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Technical Memorandum
Task 3 – Phase 1

Salt and Nutrient Water Quality Criteria Literature Review

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Prepared for

Central Valley Salinity Alternatives for Long Term Sustainability Initiative

Under contract to:

San Joaquin Valley Drainage Authority
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Executive Summary

This literature review represents an assembly of water quality criteria assigned to beneficial uses at the state, national and international levels. The literature review is part of the Phase 1 Beneficial Use and Objectives (BUO) Study conducted under a subcontract with the San Joaquin Valley Drainage Authority which is responsible for the work pursuant to a contract with the State Water Resources Control Board. The literature review focuses on criteria related to salt and nutrients not all constituents that may be present in basin plans or other documents. The BUO Phase 1 study assembled and reviewed representative policy, data, and water quality criteria for beneficial use protection.

Many regions of the world have been challenged with salt management. Past decisions without awareness of sustainability have caused environmental challenges as they relate to salt and nutrients. Water quality agencies were set up to manage salts and nutrients and in some cases reverse the damage caused by salt accumulation. Regulations, permits, and basin plans amendments have been adopted to manage salt and nutrients in the central valley basins for the protection of beneficial uses. Below is a summary of the findings related to the beneficial uses and the water quality criteria for salt and nutrient parameters at the state, national, and international levels. The table below shows three common beneficial uses and the associated water quality objectives. The total range represents all beneficial uses and all water quality objectives found in the literature search.

Beneficial Use	**TDS mg/L**	**EC µmhos /cm**	**Na mg/L**	**Cl mg/L**	**SO_4 mg/L**	**B mg/L**	**Nitrate as N mg/L**
Drinking Water	500-600	900	60-180	250	250-500	1-10	10
Agriculture-crop and livestock	450-10,000	700-16,000	69	106-142	NA	0.5-0.75	NA
Aquatic Life	<3000	NA	NA	230-860	NA	0.09-1.3	1.7-17
Total range	450-1,000,000	700-16,000[a]	60-180	106-860	250-1900	0.7-5.0	10-100

NA=Not available

[a]EC for irrigation water is often expressed as dS/m = 1,000 µmho/cm

Section 1: Introduction

This literature review represents an assembly of water quality criteria used to support beneficial uses at the state, national and international levels. The values represent levels of salinity and nitrate related constituents that, if met, will allow designated beneficial uses. Representative states and nations were used because not all areas can be surveyed. The literature review is part of the Phase 1 Beneficial Use and Objectives (BUO) Study conducted under a subcontract with the San Joaquin Valley Drainage Authority which is responsible for the work pursuant to a contract with the State Water Resources Control Board. The literature review focuses only on criteria related to salt and nutrients not all constituents that may be present in a Water Quality Control Plan (basin plan) or other water quality criteria documents. The BUO Phase 1 study assembled and reviewed representative policy, data, and water quality criteria for beneficial use protection.

Many regions of the world have been challenged with salt management. Past decisions without awareness of sustainability have caused environmental challenges as they relate to salt and nutrients. Water quality agencies were set up to manage salts and nutrients and in some cases reverse the damage caused by salt accumulation. Regulations, permits, and basin plans amendments have been adopted to manage salt and nutrients in the Central Valley of California for the protection of beneficial uses. The California State Water Resources Control Board (SWRCB) directed the nine Regional Water Quality Control Boards (Regional Water Boards) in Resolution 88-16 to designate all surface and groundwater as potential drinking water sources and additional beneficial uses may be designed by the Regional Water Boards as deemed necessary. These designations are currently found in the Water Quality Control Plans (Basin Plans) for each basin in California. To date, the Central Valley Regional Water Quality Control Board uses a total of 21 beneficial use designations in its two basin plans: Sacramento River and San Joaquin River Basin Plan and Tulare Lake Basin Plan. The table below shows the beneficial uses designated in each of the Basin Plans (Table 1). An additional Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary was also included in this work per discussions with the CV SALTS BUO project subcommittee.

Salinity Units

A variety of units are used to describe salinity in the literature. For example, water quality criteria for electrical conductivity (EC) is usually expressed as micro-mhos per centimeter (µmho/cm or micro-siemens per centimeter (µS/cm) for drinking water and freshwaters, while mmho/cm (or dS/m), while the terms milli-mhos per centimeter (mmhos/cm) and deci-siemens per centimeter (dS/cm) are commonly used for water for crop irrigation and livestock and for oceans and estuaries. Note that values expressed as µmho/cm (µS/cm) are 1,000 times higher than those expressed as mmho/cm (dS/m). Total dissolved solids and individual ions are usually expressed as milligrams per liter (mg/L), although units of micrograms per liter (µg/L) are sometimes used. Levels of cations or anions may also be described by molar equivalent per liter (meq/L) and represent the amount of substance in a solution. For example, SAR (sodium adsorption ratio) refers to the ratio of dissolved sodium to the amounts of dissolved calcium and magnesium (expressed in meq/L). SAR generally impacts soil structure.

Table 1: Beneficial Uses Designated in the Three Basin Plans that Represent the Central Valley of California

Sacramento River-San Joaquin River Basin Plan	Tulare Lake Basin Plan	San Francisco Bay/Sacramento –San Joaquín Delta Estuary Plan
MUN	MUN	MUN
AGR	AGR	AGR
IND	IND	IND
PRO	PRO	PRO
POW	POW	REC-1
REC-1	REC-1	REC-2
REC-2	REC-2	WARM
WARM	WARM	COLD
COLD	COLD	WILD
WILD	WILD	SPWN
SPWN	SPWN	MIGR
MIGR	MIGR	GWR
GWR	GWR	NAV
FRSH	FRSH	COMM
AQUA	AQUA	EST
BIOL	BIOL	RARE
NAV	NAV	SHELL
COMM		
EST		
RARE		
SHELL		

Beneficial use designations encompass various activities and the statewide definitions are listed below:

Municipal and Domestic Supply (MUN) - Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.

Agricultural Supply (AGR) - Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation (including leaching of salts), stock watering, or support of vegetation for range grazing.

Industrial Service Supply (IND) - Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well repressurization.

Industrial Process Supply (PRO) - Uses of water for industrial activities that depend primarily on water quality.

Ground Water Recharge (GWR) - Uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers.

Freshwater Replenishment (FRSH) - Uses of water for natural or artificial maintenance of surface water quantity or quality.

Navigation (NAV) - Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.

Hydropower Generation (POW) - Uses of water for hydropower generation.

Water Contact Recreation (REC-1) - Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.

Non-contact Water Recreation (REC-2) - Uses of water for recreational activities involving proximity to water, but where there is generally no body contact with water, nor any likelihood of ingestion of water. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

Commercial and Sport Fishing (COMM) - Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.

Aquaculture (AQUA) - Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.

Warm Freshwater Habitat (WARM) - Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Cold Freshwater Habitat (COLD) - Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Estuarine Habitat (EST) - Uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds).

Wildlife Habitat (WILD) - Uses of water that support terrestrial or wetland ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats or wetlands,

vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

Preservation of Biological Habitats of Special Significance (BIOL) - Uses of water that support designated areas or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance (ASBS), where the preservation or enhancement of natural resources requires special protection.

Rare, Threatened, or Endangered Species (RARE) - Uses of water that support aquatic habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened or endangered.

Migration of Aquatic Organisms (MIGR) – Uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.

Spawning, Reproduction, and/or Early Development (SPWN) - Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

Shellfish Harvesting (SHELL) - Uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sports purposes.

Water quality objectives are associated with the beneficial uses to ensure that the beneficial use is protected. Federal regulation states that the guidelines must protect the most sensitive beneficial use. At the state level, maximum, minimum, or ranges are established for this protection and are based on scientific rationale. Water quality criteria represent the integration of scientific knowledge representing environmental accumulation, persistence and effects which will provide long-term protection for a particular beneficial use. The application of a standard considers the local parameters for a specified water body. The rationale for the criteria applications has been addressed in the US EPA Water Quality Criteria (e.g., Red Book). For the purposes of this literature review the definitions relating to water quality criteria from the Phase 1 RFP apply.

“For the purpose of this literature review, water quality criteria mean Section 131.11 of the Water Quality Standards Regulation which covers water quality criteria. Water quality standards include criteria, defined as either numeric limits or narrative statements that establish the levels of a pollutant that, if met, will allow the use to be attained. Criteria are scientifically-based and must be set to protect the designated uses fully. EPA produces water quality criteria recommendations under section 304(a) of the Act. These criteria are used as the basis for State water quality standards. However, the regulation allows the States to develop their own criteria or site-specific criteria modifications to EPA's recommendations. The 304(a) criteria are scientific recommendations and are not Federal standards. Water quality criteria include aquatic life criteria, human health criteria, biological criteria, and nutrient criteria. Water quality criteria have no force of law until they have been incorporated into State and Tribal water quality standards and approved by EPA.”

Section 2: California

Title: A Compilation of Water Quality Goals
Author: Jon Marshack
Source: Central Valley Regional Water Quality Control Board
http://www.swrcb.ca.gov/rwqcb5/water_issues/water_quality_standards_limits/water_quality_goals/index.shtml
Document Type: web
Accessed: June 2010
Parameters: EC, TDS, Sodium, Chloride, Sulfate, Nitrate, Boron

Summary: The "Marshack Report" is a compilation of water quality goals, criteria, and guidelines representing drinking water including specifics related to taste and odor, agricultural irrigation water, and freshwater aquatic environments. The list of water quality guidelines utilized in the report are:

- California Department of Public Health (CDPH) Primary and Secondary MCLs for drinking water;
- US Environmental Protection Agency (US EPA) Primary and Secondary MCLs for drinking water;
- California Public Health Goal (PHG) in Drinking Water from the Office of Environmental health hazard Assessment (OEHHA);
- California State Notification Level and Response Level for Drinking Water from CDPH;
- Agricultural Water Quality Limits from United Nations Food and Agriculture Organization (FAO);
- US EPA Integrated Risk Information System (IRIS);
- Drinking Water Health Advisories or Suggested No-Adverse-Response Levels (SNARLs); and
- US EPA National Recommended Ambient Water Quality Criteria for Human Health and Welfare and Freshwater Aquatic Life.

The following references were reviewed in the report but were not applicable to the parameters in this review of salinity and nutrients.

- California Ocean Plan;
- US EPA National Recommended Ambient Water Quality Criteria for Salt Water Aquatic Life;
- California Toxics Rule Criteria for Inland Surface Waters and Enclosed Bays and Estuaries;
- Cal/EPA Cancer Factor;
- California Prop 65 Safe Harbor Level.

Both organic and inorganic constituents are represented in the tables of the Marshack Report however; the table below only shows the parameters of interest for this literature review.

Table 2: Water Quality Criteria from Federal and California Agencies as shown in the Marshack Report

Beneficial Use/Objective	Parameter	Limit (mg/L)[x]	Data Source
Drinking Water	Boron	1[a] 10[b]	California State Notification Level and Response Level
Drinking Water	Boron	1.4	US EPA Integrated Risk Information System (IRIS)
Drinking Water	Boron	1[c]	Drinking Water Health Advisories or Suggested No Adverse Response Levels (SNARLs)
Agriculture	Boron	0.7 0.75	US EPA Quality Criteria for Water, 1986 (Gold Book)
Drinking Water	Chloride	250	CDPH SMCL
Drinking Water	Chloride	250	US EPA SMCL
Agriculture	Chloride	106	FAO
Freshwater Aquatic Life	Chloride	230[d] 860[e]	US EPA National Recommended Ambient Water Quality Criteria
Drinking Water	EC	900 µmhos/cm	CDPH SMCL
Agriculture	EC	700 µmhos/cm	FAO
Drinking Water	Nitrate	45[f]	CDPH MCL
Drinking Water	Nitrate + Nitrite as N	10[g]	CDPH MCL
Drinking Water	Nitrate-N	10	US EPA MCL
Drinking Water	Nitrate-N	10[g]	OEHHA PHG for California
Drinking Water	Nitrite-N	11[h]	US EPA Integrated Risk Information System (IRIS)
Drinking Water	Nitrate-N	10 [c,i]	Drinking Water Health Advisories or Suggested No Adverse Response Levels (SNARLs)
Agriculture	Sodium	69	FAO
Drinking Water	Sodium	30 60[k]	US EPA Drinking Water Advisory
Drinking Water	Sodium	20[l]	Drinking Water Health Advisories or Suggested No Adverse Response Levels (SNARLs)
Drinking Water	Sulfate	250[m]	CDPH SMCL
Drinking Water	Sulfate	500	US EPA MCL
Drinking Water	Sulfate	250	US EPA SMCL
Drinking Water	Sulfate	250	US EPA Drinking Water Advisory
Human Welfare[n]	Sulfate	250	US EPA Quality Criteria for Water, 1976 (Red Book)
Drinking Water	Sulfate	500[c]	Drinking Water Health Advisories or Suggested No Adverse Response Levels (SNARLs)
Drinking Water	TDS	500[p]	CDPH SMCL
Drinking Water	TDS	500	US EPA SMCL
Agriculture	TDS	450	FAO

Beneficial Use/Objective	Parameter	Limit (mg/L)[x]	Data Source
Human Welfare[n]	TDS	250	US EPA Quality Criteria for Water, 1976 (Red Book)

[x] Unless otherwise noted.
[a] Notification Required
[b] The water source will be removed from service at this level of boron.
[c] US EPA
[d] Level for chloride associated with sodium; Level represents continuous concentration (4-day average)
[e] Level for chloride associated with sodium; Level represents maximum concentration (1-hour average)
[f] As NO_3
[g] As Nitrate + Nitrite (as N)
[h] As nitrogen
[i] 10 day, as nitrogen
[k] Represents a range value: see original reference www.epa.gov/safewater
[l] To protect individuals restricted to 500 mg/day of sodium
[m] Recommended level; Upper limit 500 mg/L
[n] Taste and Odor
[p] Recommended; Upper limit 1000 mg/L

Title: Manual of Good Practice for Land Application of Food Processing/Rinse Water
Author: Brown and Caldwell; Kennedy/Jenks Consultants
Publication date: December 21, 2006
Source: California League of Food Processors http://www.clfp.com/manual-of-good-practice
Document: web
Accessed: June 2010
Parameters: TDS, EC, Sodium, Chloride, Sulfate, Boron

This manual was prepared for the purpose of providing a scientific basis for the best management practices of the land application of food process/rinse water. The information for this literature review will only describe the salinity and nitrogen findings and recommendations of the manual. Nitrogen is a major nutrient constituent in food process rinse water and concerns related to leaching of nitrogen species from soils to ground or surface waters focuses the land application of this constituent. TDS is used as the measurement of salinity levels in rinse water specifically for the protection of groundwater. TDS of food processing/rinsewater is comprised of both mineral and non-mineral constituents therefore the manual recommends using FDS as the measure of total mineral salinity. Sodium, chlorides, and sulfates all contribute to the TDS (FDS) in the rinse water. Chloride and sodium are recognized as having negative effects to crops while sodium and sulfate contribute to clay dispersion or soil acidity, respectively.

The manual bases its recommendations for land application of rinse water on work done by Ayers and Westcot (1985), which is also referenced in this literature review. Based on the data, the manual recommends irrigation water EC at a maximum of 5 mmhos/cm (5,000 µmhos/cm) and soil salinity between 0-2 mmhos/cm to prevent negative effects on crops or loss in yield.

Title: Salt Tolerance of Crops in the Southern Sacramento-San Joaquin Delta
Author: Hoffman, Glenn
Publication date: January 5, 2010

Source:
http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/docs/final_study_report.pdf
Document : web
Accessed: June 2010
Parameters: EC

Summary: The State Water Resources Control Board set a 0.7 mmho/cm (dS/m) objective during the summer irrigation months and an objective of 1.0 mmho/cm (dS/m) for the winter season. This report assessed the appropriateness of these water quality objectives through the examination of 5 steady-state models and four transient state models. The models predict leaching fraction rates but were modified to predict the best water quality objective based on the data input. Various crops in the South Delta region are salt sensitive; however, beans were deemed the most sensitive and thus the representative crop for determining the salinity water quality objective. However, using beans as a representative crop draws criticism from missing data for salt tolerance at the various developmental stages of beans, the age of the data (>30 years old), and only one experiment performed in soil.

Of the models examined, the steady-state model using exponential water uptake patterns agreed with the leaching requirements of 14 crops. Of the transient models, using 40-30-20-10% water uptake patterns aligned the best with the leaching requirements. Overall, the report found that steady state models overestimate the leaching requirements albeit minimally. Results from these models under Southern Delta conditions lead to recommendations to raise the EC water quality objective for the Southern Delta region since all models showed that the water quality standard could be increased to between 0.8-1.1 dS/m without decreasing the yield of the most sensitive crops. Table 3 below describes the conditions of the various model types and the recommended EC limits as a result of the model.

Table 3: Model Type and Predicted EC Water Quality Criteria Described in the Hoffman Report to the State Water Resources Control Board in 2010

Model	Crop Uptake Distribution	EC of Irrigation Water (dS/M)	Leaching Fraction	Recommended EC (dS/m) Water Quality Objective
Steady-State Model	40-30-20-10	1.0	0.15	0.8
Steady-State Model	40-30-20-10	1.0	0.20	0.9
Transient Model (Grattan Model)	40-30-20-10	0.7-1.2[a]	0.15-2.0[a]	1.1
ENVIRO-GRO	Darcy-Richards equation[b]	1.0	<0.5	1.0
ENVIRO-GRO	Darcy-Richards equation[b]	2.0	0.15	1.0

[a]The analysis used a range of variables to come to the recommended EC water quality standard.
[b]The equation contains a function for water uptake however; the equation describes overall water flow.

Title: Statutes Related to the California Department of Public Health and Recycled Water, Excerpts from the Health and Safety Code and the Water Code, January 2009 *and*, California Department of Public Health, Regulations Related to Recycled Water, January 2009;
(collectively, these compilations of recycled water-related laws are referred to by CDPH staff and the regulated community as "The Purple Book")
Author: California Department of Public Health
Source: http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Lawbook.aspx
Parameters: no numeric criteria
Accessed: June 2010

Summary: State of California statutes related to recycled water are found in the Health and Safety Code and in the Water Code. The Health and Safety Code includes statutes related to the authority of sanitary districts with respect to water recycling and distribution, building standards such as that related to the use of graywater, requirements for augmentation of a drinking water source with recycled water, and cross-connection control. The Water Code includes statutes related to urban water management and water quality.

State of California regulations related to recycled water are found in Title 17 and 22 of the California Code of Regulations (CCR). Title 17 includes regulations pertaining to the protection of water systems via backflow preventers and related testing, while Title 22 includes regulations pertaining to water recycling criteria, uses of recycled water, requirements for use areas and dual plumbed recycled water systems, groundwater recharge, methods of treatment, and requirements for engineering, design, and reliability. Title 22 defines four categories of recycled water: undisinfected secondary recycled water, disinfected secondary-23 recycled water, disinfected secondary-2.2 recycled water, and disinfected tertiary recycled water. The definitions of these categories, and the authorized (beneficial) uses specified in Title 22, are summarized in Table 4 below.

Table 4: Categories and Authorized Beneficial Uses of Recycled Water from California's Code of Regulations Title 22

Category	Definition	Authorized Uses
Undisinfected secondary recycled water	Oxidized wastewater.	Irrigation of: (1) orchards and vineyards where the recycled water does not contact the edible crop, (2) non food-bearing trees, (3) fodder and fiber crops and pasture for animals not producing milk for human consumption, (4) seed crops not eaten by humans, (5) food crops that must undergo commercial pathogen-destroying processing before being consumed by humans, and (6) ornamental nursery stock.
Disinfected secondary-23 recycled water	Recycled water that has been oxidized and disinfected so that the median concentration of total coliform bacteria in the disinfected effluent does not exceed a most probable number (MPN) of 23 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform bacteria does not exceed an MPN of 240 per 100 milliliters in more than one sample in any 30 day period.	Irrigation of (1) cemeteries, (2) freeway landscaping, (3) restricted access golf courses, (4) ornamental nursery stock and sod farms where access by the general public is not restricted, (5) pasture for animals producing milk for human consumption, and (6) any nonedible vegetation where access is controlled so that the irrigated area cannot be used as if it were part of a park, playground or school yard; Industrial or commercial cooling or air conditioning that does not involve the use of a cooling tower, evaporative condenser, spraying, or any mechanism that creates a mist; Miscellaneous other listed uses (see regulation) such as industrial boiler feed, nonstructural fire fighting, mixing concrete, cleaning roads, sidewalks, and outdoor work areas.
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 disinfected effluent does not exceed a most probable number (MPN) of 2.2 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform bacteria does not exceed an MPN of 23 per 100 milliliters in more than one sample in any 30 day period.	Surface irrigation of food crops where the edible portion is produced above ground and not contacted by the recycled water; Restricted recreational water impoundments; Publicly accessible impoundments at fish hatcheries.

Category	Definition	Authorized Uses
Disinfected tertiary recycled water	A filtered and subsequently disinfected wastewater that meets the following criteria: (a) The filtered wastewater has been disinfected by either: (1) A chlorine disinfection process meeting specified criteria (see regulation); or (2) Other disinfection process that meets specified criteria (see regulation) (b) The median concentration of total coliform bacteria measured in the disinfected effluent does not exceed an MPN of 2.2 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed and the number of total coliform bacteria does not exceed an MPN of 23 per 100 milliliters in more than one sample in any 30 day period. No sample shall exceed an MPN of 240 total coliform bacteria per 100 milliliters.	(1) food crops, including all edible root crops, where the recycled water comes into contact with the edible portion of the crop, (2) parks and playgrounds, (3) school yards, (4) residential landscaping, (5) unrestricted access golf courses, and (6) any other irrigation use not specified in this section and not prohibited by other sections of the California Code of Regulations; Non-restricted recreational water impoundments; Industrial or commercial cooling or air conditioning that involves the use of a cooling tower, evaporative condenser, spraying or any mechanism that creates a mist; Miscellaneous other listed uses (see regulation) such as flushing toilets, structural fire fighting, car washes, decorative foundations.

Title: Salt Management Guide for Landscape Irrigation with Recycled Water in Coastal Southern California- A Comprehensive Literature Review
Author: Tanji, K.; Grattan, S.; Grieve, C.; Harivandi, A.; Rollins, L.; Shaw, D.; Sheikh, B.; and Wu, L.
Publication date: 2008
Document: http://salinitymanagement.org/Literature_Review.pdf
Accessed: June 2010
Parameters: EC, Sodium, Chloride, Boron, TDS, Nitrate

Summary: Title 22, Code of Regulations on Water Recycling Criteria is the recycled water regulation for the State of California which is focused on protecting public health and ecological health. The levels of treatment and the associated approved uses are described in the regulation. These treatment levels correspond with most discharge requirements, focus on microbial contaminants, and discharges generally contain salt levels 150-400 mg/L above potable water levels and 15-50 mg/L of NO_3-N and NH_4-N. In terms of use in California, agricultural irrigation is the largest consumer followed by landscape irrigation. However, in the Los Angeles region groundwater recharge and other applications are the largest consumer of recycled waters.

Water quality guidelines for landscape irrigation are given in this report. Depending on the types of sources into a sewage treatment facility, the composition of the recycled water can vary. Various salt ions (including high levels of NaCl associated with water softeners) and nutrients including ammonia, ammonium ions and nitrates are present in these waters with their levels dependent on the waste water treatment processes. The guidelines for irrigating crops and landscape plants are based on the information provided in the publication by Ayers and Branson, 1975 and adapted in Table 5 below.

Table 5: Water Quality Guidelines for Crop and Landscape Irrigation as Described in Ayers and Branson, 1975

Constituent	No Problem	Increasing Problem	Severe Problem
EC dS/m	<0.75	0.75-3.0	>3.0
Sodium (adjusted SAR)-root absorption	<3	>3	
Chloride-root absorption	<142	142-355	>355
Boron-root absorption	<0.5	0.5-2.0	2.0-10.0
Sodium- (foliar absorption)	<69	>69	
Chloride- (foliar absorption)	<106	>106	
NH_4-N + NO_3-N mg/L	<5	5-30	>30

Water quality guidelines for plugging potential of drip irrigation system are provided by the document. Constituents at the levels found in recycled water do not pose a plugging potential with the exception of TDS which may cause slight restrictions to use. At <500 mg/L of TDS there is no restriction to use for drip irrigation while slight to moderate restrictions occur at 500-2,000 mg/L and severe restrictions to plugging occur at >2,000 mg/L.

Section 3: National

Title: Quality Criteria for Water (Red Book)
Author: US Environmental Protection Agency
Publication date: 1976
Document: hard copyicd
Parameters: Dissolved solids, Boron, Nitrate, Chloride, Sulfate, Sodium

Summary: The US EPA Water Quality Criteria (Red Book) describes the criteria set for the various constituents and provides a rational for each of the constituents. The past constituents of interest are found in Table 6.

Table 6: US EPA Water Quality Criteria from Quality Criteria for Water (US EPA, 1976)

Impacted Use	Parameter	Guidance
Agriculture	Boron	750 µg/L
Drinking water	Nitrate nitrogen	10 mg/L
Domestic Water Supply	Chloride	250 mg/L
Domestic Water Supply	Sulfate	250 mg/L

Boron is found as a sodium or calcium borate salt and not in its elemental form. Some plant species are sensitive to boron such as citrus resulting in leaf injury, however, some species require additional boron in the soil during the growing season such as alfalfa. As a result of the sensitive crops, a criterion of 750 µg/L was established to protect sensitive crops during long term irrigation.

Nitrate criteria are heavily supported by documented adverse affects in drinking water. Scientific publications described the mechanism of action and levels of nitrate that result in Methemoglobinemia which was the primary reason for setting nitrate water quality criteria to be set for nitrate. Alternatively, toxicity experiments were documented for warm water fish which can generally tolerate greater levels of nitrate nitrogen. Based on the scientific understanding, the greatest consumption risks were toward humans and therefore the criteria was established for this purpose.

In this US EPA document the elements of salinity are grouped into TDS. While criteria for sulfate and chloride are given, other constituents do not have criteria but scientific information is presented. Based on epidemiological studies, the levels of sulfate in the water and the reported affect on the consumer were surveyed. Based on the surveys, the level of 250 mg/L of sulfate was recommended because a large majority of the population is protected from a laxative effect of the water.

Assessments for sodium are based primarily on sodium restricted diets however, since the general population at that time was not affected by sodium restricted diets, criteria were not set

for sodium. In the surveys, the results showed that at levels of 270 mg/L of sodium the water became unacceptable aesthetically; therefore, taste becomes an issue for consumers before reaching the level of TDS that may cause any physical effect. Yet, the report indicates that sodium should be given consideration in relation to other cations.

Customer surveys indicated that around 300 mg/L of TDS taste was acceptable and not acceptable around 1000 mg/L. Based on these taste surveys, a threshold of 500 mg/L was established for dissolved solids. Dissolved solids are also involved in the corrosion of metal surfaces. The report also noted that different constituents may lower the taste threshold such as chlorides. Therefore, US EPA based on taste surveys and effects of chloride on water for brewing coffee recommended a maximum level of 250 mg/L of chloride.

In terms of fish aquatic life, dissolved solid tolerance levels for most freshwater fish (≤15,000 mg/L) significantly exceed the levels for human consumption; however, some birds have lower tolerance levels based on data from studies for chicken's drinking water. However, it was anticipated that the greatest impact from salinity will occur from habitat alteration not consumption by humans or wildlife. Agricultural uses including livestock drinking water and irrigation water are higher than the taste thresholds but 5000 mg/L is the recommended limit for alkaline waters used for livestock. Irrigation levels can vary based on the detrimental effects from the dissolved solids on crops as reported in this 1976 report.

Title: 5 CCR 1002-31 Regulation No. 31 The Basic Standards and Methodologies for Surface Water
Author: Colorado Department of Public Health and Environment, Water Quality Control Commission
Source: http://www.epa.gov/waterscience/standards/wqslibrary/co/index.html
Accessed: June 2010
Parameters: salinity (TDS), boron, chloride, nitrate, sulfate

Summary: Colorado's Regulation No. 31, The Basic Standards and Methodologies for Surface Water (effective December 31, 2007), establishes basic standards, an antidegradation rule and implementation process, and a system for classifying state surface waters and assigning water quality standards. The purpose is to ensure the suitability of Colorado's waters for beneficial uses including public water supplies, domestic, agricultural, industrial and recreational uses, and the protection and propagation of terrestrial and aquatic life.

Surface waters are classified for the present beneficial uses of the water, or the beneficial uses that may be reasonably expected in the future. Numeric standards may apply on a statewide basis or to specific state surface waters. These standards may be Table Value Standards (from the numeric levels in Tables I, II, and III of the regulation), Ambient Quality-Based Standards (site-specific standards adopted where the surface waters exceed levels in Tables I, II, or III but are determined adequate to protect classified uses), or other specified standards. Selected constituents from Table II of the regulation are given in Table 7 below. With respect to salinity, the regulation refers to the salinity standards for the Colorado River Basin (Regulation No. 39) and states that other standards for salinity have not been established or assigned. Although beneficial uses are assigned, a specific numeric criterion may not be associated with the assignment.

Waters are classified according to the uses for which they are suitable or intended to become suitable. The classifications include: Recreation (Class 1a for primary contact recreation, 1b if primary contact uses have not been identified or may occur in the future, 2 if it is unlikely that primary contact uses will occur in the next 20 years); Agriculture (for irrigation of crops); Aquatic Life (Class I - Cold Water Aquatic Life or I - Warm Water Aquatic Life, capable of sustaining a wide variety of cold or warm water biota, respectively, including sensitive species, Class 2 - Cold and Warm Water Aquatic Life, not capable of sustaining a wide variety of cold or warm water biota); Water Supply (for potable water supplies); Wetlands (may be adopted if wetland functions warrant site-specific protection, otherwise tributary wetlands are classified according to the surface water segment to which they are most directly connected). Qualifiers may be appended to any classification to indicate special considerations. These qualifiers include: Goal (not fully suitable but intended to become suitable for the classified use); Seasonal (suitable for a classified use during certain periods of the year); Interrupted Flow (the continuity of flow is broken, not necessarily according to a seasonal schedule).

Table 7: Selected Inorganic Numeric Standards from 5 CCR 1002-31 Regulations No 31 (Colorado Basic Standards and Methodologies for Surface Water, 2007)

Beneficial Use	Boron mg/L	Chloride mg/L	Nitrate mg/L (as N)	Sulfate mg/L
AQUATIC LIFE	NA	NA	NA	NA
Class 1 Cold Water Biota	NA	NA	NA	NA
Class 1 Warm Water Biota	NA	NA	NA	NA
Class 2	NA	NA	NA	NA
AGRICULTURE	0.75[a,b] (30-day)	NA	100 [b,d]	NA
DOMESTIC WATER SUPPLY	NA	250[c] (30-day)	NA	250[c] (30-day)

Footnotes

[a] EPA Quality Criteria for Water, July 1976, U.S. Environmental Protection Agency, U.S. Government Printing Office: 1977 0-222-904, Washington, D.C. 256 p.

[b] EPA - Water Quality Criteria 1972, Ecological Research Series, National Academy of Sciences, National Academy of Engineering, EPA-R3-73-033, March 1973, Washington, D.C. 594 p.

[c] EPA, March 1977, Proposed National Secondary Drinking Water Regulation, Federal Register, Vol. 42 No. 62, pp 17143-17147.

"30-day" – average of all samples collected during a thirty-day period

[d] In order to provide a reasonable margin of safety to allow for unusual situations such as extremely high water ingestion or nitrite formation in slurries, the NO_3-N plus NO_2-N content in drinking waters for livestock and poultry should be limited to 100 ppm or less, and the NO_2-N content alone be limited to 10 ppm or less.

Title: 5 CCR 1002-41 Regulation No. 41 The Basic Standards for Ground Water
Author: Colorado Department of Public Health and Environment, Water Quality Control Commission
Source: http://www.cdphe.state.co.us/regulations/wqccregs/
Accessed: June 2010
Parameters: TDS, boron, chloride, nitrate, sulfate

Summary: Colorado's Regulation No. 41, The Basic Standards for Ground Water (effective November 30, 2009), establishes statewide standards and a system for classifying groundwater to protect existing and potential beneficial uses. The five groundwater classifications are: Domestic Use – Quality; Agricultural Use – Quality; Surface Water Quality Protection; Potentially Usable Quality; and Limited Use and Quality. "Domestic Uses" are defined as existing or potential future uses of groundwater for household or family use (such as drinking, municipal, etc.). "Agricultural Uses" are defined as the existing or potential future uses of groundwater for the cultivation of soil, production of crops, and/or the raising of livestock. Selected parameter standards for the Domestic Uses and Agricultural Uses groundwater classifications are given in Table 8.

Groundwater in a particular area is classified as "Surface Water Quality Protection" when proposed or existing activity will impact ground waters such that water quality standards of surface water bodies will be exceeded. Groundwater in a particular area is classified as "Potentially Usable Quality" if a number of conditions are met including TDS levels less than 10,000 mg/l, background levels that are not adequate to ensure compliance with the Human Health and Agricultural Standards, and domestic or agricultural use can reasonably be expected in the future (Table 9). Groundwater in a particular area is classified as "Limited Use and Quality" when TDS levels are equal to or greater than 10,000 mg/L or under other conditions specified in the regulation. When a groundwater has a multi-use classification, the most restrictive standard for a parameter applies.

Table 8: Summary of Domestic and Agricultural Standards Used for Colorado Ground Water Classification from 5 CCR 1002-41 Regulations No 41 (Colorado Basic Standards and Methodologies for Ground Water, 2009)

Ground Water Classification	Standards Used	TDS	EC	Boron mg/L	Chloride mg/L	Nitrate mg/L (as N)	Sodium	Sulfate mg/L
Domestic Uses	Domestic Water Supply – Human Health Standards		NA	NA	250	10.0	NA	250
Agricultural Uses	Agricultural Standards	See Table 9	NA	0.75	NA	100[a]	NA	NA
Surface Water Quality Protection	Standards necessary to prevent exceedance of surface water standards	See Table 9	NA	NA	NA	NA	NA	NA
Potentially Usable Quality		See Table 9	NA	NA	NA	NA	NA	NA

[a]Total nitrite and nitrate (as N)
NA= None available

Table 9: TDS Water Quality Standards from 5 CCR 1002-41 Regulations No 41 (Colorado Basic Standards and Methodologies for Ground Water, 2009)

Background TDS Value (mg/L)	Maximum Allowable TDS Concentrations
0 – 500	400 mg/l or 1.25 times the background level, whichever is least restrictive
501 – 10,000	1.25 times the background value
10,001 or greater	No limit

Title: Colorado River Basin Study Final Report. Report to the Western Water Policy Review Advisory Commission (August 1997).
Author: Dale Pontius (Principal Investigator), in conjunction with SWCA, Inc. Environmental Consultants, Tucson, Arizona
Source: http://wwa.colorado.edu/colorado_river/docs/pontius%20colorado.pdf
Accessed: June 2010
Parameters: salinity (TDS)

Summary: The *1997 Colorado River Basin Study Final Report* provides background information and a discussion of major water quality and quantity-related issues for the Colorado River basin. The Colorado River basin covers almost a quarter of a million square miles and includes portions of seven states, part of Mexico, and 34 Indian Reservations. The report summarizes basin hydrology, geology, and the major water uses and allocations of the river. The major issues identified are water management, ecosystem sustainability, salinity control, and Indian water rights. Recommendations associated with each of these topics are provided. With respect to salinity, the study reports that salinity of the Colorado River has fluctuated significantly over the period of record (1941-1995) and is generally inversely proportional to flow rate, e.g. it increases during periods of lower flow.

Congress has taken several actions to control salinity in the Colorado River, which has had significant domestic and international impacts in the Colorado River basin. Natural sources are partly responsible for salt loading to the river, while other sources related to human development (irrigation return flow, reservoir evaporation, municipal, and industrial) also contribute. In 1972, Congress enacted amendments to the Clean Water Act (P.L. 92-500) which required states to adopt EPA-approved basin-wide salinity standards based on numeric criteria. The standards adopted for Colorado River basin are given in Table 10. Additionally, a 1974 agreement with Mexico (Minute No. 242 to the 1944 Mexican Water Treaty) established salinity standards for water delivered upstream of Morelos Dam (the final dam on the Colorado River before reaching Mexico) at no more than 115 ppm (or mg/L) plus or minus 30 ppm over the annual average salinity of water arriving at the upstream Imperial Dam.

In order to maintain salinity levels at or below the adopted numeric standards in Table 10, the Colorado River Basin Salinity Control Forum was established by the basin states in 1974. The 1997 Colorado River Basin Study Final Report does not explicitly discuss the numeric criteria with respect to beneficial uses of Colorado River water.

Table 10: Colorado River Basin Numeric Salinity Standards

Location	Colorado River Basin Standards
Hoover Dam	723 mg/L
Parker Dam	747 mg/L
Imperial Dam	879 mg/L

Title: Regulation No. 39 Colorado River Salinity Standards
Author: Colorado Department of Public Health and Environment, Water Quality Control Commission
Source: http://www.epa.gov/waterscience/standards/wqslibrary/co/index.html
Accessed: June 2010
Parameters: salinity (TDS)

Summary: Regulation No. 39 provides water quality standards for salinity of the Colorado River measured at three stations (Table 11) as flow-weighted average annual values. The introduction of the regulation states that salinity or total dissolved solids (TDS) occurs at low concentrations in the headwaters and tributaries of the Colorado River, but increase downstream. The primary effects of salinity occur in the lower Colorado River basin, due to the higher levels of salinity and types of crops grown there. The regulation states that the purpose of the water quality standards is to protect the uses of the waters; these uses (or beneficial uses) are not explicitly given in the regulation.

Table 11: Colorado River Basin Numeric Salinity Standards

Location	Colorado River Basin TDS Standards
Below Hoover Dam	723 mg/L
Below Parker Dam	747 mg/L
At Imperial Dam	879 mg/L

Title: 2008 Review: Water Quality Standards for Salinity, Colorado River System
Author: Colorado River Basin Salinity Control Forum
Source: http://www.coloradoriversalinity.org/docs/2008%20Review.pdf
Accessed: June 2010
Parameters: salinity (TDS)

Summary: This report provides a 2008 review of the water quality standards for salinity of the Colorado River. Such review is required every three years by Section 303 of the Clean Water Act, and was conducted by the seven-state Colorado River Basin Salinity Control Forum. The Forum reviewed the existing state-adopted and US EPA approved water quality standards for salinity, which consists of numeric criteria (Table 12) and a plan of implementation for continued salinity control. The existing numeric criteria consist of flow-weighted annual average 1972 salinity levels, and are measured at three stations located on the lower main stem of the River, near the border between Arizona and Nevada followed by the border between Arizona and California. The stations were selected based on their proximity to key diversion facilities on the lower River.

Table 12: Colorado River Basin Numeric Salinity Standards as Shown in Regulation No. 39 Colorado River Salinity Standards from the State of Colorado

Location	Colorado River Basin TDS Standards
Below Hoover Dam	723 mg/L
Below Parker Dam	747 mg/L
At Imperial Dam	879 mg/L

Recently the US Bureau of Reclamation enhanced its model for analysis of Colorado River Salinity, which was considered among other factors in the Forum's review. The 2008 Review does not explicitly discuss beneficial uses as related to the numeric salinity criteria. However, it states that high salinity impacts the agricultural sector and that, based on the current use patterns in the Lower Basin and ongoing progress in the plan of implementation, the Forum recommends no change in the numeric salinity criteria at the three stations in Table 12.

Title: 5 CCR 1002-32 Regulation No. 32 Classifications and Numeric Standards for Arkansas River Basin (Table: Stream Classifications and Water Quality Standards)
Author: Colorado Department of Public Health and Environment, Water Quality Control Commission
Source: http://www.epa.gov/waterscience/standards/wqslibrary/co/index.html
Accessed: June 2010
Parameters: boron, chloride, nitrate, sulfate

Summary: These regulations provide classifications and numeric standards for the Arkansas River Basin, including all tributaries and standing bodies of water in all or parts of the following counties: Lake, Chaffee, Custer, Fremont, El Paso, Pueblo, Huerfano, Las Animas, Otero, Bent, Prowers, Baca, Kiowa, Cheyenne, Lincoln, Teller, and Elbert Counties. The Arkansas River Basin is located in the southeast corner of the state, and includes the city of Pueblo. The classifications identify the beneficial uses of the water, and the numeric standards determine allowable concentrations of various parameters.

As shown in Table 13 below, the classifications and numeric standards are assigned to numerous stream segments throughout different parts of the Arkansas River Basin. Not all stream segments or water bodies are assigned numeric standards, and many are given multiple classifications (beneficial uses). The stream segments and water bodies in the Arkansas River Basin are assigned numeric standards for boron, nitrate, chloride, and sulfate, the values are typically 0.75 mg/L boron, 10 mg/L nitrate as N (nitrogen), 250 mg/L chloride, and 250 mg/L sulfate.

Discharge permits are issued by the Water Quality Control Division to comply with basic, narrative, and numeric standards so that all discharges to waters of the state protect the classified uses. These regulations are not adopted as control regulations but guidance for the basin.

Waters are classified according to the uses for which they are suitable or intended to become suitable. The classifications include: *Recreation* (Class 1a for primary contact recreation, 1b if primary contact uses have not been identified or may occur in the future, 2 if it is unlikely that primary contact uses will occur in the next 20 years); *Agriculture* (for irrigation of crops); *Aquatic Life* (Class I - Cold Water Aquatic Life or I - Warm Water Aquatic Life, capable of sustaining a wide variety of cold or warm water biota, respectively, including sensitive species, Class 2 - Cold and Warm Water Aquatic Life, not capable of sustaining a wide variety of cold or warm water biota); *Water Supply* (for potable water supplies); *Wetlands* (may be adopted if wetland functions warrant site-specific protection, otherwise tributary wetlands are classified according to the surface water segment to which they are most directly connected). Qualifiers may be appended to any classification to indicate special considerations. These qualifiers include: *Goal* (not fully suitable but intended to become suitable for the classified use); *Seasonal* (suitable for a classified use during certain periods of the year); *Interrupted Flow* (the continuity of flow is broken, not necessarily according to a seasonal schedule).

Table 13: Selected Numeric Standards for the Arkansas River Basin as Described in 5 CCR 1002-32
Colorado Regulation No. 32 Classifications and Numeric Standards for Arkansas River Basin

Beneficial Use	Water Basin	Boron mg/L	Chloride mg/L	Nitrate mg/L	Sulfate mg/L
Aq Life Cold 1, Aq Life Cold 2, Aq Life Warm 2, Recreation 1a, Water Supply, Agriculture	Upper Arkansas River	0.75	250	10	WS
Aq Life Cold 1, Aq Life Warm 1, Aq Life Warm 2, Recreation 1a, Water Supply, Agriculture	Middle Arkansas River	0.75	250	10 (100)[a]	WS (700)[a]
Aq Life Cold 1, Aq Life Warm 1, Aq Life Warm 2, Recreation 1a, Recreation 1b, Recreation 2, Water Supply, Agriculture	Fountain Creek	0.75	250	10 (100)[a]	WS (330)[a] (490)[a]
Aq Life Cold 1, Aq Life Cold 2, Aq Life Warm 2, Recreation 1a, Recreation 1b, Recreation 2, Water Supply, Agriculture	Lower Arkansas River	0.75 (5.0)[a]	250	10 (100)[a]	WS (287)[a] (1078)[a] (1900)[a]
Aq Life Warm 2, Recreation 2, Recreation 1a, Agriculture	Cimarron River	0.75	NA	100	NA

[a] Specific reaches of the river have elevated standards. See regulation for the specific reach.
WS= Ambient levels prior to January 1, 2000 or 250 mg/L whichever is less restrictive.
NA=None available

Title: Regulation No. 36, Classifications and Numeric Standards for Rio Grande Basin (Table: Stream Classifications and Water Quality Standards)
Author: Colorado Department of Public Health and Environment, Water Quality Control Commission
Source: http://www.epa.gov/waterscience/standards/wqslibrary/co/index.html
Accessed: June 2010
Parameters: Boron, Chloride, Nitrate, Sulfate

Summary: These regulations provide classifications and numeric standards for the Rio Grande River Basin, including all tributaries and standing bodies of water in all or parts of the following counties: Alamosa, Conejos, Costilla, Mineral, Rio Grande, and Saguache Counties. The Rio Grande River Basin is located in south central Colorado, and includes the city of Alamosa. The classifications identify the beneficial uses of the water, and the numeric standards determine allowable concentrations of various parameters.

As shown in Table 15 below, the classifications and numeric standards are assigned to numerous stream segments throughout different parts of the Rio Grande River Basin. Not all stream segments or water bodies are assigned numeric standards, and many are given multiple classifications (beneficial uses). According to Table 14, for those stream segments and water bodies in the Rio Grande River Basin that are assigned numeric standards for boron, nitrate, chloride, and sulfate, the values are 0.75 mg/L boron, 10 mg/L nitrate as N (nitrogen), 250 mg/L chloride, and 250 mg/L sulfate.

Discharge permits are issued by the Water Quality Control Division to comply with basic, narrative, and numeric standards so that all discharges to waters of the state protect the classified uses. These regulations are not adopted as control regulations.

Waters are classified according to the uses for which they are suitable or intended to become suitable. The classifications include: *Recreation* (Class 1a for primary contact recreation, 1b if primary contact uses have not been identified or may occur in the future, 2 if it is unlikely that primary contact uses will occur in the next 20 years); *Agriculture* (for irrigation of crops); *Aquatic Life* (Class I - Cold Water Aquatic Life or I - Warm Water Aquatic Life, capable of sustaining a wide variety of cold or warm water biota, respectively, including sensitive species, Class 2 - Cold and Warm Water Aquatic Life, not capable of sustaining a wide variety of cold or warm water biota); *Water Supply* (for potable water supplies); *Wetlands* (may be adopted if wetland functions warrant site-specific protection, otherwise tributary wetlands are classified according to the surface water segment to which they are most directly connected). Qualifiers may be appended to any classification to indicate special considerations. These qualifiers include: *Goal* (not fully suitable but intended to become suitable for the classified use); *Seasonal* (suitable for a classified use during certain periods of the year); *Interrupted Flow* (the continuity of flow is broken, not necessarily according to a seasonal schedule).

Table 14: Selected Numeric Standards for the Rio Grande Basin as Described in Colorado Regulation No. 36, Classifications and Numeric Standards for Rio Grande Basin

Beneficial Use	Water Basin	Boron mg/L	Chloride mg/L	Nitrate mg/L	Sulfate mg/L
Aq Life Cold 1, Aq Life Cold 2, Aq Life Warm 2, Recreation 1a, Recreation 2, Water Supply, Agriculture	Rio Grande	0.75	250	10	WS
Aq Life Cold 1, Aq Life Cold 2, Aq Life Warm 2, Recreation 1a, Recreation 2, Water Supply, Agriculture	Alamosa River/La Jara Creek/Conejos River	0.75	250	10	WS (250)[a]
Aq Life Cold 1, Aq Life Cold 2, Aq Life Warm 2, Recreation 1a, Water Supply, Agriculture	Closed Basin-San Luis Valley	0.75	250	10	WS

[a] Specific reaches of the river have elevated standards. See regulation for the specific reach.
WS= Ambient levels prior to January 1, 2000 or 250 mg/L whichever is less restrictive.
NA=None available

Title: Regulation No. 35, Classifications and Numeric Standards for Gunnison and Lower Dolores River Basins (Table: Stream Classifications and Water Quality Standards)
Author: Colorado Department of Public Health and Environment, Water Quality Control Commission
Source: http://www.epa.gov/waterscience/standards/wqslibrary/co/index.html
Accessed: June 2010
Parameters: Boron, Chloride, Nitrate, Sulfate

Summary: These regulations establish classifications and numeric standards for the Gunnison River/Lower Dolores River Basins, including all tributaries and standing bodies of water in all or parts of the following counties: Gunnison, Delta, Montrose, Ouray, Mesa, Saguache and Hinsdale Counties. This also includes the lower Dolores River and its tributaries in Dolores, Montrose, Mesa and San Miguel Counties. Gunnison River Basin and Dolores River Basin are located in the southwestern corner of the state. Gunnison River Basin includes the city of Montrose. Dolores River Basin includes the city of Durango. The classifications identify the beneficial uses of the water, and the numeric standards determine allowable concentrations of various parameters.

As shown in Table 14 below, the classifications and numeric standards are assigned to numerous stream segments throughout different parts of the Gunnison River Basin and Dolores River Basin. Not all stream segments or water bodies are assigned numeric standards, and many are given multiple classifications (beneficial uses). According to Table 16, for those stream segments and water bodies in the Gunnison River Basin and Dolores River Basin that are assigned numeric standards for boron, nitrate, chloride, and sulfate, the values are typically 0.75 mg/L boron, 10 mg/L nitrate as N (nitrogen), 250 mg/L chloride, and 250 mg/L sulfate.

Discharge permits are issued by the Water Quality Control Division to comply with basic, narrative, and numeric standards so that all discharges to waters of the state protect the classified uses. These regulations are not adopted as control regulations.

Waters are classified according to the uses for which they are suitable or intended to become suitable. The classifications include: *Recreation* (Class 1a for primary contact recreation, 1b if primary contact uses have not been identified or may occur in the future, 2 if it is unlikely that primary contact uses will occur in the next 20 years); *Agriculture* (for irrigation of crops); *Aquatic Life* (Class I - Cold Water Aquatic Life or I - Warm Water Aquatic Life, capable of sustaining a wide variety of cold or warm water biota, respectively, including sensitive species, Class 2 - Cold and Warm Water Aquatic Life, not capable of sustaining a wide variety of cold or warm water biota); *Water Supply* (for potable water supplies); *Wetlands* (may be adopted if wetland functions warrant site-specific protection, otherwise tributary wetlands are classified according to the surface water segment to which they are most directly connected). Qualifiers may be appended to any classification to indicate special considerations. These qualifiers include: *Goal* (not fully suitable but intended to become suitable for the classified use); *Seasonal* (suitable for a classified use during certain periods of the year); *Interrupted Flow* (the continuity of flow is broken, not necessarily according to a seasonal schedule).

Table 15: Selected Numeric Standards for the Gunnison and Lower Dolores River Basins as Described in Colorado Regulation

No. 35, Classifications and Numeric Standards for Gunnison and Lower Dolores River Basins

Beneficial Uses	Water Basin	Boron mg/L	Chloride mg/L	Nitrate mg/L	Sulfate mg/L
Aq Life Cold 1, Aq Life Cold 2, Aq Life Warm 2 Recreation 1, Recreation 1a, Recreation 1b Water Supply, Agriculture	Upper Gunnison River	0.75	250	10	WS
Aq Life Cold 1, Warm 2 Recreation 1a, Water Supply, Agriculture	North Fork of Gunnison River	0.75	250	10 (100)[a]	WS
Aq Life Cold 1, Aq Life Cold 2, Aq Life Warm 1, Aq Life Warm 2, Recreation 1a, Recreation 2, Recreation 1b Water Supply, Agriculture	Uncompahgre River	0.75	250	10 (100)[a]	WS
Aq Life Cold 1, Aq Life Cold 2, Aq Life Warm 2, Recreation 1a, Recreation 2, Recreation 1b Water Supply, Agriculture	Lower Gunnison River	0.75	250	10 (100)[a]	WS (480)[a]
Aq Life Cold 1, Recreation 1a, Water Supply, Agriculture	San Miguel River	0.75	250	10	WS
Aq Life Cold 1, Aq Life Warm 1, Aq Life Warm 2, Recreation 1a, Water Supply, Agriculture	Lower Dolores River	0.75	250	10 (100)[a]	WS

[a] Specific reaches of the river have elevated standards. See regulation for the specific reach.
WS= Ambient levels prior to January 1, 2000 or 250 mg/L whichever is less restrictive.

Title: Regulation No. 37, Classifications and Numeric Standards for Lower Colorado River Basin (Table: Stream Classifications and Water Quality Standards)
Author: Colorado Department of Public Health and Environment, Water Quality Control Commission
Source: http://www.epa.gov/waterscience/standards/wqslibrary/co/index.html
Accessed: June 2010
Parameters: Boron, Chloride, Nitrate, Sulfate

Summary: These regulations establish classifications and numeric standards for the Lower Colorado River Basin, including all tributaries and standing bodies of water. This includes all or parts of Garfield, Mesa, Rio Blanco, Moffat and Routt Counties. The Colorado River Basin is located in northwest Colorado and includes the city of Glenwood Springs. The classifications identify the beneficial uses of the water, and the numeric standards determine allowable concentrations of various parameters.

As shown in Table 5below, the classifications and numeric standards are assigned to numerous stream segments throughout different parts of the Lower Colorado River Basin. Not all stream segments or water bodies are assigned numeric standards, and many are given multiple classifications (beneficial uses). According to Table 16, for those stream segments and water bodies in the Lower Colorado River Basin that are assigned numeric standards for boron, nitrate, chloride, and sulfate, the values are typically 0.75 mg/L boron, 10 mg/L nitrate as N (nitrogen), 250 mg/L chloride, and 250 mg/L sulfate.

Discharge permits are issued by the Water Quality Control Division to comply with basic, narrative, and numeric standards so that all discharges to waters of the state protect the classified uses. These regulations are not adopted as control regulations.

Waters are classified according to the uses for which they are suitable or intended to become suitable. The classifications include: *Recreation* (Class 1a for primary contact recreation, 1b if primary contact uses have not been identified or may occur in the future, 2 if it is unlikely that primary contact uses will occur in the next 20 years); *Agriculture* (for irrigation of crops); *Aquatic Life* (Class I - Cold Water Aquatic Life or I - Warm Water Aquatic Life, capable of sustaining a wide variety of cold or warm water biota, respectively, including sensitive species, Class 2 - Cold and Warm Water Aquatic Life, not capable of sustaining a wide variety of cold or warm water biota); *Water Supply* (for potable water supplies); *Wetlands* (may be adopted if wetland functions warrant site-specific protection, otherwise tributary wetlands are classified according to the surface water segment to which they are most directly connected). Qualifiers may be appended to any classification to indicate special considerations. These qualifiers include: *Goal* (not fully suitable but intended to become suitable for the classified use); *Seasonal* (suitable for a classified use during certain periods of the year); *Interrupted Flow* (the continuity of flow is broken, not necessarily according to a seasonal schedule).

Table 16: Selected Numeric Standards for the Lower Colorado River Basin as Described in Colorado Regulation No. 37, Classifications and Numeric Standards for Lower Colorado River Basin

Beneficial Uses	Water Basin	Boron mg/L	Chloride mg/L	Nitrate mg/L	Sulfate mg/L
Aq Life Cold 1, Aq Life Cold 2, Aq Life Warm 1, Aq Life Warm 2 Recreation 1, Recreation 1a, Recreation 1b Water Supply, Agriculture	Lower Yampa River/ Green River	0.75	250	10 (100)[a]	WS
Aq Life Cold 1, Aq Life Cold 2, Aq Life Warm 1, Aq Life Warm 2 Recreation 1a, Recreation 1b, Recreation 2, Water Supply, Agriculture	White River	0.75	250	10 (100)[a]	WS
Aq Life Cold 1, Aq Life Cold 2, Aq Life Warm 1, Aq Life Warm 2, Recreation 1a, Recreation 2, Recreation 1b Water Supply, Agriculture	Lower Colorado River	0.75	250	10 (100)[a]	WS

[a] Specific reaches of the river have elevated standards. See regulation for the specific reach.
WS= Ambient levels prior to January 1, 2000 or 250 mg/L whichever is less restrictive.

Section 4: International

Title: Guidelines for Drinking-water Quality Volume 1
Author: World Health Organization
Publication date: 2008
Source: http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/index.html
ISBN: 92 4 1546964
Accessed: June 2010
Parameters: TDS, Sodium, Chloride, Sulfate, Nitrate, Boron

Summary: Middle Eastern environmental and health websites often cite WHO guidelines for drinking water and utilize the guidelines for protection of the limited number of beneficial uses identified. The countries were not individually reviewed as the basis and numerical standards the countries use come from the table below (Table 17).

Table 17: World Health Organization Guidelines for Drinking Water and Contact Recreational Water

Use	Purpose	TDS	Sodium mg/L	Chloride mg/L	Sulfate mg/L	Nitrate mg/L	Boron mg/L
Drinking Water	Protect Public Health	NA[a]	NA[a]	NA[a]	NA[a]	50	0.5
Drinking Water	Aesthtic quality	<600	200	200-300 [b]	250 or 1000 [c]	NA	NA
Recreational water	Protection of public health	See footnote[d]	See footnote[d]	See footnote[d]	See footnote[d]	See footnote[d]	See footnote[d]

[a]Guidelines not set since occurs at levels in drinking water well below a point where toxic effects occur. However, the levels may affect aesthetic qualities.
[b] This standard relates to chloride in the forms of sodium, potassium and calcium chloride.
[c] These values represent the taste thresholds. For sodium sulfate, the threshold is 250 mg/L and the threshold for calcium sulfate is 1000 mg/L.
[d]Based on the assumptions that only 10% of daily intake may be recreational and assuming 2 L/day of water intake so 200 mL of intake/ day will be from recreational and the guideline should be set based on this. Otherwise an assumption that the guideline for recreational waters should be 10x the level of the drinking water standard.

Title: Water Quality for Agriculture, FAO Irrigation and Drainage Paper # 29 Rev 1
Author: Ayers, R.S. and Westcot, D.W.
Publication date: 1985
Source: http://www.fao.org/docrep/003/t0234e/t0234E00.htm
ISBN: 92 5 102263 1
Accessed: June 2010
Parameters: TDS, EC, Sodium, Chloride, Nitrate, Boron

Summary:
The guidelines presented in this document suggest general limits for agricultural water quality and are not the individual criteria set for a specific site. The limits are to be used as a guide for livestock health and irrigation and are not related to human drinking water standards. The development of these guidelines by the Food and Agricultural Organization used assumptions including full yield potential with no special management for unrestricted uses, soil texture from sandy-loan to clay-loam, good drainage, surface, or sprinkler irrigation methods, and water uptake at 40% from the upper quarter of the root depth. Due to crop and soil variability, the restriction in use may vary from region to region but the numerical values in Table 19 are a starting point for any evaluation.

Livestock drinking water varies greatly between species therefore the upper limits are summarized in Table 18. At levels <5.0 dS/m EC all livestock can drink the water with no adverse affects to animals acclimated to those levels. As EC increases the water becomes less acceptable for the livestock and at >16 dS/m EC is not acceptable for any livestock use.

Table 18: Guidelines for Irrigation Water from FAO Irrigation and Drainage Paper # 29 Rev 1

Restriction on Use	TDS mg/L	EC dS/m	Sodium SAR[d]; meq/L[e]	Chloride meq/L[d]; meq/L[e]	Nitrate mg/L[f]	Boron mg/L
None[a]	<450	<0.7	<3; <3	<4;<3	<5	<0.7
Slight to Moderate[b]	450-2000	0.7-3.0	3-9; >3	4-10;>3	5-30	0.7-3.0
Severe[c]	>2000	>3.0	>9; NA	>10; NA	>30	>3.0

[a] The guideline refers to irrigation water that will produce no soil or cropping problems with use.
[b] Use of water for irrigation with these parameters will require additional considerations on crop type and management.
[c] Soil and cropping problems or reduced yield will occur with the use of this type of irrigation water.
[d] Surface irrigation
[e] Sprinkler irrigation
[f] NO_3 –N

The limits set represent the limits for drinking water for all livestock (Table 19).

Table 19: Upper Limit Guidelines on Livestock Drinking Water from FAO Irrigation and Drainage Paper # 29 Rev 1

Livestock	Limit level	EC dS/m	Nitrate mg/L	Boron mg/L
All	Upper limit		100 [a]	5.0
All	Acceptable	1.5-5.0		
Poultry	Upper limit	5.0-8.0		
Pregnant or lactating animals	Upper limit	8.0-11.0		
limited use dairy, beef cattle, sheep, swine, and horses	Limited use in livestock	8.0-11.0		
Swine and young cows, horses, sheep	Upper limit	11.0-16.0		
All livestock	Not recommended	>16.0		

[a] Nitrate + Nitrite [as N]

Title: Australian and New Zealand Guidelines for Fresh and Marine Water Quality
Author: Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand
Publication date: October 2000
Source:
http://www.mincos.gov.au/publications/australian_and_new_zealand_guidelines_for_fresh_and_marine_water_quality
ISBN: 0 9578245 2 1 ISSN: 1038 7072
Document Type: web/hard copy
Accessed: June 2010
Parameters: TDS, Nitrate, Nitrite, Sodium, Chloride, Boron

Summary: The government of Australia has established national guidelines for surface and groundwater as part of the National Water Quality Management Strategy. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (WQG) were produced to provide guidelines for protecting water resources of a particular environmental value (use). The policies, strategies, and implementation of these guidelines are managed by the State, Territory or Commonwealth. The WQG is summarized in Table 20 below.

Water quality guidelines have established trigger values that guide whether a water resource is of sufficient quality for a particular use. The guidelines in WQG apply to both surface and groundwater. The environmental values established in the WQG are aquatic ecosystems, primary industries including irrigation, livestock drinking water and aquaculture, recreational water, and drinking water. Some values in WQG represent adequate quality while other values represent triggers for investigation resulting in remediation or an appropriate guideline for that use. In some situations numerical criteria have been established while for other situations flow charts to guide decisions have been developed to determine the criteria at a local level. In both situations the Australian government has approached guidelines from two perspectives either

the trigger value may represent a loading rate or was established through a risk-based tolerance level for a species or ecosystem.

Table 20: Summary of Environmental Values (Uses) and Water Quality Guidelines for Australia and New Zealand as Described in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality

Beneficial Use	Subdivision	TDS	Nitrate	Nitrite	Boron	Sodium	Chloride
Aquatic Ecosystems	See table below[5]	<3,000 mg/L[a]	17 µg/L; 1700 µg/L; 3400 µg/L; 17,000 µg/L[b,c]	No data	90 µg/L; 370 µg/L; 680 µg/L; 1300 µg/L[b]	No data	No data
Recreational and aesthetics[1]		1,000,000 µg/L	10,000 µg/L (as N)	1,000 µg/L (as N)	1,000 µg/L	300,000 µg/L	400,000 µg/L
Drinking water[2]		500 mg/L (aesthetic)	50 (as nitrate)	3 µg/L (as nitrite)	4 mg/L (1 mg/L in uncontaminated source)	180 (aesthetic)	No data
Primary Industry	Livestock drinking water	Based on tolerance of individual species[d]	<400 mg/L avoid water >1500 mg/L[e]; 30 mg/L[f]	No data	5 mg/L	No data	No data
Primary industry	Irrigation water[3]	Based on tolerance of crops for TDS, chloride, and sodium[g]	5 mg/L[h]; 25-125 mg/L[i,j]	No data	0.5 mg/L[h]; based on crop sensitivity	No data	No data
Primary industry	Aquaculture[4] and human consumption of aquatic foods	<3,000 mg/L[a]	<50,000 µg/L (as NO_3)	<100 µg/L (as NO_2)	No data	No data	No data
Industrial water	The current guidelines do not provide guidance as industry requirements vary widely and other environmental values tend to drive the management of the particular resource.						

[1] Recreational waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreation. Specific guidelines for these waters are given above for primary and secondary contact.
[2] Guidelines refer to levels at point of use (National Water Quality Management Strategy Australian Drinking Water Guidelines 6, 2004).
[3]Nutrient levels are established to maintain crop yield, prevent bioclogging of irrigation equipment and minimize off-site impacts. Concentrations should be less than recommended trigger values.
[4]Aquaculture includes food (fish and shellfish) for humans, fry for recreational and natural fishing, ornamental fish or plants, raw material for energy and biochemicals, and items for fashion industry (Table 21).

Table 21: Ecosystem and Associated Salt and Nutrient Water Quality Objectives (Footnote 4) as Described in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality

Ecosystem	Location	Salinity µS/cm	TN µg/L	NO_x as N µg/L
Upland River	SE Australia	30-350	250	15
	SW Australia	120-300	450	200
	Tropical Australia	20-250	150	30
	South Central Australia (low rain)	No data	No data	No data
	New Zealand	No data	295	167
Lowland River	SE Australia	125-2200	500	40
	SW Australia	120-300	1200	150
	Tropical Australia	20-250	200-300	10 (north 5 µg/L)
	South Central Australia (low rain)	100-5000 (depends on flow)	1000	1000
	New Zealand	No data	614	444
Freshwater lake and reservoirs	SE Australia	20-30	350	10
	SW Australia	300-1500	350	10
	Tropical Australia	90-900	350	10 (north 5 µg/L)
	South Central Australia (low rain)	300-1000	1000	100
	New Zealand	No data	No data	No data
Wetlands	SE Australia	No data	ND	ND
	SW Australia	No data	1500	100
	Tropical Australia	No data	350-1200	10
	South Central Australia (low rain)	No data	No data	No data
	New Zealand	No data	No data	No data
Estuaries	SE Australia	No data	300	15
	SW Australia	No data	750	45
	Tropical Australia	No data	250	30
	South Central Australia (low rain)	No data	1000	100
	New Zealand	No data	No data	No data
Marine	SE Australia	No data	120	5
	SW Australia	No data	230	5
	Tropical Australia	No data	100	2-8 (lower value for Great Barrier Reef)

Ecosystem	Location	Salinity µS/cm	TN µg/L	NO_x as N µg/L
	South Central Australia (low rain)	No data	1000	50
	New Zealand	No data	No data	No data

[5] Salinity, Total Nitrogen and NOx Guidelines for Ecosystems in Australia

Footnotes for water quality guideline in Table 20:
[a]Freshwater production

[b] The trigger values for freshwater represent the percent of species protected when the respective boron or nitrate level is applied. The levels of protection are 99%, 95%, 90% and 80%, respectively. Application of the trigger values and protection level is described in the WQG and guidance using a decision tree is used for application of this guidance level for a particular location.

[c]Table provides additional guidance as to the salinity, total nitrogen (TN), and oxides of nitrogen (NO_x) for specific ecosystems and their locations within Australia or New Zealand.

[d] The table below relates to salt tolerance of livestock from National Water Quality Management Strategy

Tolerances of livestock to total dissolved solids (salinity) in drinking water[a]			
Livestock	**Total dissolved solids (mg/L)**		
	No adverse effects on animals expected	Animals may have initial Loss of production and a decline reluctance to drink or there may in animal condition and health be some scouring, but stock would be expected. Stock may] should adapt without loss of tolerate these levels for short production periods if introduced gradually	
Beef cattle	0–4000	4000–5000	5000–10 000
Dairy cattle	0–2500	2500–4000	4000–7000
Sheep	0–5000	5000–10 000	10 000–13 000[b]
Horses	0–4000	4000–6000	6000–7000
Pigs	0–4000	4000–6000	6000–8000
Poultry	0–2000	2000–3000	3000–4000

a From ANZECC (1992), adapted to incorporate more recent information

b Sheep on lush green feed may tolerate up to 13 000 mg/L TDS without loss of condition or production

[e]Nitrate

[f] Nitrite

[g]Water quality trigger values are considered inappropriate for general application. Evaluation of the criteria for a particular crop must consider crop type, salt tolerance level, soil characteristics, soil and water management practices, climate, and rainfall.

[h]Long term trigger value it the maximum amount of contaminant that can be tolerated with 100 years of irrigation based on a specified loading rate.

[i]Short term trigger value if the maximum amount of contaminant that can be tolerated with 20 years of irrigation based on a specified loading rate.

[j]Short term trigger value with a specific site-assessment protocol.

Title: Nutrient Objectives for Rivers and Streams-Ecosystem Protection
Author: EPA Victoria Publication 792.1
Publication date: June 2003
Source:
http://epanote2.epa.vic.gov.au/EPA/Publications.nsf/d85500a0d7f5f07b4a2565d1002268f3/406bce9bfe614b3eca256b19000e547d/$FILE/792.1.pdf
ISBN: 0730676064
Accessed: June 2010
Parameters: Total Nitrogen
The State of Victoria EPA has set water quality objectives based on the Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Nutrient guidelines are set for total nitrogen and total phosphorus, however this literature review is focused on total nitrogen. These objectives are for the purpose of protecting the health of the aquatic ecosystem and do not represent objectives for highly urbanized areas. The ecosystems in Victoria are listed in Table 22 along with the corresponding total nitrogen objective.

Table 22: Total Nitrogen Water Quality Objectives for State of Victoria as Described in EPA Victoria Publication 792.1 (2003)

Ecosystem	Description	Total Nitrogen µg/L [a]
Highlands	Steep mountains and valleys	150
Closed Forested Foothills	Mountains, foothills, steep valleys	500
Open Forested Foothills	Mountains and foothills, steep and broad valleys	350
Open Forested Foothills	Mountain, broad valleys; lower altitude	350
Cleared Hills	Hills and broad valleys	600
Coastal Plains	Coastal plains of sand gravel or basalt lava	600
Western Plains	Broad plains of aeolian and alluvial sand or basalt lava	900
Murray Plains	Alluvial plains	900

[a] 75th percentile objective from annual monitoring data sets

Title: Water Quality Objectives for Rivers and Streams-Ecosystem Protection
Author: EPA Victoria Publication 791.1
Publication date: June 2003
Source:
http://epanote2.epa.vic.gov.au/EPA/publications.nsf/2f1c2625731746aa4a256ce90001cbb5/9f209aa11b9f7678ca256b19000e126f/$FILE/791.1.pdf
ISBN: 0730676072
Accessed: June 2010
Parameters: EC

Summary: The State of Victoria EPA has set water quality objectives based on the national guidelines. These objectives are for the purpose of protecting the health of the aquatic ecosystem and do not represent objectives for highly urbanized areas. The ecosystems in Victoria are listed in the table below (Table 23) along with the corresponding salinity objective.

Table 23: Water Quality Objectives for State of Victoria for Electrical Conductivity as Described in EPA Victoria Publication 791.1 (2003)

Ecosystem	Description	EC µS/m[a]
Highlands	Steep mountains and valleys	100
Closed Forested Foothills	Mountains, foothills, steep valleys	500
Forests A	Specific ranges listed	100-500
Forests B	Specific ranges listed	100-1500
Cleared Hills	Hills and broad valleys	500
Coastal Plains	Coastal plains of sand gravel or basalt lava	500
Western Plains	Broad plains of aeolian and alluvial sand or basalt lava	500
Murray Plains	Alluvial plains	500-1500

[a] 75th percentile objective from annual monitoring data sets

Title: Integrated Catchment Management in the Murray-Darling Basin 2001-2010
Author: Murray-Darling Basin Ministerial Council
Publication date: June 2001
Source: http://www2.mdbc.gov.au/__data/page/107/3624_ICMPolStatement.pdf
ISBN: 1876830131
Accessed: June 2010
Parameters: EC

Summary: Each state in Australia is responsible for the application of the national guidelines as they are associated with a specific beneficial use. The Basin which suffers significant dryland salinity is located in the Southeastern part of Australia. The Murray-Darling Basin Initiative is an intergovernmental cooperation for the purpose of managing the resources in the basin. The cooperative arrangement includes the states of New South Wales, Victoria, South Australia, Queensland, and the Australian Capital Territory and the Commonwealth. The summary below represents the Basin initiative for the Murray-Darling Basin and its catchments. Targets have been established and agreed upon for the purpose of monitoring the overall progress and health of the system. As an example, 5 targets where used to explain this management system as seen in Table 24.

Table 24: Example of Targets and In-stream Salinity Management for Murray-Darling Basin of Australia

Target site	Location	In-stream salinity (µS/cm)	Beneficial use
End of valley	All water drains to this point	<1000 EC for 80% of each year	Protect basin health
Within valley	Near irrigation district below major town and wetland area	<1000 EC for irrigation season	Irrigation water supply
Within valley	Above major wetland	<1500 EC during peak fish breeding season	Protect wetland ecosystem
Within valley	Above major town	<800 EC for 80% of each year	Drinking water supply
Management target	Top of the basin	NA /Revegetation of 20% of sub-catchment area	

Title: Victoria Government Gazette State Environment Protection Policy Groundwater's of Victoria
Publication date: December 1997
Source: Victoria Government Gazette No. S 160
http://epanote2.epa.vic.gov.au/EPA/Publications.NSF/2f1c2625731746aa4a256ce90001cbb5/cc4efb1a742644514a2565fc0008e5cc/$FILE/S160.pdf
Accessed: June 2010
Parameters: TDS

Summary: Groundwater in the State of Victoria is managed according to its beneficial use and objectives are established for specified beneficial uses with a corresponding TDS level (Table 25).

Table 25: Beneficial Uses and Water Quality Guidelines for TDS in Ground waters in Victoria, Australia

	TDS (mg/L)				
Beneficial use	0-500	501-1,000	1,001-3,500	3,501-13,000	>13,000
Maintenance of ecosystems	X	X	X	X	X
Potable	X				
Potable mineral water	X	X	X		
Agriculture parks and gardens	X	X	X		
Stock watering	X	X	X	X	
Industrial water use	X	X	X	X	X
Primary contact	X	X	X	X	
Buildings and structures	X	X	X	X	X

Title: Basin Salinity Management Strategy 2001-2015
Author: Murray-Darling Basin Ministerial Council
Publication date: August 2001
Source:
http://www2.mdbc.gov.au/salinity/basin_salinity_management_strategy_20012015.html#salmenu
ISBN: 1876830174
Accessed: June 2010
Parameters: Salinity, Salt load

Summary: The Basin Salinity Management Strategy establishes the target and the limits for in-stream salinity for each tributary valley and the Murray-Darling system. The end of Valley target set by this plan is ≤800 µS/cm EC for 95% of the year. Previous studies (1999) showed that to maintain this limit an overall reduction of 100 µS/cm EC will need to be obtained through new interventions and revegetation. Achieving this reduction was accomplished by establishing a integrated management strategy with established target areas. The target areas must maintain a specified salinity level and all states involved must develop salinity plans around achieving that target level. Table 26 below provides some examples of the targets for 2015 for the tributary river valleys in the Murray-Darling Basin.

Table 26: Examples of the 2015 Salinity Targets[a] for the Murray-Darling Basin of Australia

State	Location	Salinity		Salt load
		Median	95%ile	Average
All Government	Murray-Darling Basin	110%	98%	110%
South Australia	Lock 6 to Morgan	TBA	110%	
NSW	Bogan	137%	93%	133%
Victoria	Loddon	103%	101%	101%
Victoria	Goulburn	100%	100%	100%

[a] Percentage of 2000 conditions
TBA= to be advised

Title: Glenelg Hopkins Salinity Plan 2005-2008
Author: Anderson, Helen, Glenelg Hopkins Catchment Management Authority
Publication date: September 2005
Source: http://glenelg-hopkins.vic.gov.au/imageandfileuploads/Glenelg%20Hopkins%20Salinity%20Plan%202005-2008.pdf
ISBN: 0759410666
Accessed: June 2010
Parameters: EC

Based on the intergovernmental arrangements made in the Basin Salinity Management Strategy document, this plan produced by the State of Victoria for target in the Glenelg Hopkins Region. These targets represent the maximum in-stream EC levels for these rivers by 2012. Ultimately, these levels will support the 100 µS/cm EC reduction in the Murray-Darling Basin (Table 27). Recommendations related to crops and plants in saline regions for reclaiming the land are used. Studies found that trees with shallow ground waters and salinity levels of 3000 µS/cm will accumulate salt over time.

Table 27: EC Water Quality Limits for Points in Glenelg Hopkins Catchment Management Authority in Australia

Catchment point	EC limit (µS/cm)
Hopkins River at Wickliffe	<15,000; 90% of the time
Hopkins River at Hopkins Falls	<7,000; 90% of the time
Glenelg River at Sandford	<6,500; 90% of the time
Wannon River at Henty	<6,000; 90% of the time

Section 5: Conclusions

Locations throughout the world utilize standards to maintain specific levels of salt and nutrients for the protection of water resources. The guidelines set for a particular water body are driven by the most sensitive use in the area; however, prioritization of beneficial uses in a location or singling out a beneficial use of a water source is not a common practice. Although several beneficial uses and water quality objectives may be applicable, the lowest water quality value is addressed. In some cases, this objective may not be appropriate. Water quality objectives use historical data to establish a limit which may not be location specific or consider assumptions that over/under estimate an objective. For example, the Ayers and Westcot publication (1985) from FAO serves as the basis for many crop irrigation and land application water quality standards. Ayers and Westcot qualify their recommendations by stating in the publication that the levels are guidelines and will vary from region to region. Assumptions related to cropping practices were made with these recommendations that may not be applicable to all areas and irrigation practices. Work done by Hoffman indicates that the standard set for agriculture will vary based on irrigation, climate, and crops of the region, which in turn alter crop tolerances to a specific water quality and therefore alter water quality objectives of a particular basin.

Beneficial uses other than municipal and agricultural generally do not have water quality objectives assigned to them either because the water quality agency deemed it unnecessary for some industrial users, the use was an unstated lower priority, or a pre-existing objective is present with limits lower than an alternative beneficial use. Salinity objectives primarily are TDS and EC while individual ions are not usually considered. Nitrate or nitrite serves as the nutrient objective for most places in the world and the limits are consistent for all drinking water sources. Human health concerns serve as the grounds for the consistency nationally and internationally.

TDS and EC are well described throughout the literature and have supporting studies and standards. Standards have been set locally, nationally, and internationally based on taste studies with the driving beneficial use being drinking water. However, levels of TDS and EC for crops have been described for irrigation and land application of food process water. Data gaps present for TDS and EC are limits set for other beneficial uses that are not municipal or agricultural uses. Australia has described some limits for recreational use and EC establishing a level to prevent irritation of skin and mucous membranes. The maximum tolerances for TDS and EC for the various beneficial uses in California are not developed, which may limit basin-wide salt management policies as one stream's beneficial uses can tolerate higher salinity level while another cannot. Individual ion salts are not addressed in the basin plans, although through permit implementation individual ions have established criteria. While this is effective for salinity and nutrient management at the local level, a basin-wide approach may be hindered by the same water body in two different reaches with different water quality criteria. Although most individual ion levels are drinking water or agriculturally related, the criteria may not be compatible.

Limits throughout the world have been established for sodium ions based on drinking water quality. Past studies were used to establish these levels based on taste as sodium reduces the TDS levels for taste tolerance. However, no sodium limits have been established for other beneficial uses based on this literature survey and TDS continues to be the parameter for drinking water. Similar results for chloride were found in terms of taste and limits are driven by

taste surveys. Although agriculture is not the driving principal for chloride limits, sensitive crops generally are not grown near or with high-chloride waters, thus influencing the landscape of the crops in a particular area. Sensitive crops can lower the chloride limits to below drinking water, as can been seen with avocados or stone fruits. Sulfate levels were based on a past study describing the physical manifestations on sulfate on humans. The laxative effect by sulfate was the driving criterion for the standard. Other beneficial uses did not have a sulfate level associated with them. The impact of sulfate on other beneficial uses will need to be examined further since no other studies were associated with the beneficial uses other than drinking water found by this literature review.

Nitrate and nitrite levels are consistently dominated by the human health effect, Methemoglobinanemia, at the state, national, and international levels. Other beneficial uses beyond drinking water and agriculture rarely have a nitrate level associated with them. For agriculture this would be expected as nitrate is a valuable crop nutrient; however, over-application of nitrate may be a consideration which impacts groundwater quality. Internationally, nitrate has also been associated with ecosystem health and water-quality objectives in Australia have been established. A data gap identified was other beneficial uses do not have an associated standard.

Boron levels are primarily focused on agricultural beneficial uses although some drinking water guidelines have been established. Boron does not affect the soil quality but may be phytotoxic at higher levels. Thus, boron is a limiting factor for agriculture and is a driving force in the water quality objective due to crop sensitivity. Like nitrate, boron water quality limits are almost exclusively municipal and agricultural.

Based on this literature review, most beneficial uses are not assigned water quality criteria, and uses that are assigned generally constitute TDS, EC, nitrate, and drinking water. Individual ions are not addressed, assumed captured under TDS, or assigned limits through an implementation process.

Section 6: Recommendations

Drinking water quality is a driving force for the implementation of specific criteria to a water body. Although no priorities have been established amongst the various beneficial uses, water quality related to human health receives the greatest focus. Agriculture tends to be second on this list but the criteria needed to protect this beneficial use can vary based on location and crop type. Other beneficial uses rarely have criteria associated with them but are listed in basin plans. Generally the criteria to protect beneficial uses other than municipal and agriculture are at higher limits.

Based on the literature review the following recommendations will support the development of salinity and nutrient guidelines in the Central Valley.

1. Salt tolerance of crops varies between different crops and between different stages of growth. Generally even the most salt-tolerant species need to be germinated in higher quality water before low-quality water can be used for irrigation. More research is needed on crops at various developmental levels and their salt tolerance. Water quality may be managed differently for crops throughout the growing season.

2. Various models have been proposed to predict leaching rates in the soil for the purpose of irrigation management. These models have been adapted to evaluate whether the water quality objective may be altered to lower or higher levels based on the local conditions. Most water quality objectives are based on the FAO recommendations but these recommendations do not consider local conditions. A review of the various salinity and nutrient models is necessary to determine which models can be used effectively for the development of water quality objectives. Validation of the models is necessary step for fully utilizing these models. It is recommended that data from the pilot study sites from the Salt and Nitrate Sources Pilot Implementation Study Report be used for model validation.

3. Water quality data gaps related to beneficial uses other than agriculture and municipal need to be assessed for relevance. Not all beneficial uses have been assigned a water quality objective; however, general guidelines may be necessary coupled with a priority of beneficial uses at a location. For a particular area where all beneficial uses are present, prioritization of the beneficial uses should be applied. Recommended method(s) of beneficial use prioritization developed by CV-SALTS would most likely be made under the guidance of current state laws and RWQCB regulations before approaches can be used in any Basin Plan implementation program. CV-SALTS will also seek legal reviews and comments in its established methods.

4. Beneficial uses are currently not prioritized with each having equal weight in the basin plan. Although specific beneficial uses do take a priority, identification of the most critical or limiting species is necessary for each beneficial use and water quality objective. It is recommended that the pilot study sites be used as a basis for determining the critical or limiting species as these locations were selected based on their representative parameters for the Central Valley. In the Hoffman model, beans were used as the most sensitive crop; however, this may not always be the case in

another location. Alternatively, if indicator species are not appropriate then methodology for a case-by-case basis needs development either as seen with the ecosystem approach used in Australia, regional management approach, or individual evaluation of the sites which results in limitations to broader application.

5. Groundwater in all basins is considered equal regardless of depth or land use. Basin plans do provide exceptions for municipal use at specific locations. However, all groundwater is generally considered municipal supply and the objectives are the state MCL limits. Application of the objectives to groundwater regardless of depth or local land use needs to be evaluated for generalization of the objective. Groundwater is used for varying purposes and with different management approaches throughout the basin such that the quality of the groundwater in one basin may not be appropriate for municipal use but may be satisfactory for agricultural uses or industrial uses. Determining if all groundwater should be maintained at the municipal level and assessing whether various management scenarios could be used needs evaluation. Additionally, stratification of the groundwater into various depths and associated beneficial uses needs consideration. For example, the basin plan permits Tulare lake hydrologic unit to have an annual incremental increase in salinity levels. The impact of this approach on beneficial uses and depth or groundwater zones needs to be evaluated and the adoption of water quality objectives based on depth considered. These factors would influence regional management strategies for salt and nutrient management.

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