

*Automated Pavement Thickness
Evaluation for FWD
Backcalculation using GPR*

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FWD Users Group Meeting

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Applications of GPR to Pavement Evaluation

- Network-level pavement management
- Rehabilitation Design
 - Use with FWD data
 - Use for Full Depth Reclamation Design
- Quality assurance of new pavement construction
- Pavement Diagnostics

Implementation of GPR with FWD

- Option 1
 - GPR/FWD data collected independently
 - Locations coordinated by station (for project level) or by GPS coordinates (network-level)
- Option 2
 - GPR/FWD data collected simultaneously

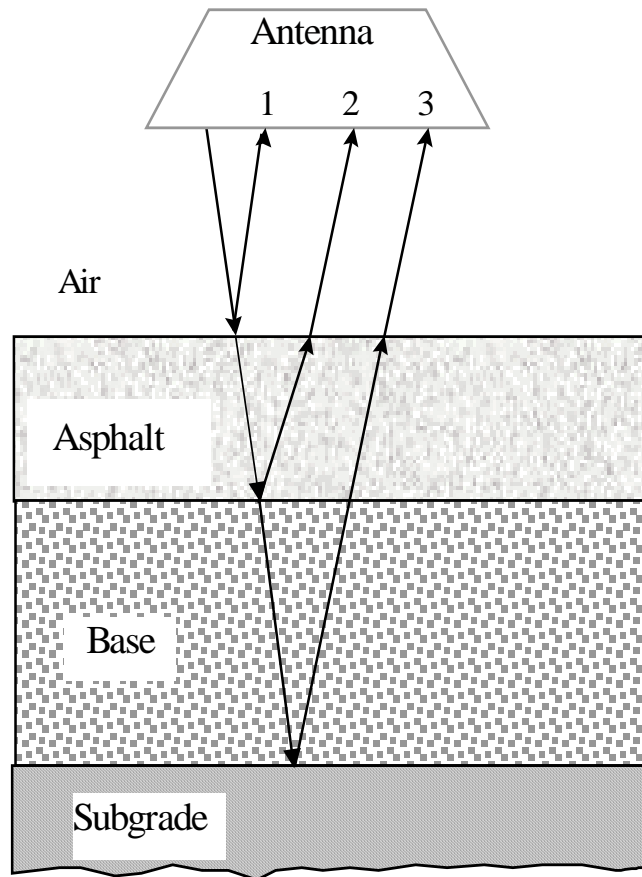
Highway GPR Equipment



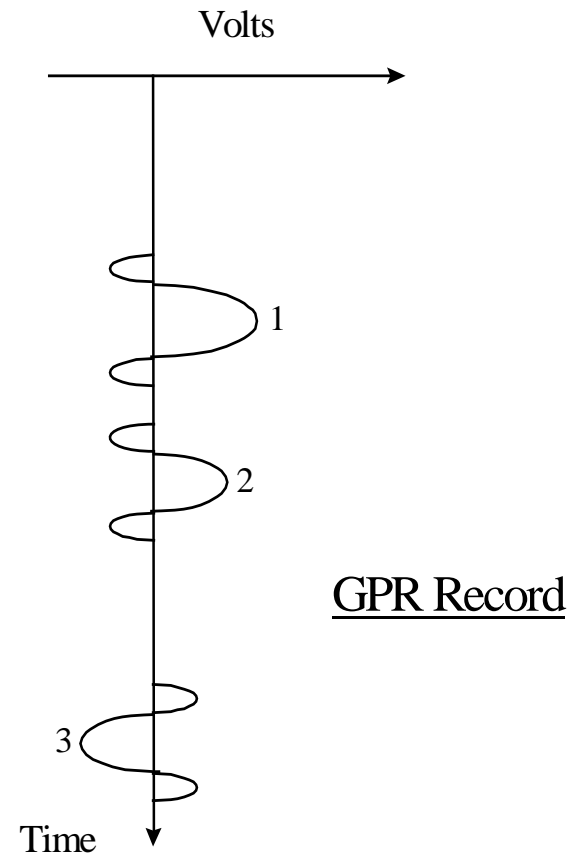
Combined GPR/FWD Equipment



GPR Application Principle

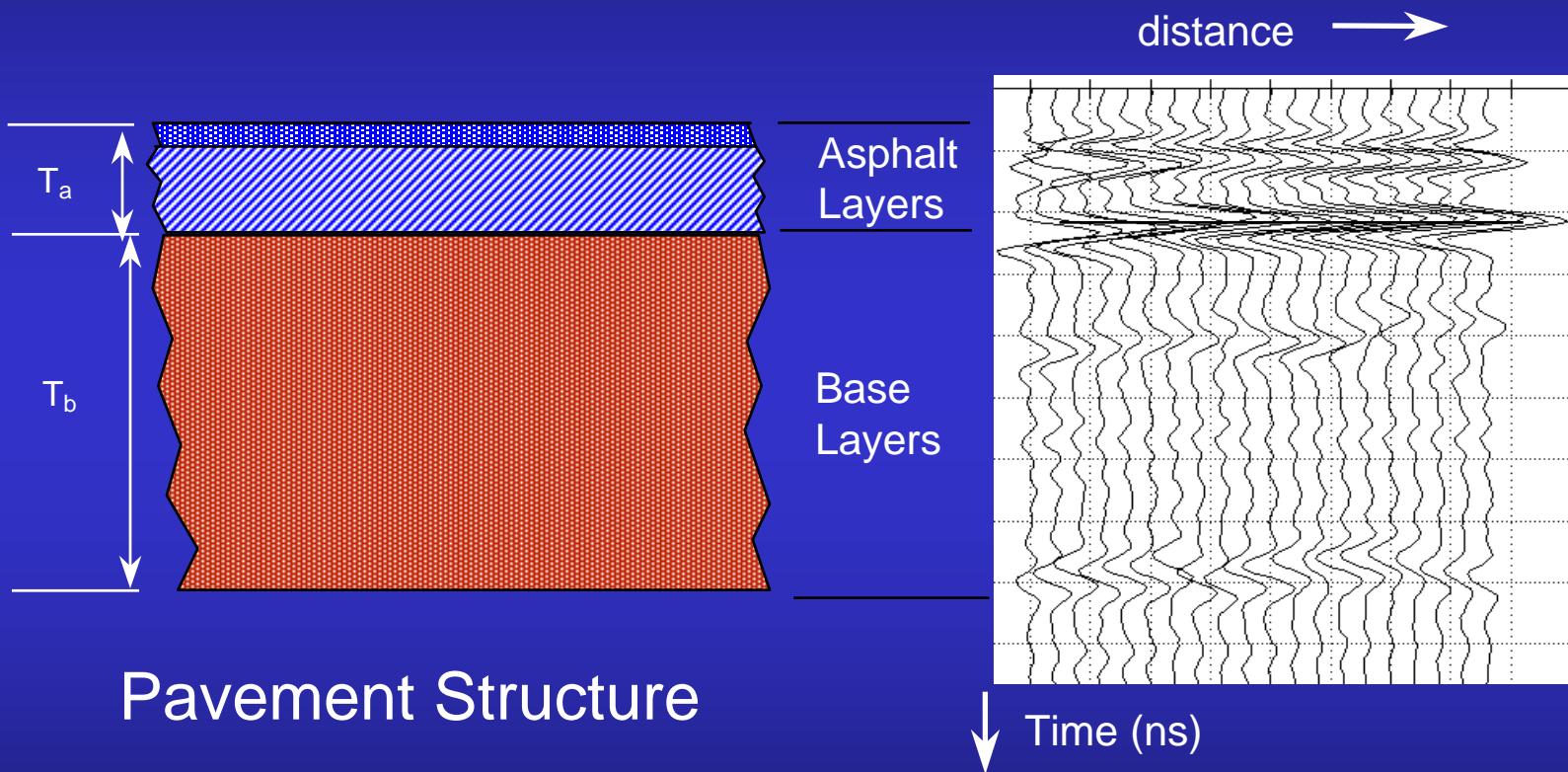


Measurement Setup



GPR Record

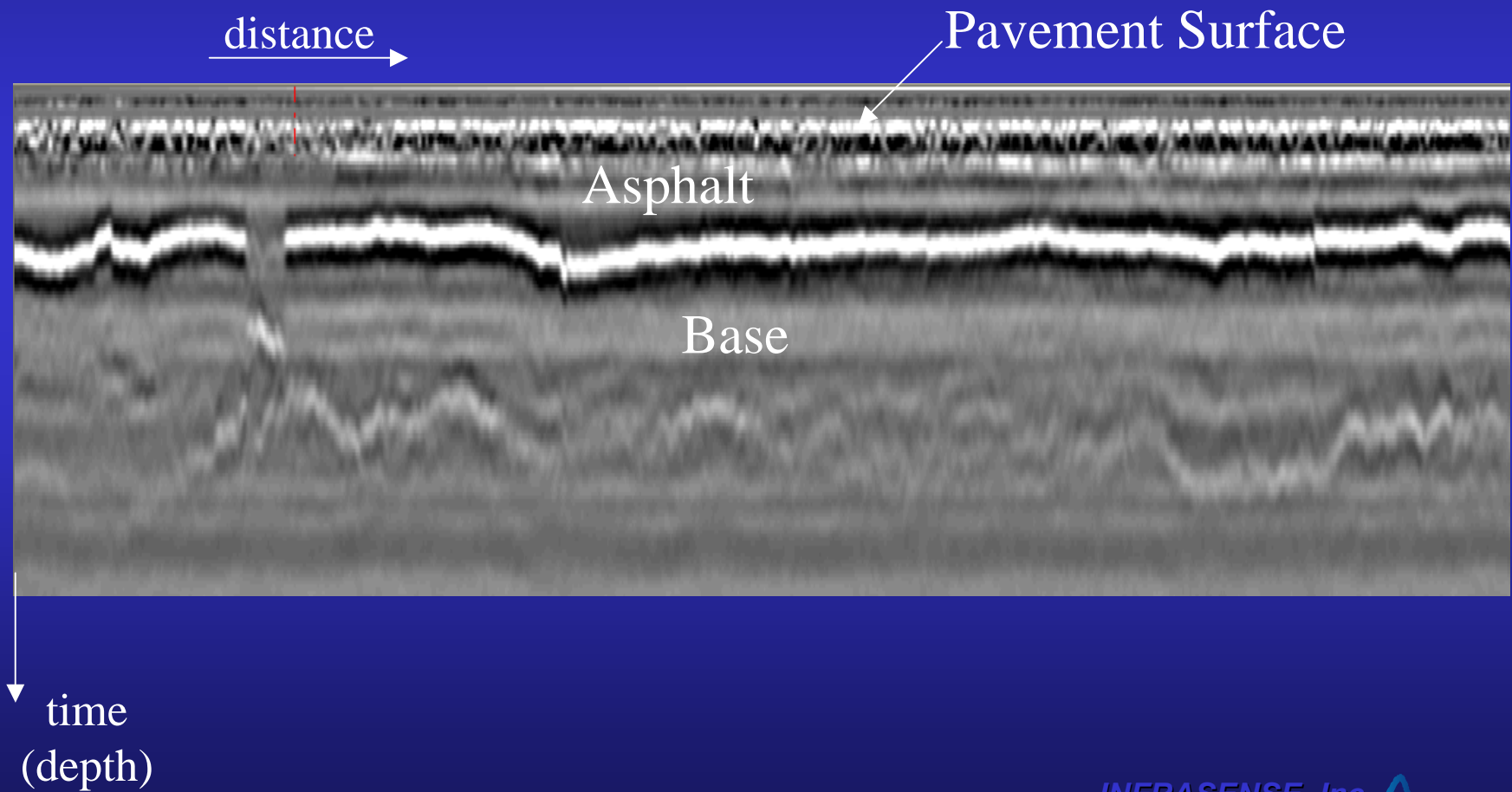
Sample of Data



Pavement Structure

GPR Record

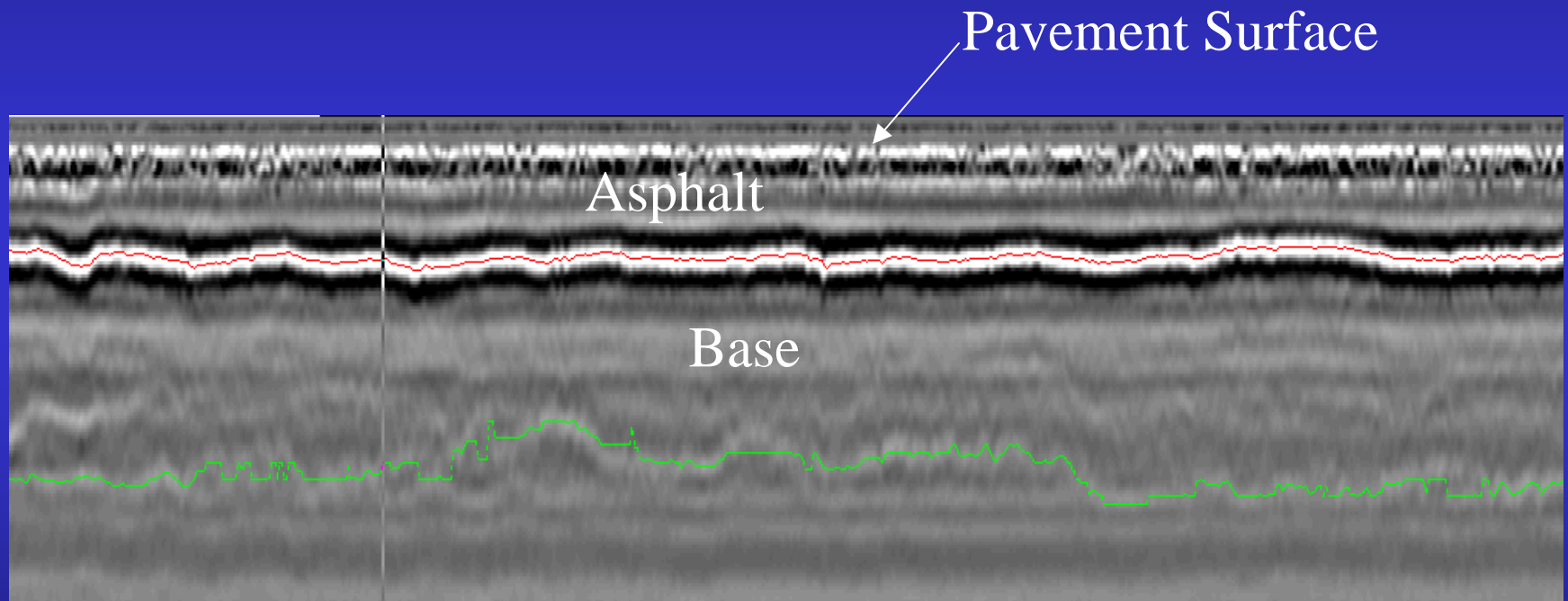
Sample Graphic GPR Data



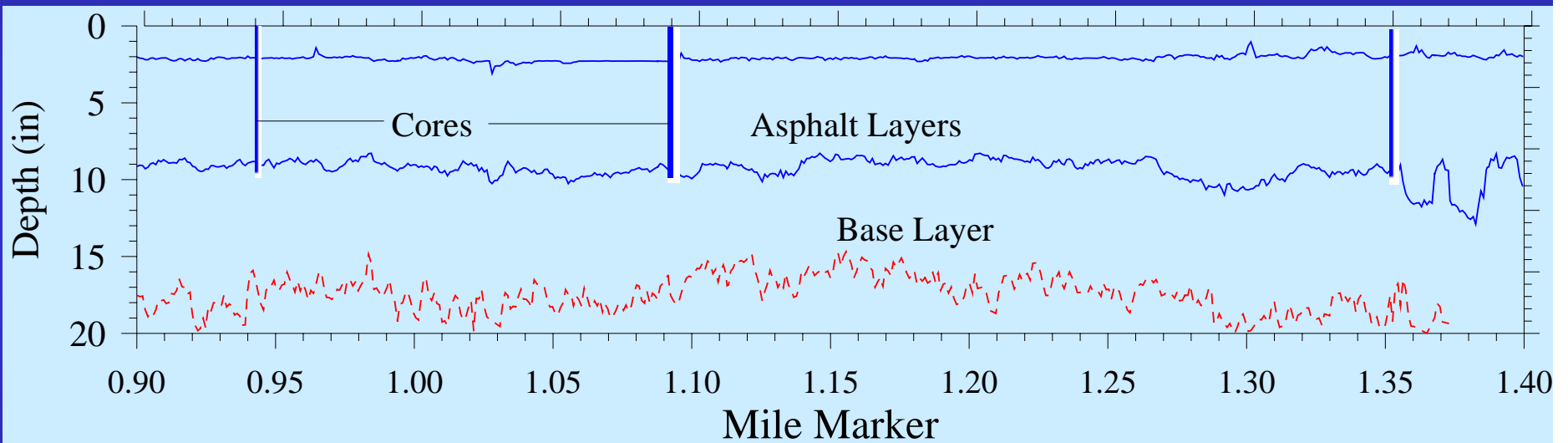
GPR Thickness Analysis

- Analyst "picks" layers and interprets material types
- Program tracks layer interfaces and outputs layer thicknesses and types
- Analysis can be continuous, at intervals (eg., 0.1, 1.0 mile), or at specified locations (e.g., GPS coordinates)

Sample Processed Graphic Data on Asphalt Pavement



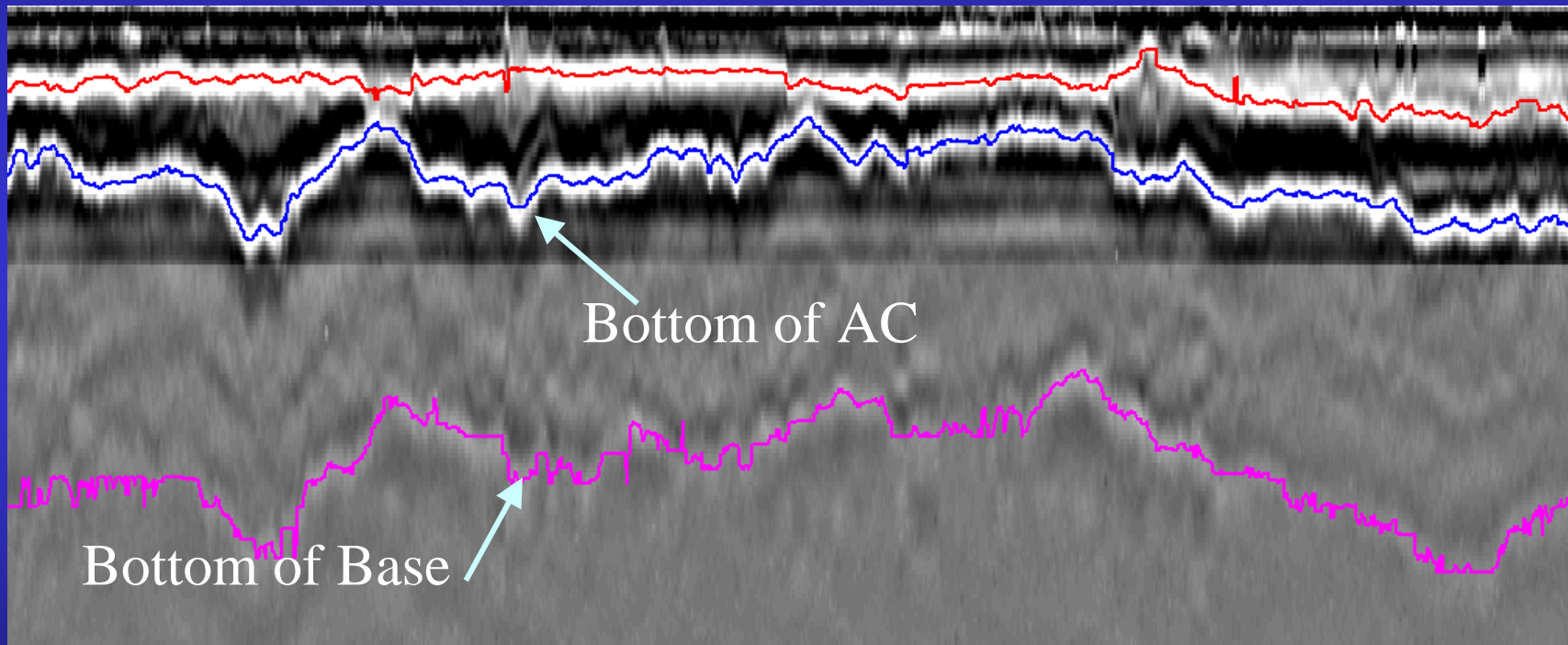
Linear Plot of Pavement Layer Thickness



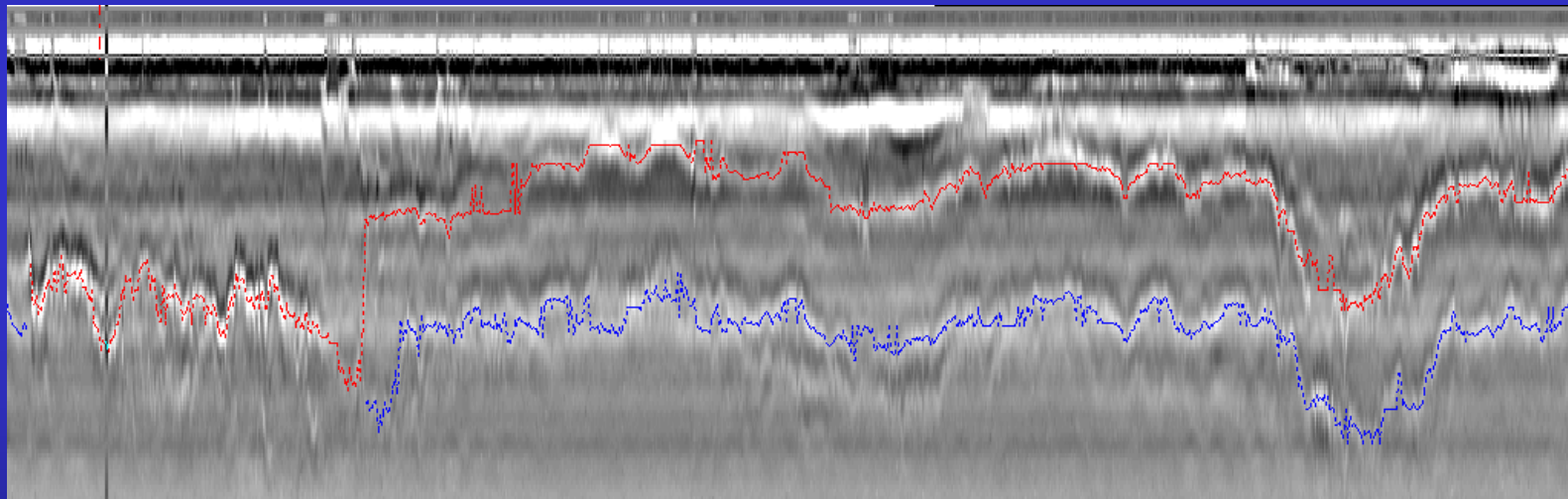
Tabular Thickness Output

SectionID	MP	L1Type	L1Thick	L1Diel	L1Conl	L2Type	L2Thick	L2Diel	L2Cont	L3Type	L3Thick	L3Diel	L3Conl	LATITUDE	LONGITUD
6822000	0.047	ac	3.15	5.85	1	ac	4.80	6.28	1	bb	11.41	5.82	1	3529.305	-9505.56
6822000	0.1	ac	3.06	5.38	1	ac	4.36	5.55	1	bb	11.21	5.20	1	3529.315	-9505.53
6822000	0.2	ac	3.67	5.03	1	ac	4.23	5.79	1	bb	13.00	4.79	1	3529.344	-9505.42
6822000	0.3	ac	3.84	5.00	1	ac	3.21	5.85	1	bb	10.89	5.42	1	3529.367	-9505.3
6822000	0.4	ac	3.55	5.61	1	ac	3.39	6.52	1	bb	9.98	6.10	1	3529.375	-9505.22
6822000	0.5	ac	3.10	6.07	1	ac	4.83	6.46	1	bb	9.38	6.14	1	3529.38	-9505.09
6822000	0.601	ac	5.44	5.30	1	ac	3.81	5.29	1	bb	11.30	4.77	1	3529.374	-9504.98
6822000	0.7	ac	4.90	6.06	1	ac	0.00	0.00	2	bb	15.28	6.57	1	3529.365	-9504.9
6822000	0.8	ac	3.46	4.99	1	ac	0.00	0.00	2	bb	14.98	5.20	1	3529.347	-9504.77
6822000	0.9	ac	2.85	6.41	1	ac	3.80	7.10	1	bb	10.87	6.47	1	3529.335	-9504.66
6822000	1	ac	3.00	5.27	1	ac	4.07	5.73	1	bb	11.34	5.07	1	3529.329	-9504.58
6822000	1.1	ac	2.93	5.09	1	ac	3.75	5.74	1	bb	11.34	5.38	1	3529.325	-9504.45
6822000	1.221	ac	3.01	4.96	1	ac	4.31	6.87	1	bb	9.77	6.52	1	3529.327	-9504.32
6822000	1.3	ac	3.15	5.89	1	ac	4.54	6.61	2	bb	8.40	6.82	1	3529.33	-9504.26
6822000	1.4	ac	3.15	4.87	1	ac	4.86	5.16	1	bb	9.58	5.37	1	3529.34	-9504.13
6822000	1.5	ac	3.65	5.20	1	ac	4.49	5.40	1	bb	9.32	5.56	1	3529.349	-9504.05
6822000	1.6	ac	3.08	4.93	1	ac	5.33	5.26	2	bb	9.36	5.54	1	3529.369	-9503.93
6822000	1.7	ac	3.05	5.18	1	ac	4.07	5.60	1	bb	10.62	5.17	1	3529.387	-9503.82
6822000	1.8	ac	2.86	6.50	1	ac	2.97	7.84	1	bb	9.20	6.87	1	3529.401	-9503.74
6822000	1.9	ac	3.83	5.80	1	pcc	9.57	8.64	1	bb	4.06	8.75	1	3529.422	-9503.61
6822000	2	ac	3.68	5.96	1	pcc	10.27	8.78	1	bb	3.78	8.54	1	3529.436	-9503.53
6822000	2.1	ac	3.68	5.67	1	pcc	10.05	8.75	2	bb	3.45	8.36	1	3529.454	-9503.42
6822000	2.174	ac	3.96	6.12	1	pcc	10.19	8.16	2	bb	3.22	7.89	1	3529.464	-9503.33

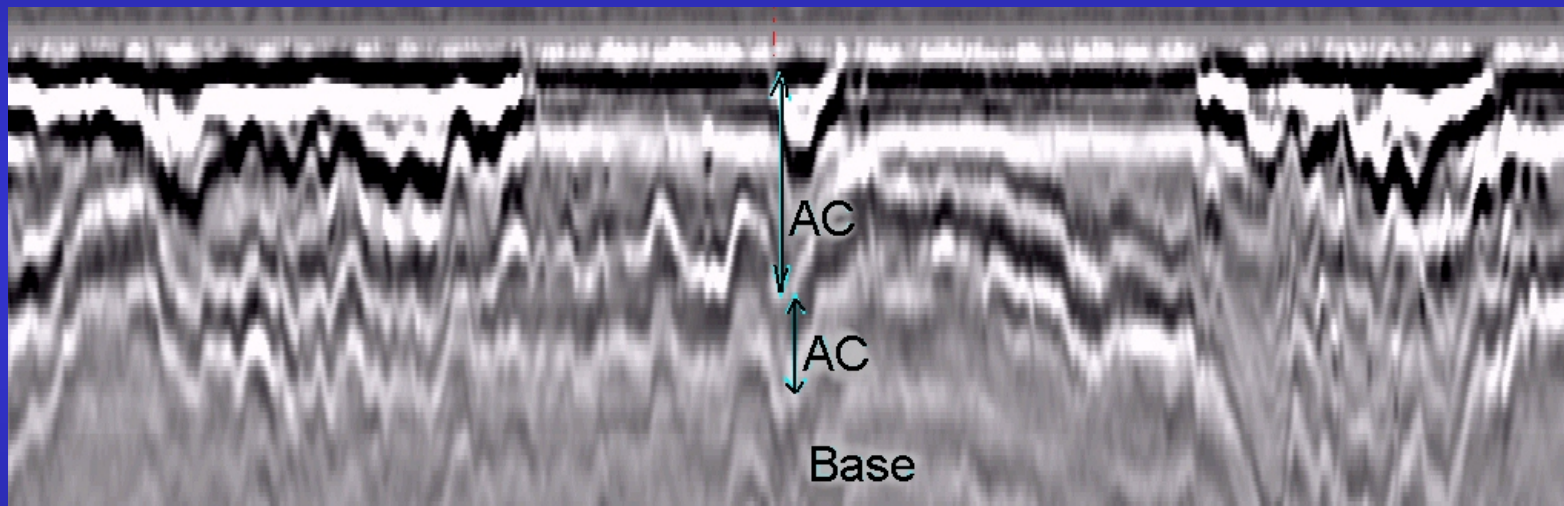
Multiple AC Layers



GPR Data with Unclear Interpretation



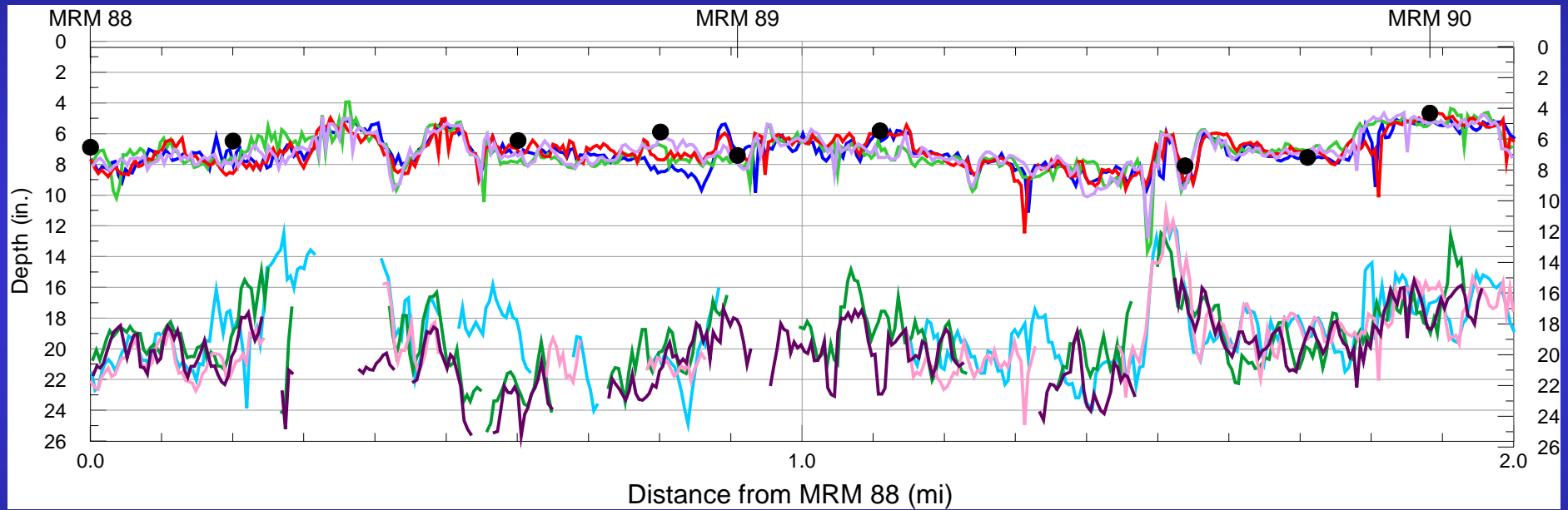
GPR Data with Unclear Interpretation



Accuracy of GPR AC Thickness

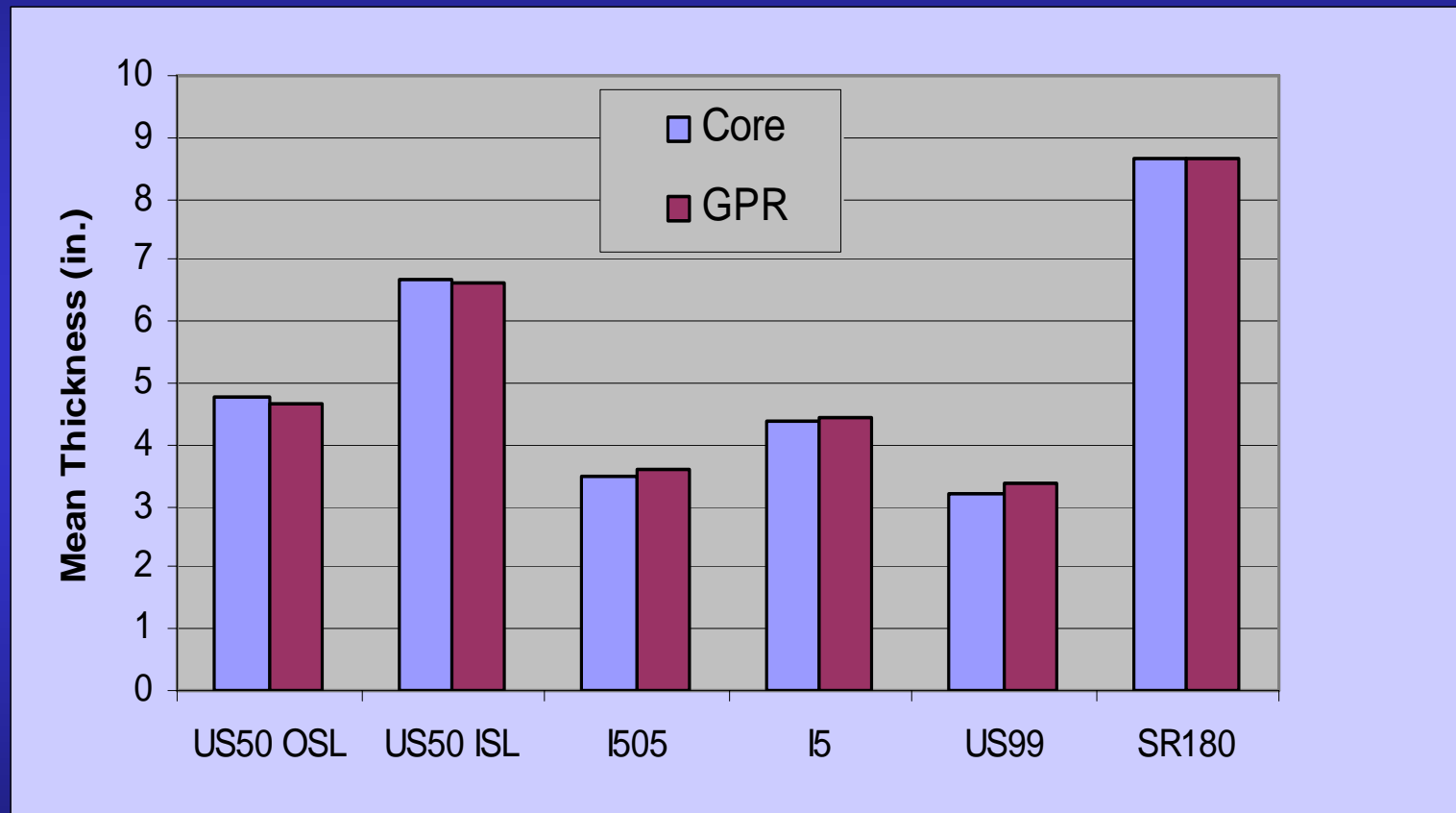
- Typically within 5-10% of core values
- More accurate on newer pavement
- Layer type interpretation on multi-layer pavements is biggest source of error

Linear Plot of Pavement Layer Thickness



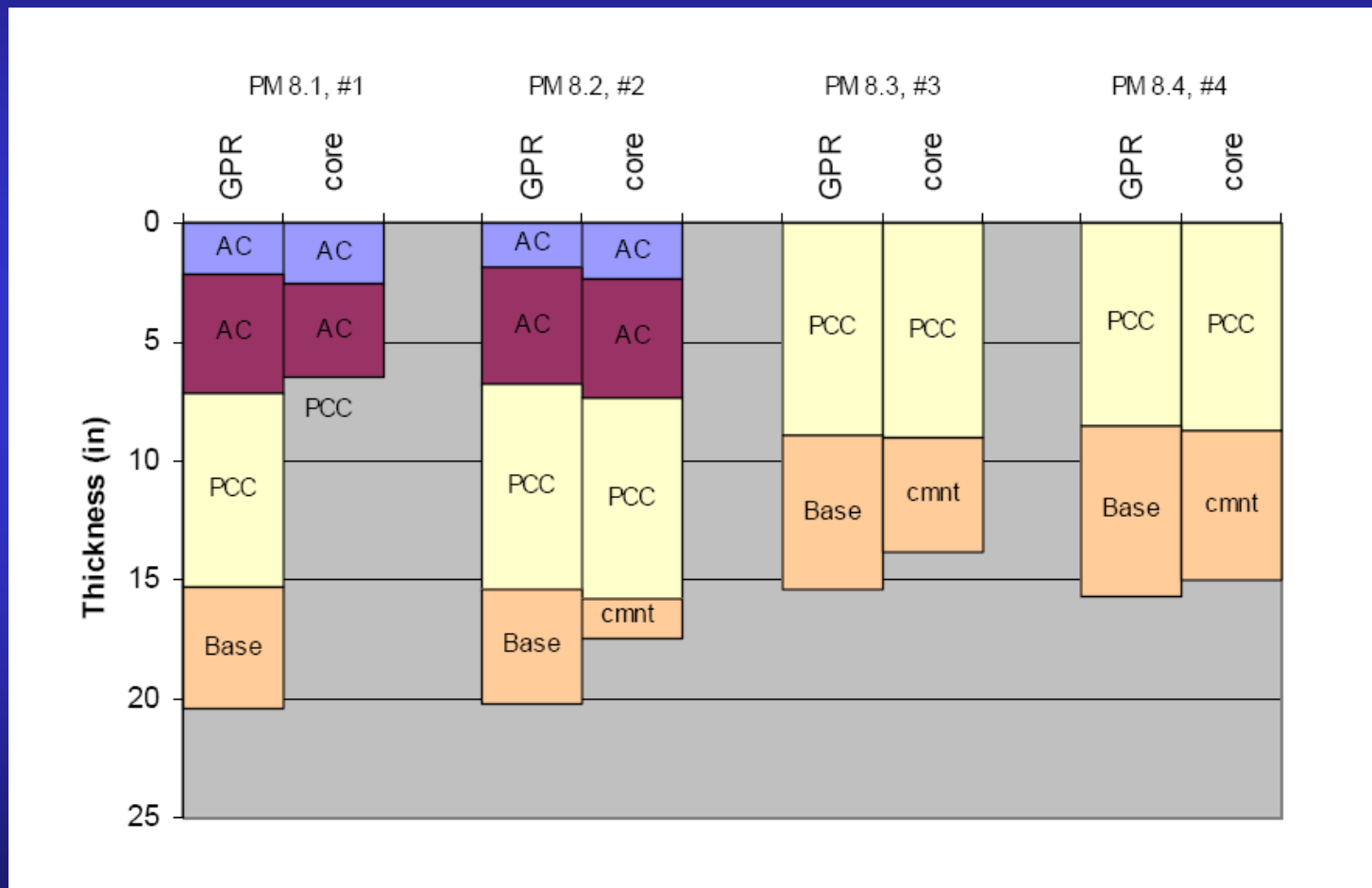
Caltrans Thickness QA Study

GPR vs. Cores



Difference < 0.1 inch

Sample Result of PPRC Study (I-505)

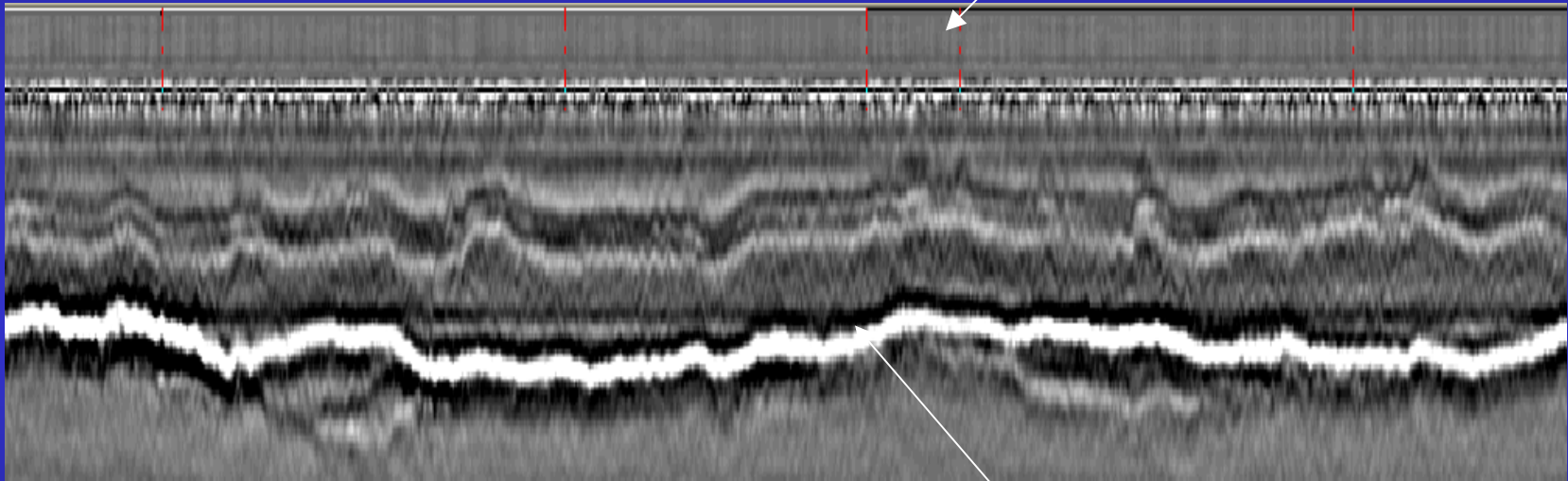


GPR Automated Processing (GPRAP)

- Focus on FWD test locations
- Identify key reflectors in GPR data
- Apply algorithm to pick AC bottom

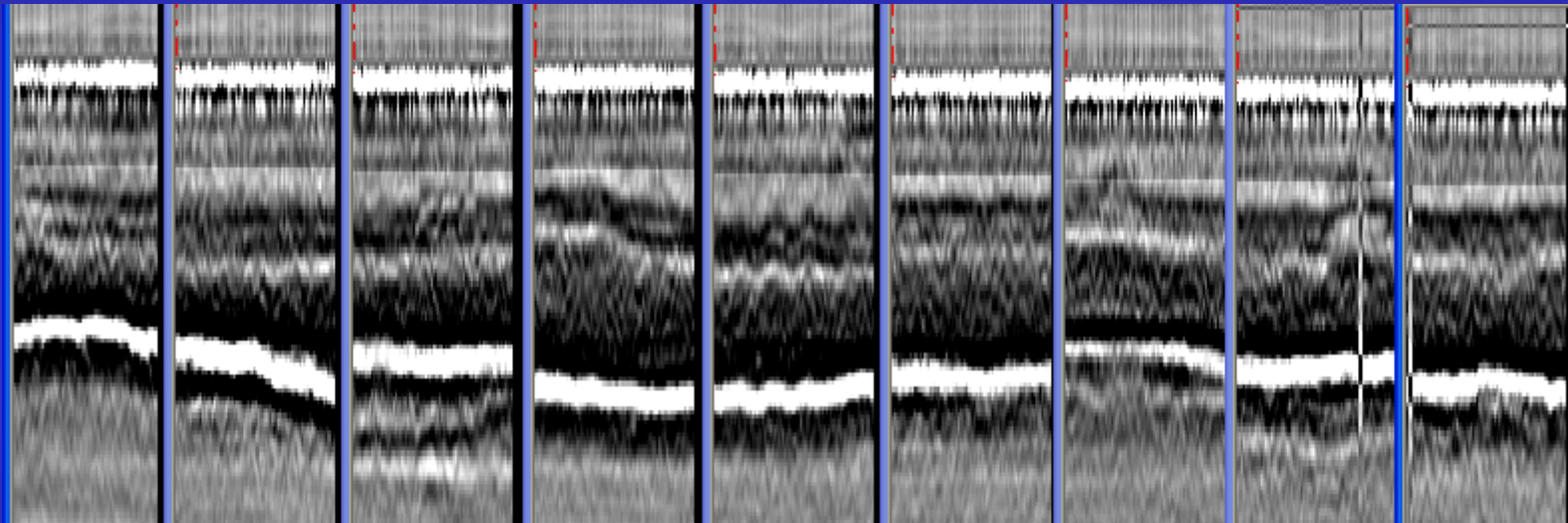
Sample Data

Pavement Surface



Bottom of AC

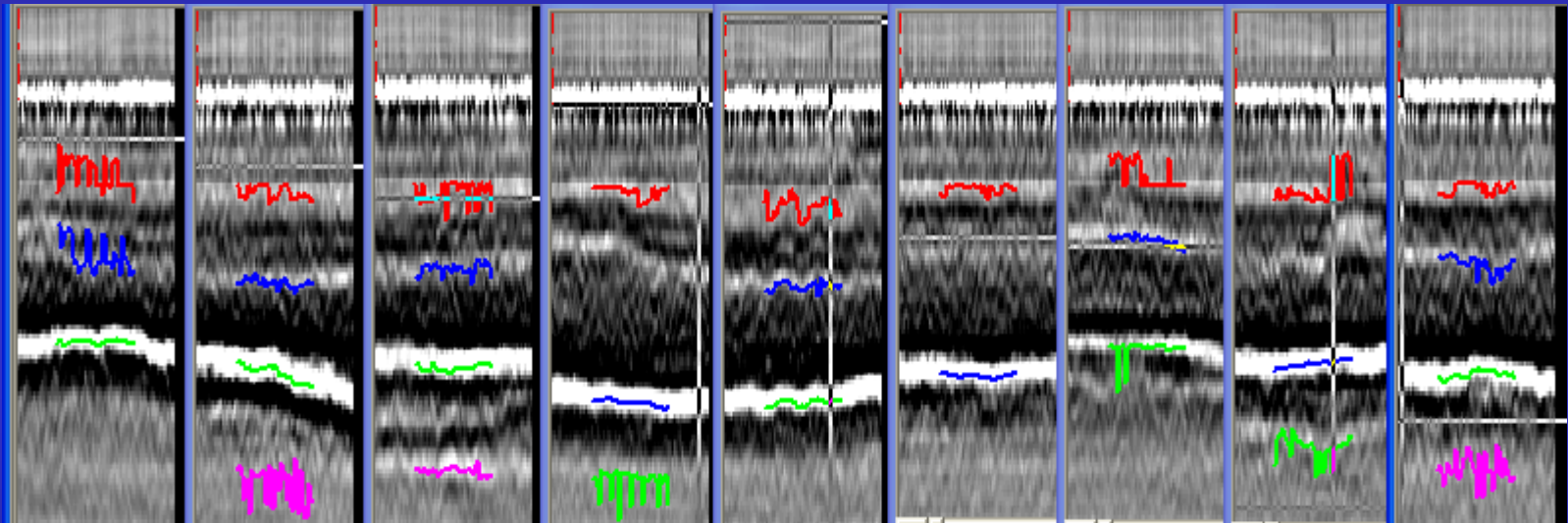
GPR Files at FWD Locations



GPRAP Output

DONE	AC Depth (in.)			Data Quality
	1st	2nd	3rd	
Data Files				
\\FWDUG\Auburn\AUBURN044	7.95	#N/A	#N/A	GOOD
\\FWDUG\Auburn\AUBURN044	8.67	#N/A	#N/A	GOOD
\\FWDUG\Auburn\AUBURN044	8.60	#N/A	#N/A	GOOD
\\FWDUG\Auburn\AUBURN044	9.61	#N/A	#N/A	GOOD
\\FWDUG\Auburn\AUBURN044	9.56	#N/A	#N/A	GOOD
\\FWDUG\Auburn\AUBURN044	9.09	#N/A	#N/A	GOOD
\\FWDUG\Auburn\AUBURN044	7.90	4.52	13.74	AVERAGE
\\FWDUG\Auburn\AUBURN044	8.45	#N/A	#N/A	GOOD
\\FWDUG\Auburn\AUBURN044	8.77	#N/A	#N/A	GOOD

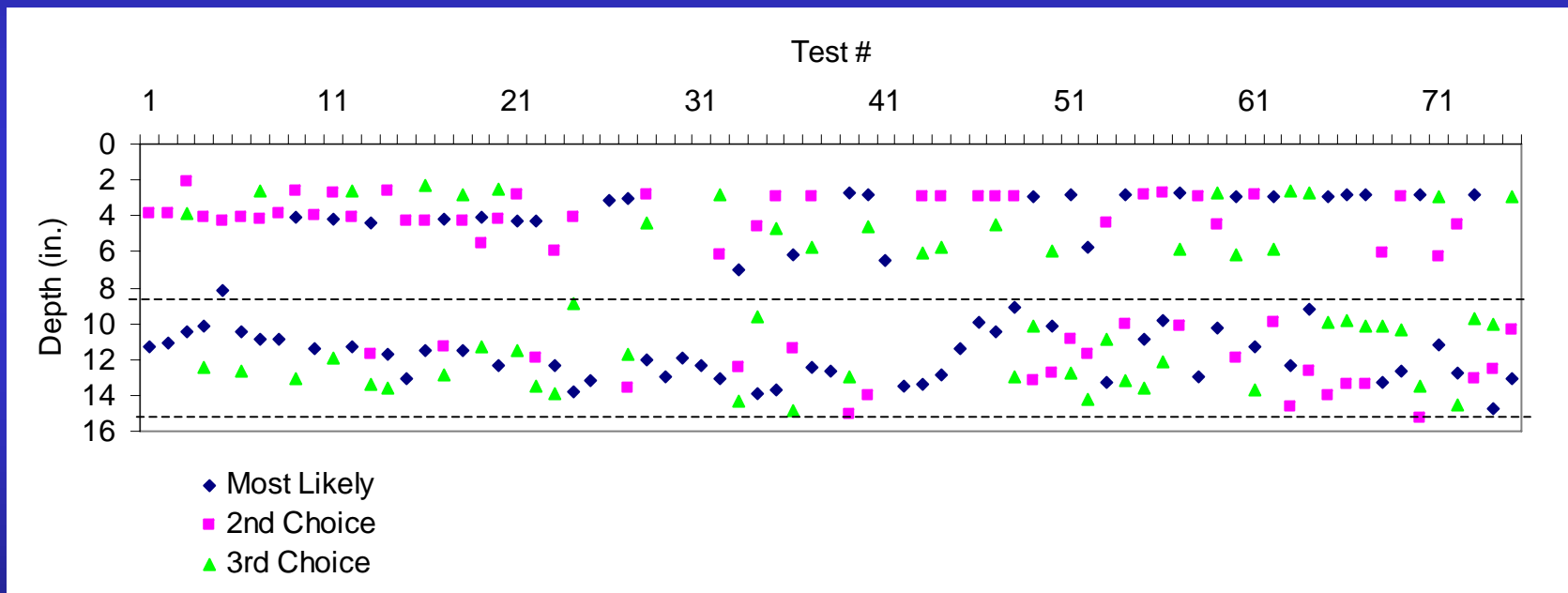
GPRAP Graphical Results



Multi-layer AC

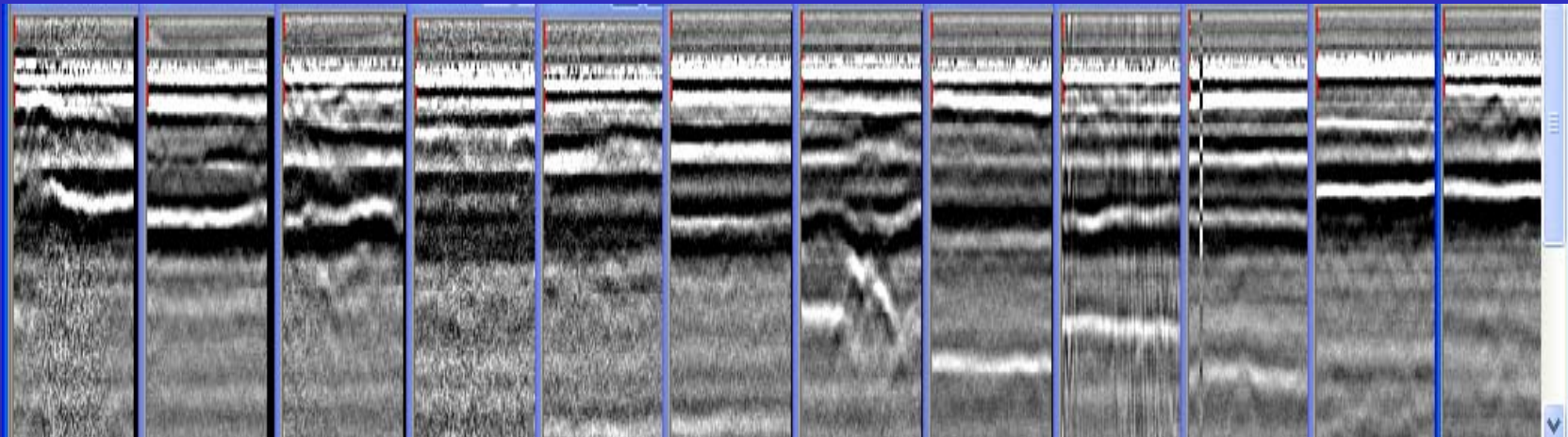
- Program identifies the most likely AC bottom
- Program also reports alternatives
- User can review choices and refine
 - Looking at pavement layer structure
 - Looking at backcalculation results

Refinement of Results using Overall Pavement Structure

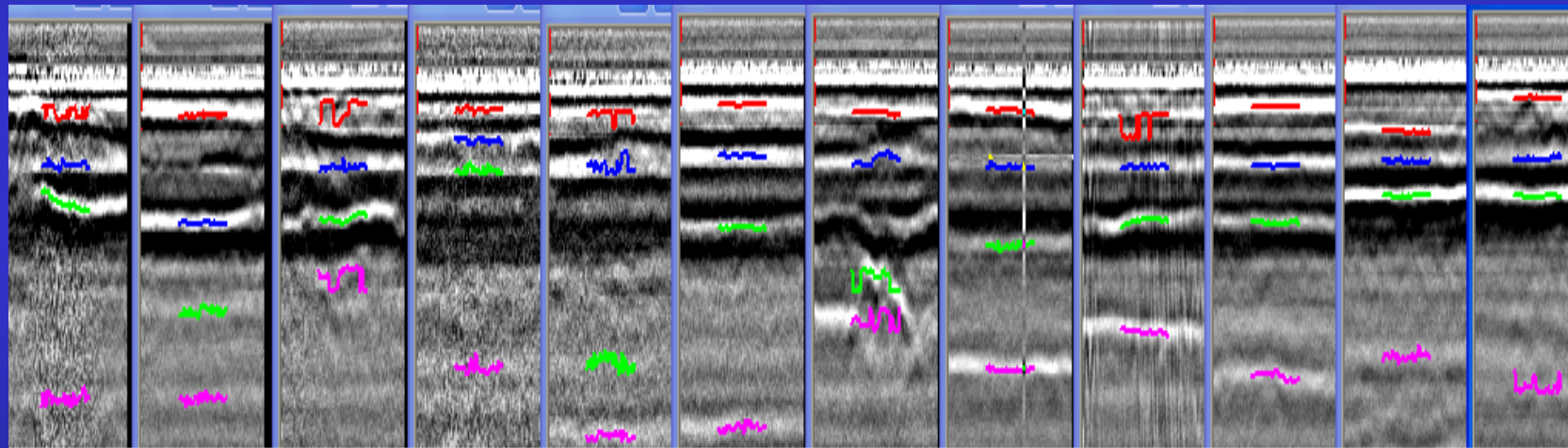


Example

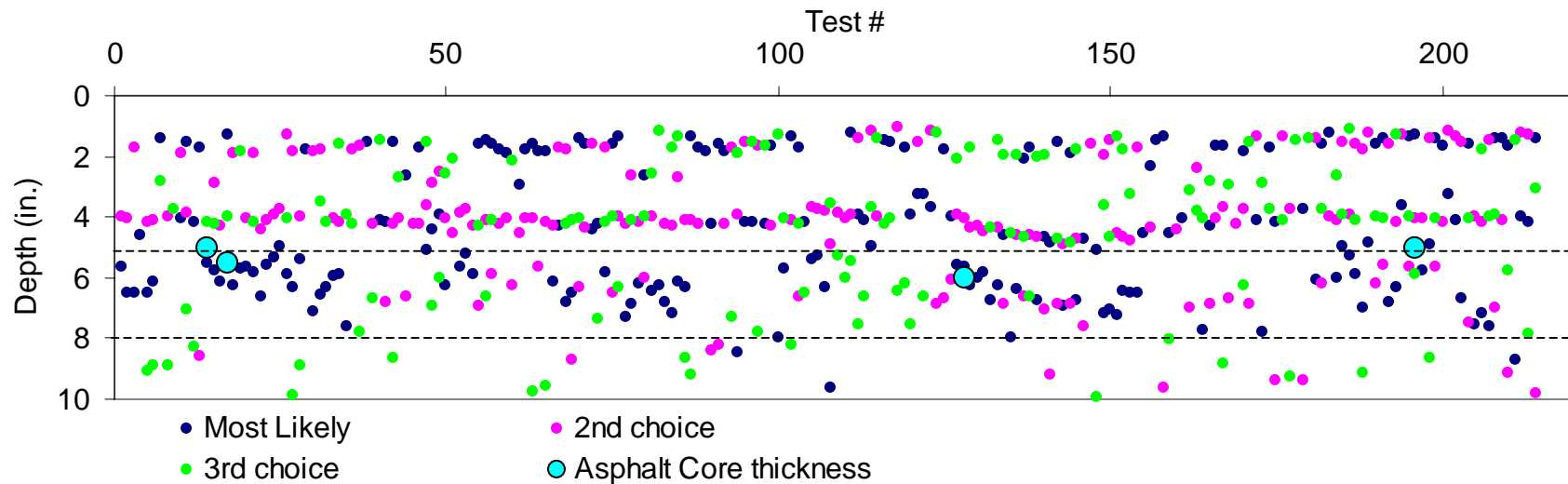
Data on Multi-layer AC



GPRAP Results on Multi-layer AC



Refinement of Results using Overall Pavement Structure



Conclusion

- GPR data collected with FWD can be automatically analyzed using GPRAP
- GPRAP makes initial determination of AC bottom for multi-layer AC pavement
- User can review and refine the automated results