RECYCLED MATERIALS RESEARCH AT UNH

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RAP ETG Meeting

December 17, 2009

UNIVERSITY of NEW HAMPSHIRE

RAP PERFORMANCE CASE STUDIES

Grad Student: Evan Anderson

Funding: Recycled Materials Resource Center

Project Completion: September 2010

Objectives

- To compare the long term performance of RAP pavements to virgin pavements using several case studies

- Gather information on selected RAP pavements that have performed well over time and perhaps are still in service

Demo 39 Sites

Willow, AK
Gila Bend, AZ
Gold Run, CA
Durango, CO
Panama City, FL
Kossuth County, IA
Elkhart County, IN
Springfield, MO
Dallas County, MO
Ellendale, ND
Concord, Manchester, Tamworth & Jackson, NH
North Brunswick, NJ
Chester, VA
Ellensburg, WA

- All of the Demo 39 sites originate from the late 70's - early 80's

- Mix and construction information
  - binder characteristics
  - some initial pavement performance

- follow up performance data difficult to find in most cases

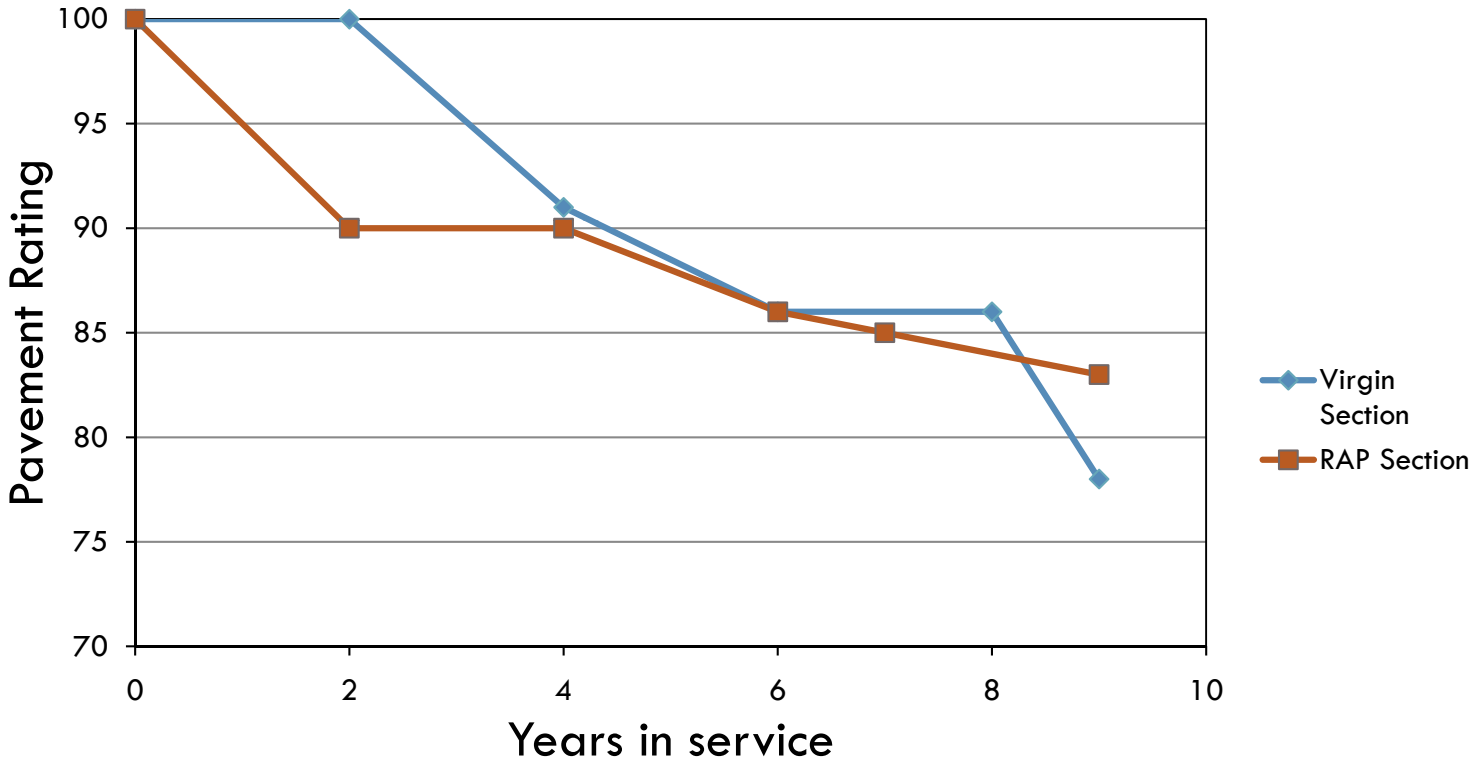
Washington State

- Demo 39-3 SR-90 Renslow to Rygrass 1977-1986
- Demo 39-11 SR-90 Akima River to W. Ellensberg 1978-1985

	Ryegrass ('77)	Ellensburg ('78)	
Old Pavement	71.75%	78.5%	78.5%
New Aggregate	27.5	20	20
Recycling Agent	0.75	1.2	1.0
New Asphalt Cement	0	0.3	0.5

Recycling agent = Cyclogen L

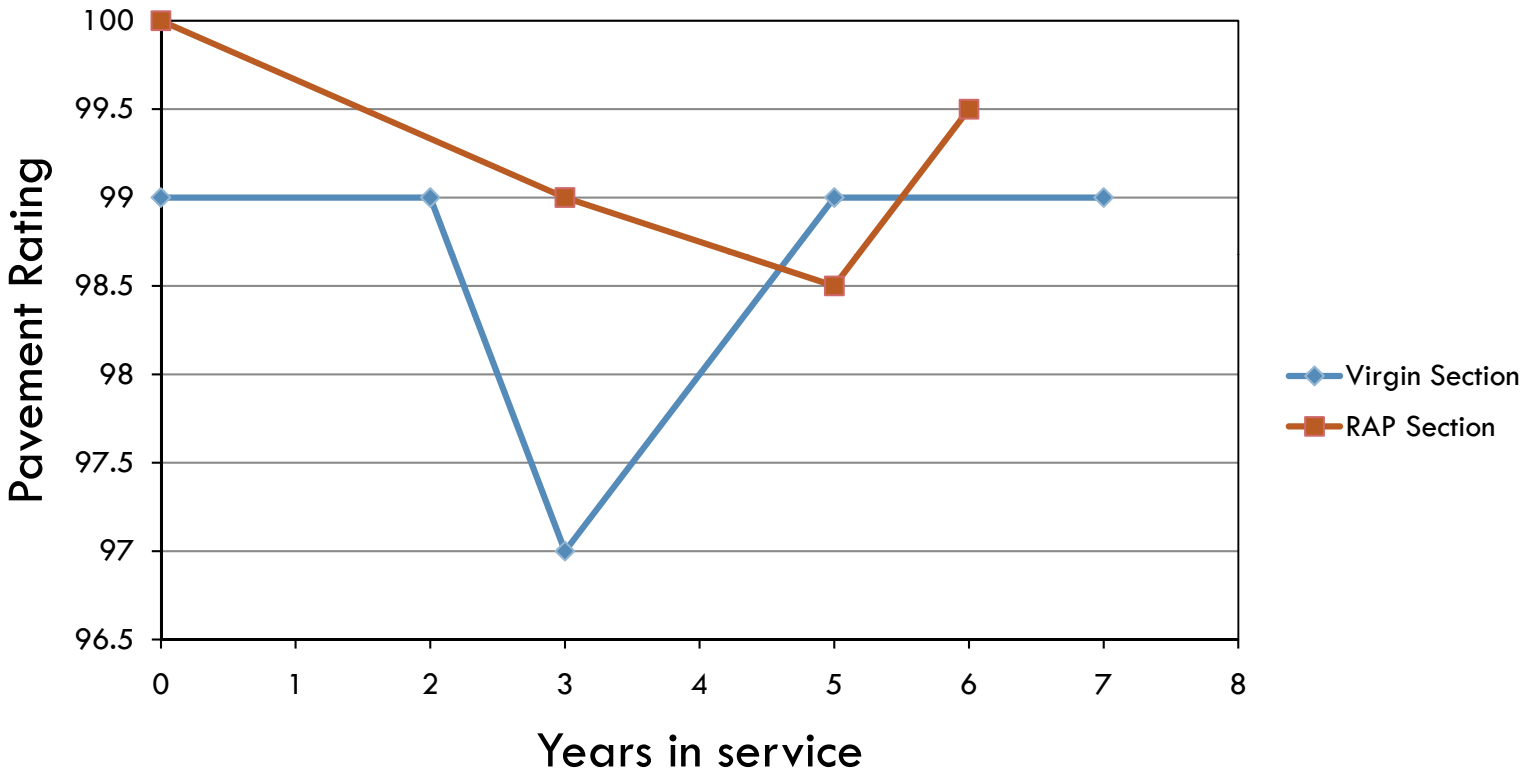
SR-90 Renslow to Rygrass



Recycled Location - MP 121.9 - MP126.1

Virgin Location – MP 137.8 – MP 143.9 (New 1975)

SR-90 Akima River to W. Ellensberg



Recycled Location - MP 102.6 - MP106.3

Virgin Location – MP 106.3 – MP 107.4 (New 1981)

Other Sites

Arizona

- Three cold recycle projects from 2000
- Comparable virgin sections
- Information on flushing, ride, rutting, friction, and maintenance costs

Connecticut

- Detailed Superpave study 1997-2003
- Performance data and images

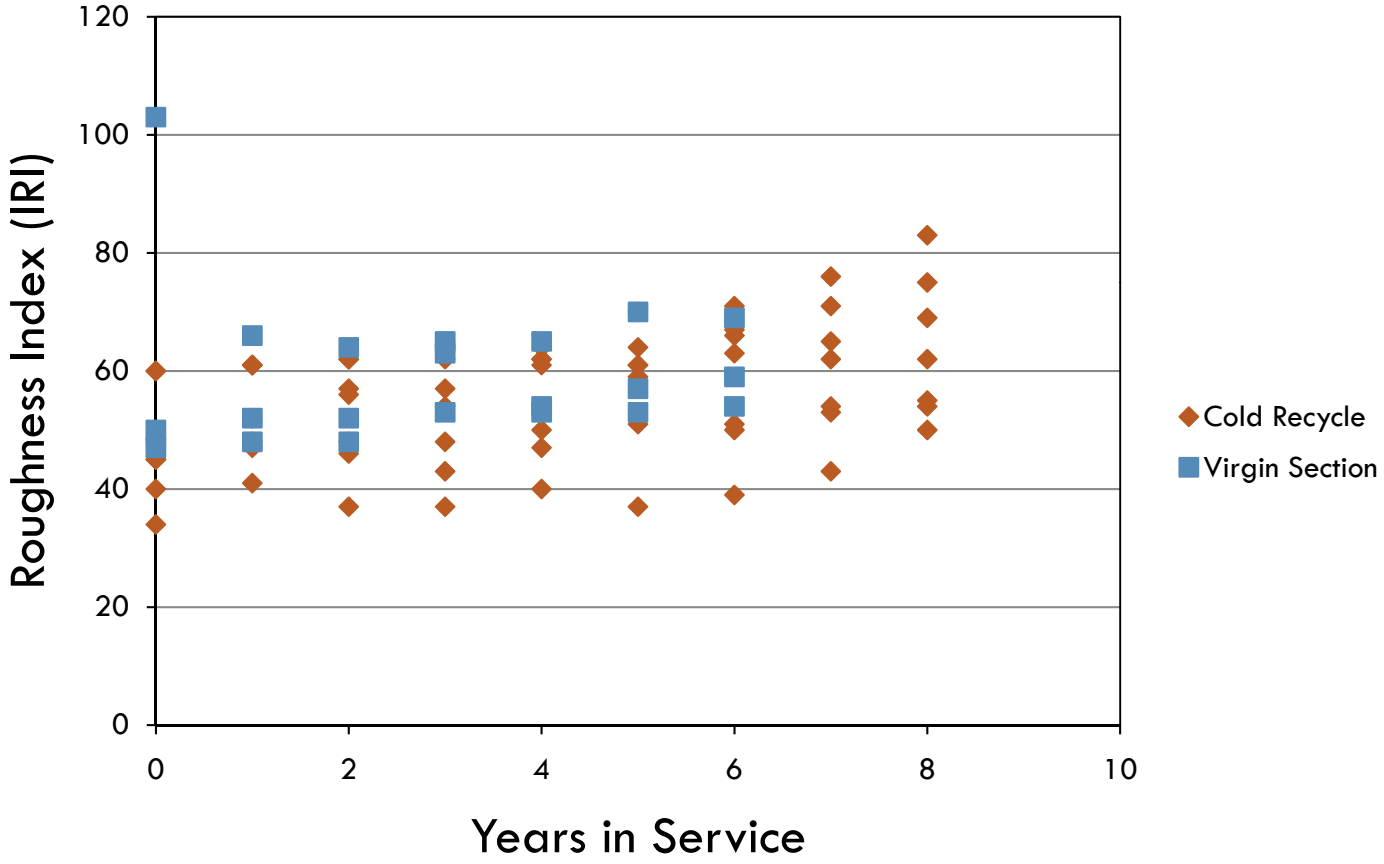
Florida

- Database on RAP sections
- Compares service life versus RAP percentages and dense vs. open graded friction coarse

Arizona

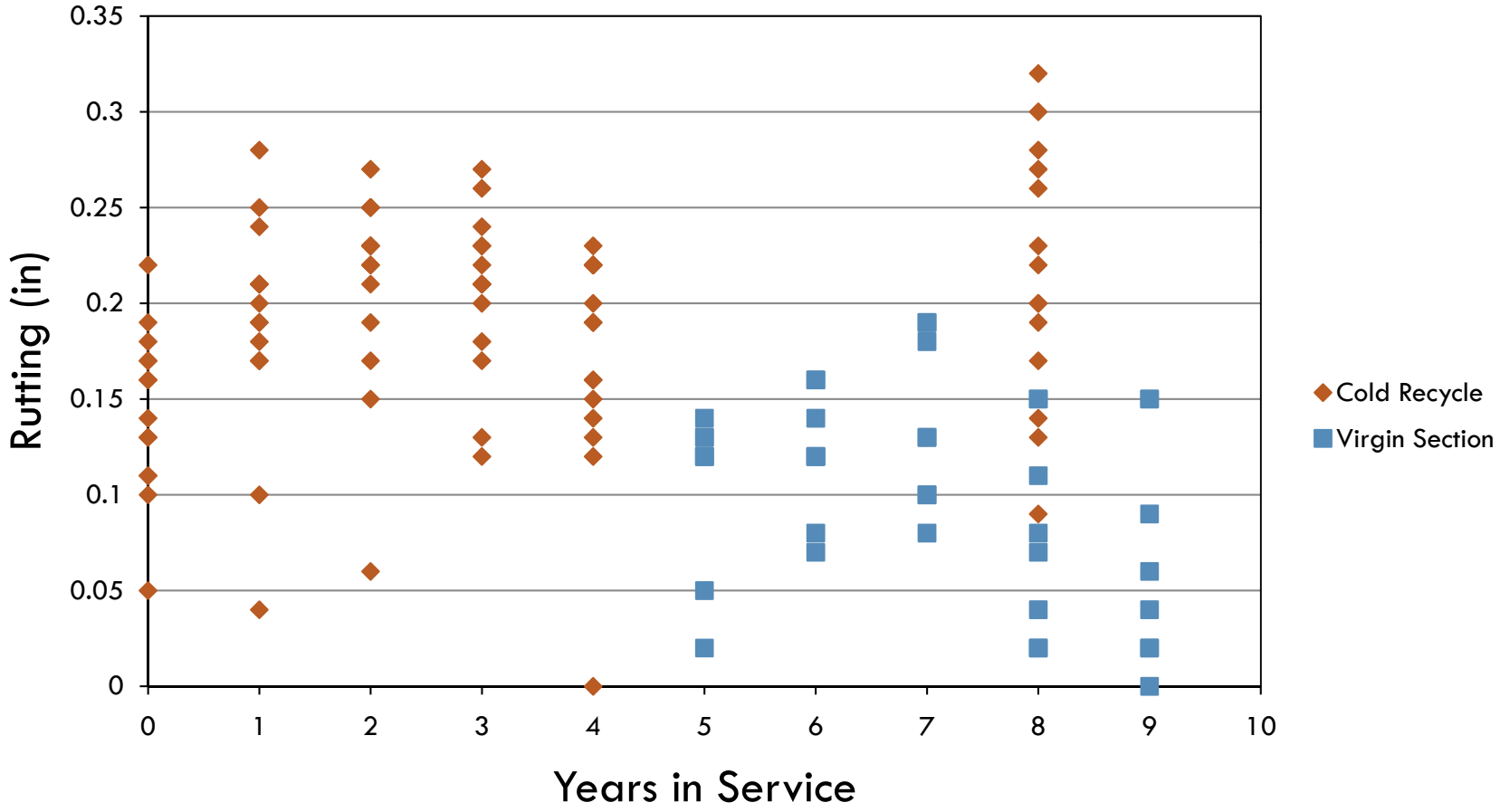
- Cold Recycle projects placed in 2000
- 3” cold recycle with 1.5-2” AC overlays
- Projects
  - SR – 73
  - US – 180
  - US – 191

Arizona – SR 73

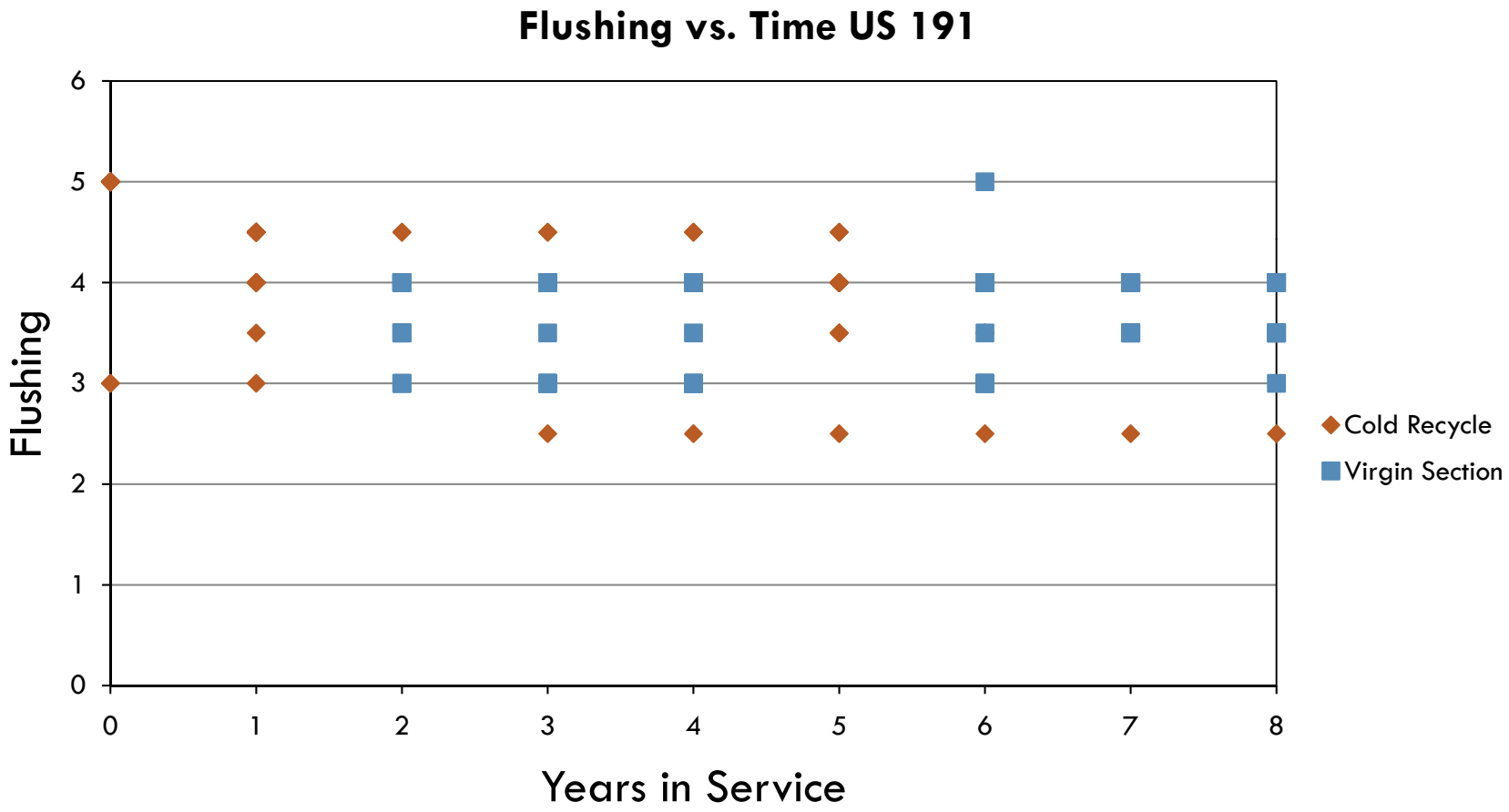


3” Cold Recycle, 2” AC, ½” Friction Course
Virgin HMA comparative section constructed 2002

US - 180


Rutting (in)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
1
2
3
4
5
6
7
8
9
10
Years in Service
Cold Recycle
Virgin Section

US - 191


Flushing vs. Time US 191
Flushing
Years in Service
0
1
2
3
4
5
6
7
8
Cold Recycle
Virgin Section

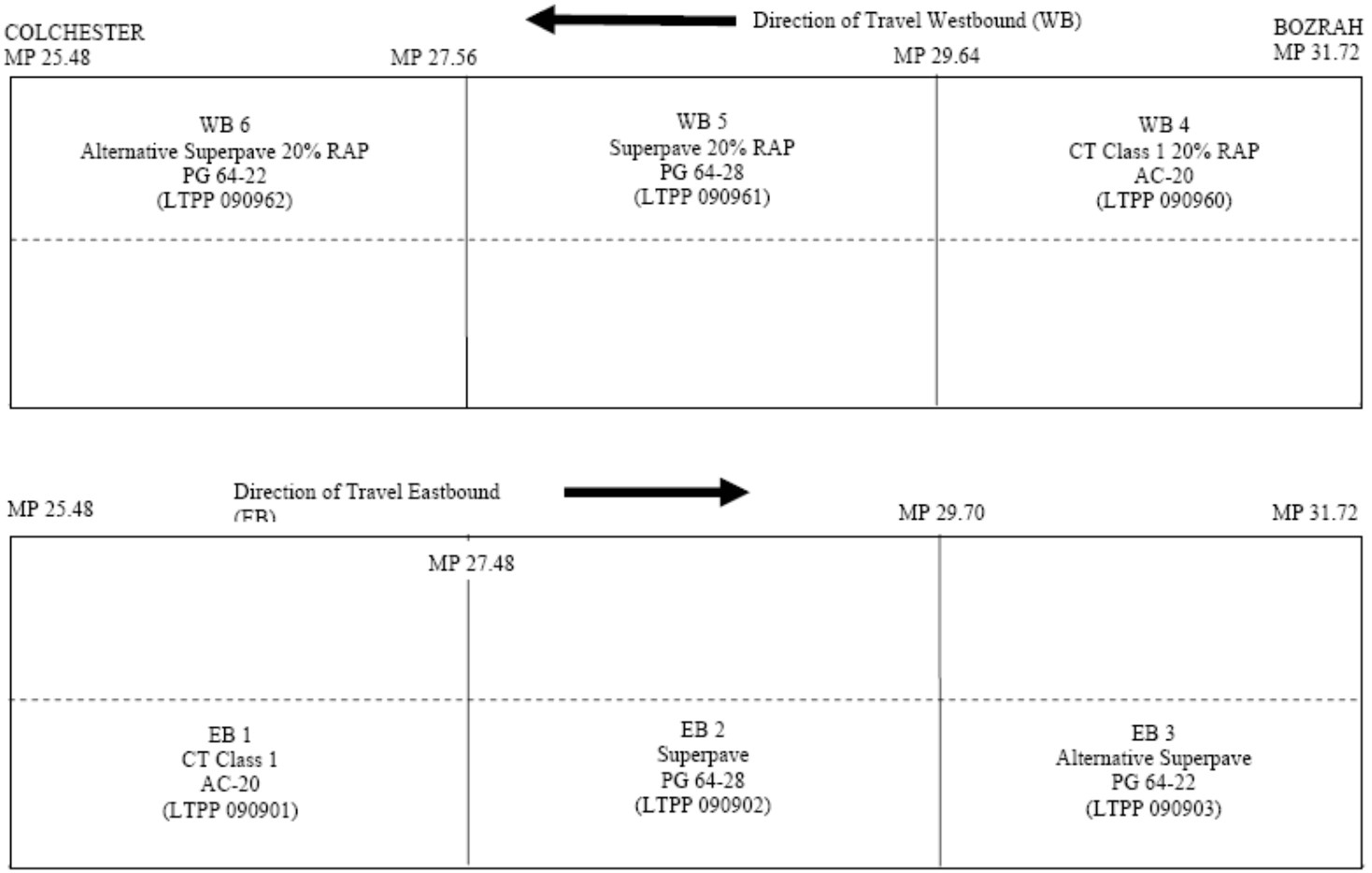
Cold Recycle Summary

- No appreciable change in flushing
- Similar ride quality over time
- More rutting in cold recycle sections
- Similar maintenance costs

Connecticut

- Superpave RAP Study 1997-2003
  - SPS-9A
  - CT – Route 2
- 20% RAP recycled sections
- Three comparative Virgin and RAP mixes
  - CT Class 1 (AC-20)
  - Superpave (PG 64-28)
  - Alternative Superpave (PG64-22), same mix

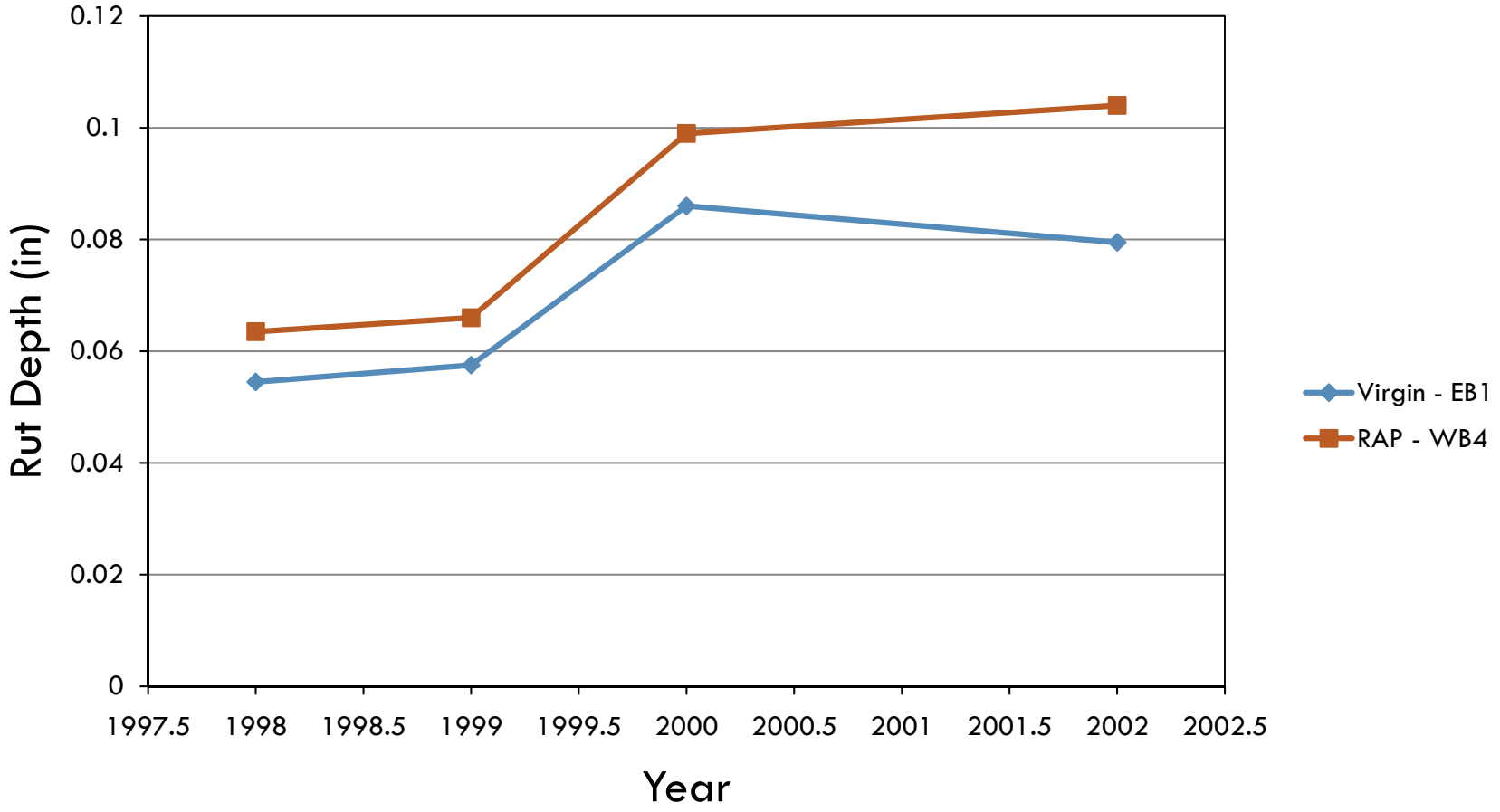
Section Layout



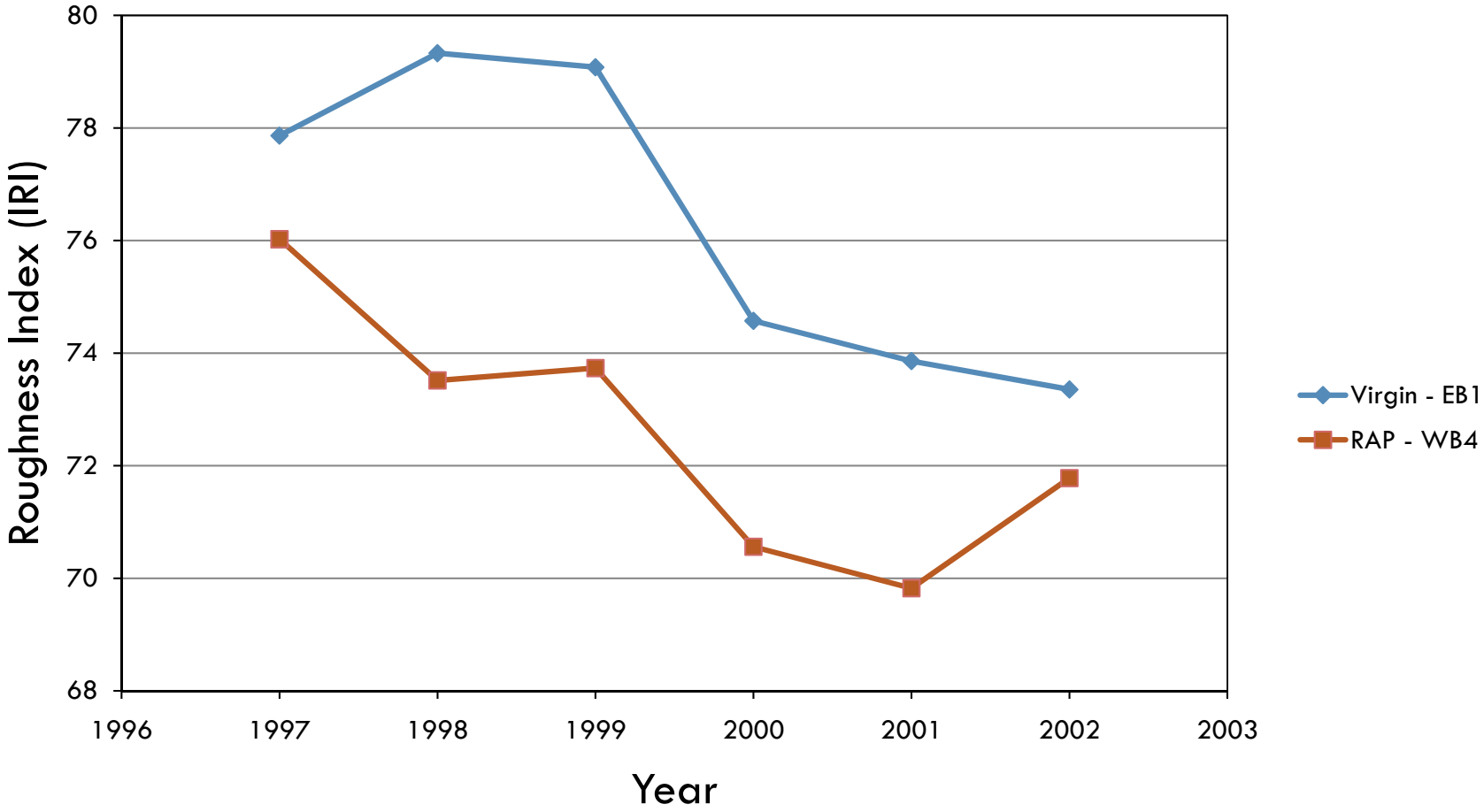
Mix Volumetrics

		% Air	VMA
AC-20	virgin	2.9	13.7
	RAP	3.5	14.8
PG 64-28	virgin	4.9	15.0
	RAP	5.5	16.1
PG 64-22	virgin	4.0	14.4
	RAP	5.1	15.9

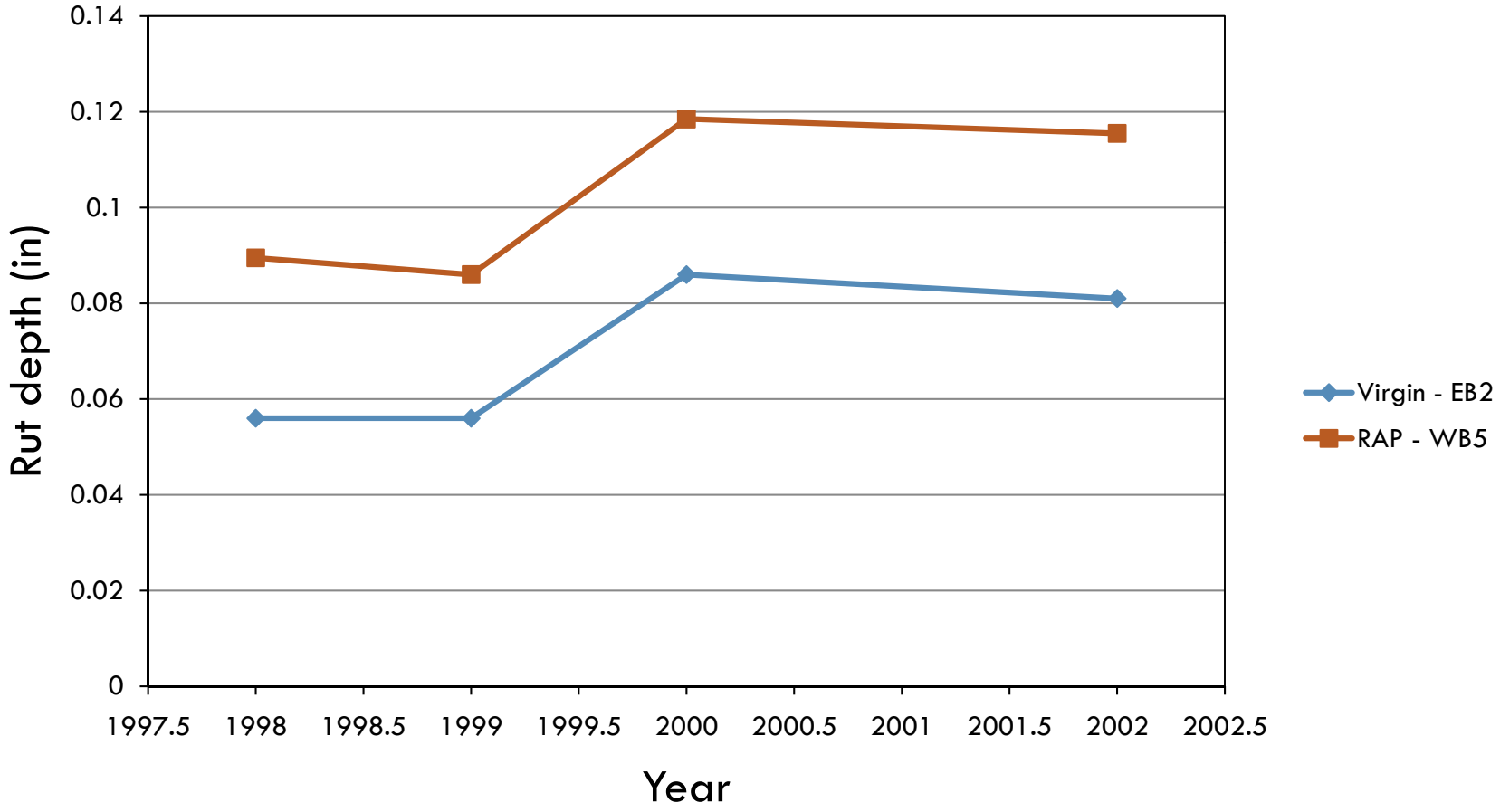
AC-20 Performance



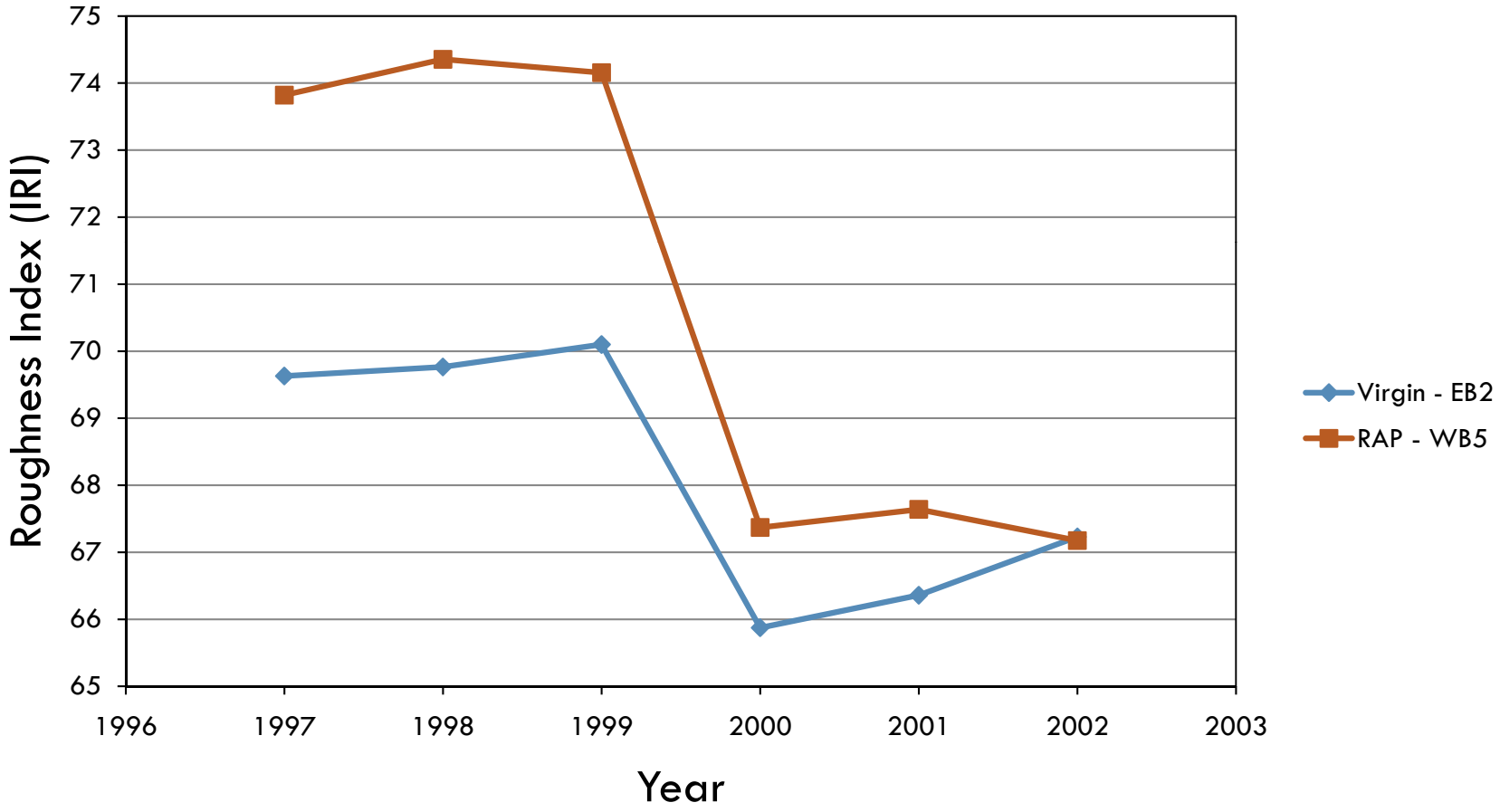
AC-20 Performance



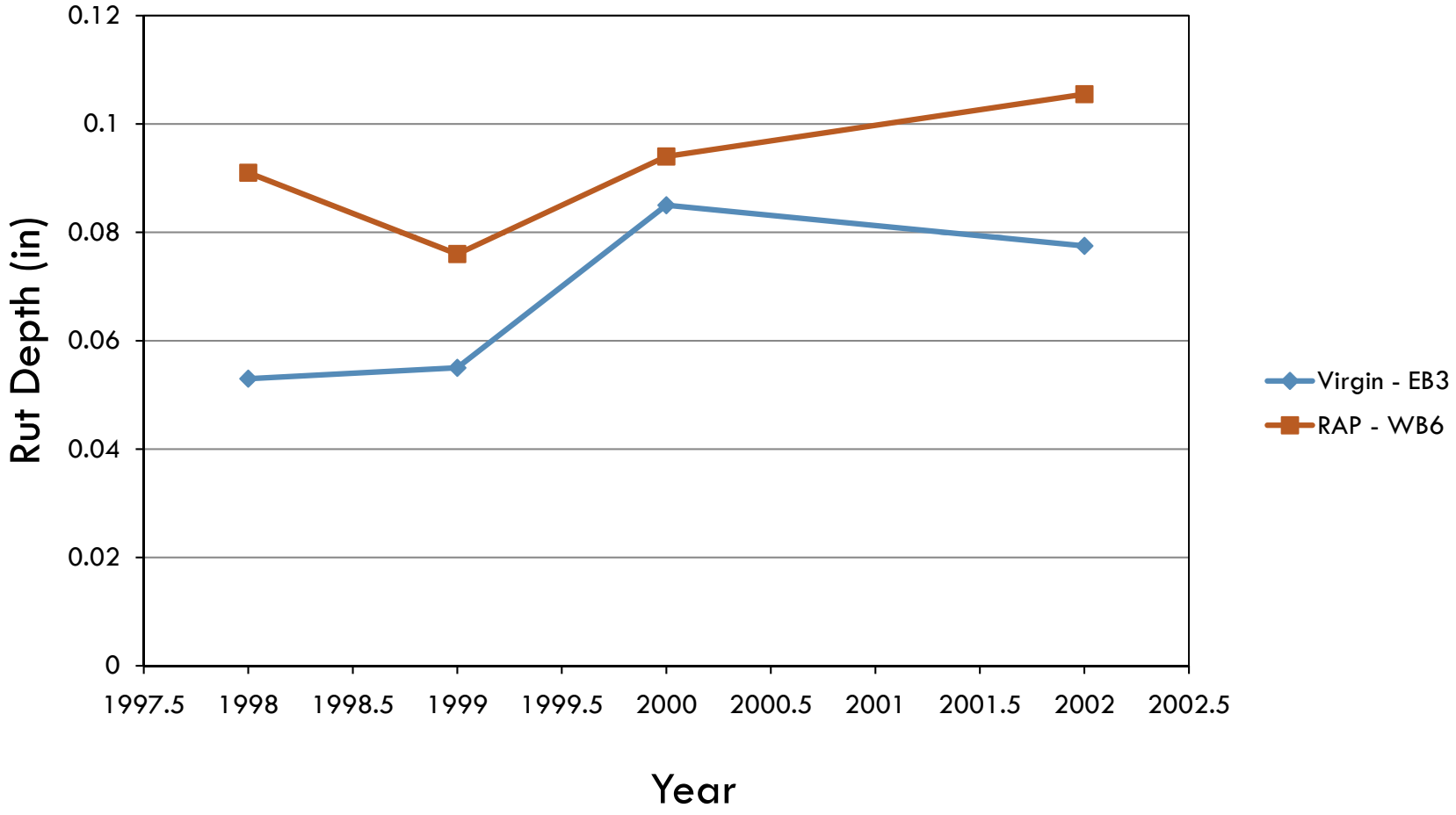
PG 64-28 Performance



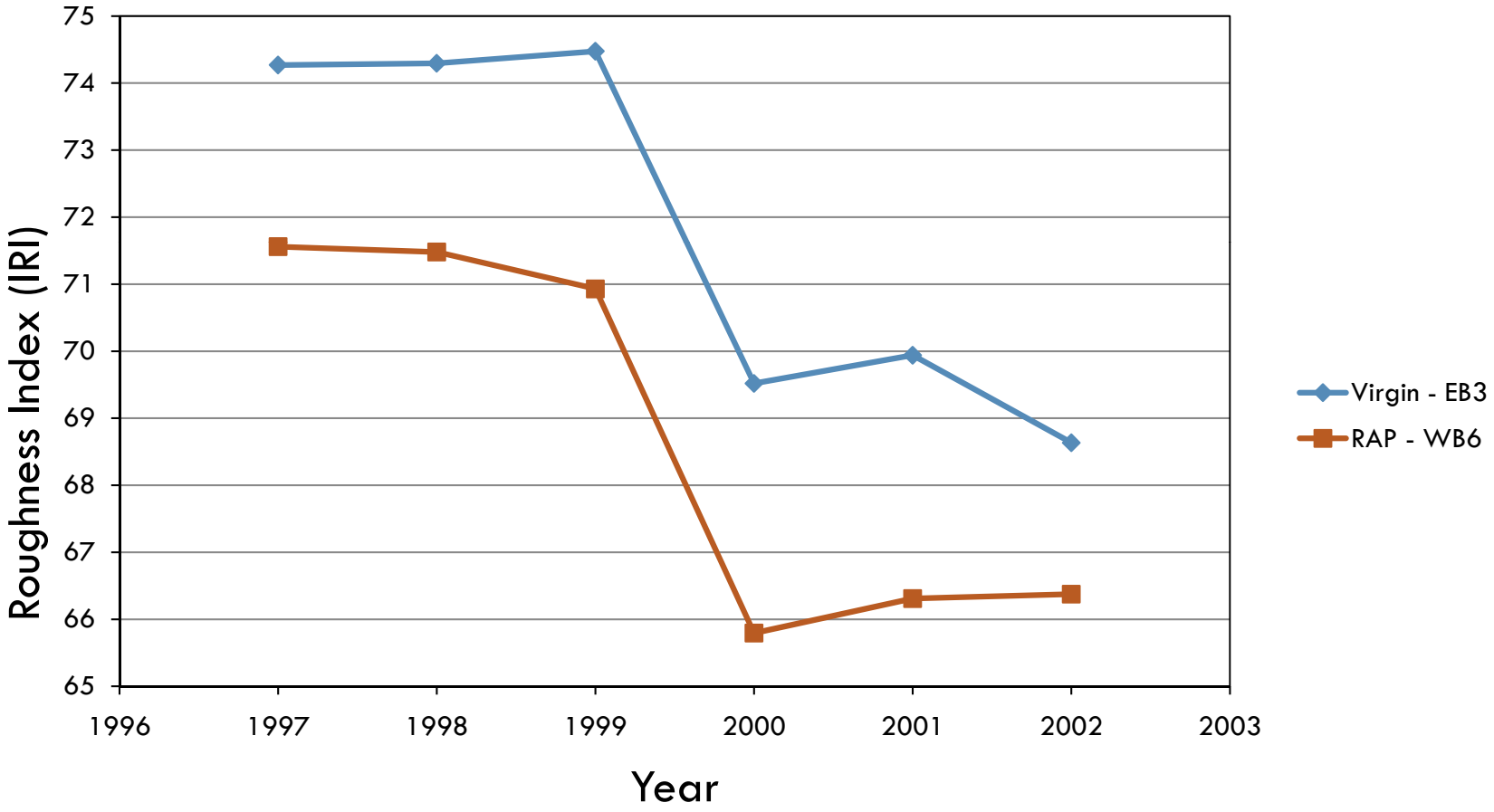
PG 64-28 Performance



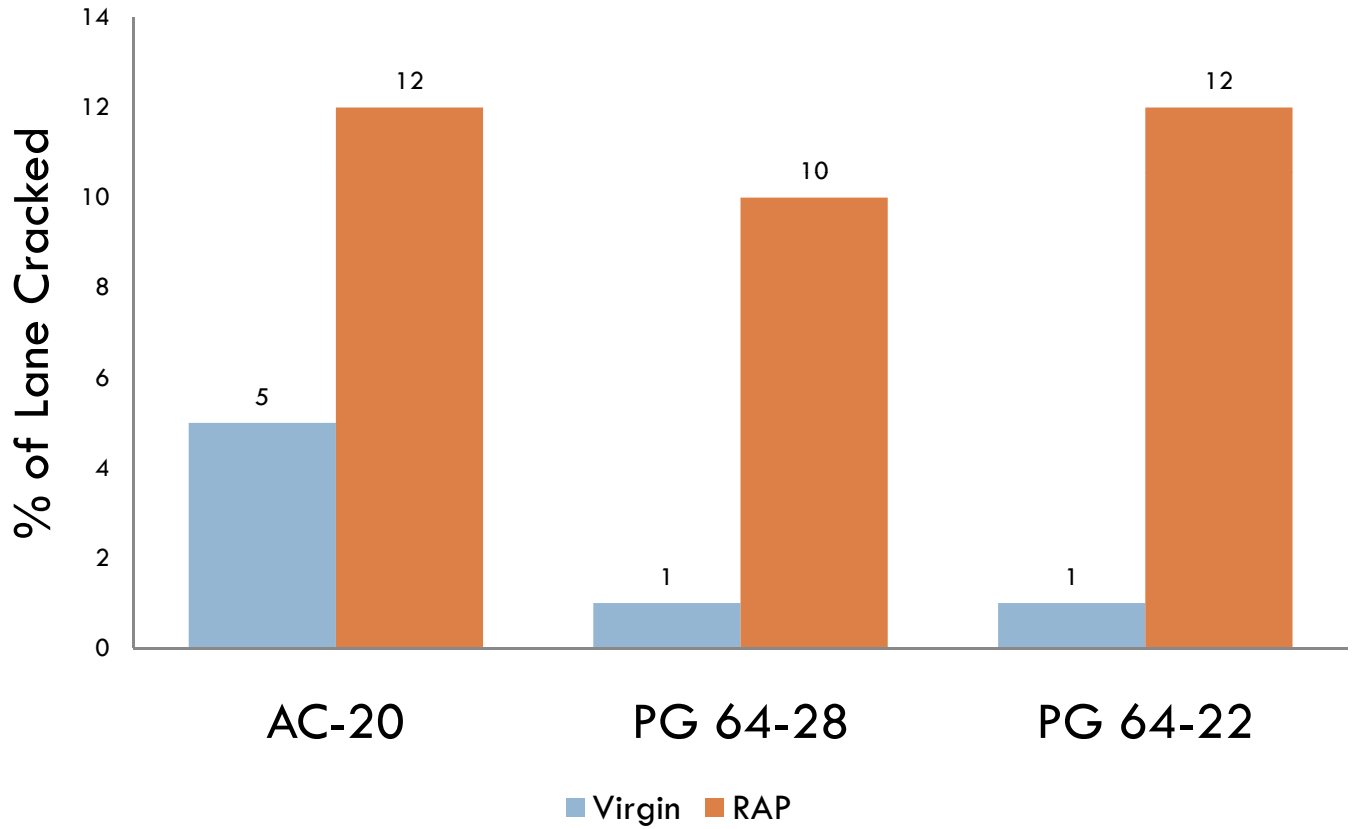
PG 64-22 Performance



PG 64-22 Performance

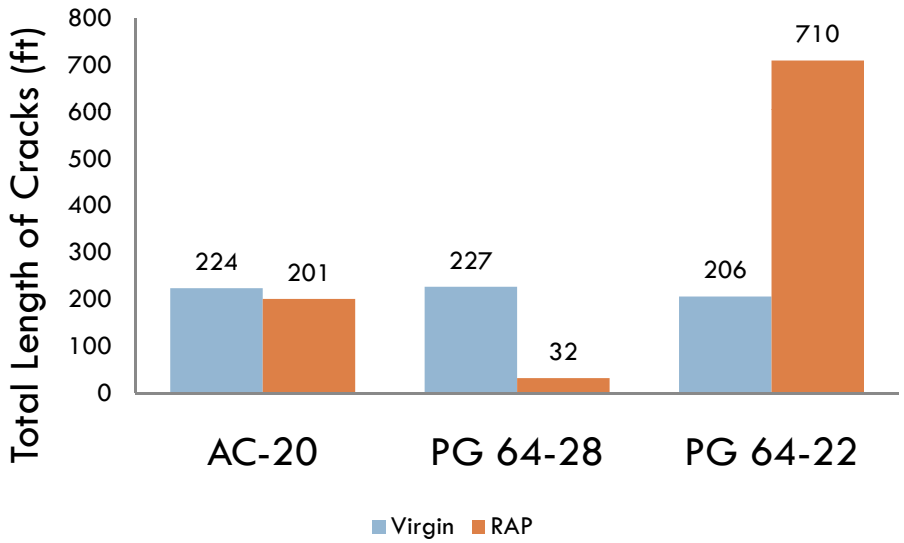


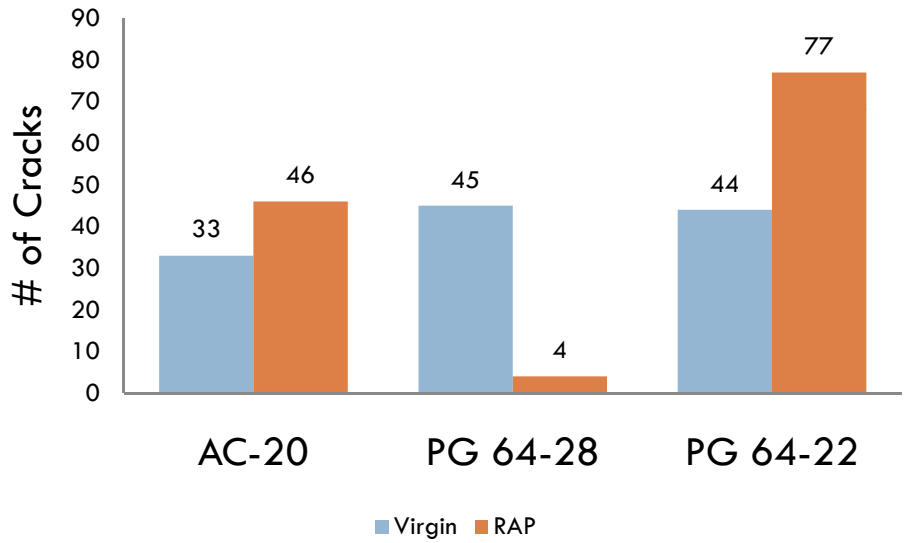
Longitudinal Cracking



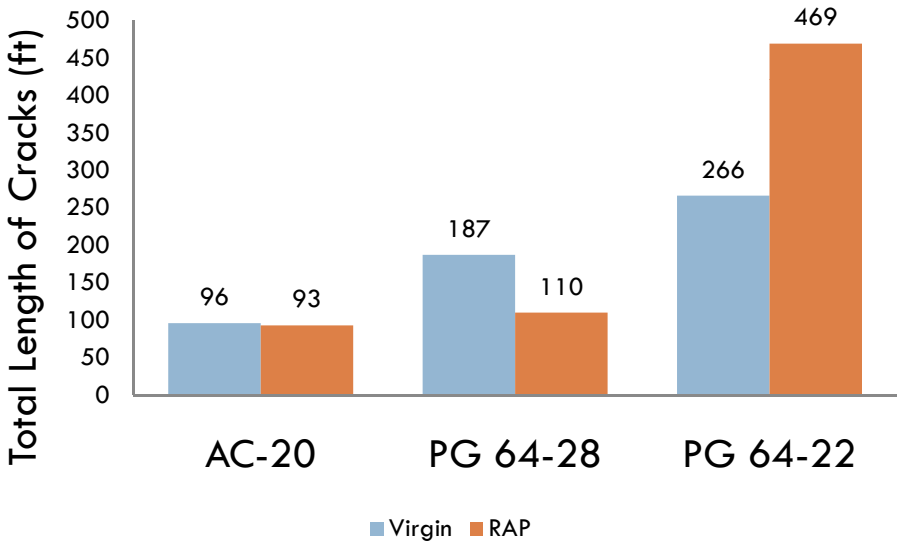
Transverse Cracking – Low Speed Lane

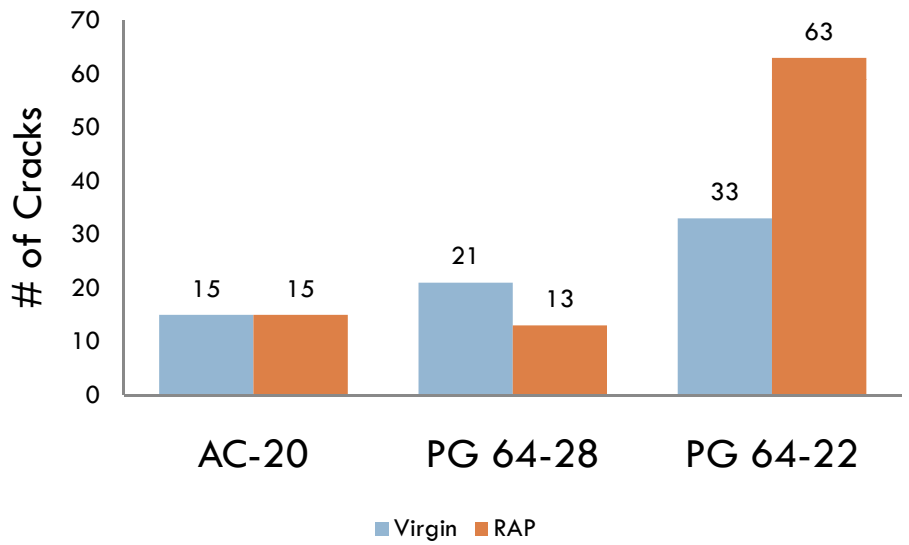
2 Mile test sections





Transverse Cracking – High Speed Lane





CT RAP Study Summary

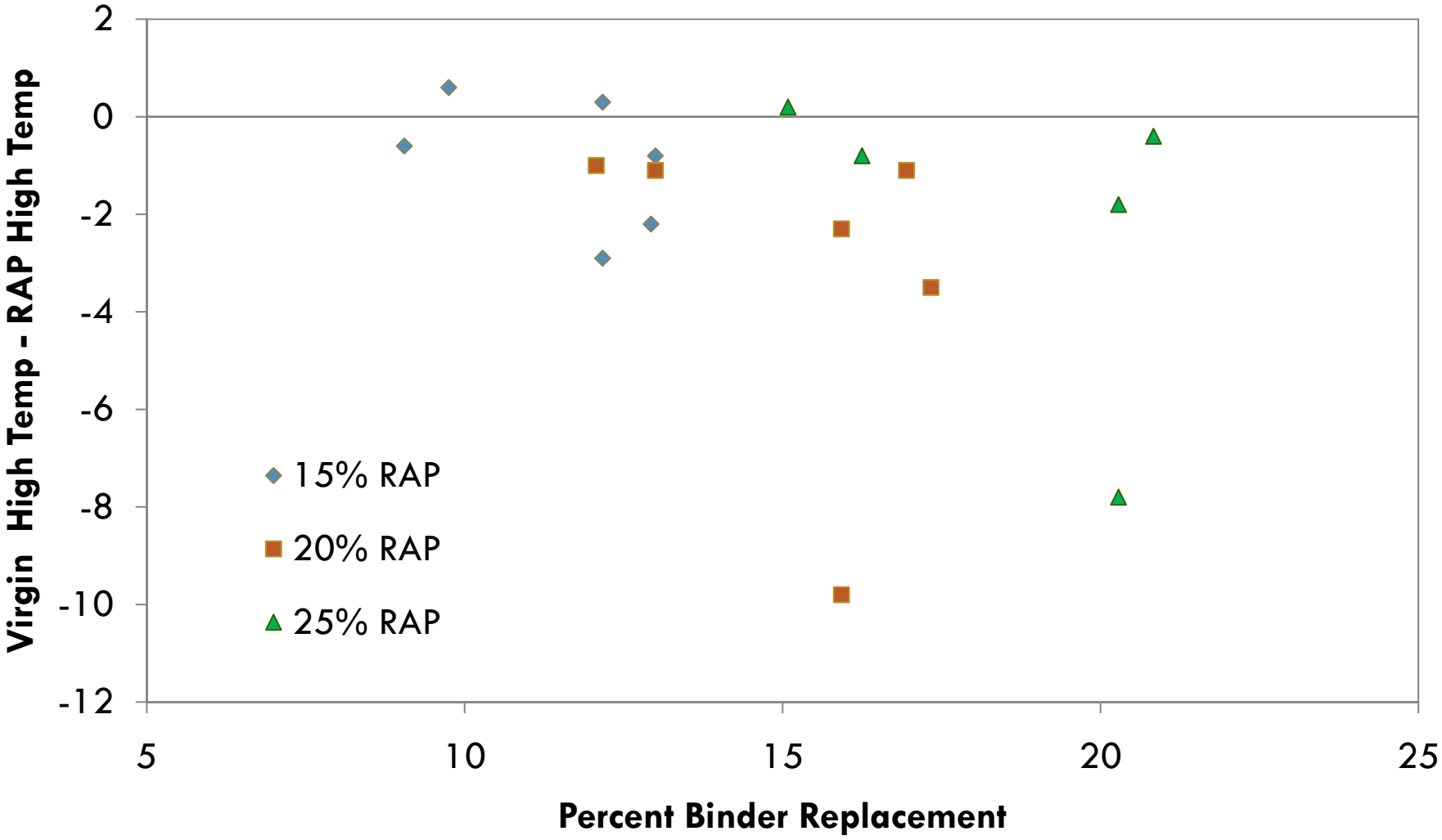
- Higher air voids in RAP sections
- More rutting
- Smoother ride with RAP in AC-20 and PG 64-22
- More Longitudinal cracking
- Thermal Cracking
  - AC-20 about the same
  - PG 64-28 RAP section better
  - PG 64-22 RAP section worse

PLANT MIX BINDER STUDY

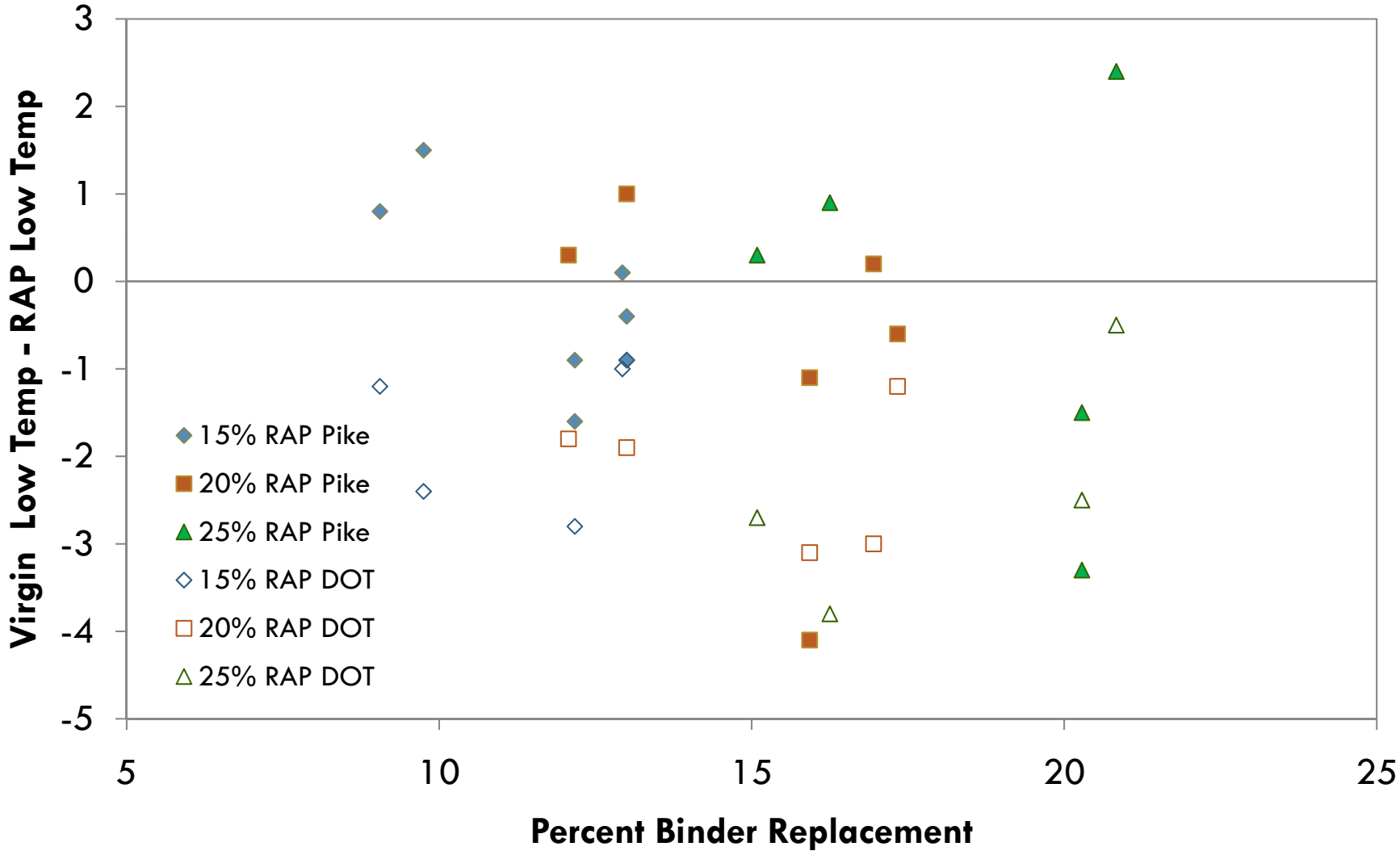
Mixtures Tested

Producer	Plant	Virgin ac grade	% ac in mix	RAP percentages	RAP ac grade	% ac in RAP
Brox	Rochester, NH	PG 64-28	5.8	0, 15, 20, 25	PG 94-10	3.5
	Hooksett, NH	PG 70-22	6.0	0, 15, 20, 25	PG 88-10	3.9
CPI	Londonderry, NH	PG 64-28	6.0	0, 15, 20	PG 82-10	5.2
	Litchfield, NH	PG 64-28	6.1	15, 20	PG 88-10	4.6
Pike	Hooksett, NH	PG 64-28	5.1, 5.3, 5.4, 5.3	0, 15, 20, 25	PG 88-10	4.3
	Poland, ME*	PG 64-28	6.3, 5.8, 5.9, 6.0	0, 15, 20, 25	PG 76-22	5.0
	Hooksett, NH Mix 2	PG 58-28	5.1, 5.3, 5.4, 5.3	0, 15, 20, 25	PG 82-16	4.3
	Waterford, VT	PG 58-34	4.8, 5.2, 5.8	0, 15, 25	unknown	unknown

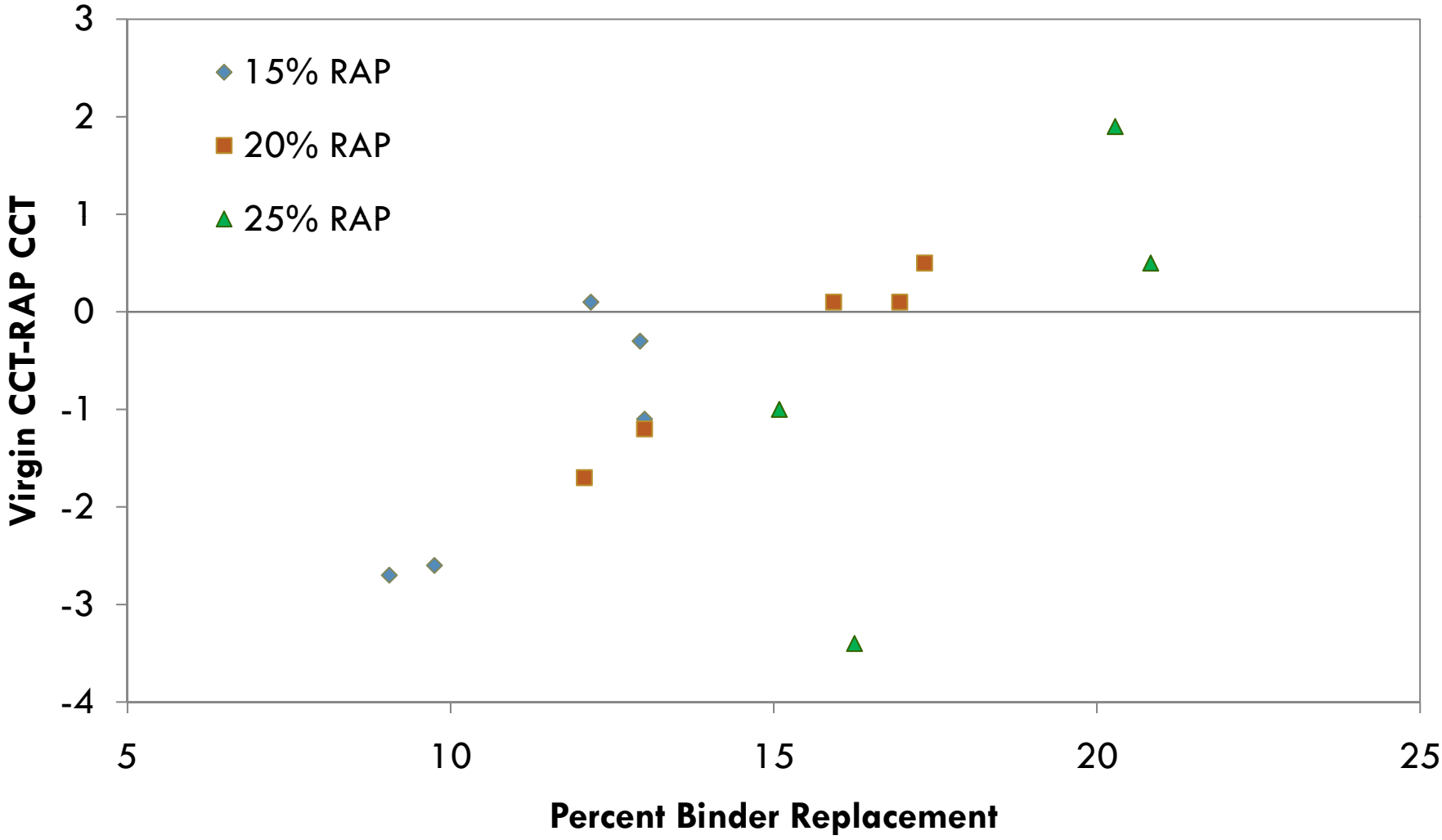
Change in High PG Grade



Change in Low PG Grade



Change in T_{cr}



Conclusions

- The high PG grade up to one grade increase
- The low PG grade stays same or only one grade increase
- Failure temps/T_{cr} only change a few degrees
- Change in high/low failure temp has decreasing trend with % binder replacement
- This data shows increasing trend of T_{cr} with % binder replacement

RAS STUDY

Grad Student: Jennifer Pollock

Funding: New Hampshire Industrial Research Council

Project Completion: January 2010

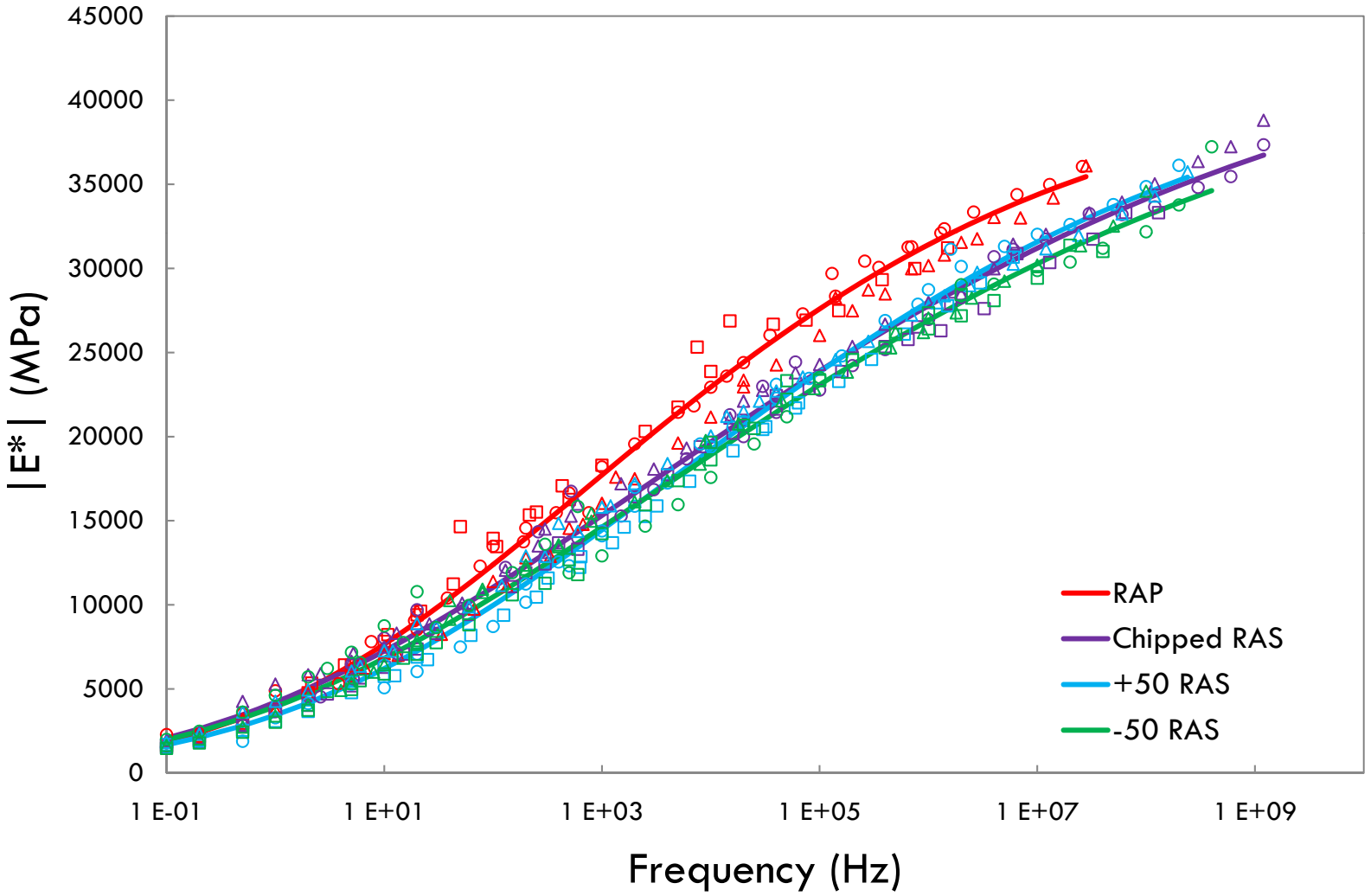
Experimental Plan

- 4 mixtures – same recycled binder contribution per current NHDOT specs
  - RAP only (0.8 RAP)
  - RAP + RAS (0.2 RAP + 0.6 RAS)
    - +50 mesh (manufacturer waste)
    - -50 mesh (manufacturer waste)
    - chipped blend (post consumer)
- Dynamic Modulus
- Binder extractions and partial master curves
- TSRST

Mix Design Info

Mixture	% ac
RAP	5.7 (0.8+4.9)
RAP and +50 RAS	6.0 (0.2+0.6+5.2)
RAP and -50 RAS	6.1 (0.2+0.6+5.3)
RAP and chipped RAS	6.5 (0.2+0.6+5.7)

Dynamic Modulus



Extracted Binder Info

Mixture	S (-18C)	m (-18C)	PG
RAP	259	0.290	71.0-26.5
RAP and +50 RAS	246	0.284	77.1-25.4
RAP and -50 RAS	248	0.284	76.3-25.7
RAP and chipped RAS	244	0.281	75.3-25.7

Questions?