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Sanitary Survey

Reference Manual

CREDITS

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PREFACE

This publication, Sanitary Survey Reference Manual, is a reference for the Water Supply Systems Training Course on "How to Conduct a Sanitary Survey".

A second reference entitled Sanitary Survey Instructor's Technical Manual is also available. Both references were previously developed as United States Environmental Protection Agency projects by the Conference of State Sanitary Engineers and the Dynamac Corporation, Rockville, Maryland. A third publication, Instructor's Guide, was organized to supplement the two aforementioned manuals.

The Instructor's Technical Manual, the Instructor's Guide, and the Reference Manual are intended for use in conducting technical assistance workshops for state and local agency personnel responsible for state public water supply programs under the Federal Safe Drinking Water Act.

The overall objective of this course is to develop the capabilities at state and federal regional office levels to train new regulatory inspectors to conduct an effective and comprehensive sanitary survey of a small water supply system. This course provides the minimum training that, when complemented by on-the-job training, will enable personnel to perform effective evaluations of small public water supply systems. Personnel attending training using these manuals should have a basic knowledge of water supply systems and some limited on-the-job experience in conducting a sanitary survey. The course is not intended to be the official document for conducting a sanitary survey but rather is to serve as a guide outlining systematic procedures for organizing a sanitary survey. It must be stressed that the course and the course publications provide only "need-to-know" information (basic questions and their rationale and importance) that an inspector needs to know to adequately evaluate a small water supply system. Neither the course nor the two accompanying publications will provide the technical detail on every facet of a water system, nor are they intended to provide an inspector with the ability to provide technical assistance.

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Unit References

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Water Treatment Plant Operation Vol. I (Chapter 2)
Small Water System Operation & Maintenance (Chapter 2)
Water Distribution System Operation and Maintenance (Chapter 5)

COURSE NOTES FOR UNIT 1

[illegible] MATERIAL

What Is a Sanitary Survey?

"Sanitary Survey" means an evaluation of operational and maintenance procedures, a review and inspection of the water sources, facilities and equipment of a public water system for the purpose of producing and distributing safe drinking water.

Sanitary Surveys may be Class I or Class II.

(i) A Class I Sanitary Survey is conducted once every three years and must include a comprehensive evaluation of all water system components, operational and maintenance procedures.

(ii) A Class I Sanitary Survey is a limited survey which is conducted on an as-needed basis and could include but not be limited to: operational and maintenance inspections, complaint investigations, follow-up inspections or the results of a compliance or enforcement related action.

Why Conduct a Sanitary Survey?

Competent personnel must conduct sanitary surveys periodically to determine whether the construction, equipment, facilities, operation, and maintenance of the parts of a water supply system are adequate, effective, and efficient in producing quantities of safe water for the consuming public, and whether the water quality meets acceptable standards.

Who Conducts a Sanitary Survey?

Sanitary surveys are conducted by sanitary engineers, sanitarians, and technicians who have experience, knowledge, and competence in the design, operation, and maintenance of water supply systems. These personnel must be qualified to assess problems using hydrological, hydraulic, mechanical, and other basic engineering knowledge and be able to make sound, adequate, and economical recommendations.

What Occurs During a Sanitary Survey?

The activities of a sanitary survey provide a comprehensive, accurate record of the component parts of water systems, assess their operating conditions and adequacy as a water system, and determine if past recommendations regarding the system have been effectively implemented.

This program of instruction presents the information needed by the inspector to effectively carry out the following activities:

- Inspect and evaluate the water source.
- Inspect and evaluate the intake structure.
- Inspect and evaluate the treatment/conditioning facilities.
- Inspect and evaluate the distribution system.

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- o Sample source and distribution water for bacteriological, physical, chemical, and radiological properties, and (as required) perform and evaluate field analyses.
- o Review operation and maintenance practices.
- o Review records, files, maps, correspondence.
- o Determine qualifications of engineering, sanitation, and ancillary personnel; review management practices and personnel needs.
- o Complete the survey report.
- o Present sanitary survey data to operating personnel and (as required) discuss onsite problems and provide recommendations.
- o Notify the owner/operator, public, State regulatory agency, and EPA of deficiencies (as required).

(Specific inspection and reporting information is included in the basic material of the following units.)

Program Objective

For the remainder of this training program, we will be covering the components of a typical water system:

- o Source
- o Intake Structure
- o Treatment
- o Storage
- o Distribution

We will be answering two questions about these components:

1. What conditions might cause sanitary risks in each of the components?
2. How might these conditions be recognized?

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A Sanitary Survey is:

A Review of:

- Source
- Facilities
- Equipment
- Operations & Maintenance

Figure 1-1

COURSE NOTES FOR UNIT 1

Sanitary Survey

Class I every 3 years & Comprehensive (All components)

Class II As needed & limited

Figure 1-2

COURSE NOTES FOR UNIT 2

UNIT 2

Unit 2: WATER REGULATIONS

Unit Summary

Safe Drinking Water Act
- National Interim Primary Drinking Water Regulations

Unit References

National Interim Primary Drinking Water Regulations
Water Treatment Plant Operation Vol. I (Chapters 2, 8, and 11)
Small Water System Operation & Maintenance (Chapters 1, 2, and 5)
Water Distribution System Operation and Maintenance (Chapters 1 and 6)

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Basic Material

In recognition of a decline in the quality of drinking water around the Nation, Congress passed the Safe Drinking Water Act designed to ensure the delivery of safe drinking water by public water systems and to protect underground water sources from contamination.

The Act required the Environmental Protection Agency to establish primary and secondary regulations limiting contaminants to a level where "no known or anticipated adverse effects on the health of persons occur and which allows an adequate margin of safety."

The National Interim Primary Drinking Water Regulations specify requirements and procedures for controlling contaminants in public water supplies.

Applicability

Although the Primary Regulations apply to all public water supply systems, the regulations make a distinction between community and noncommunity systems. Community systems generally supply drinking water to residential and institutional users who might be exposed to dangerous levels of contaminants for extended periods of time. Consequently, a wider range of contaminants is controlled by the regulations. The regulations define a "public water system" as a system for providing piped water to the public for human consumption if such a system has at least 15 service connections or regularly serves at least 25 people at least 60 days per year. The term includes any collection, treatment, storage, and distribution facilities under control of the system operator and used primarily in connection with such a system, and any collection or pretreatment storage facilities not under such control that are used primarily in connection with such a system.

Some classes and types of regulated water systems are listed below.

Community Water Systems

- Municipal systems and public water utilities
- Mobile home parks
- Condominiums
- Residential institutions and schools, including hospitals, nursing homes, homes for the aged, colleges
- Housing developments, public and private
- Multifamily housing complexes (all varieties)

Noncommunity Water Systems (with separate water systems)

- Motels-hotels-resort areas
- Schools (nonresident)
- Restaurant and other food service places
- Campgrounds
- Highway rest areas
- Marinas
- Airports

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Parks
Recreation areas
Migrant labor and construction camps
Children's and adult camps
Gasoline service stations
Industries
Churches
Medical care facilities
Shopping centers
Office and commercial buildings
Public buildings and public assembly facilities
Social and recreation clubs
Swimming pools and beaches

Siting Requirements

The siting of a water system is of primary importance in ensuring safe water. The National Interim Primary Drinking Water Regulations encourage the avoidance of hazardous locations when constructing new or expanding public water systems. Sites to be avoided are areas subject to significant risks of:

- Earthquakes*
- Floods (100-year floodplain)
- Fire or other disasters that could cause a breakdown in the water systems
- In many areas, California for example, it is impossible to construct plants which are not subject to these hazards. In those cases, good designing is even more critically important to providing a continuous supply of water.

Maximum Contaminant Levels

The regulations include maximum contaminant levels for five properties of drinking water.

- Inorganic chemicals
- Organic chemicals
- Turbidity
- Microbiological contaminants
- Radiological contaminants

The specific maximum contaminant levels are provided in Tables 2-1 through 2-3. Each category has specific sampling and analytical requirements.

Water Purveyor Requirements

The water purveyor must report to the State agency:

- Results of all tests and analyses within the first 10 days following the month in which the result is received, or within the first 10 days following the end of the required monitoring period - whichever is the shortest.

- Notice of failure to comply with any primary water regulations, including monitoring, within 48 hours.

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- Notify public when a community water system fails to comply with:
    - An applicable maximum contaminant level
    - An applicable testing procedure
    - Scheduled corrections
    - Required monitoring

- Maintain the following records:
    - Bacteriological analyses - for at least 5 years.
    - Chemical analyses - for at least 10 years. Actual laboratory reports may be kept, or data may be transferred to tabular summaries, provided that the following information is included:
        - Date, place, time of sampling; name of person collecting
        - Identification of routine distribution system sample, check samples, raw or process water samples, special purpose samples; date of analysis
        - Lab and person responsible for performing analysis
        - Analytical method used
        - Results of analysis
    - Records of action taken to correct violations - for at least 3 years after last action was taken with respect to a particular violation.
    - Copies of written reports, summaries, or communications relating to sanitary surveys conducted by itself, private consultant, or local, State or Federal agency - for at least 10 years after completion of sanitary survey involved.
    - Records concerning scheduling of improvements - not less than 5 years following expiration of scheduling time.

Responsibilities for Implementing NIPDWRs

Federal

As already noted, the Federal Government through the Environmental Protection Agency has set the MCLs and Secondary MCLs for constituents to ensure that no adverse health effects occur. If a State desires primary enforcement authority (primacy), EPA will certify the program if the State meets requirements. Annual evaluations will be performed to ensure the quality of the State program.

Research, technical assistance, training programs, and funding are provided States. EPA may take action if States fail to adopt or properly implement the regulations.

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State

Most States and territories have assumed primary enforcement responsibility for enforcement of the regulations. EPA would retain program responsibility only if a State is unable or unwilling to meet the minimum requirements for primacy. To attain primacy under the Act, a State must adopt standards at least as stringent as the Federal primacy standards. States are free to adopt and enforce more stringent standards appropriate to that State.

Additionally the States must:

- Maintain an inventory of public water systems.
- Have a systematic program for conducting sanitary surveys.
- Establish a program for certification of water testing laboratories (unless testing is done by approved State laboratories).
- Assure that new or modified public water systems are capable of compliance with State drinking water regulations.
- Establish procedures for enforcement.
  - Authority to sue in court for violations
  - Right to entry
  - Authority to require suppliers to keep accurate records and make appropriate reports to the State
- Establish and maintain recordkeeping and reporting of its activities.
- If variances or exemptions are permitted, they must be under the same conditions as granted under the Federal regulations.
- Adopt and implement an adequate plan for providing safe drinking water under emergency conditions.

Water Utility Responsibilities

The responsibility of the water purveyor is to meet the primary standards set by EPA, or the more stringent State standards.

These responsibilities include the treatment and monitoring of bacteriological, chemical, and radiological contaminants; recordkeeping and reporting of results to State agencies; and notification of any noncompliance to consumers and the public.

The National Secondary Drinking Water Regulations are designed to control contaminants that affect the esthetic quality of drinking water. High concentrations of these contaminants may have health as well as esthetic implications. The federally set contaminant levels were set as guidelines for State regulations provided in Table 2-4.

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Table 2-1 US PRIMARY AND SECONDARY DRINKING WATER REGULATIONS

Contaminant	Unit	MCL	Secondary MCL
Primary regulations*			
Inorganics			
Arsenic	mg/L	0.05	
Barium	mg/L	1.0	
Cadmium	mg/L	0.01	
Chromium	mg/L	0.05	
Fluoride	mg/L	4.0	
Lead	mg/L	0.05	
Mercury	mg/L	0.002	
Nitrate (as N)	mg/L	10.0	
Selenium	mg/L	0.01	
Silver	mg/L	0.05	
Microbials			
Coliforms		1/100 mL	
Turbidity	ntu	1-5	
Organics			
2,4-D	mg/L	0.1	
Endrin	mg/L	0.0002	
Lindane	mg/L	0.0004	
Methoxychlor	mg/L	0.1	
Toxaphene	mg/L	0.005	
2,4,5-TP silvex	mg/L	0.01	
Trihalomethanes (chloroform, bromoform, bromodichloromethane, dibromochloromethane)		0.10	
Radionuclides			
Beta particle and photon radioactivity	mrem	4 (annual dose equivalent)	
Gross alpha particle activity	pCi/L	15	
Radium-226 + radium-228	pCi/L	5	
Volatile organic chemicals			
Benzene	mg/L	0.005	
Carbon tetrachloride	mg/L	0.005	
1,2-Dichloroethane	mg/L	0.005	
1,1-Dichloroethylene	mg/L	0.007	
1,1,1-Trichloroethane	mg/L	0.20	
para-Dichlorobenzene	mg/L	0.075	
Trichloroethylene	mg/L	0.005	
Vinyl chloride	mg/L	0.002	
Secondary regulations†			
Chloride	mg/L		250
Color	color units		15
Copper	mg/L		1
Corrosivity			noncorrosive
Fluoride	mg/L		2
Foaming agents	mg/L		0.5
Iron	mg/L		0.3
Manganese	mg/L		0.05
Odor	TON		3
pH			6.5-8.5
Sulfate	mg/L		250
Total dissolved solids	mg/L		500
Zinc	mg/L		5

*Enforceable
†Nonenforceable

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Table 2-2 Maximum Permissible Microbiological Contaminants (NIPDWR)

Coliform Method	Per Month	Less than 20 Samples per Month	20 or More Samples per Month
		Number of coliform bacteria shall not exceed:	
Membrane filter (100-ml portions)	1/100 ml average density	4/100 ml in one sample	4/100 ml in 5% of samples
		Coliform bacteria shall not be present in more than:	
Multiple tube fermentation (10-ml portions)	10% of portions	3 portions in one sample	3 portions in 5% of samples

Coliform Method	Per Month	Less than 5 Samples per Month	5 or More Samples per Month
		Coliform bacteria shall not be present in more than:	
Multiple tube fermentation (100-ml portions)	60% of portions	5 portions in more than one sample	5 portions in more than 20% of samples

Table 2-3 Maximum Permissible Radioactivity (NIPDWR)*

Contaminant	Maximum Contaminant Level Picocurie per liter (pCi/l)
Natural	
Combined Radium-226 and Radium-228	5
Gross alpha particle activity, including Radium-226 but excluding Radon and Uranium	15
Man-Made	
Tritium (total body)	20,000
Strontium-90 (bone marrow)	8
Gross beta particle activity (applicable to surface water sources)	50

*For full explanation refer to Part 141, National Interim Primary Drinking Water Regulations.

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Table 2-4. Special Monitoring Requirements Under National Interim Primary Drinking Water Regulations.

Contaminant	Frequency Surface	Ground
Sodium	1 sample annually	1 sample at least every 3 years
Corrosivity	2 samples annually (1 mid summer) (1 mid winter)	1 sample annually

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Table 2-5

CONTAINANTS TO BE REGULATED* UNDER THE SDWA AMENDMENTS OF 1986

Inorganics	**Organics, continued**
Aluminum	Dioxin
Antimony	Diquat
Arsenic†	Endothall
Asbestos	Endrin†
Barium†	Epichlorohydrin
Beryllium	Ethylene dibromide
Cadmium†	Glyphosate
Chromium†	Hexachlorocyclopentadiene
Copper	Lindane†
Cyanide	Methoxychlor†
Fluoride†	Pentachlorophenol
Lead†	Phthalates
Mercury†	Pichloram
Molybdenum	Polychlorinated biphenyls
Nickel	Polycyclic aromatic hydrocarbons
Nitrate†	Simazine
Selenium†	2,4,5-TP†
Silver†	Toluene
Sodium	Toxaphene†
Sulfate	1,1,2-Trichloroethane
Thallium	Vydate
Vanadium	Xylene
Zinc	
Microbiology and turbidity	**Radionuclides**
Giardia lamblia	Beta particle and photon activity†
Legionella	Gross alpha particle activity†
Standard plate count	Radium-226 and radium-228†
Total coliforms†	Radon
Turbidity†	Uranium
Viruses	**Volatile organic chemicals**
Organics	Benzene†
Acrylamide	Carbon tetrachloride†
Adipates	Chlorobenzene
Alachlor	*cis*-1,2,-Dichloroethylene
Aldicarb	Dichlorobenzene†
Atrazine	1,2-Dichloroethane†
Carbofuran	1,1-Dichloroethylene†
Chlordane	Methylene chloride
2,4,-D†	Tetrachloroethylene
Dalapon	*trans*-1,2,-Dichloroethylene
Dibromochloropropane	Trichlorobenzene
Dibromomethane	1,1,1-Trichloroethane†
1,2-Dichloropropane	Trichloroethylene†
Dinoseb	Vinyl chloride†

*Seven substitutions are permitted.
†Already regulated

COURSE NOTES FOR UNIT 3

Unit 3: WATER SOURCES

Unit 3a: Overview

Unit Summary

Hydrologic Cycle
Ground Water
Surface Water
Quality Water
Water Demands

Unit References

Manual of Instruction for Water Treatment Plant Operations (Chapter 2)
Manual of Individual Water Supply Systems (Chapter 1)
Water Treatment Plant Operation Vol. I (Chapter 2)
Small Water System Operation & Maintenance (Chapters 1 and 2)
Manual of Water Utilities Operations (Chapter 1)

COURSE NOTES FOR UNIT 3

Basic Material

The two principal sources of water supplies are surface waters and ground waters. Both originate from precipitation. Some of the precipitation collects on the surface of the earth to form streams, lakes, and other surface waters. Some seeps downward through the earth where it accumulates in the pore spaces in the soils that overlay rock formations. The seepage continues downward and laterally to fill the interconnecting joints, cracks, solution channels, pore spaces, and other openings in these rock formations below the soils. Ground water is not static and tends to move slowly through the substrata, some of it reappearing at the edge of streams and lakes or as springs and seepage areas. Energy from the sun evaporates water from the earth, streams, lakes, and seas and promotes transpiration of moisture from growing plants to form water vapor in the atmosphere. The water vapor forms into clouds, which in turn produce rain and snow to replenish the surface and ground waters. This continuous process is called the hydrologic or water cycle; and by its very nature, water is exposed to both natural and man-induced contamination.

Ground Water

Ground water is the principal source of water for small water supply systems. Ground water generally has a more consistent good bacterial quality than surface water, having undergone considerable natural purification through straining and prolonged storage. However, a number of areas have suffered contamination of their ground water due to improper disposal of their wastes. Generally it requires little (if any) treatment prior to use, whereas surface waters invariably require rather sophisticated treatment. Furthermore, ground waters are readily available in most areas of the country in sufficient quantities to meet the needs of small water systems.

Surface Water

Precipitation that does not enter the ground through infiltration or is not returned to the atmosphere by evaporation flows over the ground surface and is classified as direct runoff. Direct runoff is water that moves over saturated or impermeable surfaces, and in stream channels or other natural or artificial storage sites. The dry weather (base) flow of streams is derived from ground water or snowmelt.

Runoff from ground surfaces may be collected in either natural or artificial reservoirs. A portion of the water stored in surface reservoirs is lost by evaporation and from infiltration to the ground water table from the pond. Transpiration from vegetation in and adjacent to ponds constitutes another means of water loss.

Because surface waters are exposed to potentially severe contamination by both man and nature and because the quality of the water varies considerably, a relatively high degree of treatment is required to ensure its

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constant safety. The treatment is generally more sophisticated than with ground waters and requires more diligent operation and maintenance and more costs.

However, there are occasions when surface water is a source for a small water supply system because of the poor quality or lack of local ground water. Other factors being equal, impoundments such as natural lakes or ponds, or reservoirs, are preferred over streams since the quality of the water is usually less variable, reducing the extremes in quality.

Quality of Water

Precipitation in the form of rain, snow, hail, or sleet contains very few impurities. Trace amounts of mineral matter, gases, and other substances may be entrained as the precipitation forms and falls through the earth's atmosphere; however, the precipitation has virtually no bacterial content.

Once precipitation reaches the earth's surface, many opportunities are presented for the introduction of foreign substances into the water, which may lower its quality to the point that it constitutes a health hazard or impairs its usefulness.

Proximity of the water source to nearby sewers, waste disposal, construction projects, animal pasturing, chemically treated agricultural land, and chemical storage areas (such as salt or petroleum) increases the likelihood of contamination. Other sources of contamination are completely natural, such as the impact of high flood runoff, chemical composition of soil above the rock (e.g., the presence of iron), or decomposition of organic matter.

Substances that alter the quality of water as it moves over or below the surface of the earth may be classified as follows:

- Organic
- Inorganic
- Biological
- Radiological

Impurities in natural waters depend largely on the circumstances of the source and its history. Water destined for an aquifer picks up impurities as it seeps through soil and rock, including possible pollution. Pollution sources may include leaking sanitary sewers, septic systems, waste disposal sites, and accidental discharges. Uptake of minerals is common. The natural straining action does remove some of the particulate matter and, combined with a relatively long retention period in the ground, will often aid in removing micro-organisms. This long retention time can, however, create problems in that ground water once contaminated can be costly to purge in terms of both time and money. Ground waters have a fairly stable quality usually not highly affected by seasonal changes. Wells affected by seasonal changes tend to be very shallow and subject to easy contamination.

COURSE NOTES FOR UNIT 5

Water Demands

The projected average daily demand is the quantity of water projected to be used by a specific system or part of a system in an average day. This is based upon experience from water meter readings in similar water systems over an extended period of time and reflects the normal seasonal and daily variations. For design purposes, it is usually determined by estimating the population or units of housing or other units and muliplying by an average person or per unit water consumption derived from past experience. Other water demand terms frequently relate to this basic term. The average daily demand will be exceeded on many days so it is not appropriate to design merely for the average. For this reason other terms are used to express the probable greatest amount of water that may be used in one day, or other period of time.

Table 3-1 provides a guide for estimating the average daily demand for various types of establishments, in gallons per day per unit. The unit is persons per day unless otherwise indicated. The values shown may vary throughout the Nation, and the inspector is advised to review local information on water systems serving similar size establishments.

The maximum daily demand is the greatest amount of water that a system will use in one day. Experience with small residential water systems suggests that the maximum day is 1.5 to 2 times the average day. However, this ratio may not apply to other types of water systems. In general, the smaller the water system, the greater the variation between the average and the maximum day.

The maximum hourly demand is the greatest amount of water that will be used in any hour during a day. Maximum hourly demand is sometimes referred to as the peak hourly demand, although there will be short-term peak demand rates lasting for several minutes that will exceed the maximum hourly demand rate. Each type of system exhibits it own maximum hourly and short-term peak demands and the hours of peak occurrence will vary. As an example, shopping centers usually experience hourly peaks in the early afternoon while residential communities may experience two peak hours, about 8:00 a.m. and 6:00 p.m. The maximum hourly demand is often expressed as a ratio of the average daily demand, in gallons per minute. Generally speaking, the smaller the system, the greater the maximum hourly rate in respect to the average daily rate.

Peak demand is the maximum amount of water necessary to meet the peak short-term demand rate that may occur several times during a day, but usually during the peak-hour period. The instantaneous peak may last for several minutes. The rate is particularly important in considering the sizing of the storage tank in a hydropneumatic system. The effective storage capacity is usually designed to meet these short-term peaks. In the absence of sufficient effective storage to meet extended peak demands, the wells and pumps must be capable of meeting the peak demands. The smaller the system, the greater the ratio of the peak demand to the average demand. Experience with small residential communities suggests that the peak hourly demand may range from about 6 to 10 times the average daily demand.

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Fire flow is the amount of water capacity that must be designed into a water system for firefighting purposes. Fire flow is not included in the definition of average daily and maximum daily demands and must be added if fire protection is desired. Fire flows are usually expressed as gallons per minute to fight a fire of a certain duration. Local fire underwriters will provide specific requirements on request.

Sanitary Risks

1. What type of source (surface, ground or combination)?

   There are specific risks for each type of source, which will be covered in later sections of Unit 3.

2. What is the total design production capacity?

   Comparison of this figure with present demand figures allows the inspector to determine if there is adequate treatment capacity.

3. What is the present average daily production?

   Comparison of this figure with values for other similar systems on a per capita basis may point out problems within the system. An evaluation of average daily production trends may indicate problems as well. For example, if consumption is excessive or production trends are increasing without an accompanying population or use increase, leakage within the distribution system may be indicated.

4. What is the maximum daily production?

   Comparison of this figure with design capacity allows determination of adequacy of treatment capacity.

5. Does system have an "operational" master meter?

   Without an operational and calibrated master meter, it is difficult for the utility to accurately monitor production.

6. How many service connections are there?

   This figure provides the inspector with an idea of the size of the system; this means the total number of homes and businesses served by the system. It should not include connections for vacant lots.

7. Are service connections metered?

   This allows a water balance to be made. There is also a correlation between metered service and water conservation. If the system is metered, the per capita consumption is reduced.

A review of the system's records and operator responses should provide answers to these questions.

COURSE NOTES FOR UNIT 5

Table 3-1. Guide for Estimating Average Daily Water Requirements*
(Adapted from various sources for small water systems)

Type of Establishment (The unit is per person unless otherwise stated)	Average Daily Use (gpd)
Airport (per passenger)	3-5
Assembly Halls (per seat)	2
Camps - Child, overnite, central facilities	40-50
- Construction	50
- Migrant labor	35-50
- Day type, no meals served	15
Churches (per member)	1
Cottages, season occupancy	50
Clubs - Residential	100
- Nonresidential	25
Factories, sanitary uses, per shift	15-35
Food Service - Restaurants	7-10
- With bars	9-12
- Fast food	2
Highway Rest Areas	5
Hotels (2 persons per room)	60
Institutions - Hospitals (per bed)	250-400
- Nursing Homes (per bed)	150-200
- Others	75-125
Office Buildings	15-30
Laundries, self service (per customer)	50
Motels (per bed)	60
Parks - Day use (with flush toilets)	5
- Mobile homes (per unit)	200
- Travel trailers (per unit)	90-100
Picnic Areas (with flush toilets)	5-10
Residential Communities	
- Multi-family (per bedroom)	120
- Rooming house and tourist homes type (per bedroom)	120
- Single family type (per house)	400
Resort Motels and Hotels	75-100
Retail Stores (per toilet room)	400
Schools - Day, no showers or cafeteria	15
- Day, with cafeteria	20
- Day, with showers and cafeteria	25
- Residential types	75-100
Shopping Centers, per sq. ft. sales area	0.16
Swimming Pools and Beaches	10
Theaters - Drive-in (per car)	3-5
- Others (per seat)	3

*The values listed in Table 3-1 are for normal water requirements and do not include special needs or unusual conditions. State and local requirements may vary from those provided in this table. Additional allowance should be made for frequent lawn watering, swimming pool maintenance, industrial or commercial process water, cooling water, firefighting, and other special uses.

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UNIT 3b: Wells

Unit Summary

Types and Characteristics
Sanitary Risk Factors
Surveying Wells

Unit References

Small Water Systems Serving the Public (Chapter 5)
Manual of Individual Water Supply Systems (Part II)
Ground Water and Wells
Well Drilling Operations
Water Supply System Operation (Chapter 3)

Basic Material

To reach the ground waters underlying the earth's surface, a well must be constructed to penetrate the desired water-bearing strata. These structures may be dug, driven, bored, jetted, or drilled, depending on the geological formations through which they must pass and the depth to which they must reach. Dug, driven, bored, and jetted wells are usually confined to relatively soft soils overlaying rock and to shallow depths normally less than 50 feet (15 meters). Wells using these sinking methods should not be constructed for use as public water sources unless specifically approved by the State regulatory agency. Drilled wells may be used in both soft and hard soil and in rock and may be sunk to depths of several hundred feet.

Drilled wells can be constructed in all instances where driven and jetted wells might otherwise be used and in many areas where dug and bored wells are constructed. The larger diameter of a drilled well, compared with a driven or jetted well, permits use of larger pumping equipment that can develop the full capacity of the aquifer.

There are various components of a well, many of which cannot be observed by the sanitary surveyor. Some of the more important ones follow.

Well casing is installed in wells to prevent the collapse of the walls of the bore hole, to exclude pollutants (either surface or subsurface) from entering the water source, and to provide a column of stored water and a housing for the pump mechanisms and pipes.

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Cement grout is used to fill the annular open space left around the outside of the well casing during construction to prevent undesirable water and contamination from entering the well.

Screens are installed at the intake point of the well to hold back unstable aquifer material and permit free flow of water into the well. The well screen should be of good quality (corrosion-resistant, hydraulically efficient, and with good structural properties).

Well head covers or seals are used at the top of the casing or pipe sleeve connections to prevent contaminated water or other material from entering the well. A variety of covers and seals are available to meet the variety of conditions encountered, but the principles and the objective of excluding contamination are the same.

Pitless adapters are used to eliminate the need for a well pit. Because of the flooding and pollution hazards involved, a well pit to house the pumping equipment or to permit accessibility to the top of the well is not recommended. Some States prohibit its use. These units vary in design but generally include a special fitting designed for mounting on the side of the well casing. The well discharge and other piping are screw-threaded into the fitting, providing a tight seal. The pitless system permits the connection of the well piping to the casing underground below frost depth and, at the same time, provides for good accessibility to the well casing for repairs without excavation.

Sanitary Risks

1. Is the aquifer recharge area protected? What is the nature of the recharge area?

   The nature of activities on the recharge zone and whether or not they are controlled can influence the quality of the water source. This information can assist the inspector in the identification of the potential source. The recharge area can be protected by means ranging from ownership of the area by the utility with restricted access to zoning laws prohibiting the use of subsurface waste disposal (septic tanks). The owner/operator should know this information.

2. Is the site subject to flooding?

   The introduction of surface waters into the well should be avoided. Runoff in the immediate area should be drained away from the well site. The well field should not be placed in a floodplain (100-year flood). To protect a well is easier than to clean an aquifer once it is contaminated. Information on flooding and site drainage may be obtained from the owner/operator, visual inspection, and flood stage records. The exposed casing should terminate 18 inches above known flood level.

3. Is the well located in the proximity of a potential source of pollution?

Your State regulatory agency should be consulted for its policy concerning well location, particularly the minimum protective distances between the well and sources of existing or potential pollution. Table 3-2 is an example of typical minimum distances. These distances are based on general experience and are not guarantees of freedom from contamination. The water purveyor should provide even greater protection where possible. The table applies to properly constructed wells with protective casing set to a depth of at least 20 feet below ground surface. Other types of wells will require special considerations.

Table 3-2 Sample Minimum Distances Between Wells and Pollution Sources

Source	Feet from Well	Remarks
Watertight Sewers	50	
Other Sewers	100	Consult the State regulatory agency for special local requirements.
Septic Tanks	100	
Sewage Field, Bed or Pit	200	
Animal Pens and Yards	200	

Source: Small Water Systems Serving the Public, Chapter 5.

4. What is the depth of the well?

The greater the depth of the aquifer utilized, the less chance of surface contamination degrading the water quality. Deeper aquifers generally have a more consistent quality of water.

5. What is the well drawdown?

Drawdown is the difference between static water levels and pumping water levels. Measuring drawdown is important since changes in drawdown can indicate problems in the aquifer (declining water levels) or well (incrustation, sand). The operator should be able to provide this information. If the operator is not measuring drawdown, he/she should be encouraged to do so.

6. What is the depth of the casing?

The casing must be strong enough to resist the pressures exerted by the surrounding materials and corrosion by soil and water environments. The casing must be of the proper length to provide a channel from the aquifer to the surface through unstable formations and through zones of actual or potential contamination. The casing should extend above potential levels of flooding and should be protected from flood water contamination and damage. In unconsolidated soils, the casing should extend at least 5 feet (1.5 meters) below the estimated maximum

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expected drawdown level. In consolidated rock formations, the casing should extend 5 feet (1.5 meters) into firm bed rock and sealed into place. The operator should be able to provide this information.

7. What is the depth of grouting?

   Specific grouting requirements of a well depend on the existing surface conditions, especially the location of sources of pollution, and the subsurface geologic and hydrologic conditions. To achieve the desired protection against contamination, the annular space must be sealed to whatever depth is necessary, but in no case less than 20 feet.

8. Does the casing extend at least 12 inches above the floor or ground?

   This provides protection against surface runoff or drainage problems. The 12 inches is recommended when there is no potential for flooding.

9. Is the well properly sealed?

   Well head covers or seals are used at the top of the casing or pipe sleeve connections to prevent contaminated water or other material from entering the well. A variety of covers and seals are available to meet the variety of conditions encountered, but the principles and the objective of excluding contamination are the same. Well covers and pump platforms should be elevated above the adjacent finished ground level and should be sloped to drain away from the well casing. Well pits should not be used, since they may result in contamination. Pitless adapters are used to eliminate the need for a well pit. Because of the flooding and pollution hazards involved, a well pit to house the pumping equipment or to permit accessibility to the top of the well is not recommended. Some States prohibit its use. A concrete slab around the well casing is not a completely reliable seal, since burrowing animals and insects can undermine it or it can be broken or cracked from frost heave or vehicles.

10. Does the well vent terminate 18 inches above ground/floor level or above maximum flood level with return bend facing downward and screened?

    This is to keep water (from water cooled bearings for example), dust, insects, and animals from entering the well casing.

11. Does the well have a suitable sampling cock?

    This is important when trying to isolate sources of contamination in a well field. If there is a well field and individual sample cocks are not provided, it is difficult to determine if one or all wells are the problem.

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12. Are check valves, blowoff valves, and water meters maintained and operated properly?

Valves should be maintained and operated to prevent contamination from entering the well.

13. Is the upper termination of the well protected?

The upper termination of the well should be either housed or fenced to protect it from vandalism and vehicle damage.

14. Is lightning protection provided?

Lightning surges can develop in powerlines during thunderstorms. Such surges can damage pump motors, creating loss of water supply as well as costly repairs. To protect against this, lightning arrestors can be provided where service lines are connected to service entrance cables or at the motor control box. A multiground arrangement can be provided that grounds the entire pump and well against damage.

15. Is pump intake located below maximum drawdown?

This prevents the pump from running dry as well as protects against contamination in upper portions of water table from being pumped.

16. Are foot valves and/or check valves accessible for cleaning?

As with above-ground valves, these valves must be maintained in an operating manner to prevent flow of undesirable water into the well.

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UNIT 3c: Springs

Unit Summary

Spring Source Collection System Components
Sanitary Risks

Unit References

Small Water Systems Serving the Public (Chapter 7)
Manual of Individual Water Supply Systems (Part II)

Basic Material

To properly develop a spring supply, the natural flow of ground water must be captured below the ground surface, and the method used must not contaminate the water. Springs are subject to contamination by wastewater disposal systems, animal wastes, and surface drainage. Springs are also susceptible to seasonal flow variations, and the yield may be reduced by the pumping of nearby wells.

Springs may be gravity or artesian. Gravity springs occur where the water-bearing stratum overlays an impermeable stratum and outcrops to the surface. They also occur where the land surface intersects the water table. This type of spring is particularly sensitive to seasonal fluctuations in ground water storage, and frequently dwindles or disappears during dry periods. Gravity springs are characteristically low-yielding sources, but when properly developed they may be satisfactory for small water supply systems.

Artesian springs discharge from artesian aquifers. They may occur where the confining formation over the artesian aquifer is ruptured by a fault or where the aquifer outcrops at a lower elevation. Artesian springs are usually more dependable than gravity springs, but they are particularly sensitive to the pumping of wells developed in the same aquifer. As a consequence, artesian springs may be dried up by nearby well pumping.

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Important criteria for spring sources include selection of a spring with acceptable water quality, development to the required quantity of water, and sanitary protection of the spring collection system. The measures taken to develop a spring must be tailored to the prevailing geological conditions.

Spring Source Collection System

Spring flow is intercepted by a system of perforated pipes driven into the water-bearing stratum or laid in gravel-packed trenches. The flow is directed into a storage tank. As an alternative, a watertight concrete collection chamber is constructed with openings in the bottom and/or a side wall to intercept the flow. This chamber may also serve as the storage tank. Where possible, the walls of the collection chamber should extend to bedrock or the impervious stratum. The watertight walls should extend 8 or more inches above ground to prevent entrance of surface water. An overlapping (shoe-box) cover will prevent entrance of debris.

The tank is usually constructed in place with reinforced concrete to intercept as much of the spring as possible. When a spring is located on a hillside, the downhill wall and sides are extended downward to bedrock or impervious soil to ensure that the structure will hold back water to maintain the desired level in the chamber. Supplementary cutoff walls of concrete or impermeable clay may be used to assist in controlling the water table in the vicinity of the tank. The lower portion of the uphill wall of the tank must have an open construction to allow water to move in freely while the aquifer material is held back. Backfilling with graded gravel will aid in restricting movement of aquifer material.

The tank cover should be cast in place to ensure a good fit. The cover should extend down over the top edge of the tank at least 2 inches, should be heavy enough to prevent dislodging by children, and should be lockable.

A drain pipe with an exterior valve should be placed close to a wall of the tank at the floor level to permit draining. The end of the pipe should extend far enough to allow free discharge to the ground surface, away from the tank. The discharge end of the pipe should be screened to prevent nesting by animals and insects.

The overflow is usally placed slightly below the maximum water-level elevation. The overflow should have a free discharge to a drain apron of rock to prevent soil erosion at the point of overflow and should be screened.

The supply intake should be located about 6 inches above the floor and should be screened. Care should be taken to ensure good bond between pipes and the concrete structure.

Infiltration Galleries

Recreational or other developments located in the mountains may have access to a head water mountain stream where the watershed is generally heavily forested and uninhabited by man. However, after periods of heavy rainfall or spring thaws, debris and turbidity may cause problems at the

COURSE NOTES FOR UNIT 3

water intake and will materially increase the required degree of treatment. If the conditions are suitable, this problem can be avoided by constructing the intake in an underground chamber (infiltration gallery) along the shore of the stream or lake.

Galleries may be considered where porous soil formations adjoin a stream or lake so that the water can be intercepted undergound to take advantage of natural filtration. Any gallery access structures should be located above the level of severe flooding.

A typical installation generally involves the construction of an underdrained, sand filter trench located parallel to the stream bed and about 10 feet from the high water mark. The sand filter is usually located in a trench with a minimum width of 30 inches and a depth of about 10 feet, sufficient to intercept the water table. At the bottom of the trench, perforated or open joint tile is laid in a bed of gravel about 12 inches in thickness, with about 4 inches of graded gravel located over the tile to support the sand. The embedded tile is then covered with clean, coarse sand to a minimum depth of 24 inches, and the remainder of the trench backfilled with fairly impervious material. The collection tile drains to a watertight, concrete chamber from which water may flow to the distribution system by gravity or pump, whichever is appropriate. Chlorination is generally necessary and may be done in the chamber or at another place, but prior to any use.

Where soil formations adjoining a stream are unfavorable for the location of an infiltration gallery, the debris and turbidity that are occasionally encountered in a mountain stream may be controlled by constructing a modified infiltration gallery in the stream bed.

If a natural pool is not available in the stream bed, a dam is usually constructed across the stream to form a pool. The filter is installed in the pool by laying perforated pipe in a bed of graded gravel, which is then covered by at least 24 inches of clean, coarse sand. About 24 inches of freeboard should be allowed between the surface of the sand and the surface water level. The collection lines may terminate in a watertight, concrete basin located adjacent to the upstream face of the dam from where the water is diverted to chlorination facilities.

Sanitary Risks

1. Is the recharge area protected?
2. What is the nature of the recharge area?
3. Is the site subject to flooding?

The rationale for the above questions is the same as that for wells.

4. Is the collection chamber properly constructed?

   The collection chamber should be watertight to prevent the inflow of undesirable water. The tank cover should be impervious and lockable. The drain should have an exterior valve and the exterior end screened. The overflow should have a free discharge to a drain apron to prevent soil erosion. This information may be obtained by inspection of the collection chamber.

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5. Is the supply intake adequate?

The supply intake should be located 6 inches above the chamber floor and screened. This location reduces the withdrawal of the sludge that may build up in the chamber.

6. Is the site adequately protected?

The following precautionary measures will help ensure spring water of consistently high quality:

- o Diversion of surface drainage from the site. A surface drainage ditch should be located uphill from the source to intercept surface water runoff and carry it away from the source. Springs in close proximity to agriculturally developed land treated by pesticides and herbicides may be particularly susceptible to contamination.

- o Protection from stray livestock and from tampering by means of site fencing, locked covers, and warning signs.

7. What conditions cause changes to quality of the water?

A marked increase in turbidity or flow after a rainstorm is a good indication that surface runoff is reaching the spring.

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UNIT 3d: Surface Sources

Unit Summary

Types and Characteristics
Sanitary Risks

Unit References

Small Water Systems Serving the Public (Chapter 8)
Manual of Individual Water Supply Systems (Part III)
Water Treatment Plant Operation (Volume 1, Chapters 2 and 3)
Water Supply System Operation (Chapter 2)

Basic Material

Surface water sources used for small water supply systems require consideration of additional factors not usually associated with ground water sources. When small streams, open ponds, lakes, or open reservoirs must be used as sources of water supply, the danger of contamination and of the consequent spread of intestinal diseases such as typhoid fever and dysentery is generally increased. Clear water is not always safe, and the old saying that running water "purifies itself" to drinking water quality within a stated distance is false.

The physical, chemical, and bacteriological contamination of surface water makes it necessary to regard such sources of supply as unsafe for domestic use unless reliable treatment, including filtration and disinfection, is provided. The treatment of surface water to ensure a constant, safe supply requires diligent attention to operation and maintenance by the owner of the system. Principal sources of surface water that may be developed are controlled catchments, ponds or lakes, surface streams, and irrigation canals. Except for irrigation canals, where discharges are dependent on irrigation activity, these sources derive water from direct precipitation over the drainage area.

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Controlled Catchments

In some areas, ground water is so inaccessible or so highly mineralized that it is not satisfactory for domestic use. In these cases, the use of controlled catchments and cisterns may be necessary. A properly located and constructed controlled catchment and cistern, augmented with a satisfactory filtration unit and adequate disinfection facilities, will provide a safe water. However, cisterns should be utilized only when no other source is available.

Ponds/Lakes/Reservoirs

The development of a pond as a supply source involves: (1) selecting a watershed that permits only water of the highest quality to enter the pond, (2) using the best water collected in the pond, (3) filtering the water to remove turbidity and reduce bacteria, (4) disinfecting filtered water, (5) properly storing the treated water, and (6) properly maintaining the entire water system.

The value of a pond or lake as a source is its ability to store water during wet periods for use during periods of little or no rainfall. A pond should be capable of storing a minimum of one year's supply of water. It must be of sufficient capacity to meet water supply demands during periods of low rainfall with an additional allowance for seepage and evaporation losses. The drainage area (watershed) should be large enough to catch sufficient water to fill the pond or lake during wet seasons of the year.

To minimize the possibility of chance contamination, the watershed should be:

- Clean, preferably grassed
- Free from barns, septic tanks, privies, and soil-absorption fields
- Protected against erosion and drainage from livestock areas
- Fenced

The pond should be:

- Not less than 8 feet deep at the deepest point
- Large enough to store at least one year's supply
- Designed to have the maximum possible water storage area over 3 feet in depth
- Fenced
- Free of weeds, algae, and floating debris

In many instances, pond development requires the construction of an embankment with an overflow or spillway.

Streams and Rivers

Streams receiving runoff from large uncontrolled watersheds may be the only source of water supply. The physical, chemical, and bacteriological

COURSE NOTES FOR UNIT 3

quality of surface water varies and may impose unusually or abnormally high loads on the treatment facilities.

Stream intakes should be located upstream from wastewater discharges, storm drains, or other sources of contamination. The water should be pumped when the silt load is low. A low-water stage usually means that the temperature of the water is higher than normal and the water is of poor chemical quality. Maximum silt loads, however, occur during maximum runoff. High-water stages shortly after storms are usually the most favorable for diverting or pumping water to storage. These conditions vary and should be determined for the particular stream.

Irrigation Canals

If properly treated, irrigation water may be used as a source of domestic water supply. Water obtained from irrigation canals should be treated the same as water from other surface water sources.

Water from irrigation canals may contain large concentrations of undesirable chemicals, including pesticides, herbicides, and fertilizer. Periodic chemical analysis should be made.

Sanitary Risks

1. What is the nature of the watershed?

   Industrial ____ Agricultural ____ Forest ____ Residential ____

   As previously noted, the activities on the watershed will impact on the water quality of the runoff. The potential for spills from industrial activities, herbicides and pesticides from agricultural land uses, organics from plant decay, and animal-borne diseases are a few problems that may be indicated by land use on the watershed.

2. What is the size of the owned/protected area of the watershed?

   To reduce the extent of contamination of the watershed, many utilities have chosen to purchase a portion of it. Another method is to restrict activities through zoning restrictions and ordinances.

3. How is the watershed controlled?

   This question allows the inspector to evaluate the effectiveness of watershed control measures. Ownership with restricted access is the most stringent measure but it is also the most costly. If ordinances are used, the inspector may wish to know how they are enforced.

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4. Has management had a watershed survey performed?

   If the utility has had a watershed survey conducted, many of the above questions may be answered by referring to it. The fact that a utility has conducted such a survey would indicate a concern on its part for the protection of the supply.

5. Is there an emergency spill response plan?

   Some industries (e.g., petroleum) are required to have emergency spill plans. Potential spill sites should be identified by the utility and contingency plans developed in the case of a spill. However, because a plan is only paper, the necessary equipment and personnel must be identified and coordination between respective agencies (fire, police, water utility) worked out prior to any emergency.

6. Is the source adequate in quantity?

   To answer this question, the inspector should determine if the source is adequate for present as well as future demands. The source should be able to continuously meet the demands of the water system. Decreasing trends in quantity are also important to note. Operation records should provide this information.

7. Is the source adequate in quality?

   A review of monitoring records should reveal this answer. As with quantity, any trends of decreasing quality should be noted.

8. Is there any treatment provided in the reservoir?

   The addition of any chemicals to the reservoir should be noted. Particular concern is assuring that only approved chemicals be utilized and that they be properly applied.

9. Is the area around the intake restricted for a radius of 200 feet?

   Restriction of contact sports (e.g., swimming and water skiing) and use of powerboats in the vicinity of the intake is important. This will reduce the coliform and organic pollution of the intake water.

10. Are there any sources of pollution in the proximity of the intakes?

    Sources of pollution such as wastewater discharges, feedlots, marinas, and boat launching ramps should be identified. If the use of the reservoir is not restricted, the impact of activities should be minimized as much as possible by keeping them away from the intakes.

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11. Are multiple intakes located at different levels utilized?

Because of fluctuations of the water surface elevation and the variability of water quality with depth, it is necessary that intakes be provided at different depths. Seasonal turnover of the reservoir, algal blooms, and thermal stratification can cause water quality problems. This applies to deep reservoirs, streams, and shallow reservoirs not subject to stratification commonly utilized at single-level intakes.

12. Is the highest quality water being drawn?

The operator should be performing monitoring tests to determine the water quality at the various depths in order to draw the best quality water. The operator should be questioned as to how the intake level is selected, what tests are accomplished, and at what frequency. Suggested tests are dissolved oxygen, metals, and nitrogen values.

13. How often are intakes inspected?

As with all components, maintenance must be periodically performed on the intake structure. Removal of debris and inspection of intake screen integrity will prevent damage to piping valves and pumps. This is particularly important during winter months due to the danger of sheet and frazzle ice buildup.

14. What conditions cause fluctuations in water quality?

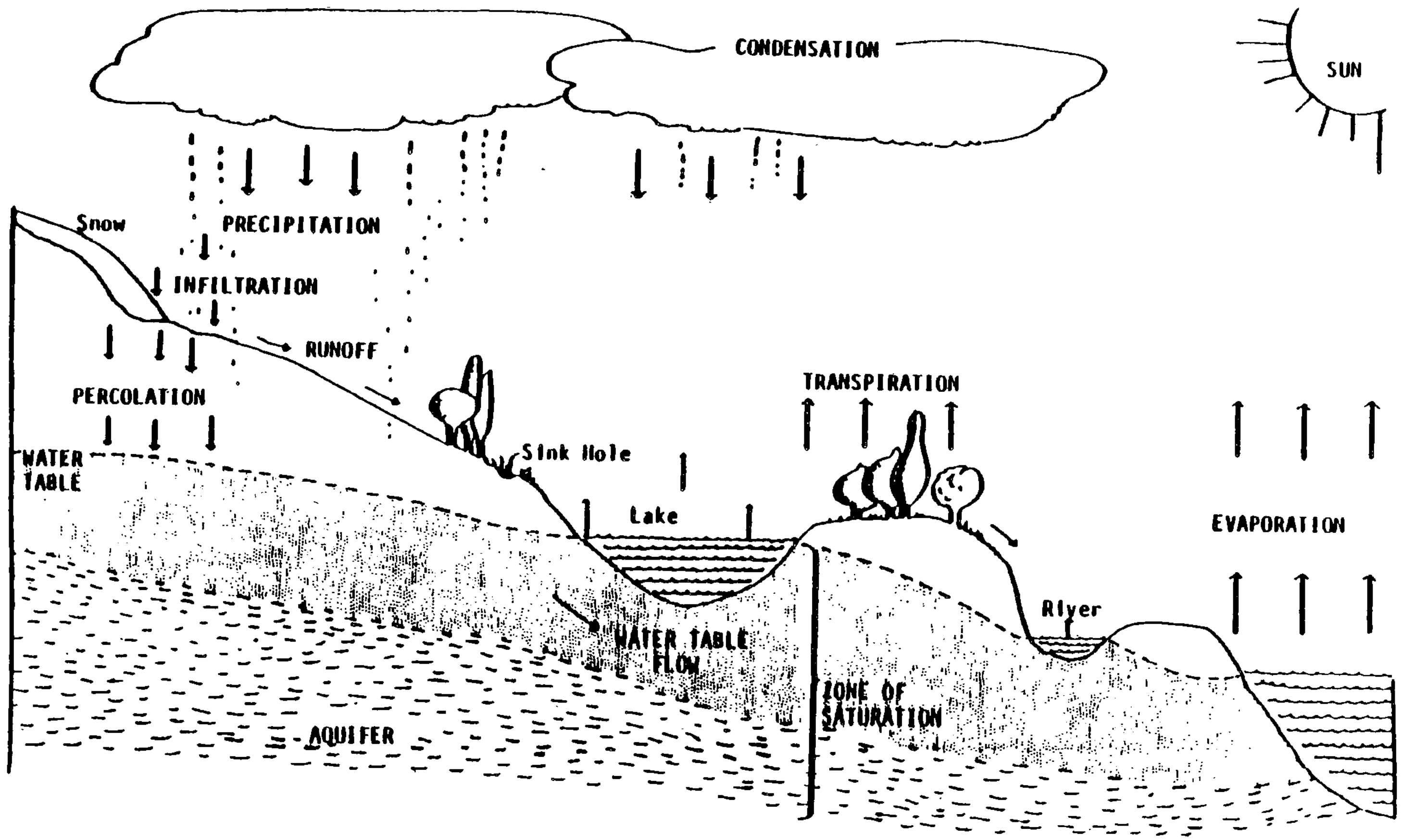
Conditions such as stratification, algal blooms, ice formation, on-shore winds, and changing currents may create adverse changes to water quality. Conditions creating such problems should be noted as well as what measures are being taken to mitigate them.

15. Has the dam been inspected for safety (if applicable)?

Dams should be routinely inspected to avoid conditions that may endanger their integrity. Many States require that such inspections be performed. However, if not required, operators should be encouraged to look for such things as erosion, sinkholes, burrowing animals, and trees growing in the dam face.

COURSE NOTES FOR UNIT 3

Figure 3-1



Hydrologic Cycle

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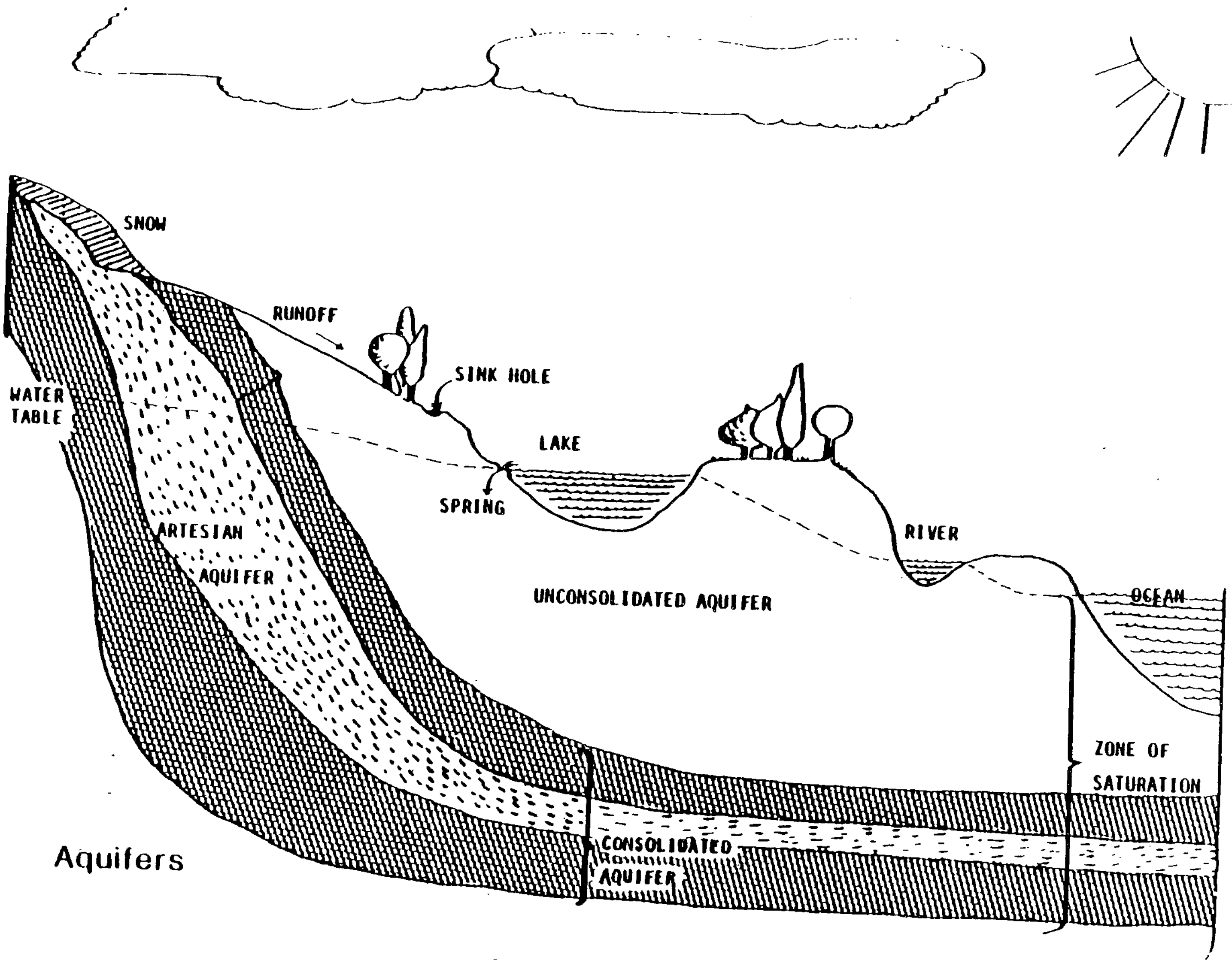
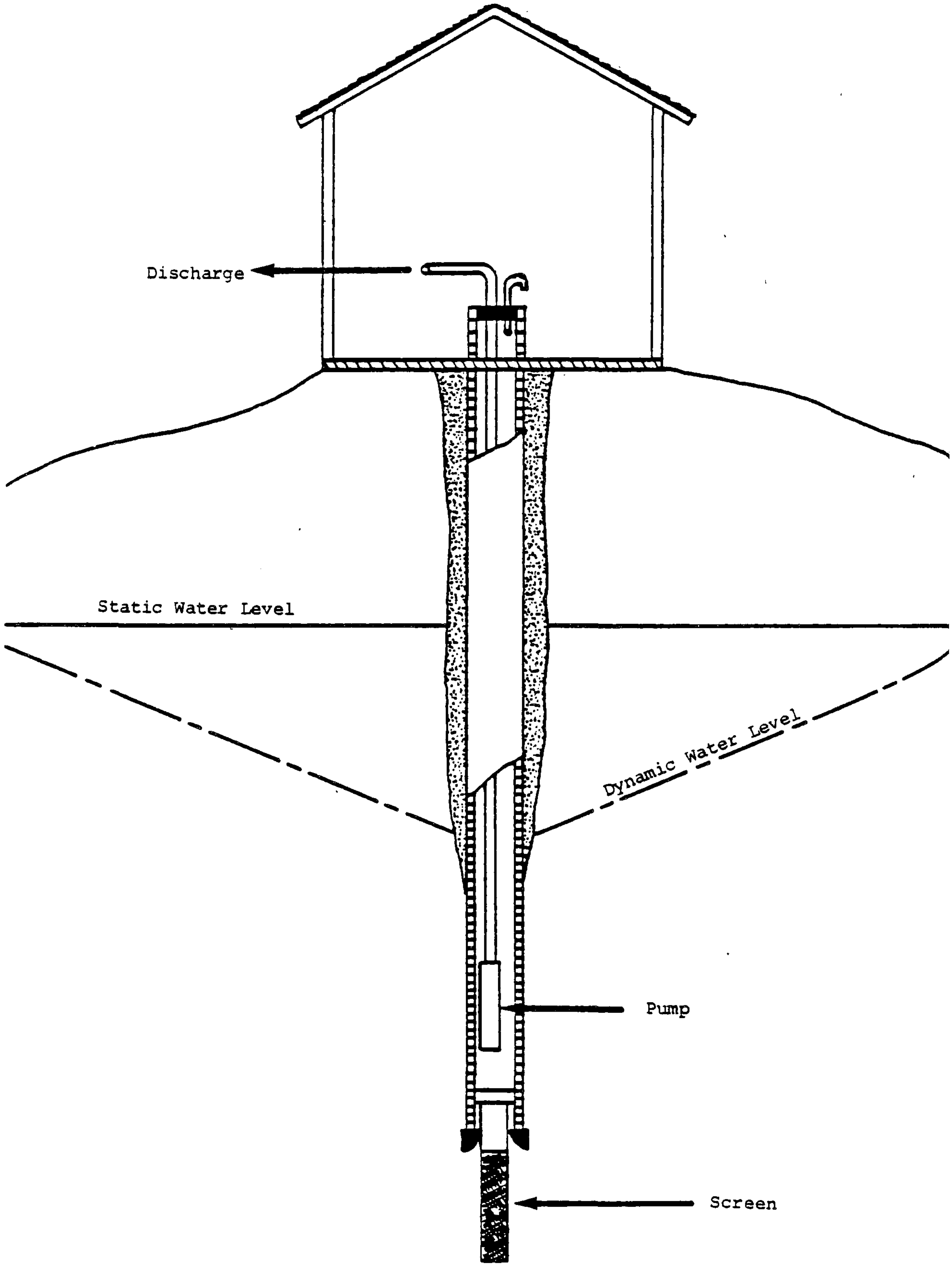


Aquifers

Figure 3-2



Discharge
Static Water Level
Dynamic Water Level
Pump
Screen

Figure 3-3

COURSE NOTES FOR UNIT 3

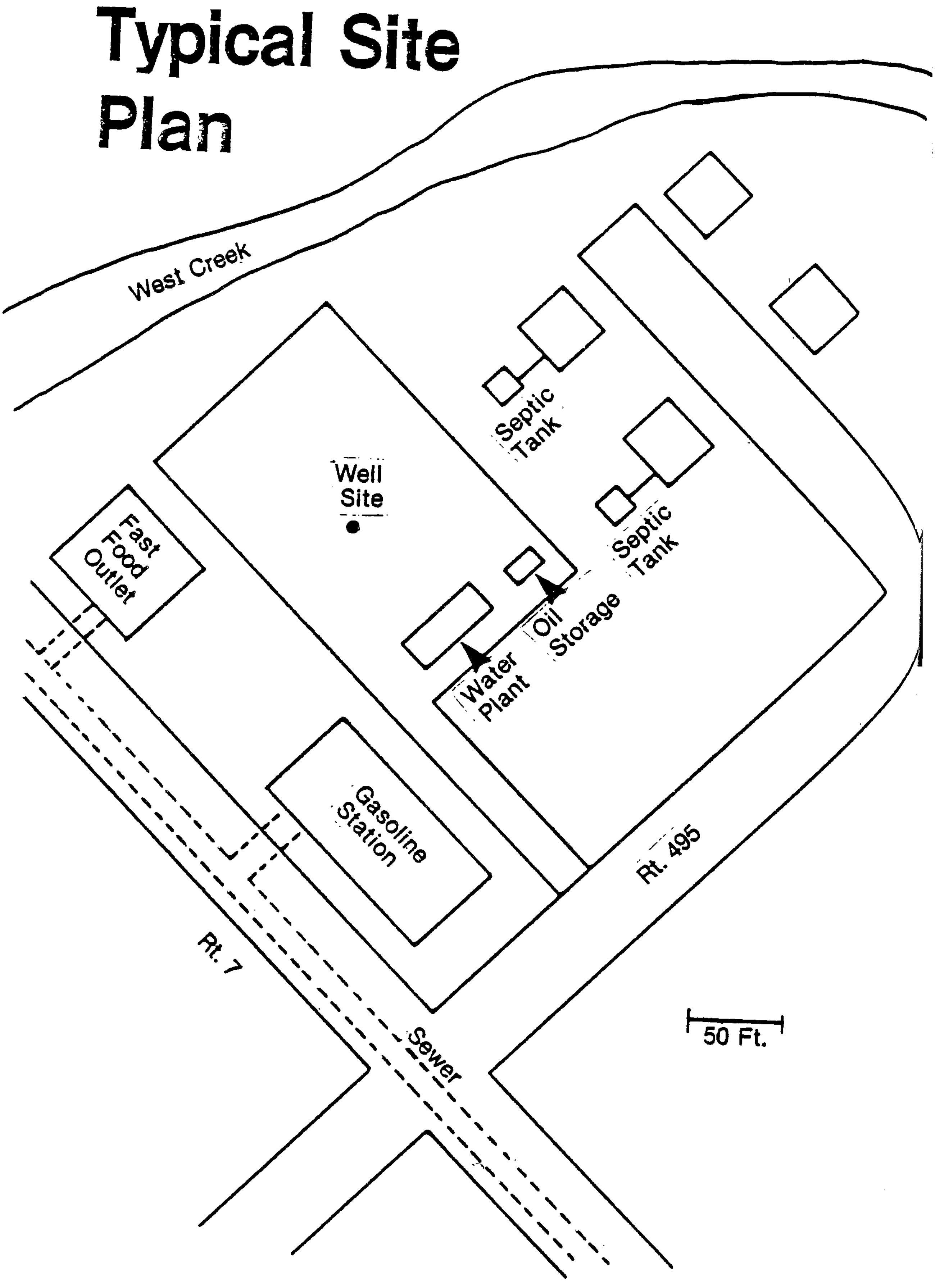

Typical Site Plan
West Creek
Well Site
Septic Tank
Septic Tank
Fast Food Outlet
Oil Storage
Water Plant
Gasoline Station
Rt. 495
Rt. 7
Sewer
50 Ft.

Figure 3-4

COURSE NOTES FOR UNIT 5

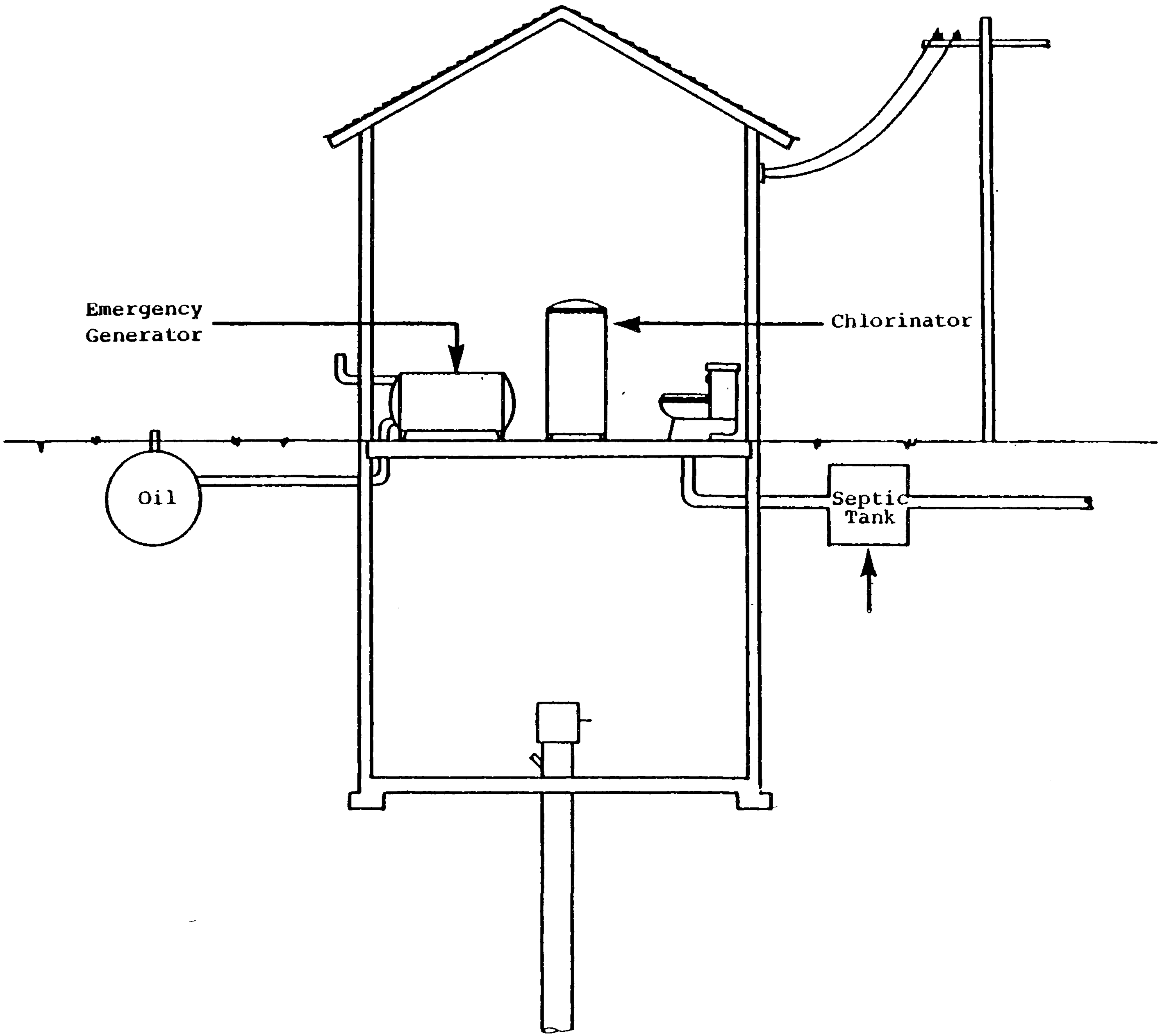


Figure 3-5

COURSE NOTES FOR UNIT 3

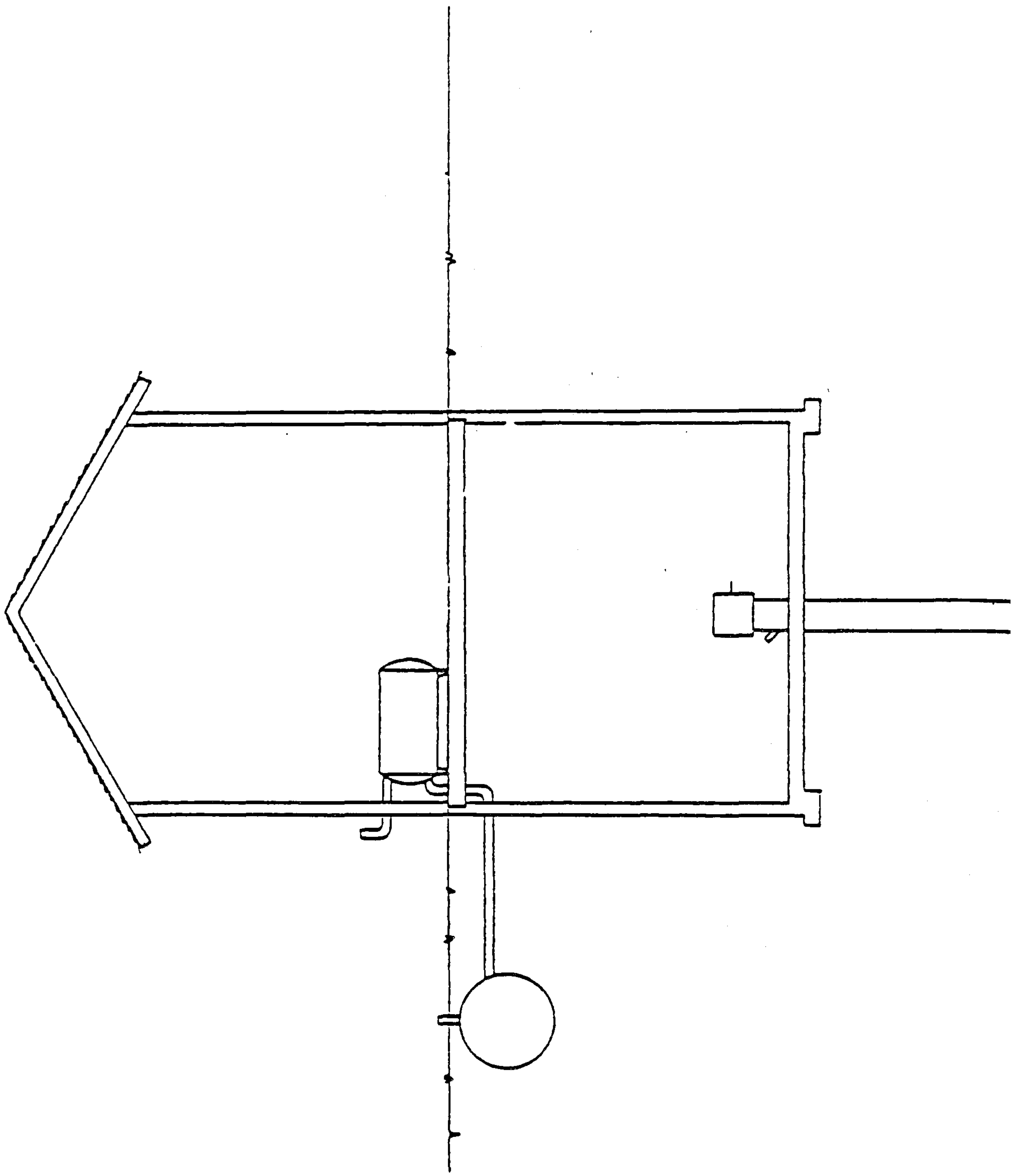
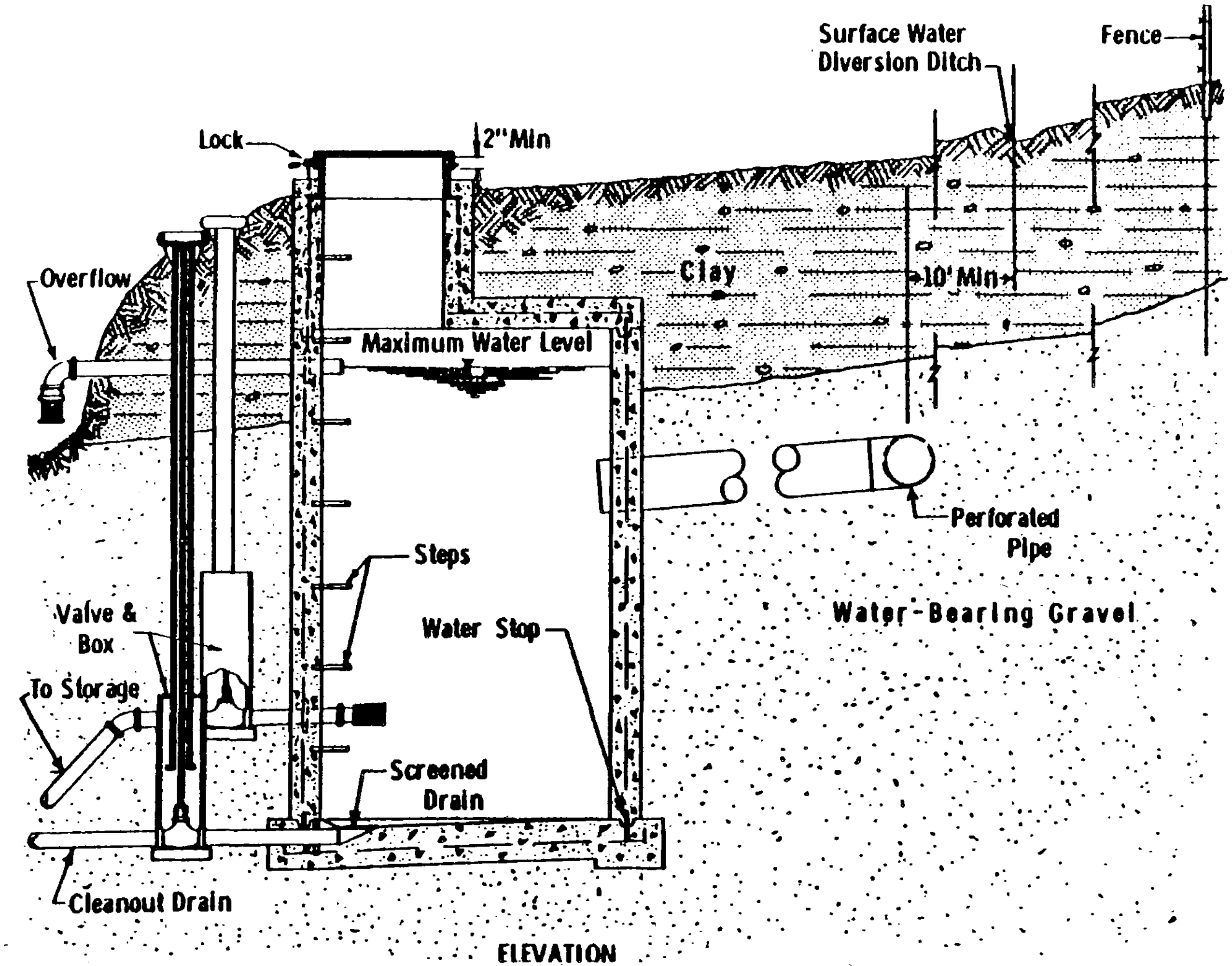


Figure 3-6

COURSE NOTES FOR UNIT 3



Surface Water
Diversion Ditch
Fence
Lock
2"Min
Overflow
Clay
10'Min
Maximum Water Level
Perforated
Pipe
Steps
Valve &
Box
Water Stop
Water-Bearing Gravel
To Storage
Screened
Drain
Cleanout Drain
ELEVATION

Figure 3-7

COURSE NOTES FOR UNIT 3

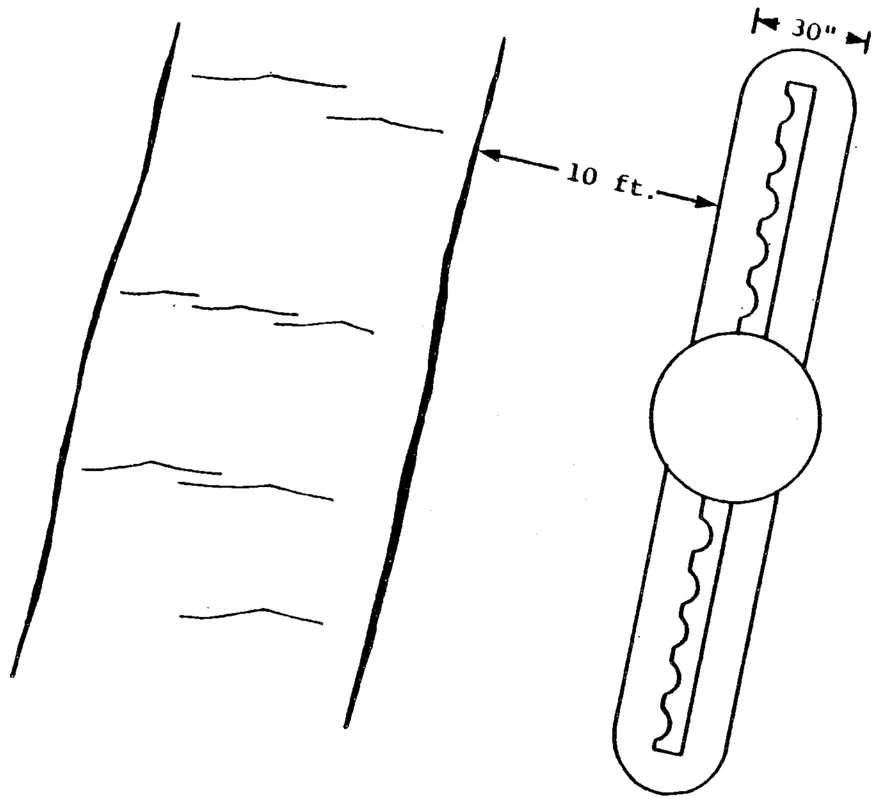
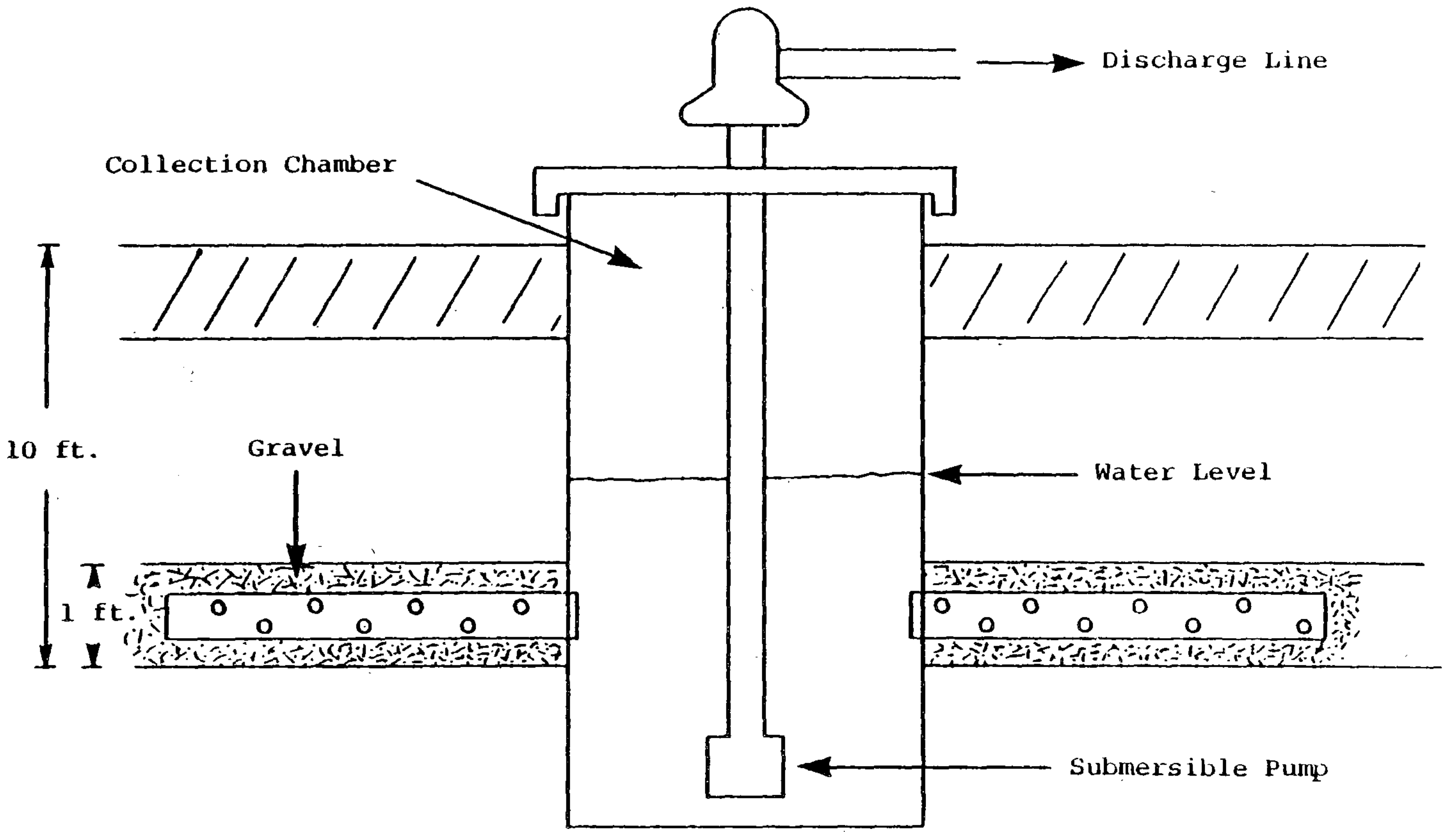


Figure 3-8

Infiltration Gallery

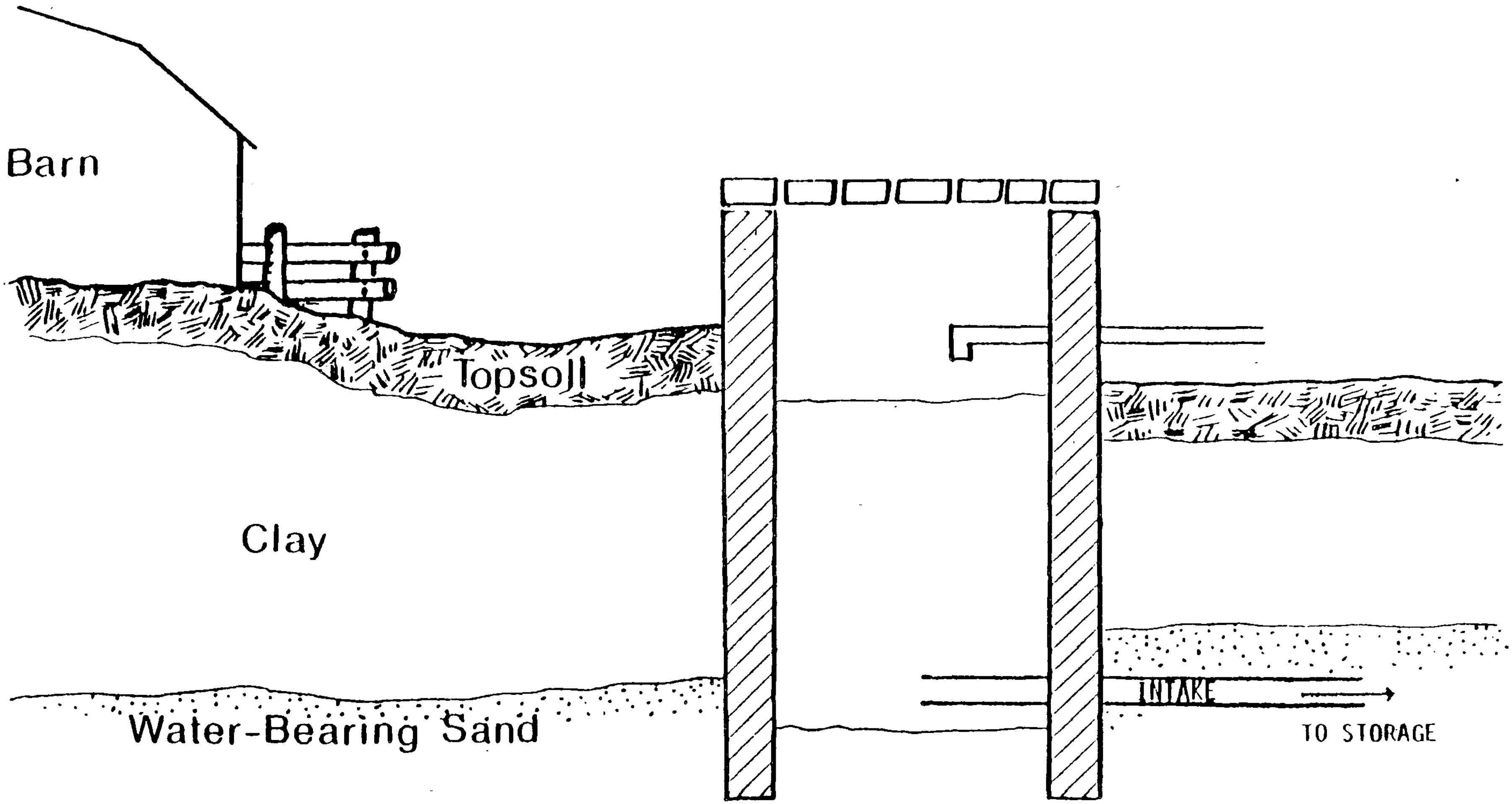
COURSE NOTES FOR UNIT 5

Figure 3-9



Infiltration Gallery

URSE NOTES F.R UNIT 3



Identify Deficiencies

Figure 3-10

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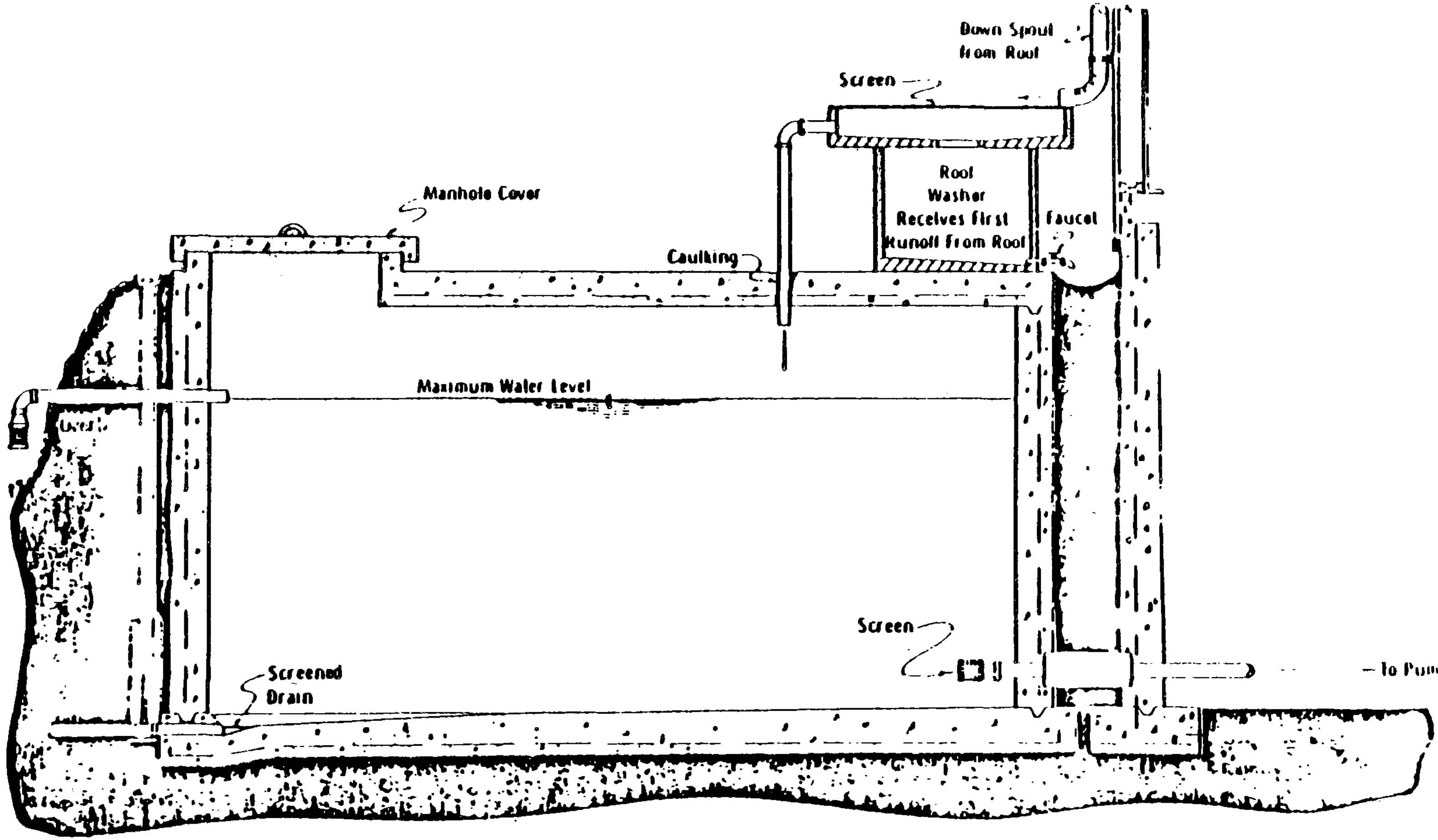
Figure 3-11



Cistern

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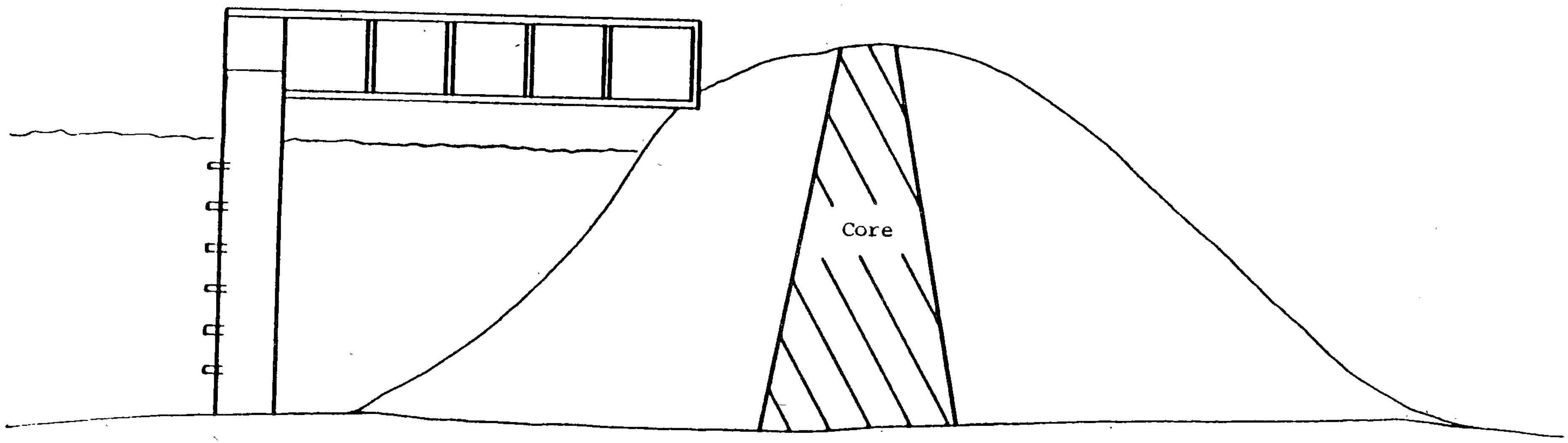
Figure 3-12



COURSE NOTES FOR UNIT 4

Unit 4: PUMPS

Unit Summary

Types and Characteristics
— Sanitary Risks

Unit References

Manual of Individual Water Supply Systems (Part V)
Manual of Water Utility Operations (Chapter 13)
Manual of Instruction for Water Treatment Plant Operators (Chapter 19)
Water Treatment Plant Operation Vol. I (Chapter 11)
Small Water System Operation & Maintenance (Chapter 3)
Water Distribution System Operation & Maintenance (Chapters 2 and 5)

Basic Material

Types of Pumps

Positive Displacement Pumps. The positive displacement pump force or displaces the water through a pumping mechanism. There are several types: reciprocating pumps, helical or spiral rotor, rege erative turbine pumps, and diaphragm pumps.

Centrifugal Pumps. Centrifugal pumps contain a rotating impeller mounted on a shaft turned by the power source. The rotating impel ler increases the velocity of the water and discharges it into a surrounding casing shaped to slow down the flow of the water and convert the velocity to pressure. This decrease of the flow furth increases the pressure.

Jet (Ejector) Pumps. Jet pumps are actually combined centrifugal and ejector pumps. A portion of the discharged water from the centrifugal pump is diverted through a nozzle and venturi tube. A pressure zone lower than that of the surrounding area exists in the venturi tube; therefore, water from the source (well) flows into this area of reduced pressure. The velocity of the water from the nozzle pushes it through the pipe toward the surface where the centrifugal pump can lift it by suction. The centrifugal pump then forces it into the distribution system.

Rotary Pumps. In the rotary pumps there are two cams or gears that mesh together and rotate in opposite directions. The gear teeth or cams fit closely to the casing so that the water will be drawn up the suction pipe and forced into the discharge pipe. Such pumps

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require no valves and are self-priming. They are positive displ ment. They can be operated at high speeds and so obtain large capacity with small size. They have the disadvantage of showing considerable slip. Water containing grit is especially injuriou them.

Sanitary Risks

1. What is the number (including reserves) and location of pump

   At least two pumping units should be provided (for both chem cal feed and water applications of pumps). Pumps may be use for a variety of reasons within the system: raw water, chem cal feed, finished water, and solids movement. The type of pump is important to assure proper application. For example positive displacement-type solution pumps should be used to feed liquid chemicals but not to feed chemical slurries. Th operator and a review of plant schematics can provide this information.

2. What is the rated capacity of the pumps?

   Pumps should have ample capacity to supply the peak demands without dangerous overload. The inspector should also ask when the pump was last rated. This is particularly importan when the pumping time is used to estimate water production. The pump may have been rated 10 years ago for 200 gpm but du to changes in the pump and system is presently only pumping 125 gpm. The inspector should also note if the pump is metered. This can help the operator detect changes in the system and take corrective action before a serious problem develops.

3. What is the condition of the equipment?

   The pumps should be operable! No benefit is provided the system when only one of its three raw water pumps is functional. The inspector should note the state of repair. Although packing gland seals require a constant drip of wate it should not be an excessive spray. The pumps should not b overgreased of overoiled. Excessive noise and vibration, pa ticularly of centrifugal pumps, would indicate problems. No the condition of the room; if it's dirty, operation can-not satisfactory. Dirt will get into the lubricants and shorten the life of the bearings.

4. What type of lubricant is used?

   In the case of well pumps, this is particularly important since oil contamination of the aquifer is possible from impr erly maintained submersible pumps. In the case of water-lubricated pumps, the possibility of cross-connection exists

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5. Is the emergency power/backup system provided?

Emergency power is necessary for continuous operation of the water system. This may be provided by an auxiliary generator or by directly connected engines. The inspector should note how emergency power is provided, how frequently it is tested, and whether there is automatic or manual switchover. The inspector should also be concerned with the number of primary power failures. Availability of replacement pumps, motors, and critical parts should also be evaluated.

6. Are all electro/mechanical rotating equipment provided with protective guards?

The inspector should not only be concerned with the sanitary aspects of the equipment but safety as well. The inspector should check to see that belts, gears, rotating shafts, and electrical wiring are properly shielded to prevent injury.

7. Are controls functioning properly and adequately protected?

All controls should be functional. Jerry-rigging of controls presents both an electrical hazard and risk of failure of the pump.

8. Are underground compartments and suction wells waterproof?

Pump stations should be waterproofed to prevent flooding of the pump room. The suction wells should be protected to prevent entrance of undesirable water into the compartment either through the walls or surface water.

9. Are permanently mounted ladders sound and firmly anchored?

As previously stated, the inspector should be concerned with safety. This concern is not only for the operator's sake, but for the inspector's own preservation. The inspector should follow safety procedures and inform the operator of unsafe conditions or acts (e.g., entering a confined space that is not properly ventilated).

10. Is the facility properly protected?

The site should be properly protected against fire, flood, vandalism, and other hazards. The location should be a minimum of one foot above the highest flood level. Runoff should drain away from the pumping station. Pumping facilities should be protected against vandalism and unauthorized entry by animals or people.

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Table 4-1. Types and Characteristics of Pumps

Type of Pump	Practical Suction Lift	Usual Well-Pumping Depth	Usual Pressure Heads	Advantages	Disadvantages	Remarks
Reciprocating: 1 Shallow well.... 2 Deep well.......	 22-25 ft. 22-25 ft.	 22-25 ft. Up to 600 ft.	 100-200 ft. Up to 600 ft. above cylinder.	• Positive action. • Discharge against variable heads. • Pumps water containing sand and silt. • Especially adapted to low capacity and high lifts.	• Pulsating discharge. • Subject to vibration and noise. • Maintenance cost may be high. • May cause destructive pressure if operated against closed valve.	• Best suited for capacities of 5-25 gpm against moderate to high heads. • Adaptable to hand operation. • Can be installed in very small diameter wells (2" casing). • Pump must be set directly over well (deep wells).
Centrifugal 1 Shallow well.... a) Straight centrifugal (single stage)	20 ft. max.	10-20 ft.	100-150 ft.	• Smooth, even flow. • Pumps water containing sand and silt. • Pressure on system is even and free from shock. • Low-starting torque. • Usually reliable and good service life. ******	• Loses prime easily. • Efficiency depends on operating under design heads and speed.	• Very efficient pump for capacities above 60 gpm and heads up to about 150 ft.
b) Regenerative vane turbine type (single stage)	28 ft. max.	28 ft.	100-200 ft.	• Same as straight centrifugal except not suitable for pumping water containing sand or silt. • They are self priming. ******	• Same as straight centrifugal except maintains priming easily.	• Reduction in pressure with increased capacity not as severe as straight centrifugal.
2 Deep well........ a) Vertical line shaft turbine (multistage)	Impellers submerged.	50-300 ft.	100-800 ft.	• Same as shallow well turbine. • All electrical components are accessible, above ground.	• Efficiency depends on operating under design head and speed. • Requires straight well large enough for turbine bowls and housing. • Lubrication and alignment of shaft critical.	

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Table 4-1 (Continued)

Type of Pump	Practical Suction Lift	Usual Well-Pumping Depth	Usual Pressure Heads	Advantages	Disadvantages	Remarks
Centrifugal (cont.) b) Submersible turbine (multistage)	Pump and motor submerged.	50-400 ft.	50-400 ft.	• Same as shallow well turbine. • Easy to frost-proof. • Short pump shaft to motor. • Quiet operation. • Well straightness not critical.	• Abrasion from sand. • Repair to motor or pump requires pulling from well. • Sealing of electrical equipment from water vapor critical. • Abrasion from sand.	• 3500 RPM models, while popular because of smaller diameters or greater capacities, are more vulnerable to wear and failure from sand and other causes.
Jet: 1 Shallow well.....	15-20 ft. below ejector.	Up to 15-20 ft. below ejector.	80-150 ft.	• High capacity at low heads. • Simple in operation. • Does not have to be installed over the well. • No moving parts in this well.	• Capacity reduces as lift increases. • Air in suction or return line will stop pumping.	
2 Deep well........	15-20 ft. below ejector.	25-120 ft. 200 ft. max.	80-150 ft.	• Same as shallow well jet. • Well straightness not critical.	• Same as shallow well jet. • Lower efficiency, especially at greater lifts.	• The amount of water returned to ejector with increased lift - 50% of total water pumped at 50-ft. lift and 75% at 100-ft. lift.
Rotary: 1 Shallow well..... (gear type)	22 ft.	22 ft.	50-250 ft.	• Positive action. • Discharge constant under variable heads. • Efficient operation.	• Subject to rapid water if water contains sand or silt. • Wear of gears reduces efficiency.	
2 Deep well..... (helical rotary type)	Usually submerged.	50-500 ft.	100-500 ft.	• Same as shallow well rotary. • Only one moving pump device in well.	• Same as shallow well rotary except no gear wear.	• A cutless rubber stator increases life of pump. Flexible drive coupling has been weak point in pump. Best adapted for low capacity and high heads.

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UNIT 5: WATER TREATMENT

Unit Summary

Treatment Processes
Sanitary Risks

Unit References

Small Water Supplies Serving the Public (Chapters 9, 10)
Manual of Instruction for Water Treatment Plant Operators (Chapters 5-15)
Manual of Water Utility Operations (Chapters 7-11)
Water Treatment Plant Operations (Volume 1, Chapters 4-9 and 11)
Water Supply System Operation (Chapter 4)

Basic Material

The purpose of water treatment is to condition, modify or remove undesirable impurities to provide a water that is safe, palatable, and acceptable to consumers. National standards (specified in the NIPDWR with maximum contaminant levels) for some of the impurities that are considered important to the health of consumers are set under the Federal Safe Drinking Water Act. If these contaminants are present in excess of the established limits, the water must be treated to reduce the levels. Some impurities that affect the esthetic qualities of the water are listed in SDWR as guidelines. Treatment or modification of the water to achieve these desirable levels is highly recommended.

Some of the common treatment processes and their purposes are:

Pretreatment - generally for removal of taste and odors.

Coagulation/Flocculation - treatment with certain chemicals for collecting nonsettleable particles into larger or other fine-grained materials to remove particulate matter too light or too finely divided for removal by sedimentation.

Sedimentation - removal of suspended matter.

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Filtration - filtering through sand, anthracite, or other fine-grained materials to remove particulate matter too light or too finely divided for removal by sedimentation.

Disinfection - destroying pathogenic organisms with chlorine, certain chlorine compounds, or other means.

For specific information on the treatment process, the suggested references should be consulted. It is suggested that the inspector be familiar with:

Coagulation:	Aluminum Sulfate and Iron Salts
Chlorination:	Gas and Hypochlorite
Filtration:	Rapid Sand
	Pressure
	Diatomaceous Earth
Ion Exchange	
Lime Softening	
Sedimentation	
Taste and Odor Control	
Corrosion Control	

Sanitary Risks

Prechlorination/Chemical Pretreatment

Although treatment for taste and odors can be performed at several locations in the treatment process, frequently it is conducted as a pretreatment. This allows the time in the pipe from the intake to the plant to be used as contact time. Chemicals commonly used are chlorine, activated carbon, potassium permanganate, ozone, and chlorine dioxide. There are other pretreatment processes such as aeration, presedimentation, and screening that may be encountered, but the following questions deal with processes utilizing chemical addition.

1. What chemical is used?

   The inspector should determine what chemicals are utilized, if they are approved, and if they are being properly applied.

2. What is the amount used?

   The amount utilized should be based on testing. The inspector should inquire as to how the dosage is determined and how frequently. In some cases the inspector will find that the dosage has been based on tests conducted in the distant past and has remained the same even though conditions have changed.

3. For prechlorination, has total trihalomethanes (TTHM) been evaluated?

   Although TTHM control is not required for systems serving a population of less than 10,000, the inspector should determine if the operator is aware of their impact and causes. The dosage and/or application point may be changed to reduce their levels.

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4. What is the point of application?

   The inspector should determine that chemicals are being added at the best point to achieve the desired results. The inspector should alert the operator to improper application such as addition of powdered activated carbon and chlorine at the same point.

5. Is proper mixing achieved based on visual observation?

   The inspector should be looking for evidence of short circuiting.

6. What other pretreatment is provided?

   Other processes should be noted and evaluated as to their sanitary risks.

<u>Chemical Feed</u>

This section deals with chemical addition for such processes as coagulation, lime softening, activated carbon addition, and corrosion control. A good policy is for the inspector to draw a simple schematic of the plant systems and where chemicals are added. The following questions apply to chemical feed.

1. What chemical is used?

   The inspector should determine what chemicals are utilized, and if they are approved. The question should be asked as to how the dosage is determined and frequency of this determination.

2. Where is it applied?

   The inspector should note the application point and evaluate it in light of the purpose of the chemical addition.

3. What is the condition of the feed equipment?

   The equipment should be functional and properly maintained. For example, with dry chemical feeders watch for problems with "bridging" of the chemical in the hopper. Liquid solution feeder lines should be observed to see that they are not clogged. The operator should be asked if a preventive maintenance program exists and is utilized. The care taken for the equipment of the facility could reflect the operator's attitude towards the system as a whole. Cross connections and the possibility of bacterial contamination of stock solutions should be noted.

4. Are instrumentation and controls for the process adequate, operational, and being utilized?

   Controlling processes is difficult when instrumentation is not functional and/or properly calibrated. The instrumentation is useless if the operator does not know the significance of the measurement. The inspector should observe the controls and question the operator about calibration checks and what is done based on the measurement.

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5. Is chemical storage adequate and safe?

At least a 30-day supply of chemicals on hand is recommended. Level indicators and overflow protection should be provided for liquid chemical storage. This is particularly important for tanks located near a well to prevent contamination of the aquifer. Chemicals stored together should be compatible. For example, hypochlorite and activated carbon should not be stored near each other. Strong acids should not contact chlorites. Chemicals should be stored in a manner that would preclude a spill from entering the water being treated or the source.

6. Are adequate safety devices available and precautions observed?

Safety goggles, gloves, hearing protection, and respirators should be provided for protection against injury by the particular chemicals. The inspector should observe safety procedures during the inspection. As stated previously, the inspector should be concerned with safety, the operator's and his own.

Mixing

1. Is mixing adequate based on visual observation?

Problems with short circuiting should be noted. Adequate solution water and agitation should be provided in the case of dry chemical addition.

2. Is equipment operated properly and in good repair?

Mixing can be accomplished by several means (mechanical mixers, diffusers, pump blenders, and baffles). The inspector should determine that the particular means utilized is functioning properly.

Flocculation/Sedimentation

1. Is the process adequate based on visual observation?

The inspector should observe if there is good floc formation prior to sedimentation. The best floc size ranges from 0.1 mm to about 3 mm. There should be little carryover of the floc from the sedimentation basin.

2. Is equipment operated properly and in good repair?

In the case of mechanical flocculators, the paddles should all be present and turning. The flocculators should not break up the floc.

3. Are jar tests being performed to determine optimum dosage of chemicals?

Proper coagulation and flocculation cannot be routinely achieved without jar testing.

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Filtration

Several types of filters are available for use in water systems such as diatomaceous earth, pressure sand filters, and rapid sand filters. As stated previously, this manual provides only the "need to know" of sanitary risks involved with the components. The inspector should consult the suggested references for specific operational considerations.

1. Is process adequate based on observation?

   The primary purpose of filtration is to remove turbidity. The inspector should be concerned that the filtration process actually reduces the turbidity. If there are multiple filters, the effluent from each filter should be observed.

2. Are instrumentation and controls for the process adequate, operational, and being utilized?

   Turbidity should be measured in the influent and effluent from the filters. Head loss through the filter is also important to filter operation, as is the use of flow rate controllers. The instruments for these measurements and controls should be present and functional. The operator should know the importance of the readings. The answers provided should indicate the operator's competence to the inspector.

3. Is equipment operated properly and in good repair?

   For rapid sand filters, the inspector should look for problems such as: mudballs, cracks in the media, backwashing difficulties resulting in short filter runs and/or failure to clean media, and loss of media. If a problem is indicated, the inspector may wish to have the operator backwash the filter.

Post-Chlorination

The primary purpose of post-chlorination is disinfection. Disinfection is the process of destroying a large portion of the microorganisms in water with the probability that all pathogenic bacteria are killed in the process. In water treatment, disinfection is almost always accomplished by adding chlorine or chlorine compounds. Other processes that may be encountered are: ultraviolet disinfection and the use of iodine or ozone. The measure used to determine effectiveness of disinfection is the coliform group. The standard test for the coliform group is either the multiple-tube fermentation technique or the membrane filter technique. An in-depth discussion of these techniques may be found in "Standard Methods for the Examination of Water and Wastewater." The coliform group is used as an indicator of pathogenic organisms. The use of this indicator group has several advantages over testing for specific pathogenic organisms. Principally these advantages are:

1. Ease of isolation: Using relatively unsophisticated analytical procedures and equipment, the presence of coliforms can be detected. The procedures can give results in 24 hours, making it a comparatively rapid bacteriological test.

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2. Coliforms are present in large numbers in feces of all animals: Any fecal pollution results in the presence of coliform organisms in sufficient quantities to determine the degree of pollution with fair accuracy.

3. Coliforms are resistant to the forces of natural purification to a greater degree than commonly encountered pathogens. Consequently, the coliforms will normally still be present after the disease-producing pathogens may have died off and will continue to indicate the possible danger to the water.

Chlorination Terminology

Regardless of the form of chlorination, chlorine gas, or chlorine compounds, the reaction in water is basically the same. The standard term for the chlorine concentration is either milligrams per liter (mg/l) or parts per million (ppm).

- Chlorine Dose: The total amount of chlorine fed into a volume of water by the chlorinator.

- Chlorine Demand: Chlorine is a very active chemical oxidizing agent. When injected into water, it combines readily with certain inorganic substances that are oxidizable (hydrogen sulfide, nitrite, ferrous iron, etc.) and with organic impurities including micro-organisms and decay products. These reactions consume or use up some of the chlorine before it can fully destroy micro-organisms. This amount used up is the chlorine demand.

  Chlorine Demand = Chlorine Dose - Chlorine Residual

- Chlorine Residual: The amount of chlorine (by test) present in the water after the chlorine demand is satisfied and after a specified time period. The presence of a "free" residual, in contrast to a "combined" residual, of at least 0.2-0.4 ppm (in relatively unpolluted, low turbidity water), after the chlorine demand is satisfied, usually provides a high degree of assurance that the disinfection of the water is complete.

  A residual also provides some protection against any chance contamination that may inadvertently enter the system. The chlorine residual test sample is usually collected before the first point in the distribution system where water is consumed. However, it is also advisable to also test at the farthest point in the system to ensure that a residual exists throughout the whole system. The residual test is the basis for increasing or decreasing the chlorinator feed rate to achieve the desired value. Too much chlorine residual will be offensive to some consumers.

  Chlorine Residual = Chlorine Dose - Chlorine Demand

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- Chlorine Contact Time: The contact time is the time interval (usually minutes) that elapses between the time when chlorine is added to the water and the time when that same slug of water passes by the sampling point. A certain minimum period of time is required for the disinfecting action to become completed. The contact time is usually a fixed condition dependent upon the rate of flow of the water and the time it takes the water to pass through the piping and storage facilities. Generally speaking, it is preferable that the contact period be not less than 30 minutes under the peak demand flow conditions. However, even more time may be necessary under unfavorable conditions.

Gas Chlorination

Chlorine gas is available in compressed gas form stored in steel pressurized cylinders. A gas chlorinator meters the gas flow and mixes it with water which is then injected as a water solution of pure chlorine. Chlorine gas is a highly toxic lung irritant and special facilities are required for storing and housing gas chlorinators. The advantage of this method is the convenience afforded by a relatively large quantity of chlorine available for continuous operation for several days or weeks without the need for mixing chemicals. Gas chlorinators have an advantage where variable water flow rates are encountered as they may be syncronized to feed chlorine at a variable rate.

Hypochlorination

Most small system operators will find the use of liquid or dry chlorine compounds mixed with water and fed into the system with inexpensive hypochlorinators a satisfactory chlorination method. These small chemical feed pumps are designed to pump (inject under pressure) an aqueous solution of chlorine into the water system. They are designed to operate against pressures as high as 100 psi but may also be used to inject chlorine solutions at atmospheric or negative head (suction side of water pump) conditions.

The pumping rate is usually manually adjusted by varying the stroke of the piston or diaphragm. Once the stroke is set, the hypochlorinator feeds accurately at that rate. However, chlorine measurements should be made occasionally at the beginning and end of the well pump cycle because if the drawdown is high, the pumping rate varies considerably and the concentration will vary since the applied dose is constant. A metering device may be used to vary the hypochlorinator feed rate syncronized with the water rate. Where a well pump is used, the hypochlorinator is connected electrically with the on-off controls of the pump.

The following questions deal with the sanitary risks of chlorination.

1. Is adequate chlorine residual being maintained?

   The answer to this lies in whether there have been any positive coliform counts. The next step in determination of adequacy would be to ensure that a detectable residual is present at the remotest

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connection in the system. The inspector should review where the utility's sample points within the distribution system are located and/or how they were selected. If the inspector is to sample, a deadend portion of the system that is remote from the plant may be selected. A free residual of 0.2-0.5 mg/l or a combined residual of 1.0-2.0 mg/l should be maintained at the most distant points in the system and at the ends of deadend sections. The chlorinator should have sufficient capacity to provide adequate treatment under peak flow conditions.

2. Is there sufficient contact time between the chlorination point and the first point of use?

   Contact time should be a minimum of 30 minutes for free residual and 2 hours for a combined residual. This may be determined by figuring detention time in the clear well, storage tank, and/or pipeline between point of chlorination and use.

3. Is the equipment properly operated and maintained?

   The inspector should determine that all equipment is operational and preventive maintenance is routinely performed. Some indicators of problems for gaseous chlorination would be valves, piping and fittings that are damaged, badly corroded or loose, no gas flow to the chlorinator, or frost on valves and piping. For powdered disinfectants, some indicators are clogged feed lines and valves. A more detailed discussion of these problems and their solutions is provided in "Water Treatment Plant Operation," Chapter 7.

4. Is operational standby equipment provided? If not, are critical spare parts on hand?

   Disinfection must be continuous! Standby equipment of sufficient capacity to replace the largest unit is recommended. Where it is not, flow to the water system should be halted and critical spare parts should be on hand for immediate replacement.

5. Is a manifold provided to allow feeding gas from more than one cylinder?

   As stated above, chlorination must be continuous. A manifold should be provided to allow empty cylinders to be changed without stopping chlorination. If only one cylinder can be utilized, the inspector should determine what procedure is followed when it is changed. The operator could be allowing water to continue to flow into the system while he changes the cylinder, a process that could take 30 minutes. Such a situation could result in contamination of the entire system.

6. Are scales provided for weighing cylinders?

   Scales should be provided and utilized to measure the amount of chlorine used each day and to determine when they are near empty so they can be changed. These scales should be located so that the cylinders will be cooler than the chlorinators to prevent condensing of the chlorine in the lines.

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7. Is the chlorine storage and use area isolated from other work areas?

Operators should be well versed on the hazards of chlorine gas, proper handling of the gas and protective equipment, and the limitations of the protective equipment. The inspector should be knowledgeable in these areas as well. A brief overview of chlorine is that it is a heavier-than-air gas, which is corrosive in moist atmospheres and is extremely toxic. Its toxicity ranges from throat irritation at 15 ppm to rapid death at 1,000 ppm. Consequently, the storage and use areas for chlorine should be above ground, well ventilated, and separated by a gas-tight partition from other work areas. Both chlorine gas and particularly sodium chlorite should not be stored with organic compounds.

8. Is room vented to the outdoors by exhaust grilles located not more than 6 inches above the floor level?

The room should be vented at a rate of one air change per minute with exhaust grilles not higher than 6 inches above the floor. An inlet grille for the room should be located near the ceiling. The vapor-tight fan switch should be located outside the room and equipped with an indicator light. The inspector should ensure that the exhaust from the chlorine room will not enter into other interior areas. Problems have resulted from locating the exhaust grilles to the chlorine room in the vicinity of the makeup air inlet for other rooms.

9. Are all doors hinged outward, equipped with panic bars, and at least one provided with a viewport?

The need for doors to be hinged outward is based on the fact that someone in the room could be overcome and passed out against the door, making rescue difficult if the door has to swing into the room. The door should also have warning signs affixed, alerting personnel to the dangers.

10. Is a self-contained breathing apparatus available for use during repair of leaks?

The use of chlorine requires protective clothing. Chemical goggles should be worn by personnel entering the area for routine inspection. When cylinders are changed or adjustments made to the system, impervious gloves, chemical goggles, and a full face shield should be worn (unless a full facepiece respirator or hood is used). Chlorine canister-type gas masks are only acceptable if the <u>known</u> chlorine vapor concentration is less than 1% and oxygen level greater than 16%. Additionally, canister-type gas masks must be checked routinely and the canister changed when it has reached its expiration date or has been damaged. When a worker enters a heavily contaminated area for repair, a self-contained breathing apparatus is required. Use of protective equipment and emergency drills should be practiced. Emergency procedures should be coordinated with fire and police personnel. The inspector should ask if the utility has an emergency plan and if it has ever been practiced.

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11. Are there means of leak detection?

The inspector should never enter a room containing chlorine gas without first opening the door slightly to check for the smell of chlorine. A squeeze bottle of dilute ammonium hydroxide can be used for leak detection by squirting a small amount into the room prior to entry. If a leak is present a "snow" will form. There are also continuous and portable chlorine detection devices that may be used.

12. Are all gas cylinders restrained by chaining to the wall or other means?

Cylinders should be restrained to an immovable object. They should be transported and stored in an upright position and kept away from direct heat and direct sun. Empty containers should be segregated from full containers.

13. Have there been any interruptions in chlorination during the past year due to chlorinator failure or feed pump failure?

Any interruptions in chlorination and their cause should be identified. The operator should be questioned as to what measures have been taken to preclude recurrence of the interruption.

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Unit 6: GRAVITY STORAGE/HYDROPNEUMATIC TANKS

UNIT 6a: Gravity Storage

Unit Summary

Characteristics of a Gravity Storage System
Sanitary Risks

Unit References

Small Water Systems Serving the Public (Chapter 6)
Manual of Individual Water Supply Systems (Part V)
Water Supply System Operation (Chapter 5)

Basic Material

Well supplies are often pumped directly to a gravity distribution reservoir (tank) from which water flows on demand to the points of use. The wells may also be pumped directly into the distribution system with the tank floating (riding) on the system. Either arrangement is acceptable. The pumps may be controlled by water level float controls or pressure switches. The storage tank is sufficiently elevated to ensure adequate operating pressures.

A gravity storage system offers several advantages over other (e.g., hydropneumatic) systems and should be considered where topographic conditions are favorable. The larger the water system, the greater the advantages. However, even smaller systems will have these advantages:

- o Less variation in pressure
- o Storage for firefighting use
- o One to two days' storage to meet water requirements
- o Greater flexibility to meet peak demands
- o Use of lower capacity wells (pumping not necessary to meet peak system demand)
- o Sizing of pumps to take better advantage of electric load factors
- o Reduced on and off cycling of pumps
- o Tie-in of several wells, each pumping at its optimal rate

Since the gravity reservoir provides the storage necessary to meet the peak system demands, the wells need not be developed to meet the peak system capacities, as is generally necessary with pressure tank systems.

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The wells should be capable of meeting the maximum day demand within the period of time when water use is significant. For example, day schools usually exert a significant water demand only over a 10- to 12-hour day. The wells must, therefore, be pumped at a rate sufficient to meet the maximum day demand in a 10- to 12-hour period. Under these conditions, the reservoir (tank) should have an effective capacity equivalent to the average daily demand.

Gravity distribution reservoirs may be elevated tanks mounted on structural supports above ground, may be located partly below ground, or may be tanks placed on pads or cradles on the ground surface. Elevated tanks are necessary when high ground is not available within the service area. The operating water levels of the tank should be sufficiently above the distribution system to produce minimum operating pressures of 35 psi (about 81 feet of head) but preferably 50-75 psi (116 to 173 feet). Pressures should not exceed 100 psi (231 feet).

Shallow reservoirs with large diameters are preferred over deep ones with smaller diameters, other things being equal. Tanks with larger diameters have more water per foot of drawdown and are thus less prone to pressure fluctuations. They are also less costly to build.

Prefabricated standpipes and elevated tanks are readily available with a wide range of capacities. Prestressed concrete tanks are quite popular, since they require less maintenance.

Sanitary Risks

1. Does surface runoff and underground drainage drain away from the storage structure?

2. Is site protected against flooding?

   Storage reservoirs should be located above probable ground water levels. Surface runoff and underground drainage should be away from the structure. Provisions should be included to guard against the sanitary hazards related to location; groundwater levels, movements, and quality; character of soil; possibility of wastewater pollution; and overtopping by floods. Sites in ravines or low areas subject to periodic flooding should be avoided. Any sewer located within 50 feet of a storage reservoir with a floor below ground level should be constructed of extra-heavy or service-weight cast iron pipe with tested, watertight mechanical joints. No sewer should be located less than 10 feet from the reservoir.

   All storage reservoirs should be protected against flood waters or high water levels in any stream, lake, or other body of water. These reservoirs should be placed above the high water level, and the structure and its related parts should be watertight. The ground surface above the reservoir should be graded to drain surface water away from the reservoir and to prevent pooling of surface water within the vicinity. Walls or fencing should surround open reservoirs, and public access should be prohibited.

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3. Is storage tank structurally sound?

The inspector should base the answer to this question on visual observation. Look for washouts and signs of foundation failure.

4. Are overflow lines, air vents, drainage lines, or cleanout pipes turned downward or covered, screened, and terminated a minimum of 3 diameters above the ground or storage tank surface?

Any overflow, blowoff, or cleanout pipe from a storage reservoir should discharge freely into an open basin from a point not less than three diameters of the discharge pipe above the top or spill line of the open basin. All overflow, blowoff, or cleanout pipes should be turned downward to prevent entrance of rain and should have removable #24-mesh screens to prevent the entrance of birds, insects, rodents, and contaminating materials. If the discharge pipes are likely to be submerged by surface or flood water, a watertight blind flange should be provided to attach to the pipe opening to prevent contaminated water backflow into the reservoir. If the reservoir must be emptied when the normal outlet is submerged by surface or flood waters, pumps with outlets above the flood water should be used for emptying.

5. Is site adequately protected against vandalism?

Manholes and manhole frames used on covered storage reservoirs and elevated tanks should be fitted with raised, watertight walls. Each manhole frame should be closed with a solid watertight cover and a sturdy locking device. The frame should be locked when not in use. The storage site should be fenced to prevent unauthorized entry. Ladders to tops of storage tanks should terminate 10 feet above the ground to deter unauthorized climbing.

6. Are surface coatings in contact with water approved?

Coatings that are in contact with water should be approved. Unauthorized coatings can create problems due to organic and inorganic contamination of the stored waters.

7. Is tank protected against icing and corrosion?

Cathodic protection may be provided for metal storage tanks. Icing can be a particularly traumatic problem in northern areas. Tanks have "blown their tops" due to the pressures that can result; in less severe cases, the cathodic protection and tank interiors may be damaged. Tanks should not be allowed to remain idle if freezing is a problem. Heaters may need to be used in tanks reserved for emergency purposes.

8. Can tank be isolated from the system?

Tanks should be able to be taken out of the system for repair without shutting down entire system.

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9. Is all treated water storage covered?

Reservoirs should be covered to prevent airborne contamination (birds and algae growths that impart tastes and odors). Covers should be watertight, made of permanent material, and constructed to drain freely and to prevent contamination from entering the stored water. The surface of a storage reservoir cover should not be used for any purpose that may result in contamination of the stored water.

10. What is cleaning frequency for tanks?

Over a period of time, reservoirs may accumulate organic and inorganic debris, which settles to the bottom as a sludge. This sludge can contribute taste, odors, and turbidity to the systems when it accumulates to a depth approaching the outlet pipe. Periodic draining of the tank and cleaning is necessary. The tank should then be disinfected before reuse.

11. Are storage tanks disinfected after repairs?

Reservoirs and elevated tanks on the distribution system should be disinfected before being put into service or after extensive repairs or cleaning have been completed.

COURSE NOTES FOR UNIT 6

UNIT 6b: Hydropneumatic Tanks

Unit Summary

Types and Characteristics
Sanitary Risks

Unit References

Small Water Systems Serving the Public (Chapter 6)
Manual of Individual Water Supply Systems (Part V)
Planning for an Individual Water System (Chapter V)
Water Supply System Operation (Chapter 3 and 5)

Basic Material

Hydropneumatic systems are very common for use in storing and distributing small water supplies. They combine the energy from a pump with the principle of air pressure to force water into the distribution system. Understanding how the hydropneumatic system is susceptible to sanitary risks requires understanding basic system operation and the role of system components.

The system operates in the following manner:

- The pump starts up at a certain pressure (cut-in pressure), and the energy from the pump moves through water to the pocket of air, air volume, at the top of the pressure tank.

- When the pressure builds to a certain point (cut-out pressure), the pump stops and the air forces the water into the distribution system.

- When the pressure becomes too low, the pump starts up again, and the cycle is repeated. The cycle rate is the number of times the pump starts and stops in 1 hour.

A typical hydropneumatic system is made up of the following parts:

COURSE NOTES FOR UNIT 6

Item	Purpose
o Steel tank	Store water
o Air volume control	Control air volume
o Relief valve	Prevent excessively high pressure
o Inlet piping	Allow flow of water into system
o Pressure gauges	Monitor pressure
o Motor controls	Control cut-in and cut-out points
o High/low water level controls	Regulate water level
o Low pressure or flow controls	Maintain balance between water and air pressure
o Discharge piping/air compressor	Discharge water from tank; force additional air in to increase pressure (prepressurizing)

Most systems differ only in the kind of pressure storage tank used. The pressure tank is a significant part of the system in that the methods of separating water and air and the tank size and placement vary. All these factors may contribute to the degree of vulnerability to sanitary risks. The three kinds of tanks are:

Conventional

- Air cushion in direct contact with water; air volume controls necessary
- Capacity ranges from a few to several thousand gallons
- Vertical or horizontal placement
- Outlet located near bottom of tank; combined inlet-outlet or separated on opposite sides of tank
- Air volume control located in upper portion of tank; provisions available for prepressurizing

Floating Wafer

- Floating wafer (rigid floats or flexible rubber or plastic) separates water and air, but separation not complete; some loss of air expected, requiring occasional recharging
- Vertical placement limits tank capacity
- Inlet and outlet combined at bottom of tank
- Internal air check valve to prevent premature loss of air due to electric outage or excess water demand

Flexible Separators

- Separator fastened around inside of tank for complete separation of air and water, either flexible diaphragm or bag type
- Vertical placement limits tank capacity
- Supercharged at factory to pressures just below pump starting pressure

COURSE NOTES FOR JNIT 6

Sanitary Risks

1. Does low pressure level provide adequate pressure?

Maintenance of adequate pressure is especially important. Too little pressure can cause a reversal in the flow of the water, allowing water from a polluted source to enter a potable, stored water source. Too high pressure can strain system components, cause high leakage rates, and can force air out with water. Low pressure can indicate improper connections, or cross-connections, made from storage to serviced facilities. Adequate pressure is needed to keep the water flowing from storage to serviced areas. Backpressure backflow occurs when potable water pressure is less than nonpotable pressure; backsiphonage backflow is a reversal stemming from a vacuum at the potable supply. Backflow and backsiphonage are especially hazardous sanitary risks when they involve poisonous or harmful chemicals. Inspectors must be aware of proximity of polluted sources and must protect stored water against cross-connections.

To ensure against backflow and backsiphonage, minimum pressure must be maintained at all times.

System Pressures
(Pounds Per Square Inch)

Optimum Working Pressure = 40-60 psi
Minimum Working Pressure = 35 psi

Maximum Pressure at Service Connections = 100 psi
Minimum Pressure at Service Connections = 20 psi

Inspectors should check engineering records to assess potential hazards in the water of facilities served by the system and consult operating records to see whether pressure is adequate at service connections.

2. Are instruments and controls adequate, operational, and being utilized?

Proper operation and maintenance of the storage system is also essential. Failure to adjust gauges and controls properly can lead to inadequate pressure and/or inadequate supplies of water. Also, pollution of the storage tank can occur from airborne or waterborne foreign matter. Careful installation and maintenance of pollution prevention devices can prevent their entry into the hydropneumatic system.

To ensure proper operation and maintenance of the system, the following components must be routinely checked and adjusted for changes in the peak demand:

- Air volume control
- Relief valve
- Motor controls
- High/low water level controls
- Low pressure flow controls
- Air compressor and controls

COURSE NOTES FOR UNIT 6

Frequently, controls are not adjusting after delivery of the system from the factory. Operating records will reveal original calibration and whether peak demand has changed.

3. Are the interior and exterior surfaces in good condition?

   The interior and exterior should be in good physical condition. The inspector may not be able to inspect the interior surfaces but should emphasize the importance of regular inspections. The inspector may determine if they are being performed by reviewing maintenance records.

4. Are tank supports structurally sound?

   The tank should be properly supported.

5. Is storage capacity adequate?

   There are several formulas for determining required storage capacity. One method is presented.

   In selecting and evaluating the tank, storage capacity must be matched to the peak demand (period of highest water use) of the system. Otherwise, the tank will supply neither sufficient daily water needs nor emergency needs, such as for firefighting.

   To ensure against inadequate storage capacity (and straining facilities at peak demand), purveyors must know pumping capacity and peak demand rates, which can be used in the formula below to compute appropriate tank size. Engineering records list pump capacity, cut-in, and cut-out pressures. Operating records show current peak demand and whether peak demand has changed since the tank was installed, which could require a change in tank size.

Formula for Estimating
Appropriate Tank Size

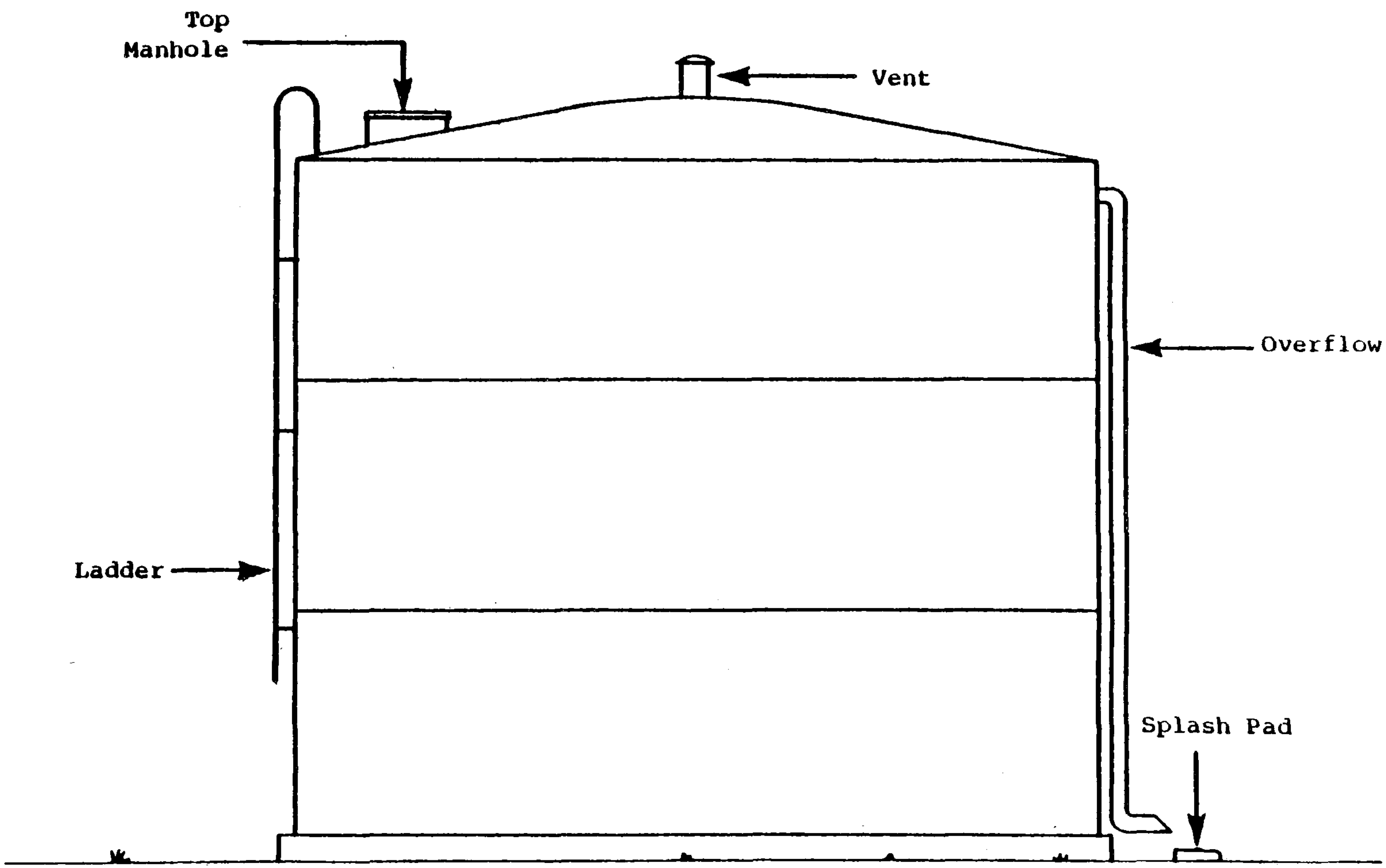
$$Q = \frac{Qm}{1-(P_1/P_2)}$$

Q = Tank volume in gallons
Qm = Peak demand rate, gpm x desired minutes of storage
P_1 = Cut-in pressure + atmospheric pressure (14.7 psi)
P_2 = Cut-out pressure + atmospheric pressure (14.7 psi)

6. What is the cycle rate?

   The pressure pump should not cycle frequently (10-15 cycles/hour acceptable). Frequent or constant operation of the pressure pump indicates a "waterlogged" tank or improper settings on the pressure controls.

COURSE NOTES FOR UNIT 6

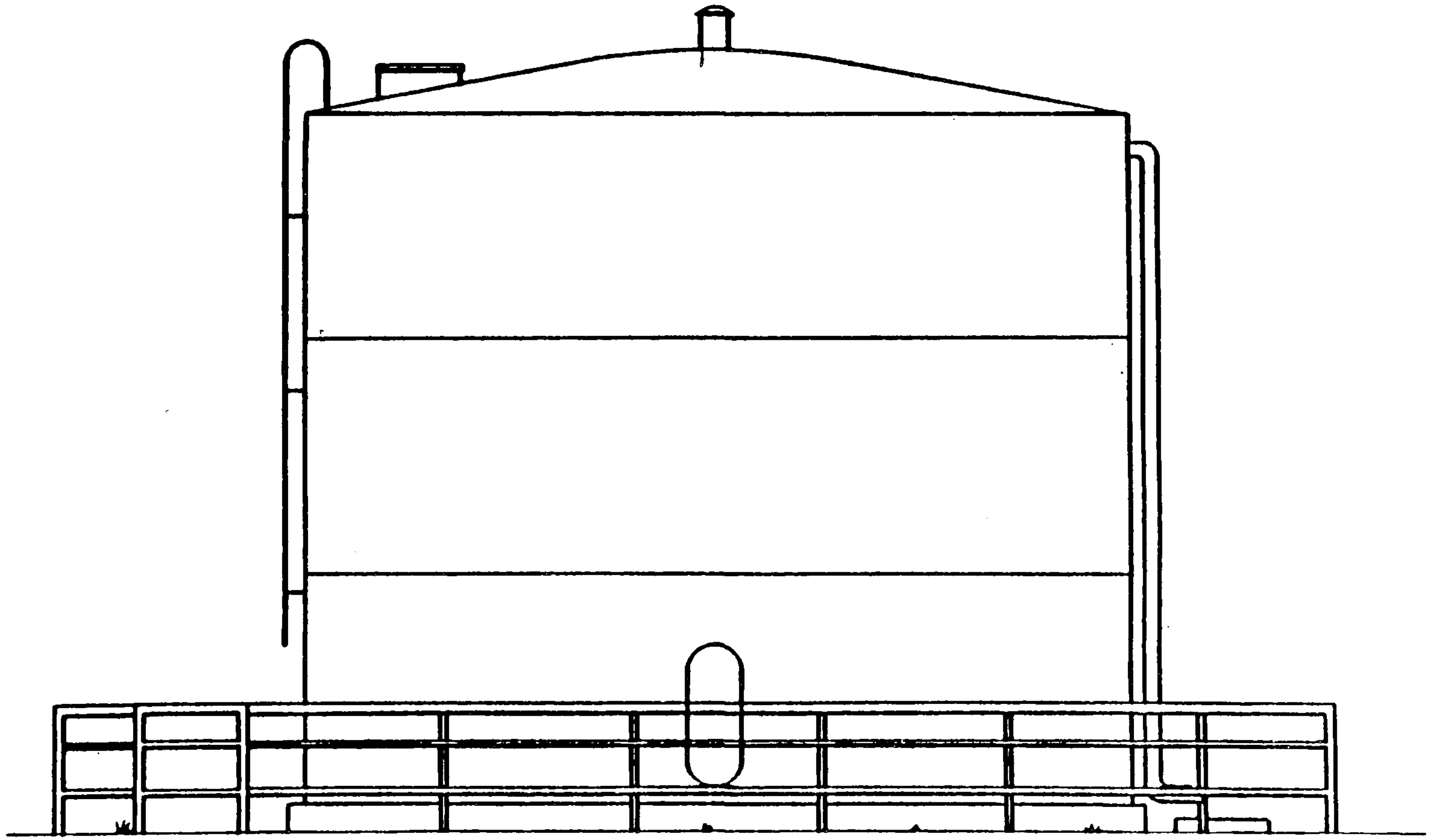


Gravity Storage Tank

Figure 6-1

COURSE NOTES FOR UNIT 6

Figure 6-2



VANDALISM PROTECTION

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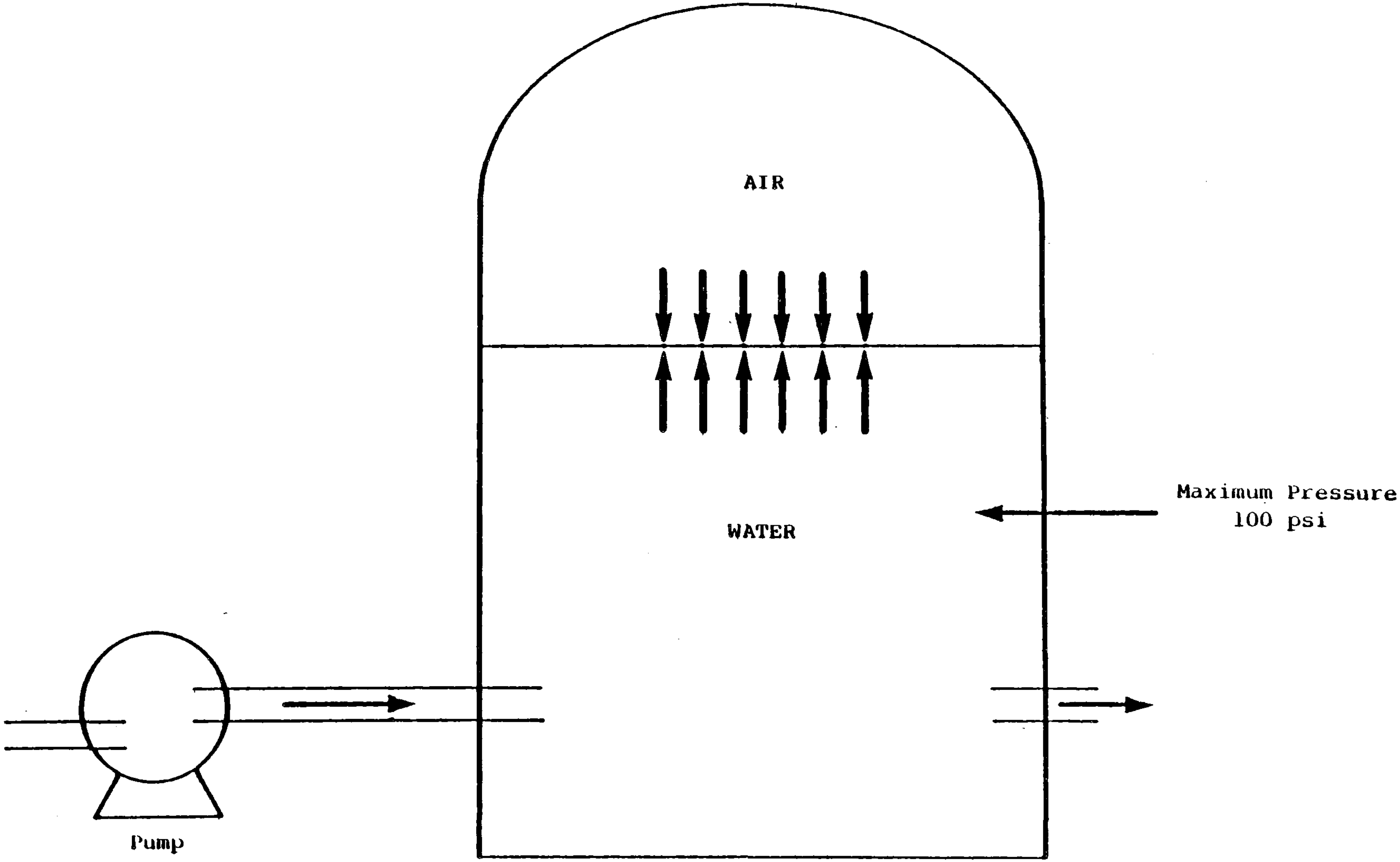
Figure 6-3



CUT-OUT PRESSURE

COURSE NOTES FOR UNIT 6

Types of Pressure Tanks

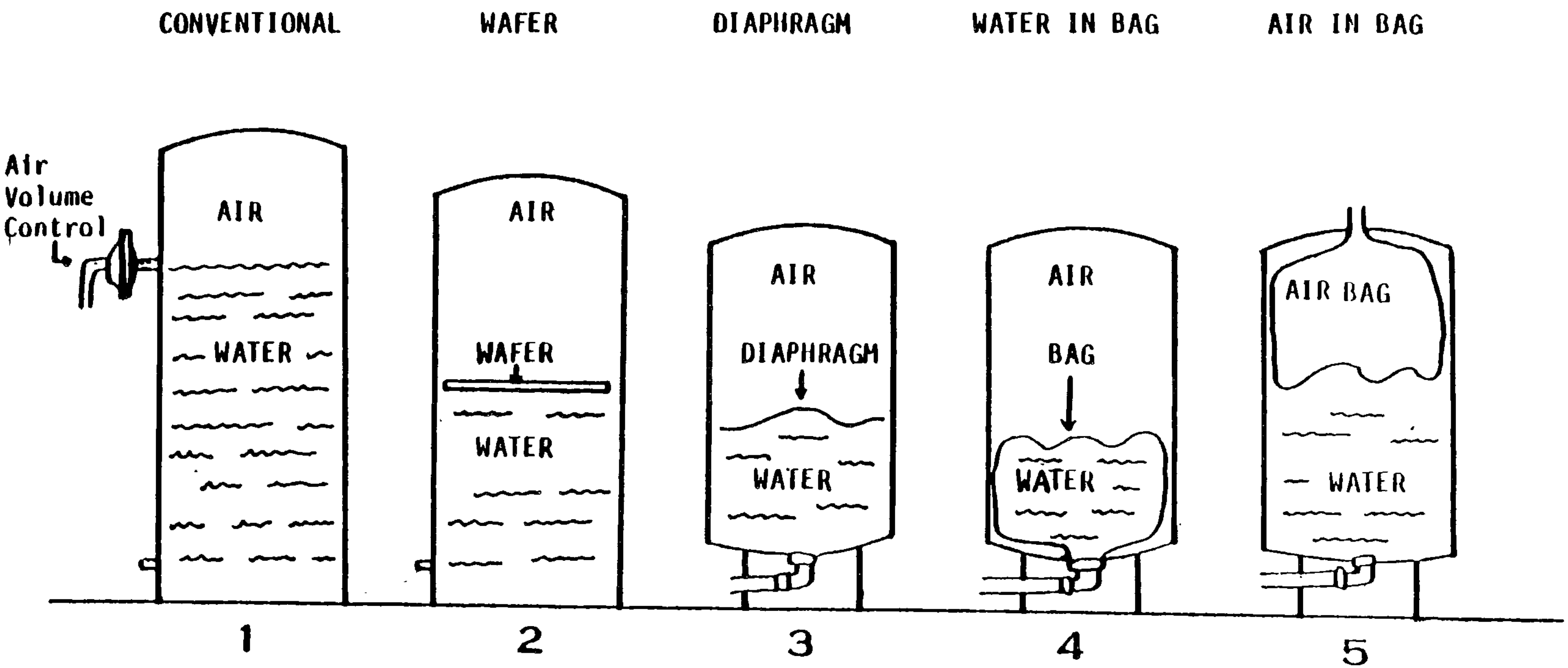


Figure 6-4

COURSE NOTES FOR UNIT 7

Unit 7: DISTRIBUTION SYSTEMS/CROSS-CONNECTIONS

UNIT 7a: Distribution Systems

Unit Summary

Components of a Distribution System
Sanitary Risks

Unit References

Small Water Systems Serving the Public (Chapter 11)
Manual of Individual Water Supply Systems (Part V)
Manual for Evaluating Public Drinking Water Supplies (Part III)
Water Supply System Operation (Chapters 6, 7, and 8)

Basic Material

Many failures to meet the requirements of the drinking water standards are directly related to the use of poor operating and maintenance procedures for distribution systems or to the presence of sanitary defects in the system. Some causes that contribute to poor water quality are:

- Insufficient treatment at the point of production
- Cross-connections
- Improperly protected distribution system storage
- Inadequate main disinfection
- Unsatisfactory main construction, including improper joint-packing
- Close proximity of sewer and water mains
- Improperly constructed, maintained, or located blowoff, vacuum, and air relief valves
- Negative pressures in the distribution system

Components of the Distribution System

The following briefly describe some of the important components of a distribution system.

COURSE NOTES FOR UNIT 7

Pipes

- o Convey supply to points of use
- o Pipe size relative to flow gpm, distance
- o Types
  - o Galvanized. Not recommended for underground use; subject to corrosion from soil, acid water
  - o Copper. Heavy types used underground; less sensitive to corrosion
  - o Plastic. Corrosion resistant; subject to puncture
  - o Cast Iron/Ductile Iron. Corrosion resistant; good hydraulic characteristics; unlined pipe can be subject to iron tubercles
  - o Asbestos Cement. Lightweight, corrosion resistant; easily cut but easily broken
  - o Lead. Used in older systems, particularly as service lines. No longer approved under any circumstances due to possibility of contaminating tapwater.

Valves

- o Control water flow
- o Control backflow
- o Adjust water levels and pressures
- o Isolate sections of system for repair
- o Types
  - o Shut-Off Valves stop flow of water.
  - o Check Valves permit water to flow in one direction only.
  - o Flow Control Valves provide uniform flow at varying pressures.
  - o Relief Valves permit water to escape from the system to relieve excess pressure.
  - o Float Valves respond to high water levels to close an inlet pipe.
  - o Blowoff Valves provide a means to flush sediment from low points/deadends in the distribution system.
  - o Altitude Valves are used to shut off flow of water into storage tank at a preset level to avoid overflow and allows water to flow into tank after level drops.
  - o Air Relief Valves are used at high points to release entrapped air.
  - o Hydrants provide water for firefighting and are a means to flush the system.

Meters

- o Monitor flow through various sections to provide regulation, reimbursement, and maintenance

Meter Vaults

- o Protect meters and controls

Thrust Blocks and Anchors

- o Protect against pipe movement

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Sanitary Risks

The questions that a surveyor should be asking with regard to the distribution system and their rationale follow.

1. Is proper pressure (40-70 psi) maintained throughout the system?

   The system should be designed to supply adequate quantities of water under ample pressure and should be operated to prevent, as far as possible, conditions leading to the occurrence of negative pressure. Steps to prevent negative pressure should include minimizing planned shutdowns, providing adequate supply capacity, correcting undersized conditions, and properly selecting and locating booster pumps to prevent the occurrence of a negative head in piping subject to suction. Continuity of service and maintenance of adequate pressure throughout a public water supply system are essential to prevent backsiphonage. The inspector should determine if complaints about inadequate pressure have been registered. He or she should determine if there is a program to periodically monitor pressures throughout the system.

2. What types of construction materials are used?

   The components of the distribution system should meet the current AWWA standards. The corrosive effects of finished water on nonferrous metal pipe used for water-service lines should be considered, together with possible toxicological effects on consumers, resulting from solution of the metals. Only nontoxic plastic pipe should be used, when plastic pipe is acceptable. Materials used for caulking should not be able to support pathogenic bacteria and should be free of oil, tar, or greasy substances. Joint packing materials should meet the latest AWWA specifications.

3. Are plans of the water system available and current?

   The minimum record of a distribution system contains maps showing locations of all mains, main size, and the location in detail of every line valve. The pipe layout should be designed for future additions and connections to provide circulation where deadends are necessary in the growth state of the pipe system. The system should be provided with sufficient bypass and blowoff valves to make necessary repairs without undue interruption of service over any appreciable area. Blowoff connections to sewers or sewer manholes should be prohibited.

4. Does the system have an adequate maintenance program?

   This is actually an overall evaluation of the answers to a series of questions, such as:

   a. What is the frequency of main breaks?

      The majority of breaks are not due to age but to leaks. The leaks undermine the pipe, consequently causing it to fail under the weight of the overburden. To prevent main breaks, a routine program for leak detection should be conducted.

b. Does the utility have a pressure testing program?

Such a program may be conducted in conjunction with the fire department to determine adequacy of fire flow. A record of pressures throughout the system may help to ide-tifv problems. If they are conducted both during the day and at night, th y will indicate the hydraulic efficiency under common requirements.

c. Does the utility have a flushing program?

The whole system should be flushed once or twice a year due to sediment deposition in the lines. The flushing should be well planned and carried out, beginning at points near the water plant/storage and moving to the outer ends.

d. Does the utility have a valve maintenance program?

All valves in a system should be inspected on a routine basis. The frequency of inspection depends on type of valve, but an annual inspection is desirable for all valves. This should include completely closing, reopening to about one-quarter, and reclosing until valve seats properly. A record of valve maintenance and operation should be kept.

e. Does the utility have a corrosion control program?

The utility should have a program to evaluate corrosion and the effectiveness of corrosion control particularly to control contaminants such as lead and cadmium.

f. Are proper disinfection procedures used after repairs?

The procedure outlined in the AWWA Standard for Disinfecting Water Mains should be followed. The inspector should question the operator as to what procedures are used. The final determining factor should be that new mains and repaired main sections should demonstrate negative bacteriological results prior to being placed in service.

5. Is the system interconnected with any other water systems?

This of of concern for two reasons:

a. The water systems to which it is connected may be of a lower quality and potentially pose a risk.

b. The other water system may provide an alternate source in the case of drought, contamination of the primary source or a similar emergency.

The inspector should evaluate the answers to such questions and the availability of records to determine the adequacy of the maintenance program.

COURSE NOTES FOR UNIT 7

COURSE NOTES FOR UNIT 7

UNIT 7b: Cross-Connections

Unit Summary

Type and Characteristics of
Cross-Connections
Sanitary Risks

Unit References

Small Water Systems Serving the Public (Chapter 15)
Cross-Connection Control Manual
Water Supply System Operation (Chapters 6 and 8)

Basic Material

To prevent contamination of the community's water supply, the purveyor must make sure that service connections are properly made and are continually monitored for cross-connection hazards. A cross-connection is a physical connection or arrangement between otherwise separate piping systems containing potable and other water, whereby water may flow between the two systems. Hazards occur when water flows toward the potable supply instead of from it to the service outlets. Unless controlled, cross-connections can result in contaminated water replacing potable water at various sites within a water system. If the contaminated water is unobstructed and its force is great enough, it can enter the potable supply at the water facility, endangering the health of the entire community.

A cross-connection link can be made either as a pipe-to-pipe connection, in which potable and contaminated water pipes are linked without the proper control valves, or as a pipe-to-water connection, in which the outlet from a potable water supply is submerged in contaminated water. Cross-connections are usually made unintentionally or are made because their hazards are not recognized. The two major types of cross-connection hazards—backpressure backflow and backsiphonage backflow—are distinguished by their origins. Backpressure backflow refers to the flow of water toward a potable supply when the contaminated water's pressure is greater than the potable water's pressure. Contaminated water pushes toward the potable supply. (Liquid flows from a place of high pressure to one of lower pressure.) Backsiphonage backflow is a type of backflow resulting from negative pressure (a vacuum) in the distributing pipes of a potable water supply. Contaminated water is sucked up toward the potable supply.

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Plumbing defects can occur within any part of a water system, and cross-connection hazards can occur where outside water pressure can exceed potable water pressure. Therefore, cross-connections must be prevented or controlled at all service sites as well as at the water facility.

Successful control of cross-connection hazards depends not only on voluntary monitoring of connections by the water purveyor and water users, but also on an enforceable community control program. If a community subscribes to a modern plumbing code, such as the National Plumbing Code, its provisions will govern backflow and cross-connections. Still, the water facility must obtain authority to conduct a community inspection program through an ordinance or other means. A cross-connection control ordinance should have at least three basic parts:

- Authority for establishment of a program.
- The technical provisions relating to eliminating backflow and cross-connections.
- Penalty provisions for violations.

Protection Against Sanitary Risks

At Service Sites: Cross-connections that occur at sites serviced by the water facility can usually be controlled at the sites themselves. For example, a submerged water outlet in an apartment building could result in contamination of the water for the entire building (as well as threatening the water facility's supply) if the water pressure of the contaminated water exceeds that of the potable water. To prevent this cross-connection hazard, each fixture in the building should have a vertical airgap between its water outlet and its flow-level rim. This will eliminate the physical cross-connection link and protect the building (and the municipal supply) against backflow. An airgap separation may also be made at a point where the water service enters the building. (This protects only the municipal supply, however, and not the building system.) Backflow prevention devices, such as double-check, double-valve assemblies, can be installed when an airgap cannot be made. They can also provide backup when airgaps are made. Surge tanks, booster systems, and color-coding and labeling of pipes in dual water systems also protect buildings against cross-connection backflow. Backsiphonage can be prevented by installation of vacuum-breaking devices at water outlets where contaminated water is used and where a vacuum could occur in the water supply pipe.

At the Water Facility: To lessen the chances of hazardous cross-connections, water facilities should not be connected to unapproved systems or to private wells. If connections must be made to wastewater treatment plants, boiler plants, and other sites with inherently dangerous contaminants, the connections must be carefully monitored at the facility to prevent contamination from entering the water supply. An airgap in the service line to a premise at which extreme hazards exist may be warranted. Waterworks officials often prescribe the installation of a backflow prevention device in the service line to a premise where

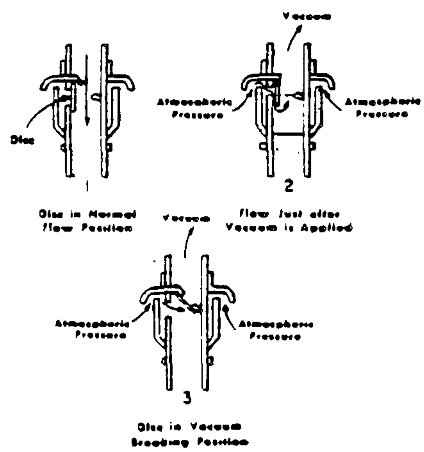
COURSE NOTES FOR UNIT 7

hazardous use of water is found. Lesser hazards can often be prevented with backflow prevention devices in other locations. Backflow prevention devices are critical (used exclusively or as backup) in all water facilities because any water pressure greater than that of the facility could cause a flow reversal. Maintenance of systematic water pressure will prevent backsiphonage stemming from the water facility. The facility must also install and maintain devices that block backsiphonage flow as a backup in cases when pressure does drop. (This can occur if a main break or a fire overburdens the pumping capacity.)

Types of Devices:

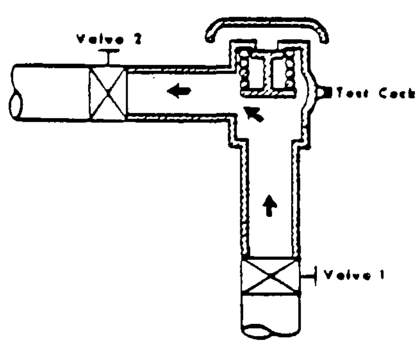
Vacuum Breaker: A device that is activated by atmospheric pressure to block the water supply line when negative pressure develops in the line. This action admits air to the line and prevents backsiphonage. A vacuum breaker is not designed to provide protection against backflow resulting from backpressure, and should not be installed where backpressure may occur.

(See Figure 7-1)



Pressure-Type Vacuum Breaker: This device is installed in pressurized systems and will operate only when a vacuum occurs. It is usually spring loaded, and should be specially designed to operate after extended periods under pressure because corrosion and deposition of material in the line might render it inoperable.

(See Figure 7-2)



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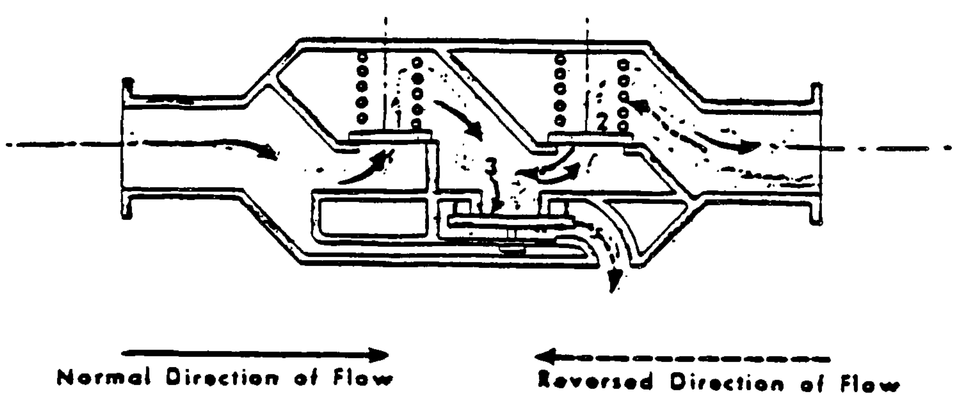
Reduced Pressure Zone Backflow Preventer (RPZ): This device consists of two hydraulically or mechanically loaded pressure-reducing check valves, with a pressure-regulated relief valve located between the two check valves. Flow from the left enters the central chamber against the pressure exerted by the loaded check valve 1. The supply pressure is reduced by a predetermined amount. The pressure in the central chamber is kept lower than the incoming supply pressure through the operation of relief valve 3, which discharges to the atmosphere whenever the central chamber pressure is within a few pounds of the inlet pressure. Check valve 2 is lightly loaded to open with a pressure drop of 1 psi in the direction of flow and is independent of the pressure required to open the relief valve. In the event that the pressure increases downstream from the device, tending to reverse the direction of flow, check valve 2 closes, preventing backflow. Because all valves may leak as a result of wear or obstruction, the protection provided by the check valves is not considered sufficient. If some obstruction prevents check valve 2 from closing tightly, the leakage back into the central chamber would increase the pressure in this zone, the relief valve would open, and flow would be discharged to the atmosphere.

When the supply pressure drops to the minimum differential required to operate the relief valve, the pressure in the central chamber should be atmospheric. If the inlet pressure should drop below atmospheric pressure, relief valve 3 should remain fully open to the atmosphere to discharge any water that may flow back as a result of backpressure and leakage of check valve 2.

Malfunctioning of one or both of the check valves or relief valve should always be indicated by a discharge of water from the relief port. Under no circumstances should plugging of the relief port be permitted because the device depends on an open port for safe operation. The pressure loss through the device may be expected to average between 10 and 20 psi within the normal range of operation, depending upon the size and flow rate of the device.

(See Figure 7-3)



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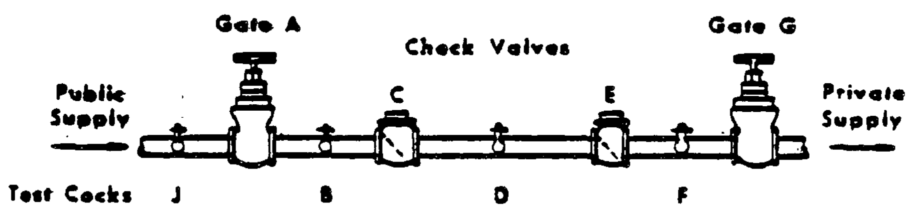
Double-Check, Double-Gate Valve Assembly: The double-check, double-gate valve assembly is a very useful and, when properly maintained, reliable means of backflow protection for intermediate degrees of hazard. As in the case of other backflow preventers, the double-check, double-gate valve assembly should be inspected at regular intervals. Some health authorities have established programs of annual inspection.

The double-check, double-gate system has the advantage of a low head loss. With the gate valves wide open, the two checks, when in open position, offer little resistance to flow.

Double-check, double-gate assemblies should be well designed and constructed. The valves should be all bronze or, for larger sizes, galvanized gray iron. The trim should be of bronze, or other corrosion-resistant material. Springs should be bronze, stainless steel, or spring steel covered with a coat of vinyl plastic. Valve discs should be of composition material with low water absorption properties. Test cocks should be provided.



Sanitary Risks

To evaluate the potential risks of cross-connections, the inspector should determine the answers to the following:

1. Does the utility have a cross-connection prevention program?

   The inspector should determine if the water facility has obtained authority to conduct a community inspection program through an ordinance or other means. A cross-connection control ordinance should have at least three basic parts:

   - Authority for establishment of a program
   - The technical provisions relating to eliminating backflow and cross-connections
   - Penalty provisions for violations

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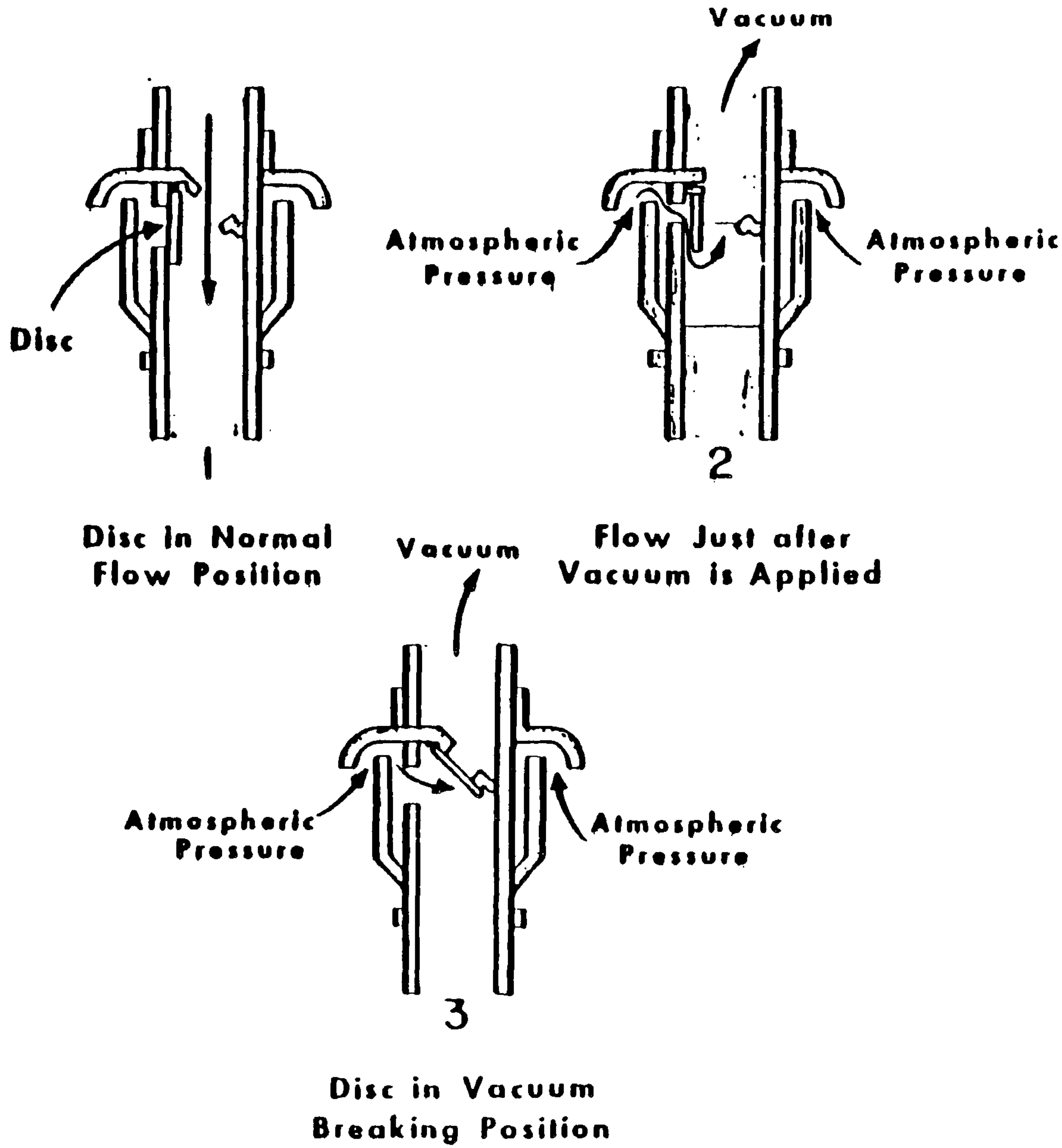
2. Are backflow prevention devices installed at all appropriate locations (wastewater treatment plants, hospitals, industrial locations)?

The threat of cross-contamination hazards is especially great at wastewater treatment plants, boiler plants, chemical manufacturing plants, hospitals, and nuclear power plants. Their water may contain inherently dangerous materials. These sites should be ensured against physical links and should be equipped with devices to prevent backflow and backsiphonage from contaminating water on the premises.

3. Are cross-connections present at the treatment plant?

The inspector should briefly discuss with the operator the importance of ensuring that there are no cross-connections at the plant either on a temporary or permanent basis. One way to help minimize the potential of cross-connections is to have the piping in the plant color coded. The primary sources of cross-connections in the treatment plant are submerged inlets to solution tanks, connections between potable water lines and process water lines, and at pumps. When using phosphate solutions, tanks must be kept covered and disinfected by carrying a 10 mg/l free chlorine residual to prevent the growth of bacteria.

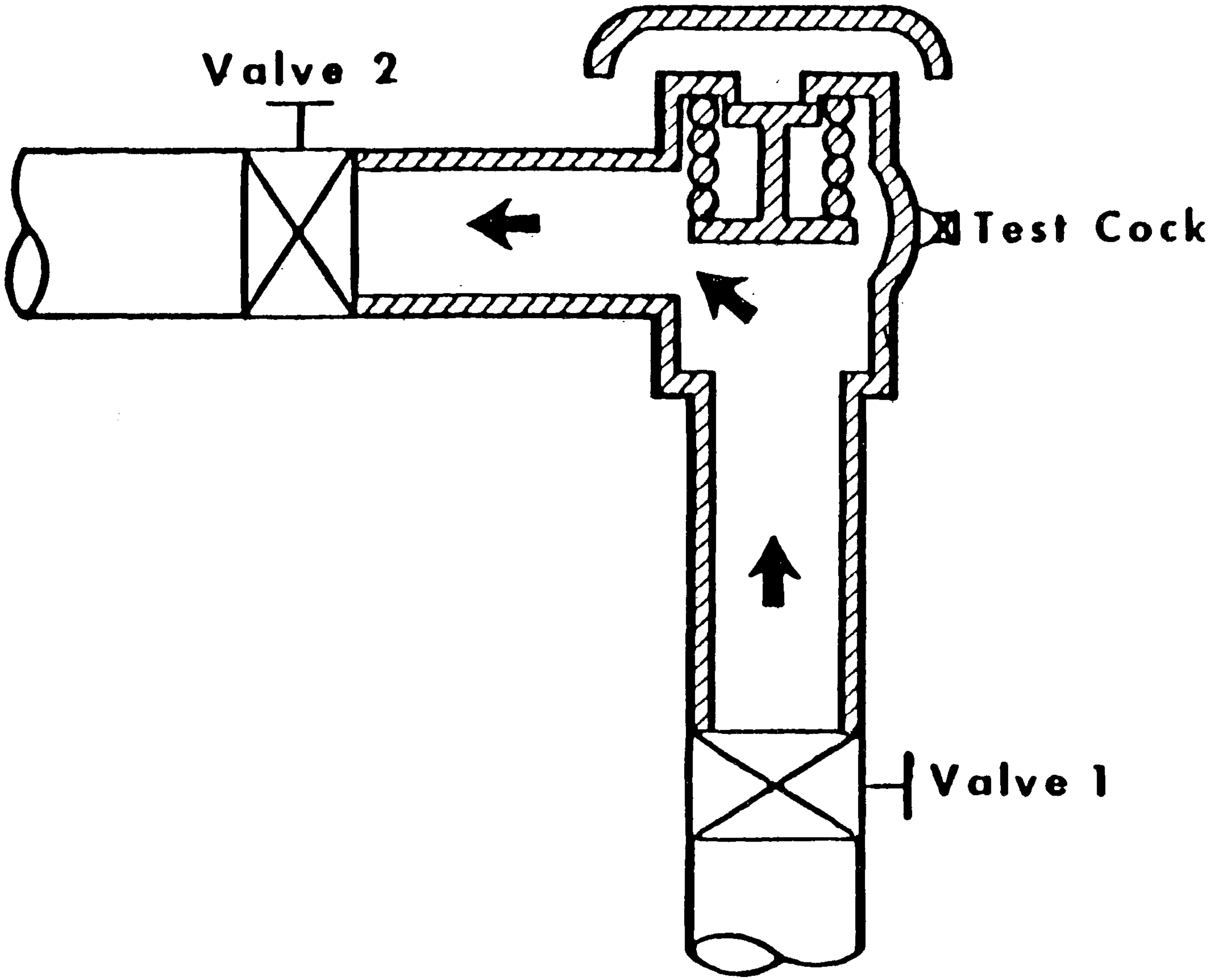


Operation of a vacuum breaker.

Figure 7-1

COURSE NOTES FOR UNIT 7

Figure 7-2



Pressure-type vacuum breaker installation.

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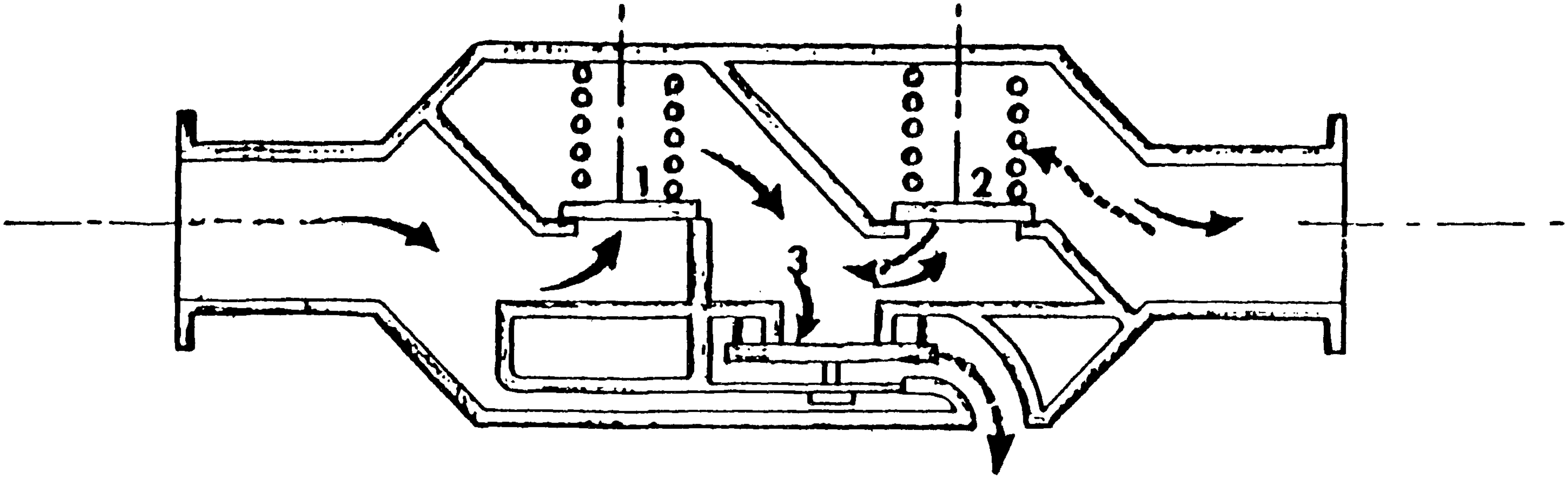
Figure 7-3



Normal Direction of Flow

Reversed Direction of Flow

Reduced pressure zone backflow preventer – principle of operation.

COURSE NOTES FOR UNIT 7

COURSE NOTES FOR UNIT 8

Unit 8: MONITORING/RECORDKEEPING/SAMPLING

Unit 8a: Monitoring

Unit Summary

Monitoring Responsibility
Monitoring Requirements
In-plant Monitoring

Unit References

National Interim Primary Drinking Water Regulations
Water Treatment Plant Operation Vol. I (Chapter 10)

Basic Material

The National Interim Primary Drinking Water Regulations (NIPDWR) outlining responsibilities and requirements of the water purveyor with respect to monitoring. The responsibilities for monitoring are:

1. Arrange for all applicable sampling required in the regulations.

2. Arrange for sample examinations at a State-approved laboratory.

The requirements for sampling frequency are provided in the tables included in this unit.

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TABLE 8-1

Frequency Requirements for Sampling and Analysis

MICROBIOLOGICAL

Contaminant	Surface Source	Ground Source
Coliform Bacteria	Monthly, based on population served Community systems of less than 1,000 people, a minimum of one per month Noncommunity systems, a minimum of one per calendar quarter	Same as for surface sources except that State agency may reduce to one sample per calendar quarter

INORGANIC CHEMICALS (Applies only to community systems except for Nitrate, which applies to both community and noncommunity)

Contaminant	Surface Source	Ground Source
Arsenic Barium Cadmium Chromium Lead Mercury Selenium Silver Fluoride Nitrate	Analysis at 1-year intervals	Analysis at 3-year intervals

COURSE NOTES FOR UNIT 8

TABLE 8-1 (cont.)

ORGANIC CHEMICALS

Contaminant	Surface Source	Ground Source
Endrin Lindane Methoxychlor Toxaphene 2,4-D 2,4,5-TP Silvex	Analysis at 3-year intervals	Analysis only if required by the State
Total Trihalomethanes	Sampling and analysis conducted quarterly	

(Individual States may require greater frequency of sampling and analysis.)

RADIOACTIVITY (Applies only to community-type systems)

Contaminant	Surface Source	Ground Source
Natural Radioactivity	Analysis completed at 4-year intervals	Analysis completed within 3 years after effective date; thereafter at 4-year intervals

SODIUM (Applies only to community-type systems)

	Surface Source	Ground Source
	Sampling and analysis conducted annually	Sampling and analysis conducted every 3 years

COURSE NOTES FOR UNIT 8

TABLE 8-1 (cont.)

CORROSIVITY CHARACTERISTICS (Applies only to community-type systems)

	Surface Source	Ground Source
(One round of sampling and analysis)	Two samples to be taken one midwinter and one midsummer	Only one sample and analysis required

(Note: Individual states may require a greater frequency of sampling and analysis.

TURBIDITY

	Surface Source	Ground Source
	Sampling of at least once per day	Not applicable

With respect to this in-house monitoring, the inspector should be concerned with the following points:

1. Is the operator competent in performing the tests?

   The inspector may wish to observe the operator's technique in collecting samples and performing analyses. The operator shoul follow the correct procedures such as calibrating and zeroing specific ion electrodes. The operator should be aware of interferences that may cause incorrect readings.

2. Are testing facilities and equipment adequate?

   The water utility should be encouraged to have equipment to enable proper operational monitoring. The equipment should be in working order. The inspector may wish to look at the equip ment. The operation of the plant is not aided by a pH electrode that the operator has been using which has been dry for the last six months. The facilities should be adequate for th equipment utilized. Many of the electronic instruments are influenced by temperature and humidity.

3. Do reagents used have an unexpired shelf life?

   The operator should be encouraged to mark the date of preparation on reagents and to discard when appropriate. The

COURSE NOTES FOR UNIT 8

manufacturer-prepared reagents should be discarded when the expiration date is reached.

4. Are records of test results being maintained?

   The records of test results should be kept so that trends ma observed. The inspector should determine what action is tak based on the test results. The operators should know the importance of the particular test and what the results mean.

For operational water quality monitoring the following parameter are generally tested:

Temperature	Color
pH	Iron
Alkalinity	Manganese
Chlorine Residual	Flouride
Hardness	Phosphate
Carbon Dioxide	Total Coliform
Turbidity	

Using the parameters listed above and any other you feel necessa list those you feel are necessary to properly monitor the treatm processes in the three problems below. Assume the role of the p operator as you perform this exercise.

SCHEMATIC OF CONVENTIONAL SURFACE WATER PLANT

Figure 8-1

SCHEMATIC OF IRON REMOVAL FACILITY

Figure 8-2

SCHEMATIC OF GROUNDWATER SYSTEM WITH SIMPLE CHLORINATION

Figure 8-3

COURSE NOTES FOR UNIT 5

Unit 8b: Recordkeeping

Unit Summary

Bacteriological Analysis
Chemical Analysis
Corrective Action Records

Unit References

Manual of Instruction for Water Treatment Plant Operations (Chapter 8)
Water Treatment Plant Operation Vol. I (Chapters 3, 4, 9, and 10)
Small Water System Operation & Maintenance (Chapters 1, 3, 4, and 5)

Basic Material

The following records must be kept by the water supplies as outlin by NIPDWR:

- Bacteriological analyses - for at least five years.
- Chemical analyses - for at least ten years. Actual laboratory reports may be kept, or data may be transferred to tabular summaries, provided that the following information is included:
    - Date, place, time of sampling, name of person collecting
    - Identification of routine distribution system sample, check samples, raw or process water samples, special purpose samples, date of analyses
    - Lab and person responsible for performing analysis
    - Results of analysis
- Records of action taken to correct violations - for at leas three years after last action was taken with respect to a particular violation.
- Copies of written reports, summaries or communications relating to sanitary surveys conducted by itself, private consultant, or local, State, or Federal agency - for at least ten years after completion of sanitary survey involved.
- Records concerning scheduling of improvements - not less than five years following expiration of scheduling time.

COURSE NOTES FOR UNIT 8

Unit 8c: Sampling

Unit Summary

Representative Samples
Sample Collection Techniques and Location
Sample Handling and Preservation

Unit References

Manual of Instruction for Water Treatment Plant Operations (Chapter 21)
Manual of Water Utility Operations (Chapter 12)
Water Distribution System Operation & Maintenance (Chapters 5 and 6)
Water Treatment Plant Operation Vol. I (Chapters 4, 6, 7, and 11)
Small Water System Operation & Maintenanc (Chapter 7)

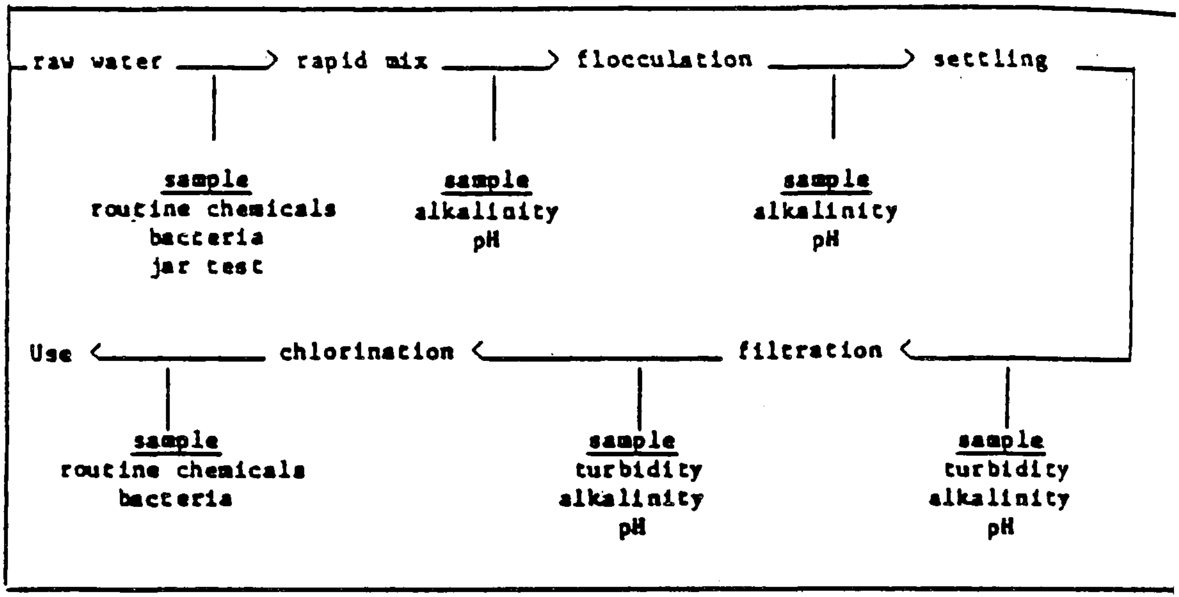
Basic Material

The inspector should ensure that the required monitoring is being conducted and that analysis is performed by a certified laboratory. Recordkeeping should also be evaluated to determine compliance with the regulation.

The previously discussed monitoring is required to comply with the regulations. The analysis for those samples, with the exception of turbidity and chlorine residual, must be conducted by an approved laboratory. The operator must establish an in-house monitoring program to properly evaluate the operation of the treatment system. The number of parameters and sample points is dependent on the type of treatment required. The frequency of the sampling will depend on the type of source, its variability of quality, and the importance of the parameter being evaluated. The following chart illustrates sampling points and suggested monitored parameters.

COURSE NOTES FOR UNIT 8

Sampling Points



Routine Analysis:

color	iron	alkalinity	chlorid
turbidity	manganese	pH	fluorid
odor	hardness	nitrogen series	

COURSE NOTES FOR UNIT 8

Since the intent of the Safe Drinking Water Act is to insure drinking water quality, meaningful analysis of the water is necessary to gauge compliance with established water quality standards. The analysis of water samples is meaningful only if three important factors are followed:

1. The sample collected must be truly representative of the water under consideration.

2. The sample must be collected using the proper sampling equipment and techniques.

3. Once collected, the sample must be protected and preserved until it is analyzed.

A wide variety of potential sample locations are associated with public water systems, and specialized sampling techniques must be used on many of these

Common Sample Location:

Source Water Sampling
- Surface Water (Streams, Lakes, Reservoirs, Rivers)
- Groundwater

In-Plant Sampling
- Raw water
- Mixed water
- Settled water
- Filtered water
- Finished water

Distribution System Sampling
- Mains
- Storage Tanks
- Customer tap

The diversity of sample collection equipment and procedures necessary to allow sampling of the locations listed above is substantial. Equipment ranging from simple glass or plastic containers to composite samplers or continuous monitors are often necessary for the proper evaluation of water quality. Inspectors should become familiar with the availability and use of sampling equipment and specifically with their own state's requirement concerning sample volume requirements, holding times, preservation techniques, reporting and chain of custody procedures.

Recommendation for Sampling and Preservation of Samples According to Measurement:

Table 8-2 provides a complete listing or recommendations for sampling and preservation of samples according to measurement. Table reprinted from Water Treatment Plant Operation, Volume I, page 489. Table 8-3 provides the sampling requirements for microbiological examination of potable water as established by the South Carolina Department of Health and Environmental Control.

COURSE NOTES FOR UNIT 8

TABLE 8–2 RECOMMENDATION FOR SAMPLING AND PRESERVATION OF SAMPLES ACCORDING TO MEASUREMENT[a]

Measurement	Vol. Req. (mL)	Container[b]	Preservative	Maximum Holding Time[c]
PHYSICAL PROPERTIES				
Color	50	P,G	Cool, 4°C	48 hours
Conductance	100	P,G	Cool, 4°C	28 days
Hardness[d]	100	P,G	Cool, 4°C HNO_3 to pH <2	6 months
Odor	200	G only	Cool, 4°C	24 hours
pH[d]	25	P,G	Det. on site	2 hours
Residue, Filterable	100	P,G	Cool, 4°C	14 days
Temperature	1000	P,G	Det. on site	Immediate
Turbidity	100	P,G	Cool, 4°C	48 hours
METALS (Fe, Mn)				
Dissolved	200	P,G	Filter on site HNO_3 to pH <2	6 months
Suspended	200		Filter on site	6 months
Total	100	P,G	HNO_3 to pH <2	6 months
INORGANICS, NON-METALLICS				
Acidity	100	P,G	Cool, 4°C	14 days
Alkalinity	100	P,G	Cool, 4°C	14 days
Bromide	100	P,G	None Req.	28 days
Chloride	50	P,G	None Req.	28 days
Chlorine	200	P,G	Det. on site	2 hours
Cyanide	500	P,G	Cool, 4°C NaOH to pH 12	14 days
Fluoride	300	P,G	None Req.	28 days
Iodide	100	P,G	Cool, 4°C	24 hours
Nitrogen				
Ammonia	400	P,G	Cool, 4°C H_2SO_4 to pH <2	28 days
Kjeldahl, Total	500	P,G	Cool, 4°C H_2SO_4 to pH <2	28 days
Nitrate plus Nitrite	100	P,G	Cool, 4°C H_2SO_4 to pH <2	28 days
Nitrate	100	P,G	Cool, 4°C	48 hours
Nitrite	50	P,G	Cool, 4°C	48 hours
Dissolved Oxygen				
Probe	300	G only	Det. on site	1 hour
Winkler.	300	G only	Fix on site	8 hours
Phosphorus				
Ortho-phosphate, Dissolved	50	P,G	Filter on site Cool, 4°C	24 hours
Hydrolyzable	50	P,G	Cool, 4°C H_2SO_4 to pH <2	24 hours
Total	50	P,G	Cool, 4°C H_2SO_4 to pH <2	28 days
Total, Dissolved	50	P,G	Filter on site Cool, 4°C H_2SO_4 to pH <2	24 hours
Silica	50	P only	Cool, 4°C	28 days
Sulfate	50	P,G	Cool, 4°C	28 days
Sulfide	500	P,G	Cool, 4°C 2 mL zinc acetate	28 days
Sulfite	50	P,G	Cool, 4°C	48 hours

[a] "Guidelines Establishing Test Procedures for the Analysis of Pollutants;" Proposed Regulations: Correction, by U.S. Environ[mental] Protection Agency, Federal Register, Part IV, Vol. 44, No. 244, Tuesday, December 18, 1979, Proposed Rules, pages 75028-75[...]

[b] Polyethylene (P) or Glass (G). For metals, polyethylene with a polypropylene cap (no liner) is preferred.

[c] Holding times listed above are recommended for properly preserved samples based on currently available data. It is recognized th[at for] some sample types, extension of these times may be possible while for other types, these times may be too long. Where shipping r[equirements or condi]tions prevent the use of the proper preservation technique or the holding time is exceeded, such as the case of a 24-hour composit[e, the] final reported data for these samples should indicate the specific variance.

[d] Hardness and pH are usually considered chemical properties of water rather than physical properties.

SPECIAL NOTE

Whenever you collect a sample for a bacteriological test (coliforms), be sure to use a sterile plastic or glass bottle. If the sample co[ntains] any chlorine residual, sufficient sodium thiosulfate should be added to neutralize all of the chlorine residual. Usually two drops (0[...]) of ten percent sodium thiosulfate for every 100 mL of sample is sufficient, unless you are disinfecting mains or storage tanks.

COURSE NOTES FOR UNIT 8

TABLE 8-3

MICROBIOLOGICAL EXAMINATION OF POTABLE WATER

Type of Examination	Amount of Sample Needed	Procedure	Time Requ Completio
1. Total Coliform (MF or MPN)	4 oz.	Analyze within a 30-hour time limit.	MF: 24 ho Verificat Additio 96 hour MPN: up t
2. Fecal Coliform (MFC or MPN)	4 oz.	Sample refrigerated and delivered to lab within 6 hours. In no case will sample be analyzed if more than 30 hours old.	MFC: 24 h Vericatio Additio 72 hour MPN: up t
3. Standard Plate Count	4 oz.	Sample refrigerated and examined within a 30-hour time limit.	48 hours
4. Non-Coliform Identification	4 oz.	Collect sample for routine Total Coliform and request NCG-ID.	Minimum of up to 2-3
5. Salmonella-Shigella	1-2 liters	Sample refrigerated and delivered to lab within 6 hours. Collect only if Fecal Coliform is positive.	1 week min possibly 2 for confir
6. Actinomycetes	4 oz.	Sample collected from raw water source from a site near intake to water plant and as close to the bottom as possible.	7 days
7. Fungi	4 oz.	Sample refrigerated and analyzed within 24 hours.	5-7 days
8. Iron Bacteria	4 oz.	Analyze within a 30-hour time limit.	24 hours
9. Giardia lamblia	5-10 liters (500 gal. preferred)	Preferred method: In-line filter left in place for 24 hours.	Must be pe in co-ordi with EPA la tories. Ca 3-6 week fo pletion.
10. Viruses	Minimum of 100 liters Potable water: 1000 liters	Must be collected by Lab personnel using cartridge filter adsorption elution procedure.	

COURSE NOTES FOR UNIT 8

Sanitary Risks:

The questions that a surveyor should ask regarding sampling are:

1. Is the operator collecting water samples at the proper location? The results of the analytical test will be meaningless unless the water tested is truly representative of the water in question.

2. Are the proper precautions being taken during sampling to provide valid and useful results? The evaluation of proper techniques including the use of proper sampling equipment, preservation techniques, reporting, and the actual analytical test should be made.

3. What type of samples should be collected by the person conducting the survey for analysis by the State Laboratory? Dependent upon the type of treatment, efficiency of treatment operation and past water quality results, the inspector should be ready to collect the appropriate samples to insure proper operation and water quality at the facility. These samples should preferably be split with the utility or at least compared with recent results obtained from the water systems own monitoring.

4. Are the samples being collected under the proper conditions? Is the operator collecting settled water samples first thing in the morning following startup? Are samples collected first thing in the morning following startup for chlorine residual monitoring? If so, from where are they collected and are they truly representative? Are sample pumps left running? If not, is sufficient flushing time allowed?

5. Is the water system collecting the proper types of samples for the type of treatment employed? Is the frequency sufficient? A review of reference material as well as common sense is necessary in evaluating a system's monitoring requirements. If a system is treating to remove "something", then that "something" generally should be monitored. If a system is adding a chemical, then generally that chemical or effect should be monitored.

COURSE NOTES FOR UNIT 8

Problem Solving Exercises:

The following four (4) problem examples should be evaluated by groups. Each group should list what sampling they feel should be conducted and any other items or actions that they feel are needed to solve the stated problems.

Example #1:

The town of Leptothrix has two deep wells providing approximately 250 gpm each, a 150,000 gallon elevated tank and a distribution system serving the town. The groundwater has the following characteristics:

pH 5.2 - 5.4
Alkalinity 24 mg/l as $CaCo_3$
Iron 4.2 mg/l
Manganese 0.37 mg/l
Color less than 15
Hardness 50 mg/l as $CaCo_3$
Turbidity 2.5 NTU

The system provides iron and manganese removal treatment by using a manganese greensand filter. Prechlorination, Pre pH adjustment, and the continuous pre feed of $KMnO_4$ is the only chemical treatment.

Problem:

Numerous complaints have been received concerning rusty discolored water which smells bad. What type of samples and from where would you collect them to ascertain the problem?

COURSE NOTES FOR UNIT 8

Example #2:

A 40 MGD conventional surface water treatment facility is located on a shallow reservior that was constructed six (6) years ago. The plant has experienced problems with manganese as high as 2.2 mg/l in their raw water and has had THM quarterly averages as high as 285 mg/l. In order to treat for manganese and to control the formation of THM's, the facility switched from pre-chlorintion to chlorination on top of the filters. They also implemented t feeding of $KMnO_4$ into their raw water line near the raw water pumping station.

Problem:

Within the last two weeks the facility has begun to receive numerous complaints concerning discolored water. What type of samples would you collect and from where to determine what may be causing this problem and to be able to prescribe a solution? With this type of treatment change, what monitoring requirements do you feel would be necessary?

COURSE NOTES FOR UNIT 8

Example #3:

A small subdivision is served by a private water utility. The operator of the system says they utilize five (5) low capacity wells (less than 30 gpm each) and provide disinfection by means of a hypochlorinator and a solution of calcium hypochlorite as the disinfectant at three (3) of the wells. The system is diagramed on the next page.

Problem:

The local Medical Director calls and says he is aware of approximately five families who are having gastrointestinal problems and that they live in the same subdivision. After further investigation, you determine that the families are all on the private water system and that the last 12 months' bacteriological self-monitoring results were satisfactory. You are requested to perform a sanitary survey. Upon arrival, you can find no physical reasons that would indicate an obvious problem at the water system. You, however, discover that the sample taker has been collecting all of the required monthly bacteriological water samples from the tank located at well #5. What samples would you collect and from where? NOTE: Your Medical Director has just indicated that eight (8) more G. I. cases have been confirmed and that they too live in the subdivision.

COURSE NOTES FOR UNIT 8

Example #4:

A conventional surface water treatment facility is experiencing difficult in treating a turbid water. The operator on duty indicates that the chemical dosages have not been changed since they historically determined the best dose for their water and that no other dose would be any better. You ask the operat to run a sample that you collect from the settled water flume to determine the turbidity. He accommodates you and says it is 18 NTU. He further explains tha is why they have filters. The filter effluent turbidity is indeed 0.18 NTU. H however, forgets to tell you they are reaching a terminal head loss in a little over 8 filter hours.

Problem:

What samples would you collect and analyze to try to ascertain what improvements could be made and to convince the operator a change in chemical dosage is necessary?

COURSE NOTES FOR UNIT 8

SCHEMATIC OF CONVENTIONAL SURFACE WATER TREATMENT FACILITY

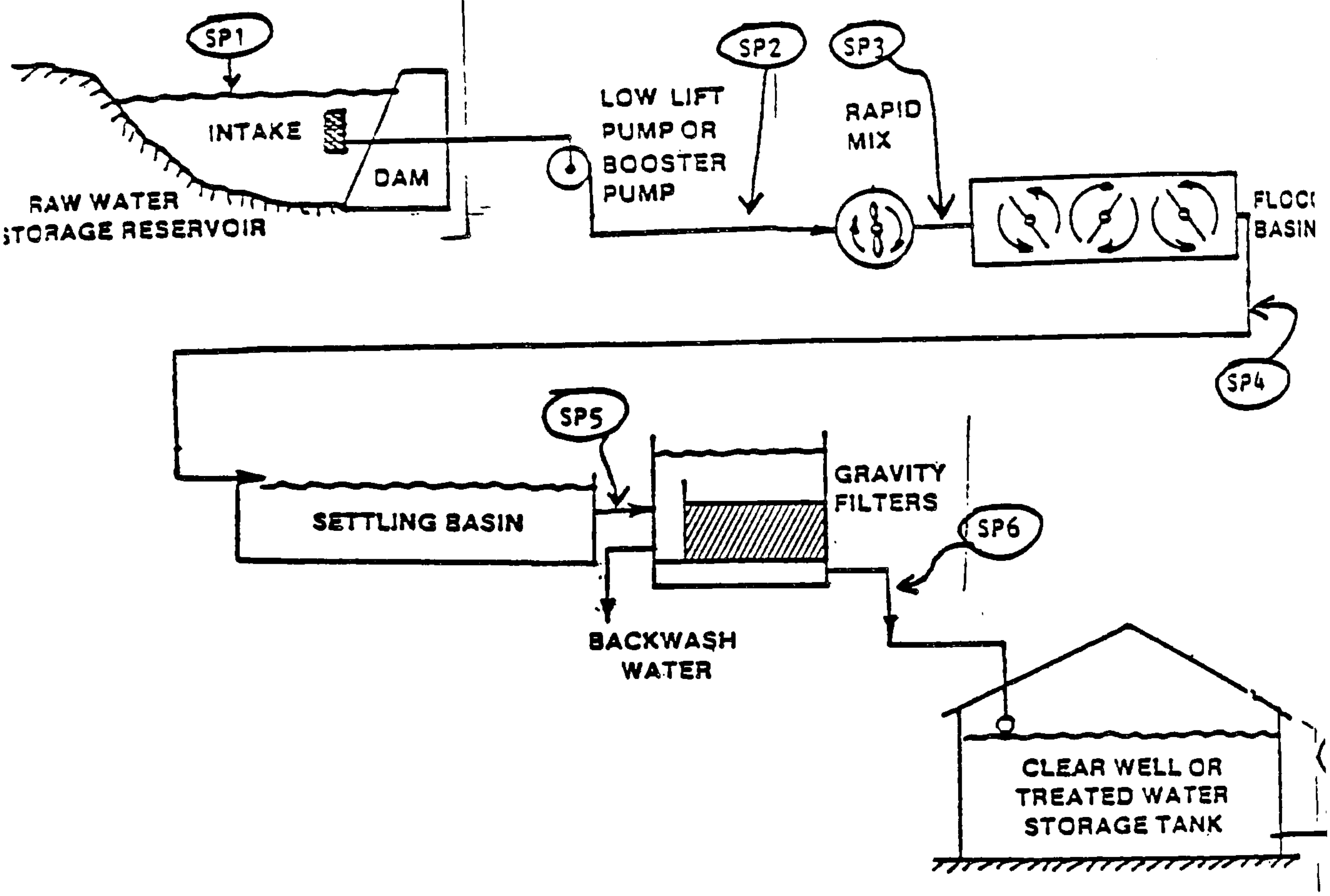


Figure 8-1

COURSE NOTES FOR UNIT 8

SCHEMATIC OF IRON REMOVAL FACILITY

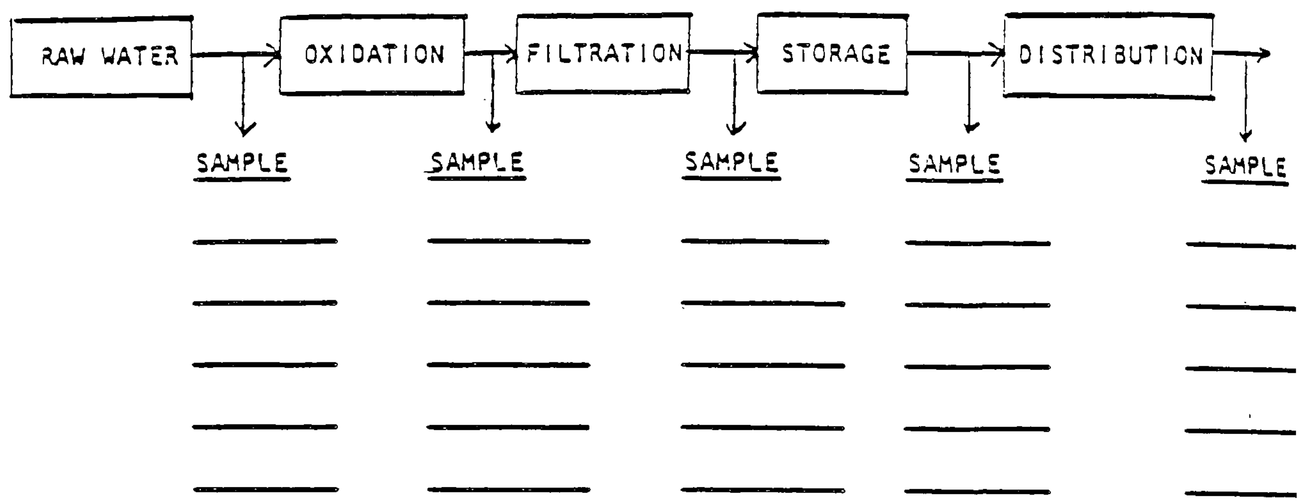


Figure 8-2

SCHEMATIC OF GROUNDWATER SYSTEM WITH SIMPLE CHLORINATION

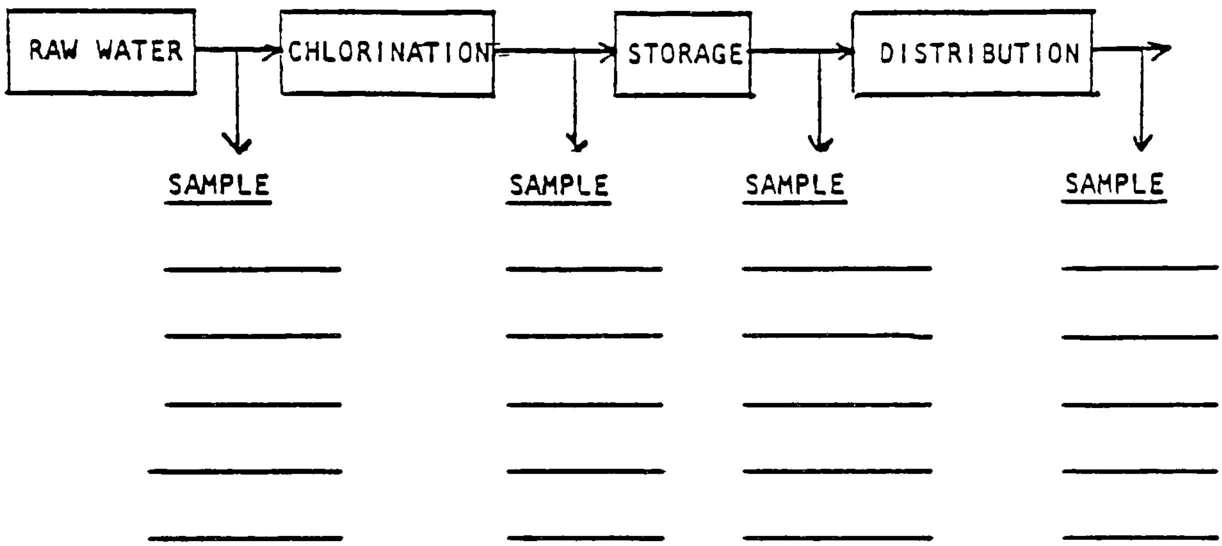
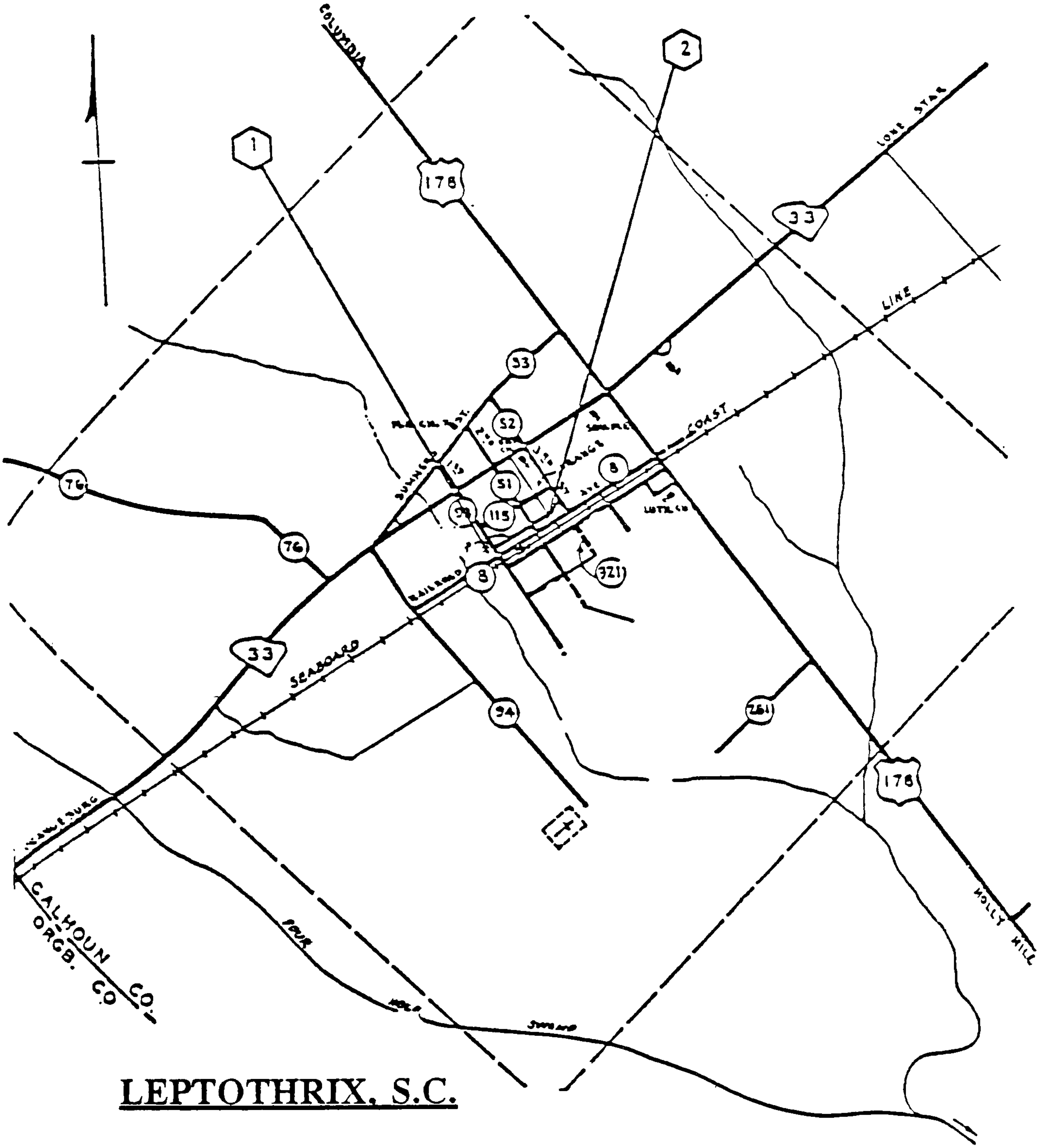


Figure 8-3

COURSE NOTES FOR UNIT 8



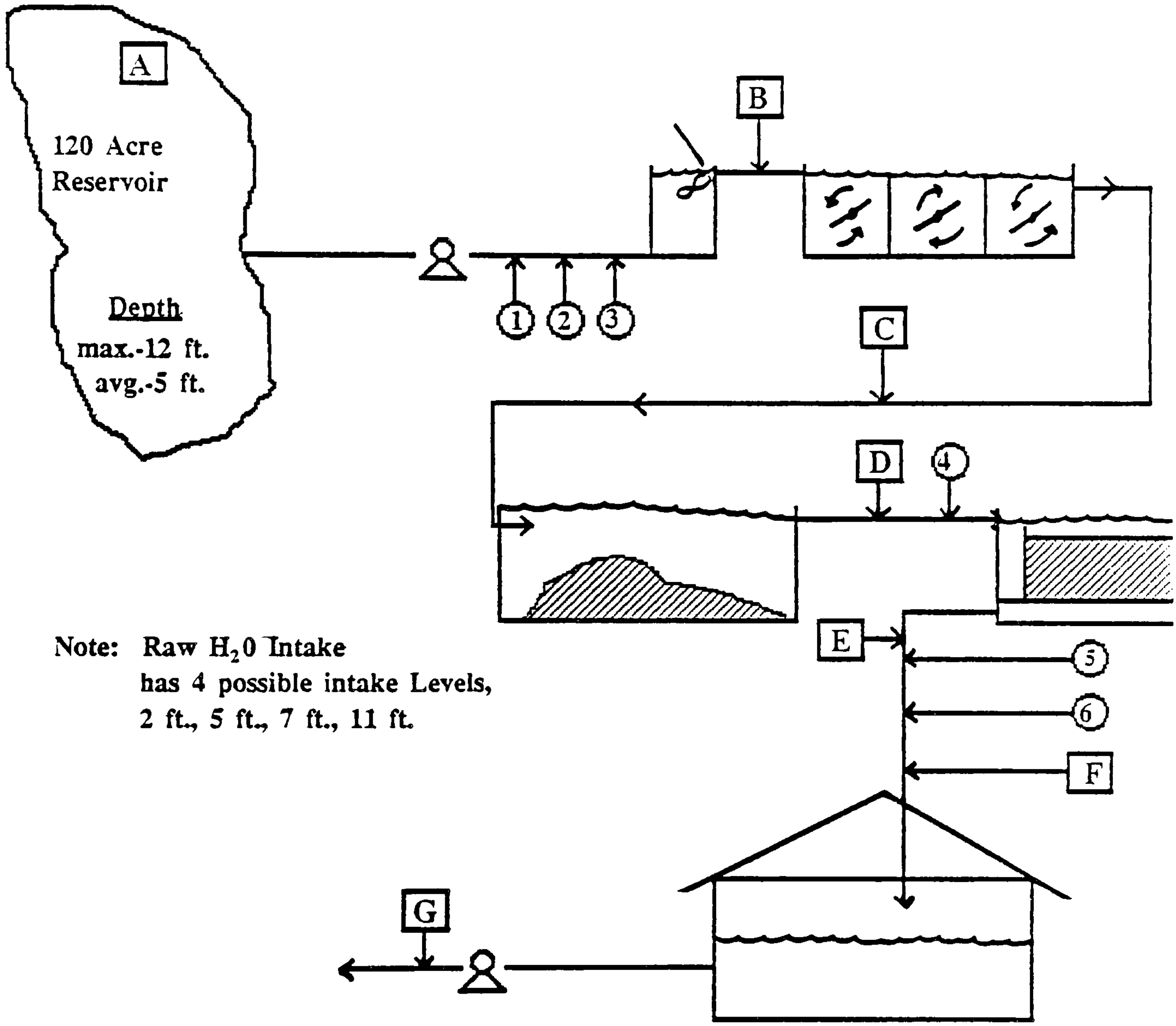
LEPTOTHRIX, S.C.

1 Tank site with 250 gpm well

2 250 gpm well

FIGURE 8-4

COURSE NOTES FOR UNIT 8



Chemical Feed

1. KM_nO_4
2. Lime
3. Alum
4. Cl_2
5. Cl_2
6. NaOH

Sample Locations

A ________________________________

B ________________________________

C ________________________________

D ________________________________

E ________________________________

F ________________________________

G ________________________________

Figure 8-5

COURSE NOTES FOR UNIT 8

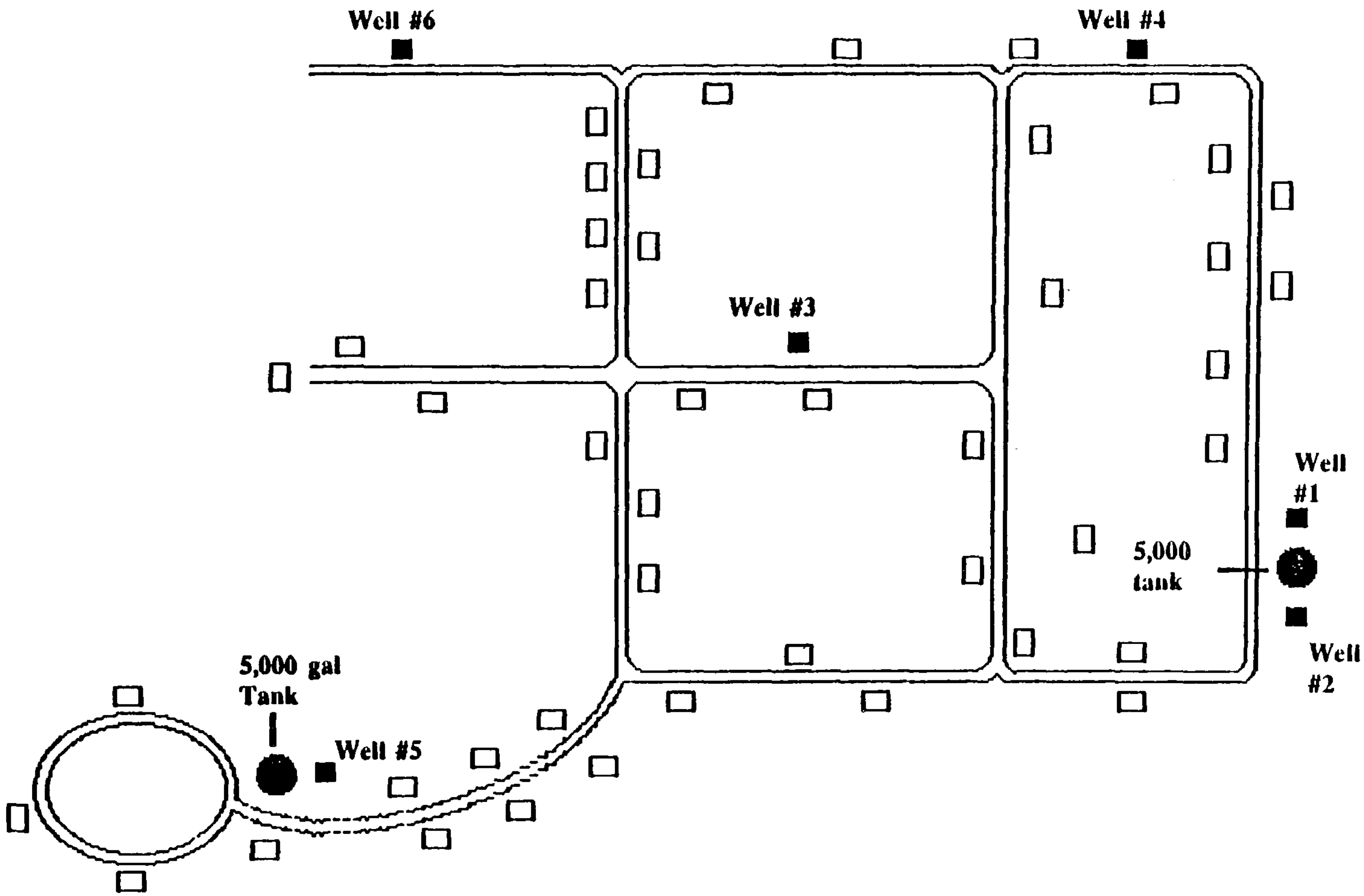


Figure 8-6

Note: Cl_2 fed only at well #1, #4, and #5.

All wells controlled by pressure switches

COURSE NOTES FOR UNIT 8

Unit 9: MANAGEMENT/SAFETY

Unit 9a: MANAGEMENT

Unit Summary

Personnel Training/Certification
Personnel Staffing
Financing
Emergency Planning

Unit References

Manual of Water Utility Operations (Chapter 19)
Water Treatment Plant Operation Vol. II (Chapter 23)
Small Water System Operation & Maintenance (Chapter 3)

Basic Material

The management of the water system does not of itself represent a sanitary risk to the quality of the water. However, there are several aspects of management that will affect the overall capabilities of the system.

Personnel

1. Are personnel adequately trained and/or certified?

   In order to properly operate a system, personnel must be adequately trained. This can be provided by an in-house training program conducted by more experienced personnel. Correspondence courses such as Water Treatment Plant Operation, Water Supply System Operation and AWWA courses are a means for a small system operator to receive training relatively inexpensively. Operators should also be certified by the appropriate state regulatory agency. Proof of certification should be prominently displayed or otherwise made available to the inspector.

2. Are there sufficient personnel?

   There should be enough personnel to provide for operation during vacations or sickness as a minimum. The number of operators is dependent on the type and size of the treatment process.

Finance

3. Are the financing and budget satisfactory?

   The system should be able to have sufficient funds for operation, maintenance, and future replacements.

COURSE NOTES FOR UNIT 9

Emergency Planning

4. The utility should have a contingency plan that outlines what action will be taken and by whom. The emergency plan should meet the needs of the facility, the geographical area, and the nature of the emergency likely to occur. Conditions such as storms, floods, and civil strife should be considered.

COURSE NOTES FOR UNIT 9

Unit 9b: Safety

Unit Summary

Safety Hazards
Accident Prevention

Unit References

Manual of Water Utility Operations (Chapter 20)
Manual of Instruction for Water Treatment Plant Operators (Chapter 19)
Water Distribution System Operation & Maintenance (Chapter 7)
Small Water System Operation & Maintenance (Chapter 7)
Water Treatment Plant Operation Vol. II (Chapter 20)

Basic Material

Another aspect of management is safety. This is a concern if the system has 1 operator or 50. It has been pointed out previously that safety should be a concern of the inspector, both his safety and that of the operator. There are a number of safety hazards including:

1. Electrical shock
2. Exposure to chemicals
3. Drowning
4. Working in confined spaces
5. High-intensity noise
6. Sprains and strains due to lifting
7. Slips and falls

The first choice in preventing accidents is to engineer out the exposure. An example of this is providing guards for all rotating equipment and belts. This choice is not always possible. The second choice is the use of protective equipment. The most frequently used equipment and a necessity of every plant are the following:

- o Safety Helmets - provide protection from falling objects in manholes and pipe galleries. Can be used as a means of identification.

- o Goggles - provide eye protection from chemicals and flying objects. They may need to be supplemented by full face shield when working with some chemicals.

- o Gloves - provide protection against injuries from chemicals and equipment.

COURSE NOTES FOR UNIT 9

- Shoes - steel-toed safety shoes provide protection from falling objects.

- Respirators - protect the wearer from inhalation of dust, organic vapors, and other chemicals. This equipment is only to be used where the atmosphere is known not to be oxygen deficient.

- Self-contained Breathing Apparatus - provides protection in oxygen deficient atmospheres where the operator must work, such as repairing chlorine leaks.

With regard to safety the inspector should be concerned with

1. Is adequate safety and personal protective equipment provided?

2. Are the facilities free of safety hazards?

COURSE NOTES FOR UNIT 9

Unit 10: SURVEYS/SANITARY SURVEY REPORT/FIELD EXERCISE

Unit 10a: Surveys

Unit Summary

- On-site Review
- Evaluation Adequacy
- File Review
- Scheduling Survey
- On-site Inspection
- Documenting Observations
- Notification of Results

Unit References

How to Conduct a Sanitary Survey

Basic Material

In the previous chapters, the concerns of a sanitary inspector have been outlined. In this unit a plan for doing the survey will be developed. As this plan is developed and the use of a standard form is discussed, it is important for the inspector to remember what the purpose of the survey is. The inspector is to perform an <u>on-site review</u> of the water source, facilities, equipment, operation, and maintenance of a public water system for the purpose of <u>evaluating the adequacy</u> of such source, facilities, equipment, operation, and maintenance for producing and distributing safe drinking water. This purpose is easy to forget and to let the survey become an exercise in completing the blanks in a particular form. As an inspector, you need to concentrate on identifying potential or existing problems and evaluating their risks.

In planning for a survey, an estimate of the time required will help in managing your schedule. The estimate should include time prior to, during, and after the survey. Although the time required will vary with the complexity and the experience of the inspector, a good rule of thumb would be two days in the office for every day in the field.

Prior to each survey the inspector should review all available file information concerning the system being surveyed. This review will assist you in being fully briefed on the system's past history and present conditions. Many times, if you are familiar with the system history, previous inspections, reports, memorandums, and telephone communications, you can dispel remarks made concerning previous letters, conversations, etc., that are taken out of context, altered, or just misunderstood. This knowledge of the system's past conveys to the water system personnel a concern for the system and professionalism on your

COURSE NOTES FOR UNIT 10

COURSE NOTES FOR UNIT 10

part. Once the owner, operator, or engineer realizes you are familiar with their operations and past dealings with your agency, they will normally take the inspecting party more seriously and the end result will be better, more accurate, and useful information concerning their operation and facilities. In this preparation period, the initial contact should be established with the water system. Telephone contact to establish a mutually acceptable date for the on-site visit is beneficial. A short notification letter giving the survey time and date should be forwarded with instructions for requesting changes to the schedule. This is also a good opportunity to reiterate the reasons for performing the survey and to inform them of specific information they will need to provide. This should be provided in sufficient time for the water system personnel to respond to the notice. If the inspector must change the schedule, it must be done at the earliest possible time. The survey must never be postponed or canceled without prior notification.

A brief synopsis of activities during this period follows:

1. Detailed general file review.

2. Detailed review of chemical and bacteriological files.

3. Review self-monitoring reports.

4. Make contact with owner/operator to establish survey date and time.

5. Give early notice of any schedule change.

In performing the on-site survey, the first step is to be punctual. This will prevent getting off to a bad start because the operator had to wait.

This brings up the necessity of the successful survey. Imperative to a successful survey is having a representative of the water system, preferably the operator, accompany the inspector during the on-site survey. This will allow the inspector and operator to ask questions and develop a mutual confidence in each other's ability. Once this trust has been developed, the operator may be more willing to be open about the operations and problems of the system. This is the period of evaluating the system. In most cases it is good to use a standard form to help the inspector cover all the points of the system. Again, filling out a form is not the primary function of the survey. Many times system owners and operators are "put off" by someone filling out a form. They wonder if you know what you are asking or whether you are just filling out a form with information that may never be used or evaluated. The inspector should know why each question is asked. The judicious use of a form will (a) provide uniformity of inspections, (b) ensure completeness of the inspection by another inspector, (c) facilitate data record, and (d) allow followup inspection by another inspector. There is no best form since each system is different and each report must be

COURSE NOTES FOR UNIT 10

tailored to the specific conditions of that system. There are several examples of survey forms provided at the end of this unit. The first is a compilation of the questions that have be asked in the previous chapters. Other examples are from the States of Alaska, South Carolina, Maine, and Missouri. These examples may be used in developing or comparing your own survey form.

Some of the activities that should be conducted at this point follow:

1. Review of system complaints.

2. Review of monthly operator reports and in-house monitoring.

3. Complete investigation of the water supply, treatment, and distribution facilities.

4. A general description of the system and a flow diagram.

5. Establishment of an exchange of information between the operator and inspector.

6. Completion of the form as required.

7. Sampling as required.

8. Debriefing of the operator/owner at the end of the evaluation.

COURSE NOTES FOR UNIT 10

Unit 10b: Sanitary Survey Report

Unit Summary

Purpose
Content

Unit References

How to Conduct a Sanitary Survey

Basic Material

The last phase of the survey is the writing of the report. This represents the official notification of the results of the evaluation. The report should be done promptly and reflect the information provided to the operator at the end of the on-site visit. If the written evaluation is different from the oral debriefing, the operator should be advised telephonically of such changes. There is little that is more exasperating to the owner/operator than to receive a written report six months after the on-site visit listing deficiencies that he knows nothing about. The purpose of the report is (a) formal notification of deficiencies, (b) motivate corrective action, (c) provide records of compliance and future inspections. The report itself can be as brief as a letter or as detailed as necessary to convey to owners and operators of the system what deficiencies exist and what must be done to correct them.

The sanitary survey report is probably the single most important item of a sanitary survey. No matter how much research is conducted or how involved and detailed the field aspects of a sanitary survey are, if the findings are not properly registered by the use of appropriate forms and documented in a sanitary survey report, then the previous efforts are all but wasted. If formal documentation and notification of deficiencies are not made following a survey, then it is very unlikely that the next inspecting party will find any improvement in a system's operation and maintenance the next time it is surveyed.

Often the inspector feels that the survey report is just a small and bothersome detail in completing a sanitary survey. No matter how professional the sanitary survey was and no matter how many deficiencies were pointed out verbally during your inspection, the parties receiving the report are not always the ones accompanying the inspector during the survey, nor are they the ones that will make the decisions to upgrade or modify the system's operation. In addition, if properly detailed documentation is not registered by the use of sanitary survey forms and a sanitary survey report, it will be very difficult to use any of the survey activities for enforcement purposes. If this accurate description of improper operation or system deficiencies is not detailed

COURSE NOTES FOR UNIT 10

in a sanitary report, then the inspector is guilty of not fulfilling his responsibilities to the system or the public.

If an accurate and detailed sanitary survey report is sent in a timely fashion to the appropriate personnel, then the survey and the organization will, in most instances, be construed by the water system personnel as being professional and will foster confidence and a willingness to cooperate towards a mutual goal· safe drinking water.

Briefly, the activities during this period are as follows:

1. Completion of formal report.

2. Notification of appropriate organizations of results.

3. Followup on technical assistance/questions asked by owner/ operator.

4. Notification of variance of written evaluation from that provided in the oral debriefing.

COURSE NOTES FOR UNIT 10

MAJOR FUNCTIONS OF A SANITARY SURVEY REPORT:

1. To Provide Formal Notification of Deficiencies.

   The formal notification of deficiencies speaks for itself. However, by ju listing the deficiencies, the inspector may not accomplish his objective informing the system of a problem and seeking its correction. Often the inspector assumes operators and water system personnel understand what he says without questioning whether they actually understand his comments or even the terminology used. The inspector is often their only contact in discussing the technical operation of their facilities and it is often wrongfully assumed that the operators have the ability to fully understand the inspector's comments. Even if the system personnel understand what th inspector wants, it will be quite unlikely that corrective actions will be taken if they cannot understand the reason for doing it. By taking the ti to describe the problem in simple terms and by explaining the reasons for requiring its correction, the inspector will receive a better response.

2. To Motivate Corrective Action.

   A sanitary survey report, in addition to verbal communication during the survey, can be used to motivate corrective actions. This motivation can b due to the professional nature of the report, including an explanation of why corrective actions are necessary. When significant violations exist, then it is indeed likely that a compliance schedule, consent agreement, administrative order, or litigation by the appropriate court may be necessary to ensure prompt and proper correction.

3. To Provide a Record.

   The survey report is an important tool for tracking compliance with the Saf Drinking Water Act, and it is a valuable tool to be used in evaluating your water supply program. The single most important feature, however, is the ability to provide a hard record for future inspecting parties and to provide much needed information during emergency situations or when technical assistance is needed.

COURSE NOTES FOR UNIT 10

Unit 10c: Field Exercise

Unit Summary

Application of Knowledge
Selection of Water Supply Systems
Team Approach
Recording Observations
Critique of Field Exercise

Basic Material

A field exercise will be organized to provide the opportunity to apply classroom instruction and discussion to actual situations an to provide practice in recognizing potential problem areas. The field exercise incorporates the principle of a Class I Sanitary Survey during the on-site inspection of one or more water supply systems.

The water supply systems are selected to reflect the size and type of water systems which are typical in that area. Preference is al given to selecting systems which have problems.

Course participants are assigned to teams to ensure a mix of experience and geography. Discussion between the team members is encouraged to increase the sharing of knowledged between team members.

As the on-site inspection is conducted, team members record their observations and evaluations on a standard field exercise form (Figures 10-1 through 10-4).

At the conclusion of the field exercise each team is requested to describe their observations and to explain what was right or wrong in each case. Team members are encouraged to comment during the discussions and to contribute their own experiences.

COURSE NOTES FOR UNIT 10

FIELD TRAINING FORM

Date of Survey ____________

Name of System: ______________________________
Owner: ______________________ Telephone: ____________
Address: ______________________________

Service Connections ____________ Emergency Connections ____________
Population ____________ ____________
System Capacity ____________ MGD ______ ____________

Surface Water Source

Source Name(s) ____________________

____

____

Type ____________________

S	U	N/A	
			Intake (location, levels, screens, maintenance)
			Access (restricted, monitored)
			Pollution Control
			Water Quality
			Quantity
			Low Service Pumps (number, capacity, condition)
SPRINGS/INFILTRATION GALLERIES			
			Recharge area protection
			Site protection
			Flood protection
			Construction
			Maintenance
			Quantity
			Quality

Figure 10-1a

COURSE NOTES FOR UNIT 10

S	U	N/A	WELL
			Quantity
			Quality (bacti., chem., rad.)
			Protection from contamination (pad, seal, casing, vent, location, etc.
			Security (fence, lock, etc.)
			Wellhead piping (check valve, blowoff, sample tap, gate valve)
			Weather protection
			Flow measuring device
			WATER TREATMENT (UNIT PROCESSES)
			Pretreatment
			Rapid Mix
			Flocculation
			Sedimentation
			Clarification
			Filtration
			WATER TREATMENT (GENERAL)
			Equipment operation & maintenance (feeders, pumps, filters, etc.)
			Gas chlorine compartment
			Adequate chlorine residual
			Safety equipment & procedures
			Chemical usage, feed rates, records
			Chemical Storage
			Chemical injection point, sample tap

Figure 10-1b

COURSE NOTES FOR UNIT 10

S	U	N/A	STORAGE
			Sanitary protection (vents, overflow, drain, etc.)
			Maintenance
			Security
			Adequate volume (total storage _______ MG)
			Bypass, drain, sample tap
			Air/water ratio (pneumatic)

			DISTRIBUTION
			High service pumps
			Booster pumps
			Adequate pressure (25 psi min)
			Water quality
			Fire flow
			Valve maintenance (exercise, testing, repair)
			Hydrant maintenance
			Flushing program
			Leak detection & repair
			System map
			Crossconnection program
			Are all services metered?
			Yes ___________ No ____________ # metered ___________

Figure 10-1c

COURSE NOTES FOR UNIT 10

S	U	N/A	GENERAL OPERATION & MAINTENANCE
			Housekeeping
			Certified operator
			Staffing
			O & M records
			Supplies & spare parts inventory
			Self monitoring reporting records, public notification
			Wastewater disposal method: ____________________
			O & M procedures manual
			OPERATOR QUALITY CONTROL
			Knowledge & ability
			Facilities & test equipment
			Daily testing
			Records
			EMERGENCY OPERATION
			Stand-by power
			Emergency operation plan

Type Inspection:
Routine: ____________________ Other: ____________________
Follow-up: ____________________ Follow Up: Yes ________ No
Complaint: ____________________ Date ____________

Overall Rating: Satisfactory ________ Unsatisfactory __________

Figure 10-1d

COURSE NOTES FOR UNIT 10

SURVEY SAMPLE FORM

Date of Survey ____________

Name of Facility ________________ System Identification _____

Owner ______________________ Telephone ____________

Address ____

________________________ County ______________

Treatment Plant Telephone Number ______________________

Name of Operator ______________ Certification __________

Water Purchased From ____________ Water Sold To ____________
(other than system)

SOURCE

1. What type of source? ____________________
2. What is the total design production capacity? _________MGD
3. What is the present average daily production? _________MGD
4. What is the maximum daily production? __________MGD
5. Does system have an operational master meter? Yes ___ No ___
6. How many service connections are there? __________
7. Are service connections metered? Yes ___ No ___

WELLS

	Yes	No
1. Is recharge area protected? Ownership ____ Fencing ____ Ordinances ____		
2. What is nature of recharge zones? Agricultural ___ Industrial ___ Residential ___ Other ___		
3. Is site subject to flooding?	___	___
4. Is well located in proximity of a potential source of pollution?	___	___
5. Depth of well ______ ft.		
6. Drawdown ______ ft.		
7. Depth of casing _____ ft.		

Figure 10-2a

COURSE NOTES FOR UNIT 10

	Yes	No
8. Depth of grout ________ ft.		
9. Does casing extend at least 12 inches above the floor or ground?	____	____
10. Is well properly sealed?	____	____
11. Does well vent terminate 18 inches above ground/floor level or above maximum flood level with return bend facing downward and screened?	____	____
12. Does well have suitable sampling cock?	____	____
13. Are check valves, blowoff valves, and water meters maintained and operating properly?	____	____
14. Is upper termination of well protected?	____	____
15. Is lightning protection provided?	____	____
16. Is intake located below the maximum drawdown?	____	____
17. Are foot valves and/or check valves accessible for cleaning?	____	____

	Yes	No
SPRINGS AND INFILTRATION GALLERIES		
1. Is the recharge area protected? Ownership ____ Fencing ____ Ordinances ____		
2. What is the nature of the recharge area? Agricultural __ Industrial __ Residential __ Other __		
3. Is site subject to flooding?	____	____
4. Is collection chamber properly constructed?	____	____
5. Is supply intake adequate?	____	____
6. Is site properly protected?	____	____
7. What conditions cause changes to quality of the water? ______________________________ ______________________________ ______________________________		

Figure 10-2b

COURSE NOTES FOR UNIT 10

Yes No

SURFACE SOURCES

1. What is nature of watershed?
   Agricultural ___ Industrial ___ Forest ___ Residential ___

2. What is size of the owned/protected area of the watershed?
   ____

3. How is watershed controlled?
   Ownership ____ Ordinances ____ Zoning ____

4. Has management had a watershed survey performed? ____ ___

5. Is there an emergency spill response plan? ____ ___

6. Is the source adequate in quantity? ____ ___

7. Is the source adequate in quality? ____ ___

8. Is there any treatment provided in the reservoir? ____ ___

9. Is the area around the intake restricted for a radius of 200 feet? ____ ___

10. Are there any sources of pollution in the proximity of the intakes? ____ ___

11. Are multiple intakes, located at different levels, utilized? ____ ___

12. Is the highest quality water being drawn? ____ ___

13. How often are intakes inspected? ________________

14. What conditions cause fluctuations in quality?
    ____
    ____
    ____

PUMPS

1. Number ____________

   Type ____________

   Location ________________

2. Rated Capacity ________________

Figure 10-2c

COURSE NOTES FOR UNIT 10

Yes N

3. Are pumps operable? ___ ___

4. What is state of repair of pumps? ______________________________
____
____

5. What type of lubricant is used? ____________________

6. Emergency power
   - What type ______________
   - Frequency of testing ________________
   - Record of primary power failures: _____________ in last year.
   - Automatic _______ Manual _______ Switchover _______
   - Are backup pumps/motors provided? ___ ___

7. Is all electro/mechanical rotating equipment provided with guards? ___ ___

8. Are controls functioning properly and adequately protected? ___ ___

9. Are underground compartments and suction well waterproof? ___ ___

10. Are permanently mounted ladders for pumping stations sound and firmly anchored? ___ ___

11. Is facility properly protected against trespassing and vandalism? ___ ___

Yes No

TREATMENT UNITS (Note: Multiple units should have a separate information section completed for each unit.)

Prechlorination/Pretreatment Units

1. What chemical is used? ________________________________

2. What amount is used? ____________________ lbs/day

3. For prechlorination, has TTHM been evaluated? ___ ___

4. Where is point of application? __________________________

5. Is chemical storage adequate and safe? ___ ___

6. Are adequate safety devices available and precautions observed? ___ ___

Figure 10-2d

COURSE NOTES FOR UNIT 10

	Yes	No
Mixing		
1. Is mixing adequate based on visual observation?	___	___
2. Is equipment operated properly and in good repair?	___	___
Flocculation/Sedimentation		
1. Is process adequate based on visual observation?	___	___
2. Is equipment operated properly and in good repair?	___	___
Filtration		
1. Is process adequate based on visual observation?	___	___
2. Are instrumentation and controls for the process adequate, operational, and being utilized?	___	___
3. What type of filter is utilized? ____________________		
4. Is equipment operated properly and in good repair?	___	___
Post-Chlorination		
1. Is adequate chlorine residual being monitored?	___	___
2. Is the disinfection equipment being operated and maintained properly?	___	___
3. Is there sufficient contact time (30 minutes minimum) between the chlorination point and the first point of use?	___	___
4. Is operational standby equipment provided? If not, are critical spare parts on hand?	___	___
5. Is a manifold provided to allow feeding gas from more than one cylinder?	___	___
6. Are scales provided for weighing of containers?	___	___
7. Are chlorine storage and use areas isolated from other work areas?	___	___
8. Is room vented to the outdoors by exhaust grilles located not more than 6 inches above the floor level?	___	___
9. Is a means of leak detection provided?	___	___

Figure 10-2e

COURSE NOTES FOR UNIT 10

	Yes	No
10. Is self-contained breathing apparatus available for use during repair of leaks?	___	___
11. Are all doors hinged outward, equipped with panic bars, and at least one provided with a viewport?	___	___
12. Are all gas cylinders restrained by chaining to wall or by other means?	___	___
12. Have there been any interruptions in chlorination during the past year due to chlorinator failure or feed pump failure?	___	___

Yes No

STORAGE

1. What type of water is stored?
   Raw _______ Treated _________

2. What type of storage is provided?
   Gravity ________gals. Hydropneumatic _________gals.

3. Total number of days of supply? _________ days

Gravity Storage

	Yes	No
1. Does surface runoff and underground drainage drain away?	___	___
2. Is the site protected against flooding?	___	___
3. Is storage tank structurally sound?	___	___
4. Are overflow lines, air vents, drainage lines or cleanout pipes turned downward or covered, screened, and terminated a minimum of 3 diameters above the ground or storage tank surface?	___	___
5. Is site adequately protected against vandalism?	___	___
6. Are surface coatings in contact with water approved?	___	___
7. Is tank protected against icing and corrosion?	___	___
8. Can tank be isolated from system?	___	___
9. Is all treated water storage covered?	___	___
10. What is cleaning frequency for tanks? ____________________		
11. Are tanks disinfected after repairs are made?	___	___

Figure 10-2f

COURSE NOTES FOR UNIT 10

Hydropneumatic	Yes	No
1. Does low pressure level provide adequate pressure?	___	___
2. Are instruments and controls adequate, operational, and being utilized?	___	___
3. Are the interior and exterior surfaces of the pressure tank in good physical condition?	___	___
4. Are tank supports structurally sound?	___	___
5. Is storage capacity adequate?	___	___
6. What is cycle rate? ______________		

DISTRIBUTION SYSTEM	Yes	No
1. Is proper pressure maintained throughout the system?	___	___
2. What types of construction materials are used? ______________ ______________		
3. Are plans of the water system available and current?	___	___
4. Does the utility have an adequate maintenance program?	___	___
5. Is the system interconnected with any other system?	___	___

CROSS-CONNECTIONS	Yes	No
1. Does the utility have a cross-connection prevention program?	___	___
2. Are backflow prevention devices installed at all appropriate locations?	___	___
3. Are cross-connections present at the treatment plant?	___	___

MONITORING	Yes	No
1. Is the operator competent in performing necessary tests?	___	___
2. Are testing facilities and equipment adequate?	___	___

Figure 10-2g

COURSE NOTES FOR UNIT 10

	Yes	No
3. Do reagents used have an unexpired shelf life?	___	___
4. Are records of test results being maintained?	___	___

MANAGEMENT	Yes	No
1. Are personnel adequately trained?	___	___
2. Are operators properly certified?	___	___
3. Are there sufficient personnel?	___	___
4. Are financing and budget satisfactory?	___	___
5. Is an emergency plan available and workable?	___	___
6. Is adequate safety and personal protective equipment provided?	___	___
7. Are the facilities free of safety hazards?	___	___

Figure 10-2h

COURSE NOTES FOR UNIT 10

SITE PLAN

TREATMENT UNIT SCHEMATIC

Figure 10-2i

COURSE NOTES FOR UNIT 11

Unit 11: Communications/Public Relations

Unit Summary

Personal Contacts and Purpose
Communicating Effectively

Unit References

Water Distribution System Operation and Maintenance (Chapter 5)
Water Treatment Plant Operation Vol. I (Chapter 10)

Basic Material

An area that the inspector of a water system must deal with is who to contact with regard to the sanitary survey. This contact is necessary for obtaining cooperation, gathering information, coordinating with other departments or agencies, and transmitting the results of the evaluation. Briefly, the persons/agencies the inspector should contact, and the purpose of the contact, are the following:

<u>Prior to On-site Visit</u>

- Owner of water system
  - Obtain cooperation and establish survey dates
  - Explain purposes of survey
  - Request that necessary information be available

- Operator
  - Coordinate gaining entry to site
  - Ensure presence of operator during survey

- Local Health Unit/Other Departments
  - Ensure cooperation and coordination
  - Obtain information pertinent to system

<u>During the On-site Visit</u>

- Owner of water system
  - Obtain information pertinent to system
  - Explain function of survey results
  - Explain recommended actions
  - Explain what action will result from survey

- Operator
  - Obtain information pertinent to system
  - Exchange of technical information
  - Explain survey results
  - Explain recommended action

COURSE NOTES FOR UNIT 11

After the On-site Visit (Survey Report)

- Owner of water system
  - Notification of deficiencies
  - Instructions for corrections
  - Compliance schedule for corrections

- State Regulatory Agency
  - Case report where formal enforcement is indicated

- U.S. Environmental Protection Agency
  - Case report when State does not have primacy under SDWA

- Public
  - If system is not in compliance with:
    - applicable MCL
    - applicable testing procedure
    - required monitoring
    - scheduled corrections
    - an exemption or variance

Briefly, we need to discuss communications with the owner/operator and with the public. There is not sufficient time in this course to fully discuss interpersonal relationships and how to deal with people. However, there are some points that inspec tors should keep in mind. The establishment of a good relationship with the operator is important to the success of the survey The operator of the small water system occupies a unique positio in the water supply industry. In most cases the operator is responsible for all aspects of the system from operation of the plant to budgeting for equipment and in small towns may also be responsible for the other services (wastewater treatment, road repair, etc.) in the community. Consequently, the operator will frequently have only a basic working knowledge of the treatment processes of that particular system. The fact that the operator may not be fully knowledgeable about the technical design criteria does not make the operator incompetent. Communicate with the operator in terms that can be understood, not by yourself or by an engineer, but by the operator. This is particularly true when providing assistance. An in-depth discussion on the Brownian movement of colloidal particles may dazzle the operator with your brilliance but do little to foster a good relationship

Communicating at the level of your audience is particularly important in dealing with the general public. A technical knowledge of water treatment and water quality cannot be assumed witl the general public. Consequently, you must be careful to couch your communications in layman's terms, particularly when dealing with problems in the system. The public should be made to realize the impact of the problem without having the dangers exaggerated.

COURSE NOTES FOR UNIT 12

UNIT 12: TECHNICAL ASSISTANCE

Unit Summary

Providing Technical Assistance
Common Problems

Unit References

Small Water Systems Serving the Public (Chapter 13)
Handbook of Individual Water Systems
Water Systems Handbook
Water Treatment Plant Operation (Volumes I & II)
Water Supply System Operation

Basic Material

The sanitary survey is in part designed to assist the water purveyor in correcting any deficiencies in water quality or the water supply system. In order to provide this assistance, the inspector must be able to communicate to water system personnel the possible causes of problems. Problem solving should be approached in a systematic manner with a concept of the elements that might contribute to water problems and with insights into possible solutions.

An effective maintenance and repair schedule is of primary importance in operating a water supply system. Every opportunity should be taken to provide guidance in the development of such a system and to supply technical assistance with potential and actual water system problems.

How the technical assistance is provided is equally important as the information given. Unless the solution is obvious, technical assistance should be given only after the entire system has been surveyed. There are two reasons for this procedure. First, the objective of your visit is to evaluate the entire water system. If you spend your time playing Sherlock Holmes in attempting to determine the cause of a problem, you have changed your objective and may very well overlook a serious sanitary risk. Isolating the cause of a water system problem is time consuming and without sampling and analytical support, generally difficult. If the operator is competent, the more common causes will have been evaluated and will have been ruled out. The second reason for surveying the entire system is that there can be causes of problems throughout the system. Consequently, judgment should be reserved until the entire system has been reviewed.

COURSE NOTES FOR UNIT 12

The operator should be asked what steps have been taken to evaluate and mitigate the problem. The inspector should determine if the problem has occurred before and what action was taken. A review of operating records may provide a clue to recent changes in the system or chemicals utilized that may be the cause.

The inspector should temper any advice with a realization of their experience and knowledge of the problem. If erroneous information is provided, a loss of money and time can result while the hazard continues to exist. The classic "I'm from the Government and I'm here to help" situation followed by assistance that intensifies the problem rather than finds a solution can be devastating. The inspector with limited experience is wiser to refer the problem to more experienced personnel.

Many States have developed a means by which assistance can be provided to a water system either by its request or a referral from a sanitary inspector. This is not to say that there should not be an exchange of technical information with the operator by an inspector. The inspector should note sanitary problems to the operator, discuss their importance, and if sure of a means of resolution, provide it.

Review the following problems in light of the possible causes. Wherever possible, relate the possible causes to indicators of the problem so as to best aid the water purveyor with any problems. Use the elements of the system as a checklist of your knowledge.

Problem 1: No or Low Water Pressure

Health Risk

- Contamination from backflow (cross-connection)

Possible Causes:

Water Source

- Water table has dropped below well screen
- Clogging of well screen with debris
- Spring flow has been diminished

Well or Intake Structure

- Debris blocking pipes
- Defective valves or valve settings
- Plugged foot valve or strainer
- Break in wall of collection chamber
- Water in collection chamber or pipes freezing
- Well screen plugged or broken
- Well pipe ruptured above water table (shallow well with suction pump)

Treatment Equipment

- Electrical safety control activated to cut off water pump due to inoperative chemical feed pump

COURSE NOTES FOR UNIT 12

Pump System

- o Power failure
- o Low line voltage
- o Blown fuses
- o Shorted-out electric motor
- o Defective pressure switch
- o System valved off
- o Air lock in suction line
- o Leak on suction side of system
- o Plugged ejector or impeller
- o Worn or defective pump
- o Discharge line check valve installed backward
- o Loss of prime in piston-type pump

Storage System

- o Ruptured tank
- o Drain valve open
- o Float switches on gravity tank defective
- o Pressure switch on hydropneumatic storage tank defective

Distribution System

- o Break in water main
- o Hydrants open
- o Excessive water demand over prolonged period

Problem 2: Water Quality Violates Standards

Health Risk

- o Disease or chemical poisoning of consumers

Possible Causes:

Water Source

- o Contamination of source by wastewater or toxic chemicals

Well or Intake Situation

- o Onsite contamination by wastewater or toxic chemicals
- o Inoperative well seal

Treatment Process

- o Contamination of treatment chemicals
- o Insufficient chlorine feed rate
- o Chlorine solution exhausted
- o Defective chemicals feed equipment

Pump System

- o Repair or replacement of pump parts without adequate disinfection
- o Use of contaminated water to lubricate package
- o Improper sealing of pump to base during repair
- o Improper drainage of pump

COURSE NOTES FOR UNIT 12

Storage System

- o Debris in storage tanks
- o Interior of tank coated with unapproved coatings
- o Access of contaminants through broken vent or open manhole

Distribution System

- o Cross-connection with source of sewage or toxic chemical

Problem 3: The Water Has Bad Taste, Odor, or Color

Health Risk

- o Possible bacterial or chemical contamination
- o Use by consumer of a more palatable but potentially less safe wate supply

Possible Causes:

Water Source

- o Contamination of source by foreign substance

Well or Intake Structure

- o Entry of contaminant into structure through defective vent, open manhole, or screen
- o Inoperative well seal, allowing entry of contaminant

Treatment Process

- o Production of chlorophenyls by action of chlorine on precursor substances

Pump System

- o Repair or replacement of pump parts without adequate disinfection
- o Use of contaminated water to lubricate package
- o Improper sealing of pump to base, allowing entry of contaminants
- o Improper drainage of pump

Storage System

- o Debris in storage tank
- o Interior of tank coated with unapproved coatings
- o Entry of contaminants through broken vent or open manhole

Distribution System

- o Iron bacteria growth in pipes

NOTES

APPENDIX

SUGGESTED REFERENCES

1. Water Treatment Plant Operations, Volume I
Water Treatment Plant Operations, Volume II
Water Distribution System Operation & Maintenance
Small Water System Operation & Maintenance
Available from: Kenneth Kerri
Department of Civil Engineering
California State University, Sacramento
6000 J Street
Sacramento, CA 95810
(Phone: 916-278-6142)
Price: $30.00/$30.00/$20.00/$20.00 per manual, respectively

2. Manual of Water Utility Operations
Available from: Texas Water Utilities Association
6521 Burnet Lane
Austin, TX 78757
Price: $17.00

3. A Manual of Instruction for Water Treatment Plant Operators
Available from: Health Education Services, Inc.
P.O. Box 7126
Albany, NY 12224
Price: $5.00

4. Planning for an Individual Water System
Available from: American Association for Vocational Instructional Materials
Engineering Center
Athens, GA 30602
Price: $7.65

5. Water Systems Handbook
Available from: Water Systems Council
221 North LaSalle Street
Chicago, IL 60601
Price: $6.00

6. Environmental Engineering and Sanitation -- by Joseph A. Salvato
Available from: John Wiley & Sons, Inc.
Somerset, NJ 08873
Price: $55.00

7. National Interim Primary Drinking Water Regulations
Available from: Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402
Stock No. 055-000-00157-0
Price: $5.50

NOTES

8. Manual of Individual Water Supply Systems
   Available from: Superintendent of Documents
   U.S. Government Printing Office
   Washington, D.C. 20402
   Stock No. 055-000-00229-1
   Price: $6.00

9. How to Conduct a Sanitary Survey Procedures Manual
   Available from: New Mexico Health and Environmental Department
   Environmental Improvement Division
   P.O. Box 968
   Santa Fe, NM 87504-0968
   Price: $4.00

10. National Secondary Drinking Water Regulations
   Available from: Environmental Protection Agency
   Office of Water Supply
   Washington, D.C. 20460
   EPA-570/9/76-000

11. The Safe Drinking Water Act Handbook for Water System Operators
   Available from: AWWA
   6666 W. Quincy Avenue
   Denver, CO 80235

12. Introduction to Water Sources Transmission, Volume I
   Available from: AWWA
   666 W. Quincy Avenue
   Denver, CO 80235

13. Introduction to Water Treatment, Volume II
   Available from: AWWA
   6666 W. Quincy Avenue
   Denver, CO 80235

14. Introduction to Water Distribution, Volume III
   Available from: AWWA
   6666 W. Quincy Avenue
   Denver, CO 80235

15. Introduction to Water Quality Analyses, Volume IV
   Available from: AWWA
   6666 W. Quincy Avenue
   Denver, CO 80235

16. Basic Science Concepts and Applications Reference Handbook
   Available from: AWWA
   6666 W. Quincy Avenue
   Denver, CO 80235

NOTES

ADDITIONAL READINGS

1. Water Treatment Plant Design, prepared jointly by the American Water Works Association, Conference of State Sanitary Engineers, and American Society Civil Engineers
   Available from: Data Processing Department, AWWA
   6666 W. Quincy Avenue
   Denver, CO 80235
   Price: To members - $14.40; nonmembers - $18.00

2. Water Quality and Treatment: A Handbook of Public Water Supplies; American Water Works Association, Third Edition, McGraw-Hill, 1971
   Available from: Data Processing Department, AWWA
   6666 W. Quincy Avenue
   Denver, CO 80235
   Order No. 10008
   Price: To members - $34.10; nonmembers - $42.60

3. Manual of Treatment Techniques for Meeting the Interim Primary Drinking Water Regulation: EPA 600/8-77-005
   Available from: ORD Publications
   USEPA-CERI
   26 West St. Clair Street
   Cincinnati, OH 45268
   Price: Free

AUDIO-VISUAL TRAINING MATERIALS

Films

1. "Anybody Can Do It"
   Supplier: Out of Print

2. "Safe Handling of Chlorine:
   Supplier: AWWA - Technical Library
   6666 W. Quincy Avenue
   Denver, CO 80235
   (Phone: 303-794-7711)

Slides/Tapes

1. "Safe Handling of Water Treatment Chemicals"
   Supplier: AWWA - Technical Library
   666 W. Quincy Avenue
   Denver, CO 80235
   (Phone: 303-794-7711)

Slides of Case Histories

Individual libraries