Arid West Water Quality Research Project Results

Symposium on Arid Areas Issues

Western Governor's Association
Western States Water Council

December 11, 2002
Tempe, Arizona

Presentation Acknowledgements

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Presentation Overview

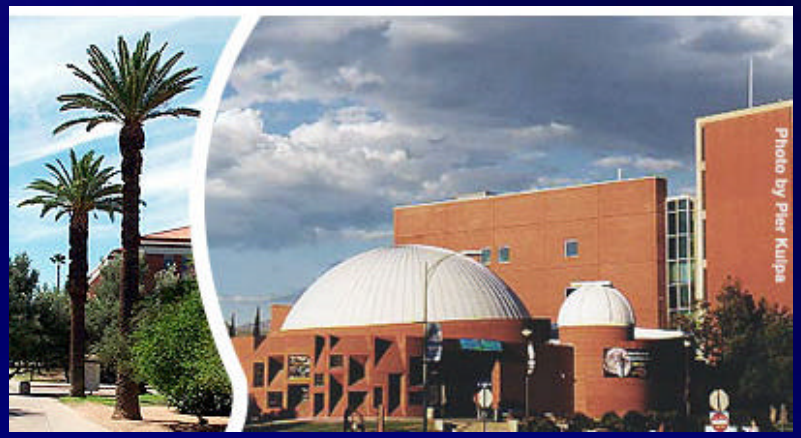
- Arid West Water Quality Research Project (AWWQRP)
  - ✓ Concept
  - ✓ Structure
- Key Research Project Findings
  - ✓ Discharger's Survey
  - ✓ Habitat Characterization Study
  - ✓ Extant Criteria Evaluation
- Research Direction

Arid West Water Quality Research Project

- Initiated in 1995 (P.L. 103-327)
- Funded by the U.S. EPA ($5,000,000 original grant; additional $500,000 appropriation in 2001)
- *Project Purpose*: Improve scientific basis for regulation of water quality and protection of species, habitats and uses of effluent dependent and ephemeral waters in the arid West

AWWQRP: Bringing Together a Strong Scientific Team

- Pima County Wastewater Management Department
- URS Corporation
- CDM
- ENSR International
- Risk Sciences, Inc.
- Hydroqual
- Parametrix
- Ecotox
- Environmental Planning Group
- U.S. Geological Survey, Tucson Desert Laboratory
- University of Arizona, School of Renewable Natural Resources
- Colorado State University, Department of Civil Engineering
- Chadwick Ecological Consulting, Inc.
- Aquatic Consulting and Testing, Inc.
- Law Offices of Tad Foster, Colorado Springs, CO



AWWQRP: Bringing Together a Strong Team of Advisors

- **U.S. Environmental Protection Agency** – Region 9
- **Quality Control/Quality Assurance Officers** – Aquatic Consulting & Testing Inc.
- **Regulatory Working Group** - Established to assist in identifying regulatory issues that should be addressed by research and to develop the Research Agenda
- **Scientific Advisory Group** - Primary role is to review proposals received, rank and recommend worthy proposals based on scientific merit and review research products

Regulatory Working Group

- **Kathleen Chavez, Chairperson**, Pima Co. Wastewater Management, AZ
- **Edward Anton**, California State Water Resources Control Board, CA
- **Rodney Cruze**, Riverside Regional Water Quality Control, CA
- **Steve Davis**, Malcom Pirnie, Tucson, AZ
- **Paul Frohardt**, Colorado Water Quality Control Commission, CO
- **Michael Gritzuk**, City of Phoenix Water Services, AZ
- **Catherine Kuhlman**, U.S. EPA, Region 9
- **Andy Laurenzi**, The Nature Conservancy, Tucson, AZ
- **Susan MacMullin**, U.S. Fish & Wildlife Service, Albuquerque, NM
- **Patrick Maley**, Strategic Environmental Management, Boise, ID
- **James Pendergast**, U.S. EPA Headquarters
- **Samuel Rector**, Arizona Department of Environmental Quality, AZ
- **Eric Rich**, Navajo Environmental Protection Agency, AZ
- **Daniel Santantonio**, City of Las Cruces, Utilities Division, NM
- **Neil Stessman,** Nat'l Audubon Soc. / Nat'l Wildlife Fed. Volunteer, MT

Scientific Advisory Group

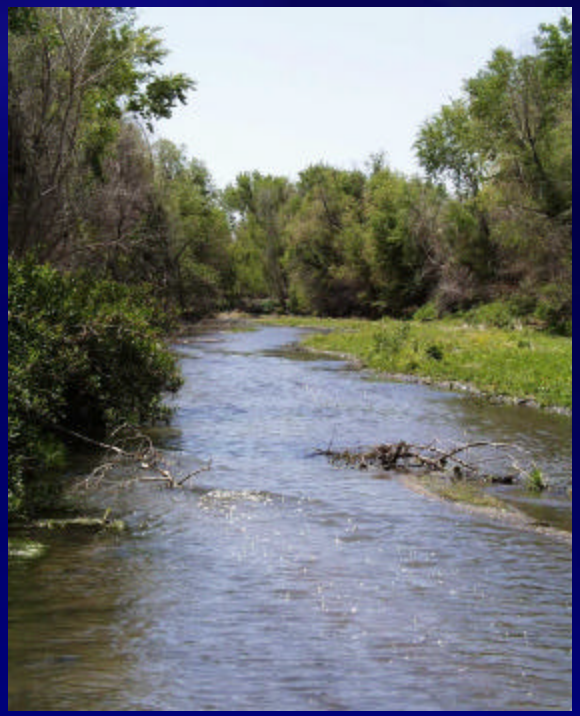
- **Paul Adamus, Ph.D., Oregon State University, Corvallis, OR** – terrestrial ecology, wetland-riparian systems, ornithology and aquatic invertebrates
- **Gary Chapman, Ph.D., Paladin Water Quality Consulting, Corvallis, OR** – water quality criteria development, aquatic and sediment toxicology
- **Karmen King, Colorado Mountain College, Leadville, CO** – aquatic toxicology, fisheries biology and aquatic chemistry
- **Robert McFarlane, Ph.D., McFarlane & Associates, Houston, TX** – aquatic and terrestrial ecology, threatened and endangered species, environmental impact assessments, habitat evaluation and wetlands
- **Benjamin Parkhurst, Ph.D., HAF, Inc. Laramie, WY** – ecological risk assessment, aquatic toxicology, fisheries biology and aquatic ecology

Alternates

- **Robert Gray, Ph.D., Richland, WA** – aquatic toxicology, environmental assessments, fisheries, herpetology and water quality
- **Carlton Sims White, Ph.D., University of New Mexico, Albuquerque, NM** – nutrient cycling and ecosystems

Santa Cruz River Nogales, AZ

Upstream of discharge



1.5 miles downstream of discharge

100 meters below discharge

What are the appropriate uses and criteria for these arid ecosystems?

Effluent Dependent Waters - Created Ecosystems

- *Effluent Dependent Waters* are surface waters where the majority of flow is comprised of treated effluent
- Fundamental differences exist between natural and created stream ecosystems - determining what is actually attainable in the aquatic community for a created ecosystem is quite difficult
- Habitat limitations may rival water quality limitations in determining what is attainable, especially in urban environments
- Tangible benefits of having water in the stream for the created ecosystem may outweigh benefits of no discharge

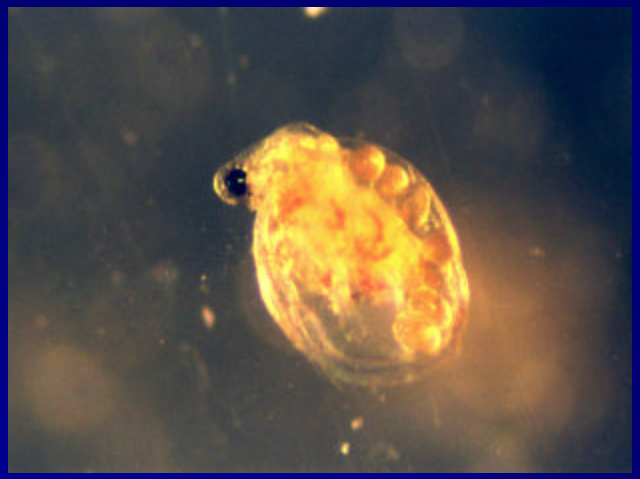
Ephemeral Streams - Limited Aquatic Ecosystems

- Are commonly established recreational uses, e.g., swimming and fishing, applicable?
- Should uses such as agriculture and water supply apply?

- What are the characteristics of the aquatic community and what are appropriate uses and criteria to protect community?

AWWQRP Research Activities

- **Survey of Municipal Dischargers in the Arid and Semi-arid West, March 2000**
- **Habitat Characterization Study, Summer 2002**
  - ✓ Study a variety of effluent dependent waters across the arid West to evaluate their physical, chemical and biological characteristics
- **Extant Criteria Evaluation, Winter 2002**
  - ✓ Evaluate the applicability of federal ambient water quality criteria to effluent-dependent and ephemeral waters



Habitat Characterization Study

- URS Corporation, Mark Murphy, Ph.D., Principal Investigator
- Project team included
  - ✓ CDM, Risk Sciences, EPG
  - ✓ Universities: CSU, UA
  - ✓ USGS
  - ✓ Law Offices of Tad Foster

- **Purpose**: Study a variety of effluent dependent waters across the arid West to evaluate their physical, chemical and biological characteristics
  - ✓ Historical data
  - ✓ Site reconnaissance

Habitat Characterization Study Sites

- Salt/Gila Rivers near Phoenix, AZ
- Santa Cruz River near Nogales, AZ
- Santa Cruz River near Tucson, AZ
- Santa Ana River near San Bernardino, CA
- Fountain Creek near Colorado Springs, CO
- South Platte River near Denver, CO
- Santa Fe River near Santa Fe, NM
- Las Vegas Wash near Las Vegas, NV
- Crow Creek near Cheyenne, WY
- Carrizo Creek near Carrizo Springs, TX

Upstream of discharge

Ca. 2 miles downstream of discharge in river mainstem

Below discharge in effluent channel

Salt and Gila Rivers Phoenix, Arizona

Upstream of discharge

Ca. 2 miles downstream of discharge

Below discharge

South Platte River Denver, Colorado

Key Findings from the Habitat Characterization Study

- **Habitat quality limitations, which directly affect aquatic community expectations, imposed by:**
  - ✓ **disequilibrium between the effluent discharge and channel characteristics; and**
  - ✓ **channel modifications, e.g., flood control**
- Stream water quality is the effluent quality as modified by the environment and often differs from the chemistry associated with toxicity test waters
- Benefits to the aquatic community from improved effluent quality appear to be limited

- Discharge of effluent may create a riparian community with ancillary benefits for wildlife.

Limitations of gradient. . .

Salt/Gila Rivers, Phoenix, AZ

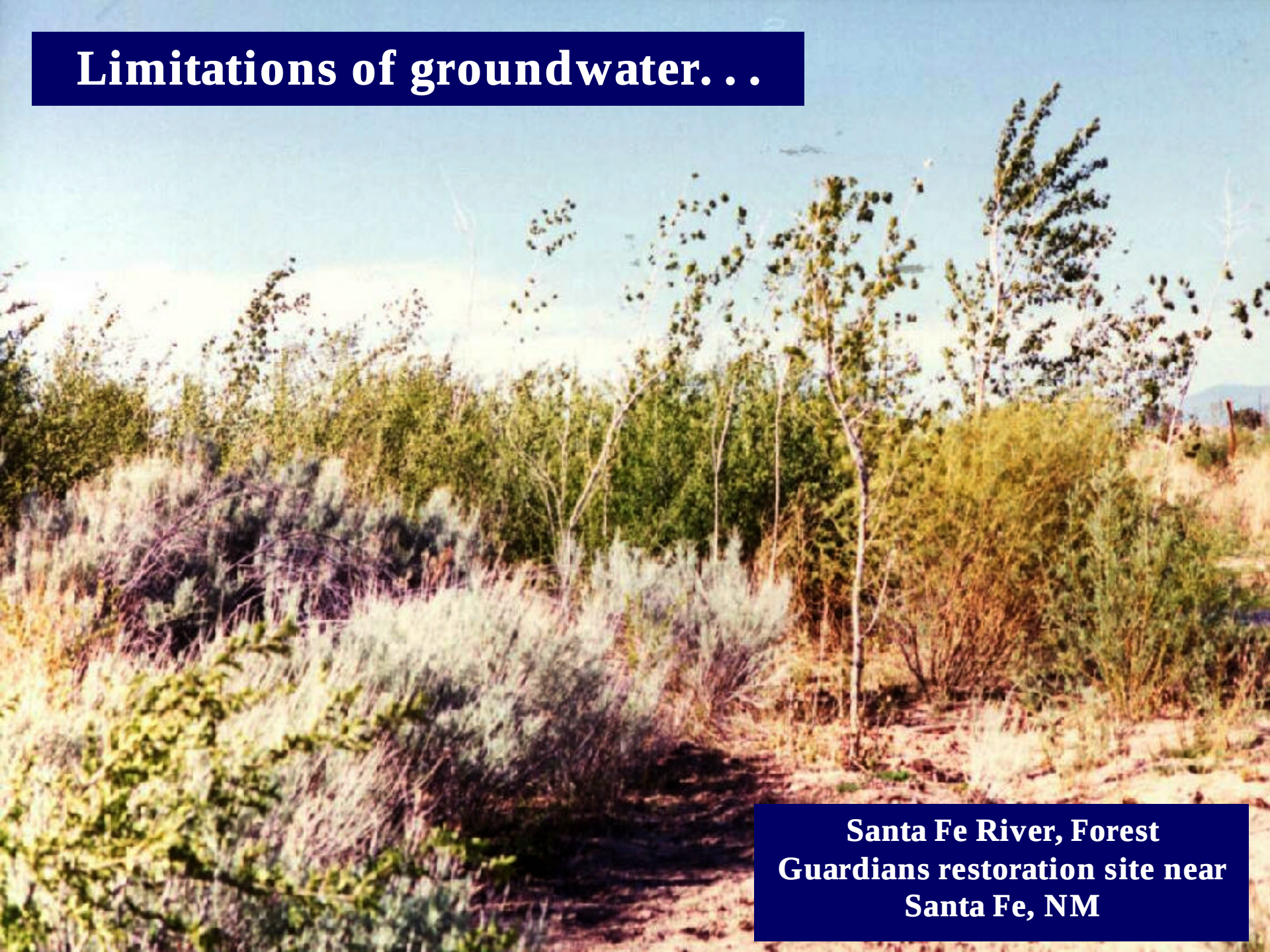
Limitations of substrate. . .

Fountain Creek, Colorado Springs, CO

Limitations of structures. . .

Santa Cruz River, Tucson, AZ

Limitations of groundwater. . .



Santa Fe River, Forest Guardians restoration site near Santa Fe, NM

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Chemical Characteristics

- Ionic composition differs between study areas & water used to conduct WET tests (best exemplified in Las Vegas Wash)
- Ionic composition of waters used to develop water quality criteria for metals differs from ionic composition of study areas. For example,
  - ✓ Conductivity in toxicity studies (0-500 umhos/cm) vs. project study sites (500-3000 umhos/cm)
  - ✓ Alkalinity in toxicity studies (25-175 mg/L) vs. project study sites (50-300 mg/L)
  - ✓ Hardness in toxicity studies (50-200 mg/L) vs. project study sites (100-900 mg/L)
- Oxygen sag typically occurs downstream of effluent but degree and extent variable depending on ratio of natural/effluent flow, diurnal/seasonal cycles, treatment

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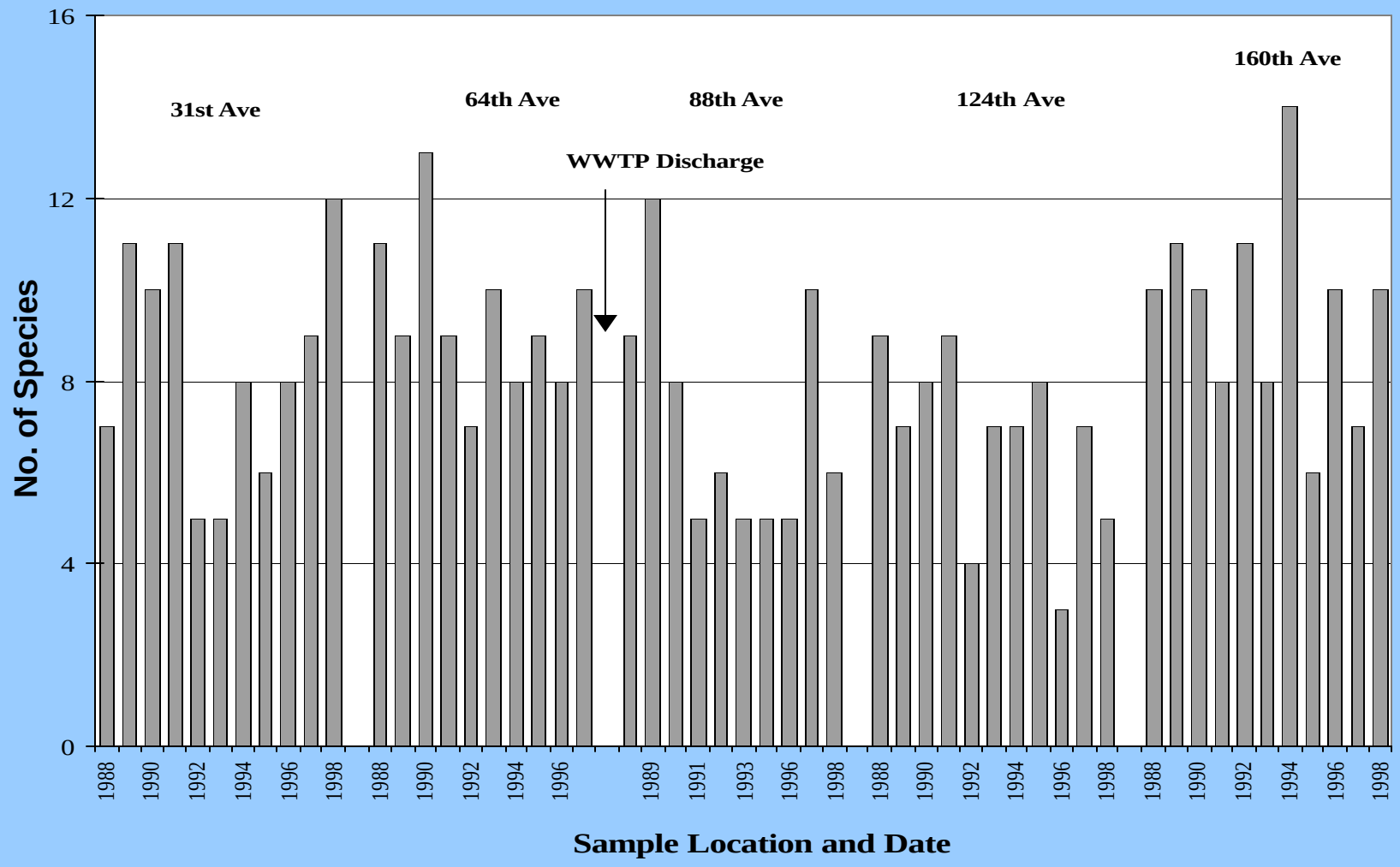
Treatment Level vs. Macroinvertebrates – Spring 2000

	Treatment Level	Taxa Richness	Percent Cleanwater Taxa
Higher quality effluent ↓	Chlorination with no dechlorination	Significant decline below discharge	None present
	Chlorination with dechlorination; nitrification with denitrification	Increase or decrease below discharge	None present to low percentage (ca. 10%)
	Chlorination with dechlorination; nitrification with denitrification; filtration	Decrease below discharge	Consistently present (17-99%) – but, few taxa

South Platte River, Denver, CO – Fish Species Richness, 1988-1998



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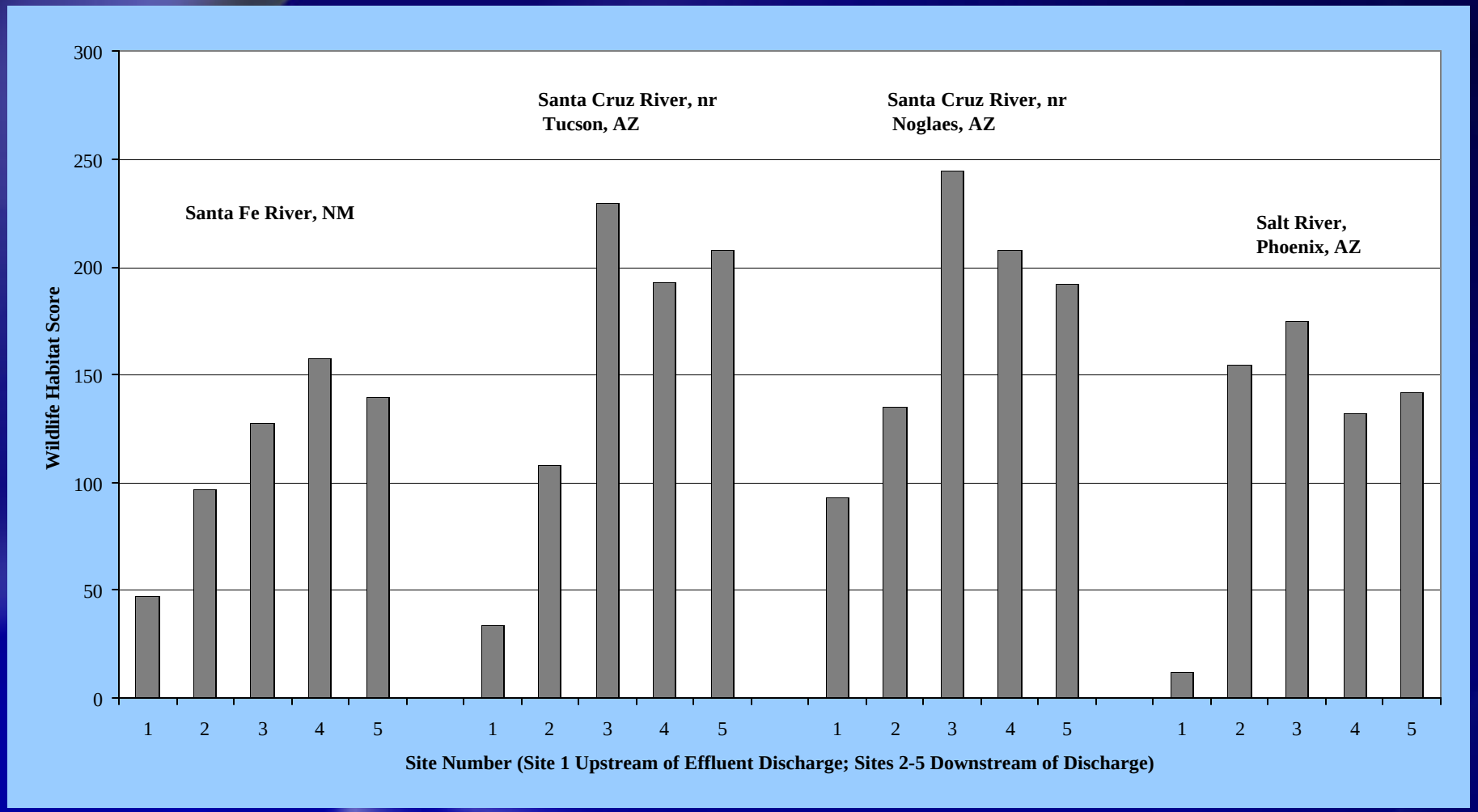
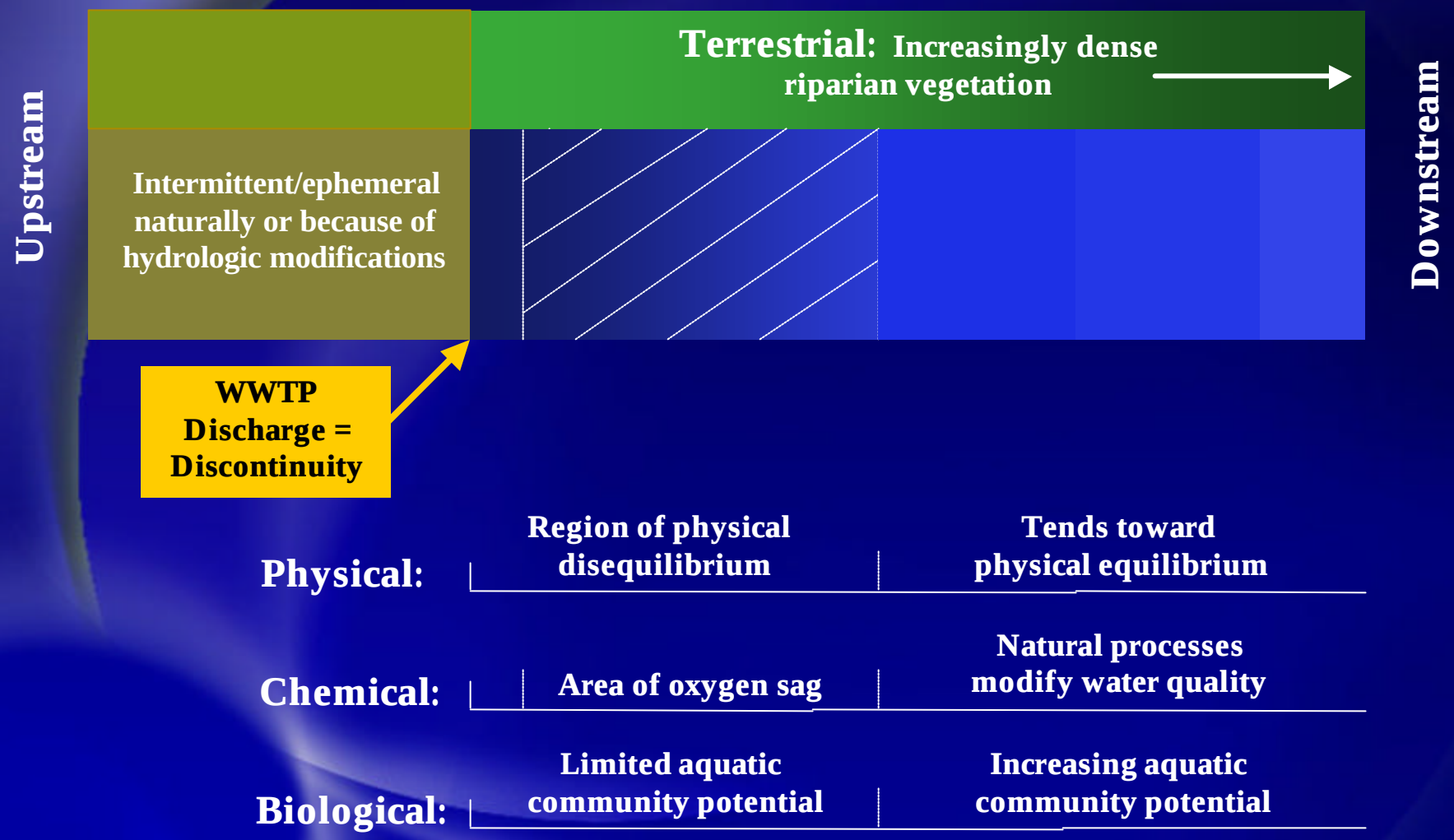
Terrestrial Values: Sites Where Effluent Comprises Approximately 100% of Instream Flow



Conceptual Model of an Effluent-Dependent Stream Ecosystem



Why Study Effluent-Dependent Ecosystems?

- Understanding ecosystem structure and potential is critical to establishment of appropriate beneficial uses and criteria
- What is presumed to be attainable in a natural perennial water may not be applicable to an effluent-dependent water

Understanding What is Attainable is Critical to Establishment of Appropriate Beneficial Uses

Designated Use (Goal)

Attainable Use = Goal

Goal is achievable, through implementation of water quality control programs

Attainable Use < Goal

Attainable use is less than goal because of local limitations, e.g., poor natural habitat

Existing Use (Actually Occurring)

What Defines the Beneficial Uses of Arid Ecosystem Waters?

- For example, how do we determine the aquatic life use goal in a created ecosystem? How do we determine what is attainable?

Existing Condition

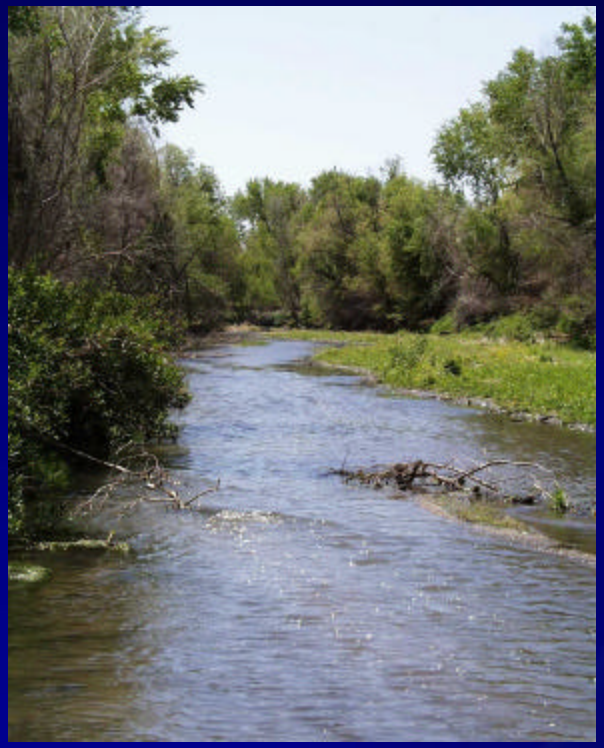
Created by Discharge

Changing the Existing Aquatic Life Use

- **Not only does the discharge change the ecosystem potential, but this potential changes along the longitudinal gradient downstream of the discharge**

Natural Processes Influence Ecosystem Potential

1.5 miles downstream



Effluent-Dependent Waters Are Dynamic Ecosystems….

Facility Upgrade = Modified Aquatic Community

…With Multiple Stressors Superimposed

Habitat Quality & Watershed Change

Habitat Characterization Study: Summary

- The Habitat Characterization Study provides a foundation for future studies on effluent dependent waters
- Determining what is attainable in these created ecosystems is critical to the establishment of appropriate beneficial uses
- Proper definition of the use is needed before appropriate water quality criteria may be established

Extant Criteria Evaluation: Project Summary

Robert W. Gensemer, Ph.D.
Parametrix, Inc.

In collaboration with:
ENSR International, EcoTox,
& HydroQual, Inc.

Why We Are Evaluating Criteria?

- **Ambient Water Quality Criteria (AWQC)**
  - ✓ ***What are the maximum allowable pollutant levels to protect designated uses?***
- **Usually similar regardless of ecoregion or designated use**
- **However, characteristics of western stream ecosystems variable, and dissimilar from conditions used to derive AWQC**

AWQC Modification

Magnitude (CMC, CCC)

1. Recalculation
2. WER
3. Resident Spp.

Duration (1 hr, 4 d)

Frequency (1x every 3 yr)

Not generally modified

Criteria Evaluation Project Goals

- **Evaluate methods for modification of AWQC for ephemeral and effluent-dependent waters**
  - ✓ ***Consider regional vs. site-specific***
- **Focus on ca. 4 "model" AWQC of primary concern to arid west**
  - ✓ ***copper, selenium, diazinon, ammonia***

AWQC Magnitudes

How do we address these unique aquatic communities?

Recalculation Procedure

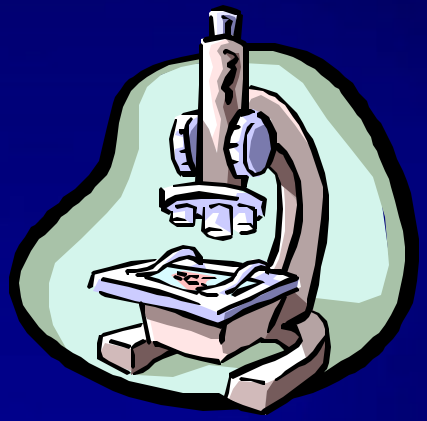
- **Adjusts AWQC magnitude for differences in species composition**
- **Ephemeral & effluent-dependent streams**
  - ✓ ***Salmonids usually absent***
    - ***little impact: metals***
    - ***significant: NH4***
  - ✓ ***Poor record for Cladocera at times***
    - ***significant: metals (e.g., 20% difference, Cu acute)***
- **Best applied regionally to designated use categories**
  - ✓ ***e.g., ephemeral (A&We) and effluent-dependent (A&Wedw); AZ***

Resident Species Procedure

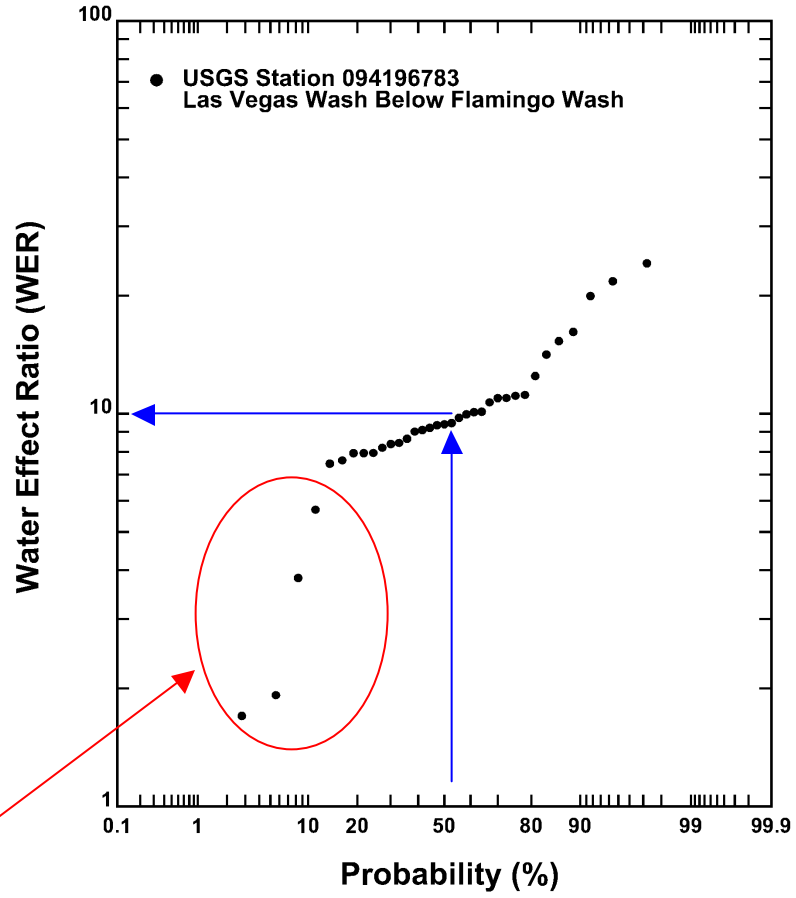
- **Generates new criteria from resident species toxicity data**
- **Only occasionally used**
  - ✓ ***e.g., DO standard, S. Platte R. (CO)***
- **But without resident species testing, following factors still not considered:**
  - ✓ ***acclimation***
    - ***e.g., hardness, elevated background concentrations***
  - ✓ ***adaptation***
    - ***resident species can be less sensitive (Sappington et al. 2001)***

AWQC Magnitudes

How might water quality characteristics influence contaminant bioavailability?



Biotic Ligand Model-predicted Water Effect Ratio (WER)
Copper: Las Vegas Wash, NV



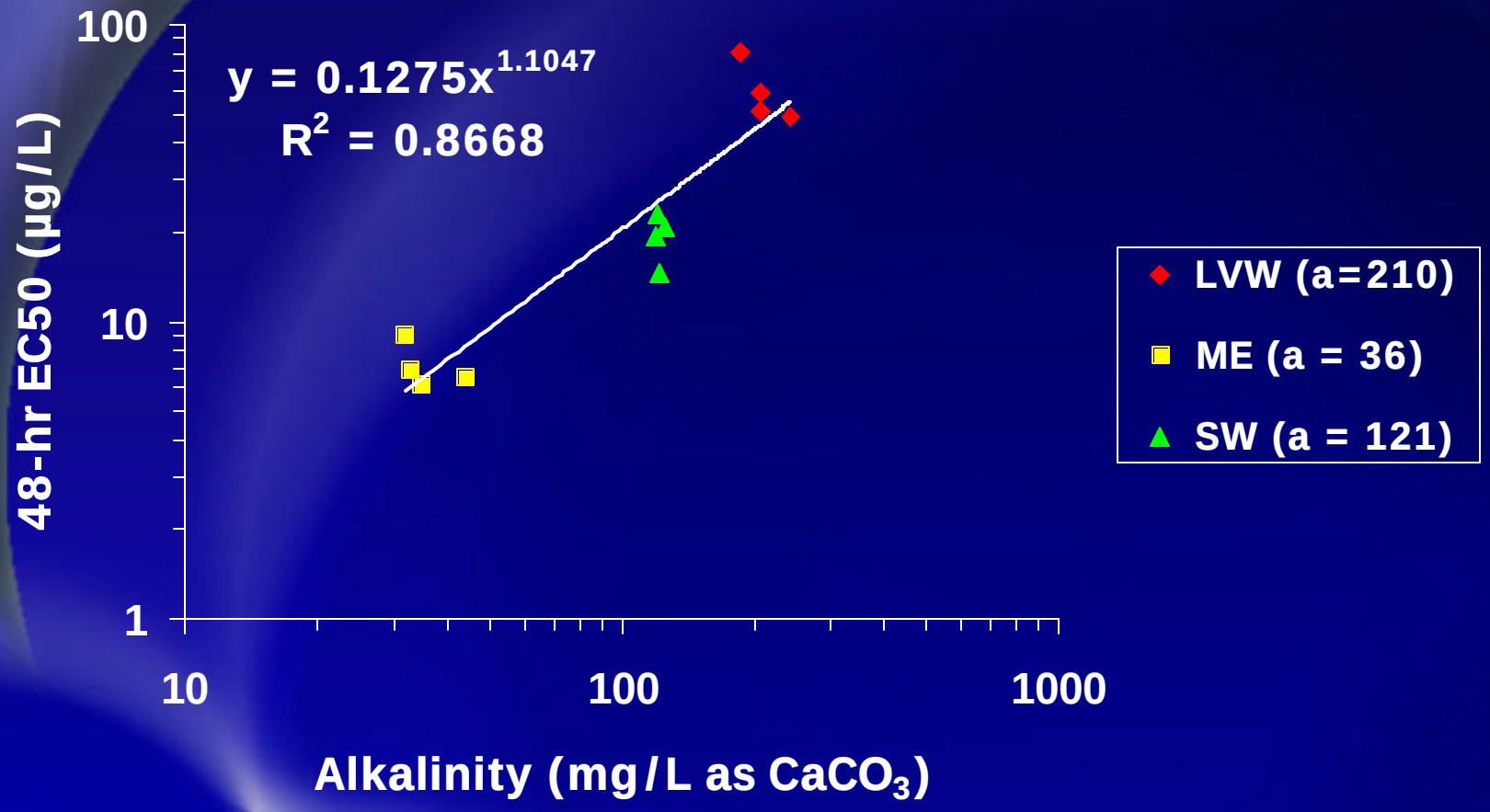
Median WER = ca. 10

Criteria potentially over-protective?

High discharges

Mon Jul 23,2001 17:34:15
/super5/werf0020/ARID_WEST/LAS_VEGAS_WASH/STORET/wqc_prob.gdp

Cu Toxicity vs. Alkalinity



Gensemer et al. 2002

Water-effect Ratio (WER)

- **WER inherently site-specific**
- **However, regional water quality often leads to reduced contaminant bioavailability**
  - ✓ ***elevated hardness***
  - ✓ ***alkalinity important for metals toxicity (Cu)***
- **WER likely useful**
  - ✓ ***But, WER magnitudes flow-dependent (may not be unique to arid west)***

AWQC Duration and Frequency

If modified, what are the potential impacts on NPDES permit conditions?

Possible Modification

- **Increased duration may be possible**
  - ✓ ***chronic NH4 (30 days); others?***
- **Decreased frequency (< 3 yr)**
  - ✓ ***relatively unmodified ephemeral streams***

Increased design flow

↓

Less conservative NPDES permit limit

Duration and Frequency Impacts

Site	Recurrence Frequency	Design flow (CFS) *			
		1 d	4 d	7 d	30 d
Santa Fe R. (NM)	1.5 yr	0.8	1.1	1.2	1.8
	3 yr	0.14	0.7	0.6	1.2
Fountain Cr. (CO)	1.5 yr	37	41	44	54
	3 yr	35	38	40	46
S. Platte R. (CO)	1.5 yr	13	19	23	38
	3 yr	10	13	16	31

**** Biologically-based design flows (DFLOW)***

General Conclusions

- **Default AWQC magnitudes might benefit from modification using existing & new procedures**
  - ✓ ***Recalculation procedure (e.g., use categories)***
  - ✓ ***Resident species procedure?***
  - ✓ ***Water quality modification important,***

    e.g., Biotic Ligand Model, metals
- **For arid west, increased emphasis on duration and frequency may be warranted**
  - ✓ ***Direct impact on NPDES permit calculations***

Arid West Water Quality Research Project: Future Activities

How Do We Focus the Research Effort?

- No shortage of research topics or ideas recommended by researchers
- Public outreach helps us understand what technical, industry and public groups are thinking
- Meetings with advisory groups provide brainstorming opportunities

Focus on the Waterbody Type

	Ephemeral	*Ephemeral*	*Intermittent*	*Perennial*
Existing	Groundwater Geomorphology Aquatic community Terrestrial & riparian	Groundwater Geomorphology Aquatic community Terrestrial & riparian	Groundwater Geomorphology Aquatic community Terrestrial & riparian	Groundwater Geomorphology Aquatic community Terrestrial & riparian
What We Create	Remains ephemeral – stormwater driven	Effluent dependent Terrestrial & riparian Limited aquatic biota	Ranges between effluent dependent and perennial (NEXT SLIDE)	Remains perennial
Minimum Criteria	No bioaccumulative pollutants Limited water quality criteria	No bioaccumulative pollutants Limited water quality criteria Minimum treatment Pretreatment	Hybrid approach ↔	Traditional approach to implementation of water quality programs

Intermittent

Existing

- Groundwater
- Geomorphology
- Aquatic community
- Terrestrial & riparian community

What We Create

Impacts of effluent on groundwater, geomorphology, aquatic, terrestrial and riparian communities will vary as a result of a variety of factors, including:

- Increasing ratio of effluent to ambient water
- Seasonal flow variability of both effluent and ambient water
- Degree of channel modification (e.g., urban vs. non-urban environments)
- Degree of flow modification (e.g., dams and diversions)

Minimum Criteria

Approach that is a hybrid between ephemeral and perennial waters. Approach will be dependent on relative proportions of effluent and ambient water

Ephemeral

Perennial

Future Proposed Research

- Future studies will build upon recommendations in completed projects
- Studies to have regulatory focus – address questions of interest to both regulators and those regulated
- Studies will be associated with all three elements of water quality standards: use designation, criteria development and implementation (antidegradation)
- Research topics focus on basic elements of Clean Water Act:
  - ✓ Biological Criteria
  - ✓ Whole Effluent Toxicity
  - ✓ Chemical Criteria
  - ✓ Habitat Considerations

AWWQRP: Looking Ahead

- **Collaboration** - Collaborative opportunities are being identified to maximize efforts to conduct research on arid West water quality issues
- **Dissemination** - AWWQRP is conducting outreach with key stakeholders, e.g., federal and state regulators, to share project results
- **Implementation** - As projects are completed, the AWWQRP plans to prepare implementation guidance that collectively brings together research results for stakeholder use

AWWQRP Provides Important Role

- Brings similar interests together
- Focuses scientific efforts
- Creates database for use by both regulators and those regulated
- Provides opportunity to discuss critical water supply and quality issues in common forum

Research is Timely

- States looking at alternative approaches for establishment and implementation of water quality standards and criteria for effluent-dependent and ephemeral waters, e.g., Colorado and California.

- Total Maximum Daily Loads (TMDLs) – waters listed as impaired may not be because of inappropriate use designations and criteria.

Importance of Issue to the Arid West

- **Natural perennial waters are disappearing because of limited water resources and growing populations**
- **Effluent-created ecosystems are increasingly providing a critical water resource for state and federal species of concern**
- **Increased focus on ecological restoration projects:**
  - ✓ Phoenix: Tres Rios Project
  - ✓ Tucson: Kino Ecosystem Restoration Project
  - ✓ Denver: South Platte River Restoration
- **Important water source for ecological restoration activities is treated effluent**

AWWQRP Updates:

www.co.pima.az.us/wwm/wqrp

- Contact: Karen Ramage Sierra, (520) 740-6344
  Fax: (520) 740-4399, wqrp@wwm.co.pima.az.us
- Background Information
- 1997 Conference Summary
- Past and Current Research (including fact sheets)
- Discharger Survey
- Habitat Characterization Study
- Extant Criteria Evaluation (Draft)
- RFPs/RFQs posted
- Work Plan
- Quality Assurance Project Plan
- Quality Integrated Work Plan Template

Arid West Water Quality Research Project

- Acknowledgements and Thanks
- Questions

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