the World Trade Center were just beginning classes when the first plane hit the North Tower. Thousands of children were exposed to the dust clouds from the collapsing buildings. Even those children not in the immediate vicinity experienced a great deal of anxiety. Children in at least three States (New York, New Jersey, and Connecticut) had parents working in or around the World Trade Center that day. In the Washington, DC, area, school children faced similar situations after the Pentagon was attacked (CDC 2003).

Many Americans feel that schools should be the safest place our children can be, perhaps at times even safer than the homes in which they live. Security is not a standalone capability; it is a critical design consideration that should be continually reviewed and scrutinized from the design phase through construction or rehabilitation and into building use.

Many Americans feel that schools should be the safest place our children can be, perhaps at times even safer than the homes in which they live.

The focus of this primer is on the threats posed by potential physical attacks on a school by terrorists and active shooters. Attacks on schools and school children are highly emotional and high profile events. At the time of publication of this primer, there has been no direct terrorist attack or credible threats against a school in the United States; however, schools could be indirectly threatened by collateral damage from a terrorist attack directed at nearby facilities. Protecting a school against terrorist attack or active shooter is a challenging task. A school may have considerable vulnerabilities, because of its well defined periods of use, designated access points, storage of sensitive personal information, minimal security forces, and numerous avenues of penetration and escape for attackers.

The focus of this primer is on the threats posed by potential physical attacks on a school by terrorists and active shooters.

This specific primer is a companion volume to FEMA P-424, *Design Guide for Improving School Safety in Earthquakes, Floods and High Winds* (2010). In dealing with the protection of school buildings from terrorist threats, this primer is also a companion to BIPS 06 (Formerly FEMA 426), R*eference Manual to Mitigate Potential Terrorist Attacks Against Buildings*. Where BIPS 06 deals with all building types and occupancies, this primer focuses on a single facility type with a very specific occupancy and vulnerability.

Scope

This primer presents an approach to protecting schools at risk of terrorist attacks and school shootings. The information presented is intended primarily for school administrators, planners, architects, engineers, and other building science professionals. The primer is designed to meet the needs of all schools, including those with serious security concerns. Because security concerns of individual schools vary greatly, some users with modest security concerns may feel beleaguered by the amount of information and technical approach presented. They should feel free to select the methods and measures that best meet their individual situations while gaining a general appreciation of security concerns and risk management.

> This primer presents an approach to protecting schools at risk of terrorist attacks and school shootings.

Several design philosophies and techniques have been incorporated into this primer, including the U.S. Department of Defense (DoD) Minimum Antiterrorism Standards, the U.S. Army and Air Force Security Engineering Manual, the General Services Administration (GSA) Public Building Standards, the Department of Veterans Affairs (VA) Building Vulnerability Assessment Checklist, and the Centers for Disease Control and Prevention (CDC)/National Institute for Occupational Safety and Health (NIOSH) Guidelines for Airborne Contaminants.

Organization and Content of the Primer

This publication contains many how-to aspects based upon current information contained in FEMA, Department of Commerce, DOD (including Army, Navy, and Air Force), Department of Justice, GSA, VA, CDC/NIOSH, and other publications. It is intended to provide an understanding of the current methodologies for assessing threat/hazard, vulnerability, and risk, and the design considerations needed to improve protection of new and existing buildings and the people occupying them. As needed, this primer should be supplemented with more extensive technical resources as well as the advice of experts.

- **Chapter 1** discusses the key aspects of security risk management with an emphasis on risk assessments. It introduces two methodologies developed by S&T that can be used for the assessment of school risks, but focuses primarily on the method based on FEMA 452, Risk Assessment: A How-To Guide to Mitigate Potential Terrorists Attacks (2005). The methodology will assist schools in performing risk management by helping them to identify the best and most cost-effective terrorism mitigation measures for their unique security needs.

- **Chapter 2** discusses comprehensive architectural and engineering design considerations (protective measures) for the school site, from the property line to the school building, including land use, site planning, standoff distance, controlled access zones, entry control and vehicular access, signage, parking, loading docks, and service access.
- **Chapter 3** reviews a number of shooting incidents from the past in an attempt to highlight the vulnerabilities that contributed to these tragic events. Using the lessons learned from these case studies, the chapter proposes a series of protective measures to address school vulnerabilities and increase their resilience to threats of this kind.
- **Chapter 4** discusses blast effects, potential school damage, injuries, levels of protection, standoff distance, and specific blast design concerns together with recommended protective measures.
- **Chapter 5** presents general information and practical measures for preventing, responding to, and minimizing the effects of toxic releases and describes architectural, mechanical, and electrical features that can be applied in new construction or retrofit of school buildings to yield better protection.

Chapter 1 discusses the key aspects of security risk management with an emphasis on risk assessments.

Chapter 2 discusses comprehensive architectural and engineering design considerations for the school site,

Chapter 3 reviews a number of shooting incidents from the past in an attempt to highlight the vulnerabilities that contributed to these tragic events.

Chapter 4 discusses blast effects.

Chapter 5 presents general information and practical measures for preventing, responding to, and minimizing the effects of toxic releases.

Additionally, seven appendices provide supplemental information and a list of references. The appendices contain:

- **Appendix A:** Acronyms
- **Appendix B:** General Glossary
- **Appendix C:** CBR Agent Characteristics
- **Appendix D:** References
- **Appendix E:** Associations and Organizations
- **Appendix F:** School Vulnerability Assessment Checklist

Acknowledgements

Project Officer

Milagros Kennett, Senior Program Manager, Lead High Performance and Resilience Program, Department of Homeland Security, Science and Technology Directorate.

Principal Authors

Michael Chipley, PMC Group

Wesley Lyon, UTD, Inc.

Robert Smilowitz, Weidlinger Associates, Inc.

Pax Williams, Battelle Memorial Institute

Christopher Arnold, Building Systems Development, Inc.

William Blewett, Battelle Eastern Science and Technology Center

Lee Hazen, Eagle Security Group

Fred Krimgold, Virginia Tech

Review Committee Members

Steve Cauffman, National Institute of Standards and Technology

Mohammed Ettouney, Weidlinger Associates, Inc.

Gwainevere Hess, Department of Homeland Security

Mary Ellen Hynes, Deparment of Homeland Security

Michael Kaminskas, Raytheon UTD, Inc.

Earle Kennett, National Institute of Building Sciences

Kurt Knight, Department of Veteran Affairs

Eric Letvin, URS Group, Inc.

Jim Rossberg, American Society of Civil Engineers

Philip Schneider, National Institute of Building Sciences

Andrea Schultz, Department of Homeland Security

Lloyd Siegel, Department of Veteran Affairs

John Sullivan, Portland Cement Association

Tom Walton, Department of Homeland Security

Technical Editors

Bogdan Srdanovic, APS Consulting

Ivy Porpotage, URS Group, Inc.

Richard Walker Jr., URS Group, Inc.

Graphic Designer

Wanda L. Rizer, Design4Impact

Learn More:

http://www.dhs.gov/files/programs/high-performance-integrated-design-program.shtm

http://www.dhs.gov/files/programs/scitech-bips-tools.shtm

Table of Contents

Contents

Appendices

Figures

Chapter 2

Tables

1

Risks for Schools

In this chapter:

This chapter discusses the key aspects of security risk management with an emphasis on risk assessments. It introduces two methodologies developed by U.S. Department of Homeland Security (DHS) Science and Technology (S&T) Directorate that can be used for the assessment of school risks, but focuses primarily on the method based on FEMA 452, *Risk Assessment: A How-To Guide to Mitigate Potential Terrorists Attacks* (2005). Given the specific nature of educational facilities, this primer includes a customized checklist for schools.

Although school building designs have evolved dramatically over the years, schools continue to be open and accessible places that offer opportunities for study, work, and play. Unfortunately, the openness and inviting environment of schools create opportunities for intruders with malicious intent. Violent attacks on students and teachers in the Nation's schools are extremely rare events, but their effects frequently, and understandably, have far-reaching consequences. Most parents' anxieties are not assuaged by statistics showing low probabilities of serious incidents. Consequently, security at schools has become a subject of widespread public concern. Introducing security requirements as part of school design requires a comprehensive approach to balance many different objectives, such as reducing risks, maintaining open access for students and staff, facilitating proper building function, conforming to aesthetic principles, hardening of physical structures beyond the required buildings codes and standards, and maximizing the use of nonstructural systems.

The management of risk of extreme events that may affect a school, such as terrorist attacks and technological or other manmade disasters, is a process that includes activities to both identify the risks and respond to them.

This chapter discusses the key aspects of security risk management with an emphasis on risk assessments. It introduces two methodologies developed by U.S. Department of Homeland Security (DHS) Science and Technology (S&T) Directorate that can be used for the assessment of school risks, but focuses primarily on the method based on FEMA 452, *Risk Assessment: A How-To Guide to Mitigate Potential Terrorists Attacks* (2005). Given the specific nature of educational facilities, this primer includes a customized checklist for schools.

1.1 Risk Management

The management of risk of extreme events that may affect a school, such as terrorist attacks and technological or other manmade disasters, is a process that includes activities to both identify the risks and respond to them. In addition to the process of risk assessment described below, risk management comprises mitigation, preparedness, and response. Rather than focusing on individual aspects of a particular threat or hazard, risk management employs a comprehensive approach to managing intentionally or accidentally caused extreme events, with the intention of reducing risks by addressing all the factors that contribute to that risk.

Although comprehensive risk management guidance is beyond the purview of this primer, understanding the role and significance of each of its components is important. The decisions that affect the security of schools are made at various levels of government and school administration and are based on a variety of criteria. The last portion of this chapter addresses some of the questions and dilemmas that decisionmakers face.

The ultimate objective of the risk assessment process is to find the most effective mitigation measures to achieve a desired level of protection against terrorist and other kinds of attacks.

1.2 Risk Assessment

This section presents methodologies for school administrators, planners, architects, engineers, and other building science professionals to identify and quantify the security risks to which a school may be exposed. The ultimate objective of the risk assessment process is to find the most effective mitigation measures to achieve a desired level of protection against terrorist and other kinds of attacks. These methodologies will help both school administrators and designers to define and evaluate threats, consequences, and vulnerabilities for the purpose of integrating the security risks into an effective design strategy. Understanding the risks will help school administrators prioritize their mitigation activities and allocate their resources accordingly, and will help architects, engineers, and security experts identify the most cost-beneficial protective measures to reduce the risk for a school's unique security needs. The methodologies described in this chapter can be used during the design process for new and existing school buildings that are undergoing renovation.

The first part of this section describes the latest risk assessment methodology, called Integrated Rapid Visual Screening (IRVS), devised by the S&T Directorate. The remaining parts of this section describe the risk assessment methodology described in FEMA 452.

1.2.1 Integrated Rapid Visual Screening

The S&T Directorate has developed an IRVS procedure for assessing risks to all types of buildings from natural and manmade hazards with the potential to cause catastrophic losses. The procedure is an enhanced version of the screening process described in FEMA 455, *Handbook for Rapid Visual Screening of Buildings to Evaluate Terrorism Risk* (2009), and includes improvements to the methodology, updates to the catalog of building characteristics, and updates to the forms to incorporate natural hazards, building types, and critical functions. IRVS has become a very popular tool, mainly because of its simplicity and accuracy, for conducting pre-assessments of schools' susceptibility to threats and hazards.

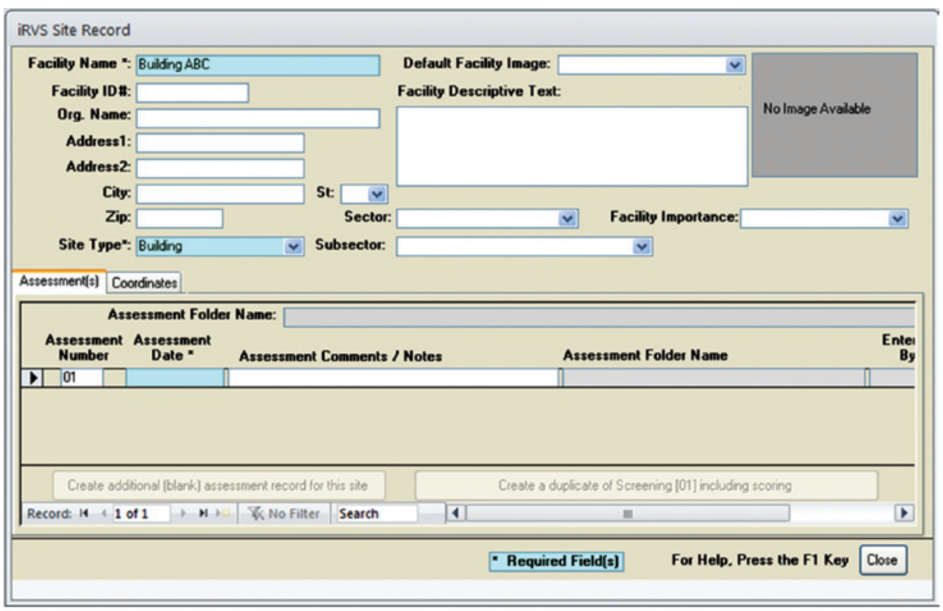
The IRVS procedure was developed to assess risks to all types of buildings from natural and manmade hazards with the potential to cause catastrophic losses.

IRVS is a quick assessment tool for obtaining a preliminary risk assessment rating.

IRVS is a quick assessment tool for obtaining a preliminary risk assessment rating. The natural and manmade hazards considered in the tool include: internal and external explosive attacks; ballistic attacks; external chemical, biological, and radiological (CBR) releases; earthquakes; high winds; floods; landslides; and fires. Risk is determined by evaluating key building characteristics to identify threats, consequences, and vulnerabilities. Experts can use the information from the visual inspection to support higher level assessments and analysis of mitigation options.

The latest improvements to the IRVS database software have made the IRVS methodology completely digital (Figure 1-1). The software facilitates data collection and functions as a data management tool. Assessors can use the software on a PC tablet or laptop to collect, store, and report screening data systematically. The software can be used during all phases (pre-field, field, and post-field) of the IRVS procedure. For more information on IRVS, please visit the S&T Directorate's Web site for Building and Infrastructure Protection Tools: http://www.dhs.gov/files/programs/scitech-bips-tools.shtm#4.

Figure 1-1: IRVS database



The IRVS tool is the first and only software to quantify a building's overall risk score in terms of a 1) resilience score and 2) a multi-hazard risk score based on a few hours of guided screening guided using the IRVS tool. Scoring for risk and resilience is based on a methodology that uses built-in weights and predefined algorithms for final scoring.

Resilience Score: Resilience is computed using three basic components—robustness, resourcefulness, and recovery (the 3 R's)—based on downtime and operational capacity (Figure 1-2). Analysis of continuity of operations and operational resilience are key to determining the resilience of the building.

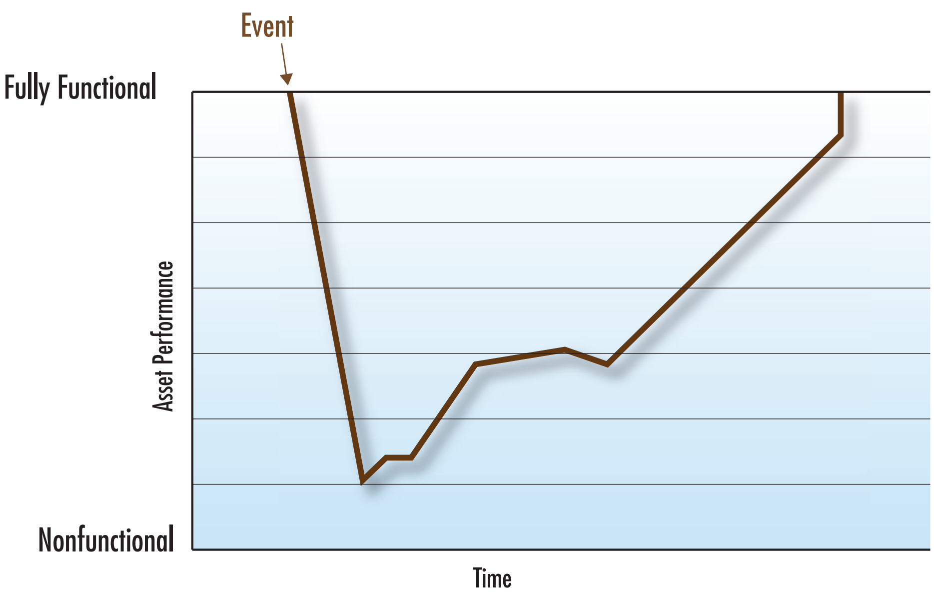


Figure 1-2:
Example of resilience

Multi-Hazard Risk Score: IRVS methodology determines the level of risk to a building from both natural and manmade hazards. A list of these hazards is provided in Table 1-1.

Table 1-1: IRVS Threat Types and Scenarios

Threat Type	Threat Scenario
Internal Attack	Explosive Attack
	CBR Release
	Intrusion
External Explosive Attack	External Zone I Explosive Attack
	External Zone II Explosive Attack
	External Zone III Explosive Attack
External CBR Release	External Zone I CBR Release
	External Zone II CBR Release
	External Zone III CBR Release
Earthquake	Ground Shaking
	Ground Failure
Flooding	Stillwater
	Velocity Surge

Threat Type	Threat Scenario
Wind	Hurricane (Wind and Water)
	Tornado
	Other High Wind
Landslide	Rainfall
Fire	Resulting from Earthquake
	Resulting from Blast
	Arson or Incidental

Note: Zone I is within 100 feet of the building; Zone II is from 100 to 300 feet of the building; and Zone III is from 300 to 1000 feet of the building.

One or two screeners can conduct and complete a screening in 1 to 5 hours. The IRVS operates on Microsoft (MS) Access 2007 with support from MS Excel 2007 and MS Word 2007, as well as PDF files. The software tool facilitates data collection and data management functions. Screeners use the software tool on a PC tablet or laptop to collect, store, and report screening data. The software tool can be used during all phases of the IRVS procedure (pre-field, field, and post-field). Data collected during the screening are transferred to a database and stored as individual records, which are used to compute the risk score.

One or two screeners can conduct and complete a screening in 1 to 5 hours.

The digital catalog guides the user through each of the screening questions.

The digital catalog guides the user through each of the screening questions in the assessment with background information to assist with answering the question. Screeners will need to become familiar with the catalog to maintain accuracy and consistency from one assessment to another. The reliability and quality of the screening depends on the amount of time devoted and the quality of information collection. The reliability and quality can be increased if screeners verify structural, mechanical, and security features, perform interior inspections, conduct interviews with security and other key personnel, and review drawings and security operation manuals.

The final product provides a color-coded legend, and a number of scores (risk, resiliency, threat, vulnerability, consequence, etc.).

The final product provides a color-coded legend, and a number of scores (risk, resiliency, threat, vulnerability, consequence, etc.) in whole numbers. The tool also allows the assessor to duplicate the assessment and add additional countermeasures to demonstrate to tenants what effect a countermeasure will have on an overall score.

FEMA 455 describes a rapid visual screening procedure, effectively a "Pre-Tier 1" assessment. The assessment is designed to be conducted by one or two screeners and, depending on the level of effort and access to building information, can be completed in as little as a few hours or as much as 2 days. The S&T Directorate has expanded FEMA 455 to include natural hazards with the development of IRVS.

FEMA 452 outlines methods for identifying the critical assets and functions within buildings, determining the threats to those assets, and assessing the vulnerabilities associated with those threats. Tier 1 is a "70 percent" assessment, while Tier 2 represents a "90 percent" assessment solution.

IRVS facilitates the comparison of the national building inventory independent of the region, multihazard exposure, and type of building. These results can be used to prioritize buildings for further assessment or mitigation, allowing for an efficient allocation of resources. IRVS is also intended to be used to identify the level of risk and resilience for a facility, as the basis for prioritization for further risk management activities and to support higher level assessments and mitigation options by experts.

1.2.2 Risk Assessment Based on FEMA 452

The main goal of the FEMA 452 approach is to help identify most cost-beneficial (in terms of effectiveness) protective measures for a school building's unique safety and security needs. Figure 1-3 depicts the risk assessment process model from which FEMA 452 methodology and its components originated. Section 1.2.2.1 describes how to identify and define the main threats and hazards to which a school may be exposed. Section 1.2.2.2 discusses the potential magnitude of losses of assets, such as people, buildings, equipment, and functions, recognizing that students, faculty, and staff will always be a school's most vital asset requiring protection. Section 1.2.2.3 discusses how to perform a vulnerability assessment to identify weaknesses that might exacerbate losses and could be exploited by a terrorist or attacker. The final step in the process is risk analysis, discussed in Section 1.2.2.4, which combines the results of the threat, consequences, and vulnerability assessments to determine the degree of the school's risk exposure.

Risk assessment of a school is best performed by security professionals who are experts in risk management, building design, blast effects, and CBR incidents, as well as the latest law enforcement and antiterrorism security measures. If hiring professionals is not feasible, members of the design community and/or school administrators can perform an assessment using the methodology presented in this primer. A key tool in the assessment process, the School Vulnerability Assessment Checklist, is provided in Appendix F.

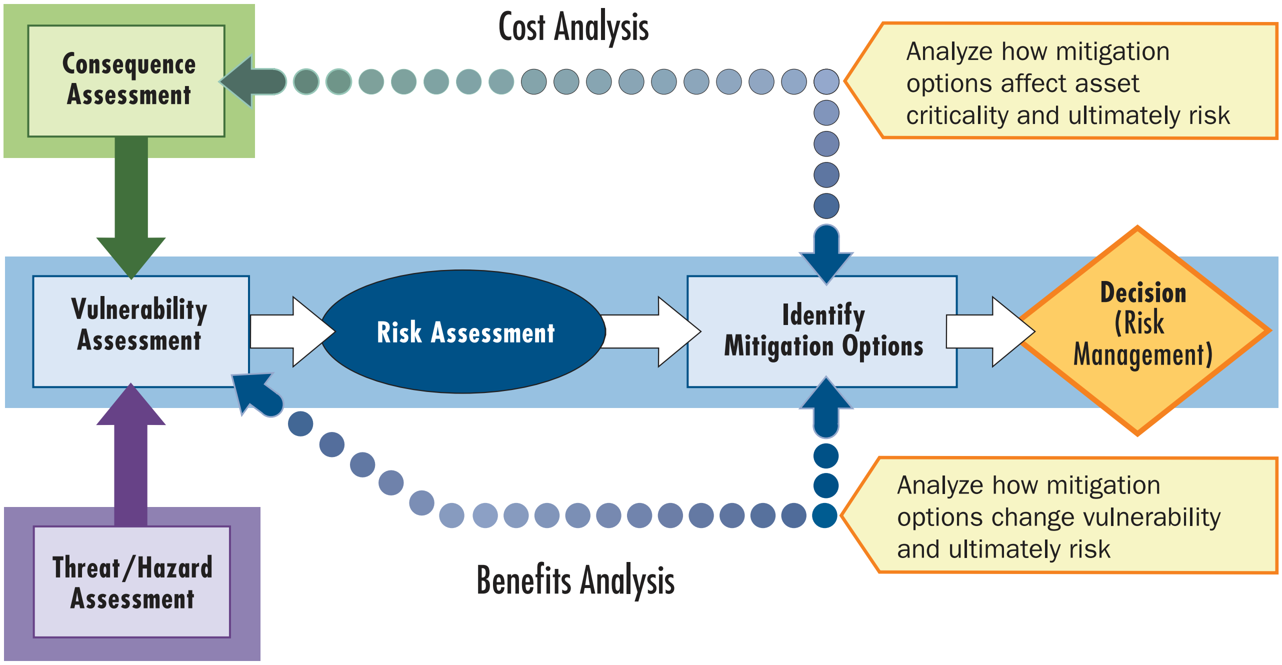


Figure 1-3: Risk assessment process model

1.2.2.1 Threat Assessment

The threat originates from people or organizations that have both the intent and capability to do harm. They may seek publicity for their cause or political gain through their actions to injure or kill people, or to destroy or damage facilities, property, equipment, or resources. For purposes of risk assessment and mitigation of risk, knowing how a school might be attacked is more important than by whom or why. When a risk assessment is conducted for a particular school, defining threats in terms of the types of attacks that may be expected is more useful than attempting to identify the attackers or the reasons why they would want to attack a particular school. Consequently, the methodology for threat analysis and risk assessment proposed in this primer focuses on threats defined as attack types regardless of their origin or cause.

In addition to intentional attack types of threats, this primer also considers various types of hazards. Hazards are defined in several contexts: natural, manmade, or technological. Natural hazard typically refers to a source of harm or difficulty created by a meteorological, environmental, or geological phenomenon or combination of phenomena, such as earthquakes, flooding, fires, lightning, and winds that can affect a school. Manmade hazards, or technological hazards, and terrorism are distinguished from natural hazards in that they originate from human activity. Technological hazards are generally assumed to be accidental and their consequences unintended, while the willful harmful human activities are described as “threats.” For the sake of simplicity, this primer will use the term “threat” for intentional acts and “hazard” when referring to natural hazards and technological accidents respectively.

Risk assessment starts with the identification and definition of threats and tactics that may be employed in an attack.

FEMA 452 methodology is devoted to the compilation and analysis of available information concerning threats and technological hazards. Risk assessment starts with the identification and definition of threats and tactics that may be employed in an attack. Schools are typically site-constrained, have well defined traffic control and entry points, and operate on standard schedules. Designers and school administrators need to evaluate attack objectives, threat event profiles, and the potential effects of the attack on the school and its occupants. Table 1-2 provides a broad spectrum of manmade threats/hazards to consider and can be used as a tool in the threat assessment process. An extensive list of potential chemical and biological agents that can be used in terrorist attacks is provided in Appendix C. Explosive blast effects are discussed in Chapter 4.

Table 1-2: Event Profiles for Terrorism and Technological Hazards

Threat/Hazard	Application Mode	Duration	Extent of Effects; Static/Dynamic	Mitigating and Exacerbating Conditions
Improvised Explosive Device (Bomb) • Stationary Vehicle • Moving Vehicle • Mail • Supply • Thrown • Placed • Suicide Bomber	Detonation of explosive device on or near target; via person, vehicle, or projectile.	Instantaneous; additional secondary devices may be used, lengthening the duration of the threat/hazard until the attack site is determined to be clear.	Extent of damage is determined by type and quantity of explosive. Effects generally static other than cascading consequences, incremental structural failure, etc.	Blast energy at a given stand-off is inversely proportional to the cube of the distance from the device; thus, each additional increment of stand-off provides progressively more protection. Exacerbating conditions include ease of access to target; lack of barriers/shielding; poor construction; and ease of concealment of device.
Armed Attack • Ballistics (small arms) • Stand-off Weapons (rocket propelled grenades, mortars	Tactical assault or sniper attacks from a remote location.	Generally minutes to days.	Varies, based upon the perpetrator’s intent and capabilities.	Inadequate security can allow easy access to target, easy concealment of weapons, and undetected initiation of an attack.

Threat/Hazard	Application Mode	Duration	Extent of Effects; Static/Dynamic	Mitigating and Exacerbating Conditions
Chemical Agent • Blister • Blood • Choking/ Lung/ Pulmonary • Incapacitating • Nerve • Riot Control/ Tear Gas • Vomiting	Liquid/aerosol contaminants can be dispersed using sprayers or other aerosol generators; liquids vaporizing from puddles/ containers; or munitions.	Chemical agents may pose viable threats for hours to weeks, depending on the agent and the conditions in which it exists.	Contamination can be carried out of the initial target area by persons, vehicles, water, and wind. Chemicals may be corrosive or otherwise damaging over time if not remediated.	Air temperature can affect evaporation of aerosols. Ground temperature affects evaporation in pools of liquids. Humidity can enlarge aerosol particles, reducing the inhalation hazard. Precipitation can dilute and disperse agents, but can spread contamination. Wind can disperse vapors, but also cause target area to be dynamic. The micro-meteorological effects of buildings and terrain can alter travel and duration of agents. Shielding in the form of sheltering in place may protect people and property from harmful effects for a limited time.
Biological Agent • Anthrax • Botulism • Brucellosis • Plague • Smallpox • Tularemia • Viral Hemorrhagic Fevers • Toxins (Botulinum, Ricin, Staphylococcal Enterotoxin B, T-2 Mycotoxins)	Liquid or solid contaminants can be dispersed using sprayers/ aerosol generators or by point or line sources such as munitions, covert deposits, and moving sprayers. May be directed at food or water supplies.	Biological agents may pose viable threats for hours to years, depending on the agent and the conditions in which it exists.	Depending on the agent used and the effectiveness with which it is deployed, contamination can be spread via wind and water. Infection can be spread via human or animal vectors.	Altitude of release above ground can affect dispersion; sunlight is destructive to many bacteria and viruses; light to moderate winds will disperse agents, but higher winds can break up aerosol clouds; and the micro-meteorological effects of buildings and terrain can influence aerosolization and travel of agents.
Radiological Agent • Alpha • Beta • Gamma	Radioactive contaminants can be dispersed using sprayers/ aerosol generators, or by point or line sources such as munitions, covert deposits, and moving sprayers.	Contaminants may remain hazardous for seconds to years, depending on material used.	Initial effects will be localized to site of attack; depending on meteorological conditions, subsequent behavior of radioactive contaminants may be dynamic.	Duration of exposure, distance from source of radiation, and the amount of shielding between source and target determine exposure to radiation.
Cyber Attacks	Electronic attack using one computer system against another.	Minutes to days.	Generally no direct effects on built environment.	Inadequate security can facilitate access to critical computer systems, allowing them to be used to conduct attacks.

Threat/Hazard	Application Mode	Duration	Extent of Effects; Static/Dynamic	Mitigating and Exacerbating Conditions
High-Altitude Electromagnetic Pulse (HEMP)	An electromagnetic energy field produced in the atmosphere by the power and radiation of a nuclear explosion. It can overload computer circuitry with effects similar to, but causing damage much more swiftly than a lightning strike.	It can be induced hundreds to a few thousand kilometers from the detonation.	Affects electronic systems. There is no effect on people. It diminishes with distance, and electronic equipment that is turned off is less likely to be damaged.	To produce maximum effect, a nuclear device must explode very high in the atmosphere. Electronic equipment may be hardened by surrounding it with protective metallic shielding that routes damaging electromagnetic fields away from highly sensitive electrical components.
High Power Microwave (HPM) Electromagnetic Pulse	It is a non-nuclear radio frequency energy field. Radio frequency weapons can be hidden in an attaché case, suitcase, van, or aircraft. Energy can be focused using an antenna, or emitter, to produce effects similar to HEMP, but only within a very limited range.	An HPM weapon has a shorter possible range than HEMP, but it can induce currents large enough to melt circuitry, or it can cause equipment to fail minutes, days, or even weeks later. HPM weapons are smaller-scale, are delivered at a closer range to the intended target, and can sometimes be emitted for a longer duration.	Vulnerable systems include electronic ignition systems, radars, communications, data processing, navigation, electronic triggers of explosive devices. HPM capabilities can cause a painful burning sensation or other injury to a person directly in the path of the focused power beam, or can be fatal if a person is too close to the microwave emitter.	Very damaging to electronics within a small geographic area. A shockwave could disrupt many computers within a 1-mile range. Radio frequency weapons have ranges from tens of meters to tens of kilometers. Unlike HEMP, however, HPM radiation is composed of shorter wave forms at higher-frequencies, which make it highly effective against electronic equipment and more difficult to harden against.

Note: Cyber attack focuses on denial of service, worms, and viruses designed to attack or destroy critical infrastructure related systems such as energy management, supervisory control and data acquisition systems, security, control valves, and voice over internet protocol telephones, which are critical systems that support multiple functions and are becoming increasingly connected to the internet.

Identification and Quantification of Threats

A threat is any indication, circumstance, or event with the potential to inflict harm and cause losses. A complete description of the threats to which a school may be exposed requires consideration of every mode of attack separately. In practice, focusing on a limited number of representative attack types that are most common, such as active shooter types of attack, attacks with explosive devices, or CBR types of attack, may suffice. The likelihood that any particular threat will be used against the school must be assessed based on the best information available.

> A threat is any indication, circumstance, or event with the potential to inflict harm and cause losses.

Unlike historical and quantitative data available on natural hazards, data for manmade hazards may be scarce and are often largely subjective. This is especially true for threats, which are by their very nature volatile and unpredictable. In most cases in the past, schools were attacked by people closely associated with that facility, such as students or school employees. However, the possibility that schools may be used as proxy targets by attackers that are not in any way related to that school should not be disregarded. The shocking nature of attacks on school children reverberates through a society and may be a sufficient incentive for unscrupulous attackers to try to inflict as much harm as possible.

Once the potential threats/hazards have been identified and defined, the ways these threats/hazards may be realized must be identified and analyzed. Understanding the nature of the threat is not enough—how will that threat be deployed is equally, if not more, important. Most planned attacks usually include advance surveillance, forced entry, in secrecy or by an open attack, or remote activation of a variety of weapons. The attack weapons can include incendiary devices, small arms (rifles and handguns), standoff military-style weapons (rocket-propelled grenades or mortars), explosives, and CBR devices, individually or combined with explosives to aid in dispersion.

Threat Rating

Once a list of potential threats or attack scenarios is compiled, the likelihood that these attacks may take place at that particular location should be considered. In case of threats, the likelihood of occurrence is not easily defined and involves many uncertainties that affect risk assessment decisions. The source of these uncertainties is our imperfect knowledge of the potential attacker's existence, capability, history, intention, or targeting. Often, information is sketchy and analysts must rely on the subjective judgment of experts to help estimate the likelihood of a particular type of attack. School authorities do not have the capability to conduct their own terrorist threat analysis, and should use the recommendations of experts and their own judgment to estimate the probabilities and assign ratings to various attack types or attack scenarios.

Table 1-3 provides a scale to help with this determination. The scale is a combination of a 7-level nominal scale and a 10-point numerical scale (10 being the greatest threat). The key elements of the scale are the likelihood/credibility of a threat, potential weapons to be used during a terrorist attack, and information available to decisionmakers. Given the extreme volatility of these threat characteristics, and the difficulties in managing them, this primer focuses on the other components of risk, in particular the vulnerabilities of school facilities.

Table 1-3: Threat Rating Scale

THREAT RATING		
Very High	10	Known aggressors or hazards highly capable of causing loss of, or damage to, the school exist. One or more vulnerabilities are present. The aggressors are known or highly suspected of having the intent to exploit the school's assets and are known or highly suspected of performing surveillance on a facility.
High	8–9	Known aggressors or hazards capable of causing loss of, or damage to, the school exist. One or more vulnerabilities are present and the aggressors are known or reasonably suspected of having the intent to exploit the school's assets.
Medium High	7	Known aggressors or hazards capable of causing loss of, or damage to, the school exist. One or more vulnerabilities are present and the aggressor is suspected of having the intent to exploit the school's assets.
Medium	5–6	Known aggressors or hazards that may be capable of causing loss of, or damage to, the school exist. One or more vulnerabilities may be present; however, the aggressors are not believed to have the intent to exploit the school's assets.
Medium Low	4	Known aggressors or hazards that may be capable of causing loss of, or damage to, the school exist. Aggressors have no intent to exploit the school's assets.
Low	2–3	Few or no aggressors or hazards exist. Their capability of causing damage to the school's assets is doubtful.
Very Low	1	No aggressors or hazards exist.

1.2.2.2 Consequences Assessment

Consequences are the adverse effects of a terrorist attack (or a hazard event) and reflect the nature and severity of losses sustained as a result of such an incident. The assessment of consequences of an attack on a school is a process of estimating the magnitude and type of damage or loss sustained as a result of that attack. Consequences can be expressed in terms of fatalities, injuries, property damage, economic losses, or other types of adverse effects such as psychological or social impacts. In the wake of some incidents, the immediate losses reverberate through the society, triggering indirect or secondary losses, which can be far reaching and sometimes even more devastating than the direct losses. This is particularly true in cases of senseless violence against school children as evidenced by the Columbine and Beslan attacks (see Chapter 3). This primer focuses on the direct or immediate consequences—the effects on human health and safety and the direct physical effects of the attack on the targeted school and its various assets.

Consequences are the adverse effects of a terrorist attack (or a hazard event) and reflect the nature and severity of losses sustained as a result of such an incident.

Estimating consequences is by its very nature fraught with uncertainties. Although considerable knowledge base exists today about the effects of various types of weapons on people and structures, the accuracy in estimating consequences is still largely dependent on the situation and conditions at the target at the time of an incident. For example, an explosion or a fire outburst, or the release of airborne toxic chemical, whether accidental or intentional, will have different consequences depending on the physical circumstances, such as timing, occupancy, wind direction, air temperature, and various other factors.

Estimating direct consequences of an attack is accomplished by:

1. Identifying potential targets
2. Identifying the effects of weapons on people and buildings
3. Identifying physical and environmental conditions at the target
4. Quantifying the potential losses

Identifying Potential Targets

Potential school attackers typically choose their targets to maximize the impact of their attack (its consequences) and minimize the effort. Schools are usually perceived as easy targets where a successful attack might produce the greatest effect. This effect may involve anything from massive casualties or physical destruction intended to induce psychological shock to symbolic acts that demonstrate a community's vulnerability and instill fear.

Potential consequences will depend on which specific school asset is most likely to be regarded as the primary target. They can be tangible, such as students and teachers, or building systems and equipment that support specific activities or operations, or intangible, such as a school's symbolic value to the community.

A school's core functions and processes define the nature of the target and, therefore, the magnitude of potential loss as a result of a particular attack type or hazard event. In terms of threats executed against a school, the potential consequences of a school's failure to protect the lives or health of its wards represent the most significant concern. Other functions range from institutional—such as educational and social functions—to the basic physical functions of a building (schools are often the designated emergency shelters). School functions can be, and have been disrupted in the past, but the consequences of such attacks are of a different order of magnitude than attacks in which the lives of children may be endangered.

By identifying core functions, the risk assessment can be focused on what a school does, how it does it, and how various threats can affect the wellbeing of occupants and the school's operations. This approach provides discussion topics and results in an accurate understanding of consequences.

Critical assets are identified in the next step. An asset is a resource of value requiring protection. An asset can be tangible (e.g., students, faculty, staff, school buildings, facilities, equipment, activities, operations, information) or intangible (e.g., processes or school's reputation). Recognizing that people are a school's most critical asset, answering the questions below will help identify and prioritize other physical assets that require protection.

- How many people may be injured or killed during a particular type of an attack or any other catastrophic incident that directly affects the school?
- What happens to occupants if a specific asset is lost or degraded? (Can primary services continue?)
- What is the impact on the school's functions and operations if one component in a system is lost or disabled?
- Who are faculty and staff whose loss would degrade, or seriously complicate the safety of students, faculty, and staff during an emergency?

First responders or the personnel responsible for shelter operations at a school that is a designated shelter for natural hazards should also be considered as critical assets.

- Does the school have any emergency backup systems?
- If so, can they be replaced quickly and at what costs if the school building systems' components are lost?

Effects of Weapons

Information on the effects of weapons may be readily available, because government agencies and many private organizations have long studied the effects of ballistic and explosive weapons as well as toxic and other substances on people and buildings. For example, a known quantity of explosive material detonated at a specific distance will produce air pressures sufficient to kill people and cause damage to structures. Similarly, information on the effects of exposure to various toxic substances or radiation is available and may be used in estimating the potential consequences of an attack with a specific type of weapon.

Identifying Conditions at the Target

The consequences of a hazardous event at or near the school are determined by the type of incident and the physical and environmental conditions at the target at the time of the event. A door left open will allow unimpeded access, just as the toxic release upwind of a nearby school will have different consequences during a windy day than during a still night. Physical conditions do not include the intrinsic characteristics of a school and its operations. These characteristics will be covered under the section on vulnerabilities. Physical and environmental conditions should be considered at their most disadvantageous state when analyzing and rating consequences, as in the following examples:

- **Timing –** Most schools operate on a fixed schedule, which means that attacks at different times of the day will have different consequences. An explosive attack during school hours can be catastrophic in terms of the number of students and staff who may be affected. In addition, schools may use different types of heating and cooling systems depending on the season, which may affect the consequences of a release of toxic substances.
- **Environment –** Wind speed and direction, air temperature, humidity, and other environmental conditions may affect the duration and severity of exposure to toxic substances in the air and aggravate the consequences of such an attack. Environmental conditions also affect the consequences of an explosive blast.

Quantifying Consequences

Rating of the gravity of consequences of an attack is difficult, because it requires judgments about relative values of various school assets. Which is worse—a small number of serious injuries or a large number of moderate injuries? Such questions cannot be answered with any objectivity and should be subject to a wider community and societal consensus.

The consequences rating should include the degree of debilitating effect that would be caused by the incapacity or destruction of the school's assets. The scale in Table 1-4 below uses the same type of numerical values used for threats and hazards to depict various levels of gravity of potential losses or consequences of an attack or hazard event. Each level describes the scope of potential fatalities and injuries and the degree of debilitating effects that would be caused by the damage to school assets. To put the consequences of an attack in the proper perspective, grave consequences such as fatalities and injuries must be rated on the same scale with potential building damages and other property losses. Although the losses associated with human assets will always be the primary criterion for assigning the consequences rating, other types of potential losses may raise or lower that rating.

> The consequences rating should include the degree of debilitating effect that would be caused by the incapacity or destruction of the school's assets.

Table 1-4: Consequence Rating Scale

CONSEQUENCE RATING		
Very High	10	Loss or damage of the school's assets would have exceptionally grave consequences, such as extensive loss of life, widespread and severe injuries, or total loss of primary services for a long time. The consequences would have an exceptionally grave effect on the community's health and safety and public confidence. The school authorities have not taken steps to maintain continuity of operations to ensure that core functions would not be significantly affected by an event.
High	8–9	Loss or damage of the school's assets would have grave consequences, such as loss of life, severe injuries, or loss of primary services for a long time. The consequences would have a grave effect on the community's health and safety and public confidence. The school authorities have taken little or no action to maintain continuity of operations to ensure that core functions would not be significantly affected by an event.
Medium High	7	Loss or damage of the school's assets would have serious consequences, such as serious injuries or impairment of core functions for a long time. The consequences would have a serious effect on the community's health and safety and public confidence. The school authorities have taken minor steps to maintain continuity of operations to ensure that core functions would not be significantly affected by an event.
Medium	5–6	Loss or damage of the school's assets would have moderate to serious consequences, such as injuries or impairment of core functions for a considerable time. The consequences would have a moderate to serious effect on the community's health and safety and public confidence. The school authorities have taken some steps to maintain continuity of operations to ensure that core functions would not be significantly affected by an event.
Medium Low	4	Loss or damage of the school's assets would have moderate consequences, such as minor injuries or minor impairment of core functions and processes for a considerable time. The consequences would have a moderate effect on the community's health and safety and public confidence. The school authorities have taken moderate steps to maintain continuity of operations to ensure that core functions would not be significantly affected by an event.
Low	2–3	Loss or damage of the school's assets would have minor consequences, such as slight effects on core functions and processes for a short time, if at all. The consequences would have a minor effect on the community's health and safety and public confidence. The school authorities have taken reasonable steps to maintain continuity of operations to ensure that core functions would not be significantly affected by an event.
Very Low	1	Loss or damage of the school's assets would have negligible consequences and their effect on the community's health and safety and public confidence would be negligible. The school authorities have taken sufficient steps to maintain continuity of operations to ensure that core functions would not be significantly affected by an event.

1.2.2.3 Vulnerability Assessment

The consequences assessment estimates the magnitude of potential effects of an attack by looking at the attributes of the threat and surroundings at the time that a target is attacked, or exposed to a hazard event. In contrast, the vulnerability assessment evaluates the attributes of the target itself, as they constitute the characteristics inherent to the system (physical, organizational, or social) that may result in losses when the target is attacked. In cases of manmade hazards, vulnerabilities of a system are defined in technical and engineering terms, such as the capacity of a system to withstand and resist the forces acting on that system. For instance, two adjacent columns in a school building may be roughly the same distance from an explosion, but only one fails because it is struck by a fragment in a way that initiates collapse. In this sense, school vulnerabilities should be analyzed with respect to each structural element and its capacity to be overwhelmed by a substantial force.

The significance of vulnerabilities is underscored by the fact that aggressors frequently choose their targets in accordance with the verified weaknesses in those targets' defenses. The Oklahoma City bomber apparently chose the Alfred P. Murrah Federal building as his target because it was easier to approach than other targets that he had inspected. The terrorists who attacked the school in Beslan, Russia, are believed to have chosen an old building because its configuration made it easier to barricade and defend against a counterattack than a modern school building. The vulnerability of the target may not be the most important consideration for an attack, but glaring weaknesses in a school's organization, layout, and security arrangements may attract attention and act as an invitation to belligerence. A vulnerability assessment is particularly useful for identifying single point vulnerabilities at critical nodes or locations where one incident caused by a threat or hazard can affect more than one critical asset or both the primary and backup capabilities of a single system.

Vulnerability estimates are usually subject to lower levels of uncertainty than threats and consequences. Because vulnerability measures the likelihood that an attack of a specific type and magnitude will be successful against a target, it can be carefully studied and evaluated, and estimates are frequently readily available. For example, engineering and military risk analyses evaluating the effects of explosive blasts on structures or personnel can be used to identify specific vulnerabilities to these types of threats.

Three main aspects of a school's vulnerability must be taken into account:

- Structural
- Nonstructural
- Organizational

Structural Vulnerability

Structural vulnerability is related to potential damage to structural components of a school building. These components include foundations, bearing walls, columns and beams, staircases, floors and roof decks, or other types of structural components that help support the building. The level of vulnerability of these components depends on the following factors:

Structural vulnerability is related to potential damage to structural components of a school building.

- The architectural and structural form or configuration of a school building
- The level to which the design of the structural system has addressed the threat/hazard forces that impact that system
- The quality of building materials, construction, and maintenance

Nonstructural Vulnerability

Nonstructural elements are much more vulnerable to explosive blast than the building structure. Nonstructural elements are attached to a building or building system, but are not part of the main load-resisting structural system of the building. They are easily damaged and costly to repair or replace. In most modern buildings, the nonstructural components account for 60 to 80 percent of the value of the building. In cases of explosive blast, many nonstructural components may be exposed to forces they were not designed to resist. Among others, interior walls, mechanical systems, fire protection systems, parapets, appendages, ornamentations, veneer, cladding systems, suspended ceilings, electrical components, and light fixtures cannot be designed and constructed to the same standards of blast and penetration resistance as the structural elements. The failure of these systems can significantly disrupt the functions and operation of the building and substantially increase the risk of death and injury for the occupants.

Most modern schools use centralized air and ventilation systems as well as municipal lifeline systems, all of which are extremely vulnerable to attacks with CBR weapons. Attacks on schools using weapons that do not primarily target the building structure, such as CBR devices could seriously impair the safety of school occupants, even when the facilities do not sustain significant structural damage. The effects of attacks on nonstructural building components and equipment can be as dangerous and as disruptive to occupant safety, as any structural damage.

Nonstructural elements are much more vulnerable to explosive blast than the building structure.

Organizational Vulnerabilities

Organizational vulnerabilities include characteristics of school spatial organization (layout and building configuration), as well as operational and procedural routines that may be exploited by the attackers. Most schools have emergency operation plans (also be known as a crisis management plans), but not all of them provide organizational alternatives in the event of an attack. The spatial organization of a school's activities and their inter-relationships frequently determine the extent to which the school facilities are vulnerable to various types of attacks. The critical nature of spatial organization represents a separate category of vulnerabilities that needs careful attention.

> Organizational vulnerabilities include characteristics of school spatial organization as well as operational and procedural routines.

Evacuation or rescue of students and staff under attack is a measure of last resort, which may be necessary in extreme situations. Many different situations may require safe escape routes and routines, but the process of evacuation itself may constitute a vulnerability that potential attackers may use to their advantage as in both the Columbine and Jonesboro shooting attacks where the schools' pre-planned drills moved students outside of the school where they were exposed to the aggressors (see Chapter 3).

The School Vulnerability Assessment Checklist provided in Appendix F is based on a checklist developed by the U.S. Department of Veterans Affairs and the National Clearinghouse for Educational Facilities and compiles many best practices, based upon technologies and scientific research, to consider during the design of a new building or an assessment of an existing school building. The checklist allows a consistent security evaluation of designs at various levels. It can be used as a screening tool for an initial vulnerability assessment or be used by subject matter experts for a comprehensive vulnerability assessment of existing school buildings.

The assessment of vulnerabilities of a school building should be done within the context of the defined threats and the school's assets or potential targets. That is, each element of the school's core functions and critical assets should be analyzed for vulnerabilities to each threat/hazard and a vulnerability rating should be assigned. The same type of numerical scale used in the threat and consequences assessments can be used for the vulnerability assessment, as presented in Table 1-5.

Table 1-5: Vulnerability Rating Scale

VULNERABILITY RATING		
Very High	10	One or more major weaknesses have been identified that make the school's assets extremely susceptible to an aggressor or hazard.
High	8–9	One or more significant weaknesses have been identified that make the school's assets highly susceptible to an aggressor or hazard.
Medium High	7	An important weakness has been identified that makes the school's assets very susceptible to an aggressor or hazard.
Medium	5–6	A weakness has been identified that makes the school's assets fairly susceptible to an aggressor or hazard.
Medium Low	4	A weakness has been identified that makes the school's assets somewhat susceptible to an aggressor or hazard.
Low	2–3	A minor weakness has been identified that slightly increases the susceptibility of the school's assets to an aggressor or hazard.
Very Low	1	No weaknesses exist.

1.2.2.4 Risk Analysis

Risk is the potential for a loss of or damage to an asset. It is determined based upon the level of potential consequences related to the given threat and the level of vulnerability of the targeted assets to that threat. Risk is based on the likelihood or probability of the attack or hazard event occurring and the probability that a successful attack or event will cause the maximum potential losses. Risk assessment analyzes the potential for occurrence of each applicable threat/hazard for each asset. The potential losses are determined based on potential consequences and vulnerabilities of the asset. Thus, a very high likelihood of occurrence with very small consequences may have a low risk rating and may warrant only simple low-cost mitigation measures, but a very low likelihood of occurrence with very grave consequences will have a high risk rating that warrants more costly and complex mitigation measures. The risk assessment provides engineers, architects, and school administrators with a relative risk profile that defines specific assets that are at the greatest risk from specific threats. Chapters 3, 4, and 5 explore school vulnerabilities to particular threats and recommend cost-effective protective measures to address those vulnerabilities.

Risk is the potential for a loss of or damage to an asset.

Numerous methodologies and techniques exist for conducting a risk assessment. One approach is to assemble the results of the threat assessment, consequences assessment, and vulnerability assessment, and to determine a numeric value of risk for each asset and threat/hazard pair in accordance with the following formula:

Risk = Threat Rating x Consequences Rating x Vulnerability Rating

Table 1-6 below provides a numerical scale to apply various levels of risk of potential losses or consequences of an attack or hazard event.

Table 1-6: Risk Rating Scale

Vulnerability		
Very High	≥ 261	The potential for loss or damage of the school's assets is so great as to expect exceptionally grave consequences, such as extensive loss of life, widespread severe injuries, or total loss of primary services and core functions and processes.
High	201–260	The potential for loss or damage of the school's assets is so great as to expect grave consequences, such as loss of life, severe injuries, loss of primary services, or major loss of core functions and processes for an extended time.
Medium High	141–200	The potential for loss or damage of the school's assets is such as to expect serious consequences, such as serious injuries or impairment of core functions and processes for an extended time.
Medium	101–140	The potential for loss or damage of the school's assets is such as to expect serious consequences, such as injuries or impairment of core functions and processes.
Medium Low	61–100	The potential for loss or damage of the school's assets is such as to expect only moderate consequences, such as minor injuries or minor impairment of core functions and processes.
Low	31–60	The potential for loss or damage of the school's assets is such as to expect only minor consequences or impacts, such as a slight impairment of core functions and processes for a short time.
Very Low	1–30	The potential for loss or damage of the school's assets is so low that the consequences or impacts would be negligible.

As a minimum, mitigation measures to reduce risk and create an acceptable level of protection should be considered for those critical assets determined to be at highest risk.

Risk assessment is an initial step in the process of managing the risks to which a school may be exposed. This process considers many more issues and requires the cooperation of school officials and other stakeholders.

1.3 Risk Reduction

Risks are quantified and prioritized to make decisions about how best to manage them. Risk reduction requires that protective policies be enforced and protective actions be taken before an incident. For all practical purposes, managing threats is outside the purview of school authorities, who must rely on law enforcement and other government agencies for help. Consequently, the risk reduction efforts of school authorities must focus on activities aimed at reducing the vulnerabilities and minimizing the consequences.

Risks are quantified and prioritized to make decisions about how best to manage them.

Most protective measures are designed to alleviate a particular vulnerability to a specific threat or hazard, or to help reduce the potential consequences, as discussed in later chapters. However, many of these measures designed to address particular vulnerabilities may have adverse effects with respect to another type of threat or hazard. To identify, select, and implement the most appropriate protective measures, the risk reduction objectives and merits of each potential protective measure must be evaluated against each identified threat or hazard. Evaluating the effectiveness of a particular measure, whether regulatory or technical, requires comprehensive technical, policy, and financial expertise combined with a thorough knowledge of the educational environment and its requirements.

1.3.1 Evaluating Protective Measures

The selection and implementation of protective measures to achieve an acceptable level of protection at an acceptable cost is perhaps the most important component of the risk management process. Because protecting against the entire range of possible threats is cost prohibitive, developing a realistic prioritization of risk reduction objectives and measures that respond to these objectives is important. When evaluating protective measures, consider the following factors:

- The results of the risk assessment, including consequences and vulnerabilities
- The costs of the protective measures (both initial installation and recurring for operation and maintenance)
- The value (in terms of life safety and protection) of risk reduction for the school and community as a whole
- The deterrence or preventive value of the protective measures
- The expected lifespan of the protective measures

To evaluate protective measures, decisionmakers should first reassess the potential effects of each measure on the vulnerabilities and consequences for each threat and/or hazard under consideration. Many protective measures affect vulnerabilities and consequences for multiple threats and hazards, some of them adversely, so a careful cross-examination of these conflicting effects is important. After evaluating the effects of the recommended protective measures on the risk rating for each attack type, costs of each measure should be estimated using a variety of economic tools and cost-estimating resources. In some cases, conducting a benefit-cost analysis may be necessary to determine which protective measures will produce the greatest reduction of risk at an acceptable cost.

The deterrent or preventive value of a protective measure is difficult to quantify but should not be underestimated. Deterrence, in the case of terrorism, may also have a secondary impact in that, once a school building is "hardened," a terrorist may turn to a less protected building, changing the likelihood of an attack for both targets. For example, the Murrah Federal Building in Oklahoma City became a target after Timothy McVeigh was deterred from attacking the FBI building, because getting the attack vehicle close to that target was too difficult. He was able to park immediately adjacent to the Murrah Federal Building and successfully target the Bureau of Alcohol, Tobacco, and Firearms.

All these factors should be considered when calculating the value of protective measures, and weighing their value against their cost. Ideally, sufficient resources would be available to achieve a desired level of protection, but this is not always the case. Consequently, every school district should identify or designate an appropriate authority to make the risk-related decisions on behalf of the school.

1.3.2 Implementing Protective Measures

Risk reduction or mitigation activities focus on minimizing the effects of an attack or hazard event, i.e., minimizing the probability that such an attack or event will cause casualties, destruction, or disruption. Determining the most appropriate protective measures is not an intuitive process. It is best undertaken as a continuation of the risk assessment process to avoid the implementation of risk reduction measures that may not be adequate for the desired level of protection, or may not address the priority concerns or vulnerabilities. A detailed risk assessment and evaluation of risk reduction measures will facilitate the design and implementation of effective protective measures that can be integrated into the normal operations and activities of educational facilities at a reasonable cost.

> Risk reduction or mitigation activities focus on minimizing the effects of an attack or hazard event.

The implementation of protective measures usually takes place in one of three different situations:

- As a result of increased focus on risk reduction following a serious incident. This heightened level of awareness provides an opportunity and a favorable social environment for implementing protective measures, for which adequate support, especially funding, might otherwise be difficult to mobilize.
- The construction of new educational facilities, which allows new measures to be integrated into the plans and designs from the very beginning. This is the most cost-efficient approach.
- The implementation of protective measures into an existing environment. This is often the most challenging situation because of the frequently insurmountable technical, logistical, or cost constraints.

To facilitate the implementation of protective measures, decisionmakers are encouraged to approach mitigation both as a comprehensive process, encompassing and integrating diverse social, educational, logistical, and technical measures, and as a continuing long-term process that reinforces and reinvents itself based on experience. Specifically, school security protective initiatives should not be isolated from the community's security and hazard risk management activities, but should be part of an integrated strategy for risk reduction. Considering the scarcity of resources, school authorities should make a compelling case to the community's decisionmakers using the methods of risk assessment described in this primer to show that the protection of schools protects the most vulnerable and most precious of a community's resources.

1.3.3 Preparing School Safety Emergency Plans

DHS has designated the U.S. Department of Education (ED) as the lead agency for school-related security. The ED has published a guide, *Practical Information on Crisis Planning: A Guide for Schools and Communities* (January 2007) that is intended to provide schools, districts, and communities with the critical concepts and components of good crisis planning, stimulate thinking about the crisis preparedness process, and provide examples of best practices. Additional general information is available from the National Advisory Committee on Children and Terrorism, as well as information specifically covering bioterrorism issues in conjunction with the Centers for Disease Control and Prevention (CDC). Other school health and safety issues are covered by various tools and publications of the CDC's Division of Adolescent and School Health.

The ED recommends each school safety emergency plan address the four major areas listed below:

- **Mitigation**
  - Conduct an assessment of each school building. Identify those factors that put the building, students, faculty, and staff at greater risk, such as proximity to rail tracks that regularly transport hazardous materials or to facilities that produce highly toxic material or house propane gas tanks, and develop a plan for reducing the risk. This plan could address evacuating students away from these areas in times of crisis and repositioning propane tanks or other hazardous materials away from school buildings.
  - Work with businesses and factories in close proximity to the school to ensure that the school's emergency plan is coordinated with their emergency plans.
  - Ensure that a process is in place for controlling access and egress to the school. Require all persons who do not have authority to be in the school to sign in.
  - Review traffic patterns, and where possible, keep cars, buses, and trucks away from school buildings.
  - Review landscaping, and ensure that buildings are not obscured by overgrowth of bushes or shrubs where contraband can be placed or persons can hide.
- **Preparedness**
  - Have site and floor plans for each school building readily available and ensure they are shared with first responders and agencies responsible for emergency preparedness.
  - Establish multiple evacuation routes and rallying points. First or second evacuation site options may be blocked or unavailable at the time of the crisis.
  - Practice responding to crisis on a regular basis.
  - Ensure a process is established for both internal and external communications during a crisis.
  - Inspect equipment regularly to ensure it will operate properly during crisis situations.
  - Create a plan for discharging students. Remember that, during a crisis, many parents and guardians may not be able to get to the school to pick up their child. Make sure the school has a secondary contact person and contact information readily available for every student.
  - Develop a plan for communicating information to parents and for quelling rumors. Cultivate relationships with the media ahead

of time, and identify a Public Information Officer to communicate with the media and the community during a crisis.

    - Work with law enforcement officials and emergency preparedness agencies on a strategy for coordination to include as part of the school emergency plan.
    - Develop a command structure for responding to a crisis. The roles and responsibilities for educators, law enforcement and fire officials, and other first responders in responding to different types of crisis need to be developed, coordinated, reviewed, and approved.
- **Response**
    - Identify the type of crisis and determine the appropriate response.
    - Maintain communications among all relevant staff.
- **Recovery**
    - Return to the business of teaching and learning as soon as possible.
    - Identify and approve a team of credentialed and adequately trained mental health workers to provide mental health services to faculty and students after a crisis. Understand that recovery takes place over time and that the services of this team may be needed over an extended period.
    - Notify parents on actions that the school intends to take to help students recover from the crisis.

Every school should have a school safety emergency plan, as described above, developed in partnership with public safety agencies, including law enforcement, fire, public health, mental health, and local emergency preparedness agencies. The plan should consider risks like fire, and natural and manmade disasters. A school's plan should be tailored to address the unique circumstances and needs of the individual school, and should be coordinated and integrated with community plans and the plans of local emergency preparedness agencies.

These plans should consider all identified threats/hazards and attack scenarios and the associated procedures for communicating instructions to building occupants related to emergency evacuations or other protective activities. They should also identify the most suitable shelter-in-place areas (if they exist) and identify appropriate use and selection of personal protective equipment (e.g., clothing, gloves, respirators). Individuals developing emergency plans and procedures should recognize that fundamental differences between different emergency situations may require different instructions and response routines. The plans should be as comprehensive as possible and shared with relevant coordinating agencies but not with the general public. When appropriately developed, these plans, policies, and procedures can have a major impact on school occupant survivability in the event of an attack or exposure to a technological hazard.

Staff training, particularly for those with specific responsibilities during an event, is essential to an effective emergency response. Holding regularly scheduled practice drills, similar to the common fire drill, allows for plan testing, as well as student and key staff rehearsal of the plan, and increases the likelihood for a successful response in an actual event. School officials should ensure that training is provided to staff that operate and maintain the school's critical systems.

1.4 Response

Each school day, more than 50 million students are entrusted to the care of the public school system and many private schools. On most days, these schools are safe havens for teaching and learning, but in an emergency, school personnel may need to serve as first responders for natural hazard events like tornadoes, earthquakes, or floods, or manmade hazards and accidents like toxic spills. Increasingly, the critical incidents that may threaten the safety of schools include intentional attacks on students, faculty, or school property.

The response to terrorist or other types of attacks and similar crises usually involves first responders (the police and other law enforcement agencies, the fire department, and ambulances) and many others, as well as scores of onlookers, media, and, in the case of schools, concerned parents and relatives that gather around the scene. The more serious the incident, the more serious is the task of organizing the response and controlling the situation. The chaotic events that surrounded the terrorist attack on a school in Beslan, Russia, (see Chapter 3) showed very clearly the pitfalls of an uncoordinated response to a critical incident.

Professional responders involved in response activities to large-scale emergencies now use an Incident Command System (ICS) to organize and coordinate the response. ICS is part of a National Incident Management System that integrates existing best practices into a consistent, nationwide approach to domestic incident management applicable at all jurisdictional levels and across functional disciplines. ICS defines the operating characteristics, interactive management components, and structure of incident management and emergency response organizations engaged in an incident. The structure of ICS facilitates activities in five major functional areas: command, operations, planning, logistics, and finance administration. ICS is also flexible and scalable allowing for functional areas to be added as necessary and terminated when no longer necessary.

ICS allows school personnel and community responders to adopt an integrated organizational structure that matches the complexities and demands of the incidents without being hindered by jurisdictional boundaries. Although school-based incidents most likely will not need many of the standard ICS facilities common to large disasters, the flexibility of ICS makes it a very cost-effective and efficient management approach for both small and large incidents.

1.5 Decisionmaking

Some of the most important aspects of risk management are the decisions that have to be made about the types of risks to which a school may be exposed and the prioritization of those risks according to a set of common criteria. The questions that are usually asked include:

- Which threats are the most immediate and most serious?
- Which ones could have the most serious consequences?
- To what extent would the identified vulnerabilities contribute to the losses, were the attack to take place?
- Are these risks serious enough to require action? If they are, what action would be the most effective in reducing that risk?

All such decisions are fraught with uncertainties, i.e., they require decisionmakers to exercise judgments that are not based on any reliable set of data or agreed values.

1.5.1 Uncertainties and Value Judgments

Uncertainties affect the risk management from the very start. To many, the risk assessment process may appear to be a neutral academic exercise, until such a time when decisions have to be made about the level of acceptable risk, or when priorities in the allocation of limited resources for school protection have to be set. According to RAND Corporation's Center for Terrorism Risk Management Policy (Willis and Kelly 2005), two important sources of uncertainty exist in assessing the risks. The first one reflects imprecise methods for estimating the likelihood of occurrence of any particular type of attack (threat) or the scope of consequences that may result from such an attack. The second stems from a lack of any universally accepted set of criteria by which to compare and value the consequences. Table 1-4 is but one attempt to map the consequences according to their relative magnitude from a community perspective. The obvious difficulty arises when determining the relative gravity of consequences of an incident with a large number of moderately wounded individuals compared with an incident that resulted in a few serious injuries or extensive physical damage. No guidelines or criteria explain what society should value more, which makes it all the more important for the risk assessment process to address these uncertainties in an open discussion with all the stakeholders.

1.5.2 Acceptable Level of Risk

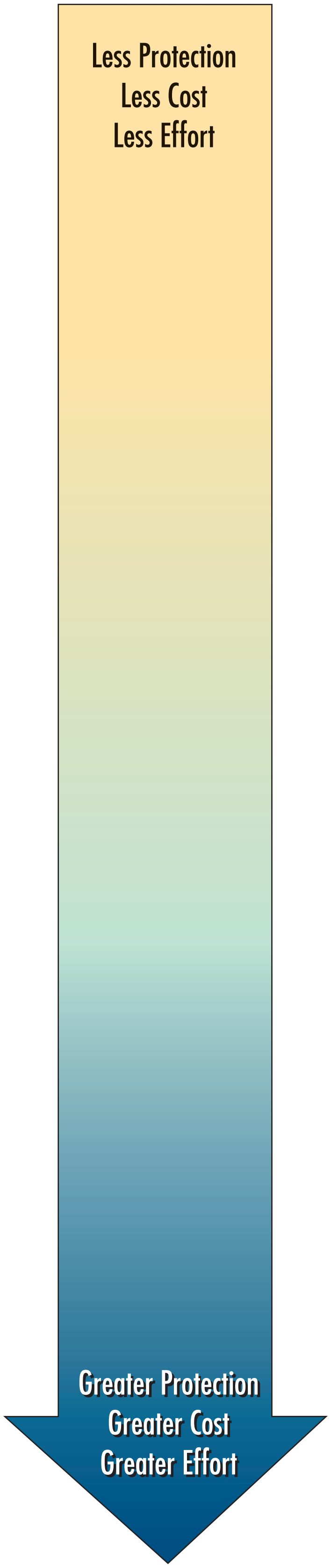
The daily lives of individuals and communities are full of risks of various types and severity. The decisions about these risks are made routinely based on experience. People do not perform a risk assessment before crossing a busy street, but they do stop to think when faced with unfamiliar risks. They also stop to think when the consequences may be too grave to ignore. In such situations, people consider the likelihood that a certain event will take place and cause feared consequences. The likelihood of a serious automobile accident is usually considered miniscule and, despite potentially grave consequences, routinely dismissed by millions of drivers on a daily basis. These decisions are a product of a conscious trade-off. The risks are usually deemed tolerable when compared with the cost and inconvenience of not using an automobile. More to the point, one other significant factor influences these and similar decisions to accept the risks—the confidence of decisionmakers in the risk reduction activities they usually employ. The drivers consciously drive on the designated side of the road, strap on their seat belts, and observe the traffic rules. That is, the decisionmakers are more likely to find the risks acceptable, in spite of potentially horrifying consequences, if the likelihood of the event is small, and sufficient and reasonable precautions, or protective measures, have been put in place.

Such decisionmaking is similar to what school administrators face when considering security threats and manmade hazards. They are no different than the decisions made daily by individuals about their own lives, except that they now affect the lives of others, frequently entire communities. The responsibility to protect the most precious resource of a society—its children—may weigh differently on individual aspects of the risk, but ultimately, decisions have to be made about the most appropriate level of protection. That level of protection is defined by the acceptable level of risk and by the selection and implementation of the most effective protective measures.

1.5.3 Cost Estimation

A general spectrum of protective measures ranging from the least protective and least costly to the most protective and most costly are provided in Figures 1-4 and 1-5. These protective measures are arranged by layers of defense (described in Chapter 2): the first layer layer is outside the perimeter of the school, the second layer is between the perimeter and the building, and the third layer generally refers to the school building itself. Examples of protective measures are provided for each layer.

Figure 1-4: Protective measures for the second layer of defense



- Place trash receptacles as far away from the 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 area (fire and police stations, hospitals, etc.).
- Identify all potentially hazardous facilities in the area (nuclear plants, chemical labs, etc.).
- Use temporary passive barriers to eliminate straight-line vehicular access to high-risk buildings.
- 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 building.
- Limit and control access to all crawl spaces, utility tunnels, and other means of under-building access to prevent the planting of explosives.
- Use a geographic information system (GIS) to assess adjacent land use.
- Provide open space inside the fence along the perimeter.
- Locate fuel storage tanks at least 100 feet from all buildings.
- Block sight lines through building orientation, landscaping, screening, and landforms.
- Use temporary and procedural measures to restrict parking and increase standoff.
- Locate and consolidate high-risk land uses in the interior of the site.
- Select and design barriers based on threat levels.
- Maintain as much standoff distance as possible from potential vehicle bombs.
- Separate redundant utility systems.
- Conduct periodic water testing to detect waterborne contaminants.
- Enclose the perimeter of the site. Create a single controlled entrance for vehicles (entry control point).

Figure 1-4 : Protective measures for the second layer of defense (cont.)

- Establish law enforcement or security force presence.
- Install quick connects for portable utility backup systems.
- Install security lighting.
- Install closed-circuit television (CCTV) cameras.
- Mount all equipment to resist forces in any direction.
- Include security and protection measures in the calculation of land area requirements.
- Design and construct parking to provide adequate standoff for vehicle bombs.
- Position buildings to permit occupants and security personnel to monitor the site.
- Site the building at an appropriate distance from to potential threats or hazards.
- Locate critical 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 building.
- Design 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 better standoff, push the line farther outward by restricting or eliminating parking along the curb, eliminating loading zones, or closing streets.
- Provide intrusion detection sensors for all utility services to the building.
- Provide redundant utility systems to support security, life safety, and rescue functions.
- Conceal and/or harden incoming utility systems.
- Install active vehicle crash barriers.

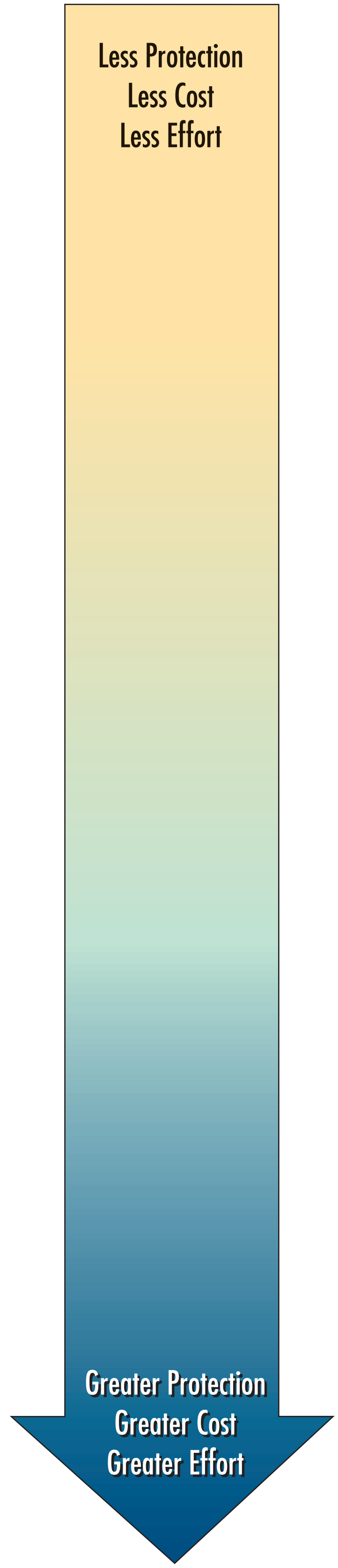
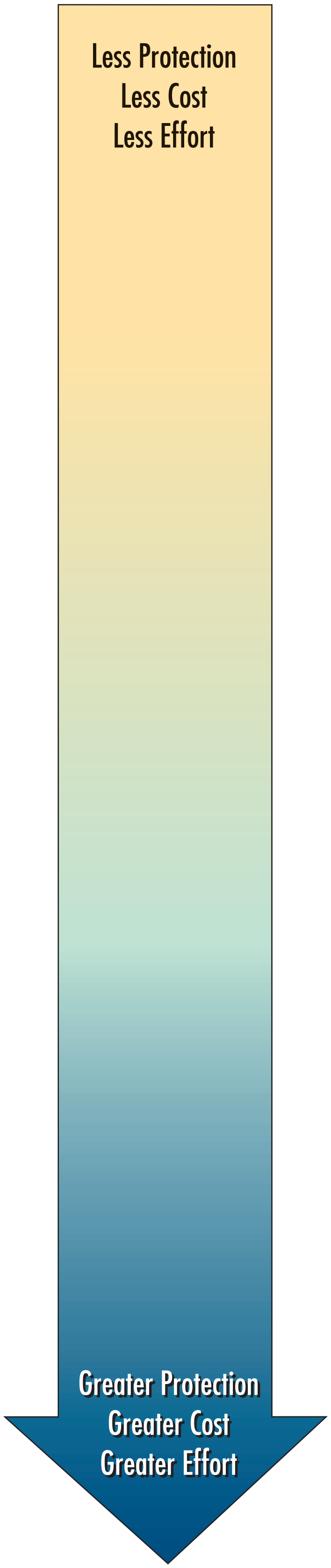


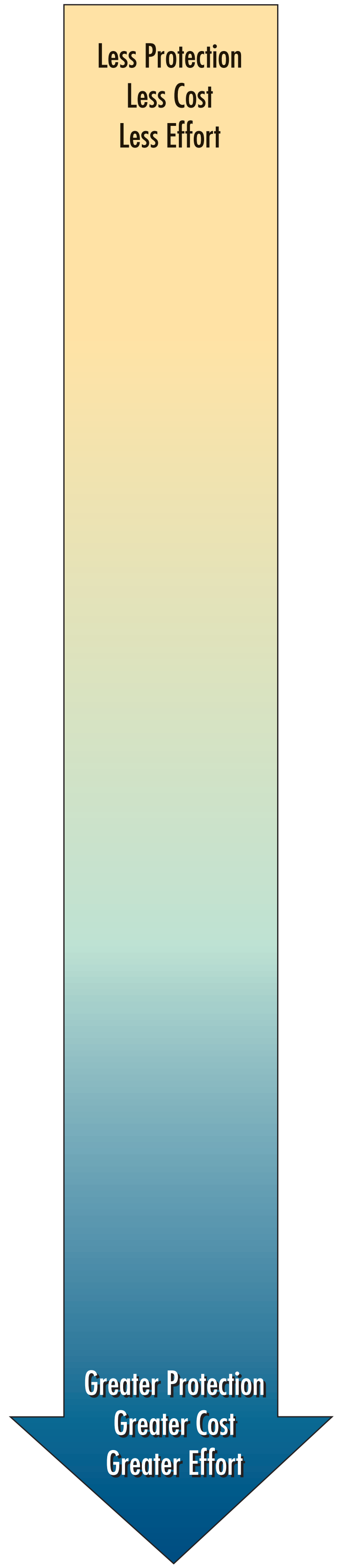
Figure 1-5: Protective measures for the third layer of defense



- Install active vehicle crash barriers. Ensure that exterior doors into inhabited areas open outward. Ensure emergency exit doors only facilitate exiting.
- Secure roof access hatches from the interior. Prevent public access to building roofs.
- Restrict access to building operation systems.
- Conduct periodic training of heating, ventilation, and air-conditioning (HVAC) operations and maintenance staff.
- Evaluate HVAC control options.
- Install empty conduits for future security control equipment during initial construction or major renovation.
- Do not mount plumbing, electrical fixtures, or utility lines on the inside of exterior walls.
- Establish emergency plans, policies, and procedures.
- Establish written plans for evacuation and sheltering in place.
- Illuminate building access points.
- Restrict access to building information.
- Secure HVAC intakes and mechanical rooms.
- Limit the number of doors used for normal entry/egress.
- Lock all utility access openings.
- Provide emergency power for emergency lighting in restrooms, egress routes, and any meeting room without windows.
- Install an internal public address system.
- Stagger interior doors and offset interior and exterior doors.
- Eliminate hiding places.
- Install a second and separate telephone service.
- Install radio telemetry distributed antennas throughout the facility.
- Use a badge identification system for building access.
- Install a CCTV surveillance system.
- Install an electronic security alarm system.
- Install rapid response and isolation features into HVAC systems.

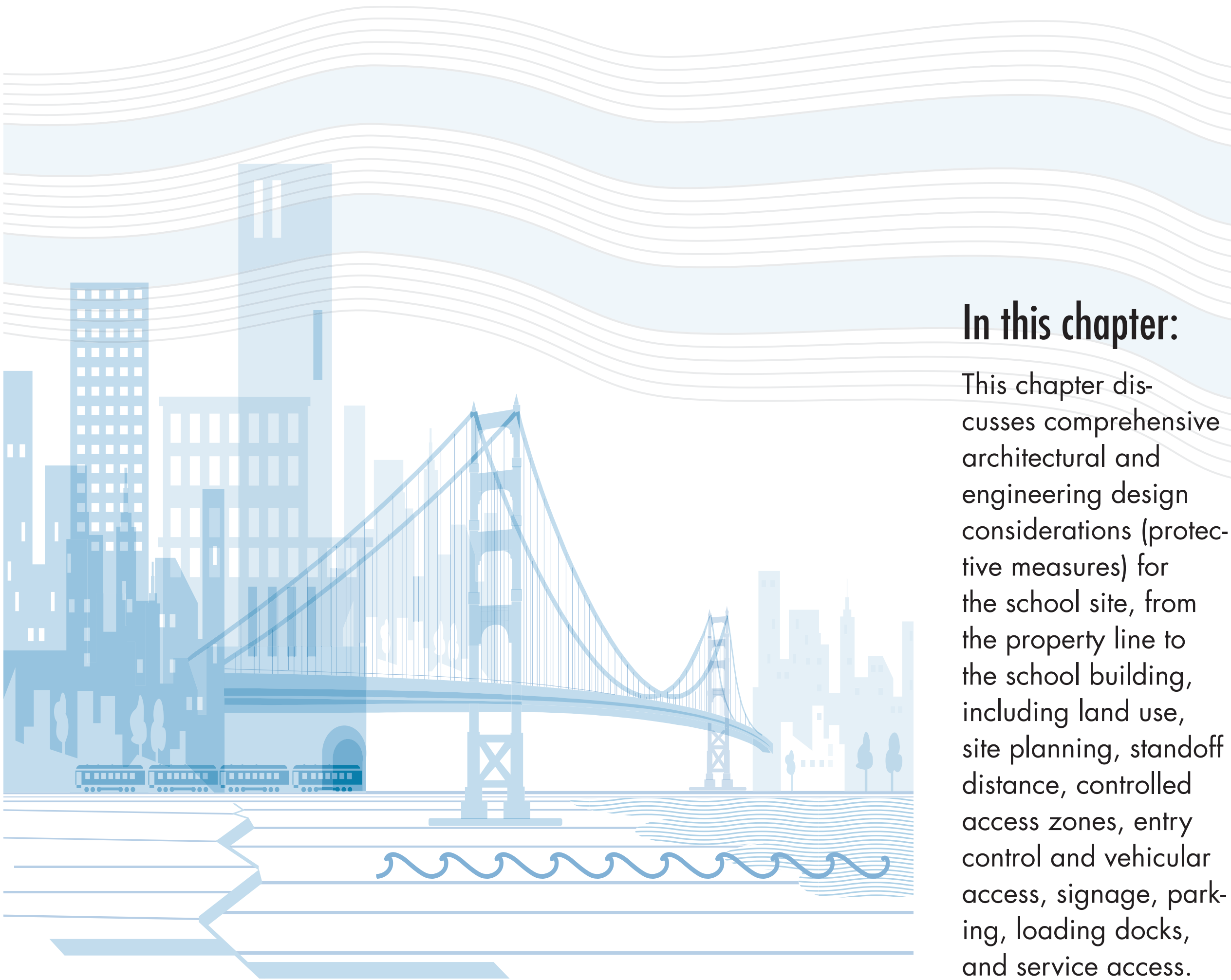
Figure 1-5: Protective measures for the third layer of defense (cont.)

- Use interior barriers to differentiate levels of security.
- Locate utility systems away from likely areas of potential attack.
- Install call buttons at key public contact areas.
- Install emergency and normal electric equipment at different locations.
- Avoid exposed structural elements.
- Reinforce foyer walks.
- Use architectural features to deny contact with exposed primary vertical load members.
- Isolate lobbies, mailrooms, loading docks, and storage areas.
- Locate stairwells remotely. Do not discharge stairs into lobbies, parking, or loading areas.
- Elevate HVAC fresh-air intakes.
- Create “shelter-in-place” rooms or areas.
- Separate HVAC zones. Eliminate leaks and increase building air tightness.
- Install blast-resistant doors or steel doors with steel frames.
- Physically separate unsecured areas from the main building.
- Install HVAC exhausting and purging systems.
- Connect interior non-load-bearing walls to structure with non-rigid connections.
- Use structural design techniques to resist progressive collapse.
- Treat exterior shear walls as primary structures.
- Orient glazing perpendicular to the primary façade facing uncontrolled vehicle approaches.
- Use reinforced concrete wall systems in lieu of masonry or curtain walls.
- Ensure active fire system is protected from single-point failure in case of blast event.
- Install a backup control center.
- Avoid eaves and overhangs or harden to withstand blast effects.
- Establish ground floor elevation four feet above grade.
- Avoid re-entrant corners as the building exterior.



2

Site Design for Security



In this chapter:

This chapter discusses comprehensive architectural and engineering design considerations (protective measures) for the school site, from the property line to the school building, including land use, site planning, standoff distance, controlled access zones, entry control and vehicular access, signage, parking, loading docks, and service access.

2.1 Introduction

This chapter discusses comprehensive architectural and engineering design considerations (protective measures) for the school site, from the property line to the school building, including land use, site planning, standoff distance, controlled access zones, entry control and vehicular access, signage, parking, loading docks, and service access. The intent of this guidance is to integrate security requirements into a comprehensive approach to design for the purpose of achieving balance among objectives such as reducing risk, facilitating proper school building function, addressing aesthetics and matching architecture, creating a school environment conducive to learning, and hardening of physical structures for added security.

> The design community must work closely with school districts and school administrators to reach the optimal balance between considerations.

The design community must work closely with school districts and school administrators to reach the optimal balance between these considerations. Thus, coordination within the design team is critical. Many school protection objectives can be achieved during the early stages of the design process when protective measures are the least costly and most easily implemented. Planners, architects, and landscape designers play an important role in implementing and integrating crucial protective measures into the design process, from site selection, orientation of school buildings on the site, to vehicle access, control points, physical barriers, landscaping, parking, and protection of utilities.

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.

2.2 School Sites

Site design can play a major role in guarding against attacks that are carried out by inside or outside perpetrators who, for whatever reasons, target a school and its occupants. The major threats faced by schools are various types of shooters, small bombs that may be carried into the school by one or two people, and the possible use of CBR agents as a direct means of attack or an indirect collateral threat.

Table 1-3 in Chapter 1 suggests a nominal school threat assessment. The threat ratings range from 1 (very low) for a stationary vehicle bomb and hydrogen sulfide bomb, 2 (low) for an attack with small arms, to 3 (low) for forced entry at night to damage school property and electronic attack of school computer records. A measure of these threat ratings may be gained from national records of the school year 2006–2007. In that year, 27 homicides and 8 suicides of school-age youths (ages 5–18) occurred at schools. Of these, nine persons were victims of five active shooter attacks in schools. One of these attacks killed five people, while the others each killed one person. In three of these attacks the perpetrator was an adult: the other attacks involved a student. During this school year, the total national enrollment of students was approximately 49 million.

In addition to the design of specific security-related measures, site design for security involves the integration of general planning tasks, such as building placement and parking and site infrastructure planning, with security needs. In this publication, security measures are discussed as they apply to existing facilities, but the measures can also be used in the design and evaluation of a proposed site and school design.

In addition to the design of specific security-related measures, site design for security involves the integration of general planning tasks, such as building placement and parking and site infrastructure planning, with security needs.

2.2.1 Suburban/Rural School Sites

As a result of the massive expansion of the suburbs of large cities following World War II, and the continued existence of small towns, most U.S. schools are located on suburban/rural sites.

Although smaller schools may have only one building, larger schools are usually organized as a campus, with a number of separate buildings connected by open or closed walkways. Figures 2-1 to 2-4 show a campus-type grades 8–12 high school. This school opened in 1898 and moved to its present location in 1919. Figures 2-2 and 2-3 show the theater and the administration building and entry tower, which date back to 1919. Figure 2-4 shows part of the 1964 campus, with one-story buildings arranged around a quadrangle.

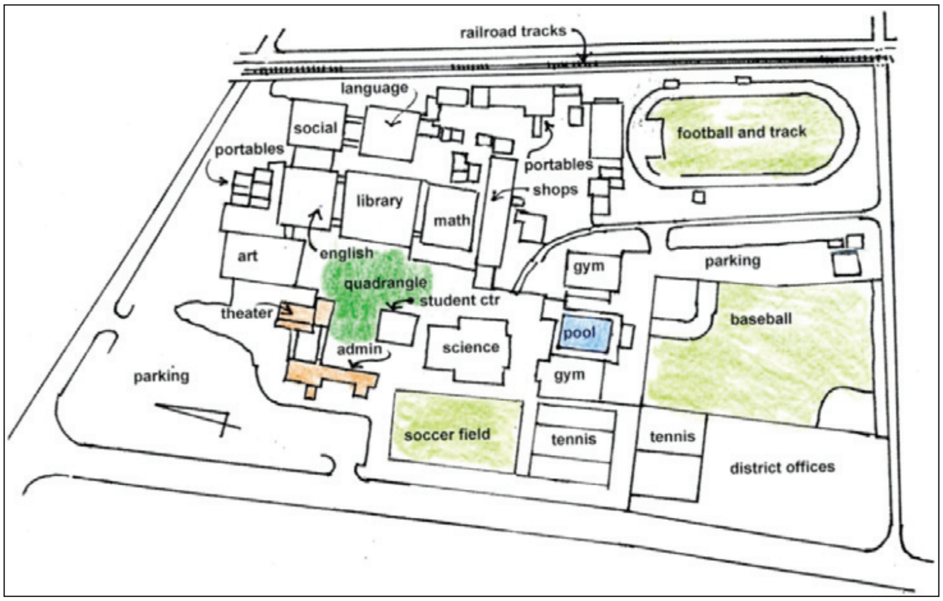


Figure 2-1:
Campus-style grades 8–12 high school

Figure 2-2:
Theatre building on the school campus

Figure 2-3:
The administration building and entrance tower on the school campus

Figure 2-4:
School campus buildings from the 1960s

Figures 2-5 to 2-7 show a campus-type grades 8–12 high school in the same school district. This school opened in 1964 and consists of a number of one-story buildings, each housing a different discipline, connected with open walkways, many also arranged around a quadrangle. Figure 2-6 shows the entry to the school and Figure 2-7 shows a typical campus building from the main street that borders the campus. Both schools provide ample parking for staff, students, and visitors and spacious on-site playing fields.

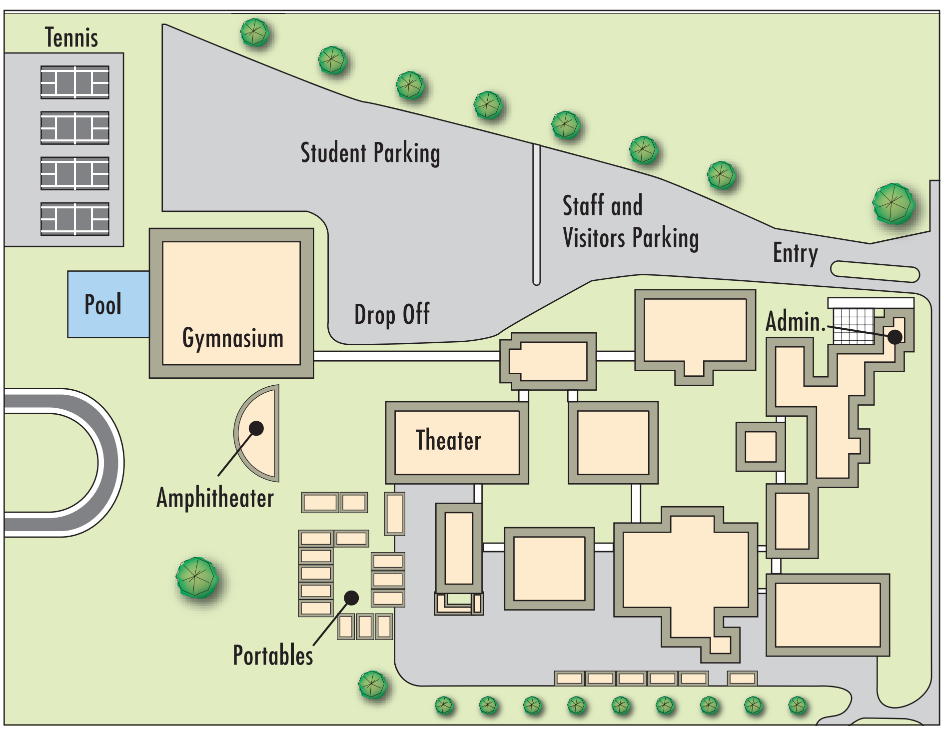


Figure 2-5:
High school campus from 1960s

Figure 2-6: Main entrance

Figure 2-7:
View from the main street

2.2.2 Urban School Sites

Urban schools are seldom placed in the central business district, but rather are located to serve the inner-residential areas, often at the site of high-density housing. For several decades, the inner-city populations have been fairly static or even reduced, and population growth has been concentrated in ever-expanding suburbs. Thus, new school construction has been largely a suburban phenomenon and, as a result, inner-city schools tend to be much older buildings. As an example, of the 16 high schools located in San Francisco, 12 are over 40 years old. The oldest was built in 1910, and three more were constructed in 1924. The three newest were built in 1995, 2000, and 2009.

City land is expensive, and so inner-city school sites are very small compared to their suburban counterparts. Buildings typically have two or three stories, and roofs often serve as playgrounds. Some older schools are located adjacent to public parks, which helps in providing a play area for the school population.

Figure 2-8 shows an urban high school constructed in 1924, and recently beautifully rehabilitated, that occupies a city block and is surrounded on all four sides by major streets. Figure 2-9 shows the site plan of this school and specifically how close the school is in relation to the public sidewalks and traffic. Figure 2-10 shows the restored entrance to the school and courtyard.

Figure 2-8:
An urban high school, constructed 1924; note the classrooms adjacent to the public sidewalk and vehicle traffic

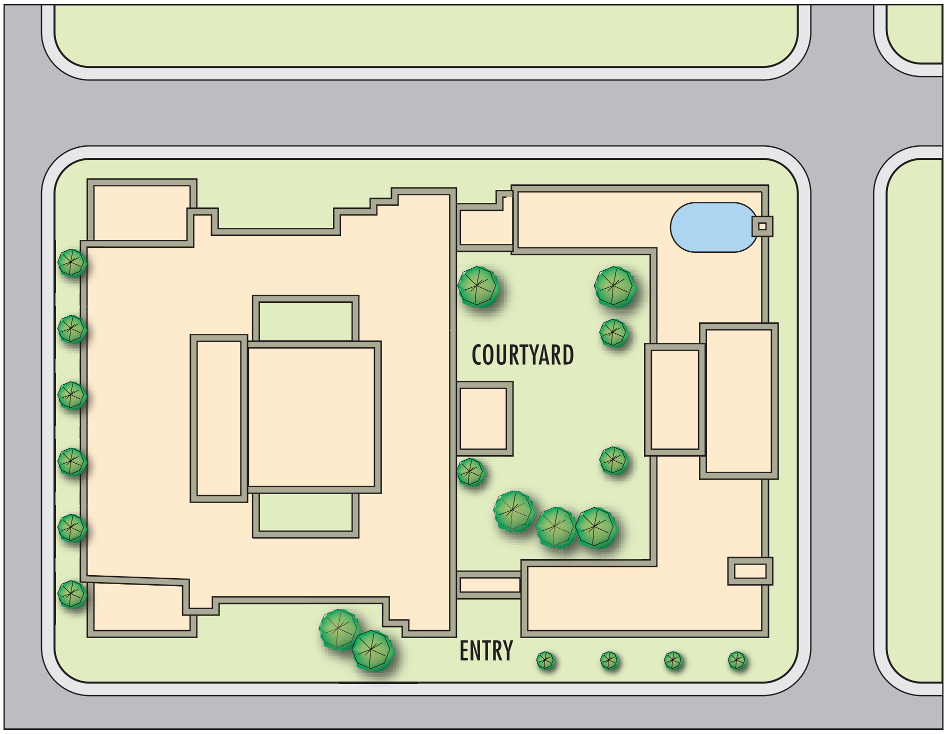


Figure 2-9:
Site plan of the high school shown in Figure 2-8; note traffic on all four sides with interior courtyard and classrooms adjacent to a public sidewalk

Figure 2-10:
Restored architecture of the school entrance and courtyard from the main street

Figure 2-11 shows a school located in an urban residential neighborhood of single-family homes and modest size multi-family apartments. Many older schools—constructed prior to World War II—were designed as important community symbols and are of a high architectural quality.

Figure 2-11:
Urban high school in inner-city residential neighborhood of single-family houses

Figure 2-12 shows an inner-city school in a dense residential and commercial location that is also across the street from a large public park. The school entrance tower is a significant neighborhood symbol. The school was founded in 1897 and the present building, constructed in 1924, houses a museum showing the evolution of the school over the last 100 years.

Figure 2-12:
Urban high school as an important neighborhood symbol, constructed in 1924

2.2.3 Security Implications of Site Characteristics

The following are some of the site characteristics that may affect the vulnerability of a school building to blast and CBR attacks:

- School footprint relative to total land available
- Existing or proposed location relative to the site perimeter and adjacent land uses, and the available distance between the defended perimeter and improved areas offsite
- Overall size and number of the buildings to be placed onsite
- Massing and placement of school buildings that may impact views, sight lines, and screening
- Access via foot, road, rail, water, and air
- Presence of natural physical barriers, such as water features, dense vegetation, and terrain, that could provide access control or shielding, or suitability of the site for the incorporation of such features
- Topographic and climatic characteristics that could affect the performance of chemical or other windborne agents and other weapons
- The number of access and egress points, such as visitor entries, staff entries, and loading docks
- Internal vehicular (e.g., driveways, surface parking areas) and pedestrian circulation
- Location of high-risk areas within the school building that require access control and higher levels of security

This section reviews the most important of these characteristics from the perspective of security protection.

2.2.3.1 Location and Size

In most cases, the size of the site corresponds to its location in a metropolitan area or in a suburban or newly developed area. Urban schools sites are usually smaller and, because of the higher cost of land, schools have at least two to three stories. Sites in the suburban and newly developed areas on the periphery are much larger and usually have low lot-coverage ratios, which means that the school building can be placed farther away from streets and other public areas.

In most cases, the size of the site corresponds to its location in a metropolitan area or in a suburban or newly developed area.

Site designers should work closely with the school building design team to integrate site and building design considerations. Initial concepts for the placement of the building(s) on the site provide the first opportunity to establish adequate standoff distances and delineate security perimeters.

Unless the site is a very high-risk site, school building placement based on construction and operational efficiencies may well take precedence over optimal security requirements for a rare or non-existent event.

2.2.3.2 Topography

The topography of the site is a very important security issue, because—depending on the placement of the school building on the site—it determines the opportunities for internal surveillance of site perimeters and screening of internal areas from external observation points. Building form, placement, and landscaping may help define the line of sight, and can facilitate effective control of potential hostile surveillance. Denying aggressors a line of sight, either from onsite or offsite, increases the security of the school buildings and their occupants.

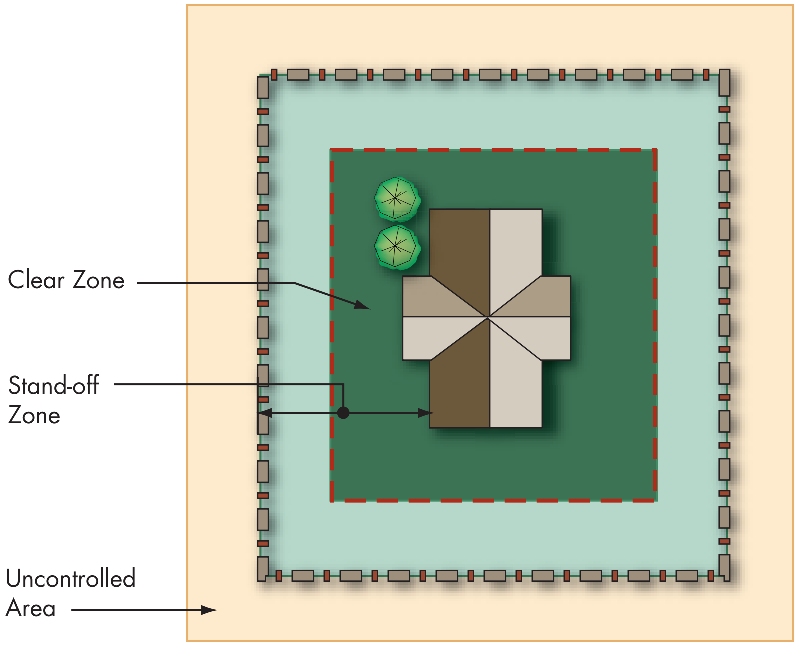
Depending on the circumstances, topography can be either beneficial or detrimental with respect to surveillance. Elevated sites may enhance surveillance of the surrounding area from inside the facility, but may also allow observation of onsite areas by adversaries. Buildings placed immediately adjacent to higher surrounding terrain may be overly exposed to intrusive surveillance.

Schools in high-risk zones may require additional protection immediately adjacent to the structure in the form of a clear zone, free of all topographic obstructions or even landscaping that might provide hiding places (Figure 2-13). The clear zone facilitates monitoring of the immediate vicinity and visual detection of attackers or intruders.

Schools in high-risk zones may require additional protection immediately adjacent to the structure in the form of a clear zone, free of all topographic obstructions or even landscaping that might provide hiding places.

Figure 2-13:
Clear zone with unobstructed views

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



2.2.3.3 Building Orientation

Orientation, or the physical positioning of a school building on site, can be a major factor for security. For the purpose of this primer, the term "orientation" refers to three distinct characteristics: a building's spatial relationship to the site, its position relative to the sun and prevailing winds, and its vertical or horizontal aspect relative to the ground. A structure's orientation relative to its surroundings defines its relationship to that area. In both aesthetic and functional terms, a building can "open up" to the area or turn its back; it can be inviting to those outside, or it can "hunker down" defensively.

> Orientation, or the physical positioning of a school building on site, can be a major factor for security.

By optimizing the positioning of the school building relative to the sun, climate control and lighting requirements can be met while reducing power consumption. Similarly, the use of light shelves, skylights, clerestories, and atria can help meet illumination requirements while reducing energy usage. Light pipes supplying natural light through the roof or a hardened wall can reduce the size and number of windows needed, reducing energy usage and reducing the cost of hardening the building envelope.

Some of these energy conservation techniques have important security implications and must be examined carefully for their vulnerability to blast loading and exposure to CBR agents. For example, although natural ventilation is an effective and time-tested technique for efficiently cooling buildings, the use of unfiltered outside air is a major vulnerability with respect to attacks with aerosolized CBR agents and accidental releases of hazardous materials. Similarly, operable windows may be more vulnerable to blast damage than the fixed ones.

School building organization, or plan configuration, directly affects the building's physical security and the ability of school authorities to monitor and enforce access control.

A structure's orientation in relation to the prevailing winds on site is significant characteristic with respect to the possibility of a CBR attack or hazardous material release. Wind may be beneficial in mitigating the effects of windborne hazards in that it reduces the concentration of agents in the air as distance from the source increases, spreading the plume laterally and upwind. The annual wind rose for the area is a good indicator of the probable distribution of wind speed and direction for a given period.

2.2.3.4 Building Configuration

School building organization, or plan configuration, directly affects the building's physical security and the ability of school authorities to monitor and enforce access control. Many suburban schools use the campus style of organization, with multiple single-story buildings spread around the school grounds. This type of organization is difficult to secure unless the perimeter is controlled and only a single access point to the school is maintained and monitored at all times. Nevertheless, the dispersed school buildings remain exposed to attacks from any direction.

A more compact organization of multiple school buildings, usually grouped around a central courtyard provides for easier surveillance and access control. By limiting the access to the inner courtyard and creating a secure enclosure, the school buildings' exposure to attack from the outside is significantly reduced. An even more compact organization involves a single building with a multi-story configuration or a single- or multi-story configuration with wings, such as U-, H-, or simple L-shaped plans. Though open, the courtyards formed by this type of school building are easier to monitor and control than the completely open grounds of a campus configuration. Figure 2-14 illustrates each type of school building configuration.

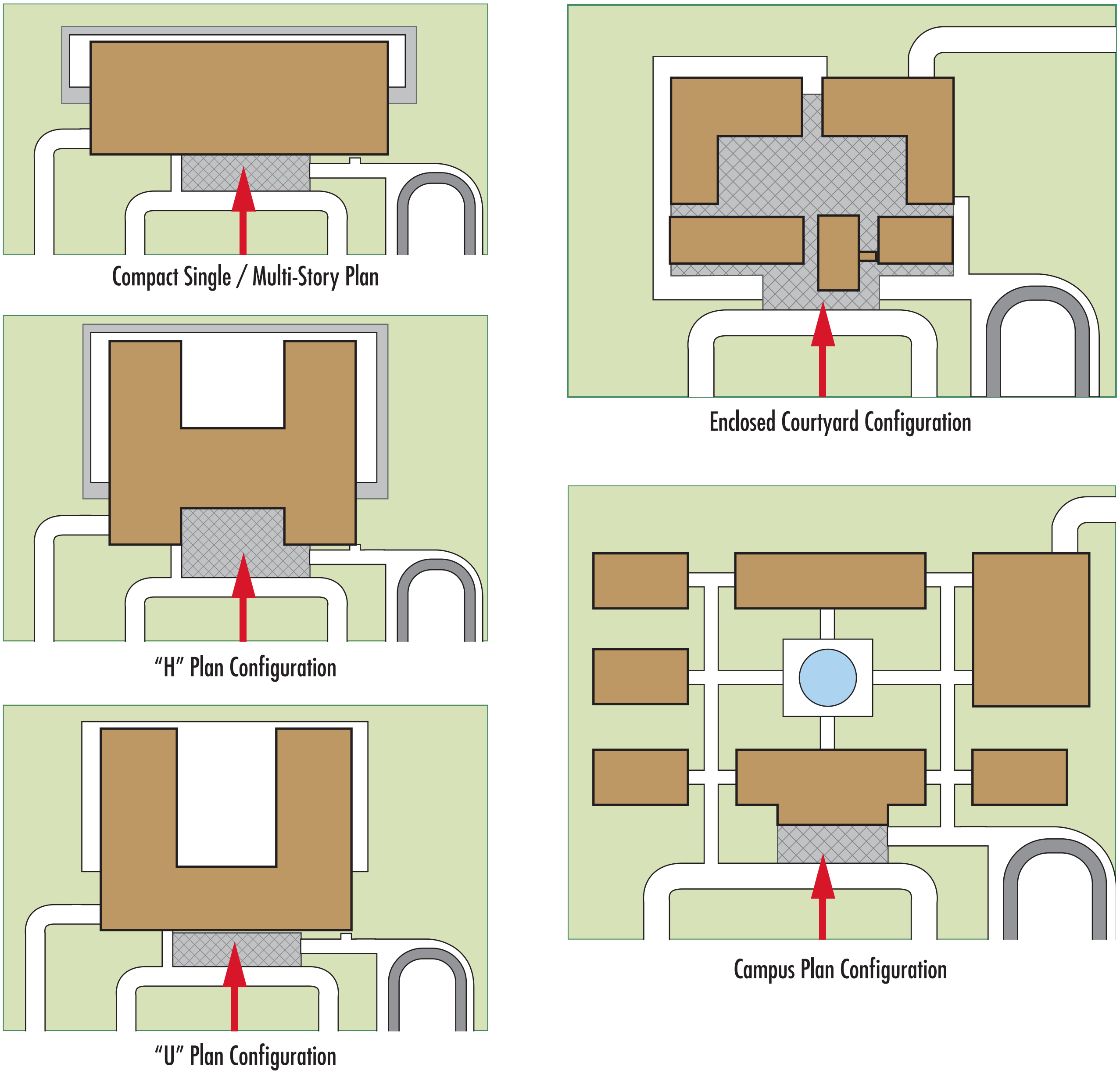


Figure 2-14: School building configurations

SOURCE: FLORIDA SAFE SCHOOLS DESIGN GUIDELINES, 2003

With respect to the attacks with explosive charge, the shape of the school building can contribute to the overall damage to the structure. For example, U-, H-, or L-shaped buildings tend to trap shock waves, which may exacerbate the effect of explosive blasts. For this reason, school buildings with re-entrant corners are much more vulnerable to blast damage (see Figure 2-15). In general, convex rather than concave shapes are preferred when designing the exterior of a school building.

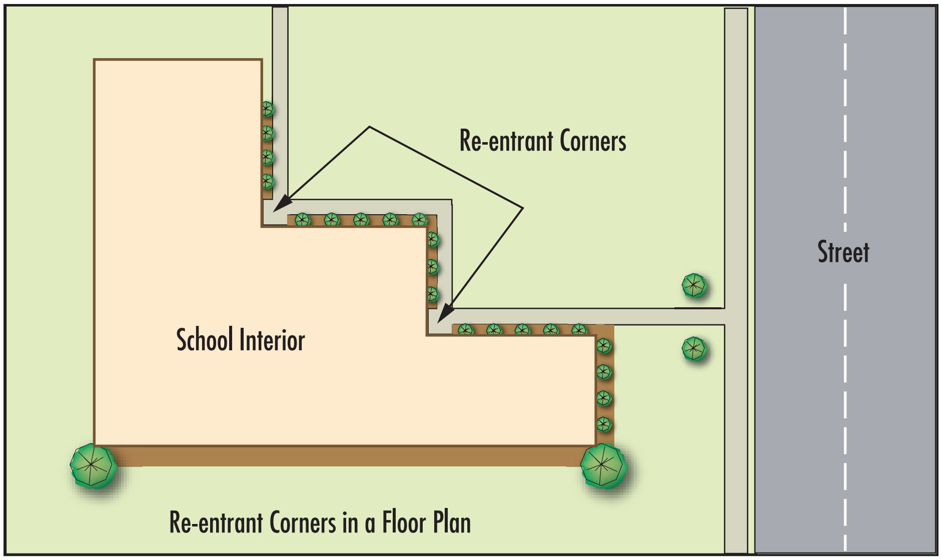


Figure 2-15:
Re-entrant corners in a floor plan

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

Additionally, school buildings with the ground floor at grade are vulnerable to vehicles being driven into them. Similarly, building openings and glazed walls oriented toward publicly accessible areas increase the vulnerability of school occupants to attacks using explosives and various projectiles.

2.2.3.5 Vegetation

Vegetation onsite can open or block views for security purposes, as well as provide shade and enhance the appearance of the site (Figure 2-16). However, vegetation at the base of school buildings and structures may exacerbate certain vulnerabilities by obscuring views, providing hiding places for people and explosive devices, and facilitating surreptitious approach by potential attackers.

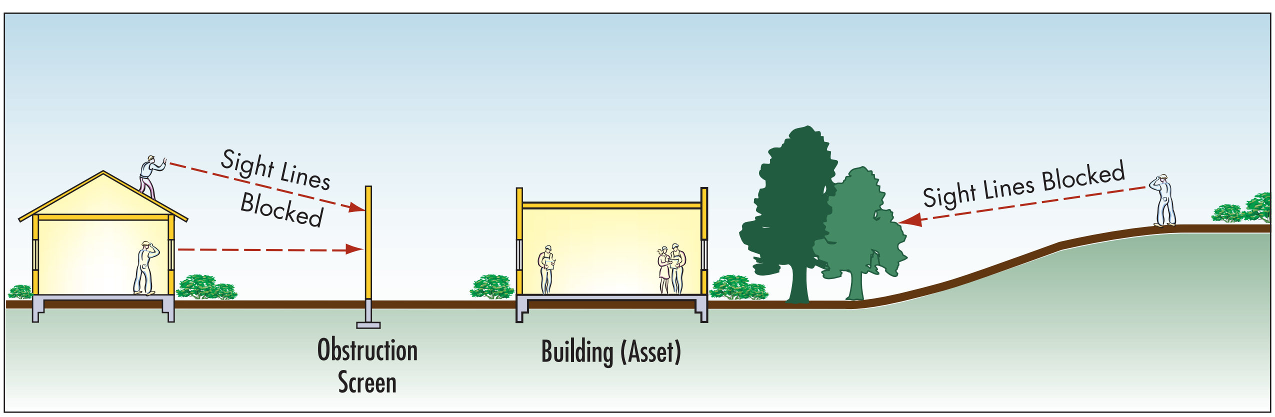


Figure 2-16: Trees and screens blocking sight lines into the site

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

2.3 General Site Security Design Strategies

The fundamental objective of site planning is to place school buildings, parking areas, and other necessary structures in such a way as to provide a setting that is functionally effective as well as aesthetically pleasing. Increasing concerns for security add another dimension to the range of issues that must be considered.

The typical threats to a school, as discussed in Chapter 1, range from low to very low on the threat rating scale, and the risk is correspondingly low in a typical situation. However, the risk may increase with several rare but possible conditions, one of which is temporary and the other permanent, relating to the school location.

A temporary high-risk situation may arise if a series of attacks occur at nearby schools or similar facilities that require security to be enhanced for the period of concern. A typical example of this is the series of attacks by the so-called Beltway sniper that took place in the Washington, DC, metropolitan area during 3 weeks in October 2002. During that time, fear of the random shootings generated a great deal of public apprehension. A 13-year-old boy was shot as he arrived at the Benjamin Tasker Middle School in Bowie, MD, but he survived the attack. The attackers subsequently delivered a specific threat against children that was made public, and some schools cancelled all outdoor activities, such as field trips and outdoor athletics. Others changed after-school procedures for parents to pick up their children to minimize the time they spent in the open. Extra police officers were also assigned to the schools.

In some situations, heightened risk to schools may be long term or permanent and, therefore, require enhanced protective measures. One such situation is the possibility of collateral damage caused by an attack on an adjoining or nearby facility. A school may be located in proximity to high-risk facilities, such as major government buildings, or structures with high symbolic value, such as bridges, iconic monuments, or national corporation headquarters buildings. The widespread collateral damage to buildings around the Murrah Federal Building in Oklahoma City (see Figure 2-17) is evidence of the magnitude of such risks.

The fundamental objective of site planning is to place school buildings, parking areas, and other necessary structures in such a way as to provide a setting that is functionally effective as well as aesthetically pleasing.

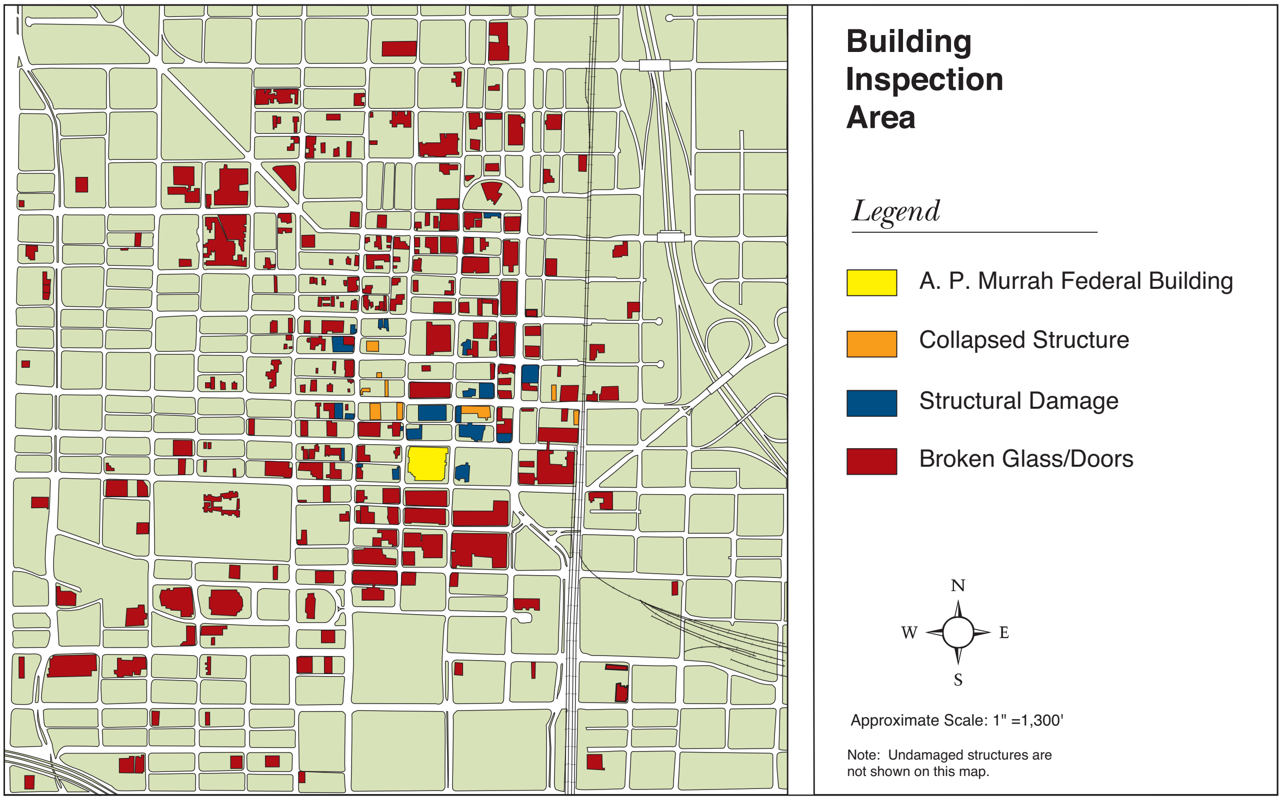


Figure 2-17: Collateral damage to buildings on sites adjacent to the Murrah Federal Building following the 1995 bombing

The design of protective measures for reducing site-related school vulnerabilities is based on a number of strategies that also represent the core principles of an effective security policy. They comprise the principles of a layered defense approach to security, standoff, access control, and a secure perimeter. Many of these principles are compatible with the Crime Prevention Through Environmental Design (CPTED) technique that has been used successfully to create 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, CPTED is often entwined with protective measures against terrorist attacks.

CPTED is a methodology for crime prevention based on studies showing how physical design contributed to victimization by criminals. The methodology was originally applied to improve security in public housing, but now embraces wider aspects of criminality and terrorism. CPTED defines three basic strategies for security design: natural access control, natural surveillance and territorial reinforcement. For more details about CPTED, refer to www.cpted.net.

2.3.1 Crime Prevention through Environmental Design

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, school building designs are not always compatible with today's more security-conscious environment.

According to CPTED principles, depending on purely conventional physical security measures (e.g., security guards and metal detectors) to correct objectionable student behavior or attacks from outside perpetrators 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 standalone measures may lead to a more negative environment, thereby enhancing violence. In short, employing standalone 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, 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 identify needs to be protected. Protecting a school from physical attack by criminals or terrorists, in many cases, only results in a change in the level and types of threats.

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.

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 results in a safer school. Each school, district, and community should institute measures appropriate for their own circumstances because no single solution 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.

The CPTED process provides direction to solve the challenges of crime and terrorism with organizational, mechanical, and natural design methods.

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 standoff and could create a vulnerability of the school structure to a vehicle bomb. In cases for which CPTED techniques conflict with security principles, designers and school administrators should seek innovative solutions tailored to their unique situation.

2.3.2 Standoff Distance

For the protection of assets against outside explosions, especially those associated with vehicle-borne explosive devices, the most cost-effective solution for mitigating blast effects is to ensure the explosion occurs as far away from the school building as possible. This distance, from the building face to nearest point that an explosive device can approach from any side, assuming that all security measures are in place is referred to as the standoff distance or simply standoff (Figure 2-18).

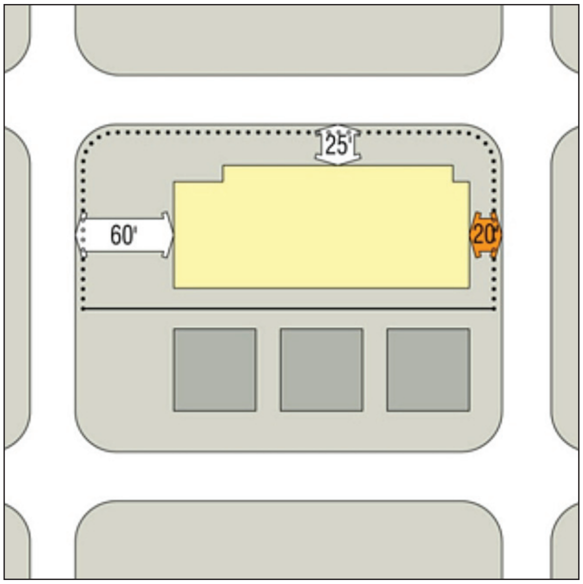


Figure 2-18: Standoff distance

SOURCE: DAVID SHAFER

For estimating purposes, the standoff distance is measured from the center of gravity of the charge located in the vehicle or other container to the face of the building under consideration.

2.3.2.1 Determining Standoff Distances

Determination of the minimum standoff is specific for each building or other asset and is based on the following:

- Prediction of the explosive weight of the weapon (expected blast load provided by the threat assessment).
- Required level of protection, which may be specified in the case of a Federal or other government building, using the Interagency Security Committee (ISC) Security Design Criteria scale, Unified Facilities Criteria (UFC), or VA criteria; for a privately owned building, the determination of acceptable risk is made during the risk assessment process.
- Evaluation of the type of building construction, whether existing or proposed, including the building structure and the nature of the building envelope.

The U.S. Department of Defense (DOD) prescribes minimum standoff distances based on the required level of protection and expected blast load. Where minimum standoff distances are met, conventional construction techniques can be used with some modifications. In cases where the minimum standoff cannot be achieved, the building must be hardened to achieve the required level of protection. See UFC 4-010-02, *UFC DOD Minimum Standoff Distances for Buildings* (DOD 2003), and UFC 4-010-01, *UFC DOD Minimum Antiterrorism Standards for Buildings* (DOD 2007).

VA criteria limit unscreened vehicles from traveling or parking within 50 feet of their mission-critical facilities; screened vehicles may travel/park as close as 5 feet to the facility. For VA life-safety protected facilities, vehicles are permitted to travel or park up to 5 feet from the facility.

The ISC Security Design Criteria, which apply to new Federal Courthouses, Government Offices, and major modernization projects, also recommend standoff distances based on the level of protection for the facility, but do not prescribe a minimum distance. These recommended distances apply to vehicles that are parked on adjacent properties and for vehicles that are parked on the building site. The ISC Security Design Criteria recognize that different levels of protection may be permitted for the building structure and its façade so that they may be economically designed to appropriate levels of protection as discussed further in Chapter 4, Section 4.4, See *ISC Security Design Criteria for New Federal Office Buildings and Major Modernization Projects*, Part 1 and Part II: Tables, Design Tactics and Additional Risk Guidelines (ISC 2004), and *ISC Security Standards for Leased Spaces* (ISC 2004).

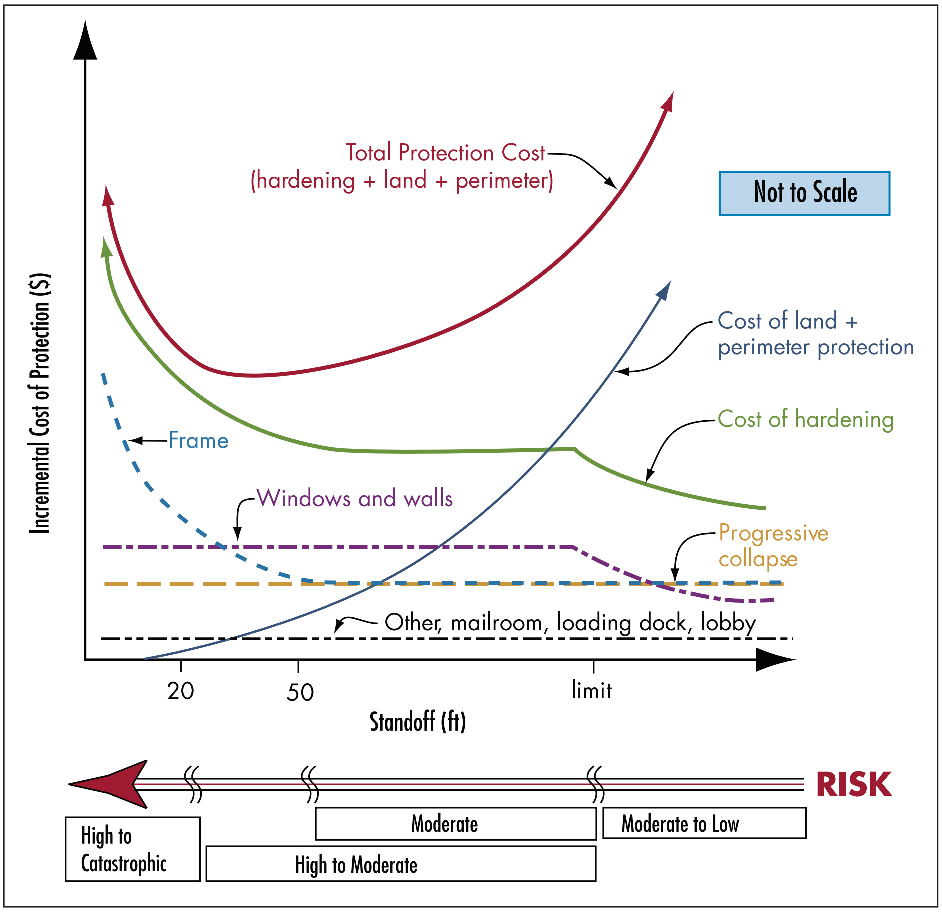
2.3.2.2 Constraints and Opportunities Provided by the Site

Because most open sites are able to provide considerable open space for standoff, conventional construction, with minor modification, may provide an acceptable level of protection against blast. However, a satisfactory standoff may be completely unachievable on a typical urban site, because the school building face may be only 10 to 20 feet from the curb, which is not an acceptable minimum distance from a potential blast. In such cases, alternative responses include protective measures, such as perimeter barriers, structural hardening, building envelope enhancement, operational procedures such as increased surveillance, or acceptance of some higher degree of risk.

At small standoff distances, even a few feet make a large difference in the blast loading. Increasing the standoff distance from 20 feet to 40 feet reduces the peak reflected pressure by a factor of four for a charge weight of 10 pounds and a factor of nearly seven for a charge weight of 1,000 pounds. The relationship between standoff distance and component cost is illustrated in Figure 2-19.

Figure 2-19:
Impact of standoff distance on component costs

SOURCE: APPLIED RESEARCH ASSOCIATES, INC.



For a more complete discussion of levels of protection, blast loading, standoff distance, and effects of blast see Chapter 4, Sections 4.3 and 4.4. See Section 2.3.2.3 for more detailed discussion of protective design for urban sites.

2.3.3 Layers of Defense

The basic approach to site security design promoted in this primer is the concept of layers of defense. These are multiple consecutive layers of protective measures deployed in concentric circles around a school. They start from the outer perimeter and move inward to the area of the school building with the greatest need for protection. The layers are mutually independent and designed to reduce the effectiveness of an attack by attrition, i.e., each layer is designed to delay and disable the attack as much as possible. This cumulative protection strategy is also known as protection-in-depth, and has been one of the basic CPTED strategies for protecting assets behind

> The basic approach to site security design promoted in this primer is the concept of layers of defense.

multiple barriers. Three main layers of defense emphasized in this publication are:

First or Outer Layer that consists of natural or manmade barriers usually at property line or sidewalk/curb line. Typically, the school perimeter is marked by no more than a fence, and is often completely open.

Second or Middle Layer usually extends from the perimeter of the site to the exterior face of a school building.

Third or Inner Layer starts at the building envelope and extends into the interior of the school building.

> **First Layer of Defense:** Consists of barriers usually at a property line or sidewalk/curb line.
>
> **Second Layer of Defense:** Extends from the perimeter of the site to the exterior face of a building.
>
> **Third Layer of Defense:** Usually inside the building and separates unsecured from secured areas.

Most of the protective measures associated with the layers of defense are relevant for high- to medium-risk buildings; the precise measures are designed in response to the calculated blast threat and the desired protection level. These measures can be implemented in conjunction with CPTED procedures.

2.3.3.1 Layers of Defense for Single Building Open Sites

Most schools are constructed on an open site where the defended perimeter may or may not be on the property line. Typically, the perimeter barrier designates the standoff distance around the school building beyond which is the area that building owners and occupants do not control.

Figure 2-20 shows the whole site as an exclusive protected area; the perimeter barrier is located on the property line, and the onsite parking is within the second layer of defense. Crash-rated barriers are used where the site is vulnerable to invasive vehicles. The rear of the site is impassable to vehicles, so the barrier is limited to a fence to deter intruders.

An alternative solution is to place the barrier inside the property line, thus reducing its length. The onsite parking is outside the access-controlled area, and a minimum standoff distance is provided. Figure 2-21 illustrates an example of a site security design for an open site. Note the indirect approaches to the building and the variety of landscape details.

Figure 2-20:
Protective barrier located on the property line to provide required standoff and onsite parking within the protected area

SOURCE: FEMA 430

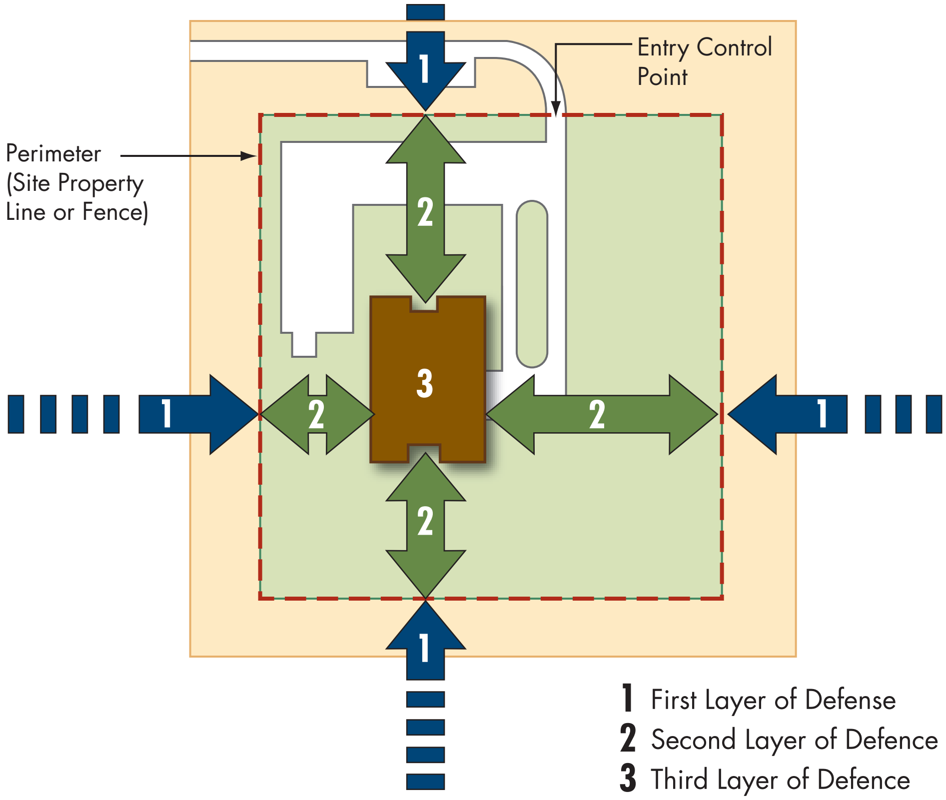
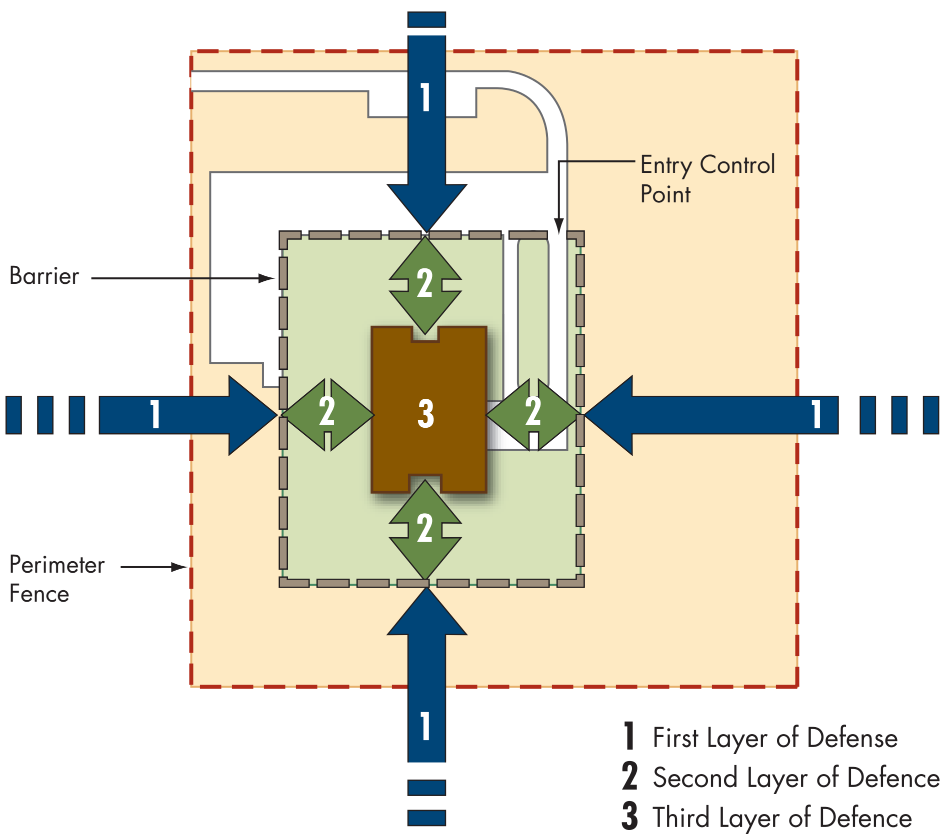


Figure 2-21:
Protective barrier located within the site providing minimum standoff

SOURCE: FEMA 430



2.3.3.2 Layers of Defense for Campus Sites

Layers of defense for a campus may take several forms, depending on the risk level for the campus as a whole as well as for individual buildings. The campus in Figure 2-22 shows a typical first line of defense at the transition between the first and second layers of defense; additionally, inside the fully protected perimeter, areas of the site also assume the role of first, second, and third lines of defense for one or more higher risk buildings.

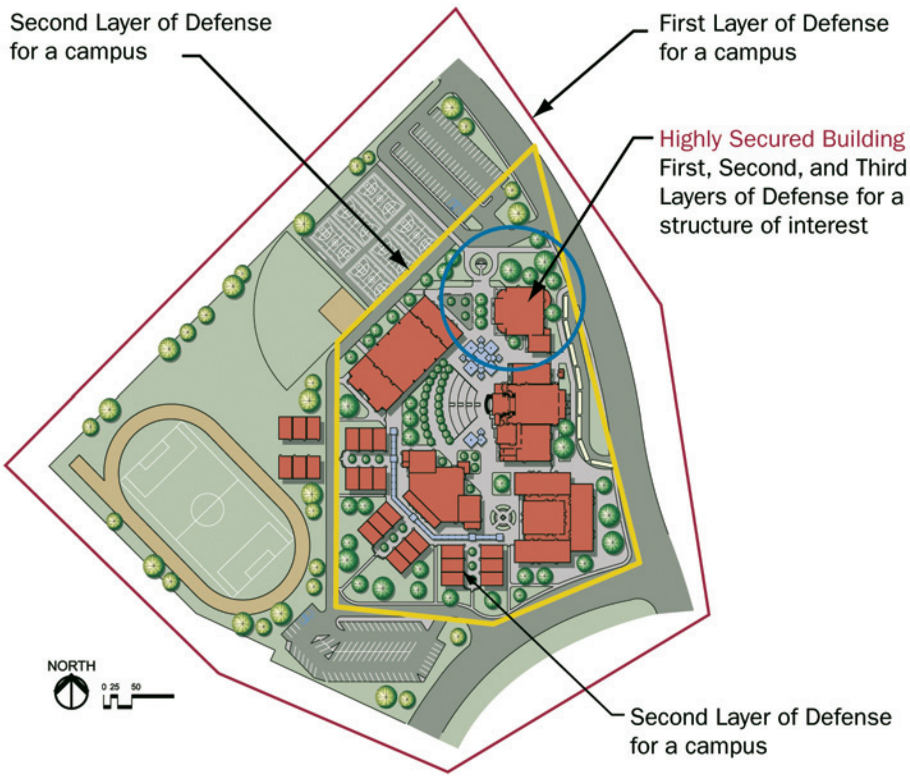


Figure 2-22:
Layers of defense for a campus site

SOURCE: WLC ARCHITECTS, INC.

In this example, the campus may have open access, but individual school buildings have varying protection, from minimal access control to the full three levels of defense around a high-risk building. In this latter case, the rest of the campus with first and second layers of defense becomes the first layer of defense for the high-risk building.

The campus may also have limited access control, as in a university that provides information and parking permits at entry points and a degree of security against common criminal activity. Specific high-risk buildings on a campus, such as laboratories, may have additional layers of defense.

2.3.3.3 Layers of Defense for Urban Sites

Though less common, many schools are still found in busy urban neighborhoods on sites restricted in size, which has significant implications for site security design. In cases where the school façade is at the property line, the first layer of defense is usually outside the school property, typically on a public sidewalk. It may take on aspects of the second layer of defense if the school is granted permission to place vehicle barriers at the curb on municipal property. The third layer of defense then starts at the school building face, i.e., the property.

Most urban schools, however, have a yard between the building face and the sidewalk (Figure 2-23). The yard is within the property line and typically consists of a grassy or planted area adjacent to the building. In such cases, the curb lane and the sidewalk form the first layer of defense. The sidewalk serves as the common space for pedestrian movement, activity, and interaction. The building yard is the second layer of defense. In the yard, security components should complement the school building architecture and landscaping, because they will be easily visible from the sidewalk, and should be located near the outer edge of the yard. An engineered planter or plinth wall can provide a good security barrier for this layer. The third layer of defense is the face and interior of the building.

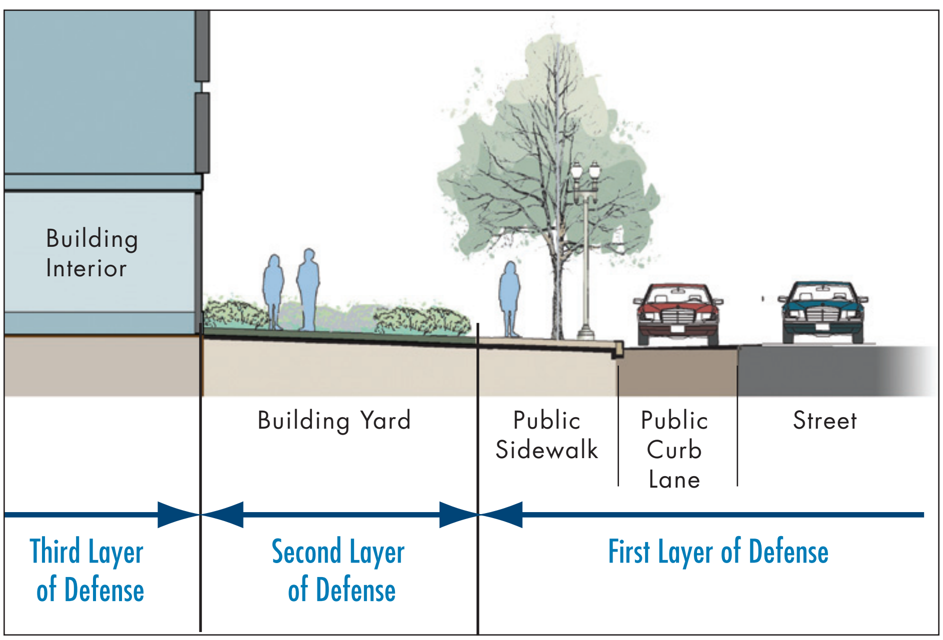


Figure 2-23:
Layers of defense with a yard

SOURDE: FEMA 430

2.3.4 Access Control

Access control is one of the key elements when determining effective placement of a school building. Designers should determine whether the building to be protected requires an exclusive or non-exclusive access zone (see Figure 2-24). An exclusive zone is defined as the area surrounding a single school building or building complex that is in the exclusive control of the owners or occupants: anyone entering an exclusive zone must have a legitimate reason. A nonexclusive zone may be either a public right-of-way, such as plazas, sidewalks, and streets surrounding a downtown school building, or an area related to several buildings, such as an industrial park with open access. The access-controlled zone may range from a complete physical perimeter barrier (full control) to relatively minimal anti-vehicle protection with full pedestrian access, or simple electronic monitoring of the perimeter.

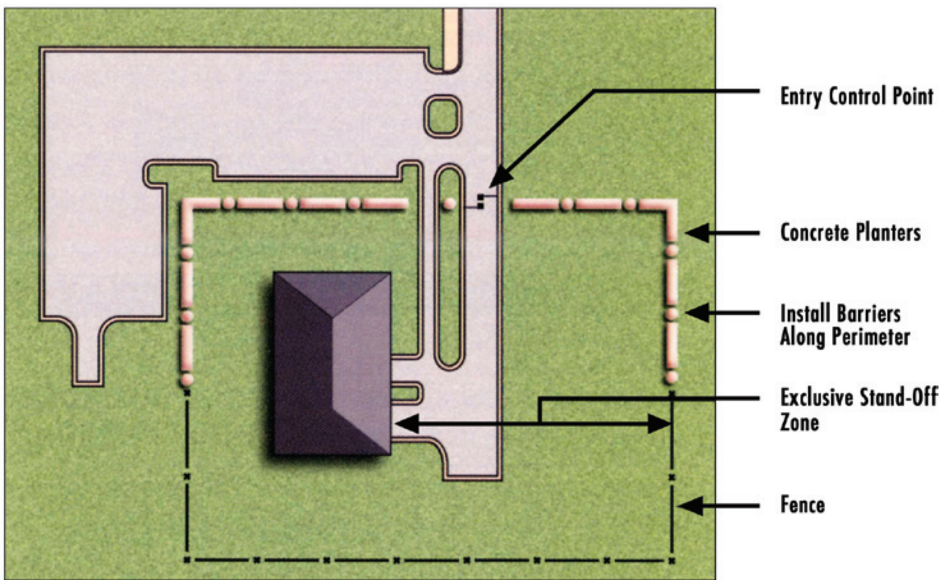


Figure 2-24: Exclusive zone within the site property

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

Some projects may require control of pedestrians and bicycles. In these cases, provision of a walkway and a turnstile for pedestrians (complying with the Americans with Disabilities Act [ADA] Accessibility Guidelines) should be considered.

2.3.4.1 Vehicle Approach Speed Control

The threat of vehicular attack can be reduced significantly by controlling vehicular speed and removing the opportunity for direct collision with the school building. If the vehicle is forced to slow down and impact a barrier at a shallow angle, the impact forces are reduced, and the barrier can be designed to lower performance requirements.

The speed of vehicles can be reduced by designing entry roads to sites and buildings that do not provide direct or straight-line access, making it impossible for a vehicle to gather speed as it approaches. Indirect approaches to a building, together with appropriate landscaping and earth forms, can also increase the attractiveness of the access road. Framing the sight of the school building by landscaping and other ways of controlling the views of the building can add to the aesthetic experience.

Figure 2-25 shows a portion of an analysis of threat vehicle approach speed used to determine the alignment and curvature of access roads to a large facility. The objective is to force the vehicle to impact the barrier at a reduced speed and at a shallow angle. This method also provides opportunities for enhancing the overall urban design of a site and its environs, as well as increasing pedestrian safety.

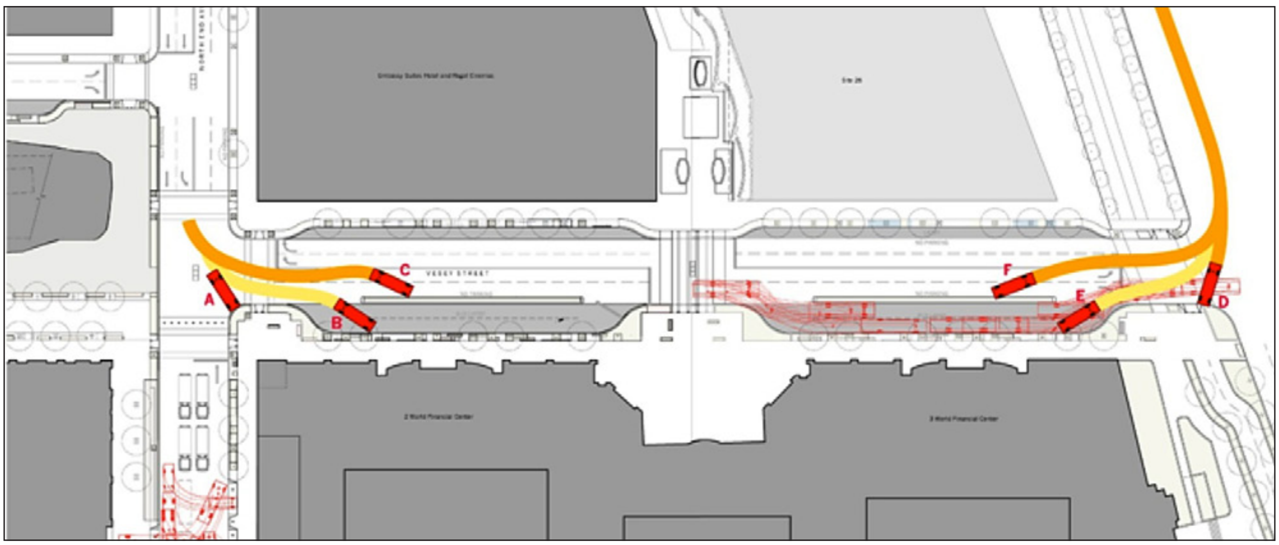


Figure 2-25: Portion of threat vehicle approach speed analysis

SOURCE: ROGERS MARVEL ARCHITECTS LLC

The following are some familiar devices and design methods of reducing vehicle speed:

- Traffic circles
- Curved roadways
- Chicanes (obstacle placement used to create a curved path on a straight roadway)
- Speed bumps and speed tables
- Raised crosswalks

- Pavement treatments
- Use of berms, high curbs, and trees to prevent vehicles from departing the roadway

Speed control of vehicles approaching gatehouses is also a concern. Some of the devices and design methods listed above can be used when approaching gates. In addition, bollards around the gatehouse can be used to narrow the approach. Truck entrances require wider lanes that can be handled by either active or removable bollards to limit the opening when trucks are not entering.

2.3.4.2 Entry Control and Vehicular Access

The objective of the access point is to prevent unauthorized access, while at the same time controlling the rate of entry for vehicles and pedestrians. An access point is a designated area for authorized school building users, such as employees, visitors, and service providers. Access points along the defended perimeter are commonly shared between the first and second layers of defense, providing observation of approach, controlled entry, and queuing areas. Structures such as control booths and equipment such as active barriers, communications, and video assessment and surveillance systems (VASS) (or closed-circuit television [CCTV])[1] are layered throughout the entry sequence to provide secured access points. Although the access itself is from a public roadway, these site features are within the site property line and form part of the first defense layer.

> The objective of the access point is to prevent unauthorized access.

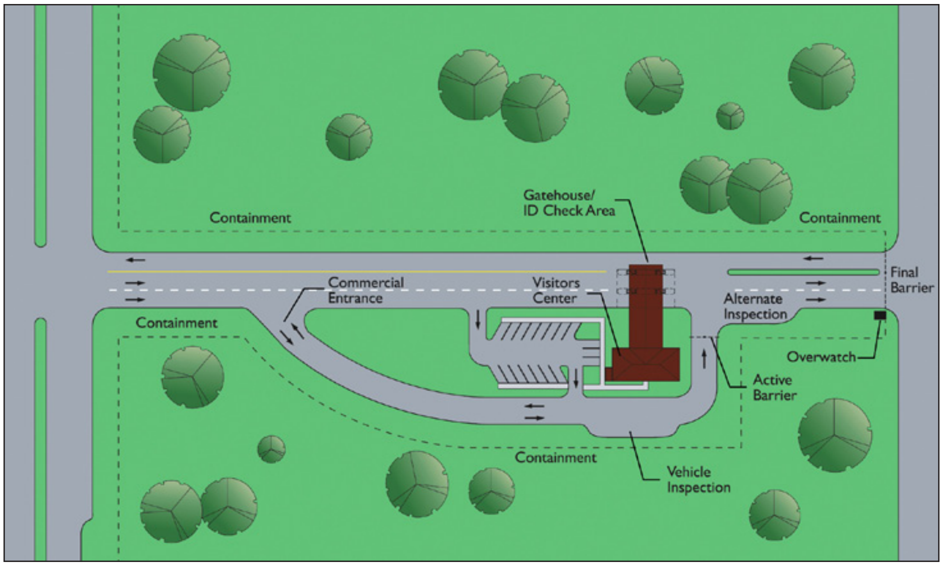
The location of access control points and inspection areas should be at sufficient standoff distance that detonation of a bomb on an uninspected vehicle does not impact the closest building and cause lethal damage. Figure 2-26 shows a typical layout of a high-security vehicle entry point and an access-controlled zone within a protected perimeter.

Whenever possible, commercial, service, and delivery vehicles should have a designated entry point to the site, preferably away from high-risk buildings. Active perimeter entrances should be designated so that security personnel can maintain full control without creating unnecessary delays. This can be accomplished by the provision of a sufficient number of entry points to accommodate the peak flow of pedestrians and vehicular traffic, as well as adequate lighting for rapid and efficient inspection.

1 See Chapter 5. Because security video serves two distinct purposes, assessment and surveillance, the term used here is video assessment and surveillance system or VASS. Historically, the term for a security video system was CCTV, a closed analog video system.

Figure 2-26: Typical entry control point layout

SOURCE: U.S. AIR FORCE, INSTALLATION ENTRY CONTROL FACILITIES DESIGN GUIDE



The number of access points into a site should be minimized because they are a potential source of weakness in the controlled perimeter, and are costly to construct and operate. However, at least two access control points should be provided in case one is shut down by maintenance, bomb squad activity, or other causes.

2.3.5 Perimeter Security

A perimeter security system consists of two main elements: the perimeter barrier that prevents unauthorized vehicles and pedestrians from entering the site, and access control points at which vehicles and pedestrians can be screened and, if necessary, inspected before they pass through the barrier.

After 9/11, many cities experienced a proliferation of barriers, street closures, and other security measures around high-risk Federal and private buildings. In some cases, these measures have been considered successful from a security, architectural, urban planning, and cultural preservation standpoint. However, in many cases, the installation of security barriers has been acknowledged as detrimental to the function, quality, and utility of the public realm. Restricting vehicle access can cause significant traffic congestion and can create unnecessary obstacles on streets and sidewalks that minimize the efficiency of pedestrian and vehicle circulation systems and hinder the access of first responders in emergencies.

A perimeter security system consists of two main elements: the perimeter barrier and access control points.

The following are suggested goals for perimeter security planning:

- Provide perimeter security in a manner that does not impede the city's commerce and vitality, excessively restrict or impede the use of sidewalks, limit pedestrian and vehicular mobility, or affect the health of existing trees.
- Provide security in the context of streetscape enhancement and public realm beautification, rather than as a separate or redundant system of components whose only purpose is security.
- Produce a coherent strategy for deploying specific families of streetscape and security elements in which priority is given to achieving aesthetic continuity along streets, rather than solutions selected solely by the needs of a particular building under the jurisdiction of one public agency.

Perimeter security protection is accomplished by design strategies that use a variety of methods to protect the site. The architecture and the landscaping of the site entry elements are the first part (and may be the only part) of the project that is visible to the general public. As such, they introduce the identity of the site, its architectural style and quality, and impart a sense of welcome or rebuff.

To achieve a welcoming atmosphere when incorporating security barrier systems, consider the following recommendations:

- Sidewalks should be open and accessible to pedestrians to the greatest extent possible, and security elements should not interfere with circulation, particularly in crowded locations.
- Barrier layout at sidewalks should be such that a constant clear path of 8 feet or 50 percent of the sidewalk, whichever is the greater, should be maintained.
- All necessary security elements should be installed to minimize obstruction of the clear path. They should be placed in an available amenity strip adjacent to most curbs, which is typically designated for street furniture and trees and not part of the existing clear path.
- Any security (or other) object placed at the curb should be at least 2 feet from the curb line to allow for door opening and to facilitate passenger vehicle pick-up and drop-off where permitted along the curb. Ideally, passenger drop-off points should be located in pullover or stopping points where the setback is greatest.
- Design and selection of barriers should be based directly on the threat assessed for the project, as well as available countermeasures and their ability to mitigate risk; excessive barriers should be avoided.

- Block after block of the same element, no matter how attractive, does not create good design. When a continuous line of bollards approaches 100 feet, it should be interspersed with other streetscape elements, such as hardened benches, planters, or trees.

Opportunities to add a palette of elements, such as varied bollard types, engineered sculptured forms, hardened street furniture, low walls, and judicious landscaping can all assist in creating a functional yet attractive barrier that will enhance the setting. Solutions that integrate a number of appropriate perimeter barriers into the overall site design will be more successful.

Barrier System Design Examples

Typical types of engineered (crash-rated) perimeter barriers are fixed bollards, engineered planters, fences, and retractable bollards. Each barrier is described further in Table 2-1.

Table 2-1: Engineered (Crash-Rated) Perimeter Barrier Types

Barrier Type	Descriptions, Installation, and Design Implications
Fixed Bollards	A bollard is a vehicle barrier consisting of a cylinder usually made of steel and filled with concrete placed on end in a deep concrete footing in the ground to prevent vehicles from passing, but allowing the entrance of pedestrians and bicycles. Bollards can be specified with ornamental steel trim attached directly to the bollard or with selected cast sleeves of aluminum, iron, or bronze that slip over the crash tube.  *Custom bollard covers* SOURCE: DELTA SCIENTIFIC INC.  *A long line of bollards can appear as a wall.* **Installation:** The need for bollards to penetrate several feet into the ground may cause problems with underground utilities whose location may not be known with certainty (see figure below). If underground utilities make the installation of conventional bollard foundations too difficult, bollards with a wide shallow base and a system of beams below the pavement to provide resistance against overturning (see figure below) are a possible solution.

<table>
<tr><th>Barrier Type</th><th>Descriptions, Installation, and Design Implications</th></tr>
<tr><td>Fixed Bollards (cont.)</td><td>

Installation of fixed bollard line (left)

SOURCE: SECUREUSA, INC.

Bollards on shallow beam system (right)

SOURCE: RSA PROTECTIVE TECHNOLOGIES

Design Implications:

Bollards are by their nature an intrusion into the streetscape. A bollard system must be very thoughtfully designed, limited in extent, and well integrated into the perimeter security design and the streetscape to minimize visual impacts.

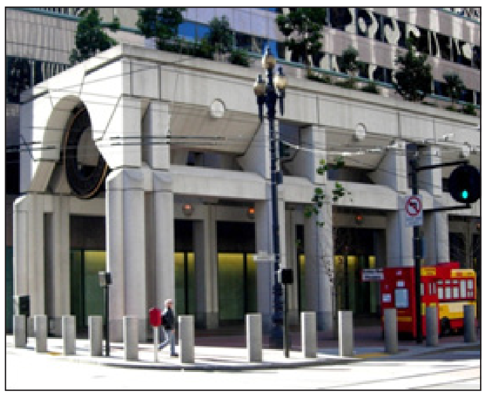
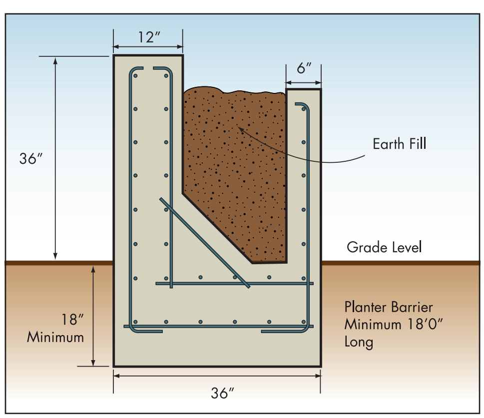
To reduce the visual impact, bollard height should typically not be more than 30 inches. However, this height may be ineffective for some vehicular threats; for example, some States allow the maximum height of a bumper to be 31 inches (0.8 meter) above grade. Site-specific conditions, such as road surface grade and curb height, may help improve the effectiveness of a bollard for impact, while making the bollard appear less obtrusive.

A bollard reduces the effective sidewalk width by the width of the curb to bollard (typically 24 inches [0.6 meter]) plus the width of the bollard. In high-pedestrian and narrow-sidewalk areas of a central Business district, the reduction in effective sidewalk width can be problematic.

Other bollard system guidelines include the following:

- Bollard spacing should be between 36 and 48 inches (0.9 and 1.2 meters), depending on the kind of traffic expected and the needs of pedestrians and the handicapped.
- Where a long line of bollards is unavoidable, the bollards can be interspersed with trees and oversize bollards that can act as seats. In a few years, the trees will dominate the streetscape, and the barriers will be unobtrusive.
- Bollards should be kept clear of ADA access ramps and the corner quadrants at streets.
- Bollards should be arranged in a linear fashion in which the center of the bollards is parallel to the centerline of existing streets.
- Bollards may be custom designed for an individual project to harmonize with the materials and form of the building; but to provide adequate protection, they must be tested by an independent laboratory.
- Closely spaced bollards can also make the navigation to curb cuts particularly challenging for wheelchairs.
- In no case should bollards exceed a height of 38 inches (1 meter), inclusive of any decorative sleeve.

</td></tr>
</table>

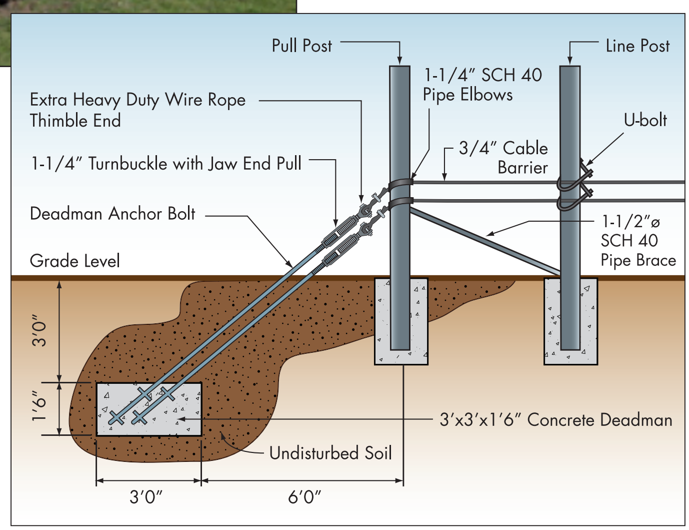
Barrier Type	Descriptions, Installation, and Design Implications
Fixed Bollards (cont.)	 *A long line of bollards with trees interspersed (left). Custom bollards used in conjunction with a sloping wall barrier (right).*  *Corner installation of custom concrete bollards that match the building architecture.*
Engineered Planters	Well-designed planters can form an effective vehicle barrier. Planters located on the surface rely on friction to stop or delay a vehicle and will be pushed aside by any heavy or fast-moving vehicles; displaced planters may become dangerous projectiles. Engineered planters need considerable reinforcing and below-grade depth to be effective and become fixed elements in the landscape design. The planter shown provides a Department of State (DOS) K12 rating.  *Typical engineering detail of reinforced planter with DOS K12 performance*  *Planter with concealed crash-rated bollards* SOURCE: WAUSAU TILE

Barrier Type	Descriptions, Installation, and Design Implications
Engineered Planters (cont.)	**Installation:** Some guidelines for planter system installation include the following: • Rectangular planters should be no more than 2 feet (0.6 meter) wide and 6 feet (1.8 meters) long, and circular planters should be no more than 3 feet (0.9 meter) in diameter. • A maximum distance of 4 feet (1.2 meters), depending on the kind of traffic anticipated, should be maintained between planters and other permanent streetscape elements. • Planters should not be used in high pedestrian traffic areas. • Planters should be oriented in a direction parallel to the curb or primary flow of pedestrian traffic. In no case should a planter or line of planters be placed perpendicular to the curb. • Landscaping within planters should be kept below 2.5 feet (0.8 meter) in height, except when special use requirements call for increased foliage. Depending on the threat, consideration should be given to ensuring that a 6-inch-high (15-centimeter-high) package could not be concealed in the foliage. **Design Implications:** Planters can have a major impact on pedestrian movement, reducing the effective sidewalk width. However, well-designed and placed planters can have multiple functions and be civic amenities.  *These planters are formed by the top of retaining walls (left). Alternating bollards and planted retaining walls as a barrier (right).*
Fences	Fences are a traditional choice for security barriers, primarily intended to discourage or delay intruders or serve as a barrier against standoff weapons (e.g., rocket-propelled grenades) or hand-thrown weapons (e.g., grenades, fire-bombs). Familiar fence types include: • Chain-link • Monumental fences (metal) • Anti-climb (CPTED) fence • Wire (barbed, barbed tape or concertina, triple-standard concertina, tangle-foot)

Barrier Type	Descriptions, Installation, and Design Implications
Fences (cont.)	These fence types are primarily intended to delay intrusion. They provide very little protection against vehicles, but they can act as a psychological deterrent when an aggressor is deciding which building to attack. Fencing can also incorporate various types of sensing devices that relay warning of an intruder to security personnel. Fences can be constructed as engineered anti-ram systems. An effective solution is to use cable restraints to stop the vehicle: these can be placed at bumper height within the fence and hidden in plantings.

Crash-rated fence

SOURCE: AMERISTAR FENCE PRODUCTS INC



Layout of cable fencing, used in conjunction with planting

SOURCE: *DOD HANDBOOK: SELECTION AND APPLICATION OF VEHICLE BARRIERS*, MIL-HDBK-1013/14, 1999

Installation:

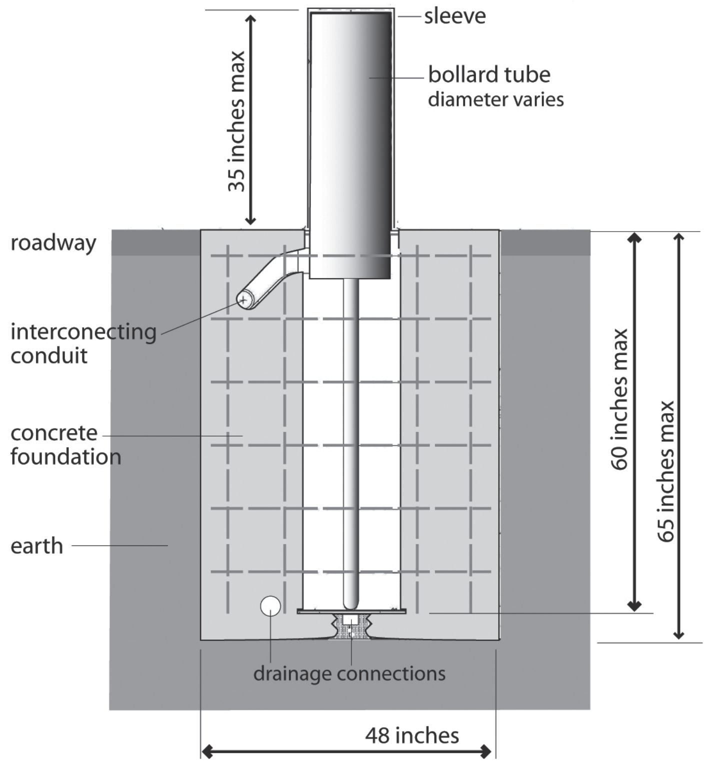
Cable system fences allow considerable deflection and partial penetration of the site before resistance occurs. The amount of deflection is based upon the distance between the concrete "dead men," typically about 200 feet. As a result, the installation requirements for fences and gates that incorporate a cable system differ slightly from other types of walls and fences.

Design Implications:

Fences for the protection of property have a long history and have also often been elements of great beauty. Modern fences are governed more by function and cost, but variations of historic fence design have been used as barriers for important historic building. The appearance of less attractive fencing can be improved by plantings.

Barrier Type	Descriptions, Installation, and Design Implications
Retractable Bollards	A retractable bollard system consists of one or more rising bollards operating independently or in groups of two or more units. The retractable bollard is a below-ground assembly consisting of a foundation structure and a heavy cylindrical bollard that can be raised or lowered by a buried hydraulic or pneumatic power unit, controlled remotely by a range of access control devices. Typical retractable bollards are 12 to 13 inches (30 to 33 centimeters) in diameter, up to 35 inches (0.9 meter) high, and are usually mounted 3 feet (0.9 meter) apart, depending on typical traffic. Retractable bollards are used in high-traffic entry and exit lanes where vehicle screening is necessary, at site entrances, and at entries such as parking garages and building services. Unlike rising or rotating wedge systems, the entry is freely accessible to pedestrians when the bollards are raised. Normal bollard operating time is field adjustable and ranges from 3.0 to 10.0 seconds. Emergency operating systems can raise bollards to the guard position from fully down in 1.5 seconds. **Installation:** Retractable bollards are expensive because they need broad and deep excavation for the bollards and operating mechanisms. Also, as with all active barriers, they require regular maintenance to ensure continued operation. **Design Implications:** Retractable bollards are relatively unobtrusive barriers that need only to be raised when screening is necessary. A retractable bollard system is generally accompanied by fixed bollards at the sides, and a secure control booth is necessary for security personnel.

Typical retractable bollard systems at a service entry; note fixed bollards at sides

Barrier Type	Descriptions, Installation, and Design Implications
Retractable Bollards (cont.)	 ***Retractable bollard installation, section*** SOURCE: DELTA SCIENTIFIC CORP

Some considerations in the design of a perimeter barrier system include the following:

- The perimeter of the site should be secured to a level that prevents unauthorized vehicles or pedestrians from entering and should be located as far from the school building as possible. Anti-ram protection may be provided by strengthened bollards, walls, and fences.
- Vehicle entry beyond check points should be controlled to permit entry by only one vehicle at a time.
- Entry check points should be space outside the protected perimeter.
- Perimeter barriers should be engineered and crash-rated.
- Manholes, utility tunnels, culverts, and similar unintended access points to the school property should be secured with locks, gates, or other appropriate devices without creating additional entrapment hazards.

- In areas subject to chemical spills, a school sited in a depression or low area may be trapped by heavy vapors and natural decontamination by prevailing winds may be inhibited.
- Outdoor containers in which explosives can be hidden (such as garbage cans, mailboxes, and recycling or newspaper bins) should be kept at least 30 feet from the school building and be designed to restrict the size of objects placed inside them, or to expose their contents (for example by using steel mesh instead of solid walls).
- In areas considered susceptible to explosive attack, the standoff distance between buildings and the nearest parking or roadway should be at least 75 feet with more distance for unreinforced masonry or wooden walls. If this standoff is not achievable, the creation of additional standoff protection by barriers and parking restriction should be considered.

2.4 Parking

2.4.1 Parking in Open Sites

Parking on open sites is typically accommodated by surface parking lots. On-street parking lanes may occur on any site but are particularly characteristic of urban areas.

All parking in an open site should be located outside the standoff zone for high-risk buildings. Access control may be necessary at the entry to parking in non-exclusive zones for regulation and fee collection. If the site has a perimeter barrier, authorization to enter the site and any necessary inspection can take place at entry control points; parking structures should not need additional control.

All parking in an open site should be located outside the standoff zone for high-risk buildings.

Warning signs that are easy to understand should be installed along the physical barriers and at each entry. An important design goal is the development of an efficient layout of the parking spaces and provision of an internal circulation that has clear paths for pedestrians and vehicles. Parking restrictions can help to keep potential threats away from a school building. Operational measures may also be necessary to inspect or screen vehicles entering parking areas.

The following considerations may help designers to implement sound parking measures for schools that may be at high risk:

- Only permit parking by inspected vehicles within the standoff zones and avoid or limit drop-off zones.
- Provide appropriate setback (standoff) from parking to the protected school building. Structural hardening may be required if the setback is insufficient. In new designs, adjust the location of the building on the site to provide adequate setback from adjacent properties, if possible.
- If possible, locate unexpected visitor or general public parking near, but not on, the site itself, or outside the standoff zone.
- Locate vehicle parking away from high-risk school buildings to minimize collateral blast effects from potential vehicle bombs.
- Locate general parking in areas that present the fewest security risks to personnel.
- If possible, design the parking lot with one-way circulation to facilitate monitoring for potential aggressors.
- Locate parking within the view of occupied school buildings. Use carefully chosen plantings around parking structures and parking lots to permit observation of pedestrians while at the same time reducing the visual impact of automobiles. Topography, existing conditions, or aesthetic objectives may make this difficult or undesirable to achieve, and CCTV surveillance cameras may substituted.
- Do not permit uninspected vehicles to park within the exclusive zone or in the second layer of defense.
- Restrict parking between individual school buildings, especially when the buildings are relatively close together, because the proximity increases reflected blast pressures.
- Provide emergency communication systems (e.g., intercom, telephones, etc.) in establishing parking areas 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.

2.4.1 Public Street Parking

In urban areas, public street parking is often located within a desired standoff zone. Evaluation of the viability of this option must consider the role of the street within the local infrastructure, whether the municipality must be reimbursed for loss of metered parking income, and whether an additional lane provides significant improvement of the standoff distance.

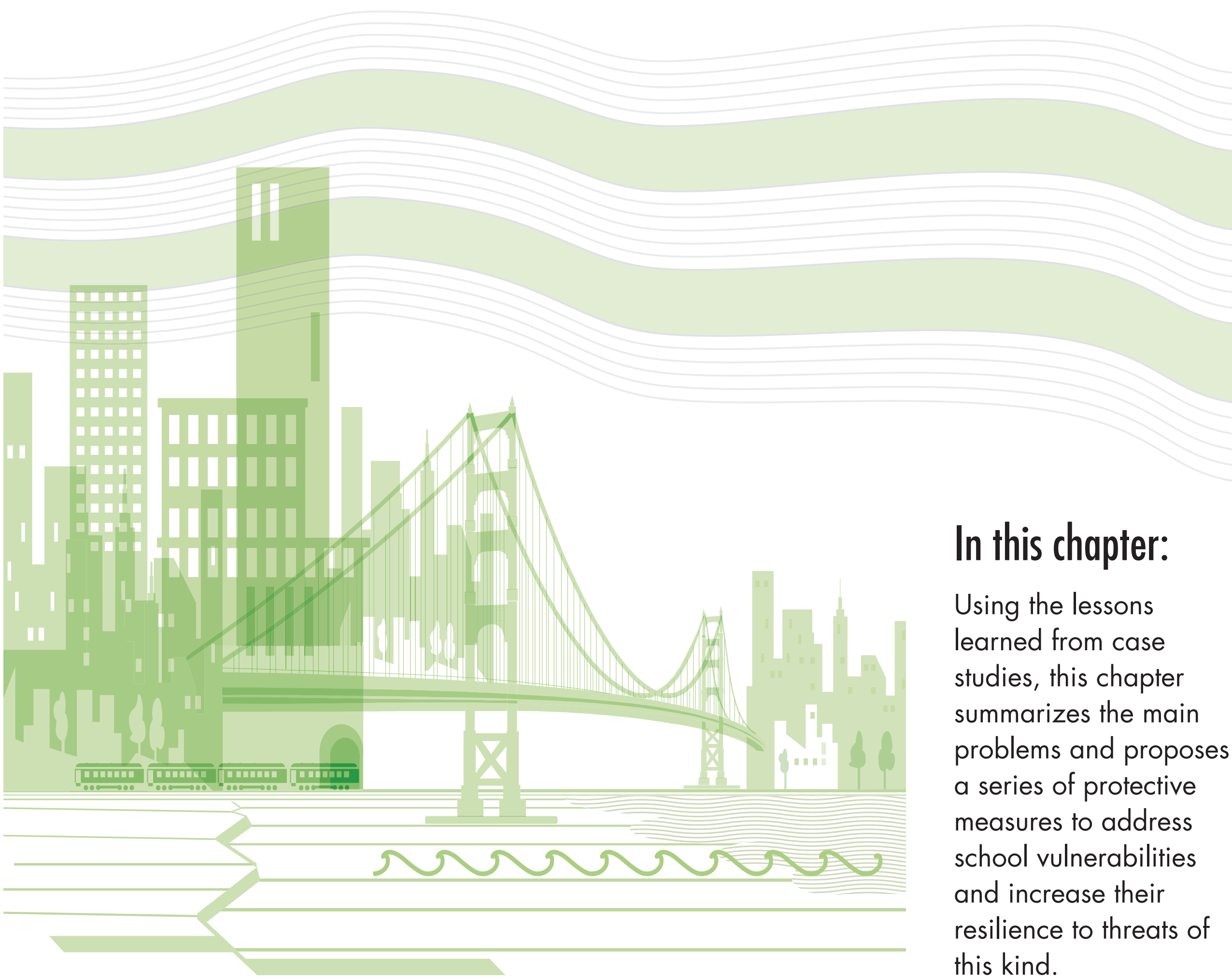
If street parking lanes are unacceptable because of the high risk, access to the vulnerable streets and parking may have to be prohibited to create an adequate standoff zone. This approach has been adopted in the New York City Financial District. Street closure has serious implications for everyday function and accessibility, and should only be undertaken if no other solution, such as building hardening, is feasible.

Considerations for public street parking include the following:

- Request appropriate permits to restrict parking in curb lanes in densely populated areas to company-owned vehicles or key employee vehicles.
- Provide appropriate setback from parking on adjacent properties, if possible. Structural hardening may be required if the setback is insufficient. In new designs, adjust the location of the school building on the site to provide adequate setback from adjacent properties, if possible.
- Pick-up and drop-off areas should have appropriate barriers at the edge of the curb to enforce standoff distances for unscreened vehicles and to address mobility and convenience for pedestrians. Barriers should be placed at a distance from the curb to allow clearance for vehicle doors to open (24 inches minimum), the provision of adequate lighting and shelter so pedestrians can wait safely for their rides, and appropriate design for handicapped access. Circulation planning should ensure that effective access is available for first responders and other emergency vehicles.

3

Targeted Shooting



In this chapter:

Using the lessons learned from case studies, this chapter summarizes the main problems and proposes a series of protective measures to address school vulnerabilities and increase their resilience to threats of this kind.

3.1 Introduction

Targeted shootings in or around schools have become a disturbing part of our Nation's history. Although, there is increased publicity of the dangers of school shootings, very little has been done to reduce the risks from similar incidents to our schools and universities. Experience from past attacks teaches us that threats of shooting incidents are as unpredictable as any other threats or hazards.

Currently our schools and campuses are highly vulnerable to attacks that may produce unacceptable levels of casualties. These institutions lack the capability and resources necessary to prevent a hostile intruder from entering and at the same time do not have the capability to intervene before any injuries occur. A targeted shooting incident typically evolves so rapidly that by the time emergency responders arrive, it is either too late or too dangerous to intervene. It is a painful, but nonetheless true fact, that once an attacker has entered a targeted school building with the intention of shooting someone, there is practically nothing, or very little, that can be done to avert the attack.

"Despite prompt law enforcement responses, most attacks were stopped by means other than law enforcement intervention and most were brief in duration. The short duration of most incidents of targeted school violence argues for the importance of developing preventive measures in addition to any emergency planning for a school or school district. The preventive measures should include protocols and procedures for responding to and managing threats and other behaviors of concern" (U.S. Secret Service and U.S. Department of Education 2002, p. 25).

In circumstances where neither the threats nor the consequences can be reduced easily, risk reduction must focus on protective measures that reduce vulnerabilities. Protective measures that address security concerns must become an integral part of the school design strategy, which needs to balance and coordinate many different objectives, from maintaining an open and accessible environment conducive to interaction and study, to providing a functional and pleasant setting for school activities while fostering a sense of unrestricted safety and security.

Vulnerabilities are typically the characteristics of educational facilities inherent to their function, operation, or physical design of the building. Before discussing the various aspects of risk, this chapter will examine briefly the evolution of school design in the United States and review the variety of shapes and configurations of school buildings, many of which continue to operate to this day. Following this introduction the chapter reviews a number of shooting incidents from the past in an attempt to highlight the vulnerabilities that contributed to these tragic events. Using the lessons learned from these case studies, this chapter summarizes the main problems and proposes a series of protective measures to address school vulnerabilities and increase their resilience to threats of this kind.

3.2 Evolution of School Design

This section presents an overview of school building design to provide a context for the chapters that follow. Every building is unique and school designs vary greatly; however, the purpose of schools, their occupancy, their economic basis, and their role in society dictate certain common features that distinguish them from other building types. The section describes school design of the past, because many older schools are still in use and must be renovated periodically to meet today's needs. In addition, some discussion is provided on current school design with some trends and ideas that might influence the design of future schools.

This section presents an overview of school building design to provide a context for the chapters that follow.

3.2.1 Past School Design

Schools are typically in use for long periods of time. As a result, learning continues in facilities that were designed and constructed at the beginning of the 20th century. Early 20th-century school design was based on late 19th-century models and was relatively static until after World War II. Schools ranged from one-room rural school houses to major symbolic civic structures in large cities (Figures 3-1 and 3-2). Many inner-city schools were more modest, inserted into small sites on busy streets and constrained by budget limitations (Figure 3-3).

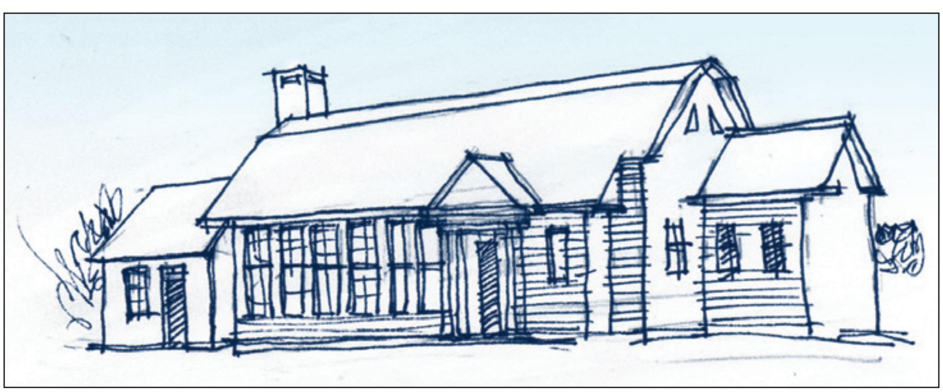


Figure 3-1: One-room schoolhouse, Christiana, DE, 1923

Figure 3-2:
High school, New York City, NY, 1929

Figure 3-3:
Elementary school, Washington, DC, constructed in 1930

The typical city school was one to three stories in height and consisted of rows of classrooms on either side of a wide, noisy corridor lined with metal lockers. Typical outdoor recreational areas were asphalt play courts and rooftops. The larger schools sometimes had libraries, special rooms for art, science, and shop, and auditoriums.

Despite the growth of suburban construction, the fundamental design with classrooms along double-loaded corridors did not change very much.

The construction surge to meet the school demands of the post-war baby boom was primarily a suburban development. Much larger sites were available, schools were one or two stories in height, auditoriums became multi-use facilities and large parking lots appeared. However, many rural schools were located far away from towns and their resources, such as fire departments and other services.

Despite the growth of suburban construction, the fundamental design with classrooms along double-loaded corridors did not change very much. However, in warm climates, the one-story "finger plan" school, constructed of wood and a small quantity of steel, was both economical and more human. For this design, the noisy tiled double-loaded corridor is replaced by a covered walkway, open to the air, with the classrooms on one side and a grassed court on the other (Figure 3-4). In California, the access hallways are open to the air. The cross-section diagram in Figure 3-4 shows the simple and effective means of day lighting and ventilation.

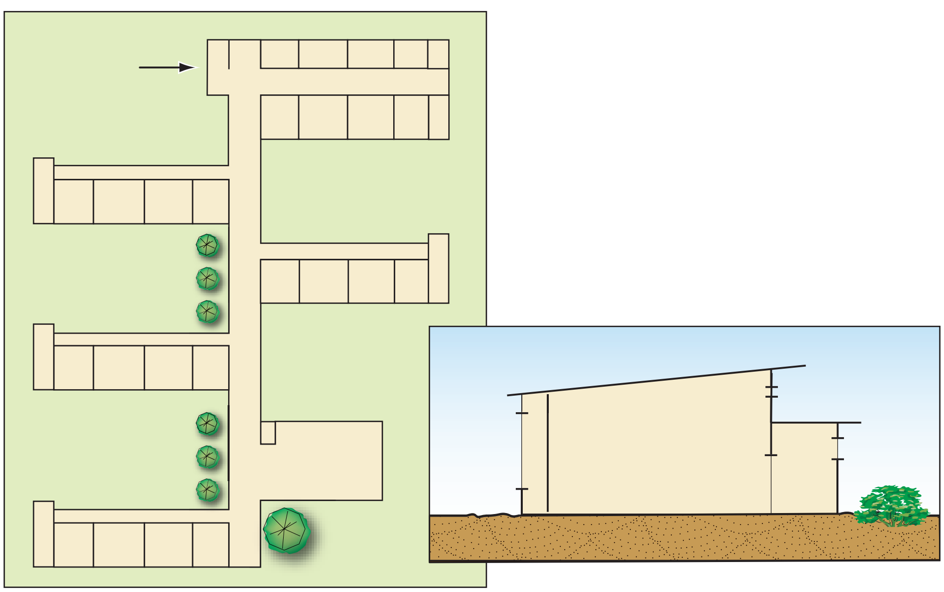


Figure 3-4:
Typical finger plan school, 1940s

Compact versions of these plans appeared as schools became larger and sites smaller (Figure 3-5).

Figure 3-5:
Compact courtyard plan, 1960s

Historically, high schools have been large facilities, housing 2,000 to 3,000 students (Figure 3-6). Some of the new large high schools were built as air-conditioned enclosures, with many windowless classrooms, in buildings that resembled the shopping malls that were replacing the main street retail centers. In the 1960s and 1970s, educational experiments such as team teaching spawned schools with open classrooms with no fixed partitions to allow flexibility in teaching methods (Figure 3-7).

However, teachers complained of poor acoustics and loss of their own individual "home" classroom. In response, schools designs combined classrooms into clusters. The Harris Hill elementary school in Penfield, NY, used clusters of five hexagonal classrooms to provide space for seminars, individual studies, and group instruction, with no fixed partitions (Figure 3-8). Other schools clustered individual classrooms together with common support spaces.

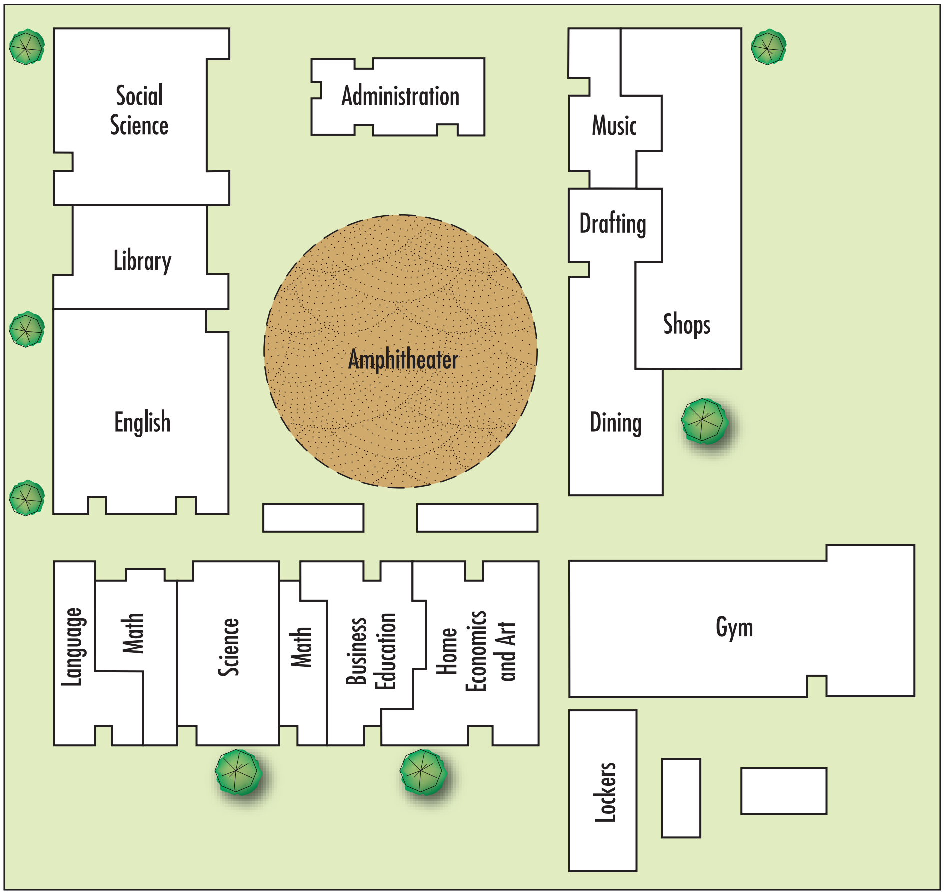


Figure 3-6:
Fountain Valley High School (3,000 students), Huntington Beach, CA, 1964

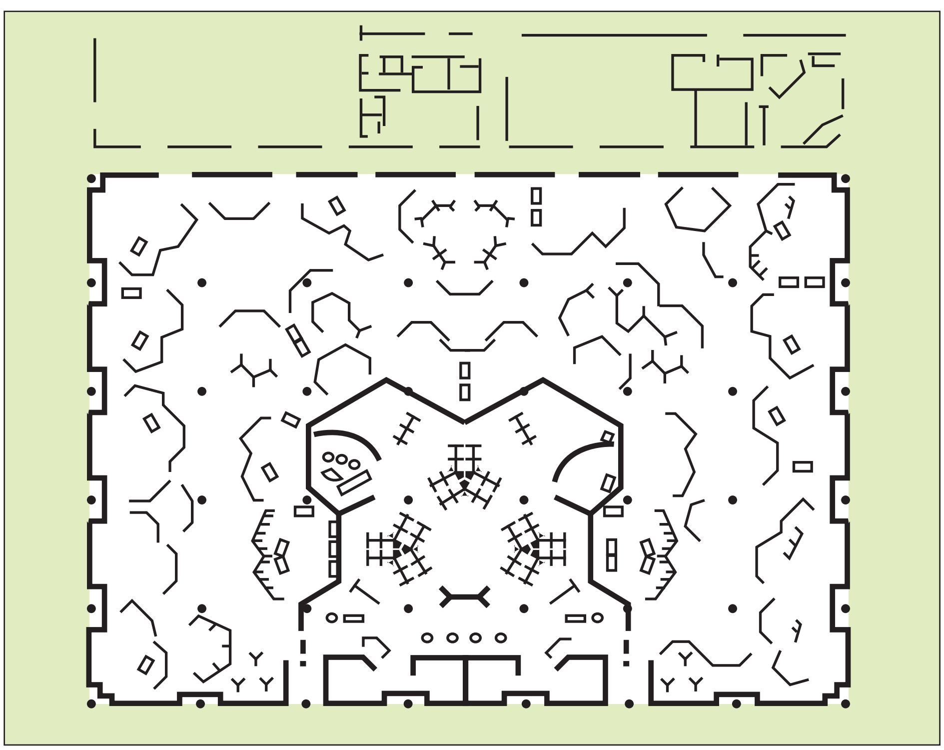


Figure 3-7:
Open-plan teaching area, with movable partitions, Rhode Island, 1970

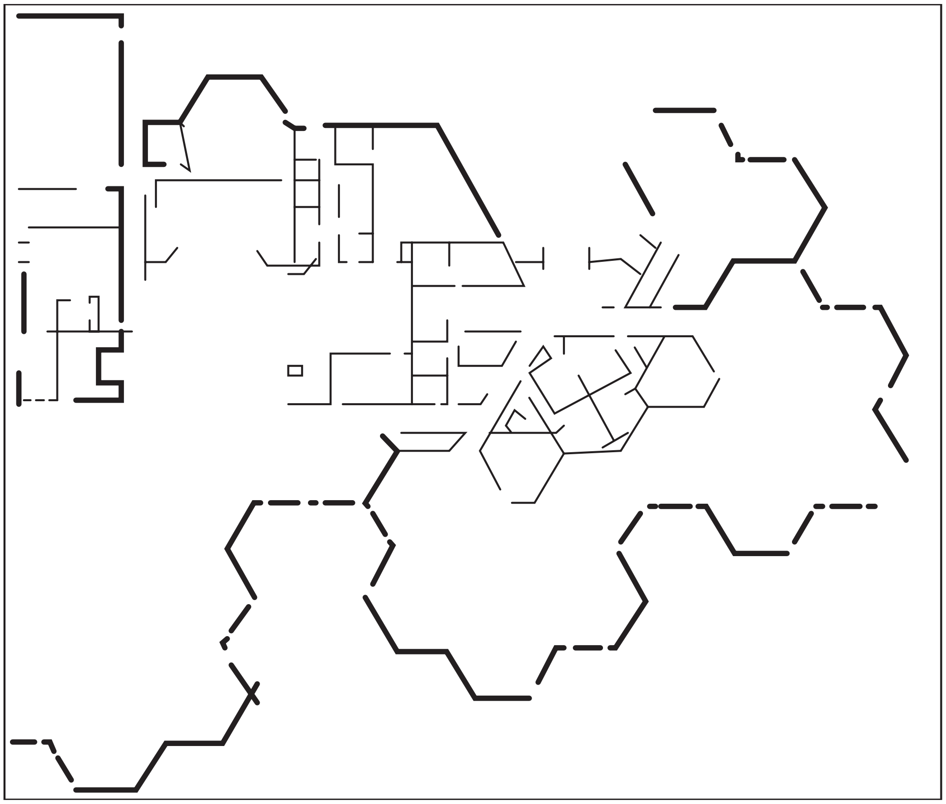


Figure 3-8:
Harris Hill Elementary School, Penfield, NY, 1970, employed clusters of classrooms

At the same time, rapid demographic changes created a need for new classrooms at a time when resources were severely limited. Many schools were expanded by adding modular (prefabricated) classrooms to accommodate the increasing enrollments. Although prefabricated classrooms were originally intended as temporary space, many still remain as permanent classrooms (Figure 3-9).

Figure 3-9:
Typical modular classrooms, 1980s, still in use

Another solution was the conversion of existing buildings, not originally intended for educational purposes; although this approach was generally used by private schools and the new concept of "charter" schools (Figure 3-10).

Figure 3-10:
Private high school located in a remodeled industrial building, Palo Alto, CA, 1990s

Other schools built in the 1980s and 1990s assumed a wide variety of forms, often focusing on providing an aesthetically pleasing learning environment (Figure 3-11).

Figure 3-11:
Elementary school, Fairfield, PA, 1980s

3.2.2 Present School Design

With the dawn of the 21st century, evolving social, economic, and educational concerns suggested changes in school design. New design goals have begun to emerge, though some of the following represent perennial concerns:

- The building should provide for health, safety, and security.
- The learning environment should enhance teaching and learning and accommodate the needs of all learners.
- The learning environment should serve as the center of the community.
- The learning environment should result from a planning/design process that involves all stakeholders.
- The learning environment should allow for flexibility and adaptability to changing needs.
- The learning environment should make effective use of all available resources.

These goals have lead, in turn, to a number of current design principles, including:

- Design for protection against natural hazards
- Design with increased attention to occupant security
- Design with increased use of daylighting and comfort control
- Design for durability
- Design with a long-life/loose-fit approach: allow for internal change and flexibility
- Design for sustainability, including energy efficiency and the use of "green" materials

Some new schools already respond to these needs and, indeed, their originators, school districts, communities, and designers are among those defining school design for the future. Some of the changes are the result of ideology and analysis. Other changes reflect efforts to provide an improved learning environment and enhanced learning resources in an economy with increasingly limited funding for school construction. Some school districts will be faced with having to provide a minimal learning environment with buildings of the utmost simplicity, while meeting the requirements for health, safety, and security.

3.2.3 Future School Design

Schools will continue to vary widely in size. However, even in the suburbs, land has become scarce and expensive. New schools will be more compact, often two stories in height, and the sprawling one-story campus will become less common (Figure 3-12).

Figure 3-12: West High School, Aurora, IL, 2000

Who teaches and how teaching occurs will affect the basic design of school facilities:

> If the future is such that for each 20 to 25 students there will be a professional teacher housed in a traditional classroom, schools will look very similar to what one sees today. However, if teaching and Instruction become more "electronic" then schools may take on largely new configurations with students assigned to telecommunication cubicles that have the appearance of modern commercial offices of today (Stevens 2006, p. 10).

Other researchers believe that the conventional library will disappear. The trend in many new schools is for the library to take the form of a multi-media center and material collections, including laptop computers that are distributed from mobile units to "classroom clusters."

Other influences include the desire for sustainable facilities and, in some cases, the rejection of traditional school plans that will likely result in more imaginative and more complex layouts (Figure 3-13).

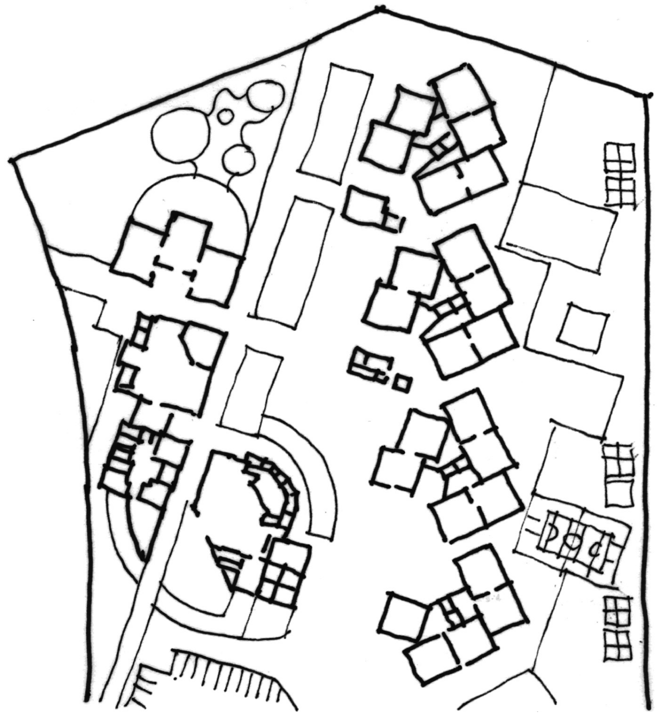


Figure 3-13:
Elementary school, Oxnard, CA, 2000, complex layout

On the other hand, the move to repopulate inner cities will also result in the construction of even more dense and compact schools. A three-story school on a small city lot, as shown in Figure 3-14, uses a traditional classroom layout.

Figure 3-14:
Elementary school, PS 253Q, Far Rockaway, NY, 2005

A major issue that affects future school design is the return to smaller schools. Studies to determine whether small schools produce better results are mixed and both proponents and opponents can find research to support their positions. An important issue is cost, and a return to small schools would clearly be costly in construction. However, proponents suggest that improved student performance and a reduction in crime may result in positive long-term benefits.

An alternative approach to achieving smaller schools without having to expend large sums of money for new buildings is gaining popularity across the country. This movement focuses on creating schools within schools. The Diamond Ranch High School in Pomona, CA, has a site plan that defines three distinctive "schools within a school" clusters of semi-independent units that each integrate a full curriculum segregated by grade level to foster teaching in a more intimate educational setting. Three teaching wings separated by a landscaped outdoor teaching area extend from an open air "street" across which more specialized teaching spaces are located (see Figure 3-15). The architecture is reminiscent of a Hollywood futuristic setting, yet the school was constructed within the strict State of California cost limits (Figure 3-16).

A major issue that affects future school design is the return to smaller schools.

Figure 3-15:
Diamond Ranch High School,
Pomona CA, 2001

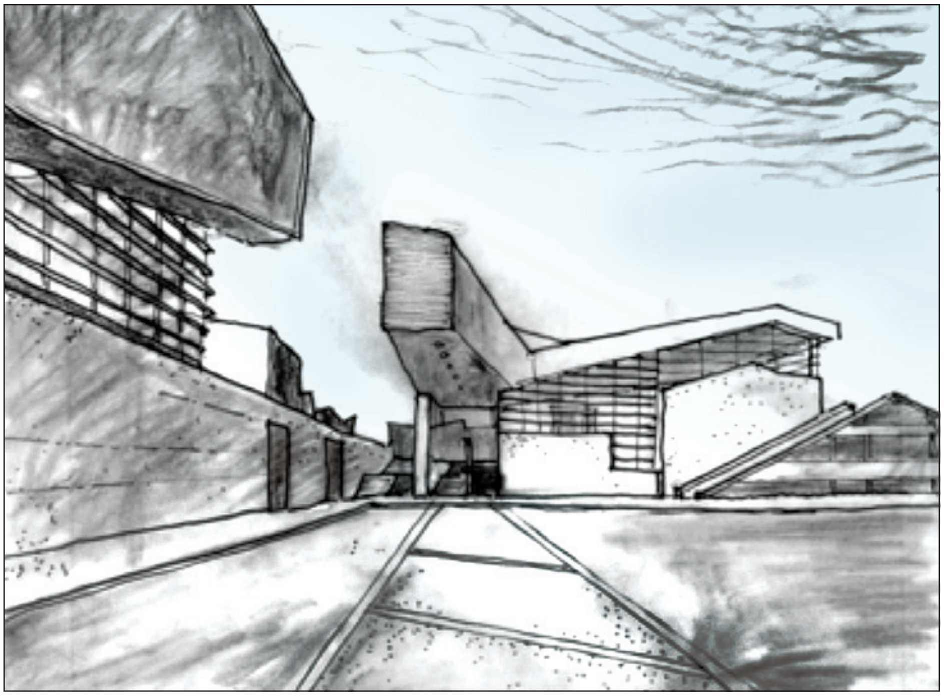


Figure 3-16:
Diamond Ranch High School, view along the "street"

For some time, schools have been considered community resources that go beyond their primary educational functions, and this trend will continue. Adult education and community events now take place in schools on evenings, weekends, and throughout traditional vacation periods. These uses provide affordable means to enhance community service resources by maximizing a facility's utilization.

Awareness is growing of the importance of recognizing all the natural and manmade hazards that may affect schools. The likelihood of floods, hurricanes, tornadoes, and earthquakes will continue to be, at some locations, a source of worry and fear. Schools in these regions are often used as post-disaster shelters and increasingly schools are constructing safe haven spaces against the threat of CBR and shooting attacks. Table 3-1 shows the numbers of arrests for a wide range of crimes in schools and colleges.

Table 3-1: Number of Arrests for Crimes in Schools and Colleges, by Offense, 2000 to 2004

Category	Offense	Year of Incident					5-Year Total
		2000	2001	2002	2003	2004	
Crimes Against Persons	Simple Assault	6,436	9,136	10,120	11,550	14,220	51,462
	Intimidation	830	1,631	1,327	1,434	1,776	6,998
	Aggravated Assault	1,009	1,228	1,291	1,427	1,531	6,486
	Forcible Fondling	231	300	357	341	446	1,675
	Kidnapping/Abduction	43	66	78	80	107	374
	Forcible Rape	48	55	31	65	60	259
	Sexual Assault with an Object	12	10	34	26	36	118
	Forcible Sodomy	19	20	23	20	22	104
	Statutory Rape	9	13	11	16	30	79
	Murder and Nonnegligent Manslaughter	1	7	7	7	5	27
Crimes Against Society	Drug/Narcotic Violations	5,819	7,860	7,850	9,949	11,816	43,294
	Weapon Law Violations	1,219	1,625	1,510	1,872	2,297	8,523
	Drug Equipment Violations	717	1,030	967	1,123	1,271	5,108
	Disorderly Conduct	194	496	557	751	947	2,945
	Trespass of Real Property	79	121	118	192	186	696
Crimes Against Property	Destruction/Damage/Vandalism of Property	1,755	2,141	2,210	2,665	3,138	11,909
	All Other Larceny	1,579	2,004	2,004	2,336	2,689	10,612
	Burglary/Breaking and Entering	1,430	1,679	1,698	2,130	2,066	9,003
	Theft from Building	1,188	1,387	1,440	1,845	1,973	7,833
	Stolen Property Offenses	213	256	313	434	476	1,692
	Arson	217	234	253	298	356	1,358
	Theft from Motor Vehicle	183	205	208	288	274	1,158

SOURCE: NOONAN AND VAVRA 2007

As funding and other resources become available, school authorities should make every effort to reduce vulnerabilities by implementing proposed protective measures during initial school construction or, renovation, or incrementally through special programs.

3.3 Risk of Shooting Attacks

Statistically, the risks of a fatal school-shooting incident are very low, but the consequences of even one student's death are far reaching to family members, friends, and the whole community. A number of statistical studies have been conducted on various aspects of crime in schools, including shooting incidents, which can give a broad picture of the risks involved.

A 2009 study recorded data on shootings in schools, colleges, and universities, and the complete data are shown in Table 3-2. The data showed that in the 20 years between 1989 and 2009, 41 shooting incidents in grade schools nationally resulted in 75 dead and 154 injured. Of these attacks, 11 were perpetrated by students and 31 by adults. One attack, Columbine High School in 1999, resulted in 12 deaths, two others resulted in 5 deaths, another in 3 deaths, and the remainder in 1 or 2 fatalities.

Table 3-2: List of School and University Shooting Incidents (1966-2009)

School	Location	Date	Time	Attack Type	Attack Purpose	Weapon(s)	No. Deaths	No. Injured	No. Perpetrators	Perpetrator Student / Adult
Dillard HS	Fort Lauderdale, FL	11/12/09	11am	Active shooter	One victim	Handgun	1	0	1	Student
Central HS	Knoxville, TN	8/21/09	8 am	Active shooter	One victim	Handgun	1	0	1	Student
Lindhurst HS	Olivehurst, CA	5/1/09	2:40 pm	Active shooter	Mass killing	Rifle, shotgun	4	9	1	Adult
University of Central Arkansas	Conway, AK	10/26/08	9:00 pm	Active shooter, team	Mass killing	Handgun	2	1	4	Adult
Northern Illinois University	DeKalb, IL	2/14/08	3:05 pm	Active shooter	Mass killing	Shotgun, handgun	6	18	1	Student
E.O. Green JHS	Oxnard, CA	2/12/08	8:15 am	Active shooter	One victim	Handgun	1	0	1	Student
Louisiana Technical College	Baton Rouge, LA	2/8/08	8:30 am	Active shooter	Mass killing	Handgun	2	0	1	Student
Success Tech Academy	Cleveland, OH	10/10/07	1:06 pm	Active shooter	Mass killing	Handgun	0	4	1	Student
Delaware State University	Dover, DE	9/21/07	1 am	Active shooter	Mass killing	Handgun	1	1	1	Student
Virginia Tech University	Blacksburg, VA	4/16/07	9:00 am	Active shooter	Mass killing	Handgun	32	23	1	Student

School	Location	Date	Time	Attack Type	Attack Purpose	Weapon(s)	No. Deaths	No. Injured	No. Perpetrators	Perpetrator Student / Adult
Henry Foss HS	Tacoma, WA	1/3/07	approx. 8 am	Active shooter	One victim	Handgun	1	0	1	Student
Amish school	Bart Township, PA	10/2/06	10:25 am	Active shooter, hostage	Mass killing	Shotgun, handgun	5	5	1	Adult
Weston HS	Cazenovia, WI	9/29/06	8:00 am	Active shooter	Mass killing	Handgun	1	0	1	Student
Platte Canyon HS	Bailey, CO	9/27/06	11:40 am	Active shooter	Sexual assault, hostage	Handgun	1	0	1	Adult
Essex ES	Essex, VT	8/24/06	Unknown	Active shooter	Mass killing	Handgun	1	2	1	Adult
Campbell County HS	Jacksboro, TN	11/8/05	2:11 pm	Active shooter	Mass killing	Handgun	1	2	1	Student
Red Lake HS	Red Lake, MN	3/21/05	2:45 pm	Active shooter	Mass killing	Shotgun, handgun	7	5	1	Student
Rocori HS	Cold Spring, MN	9/24/03	11:30 am	Active shooter	Mass killing	Handgun	2	0	1	Student
Case Western Reserve University	Cleveland, OH	5/9/03	3:57 pm	Active shooter	Mass killing	Rifle	1	2	1	Student
Red Lion Area JHS	Red Lion, PA	4/24/03	7:34 am	Active shooter	One victim	Handgun	1	0	1	Student
John McDonogh HS	New Orleans, LA	4/14/03	10:30 am	Active shooter, team	One victim	Rifle, handgun	1	3	2	Adult
University of Arizona	Tucson, AZ	10/28/02	8:30 am	Active shooter	Mass killing	Handgun	3	0	1	Student
Appalachian School of Law	Grundy, VA	1/16/02	1 pm	Active shooter	Mass killing	Handgun	3	3	1	Adult former student
Martin Luther King Junior HS	New York, NY	1/15/02	Unknown	Active shooter	One victim	Handgun	0	2	1	Student
Wallace HS	Gary, IN	3/30/01	Unknown	Active shooter	One victim	Handgun	1	0	1	Expelled student
Granite Hills HS	Granite Hills, CA	3/22/01	12:54 pm	Sniper	Mass killing	Shotgun	0	5	1	Student
Bishop Neumann HS	Williamsport, PA	3/7/01	Approx. 11:30 am	Active shooter	One victim	Handgun	1	0	1	Student
Santana HS	Santee, CA	3/5/01	9:20 am	Active shooter	Mass killing	Handgun	2	13	1	Student
Lake Clifton Eastern HS	Baltimore, MD	1/17/01	8:45 am	Active shooter	One victim	Handgun	1		2	Adult

School	Location	Date	Time	Attack Type	Attack Purpose	Weapon(s)	No. Deaths	No. Injured	No. Perpetrators	Perpetrator Student / Adult
Woodson MS	New Orleans, LA	9/26/00	n/a	Active shooter	One victim	Handgun	2	n/a	1	Student
Lake Worth MS	Lake Worth, FL	5/26/00	3:30 pm	Active shooter	One victim	Handgun	1	n/a	1	Student
Buell ES	Mount Morris Township, MI	2/29/00	10:59 am	Accidental shooting	Accidental	Handgun	1	0	1	Student
Fort Gibson MS	Fort Gibson, OK	12/6/99	n/a	Active shooter	Mass killing	Handgun	n/a	4	1	Student
Deming MS	Deming, NM	11/19/99	n/a	Active shooter	One victim	Handgun	1	n/a	1	Student
Heritage HS	Conyers, GA	5/20/99	8:03 am	Active shooter	Mass killing	Rifle, handgun	0	6	1	n/a
Columbine HS	Littleton, CO	4/20/99	n/a	Active shooter Team	Mass killing	Rifle, shotgun	12	23	2	Student
Armstrong HS	Richmond, VA	6/15/98	10:00 am	Active shooter	Mass killing	Handgun	0	2	1	Student
Thurston HS	Springfield, OR	5/21/98	7:55 am	Active shooter	Mass killing	Rifle, handgun	2	25	1	Student
Lincoln County HS	Fayetteville, TN	5/19/98	n/a	Active shooter	One victim	Rifle	1	n/a	1	Student
Westside MS	Jonesboro, AK	3/24/98	12:40 pm	Sniper	Mass killing	Rifle	5	10	2	Student
Stamps HS	Stamps, AK	12/15/97	Approx. 9 am	Sniper	Mass killing	Rifle		2	1	Student
Heath HS	West Paducah, KY	12/1/97	7:45 am	Active shooter	Mass killing	Rifle, shotgun, handgun	3	5	1	Student
Pearl HS	Pearl, MS	10/1/97	8:00 am	Active shooter	Mass killing	Rifle	2	7	1	Student
Bethel Regional HS	Bethel, AL	2/19/97	approx. 8:00 am	Active shooter	Mass killing	Shotgun	2	2	1	Student
Hetzel Union Building, Pennsylvania State University	State College, PA	9/17/96	9:30 am	Sniper	Mass killing	Rifle	1	1	1	Adult
San Diego State University	San Diego, CA	8/15/96	2:05 pm	Active shooter	Mass killing	Handgun	4		1	Student
Frontier Junior HS	Moses Lake, WA	2/2/96	Afternoon	Active shooter	Mass killing	Rifle, handgun	3	1	1	Student
Richland HS	Lynnville, TN	11/15/95	approx. 8:00 am	Active shooter	Mass killing	Rifle	2	1	1	Student
Wickliffe MS	Wickliffe, OH	11/7/94	Approx. 2:30 pm	Active shooter	Mass killing	Shotgun	1	2	1	Adult

School	Location	Date	Time	Attack Type	Attack Purpose	Weapon(s)	No. Deaths	No. Injured	No. Perpetrators	Perpetrator Student / Adult
East Carter HS	Grayson, KY	1/18/93	2:45 pm	Active shooter	Mass killing	Handgun	2	n/a	1	Student
Simon's Rock College of Bard	Great Barrington, MA	12/14/92	10:30 am	Active shooter	Mass killing	Rifle	2	4	1	Adult
University of Iowa	Iowa City, IA	11/1/91	3:42 pm	Active shooter	Mass killing	Handgun	5	1	1	Student
Cleveland School	Stockton, CA	1/17/89	11:59 am	Active shooter	Mass killing	Rifle, handgun	5	30	1	Adult
Hubbard Woods ES	Winnetka, IL	5/20/88	11 am	Active shooter	Mass killing	Handgun	1	5	1	Adult
Parkway South MS	Manchester, MO	1/20/83	11:55 am	Active shooter	Mass killing	Handgun	1	1	1	Student
Cleveland ES	San Diego, CA	1/29/79	8:30 am	Sniper	Mass killing	Rifle	2	9	1	Adult
Olean HS	Olean, NY	12/30/74	2:50 pm	Active shooter	Mass killing	.30-06 Rifle, shotgun	3	11	1	Student
University Texas at Austin	Austin, TX	8/1/66	11:48 am	Sniper	Mass killing	Rifle	14	32	1	Student

Another study for the 2003–2004 school year, summarized in Table 3-3, identified the number and percentage of the Nation's schools reporting possession of firearms, explosives, knives, and sharp objects. The total number of incidents involving firearm and explosive possession was 7,478, in 4,875 schools, and the number of incidents involving a knife or sharp object was 30,193. The highest possession rates were in high schools located in cities.

In 2003–2004, the total number of incidents involving firearm and explosive possession was 7,478, in 4,875 schools, and the number of incidents involving a knife or sharp object was 30,193.

Table 3-3: Number and Percentage of Incidents Reported in Public Schools, 2003

School Characteristic	Possession of a Firearm or Explosive Device[1]				Possession of a Knife or Sharp Object			
	Number of Schools	Percent of Schools	Number of Incidents	Rate per 1,000 Students	Number of Schools	Percent of Schools	Number of Incidents	Rate per 1,000 Students
All public schools	4,875	6%	7,478	0.2	12,830	16%	30,193	0.6
Primary[2]	1,777	4%	2,220	0.1	5,412	11%	8,606	0.4
Middle	1,147	8%	2,009	0.2	3,617	25%	9,168	0.9
High school	1,503	14%	2,728	0.2	3,179	29%	10,697	0.9
Combined	449	7%	521	0.2	621	10%	1,723	0.6
City	1,999	10%	3,164	0.2	4,418	22%	11,982	0.9
Urban fringe	1,491	6%	2,550	0.1	4,178	16%	10,331	0.6
Town	364	4%	500	0.1	1,918	20%	3,780	0.8
Rural	1,021	4%	1,264	0.1	2,316	10%	4,100	0.4

SOURCE: TABLE 5; U.S. DEPARTMENT OF EDUCATION (2004)

1 Firearm or explosive device is defined as, "any weapon that is designed to (or may readily be converted to) expel a projectile by the action of an explosive. This includes guns, bombs, grenades, mines, rockets, missiles, pipe bombs, or similar devices designed to explode and capable of causing bodily harm or property damage."

2 Primary schools are defined as schools in which the lowest grade is not higher than grade 3 and the highest grade is not higher than grade is not higher than grade 3 and the highest grade is not higher than grade 8. Middle schools are defined as schools in which the lowest grade is not lower than grade 4 and the highest grade is not higher than grade 9. High schools are defined as schools in which the lowest grade is not lower than grade 9. Combined schools include all other combinations of grades, including K–12 schools.

Figure 3-17 shows the number of total homicides and suicides in schools of youths ages 5 to 18 between 1992 and 2007.

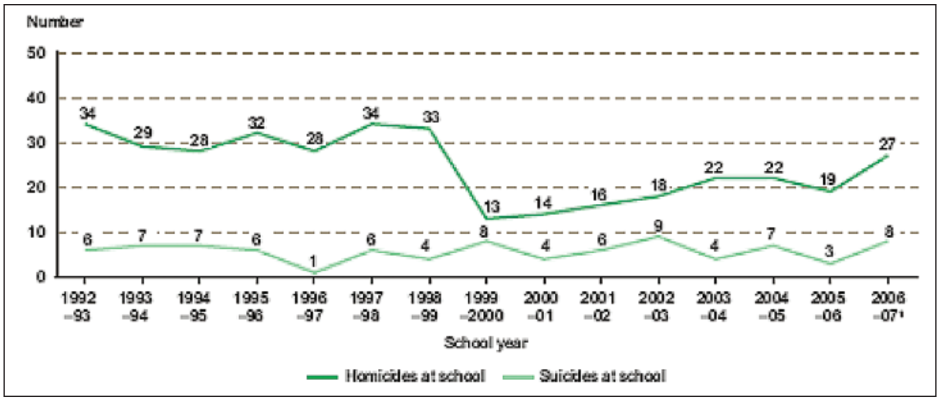


Figure 3-17: Total number of homicides and suicides in schools for youths ages 5–18, 1992–2007

SOURCE: DATA ON HOMICIDES AND SUICIDES OF YOUTH AGES 5–18 AT SCHOOL ARE FROM THE CENTERS FOR DISEASE CONTROL AND PREVENTION (CDC),1992–2007 SCHOOL-ASSOCIATED VIOLENT DEATHS SURVEILLANCE STUDY, PARTIALLY FUNDED BY THE U.S. DEPARTMENT OF EDUCATION, OFFICE OF STATE AND DRUG-FREE SCHOOLS, PREVIOUSLY UNPUBLISHED TABULATION, (JULY 2008).

1 Data are preliminary and subject to change.

Note: "At school" includes on school property, on the way to or from regular sessions at school, and while attending or traveling to or from a school-sponsored event. Estimates were revised and may differ from previously published data.

3.4 Methods of Attack

This section describes different methods used by shooters, and some general strategies for risk reduction for each of the shooter attack types. The types of threats, consequences, and school vulnerabilities are highlighted through the examination of a number of shooting incidents that have taken place in the United States and abroad.

The DHS National Protection and Programs Directorate's Office of Infrastructure Protection (NPPD/IP) provides a suite of training and awareness resources to help public- and private-sector partners prepare for an active shooter incident. These resources, which include reference material and an interactive, Web-based course, provide guidance on how to respond to an active shooter in the vicinity, and advise what to do during law enforcement response. NPPD/IP's active shooter resources provide basic survival information, and are adaptable to a variety of venues and situations. NPPD/IP Active Shooter Resources available at www.dhs.gov/cfsector include:

- Active Shooter Booklet
- Active Shooter Pocket Card
- Active Shooter Pocket Card in Spanish
- Active Shooter Break Room Poster
- Active Shooter Break Room Poster in Spanish

In addition, FEMA's Emergency Management Institute offers the course IS 907: *Active Shooter, What You Can Do*, available at http://www.training.fema.gov/EMIWeb/IS/IS907.asp.

3.4.1 Active Shooter

Law enforcement agencies define active shooters as armed persons who use deadly physical force against multiple victims in situations of unrestricted access. The many unrelated motivations for this type of attack make it difficult to categorize them. The motivations can range from revenge for real or imagined grievances to “fun,” role-playing while acting out a staged scenario. Active shooters may be heavily armed with multiple weapons and large quantities of ammunition. The method of attack can be focused on specific individuals confined to one room or completely random attacks in multiple areas. Shooters may act singly or as a team. Active shooters typically conduct significant preparation and planning, which in the case of teamed shooters may include plans for coordinated attacks that target multiple areas at the same time. Active shooter attacks are by far the most common threat for targeted shootings. They are unpredictable and evolve very quickly. Many attacks of this type are over within 10 to 15 minutes, well before law enforcement and emergency response teams arrive on the scene, which requires that school staff be well prepared, both physically and mentally, to deal with such a situation.

Law enforcement agencies define **active shooters** as armed persons who use deadly physical force against multiple victims in situations of unrestricted access.

3.4.1.1 Single Shooter Roaming the Campus: The Virginia Tech Incident

On April 16, 2007, an angry and disturbed student shot to death 32 students and faculty at the Virginia Tech campus in Blacksburg, VA. He wounded 17 more and then committed suicide after the first police officers entered the building where he had barricaded himself. The shootings involved two separate incidents, at first thought to be unrelated. This perception allowed the shooter to enter other campus buildings unrestricted where he continued his rampage. He carried two handguns, almost 400 rounds of ammunition (most of which were in rapid loading magazines), a knife, heavy chains, and a hammer. No one reported his behavior as suspicious before the shooting started.

He barricaded himself in Norris Hall by putting chains on each of the three main entrances with a note on the inside of one set of chained doors warning that a bomb would go off if anyone tried to remove the chains. Several students noticed the doors chained before the shooting started, but no one called the police or reported it to the university. The chaining successfully delayed response teams from interrupting his plan and also kept his victims from escaping.

Prior to starting the shootings, the shooter walked around in the hallway on the second floor poking his head into a few classrooms, some more than once, according to interviews by the police and the Virginia Tech Review Panel. This struck some as odd because it was late in the semester for a student to be lost, but no one raised an alarm.

The occupants of the first classroom attacked had little chance to call for help or take cover. After peering into several classrooms, the shooter walked into Room 206, shot and killed the instructor, and continued shooting at random. Of 13 students present in the classroom, 9 were killed and 2 were injured by the shooting, and only 2 survived unharmed.

The shooter then went across the hall to Room 207 and shot the instructor and several students near the door, then started down the aisle shooting others. Four students and the instructor ultimately died in this room, and another six were wounded. Students in Room 211 tried to use the instructor's table to barricade the door, but the shooter pushed his way in, shot the professor, and walked down the aisle shooting indiscriminately. A female student was lightly wounded but kept her cell phone line open, spoke quietly as long as she could to the dispatcher. By keeping the line open she helped keep police apprised of the situation. She kept the phone hidden by her head and hair so she could appear dead but not disconnect.

The shooter returned to Rooms 207 and 211 for a second time trying to shoot students cowering behind overturned desks. When he tried to enter Room 204, the instructor braced his body against the door and yelled for students to head for the window. Ten of the 16 students present escaped by pushing out the screens and jumping out before the shooter gained access by killing the professor through the door. Two students who were scrambling to leave through the window were also shot.

The shooter returned to most of the classrooms more than once and continued shooting. He methodically fired from inside the doorways of the classrooms, and sometimes walked around the classroom. Students had little place to hide other than behind the desks. By taking a few paces inside he could shoot almost anyone in the classroom who was not behind a piece of overturned furniture. Finally, when he realized that the police were closing in on him, he committed suicide by shooting himself in the head. With over 200 rounds left, more than half his ammunition, he almost surely would have continued to kill more of the wounded, and possibly others in the building, had not the police intervened.

Response

Occupants' first reaction, according to survivors, was disbelief, followed rapidly by many sensible and often heroic actions. Attempts were made by a few students to escape from classrooms and down the hall in the earliest stage of the incident. But after some of them were shot in the hall, no one else tried that route. Others attempted to barricade the doors, but in the majority of cases, the shooter managed to push his way in or shot through the doors. An instructor in a third-floor classroom led his students to safety in a small room, locked them inside, and went to investigate the gunfire on the second floor. He was shot and killed, but those who found refuge in locked rooms, though badly frightened, all survived. Several students, some of whom were injured, successfully played dead amid the carnage around them, and survived. Typically, they fell to the ground as shots were fired, and tried not to move, hoping the shooter would not notice them. The shooter systematically shot several of his victims a second time when he saw them still alive, but those who managed to hold still and keep quiet survived.

The shooter started shooting at about 9:40 am. Students and faculty in Room 211, a French class, took approximately 1 minute to realize that the sounds they heard in the nearby room were gunshots. The instructor asked a student to call 911, and the call was routed to the Blacksburg police.

The Blacksburg Police Department received the call at 9:41 am. The police were not familiar with campus building names and took approximately 1 minute to realize that the call was coming from Virginia Tech. The police then transferred the call to the Virginia Tech Police Department (VTPD). At 9:42 am, that first call reached the VTPD notifying them of a shooting in Norris Hall.

Police arrived within 3 minutes of the 911 call. By professional standards, this was an extraordinarily fast police response. Because the shooter used two different caliber weapons that sounded different, officials initially assumed more than one shooter was inside the building. After failing to break in through the chained doors, the police broke in through the maintenance shop. By the time they reached the second floor, where most of the shooting occurred, the shooting had ended. The rescue operation began even before police had established that the danger had passed. Checking all the classrooms and making sure no other shooters lurked nearby took some time. An incident commander was not named and an emergency operations center was not set up until after the shooting was over, mainly because events unfolded very rapidly. A more formal process was used for the followup investigation.

The close relationship of the VTPD and the Blacksburg Police Department and their frequent joint training, for an active shooter incident in particular, saved critical minutes. First responders must not wait for special units, but must pursue an active shooter at once, as soon as the first officers arrive on the scene. In this case, the sound of the shotgun blast that opened the doors announced officers' arrival, and most likely caused the shooter to realize that the end was imminent.

3.4.1.2 Team of Shooters Inside a School: The Columbine High School Incident

Columbine High School is a large two-story public high school serving approximately 2,000 students. Minutes after 11 a.m. on Tuesday morning, April 20, 1999, two Columbine High School seniors, heavily armed with homemade bombs, and numerous firearms, drove to the school in separate cars and strategically parked their vehicles in parking lots from which they could see two exits from the school cafeteria (Figure 3-18). They walked into the cafeteria with two bags, each containing a 20-pound propane bomb with timers set to detonate at 11:17 a.m., and left them in the middle of the room, among close to 500 students and staff present at the time. The shooters then walked back to their vehicles and waited, planning to shoot the survivors of the blast when they tried to escape the school (Figure 3-19). The bombs did not detonate.

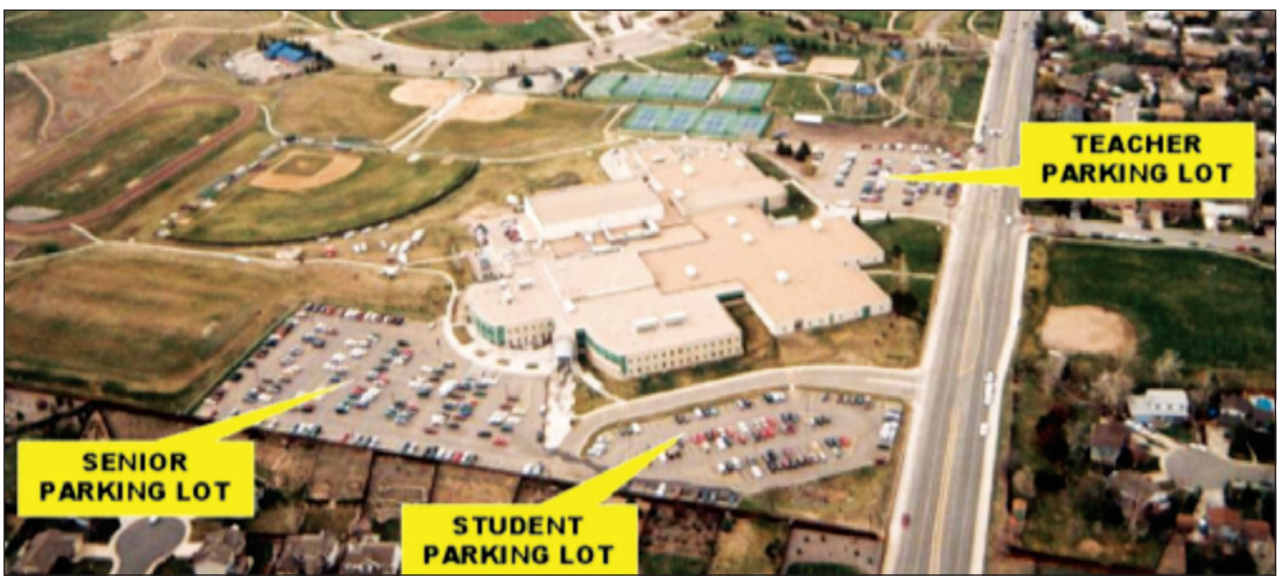


Figure 3-18: Aerial view of Columbine High School grounds

Realizing that the bombs failed to explode, the shooters dressed in long trench coats that hid their weapons, entered the school together carrying a bag containing more homemade bombs and plenty of ammunition for their weapons: sawed-off shotguns, a 9mm carbine, and a 9mm "Tec 9" handgun. Once inside, they started shooting indiscriminately, and continued in this way throughout the harrowing 46 minutes the attack lasted.

Figure 3-19: Points of attack at Columbine High School

They walked along the corridors throwing their handmade bombs and firing their weapons at anyone they encountered. The bombs were made of 6-inch galvanized pipe filled with gunpowder, nails, and BB pellets. The other bombs were comprised of CO2 containers taped together and filled with gunpowder and BB pellets. Fortunately, the gunpowder in the bombs was of a "low-order," largely taken from firecrackers.

During their initial foray into the school, and during their entire shooting spree, the shooters never entered locked classrooms. They looked into classrooms and observed teachers and students in them, but never attempted to breach the locked doors. The shooting was mainly contained to the hallways, until they entered the library located above the cafeteria, where 56 students, 2 teachers, and 2 library employees were trying to hide under the tables. For the next 7½ minutes, the shooters calmly killed 10 and seriously injured 12 students in the library. They talked with a few students whom they knew and allowed them to leave unharmed. During the library massacre, the shooters reloaded their weapons on at least two occasions and fired out the windows of the library at law enforcement and fire personnel attempting to rescue the students lying wounded outside the school.

Back in the cafeteria, the shooters attempted to shoot one of their large propane bombs, but it still did not detonate. Another attempt to detonate the bombs failed but started a fire that triggered the fire alarms and the sprinkler system. The shooters roamed the corridors some more and shot at the police from the library windows before they committed suicide shortly after noon. Officials were not aware of the suicides until 3 hours later when the Strategic Weapons and Tactics (SWAT) team found their bodies and the bodies of their numerous victims in the library. When the incident ended, 15 people were dead: 12 students (2 outside the school and 10 in the library), 1 teacher, and the 2 shooters, and 24 students were injured.

Response

Students and school staff at first thought they were witnessing some sort of a prank or play-acting. As soon as they realized that the shooting was real, staff advised the students to flee as quickly as they can, get under tables or desks, or stay in locked classrooms. Several students and staff were able to stay on line with the 911 operators throughout the active shooting. Students fleeing the building did not feel safe, as they could hear the gunshots and bomb explosions, but no one knew the location of the shooters.

First Responders were at the scene very quickly. The Deputy Sheriff serving Columbine High School as a "School Resource Officer" noticed the shooters outside the school and exchanged fire with them before they disappeared inside. Other officers, including SWAT teams from multiple agencies, arrived soon after. They immediately encountered difficulty in determining the overall status, such as the number and locations of the shooters, the locations of the injured, and the locations of other law enforcement personnel. Numerous officers later stated that communication and coordination were very difficult as the officers from different jurisdictions were unable to communicate with one another. The first officers who entered the school shortly after noon reported that they were unable to communicate verbally because of the extreme noise from the fire alarm, and their progress was slowed down by the smoke and fumes in the school. The SWAT team did not enter the library to discover the main scene of the carnage until after 3 p.m.

3.4.2 Sniper (Ambush)

Snipers typically do not enter and navigate through buildings while firing, but enter buildings on or off campus to gain access to advantageous firing positions. These positions can either be elevated or near the ground level. The threat posed by snipers is limited to the direct line of sight of the shooter. Once a sniper is identified, removing potential targets from the sight of a shooter (at windows and in outdoor areas) set up in an outdoor area effectively mitigates the threat to occupants inside a building. Snipers can also provoke the evacuation of a building to draw large groups of people outside into a preselected target area, which increases the threat significantly.

3.4.2.1 Sniper at Elevated Position: The University of Texas at Austin Incident

"The Tower" is the centerpiece of the University of Texas at Austin campus (Figure 3-20). It extends 307 feet into the air, with the top "floor" laid out as an outside observation deck that offers commanding open-air views in every direction. The outside decks are surrounded by concrete parapets, which also served as the railing, while the center of the floor functions as a reception area. The observation deck is open to the general public.

On the morning of August 1, 1966, a 25-year-old architectural engineering student at the university loaded seven weapons and hundreds of rounds of ammunition into a trunk. He also packed food, water, an AM radio, and other survival gear. The weapons consisted of three rifles (one scoped), one sawed-off shotgun, and three handguns.

Figure 3-20: View of University of Texas at Austin campus

At approximately 11:30 a.m, he drove to and parked near the tower, having procured a special short-term parking pass using his university "research assistant" identification. He used a dolly to wheel his trunk into the building and to the top floor. In the reception area at the top of the tower, he violently bludgeoned the receptionist and placed her body behind the couch. She died that afternoon from the trauma. However, she was not his first victim; unbeknownst to anyone, he had murdered both his mother and wife at two separate locations in Austin the previous night. He left letters of explanation at both locations.

Before he managed to barricade himself, two families with children showed up trying to reach the observation deck. As the boys pushed against the metal grate entrance, the shooter suddenly appeared and fired his shotgun at the unsuspecting tourists. One boy and his aunt dropped, fatally injured. The other boy and his mother fell seriously wounded. Assistance did not reach the families until over an hour later.

The shooter then took a position outside, in the observation deck area, and jammed the door to the reception area utilizing his dolly. Soon afterwards, he started raining his infamous 96 minutes of terror on anyone moving within sight of the tower, inflicting most of his carnage in the first 20 minutes. The shooter exhibited uncanny accuracy. He shot and killed an electrical worker over two blocks (more than 500 yards) away and a student who attempted to peer from behind his position of cover. Almost anyone that moved within sight of the tower observation deck was fired upon. Before the shooting ended, the shooter killed 10 and wounded 30 persons from the observation level of the tower. This number did not include the three persons killed inside the tower, nor the shooter's mother and wife. The shooter was killed by police officers who managed to reach the observation deck unnoticed.

Response

Victims' initial response was disbelief, not unlike the mindset exhibited by a couple passing the shooter in the tower when he held the weapons in his hands. Many witnesses did not believe what others told them until they saw the bodies on the ground and/or personally heard the shots fired from the tower. Students in windows of classrooms and customers in stores became aware of the reality when glass shattered around them. Many persons caught in the potential fields of fire were "pinned down" until the shooting ended. Students and faculty trapped in the tower began to lock and secure their spaces. Some of the faculty and students, when fully realizing shots were coming from the top of the tower, obtained rifles to return fire at the shooter. One university employee assisted in the ultimate confrontation with the shooter.

Citizens in the vicinity realized the nature of the incident and the limited ability of the police to engage the shooter on the tower. The police responded with handguns and shotguns. The media reported on the nature of the situation as information became available. As a result, many citizens responded to the area of the tower with their privately owned deer rifles. The suppressive fire provided by the citizens served to diminish the tower shooter's fire, both in number and accuracy. However, the citizens firing at the tower created a danger to the responding officers.

Law enforcement officers from Austin, and from nearby jurisdictions, responded to the situation in force. Because there were no cellular telephones and very few mobile radios, and because telephone lines were jammed, communication was extremely difficult. Responding officers did not know the full extent of the problem, the number of and exact location of the shooter(s), or whether any coordination was underway. Many officers were tending to victims, directing traffic away from the scene, or attempting to engage the shooter on the tower with available weapons, while a few officers were attempting to access the tower.

At least three officers ran in a zigzag fashion across the open area to access the base of the tower. Other officers contacted university officials and found a maintenance engineer to guide five of them through a maintenance tunnel to the base of the tower. When officers met on the lower level of the tower, they immediately attempted to find ways to engage the shooter. The officers determined that the 27th floor was the highest they could reach by way of the elevator and that they would then have to take three flights of steps to the observation deck level.

When the responding officers arrived on the 27th floor, they did not know what they would find, but knew that they could immediately face the shooter or shooters. They first found the wounded and dead family members from the shooter's first shots. While some officers tended to the victims, three officers and an armed citizen arrived at the observation level. From the inside reception room they could hear the shooter firing his weapons from the outdoor observation platform. They could see outside the windows to the south and west side, but did not see the shooter through the sight from the windows.

At this time, the observation area was still receiving gunfire from the citizens on the ground. One officer fired his weapon in the direction of the shooter (the west), causing the shooter to back into the northwest corner. At that time, two other officers quickly rounded the northeast corner and fired their weapons, killing the shooter and ending the massacre. The officers were not immediately certain the situation was over because they did know the number of shooters.

3.4.2.2 Snipers at Ground Position: The Westside Middle School Incident

Westside Middle School is located several miles west of Jonesboro, AR. Jonesboro is a relatively prosperous city with a population of approximately 55,000. The city is the site of Arkansas State University and is considered a safe haven from big-city crime.

The Westside School District consists of an elementary school, middle school, and high school that are on one property. In 1998, the district had a total student population of about 1,600 students. The community was small enough that most people knew each other, and many of the teachers had been students in the same district. Two hundred fifty students attended the middle school, half of them in 6th grade and half in 7th grade.

On Tuesday, March 24, 1998, two boys, an 11-year-old 6th-grade student and a 13-year-old 7th grade student, did not attend classes. They stole a van and three pistols belonging to one of their parents and then broke into the home of one of their grandparents, where they obtained additional handguns and three rifles. They drove the van, filled with camping gear, food, and the stolen weapons and ammunition to a preplanned parking place about ½ mile northeast of the school. They moved undetected and by foot, heavily armed and wearing camouflage hunting gear, to a site they reportedly scouted the previous day. The site was in a wooded area on the northern edge of the middle school campus. It was about 100 yards from the safe assembly area where the shooters knew students usually gathered during fire drills.

One of the shooters walked to the school and pulled the fire alarm and then returned to the position with his weapons, ammunition, and camouflage gear already in place. Eighty seven students and nine staff members filed out the west exit of the middle school. Nothing precluded complete adherence to their well-rehearsed fire drill, and they walked directly into the shooters' planned kill zone. The shooters fired approximately 30 shots from high-powered rifles in less than a minute, probably closer to 15 seconds. Why the shooting stopped is unclear, but a construction employee working on the school's new 5th-grade wing appears to have seen the shooters and yelled at them to stop. They stopped shooting, picked up their weapons and ran away through the woods. They shot 15 people. Four students and one teacher were killed, and nine students and one teacher were injured.

Response

Students and teachers came under a steady stream of rifle fire quite unexpectedly and immediately assumed the sounds of gunshots were firecrackers. Once aware of the gravity of the situation, shouts were heard to get down. Some did, and others ran for cover and concealment behind the school. Those who attempted to re-enter the school found the doors locked and were forced to run around the building, exposed to the shooters' line of sight.

First responders arrived very quickly and were able to assist the victims immediately. Two Sheriff's Deputies, who were the first at the scene, were told the shooters were fleeing to the north. They managed to cut off their escape, but were surprised to see well-armed children exiting the woods. The boys were arrested a mere 200 yards from the shooting site, approximately 10 minutes after they pulled the fire alarm.

The scenario, with the attackers separated from the victims, created an advantage for law enforcement compared to school shootings where the shooters enter the buildings and intermingle with students and staff. The shooters' immediate surrender can be partially attributed to luck, partially to a very rapid law enforcement response, and partially to the actions of the officers upon response.

3.4.3 Hostage Taking

A hostage is a person abducted by a criminal or a terrorist to compel another party, such as a relative, employer, law enforcement, or government, to act, or refrain from acting, in a particular way, often under the threat of serious physical harm to the hostages unless the demands of hostage takers are met. Typically, hostage-takers issue demands to the officials responding to the incident. In a planned attack, the hostage takers usually have a list of political or religious demands, often including the release of imprisoned friends or allies. In cases where the hostage situation is improvised as a desperate attempt to avoid capture, the demands usually revolve around exchanging the lives of the hostages for transport to safety.

Terrorists pose the highest hostage-taking threat internationally. Approximately 11,500 terrorist attacks against noncombatants occurred in various countries in 2010 resulting in over 50,000 deaths, injuries, and kidnappings (Page 5; National Counter Terrorism Center 2011). These numbers include all terrorist attacks. Such attacks continue to occur in large numbers, worldwide. Terrorist attacks have not been prevalent in the United States in part because of the lack of motivated and capable individuals willing to conduct an attack and in part because of the efforts of our Nation's intelligence and law enforcement communities. Attacks targeting educational institutions also occur in notable numbers. In 2010, there were 283 terrorist attacks on schools or educational facilities worldwide (Page 24; National Counter Terrorism Center 2011).

3.4.3.1 Hostages Taken by Terrorists: The Beslan School No. 1 Incident

Beslan is a poor, largely agricultural and industrial city of about 40,000 in North Ossetia-Alania, a mostly Christian Orthodox republic in southwest Russia. Since the dissolution of the Soviet Union in 1991, the neighboring republics of Ingushetia and Chechnya have struggled for independence from Russia. Consequently, North Ossetia is familiar with violence and military presence. Still, no one in North Ossetia was prepared for the carnage and brutality of the September 2004 attack on Beslan School No. 1, a 3-day siege that left over 300 dead and over 700 injured. Most of the victims were children.

Beslan School No. 1 was originally built in 1889 as a two-story brick structure shaped like a W, with a wooden roof and long main corridor on a north-south axis on the western edge of the campus. A cafeteria was on the first floor in the southwest corner of the school with an auditorium above it. The gymnasium jutted out from the center of the main corridor, creating a small courtyard to the south and a much larger courtyard to the north. The campus was surrounded by a fence and included several other small, detached structures (Figure 3-21). Among these were a boiler room, adjacent to the eastern wall, and a one-story classroom on the northwest corner. The school's staff of approximately 100 supported approximately 1,000 students in grades 1 through 11 (ages 6 to 17).

September 1 in Russia is the traditional first day of school, called the "Day of Knowledge." Extended families gather together to send off their young relatives, meeting and bringing gifts for the teachers and faculty. At 8:00 a.m. on that day, several thousand people gathered near the school, including terrorists who had infiltrated the crowd. Another group of terrorists had spent the night in a wooded encampment in Ingushetia and reportedly paid bribes at the border crossing to enter North Ossetia. At 8:45 a.m., a troop carrier truck and several smaller vehicles drove into the campus through the west entrance, where the terrorists faced the crowd. One group of terrorists then entered the school to secure it, while the remainder corralled the outdoor crowd toward the school and into the gym. By 9:05 a.m., 1,181 hostages—mostly women and children—were held in the school's gymnasium.

The terrorists immediately set out to harden and secure their position. Mobile phones were confiscated from all hostages. To prevent an immediate assault, children were placed in windows as human shields and explosives and booby traps were rigged at all key entry points throughout the building. In the gym, explosives were draped along the walls and basketball backboards, oriented toward the hostages. The terrorists also took immediate measures to demonstrate their authority and will.

Some men and boys were ordered to move furniture and equipment to barricade entrances and choke points, and many were later shot after completing their tasks. At least 21 men and boys were executed before the end of the crisis.

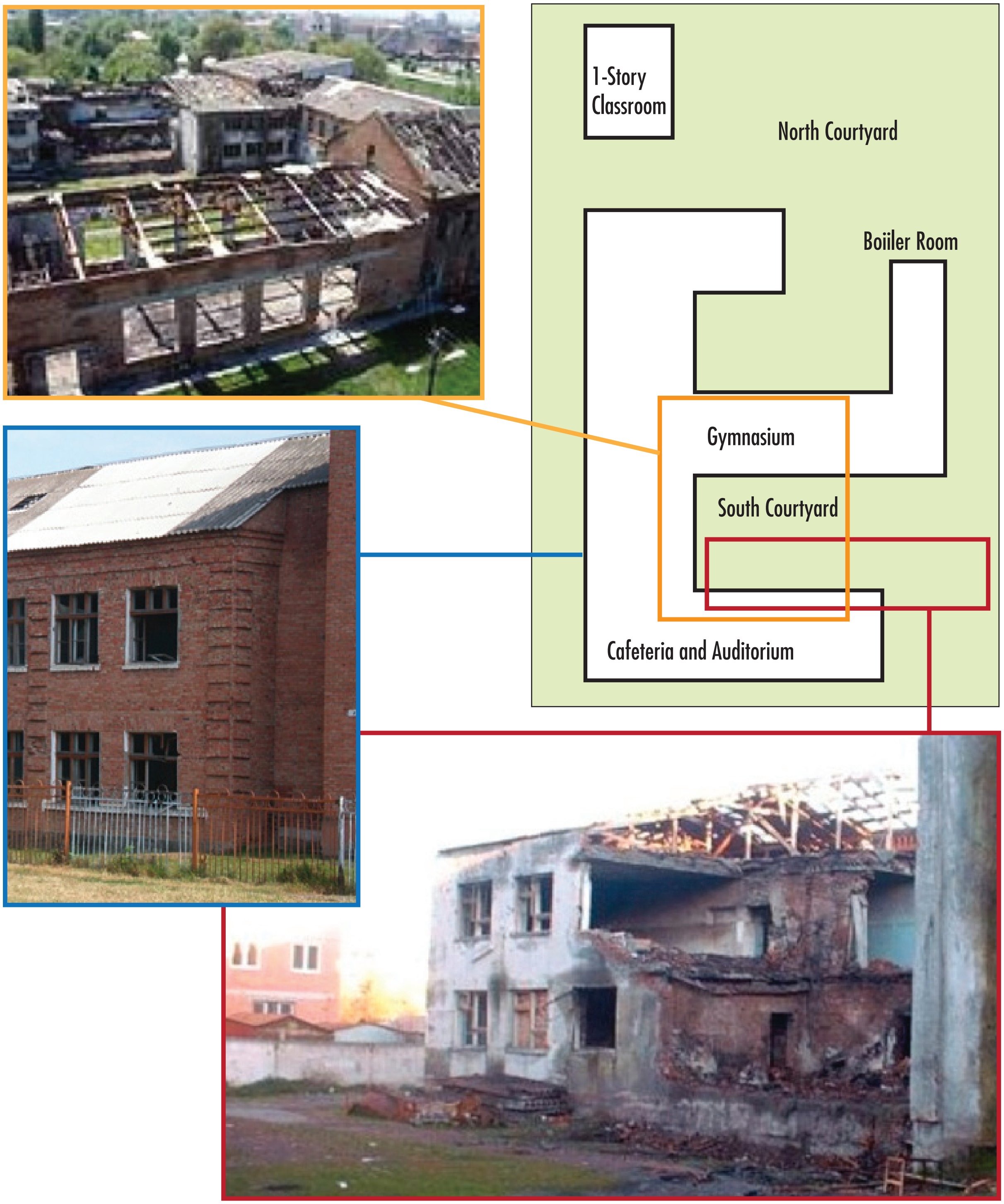


Figure 3-21: School No. 1 in Beslan

The actions of the terrorists demonstrated an understanding of Russian negotiation and assault tactics. Windows throughout the school were shattered to increase ventilation and make gas or chemicals less effective. All offers for food and water were denied for fear of poisoning. Among their threats, the terrorists stipulated that 10 hostages would be killed if electricity or communication were cut off. They assured Russian officials that they would not hesitate to shoot their own loved ones if brought to the scene. Finally, they continually checked for any invasive measures taken by Russian forces to enter through walls, ducts, or underground routes, at times even using explosives to inspect behind walls or under floors.

The first contact with officials was made through a video thrown outside by the terrorists at 12:30 p.m. Later in the day, the terrorists made their first demands, the release of 30 Ingush prisoners (related to attacks in June of that year) and for the formation of a negotiation team of current and former Ingush and North Ossetian presidents. Conditions in the school were unimaginable, and the treatment of the hostages was extremely harsh and unpredictable. Females were raped—some in front of other hostages in the gym and others in the upstairs auditorium. Hostages were forced to mop blood and dispose of dead bodies. Terrorists took turns standing on a detonator that would ignite the gym's explosives if released, a constant reminder how close they all were to death.

On the second day of siege, the terrorists released some women and small children to the main negotiator, to whom they also presented their new demand: the withdrawal of all Russian troops from Chechnya and recognition of the Republic as an independent state. Efforts at negotiation continued on the third day with talk of permitting terrorists a safe passage to Chechnya. At midday the terrorists agreed to permit four rescue workers to enter the school grounds to collect the dead bodies piled outside the windows. While they worked, two sequential explosions in the gym, the cause of which remains unknown, set off a series of irreversible events. Terrorists on the second floor, confused and cut off from their comrades in the gym, shot two of the rescue workers, while the gym roof caught fire and collapsed, killing or pinning down many hostages. Those still mentally and physically capable fled the gym through the shattered windows and holes created by the explosions. Many hostages were gunned down while crossing the open courtyards.

Special Forces reacted to the unexpected event with actions that eventually led to the recapture of the school. Several groups of terrorists attempting to flee were ultimately isolated and killed elsewhere in the town, and one was captured alive by the Special Forces troops. The rest were killed in the action of taking back control of the school. The final toll, which is still disputed, was 31 terrorists, 21 soldiers, and 338 hostages killed. Well over 700 hostages, police, soldiers, and rescue workers were injured.

Response

Victims attempted escape, with varying degrees of success, throughout the ordeal. One teacher fled to the school's boiler room with 12 students, all of whom managed to escape that same day. Once inside the school, many hostages hid in different rooms. Some managed to escape, but many were prevented from doing so, because most of the school's windows had bars. Later, some of the hostages ordered to dispose of dead bodies managed to slip away through windows that had been shattered. The rapidly declining condition of the hostages played a major role in the final outcome. Many were incapable of fleeing the gym, while others fled through the kill zone in a state of panic. Some that managed to escape, so overcome by thirst, stopped to drink water at a faucet outside the classroom on the northwest corner of the campus only to be killed in the melee.

Citizens of Beslan influenced the course of events from the start. Before police and military forces arrived, an alarming number of local citizens arrived with their own weapons, which included everything from hunting rifles to machine guns. Throughout the ordeal, they taunted the terrorists, firing at them and drawing fire. They prevented the police and military from establishing an orderly perimeter and even argued with them. By the second day, approximately 20,000 civilians had gathered near the scene. In planning a potential assault, Special Forces commanders knew they would be unable to rely on surprise with so many onlookers. Additionally, with so many well-armed, fatigued, angry, and often drunk civilians, planners were concerned about being shot by their own citizens, which in fact happened on September 3.

First responders at the scene were the local police, who were ill equipped and poorly trained for this type of event. Elite forces from Moscow did not arrive until the evening of the first day of siege. A command post was set up at the Beslan Cultural Center approximately 200 meters northeast of the campus. The regional commander of the Federal Security Services (FSB or Federal'naya Sluzhba Bezopasnosti) nominally ran the command post, but who, if anyone, was actually responsible for the operation is still unclear. Soldiers and police on the perimeter were caught offguard by the explosions that set off the conclusion of the Beslan siege. Responders had no contingency plan, and witnessing hostages being massacred inside the school and in the courtyards, Special Forces teams ceased waiting for orders and took action on their own. Unfortunately, so did the armed citizens, who began shooting indiscriminately into the school. In the chaos that ensued, some of the terrorists managed to slip away, taking advantage of the large crowds. They were pursued and cornered in different parts of the town, leading to many separate firefights.

3.5 Vulnerabilities

As discussed in Chapter 1, school vulnerabilities are the physical and operational characteristics of systems and facilities that may result in losses if a successful attack is mounted against a school. An examination of shooting incidents, similar to the ones described above, may indeed reveal a number features of the buildings and practices of schools that could have contributed to losses, even if inadvertently, i.e., by failing to impede the attack or minimize the consequences.

Specific features of the school buildings and school routines representing functional and operational requirements of the educational environment were used to the attackers' advantage and thereby may be considered vulnerabilities. Attempts to address this type of "vulnerability" may sometimes do more harm than good. While such measures may indeed deter some attackers, they are more likely to damage the educational environment. The advantages and disadvantages of risk reduction strategies that focus on managing vulnerabilities are discussed in Section 3.6.

Vulnerability to targeted shootings involving active shooters, snipers, and terrorists can be reduced to some extent by measures incorporated into the building design.

Vulnerability to targeted shootings involving active shooters, snipers, and terrorists can be reduced to some extent by measures incorporated into the building design. Preventing these adversaries from entering the building and roaming throughout the building is critically important. Intrusion detection, access control measures, and immediate video assessment can be incorporated into the building design to prevent or delay entry into the building, or trap a shooter in an isolated area designed to contain an adversary. However, preventing access to dedicated and committed attackers in most cases requires a level of security similar to a military installation, which is not feasible for most school settings.

3.5.1 Physical Design Vulnerabilities

3.5.1.1 Perimeter Security

The unfenced and unprotected school grounds allowed the shooters in the Jonesboro incident secret and unimpeded access to, and egress from, the site of the shooting. Similarly, wooded rural surroundings offered hiding places and a safe escape route in three directions. Conversely, a brick fence surrounding the urban grounds of School No. 1 in Beslan afforded the attackers visual protection from three sides as they approached the school undetected by crowds.

3.5.1.2 Building Design

Some have claimed that the terrorists who attacked the school in Beslan likely targeted the school because of its antique construction, with narrow halls that channeled the interior movement of assault forces and made it easier to defend. Additionally, a maze of small rooms afforded terrorists hiding places once the assault began. The attackers successfully blocked usual escape routes for hostages, and the windows, which were barred to prevent vandalism, were rendered useless as a means of escape.

Multiple exit doors at Columbine High School allowed many students and staff to escape to safety. However, most school egress routes did not provide any protection from gunfire. For example, the library, the area where most of the killings took place, offered a door to the outside that opened to the area where the shooters first started their rampage by killing two students outside the school. Inside, the building offered few areas of refuge that were sufficiently safe, except for the locked classrooms.

While the interior locks on classroom doors saved many lives at Columbine High School, they were not available in classrooms in Norris Hall at the Virginia Tech campus. Although attempts were made to barricade the doors with furniture or live bodies, they were not successful and the death toll was much greater.

3.5.2 Other Vulnerabilities

The chaos that ensued following the terrorist takeover of the school in Beslan has been attributed mainly to the shock and panic that permeated the whole town. Although the poor management of the crisis contributed to the tragic consequences, there were other contributing factors. The school had no preparedness plans or security systems and procedures for emergencies. The school had no known "lock-down" procedures, badge system or other access control mechanisms, safe haven locations, inner perimeter controls, or alarm to alert persons of imminent danger or a hazard event.

Unlike the Columbine High School incident, where the police were able to clear the area and establish a safe perimeter to keep the public away and prevent the escape of the perpetrators, the authorities in Beslan were not able to establish such a perimeter even after 3 days of fruitless negotiations. The unauthorized and uncoordinated interference by citizens in the resolution of the crisis likely increased the casualty toll and illustrates the need for unified incident management in accordance with emergency preparedness plans.

The havoc that the shooting at the University of Texas created on campus is often attributed to the fact that the university did not have its own police or security force prepared to deal with such an attack. As with the school in Beslan, at the time of the shooting, the university had no overall crisis management plans or specific plans to resolve this type of incident. The responding officers did not know how many shooters might be involved or their locations. The interference by citizens shooting at the tower may not have aggravated the situation as in Beslan, but it made the situation more confusing.

Effective communication during the incident at the University of Texas was almost non-existent. Cellular telephones were not available at the time of the incident, and almost all police radios were only mounted in vehicles. Also, the telephone lines were jammed and the university had limited telephone capabilities. While communications technology at the time was not very sophisticated, the breakdown in communications in the case of Columbine is more difficult to understand. Not only were the emergency response teams from different jurisdictions unable to communicate with one another, the response action was significantly hampered by poor communication inside the school. The blaring fire alarm made it almost impossible for officers to hear each other, and police radios and cell phones failed to function properly inside the building.

3.6 Protective Measures

As discussed in Chapter 1, risk is determined by the level of threat, the level of potential consequences of a successful attack, and the level of a school's physical and operational vulnerabilities. Strategies to reduce risk usually focus on managing one or more of these risk components. Influencing the level of threat is the most difficult approach, and to the extent that it is feasible, it usually requires expertise and resources beyond the reach of a typical school district. As a matter of fact, the investigation by the U.S. Secret Service of the problem of so-called "targeted violence" in schools concluded that the causes and modes of attacks were too unpredictable to be a reliable basis for common strategies to reduce the level of threat. In such circumstances, risk management efforts must focus on reducing risk by addressing vulnerabilities, through surveillance and detection, hardening, or removal of functional and operational design flaws that might reduce the success of attempted attacks. Alternatively, risk can be managed by increasing preparedness and response capabilities that reduce the losses and other effects of attacks through appropriate protective measures.

Risk is determined by the level of threat, the level of potential consequences of a successful attack, and the level of a school's physical and operational vulnerabilities.

Key approaches to preventing a targeted shooting attack are to deny access to the shooter and, if this fails, to ensure the shooter does not have unrestricted access to the entire building. Intrusion detection, access control, immediate video assessment, and effective response capabilities are essential measures that can reduce the risks of targeted shooting.

3.6.1 Layers of Defense for Schools

The basic concept of security design promoted in this primer is that of three layers of defense. As discussed in Chapter 2, the intent of this approach is to structure a defense in depth that creates cumulative security obstacles that must be penetrated to mount a successful attack.

Layers of defense for high-risk buildings may require expensive barrier and controlled access systems at the perimeter, and extensive hardening of the building exterior and interior. Such measures are neither affordable nor appropriate for school facilities, where the exposure to risk is relatively low and the security budgets are severely constrained. In these circumstances, the need for a balanced approach to school security becomes even more important.

Layers of defense for high-risk buildings may require expensive barrier and controlled access systems at the perimeter, and extensive hardening of the building exterior and interior.

The difficult decisions about appropriate strategies notwithstanding, the philosophy of layers of defense still applies and can be implemented in a limited form to reduce the risk of shooting attacks. The first two layers of defense that comprise the perimeter and the area between the school boundary and the building exterior are discussed in greater detail in Chapter 2. This section focuses on the third layer of defense, which starts at a building's exterior façade and extends into the interior of the building.

3.6.1.1 Third Layer of Defense – Building Exterior

Securing the building exterior is the only layer of defense that many schools are able to implement. Keeping armed intruders out of the school facilities and away from students, teachers, and other staff is critical. Depending on the size, location, and vulnerability of the school, some levels of intrusion detection, access control, and immediate video surveillance should be incorporated into the building design to provide a minimum level of defense to keep the building's occupants safe.

The U.S. Department of Education recommends that secure locks with quick-release capability to allow evacuations and multiple escape routes be installed at a minimum. Windows that face traffic should have protective coatings applied to enhance their resistance.

3.6.1.2 Third Layer of Defense – Building Interior

Very few protective measures can be incorporated into a building interior to prevent an armed shooter who has entered the building from inflicting harm on the occupants. Securing external doors and windows restricts entry into the building to specific controlled entrances where weapons can be detected. The area where weapons may be detected should be designed to contain the intruder and prevent unrestricted access to other areas of the school.

Weapons detection can be accomplished by installing modern detection portals similar to metal detectors. Consideration must be given to the number and location of entry points, because metal detectors can slow down entry into the school, leaving children vulnerable to other undesirable effects while they wait to be screened. However, the technology available today is significantly more flexible than in the past and can accommodate the needs of a school setting for rapid and safe screening of those entering the facility. Other problems may be more difficult to address.

The 2001 Report of Governor Bill Owens' *Columbine Review Commission*, for example, did NOT recommend metal detectors, video surveillance, and other access control security equipment as a means of forestalling violence. It stated, "The Commission believes the use of security devices should be viewed as a preventive solution for specific problems at individual schools and not as a broad based antidote to school violence in general." Obviously, when considering any physical security measure for a school, balancing its use with the risk of creating a "bunker" or "prison" atmosphere that is not conducive to learning is important. The measures recommended in this chapter should be applied judiciously and in concert with the risk management and decisionmaking principles described in Chapter 1.

3.6.2 Access Control

When considering protective measures for the targeted shooting type of attack, the primary strategy is to prevent the attacker(s) from gaining unobserved entry to the school grounds and buildings, by force or stealth. Other strategies must address the threats from inside the school, by providing safe havens; safe evacuation routes; visibility and opportunities for effective surveillance of interior spaces and corridors; barriers in the form of bullet-proofing, control gates, or safety locks; and other electronic screening, alarm, and communications devices.

Although controlling access is one of the most effective protective measures for all types of threats, it conflicts with the objective of providing an open learning environment for schools. Most schools are public institutions that are open to the public, including parents and relatives, as well as other visitors. Strict control or even limiting of access to schools may damage the role that schools play in our communities. Also, access controls may not be fully effective, especially because the majority of attackers use their established relationship with the schools (as students or staff) to gain entry into the school legitimately.

Nevertheless, the ability to verify the access privileges of those entering a school and alert the authorities to any attempt of unauthorized entry reduces the school's vulnerability to intruders. Ideally, access control systems should keep shooters out of a building completely, but in case a shooter manages to penetrate a building, the systems should include the ability to close and secure doors remotely, and thereby limit access to vulnerable targets. Limited access forces a shooter to spend more time searching for targets, giving the building occupants more time to evacuate to a safe area or seek cover in safe rooms. The delay also allows response forces more time to arrive on the scene to neutralize the threat or reduce casualties. Such systems also have the potential to trap the shooter in a specific area, increasing the chances of a positive outcome with no injuries. Immediate video assessment may give the staff the ability to notify law enforcement of an emergency and identify the exact location of the threat.

Coordinated intrusion detection, access control, and immediate video assessment increase the amount of time it takes a shooter to gain access to potential victims. Including these measures in the building's design can significantly reduce the impact of a targeted shooting event.

Design Recommendations

To control access and limit intrusion, visitors should be guided to a single control point and required to pass directly through to administration reception areas when entering or leaving the school. The combination of a main entry with a carefully located and constantly staffed administration area can enhance the supervision of school entries, stairs, and hallways without the need for an additional assigned monitor.

The main entry area should be positioned to allow for unobstructed surveillance of lobby doors, stairwells, and perpendicular hallways. Placing the administrative area on an exterior wall allows additional surveillance and a distant view of outside areas, especially visitor parking, drop-off areas, and exterior routes leading up to the main entrance. When feasible and appropriate, consider providing security camera(s) in the lobby area for electronic surveillance to enhance access control.

Administration areas should be adjacent to main entry areas and designed to allow a visual connection through windows between administrators and students or visitors (see Figures 3-22 and 3-23). This room should consist of a lockable door and a working telephone. In addition, two remote exits should be provided from the principal's office, one of which could be a window to the exterior. Faculty offices and student records should be separated from the reception area and accessible through lockable corridor doors.

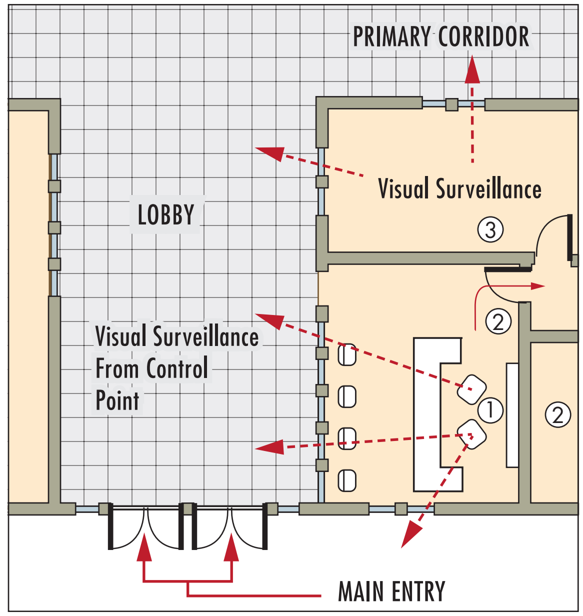


Figure 3-22: Considerations for entry areas

SOURCE: FLORIDA SAFE SCHOOLS DESIGN GUIDELINES, 2003

Access to classrooms and other areas in the interior should also be controlled to protect against armed intruders. Doors to classrooms, offices, libraries, and other rooms frequently used by students should have access control measures that prevent or delay access. The materials used to construct the doors and walls should be difficult to penetrate quickly. A central control station should have the ability to close and secure all internal doors when an alarm is sounded. Effective access control will enable the central control station to restrict the movement of the shooter and direct the safe escape of students.

Doors used in educational facilities are commonly made of wood or aluminum with significant portions of glass. These materials can easily be penetrated and provide only partial defense against an armed intruder. Bullet-resistant doors are very expensive and should be used only where no other protections exist.

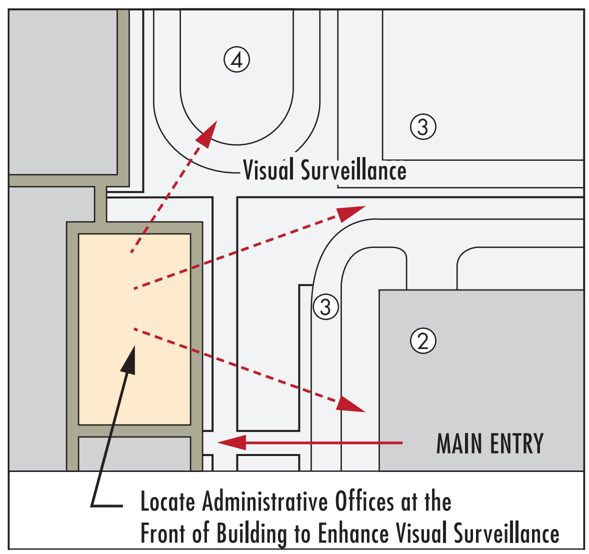


Figure 3-23: Position of administrative offices

SOURCE: FLORIDA SAFE SCHOOLS DESIGN GUIDELINES, 2003

Operation Recommendations

The identity of service personnel, including maintenance personnel seeking access to utilities, alarm systems, communications systems, and related maintenance locations, and vendors visiting the school should always be verified. Schools should keep detailed and accurate records of service and delivery personnel, including a log to record the full names, organization name, vehicle information (as appropriate), and other identification information of visitors.

Decisionmakers might also consider providing schools with an emergency kit, which should be located within the administration area in a locked cabinet. Such kits include items that administrators would use during emergency situations, such as keys; facility information such as site plans, floor plans, evacuation maps, and system control and shut-off information; radios and/or cell phones; medical supplies; attendance data; contact lists; and emergency numbers.

3.6.3 Security Measures

3.6.3.1 Fire Protection Systems

The fire protection system inside a school building should be operational and provide life-safety protection after an incident and allow for safe evacuation of the building when appropriate. Fire extinguisher and standpipe cabinets located in main circulation paths should be flush mounted in walls adjacent to classrooms. Fire alarm pull stations should be located in areas that allow for unobstructed surveillance (Figure 3-24). Like vending machine and telephones, isolated equipment is more susceptible to vandalism and misuse. Providing tamper-proof covers for fire alarm pull stations can also deter misuse of the devices as in the Jonesboro attack. Fire sprinklers should also be flush mounted in ceilings to avoid damage from vandalism, explosions, and shootings.

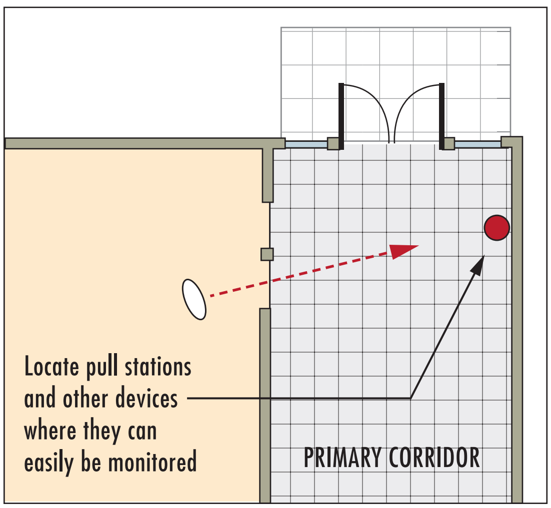


Figure 3-24: Surveillance of fire alarms

SOURCE: FLORIDA SAFE SCHOOLS DESIGN GUIDELINES, 2003

Fire protection system considerations include the following:

- A school's fire protection water system should be protected from single-point failure in case of an attack. The incoming line should be encased, buried, or located 50 feet away from high-risk areas. The interior mains should be looped and sectionalized.
- To increase the reliability of the fire protection system, a dual pump arrangement should be considered, with one electric pump and one diesel pump. The pumps should be located away from each other.
- All school security locking arrangements on doors used for egress must comply with requirements of the National Fire Protection Association (NFPA) 101, Life Safety Code.

3.6.3.2 Physical Security Systems

Physical security is defined as that part of security concerned with physical measures designed to safeguard people and to prevent unauthorized access to equipment, certain areas of the school building, and key documents. Although security technologies are not the answer to all school security problems, if applied appropriately, they can enhance security, free up administrators for more appropriate work, and sometimes save money. Figure 3-25 identifies some considerations for the design of new school security systems and Figure 3-26 depicts examples of physical security devices.

For schools requiring greater security, some general measures are contained in the National Institute of Justice Research Report NCJ 178265, *The Appropriate and Effective Use of Security Technologies in U.S. Schools,* September 1999.

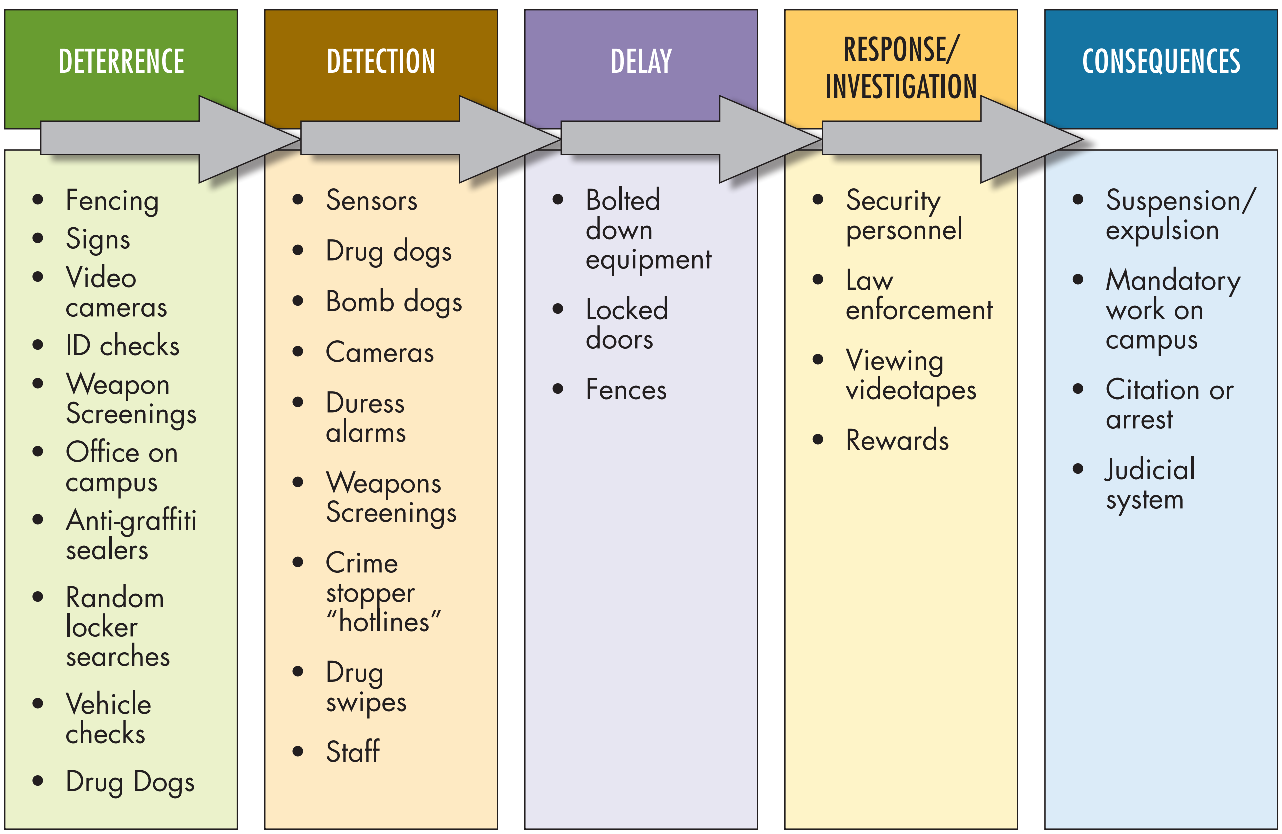


Figure 3-25: Considerations for the design of a new security system

SOURCE: NATIONAL INSTITUTE OF JUSTICE RESEARCH REPORT, NCJ 178265, *THE APPROPRIATE AND EFFECTIVE USE OF SECURITY TECHNOLOGIES IN U.S. SCHOOLS*, SEPTEMBER 1999

Figure 3-26: Physical security devices

Direct Evacuation/Escape Routes should be provided in locations where students, teachers, and staff can be trapped in rooms and create easy targets for the shooter. These emergency exits should be provided in addition to the established fire escape routes to allow for faster escapes, redundancy, and greater flexibility in emergency evacuations.

Safe Rooms are not typical features in educational facilities, but in some locations, a safe room may provide refuge from floods, high winds, or CBR attacks. With some structural and equipment enhancements, at very small cost, these safe rooms can be adapted to act as a refuge from a shooting attack. Such a room may also deter active shooters, because they do not usually exert great effort if there are other available and unprotected targets. Chapter 5 provides a more detailed description of safe rooms in schools.

Safe Rooms are not typical features in educational facilities, but in some locations, a safe room may provide refuge from floods, high winds, or CBR attacks.

Weapon Detection Systems are used in conjunction with entry control systems to prevent persons from gaining entry with a concealed weapon. Table 3-3 provides a list of weapons types that were used in the commission of crimes occurring on school grounds between 2000 and 2004. Many technologies are available today that can detect the majority of the weapons listed in Table 3-4.

Table 3-4: Type of Weapon/Force Used in Crime in Schools, by Year

Weapon Type. Force Used	Year of Incident					5-Year Total
	2000	2001	2002	2003	2004	
Personal Weapons	12,945	17,830	20,636	21,933	25,050	98,394
None	2,702	3,114	2,874	3,294	4,176	16,260
Other	1,775	2,311	2,323	2,420	2,842	11,680
Knife/ Cutting Instrument	1,511	2,082	2,080	2,445	2,842	11,680
Handgun	307	376	398	430	497	2,008
Blunt Object	283	404	394	455	469	2,005
Firearm (Type Not Stated)	94	131	103	135	146	609
Other Firearm	74	107	92	155	154	582
Explosives	145	139	93	89	95	561
Motor Vehicle	43	52	46	59	71	271
Fire/Inceniary Device	36	34	42	36	88	236
Rifle	23	33	33	24	37	150
Shotgun	15	24	30	19	24	112
Drugs/Narcotics/Sleeping Pills	9	4	8	14	6	41
Poison	1	8	4	11	16	40
Asphyxiation	2	1	3	6	2	14
Unknown	593	1,128	1,163	1,069	1,098	5,051

SOURCE: NOONAN AND VAVRA 2007

If a weapon is detected, keeping an individual from taking that weapon farther into the building is essential. Establishing a personnel screening point at the main building entry allows the building to be secured after a weapon is detected, and reduces vulnerability.

Video Assessment and Security Cameras enhance the staff's ability to respond to attacks or emergencies quickly and appropriately. Shooting incidents generally leave very little time for intervention and response. Video systems can provide responders with the capability to rapidly assess a situation and safely conduct surveillance of suspicious persons, as well as provide an immediate assessment of a triggered alarm. The systems can also function as alarms if configured with video motion detection capability. Cameras should be installed throughout the facility to enable staff to identify and assess any threats. Each room and hallway should have a camera that can be operated from a central location to ensure safety and provide a rapid means to determine the exact nature of any suspected threat to better direct response actions.

These systems frequently raise concerns about privacy and may even be considered inimical to the educational environment. Some research has shown that students may feel that an overly controlled environment has taken their creativity, individualism, and intellectual development away. Some have argued that tighter security brings about less emphasis on individualism and education, as students are forced to conform to new rules and regulations, which diminishes their academic performance. Perceived as a message of mistrust, intrusive surveillance may also damage open communication between the school administration and the student body. For these reasons, school authorities should weigh carefully the reason for and against the usage of these surveillance systems and use them only if no other options are available. Additionally, extreme care must be taken to ensure that internal cameras are used for security purposes only. Strict policies must be adhered to in order to maximize the value of internal cameras without negatively impacting the learning environment. Security cameras are intended to provide a tool to increase security and safety, not to be a tool for behavior modification.

3.6.3.3 Communications Systems

Telecommunications systems are essential to the operation of many modern security devices in addition to providing the ability to alert external responders of an emergency. Schools should have an independent system, such as radios or cellular phones, to alert responders.

Redundancy should be an important feature of a school communications system. A second telephone service should be maintained to allow communications in case of an incident. A base radio communications system with antenna should be installed in the stairwell, and portable sets should distributed to each floor as a preferred alternative.

Radio telemetry system should provide antennas throughout the school facility if required for emergency communications through a wireless transmission of data.

Alarm and information systems should not be collected and mounted in a single conduit, or even collocated. Circuits to various parts of the school building should be installed in at least two directions and/or risers. Low-voltage signal and control copper conductors should not share conduits with high-voltage power conductors. Fiber-optic conductors are generally preferred over copper.

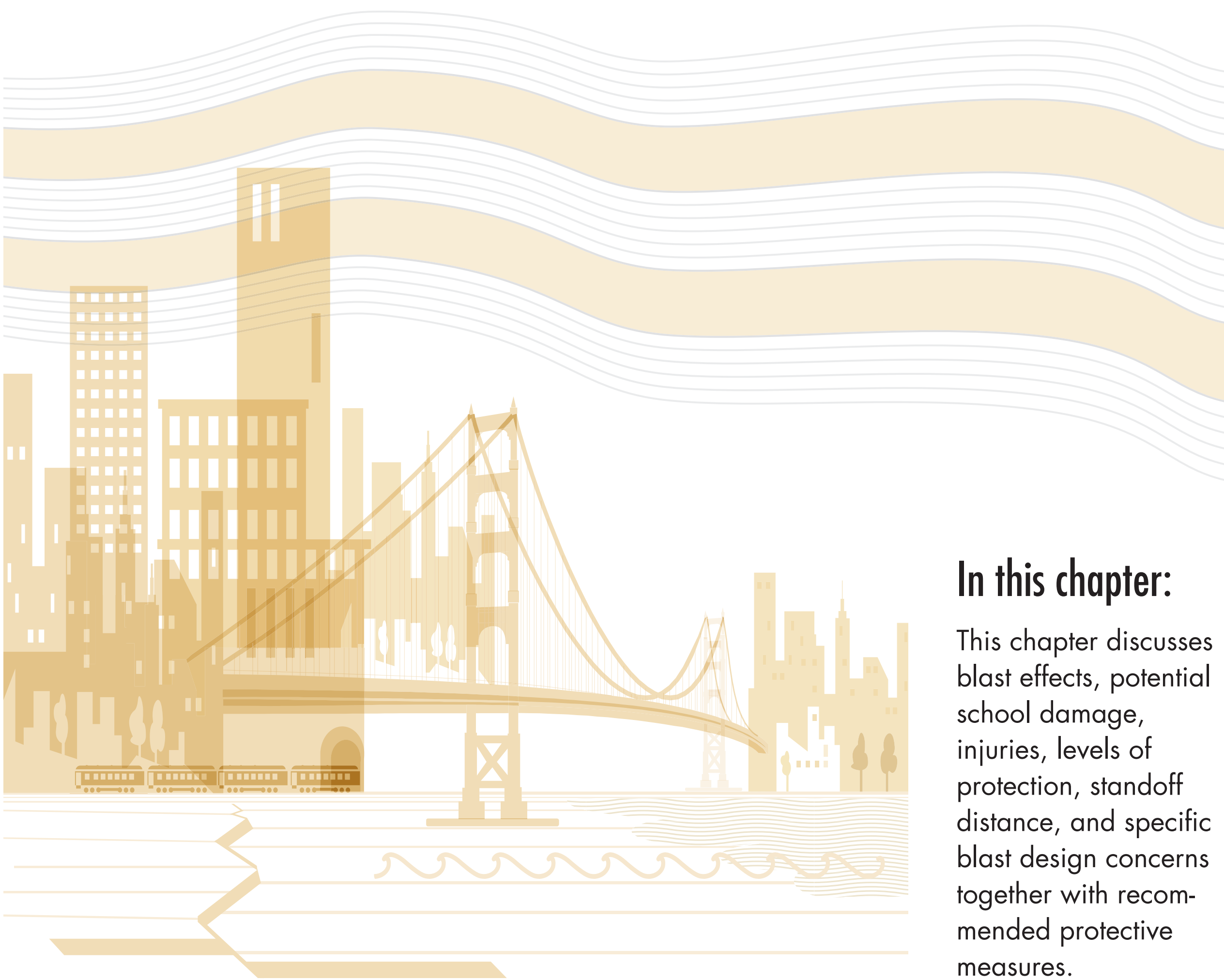
Empty conduits and power outlets should be provided for possible future installation of security control equipment.

Mass notification systems are critical for advising faculty, students, and visitors of impending danger. After the exact nature of a threat is positively identified, unsuspecting occupants must be immediately alerted of the threat or situation and advised of what actions should be taken. Addressable notification systems can provide notifications to the entire school or send messages to specific locations, such as a portion of a building. Addressable notification systems can help to control the flow of personnel by directing them to go in a different direction or to remain in a particular room.

Classroom Communication Systems can provide a rapid means for staff or students to alert the administration that a serious incident is taking place. Such communications systems can consist of a push-to-talk button installed on a wall, an identifiable telephone system, or other means. Often, the first indication of an incident is the first shots, which may not be heard by administrators. Vulnerability is greater if the administration cannot quickly receive information from faculty, students, and staff.

4

Explosive Blast Threat



In this chapter:

This chapter discusses blast effects, potential school damage, injuries, levels of protection, standoff distance, and specific blast design concerns together with recommended protective measures.

Attacks with explosives have historically been a favorite tactic of terrorists for a variety of reasons and are likely to continue to be so into the future. Even though this type of attack on schools is rare, the consequences can be devastating. According to the National Counterterrorism Center (NCTC) *2009 Report on Terrorism* (2010), of the 11,770 terrorist attacks worldwide that year, bombings made up only 35 percent of the attacks, but accounted for 47 percent of total deaths and more than 70 percent of injuries.

DOD, the General Services Administration (GSA), and DOS have considerable experience with blast effects and blast mitigation. However, many architects and building designers do not have such experience. For additional information on explosive blast, see FEMA 426, R*eference Manual to Mitigate Potential Terrorist Attacks against Buildings* (2003), FEMA 427, *Primer for Design of Commercial Buildings to Mitigate Terrorist Attacks* (2004), and FEMA 453, *Safe Rooms and Shelter* (2006). This chapter discusses blast effects, potential school damage, injuries, levels of protection, standoff distance, and specific blast design concerns together with recommended protective measures.

4.1 The Nature of Explosive Blast

An explosion is an extremely rapid release of energy in the form of light, heat, sound, and a blast wave of high speed air moving outward from the exploding material in all directions. The explosion can take two forms—detonation and deflagration. Detonation creates a blast wave, more appropriately called a shock wave, resulting in an almost instantaneous increase in air pressure of relatively short duration (milliseconds) as it travels over a given point at supersonic velocities. This peak overpressure or blast pressure is the highest pressure reached above the normal ambient air pressure. Deflagration is also rapid combustion that creates a blast wave, but it differs from detonation in that it does not result in an instantaneous increase in air pressure. The deflagration blast wave travels at subsonic speeds (below the speed of sound), and it has relatively longer duration. The way a blast wave expands is determined by the type of explosive material and its ignition, shape of the charge, and its relative location with respect to terrain and buildings for outdoor explosions, or the design of the structure if the explosion is confined inside a building.

The shock wave consists of highly compressed air traveling radially outward from the exploding source at supersonic velocities. As the shock wave expands unconfined outdoors it interacts with an ever increasing volume and surface area of ambient air giving up energy as it heats this air, causing the overpressure to decrease rapidly until it reaches equilibrium with the ambient air. These incident (unconfined, free flowing) pressures also decay rapidly over time (i.e., exponentially) after the shock wave passes. However, when the shock wave meets a substantial surface (such as the side of a building), it is reflected and the resulting amplified peak pressure may be an order of magnitude greater than the incident peak pressure. Diffraction effects, caused by obstacles, such as at the corners or overhangs of buildings, may act to confine the air blast, prolonging its duration and increasing its reflected pressure. Late in the explosive event, the shock wave becomes negative, creating suction.

def-ə-

An **explosion** is an extremely rapid release of energy in the form of light, heat, sound, and a blast wave of high speed air moving outward from the exploding material in all directions.

Behind the air-blast shock wave, three things occur. First, dynamic pressure is generated by the air molecules behind the shock front as they move at lower flow velocities and form a wind by the passage of the shock front. As the shock wave causes fragmentation of items in its path, the dynamic wind propels the fragments. Second, the afterburning of detonation products from a confined explosion produces an additional gas pressure that can add to and extend the positive phase of the blast wave. Third, the outward moving air molecules produced by the shock wave, the dynamic wind, and the expanding gases cause a vacuum (drop in pressure below ambient atmospheric pressure) to develop behind the shock front. This vacuum is commonly called the negative phase. Because nature abhors a vacuum, air rushes in, creating a change in force direction against any object in the shock wave's path. Although the vacuum cannot exceed one atmosphere (about 14.7 pounds per square inch [psi]) in reduced pressure, the duration of the negative phase vacuum is approximately three times as much as the duration of the positive phase.

In an external explosion, a portion of the energy is also imparted to the ground, creating a crater and generating a ground shock wave analogous to a high-intensity, short-duration earthquake.

In the context of other hazards (e.g., earthquake, flood, wind), an explosive event has the following distinguishing features:

- The intensity of the pressures acting on the exterior of a building can be several orders of magnitude greater during an explosive blast than the pressures generated by other hazards. A peak pressure (reflected) in excess of 2,000 psi on a building in an urban setting is not uncommon for an explosion set off in a car parked along the curb only a sidewalk away. At this pressure level, major damage is expected. In contrast, a 200-mile-per-hour (mph) wind would generate a peak pressure (reflected) of about 1.6 psi. The pressure generated by flowing flood waters would be between these two extremes.

- Explosive pressures decay extremely rapidly with distance from the source. Nevertheless, building damage, mainly glass breakage, can occur at distances up to a mile from the explosion. For earthquakes, floods, and winds, the impact area resulting in damage will cover a much larger area.
- The duration of an explosive event is very short. For a car bomb explosion, the duration of the positive pressure is measured in milliseconds (0.001 second). This differs from earthquakes and wind gusts, which are measured in seconds, or sustained wind or flood situations, which may be measured in hours. For example, standard building design for wind loading uses 3-second gusts.

Hazards induce different amplitudes and frequencies of loading upon the surroundings: people, buildings, equipment, etc. A higher amplitude is expected to cause more building damage and casualties. Everything in nature has a natural, or resonance, frequency. An example of this is a tuning fork, struck to vibrate, causing another tuning fork (designed for the same frequency) to also vibrate. A loading at this resonance frequency will cause increased damage even at lower amplitudes.

4.2 Type of Attacks

Explosive materials may be used in many ways in different types of attacks. The differences in approaches are based upon the following factors:

- Material availability and its characteristics for use (military or improvised)
- Aggressor expertise at handling explosive materials
- Quantity used for the desired effect (damage property or injure people)
- Means of delivery (vehicle-borne or hand-carried device)
- Method to initiate explosion (cause an impact; light fuse with match; trigger electric contact manually, remotely, with timer, or a combination of these)

These factors should be considered when determining the explosive threat. The attack type is usually classified by one of the following delivery methods:

- Mail bomb
- Package bomb (delivery service)
- Left in place (backpack, briefcase, package, pipe bomb, or suitcase)
- Suicide bomber (belt, vehicle, or vest)
- Thrown or propelled bomb (dynamite stick, grenade, pipe bomb)
- Vehicle bomb (stationary or moving)

Although these types of attack describe the full range of possibilities, the remainder of this chapter will cover two general situations:

- A vehicle bomb detonated in the vicinity, but not at the school, such that the school may receive collateral damage and casualties
- An attack that can result in an explosion inside the school building

4.2.1 The Bombing of Bath Consolidated School in Michigan Incident

The attack on Bath Consolidated School (Figure 4-1) in Bath, MI, that took place on May 18, 1927, is unique not only because it is the worst school tragedy in U.S. history, but also because it combined the two most feared types of attacks: a detonation of explosives inside the school and the detonation of a vehicle bomb in close proximity to the school.

Figure 4-1: Bath Consolidated School

At the time of its construction in 1922, Bath Consolidated School was typical of modern schools of the era. It was a simple two-story brick rectangular structure with a wooden roof. Interior construction was mostly wood and plaster. The long access of the structure was on a generally north-south line, so one-half of the building was known as the north wing and the other as the south wing. It sat on slightly elevated ground and was considered the center of the town.

The attacker was associated with the school for several years prior to the attack. He served on the School Board as a Treasurer and because of his handyman skills was asked to perform repair and maintenance work on a regular basis. He had a key and unlimited access to the whole building.

On the morning of May 18, an explosion almost completely destroyed the north wing of the Bath Consolidated School (see Figure 4-2). A combination of pyrotol and dynamite packed in the floors and ceilings over a period of up to 2 years turned the walls and floors to rubble, causing the unsupported roof to collapse. Some children were sent hurling through windows; most were trapped under the roof and debris. Windows in the southern wing of the school, as well as windows throughout the surrounding neighborhood, were shattered.

Figure 4-2:
Bath Consolidated School
north wing destroyed

Volunteers from all over the small town rushed to the scene. Without any rescue equipment, the citizens of Bath improvised, pulling children from the site—some wounded, some dead, some in parts, as the police and firefighters began filtering into town from nearby cities and counties. In the middle of the rescue operation, some 30 minutes after the explosion, the attacker drove his car and parked it near the school. When some of the school officials approached him, he fired a gun into the back seat that was loaded with explosives, tools, rusted farm equipment, screws, and nails and detonated the second bomb. Shrapnel was sent flying, killing five people, including the attacker, and injuring many others. The final toll from both explosions was 45 killed, mostly children aged 7 through 12, and 58 injured, not counting the attacker's wife who was killed a day earlier.

In the course of rescue efforts, police officers discovered additional explosives and wiring in the basement of the south (unexploded) wing. Over 1,000 feet of wire was intricately laid over the course of many months leading to hidden caches of explosives. The explosives had been hidden in eaves troughs (i.e., rain gutters) and in recesses above rafters, held in place with wire mesh and plastered over. The rescue operation was halted until the explosives could be disarmed and removed. By the time state police pronounced the school disarmed and resumed the rescue effort, over 500 pounds of explosives had been removed. Only 100 pounds had caused the entire north wing to crumble. The cause of the malfunction is not known, but few occupants of the building would have survived had all the explosives ignited.

4.3 The Consequences of Explosive Blasts

The extent and severity of damage to buildings and the resultant casualties caused by building component failure in an explosive event cannot be predicted with certainty. Past events show that the unique specifics of the failure sequence for a building significantly affect the level of damage. Despite these uncertainties, some general indications of the overall level of damage expected based on the size of the explosion (weapon yield in trinitrotoluene [TNT]-equivalent weight), distance (also termed range or standoff) from the event, and assumptions about the construction of the building can be determined.

The extent and severity of damage to buildings and the resultant casualties caused by building component failure in an explosive event cannot be predicted with certainty.

Building damages caused by the air-blast shock wave may be divided into direct air-blast effects and progressive collapse. The high pressure of the direct air-blast induces localized failure of windows, exterior walls, interior walls, roof systems, floor systems, columns, and beams. When a small amount of direct damage causes the building to become unstable, the building will gradually shift to a stable rest point and the additional damage that occurs to get to that rest point is called progressive collapse.

The air-blast shock wave causes building component damage in two ways based upon the mechanical properties of these components. These properties include compressive strength, tensile strength, shear capacity, ductility, strength of connections, etc. The reflection of the incident pressure on the building surfaces creates the blast loading. The earlier example of the urban car bomb and 200 mph wind noted the difference in reflected pressures of 2,000 psi for the explosion compared to the 1.6 psi reflected pressure for the wind. However, the car bomb blast wave only lasts for about 1 millisecond (msec) for a 10-foot sidewalk width (standoff), while the wind pressures are based on 200 mph wind gusts lasting 3 seconds (3,000 msec). The total impulse (area under the pressure time curve) is about 1,000 psi-msec for the exponentially decaying blast wave, compared to 4,800 psi-msec for the constant intensity hurricane loading. Although the wind has a much lower peak pressure, the damage is caused by its much greater impulse. Therefore, both the peak pressure and the duration of the pulse must be considered when calculating the potential for blast damage.

When the blast wave load strikes the building components to the point of exceeding their resistance, a component or a total building failure may occur. Reflected pressures may be several orders of magnitude greater than the loads for which the building is designed or for the strength of the materials used in construction. For example, unreinforced (plain) concrete with a compressive strength of 4,000 psi will be crushed by a significantly greater reflected pressure.

When the blast wave load strikes the building components to the point of exceeding their resistance, a component or a total building failure may occur.

The shock wave also acts in directions for which the building may not have been designed, such as upward on the floor system or outward on the exterior walls. Weak connections between building components or components not strongly tied together to react to the shock wave as a single unit are other situations in which damage results from a shock wave. Building damage can also occur from fragments and debris engulfed by the dynamic wind of the blast wave and hurled at the building. The blast wave is ever expanding, until reaching equilibrium with the environment and achieving a state of rest. Anything in its way as it travels the path of least resistance may receive some level of pressure, which can cause component failure.

4.3.1 Building Damage from External Explosions

As the air-blast shock wave from an outside explosion strikes a building, the components of the building envelope are subjected to extreme loading. If the building envelope has sufficient and balanced hardening, then the blast wave will pass over the structure without causing significant damage or injury. However, the sequence shown in Figure 4-3 is more likely. The front of the building will be subjected to reflected pressure while the roof, sides, and back of the building will be subjected to incident pressure. The magnitude of loading will depend on the distance from the explosion and the angle of incidence of the blast wave in relation to different building surfaces. The damage sequence from direct air-blast pressure usually starts with windows, then walls, and then the building structure. In terms of the timing of events, direct air-blast damage occurs within tens to hundreds of milliseconds of the shock wave striking the building. If progressive collapse is initiated as a result of explosion, it typically occurs within a few seconds.

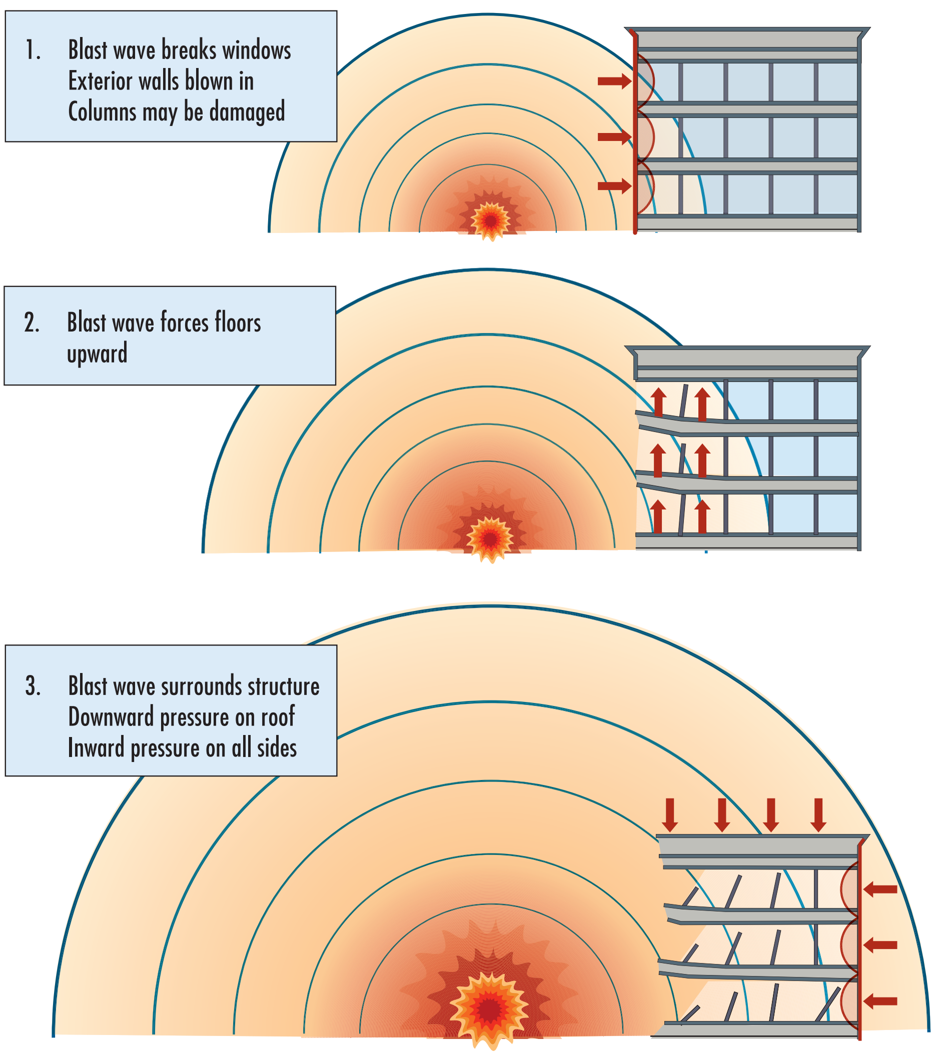


Figure 4-3:
Blast pressure effects on a structure

> As the air-blast shock wave from an outside explosion strikes a building, the components of the building envelope are subjected to extreme loading.

Any building feature that can trap the blast wave and prevent its free movement will result in multiple reflections. This increases the total impulse applied to the building facade and results in additional damage. For example, building layouts with U- or L-configurations, or others with re-entrant corners, and buildings with significant overhangs will receive additional damage from multiple reflections. Glass is often the weakest component of the building envelope, breaking at low pressures compared to other components such as walls or columns. Past incidents have shown that large external explosions may cause glass breakage as far away as a mile or more. While glass normally flies into the building as the positive phase of the blast wave breaks it, the blast wave can also pull the glass out of the building and have it fall to the sidewalk. This falling glass hazard results from the full positive phase of a blast wave that breaks the glass, while the flight of the glass is controlled by the negative phase, which may pull the damaged glass off of the building.

Once damage occurs to the building envelope, internal damage may begin as the blast wave enters the building and continues to expand. The shock wave reflects off internal surfaces and places extreme loads on components that are not designed to resist them. A “jetting” effect, in which the blast wave entering through an opening increases its pressure on the inside of the opening, may also occur. Floor failure is common in large external explosions because floor slabs typically have a large surface area for the pressure to act upon. Furthermore, the slabs are usually designed for downward (gravity) loads only, and the floor slab connections to columns and beams are not robust.

Figure 4-4 illustrates the expected incident overpressure (psi) on a building for a specific explosive weight and standoff distance. It applies to an external explosion without confinement (building sitting in a large open area), based on the typical quantities of explosives used in past events. Note that the x-axis uses a logarithmic scale and the y-axis uses a geometric scale. The standoff distance at which a weight of explosive will produce a specified incident pressure corresponds to the intersection point of the weapon yield with the incident overpressure curve. By correlating the estimated peak incident pressure with known damage-pressure data, the degree of damage that the various components of a building might receive can be estimated. Figure 4-5 provides rough approximations of building damage for various ranges of threat and standoff distance. Note that this method of estimating damage does not take into account specific reflected pressure, which is the pressure that does the actual damage.

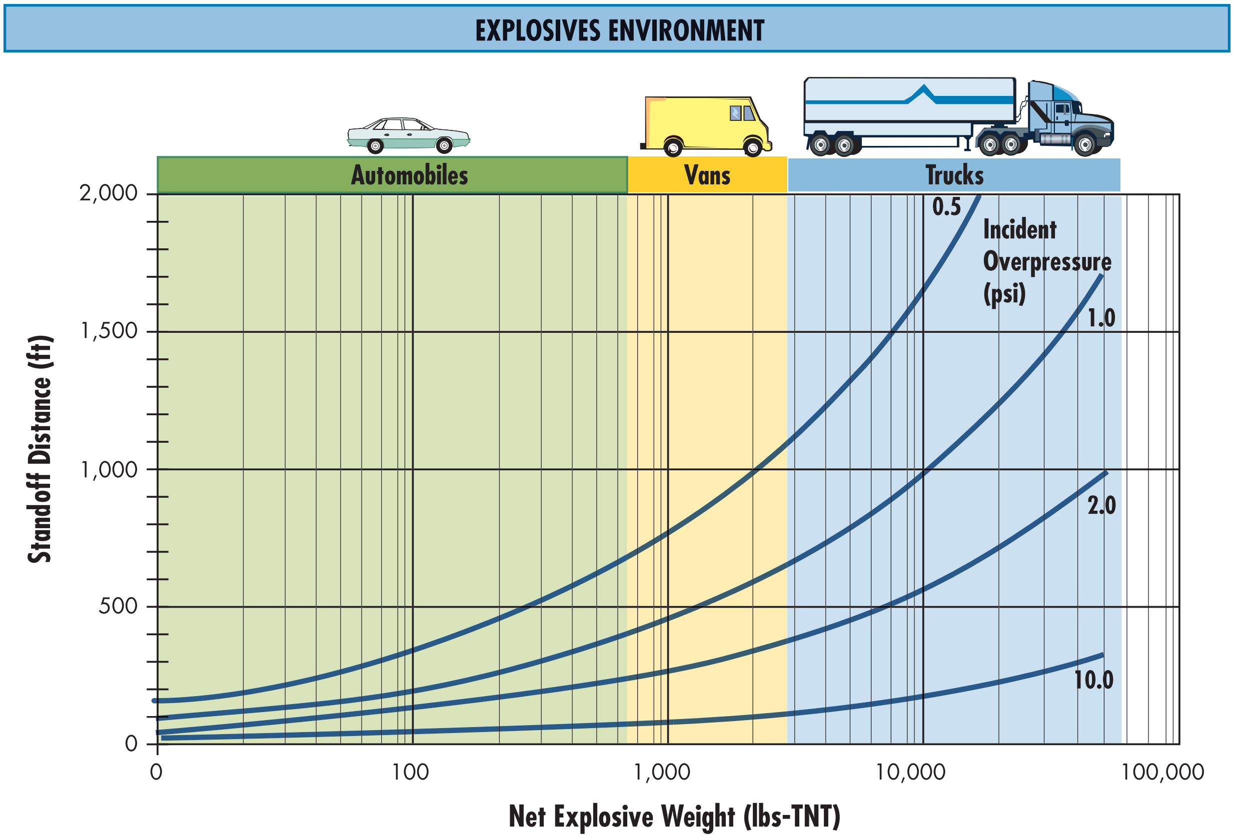


Figure 4-4: Incident overpressure measured in psi, as a function of standoff distance and net explosive weight (pounds-TNT)

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

Estimating building damage from explosive blast during building design is an iterative process, whereby bomb size, standoff distance, building materials, and construction details are modeled and adjusted to determine whether the desired level of protection is achieved. Whether an working on existing building or a new construction, the designer can consider protective measures recommended in this primer to achieve the desired level of protection in response to an external explosion.

> Once damage occurs to the building envelope, internal damage may begin as the blast wave enters the building and continues to expand.

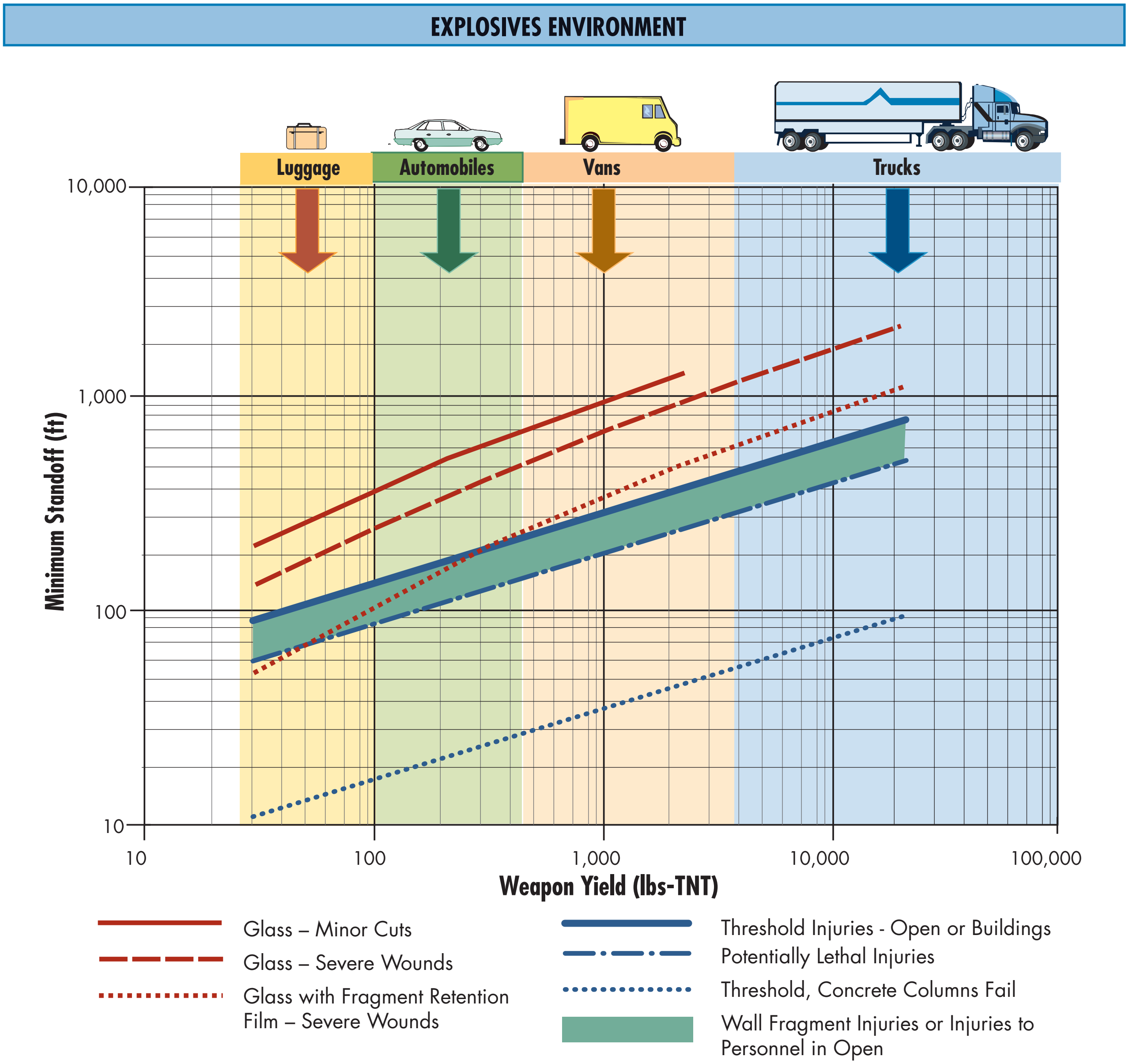


Figure 4-5: Damage approximations

SOURCE: DEFENSE THREAT REDUCTION AGENCY

4.3.2 Building Damage from Internal Explosions

An explosive event inside a building is different from an external explosive event. First, the standoff distance between the explosive and an internal surface is much smaller so that incident and reflected pressures are greater and multiple reflections occur off all surfaces, resulting in more extreme loading. Second, because the internal explosion is confined compared to the free movement of air in an external explosion, the detonation and deflagration products continue to add gas pressure in the afterburning process behind the blast wave. This gas pressure adds to and sustains the shock wave pressure for a longer positive phase duration, greatly increasing the impulse of the internal blast. Thus, an internal explosion of the same size bomb will result in more building damage than an external explosion.

The building damage produced by an internal explosion will affect building components in the same manner as an external explosion after the building envelope has been breached and the blast pressure enters the building. However, internal explosions are typically the result of smaller, hand-carried weights of explosives and unless the internal detonation results in a progressive collapse, the extent of damage is typically more localized. An exception to this is an explosion in a loading dock where a potential truck bomb would be partially or fully enclosed within the building. An internal explosion is likely to breach the slab below, especially if the bomob is placed upon that floor. The type and numbers of casualties from external and internal explosions will also be different.

4.3.3 Casualties

Explosive blasts can cause significant casualties, be it injury or death. The bombing of the Murrah Federal Building in Oklahoma City killed 168 people, most of them in the portion of the building that experienced progressive collapse. The large number of fatalities in the bombing incident in Bath (see section 4.2.1) was also caused by the collapse of the school building's second story precipitated by an internal explosion. The severity and type of injuries and lethality patterns incurred in explosive events may be related to the peak pressure, the total impulse, the level of structural damage, or a combination of these. High pressure of the air blast can cause eardrum damage and lung collapse. The shock wave and dynamic wind can throw a person, which may cause a skull fracture or other injury. As the air blast damages the building in its path, broken fragments of building components are picked up and sent flying in all directions. This blast-wave-borne debris can cause serious impact injuries. Airborne glass fragments typically cause penetration or laceration-type injuries. Larger fragments may cause nonpenetrating, or blunt trauma, injuries.

> Explosive blasts can cause significant casualties, be it injury or death. The bombing of the Murrah Federal Building in Oklahoma City killed 168 people.

For external explosions, high-velocity flying glass fragments are a major contributor to injuries, sometimes accounting for as much as 60 to 80 percent of all injuries. In the bombing of the Murrah Federal Building, for instance, 40 percent of the survivors from the building cited glass as contributing to their injuries. Laceration estimates ranged from 25 percent to 30 percent of the total injuries of people within nearby buildings. For incidents within urban areas, falling glass poses a major hazard to passersby on the sidewalks below and prolongs post-incident rescue and cleanup efforts by leaving tons of glass debris on the street. For internal explosions, injury and death can result from high pressure, blunt trauma from the impact of flying debris, and localized or progressive collapse of the building. The heat and toxic products from the afterburning of the explosive reach much higher concentrations and last longer in internal explosions. Fragmentation is also expected in internal or VBIED explosions as attackers, like the Bath bomber, add nuts, nails, bolts, and other materials to increase injury using smaller bombs.

4.4 Levels of Protection

As part of the design process, both the decisionmakers and their technical experts must determine the acceptable risk levels for the building and the level of protection to be achieved. To better determine the appropriate level of protection, the design basis threat should be identified and agreed upon at the earliest stages (prior to determining the level of protection) to assist designers in focusing their designs. In conjunction with other prescriptive requirements, the design basis threat can take various formats—TNT-equivalent weight of explosive at a given standoff distance or maximum pressure (either incident or reflected) and maximum impulse (either incident or reflected).

Table 4-1 shows how the DOD correlates levels of protection with potential damage and expected injuries. The GSA and the ISC also use the level of protection concept with implied extent of damage and injury.

Table 4-2 lists the weapons yield of various explosive threats as a function of the type of packaging or means of delivery. This chart assumes each sized package or vehicle is fully packed with explosives and the magnitudes, therefore, correspond to the maximum credible threat. Except for the most iconic facilities, schools and most other buildings should consider lower weapons yield threats (smaller explosive mass). Collateral damage may also be considered from a much larger threat targeted against an iconic building in proximity to the school. The Small Moving Van / Delivery Truck used in the Murrah Federal Building attack contained about 7,000 pounds of explosives, of which 5,000 pounds actually exploded with a TNT equivalency of about 4,000 pounds. This 4,000-pound bomb broke windows 0.9 mile away and caused major damage to some nearby buildings.

Table 4-1: DOD Correlation of Levels of Protection with Potential Damage and Injuries

Level of Protection	Potential Building Damage / Performance[2]	Potential Door and Glazing Hazards[3]	Potential Injury
Below Antiterrorism Standards[1]	Severe damage – Progressive collapse likely. Space in and around damaged area will be unusable.	Doors and windows will fail catastrophically and result in lethal hazards. (High hazard rating)	Majority of personnel in collapse region suffer fatalities. Potential fatalities in areas outside of collapsed area likely.
Very Low	Heavy damage – Onset of structural collapse, but progressive collapse is unlikely. Space in and around damaged area will be unusable.	Glazing will fracture, come out of the frame, and is likely to be propelled into the building, with the potential to cause serious injuries. (Low hazard rating) Doors may be propelled into rooms, presenting serious hazards.	Majority of personnel in damaged area suffer serious injuries with a potential for fatalities. Personnel in areas outside damaged area will experience minor to moderate injuries.
Low	Moderate damage – Building damage will not be economically repairable. Progressive collapse will not occur. Space in and around damaged area will be unusable.	Glazing will fracture, potentially come out of the frame, but at a reduced velocity, does not present a significant injury hazard. (Very low hazard rating) Doors may fail, but they will rebound out of their frames, presenting minimal hazards.	Majority of personnel in damaged area suffer minor to moderate injuries with the potential for a few serious injuries, but fatalities are unlikely. Personnel in areas outside damaged areas will potentially experience minor to moderate injuries.
Medium	Minor damage – Building damage will be economically repairable. Space in and around damaged area can be used and will be fully functional after cleanup and repairs.	Glazing will fracture, remain in the frame and results in a minimal hazard consisting of glass dust and slivers. (Minimal hazard rating) Doors will stay in frames, but will not be reusable.	Personnel in damaged area may suffer minor to moderate injuries, but fatalities are unlikely. Personnel in areas outside damaged areas will potentially experience superficial injuries.
High	Minimal damage – No permanent deformations. Facility will be immediately operable.	Glazing will not break. (No hazard rating) Doors will be reusable.	Only superficial injuries are likely.

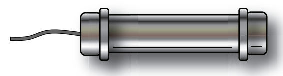
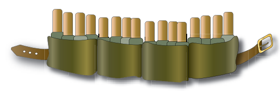
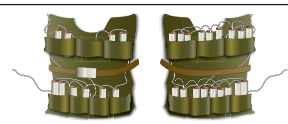
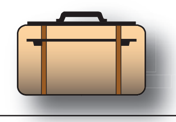
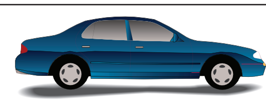
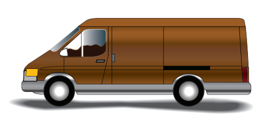
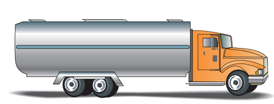
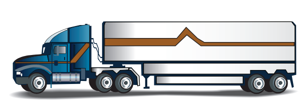
1. This is not a level of protection, and should never be a design goal. It only defines a realm of more severe structural response, and may provide useful information in some cases.

2. For damage / performance descriptions for primary, secondary, and nonstructural members, refer to UFC 4-020-02, *DOD Security Engineering Facilities Design Manual* (2007b).

3. Glazing hazard levels are from ASTM F 1642.

SOURCE: DOD 2007A

Table 4-2: Examples of Possible Design Basis Threats

Threat Description			Explosives Mass* (TNT equivalent)
High Explosives (TNT Equivalent)		Pipe Bomb	5 lbs 2.3 kg
		Suicide Belt	10 lbs 4.5 kg
		Suicide Vest	20 lbs 9 kg
		Briefcase/ Suitcase Bomb	50 lbs 23 kg
		Compact Sedan	500 lbs 227 kg
		Sedan	1,000 lbs 454 kg
		Passenger/ Cargo Van	4,000 lbs 1,814 kg
		Small Moving Van/ Delivery Truck	10,000 lbs 4,536 kg
		Moving Van/ Water Truck	30,000 lbs 13,608 kg
		Semi-trailer	60,000 lbs 27,216 kg

* Based on the maximum amount of material that could reasonably fit into a container or vehicle. Variations are possible.

To achieve a desired level of protection, the protective design requires a balance of two measures—standoff distance and building hardening. If protective measures are in place to keep the design basis threat bomb a significant distance from the building, then minimal hardening may be acceptable. Alternatively, if the available standoff distance is only the width of a sidewalk, then significant building hardening may be necessary. The actual solution may be a blend of these two measures, whereby the building is hardened for the standoff that is available. In any case, decisionmakers need some understanding of the relationship between bomb size, standoff distance, potential building damage, and potential casualties to understand the impact of selecting a design basis threat and a level of protection.

To achieve a desired level of protection, the protective design requires a balance of two measures—standoff distance and building hardening.

4.5 Building Design Guidance

Traditional building design for life safety has typically addressed fire and other natural, environmental and manmade hazards by requiring the protection of occupants against direct and indirect effects of a hazard event, and by providing safe evacuation routes in cases of emergency. The task of providing physical security, i.e., the protection of occupants against intentional attacks, is similar in many respects.

When considering protective measures for explosive blast threats, the primary strategy is to keep explosive devices as far away from the school building as possible, i.e., maximize standoff distance (see Chapter 2). This is usually the easiest and least costly way to achieve a desired level of protection. In cases where sufficient standoff distance is not available to protect against progressive collapse of a school building (i.e., schools located in urban settings), hardening of the building's structural systems may be required. Designers should try to minimize hazardous flying debris during an explosive event because a high number of injuries can result from flying glass fragments and debris from walls, ceilings, and nonstructural features. Another consideration is to balance the hardening of the building envelope so that the walls, frames, and glazing provide a consistent level of protection for the design basis threat weapon at the available standoff distance. Window design probably provides the greatest variability in performance for conventional construction. Effective blast engineering is a multidisciplinary effort that requires

When considering protective measures for explosive blast threats, the primary strategy is to keep explosive devices as far away from the school building as possible.

the concerted efforts of the architect, structural engineer, mechanical engineer, and the other design team members to achieve a balanced building envelope.

Protective measures to reduce the effects of internal explosions are based primarily on strategies to minimize the possibilities of explosive devices being smuggled in and deployed inside a building, where they could do the most damage. Similar to the risk reduction efforts for shooting type attacks, discussed in Chapter 3, minimizing these possibilities is not easy to do. Persons most likely to try to detonate a bomb inside a school, just like the persons most likely to engage in a school shooting rampage, would be individuals or groups associated with that particular school, who would typically have free access to the most vulnerable areas, as was the case in Columbine High bombing attempt and in Bath school incident. Measures to turn our public and private schools into veritable fortresses with strict access controls are often unacceptable to the school authorities as they are to the communities. The only practical measures recommended by experts and school administrators alike are based on increased vigilance and improved response to minimize consequences. For more detailed discussion of these and similar measures, see Chapter 3.

4.5.1 Structural Systems

The greatest vulnerability of any building in response to explosive blast threats is the possibility of failure of a component, or worse yet, of a whole structural system. Such failure usually causes the collapse of a portion of the building that may lead to further progressive collapse of the whole building. Progressive collapse is a chain reaction of structural failures that follows from local failure and leads to the collapse of adjoining members, which, in turn, results in more extensive collapse, quite disproportionate to the original cause.

All new school buildings should be designed to reduce the potential for progressive collapse, regardless of the required level of protection. The following structural characteristics (from GSA's *Progressive Collapse Analysis and Design Guidelines for New Federal Office Buildings and Major Modernization Projects*, November 2000) should be considered in the initial phases of structural design. Incorporation of these features will provide a much more robust structure and decrease the potential for progressive collapse.

All new school buildings should be designed to reduce the potential for progressive collapse, regardless of the required level of protection.

- **Redundancy.** The use of redundant lateral- and vertical-force-resisting systems is highly encouraged when considering progressive collapse. Redundancy tends to promote a more robust structure and helps to ensure that alternate load paths are available in the case of a structural element(s) failure. Additionally, redundancy provides multiple locations for yielding to occur, which increases the probability that damage will be constrained.
- **Ductile (flexible) structural elements and detailing.** Both the primary and secondary structural elements must be capable of deforming well beyond the elastic limit without experiencing structural collapse. Hence, the use of ductile construction materials (i.e., steel, cast-in-place reinforced concrete, etc.) for both the structural elements and connection detailing is encouraged. The capability of achieving a ductile response is imperative when considering an extreme redistribution of loading, such as that encountered in a structural element(s) failure.
- **Capacity for resisting load reversals.** Both the primary and secondary structural elements should be designed to resist load reversals in the case of a structural element(s) failure.
- **Capacity for resisting shear failure.** Primary structural elements maintain sufficient strength and ductility under an abnormal loading event to preclude a shear failure. If the shear capacity is reached before flexural capacity, a sudden, nonductile failure of the element could potentially lead to a progressive collapse of the structure.

Both the GSA and DOD take a threat-independent approach to progressive collapse. The goal of a threat-independent approach is not to prevent collapse from a specific design threat, but to control and stop the propagation of damage after localized damage or localized collapse has occurred.

The GSA and DOD guidelines require the structural response of a building be analyzed for assumed damage states in which key structural elements (e.g., vertical-load-carrying column, section of bearing wall, beam) are removed, one at a time. If effective alternative load paths are available for redistributing the loads, originally supported by the removed structural element, the building has a low potential for progressive collapse.

For higher levels of protection from blast, cast-in-place reinforced concrete is usually the construction type of choice. Other types of construction, such as properly designed and detailed steel structures are also preferred. Several material and construction types, although not disallowed by these criteria, may be undesirable and uneconomical for protection from blast.

The following guidelines are commonly used to mitigate the effects of blast on structures and to mitigate the potential for progressive collapse. See below for details and more guidance.

- Incorporate energy dissipation mechanisms into the structural system to absorb the blast impact.
- Use symmetric reinforcement to increase the ultimate load capacity of the structure.
- Incorporate design redundancy and alternative load paths to help mitigate the effects of blasts and reduce the chance of progressive collapse. The Murrah Federal Building's structural system did not have any redundancy for the slab and beam systems.
- Strengthen the structural system to help resist the effects of a blast.
- Avoid designs that expose structural elements (e.g., accessible exterior columns).
- Design lap splices to fully develop the capacity of the reinforcement.
- Stagger lap splices and other discontinuities.
- Control deflections around certain members, such as windows, to prevent premature failure. Additional reinforcement is generally required.
- Use wire mesh in plaster to reduce the incidence of flying fragments.
- Avoid the use of unreinforced masonry when blast is a threat. Masonry walls break up readily and become secondary fragments during blasts.
- Connect interior non-load-bearing walls to the structure with flexible connections.
- Use ductile connections for steel construction and develop as much moment connection as practical. Connections for cladding and exterior walls to steel frames should develop the capacity of the wall system under blast loads.
- Minimize column spacing so that reasonably sized members can be designed to resist the design loads and increase the redundancy of the system.
- Minimize floor-to-floor heights, unless there is an overriding architectural requirement.
- Use architectural or structural features that deny contact with exposed primary vertical load members in school lobbies. A minimum standoff of at least 6 inches from these members is desired.

- Avoid eaves and overhangs as they can be points of high local pressures.
- Minimize the use of venetian blinds and false ceilings and the placement of equipment such as light fixtures, partitions, ductwork, and air conditioners above ceilings wherever possible. These items may become flying debris in the event of an explosion. Placing heavy equipment such as air conditioners near the floor rather than the ceiling is one option for limiting this hazard; using exposed ductwork as an architectural device is another possibility.

4.5.2 Building Envelope

The exterior face of the building represents the most fragile, yet the most significant layer of defense against an attack on a school. Whatever the type of attack, the attackers' primary targets are behind that envelope, and for a successful attack to take place, the building envelope must be breached. The most vulnerable areas for any type of an armed attack are the points of entry and other types of openings in the building envelope. For an explosive blast threat, the exterior envelope of the school building is vulnerable wherever it is exposed to the weapon, which usually means, wherever it is close to the access points to the school grounds. For CBR types of threats, the building envelope can protect the interior of a school and its occupants only if it remains impermeable.

4.5.2.1 Exterior Wall Design

The exterior walls provide the first line of defense to prevent air-blast pressures and hazardous debris from entering the school building. Generally, simple geometries, with minimal ornamentation (which may become flying debris during an explosion), are most easily protected. If ornamentation is used, lightweight materials such as timber or plastic, which are less likely to become a projectile in the event of an explosion, are recommended. At a minimum, the objective of design is to enable the exterior walls to fail in a flexible mode rather than in a brittle mode such as shear failure. The walls should also resist the loads transmitted by the windows and doors. Beyond providing a flexible failure mode, the exterior wall may be designed to resist the actual or reduced pressure levels of the defined threat. Special reinforcing and anchors should be provided around blast-resistant window and door frames.

The exterior face of the building represents the most fragile, yet the most significant layer of defense against an attack on a school.

Poured-in-place reinforced concrete will provide the highest level of protection, but solutions like pre-cast concrete, reinforced concrete masonry unit (CMU) block, and metal studs may also be used to achieve lower levels of protection. For pre-cast panels, consider a minimum thickness of 5 inches with two-way reinforcing bars placed at a spacing not greater than the thickness of the panel. Connections into the structure should provide as straight a line of load transmittal as practical, using as few connecting pieces as possible.

For CMU block walls, use 8-inch block walls, fully grouted with vertical centered reinforcing bars placed in each cell and horizontal reinforcement at each layer. Connections into the structure should be able to resist the ultimate lateral capacity of the wall. A preferred system is to have a continuous exterior CMU wall that laterally bears against the floor system. For increased protection, consider using 12-inch blocks with two layers of reinforcement.

For metal stud systems, use metal studs back to back and mechanically attached to minimize lateral torsion effects. To catch exterior cladding fragments, attach a wire mesh to the exterior side of the metal stud system. The supports of the wall are to be designed to resist the ultimate lateral capacity load of the system. When designing schools in areas perceived as high risk, engineers and architects should consider the following recommendations:

- Substitute strengthened building walls and systems when standoff distances cannot be accommodated.
- Use ductile materials capable of very large plastic deformations without complete failure.
- Design exterior walls to resist the actual pressures and impulses acting on the exterior wall surfaces from the threats defined for the school building.
- Design exterior walls to withstand the dynamic reactions from the windows.
- Design exterior shear walls to resist the actual blast loads predicted from the threats specified. Consider shear walls that are essential to the lateral and vertical load bearing system, and that also function as exterior walls, to be primary structures.
- Consider reinforced concrete wall systems in lieu of masonry or curtain walls to minimize flying debris in a blast.
- Reinforced wall panels can protect columns and assist in preventing progressive collapse, because the wall will assist in carrying the load of a damaged column.
- Consider using sacrificial exterior wall panels to absorb a blast.
- Design exterior wall surfaces without horizontal or vertical niches or recesses that could provide footholds or handholds or hiding places.

4.5.2.2 Window Design

Extensive glazing is an inevitable feature of any school building, as it is required for natural light and frequently for ventilation as well. It also enhances the so-called "natural" surveillance of access and entry points, by providing views of these critical areas. Extensive glazing should be used to facilitate surveillance of parking areas, courtyards, and other areas where students congregate.

UTILIZE EXTENSIVE GLAZING AT MAIN ENTRANCE TO ENHANCE VISUAL SURVEILLANCE TO PARKING LOTS AND PEDESTRIAN ROUTES

Figure 4-6: Extensive glazing at main entry

SOURCE: FLORIDA SAFE SCHOOLS DESIGN GUIDELINES, 2003

Windows must be protected against forced entry without sacrificing visibility.

Window systems (e.g., glazing, frames, anchorage to supporting walls) on the exterior façade of a school building should be designed to mitigate the hazardous effects of flying glass during an explosion event. To protect school occupants, designers should integrate the capacity of the glass for the connection of the glass to the frame (bite) and anchoring of the frame to the building structure to achieve a "balanced design." This means all the components should have compatible capacities and theoretically would all fail at the same intensity of blast loading so that the damage sequence and extent of damage would be controlled. Figure 4-7 depicts how far glass fragments could enter a structure for each GSA performance condition. Table 4-3 presents six GSA glazing protection levels based on how far glass fragments would enter a space and potentially injure its occupants.

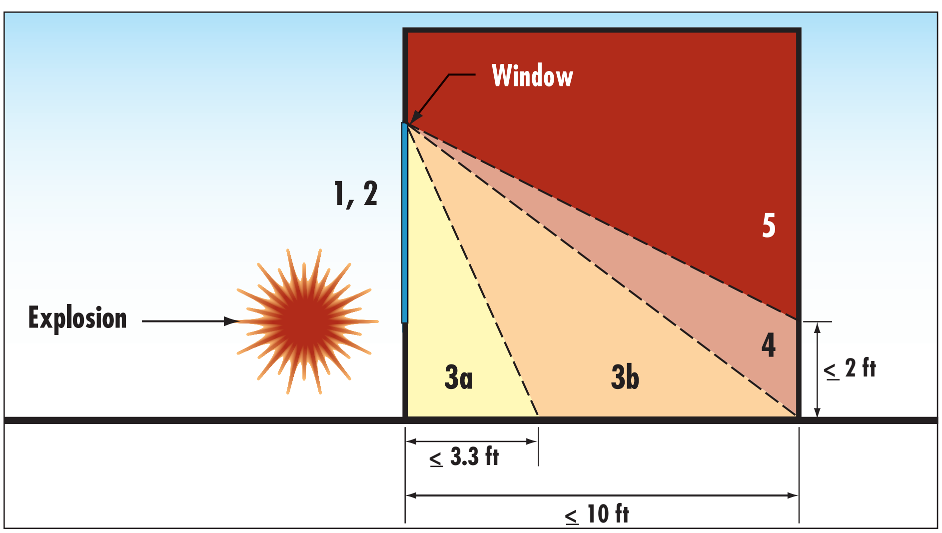


Figure 4-7: Side view of a test structure illustrating performance conditions

Table 4-3: Correlation of GSA Glazing Performance Conditions and DOD Levels of Protection for New Buildings

GSA Glazing Performance Condition	Corresponding DOD Level of Protection	Potential Structural [2] Damage	Potential Door and Glazing[3] Hazards	Potential Injury
5	Below Antiterrorism Standards[1]	Severely damaged – Frame collapse / massive destruction. Little left standing.	Doors and windows will fail and result in lethal hazards.	Majority of personnel suffer fatalities.
3b/4	Very Low	Heavily damaged – Onset of structural collapse. Major deformation of primary and secondary structural members, but progressive collapse is unlikely. Collapse of nonstructural elements.	Glazing will break and is likely to be propelled into the building, resulting in serious glazing fragment injuries, but the number of fragments will be reduced (less than for performance condition 5). Doors may be propelled into rooms, presenting serious hazards.	Majority of personnel suffer serious injuries. The number of fatalities is likely to be limited (10 percent to 25 percent).
3a	Low	Damaged – Irreparable. Major deformation of nonstructural elements and secondary structural members and minor deformation of primary structural members, but progressive collapse is unlikely.	Glazing will break, but fall within 1 meter of the wall or otherwise not present a significant fragment hazard. Doors may fail, but they will rebound out of their frames, presenting minimal hazards.	Majority of personnel suffer significant injuries. A few (<10 percent) fatalities may occur.
2	Medium	Damaged – Repairable. Minor deformations of nonstructural elements and secondary structural members and no permanent deformation in primary structural members.	Glazing will break, but will remain in the window frame. Doors will stay in frames, but will not be reusable.	Personnel suffer some minor injuries, but fatalities are unlikely.
1	High	Superficially damaged – No permanent deformation of primary and secondary structural members or nonstructural elements.	Glazing will not break. Doors will be reusable.	Only superficial injuries are likely.

1. This is not a level of protection, and should never be a design goal. It only defines a realm of more severe structural response, and may provide useful information in some cases.
2. For damage / performance descriptions for primary, secondary, and nonstructural members, refer to UFC 4-020-02, *DOD Security Engineering Facilities Design Manual* (2007b).
3. Glazing hazard levels are from ASTM F 1642.

SOURCE: GSA 1996

The transition from performance condition 3a to 3b can be equated to the "threshold of injury." The transition from performance condition 4 to 5 can be equated to the "threshold of lethality."

FEMA 426 contains a detailed description of window system design considerations. Although not all windows in a school can be designed to resist the forces from very large explosive blast events, hardened window systems can provide significant protection for students, faculty, and staff. Preferred systems include thermally tempered glass with a security film installed on the interior surface and attached to the frame, laminated thermally tempered glass, laminated heat strengthened or laminated annealed glass, and blast curtains. Glazing systems that do not provide any protection include untreated monolithic annealed or heat-strengthened glass and wire glass. Figure 4-8 depicts an unprotected window after a large explosion.

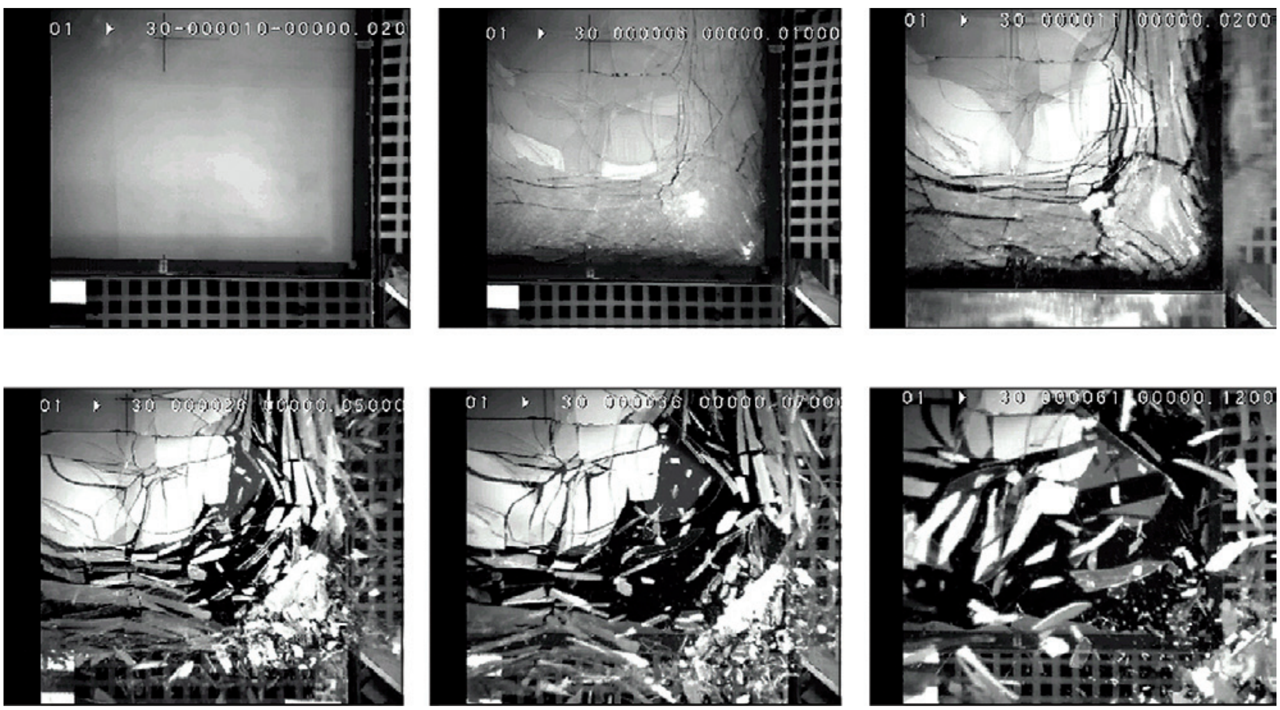


Figure 4-8: An unprotected window after large explosion

General design guidelines for windows and glazing include the following:

- Orient glazing perpendicular to the primary façade to reduce exposure to blast and projectiles (Figure 4-9).

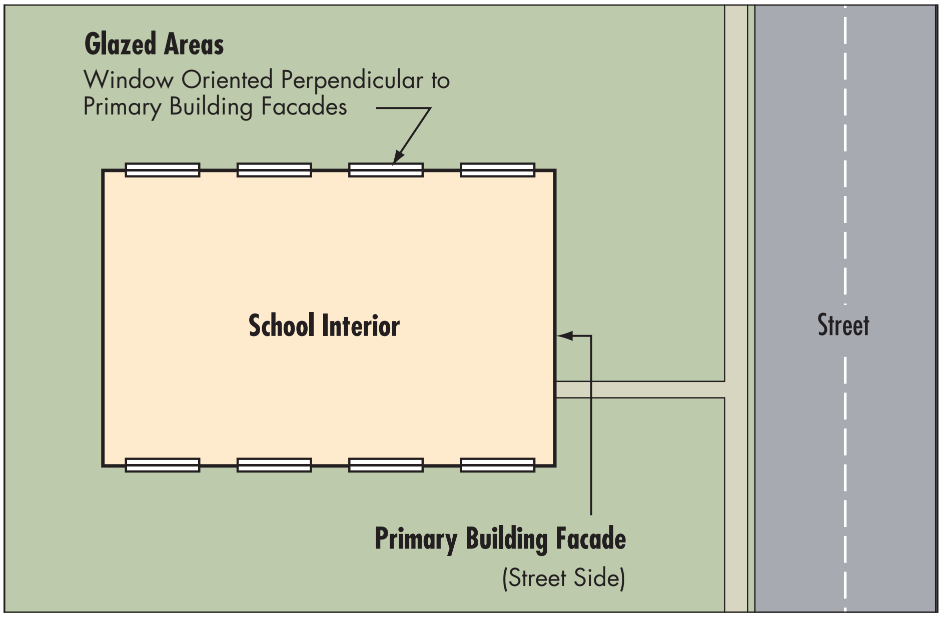


Figure 4-9:
Glazed areas oriented perpendicular to the primary façade and street

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

- Place windows away from doors so that, if the windows are broken, the door cannot be unlocked.
- In schools requiring high security, minimize the number and size of windows in a façade. The amount of blast entering a space is directly proportional to the amount of opening on the façade.
- Consider using burglary- and ballistic-resistant glazing in high-risk school areas.
- Consider using laminated glass in place of conventional glass.
- Consider window safety laminate (such as mylar) or another fragment retention film over glazing (properly installed) to reduce fragmentation.
- Position the operable section of a sliding window on the inside of the fixed section and secure it with a broomstick, metal rod, or similar device placed at the bottom of the track.
- Place horizontal windows 6 feet above the finished floor to limit entry.
- Consider using steel window frames securely fastened or cement grouted to the surrounding structure.
- Minimize interior glazing in high-risk areas (e.g., lobbies, loading docks).

Mullions are the frame members connecting adjoining windows. These members may be designed using a static approach when the breaking strength of the window glass is applied to the mullion, or a dynamic load may be applied using the peak pressure and impulse values. Although the static approach may seem easier, it often yields a design that is not practical, because the mullion can become very deep and heavy, driving up the weight and cost of the window system. In addition, the result may not be consistent with the overall architectural objectives of the project. A dynamic approach is more likely to provide a section that meets the design constraints of the project. For this approach, a single-degree-of-freedom solution is often used. The governing equation of motion may be solved using numerical methods. Charts are also available for linearly decaying loads that circumvent the need to solve differential equations. These charts only require that the fundamental period of the mullion (including the tributary area of the window glass), the ultimate resistance force of the mullion, the peak pressure, and the equivalent linear decay time are known.

Peak lateral response of the mullions should be limited to provide a desired level of protection. As with frames, good engineering practice dictates limiting the number of interlocking parts used for the mullion.

4.5.2.3 Doors

Door assemblies include the door, its frame, and its anchorage to the building. When necessary as part of a balanced school design approach, exterior doors should be designed to withstand the maximum dynamic pressure and duration of the load from the design threat explosive blast. However, blast doors are very expensive and may not comply with emergency evacuation or ADA requirements. The use of vestibules at main entry points is recommended to increase security. Multiple sets of doors in vestibules also reduce the potential of air exchange in during outdoor CBR releases. All doors should have tamper-resistant hardware. Interior doors, especially classroom doors should be able to be locked down quickly. The doors should be designed with view panels or sidelights to increase the visibility of adjacent spaces and corridors.

Other general door considerations for these types of buildings are as follows:

- Provide hollow steel doors or steel-clad doors with steel frames. Match the strength of the latch and frame anchor to that of the door and frame.
- Consider using debris-mitigating door materials for schools considered to be at high risk.

- Permit normal entry/egress through a limited number of doors, if possible, while accommodating emergency egress.
- Require exterior doors into inhabited areas to open outward. In addition to facilitating egress, by doing so, the doors will seat into the door frames in response to an explosive blast, increasing the likelihood that the doors will not enter the school building as hazardous debris.
- Replace externally mounted locks and hasps with internally locking devices because the weakest part of most door assemblies is the latching component.
- Locate hinges on the interior or use exterior security hinges to reduce their vulnerability. Use hinges with nonremovable pins to reduce the risk of breakins.
- Install emergency exit doors so that they facilitate only exiting movement.
- Consider using solid doors or walls as a backup for glass doors in foyers.
- Strengthen and harden the upright surfaces of the door jamb into which the door fits.

4.5.2.4 Roof System Design

Control access to school roofs to minimize the possibility of aggressors placing explosives or CBR agents there or gaining access through openings and other potential entry points and threatening school occupants or critical infrastructure. Designers should consider the following for the design of school roof systems:

- For new school buildings, eliminate all external roof access by providing access from internal stairways or ladders, such as in mechanical rooms.
- For existing school buildings, eliminate external access, where possible, or make roof access ladders removable, retractable, or lockable.
- Avoid placing any structures adjacent to low roofs to prevent climbing aids for roof access.
- Provide pitched roofs to allow deflection of explosives.
- Make school roof access hatches secure from intruders.
- Consider designing buildings with a sacrificial sloping roof that is above a protected ceiling (Figure 4-10).

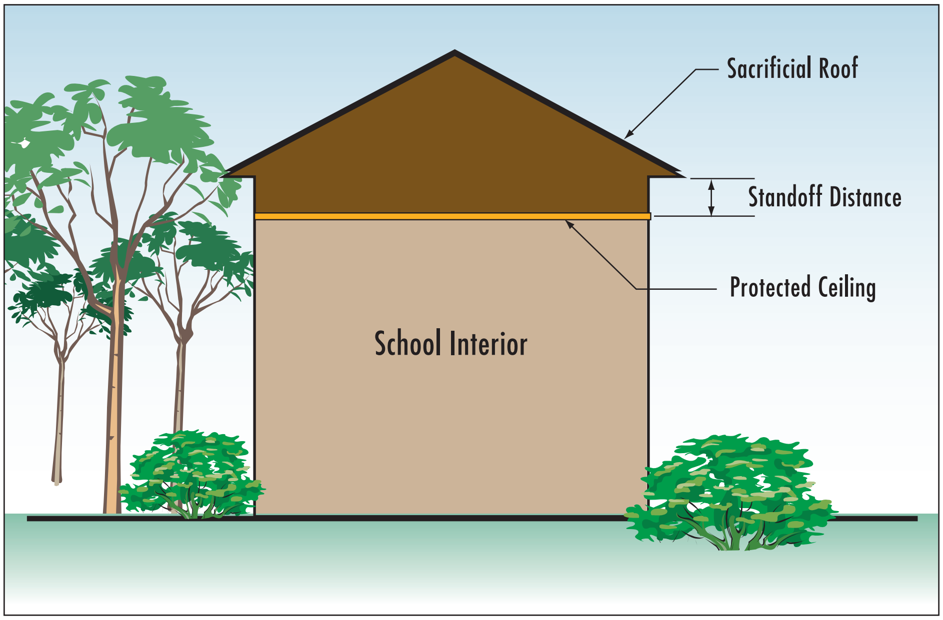
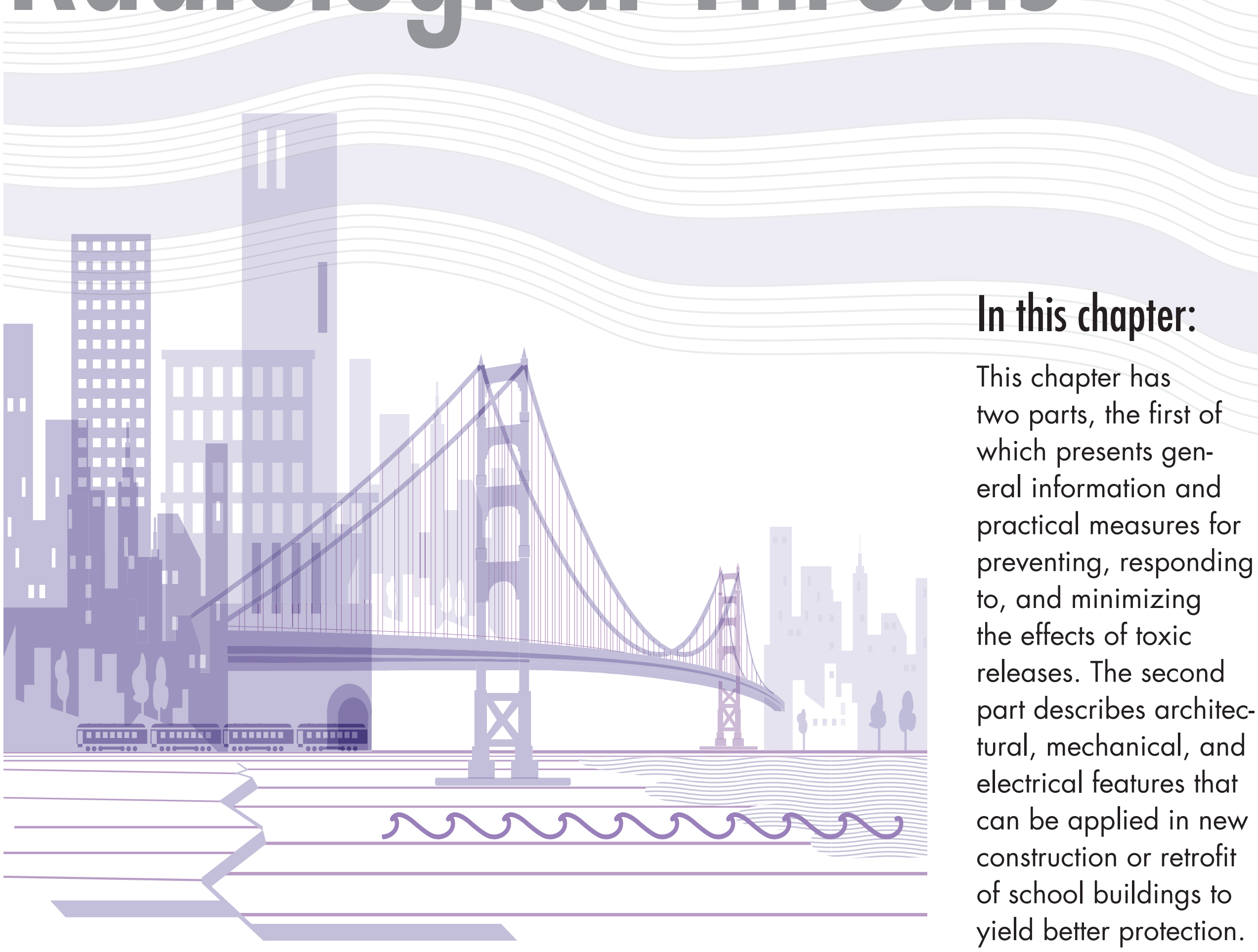


Figure 4-10: Sacrificial Roof

- Roof-mounted equipment such as HVAC cooling towers or ventilation openings should be protected with locked enclosures to prevent the introduction of toxic agents through these openings.
- Design any skylights to prevent access by adding cages and/or security grilles.
- Design roof parapets to allow surveillance from the ground whenever possible.

5

Chemical, Biological, and Radiological Threats



In this chapter:

This chapter has two parts, the first of which presents general information and practical measures for preventing, responding to, and minimizing the effects of toxic releases. The second part describes architectural, mechanical, and electrical features that can be applied in new construction or retrofit of school buildings to yield better protection.

5.1 Introduction

The challenges of protecting a school from CBR terrorist attacks are illustrated by an incident that occurred in an elementary school near Baltimore, MD, on a Friday morning in September 2002.

During a chorus class in the school cafeteria, 32 children suddenly became ill with symptoms of dizziness, nausea, and fatigue. An imperceptible toxic gas was assumed to have spread through the cafeteria, most likely carbon monoxide, the odorless, colorless gas that sends about 15,000 people to emergency rooms each year in the United States. Carbon monoxide, known as the silent cold-weather killer, is typically produced by malfunctioning furnaces in buildings. But this was the first week of autumn, not yet the heating season, making it an extremely unlikely source of toxic release.

The rapid onset of symptoms without any warning or apparent cause created immediate fear and confusion, which was probably increased by the publicity surrounding the terrorist attacks with bacillus anthracis spores in the previous year. Could this have been a terrorist attack with sarin, the odorless, colorless chemical warfare agent used in two deadly attacks in Japan?

The school building was evacuated, and those who had become ill were taken to hospitals and released by late afternoon. The analysis of air samples over the next 2 days revealed nothing about the mysterious gas. However, a chronology of the events on that Friday morning led to the conclusion that carbon monoxide had probably entered the cafeteria through a ground-level air intake when a trash truck idled near it while collecting garbage. The school reopened 3 days later with attendance temporarily down by about 10 percent. Many teachers left their classroom windows open on that Monday as a precaution.

This incident shows the uncertainties that can be encountered when a toxic condition suddenly arises in a school building—whether it is the result of terrorist attack, technological accident, mischievous or malicious act, natural process, or the byproduct of incomplete combustion. The elements and conditions that combine to produce injuries or disruptions are common to all types of airborne releases regardless of the source, cause, motive, or level of toxicity. Consequently, protective measures for a relatively minor disruptive incident would be the same as the measures for a deliberate toxic attack with the intent to produce serious consequences.

This chapter has two parts, the first of which presents general information and practical measures for preventing, responding to, and minimizing the effects of toxic releases. The second part describes architectural, mechanical, and electrical features that can be applied in new construction or retrofit of school buildings to yield better protection.

5.2 Risk of School Exposure to CBR Agents

Based on historical precedent, a U.S. school is not expected to be a probable target for a toxic terrorist attack. However, if located in the vicinity of government facilities or important buildings, a school could be exposed to collateral effects of a toxic attack or sabotage of industrial chemical storage/transportation assets.

As described in Building and Infrastructure Protection Series (BIPS) 06 (Formerly FEMA 426), *Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings* (2011), four strategies are used for protecting buildings and their occupants from airborne toxic attacks—air purification, unventilated sheltering, physical security, and individual protection. The 2002 carbon monoxide incident could have been prevented with a physical security strategy, specifically elevating and securing the intakes. Air purification and individual protection strategies have limited effectiveness against the full range of toxic gases, vapors, and aerosols. As a matter of fact, air-filtration systems that were installed in about 80 schools near storage sites of chemical warfare agents between 1993 and 2008 under the Chemical Stockpile Emergency Preparedness Program (CSEPP), are now being removed as the storage sites are demilitarized, because these systems cannot be used for protection against industrial accidents and other chemical releases (DOD 2008). In addition, school populations present special challenges that make individual protection, i.e., use of respirators, an impractical strategy.

> Four strategies are used for protecting buildings and their occupants from airborne toxic attacks—air purification, unventilated sheltering, physical security, and individual protection.

School buildings are typically open environments with high occupancy and relatively high ventilation rates. They have many mechanical air intakes, allowing the ventilation of each room to be controlled independently. Even with mechanical ventilation, buildings naturally provide some protection against airborne hazards that originate outdoors because of their limited rate of air

> School buildings are typically open environments with high occupancy and relatively high ventilation rates.

exchange between indoors and outdoors. However, this protection is of a relatively low level, even in optimal conditions. A limited air-exchange rate is a double-edged sword. Though a building provides a modicum of protection against outdoor hazards, it makes the hazard of an indoor release much more severe, with higher concentrations and greater persistence than outdoors.

5.2.1 Types of Toxic Threat Agents

Hundreds of toxic substances can produce an airborne hazard in a building, too many to list in this chapter and too many to detect in real time with even the most expensive automatic detectors. They include byproducts of combustion such as carbon monoxide, biological warfare agents, naturally occurring microorganisms such as Legionella, irritants and incapacitants such as pepper spray or tear gas, toxic industrial chemicals such as chlorine and ammonia, radioactive dust, chemical warfare agents such as sarin, and even naturally occurring gases such as carbon dioxide in high concentrations. These toxic substances differ in their levels of toxicity and persistence. The higher the toxicity, the smaller the quantity needed to cause injury. The greater the persistence, the longer the material will create a hazardous condition in a building or in the environment. These toxic materials also differ in filterability and detectability, which means that no single protective strategy is effective against all toxic substances.

5.2.2 Persistence

How long a hazard persists once a toxic substance is released in or into a building is determined mainly by the vapor pressure of the toxic liquid, solid, or gas. Chemical gases are nonpersistent; they have a high vapor pressure and tend to remain in the gaseous state, and most of them do not sorb into materials (although acid gases such as chlorine can react with metals in a building). Most gases are purged simply by aerating the building. Chemical vapors (which have a lower vapor pressure than gases) are more persistent and consequently may be absorbed by the materials of walls, floors, ceilings, and ducts of a building. Solid aerosols (fine particles), including biological and radiological agents, are most persistent. These require time-consuming and often expensive measures to remove them or decontaminate an exposed building.

5.2.3 Containers

All toxic airborne attacks begin with a toxic agent in a container. This simple observation is the basis for physical security measures such as access control and entry inspections, which focus on excluding containers that may hold toxic substances from an area or building. A container may be very large, e.g., a tanker truck or rail car, or it may be as small as an envelope. It may be a pressurized cylinder, a tear-gas grenade, a small can of pepper spray, or a jar of liquid. In the anthrax attacks of 2001, envelopes were the containers, and in response, the defensive measures focused on identifying suspicious envelopes for inspection and testing. In the Tokyo subway attack, the containers were 20-ounce plastic bags lanced by umbrella tips. The release of the toxic contents from a container often provides some warning signs, particularly if it is pressurized or its contents are explosively disseminated.

5.2.4 How an Attack Might Unfold

An attack in which a toxic substance is released into the air can be described as a slow-motion, surreptitious assault. Outdoors, a plume or cloud travels silently, usually close to the ground at the speed of the wind, and it is most hazardous when the wind is light and steady. Indoors it moves with the speed of the air movement induced by ventilation fans and pressures of wind and buoyancy. Between outdoors and indoors, it moves with the rate of air exchange between the two environments.

An attack in which a toxic substance is released into the air can be described as a slow-motion, surreptitious assault.

When exposed to toxic chemicals, a person's physiological responses are rapid but not instantaneous. That is, *chemical* agents produce an immediate effect but require a certain dosage of exposure before severe injury occurs; therefore, rapidly moving a victim to clean air reduces the gravity of the injury. The response can vary from person to person and can occur more rapidly in children. In contrast, the body's response to a *biological* or *radiological* agent (solid or liquid aerosols) is always delayed, typically by days or even weeks.

5.2.5 Probability of an Attack

Based upon the number of recorded occurrences, toxic terrorist attacks are very rare and extremely unlikely. The probability is much greater that a toxic exposure will result from an accident, mischievous act, poorly maintained HVAC equipment, or natural phenomenon. The toxic chemical that has caused the most deaths over the years is carbon monoxide, which is responsible for 400 to 500 deaths in the United States annually. In contrast, 20 deaths have resulted from two toxic terrorist attacks (with sarin) in Japan, and 5 have deaths resulted from toxic terrorist attacks (with bacillus anthracis) in the United States since 2001.

5.2.6 Detecting Hazards

Because of carbon monoxide's constant, widespread threat, low-cost, accurate, reliable, real-time carbon monoxide detectors are commercially available. However, no real-time detectors are inexpensive and accurate for hundreds of other toxic gases, vapors, and aerosols that could present a threat. With this deficiency, the human senses provide the most practical means of detecting toxic chemicals. Most, but not all, toxic *chemicals* have warning properties; that is, they can be detected by their odor, color, irritation of the eyes/respiratory tract, and in some cases taste. Warning properties can be effective for triggering protective actions, because the threshold for detecting a chemical by smell, for example, is often lower than the threshold for injurious effects. Warning properties have been more widely used than automatic detectors to alert people to chemical hazards. Soldiers in both World Wars were taught to detect chemical agents by smell. Odorants have long been added to natural gas for the same purpose. Of course, no warning properties are associated with *biological* or *radioactive* agents, but they may have perceptible cues to indicate their release or presence.

5.2.7 Cues

Whether or not a toxic agent has warning properties, cues can alert people to the presence of a hazard and serve to initiate protective actions. Such observational cues include the following:

- More than one person in an area exhibiting symptoms such as nausea, choking, collapse, or other signs of exposure to toxic chemicals
- Smoke or an unnatural fog
- A spill of an unknown material in or near a building
- An unusual noise, such as the release of gas under pressure near a building
- An explosion in or near the building
- A spray device, pressurized cylinder, battery-powered pump and nozzle, container of liquid, gas, or powder left in or near a building
- A suspicious parcel left unattended in a building or near air intakes
- Suspicious activity around a building's air intakes or other wall openings

5.3 Vulnerability of Schools to Toxic Agent Attack

Assessing a building's vulnerability to a toxic-agent attack is the process of estimating the likelihood that such an attack will cause casualties, disrupt operations, or temporarily deny use of the building. Virtually all buildings are vulnerable to toxic agent attack, simply because ventilation is necessary in all buildings. However, vulnerability varies considerably depending on the type of exposure. Most buildings are vulnerable to an indoor release if access to the building is unrestricted. Almost all buildings are vulnerable to an outdoor release, because conventional air-filtration systems in buildings are not capable of filtering gases, vapors, or micron-size aerosols. Many buildings are vulnerable to a release into a fresh-air intake because intakes are typically at or near ground level. Listed below are simple criteria for determining the vulnerability of a school building to releases indoors, outdoors, and into air intakes.

5.3.1 Vulnerability to Indoor Releases

- High vulnerability: No access control is applied to the building and visitors may enter without being observed.
- Low vulnerability: Access control consists of locked entrances monitored with CCTV cameras from the main office with remote lock control of the entrances.
- Lowest vulnerability: Access control consists of locked entrances with a security guard stationed at the main entrance. The guard is assisted by video surveillance of other entrances, hallways, obscure interior spaces such as enclosed stairwells, and exterior areas where air intakes are located (if at ground level). When a mail threat is present, procedures are in place for screening and/or opening the mail before it is delivered to the school building.

5.3.2 Vulnerability to Air-intake Releases

- High vulnerability: Air intakes are at ground level with unrestricted access.
- Low vulnerability: All air intakes are mounted on the roof on single-story buildings, and access to the roof is restricted. Intakes in air wells are protected by sloped screens over the air wells.
- Lowest vulnerability: All air intakes are located at least two stories high on tall buildings. If air intakes are roof mounted, access to the roof is restricted.

5.3.3 Vulnerability to Remote Releases

- Higher vulnerability: The school has no capability for sheltering in place.
- Lower vulnerability: All the elements of sheltering in place, including plans, procedures, and training, are present and applied.

5.3.4 Threat Related Factors

Factors that increase the threat, rather than the vulnerability to a toxic release, should be considered in assessing the need for reducing vulnerability. The primary factor is proximity to chemical manufacturing, storage, or transportation centers, or rail lines on which toxic materials are frequently transported. Information about the presence of hazardous materials in the community can be obtained from the local fire department and its hazardous materials (HazMat) unit, the Local Emergency Planning Committee (LEPC), and State Emergency Response Commission (SERC). The LEPC and SERC are local and State organizations established under a U.S. Environmental Protection Agency program. They identify critical facilities and vulnerable zones and generate emergency management plans. Most HazMat units know who handles the toxic materials that could pose a hazard to the community.

Criteria for vulnerability to remote releases do not address continuously operating high-efficiency air-filtration systems pressurizing the building. Such systems have been applied to a few military and government buildings subject to high risk, but are not typically used in school buildings, with the exception of standby filtration systems that have been installed in a number of school buildings under the CSEPP.

5.4 Protective Measures that Reduce Vulnerabilities

Protective measures are typically intended to reduce either the vulnerabilities or the potential consequences of an exposure to CBR agents. The protective measures that aim to reduce potential consequences constitute a part of the response to a toxic release, while the protective measures that reduce the vulnerabilities aim to prevent the intentional release inside or near the school building. Preventing the intentional release of toxic substances inside a school building requires physical security measures that restrict access to the buildings and thereby deter potential attackers. Protective measures can be applied not just to the building but also its surroundings, by securing the facility perimeter (see Chapter 2). The physical security measures for schools focus on containers that could hold toxic substances and on the building entrances and fresh-air intakes where they may be introduced.

Protective measures are typically intended to reduce either the vulnerabilities or the potential consequences of an exposure to CBR agents.

5.4.1 Securing Fresh-Air Intakes

Elevating a building's fresh-air intakes is an effective means of reducing its vulnerability to a CBR attack. However, doing so can be expensive, particularly in the retrofit of an existing building. Most easily applied in new construction, this measure has two benefits:

- It provides passive security against malicious or mischievous acts, making it difficult for a hazardous substance to be inserted directly from a container into the building's mechanical ventilation system.
- It makes it less likely that high concentrations of hazardous material will occur at the intakes if there is a ground-level release near the building. A common problem with ground-level intakes near streets or parking areas is that exhaust fumes can be drawn indoors under certain conditions. By elevating the intakes, the amount of toxic substance that is able to enter the building is reduced because the dilution of air toxins increases with the distance from the source. In stable conditions, contaminants released near the ground will likely remain close to the ground unless the airflow over the building lifts it upward. Contaminants heavier than air will also tend to remain close to the ground under calm conditions.

Elevating a building's fresh-air intakes is an effective means of reducing its vulnerability to a CBR attack.

The effectiveness of elevating intakes is limited with regard to releases that are far from the building. When air intakes are elevated or located on the roof, the aspect ratio of the building (height ÷ width) determines whether the plume from a ground-level release near the building will flow upward and reach the intakes. A tall slender building will force a ground-source plume to pass around, rather than over the building. This does not apply when the source is far from the building, in which case the dilution that occurs over the large distance has a greater effect in mitigating the hazard. For low-rise buildings, as most school buildings are, a plume originating at ground level near the building will travel over the building rather than around it; consequently, the wind will convey contaminants to the top of the building, with some dilution occurring.

5.4.2 Securing Mechanical Rooms

Maintaining security of mechanical rooms that contain air-handling units is a means of preventing the direct introduction of toxic substances into the system of ducts that supply air to a zone or building. It requires locking and controlling access to all mechanical rooms containing HVAC equipment, both with interior doors and exterior doors.

5.4.3 Video Surveillance and Access Control

The physical-security principles of deterrence and detection are applied in the use of video surveillance equipment. For detection to be effective in preventing a release, images from the cameras must be monitored continuously in real time. For deterrence, the surveillance must be overt rather than covert; that is, the camera must be mounted where it is visible to anyone in the vicinity. Generally, surveillance cameras should be placed to monitor common areas that are not within the normal view of teachers, administrators, or a security person, such as hallways and enclosed stairwells. Outdoor areas to be monitored include views of unsecured air intakes and areas where vehicles or pedestrians may approach them unnoticed.

Video surveillance at entrances makes access control in schools practical without requiring a security person to be stationed at the entrance. Employed with an intercom and remote control of the door lock, this allows the locked entrances to be monitored from the main office. This approach to access control is widely used in schools; however, it has shortcomings particularly at morning arrival time and when groups of students return from activities outside the building. The security challenge of access control during such periods is illustrated by a 2011 incident in which a young man entered a middle school unnoticed during the morning arrival period, hid in a restroom, and subsequently assaulted a student in the restroom even though the school used an access control system.

The restroom is a semi-private space that is not subject to video surveillance. However, it is a space in which vandalism and mischievous acts, such as igniting stink bombs, are known to occur occasionally. Video cameras directed toward the restroom entrance from the hallway provide a deterrent effect. Electronic occupancy monitors that illuminate an occupancy-indicator light over the door provide a means of determining that someone is in the restroom, making it less likely that a person can hide or carry out a malicious act undetected.

A second security procedure typically associated with access control is entry inspection. Routine entry inspections, aimed at detecting a container of toxic substance (e.g., pepper-spray canister) and deterring a student or visitor from bringing such a container into the school, would be extremely difficult to carry out within the context of normal daily routines. Entry inspections are intrusive, time-consuming, and impractical in the school setting. Without entry inspections, rules that prohibit bringing irritant and incapacitant dispensers such as tear gas and pepper spray into the building must be made known and strictly enforced.

5.5 Protective Measures that Reduce Consequences

As mentioned earlier, protective measures that reduce consequences are implemented as a response to a CBR agent release either inside or outside the school building. The goal of any response to an airborne toxic attack is to provide clean, breathable air for the building occupants. The two emergency responses that can achieve this goal in a school are evacuation and sheltering in place. One is the alternative to the other, but they can also be applied in sequence, as has been the case in precautionary sheltering followed by evacuation in hazardous materials accidents.

The goal of any response to an airborne toxic attack is to provide clean, breathable air for the building occupants.

The dilemma in the use of sheltering is that the decision between evacuation and sheltering requires immediate knowledge about the source of the hazard: is it outdoors or indoors? The decision between the two response actions must be made rapidly, even if information about the source is not available. In the absence of this information, the decision, by default, is to evacuate.

Occupants inside buildings that have central control of all HVAC fans can be sheltered in place more quickly, because all building fans can be turned off rapidly. If the source is outdoors or in an intake, taking this action can minimize the quantity of agent that infiltrates the building. If the source is indoors, it can minimize the potential spread of the agent throughout the building. In both cases, shutting off fans quickly can minimize the extent of decontamination and time required for restoration after the incident, particularly with aerosols and persistent vapors. Windows and doors can also be closed in this initial step, but only if it will not delay the evacuation of the building, if needed later.

5.5.1 Evacuation

Evacuation is the primary response for building occupants in a toxic release emergency, just as it is for fire or smoke in the building. Evacuation can follow the same plans and routes as a fire emergency with two important exceptions. In a toxic release evacuation, the evacuees should move at a right angle, or 90º, to the wind direction as soon as they exit the building. This makes it likely they will move out of a plume emanating from the source. A crosswind path also provides a margin of safety if the source is actually outdoors rather than indoors, when there is insufficient information to determine the source of the release. The second exception is that normal interior routes of evacuation may not be useable when an indoor release occurs. This problem can be overcome by ensuring that evacuation routes are short and direct, and by planning alternate routes and training building fire marshals about the effects and conditions of evacuation in a toxic release emergency.

5.5.2 Sheltering in Place

Sheltering in place, also referred to as unventilated sheltering, is a simple, inexpensive method for protecting people in buildings from airborne hazards that arise outdoors. It involves temporarily reducing the indoor-outdoor air exchange rate of the building before contaminated air reaches it, then increasing the air exchange rate after the hazardous condition passes. Sheltering in place is like holding your breath when an automobile drives past, emitting a cloud of smoke. You cannot hold your breath long, and if you breathe in while still enveloped by the cloud, the result is a lung full of smoke. This analogy describes two limitations of sheltering. First, it is beneficial only against hazards that dissipate quickly, and second, to provide significant protection, it must be implemented before the hazardous cloud or plume reaches the building.

Sheltering in place may be ineffective if it is implemented too late or if it is used for a hazard that may persist for many hours. Examples of long-duration hazards for which sheltering is the wrong decision are the upwind release of a tanker-car load of toxic chemical or a fire in a tire dump in stable atmospheric conditions.

> Sheltering in place is a simple, inexpensive method for protecting people in buildings from airborne hazards that arise outdoors.

Timely implementation requires continuous surveillance to know when a toxic release has occurred, to detect the plume's slow, surreptitious assault before it infiltrates the building. A school does not have this capability. For this reason, the best approach for schools is to employ sheltering as a first step before evacuation, when the hazard from an unknown source becomes apparent to people in the building by its warning properties or cues. When the source is unknown, sheltering as an initial step provides the benefit of retarding the flow of contaminated air into the building and—if the source is indoors—minimizing the spread within the building.

The maximum safety and protective benefit from sheltering in place depends on a community alert system in which the emergency managers make the decisions on when and how long to shelter based on real-time information. Community warning systems are present in some U.S. communities that have a greater-than-normal threat of chemical release, such as communities with chemical manufacturing and storage plants or frequent transportation of hazardous chemicals, particularly on rail lines.

With an effective warning system, sheltering in place can be employed in most buildings at varying levels of protection, cost, and preparation. In its simplest form, it can be implemented with a short list of instructions: close all windows, doors, and vents; turn off all fans and combustion heaters; and turn on the radio or TV for emergency instructions. More extensive preparations for sheltering in place are described in detail in FEMA 453, *Design Guidance for Shelters and Safe Rooms* (2006).

Sheltering in place can be a precautionary measure or a response to an actual release. Precautionary sheltering is likely to involve longer periods in the sheltering posture, because authorities may judge the threat to a building to be possible but not actual. For example, the plume of toxic gas leaking from a derailed tanker car may pose a threat to a community only if the wind shifts or corrective actions fail. There are no time limits on precautionary sheltering; however, if the duration becomes long, the effects of discomfort and carbon dioxide buildup in a tight shelter can become significant. People may decide to leave the shelter, and parents may arrive at the school to take their children.

Aside from precautionary use, sheltering in place is most effective for short durations, because the protection it provides diminishes with time. Consequently, sheltering is often the best course of action to take initially, while the incident is unfolding and until the facts are known. Evacuation takes much more time and can involve greater risk of exposure.

Aside from precautionary use, sheltering in place is most effective for short durations, because the protection it provides diminishes with time.

Once the hazard has dissipated, sheltering in place requires a second, distinct action relative to the building's indoor-outdoor air exchange rate: increasing the air exchange rate, preferably as soon as the hazardous plume has passed. This is done by opening all windows and doors and restarting all fans to ventilate the building. The decision on when to aerate or when to terminate sheltering may be more difficult than when to initiate sheltering. The decision is typically made by emergency managers, who have the ability to determine when an outdoor hazard is no longer present.

5.5.3 Plans for Sheltering in Place

Implementing sheltering in place in a school building begins with a written plan that includes the following:

- Emergency procedures and assigned responsibilities, by name for:
  - Shutting down HVAC fans, including a list of switches or circuit-breakers that control building fans, the location of the switches, their markings, and the names of the staff members assigned to reposition the switches.
  - Shutting off any furnaces or heaters that draw combustion air from within the building.
  - Closing and securing all windows, vents, and doors, including interior doors.
  - Making a public address announcement (which includes the preparation of the text of the announcement) to initiate sheltering or evacuation.
  - Evacuation after initial sheltering.
  - Accounting for all students, teachers, staff, and visitors during the emergency.
- Training and exercises in the sheltering procedures to be conducted periodically (similar to fire drills).
- Instructions for communicating with the community's emergency management office, including contact telephone numbers.
- Procedures for acquiring emergency transportation resources for evacuation after initial sheltering or precautionary sheltering.
- Procedures to keep students occupied while sheltering, such as reading to the students, and procedures for helping students with pre-existing medical conditions that could be exacerbated by stress.
- Procedures for handling calls from parents and requests by parents to take their children out the school while sheltering in place.

5.5.4 Preparations for Sheltering in Place

Preparations required for a sheltering-in-place capability include the following:

- Marking switches that control HVAC fans. For example, breakers no. 14, 15, 16, and 17 in the custodial closet (marked in red), and breakers no. 1, 2, 3, and 4 in the boiler room (marked in red). If the building has a single-witch control for the HVAC fans, it should be marked as such.
- Preparing and posting a diagram showing the boundaries of the sheltering area, particularly if it includes multiple rooms but not the entire building. A diagram of a sheltering area of an elementary school is shown in Figure 5-1.
- Instructing teachers, other staff members, and students in the procedures and providing a list of instructions to be posted in each room. Conducting periodic drills in the procedures of sheltering in place.
- Preparing and storing kits of tape and plastic material for sealing doors and vents when sheltering. Providing instructions in the use of these materials.
- Ensuring an adequate intercom or public-address system is available for building-wide notification to shelter or evacuate.
- Ensuring access to emergency information, i.e., a telephone for communication with emergency managers and a radio or television for receiving emergency information.
- Ensuring access to toilets, drinking water, and first-aid supplies.

Figure 5-1:
Diagram of the unventilated shelter area, which includes restrooms and drinking fountains, in an elementary school

5.6 Examples that Illustrate Protective Responses

Scenario No. 1. While changing classes, students of a three-story middle-school building enter an enclosed stairwell and immediately experience a burning sensation in the eyes and throat. They race out of the stairwell in obvious distress.

- **Source.** Because the exposures occurred only to those who were in the stairwell, it is likely an indoor release limited to the stairwell. Based on the symptoms, an irritant such as pepper spray was likely released in the stairwell.
- **Likely progression.** A fire-rated stairwell has no ventilation; therefore, the material will remain airborne in the stairwell, slowly depositing on the walls as long as the doors remain closed. If two or more doors of the stairwell are opened, the airborne material will flow out of the stairwell into the hallways, driven by buoyancy pressure (upward during the heating season, downward during the cooling season).
- **Appropriate immediate response.** Once it is cleared of people, the affected stairwell should be kept closed and the building should be evacuated via other stairwells using fire-evacuation procedures. Medical first responders should be summoned to render first aid to those affected. Building HVAC fans should be turned off.
- **Post-incident actions to make the building safe.** The fire department HazMat team will aerate the entire building using portable high-volume fans to speed the clearing of the stairwell. They will determine when it is safe to reoccupy the building.

Scenario No. 2. Near the end of the morning rush hour, a chemical tanker truck overturns on an expressway exit ramp near downtown. A large quantity of a toxic industrial chemical in liquid state spills onto the roadway and continues to leak steadily. An elementary school is located ½ mile from the accident scene.

- **Source.** First responders identify the type of chemical by reading the markings on the vehicle once they arrive at the accident scene. They rapidly assess the situation, including the wind conditions.
- **Likely progression.** By continuing to leak its liquid contents, the overturned tanker may produce a hazardous plume for several hours before it can be contained. Weather conditions and the absence of fire keep the plume close to the ground. Because the expected duration is long, emergency managers call for an evacuation of the areas downwind of the accident and for sheltering in place upwind of it, noting that additional evacuations will be ordered if the wind begins to shift.

- **Appropriate immediate response.** Once notified of the accident, the principal of the school ½ mile upwind initiates sheltering in place by closing all windows and doors, and turning off all fans of the building's HVAC system. He immediately begins preparing for evacuation of the school, which is likely to take 1 to 2 hours because of limited bus availability and the disruption of traffic caused by the tanker truck accident. He receives frequent situation updates from the emergency managers.
- **Post-incident actions to make the building safe.** If a wind shift occurs, some of the toxic chemical may infiltrate and be retained in the closed building. Before the building is reoccupied, the fire department will perform air-sampling tests for the specific chemical and will aerate the building until the air-sampling results are negative.

Scenario No. 3: Students in a first-floor classroom begin coughing, choking, and complaining of burning eyes and throat. A faint white smoke is emanating from the unit ventilator in the classroom. The teacher immediately evacuates his students to the hallway, where the air, for the moment, appears to be clean.

- **Source.** The white smoke provides a visual indication that the toxic material is coming through the outdoor-air intake of the unit ventilator. The symptoms indicate that the material is an irritant, probably tear gas from a grenade placed near the ground-level intake in a malicious act.
- **Likely progression.** Tear gas from the grenade will continue to flow into the building until the unit ventilator is turned off, automatically closing its air damper if it is in proper working order, or until the grenade burns itself out, or it is knocked away from the intake. Tear gas is actually a cloud of fine particles, solid aerosols that can remain suspended in the air for minutes to hours. If the classroom doors are not closed, it will diffuse out of the classroom and travel through the hallway with air movement induced by pressures of wind and buoyancy (uncontrolled interior air flows). Some of the airborne particles will settle and deposit on surfaces.
- **Appropriate immediate response.** The teacher should evacuate his students from the classroom and close the classroom doors once all the students are out. On being alerted to the emergency, the principal should immediately initiate evacuation of the school, turn off of all HVAC fans, and summon medical first responders to render first aid.
- **Post-incident actions to make the building safe.** The fire department HazMat team will aerate the building, using portable fans to speed the clearing of the tear gas aerosol that remains airborne. They will

also physically clean the building with vacuum cleaners and soap and water to remove the fine particles of the irritant that have deposited on building surfaces. They will take air samples to determine when it is safe to reoccupy the building.

5.7 Design Recommendations for New Construction or Retrofit

This section describes design solutions that increase the protection of sheltering in place and improve physical security for prevention of indoor and air-intake releases. Enhancements for sheltering in place, some of which are more appropriate for schools in communities with a higher risk of industrial accidents involving toxic materials, include the following:

- The use of prepared safe rooms for sheltering
- A building-wide rapid notification system
- Improved air-tightness of the protective envelope
- Single-switch fan control
- Rapid temporary sealing
- Recirculation filter units

Physical security enhancements relative to indoor or air-intake releases include the following:

- Securing fresh air intakes
- Isolating zones

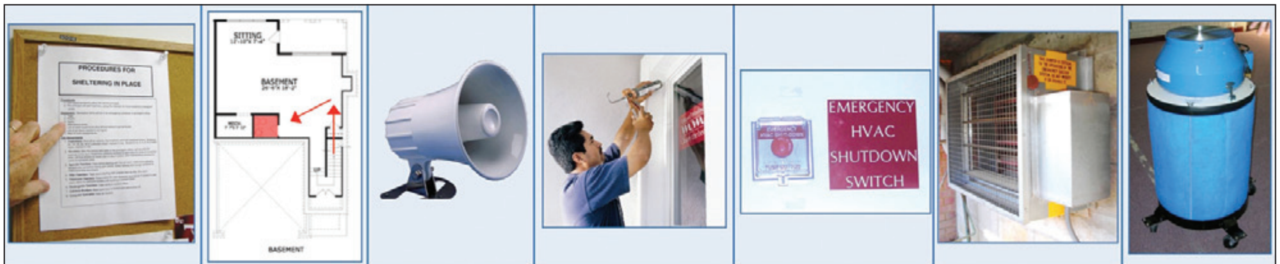
5.7.1 Enhancements for Sheltering in Place

Sheltering in place has several levels that include enhancements for two general purposes: (1) producing a tighter enclosure for sheltering; and (2) facilitating a rapid transition to the sheltering mode, particularly for large buildings.

Beyond the basic procedures of sheltering in place, a number of enhancements provide for more rapid sheltering and a higher level of protection. These levels are summarized in Figure 5-2 and are described in detail below.

5.7.1.1 Use of Prepared Safe Rooms

In unventilated sheltering, the protected space is usually defined as the whole building; however, a selected room within the building can provide a higher level of protection and/or a more comfortable environment for sheltering. A room selected and prepared for sheltering is referred to as a safe room. In schools, the gymnasium and cafeteria are most commonly designated as safe rooms, because they provide space for most if not all of the school population.



1. Developing written plans and assigning responsibilities for doors, switches, emergency announcements, training, and employee accountability.
2. Selecting and designating safe rooms.
3. Developing a rapid notification system, e.g., public address system
4. Applying permanent sealing measures (weatherization techniques) to safe rooms and/or the building.
5. Developing single-command/switch control of building fans for rapidly turning off multiple fans
6. Preparing for rapid, temporary sealing of the building and safe rooms, e.g., motorized dampers, tape and plastic
7. Installing recirculation filter units with carbon adsorbers and HEPA filters.

Figure 5-2: Setting up a safe room

In unventilated sheltering, the primary benefit of a safe room is to provide level of protection against the infiltration of contaminated air higher than the whole building provides. This additional protection may result from a tighter, windowless configuration of the room and/or having a second wall between the outdoors and the protected space. Temporary sealing measures, whether they involve tape and plastic sheeting or manual dampers, can be more easily and rapidly applied to a safe room because of its smaller size. There are several criteria for selecting safe rooms.

Accessibility: The safe room must be rapidly accessible to all who are to be sheltered, and it should be accessible with minimum outdoor exposure. Although there are no specific requirements for the time to reach a safe room, it should take no more than 2 minutes to do so from the most distant point in the building. For maximum accessibility, the ideal safe room is one in which a substantial portion of time is spent during a normal day, i.e., the classroom. The safe room should be accessible to persons with mobility, cognitive, or other disabilities.

Size: The size criterion for the toxic agent safe room is the same as that for tornado shelters. Per FEMA 361, Design and Construction Guidance for Community Safe Rooms (2008), the room should provide 5 square feet per standing person, 6 square feet per seated person, and 10 square feet per wheelchair user for occupancy of up to 2 hours.

Tightness: In the closed configuration, the safe room must have a low rate of air exchange with the outdoors and adjacent indoor spaces. Rooms with few or no windows are preferable if the windows are of a type and condition that do not seal tightly (e.g., older sliders). If the room has a suspended, lay-in ceiling, it must have a hard ceiling above the suspended one. The room should have a minimum number of doors, and the doors should not have louvers, unless they can be sealed quickly. The door undercut must be small enough to allow sealing with a door-sweep weather strip or, in emergencies, with duct tape.

HVAC System: The safe room must be isolated or capable of being isolated quickly from the building's HVAC system, or have unit ventilators with properly functioning outdoor air dampers. When the selected room is served by supply and return ducts, preparations or modifications must include a means of temporarily closing the ducts to the safe room. In the simplest form, this involves placing duct tape or contact paper over the supply, return, and exhaust grilles and turning off fans and air-handling units. More elaborate preparations may involve hinged covers. When a window-type or through-the-wall air conditioner is in the selected room, plastic sheeting and tape, or a hinged cover, as shown in Figure 5-3, must be available to place over the inside of the window and/or air conditioner, which must be turned off when sheltering in the safe room.

Figure 5-3:
Manually operated damper for sealing an air conditioner in a safe room

Location: The location of unventilated safe rooms within a building depends on three considerations. First, an interior room is preferable to a room with exterior walls if it meets the criteria for size, tightness, and accessibility. Second, relative to the prevailing wind, the safe room should be on the leeward side of a building if it also meets the other criteria. Third, in communities with nearby toxic chemical processing, storage, or transportation, the safe room should be located on the side of the building opposite the toxic chemical facilities, if it meets the other criteria. For a low-rise building, a room on the higher floors provides no substantial advantage, and a location should not be selected based on height above ground level when it increases the time required to reach the shelter in an emergency.

Communications: For sheltering situations initiated by local authorities, the safe room must contain a radio with which to receive emergency instructions for the termination of sheltering. A telephone or cell phone can be used to receive emergency instructions and to communicate with emergency management agencies. Electrical power and lighting are also required.

Water and toilets: Drinking water and a toilet(s) should be available to occupants of a safe room. This may involve the use of canned/bottled water and portable toilets.

Carbon dioxide detector: A tightly sealed unventilated safe room cannot be occupied for long periods without some risk of elevated carbon dioxide levels. High levels are less likely to occur in high-ceiling safe rooms such as gymnasiums and in rooms where the density of occupants is low. Consequently, an unventilated safe room should have a carbon dioxide detector or monitor available. This is of particular importance for precautionary sheltering, which is more likely to result in long periods of sheltering.

5.7.1.2 Developing a Rapid Notification System

Emergencies involving a toxic release require oral instructions about the specific actions of evacuation or sheltering in place. For this reason, a building-wide intercom or public address system is necessary to ensure a quick response to such emergencies. A rapid notification system must be capable of reaching all students, teachers, and staff members in and around the building.

A building-wide intercom or public address system is necessary to ensure a quick response to emergencies.

5.7.1.3 Permanent Sealing of a Safe Room or Building

The level of protection provided by sheltering in place varies with the air-tightness of the building or safe room. When the building is mechanically ventilated, as most school buildings are, a tighter envelope (less air leakage through unintentional openings in the building shell) is beneficial in reducing vulnerability to CBR attacks. A tight building envelope also provides the following benefits:

- Reduced energy consumption
- Reduced uncontrolled airflows, which have negative effects on heating, cooling, and humidity control
- Facilitated pressurization if required
- Reduced potential for mold/mildew that results from moisture infiltration

Generally, most air leakage occurs at the ceiling-to-wall interface or, if the roof is part of the boundary of the protective envelope, at the roof-to-wall interface. One approach to air-leakage reduction is to replace lay-in ceilings with gypsum wallboard ceilings when the space above the drop ceiling is naturally ventilated or when the seal between roof deck and walls is poor. Significant tightening can be achieved by sealing the juncture of the roof deck/bar joists and perimeter walls with expanded foam or sealant. Aside from replacing ceilings, leakage reduction in existing buildings generally involves measures commonly applied in weatherization. These include applying weather-stripping to doors; sealing cable penetrations, cable trays, or electrical boxes with foam; applying caulk or foam at roof-wall or ceiling-wall junctures; upgrading operable windows; or placing storm windows over operable windows.

Significant leakage may also occur at the floor-to-wall interface. A baseboard often obscures leakage paths at this juncture, and sealing these leakage paths may require sealing behind the baseboards. One approach is to temporarily remove the baseboards and apply foam sealant in the gap at the floor-to-wall juncture. An alternate approach is to use clear or paintable caulk to seal the top and bottom of baseboards and quarter rounds.

5.7.1.4 Single-Switch Control of Fans and Outdoor-Air Dampers

Sheltering in place must be implemented rapidly to achieve maximum effectiveness. Consequently, having the capability to turn off all building fans from a single location is important. In large buildings, controls or switches for deactivating HVAC fans are often in diverse locations that may not be rapidly accessible. A single-switch that controls fan interlock relays provides the capability to rapidly de-energize all fans that induce air exchange between the protected spaces and the outdoors, and to close the automatic dampers associated with each fan. In a school, this single-switch control should be located in the main office and be well marked. In some applications of enhanced sheltering under the CSEPP, this switch was included on a control panel with status lights for air-handling units, exhaust fans, unit ventilators, dampers, and doors.

Automatic dampers should be installed on fresh air intakes to close when the outdoor air fan is turned off. Similarly, back-draft dampers should be installed on exhaust fans if they are not so equipped. These dampers should be rapid acting and positive-sealing but must not be so rapid as to cause duct collapse while fans continue to turn by inertia.

The control panel may also be designed with features to accommodate the aeration phase of recovery. One switch is used to initiate sheltering. A second switch initiates the aeration phase by turning on all fans and opening dampers once the outdoor hazard had dissipated.

Figure 5-4 shows a control panel for unventilated sheltering in a school building. The panel contains a single (red) switch to control all fans and dampers and an array of status lights for the fans and dampers.

The building or selected safe room may have one or all of the following intentional openings on the boundary between the protected and unprotected spaces. These openings are necessary for normal use of the room or building but must be closed temporarily when sheltering in place in an emergency.

- Supply and return ducts
- Exhaust fans
- Door louvers
- Window-type air conditioners or unit ventilators
- Door undercuts

5.7.1.5 Rapid Temporary Sealing of a Building or Safe Room

Sealing the openings of a designated safe room beforehand is neither practical nor advisable if that room is routinely used for day-to-day activities. Transitioning to the protective mode requires that these openings be sealed temporarily and rapidly. This sealing capability can be either permanently installed or expedient.

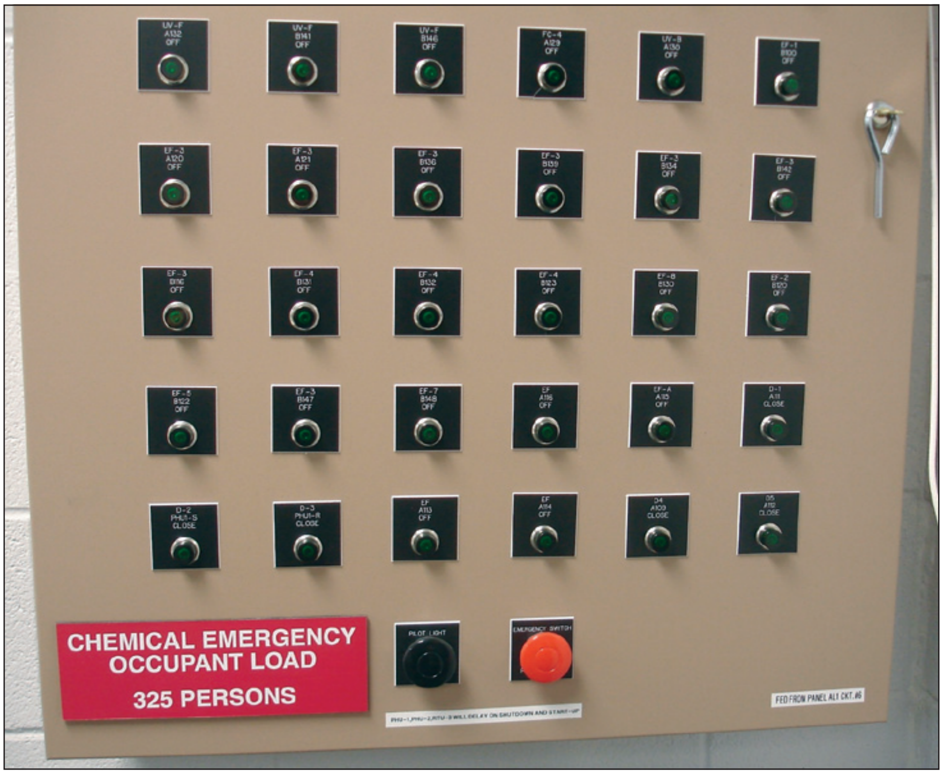


Figure 5-4:
A sheltering control panel in a school with a fan-shutdown switch (red push switch at lower center) and indicator lights for status of dampers and fans

The expedient method of sealing a safe room for sheltering in place involves the use of tape and plastic sheeting as shown in Figure 5-5. This method involves applying 2-inch-wide tape around the door(s) and covering the supply and return vents once the HVAC fans are turned off. A window can be covered if it is an operable window, such as a slider that does not seal well. Tape can also be placed over the gap at the bottom of the door and over door louvers. A small kit of materials can be provided to each safe room, along with a written checklist of the sealing measures required for that safe room. Sealing materials can be contact paper, pre-cut to size, 2-inch wide painter's tape, or plastic sheeting and 2-inch duct tape.

Permanent dampers can be installed to facilitate this rapid sealing. Dampers for supply, return, and exhaust ducts can be manually or automatically operated. Manually operated hinged covers as shown in Figure 5-6 can be custom made of sheet metal or wood to be attached above or beside the opening for all applications except the door periphery. In a safe room with several openings to seal, hinged covers allow the sealing to be completed more quickly than with tape and adhesive-backed plastic material.

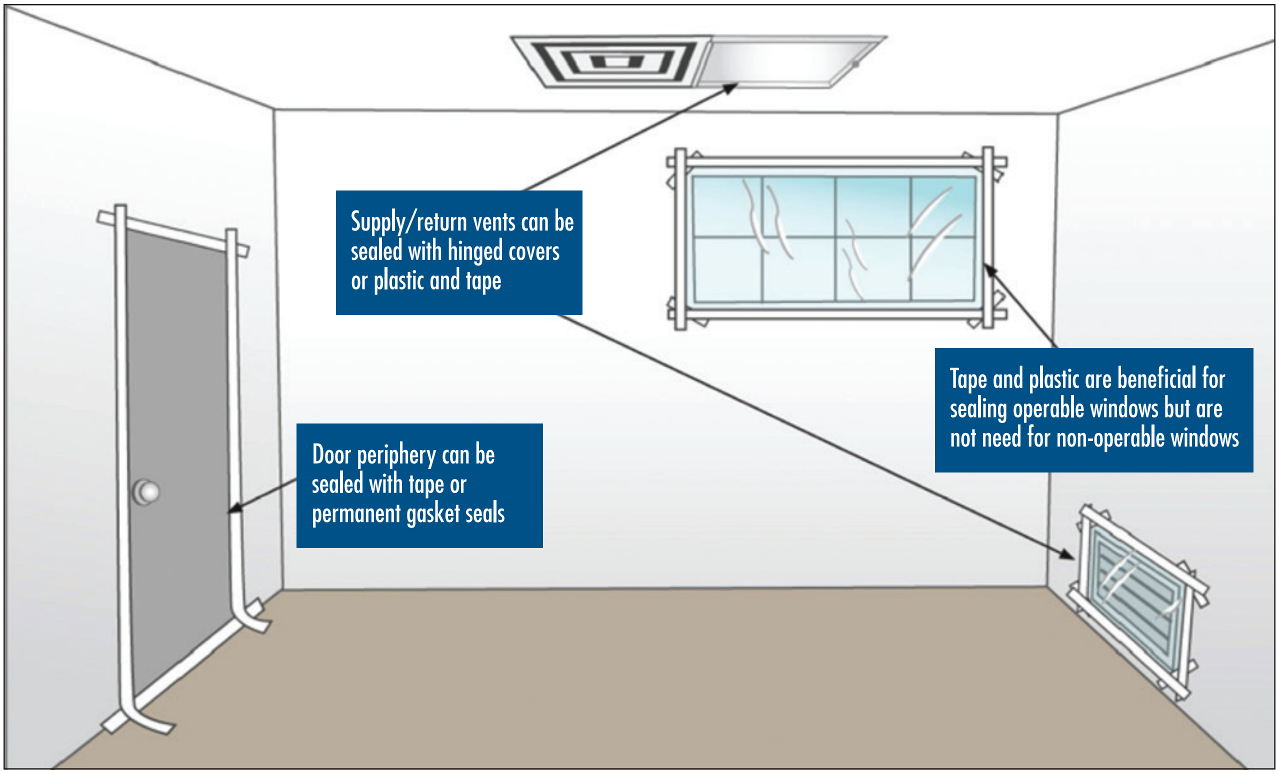


Figure 5-5: Areas to be sealed temporarily in a safe room during an emergency

Motorized dampers provide the capability to isolate the safe room from the HVAC ducts and to do so more rapidly than manual dampers. When dampers are closed for sheltering, HVAC fans must also be turned off. Leakage through the dampers can occur if the supply fan is not deactivated.

In extreme weather, confining people in a sealed safe room without air conditioning or heating can result in intolerable conditions. However, conventional air-conditioning and heating systems must not be operated during sheltering because the HVAC fans directly or indirectly introduce outside air. A mechanical ventilation system often has a greater potential for indoor-outdoor air exchange than the leakage paths of the enclosure subjected to wind and buoyancy forces. Window-type air conditioners and unit ventilators introduce outdoor air, even when set to the recirculating mode. The dampers for outdoor air in such units may not seal well if they are poorly maintained. Air-handling units and fans serving spaces outside the safe room must also be turned off. (An exception is combustion heaters of hydronic systems that are located in separately ventilated mechanical rooms.) Safe alternatives for heating and air-conditioning in sheltering mode are described in FEMA 453.

Figure 5-6:
A hinged cover for sealing the supply vent of a safe room

5.7.1.6 Recirculation Filter Units with Carbon and HEPA Filters

The protection a safe room provides can be increased substantially by adding high-efficiency air filtration in one of two ways: (1) by removing contaminants from the air as it is drawn from the outdoors and discharged into the safe room (pressurization); or (2) by removing the contaminants as air is drawn from inside the safe room, filtered, and discharged back into the safe room (recirculation).

The first means of applying filtration—pressurization—can achieve a much higher level of protection than recirculation. But not all toxic chemicals are filterable with the conventional approach of carbon adsorption. If the toxic release involves an unfilterable chemical, the protection afforded by the pressurization approach drops to a very low level. However, the recirculation approach retains a substantial level of protection if the toxic chemical released in an attack happens to be unfilterable. That level of protection is of the same level provided by unventilated sheltering without filtration.

The protection a safe room provides can be increased substantially by adding high-efficiency air filtration.

Filterability of the threat agent is the most important limitation to be considered before incorporating recirculation filter units. If the school is located near an ammonia plant, for example, conventional recirculation filter units will not provide benefit against an accidental release of ammonia, because it is not filterable by the carbon adsorbent the recirculation filter units contain. Commercially available recirculation filter units were employed in unventilated shelters under the CSEPP because each of the stockpile agents was filterable with carbon adsorbers by physical adsorption. Testing demonstrated that the protection against the stockpile agents could be increased substantially with recirculation filter units (Blewett and Arca 1999).

Aerosols are filtered by recirculation filter units because most commercial filter units contain a high-efficiency particulate air (HEPA) filter in series with the carbon adsorber. Consequently, such units will filter tear gas and pepper spray. The protection that recirculation filters can provide varies with a number of factors, including the tightness of the building or safe room, the efficiency and flow rate (i.e., clean-air delivery rate) of the unit, and the volume of the room or building the filter unit serves.

Recirculation filter units can be applied much more easily to a building, in many cases without modification to the building or installation cost.

Recirculation filter units can be applied much more easily to a building, in many cases without modification to the building or installation cost. A second benefit of recirculation filtering is in purging contaminants from a building following an indoor release. Commercially available indoor air-quality units are recirculation filters that typically contain adsorbers and HEPA filters. These are available in a variety of configurations—ceiling-mounted, duct-mounted, and freestanding floor or table-top units. Unlike the filter units for pressurized systems, there is no standard for the application of recirculation filter units in protective shelters, either in filtration capacity, clean-air-delivery rate, or flow rate per square foot of shelter area. Also, commercial recirculation filter units do not employ impregnated carbon to provide substantial capacity for toxic chemicals of high vapor pressure. Models are available from several manufacturers and their performance for filtering chemical contaminants varies widely. Additional detailed guidance for applying recirculation filter units to safe rooms is presented in FEMA 453.

5.7.2 Physical Security Measures

5.7.2.1 Securing Fresh Air Intakes

Elevating fresh air intakes by at least one story is a simple means of reducing a building's CBR vulnerability. Though simple, it can be a rather expensive retrofit for an existing building and is most easily applied in new construction. Where roof access is controlled, placing intakes on the roof provides passive security against malicious acts, making it more

The most widely used type of HVAC system in schools is the unit ventilator.

difficult for a container of hazardous material to be inserted directly into the building's HVAC system. It also makes it less likely that hazardous material released at ground level near the building will reach high enough concentrations at the intakes. In stable conditions, contaminants released near the ground will likely remain close to the ground unless the airflow over the building lifts them upward. Contaminants heavier than air will also tend to remain close to the ground under calm conditions.

The most widely used type of HVAC system in schools is the unit ventilator, which provides through-the-wall or through-the-roof fresh air, heating, and air-conditioning directly to each classroom. A through-the-wall system installed at floor level presents a higher-than-normal vulnerability because many intakes are at ground level and cannot be easily or rapidly secured, monitored, or deactivated. These often have damper systems that, if not maintained well, are not sealed fully when closed.

For single-story school buildings, ceiling-mounted unit ventilators with the outdoor air intake ducted vertically to the roof are less vulnerable to malicious acts and to drawing vehicle exhaust fumes into the building. These units typically have an "unoccupied mode" in which the outdoor air damper is closed and the fan remains off.

For buildings of more than one story, intakes should be placed at the highest practical level on the building. For tall buildings, GSA recommends 50 feet above ground (4th floor or higher). GSA-recommended separation distances from other fresh air intakes or exhausts range from 10 to 25 feet. This is to prevent short-circuiting (exhaust from one intake entering another) between systems.

For protection against malicious acts, intakes or air wells in which intakes are placed should be covered with screens so that objects, a smoke grenade for example, cannot be tossed inside from the ground level. Such screens should be sloped to allow thrown objects to roll or slide off the screen, away from the intake.

5.7.2.2 Isolating Zones

Isolating the separate HVAC zones in a building reduces vulnerability to both indoor and outdoor releases. If an indoor release occurs, it minimizes the spread of the airborne toxic substance within the building, reducing the space and number of people potentially exposed. Against an outdoor release, it increases the internal resistance to air movement induced by pressures of wind and buoyancy, thus reducing the rate of infiltration. In essence, isolating zones divides the building into many separate environments, limiting the effects of a single release to an isolated portion of the building.

A benefit of unit ventilators is that each classroom is a separate zone, and when the classroom doors are closed, the room becomes isolated from the rest of the building if the room has full-height walls. This minimizes the potential for contaminants released in one room or into one air intake to migrate to the hallway or adjacent rooms. Buildings with ducted systems have fewer outdoor air intakes, but typically include multiple rooms in each HVAC zone. In practice, these zones are not isolated, because air flows between zones through hallways, atria, and doorways normally left open. Some ducted systems use the hallway as a plenum for return air, maximizing the potential for spreading contaminants throughout the building when fans are operating. Consequently, the classroom unit ventilator, the most common type of HVAC system for schools, presents the least potential for a toxic agent to spread throughout a building. One disadvantage of the unit ventilator is that there is one air intake per classroom, usually located at ground level; however, the vulnerability of these intakes can be reduced by elevating them as noted above and providing single-switch capability for their rapid deactivation.

A

Acronyms

ADA	Americans with Disabilities Act
BIPS	Building and Infrastructure Protection Series
CBR	chemical, biological, and radiological
CCTV	closed-circuit television
CDC	Centers for Disease Control and Prevention
CMU	concrete masonry unit
CPTED	Crime Prevention Through Environmental Design
CSEPP	Chemical Stockpile Emergency Preparedness Program
DHS	U.S. Department of Homeland Security
DoD	Department of Defense
DOS	U.S. Department of State
ED	U.S. Department of Education
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
GSA	General Services Administration
HazMat	hazardous materials

HEMP	High-Altitude Electromagnetic Pulse
HEPA	high-efficiency particulate air
HMP	High Power Microwave
HVAC	heating, ventilation, and air conditioning
ICS	Incident Command System
IRVS	Integrated Rapid Visual Screening
ISC	Interagency Security Committee
LEPC	Local Emergency Planning Committee
mph	miles per hour
MS	Microsoft
msec	millisecond
NIOSH	National Institute for Occupational Safety and Health
NPPD/IP	DHS National Protection and Programs Directorate's Office of Infrastructure Protection
psi	pounds per square inch
S&T	DHS Science and Technology Directorate
SERC	State Emergency Response Commission
SWAT	Strategic Weapons and Tactics
TNT	trinitrotoluene
UFC	Unified Facilities Criteria
VA	U.S. Department of Veterans Affairs
VASS	video assessment and surveillance system
VBIED	vehicle born improvised explosive device
VTPD	Virginia Tech Police Department

B

Glossary

This appendix contains some terms that do not actually appear in this manual. They have been included to present a comprehensive list that pertains to this series of publications.

A

Access control. Any combination of barriers, gates, electronic security equipment, and/or guards that can deny entry to unauthorized personnel or vehicles.

Access control point. A station at an entrance to a building or a portion of a building where identification is checked and people and hand-carried items are searched.

Access controls. Procedures and controls that limit or detect access to minimum essential infrastructure resource elements (e.g., people, technology, applications, data, facilities), thereby protecting these resources against loss of integrity, confidentiality, accountability, and/or availability.

Accountability. The explicit assignment of responsibilities for oversight of areas of control to executives, managers, staff, owners, providers, and users of minimum essential infrastructure resource elements.

Active vehicle barrier. An impediment placed at an access control point that may be manually or automatically deployed in response to the detection of a threat.

Aerosol. Fine liquid or solid particles suspended in a gas (e.g., fog, smoke).

Aggressor. Any person seeking to compromise a function or structure.

Airborne contamination. Chemical or biological agents introduced into and fouling the source of supply of breathing or conditioning air.

Antiterrorism. Defensive measures used to reduce the vulnerability of individuals, forces, and property to terrorist acts.

Area lighting. Lighting that illuminates a large exterior area.

Assessment. The evaluation and interpretation of measurements and other information to provide a basis for decisionmaking.

Asset. A resource of value requiring protection. An asset can be tangible (e.g., people, buildings, facilities, equipment, activities, operations, information) or intangible (e.g., processes, a company's information and reputation).

Asset protection. Security program designed to protect personnel, facilities, and equipment, in all locations and situations, accomplished through planned and integrated application of combating terrorism, physical security, operations security, and personal protective services, and supported by intelligence, counterintelligence, and other security programs.

Asset value. The degree of debilitating impact that would be caused by the incapacity or destruction of an asset.

Attack. A hostile action resulting in the destruction, injury, or death to the civilian population, or damage or destruction to public and private property.

B

Balanced magnetic switch. A door position switch using a reed switch held in a balanced or center position by interacting magnetic fields when not in alarm condition.

Ballistics attack. An attack in which small arms (e.g., pistols, submachine guns, shotguns, rifles) are fired from a distance and rely on the flight of the projectile to damage the target.

Barcode. A black bar printed on white paper or tape that can be easily read with an optical scanner.

Biological agents. Living organisms or the materials derived from them that cause disease in or harm to humans, animals, or plants or cause deterioration of material. Biological agents may be used as liquid droplets, aerosols, or dry powders.

Blast curtains. Heavy curtains made of blast-resistant materials that could protect the occupants of a room from flying debris.

Blast-resistant glazing. Window opening glazing that is resistant to blast effects because of the interrelated function of the frame and the glazing material properties.

Blast vulnerability envelope. The geographical area in which an explosive device will cause damage to assets.

Bollard. A vehicle barrier consisting of a cylinder, usually made of steel and sometimes filled with concrete, placed on end in the ground and spaced about 3 feet apart to prevent vehicles from passing, but allowing entrance of pedestrians and bicycles.

Building hardening. Enhanced construction that reduces vulnerability to external blast and ballistic attacks.

Building separation. The distance between the closest points on the exterior walls of adjacent buildings or structures.

C

Cable barrier. Cable or wire rope anchored to and suspended off the ground or attached to chainlink fence to act as a barrier to moving vehicles.

Chemical agents. Chemical substances, generally differentiated by the severity of effect (e.g., lethal, blister, incapacitating), that are intended to kill, seriously injure, or incapacitate people through physiological effects.

Clear zone. An area that is clear of visual obstructions and landscape materials that could conceal a threat or perpetrator.

Closed-circuit television (CCTV). An electronic system of cameras, control equipment, recorders, and related apparatus used for surveillance or alarm assessment.

Collateral damage. Injury or damage to assets that are not the primary target of an attack.

Community. A political entity that has the authority to adopt and enforce laws and ordinances for the area under its jurisdiction. In most cases, the community is an incorporated town, city, township, village, or unincorporated area of a county; however, each State defines its own political subdivisions and forms of government.

Components and cladding. Elements of the building envelope that do not qualify as part of the main wind-force resisting system.

Confidentiality. The protection of sensitive information against unauthorized disclosure and sensitive facilities from physical, technical, or electronic penetration or exploitation.

Consequence management. Measures to protect public health and safety, restore essential government services, and provide emergency relief to governments, businesses, and individuals affected by the consequences of terrorism. State and local governments exercise the primary authority to respond to the consequences of terrorism.

Contamination. The undesirable deposition of a chemical, biological, or radiological (CBR) material on the surface of structures, areas, objects, or people.

Control center. A centrally located room or facility staffed by personnel charged with the oversight of specific situations and/or equipment.

Controlled area. An area into which access is controlled or limited. The portion of a restricted area usually near or surrounding a limited or exclusion area. Same asexclusion zone.

Controlled lighting. Illumination of specific areas or sections.

Controlled perimeter. A physical boundary at which vehicle and personnel access is controlled at the perimeter of a site. Access control at a controlled perimeter should demonstrate the capability to search individuals and vehicles.

Conventional construction. Building construction that is not specifically designed to resist weapons, explosives, or CBR effects. Conventional construction is designed only to resist common loadings and environmental effects such as wind, seismic, and snow loads.

Coordinate. To advance systematically an exchange of information among principals who have or may have a need to know certain information in order to carry out their roles in a response.

Counterintelligence. Information gathered and activities conducted to protect against espionage, other intelligence activities, sabotage, or assassinations conducted for or on behalf of foreign powers, organizations, or persons, or international terrorist activities, excluding personnel, physical, document, and communications security programs.

Counterterrorism. Offensive measures taken to prevent, deter, and respond to terrorism.

Covert entry. Attempts to enter a facility by using false credentials or stealth.

Crash bar. A mechanical egress device located on the interior side of a door that unlocks the door when pressure is applied in the direction of egress.

Crime Prevention Through Environmental Design (CPTED). A crime prevention strategy based on evidence that the design and form of the built environment can influence human behavior. CPTED usually involves the use of three principles: natural surveillance (by placing physical features, activities, and people to maximize visibility); natural access control (through the judicial placement of entrances, exits, fencing, landscaping, and lighting); and territorial reinforcement (using buildings, fences, pavement, signs, and landscaping to express ownership).

Crisis management. The measures taken to identify, acquire, and plan the use of resources needed to anticipate, prevent, and/or resolve a threat or act of terrorism.

Critical assets. Those assets essential to the minimum operations of the organization, and to ensure the health and safety of the general public.

Critical infrastructure. Primary infrastructure systems (e.g., utilities, telecommunications, transportation) whose incapacity would have a debilitating impact on the school's ability to function.

D

Debris-catching system. Blast wallpaper, fragmentation blankets, or any similar system applied to the inside of a building's exterior walls. Debris-catching systems are often made of Kevlar or geotextile material and are designed to collect wall material debris in the event of an external explosion and to shield occupants from injuries.

Decontamination. The reduction or removal of a CBR material from the surface of a structure, area, object, or person.

Defense layer. Building design or exterior perimeter barriers intended to delay attempted forced entry.

Defensive measures. Protective measures that delay or prevent attack on an asset or that shield the asset from weapons, explosives, and CBR effects. Defensive measures include site work and building design.

Design basis threat. The threat (e.g., tactics and associated weapons, tools, explosives) against which assets within a building must be protected and on which the security engineering design of the school is based.

Design constraint. Anything that restricts the design options for a protective system or that creates additional problems for which the design must compensate.

Design opportunity. Anything that enhances protection, reduces requirements for protective measures, or solves a design problem.

Design team. A group of individuals from various engineering and architectural disciplines responsible for the protective system design.

Disaster. An occurrence of a natural catastrophe, technological accident, or human-caused event that results in severe property damage, deaths, and/or multiple injuries.

Domestic terrorism. The unlawful use, or threatened use, of force or violence committed against persons or property by a group or individual based and operating entirely within the United States or Puerto Rico, without foreign direction, intended to intimidate or coerce a government, the civilian population, or any segment thereof in furtherance of political or social objectives.

Dose rate (radiation). The quantity (total or accumulated) of ionizing radiation or energy absorbed by a person or animal, per unit of time.

Dosimeter. An instrument for measuring and registering total accumulated exposure to ionizing radiation.

Duress alarm devices. Also known as panic buttons, these devices are designated specifically to initiate a panic alarm.

E

Effective standoff distance. A standoff distance at which the required level of protection can be shown to be achieved through analysis or can be achieved through building hardening or other mitigating construction or retrofit.

Electronic entry control systems. Electronic devices that automatically verify authorization for a person to enter or exit a controlled area.

Electronic security system. An integrated system that encompasses interior and exterior sensors, CCTV systems for assessment of alarm conditions, electronic entry control systems, data transmission media, and alarm reporting systems for monitoring, control, and display of various alarm and system information.

Emergency. Any natural or human-caused situation that results in or may result in substantial injury or harm to the population or substantial damage to or loss of property.

Emergency environmental health services. Services required to correct or improve damaging environmental health effects on humans, including inspection for food contamination, inspection for water contamination, and vector control; providing for sewage and solid waste inspection and disposal; performing cleanup and disposal of hazardous materials (HazMat); and conducting sanitation inspection for emergency shelter facilities.

Emergency medical services. Services, including personnel, facilities, and equipment, required to ensure proper medical care for the sick and injured from the time of injury to the time of final disposition, including medical disposition within a hospital, temporary medical facility, or special care facility; release from the site; or declaration of death. Further, emergency medical services specifically include those services immediately required to ensure proper medical care and specialized treatment for patients in a hospital and coordination of related hospital services.

Emergency operations center. The protected site from which State and local civil government officials coordinate, monitor, and direct emergency response activities during an emergency.

Emergency operations plan. A document that describes how people and property will be protected in disaster and disaster threat situations; details who is responsible for carrying out specific actions; identifies the personnel, equipment, facilities, supplies, and other resources available for use in the disaster; and outlines how all actions will be coordinated.

Emergency public information. Information that is dissem¬inated primarily in anticipation of an emergency or at the actual time of an emergency that frequently directs actions, instructs, and transmits direct orders.

Entry control point. A continuously or intermittently manned station at which entry to sensitive or restricted areas is controlled.

Equipment closet. A room in which field control equipment, such as data gathering panels and power supplies, are typically located.

Evacuation. Organized, phased, and supervised dispersal of people from dangerous or potentially dangerous areas.

Evacuation, mandatory or directed. A warning to persons within the designated area that an imminent threat to life and property exists and individuals MUST evacuate in accordance with the instructions of local officials.

Evacuation, spontaneous. Residents or citizens in the threatened areas observe an emergency event or receive unofficial word of an actual or perceived threat and, without receiving instructions to do so, elect to evacuate the area. Their movement, means, and direction of travel are unorganized and unsupervised.

Evacuation, voluntary. A warning to persons within a designated area that a threat to life and property exists or is likely to exist in the immediate future. Individuals issued this type of warning or order are NOT required to evacuate; however, it would be to their advantage to do so.

Evacuees. All persons removed or moving from areas threatened or struck by a disaster.

Exclusion area. A restricted area containing a security interest. See controlled area and limited area.

Exclusion zone. An area around an asset that has controlled entry with highly restrictive access. See controlled area.

F

Federal Response Plan. A Federal plan that establishes a process and structure for the systematic, coordinated, and effective delivery of Federal assistance to address the consequences of any major disaster or emergency.

Fence protection. An intrusion detection technology that detects a person crossing a fence by various methods, such as climbing, crawling, cutting, etc.

Fence sensor. An exterior intrusion detection sensor that detects aggressors as they attempt to climb over, cut through, or otherwise disturb a fence.

Field of view. The visible area in a video picture.

First responder. Local police, fire, and emergency medical personnel who first arrive on the scene of an incident and take action to save lives, protect property, and meet basic human needs.

Forced entry. Entry to a denied area achieved through force to create an opening in a fence, walls, doors, etc., or to overpower guards.

Fragment retention film. A thin, optically clear film applied to glass to minimize the spread of glass fragments when the glass is shattered.

Frangible construction. Building components that are designed to fail to vent blast pressures from an enclosure in a controlled manner and direction.

G

Glare security lighting. Illumination projected from a secure perimeter into the surrounding area, making it possible to see potential intruders at a considerable distance while making it difficult to observe activities within the secure perimeter.

Glazing. A material installed in a sash, ventilator, or panes (e.g., glass, plastic, including material such as thin granite installed in a curtain wall).

H

Hazard. A source of potential danger or an adverse condition.

Hazard mitigation. Any action taken to reduce or eliminate the long-term risk to human life and property from hazards. The term is sometimes used in a stricter sense to mean cost-effective measures to reduce the potential for damage to a facility or facilities from a disaster event.

Hazardous materials (HazMat). Substances or materials that, when involved in an accident and released in sufficient quantities, pose a risk to people's health, safety, and/or property. These substances and materials include explosives, radioactive materials, flammable liquids or solids, combustible liquids or solids, poisons, oxidizers, toxins, and corrosive materials.

High-hazard areas. Geographic locations that, for planning purposes, have been determined through historical experience and vulnerability analysis to be likely to experience the effects of a specific hazard (e.g., hurricane, earthquake, HazMat accident), resulting in vast property damage and loss of life.

High-risk target. Any material resource or facility that, because of mission sensitivity, ease of access, isolation, and symbolic value, may be an especially attractive or accessible terrorist target.

Human-caused hazard. Human-caused hazards are technological hazards and terrorism. They are distinct from natural hazards primarily in that they originate from human activity. Within the military services, the term threat is typically used for human-caused hazard. See definitions of technological hazards and terrorism for further information.

I

International terrorism. Violent acts or acts dangerous to human life that are a violation of the criminal laws of the United States or any State, or that would be a criminal violation if committed within the jurisdiction of the United States or any State. These acts appear to be intended to intimidate or coerce a civilian population, influence the policy of a government by intimidation or coercion, or affect the conduct of a government by assassination or kidnapping. International terrorist acts occur outside the United States or transcend national boundaries in terms of the means by which they are accomplished, the persons they appear intended to coerce or intimidate, or the locale in which their perpetrators operate or seek asylum.

Intrusion detection system. The combination of components, including sensors, control units, transmission lines, and monitor units integrated to operate in a specified manner to detect intrusion.

J

Jersey barrier. A protective concrete barrier initially and still used as a highway divider that now also functions as an expedient method for traffic speed control at entrance gates and to keep vehicles away from buildings.

L

Laminated glass. A flat lite of uniform thickness consisting of two monolithic glass plies bonded together with an interlayer material as defined in Specification C1172. Many different interlayer materials are used in laminated glass.

Landscaping. The use of plantings (shrubs and trees), with or without landforms and/or large boulders, to act as a perimeter barrier against defined threats.

Layers of protection. A traditional approach in security engineering using concentric circles extending out from an area to be protected as demarcation points for different security strategies.

Level of protection. The degree to which an asset is protected against injury or damage from an attack.

Line of sight. Direct observation between two points with the naked eye or hand-held optics.

Line-of-sight sensor. A pair of devices used as an intrusion detection sensor that monitors any movement through the field between the sensors.

Local government. Any county, city, village, town, district, or political subdivision of any State, and Indian tribe or authorized tribal organization, or Alaska Native village or organization, including any rural community or unincorporated town or village or any other public entity.

M

Mail-bomb delivery. Bombs or incendiary devices delivered to the target in letters or packages.

Minimum measures. Protective measures that can be applied to all buildings regardless of the identified threat. These measures offer defense or detection opportunities for minimal cost, facilitate future upgrades, and may deter acts of aggression.

Mitigation. Those actions taken to reduce the exposure to and impact of an attack or disaster.

Motion detector. An intrusion detection sensor that changes state based on movement in the sensor's field of view.

Moving vehicle bomb. An explosive-laden car or truck driven into or near a building and detonated.

Mutual aid agreement. A pre-arranged agreement developed between two or more entities to render assistance to the parties of the agreement.

N

Natural hazard. Naturally-occurring events such as floods, earthquakes, tornadoes, tsunami, coastal storms, landslides, and wildfires that strike populated areas. A natural event is a hazard when it has the potential to harm people or property (FEMA 386-2, Understanding Your Risks: Identifying Hazards and Estimating Losses [2001]). The risks of natural hazards may be increased or decreased as a result of human activity; however, they are not inherently human-induced.

Natural protective barriers. Mountains and deserts, cliffs and ditches, water obstacles, or other terrain features that are difficult to traverse.

Non-exclusive zone. An area around an asset that has controlled entry, but shared or less-restrictive access than an exclusive zone.

Non-persistent agent. An agent that, upon release, loses its ability to cause casualties after 10 to 15 minutes. It has a high evaporation rate, is lighter than air, and will disperse rapidly. It is considered to be a short-term hazard; however, in small, unventilated areas, the agent will be more persistent.

Nuclear, biological, or chemical weapons. Also called weapons of mass destruction. Weapons that are characterized by their capability to produce mass casualties.

P

Passive vehicle barrier. A vehicle barrier that is permanently deployed and does not require response to be effective.

Perimeter barrier. A fence, wall, vehicle barrier, landform, or line of vegetation applied along an exterior perimeter used to obscure vision, hinder personnel access, or hinder or prevent vehicle access.

Persistent agent. An agent that, upon release, retains its casualty-producing effects for an extended period of time, usually anywhere from 30 minutes to several days. A persistent agent usually has a low evaporation rate and its vapor is heavier than air; therefore, its vapor cloud tends to hug the ground. It is considered to be a long-term hazard. Although inhalation hazards are still a concern, extreme caution should be taken to avoid skin contact as well.

Physical security. The part of security concerned with measures/concepts designed to safeguard personnel; to prevent unauthorized access to equipment, installations, materiel, and documents; and to safeguard them against espionage, sabotage, damage, and theft.

Planter barrier. A passive vehicle barrier, usually constructed of concrete and filled with dirt (and flowers for aesthetics). Planters, along with bollards, are the usual street furniture used to keep vehicles away from existing buildings. The overall size and the depth of installation below grade determine the vehicle stopping capability of the individual planter.

Plume. Airborne material spreading from a particular source; the dispersal of particles, gases, vapors, and aerosols into the atmosphere.

Polycarbonate glazing. A plastic glazing material with enhanced resistance to ballistics or blast effects.

Preparedness. Establishing the plans, training, exercises, and resources necessary to enhance mitigation of and achieve readiness for response to, and recovery from, all hazards, disasters, and emergencies, including weapons of mass destruction incidents.

Primary asset. An asset that is the ultimate target for compromise by an aggressor.

Primary gathering building. Inhabited buildings routinely occupied by 50 or more personnel. This designation applies to the entire portion of a building that meets the population density requirements for an inhabited building.

Probability of detection. A measure of an intrusion detection sensor's performance in detecting an intruder within its detection zone.

Probability of intercept. The probability that an act of aggression will be detected and that a response force will intercept the aggressor before the asset can be compromised.

Progressive collapse. A chain reaction failure of building members to an extent disproportionate to the original localized damage. Such damage may result in upper floors of a building collapsing onto lower floors.

Protective barrier. Define the physical limits of a site, activity, or area by restricting, channeling, or impeding access and forming a continuous obstacle around the object.

Protective measures. Elements of a protective system that protect an asset against a threat. Protective measures are divided into defensive and detection measures.

Protective system. An integration of all of the protective measures required to protect an asset against the range of threats applicable to the asset.

R

Radiation. High-energy particles or gamma rays that are emitted by an atom as the substance undergoes radioactive decay. Particles can be either charged alpha or beta particles or neutral neutron or gamma rays.

Radiation sickness. The symptoms characterizing the sickness known as radiation injury, resulting from excessive exposure of the whole body to ionizing radiation.

Radiological monitoring. The process of locating and measuring radiation by means of survey instruments that can detect and measure (as exposure rates) ionizing radiation.

Recovery. The long-term activities beyond the initial crisis period and emergency response phase of disaster operations that focus on returning all systems in the community to a normal status or to reconstitute these systems to a new condition that is less vulnerable.

Response. Executing the plan and resources identified to perform those duties and services to preserve and protect life and property as well as provide services to the surviving population.

Restricted area. Any area with access controls that is subject to special restrictions or controls for security reasons. See controlled area, limited area, exclusion area, and exclusion zone.

Risk. The potential for loss of, or damage to, an asset. It is measured based on the value of the asset in relation to the threats and vulnerabilities associated with it.

Rotating-drum or rotating-plate vehicle barrier. An active vehicle barrier used at vehicle entrances to controlled areas based on a drum or plate rotating into the path of the vehicle when signaled.

S

Sacrificial roof or wall. Roofs or walls that can be lost in a blast without damage to the primary asset.

Safe haven. Secure areas within the interior of the facility. A safe haven should be designed such that it requires more time to penetrate by aggressors than it takes for the response force to reach the protected area to rescue the occupants. It may be a haven from a physical attack or an air-isolated haven from CBR contamination.

Secondary asset. An asset that supports a primary asset and whose compromise would indirectly affect the operation of the primary asset.

Secondary hazard. A threat whose potential would be realized as the result of a triggering event that of itself would constitute an emergency (e.g., dam failure might be a secondary hazard associated with earthquakes).

Situational crime prevention. A crime-prevention strategy based on reducing the opportunities for crime by increasing the effort required to commit a crime, increasing the risks associated with committing the crime, and reducing the target appeal or vulnerability (whether property or person). This opportunity reduction is achieved by management and use policies, such as procedures and training, as well as physical approaches such as alteration of the built environment.

Specific threat. Known or postulated aggressor activity focused on targeting a particular asset.

Standoff distance. A distance maintained between a building or portion thereof and the potential location for an explosive detonation or other threat.

Standoff weapons. Weapons such as antitank weapons and mortars that are launched from a distance at a target.

Stationary vehicle bomb. An explosive-laden car or truck stopped or parked near a building.

Structural protective barriers. Manmade devices (e.g., fences, walls, floors, roofs, grills, bars, roadblocks, signs, other construction) used to restrict, channel, or impede access.

Superstructure. The supporting elements of a building above the foundation.

Supplies-bomb delivery. Bombs or incendiary devices concealed and delivered to supply or material handling points such as loading docks.

T

Tactics. The specific methods of achieving the aggressor's goals to injure personnel, destroy assets, or steal materiel or information.

Taut wire sensor. An intrusion detection sensor using a column of uniformly spaced horizontal wires, securely anchored at each end and stretched taut. Each wire is attached to a sensor to indicate movement of the wire.

Technological hazards. Incidents that can arise from human activities such as manufacture, transportation, storage, and use of HazMat. For the sake of simplicity, technological emergencies are assumed to be accidental and their consequences unintended.

Terrorism. The unlawful use of force and violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives.

Thermally tempered glass. Glass that is heat-treated to have a higher tensile strength and resistance to blast pressures, although with a greater susceptibility to airborne debris.

Threat. Any indication, circumstance, or event with the potential to cause loss of or damage to an asset.

Threat analysis. A continual process of compiling and examining all available information concerning potential threats and human-caused hazards. A common method to evaluate terrorist groups is to review the factors of existence, capability, intentions, history, and targeting.

TNT-equivalent weight. The weight of TNT (trinitrotoluene) that has an equivalent energetic output to that of a specific weight of another explosive compound.

Tornado. A local atmospheric storm, generally of short duration, formed by winds rotating at very high speeds, usually in a counter-clockwise direction. The vortex, up to several hundred yards wide, is visible to the observer as a whirlpool-like column of winds rotating about a hollow cavity or funnel. Winds may reach 300 miles per hour or higher.

Toxic-free area. An area within a facility in which the air supply is free of toxic chemical or biological agents.

Toxicity. A measure of the harmful effects produced by a given amount of a toxin on a living organism.

U

Unobstructed space. Space around an inhabited building without obstruction large enough to conceal explosive devices 150 millimeters (6 inches) or greater in height.

V

Video motion detection. Motion detection technology that looks for changes in the pixels of a video image.

Visual surveillance. The use of ocular and photographic devices (such as binoculars and cameras with telephoto lenses) to monitor facility or installation operations or to see assets.

Volumetric motion sensor. An interior intrusion detection sensor that is designed to sense aggressor motion within a protected space.

Vulnerability. Any weakness in an asset or mitigation measure than can be exploited by an aggressor (potential threat element), adversary, or competitor. It refers to the organization's susceptibility to injury.

W

Warning. The alerting of emergency response personnel and the public to the threat of extraordinary danger and the related effects that specific hazards may cause.

Watch. Indication in a defined area that conditions are favorable for the specified type of severe weather (e.g., flash flood watch, severe thunderstorm watch, tornado watch, tropical storm watch).

Waterborne contamination. CBR agent introduced into and fouling a water supply.

Weapons of mass destruction. Any device, material, or substance used in a manner, in a quantity or type, or under circumstances showing an intent to cause death or serious injury to persons or significant damage to property. An explosive, incendiary, or poison gas bomb, grenade, or rocket having a propellant charge of more than 4 ounces, or a missile having an explosive incendiary charge of more than 0.25 ounce, or mine or device similar to the above; poison gas; weapon involving a disease organism; or weapon that is designed to release radiation or radioactivity at a level dangerous to human life.

Chemical, Biological, and Radiological Glossary

C

This appendix contains some CBR terms that do not actually appear in this manual. They have been included to present a comprehensive list that pertains to this series of publications.

Chemical Terms

A

Acetylcholinesterase. An enzyme that hydrolyzes the neurotransmitter acetylcholine. The action of this enzyme is inhibited by nerve agents.

Aerosol. Fine liquid or solid particles suspended in a gas (e.g., fog, smoke).

Atropine. A compound used as an antidote for nerve agents.

C

Casualty (toxic) agents. Agents that produce incapacitation, serious injury, or death, and can be used to incapacitate or kill victims. They are the blister, blood, choking, and nerve agents.

> **Blister agents.** Substances that cause blistering of the skin. Exposure is through liquid or vapor contact with any exposed tissue (eyes,

skin, lungs). Examples are distilled mustard (HD), nitrogen mustard (HN), lewisite (L), mustard/lewisite (HL), and phenodichloroarsine (PD).

Blood agents. Substances that injure a person by interfering with cell respiration (the exchange of oxygen and carbon dioxide between blood and tissues). Examples are arsine (SA), cyanogen chloride (CK), hydrogen chloride (HCl), and hydrogen cyanide (AC).

Choking/lung/pulmonary agents. Substances that cause physical injury to the lungs. Exposure is through inhalation. In extreme cases, membranes swell and lungs become filled with liquid. Death results from lack of oxygen; hence, the victim is "choked." Examples are chlorine (CL), diphosgene (DP), cyanide (KCN), nitrogen oxide (NO), perfluororisobutylene (PHIB), phosgene (CG), red phosphorous (RP), sulfur trioxide-chlorosulfonic acid (FS), Teflon and PHIB, titanium tetrachloride (FM), and zinc oxide (HC).

Nerve agents. Substances that interfere with the central nervous system. Exposure is primarily through contact with the liquid (skin and eyes) and secondarily through inhalation of the vapor. Three distinct symptoms associated with nerve agents are: pin-point pupils, an extreme headache, and severe tightness in the chest. See also G-series and V-series nerve agents.

Chemical agents. Substances that are intended for use in military operations to kill, seriously injure, or incapacitate people through their physiological effects. Excluded from consideration are riot control agents and smoke and flame materials. The agent may appear as a vapor, aerosol, or liquid; it can be either a casualty/toxic agent or an incapacitating agent.

Cutaneous. Pertaining to the skin.

D

Decontamination. The process of making any person, object, or area safe by absorbing, destroying, neutralizing, making harmless, or removing the hazardous material.

G

G-series nerve agents. Chemical agents of moderate to high toxicity developed in the 1930s. Examples are tabun (GA), sarin (GB), soman (GD), phosphonofluoridic acid, ethyl-, 1-methylethyl ester (GE), and cyclohexyl sarin (GF).

I

Incapacitating agents. Agents that produce temporary physiological and/or mental effects via action on the central nervous system. Effects may persist for hours or days, but victims usually do not require medical treatment; however, such treatment speeds recovery.

Vomiting agents. Agents that produce nausea and vomiting effects; can also cause coughing, sneezing, pain in the nose and throat, nasal discharge, and tears. Examples are adamsite (DM), diphenylchloroarsine (DA), and diphenylcyanoarsine (DC).

Tear (riot control) agents. Agents that produce irritating or disabling effects that rapidly disappear within minutes after exposure ceases. Examples are bromobenzylcyanide (CA), chloroacetophenone (CN or commercially known as Mace), chloropicrin (PS), CNB (CN in benzene and carbon tetrachloride), CNC (CN in chloroform), CNS (CN and chloropicrin in chloroform, CR (dibenz-(b,f)-1,4-oxazepine, a tear gas), CS (tear gas), and Capsaicin (pepper spray).

Central nervous system depressants. Compounds that have the predominant effect of depressing or blocking the activity of the central nervous system. The primary mental effects include the disruption of the ability to think, sedation, and elimination of motivation.

Central nervous system stimulants. Compounds that have the predominant effect of flooding the brain with too much information. The primary mental effect is loss of concentration, causing indecisiveness and the inability to act in a sustained, purposeful manner.

Examples of compounds that are both depressants and stimulants include agent 15 (suspected Iraqi BZ), BZ (3-quinulidinyle benzilate), canniboids, fentanyls, LSD (lysergic acid diethylamide), and phenothiazines.

Industrial agents. Chemicals developed or manufactured for use in industrial operations or research by industry, government, or academia. These chemicals are not primarily manufactured for the specific purpose of producing human casualties or rendering equipment, facilities, or areas dangerous for use by man. Hydrogen cyanide, cyanogen chloride, phosgene, chloropicrin, and many herbicides and pesticides are industrial chemicals that also can be chemical agents.

L

Liquid agents. Chemical agents that appear to be an oily film or droplets. The color ranges from clear to brownish amber.

N

Nonpersistent agents. Agents that, upon release, lose the ability to cause casualties after 10 to 15 minutes. They have a high evaporation rate and are lighter than air and will disperse rapidly. They are considered to be short-term hazards; however, in small unventilated areas, these agents will be more persistent.

O

Organophosphorous compound. A compound containing the elements phosphorus and carbon, whose physiological effects include inhibition of acetylcholinesterase. Many pesticides (malathione and parathion) and virtually all nerve agents are organophosphorous compounds.

P

Percutaneous agents. Agents that are able to be absorbed by the body through the skin.

Persistent agents. Agents that, upon release, retain their casualty-producing effects for an extended period of time, usually anywhere from 30 minutes to several days. A persistent agent usually has a low evaporation rate and its vapor is heavier than air. Therefore, its vapor cloud tends to hug the ground. They are considered to be long-term hazards. Although inhalation hazards are still a concern, extreme caution should be taken to avoid skin contact as well.

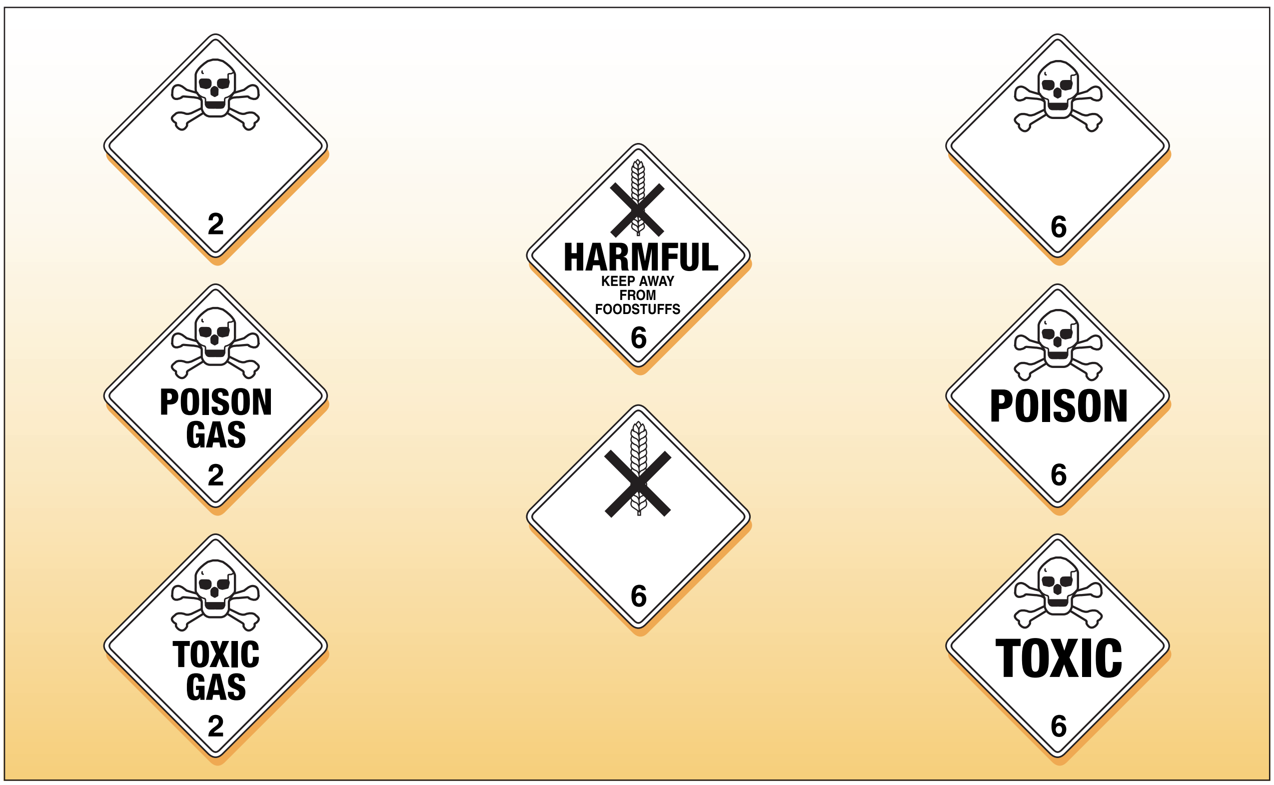
Protection. Any means by which an individual protects his or her body. Measures include masks, self-contained breathing apparatuses, clothing, structures such as buildings, and vehicles.

V

V-series nerve agents. Chemical agents of moderate to high toxicity developed in the 1950s. They are generally persistent. Examples are VE (phosphonothioic acid, ethyl-, S-[2-(diethylamino)ethyl] O-ethylester), VG (phosphorothioic acid, S-[2-(diethylamino)ethyl] O, O-diethyl ester), VM (phosphonothioic acid, methyl-, S-[2-(diethylamino) ethyl] O-ethyl ester), VS (phosphonothioic acid, ethyl, S-[2-[bis(1-methylethyl) amino] ethyl] O-ethyl ester), and VX (phosphonothioic acid, methyl-, S-[2-[bis(1-methylethyl)amino]ethyl] O-ethyl ester).

Vapor agents. A gaseous form of a chemical agent. If heavier than air, the cloud will be close to the ground. If lighter than air, the cloud will rise and disperse more quickly.

Volatility. A measure of how readily a substance will vaporize.



Placards Associated with Chemical Incidents

Biological Terms

A

Aerosol. Fine liquid or solid particles suspended in a gas (e.g., fog, smoke).

Antibiotic. A substance that inhibits the growth of or kills microorganisms.

Antisera. The liquid part of blood containing antibodies that react against disease-causing agents such as those used in biological warfare.

B

Bacteria. Single-celled organisms that multiply by cell division and that can cause disease in humans, plants, or animals.

Biochemicals. The chemicals that make up or are produced by living things.

Biological warfare. The intentional use of biological agents as weapons to kill or injure humans, animals, or plants, or to damage equipment.

Biological warfare agents. Living organisms or the materials derived from them that cause disease in or harm to humans, animals, or plants, or cause deterioration of material. Biological agents may be used as liquid droplets, aerosols, or dry powders.

Bioregulators. Biochemicals that regulate bodily functions. Bioregulators that are produced by the body are termed "endogenous." Some of these same bioregulators can be chemically synthesized.

C

Causative agents. The organism or toxin that is responsible for causing a specific disease or harmful effect.

Contagious. Capable of being transmitted from one person to another.

Culture. A population of microorganisms grown in a medium.

D

Decontamination. The process of making people, objects, or areas safe by absorbing, destroying, neutralizing, making harmless, or removing the hazardous material.

F

Fungi. Any of a group of plants mainly characterized by the absence of chlorophyll, the green colored compound found in other plants. Fungi range from microscopic single-celled plants (such as molds and mildews) to large plants (such as mushrooms).

H

Host. An animal or plant that harbors or nourishes another organism.

I

Incapacitating agents. Agents that produce physical or psychological effects, or both, that may persist for hours or days after exposure, rendering victims incapable of performing normal physical and mental tasks.

Infectious agents. Biological agents capable of causing disease in a susceptible host.

Infectivity. (1) The ability of an organism to spread. (2) The number of organisms required to cause an infection to secondary hosts. (3) The capability of an organism to spread out from the site of infection and cause disease in the host organism.

L

Line-source delivery system. A delivery system in which the biological agent is dispersed from a moving ground or air vehicle in a line perpendicular to the direction of the prevailing wind. (See also “point-source delivery system.”)

M

Microorganism. Any organism, such as bacteria, viruses, and some fungi, that can be seen only with a microscope.

Mycotoxin. A toxin produced by fungi.

N

Nebulizer. A device for producing a fine spray or aerosol.

O

Organism. Any individual living thing, whether animal or plant.

P

Parasite. Any organism that lives in or on another organism without providing benefit in return.

Pathogen. Any organism (usually living), such as bacteria, fungi, and viruses, capable of producing serious disease or death.

Pathogenic agents. Biological agents capable of causing serious disease.

Point-source delivery system. A delivery system in which the biological agent is dispersed from a stationary position. This delivery method results in coverage over a smaller area than with the line-source system. See also line-source delivery system.

R

Route of exposure (entry). The path by which a person comes into contact with an agent or organism (e.g., through breathing, digestion, skin contact).

S

Single-cell protein. Protein-rich material obtained from cultured algae, fungi, protein, and bacteria, and often used as food or animal feed.

Spore. A reproductive form some microorganisms can take to become resistant to environmental conditions, such as extreme heat or cold, while in a "resting stage."

T

Toxicity. A measure of the harmful effect produced by a given amount of a toxin on a living organism. The relative toxicity of an agent can be expressed in milligrams of toxin needed per kilogram of body weight to kill experimental animals.

Toxins. Poisonous substances produced by living organisms.

V

Vaccine. A preparation of killed or weakened microorganism products used to artificially induce immunity against a disease.

Vector. An agent, such as an insect or rat, capable of transferring a pathogen from one organism to another.

Venom. A poison produced in the glands of some animals (e.g., snakes, scorpions, bees).

Virus. An infectious microorganism that exists as a particle rather than as a complete cell. Particle sizes range from 20 to 400 nanometers (one-billionth of a meter). Viruses are not capable of reproducing outside of a host cell.

Placards Associated with Biological Incidents

Radiological Terms

A

Acute radiation syndrome. Consists of three levels of effects: hernatopoletic (blood cells, most sensitive); gastrointestinal (GI cells, very sensitive); and central nervous system (brain/muscle cells, insensitive). The initial signs and symptoms are nausea, vomiting, fatigue, and loss of appetite. Below about 200 rems, these symptoms may be the only indication of radiation exposure.

Alpha particles (α). Alpha particles have a very short range in air and a very low ability to penetrate other materials, but also have a strong ability to ionize materials. Alpha particles are unable to penetrate even the thin layer of dead cells of human skin and consequently are not an external radiation hazard. Alpha-emitting nuclides inside the body as a result of inhalation or ingestion are a considerable internal radiation hazard.

B

Beta particles (β). High-energy electrons emitted from the nucleus of an atom during radioactive decay. They normally can be stopped by the skin or a very thin sheet of metal.

C

Cesium-137 (Cs-137). A strong gamma ray source that can contaminate property, entailing extensive cleanup. It is commonly used in industrial measurement gauges and for irradiation of material. Its half-life is 30.2 years.

Cobalt-60 (Co-60). A strong gamma ray source that is extensively used as a radiotherapeutic for treating cancer, food and material irradiation, gamma radiography, and industrial measurement gauges. Its half-life is 5.27 years.

Curie (Ci). A unit of radioactive decay rate defined as 3.7 x 1010 disintegrations per second.

D

Decay. The process by which an unstable element is changed to another isotope or another element by the spontaneous emission of radiation from its nucleus. This process can be measured using radiation detectors such as Geiger counters.

Decontamination. The process of making people, objects, or areas safe by absorbing, destroying, neutralizing, making harmless, or removing the hazardous material.

Dose. A general term for the amount of radiation absorbed over a period of time.

Dosimeter. A portable instrument for measuring and registering the total accumulated dose to ionizing radiation.

G

Gamma ray (γ). A high-energy photon emitted from the nucleus of atoms; similar to an x-ray. It can penetrate deeply into body tissue and many materials. Cobalt-60 and Cesium-137 are both strong gamma-emitters. Shielding against gamma radiation requires thick layers of dense materials, such as lead. Gamma rays are potentially lethal to humans.

H

Half-life. The amount of time needed for half of the atoms of a radioactive material to decay.

Highly enriched uranium (HEU). Uranium that is enriched to above 20 percent Uranium-235 (U-235). Weapons-grade HEU is enriched to above 90 percent in U-235.

I

Ionize. To split off one or more electrons from an atom, thus leaving it with a positive electric charge. The electrons usually attach to one of the atoms or molecules, giving them a negative charge.

Iridium-192. A gamma ray emitting radioisotope used for gamma radiography. Its half-life is 73.83 days.

Isotope. Forms of the same element that have different numbers of neutrons in the nucleus. For example, deuterium (2H) and tritium (3H) are isotopes of ordinary hydrogen (H).

L

Lethal dose (50/30). The dose of radiation expected to cause death within 30 days to 50 percent of those exposed without medical treatment. The generally accepted range is from 400–500 rem received over a short period of time.

N

Nuclear reactor. A device in which a controlled, self-sustaining nuclear chain reaction can be maintained with the use of cooling to remove generated heat.

P

Plutonium-239 (Pu-239). A metallic element used for nuclear weapons. Its half-life is 24,110 years.

R

Rad. A unit of absorbed dose of radiation defined as deposition of 100 ergs of energy per gram of tissue. A rad amounts to approximately one ionization per cubic micron.

Radiation. High energy alpha or beta particles or gamma rays that are emitted by an atom as the substance undergoes radioactive decay.

Radiation sickness. Symptoms resulting from excessive exposure of the body to radiation.

Radioactive waste. Disposable, radioactive materials resulting from nuclear operations. Wastes are generally classified into two categories, high-level and low-level.

Radiological Dispersal Device (RDD). A device (weapon or equipment), other than a nuclear explosive device, designed to disseminate radioactive material in order to cause destruction, damage, or injury by means of the radiation produced by the decay of such material.

Radioluminescence. The luminescence produced by particles emitted during radioactive decay.

Roentgen Equivalent Man (REM or rem). A unit of absorbed dose that takes into account the relative effectiveness of radiation that harms human health.

S

Shielding. Materials (lead, concrete, etc.) used to block or attenuate radiation for protection of equipment, materials, or people.

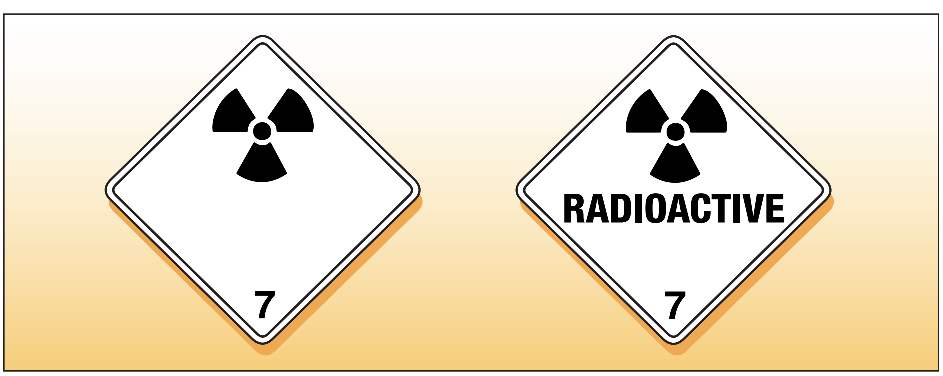
Special Nuclear Material (SNM). Plutonium and uranium enriched in the isotopes Uranium-233 or Uranium-235.

U

Uranium 235 (U-235). Naturally-occurring U-235 is found at 0.72 percent enrichment. U-235 is used as a reactor fuel or for weapons; however, weapons typically use U-235 enriched to 90 percent. Its half-life is 7.04 x 108 years.

X

X-ray. An invisible, highly penetrating electromagnetic radiation of much shorter wavelength (higher frequency) than visible light. Very similar to gamma rays.



Placards Associated with Radiological Incidents

Chemical Warfare Agent Characteristics

Sources: U.S. Department of the Army, *Potential Military Chemical/Biological Agents and Compounds*, U.S. Army Field Manual 3-9, (NAVFAC P-467, AFR 355-'7), 12 December 1990. Washington, D.C.: U.S. Government Printing Office.

Committee on Toxicology, National Research Council. 1997. *Review of Acute Human-Toxicity Estimates for Selected Chemical Warfare Agents*. Washington, D.C.: National Academy Press.

		PHYSICAL AND CHEMICAL PROPERTIES													PHYSIOLOGICAL ACTION						CWC
Agent Type	Chemical Agent; Symbol Chemical Structure	Molecular Weight	State @ 20°C	Odor	Vapor Density (Air = 1)	Liquid Density (g/cc)	Freezing/ Melting Point (°C)	Boiling Point (°C)	Vapor Pressure (mm*Hg)	Volatility (mg/m³)	Heat of Vaporization (cal/g)	Decomposition Temperature (°C)	Flash Point	Stability	Median Lethal Dose (LD_{50}) (mg-min/m³)	Median Incapacitating Dose (ID_{50})	Eye & Skin Toxicity	Rate of Action	Physiological Action	Detoxification Rate	CWC Schedule
NERVE	Tabun; **GA** $C_2H_5OPO(CN)N(CH_3)_2$	162.3	Colorless to brown liquid	Faintly fruity; none when pure	5.63	1.073 at 25°C	-5	240	0.037 @ 20°C	610 @ 25°C	79.56	150	78°C	Stable in steel at normal temperatures	15,000 by skin (vapor) or 1500 (liquid); 70 inhaled	<50 inhaled	Very high	Very Rapid	Cessation of breath -- death may follow	Slight, but definite	1.A.(2)
	Sarin; **GB** $CH_3PO(F)OCH(CH_3)_2$	140.1	Colorless liquid	Almost none when pure	4.86	1.0887 at 25°C	-56	158	2.9 @ 25°C; 2.10 @ 20°C	22,000 @ 25°C; 16,090 @ 20°C	80	150	Non-flammable	Stable when pure	10,000 by skin (vapor) or 1700 (liquid); 35 inhaled	25 inhaled	Very high	Very rapid	Cessation of breath – death may follow	cumulative	1.A.(1)
	Soman; **GD** $CH_3PO(F)OCH(CH_3)C(CH_3)_3$	182.178	Colorless liquid	Fruity; camphor when impure	6.33	1.0222 at 25°C	-42	198	0.4 @ 25°C	3,900 @ 25°C	72.4	130	High enough not to interfere w/ military use	Less stable than GA or GB	2,500 by skin (vapor) or 350 (liquid); 35 inhaled	25 inhaled	Very high	Very rapid	Cessation of breath – death may follow	Low, essentially cumulative	1.A.(1)
	(Cyclo-sarin); **GF** $CH_3PO(F)OC_6H_{11}$	180.2	Liquid	Sweet; musty; peaches; shellac	6.2	1.1327 at 20°C	-30	239	0.044 @ 20°C	438 @ 20°C	90.5	---	94°C	Relatively stable in steel	2,500 by skin (vapor) or 350 (liquid); 35 inhaled	25 inhaled	Very high	Very rapid	Cessation of breath – death may follow	Low	1.A.(1)
	VX $(C_2H_5O)(CH_3O)P(O)S(C_2H_4)N[C_2H_2(CH_3)_2]_2$	267.38	Colorless to amber liquid	None	9.2	1.0083 at 20°C	below -51	298	0.0007 @ 20°C	10.5 @ 25°C	78.2 @ 25°C	Half-life of 36 hr at 150	159°C	Relatively stable at room temperature	150 by skin (vapor) or 5 (liquid); 15 inhaled	25 by skin (vapor) or 2.5 (liquid); 10 inhaled	Very high	Very rapid	Produces casualties when inhaled or absorbed	low, essentially cumulative	1.A.(3)
	V_x ("V sub x")	211.2	Colorless liquid	None	7.29	1.062 at 20°C	---	256	0.007 @ 25°C; 0.004 @ 20°C	75 @ 25°C; 48 @ 20°C	67.2	---	---	Relatively stable	---	---	Very high	Rapid	Produces casualties when inhaled or absorbed	low, essentially cumulative	
BLISTER	Distilled Mustard; **HD** $(ClCH_2CH_2)_2S$	159.08	Colorless to pale yellow liquid	Garlic or horseradish	5.4	1.268 @ 25°C; 1.27 @ 20°C	14.45	217	0.072 @ 20°C	610 @ 20°C	94	149 – 177	105°C; ignited by large explosive charges	Stable in steel or aluminum	900 (inhaled); 5,000 by skin (vapor) or 1,400 (liquid)	500 (skin); 100 (inhaled); 25 (eyes or nose)	Eyes very susceptible; skin less so	Delayed: hours to days	Blisters; destroys tissue; injures blood cells	Very low – cumulative	1.A.(4)
	Nitrogen Mustard; **HN-1** $(ClCH_2CH_2)_2NC_2H_5$	170.08	Dark liquid	Fishy or musty	5.9	1.09 @ 20°C	-34	194	0.24 @ 25°C	1,520 @ 20°C	77	Decomposes before boiling is reached	High enough not to interfere w/ military use	Adequate	1,500 (inhaled); 20,000 (skin)	200 by eye; 9,000 by skin	Eyes susceptible to low concentration; skin less so	Delayed: 12 hours or longer	Blisters; affects respiratory tract; destroys tissue; injures blood cells	Not detoxified; cumulative	1.A.(6)
	Nitrogen Mustard; **HN-2** $(ClCH_2CH_2)_2NCH_3$	156.07	Dark liquid	Soapy (low concentrations); Fruity (high)	5.4	1.15 @ 20°C	-65 to -60	75 at 15mmHg	0.29 @ 20°C	3,580 @ 25°C	78.8	Below boiling; polymerizes with heat generation	High enough not to interfere w/ military use	Unstable	3,000 (inhaled)	<HN-1 & >HN-3; 100 by eye	Toxic to eyes; blisters skin	*Skin* – delayed 12 hrs or more; *Eyes* – faster than HD	Similar to HD; bronchopneumonia possible after 24 hours	Not detoxified; cumulative	1.A.(6)
	Nitrogen Mustard; **HN-3** $N(CH_2CH_2Cl)_3$	204.54	Dark liquid	None, if pure	7.1	1.24 @ 20°C	-37	256	0.0109 @ 25°C	121 @ 25°C	74	Below boiling point	High enough not to interfere w/ military use	Stable	1,500 (inhaled); 10,000 by skin (est.)	200 by eye; 2,500 by skin (est.)	Eyes very susceptible; skin less so	Serious effects same as HD; minor effects sooner	Similar to HN-2	Not detoxified – cumulative	1.A.(6)
	Phosgene oximedichloroforoxime; **CX** CCl_2NOH	113.94	Colorless solid or liquid	Sharp, penetrating	3.9	--	35 to 40	53 –54 at 28mmHg	11.2 @ 25°C (solid); 13 @ 40°C (liquid)	1,800 @ 20°C	101 at 40°C	Decomposes slowly at normal temperature	---	Decomposes slowly	3,200 (inhaled)	very low	Powerful irritant to eyes and nose; liquid corrosive to skin	Immediate effects on contact	Violently irritates mucous membranes, eyes, and nose; forms wheals rapidly	---	
	Lewisite; **L** $ClCHCHAsCl_2$	207.35	Colorless to brownish	Varies; may resemble geraniums	7.1	1.89 @ 20°C	-18	190	0.394 @ 20°C	4,480 @ 20°C	58 at 0°C to 190°C	>100	None	Stable in steel and glass	1,200–1,500 (inhaled); 100,000 (skin)	<300 by eye; >1,500 to 2,000 by skin	Severe eye damage; skin less so	Rapid	Similar to HD, plus may cause systemic poisoning	Not detoxified	1.A.(5)
	Mustard-Lewisite mixture; **HL**	186.4	Dark, oily liquid	Garlic	6.5	1.66 @ 20°C	-25.4 (pure)	<190	0.248@ 20°C	2,730 @ 20°C	58 to 94	>100	High enough not to interfere w/ military use	Stable in lacquered steel	15,000 (inhaled); >10,000 (skin)	200 by eye; 1,500 to 2,000 by skin	Very high	Prompt stinging; blistering agent about 13 hours	Similar to HD, plus may cause systemic poisoning	Not detoxified	1.A.(4); 1.A.(5)
	Phenyldichlorarsine; **PD** $C_6H_5AsCl_2$	222.91	Colorless liquid	None	7.7	1.65 @ 20°C	-20	252 to 255	0.033 @ 25°C	390 @ 25°C	69	Stable to boiling point	High enough not to interfere w/ military use	Very stable	2,600 (inhaled)	16 as vomiting agent; 1,800 as blister	633 mg-min/m³ produces eye casualty; less toxic to skin	Immediate eye effects; skin effects in 30 to 60 minutes	Irritates; causes nausea, vomiting and blisters	Probably rapid	
	Ethyldichlorarsine; **ED** $C_2H_5AsCl_2$	174.88	Colorless liquid	Fruity, but biting; irritating	6.0	1.66 @ 20°C	-65	156	2.09 @ 20°C	20,000 @ 20°C	52.5	Stable to boiling point	High enough not to interfere w/ military use	Stable in steel	3,000–5,000 (inhaled); 100,000 (skin)	5 to 10 by inhalation	Vapor harmful on long exposure; liquid blisters <L	Immediate irritation; delayed blistering	Damages respiratory tract; effects eyes; blisters; can cause systemic poisoning	Rapid	
	Methyldichlorarsine; **MD** CH_3AsCl_2	160.86	Colorless liquid	None	5.5	1.836 @ 20°C	-55	133	7.76 @ 20°C	74,900 @ 20°C	49	Stable to boiling point	High enough not to interfere w/ military use	Stable in steel	3,000 – 5,000 (est.)	25 by inhalation	Eye damage possible; blisters less than HD	Immediate irritation; delayed blistering	Irritates respiratory tract; Injures lungs and eyes; Causes systemic poisoning	Rapid	
BLOOD	Hydrogen cyanide; **AC** HCN	27.02	Colorless gas or liquid	Bitter almonds	0.990 @ 20°C	0.687 @ 20°C	-13.3	25.7	742 @ 25°C; 612 @ 20°C	1,080,000 @ 25°C	233	>65.5	0°C; ignited 50% of time when disseminated by artillery shells	Stable if pure; can burn on explosion	Varies widely with concentration	Varies with concentration	Moderate	Very rapid	Interferes with body tissues' oxygen use; accelerates rate of breathing	Rapid: 0.017 mg/kg/min	3.A.(3)
	Cyanogen chloride; **CK** CNCl	61.48	Colorless gas or liquid	Pungent, biting; Can go unnoticed	2.1	1.18 @ 20°C	-6.9	12.8	1,000 @ 25°C	2,600,000 @ 20°C	103	100	None	Tends to polymerize; may explode	11,000	7,000	Low; lacrimatory and irritating	Very rapid	Chokes, irritates, causes slow breathing rate	Rapid: 0.02 to 0.1 mg/kg/min	3.A.(2)
	Arsine; **SA** AsH_3	77.93	Colorless gas	Mild garlic	2.69	1.34 @ 20°C	-116	-62.5	11,100 @ 20°C	30,900,000 @ 20°C	53.7 @ -62.5°C	280	Below detonation temp.; mixtures w/ air may explode spontaneously	Not stable in uncoated metal containers	5,000	2,500	None	Delayed 2 hours to 11 days	Damages blood, liver, and kidneys	Low	
CHOKING	Phosgene; **CG** $COCl_2$	98.92	Colorless gas	New-mown hay; green corn	3.4	1.37 @ 20°C	-128	7.6	1.173 @ 20°C	4,300,000 @ 7.6°C	59	800	None	Stable in steel if dry	3,200	1,600	None	Immediate to 3 hr. depending on conc.	Damages and floods lungs	Not detoxified – cumulative	3.A.(1)
	Diphosgene; **DP** $ClCOOCCl_3$	197.85	Colorless gas	New-mown hay; green corn	6.8	1.65 @ 20°C	-57	127–128	4.2 @ 20°C	45,000 @ 20°C	57.4	300 to 350	None	Unstable; tends to convert to CG	3,200	1,600	Slightly lacrimatory	Immediate to 3 hr. depending on conc.	Damages and floods lungs	Not detoxified – cumulative	3.A.(1)
VOMITING	Diphenylchloroarsine; **DA** $(C_6H_5)_2AsCl$	264.5	White to brown solid	None	Forms little vapor	1.387 @ 50°C	41 to 44.5	333	0.0036 @ 45°C	48 @ 45°C	56.6	300	350	Stable if pure	15,000 (est.)	12 (>10 minutes)	Irritating; not toxic	Very rapid	Like cold symptoms, plus headache, vomiting, nausea	Moderate	
	Adamsite; **DM** $C_6H_4(AsCl)\text{-}NH)C_6H_4$	277.57	Yellow to green solid	None	Forms little vapor	1.65 (solid) @ 20°C	195	410	Negligible	Negligible	80	>boiling point	None	Stable in glass or steel	Variable; avg.: 11,000	22 (1 min.); 8 (60 min. exposure)	Irritating; relatively not toxic	Very rapid	Like cold symptoms, plus headache, vomiting, nausea	Rapid in small amounts	
	Deiphenylcyanoarsine; **DC** $(C_6H_5)_2AsCN$	255.0	White to pink solid	Bitter almond-garlic mixture	Forms little vapor	1.3338 @ 35°C	31.5 to 35	350	0.0002 @ 20°C	2.8 @ 20°C	71.1	300 (25% decomposed)	Low	Stable at normal temperatures	10,000 (est.)	30 (30 sec); 20 (5 min. exposure)	Irritating; not toxic	More rapid than DM or DA	Like cold symptoms, plus headache, vomiting, nausea	Rapid	
Incapacitating	**BZ**	337.4	White crystal	None	11.6	Bulk 0.51 solid; Crystal 1.33	167.5	320	0.03 @ 70°C	0.5 @ 70°C	62.9	begins at 170°C	246°C	Adequate	200,000 (est.)	112	---	Delayed; 1 to 4 hours depending on exposure	Fast heart beat, vomiting, dry mouth, blurred vision, stupor, increasing random activity	---	2.A.(3)
TEAR	Chloroacetophenone; **CN** $C_6H_5COCH_2Cl$	154.59	Solid	Apple blossoms	5.3	1.318 (solid) @ 20°C	54	248	0.0041 @ 20°C	34.3 @ 20°C	98	Stable to boiling point	High enough not to interfere w/ military use	Stable	7,000 to 14,000	80	Temporarily severe eye irritation; mild skin irritation	Instantaneous	Causes tearing; irritates eyes and respiratory tract	Rapid	
	Chloroacetophenone in Chloroform; **CNC**	128.17	Liquid	Chloroform	4.4	1.40 @ 20°C	0.23	variable, 60 to 247	127 @ 20°C	Indeterminate	n/a	Stable to boiling point	None	Adequate	11,000 (est.)	80	Temporarily severe eye irritation; mild skin irritation	Instantaneous	Cause tearing; irritates eyes and respiratory tract	Rapid	
	Chloroacetophenone and Chloropicrin in Chloroform; **CNS**	141.78	Liquid	Flypaper	~5	1.47 @ 20°C	2	variable, 60 to 247	78 @ 20°C	610,000 @ 20°C (includes solvent)	n/a	Stable to boiling point	None	Adequate	11,400	60	Irritating; not toxic	Instantaneous	Vomiting and choking agent as well as a tear agent	Slow because of effect of PS	
	Chloroacetophenone in Benzene and Carbon Tetrachloride; **CNB**	119.7	Liquid	Benzene	~4	1.14 @ 20°C	-7 to -30	variable 75 to 247	variable; mostly solvent vapor	Indeterminate	n/a	>247	<4.44°C	Adequate	11,000 (est.)	80	Temporarily severe eye irritation; mild skin irritation	Instantaneous	Powerfully lacrimatory	Rapid	
	Bromobenzylcyanide; **CA** $BrC_6H_4CH_2CN$	196	Yellow or solid liquid	Soured fruit	6.7	1.47 @ 25°C	25.5	Decomposes at 242	0.011 @ 20°C	115 @ 20°C	79.5 @ 20°C	60 to 242	None	Fairly stable in glass, lead, or enamel	8,000 to 11,000 (est.)	30	Irritating; not toxic	Instantaneous	Irritates eyes and respiratory passages	Rapid in low dosage	
	O-chlorobenzylmalonitrile; **CS** $ClC_6H_4CHC(CN)_2$	188.5	Colorless solid	Pepper	---	1.04 @ 20°C	93 to 95	310 to 315	0.00034 @ 20°C	0.71 @ 25°C	53.6	---	197°C	Stable	61,000	10 to 20	Highly irritating; not toxic	Instantaneous	Highly irritating; not toxic	Rapid	
	CR $(C_6H_4)_2(O)(N)CH$	195.25	Yellow powder in solution	Burning sensation	6.7	---	72	335	0.00059 @ 20°C	0.63 @ 25°C	---	---	188°C	Stable	---	0.15	Highly irritating; not toxic	Instantaneous	Irritates skin, eyes, nose, and throat	Moderate	
	Chloropicrin; **PS** Cl_3CNO_2	164.38	Liquid	Stinging; pungent	5.6	1.66	-69	112	18.3 @ 20°C	165,000 @ 20°C	---	>400	Not flammable	Adequate; unstable in light	2,000	9	Highly irritating	Instantaneous	Acts as tear, vomiting, and choking agent	Slow	3.A.(4)

Selected Biological Agent Characteristics

Agent Type	Disease/Condition *Causative Agent/ Pathogen*	Description of Agent	Transmissible Person to Person	Infectivity/ Lethality	Incubation Period	Duration of Illness	Persistence/ Stability	Vaccination/ Toxoids	Rate of Action	Symptoms	Treatment	Possible Means of Delivery
BACTERIA	Anthrax (inhalation) *Bacillus anthracis*	Rod-shaped, gram-positive, aerobic sporulating micro-organism, individual spores ~(1–1.2)x(3–5)μ	No	Moderate/ High	1–7 days	3–5 days	Spores are highly stable	Yes	Symptoms in 2–3 days; Shock and death occurs with 24–36 hrs after symptoms	Fever, malaise, fatigue, cough and mild chest discomfort, followed by severe respiratory distress with dyspnea, diaphoresis, stridor, and cyanosis	Usually not effective after symptoms are present, high dose antibiotic treatment with penicillin, ciprofloxacin, or doxycycline should be undertaken. Supportive therapy may be necessary.	Aerosol.
	Brucellosis *Brucella suis, melitensis & abortus*	All non-motile, non-sporulating, gram negative, aerobic bacterium; ~(0.5-1)x(1-2)μ	No	High/Low	Days to months	Weeks to months	Organisms are stable for several weeks in wet soil and food.	Yes	Highly variable, usually 6-60 days.	Chills, sweats, headache, fatigue, myalgias, arthralgias, and anorexia. Cough may occur. Complications include sacroiliitis, arthritis, vertebral osteomyelitis, epididymoorchitis, and rarely endocarditis.	Recommended treatment is doxycycline (200 mg/day) plus rifampin (900 mg/day) for 6 weeks.	Aerosol. Expected to mimic a natural disease.
	Cholera *Vibrio cholerae*	Short, curved, motile, gram-negative, non-sporulating rod. Strongly anaerobic, these organisms prefer alkaline and high salt environments.	Negl.	Low/Moderate-High	1-5 days	1 or more weeks	Unstable in aerosols and pure water, more so in polluted water.	Yes	Sudden onset after 1-5 day incubation period.	Initial vomiting and abdominal distension with little or no fever or abdominal pain. Followed rapidly by diarrhea, which may be either mild or profuse and watery, with fluid losses exceeding 5 to 10 liters or more per day. Without treatment, death may result from severe dehydration, hypovolemia, and shock.	Therapy consists of fluid and electrolyte replacement. Antibiotics will shorten the duration of diarrhea and thereby reduce fluid losses. Tetracycline, ampicillin, or trimethoprim-sulfamethoxazole are most commonly used.	1. Sabotage (food/water supply) 2. Aerosol
	Glanders *Burkholderia mallei*	Gram-negative bacillus primarily noted for producing disease in horses, mules, and donkeys	Negl.	/Moderate-High	10-14 days	N/A	N/A	No	N/A	Inhalational exposure produces fever, rigors, sweats, myalgia, headache, pleuritic chest pain, cervical adenopathy, splenomegaly, and generalized papular/pustular eruptions. Almost always fatal without treatment.	Few antibiotics have been evaluated *in vivo*. Sulfadiazine may be effective in some cases. Ciprofloxacin, doxycycline, and rifampin have *in vitro* efficacy. Extrapolating from melioidosis guidelines, a combination of TMP-SMX + ceftazidime ± gentamicin might be considered.	Aerosol.
	Plague (pneumonic, bubonic) *Yersinia pestis*	Rod-shaped, non-motile, non-sporulating, gram-negative, aerobic bacterium; ~(0.5-1)x(1-2)μ	High	High/Very High in untreated personnel, the mortality is 100%	2 to 6 days for bubonic and 3 to 4 days for pneumonic	1-2 days	Less important because of high transmissibility.	Yes	Two to three days	High fever, chills, headache, hemoptysis, and toxemia, progressing rapidly to dyspnea, sturdier, and cyanosis. Death results from respiratory failure, circulatory collapse, and a bleeding diathesis.	Early administration of antibiotics is very effective. Supportive therapy for pneumonic and septicemic forms is required.	May be delivered via contaminated vectors (fleas) causing bubonic type, or, more likely, via aerosol causing pneumonic type.
	Shigellosis *Shigella Dysenteriae*	Rod-shaped, gram-negative, non-motile, non-sporulating bacterium	Negl.	High/Low	1-7 days (usually 2-3)	N/A	Unstable in aerosols and pure water, more so in polluted water.	No	Symptoms usually within 2-3 days, however, known to demonstrate in as little as 12 hours or as long as 7 days.	Fever, nausea, vomiting, abdominal cramps, watery diarrhea, and occasionally, traces of blood in the feces. Symptoms range from mild to severe with some infected individuals not experiencing any symptoms.	The antibiotics commonly used for treatment are ampicillin, trimethoprim/sulfamethoxazole (also known as Bactrim* or Septra*), nalidixic acid, or ciprofloxacin. Persons with mild infections will usually recover quickly without antibiotic treatment. Antidiarrheal agents such as loperamide (Imodium*) or diphenoxylate with atropine (Lomotil*) are likely to make the illness worse and should be avoided.	Contaminated food or water
	Tularemia *Francisella tularensis*	Small, aerobic, non-sporulating, non-motile, gram-negative *cocco-bacillus* ~0.2x(0.2-0.7)μ	No	High/ Moderate if untreated	1-10 days	2 or more weeks	Not very stable	Yes	Three to five days	Ulceroglandular tularemia with local ulcer and regional lymphadenopathy, fever, chills, headache, and malaise. Typhoidal or septicemic tularemia presents with fever, headache, malaise, substernal discomfort, prostration, weight loss, and non-productive cough.	Administration of anitbiotics with early treatment is very effective. Streptomycin – 1 gm I. M. q. 12 hrs x 10 10-14 d. Gentamicin – 3-5 mg/kg/day x 10-14 d.	Aerosol.
	Typhoid *Salmonella typhi*	Rod-shaped, motile, non-sporulating gram-negative bacterium	Negl.	Moderate/ Moderate if untreated	6-21 days	Several weeks	Stable	Yes	One to three days	Sustained fever, severe headache, malaise, anorexia, a relative bradycardia, splenomegaly, nonproductive cough in the early stage of the illness, and constipation more commonly than diarrhea.	Chloramphenicol amoxicillin or TMP-SMX. Quilone derivatives and third generation cephalusporins and supportive therapy.	Sabotage of food and water supplies.
RICKETTSIAE	Q-Fever *Coxiella burneti*	Bacterium-like, gram-negative organism, pleomorphic 300-700 nm	No	High/Very low	10-20	2 days to 2 weeks	Stable	Yes	Onset may be sudden	Chills, retrobulbar headache, weakness, malaise and severe sweats.	Tetracycline or doxycycline are the treatment of choice and are given orally for 5 to 7 days.	May be a dust cloud either from a line source or a point source (downwind one-half mile or more).
	Typhus (classic) *Rickettsia prowazeki*	Non-motile, minute, coccoid or rod shaped rickettsiae, in pairs or chains, 300 nm	No	High/High	6-15 days	Weeks to months	Not very stable	No	Variable onset, often sudden. Terminates by rapid lysis after about 2 weeks of fever	Headache, chills, prostration, fever, and general pain. A macular eruption appears on the fifth to sixth day, initially on the upper trunk, followed by spread to the entire body, but usually not the face, palms, or soles.	Tetracyclines or chlormphenical orally in a loading dose of 2-3 g, followed by daily doses of 1-2 g/day in 4 divided doses until ind. becomes afelorite (usually 2 days) plus 1 day.	May be delivered via contaminated vectors (lice or fleas).
VIRUSES	Encephalitis	Lipid-enveloped virions of 50-60 nm dia., icosohedral nucleocapsid w. 2 glycoproteins										
	-Eastern/Western Equine Encephalitis (EEE, WEE)		Negl.	High/High	5-15 days	1-3 weeks	Relatively unstable	Yes		Inflammation of the mengies of the brain, headache, fever, dizziness, drowsiness or stupor, tremors or convulsions, muscular incoordination.	No specific treatment; supportive treatment is essential	Airborne spread possible.
	-Venezuelan Equine Encephalitis		Low	High/Low	1-5 days	Days to weeks	Relatively unstable	Yes	Sudden	Inflammation of the mengies of the brain, headache, fever, dizziness, drowsiness or stupor, tremors or convulsions, muscular incoordination.	No specific treatment; supportive treatment is essential	Airborne spread possible.
	Hemorrhagic Fever									Malaise, myalgias, headache, vomiting, and diarrhea may occur with any of the hemorrhagic fevers	No specific treatment; intensive supportive treatment is essential	Airborne spread possible.
	-Ebola Fever	Filovirus	Moderate	High/High	7-9 days	5-16 days	Relatively unstable	No		May also include a macular dermatologic eruption.		
	-Marburg	Filovirus	Moderate					No		May also include a macular dermatologic eruption.		
	-Yellow Fever	Flavivirus. Isosahedral nucleocapsid 37-50 nm diam., lipoprotein env. w/ short surface spikes	Negl.	High/High	3-6 days	1-2 weeks	Relatively unstable	Yes	Sudden			
	Variola Virus (Smallpox)	Asymmetric, brick-shaped, rounded corners; DNA virus	High	High/High	7-17 days	1-2 weeks	Stable	Yes	2-4 days	Malaise, fever, rigors, vomiting, headache, and backache. 2-3 days later lesions appear which quickly progress from macules to papules, and eventually to pustular vesicles. They are more abundant on the extremities and face, and develop synchronously.	No specific treatment; supportive treatment is essential	Airborne spread possible.
TOXIN	Botulinum Toxin	any of the seven distinct neurotoxins produced by the bacillus, *Clostridium botulinum*	No	NA/High	Variable (hours to days)	24-72 hours/Months if lethal	Stable	Yes	12-72 hours	Initial signs and symptoms include ptosis, generalized weakness, lassitude, and dizziness. Diminished salivation with extreme dryness of the mouth and throat may cause complaints of a sore throat. Urinary retention or ileus may also occur. Motor symptoms usually are present early in the disease; cranial nerves are affected first with blurred vision, diplopia, ptosis, and photophobia. Bulbar nerve dysfunction causes dysarthria, dysphonia, and dysphagia. This is followed by a symmetrical, descending, progressive weakness of the extremities along with weakness of the respiratory muscles. Development of respiratory failure may be abrupt.	(1) Respiratory failure—tracheostomy and ventilatory assistance, fatalities should be <5%. Intensive and prolonged nursing care may be required for recovery (which may take several weeks or even months). (2) Food-borne botulism and aerosol exposure—equine antitoxin is probably helpful, sometimes even after onset of signs of intoxication. Administration of antitoxin is reasonable if disease has not progressed to a stable state. Use requires pretesting for sensitivity to horse serum (and desensitization for those allergic). Disadvantages include rapid clearance by immune elimination, as well as a theoretical risk of serum sickness.	1. Sabotage (food/water supply) 2. Aerosol
	Ricin	Glycoprotein toxin (66,000 daltons) from the seed of the castor plant	No	NA/High	Hours	Days	Stable	Not effective	6-72 hours	Rapid onset of nausea, vomiting, abdominal cramps and severe diarrhea with vascular collapse; death has occurred on the third day or later. Following inhalation, one might expect nonspecific symptoms of weakness, fever, cough, and hypothermia followed by hypotension and cardiovascular collapse.	Management is supportive and should include maintenance of intravascular volume. Standard management for poison ingestion should be employed if intoxication is by the oral route.	Aerosol
	Staphylococcal enterotoxin B	One of several exotoxins produced by *Staphylococcus aureus*	No	NA/Low	Days to weeks	Days to weeks	Stable	Not effective	30 min-6 hours	Fever, chills, headache, myalgia, and nonproductive cough. In more severe cases, dyspnea and retrosternal chest pain may also be present. In many patients nausea, vomiting, and diarrhea will also occur.	Treatment is limited to supportive care. No specific antitoxin for human use is available.	1. Sabotage (food/water supply) 2. Aerosol
	Trichothecene (T-2) Mycotoxins	A diverse group of more than 40 compounds produced by fungi.	No	NA/High	Hours	Hours	Stable	Not effective	Sudden	Victims are reported to have suffered painful skin lesions, lightheadedness, dyspnea, and a rapid onset of hemorrhage, incapacitation and death. Survivors developed a radiation-like sickness including fever, nausea, vomiting, diarrhea, leukopenia, bleeding, and sepsis.	General supportive measures are used to alleviate acute T-2 toxicoses. Prompt (within 5-60 min of exposure) soap and water wash significantly reduces the development of the localized destructive, cutaneous effects of the toxin. After oral exposure management should include standard therapy for poison ingestion.	1. Sabotage 2. Aerosol

D

References

Blewett, W.K., and Arca, V.J. , 1999. *Experiments in Sheltering in Place: How Filtering Affects Protection Against Sarin and Mustard Vapor,* ECBC-TR-034, U.S. Army Edgewood Chemical Biological Center, Aberdeen Proving Ground, MD. June.

DoD (U.S. Department of Defense), 2007a, *UFC DoD Minimum Antiterrorism Standards for Buildings,* UFC 4-010-01, http://www.wbdg.org/ccb/DOD/UFC/ufc_4_010_01.pdf. October 8, 2003. Updated January 22, 2007.

DoD, 2007b, *DoD Minimum Antiterrorism Standoff Distances for Buildings,* UFC 4-010-02,

http://www.wbdg.org/ccb/DOD/UFC/ufc_4_010_02.pdf. October 8, 2003. Updated January 19, 2007.

ED (U.S. Department of Education), 2010, *Digest of Education Statistics: 2010,* U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics: Washington, DC. http://nces.ed.gov/programs/digest/d10/index.asp.

ED, 2007, *Practical Information on Crisis Planning: A Guide for Schools and Communities,* U.S. Department of Education, Office of Safe and Drug-Free Schools: Washington, D.C. January.

ED, 2004, *School Survey on Crime and Safety (SSOCS)*, U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics: Washington, DC.

Federal Bureau of Investigation, 2007, *Crime in Schools and Colleges: A Study of Offenders and Arrestees Reported via National Incident-Based Reporting System Data*, prepared by James H. Noonan and Malissa C. Vavra, Crime Analysis, Research and Development Unit, Criminal Justice Information Services Division, Federal Bureau of Investigation, U.S. Department of Justice: Washington, DC. October.

FEMA (Federal Emergency Management Agency), 2012, *Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings*, Building and Infrastructure Protection Series (BIPS) 06 (Formerly FEMA 426), Federal Emergency Management Agency: Washington, DC. To be published.

FEMA, 2010, *Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds*, FEMA P-424, Federal Emergency Management Agency: Washington, DC. December. http://www.fema.gov/library/viewRecord.do?id=1986.

FEMA, 2009a, *Handbook for Rapid Visual Screening of Buildings to Evaluate Terrorism Risks*, FEMA 455, Federal Emergency Management Agency: Washington, DC. March. http://www.fema.gov/library/viewRecord.do?id=1567.

FEMA, 2009b, *Protecting Manufactured Homes from Floods and Other Hazards, A Multi-Hazard Foundation and Installation Guide,* FEMA P-85, Federal Emergency Management Agency: Washington, DC. November. http://www.fema.gov/library/viewRecord.do?id=1577.

FEMA, 2008, *Design and Construction Guidance for Community Safe Rooms*, FEMA 361, Federal Emergency Management Agency: Washington, DC. August. http://www.fema.gov/library/viewRecord.do?id=1657.

FEMA, 2006, *Design Guidance for Shelters and Safe Rooms*, FEMA 453, Federal Emergency Management Agency: Washington, DC. May. http://www.fema.gov/library/viewRecord.do?id=1910.

FEMA, 2005, *Risk Assessment: A How-To Guide to Mitigate Potential Terrorist Attacks*, FEMA 452, Federal Emergency Management Agency: Washington, DC. January. http://www.fema.gov/library/viewRecord.do?id=1938.

FEMA, 2004, *Primer for Design of Commercial Buildings to Mitigate Terrorist Attacks*, FEMA 427, Federal Emergency Management Agency: Washington, DC. October. http://www.fema.gov/library/viewRecord.do?id=1560.

FEMA, 2003, *Reference Manual to Mitigate Potential Terrorist Attacks against Buildings*, FEMA 426, Federal Emergency Management Agency: Washington, DC. December. http://www.fema.gov/library/viewRecord.do?id=1559.

GSA (General Services Administration), 2000, *Progressive Collapse Analysis and Design Guidelines for New Federal Office Buildings and Major Modernization Projects*, General Services Administration: Washington, DC. November. Updated guidelines prepared by Applied Research Associates, Inc. June 2003.

GSA, 1996, *Facilities Standards for the Public Building Service*, GSA PBS-PQ100.1, General Services Administration: Washington, DC. June 14, 1996.

ISC (Interagency Security Committee), 2004a. *ISC Security Design Criteria for New Federal Office Buildings and Major Modernization Projects: Part I.* 29 September 2004. For Official Use Only.

ISC, 2004b. *ISC Security Design Criteria for New Federal Office Buildings and Major Modernization Projects: Part II: Tables, Design Tactics, and Additional Risk Guidelines.* 29 September 2004. For Official Use Only.

ISC, 2004c. *ISC Security Standards for Leased Space.* 29 September 2004. For Official Use Only.

National Advisory Committee on Children and Terrorism, 2003, *Schools and Terrorism: A Supplement to the National Advisory Committee on Children and Terrorism Recommendations to the Secretary*, prepared by Brenda Greene, School Health Programs Director, National School Boards Association, and Member, National Advisory Committee on Children and Terrorism, Lisa C. Barrios, DrPH, Joy Elizabeth Blair, and Lloyd Kolbe, PhD, Division of Adolescent and School Health, Centers for Disease Control and Prevention. August 12, 2003.

NCTC (National Counter Terrorism Center), 2011, *2010 Report on Terrorism*, Office of the Director of National Intelligence, National Counterterrorism Center: Washington, DC. April 30, 2011.

NCTC, 2010, *2009 Report on Terrorism,* Office of the Director of National Intelligence, National Counterterrorism Center: Washington, DC. April 30, 2010.

NCTC, 2009, 2*008 Report on Terrorism*, Office of the Director of National Intelligence, National Counterterrorism Center: Washington, DC. April 30, 2009.

NIBS (National Institute of Building Sciences), 2010, *UFC/ISC Security Design Criteria Overview and Comparison*, Whole Building Design Guide program, prepared by Joseph L. Smith, PSP and Dan E. Kelley, Last updated: July, 23, 2010, http://www.wbdg.org/resources/ufc_isc.php.

National Institute of Justice, 1999, *The Appropriate and Effective Use of Security Technologies in U.S. Schools – A Guide for Schools and Law Enforcement Agencies,* NCJ 178265, prepared by Mary W. Green, Sandia National Laboratories, for the U.S. Department of Justice, Office of Justice Programs, National Institute of Justice: Washington, DC. September.

RAND Center for Terrorism Risk Management Policy, 2005, E*stimating Terrorism Risk*, prepared by Henry H. Willis, Andrew R. Morral, Terrence K. Kelly, and Jamison Jo Medby, RAND Corporation: Santa Monica, CA.

Stevens, K.R. 2006. *Educational Facilities within the Context of a Changing 21st Century America*. National Clearinghouse for Educational Facilities: Washington DC.

The State of Colorado, 2001, The Report of the Governor Bill Owens' – Columbine Review Commission. May.

U.S. Army Chemical Materials Agency, 2008, *Collective-Protection Shelters of the Chemical Stockpile Emergency Preparedness Program: Technical Record And Lessons Learned*, 2nd Edition, CBRNIAC Report prepared by Battelle Eastern Science and Technology Center for the U.S. Army Chemical Materials Agency: Aberdeen Proving Ground, MD. September.

U.S. Department of Homeland Security (DHS), 2011, *Integrated Rapid Visual Screening Series (IRVS) for Buildings*, Building and Infrastructure Protection Series Tools, U.S. Department of Homeland Security: Washington, DC. October.

U.S. Secret Service and U.S. Department of Education, 2002, *Threat Assessment in Schools: A Guide to Managing Threatening Situations and to Creating Safe School Climates*, U.S. Secret Service and U.S. Department of Education: Washington, DC. May.

E

Associations

American Lifelines Alliance
http://www.americanlifelinesalliance.org

Applied Technology Council
http://www.atcouncil.org

Battelle Memorial Institute, National Security Program
http://www.battelle.org/natsecurity/default.stm

Center for Strategic and International Studies (CSIS)
http://www.csis.org

Centers for Disease Control and Prevention (CDC)/National Institute for Occupational Safety and Health (NIOSH)
http://www.cdc.gov/niosh

Central Intelligence Agency (CIA)
http://www.cia.gov

Council on Tall Buildings and Urban Habitat (CTBUH)
http://www.ctbuh.org

Federal Aviation Administration (FAA)
http://www.faa.gov

Healthy Buildings International, Inc.
http://www.healthybuildings.com

Institute of Transportation Engineers
http://www.ite.org

Interagency Security Committee (ISC)
http://www.dhs.gov/files/committees/gc_1194539370126.shtm

International CPTED [Crime Prevention Through Environmental Design] Association (ICA)
http://www.cpted.net/

Lawrence Berkeley National Laboratory (LBNL)
http://securebuildings.lbl.gov

National Academy of Sciences
http://www.nasonline.org/

Federal Facilities Council (FFC) Standing Committee on Physical Security and Hazard Mitigation
http://sites.nationalacademies.org/DEPS/FFC/DEPS_047556

National Research Council
http://www.nationalacademies.org/nrc/index.html

National Defense Industrial Association (NDIA)
http://www.ndia.org

Public Entity Risk Institute
http://www.riskinstitute.org

Security Design Coalition
http://www.designingforsecurity.org

Security Industry Association (SIA)
http://www.siaonline.org/

Technical Support Working Group
(Departments of Defense and State)
http://www.tswg.gov

U.S. Air Force Electronic System Center (ESC),
Hanscom Air Force Base
http://www.hanscom.af.mil/units/esc/index.asp

U.S. Army Soldiers and Biological Chemical Command (SBCCOM)
http://www.globalsecurity.org/military/agency/army/sbccom.htm

U.S. Department of Justice
http://www.justice.gov/

Federal Bureau of Investigation: Terrorism in the United States reports
http://www.fbi.gov/stats-services/publications

National Institute of Justice (NIJ)
http://nij.gov/

Office of Domestic Preparedness (ODP)
http://www.ojp.usdoj.gov/

U.S. Marshals Service (U.S.MS)
http://www.usmarshals.gov/

The Infrastructure Security Partnership (TISP)
http://www.tisp.org
Founding Organizations

American Council of Engineering Companies (ACEC)
http://www.acec.org

The American Institute of Architects (AIA)
http://www.aia.org/

American Society of Civil Engineers (ASCE)
http://www.asce.org

Architectural Engineering Institute (AEI)
http://content.aeinstitute.org/inside/intro.html

Civil Engineering Research Foundation (CERF) of ASCE
http://www.cerf.org

Structural Engineering Institute (SEI) of ASCE
http://www.seinstitute.org

Associated General Contractors of America
http://www.agc.org

Construction Industry Institute
http://construction-institute.org

Federal Emergency Management Agency (FEMA)
http://www.fema.gov

Human Caused Hazards
http://www.fema.gov/hazard/index.shtm

Mitigation Planning
http://www.fema.gov/plan/mitplanning/index.shtm

Federal Facilities Council – See National Academy of Sciences

National Institute of Standards and Technology (NIST), Building and Fire Research Laboratory
http://www.nist.gov/building-and-fire-research-portal.cfm

Naval Facilities Engineering Command
http://www.navfac.navy.mil

Society of American Military Engineers (SAME)
http://www.same.org

U.S. Army Corps of Engineers
http://www.usace.army.mil

Selected Member Organizations

Air-Conditioning and Refrigeration Institute, Inc.
http://www.ari.org

Air Conditioning Contractors of America
http://www.acca.org

Airport Consultants Council
http://www.acconline.org

Alliance for Fire & Smoke Containment & Control
http://www.afscconline.org

American Association of State Highway and Transportation Officials (AASHTO)
http://www.transportation.org

American Institute of Chemical Engineers, Center for Chemical Process Safety
http://www.aiche.org/ccps

American Planning Association
http://www.planning.org

American Public Works Association
http://www.apwa.net

American Railway Engineering & Maintenance of Way Association
http://www.arema.org

American Society for Industrial Security International (ASIS)
http://www.asisonline.org

American Society of Heating, Refrigerating, and
Air-Conditioning Engineers (ASHRAE)
http://www.ashrae.org

American Society of Interior Designers
http://www.asid.org

American Society of Landscape Architects (ASLA)
http://www.asla.org

American Society of Mechanical Engineers (ASME)
http://www.asme.org

American Underground Construction Association (AUA)
http://www.auca.org

American Water Resources Association (AWRA)
http://www.awra.org

Associated Locksmiths of America
http://www.aloa.org

Association of Metropolitan Water Agencies
http://www.amwa.net

Association of State Dam Safety Officials
http://www.damsafety.org

Building Futures Council
http://www.thebfc.org/Home_Page.html

Building Owners and Managers Association International (BOMA), Emergency Resource Center
http://www.boma.org/

California Department of Health Services, Division of Drinking Water & Environmental Management
http://www.dhs.cahwnet.gov/ps/ddwem

Construction Industry Roundtable
http://www.cirt.org

Construction Innovation Forum
http://www.cif.org

Construction Specifications Institute
http://www.csinet.org

Construction Users Roundtable
http://www.curt.org

Defense Threat Reduction Agency (DTRA)
http://www.dtra.mil

Design-Build Institute of America
http://www.dbia.org

Drexel (University) Intelligent Infrastructure & Transportation Safety Institute
http://www.di3.drexel.edu

Federal Highway Administration
http://www.fhwa.dot.gov

Florida Department of Transportation, Emergency Management Office
http://www.dot.state.fl.us/EmergencyManagement/

George Washington University, Institute for Crisis, Disaster, and Risk Management
http://www.cee.seas.gwu.edu
or
http://www.seas.gwu.edu/~icdm

Homeland Protection Institute, Ltd.
http://www.hpi-tech.org

Inland Rivers Ports and Terminals
http://www.irpt.net

Institute of Electrical and Electronics Engineers, Inc. - U.S.A
http://www.ieeeusa.org

International Association of Foundation Drilling
http://www.adsc-iafd.com

International Code Council (ICC)
http://www.intlcode.org
Consolidates services, products, and operations of BOCA (Building Officials and Code Administrators), ICBO (International Conference of Building Officials) and SBCCI (Southern Building Code Congress International) into one member service organization — the International Code Council (ICC) in January 2003.

International Facility Management Association (IFMA)
http://www.ifma.org

Market Development Alliance of the FRP Composites Industry
http://www.mdacomposites.org

Multidisciplinary Center for Earthquake Engineering Research
http://mceer.buffalo.edu

National Aeronautics and Space Administration
http://www.nasa.gov

National Capital Planning Commission (NCPC)
http://www.ncpc.gov

National Center for Manufacturing Sciences
http://www.ncms.org

National Concrete Masonry Association
http://www.ncma.org

National Conference of States on Building Codes and Standards
http://www.ncsbcs.org

National Council of Structural Engineers Associations (NCSEA)
http://www.ncsea.com/

National Crime Prevention Institute
http://louisville.edu/ncpi

National Fire Protection Association
http://www.nfpa.org

National Institute of Building Sciences (NIBS)
http://www.nibs.org and http://www.wbdg.org

National Park Service, Denver Service Center
http://www.nps.gov/dsc

National Precast Concrete Association
http://www.precast.org

New York City Office of Emergency Management
http://www.nyc.gov/html/oem/html/home/home.shtml

Ohio State University
http://www.osu.edu/homelandsecurity

Pentagon Renovation Program
http://renovation.pentagon.mil

Portland Cement Association (PCA)
http://www.cement.org/

Protective Glazing Council
http://www.protectiveglazing.org

Protective Technology Center at Penn State University
http://www.ptc.psu.edu

SAVE International
http://www.value-eng.org

Society of Fire Protection Engineers
http://www.sfpe.org

Southern Building Code Congress, International
http://www.sbcci.org

Sustainable Buildings Industry Council
http://www.sbicouncil.org

Transportation Research Board/Marine Board
http://www.trb.org

Transportation Security Administration
http://www.tsa.gov

U.S. Air Force Civil Engineer Support Agency
http://www.afcesa.af.mil

U.S. Coast Guard
http://www.uscg.mil

U.S. Department of Energy
http://www.energy.gov

Sandia National Laboratories (SNL)
http://www.sandia.gov

U.S. Department of Health and Human Services
http://www.hhs.gov

U.S. Department of Veterans Affairs (VA)
http://www.va.gov/

U.S. Environmental Protection Agency (EPA), Chemical Emergency Preparedness and Prevention Office (CEPPO)– Counter-terrorism
http://www.epa.gov/ceppo/

U.S. General Services Administration (GSA)
http://www.gsa.gov

U.S. Green Building Council
http://www.usgbc.org

U.S. Marine Corps Headquarters
http://www.marines.mil/unit/hqmc/Pages/default.aspx

U.S. Society on Dams
http://www.ussdams.org

University of Missouri, Department of Civil & Environmental Engineering, National Center for Explosion Resistant Design
http://ncerd.missouri.edu/

Virginia Polytechnic Institute and State University
http://www.vt.edu/

Water and Wastewater Equipment Manufacturers Association
http://www.wwema.org
The Partnership for Critical Infrastructure (PCIS)
http://www.pcis.org
Note: Involved mainly with information systems and not building real property.

Government

Department of Energy (DOE)
http://www.energy.gov

Department of Homeland Security
www.dhs.gov/

National Infrastructure Protection Center (NIPC)
http://www.nipc.gov
Private Sector

Anser Institute for Homeland Security (ANSER)
http://www.homelandsecurity.org

CERT® Coordination Center (CERT/CC)
http://www.cert.org

Electronic Warfare Associates (EWA)
http://www.ewa.com

The Institute for Internal Auditors (IIA)
http://www.theiia.org

National Cyber Security Alliance (Alliance)
http://www.staysafeonline.org/

North American Electric Reliability Council (NERC)
http://www.nerc.com

SANS Institute (SANS - SysAdmin, Audit, Network, Security)
http://www.sans.org

The Financial Services Roundtable Technology Group (BITS)
http://www.bits.org

The U.S. Chamber of Commerce, Center for Corporate Citizenship (CCC)
http://www.uschamber.com/chambers/ccc

Selected States and Local Organizations

Association of Metropolitan Water Agencies
http://www.amwa.net

The Council of State Governments (CSG)
http://www.csg.org

International Association of Emergency Managers (IAEM)
http://www.iaem.com

National Association of State CIOs (NASCIO)
http://www.nascio.org

National Emergency Managers Association (NEMA)
http://www.nemaweb.org

National Governor's Association (NGA)
http://www.nga.org

The National League of Cities (NLC)
http://www.nlc.org

F

Building Vulnerability Assessment Checklist

The School Buildings Vulnerability Assessment Checklist is based on the checklist developed by the National Clearinghouse for Educational Facilities that combines the nation's best school facility assessment measures into one list for assessing the safety and security of school buildings and grounds. It covers school surroundings, school grounds, buildings and facilities, communication systems, building access, control and surveillance, utility systems, mechanical systems, and emergency power.

It allows a consistent security evaluation of designs at various levels. The checklist can be used as a screening tool for preliminary design vulnerability assessment. In addition to examining design issues that affect vulnerability, the checklist includes questions that determine if critical systems continue to function in order to enhance deterrence, detection, denial, and damage limitation, and to ensure that emergency systems function during a threat or hazard situation.

The checklist is organized into the 6 sections listed below. To conduct a vulnerability assessment of a building or preliminary design, each section of the checklist should be assigned to an engineer,

> The checklist is organized into the 6 sections listed below. To conduct a vulnerability assessment of a building or preliminary design, each section of the checklist should be assigned to an engineer, architect, or subject matter expert who is knowledgeable and qualified to perform an assessment of the assigned area.

architect, or subject matter expert who is knowledgeable and qualified to perform an assessment of the assigned area. Each assessor should consider the questions and guidance provided to help identify vulnerabilities and document results in the observations column. If assessing an existing building, vulnerabilities can also be documented with photographs, if possible. The results of the assessment should be integrated into a master vulnerability assessment and provide a basis for determining vulnerability ratings during the assessment process.

1. School Grounds (Site)
2. School Buildings and Facilities (Architectural)
3. Building Access Control a d Surveillance
4. Emergency Power/Communications
5. Mechanical System
6. Security Systems

Section 1	School Grounds (Site)		
Section	Vulnerability Question	Guidance	Observations
1.1	Can site entry points can be readily observed and monitored by staff and students in the course of their normal activities? Are site entry points positioned so that one individual can monitor as many entries as possible?	Nothing should block this means of visual surveillance, neither signs, trees, shrubs, nor walls.	
1.2	Is natural surveillance from the neighborhood maintained, allowing neighbors and passing patrol cars to help serve as guardians of the school? Are there are any hidden areas on the site?	In many cases, landscaping, signs, bus shelters, trash receptacles, mailboxes, storage sheds, or street furniture can be altered or moved to improve natural surveillance.	

Section 1	School Grounds (Site)		
Section	**Vulnerability Question**	**Guidance**	**Observations**
1.3	Are there hidden areas adjacent to the school that might provide intruders or students with "cover" for illicit activities? Have they been made safer by exposure, or by some other measures?	Solid walls, tall shrubs, parked cars, outbuildings, sculptures, large signs, and other obstacles can block natural surveillance, and should not be placed adjacent to the school building. Natural methods of mitigation to increase visibility or expose these hidden areas include installing openings or windows in solid walls, replacing solid walls with wrought iron fencing, blocking access to the hidden area entirely, and removing any welcoming features such as benches that draw people into the hidden area. In addition, convex mirrors can be installed or electronic surveillance equipment, or increase patrols.	
1.4	Are the school site and buildings well maintained, reinforcing territoriality? Are there signs of graffiti, breakage, neglect, or disrepair?	Well maintained buildings and grounds promote civil order and demonstrate ownership of and respect for school property, qualities that tend to be reciprocated by users. Where necessary and possible, exterior walls should be treated to repel graffiti or tolerate repeated cleaning, and game lines should be provided on walls and 1-5 surfaces in play areas so that students are not tempted to create their own.	
1.5	Does the school have a marquee or other sign visible from outside school property that clearly identifies the school by name? Are site entry points clearly marked?	The school should have a distinctive marking to help emergency responders, new students and visitors. Site entry points should be clearly marked and distinguished between main entry points and others.	
1.6	Do adequate signs, postings, or window decals direct all visitors to the main site entry points to gain permission to enter? Are illustrations, such as a map with arrows showing visitors the route to the main entry, included where appropriate?	Signs should be simple, readable, well lit, written in all relevant languages, located at all entry points onto the property and at all entry points into the school, and easy to read from distance, such as from a car window when approaching the site by car.	
1.7	Are school property lines clearly marked, establishing territoriality?	Boundaries between public and school-only areas should be similarly marked. Examples of property line markers include fencing, landscaping, natural geographic features, ground surface treatments, sculpture, architectural features, signs, or changes in elevation.	

Section 1	School Grounds (Site)		
Section	**Vulnerability Question**	**Guidance**	**Observations**
1.8	Have future development plans in the surrounding area been identified and has the school site development planning been adjusted accordingly? Are separate wings, separate buildings, and standalone, portable or modular classrooms readily identified from a distance by colors, icons, or signage?	Future development plans in the surrounding area can change the threat and vulnerability of the school. Reflective or lighted markings are ideal. Clear identification of buildings and areas greatly aids emergency response and rescue efforts.	
1.9	Are entry points to the site kept to a minimum? Are there are at least two entry points so that if one is blocked, the other can be used? Do site entries provide for the ready passage of fire trucks and other emergency vehicles?	Entry points should be kept to a minimum to reduce the number of points the school needs staff; however, there should be at least be two entry points. The site entries should be wide enough for passage by fire trucks and other emergency vehicles.	
1.10	Can unsupervised site entrances be secured during low-use times for access control purposes and reinforce the idea that access and parking are for school business only? Are gates available for closing access points when necessary? Do perimeter fences, walls, or "hostile vegetation" provide sufficient access control, surveillance and territoriality?	Site entrances can be secure by gates during low-use times. Perimeter access control options include: a. A solid wall or fence blocks natural surveillance and can attract graffiti, but can be an effective barrier against bullets and can enhance privacy. b. Wire mesh fencing usually provides foot holds, making it easy to climb over; it is relatively easy to vandalize, but is often the most economical option. Smaller gauge wire mesh may deter climbing. Powder-coated wire mesh fencing can be more aesthetically pleasing. c. Wrought iron fencing is low maintenance, vandal resistant, does not block surveillance or provide foot holds. A short fence can establish territoriality, but is of limited value for controlling access. Tall, continual fencing can significantly restrict access, but may also block a pedestrian path serving students who walk to and from school, forcing them to take a longer route where they are more exposed to traffic, crime, or environmental hazards. A compromise such as installing lockable gates at selected locations that would define likely entry points, and provide the school with the ability to further secure the site and also create an unexpected barrier for unauthorized users.	

Section 1	School Grounds (Site)		
Section	**Vulnerability Question**	**Guidance**	**Observations**
1.10 (cont.)		d. "Hostile vegetation" (dense, thorny groundcover or bushes) often can be used effectively to define boundaries of various kinds around and within school property, providing it doesn't interfere with natural surveillance.	
1.11	Have potential threats or targets near the school been identified, along with possible collateral impact? Are appropriate crisis plans in place?	Examples of potential targets include nearby chemical plants, gas lines, railroad lines, heavy truck traffic, and also government buildings, structures with high symbolic value, power plants, communication towers and dams. A crisis plan should be implemented especially if there is a identified threat or target near the school. A terrorist attack upon adjacent a building may impact the school site.	
1.12	Are panic button or intercom call boxes used in parking areas, at entry points, in isolated areas, or along the building perimeter as needed? Where panic buttons or call boxes are impractical, do individuals carry pendant alarms?	In-coming messages from the field can help keep security staff apprised of developments. Pendant alarms are wireless panic bottoms that can be carried by students and staff.	
1.13	Is the perimeter of the site secured to a level that prevents unauthorized vehicles or pedestrians from entering, and does this occur as far from the school building as possible? Are perimeter barriers capable of stopping vehicles?	Passive barriers include bollards, walls, hardened fences, trenches, ponds/basins, concrete planters, steel furniture, plantings, trees, sculptures, and fountains. Active barriers include pop-up bollards, swing arm gates, and rotating plates and drums. Anti-ram protection may be provided by adequately designed bollards, street furniture, fences, walls, sculpture, and landscaping. Antiram protection should be able to stop the threat vehicle at the speed attainable by that vehicle at impact. If anti-ram protection cannot absorb the expected kinetic energy, speed controls such as speed bumps should be added to limit vehicle speed. Serpentine driveways can help slow down vehicle's approach. REFERENCES: MILITARY HANDBOOK 1013/14 AND GSA PBS P-100	

Section 1	School Grounds (Site)		
Section	**Vulnerability Question**	**Guidance**	**Observations**
1.14	Can vehicle entry be controlled, to permit entry by only one vehicle at a time? Is there space outside the protected perimeter to pull over and inspect cars?	Vehicle entry can be controlled on-site by identification checks, security personnel, and access control. Vehicle access control and inspection should occur as far from facilities as possible (preferably at the site perimeter) with the ability to regulate the flow of people and vehicles one at a time. REFERENCE: GSA PBS-P100	
1.15	Are manholes, utility tunnels, culverts, and similar unintended access points to the school property secured with locks, gates, or other appropriate devices, without creating additional entrapment hazards?	Eliminate potential site access through utility tunnels, corridors, manholes, storm runoff culverts, etc. These utility paths can be used by aggressors to access the site and to hide. The appropriate measures should be taken to secure these features and preventing an unintended access point without creating an entrapment hazard. REFERENCE: GSA PBS-P100	
1.16	In case of chemical spills, is the school site in a depression or low area that can trap heavy vapors and inhibit natural decontamination?	Depressions can inhibit natural decontamination by prevailing winds, and reduce the effectiveness of in-place sheltering. REFERENCE: USAF INSTALLATION FORCE PROTECTION GUIDE	
1.17	In areas of high fire risk, are fire evacuation sites at least 300 feet from at-risk buildings?	The location for students and faculty to gather after evacuating the building should be at a safe distance from the buildings (at least 300ft).	
1.18	Are the locations of bomb threat evacuation sites kept confidential on a need-to-know basis?	The location for students and faculty to gather after evacuating during a bomb threat should be kept confidential and on a need-to-know basis so that aggressors cannot include this location in their attack plans.	
1.19	Are outdoor containers in which explosives can be hidden (such as garbage cans, mailboxes, and recycling or newspaper bins) kept at least 30 feet from the building and are they designed to restrict the size of objects placed inside them or to make them visible?	Outdoor containers should be placed at least 30 feet from the building to provide minimal standoff if an explosive device is place inside. Restricting the size of the containers reduces the size of explosive that can be hidden in the containers.	

Section 1	School Grounds (Site)		
Section	**Vulnerability Question**	**Guidance**	**Observations**
1.20	In areas considered susceptible to explosive attack, is the standoff between buildings and the nearest parking or roadway at least 75 feet, or in case of unreinforced masonry or wooden buildings, even more?	If this is not feasible, consider creating additional standoff protection through barriers and parking restrictions. Unscreened vehicles need more standoff than screened vehicles. Also consider relocating vulnerable functions inside the building.	
1.21	Does landscaping reinforce access control, natural surveillance, and territoriality?	Careful design can maintain sight lines for effective surveillance. Where fences are used around property, appropriate landscaping can communicate to the public the message of privacy. It can also screen neighborhood development, soften intrusive noise, and discourage unwanted visitors. In more rural settings landscaping defines boundaries without the use of fences. Landscaping can serve to control and direct access and traffic. Trees lining sidewalks or drives can give natural direction to pedestrian and vehicular traffic and limit /deny access to sections of the school site. Hedges should be kept low enough to expose places where people could hide. North Carolina recommends that shrubs and hedges bordering walkways not exceed 18 inches in height and that tree branches and leaves be kept clear to a minimum height of 8 feet off the ground. Large tree canopies have a tremendous capacity to absorb high-speed wind energy from hurricanes and other storms, thereby reducing storm damage.	
1.22	Are trees located far enough away from buildings or are they trimmed appropriately to avoid providing roof, window, or second story access, damage from falling limbs, or a fire hazard in areas at risk of forest or brush fires?	It is recommended that a minimum distance of 10 feet be provided between buildings and trees.	
1.23	Are trees well maintained, with dead or weak limbs or trees removed? Are trees planted far enough away from exits, access roads, equipment, utilities and emergency refuge areas to ensure that, if they blow over or lose large branches, they will not block these areas?	Exits, access roads, equipment, utilities, and emergency refuge areas should be clear of potential blockages in case of an emergency.	

Section 1	School Grounds (Site)		
Section	**Vulnerability Question**	**Guidance**	**Observations**
1.24	Are planters, garbage cans, seating, tables, or other amenities on site well maintained, free of vandalism, and vandal resistant? Do they restrict sidewalk space unreasonably or create logjams for passers-by?	Well maintained grounds promote civil order and demonstrate ownership of and respect for school property, qualities that tend to be reciprocated by users. Placement of site amenities should not impair pedestrian movement especially if it restricts an evacuation route.	
1.25	Is exterior lighting uniform and does it eliminate pockets of shadow or glare?	Pockets of shadow or glare can impair site surveillance. Exterior lighting is best evaluated at night.	
1.26	Are exterior lighting fixtures vandal resistant, beyond easy reach (at least 12 to 14 feet off the ground), maintainable, and built with break-resistant lenses or protected by cages or other means? Are lighting fixtures designed to avoid providing handholds for climbing onto the building?	Light fixtures are a frequent target of vandalism. The damage and theft of a fixture can leave an area vulnerable to thieves and dangerous to walk through. Therefore, the proper selection and installation of fixtures is critical. They should be mounted as high as possible and still provide the illumination required. Fixtures should not be hanging or projecting to provide footholds for scaling a wall. They should be flush mounted or recessed whenever possible and covered with an impact resistant material.	
1.27	Is exterior lighting well maintained? Is the exterior lighting scheme effective for enhancing natural surveillance, discouraging trespassing, and preventing school vandalism? Can exterior lighting controls be centrally accessed from the main administration area? Does school lighting avoid excessive illumination of adjacent properties?	Practice either "full lighting" or "dark campus" approach after hours. Dark campus approach discourages trespassing inside the building at night (intruders' lights are readily visible) and saves on electricity. Motion detectors should be used to activate lighting as needed. Security lighting should be directed at the building if the building is to be patrolled from the exterior. Lighting should illuminate the grounds if the building is to be patrolled from the interior, without compromising surveillance by creating glare for the observer. Timers or motion detectors should illuminate entry points.	
1.28	Are all vehicle pathways, access points, and interfaces with main thoroughfares designed to avoid accidents, speeding, blind spots and traffic conflicts? Are transitional areas between streets and school access points clearly marked, such as with "School Zone" signs?	Traffic control options include: Traffic controls or calming devices such as speed humps, bumps, raised crosswalks or traffic circles that reduce the likelihood of injury due to speeding vehicles. Driveways that curve, change direction, or are broken into short enough segments to prevent cars from building up speed. Driveways that access side streets, rather than main streets. Signs, fences and landscaping at intersections do not block vision.	

Section 1	School Grounds (Site)		
Section	**Vulnerability Question**	**Guidance**	**Observations**
1.29	Is pedestrian safety addressed by well-designed crossing areas and separation from vehicle traffic?	Pedestrian safety options include: Lighting, traffic signals, flags, painted crosswalks, signs, and crossing guards that are visible to drivers. Electronically controlled "Walk/Don't Walk" lights with countdown displays and push buttons. Pedestrian islands or median strips that provide safe havens for students crossing streets. Pedestrian bridges, walking or biking paths that provide alternatives to walking near traffic.	
1.30	Does emergency vehicle access around the building meet local requirements?	If emergency vehicle access lanes are required by local codes, they should be constructed as wide sidewalks or grassed, hardened surfaces. Vehicular access should be over the curb, rather than via curb cuts that could encourage unauthorized use. California requires a 20-foot-wide fire lane.	
1.31	Are bus, car, pedestrian and bike traffic reasonably safe from each other at entry and exit points as well as throughout the site, and do traffic calming strategies discourage speeding?	Options include raised and marked pedestrian or bicycle crossings, median strips, pedestrian safety islands, one-way traffic, speed bumps, speed humps, and the elimination or remediation of blind spots through the installation of convex mirrors.	
1.32	Are vehicle circulation routes to service and delivery areas, visitors' entry, bus drop-off, student parking, and staff parking separated as needed and do they function safely in the context of the site?	Pedestrian access and traffic should not be endangered by car traffic. Pedestrian access, especially from public transportation, should not cross vehicle traffic if possible.	
1.33	Where there are roadways through the site, are they serpentine or otherwise indirect or do they include traffic calming features, with gates or barriers as needed? Do signs prohibit through traffic?	Through traffic should be eliminated on the school campus.	
1.34	Are designated entries, routes, and parking lots for after-hours use clearly identified and controlled within the context of the site?	Signage should be visible and clearly identify designate entries, routes, and parking lots for after-hours use to direct vehicle traffic.	

Section 1	School Grounds (Site)		
Section	**Vulnerability Question**	**Guidance**	**Observations**
1.35	Are hiding places minimized or eliminated along pedestrian routes?	Hiding places can be exposed to natural surveillance by trimming landscaping, improving lighting, removing solid fencing, or installing convex mirrors.	
1.36	Can buses drop and pick up students directly from a designated, marked loading and unloading zone near a designated and supervised school entrance, in full view of designated school staff? Do students have to walk in front of the bus or other traffic to move between the bus and the school? Do busses have to back up to turn or park, or do they have to be parked in double rows?	The site should be designed to have a separate loading and unloading zone for students that is adjacent to the school entrance with proper supervision. Buses should park appropriately in the drop and pickup zone so that students do not have to walk in front of the bus or other traffic to move to the entrance. This can be eliminated by having busses park in a single row with no busses having to back up or turn to park.	
1.37	Are areas where students congregate while waiting for buses, and associated pedestrian paths, adequate to avoid overcrowding? Are curb lanes adjacent to school facades marked to prohibit parking?	Paths from drop off areas need to be wide enough to accommodate peak periods of use, thus preventing congestion, pushing, and accidents. If adequate standoff distance is not provided between the school and the curb, parking along the curb should be prohibited and clearly marked.	
1.38	Are parent drop-off and pick-up zones clearly designated and separated from bus traffic?	Parent drop-off and pick-up zones should be separated from bus traffic to avoid conflicts. Signage should clearly indicate and direct parents to appropriate zone.	
1.39	Are parking areas within view of the main office, other staffed areas, or surveillance cameras? Do signs or posted rules clearly identify who is allowed to use parking facilities and when they may do so? Is visitor parking located near the main entrance, with clear signs directing visitors to the main office?	All parking areas should be monitored and provide signs posting rules. Surveillance of parking areas can be provided by locating the parking adjacent to main-offices or other staffed areas with clear views of the entire lot. In addition, routine patrols can be conducted or cameras can be installed.	

Section 1	School Grounds (Site)		
Section	**Vulnerability Question**	**Guidance**	**Observations**
1.40	In high schools, are parking spaces numbered and marked for the designated users: students, faculty, staff, and visitors? Are unassigned parking spaces minimized, especially in student parking zones? In high schools, is a section of the parking lot reserved for students who attend part time or who spend part of the day off-site? Is access to parking areas limited by curbs, fencing, gates, and a minimum number of entry points?	This makes it easier for the school to secure the main parking area during the day and for staff to pay attention to cars coming and going during the school day.	
1.41	Can gates close off unnecessary parking entrances during low-use times to control access and reinforce the perception that school parking areas are private? Are student and staff parking areas separated or mixed appropriately for the school's circumstances?	Separate parking areas may protect staff's cars from vandalism. They can also make it easier to manage parking overload. Staff can park near a secondary entry where they can use proximity cards to gain entry. Unlike publicly accessible entries, the staff parking entry does not need to be supervised. Mixed parking can provide adult supervision in areas prone to inappropriate behavior in student vehicles.	
1.42	Do school expansion plans include anticipated parking expansion?	Note that parking patterns predict entry points; if drivers start using a new lot on the south side; they will enter and exit on the south side regardless of where the official entry is. Plans for expanded parking should anticipate this by adding a fully controlled entry that serves the new area.	
1.43	Are dumpsters either enclosed in a designated service area or surrounded on three sides by a high wall, preferably a see-through, climbing-resistant fence, and provided with a securable gate? Are dumpsters and their enclosures positioned so that they cannot be used as ladders for gaining access to the school roof?	Through the use of see-through fencing, wall openings, convex mirrors or motion response lighting, hiding around these enclosures can be made difficult.	

Section 1	School Grounds (Site)		
Section	**Vulnerability Question**	**Guidance**	**Observations**
1.44	Is access to site utilities, such as electrical transformers, generators, and meters, limited and secure, and is exposed equipment protected against vandalism and vehicular damage? Do site utilities create hiding places? Do site utilities impede access by emergency vehicles?		
1.45	Are fire hydrants on or around the site readily visible and accessible?	Just as vehicle access points to the site must be able to transit emergency vehicles, so too must the emergency vehicles, so too must the emergency vehicles have access to the buildings and, in the case of fire trucks, the fire hydrants. Thus, security considerations must accommodate emergency response requirements. REFERENCE: GSA PBS-P100	
1.46	Are school buildings and structures located an appropriate distance from power transmission lines?	It is recommended that the following minimum distances between school facilities and power transmission lines: 100-110 kV line, 100 feet from easement 220-230 kV line, 150 feet from easement 345 kV line, 250 feet from easement	
1.47	Where used, are storm water retention areas located to help limit access to school property, demarcate school boundaries, or segregate play and pedestrian areas from heavy vehicular traffic?	Storm water retention areas can be used to demarcate school boundaries.	

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
Art Rooms			
2.1	Does faculty have a clear view of the entire art room area, including the kiln room entry?	Classrooms should be organized for easy monitoring. This aids natural surveillance and reduces opportunities for misbehavior.	
Music Rooms			
2.2	Does faculty have a clear view of the entire music room area, including practice and storage room entries?	It is important to facilitate visual supervision by one person over a large assembly of students.. This aids natural surveillance and reduces opportunities for misbehavior.	
2.3	Are there lockable rooms for storing equipment and instruments? Does the music room have an alarm system to deter breaking and entering?	Storage for equipment and supplies should be locked at all times. Both sets of doors in entry vestibule should have locking hardware and access detection alarms.	
Dance Rooms			
2.4	Does faculty have a clear view of the entire dance room area?	Classrooms should be organized for easy monitoring. This aids natural surveillance and reduces opportunities for misbehavior.	
Auditoriums			
2.5	Are there separate, secure, controllable entrances to the auditorium, theater, or center for after-hours activities? Is attendee access to the rest of the school controlled?	A separate, secure entrance should be provided to the auditorium to prevent people from having to walk through other areas of the school after-hours. Access to the rest of the school from the auditorium should be controlled. This can be accomplished by locking wing doors or accordion-style gates or other means, provided emergency egress is not blocked.	
2.6	Do clear sight lines allow for visual surveillance?	Large school assembly area auditoriums should provide clear sight lines. Niches along walls should be eliminated, and if the auditorium is subdivided by for dual use as classrooms, the partitions should fully recess into the wall. Partitions that do not recess can form a barrier for people to hide behind when the auditorium is empty, as well as giving cover to those intent on disrupting a general assembly. This aids natural surveillance and reduces opportunities for misbehavior.	

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
2.7	Do seating and circulation layouts reduce or eliminate traffic flow conflicts?	The seating and circulation layout should allow for easy traffic flow that allows for continuous and efficient egress in case of an emergency.	
2.8	Is there a secure and fireproof storage for stage equipment, props, costumes, and tools?	Stage equipment, props, costumes, and tools can be fire hazards and should be properly stored.	
2.9	Is suspended lighting equipment and cabling safe and in good repair? Is lighting and scenery hoisting equipment in good repair?	Suspended lighting and scenery can become falling hazards.	
2.10	Is access to catwalks, scaffolding, and upper level platforms limited and controlled?	Catwalks, scaffolding, and upper platforms should limit access to appropriate staff. Care must be taken not to locate roof openings close to these structures as it is possible to gain entry into an auditorium by prying open a roof hatch or smoke vent and traveling via a scaffold down to floor level.	
Classrooms			
2.11	Are all parts of the classroom visible from the classroom door, with no parts of the classroom hidden from sight?	Classrooms should be organized for easy monitoring.	
2.12	Do interior windows between classrooms and corridors promote visual surveillance in both directions? Are they obstructed by posters, pictures, or other posted materials?	Visual access to the hallway is desirable. Interior windows can allow for additional visual surveillance between classrooms and corridors. Posters, pictures, or other posted materials should not cover more than 20% of the window obstructing visual surveillance.	
2.13	Do classroom windows enhance visual surveillance of the school grounds?	Visual access to the exterior is desirable. Classroom windows can be used to enhance natural surveillance of the school grounds.	
2.14	Do retractable classroom partitions fully recess into permanent, lockable niches to eliminate hiding places?	Classrooms that include retractable partitions must provide an opening in the partition for egress and visual access. Niches should be provided for housing partitions when they are in a retracted position.	

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
2.15	Are classrooms well lit, with as much natural light as possible?	Well-lit classrooms are safer, and natural light does not depend on a power source.	
2.16	In high risk areas, are windows and their framing and anchoring systems designed and located to resist the effects of explosive blasts, gunfire, and forced entry?	Windows overlooking or directly exposed to public streets or dangerous areas should be either minimized or protected. The greatest risk to occupants from an explosive blast originating near the school or even blocks away is injury from flying glass shards, so window glazing should be laminated or protected with an anti-shatter film. Glass-clad polycarbonate and laminated polycarbonate are two types of alternative glazing material. Bullet resistant glazing should meet the requirements of UL 752. Security glazing should meet the requirements of ASTM F1233 or UL 972. Window assemblies containing forced-entry-resistant glazing should meet the requirements of ASTM F588.	
2.17	Are light levels appropriate and uniform, creating minimal glare or pockets of shadow? Are they well maintained? Fluorescent lighting fixtures manufactured before 1979 contain both mercury and PCBs. Were they replaced with PCB-free models and disposed of as required by law?	Well lit classrooms are safer classrooms. It is important to be aware of the line of sight between the light fixtures location and objects that may cast a shadow. Careful placement will avoid dark corners behind doors, trashcans, etc. Most types of high-intensity discharge (HID) lamps (mercury vapor, metal halide, and high-pressure sodium) also contain mercury.	
2.18	Are all classrooms, including portable classrooms, on the public address system? Do intercoms, phones, or radios allow for two-way verbal communication between all classrooms and the school's administrative or security offices?	Public address systems provide a means of mass communication and can be used to provide warning and alert information, along with actions to take before and after an incident if there is a redundancy and power. Two-way communication is desirable. REFERENCE: DOD UFC 4-010-01	

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
2.19	Does door hardware allow staff to quickly lock down classrooms from the inside without having to step into the hallway? Do door access devices such as master keys or proximity cards allow staff to gain quick entry to any room where students have secured themselves? Does door hardware permit criminals or vandals to lock or chain classroom doors as a way of significantly slowing down security officers in pursuit? Can classroom doors always be opened from the inside for emergency egress purposes? Are exterior classroom doors made of metal or solid wood, with heavy duty, vandal-resistant locks?	Every schoolroom should be able to serve as a safe haven. The rooms should be easy to lock during a crisis without requiring someone to first move into a danger zone. The door should lock automatically or have a simple locking mechanism, such as a button to push in. Dual cylinder, ANSI F88 locksets are recommended for all classroom doors. They allow doors to be locked from either side to prevent entry into the classroom from the corridor side, but they cannot be locked (in accordance with building and fire code requirements) to prevent egress from the classroom. The capability to quickly lock the door from either side is the fastest solution for "lockdown" situations. Additionally, F88 locksets meet all ADA requirements. Installation costs are a few hundred dollars per door.	
2.20	Does door and window security hardware allow egress from classrooms at all times? Do all classrooms have secondary escape routes where required by the building code? Are windows designated for escape readily operable and not blocked by grills or screens?		
2.21	Are egress paths along the secondary escape route at least 28 inches wide?	Examples of violations include a space of only 17 inches between a desk and wall in an egress path or only 14 inches between rows of desks or tables.	
2.22	Do teaching materials and children's artwork cover more than 20 percent of the wall area? Are decorative materials, curtains, draperies, streamers, and fabrics flame resistant?	Section14.7.3.3 of the NFPA 101 Life Safety Code prohibits greater than 20 percent coverage for reasons of fire safety.	

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
2.23	Are corridor sight lines maximized for natural surveillance and safety? Are corridors well lit with artificial or natural lighting and have no dark or shadowed recesses?	As a general rule hallways should be broad, well lit, and void of projections. Clear direct views provide opportunities for natural surveillance, which deters misbehavior. Students are less inclined to misbehave when they know they can be seen, and thus are likely to be caught.	
2.24	Are recesses, niches, or blind corners visually exposed with windows, convex mirrors, chamfered (angled) corners, or surveillance cameras? Are they shallow enough in depth not to serve as hiding areas or sealed off against illicit use?	Designs which lead to sudden 90 degree turns and narrow hallways should be avoided. The corners allow people to hide and cause others to run into each other. Chamfered corners allow better visibility as well as smoother pedestrian traffic flow. Windows near classroom doors allow instructors to monitor corridors. If door niches are provided they should be chamfered and wide enough to allow a clear line of sight down the hall	
2.25	Do otherwise hidden corridors and stairwells receive visual surveillance through the placement of windowed administrative offices or other spaces occupied by adults or through the use of video surveillance equipment?	Blind corners and stairwells can hide inappropriate behavior. Windows add natural surveillance, while mirrors provide a secondary view. If neither of these is an option, cameras or staff patrols are alternatives.	
2.26	Are corridors wide enough to prevent crowding and provide adequate room for maneuvering wheelchairs?	Much of the design of school corridors is dictated by the life safety requirements which ensure that hallways are wide enough to allow students to evacuate the building quickly. Corridors are usually cited as the second most common indoor location for school fights (cafeterias are first), primarily because of crowding. Wide corridors prevent crowding and jostling. During class changes, corridors also serve as commons areas, and spacious corridors help reduce undesirable behavior. North Carolina recommends the following corridor widths: a. Corridors serving classroom feeder corridors and large-group spaces such as cafeterias, media centers, gyms and auditoriums: elementary and middle schools, 10 feet; high schools, 12 feet. b. Classroom corridors serving more than 2 classrooms, 8 feet. c. Classroom corridors serving more than 8 classrooms, 9 feet. d. Corridors with lockers along one wall, add 2 feet; with lockers along both walls, add 3 feet.	

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
Corridors			
2.27	Are exit signs well maintained, easily seen, and pointing in the right direction?	The maintenance program for corridor, stairwell, and exit sign lighting should ensure functioning under normal and emergency power conditions. Expect state or local building codes to be updated to require floor proximity signs, which are needed when heat and smoke drive occupants to crawl along the floor to get out of a building; signs and lights mounted high on the wall or on the ceiling may be of little or no benefit in such situations. Consider glow-in-the-dark technology. Good quality, consistent exit lighting is cost-effective in the long term and worthwhile from a maintenance perspective. Using different exit lighting at different doors makes it harder to stock, keep track of, and replace parts efficiently.	
2.28	Are clear and precise emergency evacuation maps posted at critical locations? Are they customized or posted to match their positions in the building and protected from vandalism or removal?	Evacuation procedures and maps should be strategically placed throughout the school. It is desirable to have customized maps posted to match the position in the school and to be encased in a protective cover.	
2.29	Are vending machines and public telephones located in well-monitored activity areas rather than in isolated areas? Are vending machines recessed flush in alcoves that do not provide hiding places? Do vending machines and public telephones impede natural surveillance or cause foot traffic conflicts?	To reduce hiding places and possible injury, water coolers, vending machines, trash containers, and lockers should be either low profile or flush with the wall. Avoid creating alcoves, nooks and other small spaces along corridors that promote criminal activity. Move vending machines and public telephones from isolated areas (these draw people into the hidden area) to well-monitored areas. .	
2.30	Are doors sized and arranged to reduce congestion and avoid crowding?	Multiple single doors reduce congestion and are recommended over double doors. Oversize doors accommodate movement of large items and are recommended for accessible areas, music rooms, vocational development spaces, kitchens, and receiving areas.	

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
2.31	Do locker locations and designs cause crowding or security problems?	Options to consider are: Lockers are easiest to supervise if they are in controlled classrooms, such as homerooms. Lockers in hallways should be mounted flush to the wall so that they don't narrow the hallway. Single lockers lead to less conflict than over and under designs. Spreading lockers out can help avoid congestion and conflict. Unused lockers should be locked. If the supply of lockers is excessive, locking every other locker can help avoid congestion. Locker bays should not block natural surveillance into or around the bays, or the bays should be electronically monitored. Metal mesh doors allow natural surveillance into the lockers. Locker bays should be well lit and allow ample room for circulation. Lockers should be bolted in place. Assign locker privileges selectively and revoke them for related abuse, such as for storing contraband. If nothing else works, consider removing or locking all lockers against any use, even temporarily.	
Custodial Rooms			
2.32	Are all rooms containing mechanical, electrical, communications, water, fire, security, and other critical equipment identified by number or simply as "Equipment Room" to provide less information to intruders?	Check with local emergency responders to ensure they are comfortable with this kind of unspecific designation.	
2.33	Are doors to these rooms made of metal or solid wood, with concealed hinges, pick plates, high quality deadbolt locks, and high security strike plates?	The use of hinges with non-removable pins and strike plate covers reduce the potential for forced break-ins.	

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
2.34	Are fire doors tight fitting and in good operational condition?	Custodial rooms are high risk areas for fires. Fire doors will limit the spread of fire and significantly reduce the area that could be affected. Fire doors are sometimes rendered unable to provide its listed fire resistance by ignorance of the intended use and associated restrictions and requirements, or by inappropriate use. For example, fire doors are sometimes blocked open, or carpets are run through them, which would allow the fire to travel past the fire barrier in which the door is placed.	
2.35	Are chemical storage areas labeled with appropriate NFPA hazard diagrams?	Store flammable materials in a properly labeled storage cabinet that meets design criteria set forth by the National Fire Protection Association.	
2.36	Are custodial closets containing cleaning solvents or other potentially toxic materials, potentially hazardous tools, or master keys, able to be securely locked?	All chemicals should be in lockable/securable closets such that access is limited to appropriate school staff.	
Elevators			
2.37	Do elevators have adequate security measures in place to address local conditions? Are elevator cabs and landing areas well lit?	General access to elevators should be controlled with limited access to authorized individuals. The use of elevators for criminal activities could be significantly deterred by: Limiting use and access to authorized individuals. Installing elevators in the main lobby or other areas with good visual surveillance. Including a 5-foot-deep landing area in front of the elevator, out of hallway traffic, to minimize traffic conflicts. Installing video cameras in front of and within elevator cabs. Providing elevator recall and emergency message capability.	

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
Entry Areas			
2.38	Is the main point of entry at the front of the school and readily identifiable? Is the main entry, or a supervised and controlled designated secondary entry, the closest entry option for visitors approaching after parking?	Ideally, the main point of entry should be at the front of the school and provide a safe, well lit, and protected shelter for people entering the school. The main entrance should be clearly identified by signage.	
2.39	Are the areas directly outside and inside the main entry well-lit, sheltered from the elements, and spacious enough to avoid becoming overcrowded? Are entry walkways and doors wide enough to avoid overcrowding at peak times? Where building and stair exit doors are protected from the weather, do they serve as concealed areas for unwanted activity?	An overhang should be large enough to shelter a large number of people. The walkway must be wide enough to accommodate seating areas without obstructing normal pedestrian movement. Vandal proof lighting should be provided. Covered areas require careful design to prevent them from becoming dark alcoves that someone can hide in. Completely hidden alcoves may shield door and stairs from inclement weather, but also can serve as concealed areas for criminal activity.	
2.40	Do signs spell out behavioral expectations, access restrictions, and applicable local and state regulations? Where security screening is warranted, does the entry have adequate space for queuing, equipment, and pulling students aside for more thorough investigation?		
2.41	Is the number of building entries and exits kept to a minimum, and are all controlled or supervised?		

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
2.42	Are panic or duress alarm buttons installed at the reception desk? Can doors be electronically locked to block visitors' entry into the building? When the main entry doors are unlocked, can securable internal doors oblige visitors to confer with the receptionist to gain entry beyond the reception area?		
2.43	Do windows facilitate surveillance from the reception area, providing, on the outside, an unimpeded view of the main entry and drop-off and visitor parking areas, and, on the inside, a view of the adjoining halls and stairwells, and, preferably, the closest bathroom entries?	The school receptionist is in a key position to conduct natural surveillance if windows permit.	
2.44	Does the reception area include adequate protective Features?	This includes: counter or desk to serve as a protective shield, a panic or duress button to call for help, and a telephone, a radio base station if radios are used.	
2.45	Is the school's main administrative area located off the reception area so administrators can see who is coming and going?	Administration areas should be adjacent to main entry areas and be visibly accessible through windows to provide a connection between administrators and students or visitors.	
2.46	Does the school layout require visitors to pass through at least visual screening before they can gain access to bathrooms, service spaces, stairwells, or other amenities inside the school? Can anyone get past the reception area without being seen close enough by staff to be identified?		

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
2.47	Is the reception area protected by a bullet-resistant windows and walls or does it have a rear exit or safe haven into which the receptionist can retreat?	A safe haven is a windowless room with a solid door, easily locked from the inside without requiring a key, and in which there is a telephone for calling for help.	
2.48	Are entries designed to mitigate explosive blast hazards? Do they contain design elements that could entrap an explosion, thus amplifying its impact? Are interior and exterior foyer doors offset from one another? Do doors and walls along the line of security screening meet requirements of UL 752, Standard for Safety: Bullet-Resisting Equipment?		
2.49	Are windows and their framing and anchoring systems designed and located to resist the effects of explosive blasts, gunfire, and forced entry?	Windows overlooking or directly exposed to public streets or dangerous areas should be either minimized or protected. The greatest risk to occupants from an explosive blast originating near the school or even blocks away is injury from flying glass shards, so window glazing should be laminated or protected with an anti-shatter film. Glass-clad polycarbonate and laminated polycarbonate are two types of alternative glazing material. Bullet resistant glazing should meet the requirements of UL 752. Security glazing should meet the requirements of ASTM F1233 or UL 972. Window assemblies containing forced-entry-resistant glazing should meet the requirements of ASTM F588.	
Exit Ways			
2.50	Does the school layout require visitors to pass through at least visual screening before they can gain access to bathrooms, service spaces, stairwells, or other amenities inside the school? Can anyone get past the reception area without being seen close enough by staff to be identified?		

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
2.51	Is the reception area protected by a bullet-resistant windows and walls or does it have a rear exit or safe haven into which the receptionist can retreat?	A safe haven is a windowless room with a solid door, easily locked from the inside without requiring a key, and in which there is a telephone for calling for help.	
2.52	Are entries designed to mitigate explosive blast hazards? Do they contain design elements that could entrap an explosion, thus amplifying its impact? Are interior and exterior foyer doors offset from one another? Do doors and walls along the line of security screening meet requirements of UL 752, Standard for Safety: Bullet-Resisting Equipment?		
2.53	Are windows and their framing and anchoring systems designed and located to resist the effects of explosive blasts, gunfire, and forced entry?	Windows overlooking or directly exposed to public streets or dangerous areas should be either minimized or protected. The greatest risk to occupants from an explosive blast originating near the school or even blocks away is injury from flying glass shards, so window glazing should be laminated or protected with an anti-shatter film. Glass-clad polycarbonate and laminated polycarbonate are two types of alternative glazing material. Bullet resistant glazing should meet the requirements of UL 752. Security glazing should meet the requirements of ASTM F1233 or UL 972. Window assemblies containing forced-entry-resistant glazing should meet the requirements of ASTM F588.	

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
2.54	Are all exits and the routes to them clearly visible, conspicuously indicated and reliably illuminated, with signs in appropriate languages, so everyone readily knows the direction of escape from any point? Are exit signs distinctive in color and easily distinguished from decorations, finishes, and other signs. Is "EXIT" lettering at least 6 inches high with principal strokes not less than 3/4-inch wide?		
2.55	Do exits rely on passage through rooms or spaces subject to locking?	All exit ways must be through areas that provide free passage at all times, with doors swinging in the direction of egress.	
2.56	Are exit signs well maintained, easily seen, and pointing in the right direction?	The maintenance program for corridor, stairwell, and exit sign lighting should ensure functioning under normal and emergency power conditions. Expect state or local building codes to be updated to require floor proximity signs, which are needed when heat and smoke drive occupants to crawl along the floor to get out of a building; signs and lights mounted high on the wall or on the ceiling may be of little or no benefit in such situations. Consider glow-in-the-dark technology. Good quality, consistent exit lighting is cost-effective in the long term and worthwhile from a maintenance perspective. Using different exit lighting at different doors makes it harder to efficiently stock, keep track of, and replace parts.	
2.57	Are doors, passageways, or stairways that are neither exits nor leading to exits, but that can be mistaken for exits, marked with a "NOT AN EXIT" sign or similar designation?	Supplemental markings could be "To Basement," "To Store Room," "To Mechanical Room," etc.	

Section 2	School Buildings and Facilities		
Section	Vulnerability Question	Guidance	Observations
Cafeterias/Food Services			
2.58	Are entry doors to food services and student commons areas large enough to prevent bottle-necking and student conflict? Do food services and student common areas have separate entrances and exits into adjacent corridors or walkways to reduce conflict?	Cafeterias that are overly cramped and crowded in layout suffer from the same security problems as any place of general assembly. It is important to avoid overcrowding by providing sufficient space.	
2.59	Are food services and student commons areas well lit, with no shadowy or dark or hidden areas?	Well-lit areas are safer, and natural light does not depend on a power source.	
2.60	Are food services and student commons areas' acoustics designed to keep noise levels low?	Low noise levels reduce occupant stress and the incidence of misbehavior.	
2.61	Is there a clear view of the entire dining area and serving line from a controlled entry point?	A designated control point near the main entrance and exit can allow a clear line of sight of the whole cafeteria.	
2.62	Is there sufficient circulation space between and around table areas and serving lines?	It is important to avoid overcrowding by providing sufficient space between tables to allow ample circulation. This also gives cafeteria monitors room to freely move between tables during meal time. Care must be taken to maintain continuous, easy flow from the serving line into the dining area.	
2.63	Can the kitchen and serving areas be secured during and after school hours?	It is important to be able to properly secure the serving and kitchen area since food is a frequent target of theft in schools.	
2.64	Are food services or students commons areas that are used after school designed to prevent unauthorized access further into the building?	Access to the rest of the school from the cafeteria should be controlled (if used after hours). This can be accomplished by locking wing doors or accordion-style gates or other means, provided emergency egress is not blocked	

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
2.65	In high risk areas, are windows and their framing and anchoring systems designed and located to resist the effects of explosive blasts, gunfire, and forced entry?	Windows overlooking or directly exposed to public streets or dangerous areas should be either minimized or protected. The greatest risk to occupants from an explosive blast originating near the school, or even blocks away, is injury from flying glass shards, so window glazing should be laminated or protected with an anti-shatter film. Glass-clad polycarbonate and laminated polycarbonate are two types of alternative glazing material. Bullet resistant glazing should meet the requirements of UL 752. Security glazing should meet the requirements of ASTM F1233 or UL 972. Window assemblies containing forced-entry-resistant glazing should meet the requirements of ASTM F588.	
Health Services			
2.66	Can medical equipment and supplies be locked in an observable area?	Medical supplies and equipment should be locked in a storage closet located in the nurse's office.	
Indoor Athletics			
2.67	Does the facility have separate, secure entrances for school use and after-hours activities? Is user access to the rest of the school controlled?	Separate and secure entrances should be provided for indoor athletic facilities used after-hours to eliminate the need for visitors to pass through other areas of the school. Access to the rest of the school from the facilities should be controlled (if used after hours). This can be accomplished by locking wing doors or accordion-style gates or other means, provided emergency egress is not blocked	
2.68	Is there a secure area for equipment, with an entry visible to users and staff?	Locked equipment rooms should be visible from the exterior of the gymnasium. Glass block walls or impact resistant windows along a common corridor would allow monitoring of the interior of the equipment room.	
2.69	Are walls and entryways free of hiding places, such as deep niches or recesses?		

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
2.70	Can retractable partitions be fully recessed into walls and locked in place?	Retractable bleachers should be capable of being locked in place when not in use to prevent vandalism and persons using the space underneath to hide.	
2.71	Do the coach/instructor's offices have window walls with an unobstructed view of the locker rooms?	Gym instructors' offices should be located near the main entry and exit and provided with windows to monitor the locker area.	
2.72	Do the locker rooms have a solid ceiling so contraband cannot be hidden in above-ceiling spaces?	Acoustical ceiling tiles should not be used in any area of the locker room. Exposed concrete or plaster finished ceilings eliminate the opportunity to use the space above as a hiding place for persons and stolen property.	
2.73	Are lockers of the open mesh type, making concealment of prohibited items more difficult?		
Laboratories			
2.74	Does faculty have direct surveillance over work and entry areas, with no visual obstructions?	Faculty offices should be located to allow direct visual access to work room and entry.	
2.75	Do labs, shops, and computer room entries have alarm systems to deter breaking and entering?	Entry vestibules to workspaces equipped with an alarm system makes breaking and entering difficult from interior hallways.	
2.76	Do rooms for storing equipment, supplies, chemicals, tools, or other items that could be used for dangerous purposes have adequate, locking doors?	Valuable equipment and supplies should be protected by providing storage in a lockable closet within the office. Equipment in workspaces should be secured to tables or counters with concealed through bolts or one-way screws.	
2.77	Are chemical storage areas labeled with appropriate NFPA hazard diagrams?	Store flammable materials in a properly labeled storage cabinet that meets design criteria set forth by the National Fire Protection Association	
2.78	Are fire extinguishers located in all laboratory and shop areas?		

Section 2	School Buildings and Facilities		
Section	Vulnerability Question	Guidance	Observations
Library/Media Center			
2.79	Does the library or media center, if jointly used by the school and the community, have separate and secure access for school use and after-hours activities, and does it restrict access to and from other areas of the school?	Separate and secure entrances should be provided for library/media center facilities (if used after-hours or open to the public) to eliminate the need for visitors to pass through other areas of the school. Access to the rest of the school from the facilities should be controlled (if used after hours). This can be accomplished by locking wing doors or accordion-style gates or other means, provided emergency egress is not blocked	
2.80	Is the library or media center well lit, with no dark or shadowy areas?		
2.81	Are the library's or media center's reception area and circulation desk located near the main entrance and positioned to control traffic in and out of the area?	The reception area or circulation librarian should be placed in a central location near the main entry to police student traffic.	
2.82	Do the library's or media center's reception area and circulation desk positions have unobstructed surveillance of the entire area and can all users be monitored?	Low stacks (maximum 4 feet high) parallel to the librarian's line of sight help accomplish this. Shelves along walls can be full height.	
2.83	Are there separate, lockable areas for storing media equipment, or are other security measures in place?		
2.84	Are adequate theft deterrents used, such as magnetic strips in books, door readers, and alarmed exits? Are computers, printers, copiers, and other equipment secured against theft?	Serious consideration should be given to installing a magnetic book alarm system. Detection devices that use a turn-style or gate element shall not impede or be placed in designated means of egress.	
2.85	Is all shelving securely fastened to walls or floors and designed to keep from tipping or falling due to student misbehavior or natural disasters?	Book shelving is a particular hazard in earthquake areas.	

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
2.86	In high risk areas, are windows and their framing and anchoring systems designed and located to resist the effects of explosive blasts, gunfire, and forced entry?	Windows overlooking or directly exposed to public streets or dangerous areas should be either minimized or protected. The greatest risk to occupants from an explosive blast originating near the school or even blocks away is injury from flying glass shards, so window glazing should be laminated or protected with an anti-shatter film. Glass-clad polycarbonate and laminated polycarbonate are two types of alternative glazing material. Bullet resistant glazing should meet the requirements of UL 752. Security glazing should meet the requirements of ASTM F1233 or UL 972. Window assemblies containing forced-entry-resistant glazing should meet the requirements of ASTM F588.	
Administrative Offices			
2.87	Are confidential records separated from the reception area and stored in locked, vandal- and fire-resistant Containers?	Faculty offices and student records should be separated from reception area, accessible through locked hall doors. Student records shall be stored in a fire resistant vault within a locked room.	
2.88	Does the main office have two-way communication capability with all classrooms? Does a mass notification system reach all building occupants (public address, pager, cell phone, computer override, etc.)? Does it provide warning and alert information, along with actions to take before and after an incident?		
2.89	Does the main office have a windowless space or “safe room” with a lockable door and a telephone for emergencies?		

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
2.90	Does the principal's office have a window or door that can serve as a secondary emergency exit?		
2.91	In high risk areas, are windows and their framing and anchoring systems designed and located to resist the effects of explosive blasts, gunfire, and forced entry?	Windows overlooking or directly exposed to public streets or dangerous areas should be either minimized or protected. The greatest risk to occupants from an explosive blast originating near the school or even blocks away is injury from flying glass shards, so window glazing should be laminated or protected with an anti-shatter film. Glass-clad polycarbonate and laminated polycarbonate are two types of alternative glazing material. Bullet resistant glazing should meet the requirements of UL 752. Security glazing should meet the requirements of ASTM F1233 or UL 972. Window assemblies containing forced-entry-resistant glazing should meet the requirements of ASTM F588.	
Outdoor Athletics			
2.92	Are athletic facilities and playgrounds in direct view of front office staff or other staff in the building? Do play areas have clearly defined boundaries and are they protected by fencing?	Supervision of recreational areas can be provided in new construction by organizing play areas along one axis to facilitate immediate visual surveillance of the entire area. School buildings placed on a higher elevation than the recreation area provide better opportunities for outlooks. Ramping down to the play area allows the physical education director to command a broad visual sweep of all activities from the high ground.	
2.93	Are student gathering places set back from streets, driveways, and parking areas by at least 50 feet?	A generous setback makes it harder for intruders to sell drugs to students, lure them off campus, or victimize them with drive-by shootings. One urban school solved this problem by building a basketball court on the roof; others incorporate completely contained inner courtyards. This recommendation may be unworkable for schools built on small lots.	
2.94	Are bleachers well maintained, with no signs of rust, rot, or splintering?	Risers between bleacher seats should prevent entrapment and keep children from falling through, and handrails and guardrails for bleachers or seating areas should be adequate.	

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
Portable Classrooms			
2.95	Has the location of the portable units been carefully thought out to optimize security?	a. Windows from the main building overlook the school's portable classrooms and the pedestrian paths to them. b. Portables are placed together as much as possible to prevent avoidable sprawl, but are sufficiently separated from one another and from permanent structures to meet fire code requirements. c. Portables are gathered within security fencing, but have direct access to the main school. d. Portables are reasonably close to the main school so students aren't forced to walk long distances between buildings. e. Evacuation paths are pre-determined to avoid unreasonable time or distance requirements. f. Power and computer cabling are run in a manner that makes them resistant to vandalism, such as underground. g. Ramps meet ADA requirements, running 1 foot in length for every inch of rise. h. Positioning, lighting and screening decisions maximize natural surveillance between and under portables. i. Walkways to portables are direct, logical and well indicated with signs or markings. j. Isolated portables are monitored by CCTV cameras.	
2.96	Do the portables have adequate internal security features?	a. Windows or fisheye viewers permit people inside the classroom to see people outside the classroom. b. Communication devices, including the PA system, allow teachers and the office to reach each other. c. Classrooms can be locked and unlocked from inside by teachers. d. Sliding windows have lift and slide protection against burglars.	

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
Restrooms			
2.97	Is the restroom located to maximize visual surveillance, such as near administrative areas?	Restrooms are the fourth biggest problem area in schools, primarily because they are difficult to supervise. The most common concerns are vandalism, bullying, fighting, disorderly conduct, and alcohol and drug use. Locate toilet rooms directly adjacent to main corridors to maximize visibility and surveillance.	
2.98	Is the restroom well maintained, with no offensive smells and no graffiti? Is everything operable? Are mirrors intact and unbroken? Are the restroom mirrors shatterproof?	Well maintained restrooms promote orderly behavior by demonstrating respect for ownership of property. They draw legitimate users, boosting safety through their presence in larger numbers. Poorly maintained restrooms repel legitimate users, including school staff, thereby reducing supervision.	
2.99	Is the restroom bright, well lit, and easy to supervise? Do restroom lighting fixtures have protective, vandal proof covers?	Light fixtures are a frequent target of vandalism.	
2.100	Can restroom entry/exit doors be locked only from the outside and not be readily blocked from the inside?		
2.101	Are stall doors and partitions limited to no more than 5′-6″ in height and do they have 12″clearance above the floor for surveillance?	Maintain partition heights at five feet, with a twelve-inch clearance above the floor to allow visual surveillance.	
2.102	Do restroom smoke detectors have vandal-resistant features, such as protective cages or tamper alarms?		
2.103	If the restroom is intended for use by people engaged in after-school activities, is it conveniently located and able to be used without providing access to the rest of the school?		

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
2.104	Does the restroom have a hard ceiling that prevents hiding contraband in above-ceiling spaces?		
2.105	Does the restroom have windows?	It is recommended to not use windows for ventilation in bathrooms because windows can serve as passageways for weapons, people, or contraband.	
Shelters			
2.106	In high risk or wind hazard areas, are shelter spaces such as school gymnasiums, hallways, or other windowless areas identified, with special consideration given to egress, lockdown ability, and emergency supply storage?		
2.107	Are all standing or wall- or ceiling-mounted objects secured from falling?		
2.108	Do shelter spaces have the necessary provisions to ensure cell phone or radio communication by EMS personnel?	Radio frequency (RF) communication may not be possible without the use of repeaters in parts of larger schools, particularly if the school's construction incorporates many steel components such as structural steel framing, steel bar joists, steel studs, and metal roof and floor decking.	
2.109	Do shelter spaces have provisions for emergency power? Is there an exterior connection for emergency power from sources such as portable generators?		
2.110	Do shelter spaces have access to drinking water and, if needed, water for cooking, washing, and toilet facilities?		
2.111	Are all necessary exterior utility lifelines (power, voice, data and internet communications, fuel, and water) adequately protected from attack or natural disaster, preferably by concealing, burying, or encasing?		

Section 2	School Buildings and Facilities		
Section	**Vulnerability Question**	**Guidance**	**Observations**
Stairs			
2.112	Are stairs adequately located and designed to avoid congestion and accidents?	For efficiently moving large numbers of students, additional sets of stairs may function more safely and effectively than very wide stairs. North Carolina requires single stair runs not to exceed 8 feet without a landing and a minimum stair width of 6 feet for grades 6 through 12. Consideration should be given to enlarging stair landings beyond minimum code requirements to prevent overcrowding and unsafe conditions.	
2.113	Are stairwells adequately lit, including exit signs?	Stairs should also be well lit with adequate foot-candles of illumination.	
2.114	Do stair handrails and guardrails allow visual surveillance from either side of the stairs?	Open handrails allow visual access to immediate areas on both sides of the stairwells.	
2.115	Are stair risers enclosed to prevent persons under the stairs from grabbing the ankles of others using the stairs, or are under-stair areas completely blocked off?	Risers must be enclosed to prevent people from grabbing the ankles of those on the stair. The entire area under all stairs should be enclosed, and made inaccessible for any use.	
2.116	Do windows or openings provide natural surveillance into stairwells located on outer walls?		
2.117	Where natural surveillance is inadequate, are enclosed stairwells electronically monitored?	All enclosed stairwells should have surveillance equipment to provide motion detection at main access points. This will allow schools to minimize security system requirements on upper levels.	
2.18	In high risk areas or areas subject to earthquakes or high winds, are stairwell materials and designs adequate to prevent their collapse and limit the extent of falling debris that would impede safe passage and reduce the flow of evacuees?		

Section 3	Building Access Control and Surveillance Vulnerability		
Section	**Vulnerability Questions**	**Guidance**	**Observations**
3.1	Is access into the building(s. fully controllable?	100% of all access points to the school building should be controlled through designated, supervised, or locked entry points, including windows and service entries.	
3.2	Is entry granted by supervising staff or through the use of proximity cards, keys, coded entries, or other devices?	There should be no entry into the school allowed without supervising staff or appropriate access control devices. Entry for visitors or students should be granted at locations with supervising staff. The use of proximity cards, keys, coded entries, or other devices are typically used for school staff at doors such as teachers' parking lot entrances, main entrance, doors used for recess/playground activities, doors used for physical education class activities, etc.	
3.3	Can portions of the school that are not being used be readily secured?	This can be accomplished by locking wing doors or accordion-style gates or other means, provided emergency egress is not blocked.	
3.4	Are there entry signs, in all relevant languages and with simple maps or diagrams where needed, to direct visitors to designated building entrances?	Clearly worded and placed signage should direct visitors to the main office or designated visitor reception areas where they can be screened, using uniform visitor screening procedures, to ensure that they have legitimate business on campus. REFERENCE: SAFE SCHOOLS FACILITIES PLANNER. HEALTH AND LIFE SAFETY, SCHOOL CLIMATE AND ORDER (NORTH CAROLINA STATE DEPT. OF PUBLIC INSTRUCTION, DIV. OF SCHOOL SUPPORT, RALEIGH , FEB 1998)	
3.5	Where appropriate, do signs warn in a friendly but firm way about trespassing and illicit behavior and cite applicable laws and regulations?	Clearly worded and placed signage with warnings about trespassing and citing applicable laws and regulations can deter illicit behavior.	
3.6	Is the number of exterior doors minimized?	Reduce the number of doors which may be opened from the outside. This does not mean chaining doors or creating a fire hazard. It does mean using doors that cannot be opened from the outside, but which from which those inside can exit in the event of a fire or other emergency.	
3.7	Are all exit doors and gates equipped with emergency exit hardware and not locked or secured by any other means?	Under no circumstances may exit doors be otherwise locked or chained shut. See Section 15.2.2.2 of the NFPA Life Safety Code for existing educational buildings (for new educational buildings, see the International Building Code, Section 1008.1.8, and the NFPA 101 Life Safety Code, Section 14.2.2.2).	

Section 3	Building Access Control and Surveillance Vulnerability		
Section	**Vulnerability Questions**	**Guidance**	**Observations**
3.8	Are all exterior doors designed to prevent unauthorized access into the building?	a. Exterior doors should have as little exposed hardware as possible. b. Exterior doors should be equipped with hinges with non-removable pins. c. Exterior exit-only doors do not need handles and locks protruding on the outside. However, it should be possible to open the doors from outside during an emergency in some manner, such as with a proximity card. d. Exterior doors should be constructed of steel, aluminum alloy, or solid-core hardwood. e. Exterior door frames should be installed without excess flexibility to deter vandals from prying them open. f. Exterior glass doors should be fully framed and equipped with breakage-resistant tempered glass. Door locks as the primary means of security should be mounted flush to the surface of the door. h. Exterior doors should not rely on key-in-knob or other protruding locking devices. i. Exterior swinging doors should have a minimum 1-inch deadbolt lock with a 1-inch throw bolt and hardened steel insert, a free-turning brass or steel-tapered guard, and, if glass is located within 40 inches of the locking mechanism, double cylinder locks. j. Panic bar latches on exterior doors should be protected by pick plates to prevent tools and plastic cards from releasing the bolt. k. Exterior doors with panic push-bars should be equipped with tamper-proof deadbolt locks to prevent easy exit after school hours by criminals or vandals. They should also be equipped with an astragal (metal plate. covering the gap between the doors. l. The armored strike plate on exterior doors should be securely fastened to the door frame in direct alignment to receive the latch easily. m. Key-controlled exterior doors can be equipped with contacts so they can be tied into a central monitoring and control system. n. Exterior double doors should be equipped with heavy-duty, multiple-point, long flush bolts. o. Doors that are vulnerable to unauthorized use, when students open them from inside the building, can be made more secure by installing door alarms, delayed opening devices, or sensors or cameras monitoring doors from the central office.	

Section 3	Building Access Control and Surveillance Vulnerability		
Section	**Vulnerability Questions**	**Guidance**	**Observations**
3.9	Are exterior doors sized and arranged to reduce congestion and avoid crowding?	Multiple single doors reduce congestion and are recommended over double doors. Wider-than-normal doors accommodate movement of equipment and supplies and are recommended for accessible entries and for music, vocational technology, kitchen, and receiving areas.	
3.10	Do exterior doors have narrow windows, sidelights, fish-eye viewers, or cameras to permit seeing who is on the exterior side?		
3.11	Are windows and sidelights sized and located so that if they are broken, vandals cannot reach through and open a door from the inside?		
3.12	Are exterior doors airtight?	Airtight doors not only improve energy efficiency but they retard interior contamination during a hazardous chemical or other harmful outdoor release.	
3.13	Do exterior walls provide niches or blind spots that provide places to hide? Are building niches and recesses fenced off, well lit, or observable from inside the building? Do walls provide footholds, or are the top 3 to 4 feet nearest the roof non-climbable?	Fence off or otherwise enclose niches and blind spots in exterior walls that provide hiding places. Do not, however, impede or obstruct any means of egress.	
3.15	Are windows used to enhance natural surveillance of courtyards and school grounds and parking lots, especially from classrooms and administration areas?	Windows in administrative areas are particularly important for helping staff monitor the main entrance area and the school grounds around it.	
3.16	Do all windows lock securely? Do sliding windows have lift and slide protection?	California suggests avoiding sliding and casement windows, which are associated with security problems, and any operable windows with crank and worm-gear openers, which tend to break or jam.	

Section 3	Building Access Control and Surveillance Vulnerability		
Section	**Vulnerability Questions**	**Guidance**	**Observations**
3.17	Are window hardware and frames in good condition, and are transom windows or other window configurations that have clear security weaknesses either permanently closed (provided they are not to be used as a means of emergency egress. or reinforced with slide bolts or other security devices?	If windows are not in good condition and are clearly a security weakness, measures should be taken to secure the window.	
3.18	Are windows located strategically, providing natural light and natural surveillance, while providing sufficient stand-off distance and the means to deter vandalism and forced entry?	Glass replacement is the highest routine maintenance cost for some schools. Consider incorporating skylights (but only if roofs are fully protected from climbers), solar light tubes, clerestory windows, and light shelves in lieu of normal-height windows in exposed or vulnerable locations. Some school districts prohibit skylights because they are considered impossible to protect from climbers. Clerestory windows allow for ventilation, light, and privacy while minimizing wall penetrations, but do not allow for natural surveillance. California suggests that ground floor windows be eliminated where possible on the building perimeter, but this must be weighed against the need for natural light and ventilation in occupied areas and the loss of visual surveillance of school grounds.	
3.19	Are windows designed to serve as a secondary means of escape blocked by screens, security grills, louvers, awnings, or other devices, and are they readily opened from the inside?	In Florida, security grills or louvers may be used if they open in one operation with the secondary means of egress.	
3.20	Are second-floor windows inaccessible or protected against entry?	Second floor windows do not need to be secured if they are inaccessible. If they are accessible (e.g., by climbing an adjacent tree. the window should be secured from entry from the exterior.	
3.21	Are basement windows protected from unauthorized entry by security grills or window well covers?	Basement windows are a main target for many intruders and therefore should be secured by grills or window well covers.	

Section 3	Building Access Control and Surveillance Vulnerability		
Section	Vulnerability Questions	Guidance	Observations
3.22	Does tempered and wired glass meet the building code and Consumer Product Safety Commission's requirements when used in doors, sidelights, locations near the floor, and other "hazardous" locations?	The 2003 edition of the International Building Code no longer permits wired glass to be used in K-12 facilities, but newer fire-rated glass products may be used in its place.	
3.23	In high risk areas, are windows and their framing and anchoring systems designed and located to resist the effects of explosive blasts, gunfire, and forced entry?	Windows overlooking or directly exposed to public streets or dangerous areas should be either minimized or protected. The greatest risk to occupants from an explosive blast originating near the school or even blocks away is injury from flying glass shards, so window glazing should be laminated or protected with an anti-shatter film. Glass-clad polycarbonate and laminated polycarbonate are two types of alternative glazing material. Bullet resistant glazing should meet the requirements of UL 752. Security glazing should meet the requirements of ASTM F1233 or UL 972. Window assemblies containing forced-entry-resistant glazing should meet the requirements of ASTM F588.	
3.24	Is built-in roof access from inside the building only? Is the access point locked and located inside a secure room?	Some schools apply slippery finishes or coatings to exterior pipes and columns to block unauthorized access to the roof. (In new buildings, the use of permanent exterior roof access ladders or exterior building materials and architectural elements that allow climbing to obtain roof access should be avoided.)	
3.25	Are mechanical equipment enclosures on the roof protected from unauthorized access or vandalism?		
3.26	Is access into the school through skylights blocked by security grilles or other devices?		
3.27	Are roof parapets low enough to allow visual surveillance of the roof from the ground?		

Section 3	Building Access Control and Surveillance Vulnerability		
Section	Vulnerability Questions	Guidance	Observations
3.28	Are heavy roofing materials such as tile and slate securely attached to the structure, especially over points of egress?	Roofing materials can become falling hazards if they are not securely attached to the structure.	
3.29	Do covered walkways and adjoining posts, structures, walls, planters, or other building features provide climbing access to adjoining windows, roofs, or other upper-level areas? Are covered walkways and their surroundings adequately lit to promote visual surveillance while in use? Do windows in occupied areas of the building overlook walkways for natural surveillance?		
3.30	Are lines of sight across courtyards unobstructed so one person can supervise the entire area? Are entries into courtyards from the exterior of the school controlled and lockable? Do courtyard entries permit visual surveillance by administration staff?		
3.31	Are courtyards configured to eliminate unauthorized after-hours access? Do windows in occupied areas of the building overlook courtyards? Are courtyard entry doors wide enough to prevent congestion?	Avoid using swinging doors that must be held open by students. Mishaps at swinging doors are a common cause of fighting, especially in middle schools.	

Section 3	Building Access Control and Surveillance Vulnerability		
Section	Vulnerability Questions	Guidance	Observations
3.32	Are outer courtyard walls climbable? Are outside seating, planters, and landscaping features far enough from courtyard enclosures to eliminate climbing opportunities?		

Section 4	Emergency Power and Communications		
Section	Vulnerability Questions	Guidance	Observations
4.1	Does an uninterruptible power supply (UPS) provide emergency backup power?	A UPS should be located at all computerized points, from the main distribution facility to individual data closets and critical personal computers/terminals. Critical local area network (LAN) sections also should have uninterruptible power.	
4.2	In high risk areas, is communications system wiring distributed in secure chases and risers, or otherwise secure areas, to prevent tampering?		
4.3	Does the school have the necessary transmitters, receivers, and repeaters to ensure radio communication by EMS personnel everywhere in the building?	Radio frequency (RF) communication may not be possible within parts of larger schools, particularly if their construction incorporates many steel components such as structural steel framing, steel bar joists, steel studs, metal roof and floor decking.	
4.4	Are a sufficient number of hand-held two-way radios or cellular phones available to school staff?	The principal, vice principal, front office staff, playground supervisors, bus drivers, lunch duty staff, crossing guards, and school resource officers should have these devices.	
4.5	Is the main telephone distribution room secure?		
4.6	Does the telephone system have an uninterruptible power supply (UPS)?	Many telephone systems are computerized and need a UPS to ensure reliability during power fluctuations. The UPS is also needed while waiting for emergency power or to allow an orderly shutdown.	

Section 4	Emergency Power and Communications		
Section	**Vulnerability Questions**	**Guidance**	**Observations**
4.7	Are provisions for emergency power throughout the building, and especially for critical areas, in place?		
4.8	Is there an exterior connection for emergency power from sources such as portable generators?		
4.9	In high hazard areas, does any single critical node allow both the normal electrical service and the emergency backup power to be affected by a single incident?	Emergency and normal electrical equipment should be installed at different locations that are as far apart as possible.	
4.10	In high risk areas, are there multiple, redundant locations for the telephone and communications service entering the site and serving the building?		
4.11	Do only authorized personnel have access to exterior utility lifelines and their controls?		

Section 5	Mechanical Systems (HVAC and CBR)		
Section	**Vulnerability Questions**	**Guidance**	**Observations**
5.1	Are fresh air intakes located on roofs or placed high on exterior walls, at least 12 feet off the ground (or the fourth floor or higher in tall buildings), and away from vehicle-exhaust-laden areas? Are fresh air intakes located within secure fenced areas, cages or enclosures and protected by metal mesh sloped at least 45 degrees to reduce the threat of objects being tossed onto them?	Raising air intakes makes the building ventilation system less accessible and therefore less vulnerable to threats that might introduce contaminates directly into the intakes. Otherwise secure within CPTED-compliant fencing or enclosure. The fencing or enclosure should have a sloped roof to prevent the throwing of anything into the enclosure near the intakes.	
5.2	Are exhaust air outlets located downwind from air intakes and separated by the maximum distance possible?		
5.3	Is there a master ventilation system shut-off in the principal's office or other designated area, making it possible to control the spread of airborne contaminants through the ventilation system from any source, chemical spills to volcanic ash fall to chemical-biological-radiological (CBR) agents?		
5.4	Have critical air systems been balanced after initial construction or rebalanced after later renovation?	Although the system may function, it must be tested periodically to ensure it is performing as designed. Balancing is also critical after initial construction to set equipment to proper performance per the design. Rebalancing may only occur during renovation. REFERENCE: CDC/NIOSH PUB 2002-139	
5.5	Are functional, tight-sealing fire dampers installed and operational at all fire barriers, as required by building and fire codes?	All dampers must be functional for proper protection within the building during an incident. REFERENCE: CDC/NIOSH PUB 2002-139	

Section 5	Mechanical Systems (HVAC and CBR)		
Section	**Vulnerability Questions**	**Guidance**	**Observations**
5.6	In high risk areas, is a smoke evacuation system with adequate purge capacity operational, installed facing away from high-risk buildings, with controls and wires protected against damage, and connected to emergency power?	For an internal blast, a smoke removal system may be essential, particularly in large, open spaces. The equipment should be located away from high-risk areas, the system controls and wiring should be protected, and it should be connected to emergency power. This exhaust capability can be built into areas with significant risk on internal events, such as lobbies, loading docks, and mailrooms. Consider filtering of the exhaust to capture CBR contaminants. REFERENCES: GSA PBS-P100, CDC/NIOSH PUB 2002-139, AND LBNL PUB 51959	
5.7	If the school has designated areas of refuge or is designed to serve as a community shelter, is the mechanical system equipped to heat or cool these areas during an emergency?		
5.8	Are major mechanical, electrical, plumbing, communications, security, and other systems maintained, recommissioned, and tested on a preventive maintenance schedule, by trained workers in cooperation with security staff?	Recommissioning involves testing and balancing of systems to ascertain their capability to perform as described. REFERENCE: PHYSICAL SECURITY ASSESSMENT FOR THE DEPARTMENT OF VETERAN AFFAIRS FACILITIES	

Section 6	Security Systems		
Section	**Vulnerability Questions**	**Guidance**	**Observations**
6-1	Is basic security alarm system installed throughout hallways, administrative offices, exit doors, and rooms containing high-value property such as computers, shop equipment, laboratory supplies, and musical instruments? Have expert contractors install and maintain these systems?	As needs and budgets allow, use room alarm, motion detection, and electronic surveillance systems at primary and secondary entry points, stairwells, courtyards, unsupervised or hidden areas inside the building and along the building perimeter, rooms containing valuable equipment or student records, and in rooms containing dangerous chemicals such as chemistry labs and maintenance supply areas.	
6-2	Are card access systems installed throughout the campus for use by students and staff?	Card access systems greatly simplify access control and eliminate problems associated with lost keys.	
6-3	Where keyed locks are used, is a master key control system in place to monitor keys and duplicates?		
6-4	Are devices used for physical security integrated with computer security systems?		
6-5	In high risk areas, are magnetometers (metal detectors) and x-ray equipment installed? Where installed, are they used effectively?		
6-6	Is access to information on building operations, schematics, procedures, detailed drawings, and specifications controlled and available only to authorized personnel?		

Section 6	Security Systems		
Section	**Vulnerability Questions**	**Guidance**	**Observations**
6-7	Do CCTV camera systems cover appropriate areas of the school and record to digital or tape devices? Are these devices set up to send images to printers or be downloaded onto disks? Do the pictures printed from this equipment provide clear enough images to identify suspects in a court of law?		
6-8	Do CCTV cameras use lenses that capture useful images under existing lighting conditions? Is infrared used if needed for dark areas or at night?		
6-9	Are cameras triggered by motion or intrusion?		
6-10	Are camera housings designed to protect against tampering, vandalism, and exposure to extreme temperature or moisture?		
6-11	Do cameras have an uninterruptible power supply, and are they connected to the building's emergency power supply?		
6-12	Are camera servers located in a secure location so they can't be tampered with?		
6-13	Is the surveillance system protected with adequate firewalls so it can't be broken into?		