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LESSONS LEARNED

CROSS-CONNECTION CONTROL PROGRAMS AT ARMY INSTALLATIONS

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CROSS-CONNECTION CONTROL: LESSONS LEARNED

1. Purpose. This Public Works Technical Bulletin (PWTB) transmits a Cross-Connection Control Lessons Learned Document. The document is a summary of the "Lessons Learned" from the evaluation of Cross-Connection Control Programs in potable water systems at US Army installations.

2. Applicability. This PWTB applies to all U.S. Army Public Works water purveyors or system owners.

3. References.

a. Army Regulation 420-49, Facilities Engineering, Utility Services, April 1997.

b. MIL-HDBK-1164, DoD Handbook, Operations and Maintenance of Water Supply Systems, Department of the Army, Navy, and the Air force, March 1997.

4. Discussion. A Cross-Connection Control Program was implemented at various U.S. Army installations during the period 1989 to 1999 under the auspices of the U.S. Army Corps of Engineers Installation Support Center (formerly Center for Public Works, CPW). Many US Army installations had identified cross-connection locations and the existence of backflow prevention devices, but the intended degree of protection was not being provided. As the Cross-Connection Program progressed, similar problems were identified at each installation to include lack of awareness, insufficient training, and inattention to applicable regulations, codes, and guidelines. Each problem, or "lesson learned" is presented with a synopsis, a general discussion, existing Army guidance, as well as recommended actions where appropriate.

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PWTB 420-49-26
24 May 2001

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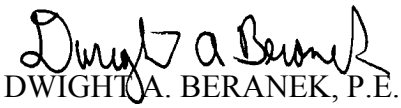

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TABLE OF CONTENTS

Contents **Page**

1.0 INTRODUCTION

This report is a summary of the "Lessons Learned" from the conduct of Cross-Connection Control Programs (CCCP) in potable water systems at US Army installations under the auspices of the US Army Corps of Engineers, Operator Assistance Program (OAP). The OAP was implemented at various Army installations in the United States during the period 1989 to 1999. The information used to produce this report was obtained from four basic sources: 1) site-specific reports documenting on-site evaluations of cross-connection control and backflow prevention efforts at various Army installations; 2) telephone interviews with personnel from several US Army installations to solicit input (lessons learned) from the conduct of cross-connection and backflow prevention evaluations and surveys; 3) information on cross-connection control and backflow prevention from industry periodicals and technical guides; and 4) experiences in evaluating, reviewing, and preparing Cross-Connection Control and Backflow Prevention Programs, surveying buildings to identify existing and potential cross-connections, and inspecting and testing existing backflow prevention devices at military installations.

1.1 PURPOSE AND SCOPE

The purpose of this report is to identify, document, and disseminate similar and/or specific lessons learned through the implementation of CCCPs at US Army installations, and to suggest steps that can be taken to remedy the problems identified.

Each "lesson learned" is presented with a synopsis, a general discussion, existing Army guidance, as well as recommended actions where appropriate. The synopsis of each lesson provides a brief overview of the problem. The discussion is intended to provide the reader with a sense of the magnitude and significance of each problem. Existing Army guidance provides specific regulations and/or technical guidelines directly or indirectly related to the problem. The recommended actions provide steps that can be taken to remedy the problem.

1.2 BACKGROUND

The OAP originally evolved in 1984 as a three-phase program to assist US Army water and wastewater treatment plants in compliance with regulatory requirements and their operating permits. This was done through plant engineering evaluations, recommending corrective actions and providing site-specific/problem-specific operator training. In the years following, the OAP expanded to include assistance with other environmental issues, including the implementation of CCCPs for potable water systems at Army installations. As this program progressed, similar problems were often identified at each installation during the conduct of cross-connection surveys and the implementation of CCCPs. These included a general lack of awareness, insufficient training, and inattention to applicable regulations, codes and guidelines. The specific problems, or *"Lessons Learned,"* are elaborated in the remainder of this report.

2.0 LESSONS

2.1 CROSS-CONNECTION CONTROL

Lesson: *Installations that lack a comprehensive CCCP increase in the risk of potentially serious health problems resulting from pollution or contamination of the drinking water in the event backflow were to occur.*

2.1.1 OAP Findings:

- Numerous unprotected cross-connections exist, or have the potential to exist, in buildings and facilities typical to Army installations.

- Cases of adverse health effects attributed to the occurrence of backflow have been reported at several military installations.

2.1.2 Discussion:

The potential risk to consumers due to the existence of cross-connections and the lack of a comprehensive Cross-Connection Control Program is significant.

- A cross-connection can be found in any arrangement of pipes, fittings, fixtures, or devices that connects a nonpotable water system or any used water, industrial fluid, gas or other substance to a potable water system (such as a boiler or chiller make-up pipe, a photographic or x-ray processor chemical/water mixing valve, and a water make-up line to a radiator soaking/cleaning tank).

- The more complex industry and technology becomes, the greater the potential hazards to human health. In spite of advanced water systems and equipment, the potential for contamination is growing. An estimated 100,000 new cross-connections are formed daily.

- Cross-connections appear in many subtle forms and in unsuspecting places. Pressure changes in a water distribution may be freakish and are unpredictable. Therefore, even the most unlikely potential cross-connection can allow backflow to introduce pollution or contamination to the potable water system.

- Locating existing and potential cross-connections, correcting potential problems and routine inspecting/testing is the best method for protecting the potable water system and, ultimately, the health of consumers.

Sanitary and cross-connection surveys have identified numerous cross-connections that were previously unknown.

- At a US Army installation in 1987, E Coli bacteria was found in drinking water samples collected from a hospital distribution system. At the time of this incident, fire-fighting activities had created a negative pressure in the installations

potable water main. An investigation of the hospital water piping identified several unprotected cross-connections between potable water and wastewater conduits at the hospital. Fortunately, there were no reported illnesses or injuries.

- At a US Army installation in 1992, 352 soldiers became ill and 163 were hospitalized with acute gastroenteritis. An investigation implicated a dining facility as the source of the epidemic. Foods at the facility were tested and found safe. It was discovered that the dining facility had experienced problems with its sewerage system. Numerous unprotected cross-connections were identified during the investigation. Hence, the outbreak was attributed to contamination of the dining facilities' potable water from the cross-connections.

- At a military installation in 1994, the water from drinking fountains had a yellow tint. It was later discovered that sodium dichromate had entered the potable water system within the building through a faulty check valve in the chillwater make-up pipe. Fortunately, no one became ill.

- At a US Army installation in 1989, a maintenance mechanic was washing his hands in the water from a fire hydrant after completing the repair of a broken water main. Suddenly, the water became very hot. It was later discovered that the water from a large hot water storage tank in a nearby building had flowed backwards into the water main through a malfunctioning check valve. No one was injured.

2.1.3 Existing Army Guidance:

Applicable excerpts from Army Regulation (AR) 420-49, Utility Services, November 1996, are as follows:

- Chapter 4, Water Supply and Wastewater, Section 4-1, Water Supply and Wastewater Policy:

  - Paragraph a:

    "Sanitary control and surveillance of potable water supplies will be in accordance with AR 40-5, Technical Bulletin (TB) Medical (MED) 576 or applicable State and local regulations."

  - Paragraph g:

    "Operation, maintenance and repair of water supply systems will be in accordance with Military Handbook (MIL-HDBK) 1164."

- Chapter 4, Section 4-7, Water Supply Treatment and Surveillance:

  - Paragraph f:

"Army installations located within the State that have been granted primary enforcement responsibility (primacy) will comply with applicable requirements promulgated by State regulatory authorities."

- Paragraph k:

> *"A cross-connection control program will be established at each installation. Cross-connection control plans will be prepared to regulate those areas in the distribution system where potable water may come in contact with nonpotable water. The plan will list the existing and potential cross-connections and develop a plan for the installation of backflow prevention devices, as well as a schedule for testing, inspection and maintenance. A routine inspection and maintenance program for backflow prevention devices performed by State certified personnel will include those facilities that have the potential to contaminate the water supply system (for example, pest control shops, photographic laboratories, and medical facilities). Design, operation and maintenance of cross-connection control components will be in accordance with MIL-HDBK-1164 and TB MED 576."*

Applicable excerpts from AR 40-5, Preventive Medicine, June 1985, are as follows:

- Chapter 12, Sanitation, paragraph 12-2f:

> *"Cross-connections between potable and nonpotable water systems are prohibited. TB MED 576 and MIL-HDBK-1164/AFR 91-26/NAVFAC MO-210 discuss cross-connections and provide proper references. The current National Standard Plumbing Code will be followed in the testing, maintenance and renovation of water distribution systems and in the selection of all plumbing fixtures."*

Applicable excerpts from TB MED 576, Sanitary Control and Surveillance of Water Supplies at Fixed Installations, March 1982, are as follows:

- Chapter 4, Water Distribution Systems, paragraph 4-2, Cross-Connections:

> *" No interconnection between a potable water distribution system and a sanitary sewage system shall be permitted. Each installation shall undertake an organized program that includes instruction, inspection, and required improvements in order to detect and remove all potential and existing cross-connection, and to insure that proper measures (e.g., air gaps and backflow prevention devices) are taken to prevent backsiphonage. Only through routine inspection and periodic surveys can the control and elimination of existing and potential hazards be accomplished. EPA Publication 430/9-73-002 and AWWA Publication No. 20106 provide excellent information concerning methods and devices for backflow prevention, testing procedures for backflow prevention, and administration of a cross-connection* control *program."*

Applicable excerpts from MIL-HDBK-1164, Operations and Maintenance of Water Supply Systems, March 1997, are as follows:

- Section 10, Cross-Connection Control and Backflow Prevention, paragraph 10.1:

> *" Cross-connections are the physical links through which contaminated materials can enter a potable water supply. The contaminant enters the potable water supply when pressure of the polluted source exceeds the pressure of the potable source. The flow of contaminated water to the potable system is called "backflow". Backflow of contaminated water through cross-connections can occur in all water systems and does occur in most water systems. Backflow results from either back-pressure or back-siphonage. Backflow due to backpressure occurs when the user's water system is under higher pressure than the public water supply system. Back-siphonage is caused by the development of negative or sub-atmospheric pressures in the water supply piping. This condition occurs when system pressure is lowered by pump malfunction or high fire flow."*

The remainder of Section 10 describes the classifications and degrees of hazard, lists approved and unapproved types of backflow prevention devices and methods, lists the references that are to be followed for the installation of backflow preventers, and discusses time intervals and record keeping for inspection and testing of devices.

2.1.4 Recommendation:

- Continue to implement measures at all US Army installations to protect the potable water systems and the consumers from the potential dangers of contamination and pollution that can result from backflow through cross-connections. This should include:

  - Developing a comprehensive site-specific CCCP describing the regulations, codes, policies, responsibilities and procedures for managing the site-specific cross-connection control program; procedures for installing, testing and maintaining backflow prevention devices; and the records necessary to track the success of the program.

  - Surveying/inspecting buildings, facilities, and equipment on a regular basis to identify cross-connections between potable water systems and nonpotable waters, gases or other potentially dangerous substances.

  - Eliminating cross-connections where possible and practical.

  - Installing, regularly testing, and routinely maintaining backflow prevention devices.

  - Training military and civilian workers and educating consumers on cross-connections and cross-connection control methods.

  - Ensuring the enforcement and compliance with the requirements of applicable Army, State-specific and/or local regulations, codes and technical guidance, and the site-specific CCCP.

2.2 CROSS-CONNECTION SURVEYS

Lesson: *The conduct of cross-connections surveys at US Army installations can be optimized, streamlined, and made more efficient.*

2.2.1 OAP Findings:

The following factors have been noted as contributors to inefficiency:

- Since funding restraints often preclude the survey of all buildings at an installation, the selection of buildings and structures to be surveyed is usually made on a representative or percentage basis instead of the potential hazard to the potable water distribution system in the event backflow were to occur.

- Personnel making the selection of buildings and structures to be surveyed often are not acquainted with the types of activities or equipment within a particular building, or about the potential existence and dangers of cross-connections based on type of activity or equipment.

- Most often, building tenants are unaware of the survey and unfamiliar with cross-connection control and backflow prevention. Hence, access to buildings and/or facilities to conduct cross-connection and backflow prevention surveys is often delayed while questions are answered and/or permission to perform the work is obtained from the unit commander, building administrator, manager, NCOIC, maintenance foreman, or tenant.

- "As-built" blueprints of buildings are generally not available or up-to-date.

- Often, the piping within mechanical rooms is found unlabeled, making identification of system piping more difficult and time consuming.

2.2.2 Discussion:

- A list of buildings to be surveyed for cross-connections and backflow prevention devices at the installation is usually obtained from the Real Property Office. From this, building selections are usually made at random or in numerical order directly from the installations' Real Property Inventory.

- To properly select buildings for a cross-connection survey, and effectively administer a cross-connection control program, a good sound working knowledge of cross-connection control and backflow prevention is required.

- The age, use, activities and number of floors of a building are generally not taken into consideration when selections are made for a cross-connection survey. Those buildings that can potentially present a high risk to the potable water system are sometimes overlooked for initial survey selection, and those that pose little-to-no risk are included in the initial selection. In many cases, a building may be selected as a

representative sample because adjacent or nearby buildings are identical or similar in structure and design. However, tenants, activities, building uses and plumbing systems in buildings frequently change. Consequently, even though the building structure may be identical, often no two building plumbing systems are alike.

- The lack of information provided to the tenant prior to the conduct of a survey often results in delays while authorization for building access is verified. Occasionally, tenants refuse an on-the-spot survey and, therefore, an appointment must then be made to conduct the work at a later date and time.

- Training and education in cross-connection control and backflow prevention is generally provided only to those at the installation who are responsible for installing, testing and maintaining backflow prevention devices. Unit Commanders, Division and Branch Administrators or Managers, Supervisors, Foremen, building representatives and consumers often have never heard of a cross-connection and the potential risks they can pose, and therefore, object to or question, the authority or need for such work.

- Many buildings at military installations were built in the 1940's, 1950's and 1960's, and have received numerous upgrades over the years to meet the changes in use and to increase efficiency of utility systems. Hence, original construction or "as-built" blueprints rarely reflect actual conditions, making it virtually impossible to identify piping where there may be a potential cross-connection between a potable water system and a nonpotable water system.

- Piping in mechanical rooms is often unmarked, requiring extra effort to trace potable and nonpotable water lines within a building and determine the locations of cross-connections and the locations types and sizes of backflow prevention devices necessary to properly protect the potable water system from nonpotable systems, piping, equipment and plumbing fixtures.

- Building tenants are not usually informed of cross-connection surveys or inspections, or knowledgeable of cross-connections and backflow control measures.

2.2.3 Existing Army Guidance:

Applicable excerpts from AR 420-49 are as follows:

- Chapter 4, Water Supply and Wastewater:

  - Paragraph 2-2a:

    "The control and surveillance of potable water supplies will be as specified in AR 40-5 and TB MED 576 or applicable State and local regulations."

  - Paragraph 2-2g:

"Operation, maintenance and repair of water supply systems will be in accordance with MIL-HDBK-1164."

An applicable excerpt from AR 40-5 is as follows:

- Chapter 12, Sanitation, paragraph 12-2f:

  "Cross-connection between potable and nonpotable water systems are prohibited."

Applicable excerpts from TB MED 576 are as follows:

- Chapter 4, Water Distribution Systems, paragraph 4-2:

  "Each installation shall undertake an organized program that includes instruction, inspection, and required improvements in order to detect and remove all potential and existing cross-connections, and to insure that proper measures (e.g. air gaps and backflow prevention devices) are taken to prevent backsiphonage. Only through routine inspection and periodic surveys can the control and elimination of existing and potential hazards be accomplished."

An applicable excerpt from MIL-HDBK-1164 is as follows:

- Section 10, Cross-Connection Control and Backflow Prevention, paragraph 10.6.1, Inspection:

  "A certified backflow inspector must inspect all cross-connections, and backflow prevention devices."

Applicable excerpts from the National Standard Plumbing Code, 1996 Edition, are as follows:

- Chapter 10, Water Supply and Distribution:

- Paragraph 10.2:

  "In buildings where dual water distribution systems are installed, one potable water and the other non-potable water, each system shall be identified either by color marking or metal tags, or other appropriate methods such as may be approved by the Administrative Authority. Each outlet on the nonpotable water line which may be used for drinking or domestic purposes shall be posted: DANGER - UNSAFE WATER.

- Paragraph 10.4.1:

"A potable water supply shall be designed, installed and maintained to prevent contamination from non-potable liquids, solids or gases by cross-connections."

2.2.4 Recommendations:

- Select buildings for a cross-connection survey based on type of activities conducted in the building, the potential for the existence of cross-connections; the processes and equipment used in the building and in the conduct of activities in the building; the extent of piping; the potential contaminants or pollutants in the building; and the associated risk to the potable water system and the consumers in the event backflow were to occur.

- Prior to conducting a survey, categorize all buildings and structures by the potential Degree of Hazard each may pose to the potable water distribution system. Those that present a High Degree of Hazard should be surveyed first and without delay. Those that present a Moderate to Low Degree of Hazard should be surveyed in that order.

- Use personnel who are familiar with the activities, construction type, and/or equipment in buildings typically found at US Army installations, and also have a good working knowledge of plumbing (residential, commercial and industrial) and cross-connection control, to select and categorize the buildings for the survey.

- Educate tenants and consumers at the installation on the basics of cross-connection control and backflow prevention, and ensure their awareness of the survey prior to its implementation.

- Update blueprints of buildings periodically to reflect actual conditions. Prepare and post piping and/or valve charts in mechanical rooms to provide additional information to mechanics, technicians and contractors conducting routine maintenance and/or cross-connection surveys.

- Correctly identify piping (by physical marking) in buildings to comply with regulations and codes, establish adequate control of potential and existing cross-connections, ensure the proper type of backflow prevention device is installed where necessary, ensure the safety of consumers, and to protect the equipment.

- Inform building tenants in advance of conducting cross-connection surveys or inspections.

- Educate consumers about cross-connections and backflow prevention.

2.3 INSTALLATION OF BACKFLOW PREVENTION DEVICES

Lesson: *Incorrect installation of backflow prevention devices results in the following:*

- *Non-compliance with regulations, codes and technical guidelines.*
- *Safety hazards for test and maintenance technicians.*
- *Neglect or inattention to required and essential routine testing and maintenance.*
- *Ineffective operation of the backflow prevention device.*

- *Increased risk of contamination/pollution of the potable water system and injury/illness to the consumer.*
- *Insufficient identification of the device.*

2.3.1 OAP Findings:

- Existing backflow prevention devices are often found installed without regard to the requirements of applicable regulations, plumbing codes and technical guidelines. The majority of existing backflow prevention devices identified during surveys conducted at Army installations are typically found installed in the following manner:

  - 10 to 20 feet above the floor level,
  - In below grade pits subject to flooding,
  - Downstream of pressure reducing valves,
  - Lacking adequate or proper drains,
  - Without redundancy, and/or
  - Not physically identified.

- Problems that are created by these improper installation methods include:

  - Difficult access for maintenance and testing,
  - Safety risks from scrapes, burns, falls , oxygen deficiency and noxious gases,
  - Equipment failure due to backflow device discharges,
  - Unnecessary or excessive downtime of equipment or systems located downstream of the backflow device during routine testing and maintenance, or emergency repair or replacement, and
  - Inadvertent tampering, alteration, and removal of or attachments to the backflow device.

- Most existing Army site-specific CCCPs do not directly specify backflow prevention device installation methods.

- Specifications that are prepared for the installation of backflow prevention devices generally do not stipulate particular installation methods or criteria. The specifications relate more to other tasks associated with construction projects (such as excavation, trenching and backfilling; concrete and metals; insulation; and general plumbing and electrical work). Information in the specifications that is applicable to backflow prevention devices generally includes only a few references and a brief paragraph stating that the devices installed must be tested, approved and listed in accordance with the referenced standards. No additional criteria are provided.

2.3.2 Discussion

- Plumbing codes and technical guidelines were developed to ensure that plumbing systems and fixtures conform to standards of construction, are installed correctly, and protect the public health. Plumbing codes specify, and technical guidelines recommend, particular methods of installing backflow prevention devices that favor

proper operation, maintenance and testing, and provide the current best available technology for protecting the health of the consumer.

- Manufacturer's general installation guidelines often do not specify height and work space clearances, and access requirements to benefit safe work practices and periodic maintenance and testing of the device. Consequently, installation methods for backflow prevention devices are typically left to the decision and judgment of the installer. This can result in varying interpretations of the specifications, plumbing codes and manufacturer's installation guidelines.

- Installing a backflow prevention device in a straight portion of pipe generally requires only basic plumbing skills and is the most often preferred method. Extensive materials and labor are not required, and, of course, the project is less costly. However, this basic installation method does not consider that the backflow prevention device must be routinely maintained and periodically inspected and tested to determine if it is operating properly, in need of repair, and provides adequate protection against the potential hazard created by the downstream nonpotable system or equipment.

- If not readily accessible, a technician (who usually works alone) often must either climb on or over the top of pipes and equipment or use a ladder to reach the device. Specialized equipment and mechanical tools needed to complete the test must then be carried or lifted to the device. During test procedures, water often squirts or discharges from the device, which can startle the technician or knock tools off their resting place. Since most backflow prevention devices are located in remote areas (boiler rooms), a fall may go unnoticed.

- Several types of backflow prevention devices are designed to discharge through a relief valve or outlet when imbalances in pressure occur. When a backflow device is installed above other equipment, the discharge can damage the equipment, especially electrical components. From this, there is also a potential risk of a fire in electrical components.

- Installation of backflow prevention devices in pits is generally not allowed by regulations, or recommended by plumbing codes and technical guidelines. Areas where entrances, workspace, and exits are restricted may meet the criteria for confined spaces. Hence, if a backflow prevention device is installed in a below grade pit or vault then appropriate measures must be taken to comply with the Occupational Safety and Health Administration (OSHA) standards for confined spaces. Additionally, drainage outlets in below grade pits usually become clogged, allowing water (possibly contaminated) to accumulate in the pit or vault and flood the device, rendering its purpose ineffective.

- Backflow prevention devices should be installed where they will receive full supply pressure in order for them to operate without failure for long periods of time. Additionally, they are designed to operate at minimum and maximum water flow rates and pressures (depending on their size) and also reduce water pressure as it passes through the device. Pressure reducing valves (PRV), typically installed in potable water supply pipes to various types of equipment, are commonly used to reduce high water pressures, volumes of water, and to protect piping and equipment from damage resulting from pressure surges. Emergency pressure relief valves

(PREV) are also typically installed adjacent to the PRV to relieve excessive pressure. Consequently, the reduced pressure created by the PRV may not be sufficient in order for the backflow preventer to operate as designed. Additionally, applicable plumbing codes prohibit any type of valve to be installed between a pressure relief valve and the vessel it protects.

- Backflow prevention devices approved for use are required by industry standards to be equipped with specific identification information. This is usually found either directly stamped on the exterior body of the device or on a dataplate located somewhere on the device. The information generally provided includes the manufacturers name, the model number, serial number, and size of the device, approving agency reference number, and maximum water pressure and temperature. Most of this information is necessary to keep track of the devices' location, the performance of preventive or corrective maintenance, and the results of routine tests.

- If only a solitary backflow prevention device is installed in a potable water supply to a system where continuous water service is required, then the water service to the system must be interrupted while testing and/or maintenance is performed on that device. If the existing device is installed in the water main to the building, then water service to the entire building must be interrupted.

2.3.3 Existing Army Guidance:

MIL-HDBK-1164, paragraph 10-5, Selection and Installation of Backflow Preventers, emphasizes the importance of proper selection and installation of backflow prevention devices, discusses the installation of parallel backflow prevention devices where a continuous water supply is critical, discusses unapproved backflow prevention methods and devices, and references the Manual of Water Supply Practices, M14, "Recommended Practice for Backflow Prevention and Cross-Connection Control," published by the American Water Works Association (AWWA), for the selection and installation of backflow prevention devices. The AWWA manual, Chapter 4, Backflow Control, provides guidance for the selection of backflow prevention devices, describes each device in detail, and discusses its proper application and installation method. For the types of backflow prevention devices most commonly used (Reduced Pressure Zone Assembly, Double Check Valve Assembly, Pressure Vacuum Breaker and Atmospheric Vacuum Breaker), typical installation guidelines include the following:

- Pipelines should be flushed prior to installing a device in order to remove foreign material.

- Devices must be installed in an accessible location, with ample clearance for testing and maintenance.

- Drainpipes from RPZ relief valve ports must not be into sumps or floor drains unless the proper air gap is provided between the drain pipe outlet and the floor drain opening.

- Devices should be protected from freezing and installed in protective insulated enclosures or installed within a building.

- Air Gaps must be physically separated from the water supply outlet and the receiving tank or vessel a minimum of two times the inside diameter of the water outlet pipe.

- PVB devices must be installed a minimum of 12-inches above the highest outlet or overflow rim of a tank.

- AVB devices must be installed a minimum of 6-inches above the highest outlet or overflow rim of a tank.

- A parallel backflow prevention device should be installed where the water supply is critical to avoid interruption of water service during testing and maintenance of the device.

AR 40-5 stipulates that the current National Standard Plumbing Code will be followed in the testing, maintenance and renovation of water distribution systems and in the selection of all plumbing fixtures. The installation requirements for backflow prevention devices are provided in Chapter 10, Water Supply and Distribution, Section 10.5, Backflow Prevention, and Section 10.16, Safety Devices for Pressure Vessels, of this Code. These methods are summarized below. However, additional requirements for the installation of backflow prevention devices can also be found in several other chapters of the code.

- Air Gaps must be physically separated from the water supply outlet and the receiving tank or vessel a minimum of two times the inside diameter of the water outlet pipe unless the outlet is less than three times the outlet opening away from a wall or similar vertical surface in which case the air gap must be 3 times the outlet opening.

- All backflow prevention devices shall be accessible. Devices with atmospheric vents shall not be installed in pits, vaults or similar potentially submerged locations.

- Vacuum breakers and other devices with vents shall not be installed in fume hoods.

- PVB devices must be installed a minimum of 12-inches above the highest outlet or overflow rim of a tank.

- AVB devices must be installed a minimum of 6-inches above the highest outlet or overflow rim of a tank. There shall be no downstream control valve to the fixture being served.

- RPZ and DCV backflow preventers should be installed a minimum of 12-inches and a maximum of 60-inches above the finished floor (Note: Army guidance is more stringent).

- Spill-proof vacuum breakers shall be installed not less than one-inch above the flood level rim.

- There shall be no shut-off valve, check valve or other restricting device between a relief valve and the pressure vessel or piping system being protected.

2.3.4 Recommendations:

- Install backflow prevention devices only in accordance with regulations, codes and guidelines.

- Ensure that devices are installed so that easy access for routine maintenance and regularly scheduled testing is provided.

- Include detailed installation requirements for backflow prevention devices in specifications for contracts for new construction or renovation projects.

- Include detailed requirements for the installation of backflow prevention devices or specific references that must be followed for installing these devices in Cross-Connection Control Programs (or Plans) at Army installations.

- Locate backflow prevention devices where spillage from the device will not be objectionable or cause damage to nearby equipment. Installation of a device should be planned and designed to meet minimum and maximum heights and clearances recommended or specified by guidelines and codes.

- Ensure that backflow prevention devices are not installed in below grade pits. Instead, above ground lockable enclosures should be provided.

- Provide a drainpipe from the device to the floor at any location where drainage or spillage from a backflow prevention device relief valve or port may be objectionable or damaging to nearby equipment. In addition, ensure that an air gap is provided between the device relief valve or port and the inlet of the drainpipe and between the outlet end of the drainpipe and the floor.

- Ensure proper identification of backflow prevention devices for inspection, maintenance, and testing by placing a tag on the body of the device.

- Construct a platform to provide safe access so that the maintenance or testing technician can safely conduct the required tasks (if the device must be located at a height above that recommended by codes and guidelines).

- Install a redundant device so continuous water service can be provided to the building, facility or equipment if a backflow prevention device is required in a potable water service main and disruption of water service is not considered acceptable.

2.4 TESTING AND MAINTAINING BACKFLOW PREVENTION DEVICES

Lesson: *Backflow prevention devices (existing or new) must be tested and maintained routinely to ensure their proper operation and protection of the potable water distribution system from contamination or pollution.*

2.4.1 OAP Findings:

- Backflow prevention devices are often not being tested upon installation.
- Existing backflow prevention devices are generally being ignored once installed and seldom inspected, tested and maintained at the recommended frequencies.
- Tested devices are rarely tagged. Hence, there is no indication or record of the date of inspection and test, and who performed it.

2.4.2 Discussion:

- All backflow prevention devices must be tested after installation to ensure they have been properly installed and are functional.
- A backflow prevention device is a valve, and like any other valve it needs to be checked and maintained on a regular basis.
- It is not unusual for debris to be found in water supply lines, especially after construction projects or backflow prevention device installation. This debris can collect in the device, causing the valves to leak. Additionally, if backflow prevention device routine testing introduces foreign material into the device from pipe sediment that comes loose during the opening and closing of related valves, there is a risk that the debris may enter the backflow preventer and prevent a check valve or the relief valve from fully closing. Hence, the device may discharge from the relief valve intermittently or continuously after completion of the test. Most privately contracted testing technicians are authorized, certified or licensed only to conduct the test, not to perform repairs of backflow devices. Thus, the water service must remain disrupted until repairs, overhauls or replacement and retesting is completed.
- Devices are required to be tested at a frequency deemed necessary to ensure proper and consistent operation.
- Tagging of devices with the date of the last test, results of the test, and the testers name and/or initials provides a backup or duplicate record in case of accidental loss or misplacement or other records.

2.4.3 Existing Army Guidance:

Applicable excerpts from MIL-HDBK-1164 are as follows:

- Section 10, Cross-Connection Control and Backflow Prevention:

  - Paragraph 10.6, Inspection and Testing Schedule, Table 33, Suggested Intervals for Inspecting Backflow Devices:

Degree of Hazard	*6 Months*	*12 Months*
Class I		*X*
Class II		*X*
Class III	*X*	
Class III (Air Gap)		*X*

- Paragraph 10.6.1, Inspection:

"A certified backflow inspector must inspect all cross-connections and backflow prevention devices to ensure that:

a. An approved air gap is maintained.

b. Backflow prevention devices are in good condition.

c. New devices are properly installed and debris from the installation does not interfere with functioning of the device. (The inspection is to be completed within 1 week after acceptance and 3 months after installation.)"

2.4.4 Recommendations:

- Test all devices immediately upon installation to ensure proper operation.
- Comply with the testing frequencies suggested in TM 5-660, as a minimum.
- Comply with the testing procedures recommended by the manufacturer or by industry guidelines.
- Install a tag on the physical body of the device annotating the date, results of, and the initials of the tester.

2.5 TRAINING AND CERTIFICATION

Lesson: *Progress has been made in increasing the number of certified backflow prevention device testers at Army installations. However, training and certification requirements are increasing and the type of training that is being required is also changing. These are not being met with existing training programs.*

2.5.1 OAP Findings:

- Army regulations require testers to be State certified (if required by the State).
- Certification and training requirements vary from state-to-state. Some states do not have certification requirements.

- Many training programs are limited to instruction in the testing of devices and do not include training in conducting cross-connection surveys and inspections. In addition, many certification courses require 40 hours of instruction.

- Training courses are usually attended only by those personnel assigned the task of testing backflow prevention devices, not those responsible for management of a cross-connection control program or involved with the planning, designing, and preparation of specifications for construction and installation of backflow prevention devices.

- Management, supervisory and engineering personnel rarely attend training programs.

- Education of the consumer on the potential dangers associated with cross-connections is not customary.

2.5.2 Discussion:

- Certification requirements vary from state-to-state. Some states provide reciprocity while others do not. Counties, municipalities or localities may have specific requirements that are more stringent than those of adjacent counties, municipalities or localities. When an Army installation is located within several counties in one particular state, there is confusion as to which regulations or requirements apply. . There is a need for standardization of certification.

- The majority of available training programs stress testing and maintenance of backflow prevention devices or provide a general overview of all the aspects of cross-connection control in a relatively short instruction period (1 to 2 days). Infrequently are specific classes provided for particular and specialized areas of cross-connection control (such as conducting cross-connection surveys and managing cross-connection programs). Instruction that is available usually requires extensive travel, loss time from work to attend (many training courses in this specialized field require a minimum of 40 hours of attendance to meet certification requirements), and can be expensive.

- Implementation of an effective cross-connection control program requires that everyone involved have a good working knowledge of the subject as it relates to his or her responsibilities. This includes administrators, managers, engineers, designers, inspectors, supervisors, and plumbers.

- Since many cross-connections are made temporarily or are intermittent (particularly with garden hoses) it is important that consumers understand the basics of cross-connection control and backflow prevention.

2.5.3 Existing Army Guidance:

An applicable excerpt from AR 420-49, is as follows:

- Chapter 4, Water Supply and Wastewater:

  - Paragraph 4-7k, fourth sentence:

    "A routine inspection and maintenance program for backflow prevention devices performed by State certified personnel will include backflow prevention devices for those facilities that have the potential to contaminate the water supply system."

An applicable excerpt from TB MED 576 is as follows:

- Chapter 4, Water Distribution Systems:

  Paragraph 4-2, second sentence:

  "Each installation shall undertake an organized program that includes instruction, inspection, and required improvements in order to detect and remove all potential and existing cross-connection, and to insure that proper measures are taken to prevent backsiphonage."

2.5.4 Recommendations:

- Standardize training courses for Army personnel (military and civilian) to provide, as a minimum, a fundamental knowledge and understanding of cross-connection control and backflow prevention and serve as a basis for state-specific certification.

- Provide specialized training to personnel involved with the establishment, preparation and enforcement of a Cross-Connection Control Program, and those involved with review of construction plans, specifications and construction inspection, so they will understand: the implications of water contamination from backflow, the importance of cross-connection control, the measures that must be taken to prevent backflow and protect the water system from cross-connections, and backflow prevention device installation methods and requirements.

- Incorporate the need for consumer education programs in an installation's Cross-Connection Control Program, and implement such awareness programs in conjunction with the Public Affairs Office.

2.6 RECORD KEEPING

Lesson: *Maintaining proper and complete records is an essential part of the implementation and successful administration of any Cross-Connection Control Program.*

2.6.1 OAP Findings:

- Cross-connection inspection records are usually incomplete, inadequate or outdated.

- Most cross-connection control program records at Army installations consist only of backflow prevention device inventories.

- Most inventories are incomplete, lacking essential information such as the devices' location within a building, the manufacturer dataplate information (model and serial number, size), and the equipment that the device serves.

2.6.2 Discussion:

- Records provide detailed information such as the degree of hazard a building, system or equipment may pose to the potable water system, the location and type of existing or potential cross-connections, the location and type of backflow prevention device installed or required, the backflow devices' manufacturer, size, model number, serial number, and results of scheduled maintenance and testing, and the names of certified and authorized cross-connection inspectors and device testers. This is essential to effective management of the program.

- Information from records provides the inspector prior knowledge of where previous problems occurred and what corrective actions were taken. This information is valuable when buildings are re-inspected because consumers sometimes breech air gaps or backflow prevention devices for various reasons.

- Records provide information and documentation that is necessary to demonstrate compliance with regulations and codes.

- Records provide historical information that may be valuable when recurring problems develop.

- Computerized record keeping systems provide streamlined access and tracking of records. They also provide timely program management information, reduce the paperwork automatically generate reports, notifications, letters and work orders in a consistent and uniform manner, and help realize considerable savings in time and effort for productive management of a CCCP.

2.6.3 Existing Army Guidance:

Applicable excerpts from MIL-HDBK-1164, Section 10, Cross-Connection Control and Backflow Prevention, is as follows:

- Paragraph 10.9, Records of Inspection:

"Use an appropriate form approved by the military service to record data on all. Provide the location, degree of hazard, description of air gap or protective device installed, and a sketch of the installation on the form. After each inspection is completed, record the date of inspection, test results, observations, corrective action taken, and name of the inspector on the appropriate form. For air gap, the test consists of a visual

inspection, with "OK" recorded. Testing for other backflow devices is more involved"

- Paragraph 10.10, Location Records:

> *"In general, records of all cross-connection control or backflow prevention devices must be prepared and maintained. These records are to include an inventory of all locations and an individual record on each location."*

2.6.4 Recommendations:

- Establish standard record keeping procedures, types and sample record forms, and provides samples of written Cross-Connection Control Programs (Plans) for Army installations.

- Ensure availability of records to all personnel and offices responsible for the various aspects of the management, operation, and maintenance of an installation's CCCP.

- Develop or purchase, and use, specific standardized computer software programs for cross-connection control record keeping at Army installations.

3.0 SUMMARY

The lessons and recommendations suggest that although significant progress has been made in cross-connection control at Army installations, continued improvements are necessary to properly protect potable water systems from potential contamination or pollution that can result from backflow, and most importantly, to protect the health of the consumer. The suggested improvements include:

- Implementing cross-connection control programs at every Army installation, regardless of size, activities, or location.

- Ensuring compliance with the requirements and guidance stipulated and provided in applicable Federal, State, Army and/or local regulations, plumbing codes and technical manuals.

- Streamlining the conduct of cross-connection and backflow prevention surveys at Army installations by more thorough planning, increasing funding and providing the necessary technical training to installation personnel, including managers, supervisors and technicians.

- Placing greater emphasis on the installation methods and techniques, regular testing and routine maintenance of backflow prevention devices.

- Standardizing basic and specialized cross-connection control and backflow prevention training requirements and basic education programs for military and civilian employees who are directly involved with cross-connection control programs and for all persons who consume drinking water provided by the US Army.

- Establishing standard procedures, and utilizing forms, computer software programs and other tools necessary for properly administering, managing and maintaining installation cross-connection control programs.

The OAP has provided excellent services and support to a number of Army installations nationwide by assisting them in improving cross-connection control and protecting potable water systems from potential contamination or pollution that can result from backflow.

Continued and improved emphasis in the increasingly significant subject of cross-connection control and backflow prevention will benefit Army installations by helping to ensure that contamination- and/or pollution-free water is provided to the consumer. This can reduce the number of incidents of illness, protect mechanical and electrical equipment from damage, reduce costs through better management practices, and ensure compliance with applicable laws and regulations.