GUIDELINES FOR THE ON-SITE RETROFIT OF FACILITIES USING DISINFECTED TERTIARY RECYCLED WATER

CALIFORNIA-NEVADA SECTION
American Water Works Association

CALIFORNIA-NEVADA SECTION

AMERICAN WATER WORKS ASSOCIATION

GUIDELINES FOR THE ON-SITE RETROFIT OF FACILITIES USING DISINFECTED TERTIARY RECYCLED WATER

1997

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DISCLAIMER

This manual is intended to serve as a guideline document and does not in and of itself constitute law, regulation, or code.

State and local regulatory agencies have jurisdiction over the use of recycled water. Therefore, additional specific requirements for individual users as well as for distribution entities may apply.

The American Water Works Association, California-Nevada Section, has developed and published these guidelines to assist those involved in the distribution and/or use of recycled water. These guidelines are not intended to be used in place of existing laws, regulations, or codes related to the implementation, construction, and use of recycled water. The American Water Works Association, California-Nevada Section, assumes no liability in connection with the use of these guidelines. Any individual or entity using these guidelines should study local circumstances and make a careful determination on how or whether to apply them to site-specific needs.

STATE OF CALIFORNIA —HEALTH AND WELFARE AGENCY PETE WILSON, Governor

DEPARTMENT OF HEALTH SERVICES

714/744 P STREET
P.O. BOX 942732
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September 10, 1997

Charles Steinbergs, Chairman
Reclaimed Water Committee
California-Nevada Section
American Water Works Association
1225 Bon View Avenue
Ontario, CA 91761

Dear Mr. Steinbergs:

GUIDELINES FOR THE ON-SITE RETROFIT OF FACILITIES USING DISINFECTED TERTIARY RECYCLED WATER

The California Department of Health Services (Department) has reviewed the final draft guideline document produced by the California-Nevada Section of the American Water Works Association (CA/NV AWWA) entitled, "Guidelines for the On-site Retrofit of Facilities Using Disinfected Tertiary Recycled Water" (Retrofit Guidelines). The Department finds the Retrofit Guidelines acceptable for use as a general guidance document.

The Department appreciates the efforts of the CA/NV AWWA in producing these guidelines. The release of the Retrofit Guidelines is very timely and should provide general assistance to those interested in retrofitting sites for recycled water use.

Sincerely,

David P. Spath

David P. Spath, Ph.D., P.E., Chief
Division of Drinking Water and
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DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

DIVISION OF ENVIRONMENTAL PROTECTION

333 W. Nye Lane, Room 138
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August 15, 1997

California-Nevada Section
American Water Works Association
1225 Bon View Avenue
Ontario, California, 91761

Attention: Charles Steinbergs, Chairman
Reclaimed Water Committee

RE: GUIDELINES FOR THE ON-SITE RETROFIT OF FACILITIES USING DISINFECTED TERTIARY RECYCLED WATER

Dear Mr. Steinbergs:

The Nevada Division of Environmental Protection (NDEP) has reviewed the above referenced guideline document produced by the California-Nevada Section of the American Water Works Association (AWWA) and finds the Retrofit Guidelines acceptable for use as a general guidance document.

The NDEP appreciates the efforts of the California-Nevada Section of the AWWA in developing these guidelines. Users of the guideline who require additional information regarding reuse in Nevada should contact Icyl Mulligan with the Bureau of Water Pollution Control (702) 687-4670, ext. 3139 for further information.

Sincerely,

Darrell W. Rasner, P.E.
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Bureau of Water Pollution Control

cc James B. Williams, P.E., Bureau Chief
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TABLE OF CONTENTS

Part 2 - AGRICULTURAL IRRIGATION

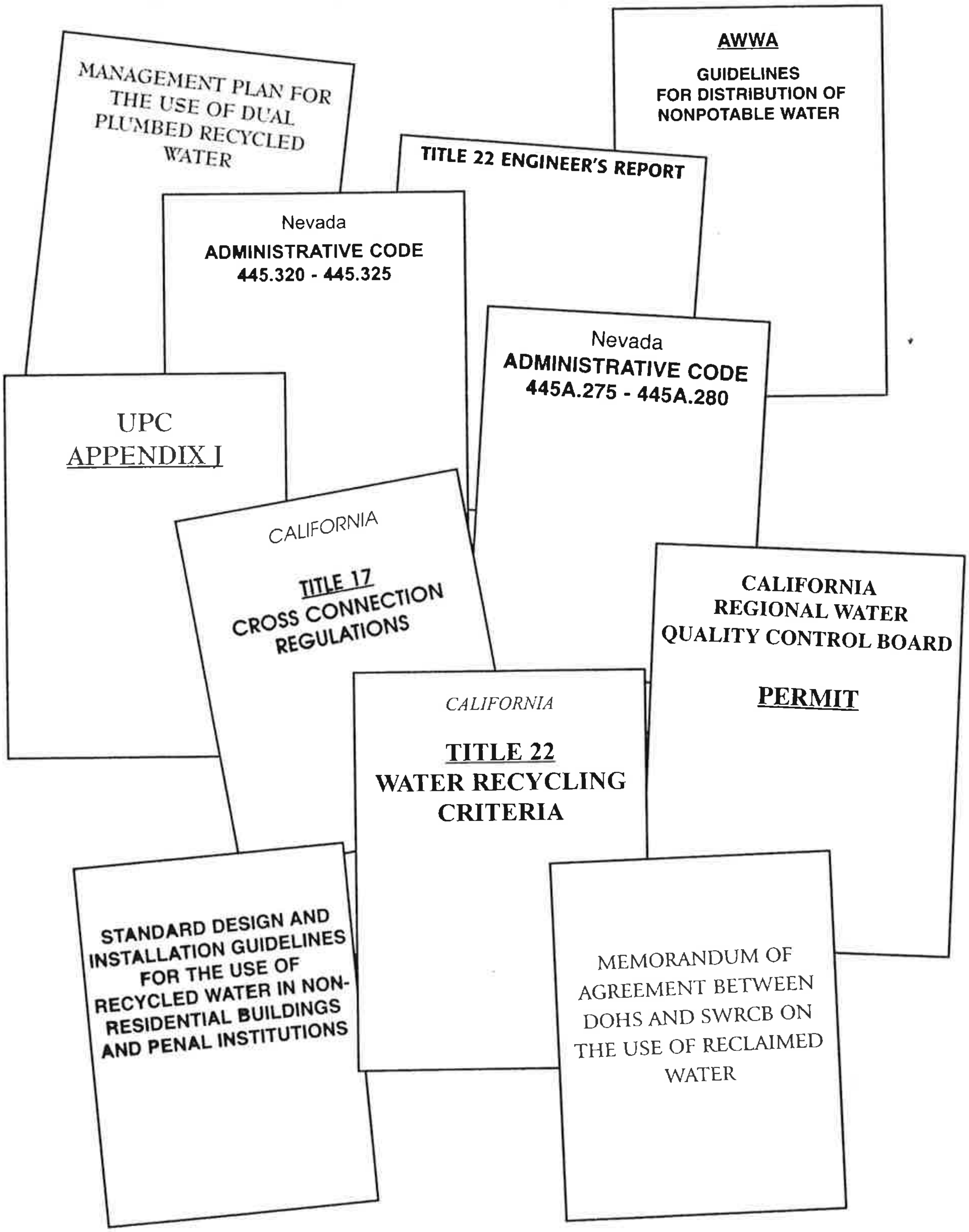
SECTION 5: COMMERCIAL/INDUSTRIAL

SECTION 6: IMPOUNDMENTS

APPENDIX

REFERENCES

TABLES


MANAGEMENT PLAN FOR THE USE OF DUAL PLUMBED RECYCLED WATER
AWWA
GUIDELINES FOR DISTRIBUTION OF NONPOTABLE WATER
TITLE 22 ENGINEER'S REPORT
Nevada
ADMINISTRATIVE CODE
445.320 - 445.325
Nevada
ADMINISTRATIVE CODE
445A.275 - 445A.280
UPC
APPENDIX J
CALIFORNIA
TITLE 17
CROSS CONNECTION REGULATIONS
CALIFORNIA
REGIONAL WATER QUALITY CONTROL BOARD
PERMIT
CALIFORNIA
TITLE 22
WATER RECYCLING CRITERIA
STANDARD DESIGN AND INSTALLATION GUIDELINES FOR THE USE OF RECYCLED WATER IN NON-RESIDENTIAL BUILDINGS AND PENAL INSTITUTIONS
MEMORANDUM OF AGREEMENT BETWEEN DOHS AND SWRCB ON THE USE OF RECLAIMED WATER

SECTION 1

INTRODUCTION AND DEFINITIONS

1.1 Purpose

In 1992, the American Water Works Association, California-Nevada Section (AWWA CA-NV Section) published a guidance document entitled, "Guidelines For Distribution Of Non-Potable Water." This document provides guidance for the design, installation, and operation of new non-potable water delivery systems to multiple customers. These guidelines have been well received within the water reclamation field, but since their publication, AWWA CA-NV Section has received numerous requests for guidelines on retrofitting existing on-site water distribution systems for recycled-water use. This provided the impetus to develop the "GUIDELINES FOR THE ON-SITE RETROFIT OF FACILITIES USING DISINFECTED TERTIARY RECYCLED WATER," hereafter referred to as Retrofit Guidelines. The two guidelines overlap in some areas (e.g., signage requirements) that are common to both new and retrofit systems. In these cases, the Retrofit Guidelines should be considered an upgrade to references found in the previous guidelines. While the Retrofit Guidelines specifically cover retrofit issues, they also provide guidance in other important areas (e.g., water quality) not previously addressed in the 1992 guidelines.

On-site facilities that use recycled water are generally referred to as new construction or retrofit. Whereas new construction involves pre-designed, detailed planning of distribution piping and related recycled-water facilities, a retrofit is the adaptation of a property previously served with potable water to accommodate recycled water.

The retrofit of an existing piping system presents unique challenges to the water purveyor, user and installer. These guidelines are intended to assist those involved in or considering the retrofit of systems to recycled-water use. This document is not a recipe for retrofits and does not provided step-by-step procedures for implementing a retrofit. Rather it is intended to elevate the thought process of those attempting retrofits and to point out concerns which may be appropriate to a specific retrofit site.

The level of water quality will determine the types of of allowable use(s) and may influence procedures and precautions necessary for the retrofit. Currently, the majority of recycled water used for retrofit purposes is of the highest quality. In California this quality of water is called **disinfected tertiary recycled water**. While Nevada does not have the same recycled-water quality classifications, they do identify levels of treated effluent suitable for specific reuse. It is expected that the number of water-recycling projects using the highest quality recycled water, both in California and Nevada, will increase substantially in the future as more tertiary treatment plants are constructed and the need for water recycling grows. **Recycled water of the highest quality is suitable for all recognized non-potable uses. For this reason, these guidelines are written with disinfected tertiary recycled water in mind.** Tables 3.1(California) and 3.2 (Nevada) present the general levels of recycled-water treatment necessary for each specific use.

The Retrofit Guidelines are not intended to be viewed as an all-encompassing document. Local rules and regulations may be more stringent, and the quality of recycled water produced may have limited applications. For instance, salt levels may be too high to use recycled water for irrigation in some areas. Consultation with the appropriate regulatory agencies along with those possessing expertise in water quality and recycled-water applications is essential before undertaking any retrofit project.

These guidelines have been organized into six sections. Section 1 provides a general introduction to the recycled-water system, including definitions of commonly used terms. Section 2 provides an overview of the areas of responsibility involved in a retrofit project and discusses the agency/user involvement with each of these areas. Section 3 provides general information common to all retrofit projects. Section 4 provides discussion and information regarding the retrofit of irrigation systems to recycled-water use and is further separated into two areas: (1) landscape irrigation and (2) agricultural irrigation. Section 5 discusses commercial and industrial use of recycled water such as cooling towers and process waters. Section 6 discusses impoundments ranging from recreational lakes to golf course impoundments, decorative fountains, and wetlands.

1.2 Introduction

Recycled water, also referred to as "reclaimed water" or "reclaimed wastewater" (Nevada refers to it as treated effluent), is generally defined as "*water which, as a result of treatment of domestic wastewater, is suitable for a direct beneficial use or a controlled use that would not otherwise occur.*" These uses of recycled water allow our existing, limited potable-water supplies to be extended and used for more essential purposes.

Many areas of the United States are arid or semi-arid, having limited domestic-water supplies. As these areas develop, efforts to transform them into hospitable living environments by installing landscapes, providing agricultural areas, adding recreational facilities, and supplying cool building spaces, place a severe stress on the limited water supplies. Importing water into these areas has become crucial to meeting the ever-increasing demands. As the demand for water increases and the availability of local and imported supplies dwindles or is stretched to its limits, water reuse becomes an essential and cost-effective means of developing "new water."

The use of recycled water enables water agencies to remove existing non-potable uses from the domestic system so as to meet increasing domestic-water demands from existing supplies. Although using recycled water may require extra effort, the advantages soon prove beneficial. For instance, during a drought, users of recycled water have a non-interruptible water source that is unlikely to be subject to the same voluntary or mandatory restrictions imposed on domestic-water users.

Modifying an existing potable-water system for recycled-water use presents many challenges not found in new construction. Construction of a recycled-water delivery system at a new site provides the opportunity to observe the pipelines as they are installed. However, when retrofitting an existing site for use with recycled water, pipelines cannot always be observed. Design or as-built plans are generally not available or are inaccurate/incomplete. Maintenance personnel frequently change, leaving the location of piping systems, points of connection and appurtenances unknown. Because these conditions are commonly found when attempting to retrofit an existing site, it is important to locate, identify, and verify each system component in the field. All decisions concerning the retrofit should be made cautiously and only after careful review. It is the hope of the authors that this document will provide some valuable insights and practical assistance to all those involved in the retrofit process.

1.3 Definitions and Abbreviations (as used in this document)

Absorption (plants)
The process by which a substance is taken into and incorporated within the plant, such as a nutrient.

Activated Carbon
A form of carbon having very fine pores, suitable for adsorbing gases or solutes, as in various filter systems for purification, deodorization, and dechlorination.

Adjusted Sodium Adsorption Ratio (SAR adj)
A refinement of SAR, including the added effects of precipitation and solution of calcium in soils as related to carbonate (CO_3) and bicarbonate (HCO_3) concentrations. Ca_x is a calcium value modified due to the salinity of the applied water, its HCO_3/Ca ratio, and the estimated partial pressure of CO_2 in the surface few millimeters of soil.

Administrative Authority (plumbing)
Any individual, official, board, department, or agency established and authorized by a state, county, or other political subdivision created by law to administer and enforce the provisions of the plumbing code.

Adsorption
The process by which an ultra-thin layer of one substance forms on the surface of another substance.

Aeration (soil)
The exchange of air in the soil with air from the atmosphere.

Air-gap Separation
A physical separation of at least double the diameter of the supply pipe between the free-flowing discharge end of a potable water supply pipeline and an open or non-pressure receiving vessel, measured vertically above the overflow rim of the vessel. In no case shall the air-gap be less than one inch.

Algae
Any of numerous groups of eukaryotic one-celled or colonial organisms that contain chlorophyll, usually flourishing in aquatic or damp environments and lacking true roots, stems, or leaves.

Amendment (soil)
A substance or material which improves soil by modifying its physical properties rather than by adding appreciable quantities of plant nutrients.

Anion
An ion carrying a negative electrical charge.

Aquaculture
The commercial production of fish and/or shellfish for human consumption.

Aquifer
A water-bearing geological formation of permeable rock or sand containing or conducting ground water.

Backflow
The undesirable reversal of the flow of water or mixtures of water and other liquids, gases, or other substances into the distribution pipes of the potable water supply from any source(s).

Backflow Prevention Assembly
Any effective assembly used to prevent backflow into a water distribution system.

Blowdown
A portion of the recirculating cooling water which is continuously discharged to the sanitary sewer to prevent the build-up of salt contaminants due to evaporation.

Biological Oxygen Demand (BOD)
The estimated amount of oxygen-demanding organic material in the water.

Cation
An ion carrying a positive electrical charge.

Chlorosis
Yellowing or bleaching of the green portion of a plant, particularly the leaves.

Cross Connection
An actual or potential connection or structural arrangement between a public or a consumer's potable water system and any other source or system through which it is possible to introduce into any part of the

potable water system any used water, industrial fluid, gas, or substance other than the intended potable water with which the system is supplied.

Crusting (soil)
Compaction at the immediate soil surface due to an externally applied force (e.g., raindrops, overhead applied irrigation water).

Cycles (cooling water)
Number of times cooling water is recirculated in a cooling tower prior to discharge into the sanitary sewer system.

Denitrification
The process by which nitrate or nitrite deposits are reduced to lower oxides of nitrogen by bacterial action. The process results in the escape of nitrogen into the air.

Discharge
The release of water from one point to another point, such as water from a pipe.

Disinfected Secondary - 2.2 Recycled Water
Recycled water that has been oxidized and disinfected so that the median concentration of total coliform bacteria in the effluent does not exceed 2.2 MPN. See MPN definition.

Disinfected Secondary - 23 Recycled Water
Recycled water that has been oxidized and disinfected so that the median concentration of coliform bacteria in the effluent does not exceed 23 MPN. See MPN definition.

Disinfected Tertiary Recycled (Reclaimed) Water
A disinfected filtered wastewater that either:

(1) is produced by a disinfection process combined with a filtration process that has been demonstrated to reduce the concentration of plaque-forming units of F-specific bacteriophage MS2 or polio virus; or

(2) has a median concentration of total coliform bacteria that does not exceed 2.2 MPN. See MPN definition.

Double Check Valve
An assembly composed of two independently acting valves, including tightly closing resilient-seated shutoff valves attached at each end of the assembly and fitted with properly located resilient seated test cocks.

Drip Irrigation
A form of localized irrigation where water is emitted from a tube, pipe, or head in drips or drops.

dS/m
A measurement of electrical conductivity (deciSiemens per meter at 25°C).

Treated Effluent (Nevada)
Sewage that has a 5-day inhibited biological oxygen demand (BOD) concentration of 30 milligrams per liter or less.

Electrical Conductivity (ECw)
The property of water to transfer an electrical charge. Used for measurement of the salt content in water.

Electrical Conductivity (ECe)
The property of soil to carry an electrical charge. Used for measurement of the salt saturation extract.

Eutrophication
An abundant accumulation of nutrients that support a dense growth of algae and other organisms, the decay of which depletes oxygen from shallow waters during summer.

Evapotranspiration (ET)
The loss of water from the soil by evaporation and plant transpiration.

Fertigation (Chemigation)
The injection of fertilizer into an irrigation system by such means as a pump or an aspirator.

Freeboard
The height above the overflow level that allows water in an impoundment to rise without causing discharge expressed in feet.

Horizon (soil)
A layer of soil approximately parallel to the soil surface with distinct characteristics produced by soil-forming processes.

Hydrozone
A landscaped area having plants of similar water needs which are served by a valve or a set of valves with the same watering schedule.

Infiltration
The downward entry of water into the soil.

Infiltration Rate
A soil characteristic describing the maximum rate at which water can enter the soil under specified conditions, including the presence of excess water.

Ion
An electrically charged particle. As used in soils, an ion refers to an electrically charged element or combination of elements resulting from the breaking up of an electrolyte in solution. Since most soil solutions are very dilute, many of the salts exist as ions.

Ion Exchange
A demineralization process in which soluble ions in water are removed and replaced with hydrogen or hydroxide ions.

Leaching
Applying more water than is needed by the crop/plant during the growing season to move excess soluble salts in the soil to an area below the root zone.

Lodging
The beating down of crops by wind or rain; the tendency of certain long-stalked grasses to collapse due to nutrient deficiency.

Median
The middle number in a given sequence of numbers or the average of the middle two numbers when the sequence consists of an even amount of numbers.

me/L
Milliequivalent per liter

mg/L
Milligrams per liter

Most Probable Number (MPN)
The most probable number of coliform organisms in a 100 millimeter sample.

Necrosis (plants)
Death of plant tissue due to disease, nutrient deficiency, toxicity, or climatic conditions.

Nitrification
A process used to convert ammonia from recycled-water to nitrate and nitrite.

Osmotic Effect
The force a plant must exert to extract water from the soil.

Oxidation
The addition of oxygen, removal of hydrogen, or the increase in the valance of an element.

Percolation
The downward movement of water through the soil.

Permeability
The ease with which water penetrates or passes through a soil horizon.

pH
A numerical designation of acidity and alkalinity as in soils and other biological systems. Technically, pH is the common logarithm of the reciprocal of the hydrogen ion concentration of a solution. A pH of 7.0 indicates precise neutrality; higher values indicate increasing alkalinity and lower values indicate increasing acidity.

Point of Connection (POC)
That point at which the purveyor's delivery system stops and the consumer's distribution system begins.

Ponding
Build-up of water on soil surface due to over-watering, poor soil infiltration, and/or poor soil permeability.

Purveyor
Producer, distributor, wholesaler, and/or retailer; holder of permit and agency of primary responsibility for all requirements in permit (order) from permitting agency.

Recreational Impoundment (Nonrestricted)
An impoundment of recycled water in which no limitations are imposed on body-contact water recreational activities.

Recreational Impoundments (Restricted)
An impoundment of recycled water in which recreation is limited to fishing, boating, and other non-body-contact water recreational activities.

Reduced Pressure Principle Assembly (RP)
A backflow assembly containing two independently acting approved check valves, together with a hydraulically operating, mechanically independent pressure differential relief valve, located between the check valves and at the same time below the first check valve. The unit shall include properly located resilient-seated test cocks and tightly closing resilient-seated shut-off valves.

Regulatory Agency
Any agency having regulatory jurisdiction regarding the treatment, permitting, and use of recycled water.

Retention Time
Expressed in hours; calculated by dividing the impoundment volume by the average recirculation rate.

Reverse Osmosis (RO)
A process of getting "pure" water from salty water. A concentrated salt solution is forced under pressure through a semi-permeable membrane resulting in pure water diffusing through the membrane with the more salty concentrate being left behind.

Root Zone
The area of the soil from which the roots of a crop or plant extract water and nutrients.

Runoff
Water that is released from an upstream water body, mountains, and/or creeks; water that escapes the designated area for irrigation.

Salts
The products, other than water, of the reaction of an acid with a base. Salts commonly found in soils break up into cations and anions when dissolved in water.

Scaling
The formation of hard deposits within piping systems and related appurtenances. The principal causes of scaling are calcium and magnesium.

Sodium Adsorption Ratio (SAR)
A ratio for soil extracts and irrigation waters used to express the relative activity of sodium ions in exchange reactions with the soil.

Specific Ion Toxicity
Any adverse effect from a salt constituent in the substrata on plant growth that is not caused by the osmotic properties of the substrata.

Structure (soil)
The physical arrangement of soil particles.

Tailwater
Excess surface water draining from a field under cultivation.

Texture (soil)
The relative proportions of the various sized groups of individual soil grains in a mass of soil, specifically the proportions of sand, silt, and clay.

Total Dissolved Solids (TDS)
A measure of water salinity. High levels promote corrosion by increasing the electrical conductivity of the water.

Transpiration
Loss of water vapor from the leaves and stems of living plants to the atmosphere.

Turn-over
The rate at which recycled water is used and replaced in an impoundment.

Undisinfected Secondary Recycled Water
Oxidized wastewater.

Vector
Something that carries and transmits a disease-causing organism.

Wastewater Effluent
Sewage or other liquid waste which has received at least partial treatment prior to release or reuse.

SECTION 2

RESPONSIBILITIES

2.1 General

Development of a recycled-water program involves a number of different participants who are responsible in varying degrees for the safe and effective production, delivery, and use of the recycled water. For those not familiar with a recycled-water program, it can be difficult to determine responsibility for each step of the process, from the initial regulatory review to the actual point of use. This section is devoted to clarifying the potentially confusing issues concerning responsibility.

Rules and regulations affecting a recycled-water program can originate at either the state or local level; it is important to determine which has jurisdiction. In some locales there may be a single entity that develops and operates the entire recycled-water program, while elsewhere numerous entities may be involved. For example, a sanitary agency may produce a treated effluent for a water wholesaler who in turn treats the effluent to recycled-water standards. The recycled water is then sold to a water retailer(s) for distribution to the end user(s). When several entities are involved, there is usually a lead agency, with other agencies or entities in supporting roles.

Table 2.1 (California) and Table 2.2 (Nevada) list the areas of responsibility and the agencies/entities designated in each of the two states to fulfill those responsibilities. These tables can be useful in determining the appropriate agencies or entities to contact when developing a recycled-water program.

2.2 Responsibilities of Primary Agencies

California

Regional Water Quality Control Board (RWQCB)

The RWQCB is the lead agency for recycled-water matters. The RWQCB, through a cooperative agreement with the state Department of Health Services, Drinking Water Branch, guides reclamation projects from the initial submission of engineering reports through the ongoing review of self-monitoring reports. Because the RWQCB is concerned with the impact that recycled-water discharges may have on waters of the state, they review proposed recycled-water projects, prescribe reclamation criteria based on this review, consider comments submitted by the DOHS, issue reclamation permits, and evaluate and maintain self-monitoring reports from the permit holder.

State of California Department of Health Services, Division of Drinking Water and Environmental Management (DOHS) - Drinking Water Branch

The Drinking Water Branch of the DOHS has the basic responsibility for protecting public health and safety. Since recycled water is not considered a potable-water supply, matters involving public exposure to recycled water and interconnections to potable-water supplies are of primary concern. The DOHS analyzes and comments to the RWQCB on health issues that arise during the initial review of a recycled-water project. Typical issues include:

- codes and regulations for the production, delivery, and use of recycled water
- deviations from standard recycled-water requirements

- approval of use areas and types of use
- public health and safety as related to recycled-water use
- comprehensive cross-connection control programs

County Department of Environmental Health (DEH)

In some locales, the county health department may take an active role in recycled-water projects. The DEH's interests may include the planning of reclamation projects, the on-site activities (including cross-connection testing/shut-down), the education of both the users and the general public about recycled-water use, and related health concerns. To protect these interests the DEH may participate in the early stages of a project by reviewing and commenting on the project plans, specifications, and engineering report. They may also participate in the inspection of recycled-water treatment facilities, distribution systems, recycled-water user areas, and cross-connection programs. In some instances they may issue additional permits for the use of recycled water.

Recycled-Water Purveyor (Permit Holder)

The recycled-water purveyor may have the greatest responsibility, generally serving as the lead agency in: 1) requesting the use of recycled water, 2) submitting the engineering report, 3) working directly with the end user(s), 4) training the user(s), and 5) submitting self-monitoring reports to the RWQCB. Where multiple agencies are cooperating, only one agency will be listed on the permit and will take the lead in these activities. However, the permit holder may share portions of the recycled-water program responsibilities with the other participants. For example, a recycled-water purveyor may require the submittal of water-quality data from participating wastewater agencies for the self-monitoring report that goes to the RWQCB.

Potable-Water Purveyor

The potable-water purveyor plays an important role in the implementation of a successful recycled-water program, even without actually supplying any recycled water, because the potable-water purveyor is responsible for maintaining an extensive and active cross-connection control program. This includes:

- establishing operating rules/regulations for implementation of the program
- conducting surveys to identify water-user premises where cross-connection potential exists
- installing and maintaining adequate backflow protection, where necessary
- developing or adopting adequate testing procedures for backflow assemblies
- providing trained personnel to manage the cross-connection control program

In addition, trained personnel must be intimately familiar with recycled-water issues. This is best accomplished by training a certified AWWA CA-NV Section Cross-Connection Control Program - Specialist in recycled-water use criteria and cross-connection (shut-down) testing procedures. It is essential for effective operation and maintenance that both the cross-connection control program and the recycled-water program are adequately staffed with personnel who have attained the necessary level of expertise to address any potential problems.

User

The user is that person, group, or other entity permitted to use recycled water for a specific purpose(s). The user should, at all times, use recycled water in a responsible manner by complying with all regulations that apply to the specific use. User responsibilities include:

- informing the public of the use of recycled water
- using recycled water in a manner consistent with recycled-water use criteria
- exercising a high degree of responsibility for the maintenance of the use area
- assigning and maintaining a site supervisor position

The site supervisor may be the user, an employee of the user, or an individual under contract to the user and should:

- have an intimate knowledge of the use-area piping systems
- preview all planned or emergency piping changes
- maintain piping plans in a current status
- notify the recycled-water purveyor of problems and proposed changes
- act as liaison between the user and the recycled-water purveyor
- assist the recycled-water purveyor in the training of on-site personnel
- provide on-site supervision of personnel directly associated with the use and maintenance of the recycled-water system

Nevada

Nevada Division of Environmental Protection (NDEP), Bureau of Water Pollution Control

The NDEP's Bureau of Water Pollution Control reviews, approves, and monitors effluent-reuse projects in Nevada. The NDEP permits the use of treated effluent for irrigation, with limitations, under Nevada Administrative Code, 445A.275 through 445.280 inclusive. The Uniform Plumbing Code (UPC), specifically Chapter 6 (Water Supply and Distribution) and Appendix J (see Appendix) are the primary guidance documents for the reuse of treated effluent. Before any reuse can occur, an Effluent Management Plan (EMP) must be submitted to the NDEP for review and approval. For details regarding the EMP, refer to Section 2.4.

2.3 Additional Responsibilities

In addition to the responsibilities of the primary agencies, those of others agencies, the maintenance contractor, and the public are important to a successful recycled-water project.

Other Agencies

State agencies (e.g., Department of Food and Drug, Licensing and Certification, and the Office of Statewide Planning and Development) and federal agencies (e.g., U. S. Department of Agriculture) may have regulatory authority with on-site reuse.

Maintenance Contractor

Works closely with the site supervisor; follows all recycled-water criteria established for the use area; and keeps the site supervisor informed of concerns, changes, or activities which may impact on-site recycled-water use.

Public

The public has a responsibility to accept the use of recycled water where it has been approved by regulatory agencies, to become informed as to the safe and effective use of recycled water, and to treat the use area in a responsible manner (i.e., adhering to recycled-water use and water conservation criteria).

TABLE 2.1 - AGENCY/USER RESPONSIBILITIES FOR RECYCLED WATER USE (CALIFORNIA)

AREA OF RESPONSIBILITY	DOHS	RWQCB	DEH	PURVEYOR	USER
TREATMENT FACILITY					
Review treatment plant design criteria	2	1	3		
Review Title 22 engineering report	2	1	3		
Notify involved agencies/users of significant non-compliance	3	2	3	1	
Conduct treatment plant inspections		1			
Issue discharge permits/recycled-water requirements	2	1	3		
Enact enforcement actions for non-compliance	3	1	3		
Review self-monitoring reports	3	1			
DISTRIBUTION SYSTEM					
Review for conformance with standards	2			1	
Review deviations from standard requirements	1				
Issue recycled-water requirements (permits)		1			
Conduct annual Title 17 inspection of supplier's facilities	1				
Conduct backflow device testing on potable services				1	3
Enact enforcement actions for non-compliance		1			
Review cross-connection programs	1				
USE AREAS					
Conduct market studies of recycled-water users				1	
Produce initial master plans and updates				1	
Produce/distribute standards, rules, regulations to users				1	
Review/approve supplier's rules and regulations	2	1			
Approve reuse area and type of use	1				
Review/approve on-site plans	2		2	1	
Conduct on-site inspections	3		3	1	
Conduct cross-connection inspections	2		2	1	1
Conduct cross-connection (shut-down) tests	2		2	1	1
Monitor on-site use for compliance				1	1
Verify supplier's compliance monitoring procedures		1			
Enact enforcement actions for use area violations		2		1	
Notify involved agencies/users of significant non-compliance				1	1
Respond to complaints	3			1	
GENERAL					
Produce/prescribe codes of regulations for production, delivery, and use of recycled-water	1				
Prescribe/review basin plans		1			
Participate in statewide policy review	1	2			
Participate in planning and educational efforts	1	1	1	1	1

(1) Agency/user with primary responsibility
(2) Agency/user with responsibility for review
(3) Supporting agency/user, as needed

TABLE 2.2 - AGENCY/USER RESPONSIBILITIES FOR RECYCLED WATER USE (NEVADA)

AREA OF RESPONSIBILITY	NDEP	REGISTERED ENGINEER	PURVEYOR	USER
TREATMENT FACILITY				
Prepare & stamp plans/specifications		1	2	
Review/approve plans/specifications	1			
Issue discharge permit	1			
Submit Effluent Management Plan			1	2
Review/approve Effluent Management Plan	1			
DISTRIBUTION SYSTEM				
Review for conformance with standards	1			
Review deviations from standard requirements	1			
Issue recycled-water requirements (permits)	1			
Conduct inspection of supplier's facilities	1			
Conduct backflow device testing on potable services			1	
Enact enforcement actions for non-compliance	1			
USE AREAS				
Conduct market studies of recycled-water users			1	
Produce initial master plans and updates		3	1	2
Produce/distribute standards, rules, regulations to users	1		1	
Review/approve supplier's rules and regulations	1			
Approve reuse area and type of use (permit)	1			
Review/approve on-site plans	1			
Conduct on-site inspections	1			
Conduct cross-connection inspections	1		1	
Conduct cross-connection (shut-down) tests	1			
Monitor on-site use for compliance	1			
Verify supplier's compliance monitoring procedures	1			
Enact enforcement actions for use area violations	1			
Notify involved agencies/users of significant non-compliance	1			
Respond to complaints	1			
GENERAL				
Produce/prescribe codes of regulations for production, delivery, and use of recycled-water	1			
Prescribe/review basin plans	1			
Participate in statewide policy review	1			
Participate in planning and educational efforts		3	2	1

(1) Agency/user with primary responsibility
(2) Agency/user with responsibility for review
(3) Supporting agency/user, as needed

2.4 Reports

Several reports must be submitted, reviewed and approved before any recycled-water project can be implemented. These reports explain how the recycled-water project will be constructed, what treatment methods will be used to meet specific water quality parameters, where and how the distribution system will be constructed, and where recycled water will be used. Where special uses (e.g., indoor sanitary fixture flushing, cooling tower make-up water) are desired, additional reports must be submitted and approved prior to use. Once a recycled-water program is in operation, regular monitoring reports are required.

California

At the initial phase of a recycled-water project a Title 22 Engineering Report must be submitted to the RWQCB and the DOHS for approval. This report must be stamped and signed by a registered engineer and should detail the treatment facilities, the proposed use area and users, and the transmission and distribution facilities of the proposed recycled-water program. Also included should be applicable charts, maps, spreadsheets, pictures, test data, etc. Assistance in formulating this report may be obtained from the DOHS document "Guidelines for the Preparation of An Engineering Report for the Production, Distribution, and Use of Recycled Water." Listed below are some of the more important items which should be addressed.

Treatment Facilities

- recycled-water quality requirements
- effluent quality
- reliability features
- supplemental water supplies
- monitoring features
- contingency plans

Proposed Use Area and Users

- general description of service area
- description of existing recycled-water system and use-areas, if any
- potential recycled-water users
- projected recycled-water use
- use-area information specific to each projected recycled-water use
- detailed cross-connection procedures
- location and type of signage
- use-area inspections and monitoring
- contingency plans
- use-area employee training
- recycled-water rules and regulations

Transmission and Distribution Facilities

- maps and/or plans
    - location of transmission facilities
    - distribution system layout
    - location of all water and sewer lines within use area
- regulatory-agency design guidelines
    - Guidelines for the Distribution of Non-Potable Water (AWWA CA-NV Section)
    - California Waterworks Standards (1997)

- Regulations Relating to Cross-Connections (Title 17, Chapter 5, Group 4)
- Manual of Cross-Connection Control/Procedures and Practices (DOHS)
- Guidelines for the On-Site Retrofit of Facilities Using Disinfected Tertiary Recycled water (AWWA CA-NV Section)

Once the treatment facility has been completed, a recycled-water permit issued, and the distribution system constructed, then those users identified in the Title 22 Engineering Report can be connected to the system. Generally, the first users will be irrigation users. These are by far the largest and easiest retrofits to make. As the recycled-water purveyor completes these retrofits and becomes more comfortable with the retrofit process, often special uses become apparent that were not previously identified. Such special uses include cooling towers, sanitary fixture flushing (dual-plumbed), industrial process waters, and wetlands.

Special uses require additional Title 22 Engineering Reports to address each individual use. These reports, which must be stamped and signed by a registered engineer and submitted directly to the DOHS for review and approval, should include the following:

- description of the proposed use area
- assignment and use of a site supervisor
- method of system separation and identification
- cross-connection test procedure (shut-down test)
- description of valve seals
- annual inspections
- backflow requirements and testing

Permits authorizing the use of recycled water also require monitoring of the use areas to ensure the appropriate use of recycled water. These reports, submitted to the RWQCB, include the following parameters:

Treatment

- daily flow (MGD)
- coliform testing results
- turbidity
- BOD
- oil and grease
- color
- pH
- temperature
- dissolved oxygen
- TDS (total dissolved solids)
- boron

Use Area

- occurrences of recycled-water discharge by overspray and/or runoff
- corrective actions taken

Any non-compliance with permit restrictions by the producer and/or user, together with corrective actions taken, should be described in detail in the monitoring report.

Nevada

The following steps are required in order to obtain approval for a treated-effluent project and to acquire a discharge permit for the specific reuse application:

(1) A complete set of plans and specifications for the reuse irrigation delivery system, storage pond, and ancillaries is submitted to the NDEP. These must be prepared, stamped, and signed by a Nevada-registered professional engineer having experience in the environmental field. Information should include but not be limited to the following:

- depth and quality of ground water; groundwater gradient
- topography and climate conditions
- soil characterization/compatibility with effluent for sustaining plant materials
- flood hazards/100 year flood plain; stormwater controls
- distances to residential areas
- location of surface waters and distances to domestic water supply wells
- areas of public access
- water budget to demonstrate full uptake by vegetation
- water balance for storage ponds
- irrigation system and ancillary plans and calculations
    - piping
    - valves
    - pump stations
    - anti-syphon and backflow prevention controls
    - cross-connection protection
    - air-gaps
    - method of pipe marking
- storage pond design details
    - liner specifications
    - inlet and outlet structures
    - berms
    - aeration specifications
    - water level regulation/high water alarm control details
- nutrient balance
- buffer zone delineation (if applicable)
- odor control
- flow metering
- tailwater control (if applicable)
- high wind shut-off controls for spray irrigation
- additional treatment systems (plans and specifications)

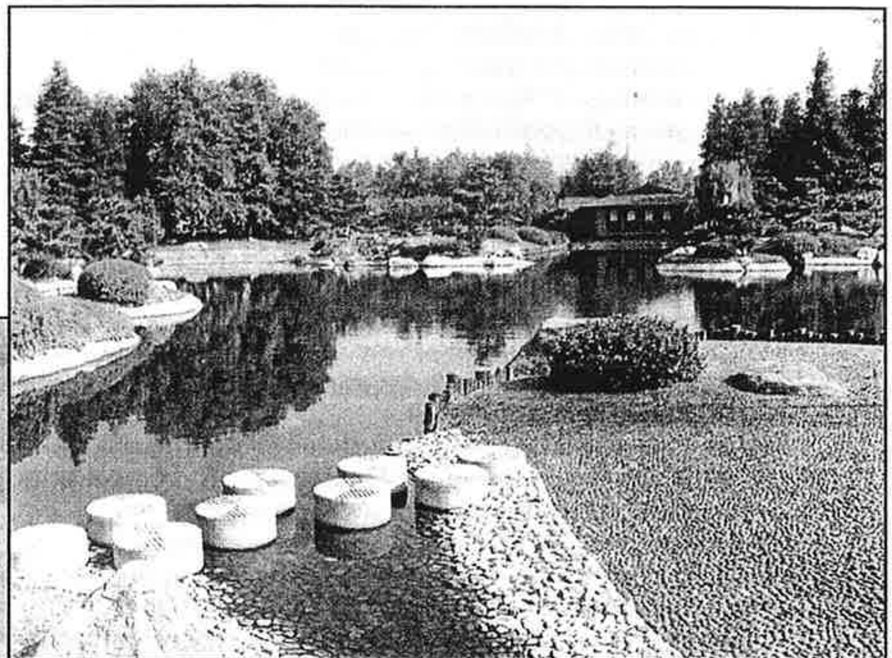
(2) Following receipt of this information, the NDEP conducts a detailed review. A discharge permit may then be issued, but only after:

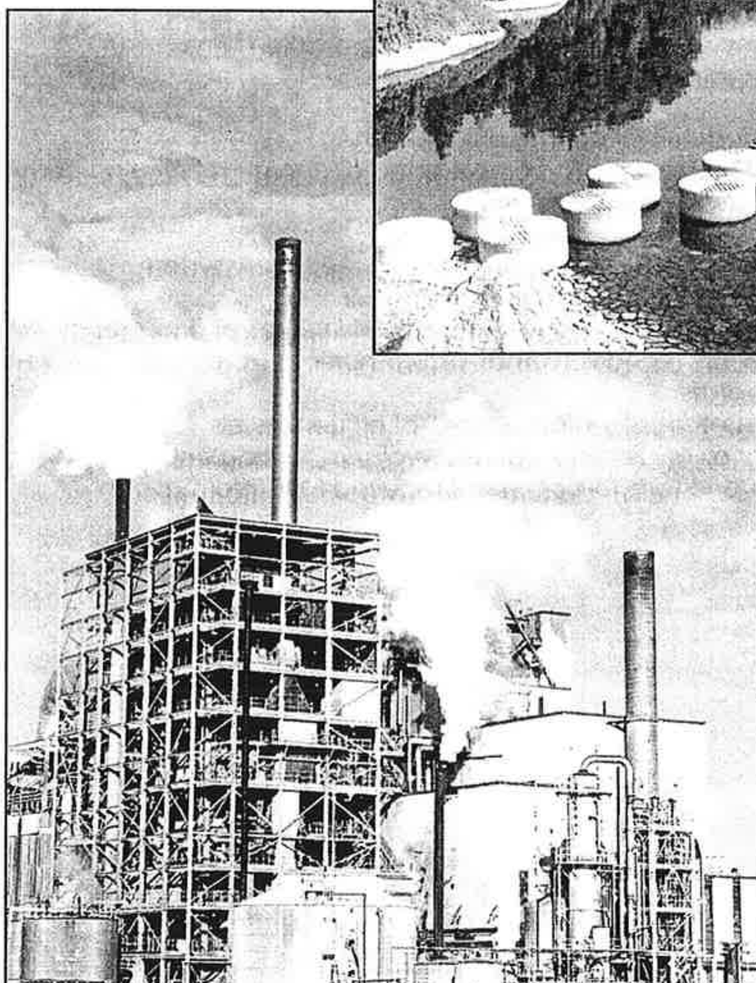
- all information has been supplied
- conditions have been correctly applied
- permit application fees have been paid
- the technical services review has been completed and approved

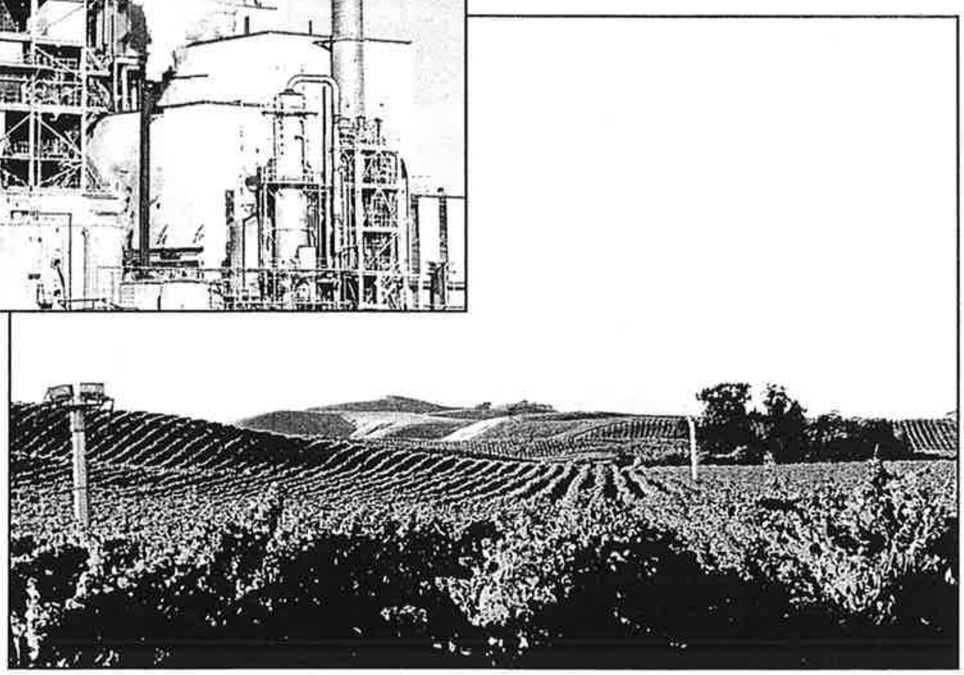
(3) After the treatment facility(ies) have been constructed, an Effluent Management Plan (EMP) must be submitted and approved for each reuse site. The final EMP must be submitted prior to the start of treated-effluent application (reuse), but after the permit has been granted. The EMP outlines the basic management and operational elements necessary for the proper reuse of wastewater effluent. All restrictions and controls contained in the NDEP Guidelines should be

incorporated into the EMP. As a minimum the EMP should include the following:

- a site plan showing
  - location of effluent storage
  - location of transfer structures
  - location of flow diversion and control structure/equipment
  - areas of application w/methods of application
  - groundwater monitoring well locations and buffer zones
  - distances to surface waters, groundwater and water supply wells within 200 feet
- a means of flow measurement
- a method of calculating water balance via evapotranspiration rates
  - operator field procedures
  - frequency of effluent application
  - area and site rotation including conditions governing rotation
  - anticipated monthly irrigation schedule
- user, generator information
- normal and emergency procedures for communication
- monitoring requirements and procedures to complete the discharge monitoring permit
- emergency procedures to prevent discharge
- measures and procedures for minimizing ponding
- measures and procedures for operating tailwater control or recovery system
- measures and procedures to prevent aerosol drift
- agreements, procedures, or measures to dispose of effluent in times of emergency
- description of crop, soil, and site conditions that assure nutrient uptake and prevent degradation of waters of the state
- notification procedures and methods to inform public of effluent reuse
- capacities, with freeboard, of all effluent storage reservoirs/impoundments
- a complete set of forms and/or charts to document required EMP information







SECTION 3

GENERAL RETROFIT REQUIREMENTS

3.1 Categories of Recycled Water

The quality of recycled water dictates the ways in which the water can be used. In California, recycled water is categorized into four distinct water quality groups (see Table 3.1), each having specific treatment requirements:

1. disinfected tertiary
2. disinfected secondary - 2.2
3. disinfected secondary - 23
4. undisinfected secondary

The fourth category has a very limited range of allowable uses due to health risks associated with the lack of disinfection.

Nevada has three categories of treated effluent (some minor variations occur in two of the categories as noted in Table 3.3) with specific uses approved for each water quality category based on the level of treatment and the level of human or crop exposure. Table 3.2 lists the approved uses for Nevada by water quality. Since Nevada water quality classifications differ from those in California, Table 3.3, which defines Nevada's water qualities, has been added for clarification.

3.2 Benefits of Recycled Water Use

The use of recycled water can provide substantial benefits for the user as well as for the water purveyor. When facing the prospect of retrofit, however, users frequently are more concerned with the financial impact than with the potential benefits.

In addition to some of the more general benefits, such as conserving potable-water supplies and reducing wastewater discharges, there are a number of more specific benefits which may be available to the recycled-water user:

- water service provided at no cost or at reduced cost
- installation of backflow and thermal-expansion protection assumed by the purveyor
- water supply resistant to drought/rationing restrictions
- recycled water provided at a lower rate per unit
- increased nutrient content, reducing fertilization requirements, enhancing plant growth
- uniform application of fertilizers with each irrigation
- financial assistance may be available in the form of:
    - grants and low or no-interest loans to assist in the retrofit process
    - assistance with design, construction and equipment requirements

3.3 Public Awareness Considerations

The public will generally agree that developing a recycled-water program is desirable, but few visualize the use of recycled water in their own daily lives. To promote consumer acceptance of recycled-water use, the purveyor must continually inform the general public, and especially the potential users, of the overall project status. This will help to instill a sense of involvement, while at the same time aiding in the development of the public's understanding of the project. During this time the recycled-water purveyor is also laying the foundation necessary for undertaking successful future retrofit projects. Following is a list of potential benefits a recycled-water purveyor should consider using as marketing tools when presenting the retrofit concept to the user.

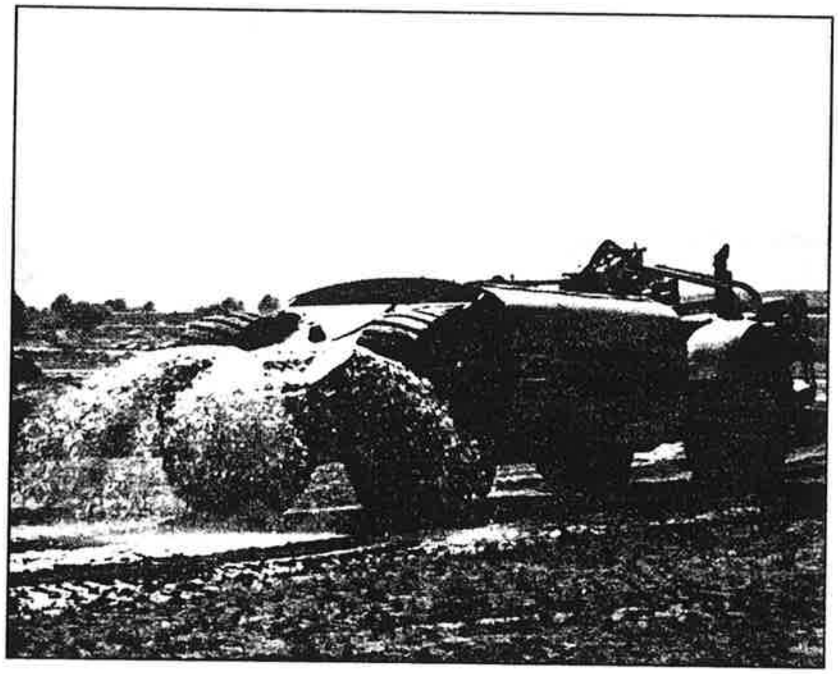
- a water supply protected from drought conditions
- a reliable alternate water source to replace or supplement inconsistent and/or limited water supplies
- an environmentally beneficial use of wastewater which reduces discharges
- a sound conservation method conserving limited domestic-water supplies
- an appropriate investment having a reasonable payback period
- a water system with greater flexibility
- a more economical water supply

A successful retrofit project requires customer approval and involvement. While some users may readily agree to use recycled water, others may need to be convinced. Typical areas of concern for the user are:

- the cost of retrofitting
- the work necessary to accomplish the project
- who is responsible for doing the work
- when recycled water will be available
- the reliability of the recycled-water supply

From design through construction and ultimately to service activation, the purveyor and the user must work together, each depending on the knowledge and expertise of the other. Each retrofit project will have unique concerns and problems. The following is a list of actions that the recycled-water purveyor can take to avoid potential problems.

- Identify specific recycled-water user needs.
- Notify the public that recycled water will be used on site.
- Identify the user's potential health concerns.
- Recognize water-quality concerns as they relate to specific uses (i.e., irrigation, cooling towers, industrial processes, impoundments).
- Provide guidance and information regarding the use of recycled water.
- Assist the user with:
    - liaison activities with contractors, inspectors, other agencies, etc.
    - written materials (i.e., specifications, ordinances, guidelines, etc.)
    - resolutions to health concerns and water-quality issues
    - training of on-site personnel
        - preparation and placement of signs
        - inspections, testing, and ongoing reviews



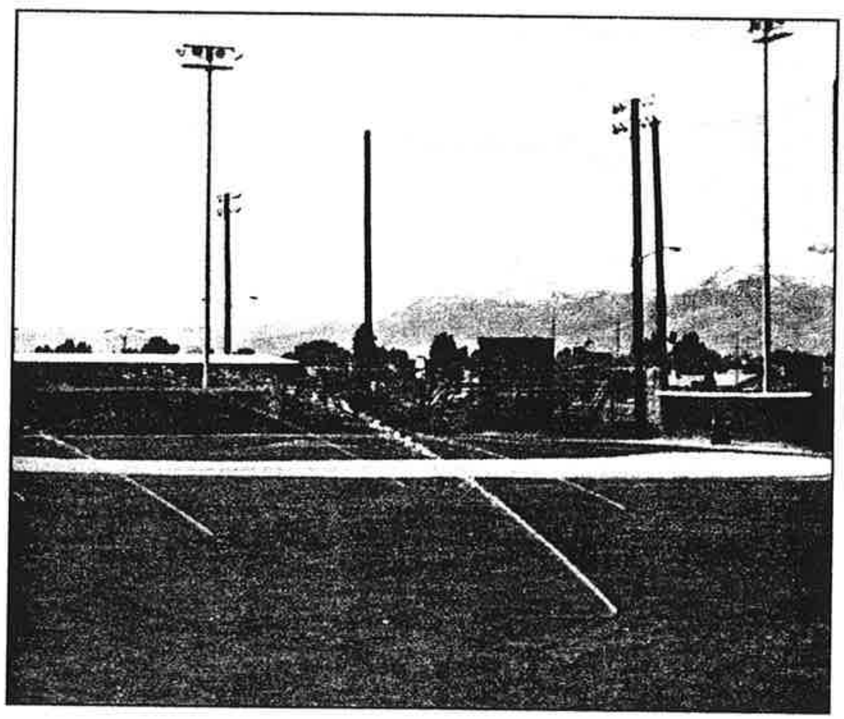


TABLE 3.1 - RECYCLED WATER USES BY WATER QUALITY (CALIFORNIA)

SPECIFIC USES	DISINFECTED TERTIARY -2.2	DISINFECTED SECONDARY -2.2	DISINFECTED SECONDARY -23	UN-DISINFECTED SECONDARY
LANDSCAPE IRRIGATION				
Parks & Playgrounds	•			
Schoolyards & Playfields	•			
Residential Landscaping	•			
Golf Course - unrestricted access	•			
Cemeteries	•	•	•	
Freeway Landscaping	•	•	•	
Golf Courses - restricted access	•	•	•	
Ornamental Nurseries & Sod Farms	•	•	•	• (10)
Landscape Impoundments	•	• (4)	• (4)	
Non-Edible Vegetation - w/controlled access	•	• (2)	• (2)	•
AGRICULTURAL IRRIGATION				
Food Crops - contact with edible portion of crop	• (1)			
Food Crops - no contact w/edible portion above ground	•	•		
Pastures - animals producing milk for humans	•	•	•	
Pastures - animals not producing milk for humans	•	•	•	•
Orchards - no contact with edible portion	•	•	•	•
Vineyards - no contact with edible portion	•	•	•	•
Non-Food Bearing Trees	•	• (9)	• (9)	• (9)
Fodder & Fiber Crops	•	•	•	•
Seeds - not for human consumption	•	•	•	•
Food Crops - processed	•	• (3)	• (3)	
Fish Hatcheries	•	•		
COMMERCIAL/INDUSTRIAL				
Toilet & Urinal Flushing	•			
Drain Trap Priming	•			
Evaporative Condensers	•			
Cooling & Air Conditioning - w/cooling towers	• (6)	• (5)	• (5)	
Industrial Processes - w/possible worker contact	•			
Structural Fire Fighting	•			
Decorative Fountains	•			
Commercial Car Washes	• (7)			
Commercial Laundries	•			
Backfill Consolidation - around potable lines	•			
Artificial Snow Making	•			
Industrial Boiler Feed	•	•	•	
Non-Structural Fire Fighting	•	•	•	
Backfill Consolidation - around non-potable lines	•	•	•	
Soil Compaction	•	•	•	
Concrete Mixing	•	•	•	
Dust Control - on roads and streets	•	•	•	
Sanitary Sewer Cleaning/Flushing	•	•	•	
Cleaning - roads, sidewalks, outdoor work areas	•	•	•	
IMPOUNDMENTS				
Restricted Recreational	•	•		
Unrestricted Recreational	• (8)			

1. Recycled water used for the irrigation of food crops where edible portions are contacted by recycled-water.
2. Access is controlled; irrigated area cannot be used as if it were a park, playground, or school yard.
3. Food crop must undergo pathogenic destroying process prior to human consumption.
4. Does not utilize decorative fountains.
5. Cannot be used if cooling towers, evaporative condensers, or spraying that creates a mist are present in the cooling system.
6. Where system creates mist that could contact employees or where cooling tower is used in conjunction with an air conditioning system:
    - drift eliminators must be used.
    - chlorine or other biocide residual shall be used to treat cooling system recirculating water to minimize growth of Legionella and other micro-organisms.
7. Where the washing is not done by hand and where the general public is excluded from the washing process.
8. Conventional treatment not required, but must monitor for pathogenic organisms.
9. Not irrigated within 14 days of harvest (e.g. christmas tree farms).
10. Not irrigated within 14 days of harvest, retail sale, or allowing of access by general public.

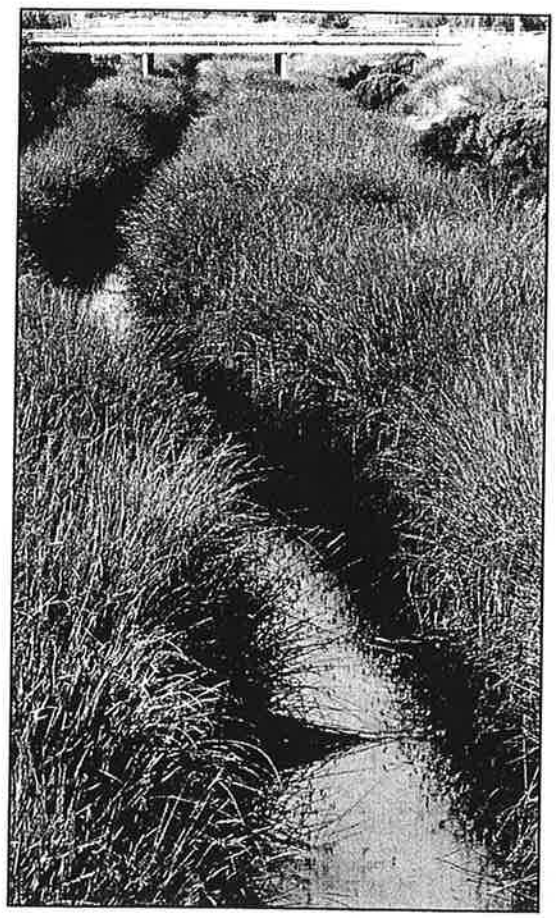


TABLE 3.2 - RECYCLED WATER USES BY WATER QUALITY (NEVADA)

SPECIFIC USES	CATEGORY C	CATEGORY B	CATEGORY A (1)	CATEGORY A
LANDSCAPE IRRIGATION				
Residential Lawns	•			
Commercial Lawns	•			
Highway Islands	• (6)			
Medians	• (6)			
Shoulders	• (6)			
Playgrounds	• (6)			
Parks	• (6)			
Greenbelts - prevented access	• (1)	• (1)	• (1)	• (1)
Greenbelts - controlled access	•	• (2)		
Greenbelts - controlled access w/public approach	• (6,7)			•
Highway Medians	•			
Cemeteries	•	• (2)		
Golf Courses	• (3,4)	• (2)		
AGRICULTURAL IRRIGATION				
Pastures	• (1)	• (1)	• (1)	• (1)
Forage	• (1)	• (1)	• (1)	• (1)
Fiber Crops	• (1)	• (1)	• (1)	• (1)
Seed Crops	• (1)	• (1)	• (1)	• (1)
COMMERCIAL/INDUSTRIAL				
Closed Cooling Systems	•	•	•	
Sand and Gravel Operations	•	•	•	
Construction Uses	•	•	•	
Compaction	•	•	•	
Non-Potable Process Water Additions	•	•	•	
Dust Control	•	•	•	
Equipment Washdown	•	•	•	
Cooling Towers	•	•	•	
Tools Using Spray Nozzles	•	•	•	
IMPOUNDMENTS				
Controlled Recreational	• (8)			
Controlled Landscape	•	• (9)		
Golf Course Water Hazards	• (5)	• (5)		
Unrestricted Recreational	•			
Effluent Storage Reservoirs	•	•		

1. No disinfection or buffer zone requirements when surface irrigation is used.
2. All routine irrigation shall be completed at night when public is not present on site. Public not allowed on specific areas of site with in one hour after irrigation completion or until grasses are dry.
3. Routine irrigation can be initiated before play is finished for the day, but players must have completed play and be removed from any sprinkler head influences in a specific area when 3 NTU effluent is used.
4. Routine irrigation can take place during day when public access is unrestricted if carried out in accordance with the approved effluent management plan when using 2 NTU effluent.
5. Water hazards can be utilized effluent holding reservoirs.
6. Irrigation of specific areas within the site first accessed by public will be completed first.
7. No routine irrigation is to take place when public is allowed or present when using 3 NTU effluent.
8. A minimum 3 NTU effluent shall be maintained.
9. No fishing, boating, swimming, wading, or aerosol generating fixtures (e.g., decorative aerators, waterfalls, fountains) are allowed.

TABLE 3.3 - SPRAY IRRIGATION REQUIREMENTS FOR BACTERIOLOGICAL QUALITY AND BUFFER ZONE LIMITATIONS - NAC 445A.276 (NEVADA)

PERMITTED REUSE BY CATEGORY	A	A(1)	B*	C**
30-Day Geometric Mean (mpn/100 ml***) Fecal Coliform	No Limit	200	23	2.2
Maximum Daily Number (mpn) Fecal Coliform	No Limit	400	240	23
Minimum Buffer Zone (feet)	800	400	100	0

Category "A" - irrigation with treated effluent of land used for pasture or other agricultural purposes except growing crops for human consumption where public access is prohibited. Effluent used for category "A" activities must meet category "A" or "A(1)" requirements for bacteriological quality and buffer zone limitations.

Category "B" - irrigation with treated effluent of land used for:

(1) Golf courses, cemeteries, or greenbelts where public access is controlled and human contact with effluent does not occur.
(2) Impoundments where all activities are prohibited and no human contact with effluent occurs.
(3) Any combination of category "A" and "B" uses.

Category "C" - irrigation with treated effluent of land used for:

(1) Cemeteries, highway medians, greenbelts, parks, playgrounds, residential or commercial lawns where public access is controlled and human contact cannot reasonably be expected.
(2) Impoundments where full body contact with effluent cannot reasonably be expected.
(3) Any other purpose not included in category "A" or "B".
(4) Any combination of activities listed in category "A", "B", and "C".

* Secondary recommended limit of 5 NTU (nephelometric turbidity units) - single maximum value

** Secondary recommended limit of 3 NTU - single maximum value when measuring fecal coliform and 2 NTU when measuring total coliform

*** Most probable number per 100 milliliters of treated effluent, also written as colony forming units (cfu)

3.4 Initial Site Evaluation

An initial site evaluation is the first visit to a proposed use area for the express purpose of determining its suitability for recycled-water use. Frequently, this evaluation is conducted as a part of or as a follow-up to the first contact with the potential user and provides the opportunity to identify possible problems and gain insights into the complexity of the proposed retrofit project. See Figure 3.1 for a typical retrofit site. Whether investigating a simple irrigation system retrofit or a complex industrial process, the person(s) conducting a site evaluation should:

- Obtain site history:
  - water-use history
  - water rights (entitlement)
  - availability of other water sources
  - existing and anticipated uses
  - existing wells on-site
- Tour the site with a knowledgeable representative. During the tour, careful observation of the following will provide a general understanding of the site's layout, use(s), and operation(s):
  - topography
  - climate
  - soil
  - infiltration rates
  - drainage
  - water-quality concerns, (e.g., storage and treatment needs)
  - current water-use practices
  - demand criteria (peak and seasonal)
  - specific site needs
- Obtain record drawings, when available. Careful review of these drawings will assist in the identification of piping systems, types and locations of pipes, equipment, and appurtenances associated with the retrofit project, which may not be visible during the site visit. When record drawings are not available, it may be necessary to document existing piping and appurtenances associated with the retrofit project. Such documentation should be developed with the cooperation of the user. Conducting a preliminary cross-connection test will assist in the development of this documentation.
- Identify high-risk or susceptible populations (young children, the elderly, and others having compromised immune system functions) .

After the retrofit site has been thoroughly evaluated and all necessary drawings reviewed, all areas of concern should then have been identified. At this point, a preliminary cross-connection test, if not already conducted, should be performed by a certified AWWA CA-NV Section Cross-Connection Control Program - Specialist or approved equivalent. This will provide physical confirmation of system piping layout, operation and location of appurtenances associated with the retrofit, system separation, and point(s) of connection both known and unknown. A Preliminary Cross-Connection Test Procedure is provided in the Appendix to this document.

A design and retrofit plan can now be developed with the cooperation and expertise of all involved parties. During the development of the retrofit plan, each concern noted during the initial site evaluation should be effectively addressed. Participants (retrofit team) involved in the development of the plan should include the following, if possible:

- recycled-water purveyor
- consumer's representative
- contractor and/or plumber

- design consultant
- health department representatives
- association board members
- master association
- property management

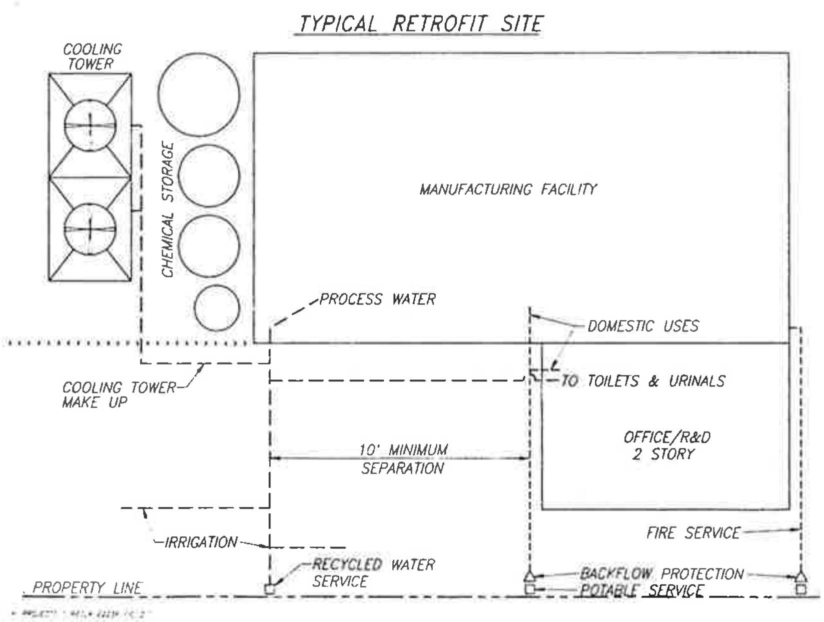


Figure 3.1

3.5 Site Retrofit Considerations

Following the initial site evaluation and review of design drawings, the purveyor and retrofit team should be familiar with the retrofit site, its equipment, and appurtenances. The retrofit team should now identify additional existing and potential problem areas not previously noted. Some examples are (1) landscapes which have poor or no drainage and exhibit areas of standing water and (2) industrial sites requiring non-interruptible water service or existing on-site treatment. Early notation of these problem areas will allow for correction and/or modification during the retrofit process. Listed below, by major use, are some of the more commonly found problem areas.

Irrigation

- multiple points of connection throughout the project
- unknown appurtenances such as:
  - piping, valves, and tubing to areas not designated for retrofit
  - irrigation areas beyond the designated retrofit area
  - drinking fountains, water features, play equipment
  - parking structures, residential units, car-wash stations
- severe slopes
- poor or no drainage

- inadequate equipment or components of a piping system and poor equipment repair
- practices of overspray, run-off
- public facilities (picnic tables, cooking areas, drinking fountains, pools, fruit stands, etc.)
- plant materials sensitive to available water quality
- cross-connection potentials and backflow requirements
- location(s) of existing auxiliary water supplies to potable-water supplies (wells, treated water, etc.)
- employee/public contact with recycled water

Commercial and Industrial

- point(s) of connection
- use of existing piping and appurtenances
- components which are difficult to locate and identify (existing piping, equipment, and appurtenances)
- separation of piping systems
- additional equipment found on site (hose bibs, filters, valves, by-passes, water conservation equipment, regulator stations, etc.)
- additional sources of supply (wells, treated water, etc.)
- existing on-site treatment processes in use
- chemical feed/handling facilities
- inappropriate discharge of waste, e.g., cooling tower blow-down
- employee and public exposure concerns
- methods for providing training to site supervisor(s) and employees
- cross-connection potentials and backflow requirements

Impoundments

- public accessibility, exposure, and notification
- public facility locations (picnic tables, etc.)
- alternate supply sources
- on-site treatment requirements
- discharge of overflow facilities
- employee and public exposure concerns
- training of user supervisor and employees

3.6 Special Considerations

As the variety of recycled-water uses continues to expand, it is apparent that specific uses and site conditions may warrant special considerations. For example, commercial and industrial uses and golf courses may require on-site storage and/or on-site water treatment. When considering the use of recycled water inside a building or industrial facility, there are often unique and complex conditions which may require special attention. This may also be true when supplying recycled water to an impoundment (e.g., golf course water hazard).

- water-storage concerns:
  - algae growth in storage facilities
  - pathogens and nuisance bacteria
  - maintaining disinfection residual
  - turn-over rate
  - water-quality degradation in storage, etc.
- on-site treatment:
  - softening
  - filtration

    - micro-filtration
    - reverse osmosis
    - dechlorination
    - ammonia removal (stripping)
    - pH control
    - corrosion control
    - denitrification
- operational concerns:
    - identification of piping systems
    - employee/public contact with recycled-water
    - signage of work areas
    - change of appurtenances (i.e., strainers, regulators, pressure)
    - training of workers

When using recycled water in decorative fountains, streams, ponds, and impoundments, challenges with water quality and public exposure will also be presented.

3.7 Water Quality Considerations

Aside from cost considerations, water quality is probably the greatest concern for the user when considering a retrofit. Whether recycled water is used for irrigation, commercial/industrial applications, or impoundments, a number of constituents found in recycled water can affect its successful use. The recycled-water quality should be compared to the quality of existing potable-water supplies and evaluated as to its effect on the proposed use(s).

Table 3.4 provides a reference of major non-health related water-quality concerns by use as identified in this document. Further discussion can be found in subsequent sections.

TABLE 3.4 - NON-HEALTH RELATED WATER QUALITY CONCERNS BY USE

AREAS OF CONCERN	LANDSCAPE IRRIGATION	AGRICULTURAL IRRIGATION	COMMERCIAL & INDUSTRIAL	RECREATIONAL IMPOUNDMENTS
Salinity	•	•	•	•
pH	•	•	•	•
Corrosivity	•	•	•	
TDS	•	•	•	•
Nutrients	•	•	•	•
Boron	•	•		
Chloride	•	•	•	•
Sodium	•	•	•	•
Bicarbonate	•	•	•	
Cl_2 Residual	•	•	•	•

3.8 Site Supervisor

The site supervisor is the designated representative of the user, chosen by the user and approved by the purveyor. The site supervisor's primary responsibilities are to prevent cross connections and to serve as a single contact for the recycled-water purveyor and regulatory agencies. Ideally the site supervisor will be a full-time, on-site maintenance supervisor. As an alternate, the site supervisor may be an individual in authority and readily accessible to the recycled-water purveyor and regulatory agencies.

Qualifications

When choosing the site supervisor, the purveyor should consider the following qualities:

- intimate working knowledge of the site and its processes
- knowledge of operational and maintenance activities
- understanding of the locations where recycled-water use is approved at the use area
- authority to modify or change system operations, to prevent cross connections and protect public health
- basic understanding of cross-connection control and backflow prevention principles and practices
- understanding of state and local regulations governing use of recycled water
- availability for contact by the recycled-water purveyor or regulatory agencies within a reasonable period of time during normal working hours

Records and Signage

To function effectively, the site supervisor should have oversight responsibilities for all water-system records and signage. The site supervisor's responsibilities should include the following:

- maintain records and drawings of the water system's
    - plumbing changes
    - shutdowns
    - maintenance and repair records
    - inspections
    - testing
- maintain appropriate signage throughout the use area

Training

Training of persons working in, around, and with recycled water is essential. The site supervisor should provide ongoing training on the following:

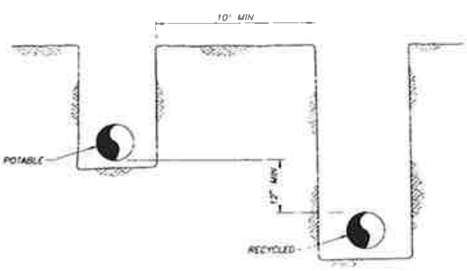
- procedures used when working with recycled water
- rules and regulations associated with recycled-water use
- basic cross-connection and backflow principles and procedures

Where there are multiple uses of recycled water (landscaping, cooling tower, industrial processes) located on-site, designation of multiple site supervisors may be necessary. However, this group of site supervisors should be under the guidance of a primary site supervisor. The primary site supervisor has the responsibility to maintain close contact with job/area-specific site supervisors and the recycled-water purveyor regarding activities associated with the use of recycled water.

3.9 System Separation

When burying recycled-water lines, separation from other potable-water systems is essential. By incorporating proper separation between potable and recycled-water lines, the potential for cross connections will be reduced.

SYSTEM SEPARATION REQUIREMENTS



SEPARATION REQUIREMENTS

The Uniform Plumbing Code (1994), Appendix J, requires a physical separation of potable and recycled-water piping systems. The following conditions apply.

- A ten-foot-wide section of soil should exist between recycled-water and potable-water piping.

- The potable-water pipe shall be installed a minimum of 12 inches above the recycled-water piping.

Figure 3.2

The 1994 Uniform Plumbing Code, Appendix J (see Appendix) requires buried recycled-water lines, intended for indoor use (such as toilet flushing), to be separated from potable-water lines by a 10-foot horizontal and 1-foot vertical distance (see Figure 3.2). Where this separation cannot reasonably be attained, a common trench installation method of separation (see Figure 3.3) may be used, but only with approval from the proper responsible agency(ies). Because the UPC does not address irrigation systems, no separation requirements exist for irrigation lines, whether under constant or intermittent pressure. This may be due, in part, to the understanding that irrigation lines are not considered to be potable-water lines.

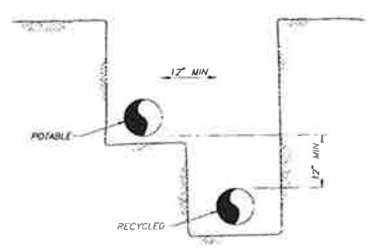
Typically, any existing piping which is retrofit to convey recycled water is not required to be separated from potable-water lines. However, local jurisdictions may require more restrictive criteria than noted in the UPC. A thorough discussion of separation issues with local authorities is recommended prior to proceeding with any retrofit project.

3.10 Backflow Prevention

Potable-Water System

The existence of an alternate water supply to a property, whether an auxiliary well supply or recycled water, increases the potential for a cross-connection with the potable-water system. Identifying recycled-water piping and conducting frequent inspections does not ensure that a cross connection will not occur. A cross-connection would result in the contamination of the potable-water system. For this reason, installation of an approved reduced-pressure-principle assembly (RP) on the potable-water service is required. Initial and annual testing of the backflow assembly is also required and must be performed by a certified AWWA CA-NV Section Backflow Prevention Assembly Tester. Annual testing will confirm that the backflow assembly's proper operational performance is maintained.

COMMON TRENCH INSTALLATION



COMMON TRENCH REQUIREMENTS

Recycled-water and potable-water piping can be laid in the same trench provided the following conditions are followed

- The bottom of the water pipe, at all joints, shall be at least twelve (12) inches above the top of the recycled-water pipe.

- The water pipe shall be placed on a solid shelf excavated at one side of the common trench with a minimum clear horizontal distance of at least twelve (12) inches from the recycled-water pipe.

Figure 3.3

In California, an exception to the above-noted requirement has been made where recycled water is used for landscape irrigation at single-family residences. In these cases, installation of an approved double-check valve assembly on the potable-water service will provide an acceptable level of backflow protection.

> **NOTE:** A double-check valve assembly may be installed below grade only when adequate drainage and access for testing and repair are provided.

Fire-Service Connection

When recycled water is plumbed inside a building having a fire-sprinkler system served from the potable-water system, backflow protection is required on the fire service. The installation of a double-check valve assembly (DCV) or double-check-detector-check valve assembly (DCDA) on the fire service will provide the minimum required protection. This backflow assembly must be tested when installed and annually thereafter by a certified AWWA Backflow Prevention Assembly Tester.

> **CAUTION**: Installation of a backflow-prevention assembly on an existing fire service may result in an increase in head loss which may alter the design characteristics of the fire system. Careful evaluation of design characteristics of the on-site fire system should be performed by a knowledgeable fire system contractor/consultant prior to installation of backflow protection. In some cases, the on-site fire system may require upgrading to accommodate additional head loss imposed by backflow protection.

Where backflow protection is not required on the fire system (i.e.,where recycled water does not enter building), installation of a backflow assembly should only be permitted if agreed to by all involved agencies (i.e., purveyor, fire department, health agencies, etc.).

Recycled Water Services

Backflow protection on recycled-water services is not addressed by any code. However, backflow protection should be considered when the potential for contamination or alteration of recycled-water quality exists (e.g., chemical injection, fertigation). Selection of appropriate backflow protection should be based on the degree of hazard presented to the recycled-water system. When backflow protection is installed on a recycled-water service, initial and annual testing should be maintained in the same manner as applied to potable-water services.

> **NOTE**: At this time there are no approved backflow assemblies for recycled-water or non-potable-water systems.

> **CAUTION**: Separate test equipment should be used to test backflow assemblies located on recycled-water services. This same test equipment must not be used to test backflow assemblies installed on potable-water services.

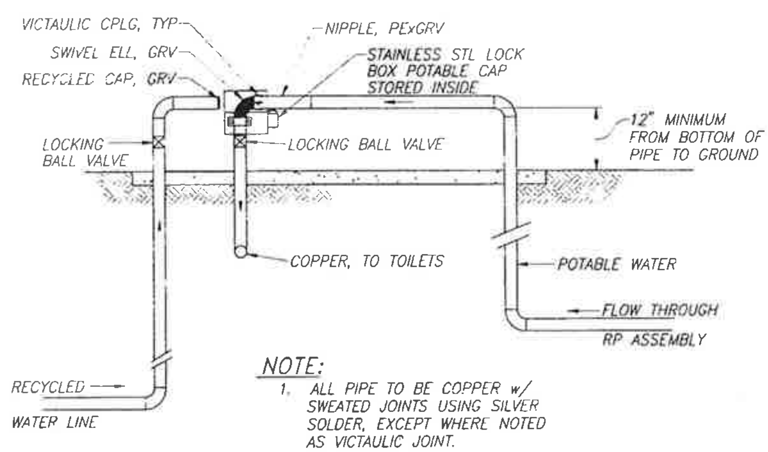
Permanent Backup Supply

Permanent backup or a supplemental potable-water make-up supply to a recycled-water system is permitted only when accomplished through the use of an air gap. No other method of protection should be used to provide a permanent potable-water backup to a recycled-water system.

Temporary Potable-Water Backup Supply

A temporary potable-water backup supply to a recycled-water system is sometimes necessary in emergency situations. These temporary connections cannot always be accomplished through the use of an air gap. In California, a swivel-ell type connection (see Figures 3.4, 3.5, and 3.6) has been approved for emergency uses, provided criteria specified by the State Health Department (Policy 95-004) is strictly adhered to and written approval is obtained from the potable-water purveyor, recycled-water purveyor, and/or local and state health agencies. Nevada regulations do not allow the use of a swivel-ell or any other form of temporary connection unless accomplished by means of an air gap. In general, the following restrictions will be applied:

- Only disinfected tertiary recycled water may be used in a swivel-ell arrangement.
- The potable-water supplier must have a state health agency approved cross-connection testing program.
- There can be only one recycled-water service connection to the recycled-water system.
- The swivel-ell must be located above ground and appropriately labeled.
- Gate valves must be locked and meters must be provided on both the potable and recycled-water service lines.
- Quarterly inspection of the swivel-ell assembly will be conducted by the potable-water purveyor.
- An RP must be installed on the potable-water backup supply upstream of the swivel-ell.
- The recycled-water and potable-water supply lines cannot approach the service riser at a 180-degree angle such that a tee could replace the swivel-ell.
- The potable-water supplier and the state health agency must be notified at least 24 hours prior to each switchover.
- The RP on the potable-water backup supply line must be tested immediately prior to the switchover.
- The switchover must be supervised by the potable-water purveyor.
- The switchover should not extend for more than 90 days.



SWIVEL ELL CONNECTION

Figure 3.4

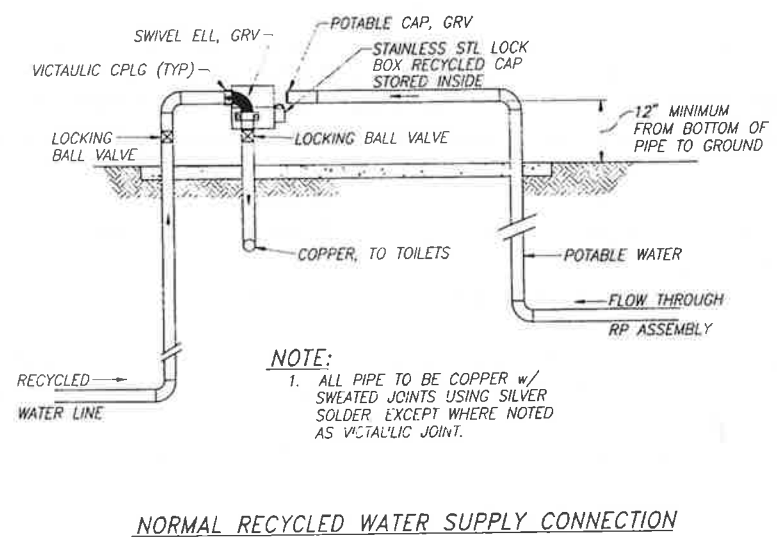


Figure 3.5

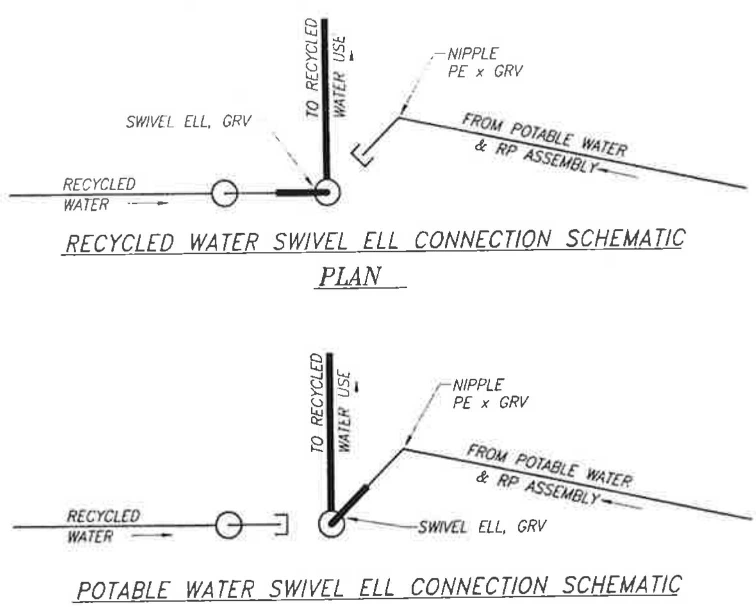
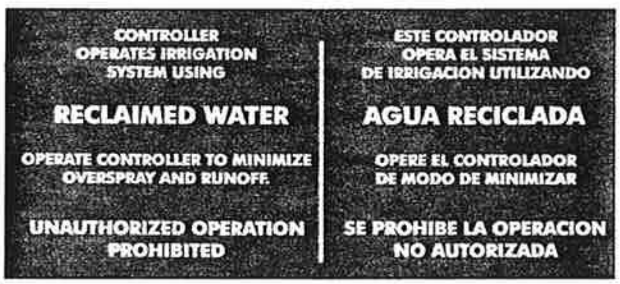


Figure 3.6

3.11 System Appurtenance Identification

Even when using disinfected tertiary recycled water, it is necessary to identify and label piping, fittings, equipment, and components associated with the use of recycled water. The color purple (Pantone 512) is the approved color for recycled water and should be used when identifying recycled-water components. New piping must be adequately identified by the use of purple PVC, or where other pipe materials are used (i.e., copper pipe), the pipe shall be labeled as specified in the Appendix to this document.

The reason for identifying appurtenances is to limit the potential for cross-connections and to eliminate the reuse of recycled-water equipment on potable-water systems. Therefore, care should be taken when requiring appurtenance identification. Appurtenances such as irrigation control valve boxes, irrigation controllers, pumps and motors, cooling towers, and other such equipment may be identified by means of signs and tags.



3.12 Signage

Conspicuous posting of signs around the use area provides continuous notification that recycled water is being used. Signs should be placed at strategic points around the use area (e.g., entrance points, specific work areas, and areas where recycled-water equipment is housed or recycled water is stored). Careful consideration should be given to sign placement depending on the size and configuration of the use area, access points, public exposure, and the general use of the area. Additional text may also be included to promote the positive aspect of using recycled water.

MINIMUM SIGN CRITERIA

Figure 3.7

Sign wording may differ according to use. Generally, irrigation signage will state that the landscape or the crop is being irrigated with recycled water, while commercial uses may suggest contacting the building management, etc. Where appropriate, signs should clearly state the purpose for which recycled water is used. California has minimum size and symbol criteria for recycled-water signs, whereas Nevada criteria specify only the posting of signs. The following requirements are for signage in California.

Irrigation

Irrigation signs shall be at least 4 inches high and 8 inches wide and as a minimum, include the wording and international symbol shown in Figure 3.7.

General Indoor Uses

The international symbol is not required on indoor signs. Uses such as cooling towers, industrial process waters, boiler make-up water, commercial laundry facilities, and sanitary fixture flushing should have signs which are specifically tailored to these uses and should present recycled-water use in a positive manner. The current major indoor uses and related sign requirements are discussed in detail below.

Restrooms

Signs used to identify the use of recycled water for toilet and urinal flushing shall be conspicuously located such that they are visible to all users. Signs shall be of a highly visible color on a contrasting background and shall have the following wording with lettering a minimum one-half inch in height.

TO CONSERVE WATER, THE RESTROOMS IN THIS BUILDING USE RECYCLED WATER IN THE TOILETS AND/OR URINALS

RESTROOM SIGN

Figure 3.8

Equipment Rooms

Signs shall be posted on equipment-room doors and on or near recycled-water equipment. Signs should be printed on a purple background (Pantone 512) and have lettering a minimum one-half inch in height with wording as in Figure 3.9. See Appendix.

CAUTION:

RECYCLED WATER
DO NOT DRINK

DO NOT CONNECT WITH THE POTABLE WATER SYSTEM

EQUIPMENT ROOM SIGN

Figure 3.9

Valve Access Doors

Access doors to valves located in walls should have signs posted inside the access door, measuring approximately six (6) inches by six (6) inches with lettering a minimum one-half inch in height. Wording should be the same as that noted for equipment rooms. Signs should be on a purple (Pantone 512) background and should be attached to the inside of the access door enclosure. See Appendix.

3.13 Inspections

The inspection process is perhaps the most important aspect of a retrofit project. For clarity, inspections are separated into the following four phases.

- Phase 1 - Initial site evaluation, conducted with representatives from the user, the health agencies, potable-water agency, recycled-water purveyor, and retrofit design team (or contractor), provides an opportunity for the parties to become familiar with the site layout, use areas, exposure concerns, water quality considerations, etc.
- Phase 2 - Review of the record drawings, when available, as an aid in identifying points of connection, piping systems, and appurtenances.
- Phase 3 - Construction inspections conducted during the retrofit process will ensure that
    - system modifications meet the recycled-water use criteria being imposed.
    - concerns noted during the initial site inspection are appropriately addressed.
    - system separation is achieved.
- Phase 4 - Final inspection of the retrofit project provides the opportunity for a complete walk-through and a review of the project. A thorough cross-connection test should be conducted to verify system separation (see Appendix for cross-connection test procedure). In addition, sign installations, backflow installations, and backflow testing must be verified. Where recycled water is used for irrigation, a thorough coverage test should also be performed.

Both the initial and construction inspections should be conducted by the recycled-water purveyor. The final inspection must be conducted by the recycled-water purveyor in the presence of a health agency representative, a certified AWWA CA-NV Section Cross-Connection Control Program - Specialist or approved equivalent, and the site supervisor. Upon successful completion of the final inspection, conditional approval may be given and the service activated.

3.14 Approval and Service Activation

Following successful completion of the final inspection, the recycled-water service can be activated. This should not be considered the final approval, however. Prior to final approval of a retrofit project, the recycled-water purveyor should conduct a review of project files to ensure that all documentation of the retrofit process has been completed. Only after receipt of 1) letters of acceptance; 2) approved and signed construction drawings, where necessary, from reviewing agencies (state health, local health, etc.); and 3) record drawings should the recycled-water service be approved.

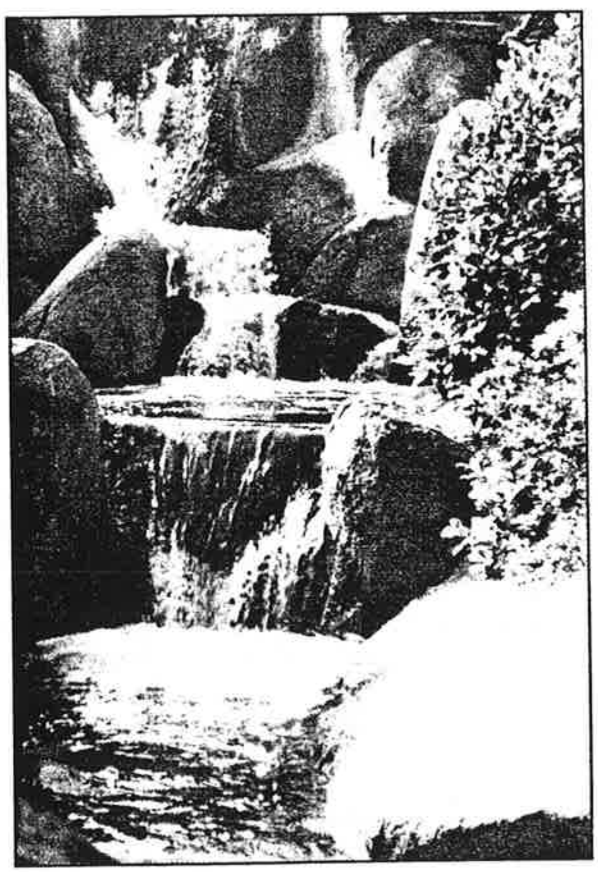
3.15 Monitoring and Reporting

Permits issued by the regulatory agency require a recycled-water purveyor to monitor the use of recycled water. The purveyor has primary responsibility to monitor use-area conditions and ensure prompt correction of any conditions which violate the permit requirements. Frequently, the purveyor will require the site supervisor to monitor conditions at a specific use area and report to the purveyor any conditions that result in violations.

It may be necessary to monitor some sites more closely than others. For example, landscape irrigation may require constant monitoring to maintain compliance with permit requirements, while agricultural users may require less frequent reviews. To assist in landscape site monitoring it is helpful to maintain irrigation system controller schedules. See Figure 3.10.

Monitoring of use areas generally works best when shared by the purveyor and the site supervisor. Reporting can occur in either of two ways: 1) the site supervisor monitors and reports problems and violations to the purveyor, who then reports to the regulatory agency; or 2) the purveyor conducts all monitoring and reporting functions. In either case, the purveyor has ultimate responsibility for monitoring and reporting. This responsibility cannot be transferred.

Records of annual testing of backflow assemblies installed at recycled-water use areas should be reviewed by the purveyor or administrative authority both for accuracy and for information regarding the working condition of the assemblies. Where a periodic or annual cross-connection test has been approved by the state health department and/or local health department, careful review and reporting of the method and results of such testing shall be forwarded to the appropriate agencies.



CONTROLLER SCHEDULE

PROGRAM TIME (HRS)					PROJECT LOCATION	CONTACT NAME
ON					CONTROLLER #	FIRM NAME
OFF					CONTROLLER LOCATION	FIRM PHONE

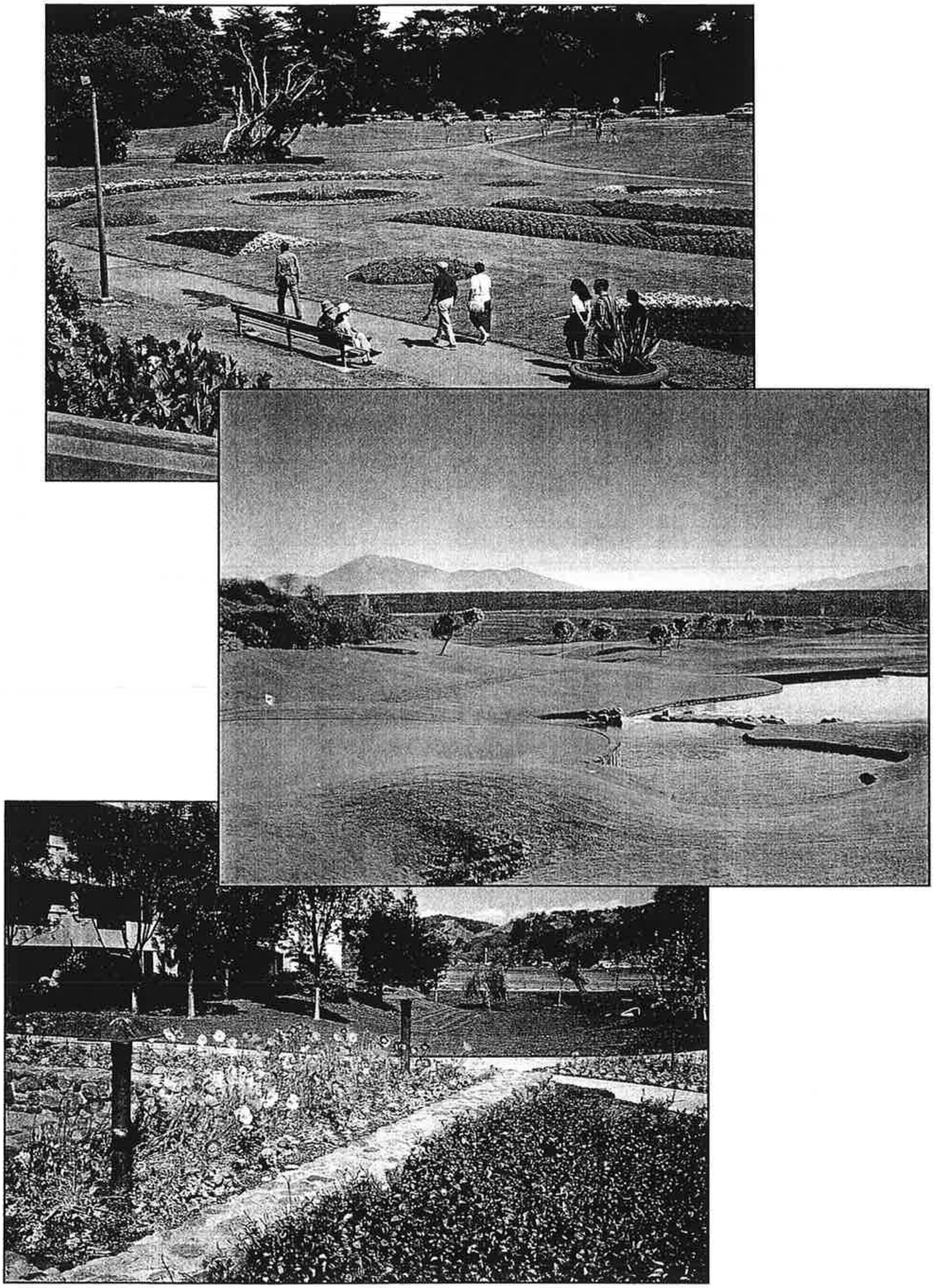
STA #	PROG 1 (MIN)	PROG 2 (MIN)	PROG 3 (MIN)	PROG 4 (MIN)	GPM PER STA	DAY OF WEEK S,M,T,W,Th,F,S	SPRINK-LER TYPE	PLANT TYPE	STATION AREA DESCRIPTION

<u>SPRINKLER TYPE</u>
S.......Spray
IMP....Impact
R.......Rotor
D.......Drip

<u>PLANT TYPE</u>
T.........Tree
Tf.......Turf
S........Shrub
GC.....Ground Cover

CONTROLLER SCHEDULE

Figure 3.10



SECTION 4

LANDSCAPE AND AGRICULTURAL IRRIGATION

Part 1 - LANDSCAPE IRRIGATION

4.1 General

Currently, more than 30% of residential water demand in the United States is for outdoor uses (Sanders and Thurow, n.d.). Of this, the majority is used for landscape irrigation. In California, however, outdoor residential use accounts for almost 45% of the total urban potable-water demand. With this in mind, it becomes clear that using recycled water to replace potable water for landscape irrigation can make a considerable contribution to current water supplies, especially in arid and semi-arid areas.

Because of the difference in quality between potable and recycled water, it is important to consider the effects on the landscape. However, lacking accurate scientifically-based information on recycled-water effects and considering the wide diversity of landscape plant materials and soils, it is extremely difficult to predict how each species will react to recycled water. Research, initiated in 1994 by the University of California at Davis, is establishing degrees of tolerance for landscape plants in relation to elevated constituent levels (e.g., salts) commonly found in recycled water. But even with this information, there can be no substitute for using sound horticultural practices, specifically in the areas of site and water management, when retrofitting a landscape to use recycled water.

4.2 Types of Recycled-Water Use

This section refers to existing landscape-irrigation sites to be retrofitted for the use of tertiary treated recycled water. Along with traditional landscape irrigation, other uses of recycled water in the landscape may include decorative ponds and streams, fountains and waterfalls, and impoundments such as water hazards on golf courses. Following are typical examples of landscape sites where recycled water is used.

- community parks and playgrounds
- school yards and athletic fields
- golf courses
- cemeteries
- freeway landscaping and street median strips
- homeowners associations (common-area landscaping)
- commercial building landscaping
- industrial complex landscaping
- churches
- residential landscaping (both front and back yards)*

* In California, considered as dual-plumbing, may be subject to greater restrictions.

4.3 Benefits of Recycled-Water Use

Benefits to be gained from the retrofit of landscape irrigation to recycled-water use are numerous, but generally fall into two categories: financial and aesthetic. Some important benefits are:

- System upgrades - Irrigation systems are generally upgraded through the retrofit process. This results in increased savings through more efficient water use and also provides a healthier and more attractive landscape.
- Leaks and breaks are discovered and repaired.
  - Water-efficient sprinkler heads may be installed.
  - Spray systems should be converted to drip.
  - Controllers or clocks should be installed or upgraded.
- There is a more reliable water supply less affected by drought concerns.
- The water supply may be lower in cost.
- Backflow prevention assemblies including vacuum breakers, which require maintenance and annual testing, can usually be removed from the irrigation systems. See Section 3.10.
- Nutrients in the recycled water can alter the kind and/or amount of fertilizers needed.

4.4 Initial Site Evaluation

Each potential retrofit site requires an initial visual inspection. This inspection familiarizes the purveyor with the site and assists in determining the feasibility of a retrofit. Some major items to consider are listed below. They include plant, soil, and irrigation system considerations.

- Determine the sensitivity of existing plants to the recycled-water quality (e.g., elevated salt levels).
- Examine the general topography.
  - Check for severe slopes which may produce runoff situations.
  - Locate storm and area drains.
  - Examine soil surface for deterioration (e.g., crusting, erosion).
  - Locate areas where water collects and ponds.
- Evaluate age and condition of irrigation system.
- Identify existing backflow protection or required backflow protection. Refer to Section 3.10 for more information on backflow requirements.
- Identify potential cross connections.
- Identify any existing water on or in close proximity to the property:
  - active and/or inactive water-piping systems
  - creeks, streams, lakes, impoundments, etc.
  - treatment systems
  - location and use of wells (irrigation or potable)
- Identify the location of drinking fountains in the use area which may require relocation or shielding from direct spray. In Nevada, all drinking-water fountains located within the irrigation site must be covered during all times of effluent reuse.
- Locate any hose bibs and/or quick couplers on the irrigation system.

4.5 Site Retrofit Considerations

As noted above in Section 4.4, it is important to consider not only plant types, but also soil conditions and methods of irrigation. Plants can vary widely, even between like species, and should be looked at closely to predetermine tolerance to the elevated salt levels typically found in recycled water. Although very little relevant information exists (other than for agricultural applications), research is currently underway to determine the effects of elevated salt levels on landscape plants, soils, and irrigation components. Until this research is complete and the data is available, Table 4.1 is supplied as a general guideline for analyzing water-quality effects on landscape plants. Although lacking the specific levels of toxicity, this table should help the user to determine which areas of plant health will be most affected when elevated salt levels are found in the irrigation water.

Soil conditions will frequently vary across a site. Therefore, soil samples should be taken and examined prior to retrofitting. Examination of the soil will assist in pinpointing soil structure, soil texture, and drainage concerns. Table 4.2 looks at the water quality effects on soil surface and physical conditions.

Careful consideration must be given to the method(s) of water application and how such method(s) will affect the landscaping. This evaluation should be performed by a landscape professional retained by either the purveyor or the user. Only after careful review of these results should any changes be made to the landscape. Following is a more detailed look at each of the previously mentioned considerations.

Landscape Plants

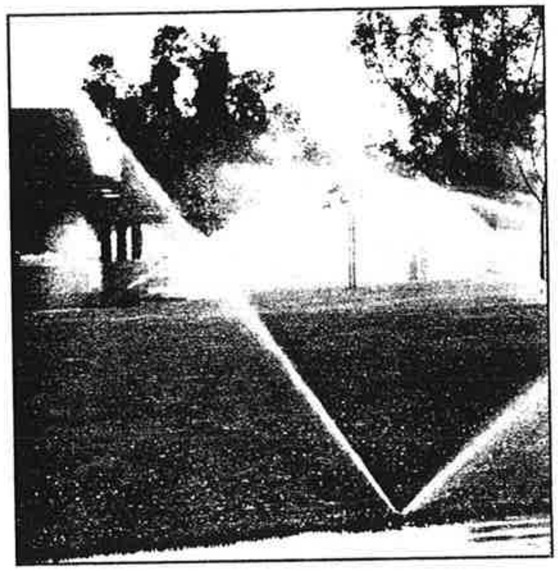
- Types of plantings - are they sensitive to elevated salt levels?
  - trees (deciduous and evergreen)
  - shrubs
  - ground covers
  - annuals and perennials
  - turf and other grasses
- What is the condition of the landscape plantings?
  - Young plants or mature?
  - Healthy or stressed?
- Hydrozones
  - Are plants of similar water needs grouped together or mixed (e.g., oak trees planted in turf)?
  - Is irrigation schedule set for highest-water-use plants, lowest, or somewhere in between?
- Spacing - Are plants spaced properly or are they crowded?

Soils

- Soil profile - Depth of the soil (topsoil, subsoil, parent material) will help to determine potential plant growth and water needs.
- Soil texture - Relative proportions of sand, silt, and clay largely determine the soil physical properties (e.g., ability to hold nutrients and water, movement of air and water, and workability).
- Soil structure - The way in which soil particles are grouped together affects moisture relationships, aeration, heat transfer, and mechanical impedance of root development.
- Soil chemical nature - pH affects nutrient availability.
- Soil management procedures
  - Tillage and amendments can improve water penetration and aeration .
  - Leaching - needed to reduce accumulated salts in root zone.
- Drainage - necessary to remove excess subsurface water.
  - Does the existing soil drain well?
  - Is artificial drainage necessary?
- Slopes - Containment of runoff and erosion are potential problems.

Irrigation System

- Method of irrigation
  - Foliar applied (overhead spray) - Constituents in recycled water may cause damage to some plants when directly contacting the leaf surface. Some commonly used spray heads are:
    - pop-up and fixed-impulse heads



- rotary and fixed-impact heads
- pop-up and fixed-spray heads
- micro spray and mist heads

- Soil applied (surface and subsurface) - Constituents in recycled-water may damage some plants when absorbed through the root structure. Some commonly used drip emitters or heads are:
  - drip (surface and subsurface) emitters
  - bubbler (flood, stream) heads

- Location and necessity of quick couplers - Quick couplers on recycled-water systems should be physically and visually different from those used on the potable-water system serving the same site. Check with the purveyor for acceptability of specific quick couplers.
  - acme thread key instead of single or double lug key
  - appropriately colored signage on top of quick coupler cap or tag around quick coupler located in valve box
- Determine location and necessity of hose bibs.
  - No hose bibs are allowed on recycled-water systems.
  - Hose bibs located on potable system within recycled-water area must be appropriately identified.
  - Hose bibs should incorporate appropriate backflow protection (e.g., hose bib vacuum breakers).
- POC(s) - Determine point(s) of connection to existing mainline.
  - Is there a separate irrigation service to the site or is it part of a combined service?
  - Are there single or multiple points of connection?
  - Any existing backflow device(s) on the irrigation system may be removed. See Section 3.13 and 4.11.
- Determine age and condition of irrigation system.
  - Determine type of hardware used in system.
  - Determine condition of hardware - is system operative?
- Determine whether there is an automatic or manual irrigation system.
  - Automatic controllers are necessary to irrigate at nighttime and to control overspray and runoff.
  - Are control valves electronically or hydraulically actuated?
  - Are sprinkler heads electronically or hydraulically actuated?
- Locate areas of overspray.
  - narrow parking and planting strips
  - oddly shaped areas
  - areas too small to contain existing sprinkler radius and/or pattern
- Locate areas of runoff.
  - slopes, berms, raised areas
  - heavily compacted areas
  - bare ground
  - areas where water hits hardscape (e.g., sidewalks)

4.6 Special Considerations

When using recycled water for landscape irrigation, consideration should be given regarding certain conditions. Following are some of the unique areas where recycled water may be permitted, but extra attention may be necessary.

- storage of recycled water in ponds or other impoundments (i.e., golf courses, lakes)
- supplemental disinfection and/or circulation/aeration
- containment of overflow and runoff, especially during rainy season
- algae control

The following may require added protection when located in a recycled-water area:

- auxiliary water sources (wells)
    - proximity to recycled-water use area
    - potential for well-water pollution
- drinking fountains within recycled-water use area where there is direct contact with irrigation spray
- designated eating areas within recycled-water use area where there is direct contact with irrigation spray

4.7 Water Quality Considerations

Evaluating recycled-water quality is essential to successful landscape management. A proper evaluation includes chemical and biological analysis of the water and determination of any potential effects on plants and soils. Table 4.3 is supplied as a practical management tool to help in the understanding of water-quality effects on plants and soils. *When using tables such as Table 4.3, however, care must be taken not to base conclusions solely on the laboratory analyses and guideline interpretations.* The guidelines are intended to cover a wide range of conditions found in landscape irrigation, but it must be made clear that several basic assumptions were used to define the range. A list of the basic assumptions used immediately follows Table 4.3.

The source of a water-quality problem can be difficult to determine precisely, as it is often the result of a combination of factors. To ensure a thorough and effective evaluation, use the major soil problem categories (salinity, infiltration, toxicity and miscellaneous problems) and look at specific factors relative to each problem area. These factors include the type and concentration of salts causing the problems; the soil/water/plant interactions affecting growth; potential long-term effects of recycled-water use; and available management procedures to prevent, correct, mitigate, or delay problems.

Salinity

Total salt content is measured as electrical conductivity (ECw) and/or total dissolved solids (TDS). Recycled waters with similar total salt contents can differ profoundly depending on the types of salts that make up the total salt content (e.g., sodium and chloride are generally more harmful to plants and soils than calcium and magnesium). Because of this it is more important to consider the types and concentrations of salts than the total salt content measurements when evaluating recycled-water quality for landscape irrigation.

- The buildup of salinity in the soil reduces the amount of soil water available to the plant, thus retarding growth. This occurs when salts accumulate to damaging levels in the root zone.

- The plant removes much of the applied water from the soil, leaving most of the salt behind. Each irrigation introduces more salt into the root zone; and over a period of time, the plant will exhibit symptoms such as stunting, leaf damage and necrosis.
- The most practical method for controlling salinity buildup in the soil is leaching (i.e., applying a sufficient amount of water to the plant to carry accumulated salts through and below the root zone).

Infiltration

The most commonly used procedure for predicting water-quality effects on the rate of water infiltration into the surface soil is to calculate the sodium adsorption ratio (SAR), which expresses the amount of sodium in relation to calcium and magnesium. Excessive sodium in irrigation water (when sodium exceeds calcium by more than a 3:1 ratio) contributes to soil dispersion and structural breakdown, where the finer soil particles fill many of the smaller pore spaces, sealing the surface and greatly reducing water infiltration rates.

Na = sodium in me/L
Ca = calcium in me/L
Mg = magnesium in me/L

$$SAR = \frac{Na}{\sqrt{(Ca + Mg)/2}}$$

An alternative procedure, calculating the adjusted sodium adsorption ratio (SARadj),considers the changes in soil water calcium concentrations which occur during or following an irrigation. These concentrations are raised by the dissolution of soil minerals into the soil water (encouraged by dilution and by carbon dioxide dissolved in the soil water) or lowered by their precipitation from the soil water (occurring from the presence of sufficient calcium along with carbonate, bicarbonate or sulphates that exceeds the solubility of calcium carbonate or calcium sulphate). It is used in place of SAR to more accurately predict potential infiltration problems due to high sodium or low calcium concentrations in the irrigation water.

Na = sodium in irrigation water in me/L
Ca_x = a modified calcium value in me/L modified due to salinity of applied water (ECw), its HCO_3/Ca ratio (HCO_3 and Ca in me/L) and the estimated partial pressure of CO_2 in the surface few millimeters of soil
Mg = magnesium in irrigation water in me/L

$$SAR\ adj = \frac{Na}{\sqrt{(Ca_x + Mg)/2}}$$

Generally, the infiltration rate increases as the salinity increases, and decreases with decreasing salinity or increasing SAR (increasing sodium content relative to calcium and magnesium). Therefore, it is important to consider these two factors together when evaluating the effect of water quality on water infiltration rates.

- Infiltration problems result from the inability of the applied water to penetrate the surface soil and replenish the soil water. Adequate soil water is necessary for sustaining plant growth between irrigations.
- Problems such as soil crusting can result from long-term use of poor-quality recycled water. In addition, the amount of water that actually enters the soil is reduced, thereby causing water stress.

- The procedures available for managing infiltration problems can be either chemical or physical. Amendments such as gypsum can be added to either the soil or the water to increase infiltration rates. When available, water supplies can sometimes be blended to reduce high SAR. Cultivation and deep-tillage methods can be employed to keep the soil open by mechanical means.

Toxicity

The toxic ions of most concern found in recycled water are sodium, chloride, and boron. Damage can occur from one or a combination of these.

- Chloride toxicity is the most common, with symptoms appearing first as leaf burn or drying of leaf tissue (usually appearing at the extreme leaf tip) and then developing into leaf drop or defoliation.
- Typical sodium toxicity symptoms are leaf burn, scorch, and dead tissue along the outside edges of leaves.
- Boron toxicity normally appears first as a yellowing, spotting, or drying of leaf tissue on older leaves at the tips and edges and then progresses toward the center.

Critically limiting (toxic) levels of these ions for ornamental plant species are currently being determined by scientific studies at U.C. Davis. In addition, many trace elements are toxic to some plants at low concentrations. Suggested maximum concentration levels for these trace elements are found in Table 4.4. These levels are based on limits established to protect soils from contamination if continuously irrigated with water which contains high levels of these elements.

- Toxicity problems occur within the plant itself and are not caused by water stress. Normally, these problems are the result of specific ions being taken up by the plant through the soil-water where they accumulate to damaging levels in the leaves.
- The long-term effect of toxicity is a reduction in overall plant growth and, if the concentrations are high enough, eventual plant dieback.
- Methods for managing a toxicity problem include leaching, selection of more tolerant plant species, changes in cultural practices (grading, installing drainage, changing fertilization practices), and blending water supplies, if an alternative water supply is available.

Miscellaneous (Several other problems are worthy of mention that do not fall into any of the preceding categories.)

- Type and concentration of salts
  - Nitrogen, in the form of nitrate (NO_3-N) and ammonium (NH_4-N), is commonly found at high concentrations in recycled-water.
  - Recycled water can also contain high levels of slightly soluble salts such as calcium, bicarbonate, and sulphate.
  - Abnormal pH values can also be found (normal range is 6.5 - 8.4).
- Soil/water/plant interactions affecting growth
  - A high concentration of nitrogen can over-stimulate plant growth causing problems such as lodging and excessive foliar growth.
  - Water containing excess calcium, bicarbonate, and sulphate can present white scale formation problems on leaves and flowers.
  - Water with a pH outside the normal range may cause a nutritional imbalance affecting plant growth and health, or it may be an indication that it contains a toxic ion.

- Long-term effects
  - With the over-stimulation of growth brought about by excess nitrogen, plants can produce weak stalks, stems, and/or branches unable to uphold the weight of the vegetation in windy or rainy conditions.
  - White scale formation reduces the aesthetic qualities of the plant and certainly the marketability. In addition, these deposits can accumulate to cause clogging of small openings in irrigation equipment such as drip emitters and spray nozzles.
  - Abnormal pH is usually not a concern with regard to soils and plants, but can be very corrosive to such appurtenances as pipelines, sprinklers, and control valves.
- Management techniques can control most of these problems.
  - Changes in the fertilization practices can correct nitrogen excesses.
  - Changing the irrigation method from foliar-applied to soil-applied can correct scale-deposit problems.
  - Substituting plastic, where applicable, for metallic irrigation components will avert corrosion problems.

TABLE 4.1 - WATER QUALITY EFFECTS ON LANDSCAPE PLANTS

Parameter (symbol)	Visual Appearance		Growth Characteristics			Method of Irrigation	
	Color	Burn	Root	Stem	Foliage	Foliar	Soil
Calcium (Ca)[1]	•	•	•	•	•	•	
Magnesium (Mg)[2]	•				•		
Sodium (Na)[3]		•	•	•	•	•	•
Carbonate (CO_3)[4]		•	•	•			
Bicarbonate (HCO_3)[5]	•	•			•	•	•
Chloride (Cl)[6]	•	•	•		•	•	•
Sulfate (SO_4)[7]	•			•	•	•	
Nitrate (NO_3)[8]	•	•		•	•		
Ammonium (NH_4)[9]	•	•		•	•		
Phosphate (PO_4)[10]	•			•	•		
Potassium (K)[11]		•	•	•	•		
Boron (B)[12]	•	•			•	•	•
Acidity/Basicity (pH)[13]	•	•	•	•	•	•	•
Sodium Adsorption Ratio - adjusted (SAR adj)[14]		•	•			•	•

1 Calcium is a structural nutrient absorbed by plants and is also essential for healthy leaf, bud, and root growth. In too high concentrations it can leave deposits on leaves via spray irrigation.
2 Magnesium is essential for photosynthesis and plant growth.
3 Sodium toxicity can result in leaf burn, scorch, and even dead tissue along outside edge of leaf. These effects can occur through both soil applied and foliar applied irrigation methods.
4 Carbonate toxicity can restrict plant growth.
5 Bicarbonate toxicity can restrict plant growth and precipitate on leaf surface leaving an unsightly white deposit..
6 Chloride toxicity can result in leaf burn, drying of leaf tissue, early leaf drop, or defoliation. Toxicity occurs through both soil applied and foliar applied irrigation methods.
7 Sulfate is essential for proper growth and maturity, but in excess can combine with calcium to form unsightly deposits on leaves.
8 Nitrate excess can cause problems such as overabundance of vegetative growth or lodging.
9 Ammonium acts much the same as nitrate.
10 Phosphate is an essential requirement for early growth and root formation.
11 Potassium is essential for plant and root growth, disease resistance, and efficient water use.
12 Boron toxicity appears on older leaf tips and edges as a yellowing, spotting, and/or drying of leaf tissue.
13 pH affects the uptake of nutrients and water.
14 SAR adj values over 9 can severely limit or in some cases stop plant growth.

References: FAO. Irrigation and Drainage paper. 29 Rev. 1.Water Quality for Agriculture, 1985
Western Fertilizer Handbook - Horticulture Edition. California Fertilizer Association, Interstate Publishers, Inc., 1990
Irrigation with Reclaimed Municipal Wastewater - A Guidance Manual. G. Stuart Pettygrove/Takashi Asano, Lewis Publishers, Inc., 1984

TABLE 4.2 - WATER QUALITY EFFECTS ON SOILS

Parameter (symbol)	Surface Conditions		Physical Conditions	
	Infiltration	Deposits	Structure	Drainage
Calcium (Ca)[1]	•	•	•	•
Magnesium (Mg)[2]	•	•	•	•
Sodium (Na)[3]	•		•	•
Carbonate (CO_3)[4]	•		•	•
Bicarbonate (HCO_3)[5]	•		•	•
Acid/Basicity (pH)[6]	•		•	•
Sodium Adsorption Ratio (SAR)[7]	•		•	•

1 Calcium allows for a friable soil that water can easily penetrate.
2 Magnesium behaves much the same as calcium.
3 Sodium attaches to clay particles. When wet, the particles bind together becoming impermeable to water. When dry, they form hard clods making the soil unworkable.
4 Carbonate reacts similarly to bicarbonate leaving an alkali sodic soil.
5 Bicarbonate reacts with calcium and magnesium, precipitating calcium from the soil as it dries, and leaving a sodium-dominant sodic soil.
6 pH affects nutrient availability, the solubility of toxic substances, and soil microorganisms.
7 SAR can help to predict the potential for a soil permeability problem.

NOTE: The following constituents do not present specific problems to soil physical properties and have been omitted from Table 4.2.

- Chloride has no substantial effect on soil except for adding to the total salt content.
- Sulphate has no substantial effect on soil except for adding to the total salt content.
- Nitrate has no significant effect on the physical properties of soil.
- Ammonium is similar to nitrate in the soil, although it reduces soil pH.
- Phosphate has no substantial effect on soil except for adding to the total salt content.
- Potassium has no substantial effect on soil except for adding to the total salt content.
- Boron has no measurable effect on the soil physical properties or soil salinity in the amounts that can be tolerated by plants.

References: FAO. Irrigation and Drainage paper. 29 Rev. 1. Water Quality for Agriculture, 1985.
Western Fertilizer Handbook - Horticulture Edition, California Fertilizer Association, Interstate Publishers, Inc., 1990.
Irrigation with Reclaimed Municipal Wastewater - A Guidance Manual. G. Stuart Pettygrove/Takashi Asano, Lewis Publishers, Inc., 1984.

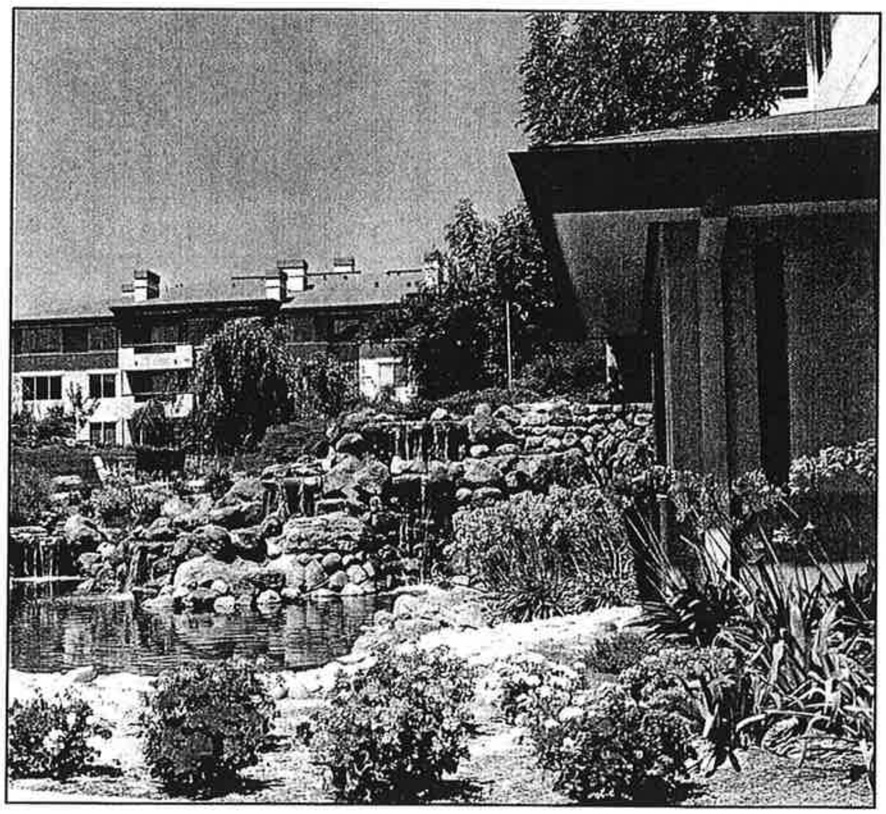


TABLE 4.3 - GUIDELINES FOR INTERPRETATIONS OF WATER QUALITY FOR LANDSCAPE IRRIGATION[1]

Potential Irrigation Problem	Units	Degree of Restriction on Use		
		None	Slight to Moderate	Severe
Salinity *(affects plant water availability)*				
EC_W	dS/m	<0.7	0.7 - 3.0	>3.0
TDS	mg/L	<450	450 - 2000	>2000
Infiltration *(SAR and EC_W affects infiltration rate of water into the soil. Evaluate using EC_W and SAR together.)*				
SAR = 0 - 3 and EC_W =		>0.7	0.7 - 0.2	<0.2
SAR = 3 - 6 and EC_W =		>1.2	1.2 - 0.3	<0.3
SAR = 6 - 12 and EC_W =		>1.9	1.9 - 0.5	<0.5
SAR = 12 - 20 and EC_W =		>2.9	2.9 - 1.3	<1.3
SAR = 20 - 40 and EC_W =		>5.0	5.0 - 2.9	<2.9
Specific Ion Toxicity *(affects sensitive plants)*				
Sodium (Na)	SAR	<3	3 - 9	>9
root absorption	me/L	<3	>3	
foliar absorption	mg/L	<70	>70	
Chloride (Cl)	me/L	<2	2 - 10	>10
root absorption	mg/L	<70	70 - 355	>355
	me/L	<3	>3	
foliar absorption	mg/L	<100	>100	
Boron (B)	me/L	<1.0	1.0 - 2.0	>2.0
Miscellaneous Effects *(affects susceptible plants)*				
Bicarbonate (HCO3)	me/L	<1.5	1.5 - 8.5	>8.5
(unsightly foliar deposits)	mg/L	<90	90 - 500	>500
pH (normal range 6.5 - 8.4)				
Residual chlorine	mg/L	<1.0	1 - 5	>5

[1] Source: Adapted from Westcot and Ayers 1984; Farnham, et al, 1985

Assumptions in the Guidelines

The water quality guidelines in Table 4.3 are intended to cover the wide range of conditions encountered in irrigated agriculture. Several basic assumptions have been used to define their range of usability. If the water is used under greatly different conditions, the guidelines may need to be adjusted. Wide deviations from the assumptions might result in wrong judgements on the usability of a particular water supply, especially if it is a borderline case. Where sufficient experience, field trials, research or observations are available, the guidelines may be modified to fit local conditions more closely.

The basic assumptions in the guidelines are:

Yield Potential: Full production capability of all crops, without the use of special practices, is assumed when the guidelines indicate no restrictions on use. A "restriction on use" indicates that there may be a limitation in choice of crop, or special management may be needed to maintain full production capability. A "restriction on use" does not indicate that the water is unsuitable for use.

Site Conditions: Soil texture ranges from sandy-loam to clay-loam with good internal drainage. The climate is semi-arid and rainfall is low. Rainfall does not play a significant role in meeting crop water demand or leaching requirement. (In a monsoon climate or areas where precipitation is high for part or all of the year, the guideline restrictions are too severe. Under the higher rainfall situations, infiltrated water from rainfall is effective in meeting all or part of the leaching requirement.) Drainage is assumed to be good, with no uncontrolled shallow water table present within 2 meters of the surface.

Methods and Timing of Irrigations: Normal surface or sprinkler irrigation methods are used. Water is applied infrequently, as needed, and the crop utilizes a considerable portion of the available stored soil-water (50 percent or more) before the next irrigation. At least 15 percent of the applied water percolates below the root zone (leaching fraction [LF] > 15 percent). The guidelines are too restrictive for specialized irrigation methods, such as localized drip irrigation, which results in nearly daily or frequent irrigations, but are applicable for subsurface irrigation if surface applied leaching satisfies the leaching requirements.

Water Uptake by Crops: Different crops have different water uptake patterns, but all take water from wherever it is most readily available within the rooting depth. On average about 40 percent is assumed to be taken from the upper quarter of the rooting depth, 30 percent from the second quarter, 20 percent from the third quarter, and 10 percent from the lowest quarter. Each irrigation leaches the upper root zone and maintains it at a relatively low salinity. Salinity increases with depth and is greatest in the lower part of the root zone. The average salinity of the soil water is three times that of the applied water and is representative of the average root zone. The average salinity of the soil water is three times that of the applied water and is representative of the average root zone salinity to which the crop responds. These condition result from a leaching fraction of 15 - 20 percent and irrigations that are timed to keep the crop adequately watered at all times.

Salts leached from the upper root zone accumulate to some extent in the lower part but a salt balance is achieved as salts are moved below the root zone by sufficient leaching. The higher salinity in the lower root zone becomes less important if adequate moisture is maintained in the upper, "more active" part of the root zone and long-term leaching is accomplished.

Restrictions on Use: The "Restrictions on Use" shown in Table 4.3 is divided into three degrees of severity: none, slight to moderate, and severe. The divisions are somewhat arbitrary since change occurs gradually and there is no clear-cut breaking point. A change of 10 to 20 percent above or below a guideline value has little significance if considered in proper perspective with other factors affecting yield. Field studies, research trials and observations have led to these divisions, but management skill of the water user can alter them. Values shown are applicable under normal field conditions prevailing in most irrigated areas in the arid and semi-arid regions of the world.

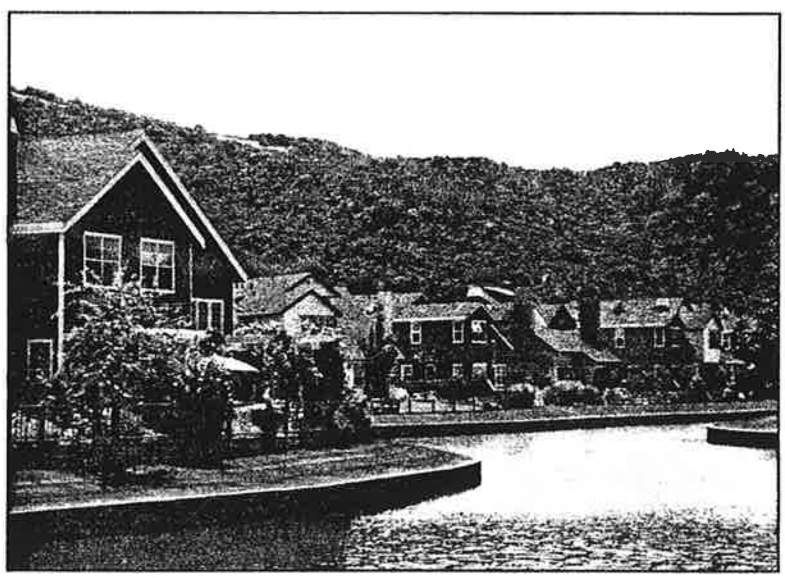


TABLE 4.4 - RECOMMENDED MAXIMUM CONCENTRATIONS OF TRACE ELEMENTS IN RECYCLED WATER[1]

Element (symbol)		Recommended Maximum Concentration[2] (mg/L)	Remarks
Aluminum	**(Al)**	5.0	Can cause non-productivity in acid (pH < 5.5), but more alkaline soils at pH > 7.0 will precipitate the ion and eliminate any toxicity.
Arsenic	**(As)**	0.10	Toxicity to plants varies widely, ranging from 12 mg/L for Sudan grass to less than 0.05 mg/L for rice.
Beryllium	**(Be)**	0.10	Toxicity to plants varies widely, ranging from 5 mg/L for kale to 0.5 mg/L for bush beans.
Cadmium	**(Cd)**	0.01	Toxic to beans, beets, and turnips at concentrations as low as 0.1 mg/L in nutrient solutions. Conservative limits recommended due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans.
Cobalt	**(Co)**	0.05	Toxic to tomato plants at 0.1 mg/L in nutrient solution. Tends to be inactivated by neutral and alkaline soils.
Chromium	**(Cr)**	0.10	Not generally recognized as an essential growth element. Conservative limits recommended due to lack of knowledge on its toxicity to plants.
Copper	**(Cu)**	0.20	Toxic to a number of plants at 0.1 to 1.0 mg/L in nutrient solutions.
Fluoride	**(F)**	1.0	Inactivated by neutral and alkaline soils.
Iron	**(Fe)**	5.0	Not toxic to plants in aerated soils, but can contribute to soil acidification and loss of availability of essential phosphorus and molybdenum. Overhead sprinkling may result in unsightly deposits on plants, equipment and buildings.
Lithium	**(Li)**	2.5	Tolerated by most crops up to 5 mg/L; mobile in soil. Toxic to citrus at low concentrations (<0.075 mg/L). Acts similarly to boron.
Manganese	**(Mn)**	0.20	Toxic to a number of crops at a few tenths to a few mg/L, but usually only in acid soils.
Molybdenum	**(Mo)**	0.01	Not toxic to plants at normal concentrations in soil and water. Can be toxic to livestock if forage is grown in soils with high concentrations of available molybdenum.
Nickel	**(Ni)**	0.20	Toxic to a number of plants at 0.5 to 1.0 mg/L; reduced toxicity at neutral or alkaline pH.
Lead	**(Pd)**	5.0	Can inhibit plant cell growth at very high concentrations.
Selenium	**(Se)**	0.02	Toxic to plants at concentrations as low as 0.025 mg/L and toxic to livestock if forage is grown in soils with relatively high levels of added selenium. An essential element to animals, but in very low concentrations.
Tin	**(Sn)**	---	Effectively excluded by plants; specific tolerance unknown.
Titanium	**(Ti)**	---	
Tungsten	**(W)**	---	
Vanadium	**(V)**	0.10	Toxic to many plants at relatively low concentrations.
Zinc	**(Zn)**	2.0	Toxic to many plants at widely varying concentrations; reduced toxicity at pH > 6.0 and in fine textured or organic soils.

1 Adapted from the National Academy of Sciences (1972) and Pratt (1972).

2 The maximum concentration is based on a water application rate which is consistent with good irrigation practices (10,000 m^3 per hectare per year). If the water application rate greatly exceeds this, the maximum concentrations should be adjusted downward accordingly. No adjustment should be made for application rates less than 10,000 m^3 per hectare per year. The values given are for water used on a continuous basis at one site.

4.8 System Separation

As noted in Section 3.9 and in the Appendix, separation requirements do not apply to recycled-water irrigation piping located in the vicinity of potable-water piping. Irrigation piping intended to convey recycled water must be physically disconnected from existing potable-water piping points of connection. Separation must be verified by a cross-connection test. In addition, when irrigating with recycled water, the following apply:

- No irrigation shall take place within 50 feet of any potable-water supply well.
- No impoundment of disinfected tertiary recycled water shall occur within 100 feet of any domestic-water well.
    - Geological investigation indicates that an aquitand exists at the well between the uppermost aquifer from which water is being drawn and the ground surface.
    - The well contains an annular seal extending from the surface into the aquitand.
    - The well is housed to prevent recycled-water contact.
    - The ground surface contours away from the well head.
    - Owner of well approves elimination of buffer-zone requirements.

4.9 System Appurtenance Identification

Components of a recycled-water irrigation system should be identified with appropriate signage or marking to notify those working on or using the system as to the source of the water being used. The water purveyor should specify those appurtenances which require marking, including:

- storage tanks/ponds
- meters
- valve boxes and valves
- automatic controllers
- quick couplers
- pumps

4.10 Signage

Signs should be located at points where the public may enter the use area. Potable-water facilities in close proximity to the recycled-water system should also be identified (e.g., hose bibs). See Figures 4.1 through 4.5 for examples of signs.

4.11 Inspections

To ensure the success of the retrofit, inspections are conducted throughout every phase of the retrofit process. Following are some of the major areas of concern that should be addressed during these inspections.

- Overspray and runoff should be identified and minimized by necessary alterations.
- Existing potable POCs to be eliminated should be inspected and recorded before being buried or covered.
- All backflow protection may be removed from the irrigation system, unless required by the purveyor. See Section 3.10.
- Hose bibs and unnecessary quick couplers should be removed and capped or plugged.
- Purple pipe and/or taping should be inspected before it is buried or covered.
- A thorough cross-connection test must be performed.

- All backflow prevention requirements on potable-water service(s) should be completed. before activating recycled-water service. Backflow assemblies should be tested and in proper working condition.

IRRIGATION SIGN

Figure 4.1

IRRIGATION SIGN

Figure 4.2

IRRIGATION SIGN

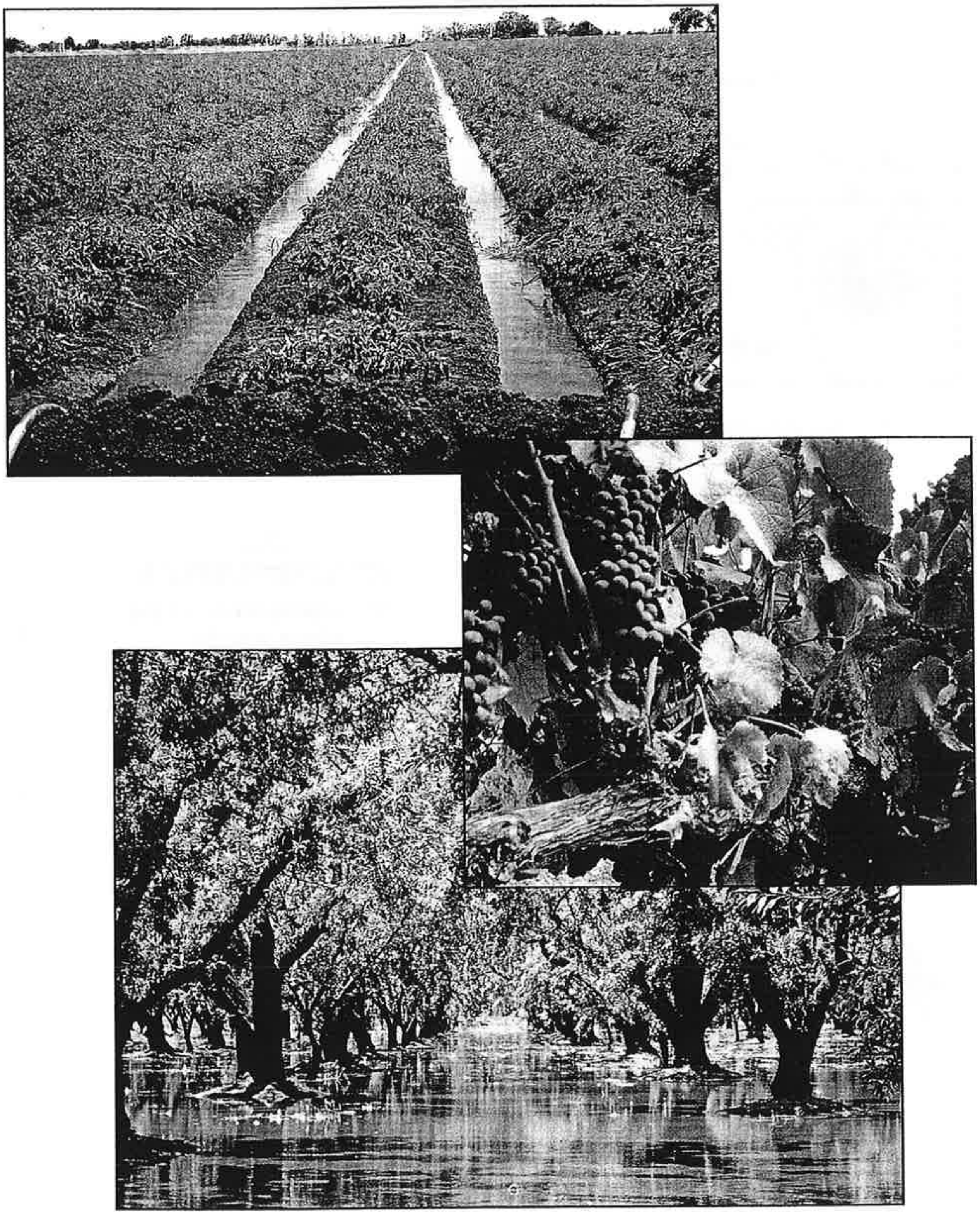
Figure 4.3

IRRIGATION SIGN

Figure 4.4

IRRIGATION SIGN

Figure 4.5



Part 2 - AGRICULTURAL IRRIGATION

4.12 General

Agricultural irrigation is estimated to use 40% of the total water demand for the United States (Solley et al., 1988). In California, 80% - 85% of the total water demand is used for agricultural purposes (irrigation, drinking water for livestock and poultry, general maintenance). Of these, irrigation is by far the largest single use. Considering this tremendous volume of water, it is easy to see how great an impact the use of recycled water for agricultural irrigation could have on the overall water supply picture.

4.13 Types of Recycled-Water Use

Disinfected tertiary recycled water can be used for the irrigation of production crops, commercially raised fish and shellfish, and as drinking water for animals. Lesser qualities of recycled water can be used for limited agricultural applications, when available (see Table 3.1). Agricultural applications include the irrigation of food crops where recycled-water directly contacts the edible portion of the crop (including edible root crops, fish and shellfish); irrigation of nursery stock (trees, shrubs, ground covers, and turf); drinking water for livestock and poultry; and the wash-down of holding pens and other farm-maintenance uses. Listed below are some typical agricultural uses for recycled water.

- commercial farms
  - field crops (e.g., barley, cotton, sugarbeet, wheat, rice)
  - vegetable crops (e.g., squash, beet, broccoli, tomato, lettuce)
  - forage crops (e.g., wheatgrass, ryegrass, clover, alfalfa)
  - orchards and fruit crops (e.g., date, almond, blackberry, strawberry)
  - avocado and citrus groves
  - vineyards
  - christmas tree farms
  - sod farms
- nurseries
- greenhouses
- ranches
  - pasture land for livestock and poultry
  - holding pens
- aquaculture farms (e.g., fish and shellfish)
- community vegetable gardens

4.14 Benefits of Recycled-Water Use

Beyond the more apparent benefit of conserving the potable-water supply, benefits to the agricultural user when converting to recycled water (see Section 3.2) may not be as obvious as those benefits associated with other uses. For instance, the user may ultimately obtain a water supply of better quality than that currently being used. More importantly, in areas where drought or dwindling water supplies are a concern, recycled water may prove to be a more reliable water source and much less difficult to obtain politically and environmentally.

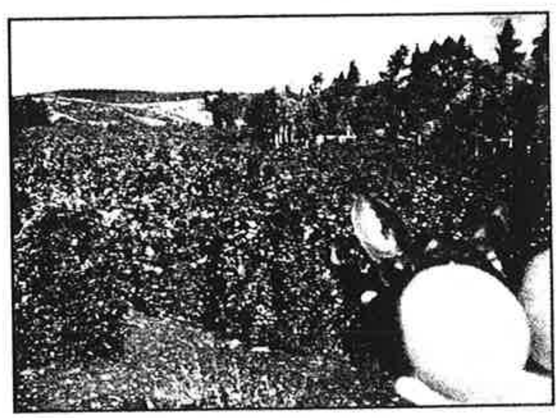
4.15 Initial Site Evaluation

A preliminary evaluation of the site is necessary to assess the feasibility of retrofitting the property to use recycled water. It should determine the type of crop(s) used on the site, any associated agricultural processes on site, method(s) of irrigation, general topography, and location of water sources on and/or adjacent to the potential retrofit property. Some important components of the initial site evaluation are:

- Identify crops produced and their sensitivity to irrigation water with elevated salt levels.
- Locate auxiliary water sources (active or inactive).
  - potable and/or irrigation wells
  - storage reservoirs and ponds
  - tailwater reuse systems
  - groundwater aquifers
- Examine general topographical layout.
  - Identify areas where water may collect and pond.
  - Identify areas of erosion.
  - Examine existing soil conditions.
- Identify site conditions affecting discharge.
  - direction, depth, and means of overall site drainage
  - rivers, streams, creeks, and/or other bodies of water (e.g., aquifers, holding ponds) on or near the site
  - use and identity of fertilizers, pesticides, and/or herbicides used on site
  - location of drainage channels and their point of discharge
- Identify and discuss adjacent land uses.

4.16 Site Retrofit Considerations

When considering recycled water for agricultural uses, a wide variety of factors must be carefully examined, including but not limited to crop type, soil conditions, method(s) of irrigation, and the cultural practices currently in use.



Crop type

Crop types vary in their response to certain toxicity problems. Levels have been established showing tolerance to sodium, chloride, and boron; but little information is available with respect to other toxic ions. Tables showing these levels can be found in *FAO Irrigation and Drainage Paper 29 Rev. 1*. Even with these established levels, it should be remembered that certain factors may alter their effect on the crop. The following factors are the most important of these to consider.

- Climate - affects the amount of water to apply.
- Irrigation management - applying the correct amount of water at the appropriate time reduces toxicity and improves yields.
- Leaching fraction - the amount of water necessary to reduce and control accumulation of toxicity in root zone.
- Drainage - necessary to control toxicity build-up in soil.
- Growth stage of the crop determines cultural practices to employ.
- Crop maturity date also determines cultural practices to employ.

Soils

The most common soil problems related to water quality are salinity, water infiltration rate, toxicity, and a group of miscellaneous problems (e.g., high nitrogen concentration, unsightly deposits on fruit and leaves, nutrient uptake deficiency).

- Salinity - Soils irrigated with recycled water will contain a mixture of naturally occurring salts. These salts will accumulate with each irrigation dependent upon:
  - water quality (salinity level of applied irrigation water)
  - irrigation management (degree to which accumulated salts have been leached below the root zone)
  - adequacy of drainage (to remove salty subsurface water)

  This build-up of soil salinity can reduce the amount of water available to the crop, thus reducing yields, by the following three ways.
  - osmotic effects (plant expends excessive energy adjusting salt concentrations within its own tissues so that it may obtain needed water from the soil.)
  - specific ion toxicity effects (adverse effects due to excessive concentrations of toxic ions, e.g., sodium, chloride, boron, bicarbonate)
  - poor soil physical-condition effects - resulting in crusting, water-logging, poor permeability
- Infiltration - Problems can occur when water remains on the surface too long or penetrates too slowly to supply sufficient water for maintaining acceptable crop yields. Some of these problems are soil crusting, poor seedling emergence, lack of aeration, plant and root diseases, and the need for weed and mosquito control. The infiltration rate can be affected by any or all of the following means.
  - water quality (see Section 4.18)
  - soil structure (clay soils do not accept water readily)
  - degree of compaction (surface compaction reduces infiltration)
  - organic matter content (improves water penetration)
  - soil chemical make-up (Low salinity or excessive sodium/SAR problems can be corrected by the addition of chemical amendments, such as gypsum).
- Toxicity - Problems can occur when certain constituents in the soil or water are taken up by the plants and accumulate in high enough concentrations to cause crop damage or a reduction in crop yield. The principal constituents of concern are chloride, sodium, and boron.
- Miscellaneous problems - Several other soil problems related to water quality such as excessive nitrogen concentrations, scale deposit build-up, and abnormal pH are also concerns. They are discussed more fully in Section 4.18.

Method of irrigation

- Sprinkler irrigation systems (pressurized) - used for corn, soybeans, vegetables, grain, potatoes, alfalfa, nut trees, nurseries, pastures, and turf. Some common types of sprinkler irrigation are:
  - hand move - used for orchards, pastures, grain fields, alfalfa fields, vineyards, and low-growing field crops
  - wheel roll - used for all crops less than three feet high
  - stationary (permanent set/solid set) - can be used anywhere
  - side roll
  - wheel line

- mechanized
  - center pivot (rotates around a center pivot) - used for all crops except trees
  - lateral move (travels back and forth over a field) - used for all crops except trees
- Drip/micro irrigation (pressurized) - used for citrus, grapes, tomatoes, vegetables, sugar cane, nut crops, deciduous fruits, nurseries, strawberries, and pineapples
  - micro
  - drip surface - used for orchards, vineyards, vegetables, and nursery plants
  - drip subsurface
  - trickle
  - micro-spray
- Gravity irrigation systems (basin, flood, valved pipe, pulse, reel, seepage, siphon tube, and flat-lay pipe) - used for corn, grains, soybeans, cotton, alfalfa, sorghum, rice, pastures, peanuts, and sugar beets
  - level and graded furrow - used for vegetables, row crops, orchards, and vineyards
  - graded border (narrow and wide) - used for pastures, grain fields, alfalfa fields, vineyards, and orchards
  - level border - used for grain fields, field crops, rice, and orchards

Cultural Practices

Cultural practices affect all aspects of the plant/soil/water relationship. They are used to control water and soil problems and ultimately to increase crop yield. Following are some of the major cultural practices used in agriculture to address specific problems that may be encountered. Many of these are discussed in more detail in Section 4.18.

- Salinity problems
  - leaching salts past the root zone
  - adequate drainage to allow for leaching
  - crop selection to more tolerant crop
  - land smoothing or grading for uniform water distribution
  - irrigation timing to prevent water stress
  - placement of seed to enhance germination
  - timing, placement and amount of fertilization
  - changing method of irrigation to eliminate direct contact with leaf surface
  - deep cultivation to enhance percolation of applied water
  - changing or blending water supplies
- Infiltration problems
  - soil and water amendments
  - blending water supplies
  - cultivation and deep tillage to keep the soil open
  - organic residue distribution to improve water penetration
  - irrigation management
- Toxicity problems
  - leaching toxic ions past root zone
  - crop selection to a more tolerant crop
  - land grading for better control and distribution of applied water
  - soil profile modification for better control and distribution of applied water
  - artificial drainage where natural drainage is inadequate
  - fertilization modification
  - soil and water amendments
  - blending water supplies
  - changing irrigation method for crops sensitive to overhead spray

  - irrigation management
- Miscellaneous problems
  - blending water supplies
  - denitrification to remove excess nitrogen from water supply
  - fertilization modification compatible with growth stage of crop
  - soil and water amendments
  - equipment selection where corrosion is a concern
  - irrigation management

4.17 Special Considerations

Each agricultural site and application may present a variety of conditions which require considerations not normally associated with an agricultural use. Some of the more important factors to consider include:

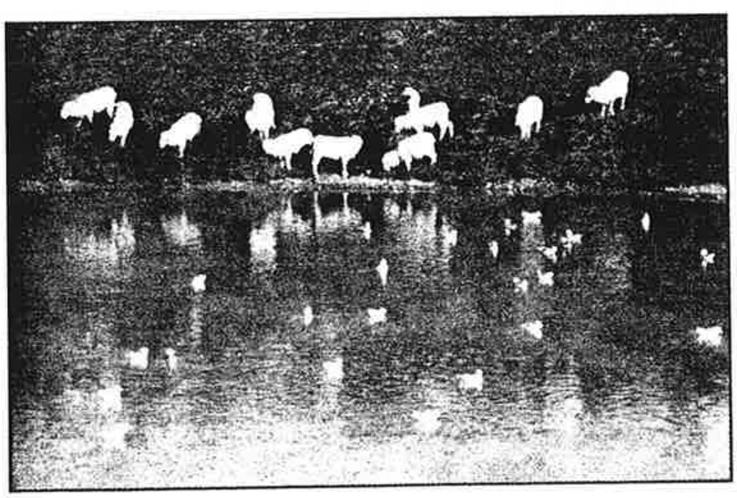
- Recycled-water storage
  - reservoirs
  - tanks
- Tailwater return system - contains runoff of recycled water from the site via reservoir, pump, and return pipeline.
  - Runoff controls are required to prevent discharge.
  - National Pollutant Discharge Elimination System (NPDES) permit may be required for discharge to a surface water.
- Auxiliary water sources
  - groundwater aquifers
  - wells
- Environmental concerns
  - Creeks, streams, rivers, and ponds
  - Wetlands
  - Vernal pools
  - Inappropriate watering of drought-tolerant native species (e.g., oak trees)
- Location within a flood plain
- Supplying a potable-water source (e.g., drinking, washing, etc.)
- Picnic tables and benches
- Fertilization practices
  - Adjustments should be made to compensate for the elevated levels of constituents in recycled water (e.g., nitrate, calcium, magnesium).
  - Pruning and/or training techniques may be implemented to compensate for excessive growth (e.g., excessive foliar growth in grape growing).
- Drinking water for livestock
  - Generally, waters with a salinity of <1.5 ECw (dS/m) are safe and usable for all classes of livestock and poultry. This assumes that there are no specific ion toxicity levels that would be harmful.
  - Suggested limits for levels of toxic substances in livestock drinking water are available from the National Academy of Sciences. See Table 4.5.
- Water used for the commercial production of fish and shellfish may require additional on-site treatment (e.g., pH control, dechlorination).

TABLE 4.5 - GUIDELINES FOR LEVELS OF TOXIC SUBSTANCES IN LIVESTOCK DRINKING WATER[1]

Constituent (symbol)	Upper Limit (mg/L)
Aluminum (Al)	5.0
Arsenic (As)	0.2
Beryllium (Be)[2]	0.1
Boron (B)	5.0
Cadmium (Cd)	0.05
Chromium (Cr)	1.0
Cobalt (Co)	1.0
Copper (Cu)	0.5
Fluoride (F)	2.0
Iron (Fe)	not needed
Lead (Pb)[3]	0.1
Manganese (Mn)[4]	0.05
Mercury (Hg)	0.01
Nitrate + Nitrate (NO_3-N + NO_2-N)	100.0
Nitrate (NO_2-N)	10.0
Selenium (Se)	0.05
Vanadium (V)	0.10
Zinc (Zn)	24.0

1 Adapted from the National Academy of Sciences
2 Insufficient data for livestock. Value for marine aquatic life is used here.
3 Lead is accumulative and problems may begin at a threshold value of 0.05 mg/L.
4 Insufficient data for livestock. Value for human drinking water used.

References: FAO. Irrigation and Drainage paper. 29 Rev. 1. Water Quality for Agriculture, 1985.



4.18 Water Quality Considerations

As with landscape irrigation, evaluating recycled-water quality is essential to the implementation of sound agricultural management practices. Refer to Section 4.7 for evaluation criteria. Table 4.6 is provided as a management tool, specific to agriculture, for help in understanding the water-quality related effects on crops and soils. In addition to the information found in Section 4.7, examination of the following factors is recommended.

Salinity

The level of recycled-water salinity affects the build-up of salinity in the soil. It is necessary to supply the crop with adequate and timely amounts of water to avoid yield losses caused by water stress. The crop removes much of the applied water from the soil but leaves most of the salt behind where it concentrates with each irrigation. Excessive salt build-up in the root zone can reduce the water available to the crop and result in reduced crop yield.

Salinity effects closely resemble drought effects which cause water stress to the plant and reduced growth. Over a period of time, high salinity can result in:

- stunting
- leaf damage
- necrosis
- obvious injury to the plant
- reduced or slowed germination

Several salinity-control management options are available for maintaining acceptable crop yields. These options can be separated into long-term and short-term cultural practices.

- Long-term salinity build-up can be managed by:
  - adequate drainage
  - leaching to within the tolerance of the crop
  - changing to a more salt-tolerant crop
  - changing the method of irrigation
- Short-term or temporary salinity build-up can be managed by such practices as:
  - increasing the frequency of irrigation to reduce water stress
  - land grading for uniform water distribution
  - timing of fertilization
  - methods of seeding

Infiltration

Excessive sodium in the irrigation water promotes soil dispersion and structural break-down when the sodium level exceeds the calcium level by more than a three-to-one ratio. In sufficient quantity, calcium acts to counter the dispersing effects of sodium. An infiltration problem occurs when the surface soil disperses, plugging and sealing the surface pores. Water is unable to penetrate the surface to replenish the soil water needed by the crop. This results in a reduction of available water to the crop, soil crusting, poor seedling emergence, lack of aeration, plant and root diseases, and weed and mosquito control problems. As with landscape irrigation, the methods for managing infiltration problems can be either chemical or physical.

- Chemical practices include:
  - addition of amendments which supply calcium to the soil, either directly (gypsum) or indirectly (sulphur)

    - blending of two or more water supplies, when available
- The most common physical practices for keeping the soil open are:
    - cultivation
    - deep tillage
    - working organic residues back into the soil

It has proven most effective to combine both the chemical and physical methods to manage infiltration problems, but these methods can be even further enhanced by the use of specific irrigation practices such as:

- more frequent irrigation
- pre-plant irrigation
- longer irrigation times
- changing the method of irrigation

Toxicity

A toxicity problem normally occurs when specific ions are taken up by the plant with the soil water and accumulate in the leaves during transpiration to concentrations that damage the plant. The most common toxic ions are chloride, sodium, and boron. Damage is caused by each ion individually or in combination with the others. For more detailed information see Section 4.7.

Crops vary in their sensitivity to toxic ions. Most annual crops are not sensitive at the concentrations shown in Table 4.6, but many of the tree crops and woody perennial-type plants do fall within these limits. Symptoms of toxicity can appear on any crop, however, if the concentrations are high enough. Often, toxicity problems appear along with salinity or infiltration problems, making it difficult to define precisely.

The extent to which crops are damaged depends upon:

- length of time exposed to the toxic ions
- concentrations of the toxic ions
- crop sensitivity
- crop water used

Severe toxicity problems result in crop yield reduction. Overhead sprinkling can also cause toxicities to sensitive crops through direct leaf absorption of sodium and chloride. Extreme cases can result in severe leafburn and defoliation.

Management of toxicity problems includes:

- leaching
- changing of crop selection
- changing cultural practices
- blending of water supplies

Leaching can correct sodium, chloride, and boron toxicity; but when depth of water required becomes excessive, a change in crop selection may be more beneficial. Minor toxicity problems can often be corrected by better controlling and distributing the water by means of:

- land grading
- profile modification
- artificial drainage

Methods for managing overhead-sprinkler damage include:

- irrigating at night
- avoiding periods of high wind when irrigating
- controlling sprinkler drift
- increasing sprinkler rotation
- increasing rate of application
- changing irrigation method
- increasing droplet size
- selection of different crop
- planting during cooler seasons

Miscellaneous

Problems can also be caused by:

- excess nitrogen
- abnormal pH
- high levels of calcium, bicarbonate, and sulphate
- excessive quantities of trace elements

Plant growth can be affected in the following ways.

- Excessive quantities of nitrogen can over-stimulate crop growth, delay maturity, or produce poor quality.
- Although not a problem by itself, abnormal pH may indicate ion toxicity in the water or it may cause a nutritional imbalance in the plant/soil/water relationship. The greatest hazard may be to irrigation equipment (e.g. ,corrosion).
- High proportions of calcium, bicarbonate and sulphate can form white scale deposits on leaves and fruit when overhead spray is used.
- Some trace elements in high concentrations can accumulate in plant tissue causing a reduction in growth.

Some of the long-term effects are noted below.

- High nitrogen concentrations can reduce quality and quantity, thus affecting marketability and storage life.
- High nitrogen can also cause excessive vegetative growth, producing weak stalks which result in severe lodging and machine-harvesting problems.
- Nitrogen sensitivity varies with the developmental stage of the crop and may be beneficial during growth stages but cause yield losses during flowering/fruiting stages.
- Another effect of nitrogen is the stimulation of algae growth in streams, lakes, canals, and drainage ditches. Algae growth can also result in plugged valves, pipelines, and sprinklers.
- Excessive nitrogen applications to pastures may be hazardous to livestock.
- Scale deposits, although non-toxic, reduce the marketability of fruit and foliage.
- Effects of trace element toxicity can be found in Table 4.4.

TABLE 4.6 - GUIDELINES FOR INTERPRETATIONS OF WATER QUALITY FOR AGRICULTURAL IRRIGATION[1]

Potential Irrigation Problem	Units	Degree of Restriction on Use		
		None	Slight to Moderate	Severe
Salinity *(affects plant water availability)*				
EC_w	dS/m	<0.7	0.7 - 3.0	>3.0
TDS	mg/L	<450	450 - 2000	>2000
Infiltration *(SAR and EC_w affects infiltration rate of water into the soil. Evaluate using EC_w and SAR together.)*[2]				
SAR = 0 - 3 and EC_w =		>0.7	0.7 - 0.2	<0.2
SAR = 3 - 6 and EC_w =		>1.2	1.2 - 0.3	<0.3
SAR = 6 - 12 and EC_w =		>1.9	1.9 - 0.5	<0.5
SAR = 12 - 20 and EC_w =		>2.9	2.9 - 1.3	<1.3
SAR = 20 - 40 and EC_w =		>5.0	5.0 - 2.9	<2.9
Specific Ion Toxicity *(affects sensitive crops)*				
Sodium (Na)				
surface irrigation	SAR	<3	3 - 9	>9
sprinkler irrigation	me/L	<3	>3	
Chloride (Cl)				
surface irrigation	me/L	<4	4 - 10	>10
sprinkler irrigation	me/L	<3	>3	
Boron (B)	mg/L	<0.7	0.7 - 3.0	>3.0
Trace Elements (see Table 4.4)				
Miscellaneous Effects *(affects susceptible crops)*				
Nitrogen (NO_3-N)	mg/L	<5	5 - 30	>30
Bicarbonate (HCO_3) *(overhead sprinkling only)*	mg/L	<1.5	1.5 - 8.5	>8.5
pH (normal range 6.5 - 8.4)				

[1] Source: Adapted from Westcot and Ayers 1984; Farnham, et al, 1985

[2] At a given SAR, the infiltration rate increases as water salinity increases. Evaluate the potential infiltration problem by SAR as modified by ECw. Adapted from Rhoades 1977, and Oster and Schroer 1979.

Assumptions in the Guidelines

The water quality guidelines in Table 4.6 are intended to cover the wide range of conditions encountered in irrigated agriculture. Several basic assumptions have been used to define their range of usability. If the water is used under greatly different conditions, the guidelines may need to be adjusted. Wide deviations from the assumptions might result in wrong judgements on the usability of a particular water supply, especially if it is a borderline case. Where sufficient experience, field trials, research or observations are available, the guidelines may be modified to fit local conditions more closely.

The basic assumptions in the guidelines are:

Yield Potential: Full production capability of all crops, without the use of special practices, is assumed when the guidelines indicate no restrictions on use. A "restriction on use" indicates that there may be a limitation in choice of crop, or special management may be needed to maintain full production capability. A "restriction on use" does not indicate that the water is unsuitable for use.

Site Conditions: Soil texture ranges from sandy-loam to clay-loam with good internal drainage. The climate is semi-arid and rainfall is low. Rainfall does not play a significant role in meeting crop water demand or leaching requirement. (In a monsoon climate or areas where precipitation is high for part or all of the year, the guideline restrictions are too severe. Under the higher rainfall situations, infiltrated water from rainfall is effective in meeting all or part of the leaching requirement.) Drainage is assumed to be good, with no uncontrolled shallow water table present within 2 meters of the surface.

Methods and Timing of Irrigations: Normal surface or sprinkler irrigation methods are used. Water is applied infrequently, as needed, and the crop utilizes a considerable portion of the available stored soil-water (50 percent or more) before the next irrigation. At least 15 percent of the applied water percolates below the root zone (leaching fraction [LF]> 15 percent). The guidelines are too restrictive for specialized irrigation methods, such as localized drip irrigation, which results in nearly daily or frequent irrigations, but are applicable for subsurface irrigation if surface applied leaching satisfies the leaching requirements.

Water Uptake by Crops: Different crops have different water uptake patterns, but all take water from wherever it is most readily available within the rooting depth. On average about 40 percent is assumed to be taken from the upper quarter of the rooting depth, 30 percent from the second quarter, 20 percent from the third quarter, and 10 percent from the lowest quarter. Each irrigation leaches the upper root zone and maintains it at a relatively low salinity. Salinity increases with depth and is greatest in the lower part of the root zone. The average salinity of the soil water is three times that of the applied water and is representative of the average root zone. The average salinity of the soil water is three times that of the applied water and is representative of the average root zone salinity to which the crop responds. These condition result from a leaching fraction of 15 - 20 percent and irrigations that are timed to keep the crop adequately watered at all times.

Salts leached from the upper root zone accumulate to some extent in the lower part but a salt balance is achieved as salts are moved below the root zone by sufficient leaching. The higher salinity in the lower root zone becomes less important if adequate moisture is maintained in the upper, "more active" part of the root zone and long-term leaching is accomplished.

Restrictions on Use: The "Restrictions on Use" shown in Table 4.6 is divided into three degrees of severity: none, slight to moderate, and severe. The divisions are somewhat arbitrary since change occurs gradually and there is no clear-cut breaking point. A change of 10 to 20 percent above or below a guideline value has little significance if considered in proper perspective with other factors affecting yield. Field studies, research trials and observations have led to these divisions, but management skill of the water user can alter them. Values shown are applicable under normal field conditions prevailing in most irrigated areas in the arid and semi-arid regions of the world.

Some commonly used management practices for miscellaneous toxicity problems are :

- nitrogen problems
  - modification of nitrogen fertilizer application
  - blending water supplies during critical growth stages
  - crop rotation
  - screens, filters, or chemical control (e.g., copper sulphate) to minimize algae growth.
  - denitrification (the cost is usually prohibitive)
- pH problems
  - Unless there is pH control on the water system, it may be easier to correct the pH problem by the addition of soil amendments (common amendments are lime for low pH and sulphur for high pH).
- scale-deposit problems (cost can be prohibitive)
  - adding an acid material to the water supply
  - irrigating at night
  - increasing the speed of sprinkler rotation or using spray heads
  - decreasing the frequency of irrigation
  - changing the method of irrigation to keep water off fruit and foliage.

For more information regarding water-quality effects on plants and soils, refer to Tables 4.1 and 4.2.

4.19 System Separation

Recycled-water piping and appurtenances must be kept completely separate from potable-water systems.

- Potable make-up water, when used, must be delivered through an air-gap.
- No irrigation with recycled water shall take place within 50 feet of a domestic-water well unless the following conditions have been met:
  - Geological investigation indicates that an aquitand exists at the well between the uppermost aquifer from which water is being drawn and the ground surface.
  - The well contains an annular seal extending from the surface into the aquitand.
  - The well is housed to prevent recycled-water contact.
  - The ground surface contours away from the well head.
  - Owner of well approves elimination of buffer-zone requirements.

4.20 System Appurtenance Identification

Facilities and equipment used in the distribution and application of recycled water within any user's site should be appropriately identified. Some of the most common are:

- pumps
- fertigation equipment
- tanks and reservoirs
- piping
- POCs
- quick couplers

Hand-moved irrigation systems should be identified as using recycled water at the main valve(s) serving the systems.

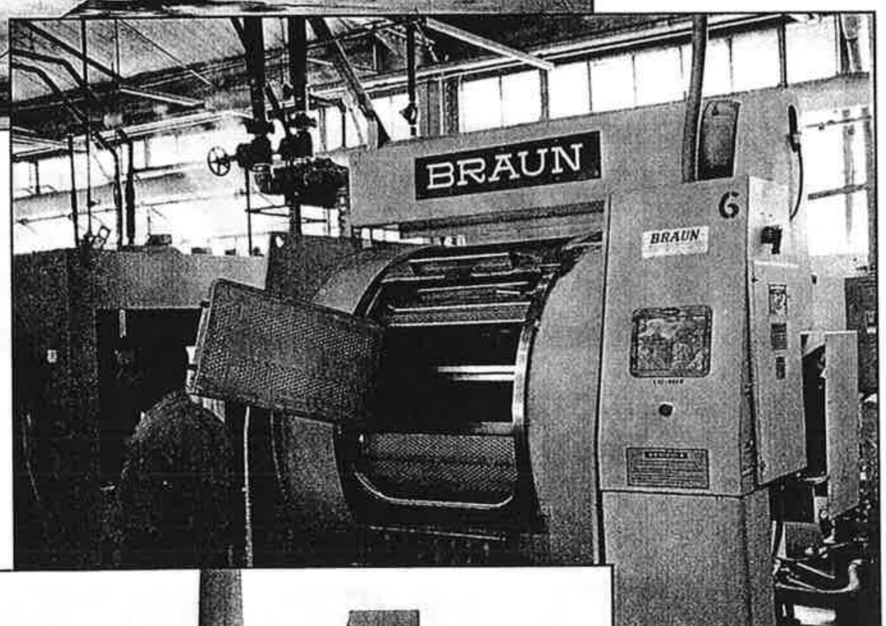
4.21 Signage

The purpose of signage in an agricultural application is to notify workers, both old and new, as well as any visitors, that recycled water is being used on the premises.

- Signs should be posted along perimeter locations of the use area.
- Signs should be posted at access points to the use area.
- Major system components should be identified (i.e., valves, pumps, etc.).

4.22 Inspections

Inspections begin with the initial site evaluation and continue throughout the completion of the retrofit process. Careful inspection of the retrofit work is necessary to ensure that inadvertent connections do not exist between the recycled-water piping and any other water-supply source. In some cases, an annual cross-connection inspection may be required (see Section 3.15).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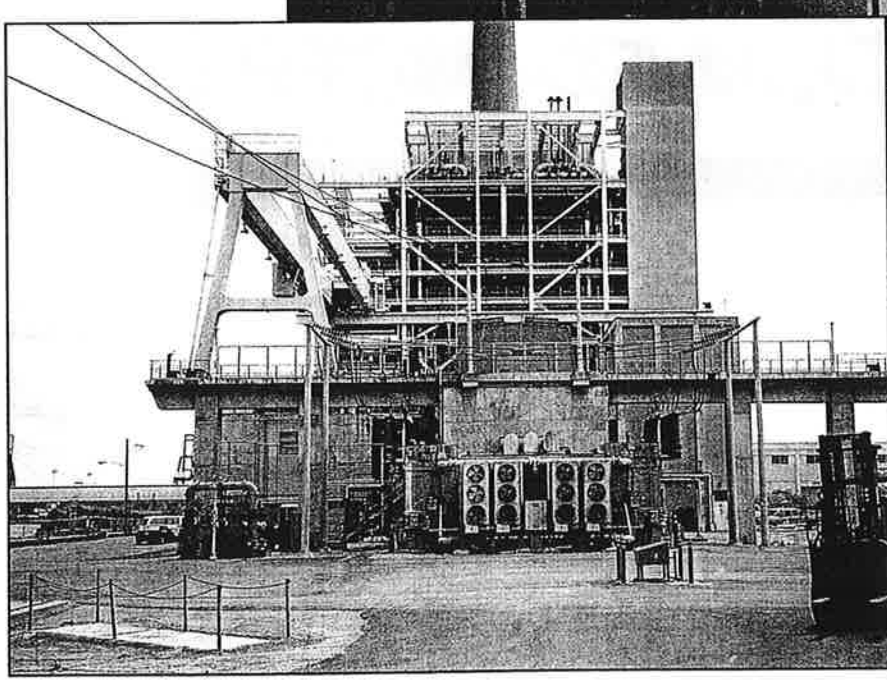


SECTION 5

COMMERCIAL/INDUSTRIAL

5.1 General

Commercial and industrial accounts are often among the largest served by water purveyors. These customers require a reliable "drought-proof" supply so as not to affect production. It is not surprising, therefore, that this area of recycling comprises the newest, most innovative, and fastest growing applications for water reuse. The use of recycled water within this area may be limited and in some cases seasonal, but it can assist the purveyor's efforts to more evenly spread out usage over the 24-hour day. Such cases can go a long way toward maximizing and optimizing the use of recycled-water treatment and distribution facilities. One key to using recycled water for a variety of commercial and industrial uses is maintaining a consistent high-quality, disinfected tertiary water. When this is accomplished, the maximum number of beneficial uses can be obtained. The field of commercial uses and industrial processes provides a broad range of possibilities.

5.2 Types of Recycled-Water Use

There are many potential uses of recycled water within the field of commercial and industrial applications. Some of the more common uses are listed below. These uses have been divided into three categories as follows.

Industrial Processes

- vehicle washing
  - bus
  - car
  - truck
  - airplane
- laundries
  - commercial and public facilities
- manufacturing
  - carpet, clothing or other dyeing operations
  - chemical plants
  - paper and paperboard products
- concrete mixing, ready mix and concrete products
- dust control and soil compaction
- industrial water
  - cooling towers
  - boiler make-up
- process water
  - metal quenching
  - washdown
  - electronic product manufacturing

Indoor Uses

- toilet and urinal flushing
- trap priming

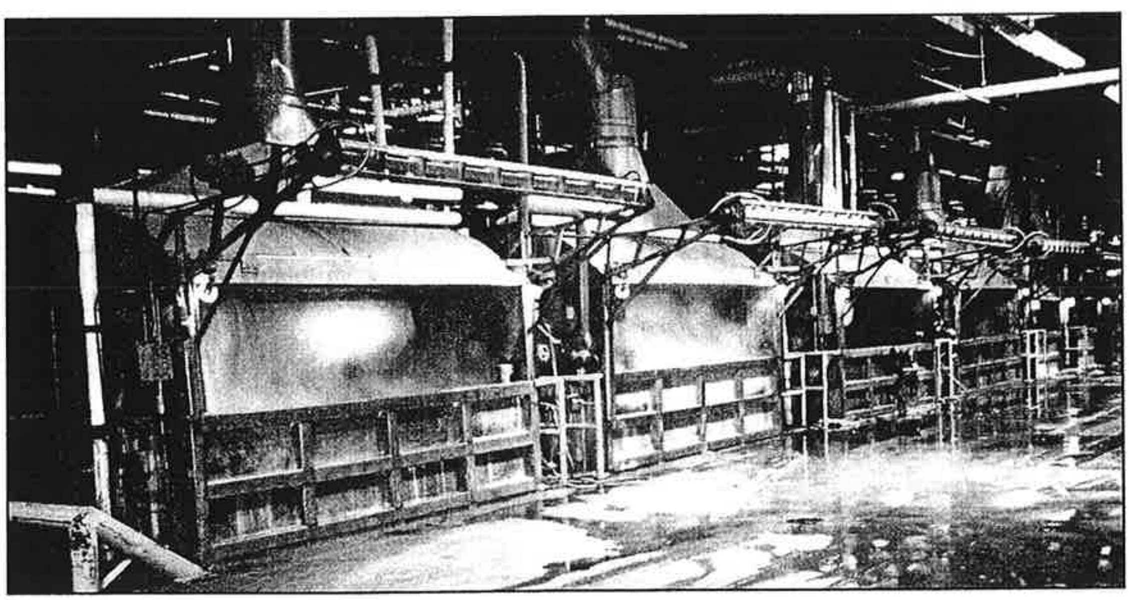
Commercial Uses

- Cooling towers
  - HVAC
  - computer cooling
- Evaporative condensers

General concerns relative to recycled-water quality and the retrofitting of these uses to recycled water are listed in Table 5.1.

TABLE 5.1 - GENERAL CONCERNS REGARDING COMMERCIAL/INDUSTRIAL USES

Industrial Processes • Vehicle Washing • Laundries • Manufacturing • Concrete Mixing • Industrial • Process Water	***Concerns*** Spotting on vehicles Effects of soaps and detergents Change in final product Effect on mortar strength High total dissolved solids, salts, minerals, ammonia Discoloration of fabric
Indoor Uses • Toilet and Urinal Flushing • Trap Priming	***Concerns*** Aesthetics of the water Odors
Commercial Uses • Cooling Towers • Evaporative Condensers	***Concerns*** TDS decreases cycles, increases blow-down Higher levels of TDS, regrowth potential, ammonia Higher levels of TDS Ammonia-induced stress, corrosion, cracking



5.3 Benefits of Recycled-Water Use

Each potential application of recycled water will provide its own benefits. Many benefits will be common to other uses while some will be unique to specific uses. The drought resistance of recycled water and the reduction in wastewater discharges are beneficial to the user as well as others. More specifically, the user benefits from a reliable, low-cost water supply. As noted earlier, many of these uses have not yet been developed, thus all the benefits have not yet been realized.

As each user will have specific concerns related to the process, product or site conditions, the water purveyor should develop a rapport and understanding with the user during the retrofit process. This communication should be ongoing and continue well after use is initiated. In this way, the user will feel very comfortable with the new water supply source and its use, and will transmit this feeling to others. It is important that the water purveyor fully address any concerns the user may have during the retrofit process. See Section 3.3 for more information.

5.4 Initial Site Evaluation

The initial site evaluation allows the water purveyor to review the user's plumbing system. This evaluation should be conducted in the presence of a user's representative who possesses a good working knowledge of the plumbing system and the commercial or industrial process. The following basic steps are necessary to evaluate an industrial process, indoor use, or commercial use for retrofit to recycled water.

Initial Site Walk-through

An initial site walk-through is the first step in evaluating any site for compatibility with recycled water. The site evaluation provides the water purveyor with a general understanding of the operations and water uses on the site. Following is a list of items which should be considered when conducting the initial site evaluation walk-through.

- Include the user's representative in the site evaluation.
- Identify the location of all utility POCs (e.g., potable service, sewer connection).
- Identify the location and type of potable-water piping.
- Locate all available auxiliary water sources and those that are being used.
- Determine whether the piping is exposed or located within walls.
- Identify all existing and potential systems and uses (e.g., boilers, toilets, cooling systems, pump seal water, process water).
- Determine the current water uses (type and quantity).
- Determine potable and non-potable demands and their source of supply. Determine if and how these systems are inter-connected.
- Identify the types of equipment (e.g., storage facilities, pumps, on-site treatment, backflow assembly).
- Determine if hose bibs are used at the facility and locate source of supply .
- Determine current system identification methodology.
- Determine potential effects of retrofit on adjacent properties.
- Determine water-quality expectations and any critical water-quality requirements.
- Determine the pressure requirements for system operation.
- Determine if there is a need for an uninterruptible water supply.
- Determine need and requirements for a backup water supply.

As-built Plan Review

- Obtain record drawings where available. Where no drawings are available, the information may exist informally. Obtain available pertinent documentation and information regarding water uses and the conversion process.
- Verify accuracy of available documentation (e.g., additional site walk-through or meeting with person knowledgeable of the system).
- Review prior piping modifications (remodeled bathrooms, changes to the process) as reflected on the record drawings and/or available documentation.

5.5 Site Retrofit Considerations

There are numerous matters which should be considered when attempting retrofit of commercial and industrial potable-water uses to recycled water. Some major ones are listed below:

Industrial

- location of the future point of connection for recycled water
- approximate potable-water pressure
- process pressure requirements
- current method of backflow prevention (e.g., double-check, air-gap, or reduced-pressure backflow assembly)
- identification of system type(s) (boilers, toilets, cooling systems, sealing water, process water)
- alterations to the discharge permit, if necessary
- necessity for on-site treatment, projected costs, and availability of space for needed equipment
- determination of non-potable and potable uses
- water demands (peak and average) and any variations in pattern (e.g., seasonal, morning only, etc.)
- flow requirements necessary to maintain the process(es)
- necessity of additional on-site storage
- existence of cross connections between the potable-water system and the proposed recycled-water system (Note: A preliminary cross-connection test, with shutdown, may be required to verify system isolation.)
- general types of equipment involved at the facility (e.g., water tanks, pumps, backflow assemblies, strainers)
- identification of the existing hose-bib use and locations
- method of identification (e.g., color indicator, direction indicator) for existing systems (e.g., salt water, boiler water, chiller water, potable water, washdown water)
- isolation of existing systems (e.g., piping exposed or hidden behind walls, ceilings, or under floors)
- application method(s) for current water supplies (e.g., tanks and enclosures for process, automated aerosol sprays, hoses, manual)
- potential for employee contact with the water
- identification of potential site supervisor

Indoor

- recycled-water POC entering building
- potable-water POC to the building
- appropriate method to achieve lateral pipe separation
- other available sources of water currently being used (e.g., in some older buildings

groundwater may currently be used for toilet flushing)
- supply pressure of the recycled water
- use of booster-pump system(s) in the building (Note: If no booster pump, determine if one will be needed to reach recycled-water facilities on top of building or upper floors.)
- need for the potable and non-potable system to have a booster pump
- toilets operated by in-line pressure or water tank on top of building
- location of the piping (e.g., exposed or hidden behind walls, ceilings, or under floors) (Note: Bathrooms may be retrofit more easily when building is being remodeled.)
- need for a new water-supply riser to building (Note: This may best be placed in the same portion of the building as the existing water-supply riser.)
- existence and location of utility valve on each floor in a service area
- existence and location of a valve access panel in each bathroom on each floor
- identification of all types of equipment (e.g., water tanks, pumps, double checks, reduced-pressure backflow assembly) and their uses
- identification of potable-water POCs for coffee machines, drinking fountains, janitor-closet faucets, and eye washes that may not be shown on plans as well as any additional uses off the same line(s) which serve bathrooms
  (Note: Special restrictions may apply to premises where food handling facilities exist.)
- identification of the user supervisor (e.g., a company employee or a privately contracted individual)

Commercial

- water demands (peak, average, or seasonal) and any additional water that may be required for reduced cycles and increased blowdowns
- frequency of cooling system dumping (cleaning)
- method of water-quality monitoring
- existing on-site water treatment and the need for additional water treatment
- operational parameters
- equipment compliance with local codes
- existing water-quality problems (e.g., scaling, corrosion, biological growth)
- existence and type of disinfection and/or biocide used in the system
- existence of drift eliminator
- location of the waste line and its ultimate destination
- blowdown discharge treatment requirements
- location of the make-up water feed line
- metal alloys in the process equipment that will contact cooling water

5.6 Special Considerations

As previously stated, use of recycled water for commercial and industrial applications is a new field. These uses can present situations not previously considered with traditional uses. Table 5.2 lists some general use categories with specific considerations that should be addressed during the retrofit process. A brief description of these concerns follows the table. Processes which are considered critical and that require an "uninterrupted" water supply may necessitate the use of appurtenances such as a "swivel-ell" connection. See Section 3.10, Figures 3.4, 3.5, and 3.6.

TABLE 5.2 - CONSIDERATIONS FOR RETROFIT RELATIVE TO RECYCLED WATER QUALITY

TYPES OF USES	CONSIDERATIONS						
	Sprays and Aerosols (1)	Change to Product (2)	Change in Demand (3)	Pre-Treatment (4)	Chemical Additives to Water (5)	On-Site Storage (6)	Exposure (7)
INDUSTRIAL							
Vehicle Washing	•	•		•	•	•	•
Snow Making				•			
Laundries					•		•
Manufacturing/ Dyeing		•			•	•	•
Concrete Mixing		•				•	•
Boiler Make-up			•	•	•		•
Washdown	•						•
INDOOR							
Toilet/Urinal Flushing		•			•		•
COMMERCIAL							
Cooling Towers	•	•	•	•	•	•	•

(1) ***Sprays and Aerosols***
Some industrial applications may require spray applications. In areas where water is sprayed, worker exposure to contact may be a concern.

(2) ***Change to Product***
In some cases, the change of water source can affect the end product. This would be due to factors such as water quality, temperature, solids, etc. When the water source change is made, then alterations to the process may be required for manufacturing reliability.

(3) ***Change in Demand***
Depending on the application, conversion from potable to recycled water can increase the total amount of water required. For example, in cooling towers the accumulation of metals and salts occurs much faster when using recycled water, requiring an increased turnover of water (reduced cycles).

(4) ***Pretreatment***
Processes which require water with low TDS may require pretreatment. Chlorination may also be necessary for some applications. See Section 5.7 for a thorough discussion on pretreatment.

(5) ***Chemical Additives***
Some industrial processes and cooling systems may require the addition of chemicals such as anti-scalants, coolants, corrosion inhibitors, dyes, etc. The addition of chemicals to the recycled-water system should be through an approved backflow prevention method (e.g., reduced-pressure principal assembly or air gap).

(6) ***On-site Storage***
Operational conditions, such as high volume required in short duration, may dictate the need for on-site storage of recycled water (e.g.,a closed process or a supply for booster pumps). On-site storage may be supplemented by a back-up water supply from another source when fed through an air gap.

(7) ***Exposure***
Public health effects depend on a number of factors including the potential for public exposure to recycled water. This exposure may occur through such means as direct or indirect contact, inhalation, and/or ingestion. There is little risk with recycled water because it is highly treated and all points of access to the water are clearly marked. For commercial and industrial uses the risk of further exposure can be minimized through education and identification.

5.7 Water Quality Considerations

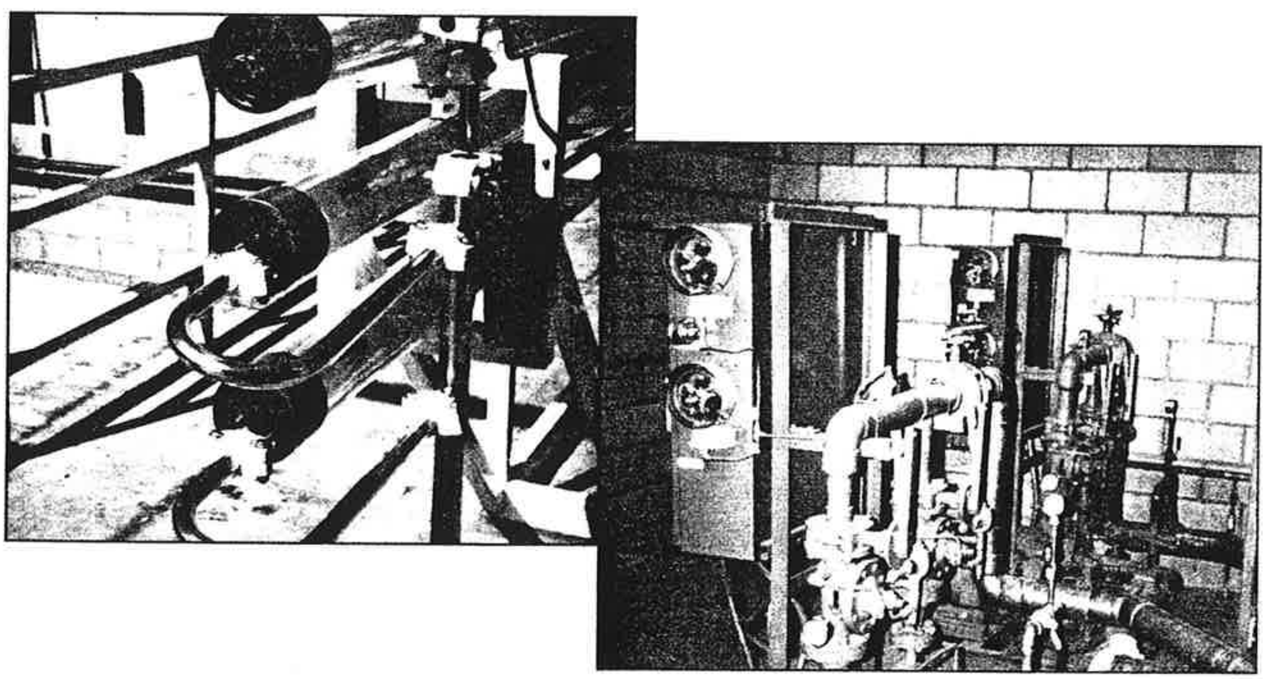
In almost all cases, industrial and commercial uses require a specific water quality. Thus, the use of recycled water for different applications will often present specific water-quality concerns. Tables 5.3, 5.4, and 5.5 describe typical concerns found in industrial processes, indoor uses, and cooling towers. Other water-quality concerns may be presented by the user during the retrofit process and should be addressed in detail by the water purveyor. Water-quality concerns should never be ignored.

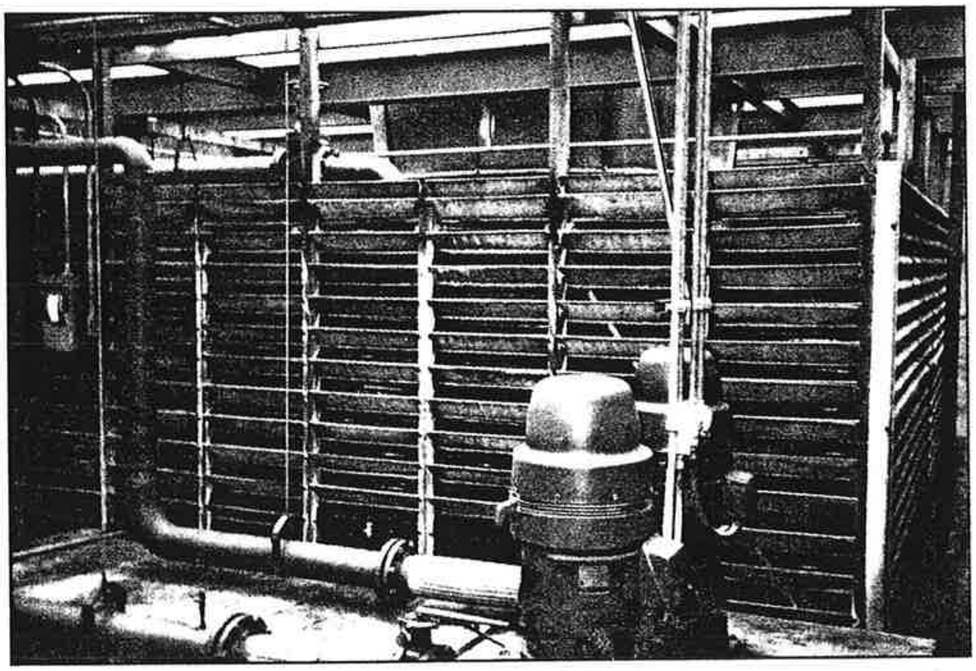
In California, whenever a cooling system using recycled water (in conjunction with an air-conditioning facility) utilizes a cooling tower, a drift eliminator is required. Addition of chlorine or another biocide is required to prevent growth of micro-organisms. Although not currently required by the state of Nevada, the NDEP reserves the right to impose more stringent limits at the use site.

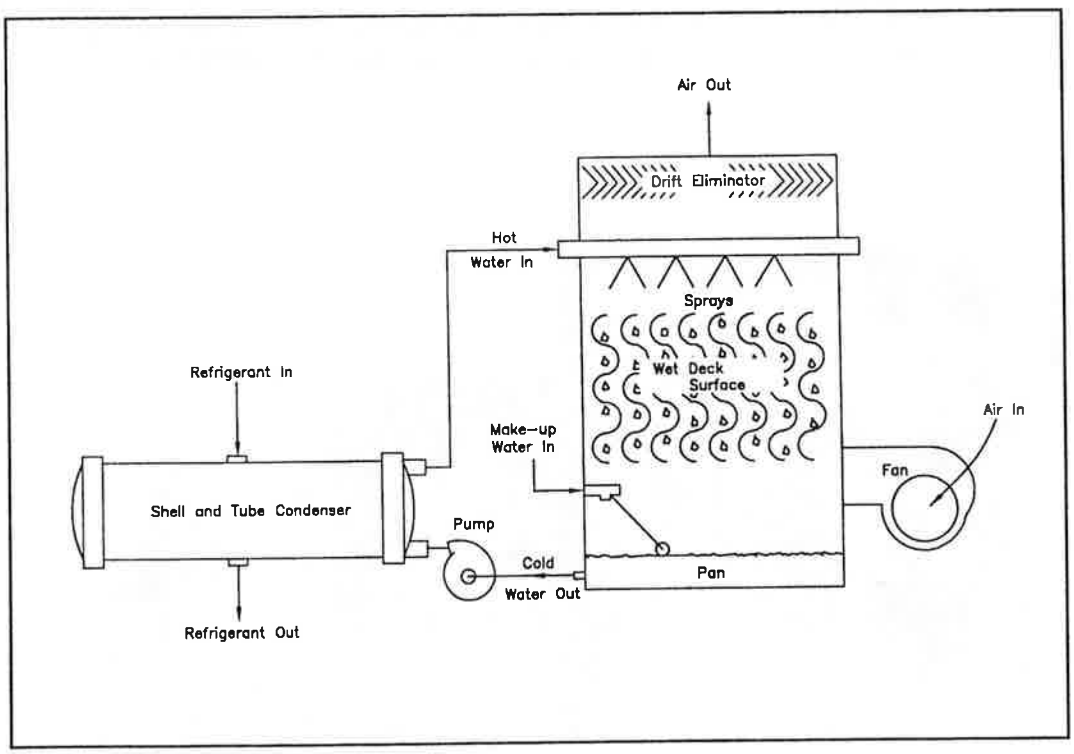
In Nevada, advanced secondary effluent may be used for some commercial or industrial applications, but these should be verified by the NDEP. The minimum quality requirement for the applications described in this section (from an operational standpoint) is tertiary effluent, defined as meeting water quality criteria 2 NTU and 2.2 MPN. Some applications may require additional on-site treatment as described below.

On-site Treatment

On-site treatment may be as simple as the addition of a chemical to an existing treatment process (e.g., corrosion inhibitor) or a more complex approach such as reverse osmosis. Examples of situations where on-site treatment may be applicable are shown in Table 5.6.







COOLING TOWER DIAGRAM

Figure 5.1

TABLE 5.3 - RECYCLED WATER QUALITY CONCERNS FOR INDUSTRIAL PROCESSES

Water Quality Constituent	Corrosion	Stains	Scale, Spots	Biological Regrowth	High Solids	Problems with Soaps
pH	•		•			
TDS	•					•
Hardness	•	•	•			•
Alkalinity	•	•	•			
Total Suspended Solids		•			•	
Ammonia	•					
Iron		•				
Manganese		•				
Calcium	•	•	•			
Magnesium		•				
Bicarbonate	•					
Sulfate			•			
Phosphorus			•			
Silica	•		•			
Chloride	•					
Chlorine				•		
Total Coliform				•		
Nitrate				•		
Nitrite				•		

TABLE 5.4 - RECYCLED WATER QUALITY CONCERNS FOR INDOOR USES

Water Quality Constituent	Staining, Spotting	Aesthetics	Odor
Manganese	•		
Iron	•		
Color Units		•	
Chlorine			•
Organics	•	•	•

Reference: Crook, Ammerman, Okun and Matthews. Guidelines for Water Reuse. EPA, Office of Technology Transfer and Regulatory Support, Center for Environmental Research Information, Publication No. EPA/65/R-92/004, September 1992.

Water Pollution Control Federation, 1989
Strauss and Puckorius, 1984
Treweek *et al.* 1981
Troscinski and Watson, 1970
California State Water Resources Control Board, 1980

TABLE 5.5 - RECYCLED WATER QUALITY CONCERNS FOR COOLING TOWERS [1]

Water Quality Constituent	Corrosion	Scaling	Biological Regrowth	Fouling	Foaming	Recommended Criteria [2]
Chloride	•					500
TDS	•			•		500
Hardness	•	•				650
Alkalinity	•	•				350
pH	•	•				6.9 - 9.0
COD			•			75
Total Suspended Solids			•	•	•	100
Turbidity			•	•		50
BOD			•			25
Organics			•	•		1
Ammonia	•					1
Phosphorus		•				4
Silica		•				50
Iron		•				0.5
Manganese		•				0.5
Calcium	•	•				50
Magnesium		•				0.5
Bicarbonate	•					24
MBAS (soaps)			•		•	N/A
Chlorine			•	•		N/A
Micro-organisms		•	•	•	•	

1 All values in mg/L except pH
2 Water Pollution Control Federation, 1989

Reference: Crook, Ammerman, Okun and Matthews. Guidelines for Water Reuse. EPA, Office of Technology Transfer and Regulatory Support, Center for Environmental Research Information, Publication No. EPA/65/R-92/004, September 1992.

Water Pollution Control Federation, 1989
Strauss and Puckorius, 1984
Treweek *et al.*, 1981
Troscinski and Wattson, 1970
California State Water Resources Control Board, 1980

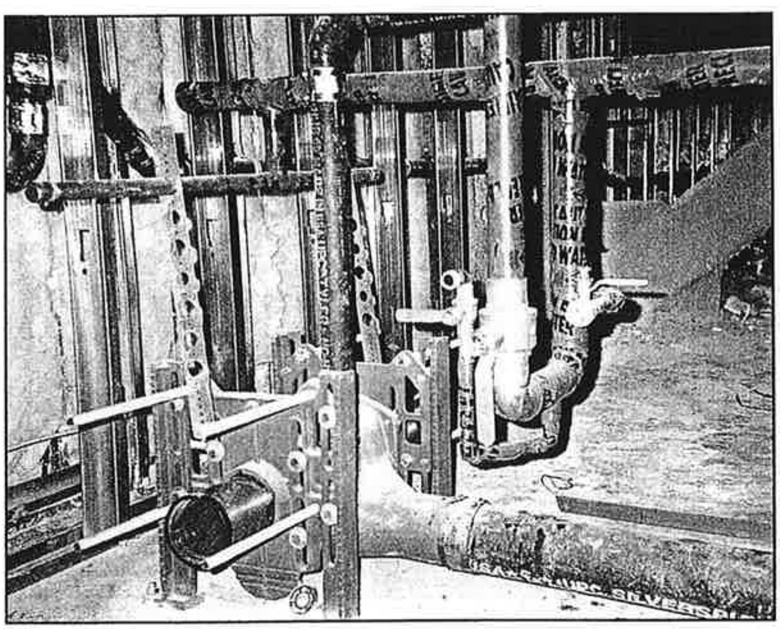
TABLE 5.6 - SPECIFIC WATER QUALITY CONCERNS REQUIRING ADDITIONAL TREATMENT

Water Quality Constituents	Concerns	Remedial Treatment
Residual Organics	Causes bacterial growth, slime and/or scale formation, foaming in boilers.	Carbon adsorption or ion exchange
Ammonia	Interferes with formation of free chlorine residual. Causes stress corrosion in copper-based alloys. Stimulates microbial growth.	Replace admiralty metals (certain copper/zinc alloys), ion exchange, air stripping, reverse osmosis, chemical treatment, breakpoint chlorination, bionitrification
Phosphorus	Causes scale formation. Stimulates microbial growth.	Chemical precipitation, ion exchange, biological phosphorus removal
Total Suspended Solids	Causes deposition. Provides nutrients for microbial growth.	Filtration
TDS	Increases fouling. Causes corrosion. Creates spotting on vehicles.	Reverse osmosis, ion exchange
Hardness	Causes scale formation and corrosion. Leaves deposits on products. Causes problems with soaps.	Lime softening, alum treatment, ion exchange
Calcium, Magnesium, Iron, Silica	Causes scale formation.	Chemical softening, precipitation
pH	Causes corrosion.	Lime or caustic
Micro-organisms	Causes bacterial growth.	Chlorination or addition of an alternate biocide

5.8 System Appurtenance Identification

It is essential that all recycled-water equipment and appurtenances be identified as conveying recycled water. See Appendix.

- Piping (exposed) - recycled-water piping and fittings, whether newly installed or existing, should be identified by the application of purple tape. The tape should be imprinted with wording identifying the pipe as recycled-water piping.
- Piping (buried) - Newly installed recycled-water piping and fittings buried below ground should be identified by the use of purple PVC pipe imprinted with "**CAUTION: RECYCLED WATER - DO NOT DRINK**," or where other types of pipe material are used the pipe should be identified by the use of purple-colored Mylar tape imprinted with "**CAUTION: RECYCLED WATER - DO NOT DRINK**." Identification of existing piping which is not exposed should not require identification as herein noted.
- Valves and other outlets which are used to convey recycled water should be identified in the same manner as noted above for exposed piping. Provided that existing equipment is functioning properly and in good repair, it should not be necessary to replace this equipment; however, identification of the following appurtenances is necessary:
    - valves
    - pressure regulators
    - flow meters
    - quick couplers
    - strainers
    - other related components (e.g., trap primers, shock arresters)
- Hose bibs - The use of hose bibs is not permitted on recycled-water systems. In isolated situations, it may be possible to allow hose-bib use where access is restricted to trained personnel and each hose bib is clearly identified as conveying recycled water. In these cases, signage should read "**CAUTION: RECYCLED WATER - DO NOT DRINK**." The use of hose-bibs should only be by written approval of the regulatory agency.



5.9 Signage

Signs posted at recycled-water use areas provide notification to workers and visitors that recycled water is being used. Signs should be developed in languages understood by those persons using the area and be placed at locations readily visible to persons using the areas served with recycled water. Some location examples are: 1) entrance points to work areas and 2) specific pieces of equipment using recycled water within the work area.

Industrial Processes

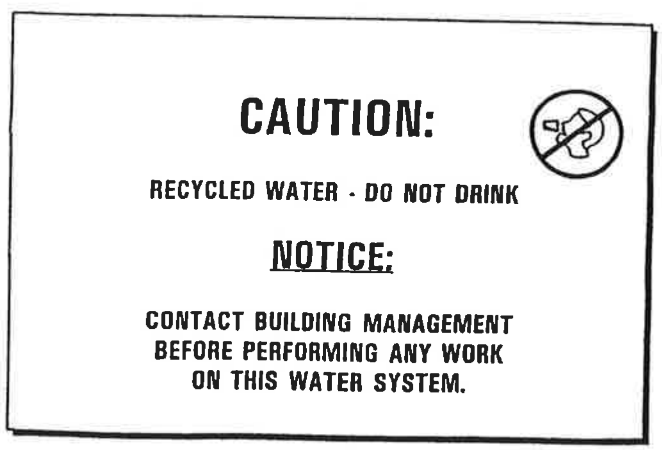
Industrial processes may have multiple water supplies. In addition to the identification of recycled-water lines, all other process-water supplies should be identified using approved methods.

Indoor

Signs used to identify the use of recycled water for sanitary-fixture flushing in restrooms should be of a highly visible color on a contrasting background. See Appendix. Signs should be installed in locations where they are visible to all users.

Commercial

Mechanical rooms, cooling tower enclosures, and similar equipment-room locations containing recycled-water equipment should have signs posted identifying the use of recycled water. See Figure 5.2 for an example. Signs should use language specified in the Appendix and be posted in locations visible to anyone working on or near recycled-water equipment. In addition, access to cooling-tower areas should be restricted to authorized personnel.



EQUIPMENT ROOM SIGN

Figure 5.2

Special

Potable-water hose bibs located near areas where recycled water is used should be clearly labeled as providing potable water.

5.10 Inspections

At every commercial or industrial site where recycled water is used, inspections are critical. As with other types of retrofit, the inspection process begins with the initial site visit and continues through completion and final approval.

Initial Site Evaluation

The lead agency for the retrofit (usually the water purveyor) will conduct the initial site evaluation. A local health department representative and/or building inspection official may also accompany the purveyor. The initial (visual) evaluation of the property is a fact-finding tour of the facilities. The evaluation should begin at the existing potable-water-service connection and continue throughout the facility. All areas of the facility should be reviewed, even those areas not intended for recycled-water use. Careful observation of all piping systems, interconnection of piping systems, current water-use practices, equipment, and employee involvement with the process is necessary.

A preliminary cross-connection test, with shutdown, may be necessary to confirm either interconnection or separation of systems.

Construction

During the retrofit process, the recycled-water purveyor should make regular inspections of the construction work to ensure compliance with all recycled-water use criteria (i.e., type of pipe, identification methods, location, etc.). In no case should piping be buried without first being visually inspected by all responsible agencies. Throughout the construction period, other approving agencies may participate in the inspection process.

Final Inspection

The final inspection is the most critical. In addition to a review of all previous work, a thorough cross-connection test must be performed. This test requires the shutdown of systems for a period of time while each fixture within the premises is operated individually to determine if water is present. See Appendix.

SECTION 6

IMPOUNDMENTS

6.1 General

Recycled water is used in lakes, ponds, and reservoirs for a variety of recreational and environmental purposes. In some areas this has been a practice for decades. Although these uses typically require small quantities of recycled water (make-up for evaporation and leakage), they are often incidental to other demands, such as irrigation. In some cases, climate or environmental demands may present an opportunity for recycled water to replace potable water. As water supply shortages continue to threaten future water demands, greater opportunities to use recycled water for recreational and environmental impoundment projects will become evident. This is especially true at golf courses where recycled water is supplied to water hazards and aesthetic impoundments.

6.2 Types of Recycled-Water Use

Recycled water can be used for a variety of recreational and environmental impoundments. These uses include golf-course ponds; decorative fountains; stream-flow augmentation; creation or restoration of wetlands and wildlife habitats; and full-body-contact, water-based recreational activities such as swimming, fishing, water skiing, wind surfing, etc. As with any form of reuse, the feasibility depends on the water demands, a cost-effective source of recycled water, and a recycled water of consistent quality and quantity.

Applications of recycled water for impoundments can be grouped into two categories: restricted and non-restricted. A restricted impoundment is one in which recreation is limited to non-body-contact, water-recreational activities. A non-restricted impoundment is one with no limitations imposed on body-contact water activities. Typical uses for non-restricted and restricted impoundments are listed below.

Non-restricted Impoundments

- full-body-contact water activities
  - swimming
  - water skiing
  - wind surfing

Restricted Impoundments

- aesthetic impoundment (decorative fountains, ponds, etc.)
- aesthetic stream flows (landscape stream, etc.)
- golf-course water hazards
- wetland and wildlife habitats
- lakes or ponds for fishing and boating
- storage reservoir

6.3 Benefits of Recycled-Water Use

Impoundment reuse accounts for only a small fraction of the recycled water used today. With some communities having insufficient water supplies available for impoundments, recycled water can fill this necessary gap. Some benefits of recycled-water use for impoundments are:

- conserves domestic water supplies
- provides a water source for water-dependent activities
- creates and/or restores wildlife habitats and wetlands
- provides beneficial uses for recycled water, which otherwise would be discharged
- provides a valuable water source for fire protection
- provides seasonal storage of recycled-water
- provides natural treatment to reduce BOD, total suspended solids, nitrogen, phosphorus, fecal coliform, etc., in the surface and subsurface flow in the wetland application
- provides fish and riparian habitats in the stream-flow augmentation application

6.4 Initial Site Evaluation

An initial site evaluation, conducted prior to retrofit of an existing impoundment, provides valuable insight as to the alterations required to accommodate recycled water. See Section 3.4 regarding general retrofit requirements. Additional considerations for impoundment applications are listed below.

Non-restricted and restricted aesthetic impoundments

- Determine type of use.
- Evaluate suitability of recycled-water quality for the use.
- Compare the quality of existing water source with the available recycled-water source.
- Address ways to handle overflow of recycled water, and review discharge issues with regulatory agencies.
- Evaluate the potential of recycled-water infiltration into aquifers and discuss with regulatory agencies.
- Determine potential environmental impacts.
- Determine volume of local runoff for both seasonal average and peak storm flows.
- Determine potential impacts to aquatic life associated with temperature changes, heavy-metal accumulation, and disinfection.
- Coordinate with permitting agency for potential recharge of recycled-water to groundwater basin.

Restricted impoundments such as wetlands and wildlife habitats (created, restored, enhanced wetlands)

- Evaluate site-specific project goals.
- Evaluate operation of wetlands.
- Consider design changes to impoundment due to water quality.
- Evaluate hydrology for potential flooding and peak storm flows.
- Evaluate ecosystems.
- Research site history.

6.5 Site Retrofit Considerations

In addition to the general site considerations noted in Section 3.5, the following information should also be considered.

Non-restricted impoundments (suitable for full-body-contact water activities)

- Determine any necessary modifications to existing equipment and appurtenances.
- Develop a monitoring program.

- Estimate potential runoff into the impoundment and its effect on discharges.
- Evaluate the impact of disinfectants, algicide, etc., if used in the impoundment.
- Determine location of suction and outlet for recirculation system.
- Determine the additional facilities that need to be installed to meet water quality requirements.
- Evaluate potential contamination from local runoff and determine the treatment system necessary to remove contamination.
- Evaluate potential for algae growth and determine the treatment system necessary for algae control and removal.

Restricted impoundments (divided into aesthetic impoundments, aesthetic stream flow, and wetlands and wildlife habitats)

- Aesthetic Impoundment (decorative fountains, golf course water hazards, landscape stream flow, storage reservoirs, etc.)
  - Determine necessary modifications to the existing equipment and appurtenances.
  - Evaluate the impact of disinfectants and algicide use on impoundment and overflow.
  - Evaluate impoundment design, recirculation, aeration, etc.
  - Evaluate effects of recycled water on fish and livestock.
  - Determine recycled-water inflow quantity for the impoundment.
  - Determine recycled-water use pattern(s) such as continuous flow or intermittent flow.
  - Determine location of suction and outlet of recirculation system.
  - Evaluate potential for algae regrowth and determine the treatment system necessary for algae control and removal.
- Aesthetic Stream Flow (stream-flow augmentation)
  - Determine the potential wetland or wildlife habitat(s) created by recycled-water release to a natural or artificial stream.
  - Determine the suitability of recycled water for existing vegetation, fish, and wildlife with regard to:
    - temperature
    - chlorine levels
    - ammonia
    - heavy metals
  - Determine flooding potential from recycled-water release.
  - Discuss with RWQCB, DHS, and other administrative authorities with jurisdiction the potential for recycled-water stream releases entering the groundwater. Prepare a groundwater monitoring program, if necessary.
  - Discuss water-rights issues resulting from recycled-water stream releases with responsible regulatory agencies.
- Wetlands and Wildlife Habitats
  - Evaluate effects of recycled water on existing vegetation.
  - Evaluate effects of recycled water on soil (chemical and physical properties).
  - Determine necessary modifications to the existing impoundment.

- Evaluate the impact(s) of nutrient and heavy metal loading.
- Coordinate planning of all designs with local, state, and federal officials such as RWQCB, NDEP, U.S. Army Corp of Engineers, U.S. Fish and Wildlife Service, EPA, etc., and obtain all necessary permits and approvals.

6.6 Special Considerations

When any water is stored for an extended length of time, algae will grow. This is particularly true with recycled water having elevated levels of nutrients. Depending on the type of impoundment, intended use, configuration, and turn-over, special considerations may apply. These considerations are interdependent and should be considered as a whole.

- Public education - All efforts should be made to educate the public that recycled water in recreational impoundments is not intended for drinking purposes. Although this is true for the water found in all non-potable lakes, streams, and/or reservoirs, an extra effort should be made where recycled water is involved.
- Freeboard - is the difference between the normal storage capacity of an impoundment and the maximum storage level at which water will then overflow. The design requirements for freeboard are site-specific, and depend on capacity (volume) of the impoundment and potential inflow and outflow capacity.
- Runoff - occurs when impoundment inflow exceeds the maximum storage capacity of the impoundment. The concern here is that the impoundment waters may contain constituents such as metals, pesticides, algicide, etc., which may adversely affect the receiving waters. Because of this, consultation with the appropriate regulatory agency (e.g., Regional Board) staff should occur early in the retrofit process.
- Retention time - critical to a successful retrofit in recreational and aesthetic impoundments. Impoundments having prolonged retention times may develop excessive algae blooms leading to both aesthetic and maintenance concerns. Careful evaluation of the existing retention time is recommended before embarking on an impoundment retrofit.
- Discharges - Discharging of recycled water is permitted only when specifically allowed in the permit. Permitted discharges must conform to the requirements set forth by the appropriate regulatory agency. Consultation with the appropriate regulatory agency concerning discharge issues should be made early in the retrofit process.
- Aeration/filtration - Generally, it is a good idea to provide aeration for the impoundment and filtration for the recycled water supplying the impoundment.
- Internal recirculation - is often necessary for both recreational and aesthetic impoundments. Sufficient circulation is dependent on several factors, including the impoundment location, size, configuration, and the inflow and outflow locations. An adequately designed recirculation system can prevent the development of anoxic zones (areas lacking oxygen) which generally create odor problems. Recirculation can be provided using a pumping system with intake and discharge points designed to ensure complete and adequate circulation within the impoundment.
- Algae - Recycled water will have elevated nutrient levels. Some of these nutrients accelerate the growth of algae. Algae growth in an impoundment is characterized by a greenish-colored water. There are a variety of preventive treatment methods which will control the growth of algae. These methods are summarized below.
    - Provide sufficient oxygen through an aeration system.
    - Modify recirculation patterns.
    - Reduce nutrient loading by the addition of micro-organisms which consume nutrients.
    - Chemical treatment (i.e., copper sulfate).
    - Reduce retention times or maintain a continuous flow through the impoundment.

- Introduce dyes into the impoundment to reduce transparency and sunlight penetration (generally effective in depths greater than four feet).
- Incorporate a nitrification process into the reclamation treatment train.

- Temperature - range of recycled water is from 20-25°C. In some areas, summer temperatures can raise the water temperature as high as 29°C. Some aquatic life can be affected by the temperature of water (i.e., trout, steelhead, and salmon require a cold water).
- Monitoring - Total coliform concentration monitoring is required for recycled water used in a nonrestricted recreational impoundment, regardless of whether it has undergone conventional treatment. In addition, recycled water that has not undergone conventional treatment must be monitored for giardia, enteric viruses, and cryptosporidium. See state regulations/guidelines for details of monitoring program requirements.
- Sediments - in recycled water are very similar to other water sources in regard to the accumulation of sediments. Sediment accumulation in impoundments will be affected more by surface runoff than by the use of recycled water.
- Dissolved oxygen - High rates of algae production result in a dissolved oxygen cycle that goes from super-saturation during daylight to less than 1 mg/L (7 mg/L in some cases) in the early morning pre-dawn hours. Most fish cannot survive these low concentrations of oxygen. The depletion of oxygen levels is caused by several factors including bacterial decomposition and photosynthesis. To limit the rate of production of algae, one of the key algal nutrients must be reduced to the point where it inhibits growth. The nutrient usually controlled is phosphorus, which is discussed in Section 6.7. To mitigate the depletion of dissolved oxygen, particularly in recreational impoundments, aeration systems are used to increase oxygen transfer from the atmosphere to the water. This acts to increase the dissolved oxygen level.

6.7 Water Quality Considerations

Water-quality criteria, which apply to recycled water used for recreational impoundments, are determined by the level of human exposure. The water-quality concerns should include the following:

- pH - For a full-body-contact recreational impoundment, the acceptable range of pH is 6.5 to 8.3. A deviation from this range may result in eye irritation. Through photosynthesis, algae form carbohydrate from CO_2 in the presence of sufficient light. Removal of CO_2 from the water causes the pH to rise. If the pH of recycled water deviates from this range, a treatment method should be incorporated into either the treatment process or at the use site. Common treatment methods used are the addition of caustic or acid, depending on the acidity or alkalinity of the water.
- Nutrients - A recreational impoundment supplied with recycled water may have a high eutrophication potential. Excessive algae growth is a result of high levels of nutrients commonly found in recycled water.
  - Phosphorus is a typical nutrient found in recycled water which, along with nitrogen compounds, will promote algae growth. The majority of phosphorus compounds

in recycled water are soluble, and can be removed effectively by chemical precipitation using a coagulant such as alum or ferric chloride. A phosphorus concentration of 0.1 mg/L as P or less should be maintained throughout the system to limit excessive algae growth.

- Nitrogen is another source of nutrients in recycled water. Common forms of nitrogen are organic nitrogen, ammonia, nitrite, nitrate, and gaseous nitrogen. Although it is considered useful to reduce nitrogen, it is rarely limiting as an algal nutrient because it is available in abundance from the atmosphere. On the other hand, it is important that ammonia be reduced to very low levels to avoid toxicity to fish and aquatic organisms. Algae growths will cause the pH to rise. When pH rises above 8, the ammonia is in the form of ammonia hydroxide which is relatively toxic to fish. The percentage of nitrogen removal through the tertiary treatment process is greater than 70%. Further reduction can be achieved, if necessary, by including reverse osmosis, ion exchange, or nitrification.

- Heavy metals - are primarily generated from the discharge of industrial wastes into the sewage collection system. Metals such as mercury, lead, nickel, silver, zinc, etc. are of concern when allowed to accumulate in an impoundment. Although levels of heavy metals in recycled water may meet regulatory requirements, the cumulative effects of these heavy metals could become detrimental to wildlife, fish, and humans. Testing for heavy metals should be done on a regular basis. Treatment for heavy-metal removal can be accomplished through the following treatment processes.
  - reverse osmosis
  - chemical precipitation followed by filtration (micro-filtration or ultra-filtration)
  - ion exchange
  - reduced retention time
- Salinity - levels found in recycled water vary widely. Although saline recycled water may be particularly valuable for coastal wetland habitats, high salinity may limit vegetative growth in some wetland applications. However, salinity is not a major concern in recreational impoundments, decorative fountains, lakes or ponds used for boating and fishing. A salinity evaluation should be completed prior to selecting plant species intended for wetland use.
- Disinfection - Chlorine is one of the most common disinfection processes in reclamation facilities. Following the discharge of recycled water into an impoundment, the disinfectant residual will rapidly evaporate.

6.8 Signage

As noted in Section 3.12, signage provides notification that recycled water is being used. This is particularly important around impoundments. Signage should be posted at all public entrances and other locations where the public has access. Signs should include the wording and international symbol for "**DO NOT DRINK**" (See Figure 3.9). Use of this wording and symbol may prove awkward where full-body-contact water activities (swimming) are allowed. Alternate wording may be developed but must be approved by the regulatory agencies.

TABLE 6.1 - RECYCLED WATER QUALITY CONCERNS FOR SELECTED IMPOUNDMENT APPLICATIONS

Selected Application	Chlorine	Nitrate	Ammonia	Phos-phorus	Dissolved Oxygen	Heavy Metals	Bacteria & Virus
Non-restricted Impoundment							
Swimming, Skiing, or Wind Surfing		•	•	•		•	•
Restricted Impoundments							
Aesthetic Impoundments *(e.g., decorative fountains, ponds)*	•	•	•	•			
Stream Flow Augmentation	•	•	•	•		•	
Aesthetic Stream Flow			•	•			
Golf Course Water Hazards			•	•	•		
Wetlands and Wildlife Habitats	•		•			•	
Lakes for Recreational Activities *(e.g., fishing, boating)*		•	•	•	•		

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Hamilton, Leanne E. Importance of Open Water Areas in Multipurpose Constructed Wetlands, 1997.
A Natural System for Wastewater Reclamation and Resource Enhancement, City of Arcata, California.
Pintail Lake and Redhead Marsh, Created Wetland in Northern Arizona.
Kelly Farm Demonstration Wetland, City of Santa Rosa.
Guidelines for Water Reuse Manual. EPA, September 1992.

APPENDIX

NOTE: The shutdown procedure noted below may not be adequate as a cross-connection test for all sites. The AWWA CA-NV Section Cross-Connection Control Program - Specialist or approved equivalent should modify this procedure to address specific site conditions and consult with health representatives prior to implementation.

INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS

UNIFORM PLUMBING CODE, 1994

APPENDIX J

Part 1 - RECLAIMED WATER SYSTEMS FOR NON-RESIDENTIAL BUILDINGS

J 1 Reclaimed Water Systems - General

(a) The provisions of this appendix shall apply to the installation, construction, alteration, and repair of reclaimed water systems intended to supply water closets, urinals, and trap primers for floor drains and floor sinks. Use is limited to these fixtures that are located in non-residential buildings. Fixtures within residential buildings are excluded from the list of approved uses. The reclaimed water system shall have no connection to any potable-water system, with or without mechanical backflow prevention devices. If reclaimed water is utilized on the premises, all potable-water supplies shall be provided with appropriate backflow protection, as required by the authority having jurisdiction. Except as otherwise provided for in this appendix, the provisions of this Code shall be applicable to reclaimed water system installations.

(b) No permit for any reclaimed water system shall be issued until complete plumbing plans, with appropriate data satisfactory to the Administrative Authority, have been submitted and approved. No changes or connections shall be made to either the reclaimed water system or the potable-water system within any site containing a reclaimed water system, without approval by the Administrative Authority.

(c) Before the building may be occupied, the installer shall perform the initial cross-connection test in the presence of the Administrative Authority and other authorities having jurisdiction, and the test shall be ruled successful by the Administrative Authority before final approval is granted.

J 2 Definitions

Reclaimed water is water which, as a result of tertiary treatment of domestic wastewater by a public agency, is suitable for a direct beneficial use or a controlled use that would not otherwise occur. The level of treatment and quality of the reclaimed water shall be approved by the public health authority having jurisdiction.

For the purpose of this appendix, tertiary treatment shall result in water which is adequately oxidized, clarified, coagulated, filtered and disinfected, so that at some location in the treatment process, the seven- (7) day median number of total coliform bacteria in daily samples does not exceed two and two tenths (2.2) per one hundred (100) milliliters, and the number of total coliform bacteria does not exceed twenty-three (23) per one hundred (100) milliliters in any sample. The water shall be filtered so that the daily average turbidity does not exceed two (2) turbidity units upstream from the disinfection process.

Specifically excluded from this definition is "graywater," which is defined in Appendix G of this Code.

J 3 Permit

It shall be unlawful for any person to construct, install, alter, or cause to be constructed, installed, or altered any reclaimed water system within a building or on a premise without first obtaining a permit to do such work from the Administrative Authority.

J 4 Drawings and Specifications

The Administrative Authority may require any or all of the following information to be included with or in the plot plan before a permit is issued for a reclaimed water system.

(a) A plot plan drawn to scale: completely dimensioned; showing lot lines; structures; location of all present and proposed potable-water supply and meters, water wells, streams, auxiliary water supply and systems, reclaimed water supply and meters; drain lines; and locations of private sewage disposal systems and one hundred (100) percent expansion areas, or building sewer connected to the public sewer.

(b) Details of construction, including riser diagrams or isometrics, and a full description of the complete installation, including installation methods, construction and materials as required by the Administrative Authority. To the extent permitted by structural conditions, all reclaimed water risers within the toilet room, including appurtenances such as air/vacuum relief valves, pressure reducing valves, etc., shall be installed in the opposite end of the room containing the served fixtures from the potable-water risers, or opposite walls as applicable. To the extent permitted by structural conditions, reclaimed water headers and branches off of risers shall not be run in the same wall or ceiling cavity of the toilet room where potable-water piping is run.

(c) Detailed initial and annual testing requirements as outlined elsewhere in this appendix.

J 5 Pipe Material/Pipe Identification

Reclaimed water piping and fittings shall be as required in this Code for potable-water piping and fittings. All reclaimed water pipe and fittings shall be continuously wrapped with purple-colored Mylar tape. The wrapping tape shall have a minimum nominal thickness of five ten-thousandths (0.0005) inch (0.127 mm) and a minimum width of two (2) inches (50.8 mm). Tape shall be fabricated of polyvinyl chloride with a synthetic rubber adhesive and a clear polypropylene protective coating or approved equal. The tape shall be purple in color (Pantone color #512) and shall be imprinted in nominal one-half (1/2) inch (12.7 mm) high, black, uppercase letters, with the words "CAUTION: RECLAIMED WATER, DO NOT DRINK". The lettering shall be imprinted in two (2) parallel lines, such that after wrapping the pipe with a one-half (1/2) width overlap, one (1) full line of text shall be visible. Wrapping tape is not required for buried PVC pipe manufactured with purple color integral to the plastic and marked on opposite sides to read "CAUTION: RECLAIMED WATER, DO NOT DRINK" in intervals not to exceed three (3) feet (0.9 m). All valves, except fixture supply control valves, shall be equipped with a locking feature. All mechanical equipment which is appurtenant to the reclaimed water system shall be painted purple to match the Mylar wrapping tape.

J 6 Installation

(a) Hose bibs shall not be allowed on reclaimed water piping systems.

(b) The reclaimed water system and the potable-water system within the building shall be provided with the required appurtenances (valves, air vacuum relief valves etc.) to allow for deactivation or drainage as may be required by J 8 of this appendix.

(c) Reclaimed water pipes shall not be run or laid in the same trench as potable-water pipes. A ten (10) foot (3.0 m) horizontal separation shall be maintained between pressurized buried reclaimed and potable-water piping. Buried potable-water pipes crossing pressurized reclaimed water pipes shall be laid a minimum of twelve (12) inches (0.3 m) above the reclaimed water pipes. Reclaimed water pipes laid in the same trench or crossing building sewer or drainage piping shall be installed in compliance with Sections 609.0 and 720.0 of this Code. Reclaimed water pipes shall be protected similar to potable-water pipes.

J 7 Signs

(a) Room Entrance Signs. All installations using reclaimed water for water closets and/or urinals shall be identified with signs. Each sign shall contain one-half (1/2) inch (12.7 mm) letters of a highly visible color on a contrasting background. The location of the sign(s) shall be such that the sign(s) shall be visible to all users. The number and location of the signs shall be approved by the Administrative Authority and shall contain the following text:

TO CONSERVE WATER, THIS BUILDING USES RECLAIMED WATER TO FLUSH TOILETS AND URINALS.

(b) Equipment Room Signs. Each equipment room containing reclaimed water equipment shall have a sign posted with the following wording in one (1) inch (25.4 mm) letters on a purple background:

CAUTION
RECLAIMED WATER, DO NOT DRINK.
DO NOT CONNECT TO DRINKING WATER SYSTEM.

NOTICE
CONTACT BUILDING MANAGEMENT BEFORE PERFORMING ANY WORK ON THIS WATER SYSTEM.

This sign shall be posted in a location that is visible to anyone working on or near reclaimed water equipment.

(c) Where tank-type water closets are flushed with reclaimed water, the tank shall be labeled:

RECLAIMED WATER - DO NOT DRINK

(d) Valve Access Door Signs. Each reclaimed water valve within a wall shall have its access door into the wall equipped with a warning sign approximately six (6) inches by six (6) inches (152.4 mm x 152.4 mm) with wording in one half (1/2) inch (12.7 mm) letters on a purple background. The size, shape and format of the sign shall be substantially the same as that specified in subsection (b) above. The signs shall be attached inside the access door frame and shall hang in the center of the access door frame. This sign requirement shall be applicable to any and all access doors, hatches, etc. leading to reclaimed water piping and appurtenances.

(e) Valve Seals. Each valve or appurtenance shall be sealed in a manner approved by the Administrative Authority after the reclaimed system has been approved, and placed into operation. These seals shall either be a crimped lead wire seal, or a plastic break-away seal which, if broken after system approval, shall be deemed conclusive evidence that the reclaimed water system has been accessed. The seals shall be purple with the words "RECLAIMED WATER", and shall be supplied by the reclaimed water purveyor, or by other arrangements acceptable to the Administrative Authority.

J 8 Inspection and Testing

(a) Reclaimed water piping shall be tested as outlined in this Code for testing of potable-water piping.

(b) An initial and subsequent annual cross-connection inspection and test shall be performed on both the potable and reclaimed water systems as follows:

(1) Visual Dual System Inspection. Prior to commencing the cross-connection testing, a dual system inspection shall be conducted by the Administrative Authority and other authorities having jurisdiction.

(i) Meter locations of the reclaimed water and potable-water lines shall be checked to verify that no modifications were made, or cross-connections are visible.

(ii) All pumps and equipment, equipment room signs, and exposed piping in equipment room shall be checked.

(iii) All valves shall be checked to insure that valve lock seals are still in place and intact. All valve control door signs shall be checked to verify that no signs have been removed.

(2) Cross-Connection Test. The following procedure shall be followed by the applicant in the presence of the Administrative Authority and other authorities having jurisdiction to determine if a cross-connection occurred.

(i) The potable-water system shall be activated and pressurized. The reclaimed water system shall be shut down and completely drained.

(ii) The potable-water system shall remain pressurized for a minimum period of time specified by the Administrative Authority while the reclaimed water system is empty. The minimum period the reclaimed water system is to remain depressurized shall be determined on a case by case basis, taking into account the size and complexity of the potable and reclaimed water distribution systems, but in no case shall that period be less than one (1) hour.

(iii) All fixtures, potable and reclaimed, shall be tested and inspected for flow. Flow from any reclaimed water system outlet shall indicate a cross-connection. No flow from a potable-water outlet would indicate that it may be connected to the reclaimed water system.

(iv) The drain on the reclaimed water system shall be checked for flow during the test and at the end of the period.

(v) The potable-water system shall then be completely drained.

(vi) The reclaimed water system shall then be activated and pressurized.

(vii) The reclaimed water system shall remain pressurized for a minimum period of time specified by the Administrative Authority while the potable-water system is empty. The minimum period the potable-water system is to remain depressurized shall be determined on a case by case basis, but in no case shall that period be less than one (1) hour.

(viii) All fixtures, potable and reclaimed shall be tested and inspected for flow. Flow from any potable-water system outlet shall indicate a cross-connection. No flow from a reclaimed water outlet would indicate that it may be connected to the potable-water system.

(ix) The drain on the potable-water system shall be checked for flow during the test and at the end of the period.

(x) If there is no flow detected in any of the fixtures which would have indicated a cross-connection, the potable-water system shall be repressurized.

(3) In the event that a cross-connection is discovered, the following procedure, in the presence of the Administrative Authority, shall be activated immediately:

(i) Reclaimed water piping to the building shall be shut down at the meter, and the reclaimed water riser shall be drained.

(ii) potable-water piping to the building shall be shut down at the meter.

(iii) The cross-connection shall be uncovered and disconnected.

(iv) The building shall be retested following procedures listed in subsections (b)(1) and (b)(2) above.

(v) The potable-water system shall be chlorinated with fifty (50) ppm chlorine for twenty-four (24) hours.

(vi) The potable-water system shall be flushed after twenty-four (24) hours, and a standard bacteriological test shall be performed. If test results are acceptable, the potable-water system may be recharged.

(c) An annual inspection of the reclaimed water system, following the procedures listed in subsection J 8 (b)(1), shall be required. Annual cross-connection testing, following the procedures listed in subsection J 8 (b)(2), shall be required by the Administrative Authority, unless site conditions do not require it. In no event shall the test occur less often than once in four (4) years. Alternate testing requirements may be allowed by the Administrative Authority for institutional buildings.

The Health Officer or other designated appointee may substitute for the Administrative Authority in the above mentioned inspection and tests.

J 9 Sizing

Reclaimed water piping shall be sized as outlined in this Code for sizing potable-water piping.

J 10 Approved Uses of Reclaimed Water

Reclaimed water is allowed in all non-residential buildings to supply fixtures as specified in this appendix, except where prohibited by statute, regulation, or ordinance.

Part 2 - PRELIMINARY CROSS-CONNECTION TEST PROCEDURE

This cross-connection test procedure can be used as part of the initial site-evaluation process to determine connections to the potable-water supply. Conductance of this procedure should only be done by an AWWA Certified Cross-Connection Control - Specialist.

Participants may include:

- Water Purveyor
- Plumbing or Landscape Contractor
- Health Agency
- Owner/Owners Representative
- Site Supervisor (if designated)

1. Observe known points of connection and existing backflow protection.
2. Shut off and de-pressurize the future retrofit system at the point of connection.
3. Verify system is de-pressurized by operating fixtures.
4. Operate fixtures remaining pressurized to confirm water supply.
5. Pressurize the future retrofit system and confirm water supply at each fixture.

Following this procedure should provide cursory confirmation of the point(s) of connection.

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