Chapter **4**

Mitigation Actions

The vulnerable components identified in the previous chapter can be made less vulnerable through mitigation actions. The actions are intended to eliminate or reduce the damaging effects of disasters. Mitigation actions cover a wide spectrum of activity, from incorporating disaster-effect mitigation at the design stage of system components or retrofitting a treatment plant, to simply strapping down a chlorine tank or keeping enough spare tires on hand.

Before implementing any mitigation actions, consider the following: how critical is the component to the system, what is the age of the component, what are present and projected expansion, replacement, or construction programs, and what is the cost of the mitigation action?

In the first part of this chapter, mitigation actions for the most probable disaster effects will be presented for each category of system components.

PERSONNEL

The key system component is personnel. Safety of personnel should be the utility's first responsibility. If a system is safe for its employees, it is generally safe for its customers as well

There are four ways to help mitigate personnel shortages: education, cross-training, replacement, and assuring a safe workplace. Training and practice based on a finished emergency-preparedness plan are covered in chapter 6.

Education

Education is the first step in assuring employee safety, or more precisely, reducing death and injury during an emergency. Review with employees the results of the first steps of the emergency planning process: the hazard summary and vulnerability analysis. Make sure they understand that their safety is the first concern in a disaster. Risking their own well-being will usually make things worse For example, there have been incidents when improperly prepared co-workers have tried to rescue a worker overcome by a chlorine leak, only to be overcome themselves.

Education is a continuous process on the part of both staff and management. Ask employees to provide input when determining the mitigation actions. They are most intimate with system components and the processes that make it all work.

Extend education beyond the workplace as well. Teach employees what to do at home in case of a disaster. Family safety plans help assure quicker return of off-duty employees.

Cross-training

Many components in a system are operated and maintained by only one or two key people. To provide backup for critical components, such as operating a valve on a water storage tank, instruct other employees in how to operate and maintain the components. Another example would be to train administrative personnel to assist field crews during an emergency or document the actions taken using forms, photos, or videotape.

Replacement

Often a mutual-aid agreement with other utilities can be made to supply replacement personnel. Provide the other utilities with a description of the system, perhaps using the information generated in the vulnerability assessment in the previous chapter or a copy of the system's emergency plan.

Private contractors are another source of replacement personnel. Draw up agreements with them beforehand. Include hourly rates and specify the types of services they are able to provide. Be sure to give them a copy of the emergency plan. The agreements will need to be updated regularly to account for changes in services and rates, and updates of the emergency plan.

A Safe Workplace

Utilities need to provide a workplace that is safe for employees during normal operations and as safe as possible in emergencies. This includes meeting applicable OSHA regulations (such as *Code of Federal Regulations* 29 CFR 1910.119 — *Process Safety of Highly Hazardous Materials*) and other federal, state or provincial, and local regulations. Be sure to provide first-aid supplies and training. Specific mitigation measures will be discussed in the following sections.

SOURCE WATER AND TRANSMISSION

Mitigation measures relating to source water and transmission range from providing alternative sources, to protecting wellheads, to retrofitting dams or aqueducts. The following section provides mitigation actions for surface water and groundwater sources.

Surface Water Sources

The components of surface water sources include watersheds, surface sources (such as rivers), reservoirs, and dams.

Large-scale watershed damage from hurricanes, earthquake landslides, fires, flooding, or volcanic eruptions is difficult to mitigate. For example, stabilizing slopes vulnerable to landslides could be a Herculean task. And the effort might do more damage to the watershed in the long run, especially if vegetation is disturbed. Watersheds are best left undisturbed. Watersheds should be monitored to determine whether conditions exist that could contribute to disaster hazards. Such conditions include illegal dumps, a buildup of flammable material, hazardous-materials spills, and construction activities that cause erosion. Find out which agency is responsible for fire suppression in the watershed area. Coordinate a fire-suppression plan with the agency. For example, if chemical fire retardants could contaminate source water, find out who should be called if a fire is spotted.

Mitigation actions for watershed damage or contamination over wide areas include providing automated monitoring equipment, using alternative sources or intakes, and changing treatment of the source water at the plant. An example of the latter would be to have an additional settling basin available.

Mitigation of smaller-scale contamination of watersheds or surface water sources from hazardous-materials spills is best handled by an emergency spill-response plan. This type of plan is discussed in chapter 5. Elements of the plan include notification, containment, and cleanup.

The effects of disaster hazards on open reservoirs can be mitigated by controlling access, identifying alternative sources, providing alternative intake-structure locations, and providing flexible treatment facilities. Access can be controlled by installing fences, gates, and signs; closing unnecessary roads; and increasing security patrols.

Dams have come under close scrutiny because of the potential damage and loss of life caused by a failure. Retrofitting dams includes raising the dam's height to accommodate higher design floods and seiche, increasing spillway capacity to provide for design floods, and improving the structural strength to withstand seismic forces. As an example, in 1988 the Bear Valley Dam, near Big Bear, Calif., was converted from a concrete multiple-arch dam to a gravity dam. Earlier studies had shown that an arch dam would be overstressed by seismic design loads for the area. In the 1992 Landers/Big Bear earthquakes (7.2 and 6.7 on the Richter scale), the retrofitted structure survived horizontal forces lasting 15 seconds that were greater than half the structure's weight (Denning 1993). Another example is the East Bay Municipal Utility District's (EBMUD), Calif., rehabilitation of earthquake-prone hydraulic fill dams in the 1970s.

Intake structure damage can be mitigated by providing temporary bypass pumps; having filtration materials, such as boom floats or screens, on hand; providing multiple intakes; strengthening the structures to resist wind or earthquake hazards; and making sure access to the structures is available by such means as a boat. Valves or other methods to drain or shut off flow to the system should be redundant, hazard-resistant, and properly maintained.

One important alternative source of emergency water supplies is an interconnection with an adjacent system. For more information, refer to the text on mitigating the effects on distribution components later in this chapter.

Groundwater and Wells

Methods of mitigating groundwater contamination potential include identifying alternative water sources, providing shutoff valves, maintaining adequate setbacks from sewage pipes and disposal systems, and installing wellhead protection and well seals. A spill-response plan and hazardous-waste disposal plan are also recommended to mitigate groundwater contamination. Earthquakes can produce a change in hydrogeology; deep aquifers are less of a problem.

Many natural-disaster hazards will cause power outages to the well pumps. A system should send the location of the wells to the electric-power provider, and request that the wells be a priority for service. Also, the pumps should have backup electrical power generators with adequate fuel on hand. Refer to the following section on treatment for additional electric-power mitigation actions.

Mitigation actions for the structure and equipment of pumping stations are the same for similar system components, such as treatment plants. These actions are discussed in the section on treatment, which follows.

Wells are vulnerable to earthquake hazards. Mitigation actions can be applied to the following subcomponents:

Casing. Wells should not be installed in liquefiable soils or soils subject to lateral spreading that could bend the casing. If such soils are unavoidable, mitigation actions might include the following.

- stabilize the liquefiable layer
- use double well casing
- use a submersible pump (straight drive shaft not required)

Well screens and slotted casing. Provide a good quality well screen to avoid sanding problems with slotted casings.

Connecting pipes. Provide flexible piping to mitigate settlement or relative movement hazards

Well pump materials. To help prevent pump and motor castings from breaking during ground shaking, use ductile-iron or steel castings.

Electric power. Anchor transformers, controls, and standby generators.

TREATMENT

Treatment facilities are composed of highly complex components critical to system operation. Fundamental to the design of reliable water treatment facilities should be the philosophy that failure of any component will not put the entire facility out of service.

In a worst-case scenario, the treatment plant will be off-line. In fact, it may be necessary to isolate the facility from the system, as in cases of contamination at the plant. Be sure isolation valves are installed and their locations well marked. Mitigation for the off-line scenario includes providing alternative treatment, such as increasing production in another facility in the system or identifying alternative sources of treated water from adjacent systems. Another measure is to provide a bypass with disinfection capability.

Treatment facilities should generally be fire-resistant The local fire department is a good resource; request that they regularly inspect the facility.

Treatment facilities are often located near floodplains or in flood-prone areas Facility design should include a hydrologic and hydraulic analysis.

Mitigation of potential hazards effects for treatment components will be discussed in the following sections. Also, refer to *Water Treatment Plant Design* (see bibliography) for a detailed discussion of the behavior and design of treatment plants subject to earthquake hazards.

Facility Structures

Treatment plant structures and other water system structures, such as pump stations, are often single-story, symmetrical, shear-wall buildings that perform well in earthquakes, high winds, and other disasters. Design considerations and mitigation actions include the following:

Earthquake

- use reinforced masonry and other hazard-resistant construction
- avoid liquefiable soils for structure foundations

- avoid using dissimilar foundation types when adding onto a structure

Earthquake and wind

- make sure roof and wall connections, and roof and foundation connections are adequate
- correct modifications that may have weakened structures, such as removed bracing or bearing walls cut for doors

Vandalism

- have adequate locks, window security, and lighting
- install intrusion-prevention devices, such as electronic keys, identification-card checkers, 10-key code units, joint 10-card/10-key checkers, and noncontact-type identification-card checkers to control access to the strategic facilities of the system (AWWARF and JWWA 1993)
- install situation display monitors that consist of closed-circuit television systems with high-sensitivity image pickup tubes, including camera and sound collectors; as well as alarm systems with ultrasonic, heat, or beam sensors, and magnetic switches to detect intruders (AWWARF and JWWA 1993)

Electrical Power and Instrumentation

Standby power should be available for such critical components as pumps and controls. A duplicate power supply from a distinct power distribution point following different routing is one method Specific mitigation actions for electrical power and instrumentation components and backup power include the following:

Transformers. Anchor ground-level units to the foundation pads and protect from flooding. Securely anchor pole-mounted transformers to the pole. Make sure the pole is secure in the ground. Transformer aerial conductors must be protected from swinging shorts in earthquakes and high winds.

Emergency generators. Anchor generators directly to the floor, or use "snubbers" on vibration-isolated bases. Figure 4-1 shows a collapsed spring-vibration isolator. Keep portable generators at various locations in the system to avoid a complete loss of standby power. Operate generators regularly under load. Review and maintain the support system: fuel, cooling, starting power, and exhaust.

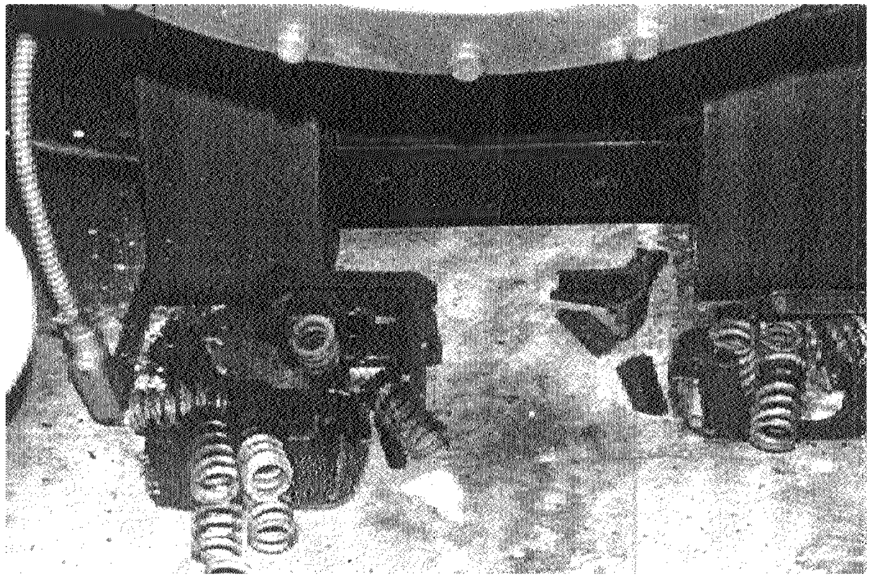
Electric cabinets. Anchor to the floor and at the top using angle clips on the wall or other secured structural element.

Motors. Provide automatic shutdown to avoid voltage or phase fluctuation that may cause damage.

Batteries. Batteries for backup instrumentation power or starting generators should be firmly anchored to prevent toppling. They should be off the floor to prevent water damage.

Telemetry. A radio system with adequate backup power can provide a replacement for broken cables or downed phone lines. Provide lightning-strike protection if needed.

Computers. Larger computers located on top of a special computer floor can be base isolated to prevent damage from a floor collapse. Also, the floor can be strengthened to resist seismic forces. Desktop computers can be secured to desks with Velcro or Quake Grip-type restraints. Be sure to backup computer files and keep them at separate locations



Source D B Ballantyne

Figure 4-1 Collapsed spring-vibration isolator supporting emergency generator, Whittier. Calif., 1987

The effects of computer failure can be minimized by providing the utility with the following elements.

- off-site backup for the computer system
- a preventive-maintenance program for hardware
- an uninterruptible power supply to protect the source of power for the computer hardware
- adequate computer room security
- compatible computer hardware components
- written procedures for testing software and operational problems
- adequate training for programmers
- control of operating files and documentation by data processing personnel
- virus and "hacker" prevention
- lightning-strike protection
- anchored, suspended ceilings

Equipment, Chemical Storage, and Piping

Most equipment and chemical storage containers in a treatment plant will become damaged from sliding and toppling. Simply anchoring or restraining equipment and containers can prevent much of the damage. Equipment supported on legs should have angle braces installed on the legs for additional strength. Waterproof plastic sheeting should be stockpiled in case the equipment or chemicals become exposed to the elements.