

MANAGING REUSE SALINITY FOR HEALTHY LANDSCAPES

Drainage / Water Quality / Trees & Shrubs Baseline Study / Soil Baseline Study/ Salt Tolerance



Joint Reuse Committee



INTRODUCTION

Salinity and other compounds found in reuse may have adverse effects on landscaping if not managed properly. The following management practices and guidelines were compiled to help reuse treaters and users mitigate these effects. Solutions and suggestions include designing and installing proper drainage, trying chemical additives, developing water and soil baseline studies, understanding plant salinity tolerances and other helpful information.



DRAINAGE

What is drainage and why is it important?

Proper drainage facilitates the movement of water over the ground or under the surface to minimize the build up of water and chemical constituents at root level. Build up of sodium in the soil causes soil compaction and reduces water absorption and infiltration through the soil. These conditions can prevent water from moving into the root zone and allow Chlorides and other toxins to accumulate and potentially damage the plant.

Considerations When Designing a Site to Use Reclaimed Water.

1. The soil structure and type should be evaluated and the water quality analyzed. See the following sections on [WATER QUALITY](#) and [SOIL BASELINE STUDY](#).
2. Plant selection should be based on the results of the soil and water analysis. Consider using salt tolerant species. See the following section discussing [SALT TOLERANCE](#).
3. Soil amendments should be added to the soil based on the results of the soil and water



When problems are noted with drainage, percolation or plant toxicity, steps should be taken to improve the situation.

- analysis. Guidelines for soil analysis can be found in the **SOIL BASELINE STUDY** section.
4. Proper incorporation of an appropriate soil amendment will help to increase infiltration and subsurface drainage.
 - a. It is recommended that 3 – 5 cubic yards of soil amendment containing composted organic matter be incorporated into the existing soil to a minimum depth of 6 inches for every 1000 square feet of landscaped area.
 5. The addition of soil amendments will also
 - a. Improve soil structure and allow salts to move through the root zone.
 - b. Increase water holding capacity resulting in lower water demand and water costs.
 6. High use area such as golf courses and sports fields should consider subsurface drain systems to facilitate the movement of salts and water out of the root zone.
 - a. High traffic areas compact more quickly and may take special consideration.
 - b. An under drain system offers an added benefit by expediting drainage and drying of fields following periods of heavy rain. This also improves the playability of the field.
 7. The site should be surveyed and graded to prevent water from pooling in low areas and to allow the water to drain using the influence of gravity.
 - a. Minimize areas that reclaimed water could pond on the surface and evaporate creating a salt pan
 8. Consider local topographical issues in plantings. For example, trees should be placed in areas where sodium build up will be minimized.
 9. Healthy well planted trees show fewer signs of sodium stress. Extra care should be taken to plant trees according to local tree planting specifications. Which may include:



- a. Planting trees in holes 2 times the size of the root ball, removing the basket, burlap and twine.
10. The irrigation system should be designed to minimize direct spray on salt sensitive species, specifically evergreen trees.

When problems are noted with drainage, percolation or plant toxicity, steps should be taken to improve the situation. The following is a list of considerations for best management practices.

1. Flushing: While consistent over irrigation is not recommended it has been suggested that periodic over watering or flushing may facilitate the movement of salts out of the root zone. This may also occur with heavy rainfall.
2. Aeration: Aeration is the practice of removing small plugs of soil from the root zone and randomly discarding them on the turf surface. Aeration improves the movement of water through the soil, reduces soil compaction, and decreases thatch buildup thus minimizing potential for ponding and salt buildup in the root zone.
3. Application remedies: Dr. Yaling Qian at Colorado State University is conducting research on mitigating sodium stress in turf grass. She is researching the application of the following products in mitigating sodium impacts.
 - a. Gypsum (CaSO_4) application: This compound is moderately soluble in water and can substitute soil sodium by releasing calcium, thereby helping to leach sodium to deeper depths.
 - b. Calcium chloride (CaCl_2) application: This compound functions like gypsum but is completely soluble in water and readily available to substitute soil sodium by releasing calcium. It helps to leach sodium to deeper depths.
 - c. Humates: These products have claimed to buffer salts, augment micronutrient





- availability to plants, promote soil aeration and water penetration, and encourage flocculation of soil particles
- d. Vesicular-arbuscular mycorrhizal (VAM) inoculation: Wastewater irrigation has been found to deplete arbuscular mycorrhizae, which may be a significant constraint on landscape plants performance under saline conditions.
 - e. Combination of two amendments is also being examined for 1) humate and gypsum as well as 2) Vesicular-arbuscular mycorrhizal (VAM) inoculation and Gypsum.

**Study suggests:
"starting calcium material treatment as soon as the initiation of recycled wastewater irrigation to prevent the sodium deterioration of soil and turf."**

Preliminary results, after two years (2005 and 2006) of a three year study, show that application of the above compounds (alone or combined) help, "to some degree", mitigate the salinity effects of reuse application. Currently the study suggests "starting calcium material treatment as soon as the initiation of recycled wastewater irrigation to prevent the sodium deterioration of soil and turf."



WATER QUALITY

Reuse, the product of treated wastewater, inherently contains some level of salts and other constituents (see **Parameter Study** below) that can affect water quality. Understanding the level of these compounds in the applied reuse and their affect on plants at various concentrations, in combination with soil types and vegetation salt tolerances, will enable the development of useful salinity management strategies.

MITIGATING SALINITY GENERATION



Another method of minimizing salinity's impacts on landscaping includes minimizing source generation of salinity. Salinity in reuse can be generated from saline source waters, water softeners, detergents, personal care products, and food additives. Mitigating salinity generation can begin with public education and even go as far as the banning of certain water softener medias. Public education materials regarding ways to reduce salinity generation can be posted at local municipal buildings, clubs, or distributed through bill mailings. Banning of sodium water softener medias or developing an incentive program to encourage installation of other softening technologies for in house use will require a cooperative effort between local authorities, utilities, and homeowners. New communities should consider incorporating regulations that prohibit salinity generating water softener installation.



WATER QUALITY PARAMETERS STUDY

Objective:

Reference and/or study of reuse water quality. Consider conducting soil and tree/shrub baseline studies as well.

Scope of Work:

1. Determine reuse sampling frequency [i.e., weekly, monthly, quarterly (seasonally), annually.]
2. Determine location for sampling (Consider testing the water quality at storage sites and discharge points in the distribution system.)
3. Include detailed sampling methodology so the testing can be replicated in future years with comparable samples.
4. Conduct tests for the following parameters:
 - **Turbidity** (Can affect soil percolation/infiltration)
 - **Total P** (Nutrients for plants. Phosphorus may affect ground water and/or surface water quality)
 - **Electrical Conductivity** (Indicator of salinity)
 - **Sodium Adsorption Ratio (SAR)** (Indicator of sodicity level)
 - **ADJUSTED SAR**
 - **Sodium** (Test in both the incoming raw wastewater and reuse. May contribute to soil and plant toxicity.)
 - **Chloride** (May contribute to plant toxicity)
 - **Bicarbonate** (Affects pH of soil and will increase adjusted SAR.)
 - **Calcium** (Improves soil structure)
 - **Magnesium** (Improves soil structure)
 - **Boron** (May contribute to plant toxicity)
 - **Iron** (micronutrient for plant health)
 - **Total Suspended Solid** (Can affect soil percolation/infiltration)
 - **BOD** (May affect oxygen availability in soils competing with microbes.)
 - **COD** (May affect oxygen availability in soils competing with microbes.)
 - **pH**

Include detailed sampling methodology so the testing can be replicated in future years with comparable samples



- **NH₄-N** (Nutrient for plants. Ammonia may affect ground water and/or surface water quality)
 - **NO₃-N** (Nutrient for plants. Nitrates may affect ground water and/or surface water quality)
5. Write a summary report for the layperson, but include appendices that detail the scientific background necessary for the utility and its customers to make informed decisions in the future. If possible, include statements of acceptable water quality ranges that will still allow plants to be healthy. File reports for up to 25 years.

If possible, include statements of acceptable water quality ranges that will still allow plants to be healthy.



TREES AND SHRUBS BASELINE STUDY

OBJECTIVE OF THE STUDY

The objective of this type of study is to research and compile a detailed report based on data concerning the current health and condition of trees and shrubs on sites to be served with reclaimed water. The report can serve as a baseline and methodology that can be replicated every three (3) years into the future to detect any changes in soils that might impact trees, shrubs, and plants irrigated with reuse. It is recommended that this study coincide with soil baseline and water quality studies.



There are three distinct phases to the study: Conducting the inventory, documenting the methodology, and writing the report.

The inventory of woody plants:

- A baseline general inspection and rating of all trees on a scale of "Excellent, Good, Average, Fair, Poor."
- A detailed inspection for trees and shrubs showing symptoms of biotic stress or that look questionable.
 - Take tissue samples of any trees and shrubs showing biotic stress.
 - Take digital photos of any trees and shrubs sampled.
 - Complete a detailed analysis of these trees and shrubs using industry accepted guidelines.

If possible, include statements of acceptable water quality ranges that will still allow plants to be healthy.

The Methodology will include:

- Documenting the specific methods used for analysis, tissue sampling, etc. or referring to a



specific industry standard and the year that standard was current and published.

- Marking any problems and potential problems on aerial or topographical maps.
- Coordinating with consultant doing baseline of soils before finalizing report.
- Archive samples for up to 25 years for further analysis and study.

The Report:

- Summarize the overall quality of tree/shrubs at sites served by reclaimed water. Highlight problem areas and evaluate possible remediation alternatives. Reference any relevant information discovered in the soil and water baseline studies.
- Attach appendixes to include specific methods used for analysis, tissue sampling and industry standards. Include maps delineating potential problems.
- Save report for up to 25 years as a reference tool.

Thanks to Denver Water for providing tree/shrub baseline study information.

Archive samples for up to 25 years for further analysis and study.



SOIL BASELINE STUDY

OBJECTIVE

Publish a report on soil quality at selected sites to be served with reuse. The report should contain the analysis of the soil samples of the sites.

SCOPE OF WORK

Select sites for testing:

- When making the selection consider cost of soil testing per sample and the size of the application area(s).
- Discuss how compacted soils should affect site sampling choices since salts won't move as quickly through compacted soils. Take into account other collecting samples on sites that might be affected by the use of magnesium chloride for street deicing.
- Include samples from control group sites receiving potable water.
- Within each site, collect samples at 3 random locations (3 replicates).
- Consider burying a metal rod at each sampling spot as future reference.
- Consider taking soil samples over different depths at representative sites.
- Provide storage for these samples for at least 25 years.
- Send 10% of the soil samples to a lab other than the contracted testing lab.

1. Report on results for each site separately.

- Include analysis of the following parameters:
 - Sodium
 - Boron
 - Chloride
 - Nitrate (NO₃)
 - Electrical Conductivity (dS/m)





- Sodium Absorption Ratio (SAR)
 - Bicarbonate (HCO_3)
 - PH
 - Calcium
 - Magnesium
 - ESP (exchangeable sodium percentage)
- Include detailed sampling methodology so that the inventory can be replicated in future years.
 - If possible, include statements of acceptable ranges of changes in soil parameters that will still allow plants to be healthy.
 - Write the report for the lay person, but include appendices that detail the scientific background necessary to help the utility and its customers make informed decisions in the future.

Include detailed sampling methodology so that the inventory can be replicated in future years.



SALT TOLERANCE:

- < 2 dS/m intolerant
- 2 dS/m slight tolerance
- 4 dS/m moderate tolerance
- 6 dS/m & above tolerant

GRASSES

| Less than 4 dS/m | 4 to 8 dS/m | 8 to 12 dS/m | Up to 18 dS/m |
|---|---|---|--|
| <i>Alopecurus pratensis</i> - Meadow foxtail <i>Festuca rubra</i> - Red fescue <i>Festuca elatior</i> - Meadow fescue <i>Poa partensis</i> - Kentucky bluegrass | <i>Agropyron cristatum</i> - Crested Wheatgrass <i>Agropyron riparium</i> - Streambank Wheatgrass <i>Agropyron trachycaulum</i> - Slendar Wheatgrass <i>Arrhenatherum elatium</i> - Tall Meadow Oatgrass <i>Bromus inermis</i> - Smooth Brome <i>Buchloe dactyloides</i> - Buffalograss <i>Dactylis glomerata</i> - Orchardgrass <i>Elymus giganteus</i> - Mammoth Wildrye <i>Elymus junceus</i> - Russian Wildrye <i>Festuca arundinacea</i> - Tall Fescue <i>Phalaris arundinacea</i> - Reed Canarygrass | <i>Bromus marginatus</i> - Mountain Brome <i>Lolium perenne</i> - Perennial Ryegrass <i>Melilotus alba</i> - White Sweet Clover <i>Melilotus officinalis</i> - Yellow Sweet Clover <i>Trifolium fragiferum</i> - Strawberry Clover | <i>Agropyron elongatum</i> - Tall Wheatgrass <i>Agropyron smithii</i> - Western Wheatgrass <i>Distichlis</i> - Saltgrass <i>Elymus triticoides</i> - Beardless Wildrye <i>Lotus corniculatus</i> - Bridtrefoil <i>Puccinellia</i> – Alkaligrass <i>Sporobolus airoides</i> - Alkali Sacaton |



FLOWERS AND GROUND COVERS

| Up to 4 dS/m | Up to 4 dS/m | Up to 4 dS/m |
|--|--|---|
| <i>Argemone</i> species- Prickly Poppies <i>Calochortus</i> species- Mariposa Lilly <i>Chrysopsis villosa</i> - Hairy Golden Aster <i>Gallardia pennatifida</i> - Cutleaf Blanket Flower <i>Mentzelia</i> species- Blazing Stars | <i>Fallugia paradoxa</i> - Common Apache <i>Oenothera caespitosa</i> – Tufted Evening Primrose <i>Sphaeralcea coccinea</i> - Scarlet Globemallow <i>Yucca elata</i> - Soaptree <i>Yucca glauca</i> - Small Soapweed | <i>Aquilegia micrantha</i> - Cliff Columbine <i>Machaeranthera xylorrhiza</i> - Common Woody Aster <i>Psilostrophe bakerii</i> - Paperflower <i>Stanley pinnata</i> - Prince’s Plume |



SHRUBS

| Up to 2 dS/m | Up to 4 dS/m | 4 to 8 dS/m | Up to 6 dS/m | Up to 10 dS/m |
|--|---|--|---|--|
| <i>Chaenomeles speciosa</i> - Flowering Quince <i>Ligustrum vulgare</i> - Common Privet <i>Rosa rugosa</i> - Rugosa Rose <i>Viburnum opulus</i> - High Brush Cranberry | <i>Artemisia cana</i> - Silver Sagebrush <i>Berberis fremontii</i> - Fremont Barberry <i>Robinia neo-mexicana</i> - New Mexican Locust | <i>Artemisia frigida</i> - Fringed Sagewort <i>Artemisia spinescens</i> - Bud Sagebrush <i>Artemisia tridentata</i> - Basin Big Sagebrush <i>Buxus microphylla</i> - Japanese Boxwood <i>Chrysothamnus nauseosus</i> - Rubber Rabbitbrush <i>Chrysothamnus visci diflorus</i> - Douglas Rabbitbrush <i>Ephedra nevadensis</i> - Nevada Mormontea <i>Forsythia x intermedia</i> - Showy Border Forsythia <i>Juniperus communis</i> - Common Juniper <i>Philadelphus coronarius</i> - Sweet Mockorange <i>Purshia glandulosa</i> - Desert Bitterbrush <i>Pyracantha fortuneana</i> - Pyracantha <i>Rhus glabra</i> - Smooth Sumac <i>Rhus trilobata</i> - Skunkbush Sumac - Three-leaf Sumac | <i>Br Caragana arborescens</i> - Siberian Peashrub <i>Chrysothamnus albidus</i> - Alkali Rabbitbrush <i>Cytisus scoparius</i> - Scotch Broom <i>Elaea gnus commutata</i> - Silverberry <i>Elaea gnus multiflora</i> - Cherry Elaeagnus <i>Euonymus japonica</i> - Spindle Tree <i>Halimodendron halodendron</i> - Salt-tree <i>Hippophae rhamnoides</i> - Sea Buckthorn <i>Juniperus chinensis</i> - Pfizer Juniper <i>Lonicera tatarica</i> - Tararian honeysuckle <i>Rhamnus cathartica</i> - Common Buckthorn <i>Rhus trilobata</i> - Squawbush <i>Rhus typhina</i> - Staghorn Sumac <i>Rhamnus frangula</i> - Glossy Buckthorn <i>Shepherdia canadensis</i> - Buffaloberry <i>Spiraea vanhouttei</i> - Van Houtte Spirea <i>Symphoricarpos albus</i> - Snowberry <i>Syringa amurensis japonica</i> - Japanese Tree Lilac <i>Syringa vulgaris</i> - | <i>Atriplex canescens</i> - Fourwing Saltbush <i>Atriplex convertifolia</i> - Shadscale Saltbush <i>Atriplex corrugata</i> - Mat Saltbush <i>Atriplex nuttalli</i> - Nuttall Saltbush <i>Atriplex nuttalli cuneata</i> - Castle Valey Clover <i>Atriplex nuttalli gardneri</i> - Gardner Saitbush <i>Baccharis emoryl</i> - Emory Baccharis <i>Baccharis glutinosa</i> - Seep-Willow <i>Ceratoides lanata</i> - Common Winterfat <i>Chiysothamnus greenel</i> - Greene Rabbitbrush <i>Chiysothamnus linifolius</i> - Flaxleaf Rabbitbrush <i>Ephedra species</i> - Mormon Teas <i>Ephedra torreyana</i> - Torrey Ephedra <i>Kochia americana</i> - Greenmolly Summercypress |





| | | | | |
|--|--|--|---|---|
| | | <i>Shepherdia rotundifolia</i> - Roundleaf Buffaloberry <i>Spiraea</i> 'Froebel's' - Froebel's spirea | Common Lilac <i>Potentilla fruticosa</i> 'Jackman ii' - Jackman's potentilla <i>Tamarix gallica</i> - Manna Plant - Tamarisk | <i>Sarcobatus vermiculatus</i> - Black Greasewood <i>Tamarix pentandra</i> - Five-Stamen Tamarix, Tamarisk |
|--|--|--|---|---|

DECIDUOUS TREES



| Up to 2 dS/m | Up to 4 dS/m | Up to 6 dS/m | Up to 8 dS/m |
|--|---|--|--|
| <i>Acer rubrum</i> - Red Maple <i>Acer saccharinum</i> - Silver Maple <i>Acer saccharum</i> - Sugar Maple <i>Cercis canadensis</i> - Eastern Redbud <i>Juglans nigra</i> - Black Walnut <i>Malus</i> species- Crabapple <i>Plantanus acerifolia</i> - London Plane <i>Sorbus aucuparia</i> - European Mountain Ash <i>Tilia Americana</i> - American Linden <i>Tilia cordata</i> - Little Linden <i>Quercus palustris</i> - Pin Oak | <i>Catalpa speciosa</i> - Northern Catalpa <i>Celtis occidentalis</i> - Hackberry <i>Celtis reticulata</i> - Netleaf hackberry <i>Cercis occidentalis</i> - Western Redbud <i>Fraxinus anomala</i> - Singleleaf Ash <i>Fraxinus excelsior</i> - European Ash <i>Fraxinus pennsylvanica</i> - Green Ash <i>Ginkgo biloba</i> - Maidenhair Tree <i>Koelreuteria paniculata</i> - Goldenrain Tree <i>Maclura pomifera</i> - Osage-Orange <i>Pyrus</i> species - Pear | <i>Acer negundo</i> - Box-elder <i>Acer ginnala</i> - Amur maple <i>Betula lenta</i> - Sweet Birch <i>Betula populifolia</i> - Grey Birch <i>Betula alleghaniensis</i> - Yellow Birch <i>Betula papyrifera</i> - Paper Birch <i>Fraxinus americana</i> - White Ash <i>Populus alba</i> - White Poplar <i>Populus deltoides</i> - Eastern Cottonwood <i>Populus grandidentata</i> - Large-toothed Aspen <i>Populus nigra</i> - Lombardy Poplar <i>Populus tremuloides</i> - Trembling (Quaking) Aspen <i>Prunus padus</i> - European Bird Cherry <i>Prunus serotina</i> - Black Cherry <i>Prunus virginiana</i> - Choke Cherry <i>Salix alba</i> 'Tristis' - Golden Weeping | <i>Acer plantanoides</i> - Norway Maple <i>Aesculus hipocastanum</i> Common Horsechestnut <i>Allanthus altissima</i> - Tree of Heaven <i>Amelanchier canadensis</i> - Shad blow <i>Crataegus crus-galli</i> - Cockspur Hawthorn <i>Elaeagnus angustifolia</i> - Russian Olive <i>Gleditsia triacanthos</i> - Honeylocust <i>Quercus alba</i> - White Oak <i>Quercus robur</i> - English Oak <i>Quercus rubra</i> - Red oak <i>Robinia pseudoacacia</i> - Black Locust <i>Pteiea trifoliata</i> - Wafer Ash |



| | | | |
|--|--|---|--|
| | | Willow <i>Salix alba</i> 'Vitellina' - Golden Willow <i>Salix nigra</i> - Black Willow <i>Sophorajaponica</i> - Japanese Pagoda Tree <i>Ulmus pumila</i> - Siberian Elm | |
|--|--|---|--|

CONIFEROUS TREES



| < 2 dS/m | Up to 2 dS/m | Up to 6 dS/m | Up to 8 dS/m |
|---|---|---|---|
| <i>Abies balsamea</i> - Balsam firs <i>Pinus resinosa</i> - Red or Norway pine <i>Pinus sylvestris</i> - Scotch Pine | <i>Picea albies</i> - Norway Spruce <i>Pinus strobus</i> - Eastern White Pine <i>Pinus sylvestris</i> - Scot's Pine <i>Pseudotsuga menziesii</i> - Douglas Fir <i>Taxus cuspidata</i> - Japanese Yew | <i>Pinus ponderosa</i> - Ponderosa Pine <i>Pinus thunbergiana</i> - Japanese Black Pine <i>Thuja occidentalis</i> - American Arborvitae | <i>Juniperus chinensis</i> - Pfitzer juniper <i>Picea glauca</i> 'densata' - Black Hills Spruce <i>Pinus mugo</i> - Mugho Pine <i>Pinus nigra</i> - Austrian Pine |



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