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# Development of Improved Water Spray Patterns from Construction Water Trucks

## Water Smart Innovations Conference – October 2008


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# Objectives of Project

- Evaluate overall construction water use
- Develop techniques to measure water sprays
- Evaluate rear spray distribution, different types of equipment
- Develop solutions to improve application uniformity of water

# Section 2 Valley Wide Water Use

| Utility | Total delivered (MG) | Total construction (MG) | Construction Percentage | Monthly ave construction (MG) | Period of record |
|---|---|---|---|---|---|
| City of Hend | 65,994 | 1,948 | 3.0% | 63 | 6/01-12/03 |
| LVVWD | 305,748 | 6,703 | 2.2% | 210 | 1/01-8/03 |
| City of NLV* | 22,829 | 2,159 | 9.5% | 127 | 1/02-9/03 |
| Total | 394,572 | 10,810 | 2.7% | 400 | |

*NLV record shorter than others

400 MG/month = 1200 AF/month × 12 mo/yr = 14,400 AF/yr (14,400 homes/yr – 40,000-50,000 people)

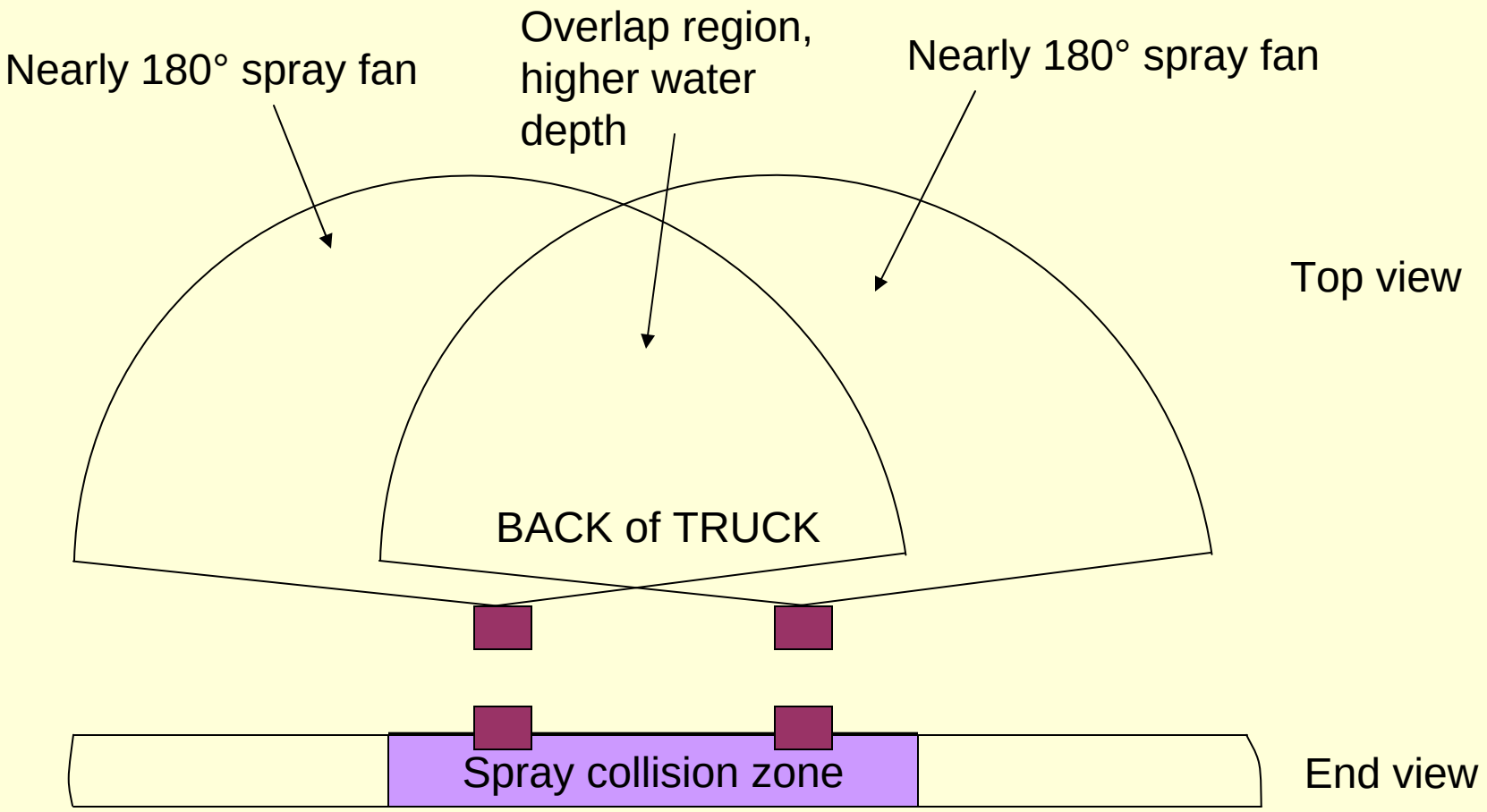
# Fugitive Dust Control: BMP

- BMP (Best Management Practices, CCDAQM, 2003)
- Site-specific dust control measures
  - Water application recommended for 17 activities including:
    - Haul roads
    - Material staging or stockpiling
    - Cut & fill activities
    - Material transfer (loader & truck operations)
    - Trenching, screening, etc.
    - Blasting, demolition, etc.

# Water Truck Characterization

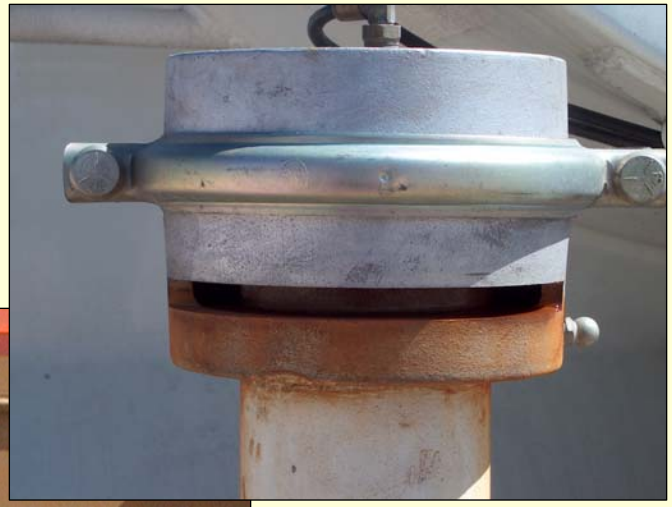
- Examination of truck systems
- Modeling of truck rear spray application
- Testing of truck rear spray patterns
- Development & testing of rear spray modifications

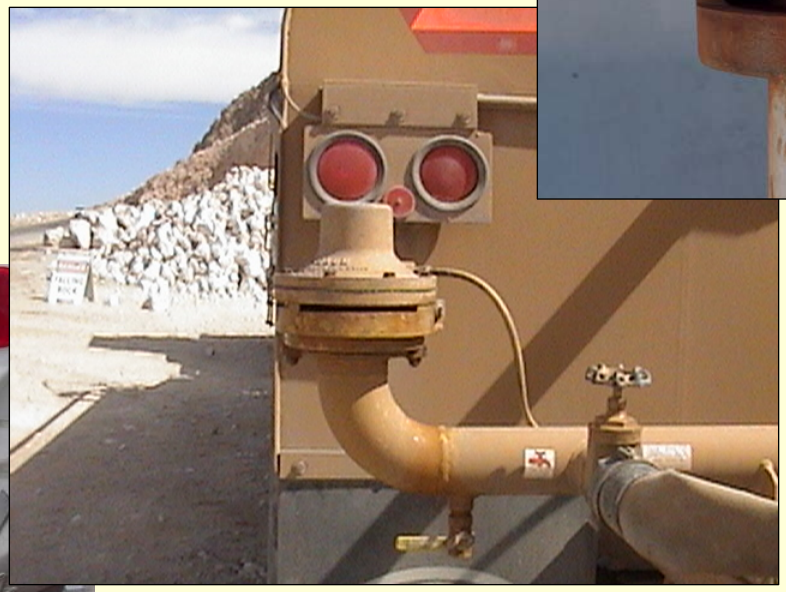
# Standard Pattern – Overlap at Any Spray Rate



# Types of rear nozzles tested

- Combined actuator-nozzle:
  - Valew
  - Megacorp
  - Bertolini



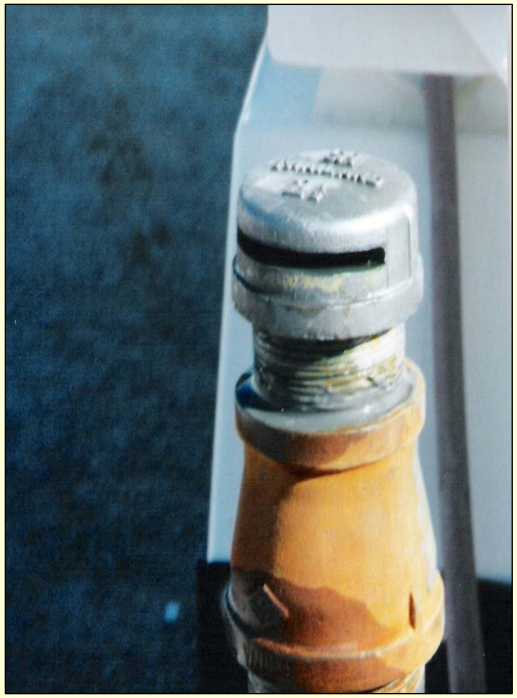


# Simple Nozzles: Flat Fan Nozzles

## With Collar

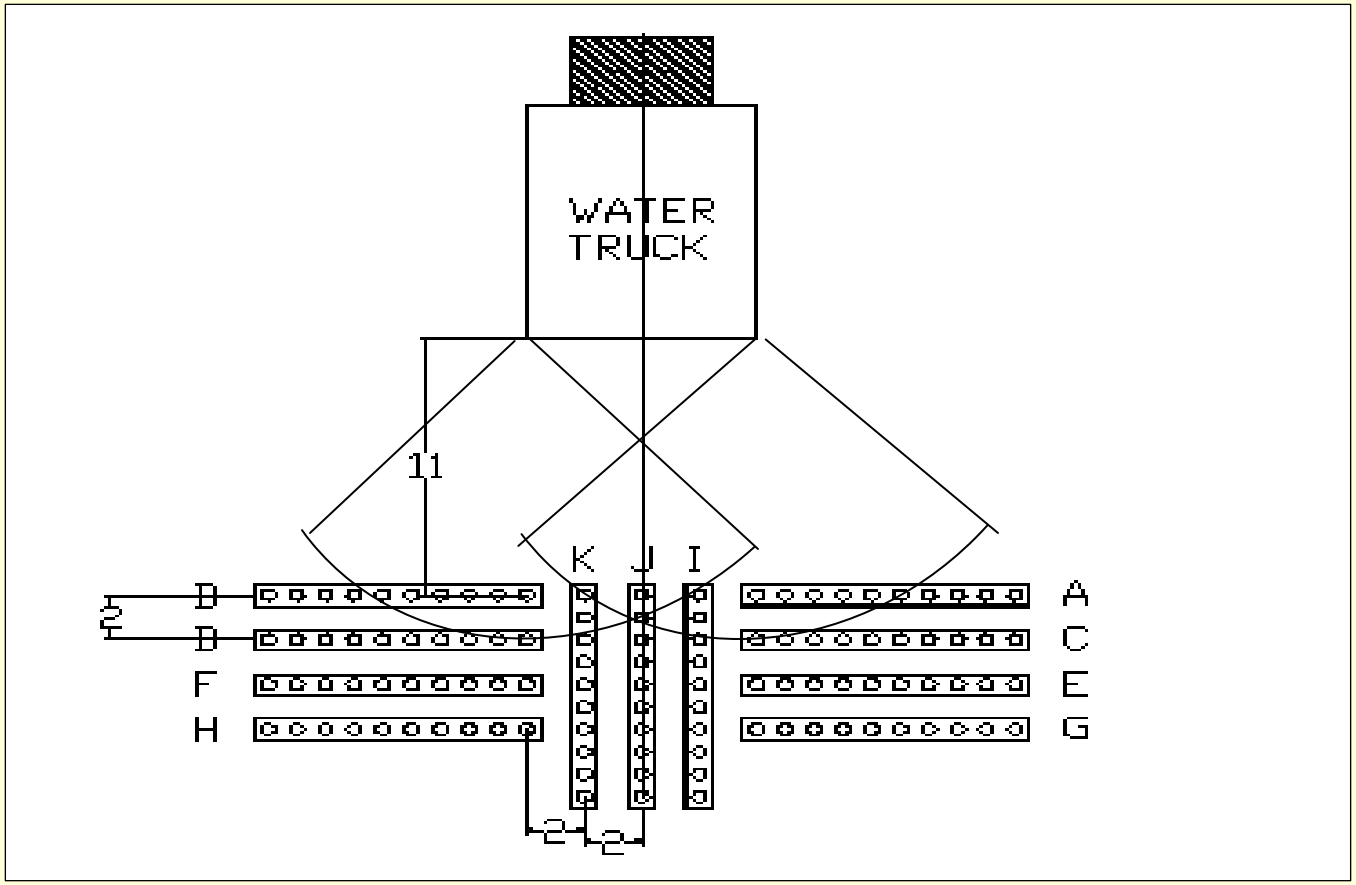
## Without Collar

# Typical Pipe Cap Installation



# Test Troughs

# Typical Trough Layout



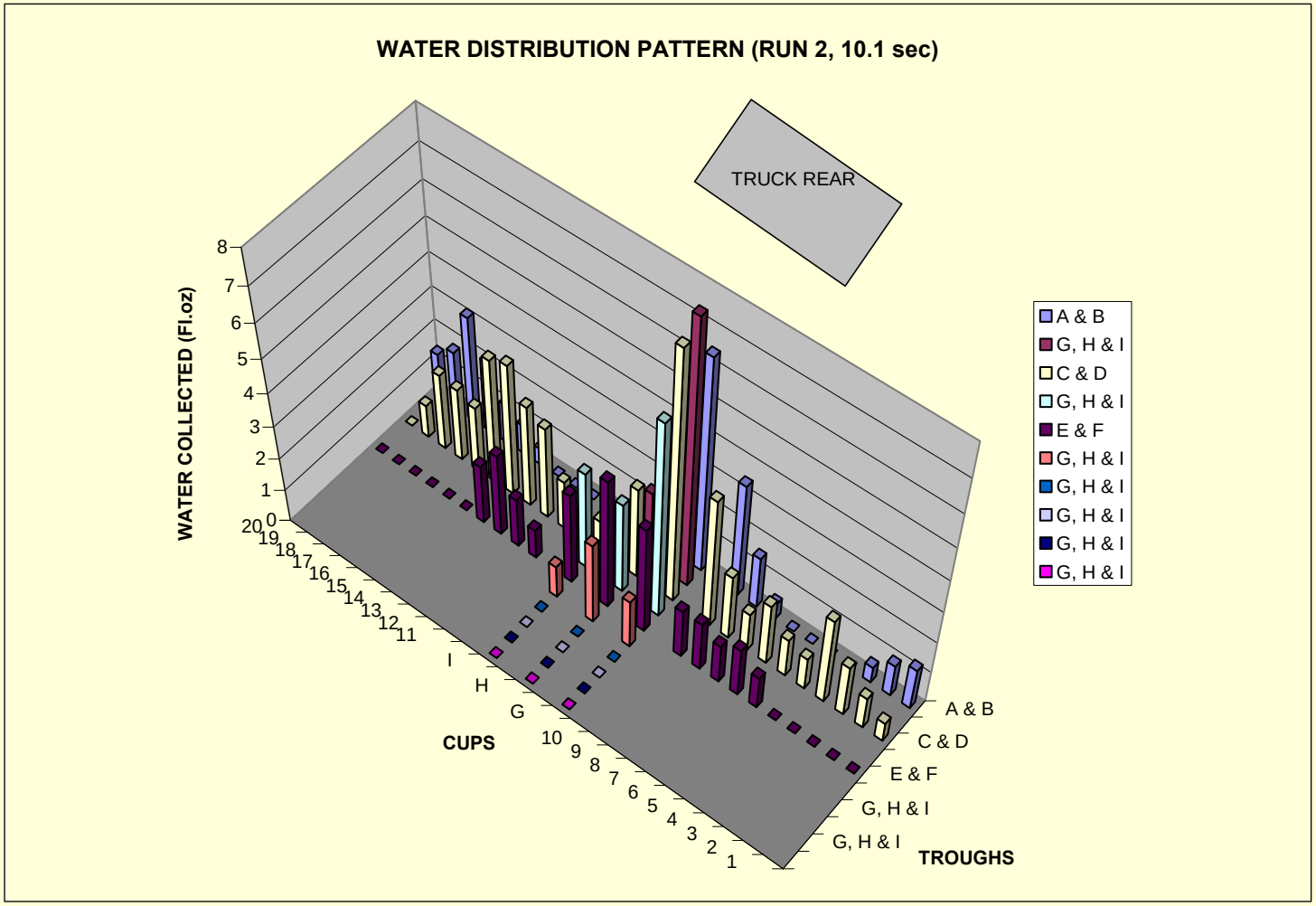
# Types of Equipment Tested

| Type | Number tested |
|---|---|
| 4,000-gallon water truck | 5 |
| 2,000-gallon water truck | 1 |
| 1,500-gallon water truck | 2 |
| 10,000-gallon off-road truck (Caterpillar 773B) | 1 |
| 5,000-gallon water pull (Caterpillar 613C) | 1 |

# Test in Progress – End View

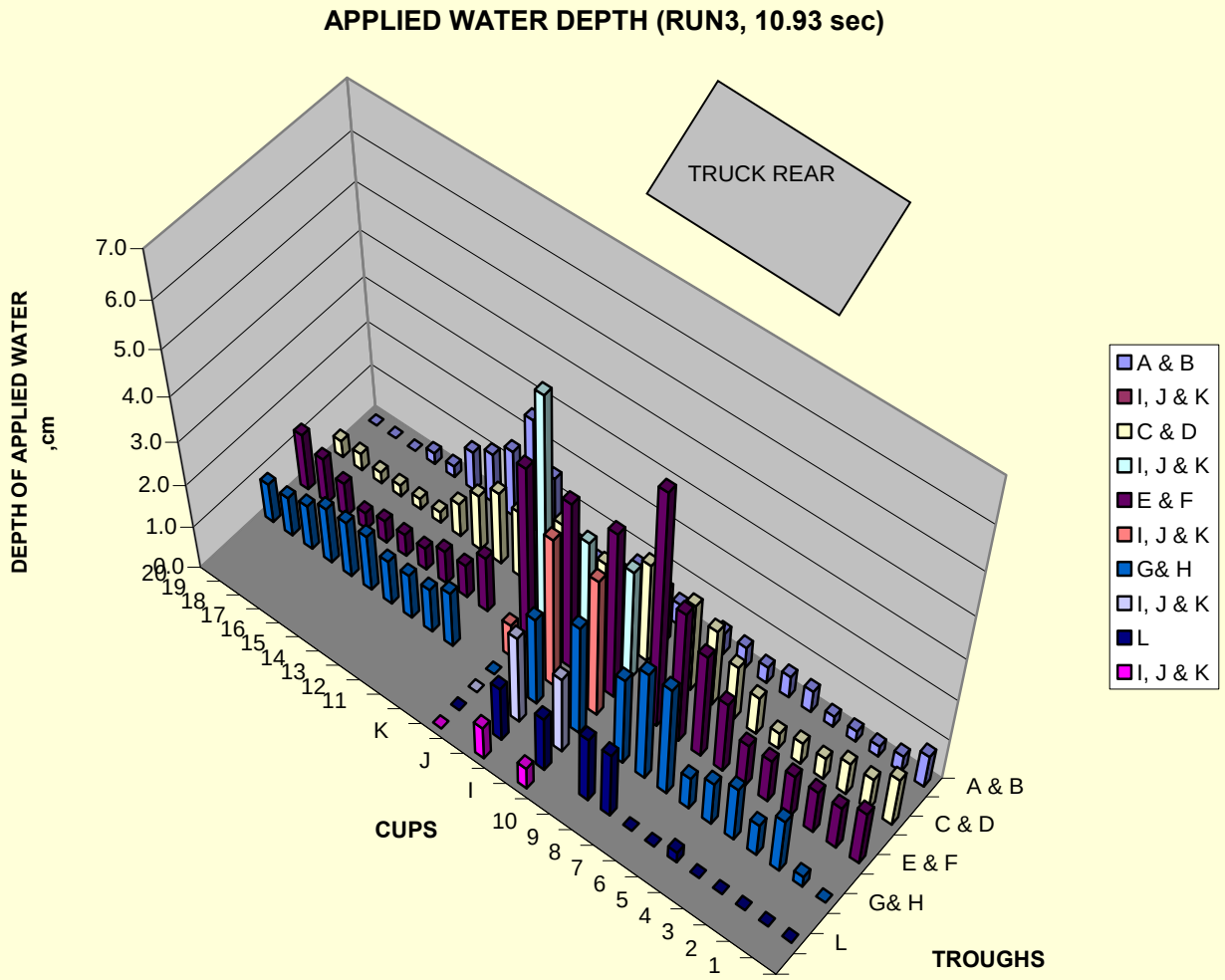
Nozzle used for test run # 1,2 & 3
2.5” pipe caps with 5.75 x⅛” slots; 180°

# Paired Nozzle Result CU 0.12 4,000 Gallon




Frehner, Jan 22, 2004, ¾” x 6”, 180°, Flat fan nozzle

# High CU = 0.34




LVVWD – 6/2/04, Flat fan nozzles, ¼” wide, 180°

# Results – Flat Fan Sprays

180° dual flat fan spray

- Significant center overlap between wheels
- Significant non-uniformities - center/edge = 3X
- Typical fan width – 35-40 feet
- Typical flow rate – 350-450 gallons minute
- Average spray depth per pass @ 5 mph 0.04 - 0.08 inch
- Uniformity coefficient range: -0.01 to 0.34

# Summary – Simple,180° Nozzles

| Nozzle Type | Nozzle Fan Angle (θ) & Orientation Angle (α), degrees | Number of Runs | Application Rate, cm/sec, Mean +/- Std. Dev | Coefficient of Variation, Mean +/- Std. Dev | Coefficient of Uniformity, Mean +/- Std. Dev |
|---|---|---|---|---|---|
| Single Flat Fan | 180 & 0 | 5 | 0.086 +/- 0.01 | 0.90 +/- 0.09 | 0.21 +/- 0.08 |
| Single Flat Fan (off-road) | 180 & 0 | 3 | 0.064 +/- 0.01 | 1.03 +/- 0.22 | 0.13 +/- 0.17 |
| Dual Flat Fan | 180 & 0 | 19 | 0.125 +/- 0.01 | 1.14 +/- 0.13 | 0.13 +/- 0.09 |
| Dual Flat Fan (Trench Method) | 180 & 0 | 4 | — | 0.90 +/- 0.24 | *0.36 +/- 0.12* |
| Dual Flat Fan (off-road) | 180 & 0 | 7 | 0.066 +/- 0.01 | 1.11 +/- 0.09 | 0.16 +/- 0.08 |
| Dual Pipe caps 1/8" by 5.75" | 180 & 0 | 3 | 0.038 +/- 0.00 | 1.06 +/- 0.11 | 0.24 +/- 0.08 |
| Dual Pipe caps*, 3/8" by 5.75" | 180 & 0 | 3 | 0.097 +/- 0.02 | 1.10 +/- 0.14 | 0.21 +/- 0.05 |

# Summary – Combined Nozzle Actuators

| Nozzle Type | Nozzle Fan Angle (θ) & Orientation Angle (α), degrees | Number of Runs | Application Rate, cm/sec, Mean +/- Std. Dev | Coefficient of Variation, Mean +/- Std. Dev | Coefficient of Uniformity, Mean +/- Std. Dev |
|---|---|---|---|---|---|
| Valew® | 150 & 0 | 6 | 0.092 +/- 0.02 | 1.23 +/- 0.17 | 0.04 +/- 0.10 |
| Mega Corp® | 85 & 0 | 6 | 0.129 +/- 0.02 | 0.81 +/- 0.08 | *0.37 +/- 0.06* |
| Bertolini® without Collar | 152 & 0 | 2 | 0.115 +/- 0.01 | 1.08 +/- 0.06 | 0.24 +/- 0.03 |
| Bertolini® with Collar | 152 & 0 | 2 | 0.156 +/- 0.02 | 0.99 +/- 0.05 | 0.09 +/- 0.10 |
| Bertolini® with* Collar | θ= 115-135, α= π/2-θ/2 | 5 | 0.115 +/- 0.05 | 0.92 +/- 0.12 | 0.29 +/- 0.13 |

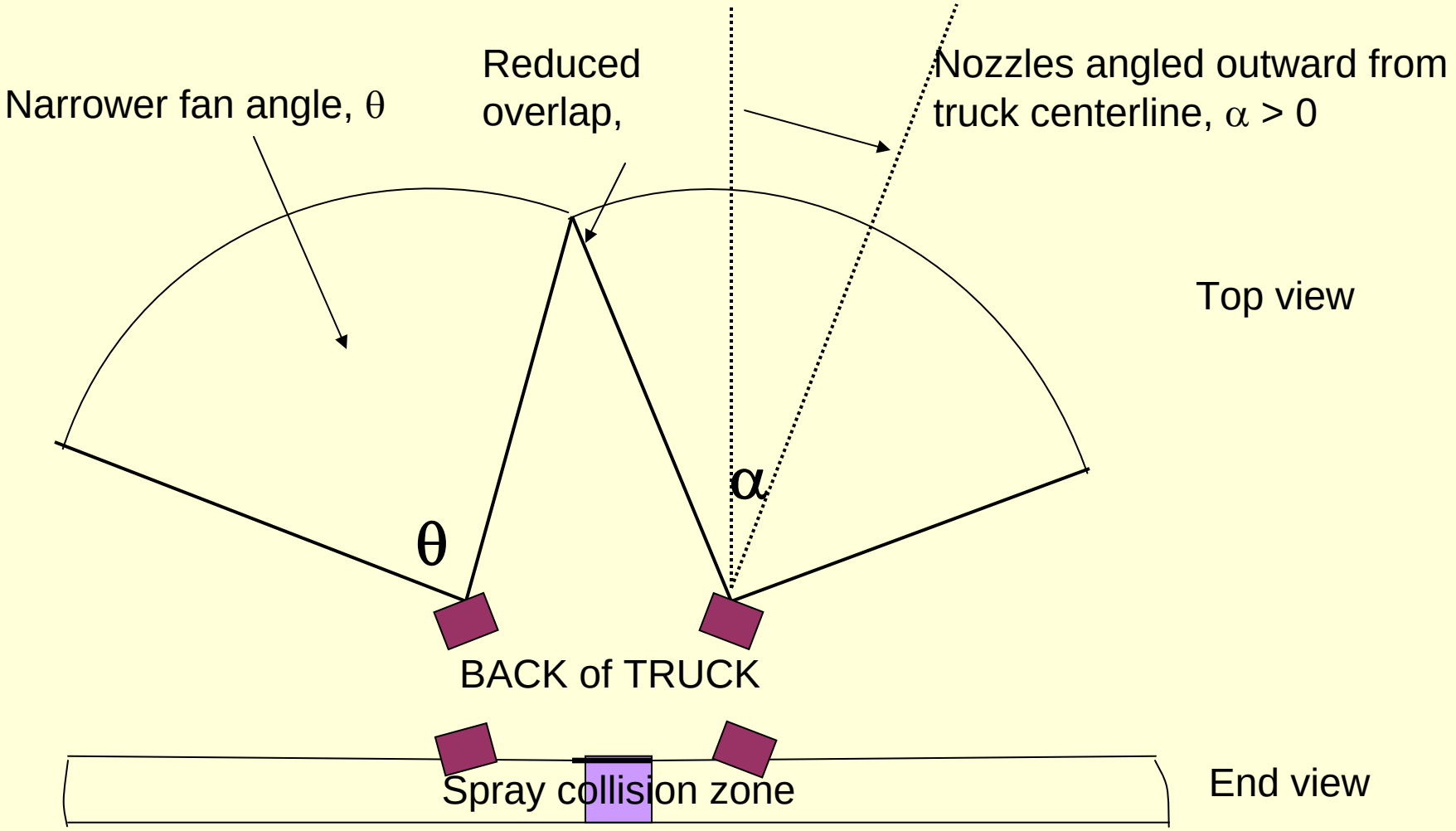
*Values depend on orientation of nozzles. Minimum CU = 0.14 with gap in center. Max CU = 0.47 for some overlap in center

# Why Are Spray Patterns Non-Uniform?

- Spray overlap
  - Individual nozzle fan angles 150-180° – increases spray overlap in center
  - Paired nozzle orientations perpendicular to truck centerline, increases overlap

- Spray collision
  - Paired nozzles mounted at same height - collision of sprays in overlap zone

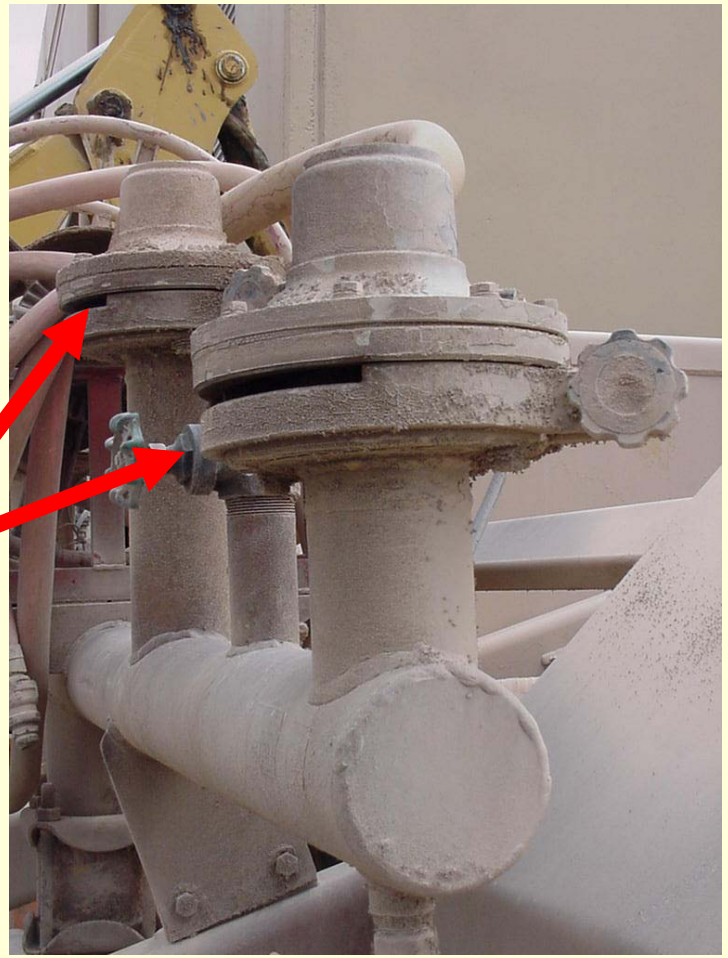
# Narrowed Nozzle Angle, θ, + Increase α, Reduces Overlap



# Potential Fixes

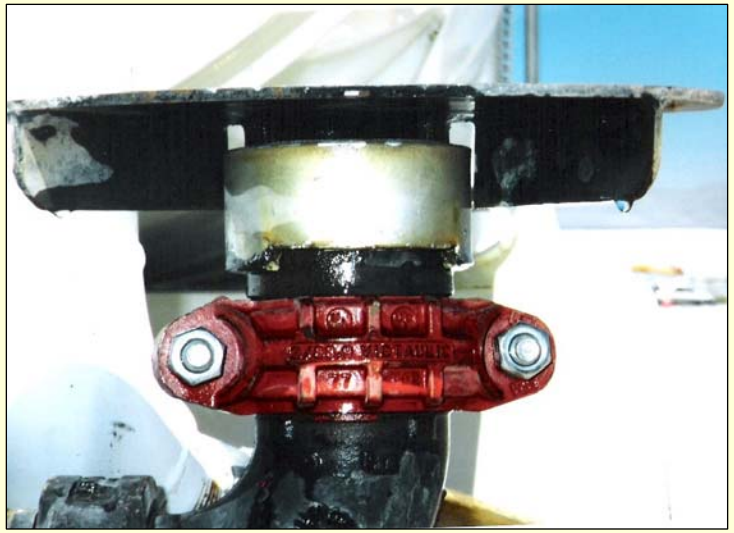
1) Decrease nozzle fan angles to 90-120°
2) Angle paired nozzles outward from truck centerline – still want minimal overlap at standard engine speed, increase $\alpha$
3) Mount nozzles at different heights to avoid spray collision

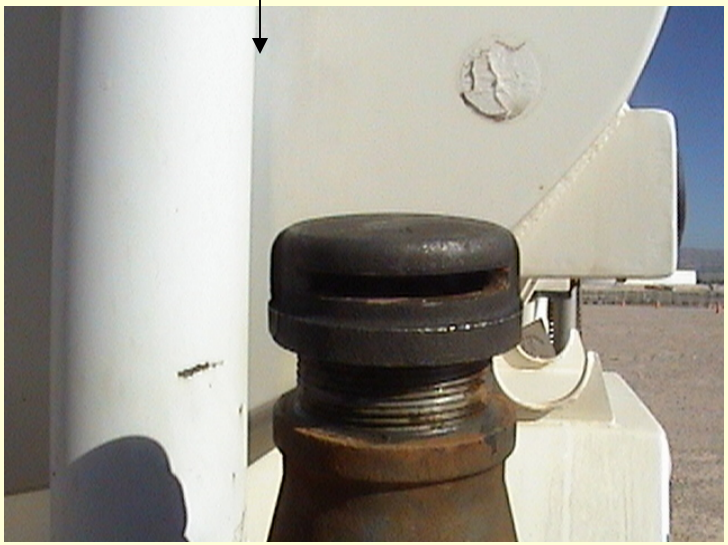
MegaCorp water pull uses #1) & #3)



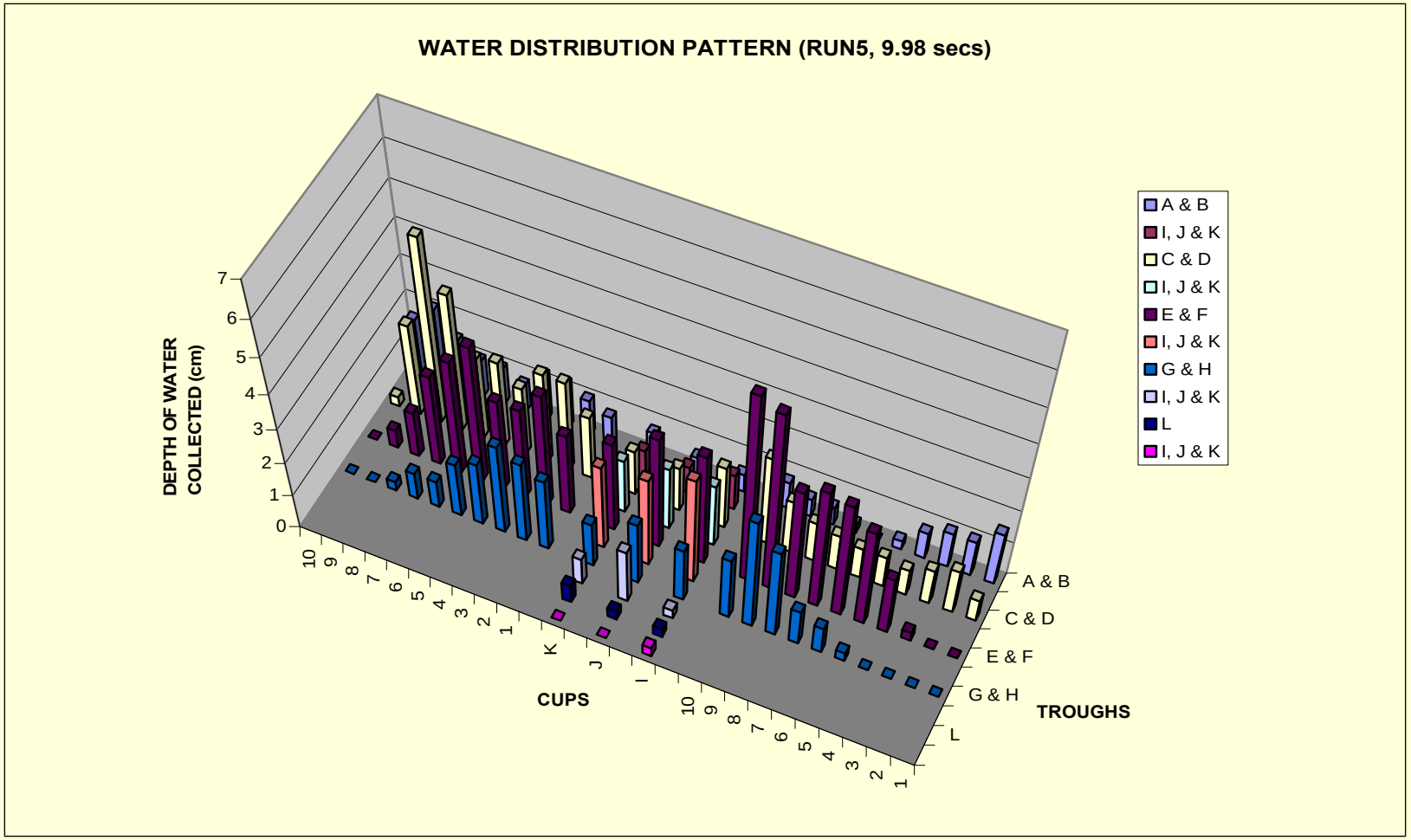
# For Other “Standard” Nozzles

- Flat fan – add a collar or ears to plate
- Pipe cap - drilled holes
- Pipe cap – slot cut to smaller circumference



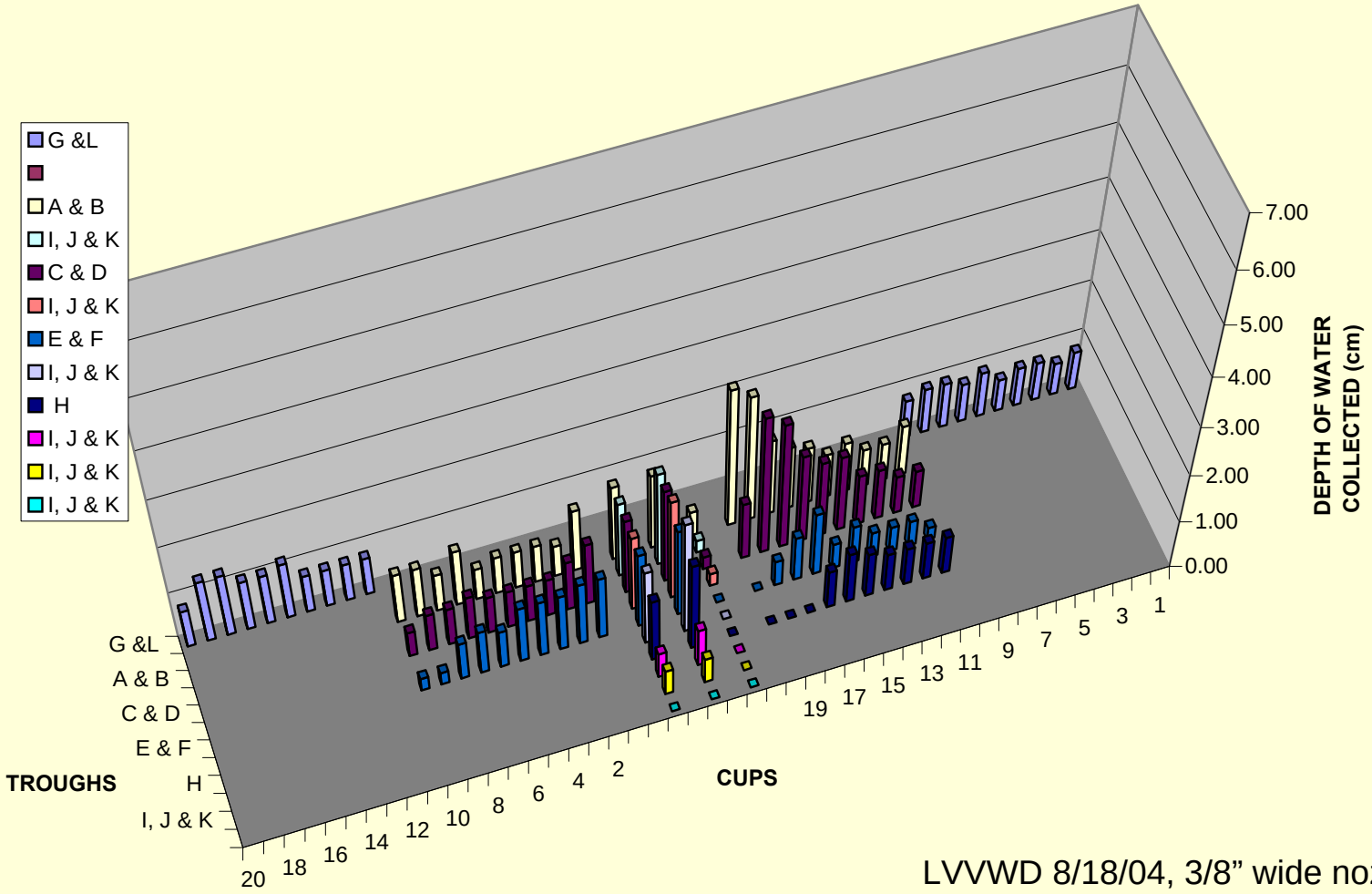


# Modified Flat Fan Results, CU = 0.32




Nozzle details: Flat fan nozzle with side baffles, 5/8” × 4” , 120° (Right), 5/8” X 3”, 90° (Left)

# Bertolini Collar Plug – CU 0.55




LVVWD 8/18/04, 3/8” wide nozzle slot, 115° nozzle angle, 32.5° orientation angle

# Summary: Improved Simple Nozzles

| Nozzle Type | Nozzle Fan Angle (θ) & Orientation Angle (α), degrees | Number of Runs | Application Rate, cm/sec, Mean +/- Std. Dev | Coefficient of Variation, Mean +/- Std. Dev | Coefficient of Uniformity, Mean +/- Std. Dev |
|---|---|---|---|---|---|
| Dual Flat Fan with Ears | 120(R), 90(L) & 0 | Improved =2 | 0.144 +/- 0.01 | 0.91 +/- 0.16 | 0.28 +/- 0.06 |
| | 180 & 0 | Original = 5 | 0.105 +/- 0.01 | 1.24 +/- 0.18 | 0.13 +/- 0.10 |
| Dual Flat Fan with Ears and Slotted Collar | 120(R), 90(L) & 0 | Improved =2 | 0.155 +/- 0.01 | 0.87 +/- 0.08 | 0.36 +/- 0.06 |
| | 180 & 0 | Original = 5 | 0.105 +/- 0.01 | 1.24 +/- 0.18 | 0.13 +/- 0.10 |
| Dual Pipe caps, 1/4" | 120 & 30 | Improved =2 | 0.075 +/- 0.01 | 1.00 +/- 0.05 | 0.22 +/- 0.02 |
| | 180 & 0* | Original = 3 | 0.038 +/- 0.00 | 1.06 +/- 0.11 | 0.24 +/- 0.08 |
| Dual Pipe caps, 3/8" | 120 & 30 | Improved =2 | 0.064 +/- 0.01 | 0.83 +/- 0.06 | 0.38 +/- 0.06 |
| | 180 & 0** | Original = 3 | 0.097 +/- 0.02 | 1.10 +/- 0.14 | 0.21 +/- 0.05 |

** irregular slot surface, * nozzle with ⅛” wide slot.

# Bertolini Modified Band Video

LVVWD 8/18/04, 3/8” wide nozzle slot, 127° nozzle angle, 26.5° orientation angle

# Advantages – Conserve water

- Narrow spray pattern & adjust outward will conserve water by about 20%
  - Covers more area per gallon of water applied
  - Services 20% larger area with same load
  - Higher uniformity of applied water
    - Fewer areas too dry or too muddy

# Advantages - Cut costs

- Narrower nozzle spray pattern & adjust outward will use less water and increase time on-site
  - Enhances site productivity (fewer trips to refill → equipment moves soil greater fraction of shift time)
  - For Las Vegas Valley activity - May conserve 1,000-2,000 AF/year at modest investment cost

# Three Things You Can Do Now to Improve Water Efficiency & Cut Costs

- Minimize nozzle spray overlap
  - Adjust nozzle fan angle
  - Adjust nozzle orientation
  - Stagger nozzle heights

- Replumb trucks for positive nozzle shut off with no air pressure (avoid leakage of truck contents when air pressure lost)
  - Bertolini and Valew valves are positive shut-off with 0 air pressure

- Adjust rewetting time to maintain dust control but not overapply water (high PEP – apply hourly in summer)

# Three possible follow-up projects

- Evaluate side spray patterns from trucks
- Evaluate effectiveness of spray nozzles in suppressing airborne dust & compare “just in time” wetting with pre-wetting
  - Preliminary evidence shows fire hose nozzles, large drop sizes do not effectively suppress dust when applied “just in time” during excavation
- Evaluate impact of optimized water application on construction operations & costs – 1 less truck covering more area → What are impacts on site costs?

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Questions?