

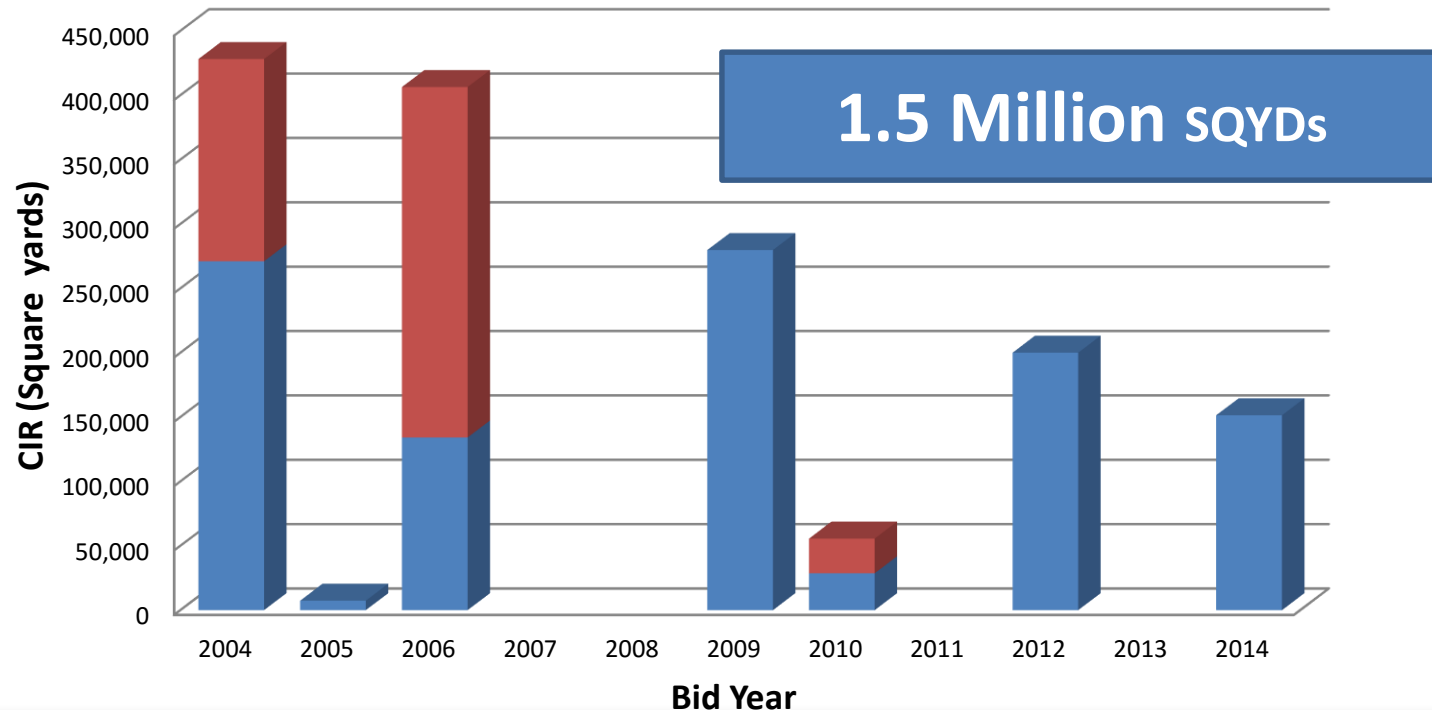
Cold Recycling within ADOT

Lessons Learned and Future Implementation

Prepared by: Nye F. McCarty, P.E.

Brief History of CIR in AZ (ADOT)

- In use since 1980's
 - Limited to low volume/rural highways
 - 10 ADOT projects since 2004



Past CIR Projects (ADOT)

Year	Route (BMP)	Square Yards of CIR	Notes				AADT
2004	SR 98 (348.4)	271,018	2% Trucks, Excessive Crack Seal				2555
2004	US 160 (416)	157,095	7% Trucks, Chip Seal, crack sealant				3500
2005	I-10 FR (267.3)	7,368	Chip Seal, crack sealant				
2006	SR 61 (352.9)	134,146	12% Trucks, Double Chip				2650
2006	US 60 (49.6)	272,238	46% Trucks, Chip Seal, crack sealant				3430
2009	US 160 (402)	279,705	6% Trucks, Double Chip, crack sealant				2376
2010	RT 66 (Flag)	28,686					
2010	Goodyear	26,900					
2012	SR 77 (395)	200,000	13% Trucks, Chip Seal				1205
2014	US 89 (510)	151,381	12% Trucks, Double Chip, Crack sealant				4150

US 89 CIR Failure



US 89 – Gray Spot Wash to North Red Hill



Project Overview

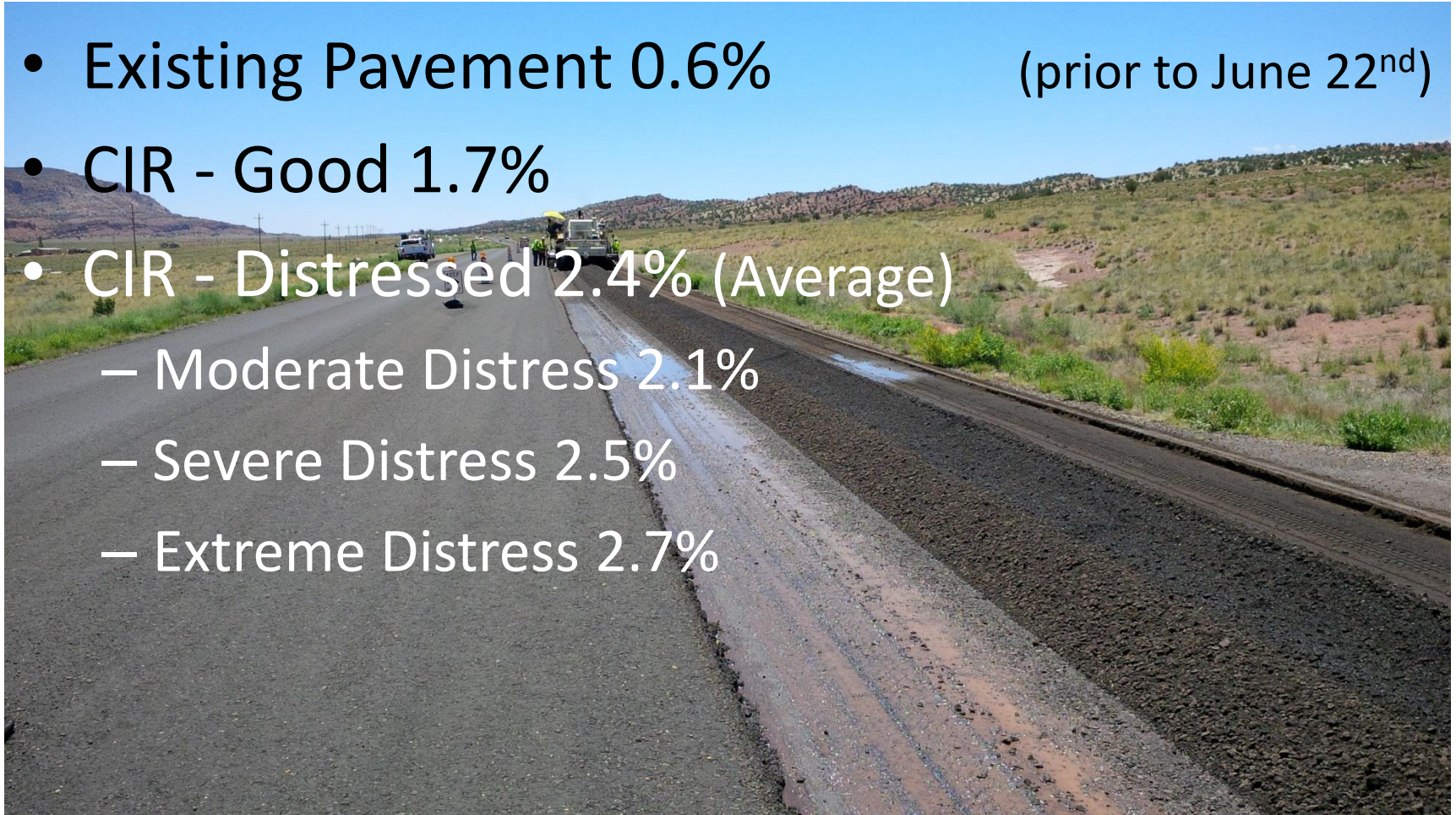
- MP 510.00 – 517.43
- Cold in-Place Recycling (CIR) with AC Overlay
 - Address Pavement Distress (cracking / rutting)
 - Cost Savings (compared to mill and overlay)
 - Increase Structural Capacity
- CIR Operations began June 3rd
- CIR began to fail June 19th
- Removal of CIR material, and shoulder build up operations began shortly thereafter.
- Placed an increased thickness of AC

Progression

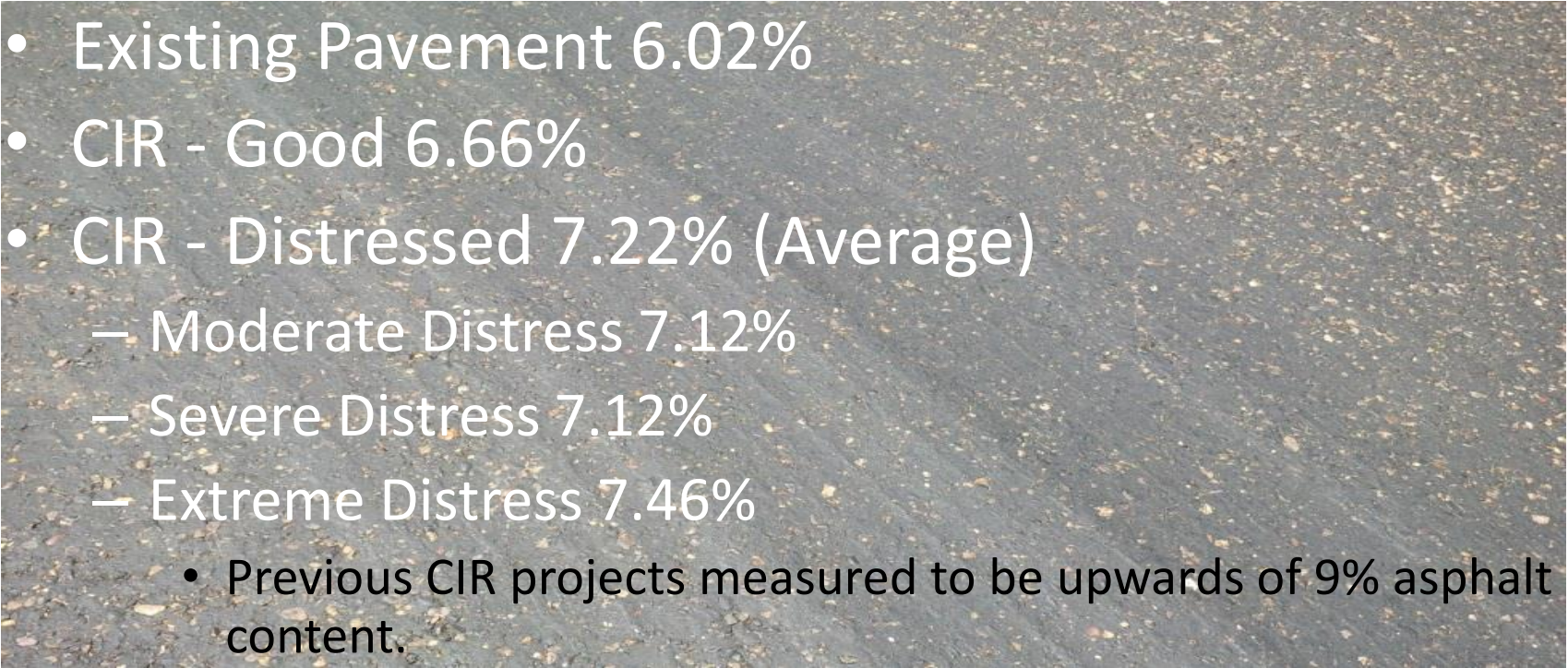


Investigation - Moisture Content

- Existing Pavement 0.6% (prior to June 22nd)
- CIR - Good 1.7%
- CIR - Distressed 2.4% (Average)
 - Moderate Distress 2.1%
 - Severe Distress 2.5%
 - Extreme Distress 2.7%



Investigation - Binder Content

- Numerous Maintenance Activities
 - Not well documented
 - Presence of Chip Seal / Double Chip Seal
- 
- Existing Pavement 6.02%
 - CIR - Good 6.66%
 - CIR - Distressed 7.22% (Average)
 - Moderate Distress 7.12%
 - Severe Distress 7.12%
 - Extreme Distress 7.46%
 - Previous CIR projects measured to be upwards of 9% asphalt content.

Rounded / Smooth Aggregate

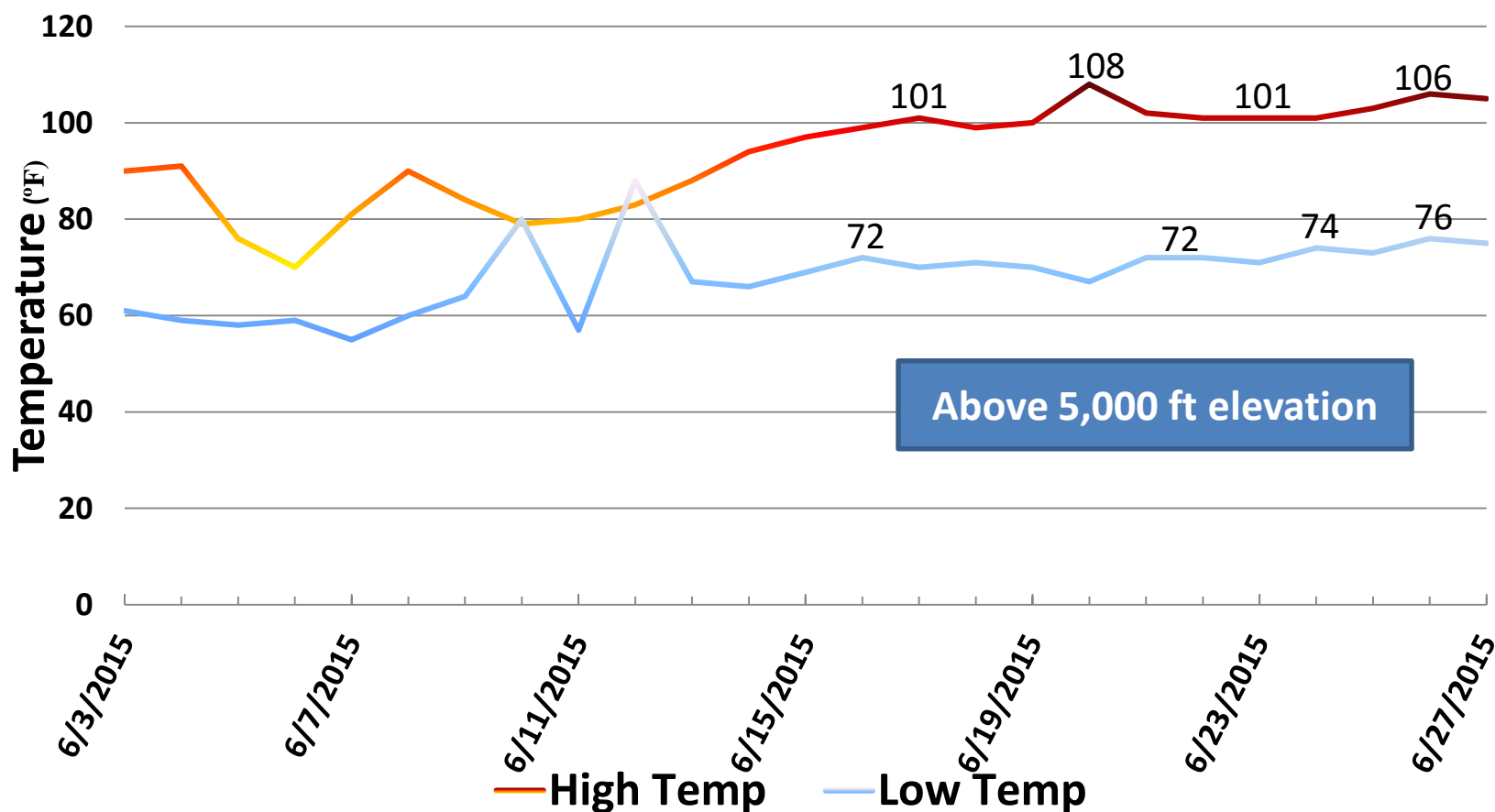
- Observed at surface in existing Chip Seal
- Uncoated aggregate observed in paver screed



Causes for CIR Failure

- Primary
 - Excessively warm Ambient / Pavement Temperature
 - Record daily high temperatures during CIR operations
- Secondary

Ambient Temperature (Bitter Springs)



Causes for CIR Failure

- Primary
 - Excessively warm Ambient / Pavement Temperature
 - Record daily high temperatures during CIR operations
 - Type of Emulsion (HFE-300P)
 - Up to 7.5% solvent content (FHWA)

HFE-300P

- Softest Binder Rating (cold climate binder)
 - Solvent (diesel) is added to soften binder
 - High penetration (30mm) allows for improved coating of aggregate
- Requires 2 hours to break
- Must cure (sufficient volatilization of solvent)
- Effectiveness for cold recycling is limited to low volume rural roads with moderate temperatures

Causes for CIR Failure

- Primary
 - Excessively warm Ambient / Pavement Temperature
 - Record daily high temperatures during CIR operations
 - Type of Emulsion (HFE-300P)
 - Up to 7.5% solvent content (FHWA)
 - Traffic
 - Moderate amount of heavy truck traffic
 - Increased holiday/recreational traffic

Traffic

- Increased Traffic prior to Independence Day.
 - RVs
 - Boats
 - Trailers
- Slowing, stop-and-go traffic through project
 - More prevalent once failures required alteration of traffic control

Causes for CIR Failure

- Secondary
 - Excessive Emulsion / Moisture Content
 - Solvent /Binder Content of Existing Pavement
 - Rounded / Smooth Aggregate

Review of Existing ADOT Specifications for Cold Recycling

Material Requirements (408COREC)

- **Recycling Agent** (asphalt emulsion)
 - HFE-300P
 - Soft binder to assist in coating (cold climate emulsion)
 - Up to 7% solvent (for coating)
- **Recycling Additive**
 - No mineral admixture or corrective aggregate
- **Mix Design**
 - Not required (informal)
 - Material sampled from shoulder in two locations
 - Marshall Stability and Flow, Bulk Density

Material Requirements (REV408COREC)

- **Recycling Agent** (asphalt emulsion)

- Solventless (engineered emulsion)

- Maximum of 1% solvent

- **Recycling Additive**

- Lime or Po

- Minimum

- **Mix Design**

- ARRA CR2

- Compre
- Medium
- Volume
- Indirect

Raveling Test, Fracture Energy

- High temperature validation (> 85 deg. F)

Colorado DOT

Distress

Rutting

Fatigue

Transverse

2 in. overlay on CIR

vs.

4 in HMA:

Savings of \$3/sq.yd.

Construction Requirements (408COREC)

- **Top Size**
 - Process RAP to 100% passing 1-1/4" sieve
- **Moisture Content**
 - Add approximately 1.5% mixing water
 - Maximum of 3.0% moisture in CIR material prior to addition of an emulsified recycling agent
- **Recycling Agent** - Add an amount of recycling agent determined by laboratory testing.
 - No definition of required laboratory testing.
 - +/- 0.3% allowance from mix design target during production.
- **Temperature Requirements**
 - Ambient / Pavement Temperature at least 65°F and rising

Construction Requirements (REV408COREC)

- **Top Size** - 1-1/4" or 1" based on mat thickness
- **Moisture Content** – based on existing conditions and mix design
- **Recycling Agent Content**– Mix Design
 - Production Target within +/- 0.3% of mix design
 - +/- 0.2% allowance from production target
- **Temperature & Seasonal Requirements**
 - Pavement Temperature: 65°F and rising, 130°F max.
 - Ambient Temperature: above 60°F, 95°F max.
 - Minimum overnight Low of 35°F following placement
 - Seasonal exclusions based on project elevation

Construction Requirements (408COREC)

- **Compaction**

- Commence when the emulsion begins to break or after 2 hours
- Initial Compaction with pneumatic tired rollers
 - 30 ton pneumatic rollers operating in tandem
 - Minimum of 9 coverages and having “walked-out” the mat
- Final Compaction with steel wheel rollers
 - Minimum of two coverages with a 12 ton roller

- **Return to Traffic**

- 2-hour waiting period

- **Placement of Surfacing**

- Maximum of 1.5% moisture in cold recycled material

Construction Requirements (REV408COREC)

- **Compaction**

- Cold In-Place Recycled Asphalt Field Shear Vane Test**

- Utah DOT Materials Manual Section 965, “Guidelines for Evaluation, Mix Design and Field Acceptance of Cold Recycling of Asphalt Pavements using Solventless Emulsion”, Appendix F

- Determining In-place Flow of Cold In-place Recycled (CIR) Asphalt using the Marshall Hammer**

- Appendix G

- **Return to Traffic**

- Shear vane / Marshall hammer

- **Secondary Compaction**

- Ambient temperature of at least 80°F

Construction Requirements (REV408COREC)

Fog Seal

Slurry Mixing/Storage

Cold Recycling Operations Plan

Equipment Cal

CCPR

Paver

Metering and Proportioning

Quality Control

haul trucks

Just in time Training

Maintenance

Addition

MTV

reader

Water truck

Test Strip

Surface Preparation

Quality Control (408COREC)

- **None**
 - No quality control required by 408COREC
 - Adjustments made purely on visual assumptions

“Cold in-Place Recycling is a pure artform.”

Quality Control (REV408COREC)

- **Quantities / addition rates**
 - Mineral Admixture / Slurry Water
 - RAP
 - Recycling Agent
 - Mixing Water
- **Maximum aggregate size @ 1,000 ft intervals**
- **Field compacted specimens @ 500 ton intervals**
 - Includes moisture content determination
- **Monitoring compaction with a thin lift nuclear density gauge**
 - Compare wet density to field compacted specimens
 - Compare dry density to Gmm in mix design

Acceptance (408COREC)

- Visual Inspection
 - Material has been “walked-out” with no roller marks
- Smoothness
 - $\frac{1}{4}$ ” with a 10’ straightedge
- Moisture Content
 - 1-1/2% or less prior to placement of surfacing course

Acceptance (REV408COREC)

- Emulsion Content
 - Within +/- 0.3% of production target based on volume of recycled material
- Compaction
 - Minimum core density of 96% relative compaction when compared to dry density of field compacted specimens.
- Moisture Content
 - 2% or less, or 10 consecutive days without rain
 - No more than 0.5% greater than moisture content prior to recycling
- Surface Requirements
 - 3/8" with a 10' straightedge

408COREC, as it existed previously, was a method specification that specified very few method requirements.

Cold Recycling by Neighboring DOTs

- UDOT, CDOT, NMDOT, NDOT
 - Wide use from rural highways to interstates
 - Up to 10 000 ft + elevation
- CDOT
 - Interstates
 - 10 to 100 trucks/day
- NMDOT
 - I-40, I-10
- UDOT
 - I-15 with typically a 2-3 inch overlay.

Millions of square yards of
recycled material each year

Far Reaching Effort

- ARRA – Asphalt Recycling and Reclaiming Association
 - BARM – Basic Asphalt Recycling Manual
 - CR101, CR102, CR201, CR301
- Rocky Mountain Asphalt User/Produce Group
- State / Local DOTs
 - Colorado, Utah, New Mexico, California, Nevada, Coconino County, City of Mesa
- Local Industry / Experts
 - CIR subcontractors, Emulsion Suppliers, Materials Testing Firms, Equipment Manufacturers, Association of General Contractors
- ADOT Personnel

Thank You

Nye F. McCarty, P.E.

Flagstaff Regional Materials Engineer
Arizona Department of Transportation

NMcCarty@azdot.gov

(928) 779-7522