Integrating Pavement Preservation into a Pavement Management System

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Pavement Management Today

- Pavement Management has been shifting in focus from capital investment in new projects to the enhanced management and preservation of existing assets.

- The health of road networks are significantly and positively impacted by advanced Pavement Management Systems that optimize and simplify the management of road networks, including optimization of treatments and resource allocation.

Case Studies

VDOT
Virginia Department of Transportation

Québec

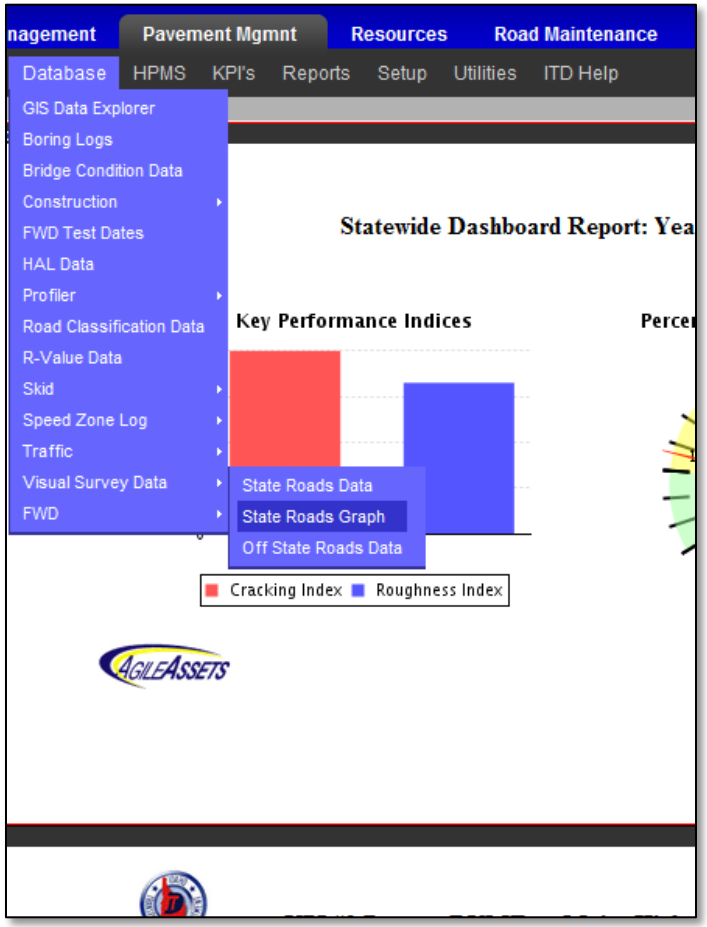
STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

Advanced PMS Features

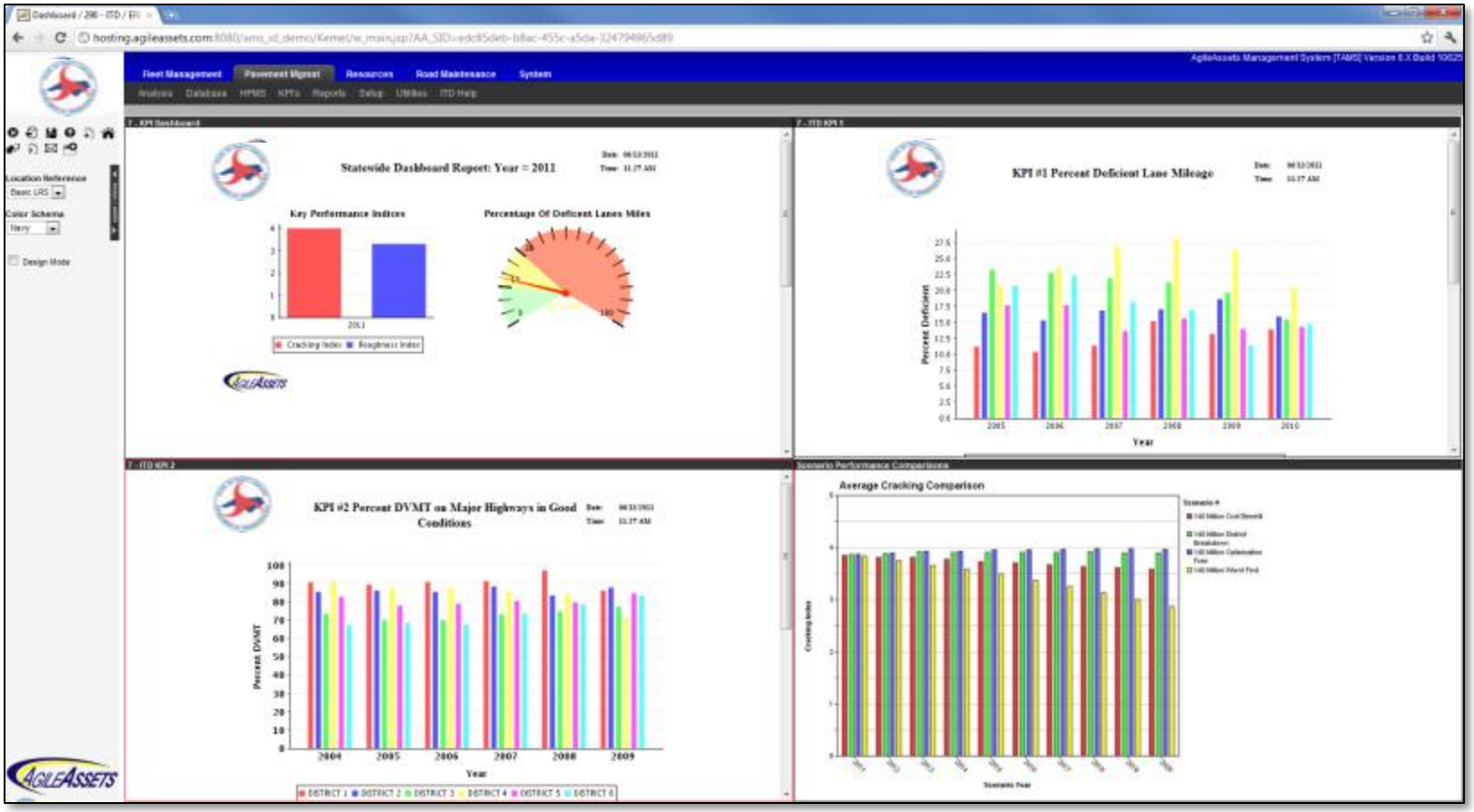
- 100% web-based application, zero footprint
- User-configurable database structure
- User-configurable models and calculations
- Multi-year & Multi-constraint Integer Optimization
- User-definable analysis variables
- Analytical performance modeling function

Database Menu and Configuration

- Database contains client data sources
- Fully front-end configured
- No required tables
- No generic fields



General Layout

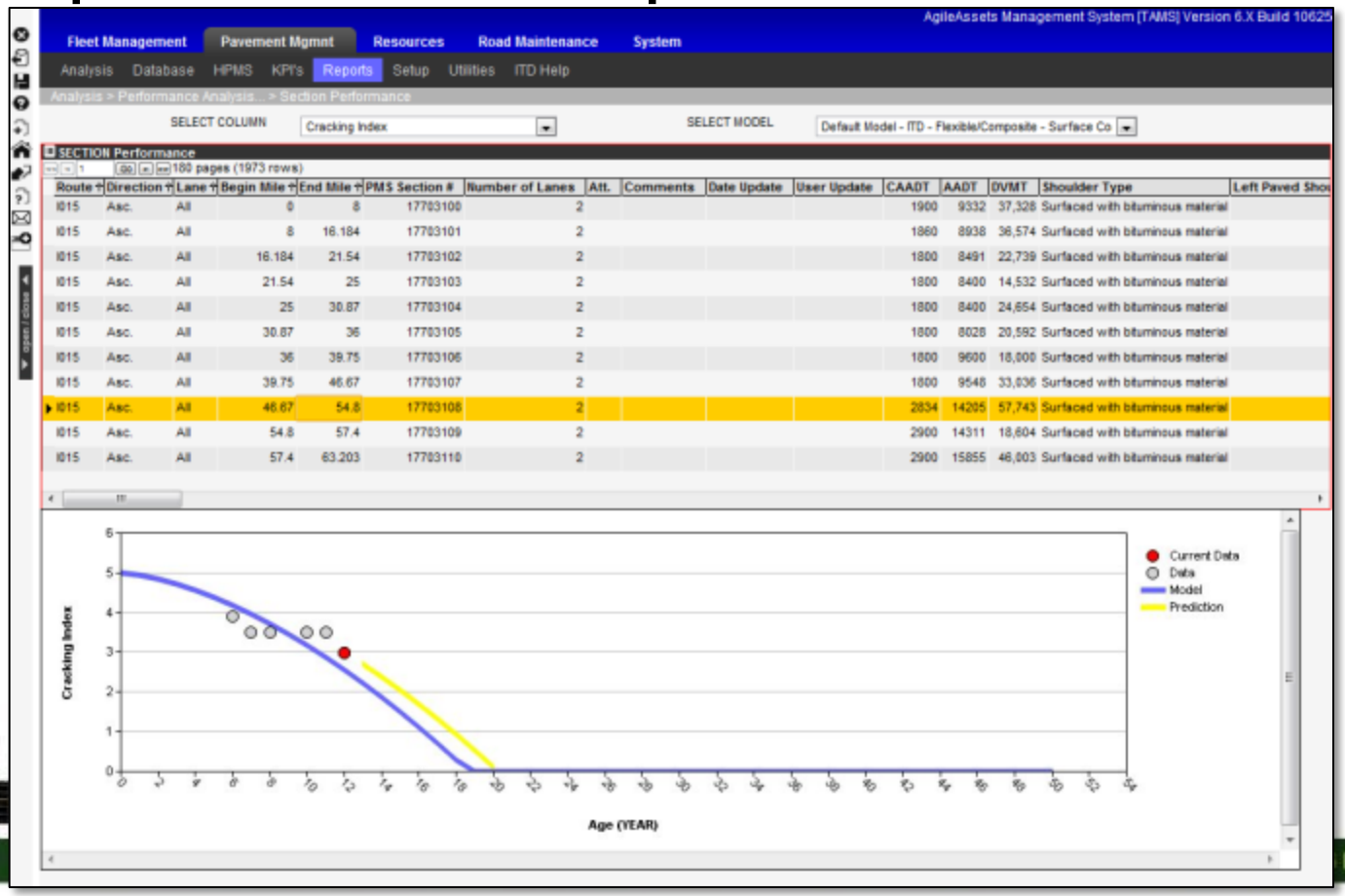


Pavement Life Extension with PMS

- How can pavement life extension be measured with PMS? With respect to modeling, how can PMS software be used to show how a preservation treatment would actually extend the life of the underlying pavement.

Pavement Life Extension with PMS

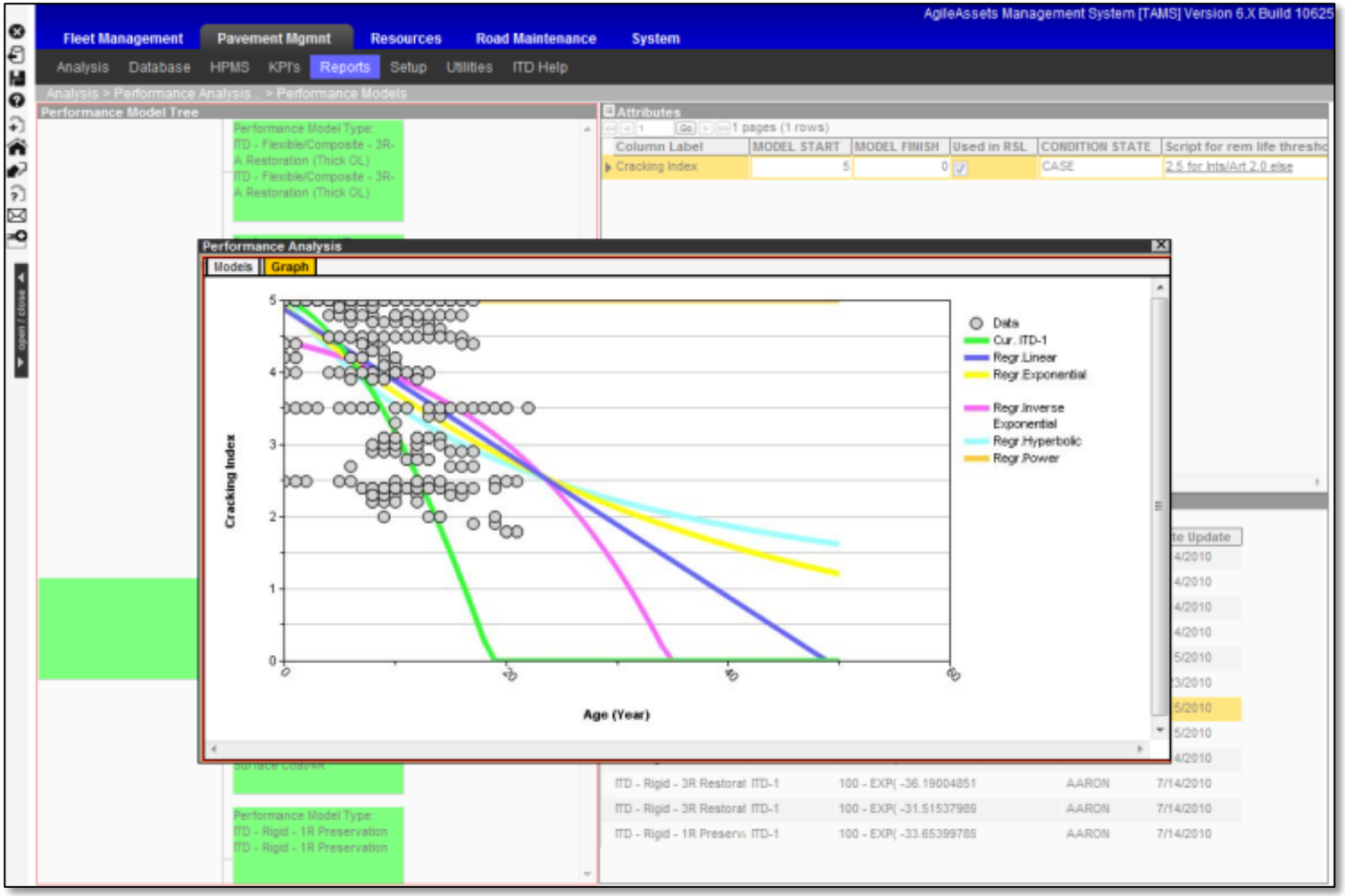
- Quebec uses Pavement performance monitoring analysis - Section performance compared to model prediction



Pavement Life Extension with PMS

- VDOT PMS stores all condition data and treatment history.
- Extrapolated deterioration curves of sections prior to treatment can be compared to actual deterioration after the treatment to draw conclusions on the pavement life extension of preservation treatments.
- These comparisons can be performed on a section by section basis or on the network level.

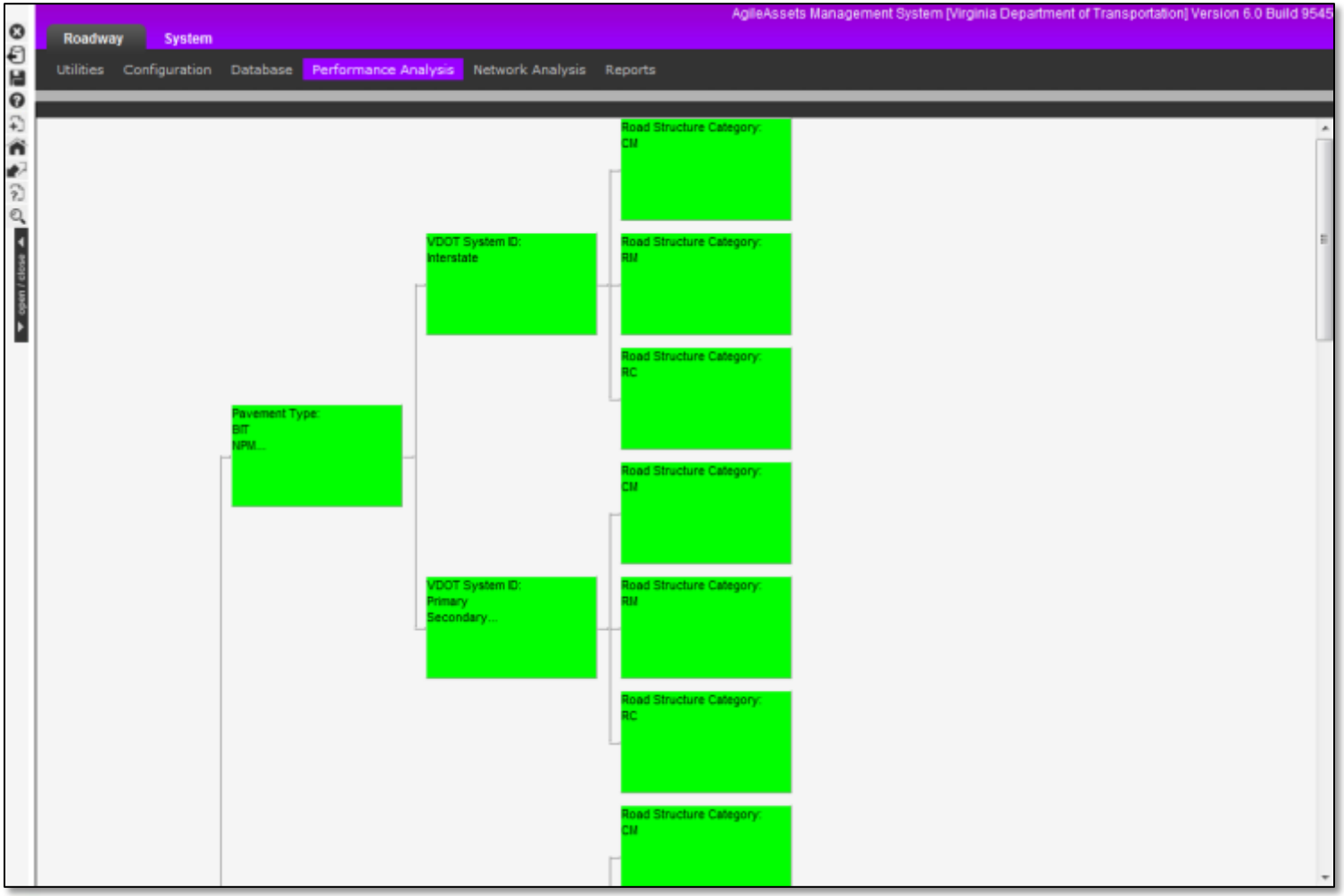
Family Models



Pavement Life Extension with PMS

- NCDOT uses the section performance window to try to get a handle on the degree to which pavement treatments extend life.
- Also, they use the PMS as a convenient storage system so that condition and treatment data can be easily cross-referenced and they can analyze the data

Modeling Family Definition



Automated vs. Manual Data Collection

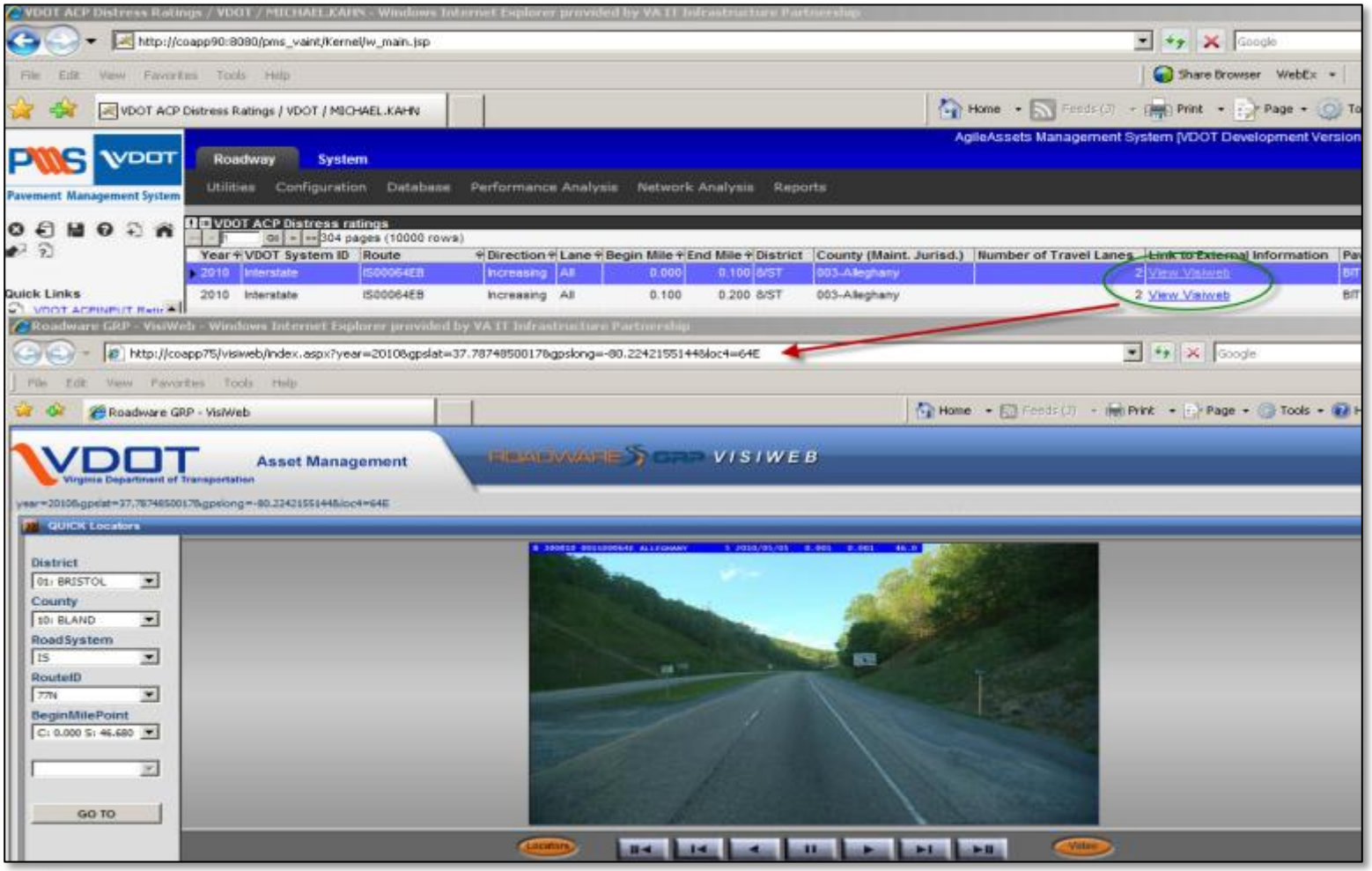
- Identify the pros and cons of automated data collection versus “windshield” data collection.

Automated vs. Manual Data Collection

- Automated data collection for IRI, rutting and surface distresses has been used by VDOT since 2007.
- Automated data is recognized as more objective, accurate, repeatable and safer than windshield data; however windshield rating is less expensive.
- Automated data collection also produces high quality Right of Way images which can be analyzed for data collection on other assets (such as signs or guardrail).
- Automated collection vehicles can collect additional data at the same time as the surface condition survey, such as Ground Penetrating Radar, roadway geometry or other safety related information.

VDOT
Virginia Department of Transportation

Video Log Viewers

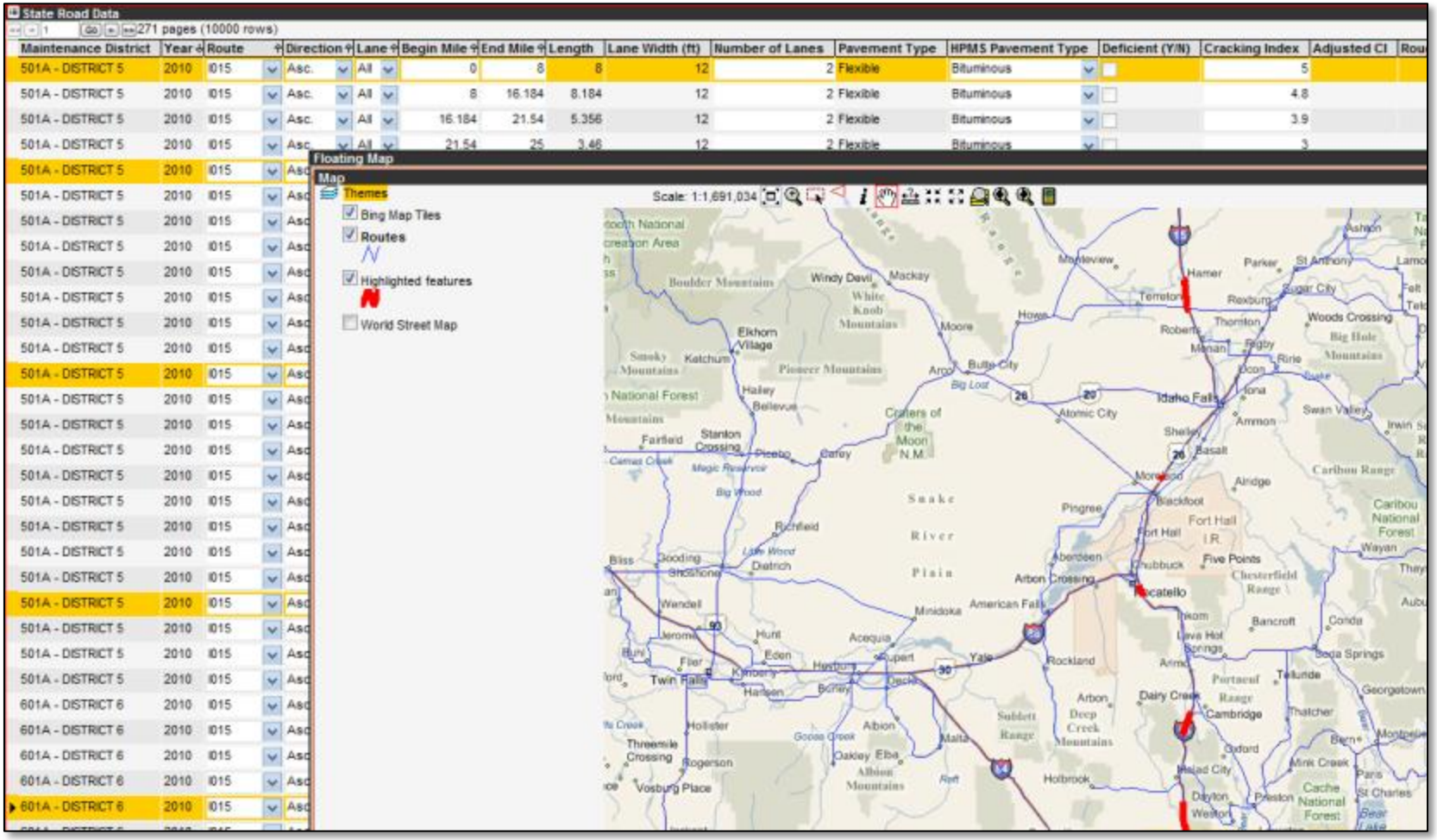


Automated vs. Manual Data Collection

- Automated data collection has been used by MTQ since 2000 for IRI and rutting, since 2007 for cracking (fully automated 3D laser technology) and since 2011 for macrotexture (same 3D laser technology).
- For automated data collection
  - pros: objective, precise, high performance, safer for collection personnel and road users.
  - cons are: complex and expensive technology, large volume of data, limitations due to environmental conditions
- For windshield survey
  - pros: simple, allow student hiring.
  - cons: subjective, slow, risky for collection personnel and road users, data transfer required.

Québec

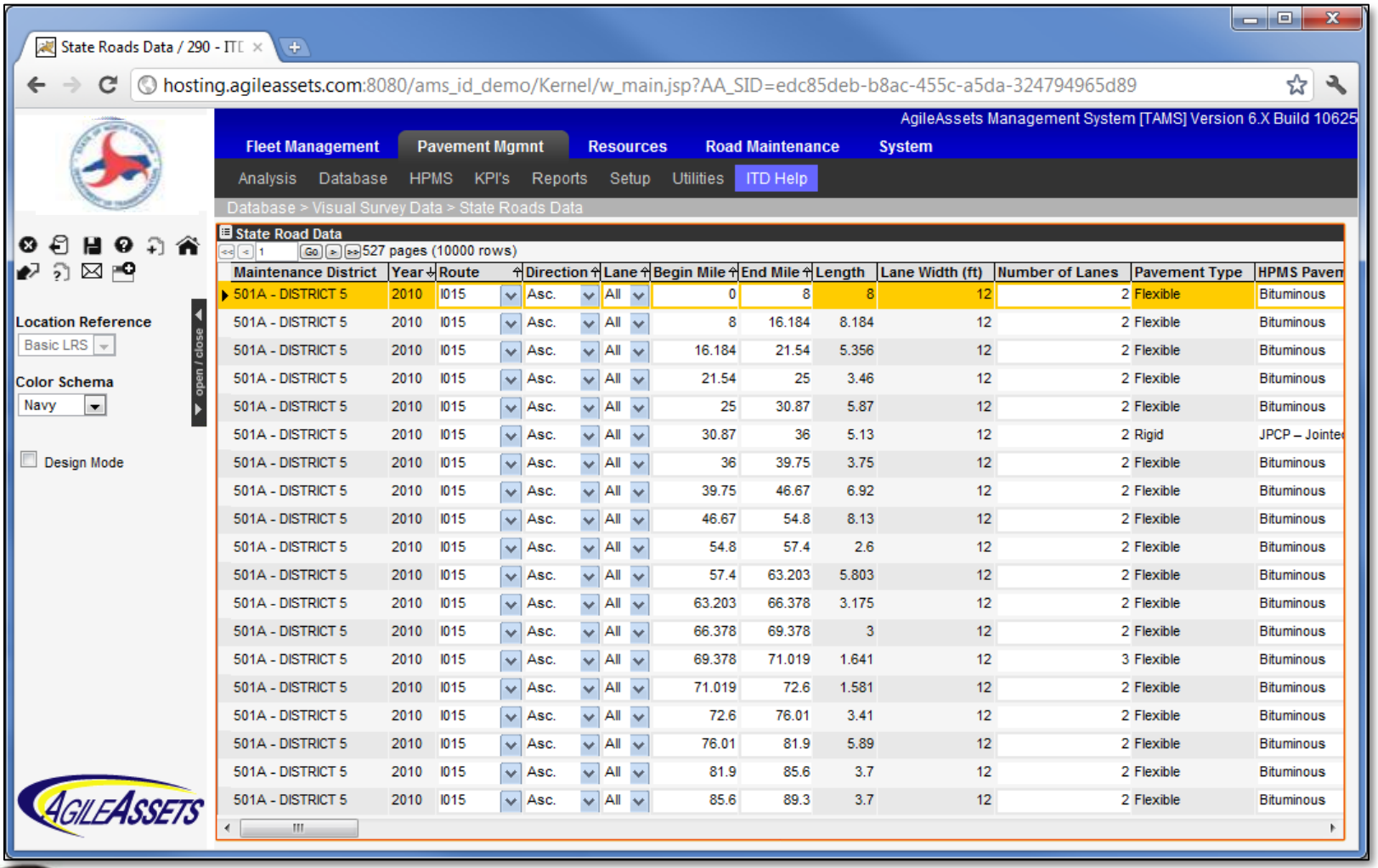
View Data in Maps



Automated vs. Manual Data Collection

- NCDOT is in their first cycle of automated distress data collection.
  - Pros: More repeatable data, better coverage of key network areas. Distress and RoW imagery can be used by all DOT users. Collects multiple data sets in one pass. Potentially useful for inventory of signs and safety.
  - Cons: Large data storage needs. Expensive - either contract out collection and processing for a high rate or buy an expensive vehicle and hire additional employees to process. However, balanced against the number of personnel involved in a windshield survey, it's potentially not so bad.
- Windshield:
  - Pros: Employees that own the roads, ride the roads. They get a first hand look at conditions.
  - Cons: Slow. High variability. Safety issues. Painful data validation issues.

Data Grid Windows



Maintenance District	Year	Route	Direction	Lane	Begin Mile	End Mile	Length	Lane Width (ft)	Number of Lanes	Pavement Type	HPMS Paven
501A - DISTRICT 5	2010	I015	Asc.	All	0	8	8	12	2	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	8	16.184	8.184	12	2	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	16.184	21.54	5.356	12	2	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	21.54	25	3.46	12	2	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	25	30.87	5.87	12	2	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	30.87	36	5.13	12	2	Rigid	JPCP – Jointe
501A - DISTRICT 5	2010	I015	Asc.	All	36	39.75	3.75	12	2	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	39.75	46.67	6.92	12	2	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	46.67	54.8	8.13	12	2	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	54.8	57.4	2.6	12	2	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	57.4	63.203	5.803	12	2	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	63.203	66.378	3.175	12	2	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	66.378	69.378	3	12	2	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	69.378	71.019	1.641	12	3	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	71.019	72.6	1.581	12	2	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	72.6	76.01	3.41	12	2	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	76.01	81.9	5.89	12	2	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	81.9	85.6	3.7	12	2	Flexible	Bituminous
501A - DISTRICT 5	2010	I015	Asc.	All	85.6	89.3	3.7	12	2	Flexible	Bituminous

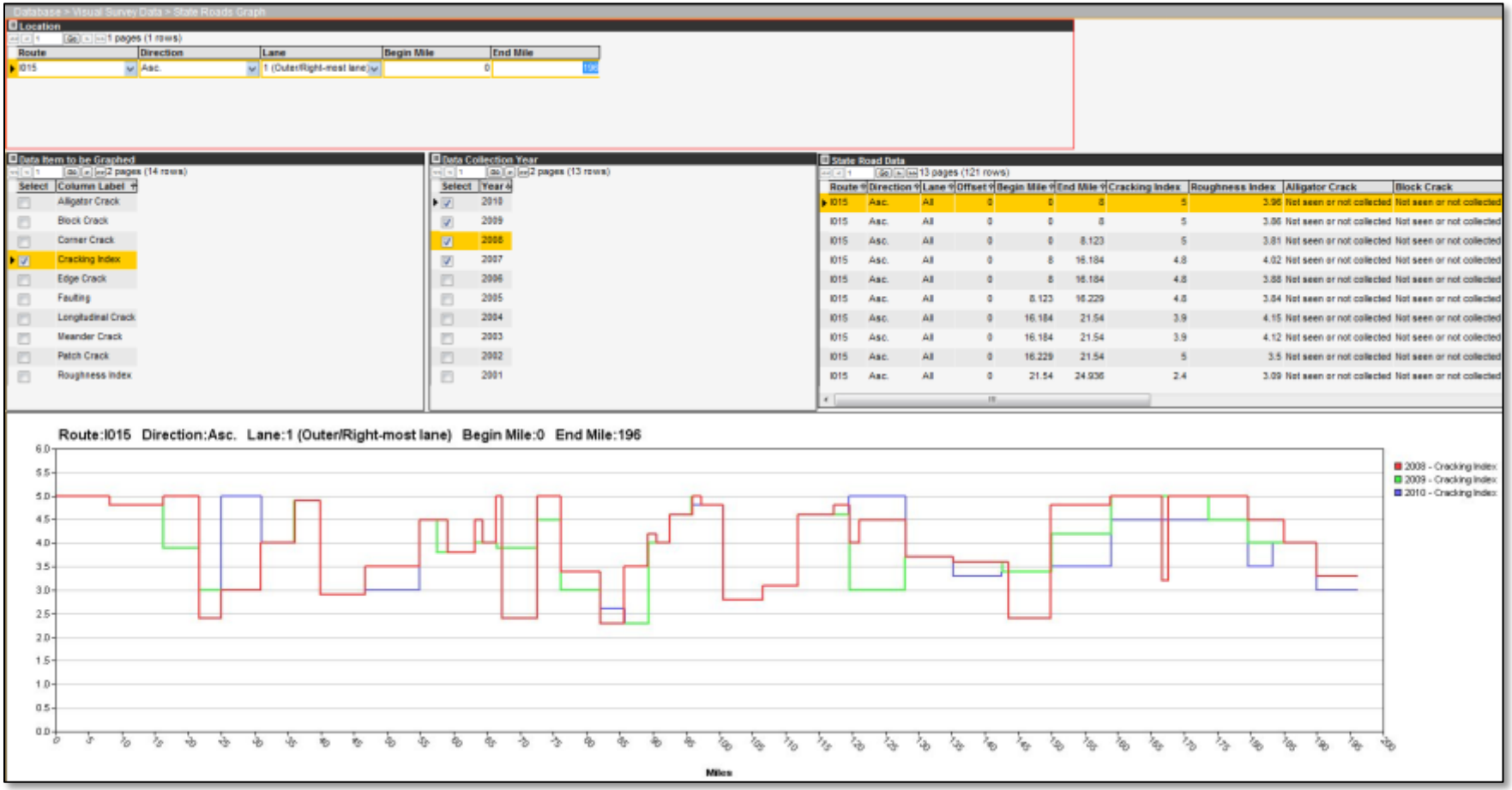
Sealed Cracks in Survey

- How does the PMS address the benefits of crack treatments in the condition rating? Specifically, how does the PMS analyze crack data for treated cracks?

Sealed Cracks in Survey

- VDOT
  - Sealed cracks are rated as the lowest severity of cracking, this can improve the condition rating of the section.
- MTQ
  - Global cracking index: increase 70, no higher than 100
  - Transverse cracking index: increase 30, no higher than 100
  - IRI index: increase RSL by 2 years
- NCDOT
  - Sealed cracks (well sealed without significant alligator patterns) are considered low severity. Cracking indices are bumped up to the low severity level.

Comparing Condition Graphically



Data Used for PP Decisions

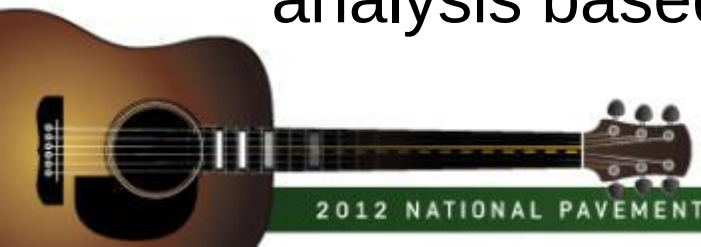
- What condition data do you look for to trigger a pavement preservation treatment? For certain treatments should timing be used?

Data Used for PP Decisions

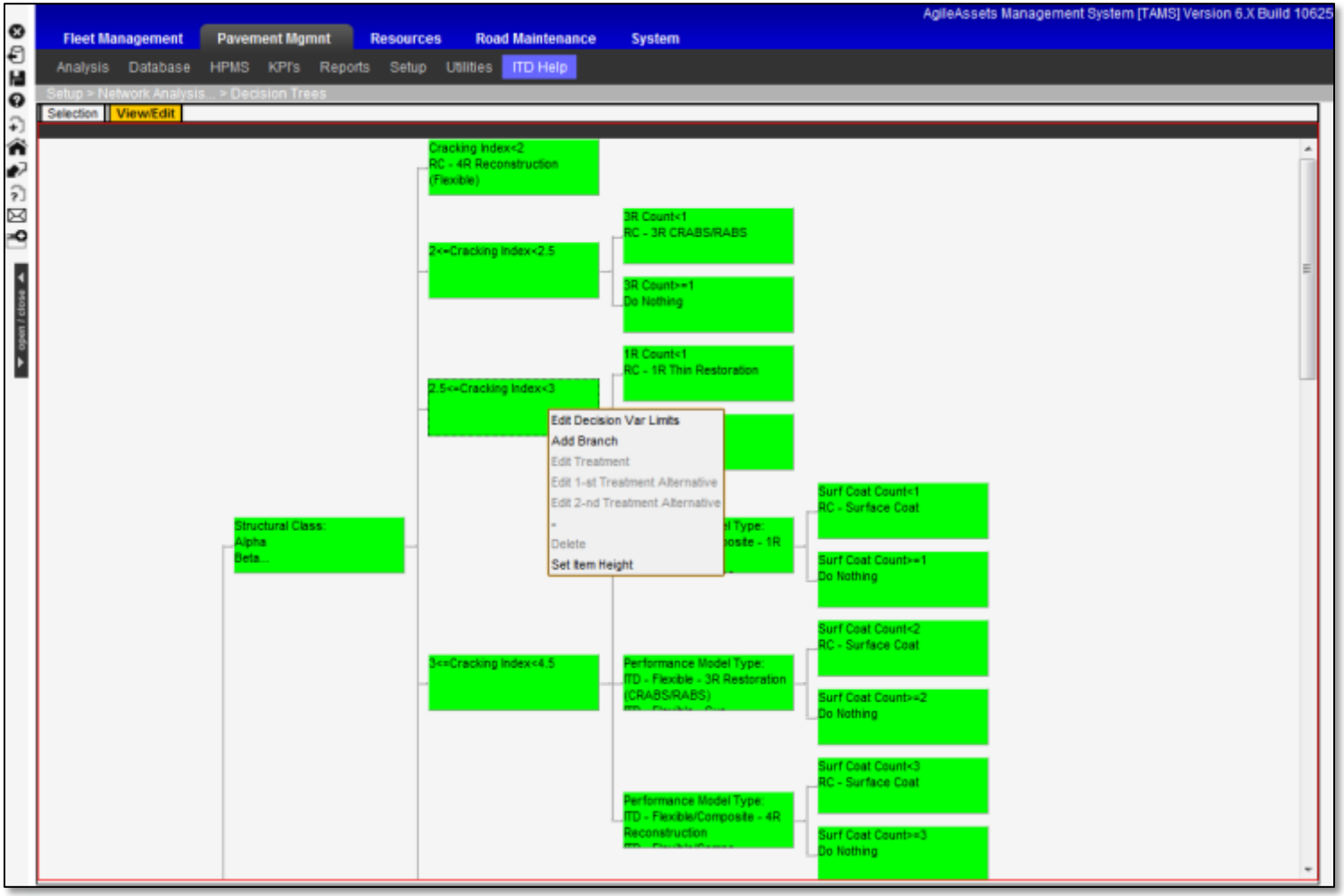
- MTQ
  - Crack sealing: defined min and max cracking presence.
  - Thin overlay, micro-surfacing: age.
- VDOT
  - An extensive decision matrix is used to identify the appropriate category of maintenance activities to apply to a section. This matrix utilizes detailed distress severity/frequency information in combination with traffic, surface age and FWD information if available.

Data Used for PP Decisions

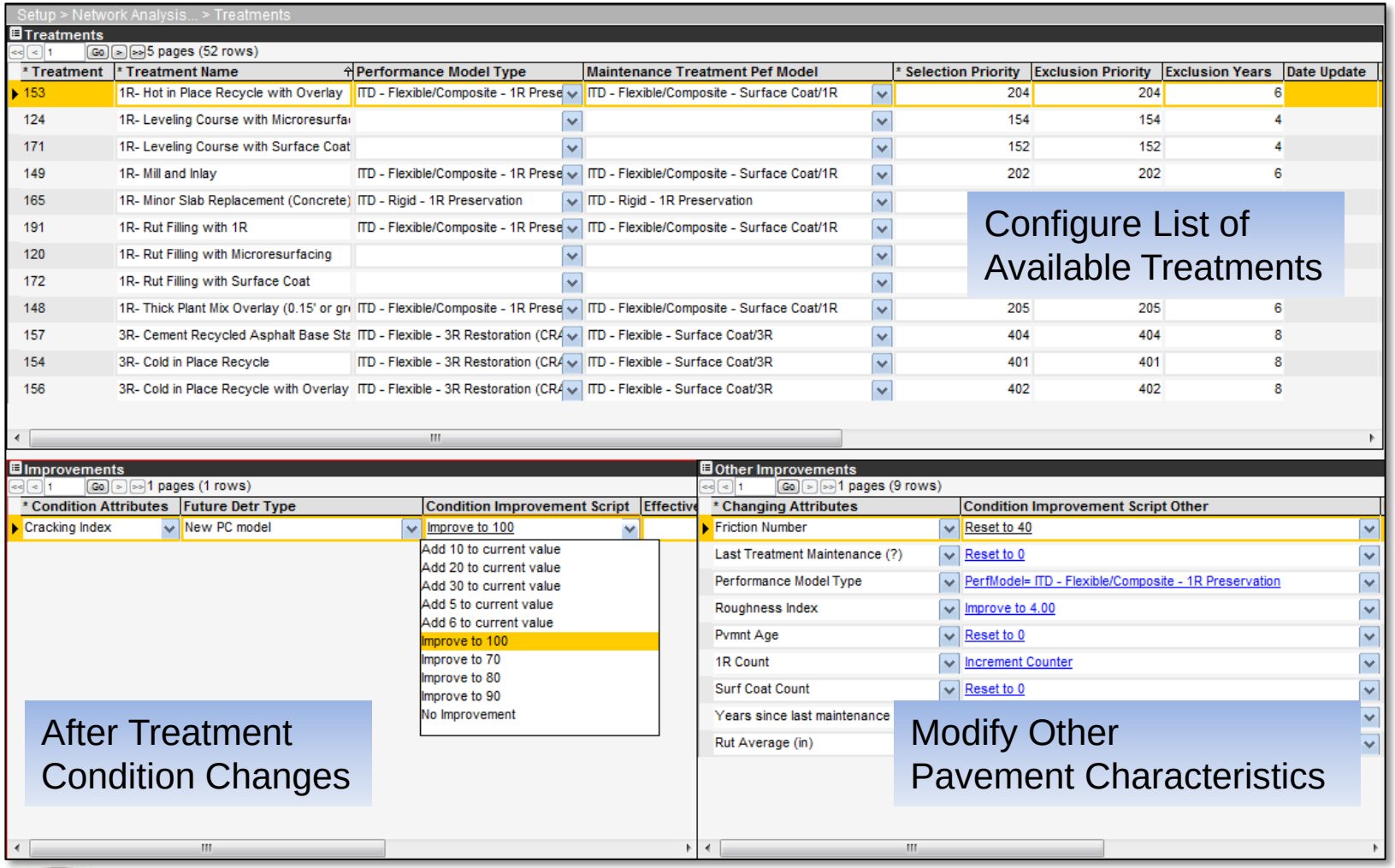
- NCDOT
  - NCDOT triggers PP treatments based on individual distresses for asphalt pavements. Cracking indices and rutting should be fair to good.
  - The overall goal is to treat when the composite rating index is 80 or higher.
  - NCDOT has found that for some activities such as chip seal programs, timing based treatments (every N years) are often more beneficial than analysis based treatments.



Configuring Decision Trees



Treatment Configuration



The right treatment on the right road at the right time

- Many pavement preservation treatments are placed on roads in poor condition (as a band-aid fix). This practice can contaminate the overall treatment data. What is the best way to segregate the data in the PMS to avoid mislabeling the treatment's performance?

The right treatment on the right road at the right time - MTQ

- Specifically identify roads where a “band-aid fix” (MTQ calls it a “palliative” treatment) has been applied. A specific performance curve with a steeper slope is attached to those roads.
- At MTQ, palliative treatments are embedded in a pavement conservation strategy, where they are considered as a cheap temporary solution pending the rehabilitation treatment to be done a few years later.

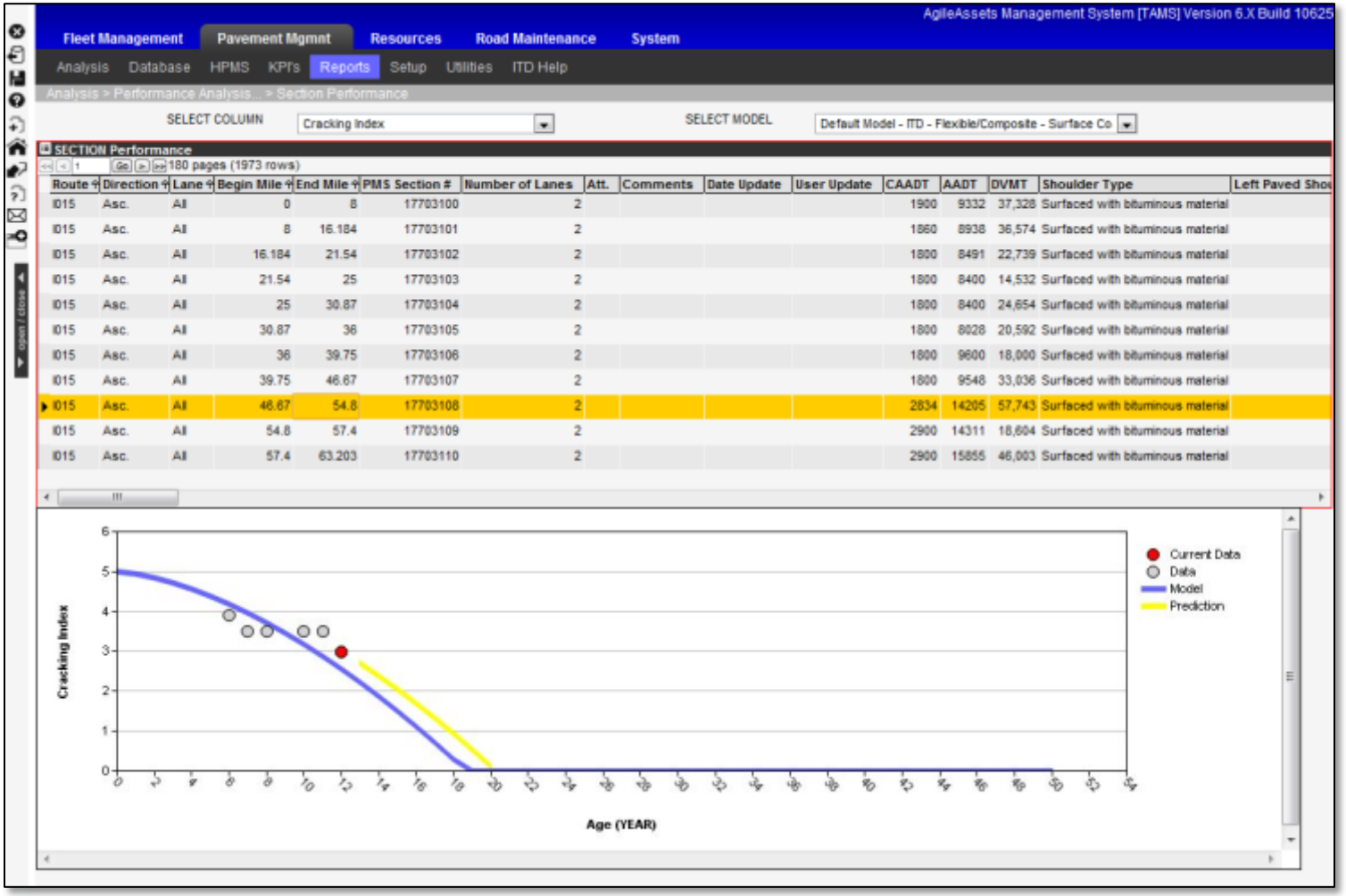
The right treatment on the right road at the right time - VDOT

- VDOT is currently establishing a process to verify treatment selection against the maintenance need at the location. This process may evolve to include the development of deterioration models for “misapplied” treatments.

The right treatment on the right road at the right time - NCDOT

- The NCDOT models and decision trees specifically handle “band-aid fixes”. With good data, treatments will not be recommended that conflict with the condition of the road.
- NCDOT has also created a PMS report that allows anyone to look at project selection retroactively. The user can look at the most recent chip seal program and determined if good preservation guidelines were followed .
- When the integrated PMS/MMS is used for planning, they can proactively run such a report.

Section Modeling



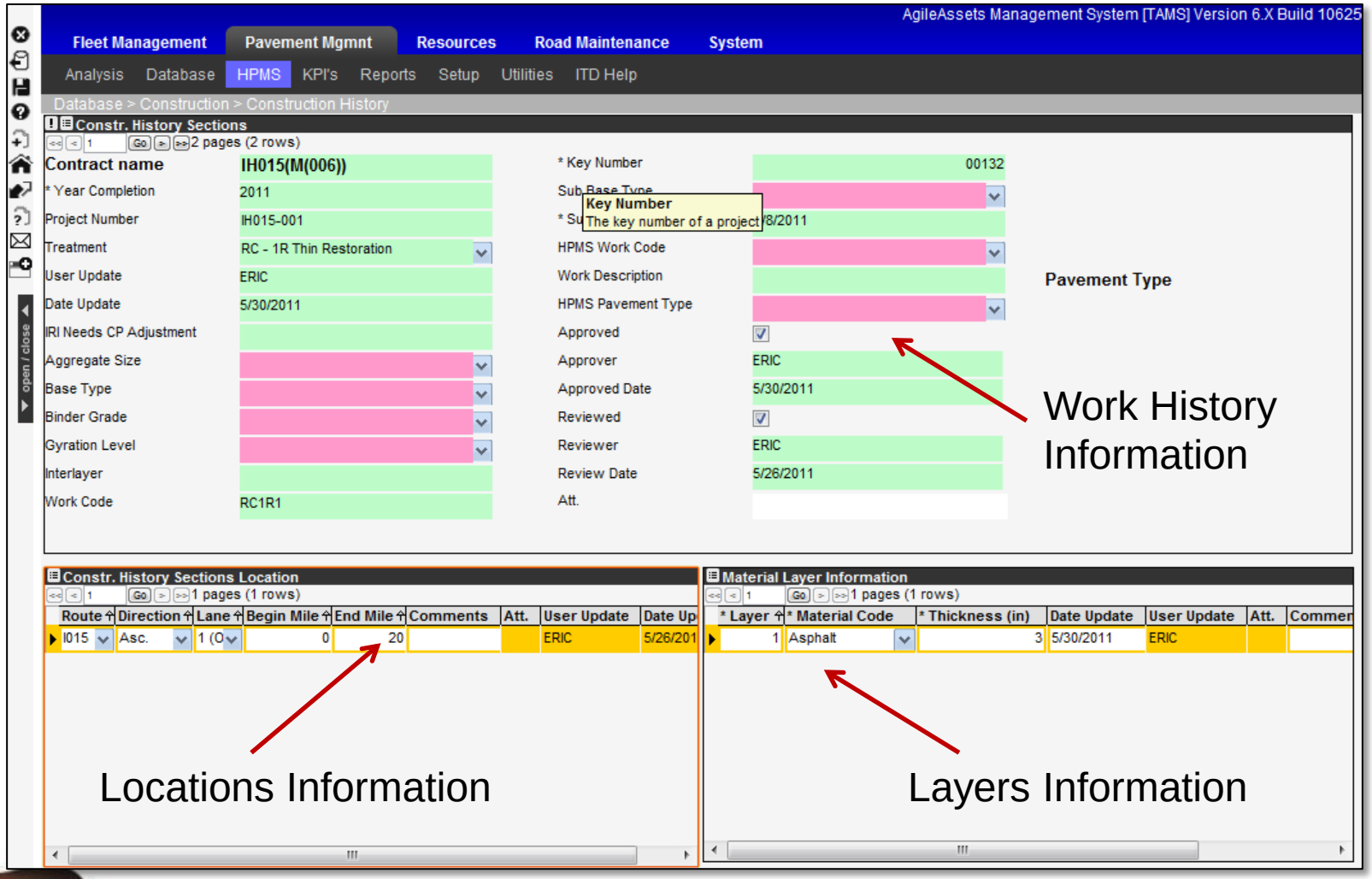
Differentiation in Preventive Treatments

- Can pavement management models be fine tuned enough to indicate which exact preventive treatment should be applied (crack sealing vs. chip seal vs. slurry seal vs. microsurfacing, for example)?

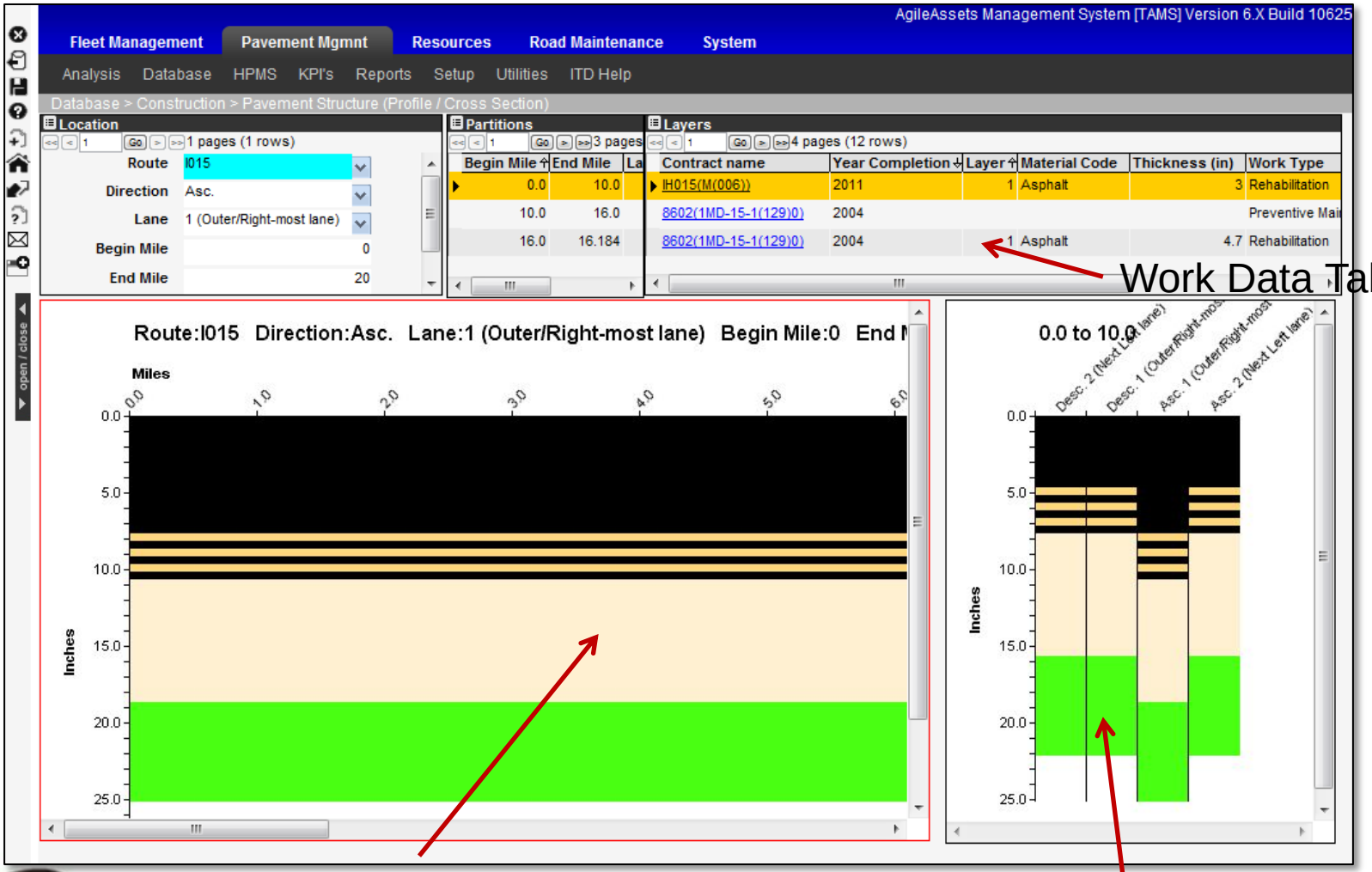
Differentiation in Preventive Treatments

- MTQ – Can be done with a combination of models and condition indexes.
- VDOT - Current VDOT/VTTI research project is developing “fine tuned” models to incorporate in PMS to accomplish this.
- NCDOT – A judicious combination of models and decision trees makes it work. It does require vetting by various resources and getting field feedback as well. Even so, the final decision will always be a field decision for NCDOT.

Construction History: Data Entry Forms



Construction History Review



Work Data Table

Longitudinal Layer Data

Cross Sectional View

How to Best Integrate PP into PMS

- Provide some pointers on how to best integrate pavement preservation into a PMS.

How to Best Integrate PP into PMS

- MTQ - Give a specific budget in the analysis (sub-constraint). At MTQ, preventive maintenance is also embedded in the pavement conservation strategy.
- NCDOT - Careful decision tree setup. Understanding the index improvement values that should be applied during analysis. Use multiple budgets.
- VDOT - Optimizations are run in the PMS to determine the ideal treatments to achieve agency established performance targets. These will include Preservation activities.

Network Analysis

Multi-Constraint Optimization

The Goal

- Best set of projects
  - The projects meet a set of constraints
  - Maximizes or minimizes an objective (Maximize condition, minimize budget, etc.)
- The desired **Output** of the analysis is a **Workplan** that tells us:
  - Which treatments to apply (What – including PP)
  - To which sections (Where)
  - In which year (When)

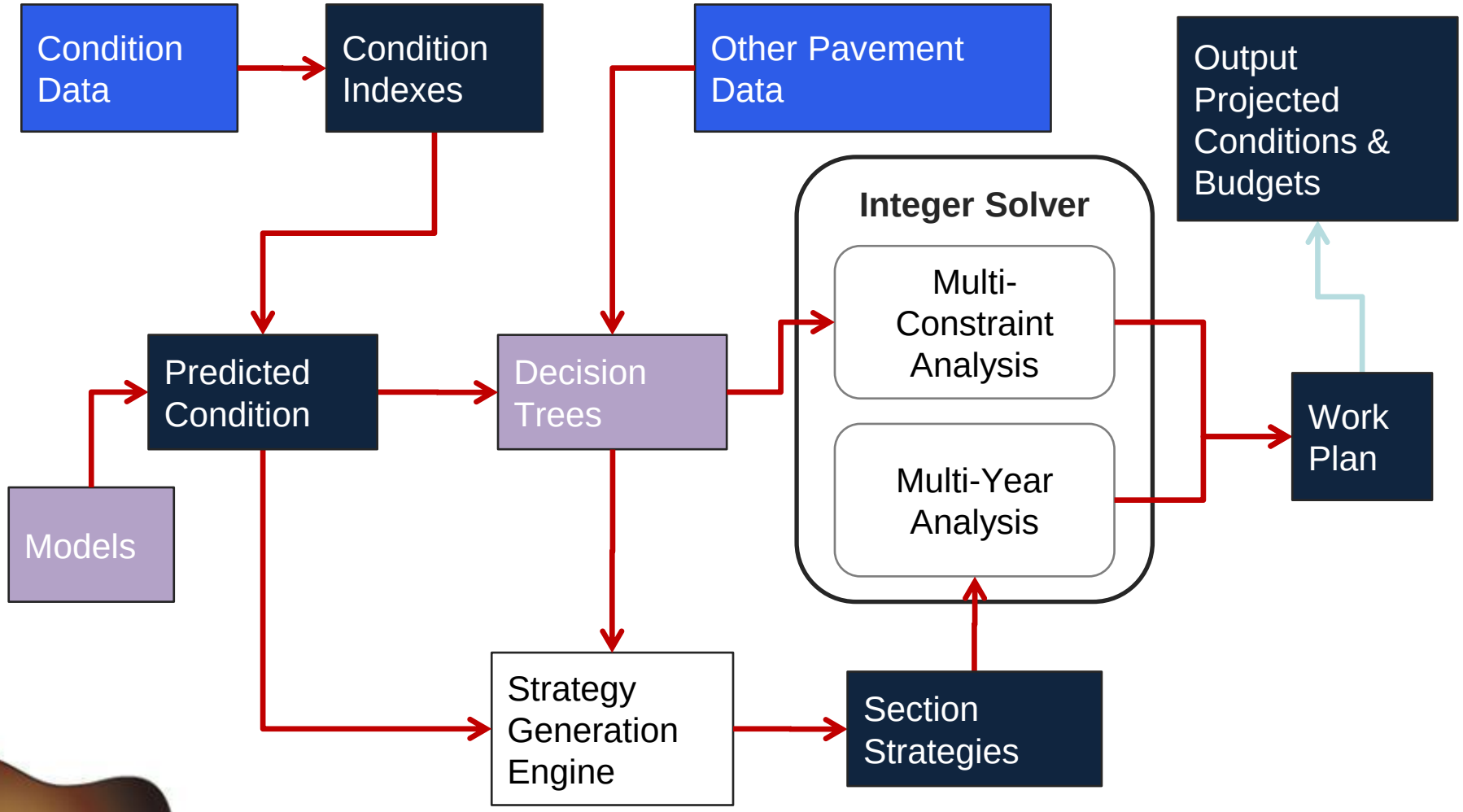
History

- VDOT desired multi-constraint analysis
  - Maintain certain average condition
  - No more than 18% of deficient lane mileage
  - Precluded the use of Incremental Benefit Cost methods because they can only analyze one constraint at a time
- For VDOT we developed an integer programming based optimization to allow these types of analysis

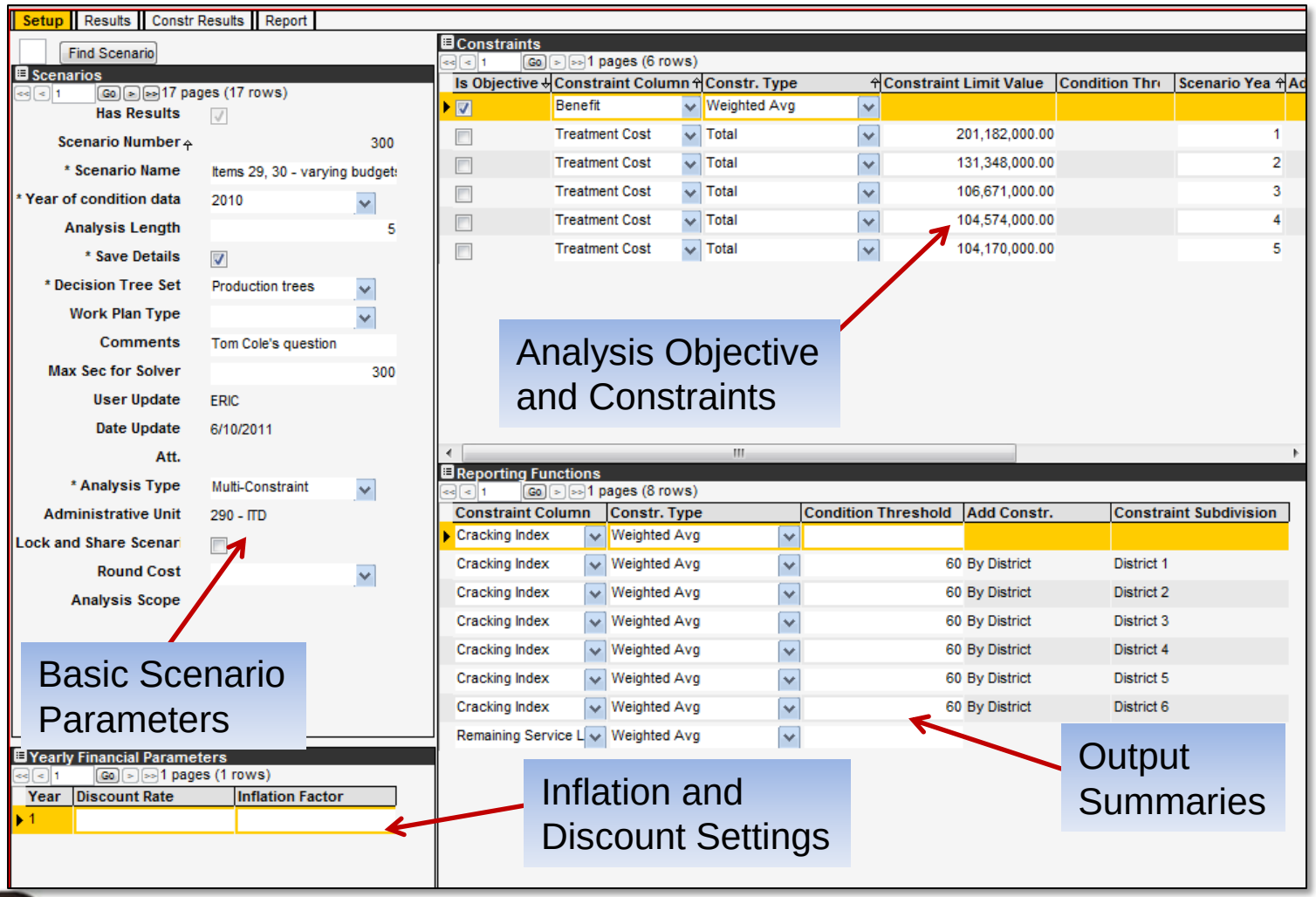
Integer Optimization Features

- State of the art Optimization analysis
  - Integer programming
  - Optimal work plans, **not** worst-first or INCBEN ranking
- Greater flexibility than prioritization and incremental benefit cost ranking methods
  - Analyze multiple constraints at once
    - Maintaining average condition **and** cap deficient mileage
    - Meet a budget constraint and limit on deficient mileage
  - Subdivide constraints within the same scenario
    - Specify minimum condition by functional class
    - Break down budgets by treatment type (Rehab, Preservation, Reconstruction)

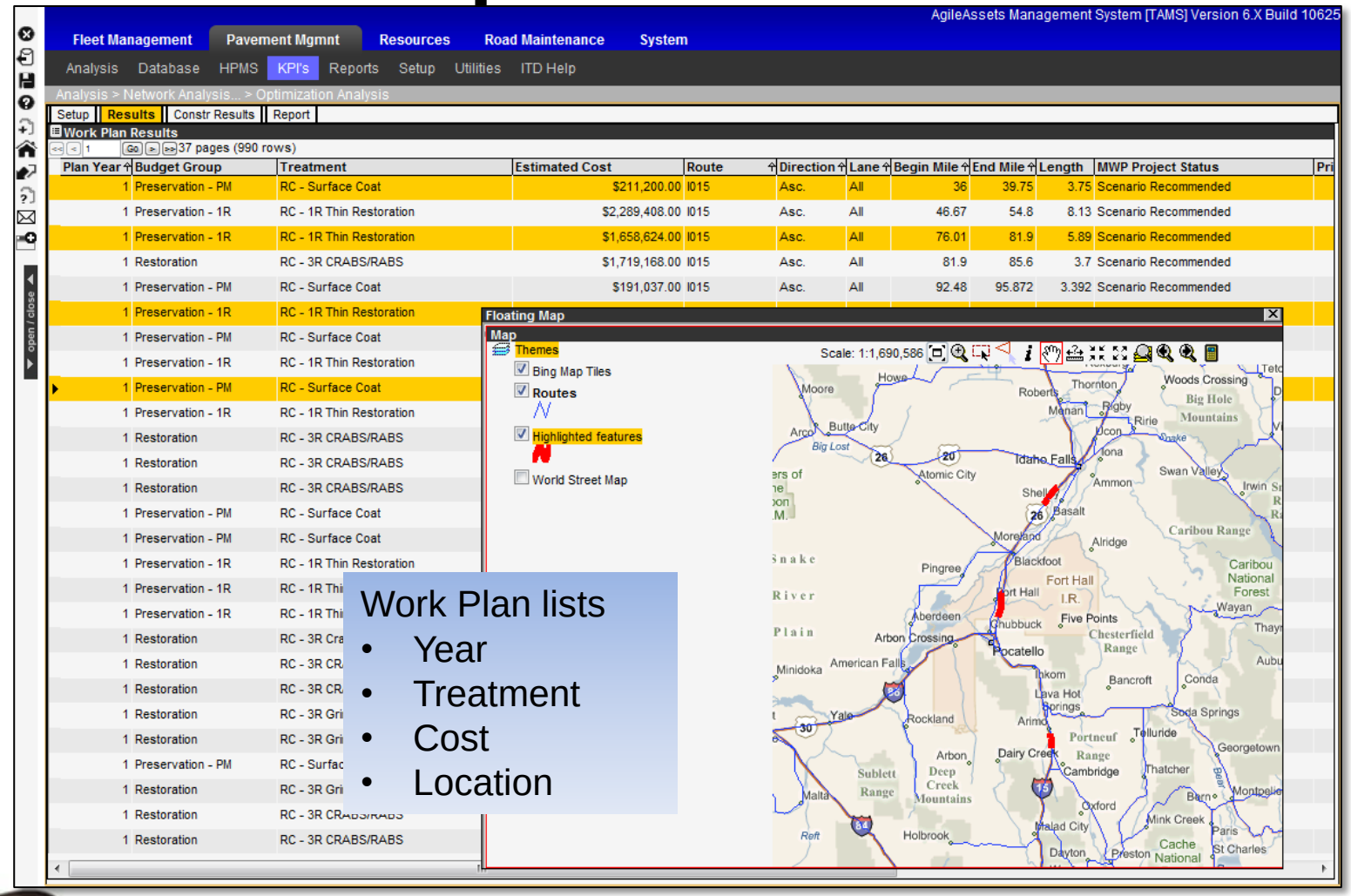
Optimization Analysis



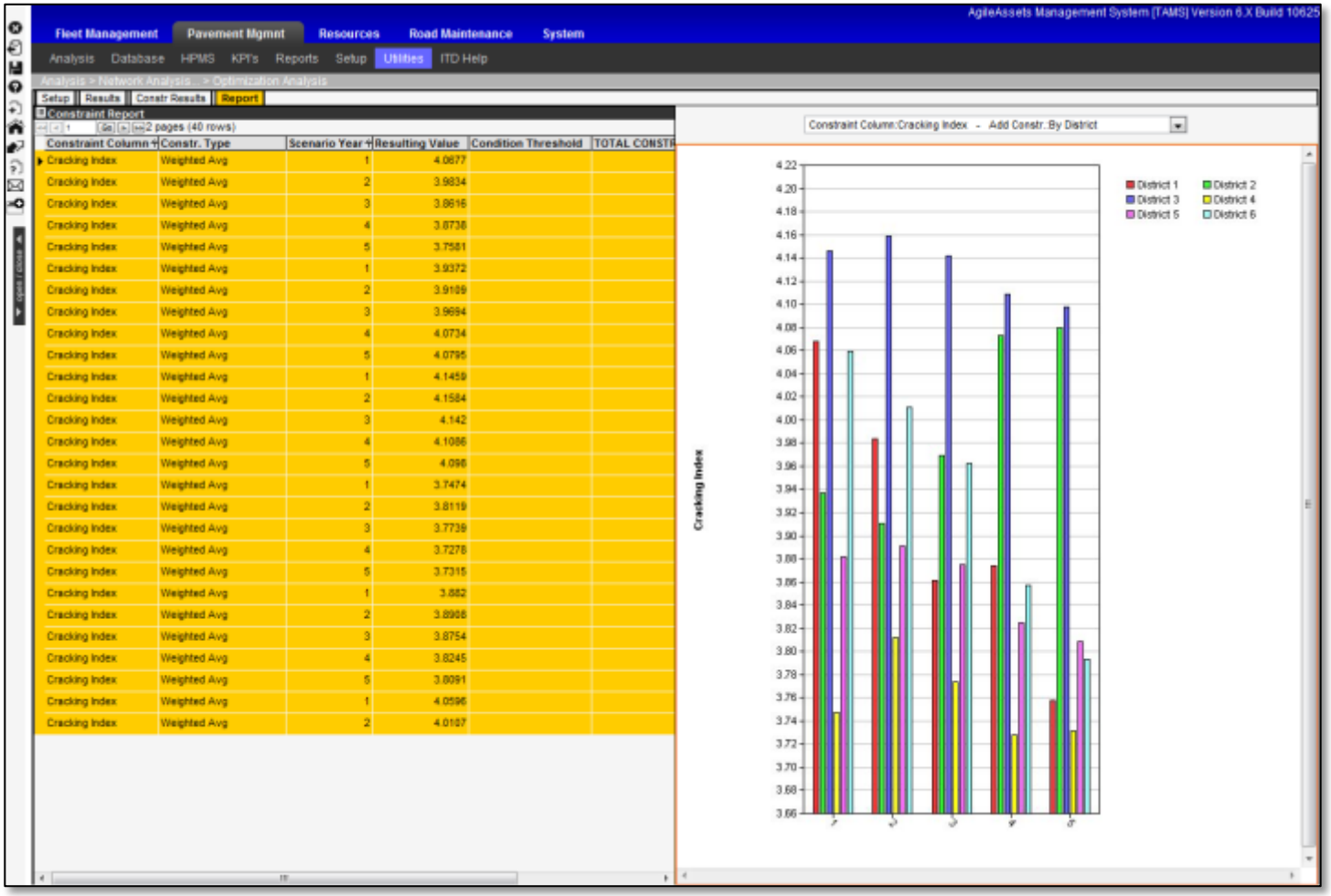
Setting Up A Scenario



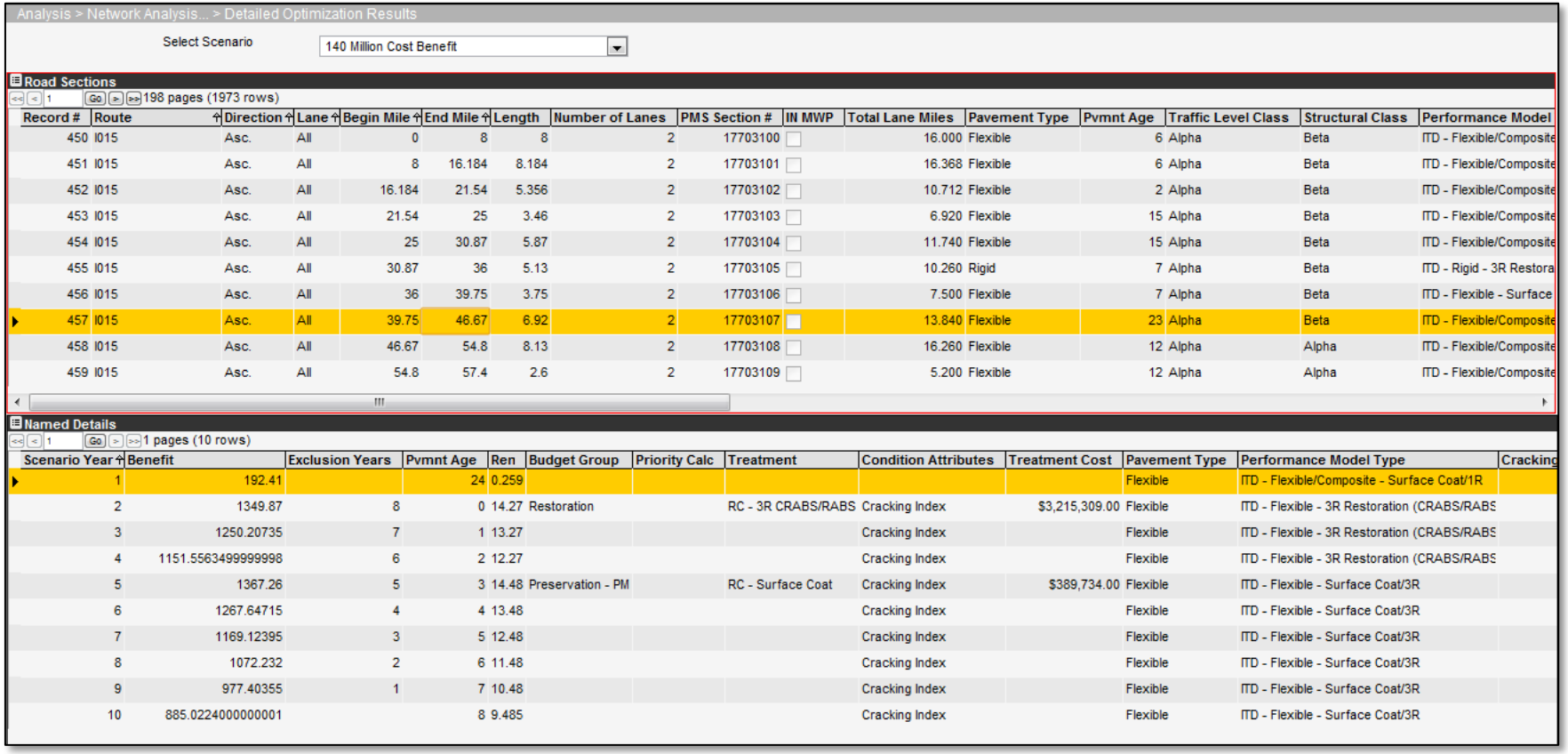
Output Work Plan



Scenario Summaries



Predicted Section Data



Analysis > Network Analysis... > Detailed Optimization Results

Select Scenario: 140 Million Cost Benefit

Road Sections

198 pages (1973 rows)

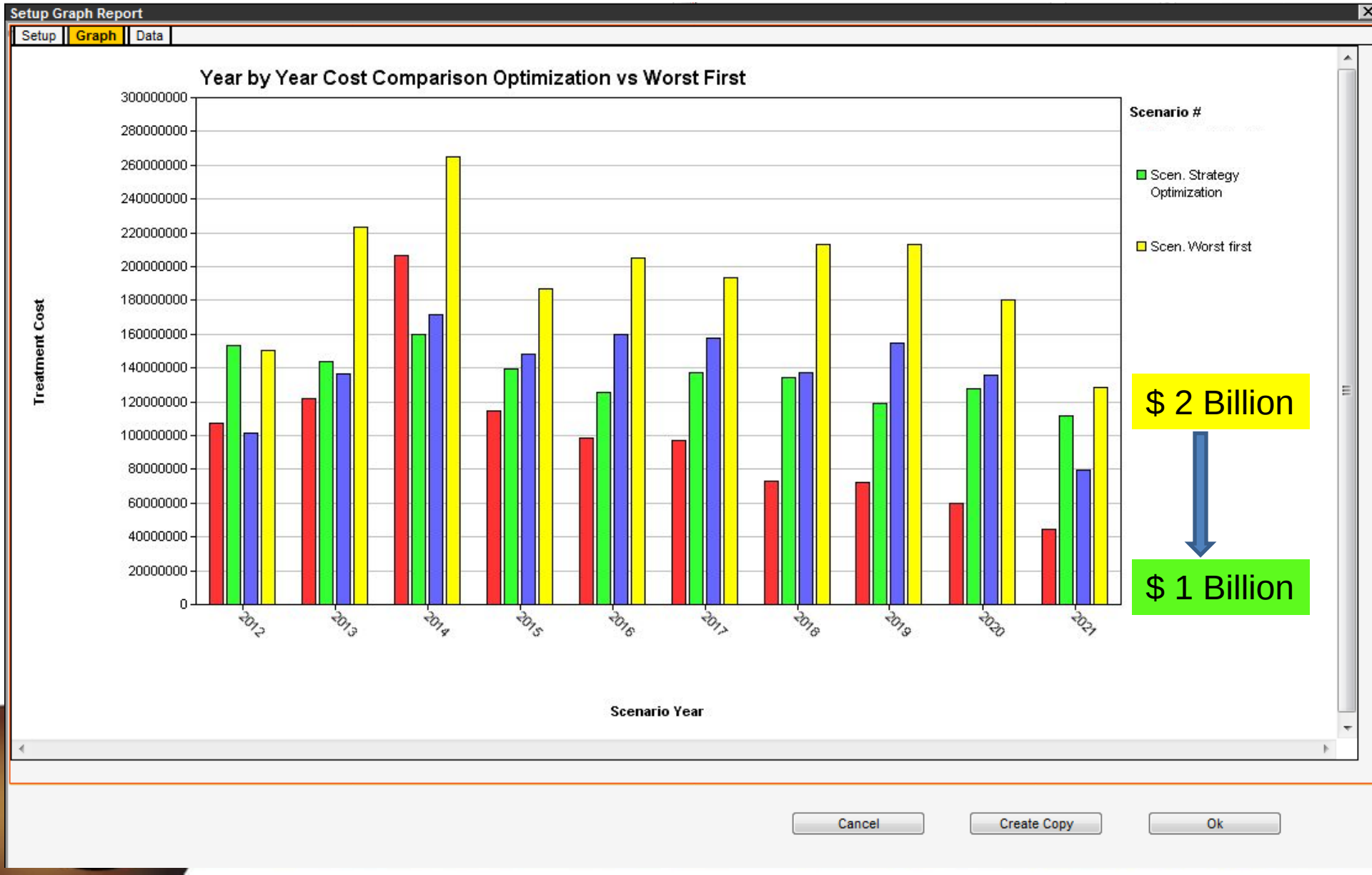
Record #	Route	Direction	Lane	Begin Mile	End Mile	Length	Number of Lanes	PMS Section #	IN MWP	Total Lane Miles	Pavement Type	Pvmnt Age	Traffic Level Class	Structural Class	Performance Model
450	I015	Asc.	All	0	8	8	2	17703100		16.000	Flexible	6	Alpha	Beta	ITD - Flexible/Composite
451	I015	Asc.	All	8	16.184	8.184	2	17703101		16.368	Flexible	6	Alpha	Beta	ITD - Flexible/Composite
452	I015	Asc.	All	16.184	21.54	5.356	2	17703102		10.712	Flexible	2	Alpha	Beta	ITD - Flexible/Composite
453	I015	Asc.	All	21.54	25	3.46	2	17703103		6.920	Flexible	15	Alpha	Beta	ITD - Flexible/Composite
454	I015	Asc.	All	25	30.87	5.87	2	17703104		11.740	Flexible	15	Alpha	Beta	ITD - Flexible/Composite
455	I015	Asc.	All	30.87	36	5.13	2	17703105		10.260	Rigid	7	Alpha	Beta	ITD - Rigid - 3R Restora
456	I015	Asc.	All	36	39.75	3.75	2	17703106		7.500	Flexible	7	Alpha	Beta	ITD - Flexible - Surface
457	I015	Asc.	All	39.75	46.67	6.92	2	17703107		13.840	Flexible	23	Alpha	Beta	ITD - Flexible/Composite
458	I015	Asc.	All	46.67	54.8	8.13	2	17703108		16.260	Flexible	12	Alpha	Alpha	ITD - Flexible/Composite
459	I015	Asc.	All	54.8	57.4	2.6	2	17703109		5.200	Flexible	12	Alpha	Alpha	ITD - Flexible/Composite

Named Details

1 pages (10 rows)

Scenario Year	Benefit	Exclusion Years	Pvmnt Age	Ren	Budget Group	Priority Calc	Treatment	Condition Attributes	Treatment Cost	Pavement Type	Performance Model Type	Cracking
1	192.41		24	0.259						Flexible	ITD - Flexible/Composite - Surface Coat/1R	
2	1349.87	8	0	14.27	Restoration		RC - 3R CRABS/RABS	Cracking Index	$3,215,309.00	Flexible	ITD - Flexible - 3R Restoration (CRABS/RABS	
3	1250.20735	7	1	13.27				Cracking Index		Flexible	ITD - Flexible - 3R Restoration (CRABS/RABS	
4	1151.5563499999998	6	2	12.27				Cracking Index		Flexible	ITD - Flexible - 3R Restoration (CRABS/RABS	
5	1367.26	5	3	14.48	Preservation - PM		RC - Surface Coat	Cracking Index	$389,734.00	Flexible	ITD - Flexible - Surface Coat/3R	
6	1267.64715	4	4	13.48				Cracking Index		Flexible	ITD - Flexible - Surface Coat/3R	
7	1169.12395	3	5	12.48				Cracking Index		Flexible	ITD - Flexible - Surface Coat/3R	
8	1072.232	2	6	11.48				Cracking Index		Flexible	ITD - Flexible - Surface Coat/3R	
9	977.40355	1	7	10.48				Cracking Index		Flexible	ITD - Flexible - Surface Coat/3R	
10	885.0224000000001		8	9.485				Cracking Index		Flexible	ITD - Flexible - Surface Coat/3R	

Why Does Best in Class Analysis Matter?

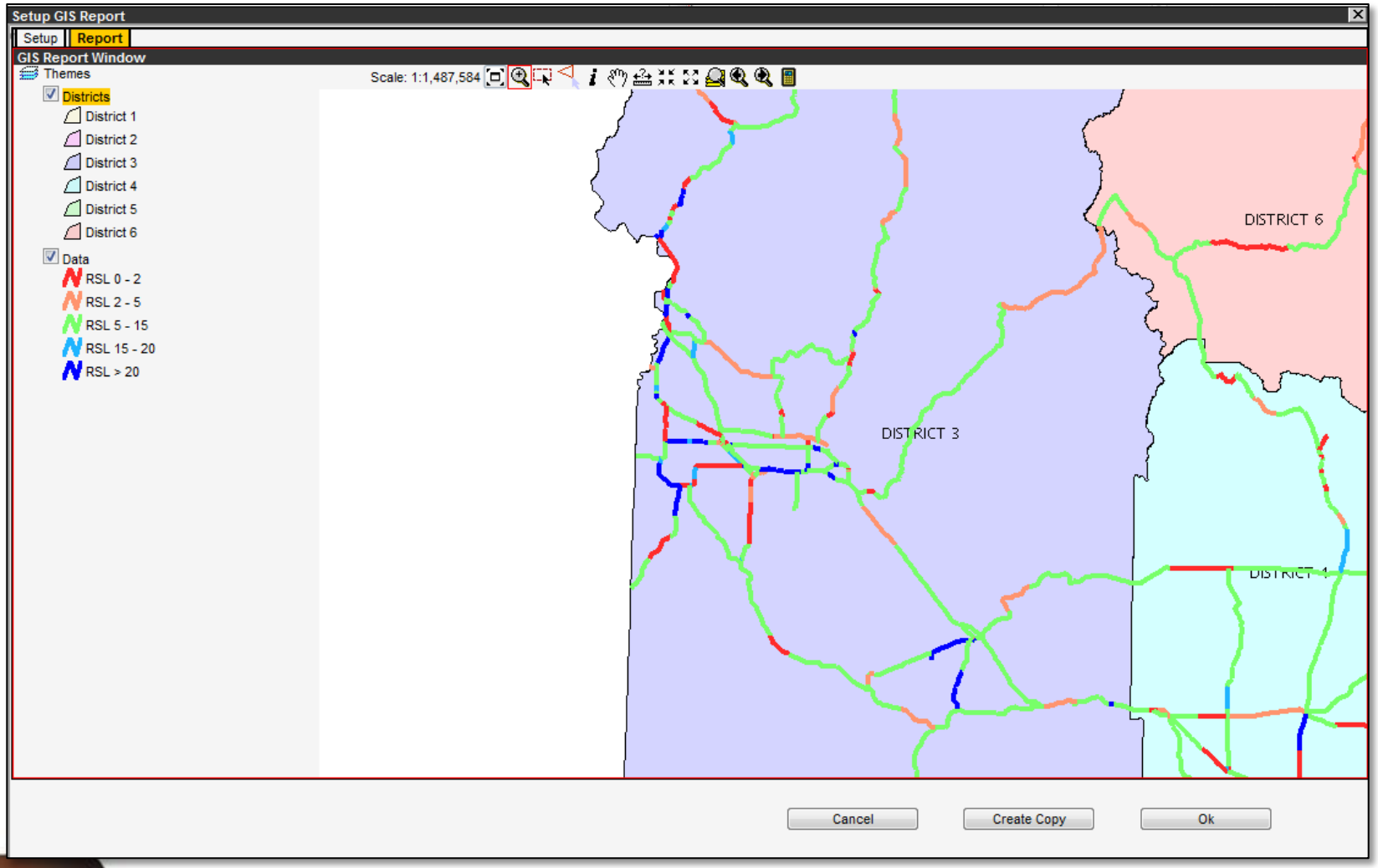


Why Does Best in Class Analysis Matter?

Approved Projects to Scenario Comparison

Route and Direction	Location				Projects in Approved Program			Projects in 140 Million Optimization Free		
	Seg. From	MP From	Seg. To	MP To	Year	Treatment	Cost	Year	Treatment	Cost
	001330	179.50	001330	181.21				2016	RC - 1R Thin Restoration	$480,410.00
								2019	RC - Surface Coat	$96,082.00
		181.21		188.50				2016	RC - 1R Thin Restoration	$2,052,864.0
								2019	RC - Surface Coat	$410,573.00
		188.50		196.00				2020	RC - 1R Thin Restoration	$2,112,000.0
I015 B BlackF		Both								
	001370	0.000	001370	2.180				2014	RC - 3R CRABS/RABS	$1,012,915.0
								2017	RC - Surface Coat	$122,778.00
		0.327		2.475	2015	Sealcoat (Chip Seal)	$101,000.00			
		2.180		2.400				2012	RC - 3R CRABS/RABS	$102,221.00
								2015	RC - Surface Coat	$12,390.00
								2020	RC - Surface Coat	$12,390.00
		2.400		3.659				2012	RC - 3R CRABS/RABS	$1,169,964.0
								2015	RC - Surface Coat	$141,814.00
								2020	RC - Surface Coat	$141,814.00
		2.485			2012	Sealcoat (Chip Seal)	$170,000.00			
		3.659		4.802	2011	3R- Mill and Inlay, Overlay	$0.00			
				4.244				2012	RC - Surface Coat	$32,947.00
								2017	RC - Surface Coat	$32,947.00
		4.244		4.454				2019	RC - 1R Thin Restoration	$118,272.00

Predicted Condition on Maps



Advantages of Commercial PMS

- What is the advantage of a commercial PMS over an agency built system?

Advantages of Commercial PMS

- MTQ - Get an already functional PMS, benefit from the expertise of the company, benefit from the enhancements brought by other clients.
- VDOT – Same as above
- NCDOT - Numerous: We get timely service rather than relying on getting scheduled in by IT. We get unexpected enhancements due to vendor development and requests from other agencies. Historically, optimization analysis has been a thorny problem to execute gracefully and the PMS gave us a state-of-the-art capability in that area.

Thank You.

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