



**The Streets of Seattle:**  
Collecting and assessing year-over-year pavement condition data for a unique network of pavements



**Seattle**



**QES IMS**  
Infrastructure Management Services

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## Presenters



**Kurt Keifer, PhD, PE**  
Principal Engineer  
President



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Project Manager



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Project Manager (QES)

Pavement Assessment



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# AGENDA

- Background
- Data Collection
- Data Processing
- Challenges
- Data in Action

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## Project Scoping Philosophy

- 1**  
Rooted in the City's desired outcomes.
- 2**  
Compliant with all technical requirements.
- 3**  
Collaborative to ensure relevance and usability of the deliverables.
- 4**  
Focused on optimizing resources to be cost-effective while meeting project goals.

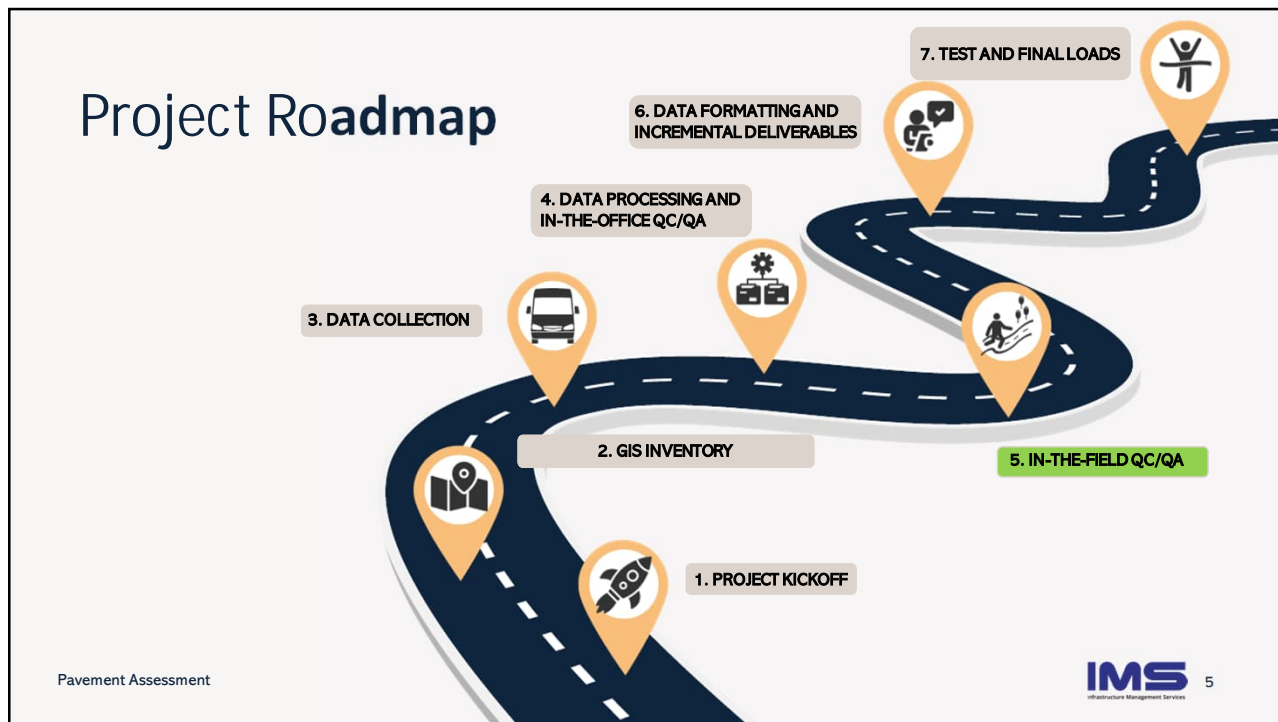
"To begin with the end in mind means to start with a clear understanding of your destination..." - Stephen Covey

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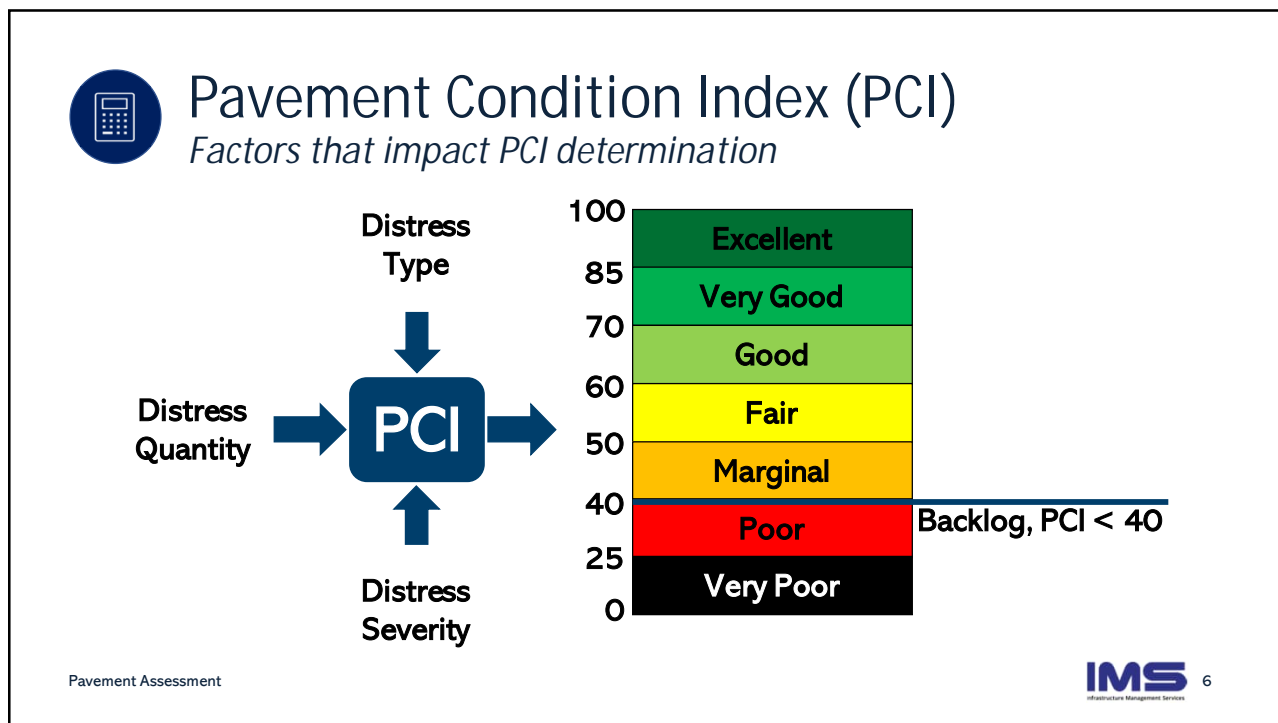


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# ASTM D6433-20 Expertise and Experience

COMMITTEE PARTICIPATION FROM D6433-98 THROUGH D6433-20

	DENSITY %	DEDUCT VALUE
13	0.12	7.9
14	0.16	11.4
15	0.20	14.9
16	0.24	18.4
17	0.28	21.9
18	0.32	25.4
19	0.36	28.9
20	0.40	32.4
21	0.44	35.9
22	0.48	39.4
23	0.52	42.9
24	0.56	46.4
25	0.60	49.9
26	0.64	53.4
27	0.68	56.9
28	0.72	60.4
29	0.76	63.9
30	0.80	67.4
31	0.84	70.9
32	0.88	74.4
33	0.92	77.9
34	0.96	81.4
35	1.00	84.9

After 24 years, the only major change has been...  
*Separation of Raveling from Weathering*

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## ASTM D6433 Asphalt Roadways

1. Alligator Cracking
2. Bleeding
3. Block Cracking
4. Bumps and Sags
5. Corrugation
6. Depression
7. Edge Cracking
8. Joint Reflection Cracking
9. Lane/Shoulder Drop Off
10. Longitudinal and Transverse Cracking
11. Patching and Utility Cut Patching
12. Polished Aggregate
13. Potholes
14. Railroad Crossing
15. Rutting
16. Shoving
17. Slippage cracking
18. Swell
19. Raveling
20. Weathering

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## ASTM D6433 Concrete Roadways

- |                                     |                               |
|-------------------------------------|-------------------------------|
| 21. Blow Up                         | 31. Polished Aggregate        |
| 22. Corner Break                    | 32. Popouts                   |
| <b>23. Divided (Shattered) Slab</b> | 33. Pumping                   |
| 24. Durability Cracking             | 34. Punchout                  |
| <b>25. Faulting</b>                 | 35. Railroad Crossing         |
| 26. Joint Seal Damage               | 36. Scaling                   |
| <b>27. Lane/Shoulder Dropoff</b>    | <b>37. Shrinkage Cracking</b> |
| <b>28. Linear Cracking</b>          | 38. Corner Spalling           |
| 29. Large Patch                     | 39. Joint Spalling            |
| 30. Small Patch                     |                               |

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# IrisPRO Pave™

**Safety**  
Travels at posted speed, and no traffic control is required

**3D Pavement Imaging**  
Laser Crack Measurement System (LCMS)  
– Second Evolution  
[ASTM D6433 PCI Surveys]

**Inertial Profiler – International**  
Roughness Index (IRI) – NCAT/TTI certified

**360-Degree Imaging Right-of-way (ROW)** asset data collection

*Note: Manufactured by IMS/ICC – We've got 8 systems!*

**Safety Lighting**  
Front and back facing flashing lights ensure high visibility.

**NOMAD**  
Manual entry of pavement distresses and field observations

**Teledyne FLIR Ladybug 5+**  
Captures 360° imagery at defined intervals

**GPS Positioning**  
GPS with integrated IMU, sub meter positional accuracy

**Pavement Distress Imaging**  
LCMS-2, continuous 3D imaging, 1mm resolution

**Samsara Monitoring**  
Real time tracking and reporting

**Profiler**  
Continuous right and left wheel path roughness measurements

**Linear Distance Positioning**  
DMI for precise linear distance measurements

**Texture**  
Continuous surface texture measurements

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## 3D PAVEMENT IMAGING W/LASER ILLUMINATION

Laser Crack Measurement System (LCMS) Second Evolution Technology

Cracking

Sealed Cracking


Concrete Joints

Utilities

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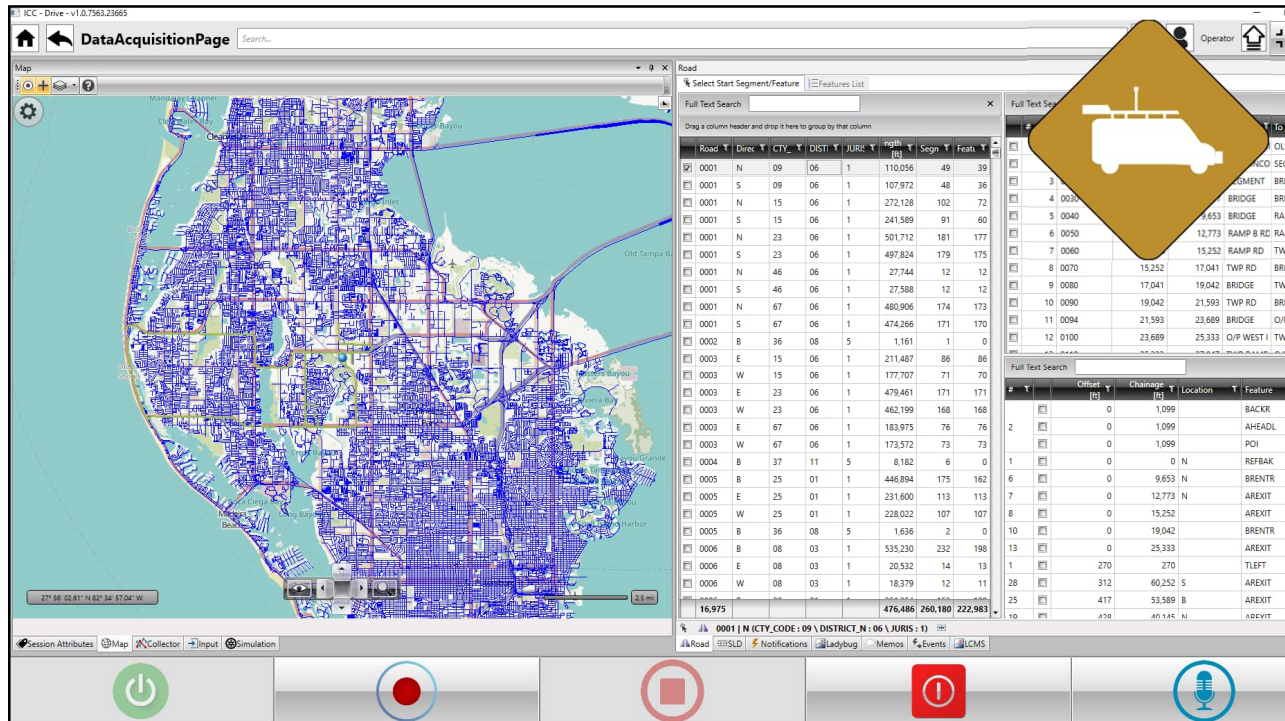
Drive™      Connect™      Inform™



# Unify Suite

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Road	Dir	City	Dist	Jur	Length (ft)	Segn	Feat
0001	N	09	06	1	110,056	49	39
0001	S	09	06	1	107,972	48	36
0001	N	15	06	1	272,128	102	72
0001	S	15	06	1	241,589	91	60
0001	N	23	06	1	501,712	181	177
0001	S	23	06	1	497,824	179	175
0001	N	46	06	1	27,744	12	12
0001	S	46	06	1	27,588	12	12
0001	N	67	06	1	480,906	174	173
0001	S	67	06	1	474,266	171	170
0002	B	36	08	5	1,161	1	0
0003	E	15	06	1	211,487	86	86
0003	W	15	06	1	177,707	71	70
0003	E	23	06	1	479,461	171	171
0003	W	23	06	1	462,199	168	168
0003	E	67	06	1	183,975	76	76
0003	W	67	06	1	173,572	73	73
0004	B	37	11	5	8,182	6	0
0005	B	25	01	1	446,894	175	162
0005	E	25	01	1	231,600	113	113
0005	W	25	01	1	228,022	107	107
0005	B	36	08	5	1,636	2	0
0006	B	08	03	1	535,230	232	198
0006	E	08	03	1	20,532	14	13
0006	W	08	03	1	18,379	12	11
<b>16,975</b>					<b>476,486</b>	<b>260,180</b>	<b>222,983</b>

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**Concrete Pavements**

Platform	System	Ses	Date	Time	Length [m]	Matched [m]	Start [m]	End
ICC Drive	ICC43	230324135059	3/24/2023	1:51 PM	1.022	0.996	0.000	
ICC Drive	ICC43	230324135707	3/24/2023	1:57 PM	0.135	0.117	0.000	
ICC Drive	ICC43	230324135806	3/24/2023	1:58 PM	0.140	0.117	0.000	
ICC Drive	ICC43	230324135923	3/24/2023	1:59 PM	0.285	0.258	0.000	
ICC Drive	ICC43	230324140124	3/24/2023	2:01 PM	1.020	0.996	0.000	
ICC Drive	ICC43	230324140836	3/24/2023	2:08 PM	0.194	0.181	0.000	
ICC Drive	ICC43	230324141058	3/24/2023	2:10 PM	0.187	0.181	0.000	
ICC Drive	ICC43	230325105255	3/25/2023	10:52 AM	1.551	1.530	0.000	
ICC Drive	ICC43	230325105929	3/25/2023	10:59 AM	1.548	1.530	0.000	
ICC Drive	ICC43	230325110821	3/25/2023	11:08 AM	0.174	0.132	0.000	
					1394	847.861	782.411	

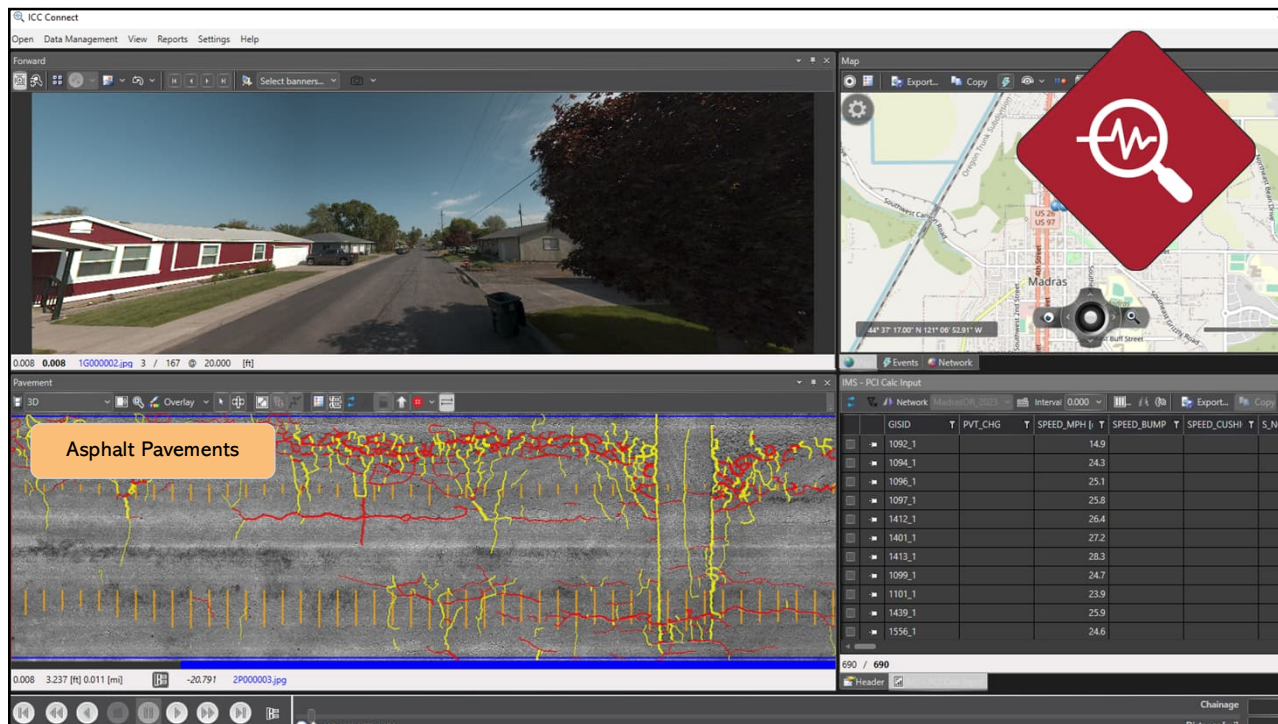
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**Composite Pavements**

Platform	System	Ses	Date	Time	Length [m]	Matched [m]	Start [m]	End
ICC Drive	ICC43	230324135059	3/24/2023	1:51 PM	1.022	0.996	0.000	
ICC Drive	ICC43	230324135707	3/24/2023	1:57 PM	0.135	0.117	0.000	
ICC Drive	ICC43	230324135806	3/24/2023	1:58 PM	0.140	0.117	0.000	
ICC Drive	ICC43	230324135923	3/24/2023	1:59 PM	0.285	0.258	0.000	
ICC Drive	ICC43	230324140124	3/24/2023	2:01 PM	1.020	0.996	0.000	
ICC Drive	ICC43	230324140836	3/24/2023	2:08 PM	0.194	0.181	0.000	
ICC Drive	ICC43	230324141058	3/24/2023	2:10 PM	0.187	0.181	0.000	
ICC Drive	ICC43	230325105255	3/25/2023	10:52 AM	1.551	1.530	0.000	
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ICC Drive	ICC43	230325110821	3/25/2023	11:08 AM	0.174	0.132	0.000	
					1394	847.861	782.411	

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# Engineer-Led Approach to QC/QA

## ASTM D6433 Pavement Condition Index (PCI) Surveys

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# Reality isn't Perfect...

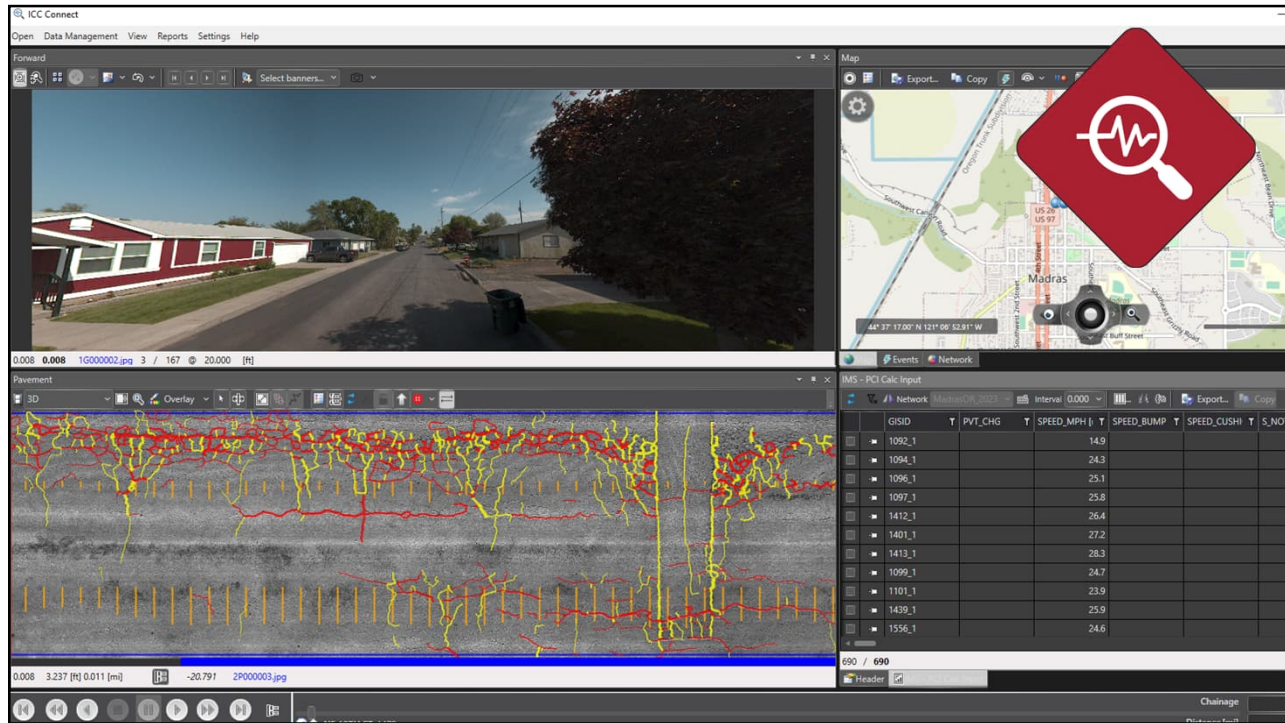
Some distresses simply require manual review by trained and certified ASTM D6433 Pavement Condition Index (PCI) raters

LCMS Results:	NOMAD Info:	NOMAD Quantiles:	Section Info:
Soil Type: Asphalt	SoilType: Asphalt	Gator (P*2): 353.5	GISID: 4002.0
Algorithm (P*2): 103.6	SoilName:	Block (P*2): 0.0	Street Name: WEBSTER RD
LAT (P): 607.4	SoilDistress:	Ravelling (P*2): 0.0	Street From: PVT-394B
Edge (P): 0.0		Bleeding (P*2): 0.0	Street To: PVT-3947
Swelling (P): 102.2		Patching (P*2): 0.0	Width (P): 20.0
Rutting (P*2): 0.0			Length (P): 197.0 of 459.7
			Total Sample Area (P*2): 5976.1
			Total Pavnt Area (P*2): 9734.0

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## Proactive and Collaborative QC/QA *In-the-Field Validation of Pavement Conditions*

**Data Quality Management Plan (DQMP)**

Tailored to the project.



**Pilot Study "Fast Track" Processing**

Run for pavements prior to data processing.



**In-the-Field Validation of Pavement Conditions**

During data collection and processing.



**Collaborative, Multi-Step QC/QA**

Active participation from the City.





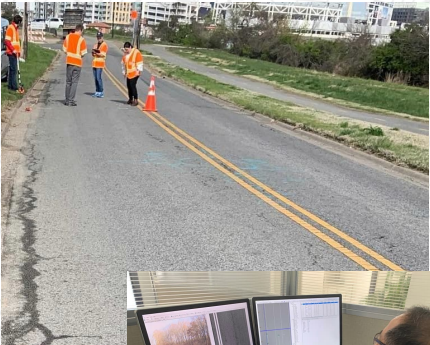

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## USE OF MULTIPLE CALIBRATION SECTIONS

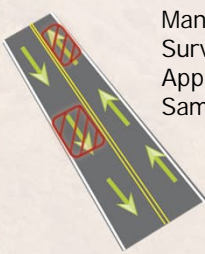
1. Ground Reference Measurements (2 QES Raters with SDOT Conformation)
2. Calibrate Semi-Automated Rating Process
3. Sampling Rate vs. Full Lane Survey

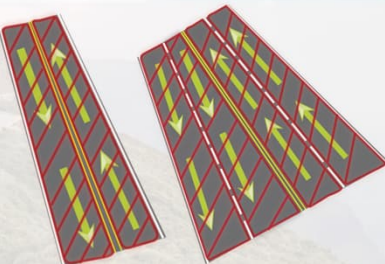
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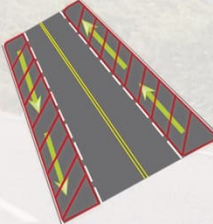
## SAMPLING VS FULL LANE SURVEYS



Manual PCI Surveys Based on Approx. 10% Sampling



Automated PCI Surveys – All Lanes  
*Good for Baseline Surveys*

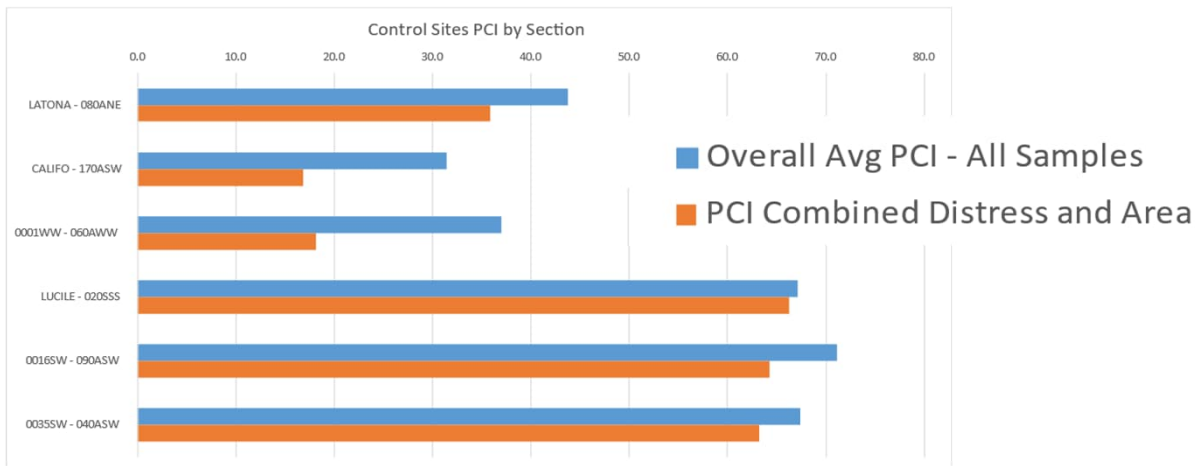


Automated PCI Surveys – 1 Pass/2 Pass  
*Most Common Approach for Routine Surveys*

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## CONTROL SITES PCI BY SECTION



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## GROUND REFERENCE SURVEYS



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# GROUND REFERENCE SURVEYS



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# GROUND REFERENCE SURVEYS



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## OVERALL CHALLENGES

- Primary and Secondary Segments Associated with the Same Centerline ID
- Multiple Pavement Types in the Same Block
- Urban Area with Dense Traffic and Parked Cars




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## CHALLENGES



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## JOINTED CONCRETE PAVEMENT CHALLENGES

- Non-Typical Joint Configurations
- Longitudinal Joints Don't Match Lane Striping
- Wide Slabs
- Parked Cars



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## JOINTED CONCRETE PAVEMENT REMEDIES

- 100% Manual Image Reviews
- Outlier Analysis
- Google Earth Street View
- Compare to Last Survey

LCMS Results:	NOMAD Info:	NOMAD Quantities:	Section Info:
Srf Type: Asphalt	SrfType: Jointed Concrete	Shattered Slab: 3	Station: 487.7
Aligner (ft): 6.7	Section:	Tearing: 0.0	Street Name: SW THISTLE ST
LAT (ft): 490.0	SurfDietess:	Faulting: 13.0	Street From: 40TH AVE SW
Edge (ft): 50.5	Name: Strip Rows: 2	Spalling: 0.0	Street To: 41ST AVE SW
Sealed (ft): 45.2	Crw Bk: 1	Bad Joint Seal: 0.0	Width (ft): nan
Rutting (ft): 21.6	Spalling: 1	Crk Narrow: 0.0	Length (ft): 261.4 of 448.0 (GIS: 448.4)
	Patching: 2	Crk Wide: 0.0	Slab Count: 13.0 of 23.0
	Collection Day: 2022-09-01		Total Paved Area (ft <sup>2</sup> ): nan
			Pave: 2.0

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## QC/QA OF COLLECTED DATA – AC SECTIONS

Attributes	Flagging Rules (Criteria)
Longitudinal/Transverse Cracks	Total area of Longitudinal/Transverse cracks is greater than 30% of inspection area.
Longitudinal/Transverse Cracks	Total area of longitudinal/transverse cracks is greater than 22% of the inspection area minus total area of alligator and block cracks and patching.
Alligator Cracks	Total area of alligator cracks is greater than Inspection area minus total area of block cracking, patching and raveling.
Block Cracks	Total area of block cracks is greater than Inspection area minus total area of alligator cracking, patching and raveling.
Patching	Total area of patching is greater than 60% of inspection area.
Rutting	Total area of rutting is greater than 30% of the inspection area.
Raveling	Total area of raveling is greater than the inspection area minus total area of patching and weathering.
Weathering	Total area of weathering is greater than inspection area minus total area of patching and raveling.
Inspection PCI & Historical M&R	Difference between the inspection PCI and StreetSaver projected historical PCI is greater than 25 and no M&R activity has reported since the last inspection.
Inspection PCI	Difference between the inspection PCI and StreetSaver projected historical PCI is less than -16.
Historical M&R and pavement distresses	Either of alligator cracks, block cracks, longitudinal/transverse cracks, patching, raveling, rutting or weathering was reported in the last inspection cycle but not in the current cycle, and no M&R activity was reported since the last inspection.

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## QC/QA OF COLLECTED DATA – JCP SECTIONS

Attributes	Flagging Rules (Criteria)
Individual distress count	Total number of slabs with each individual distress (e.g., corner break) is greater than the total number of slabs.
Divided slab	Total number of divided slabs is greater than total number of slabs minus slab counts with faulting.
Linear cracks	Total number of slabs with linear cracks is greater than total number of slabs minus divided slab counts.
Scaling/map cracking	Total number of slabs with scaling is greater than total number of slabs minus divided slab counts.
Corner break	Total number of slabs with corner break is greater than total number of slabs minus divided slab counts.
Patching & utility cuts	Total number of slabs with patching is greater than total number of slabs minus divided slab counts.
Spalling	Total number of spalled slabs is greater than total number of slabs minus divided slab counts.
Inspection PCI & Historical M&R	Difference between the inspection PCI and StreetSaver projected historical PCI is greater than 25 and section has not received any M&R activity since the last inspection.
Inspection PCI	Difference between the inspection PCI and StreetSaver projected historical PCI is less than -16.
Historical M&R and pavement distresses	Either of corner break, divided slab, faulting, linear crack, patching, scaling, or spalling was reported in the last inspection cycle but not in the current cycle, and the section has not received any M&R activity since last inspection.

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## RERATING THE FLAGGED SECTIONS

- Review of Flagged Sections by QES Raters and SDOT
- Rerating and Adjustment of Distress Rating
- Some Flagged Sections Were Excluded per SDOT Recommendation

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## STREETSAVER CHALLENGES

Hanson Sections Didn't Meet Sample Size Requirements

- AC Sections Were Broken Into Smaller Samples of 1,000 to 4,000 ft<sup>2</sup>
- JCP Sections Were Broken Into Smaller Samples with 10-30 Slabs
- Smaller samples were prorated and imported into StreetSaver

Section: 000551-010SNE

**Executive Dashboard**

Pavement Area (square miles): 8.36 | Centerline Miles: 1676.6

**Historical Pavement Condition Trends**

Year	2018	2019	2020	2021	2022	Current
PCI	57	56	54	53	54	53

**Current PCI by Functional Class**

Category	PCI
Other	52
Residential/Local	48
Urban Collector (3)	57
Urban Minor Arterial (4)	59
Urban Principal Arterial-Other (2)	62

**Percent of Area by Surface Type**

Surface Type	Percentage
PCC	30%
AC/PCC	20%
AC	20%
ACIAC	10%
ST	10%

**Historical Network Condition Trends**

Category	% of Sections
Very Good	80%
Good	10%
Fair	7%
Very Poor	2%

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# AGENDA

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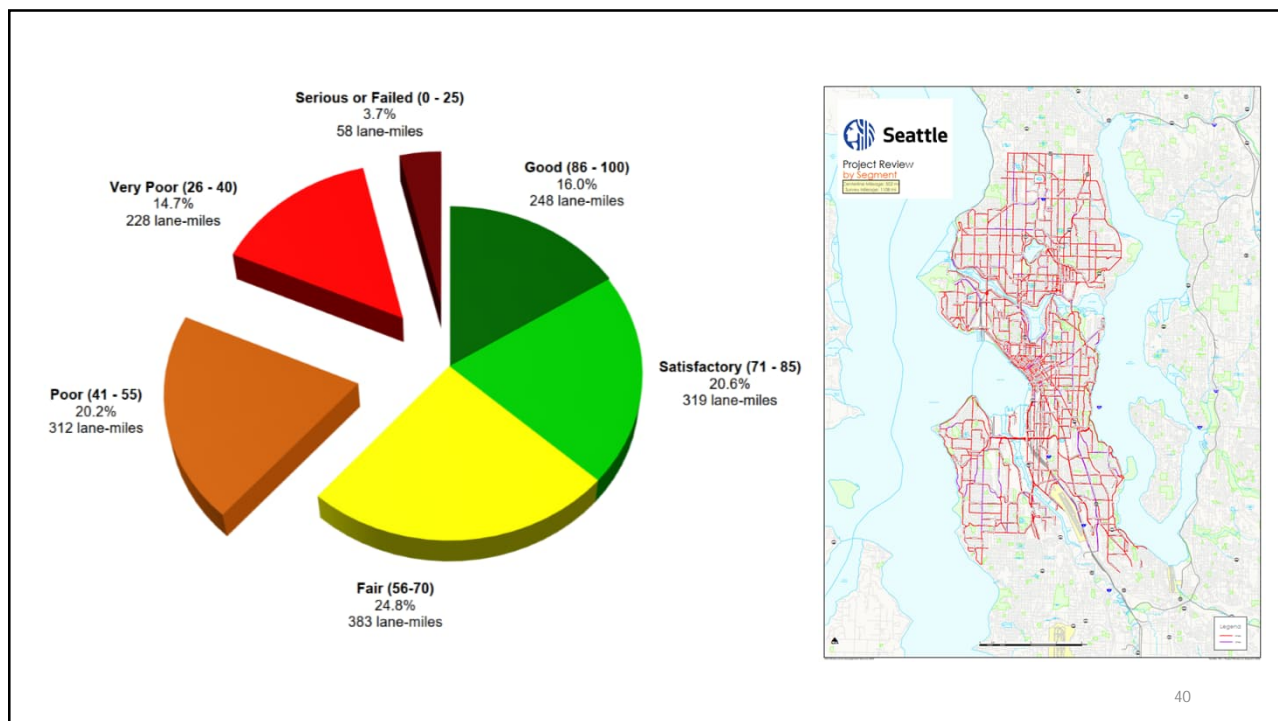
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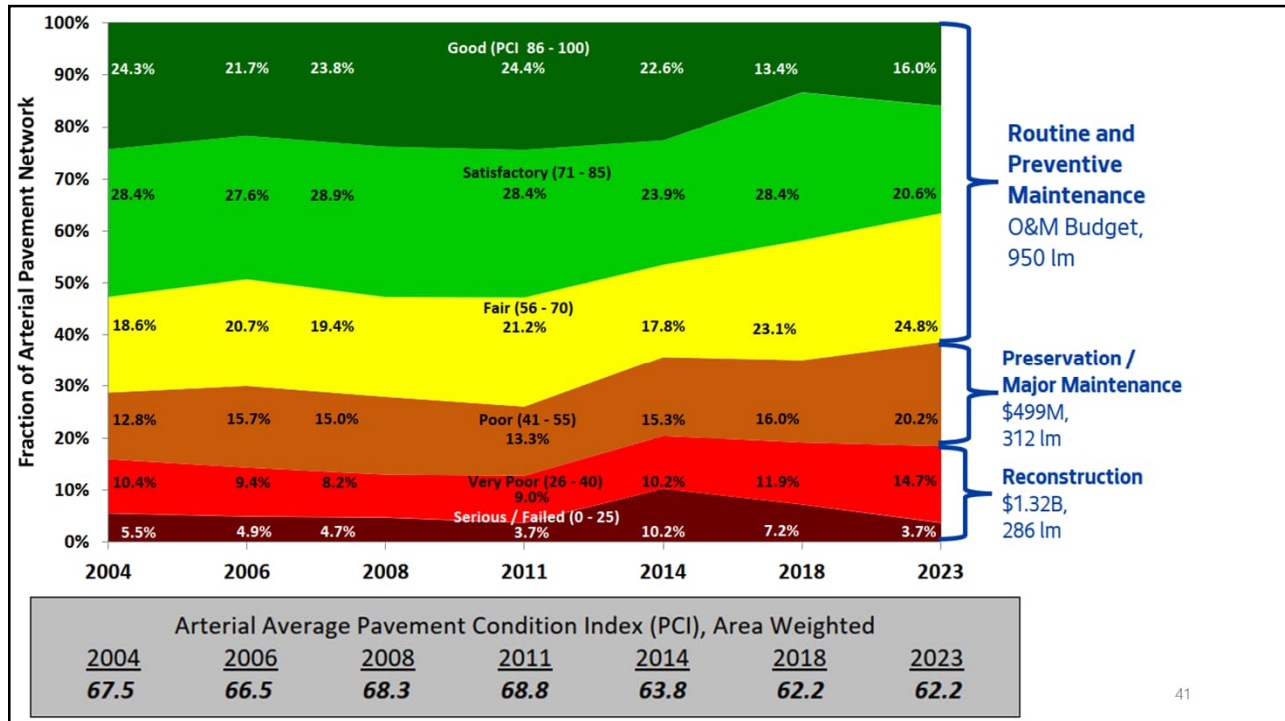
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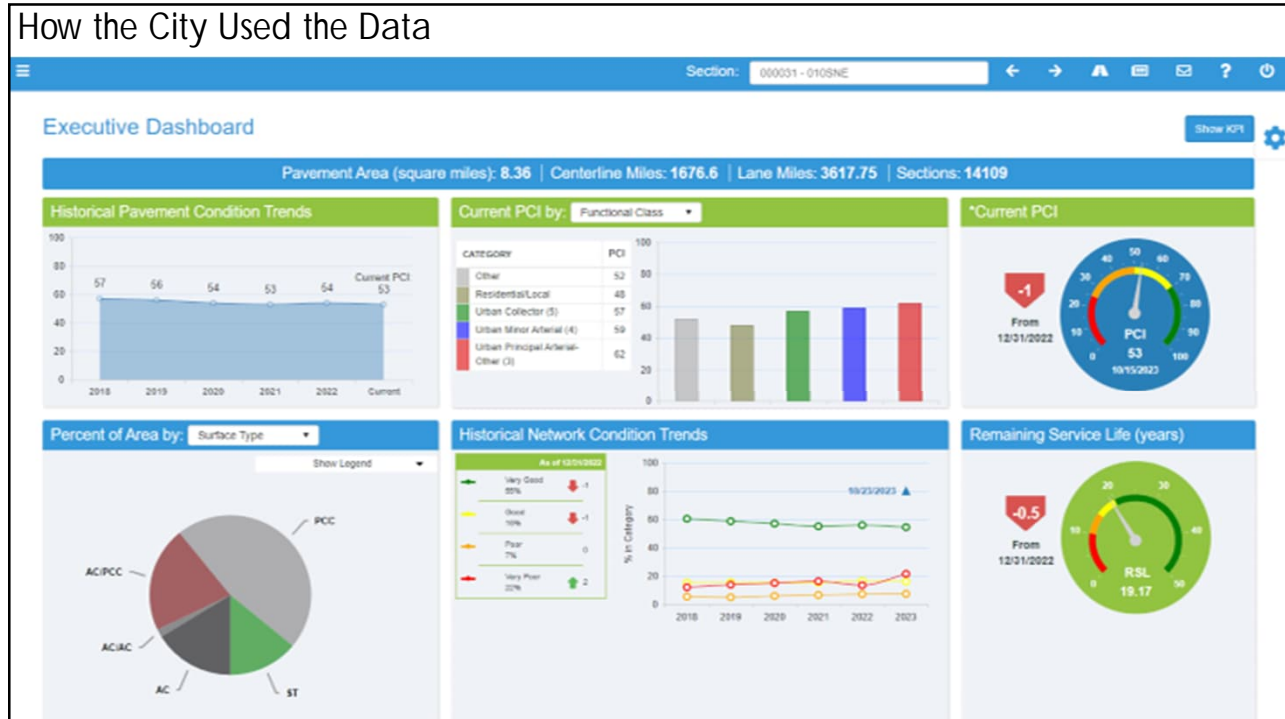
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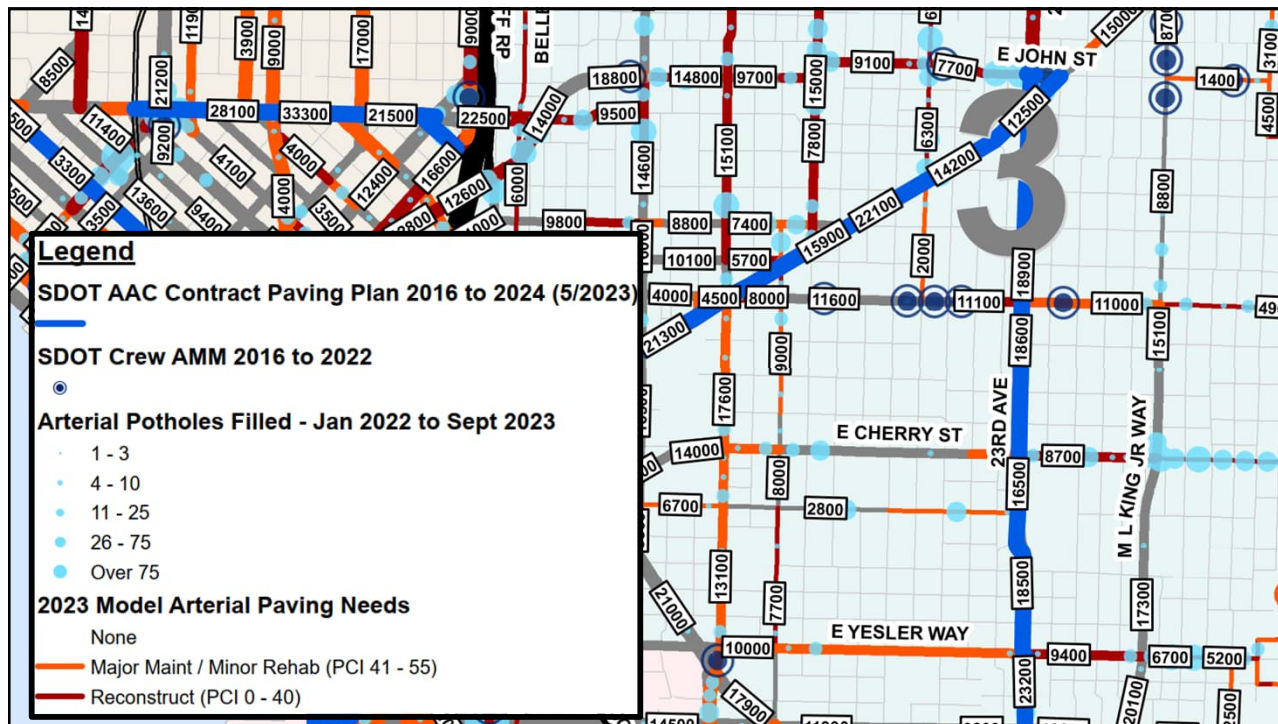
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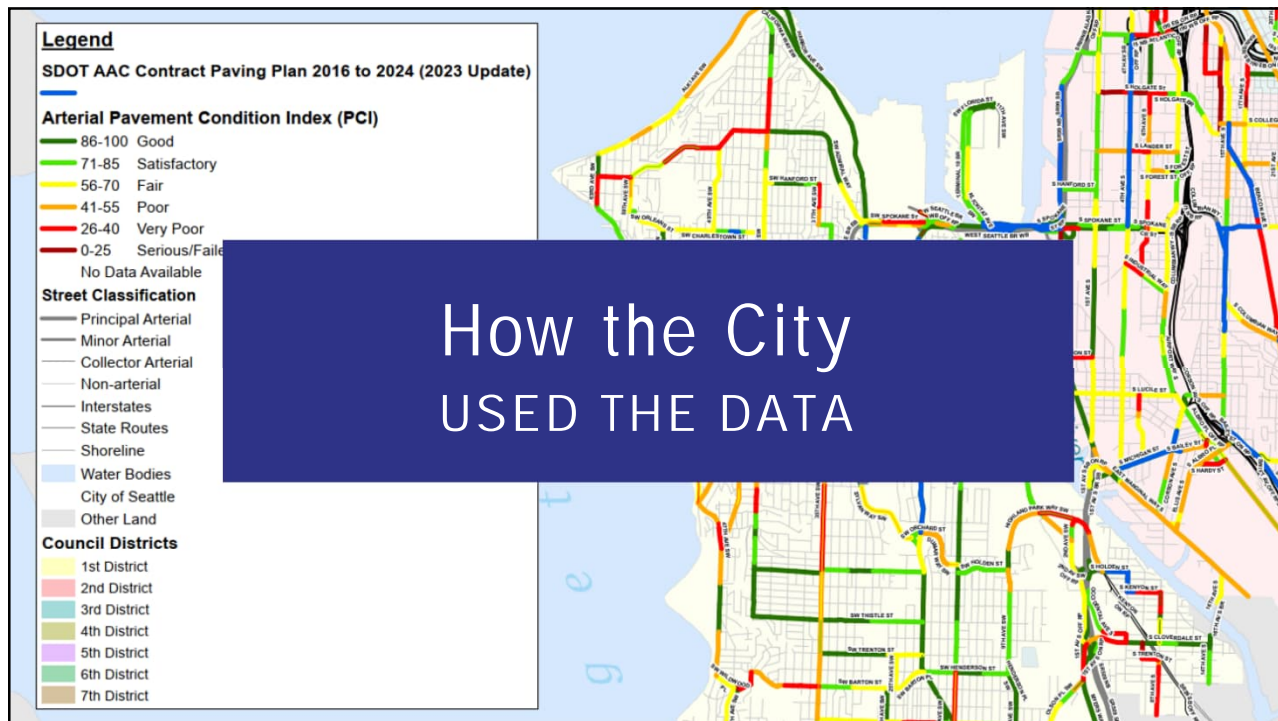
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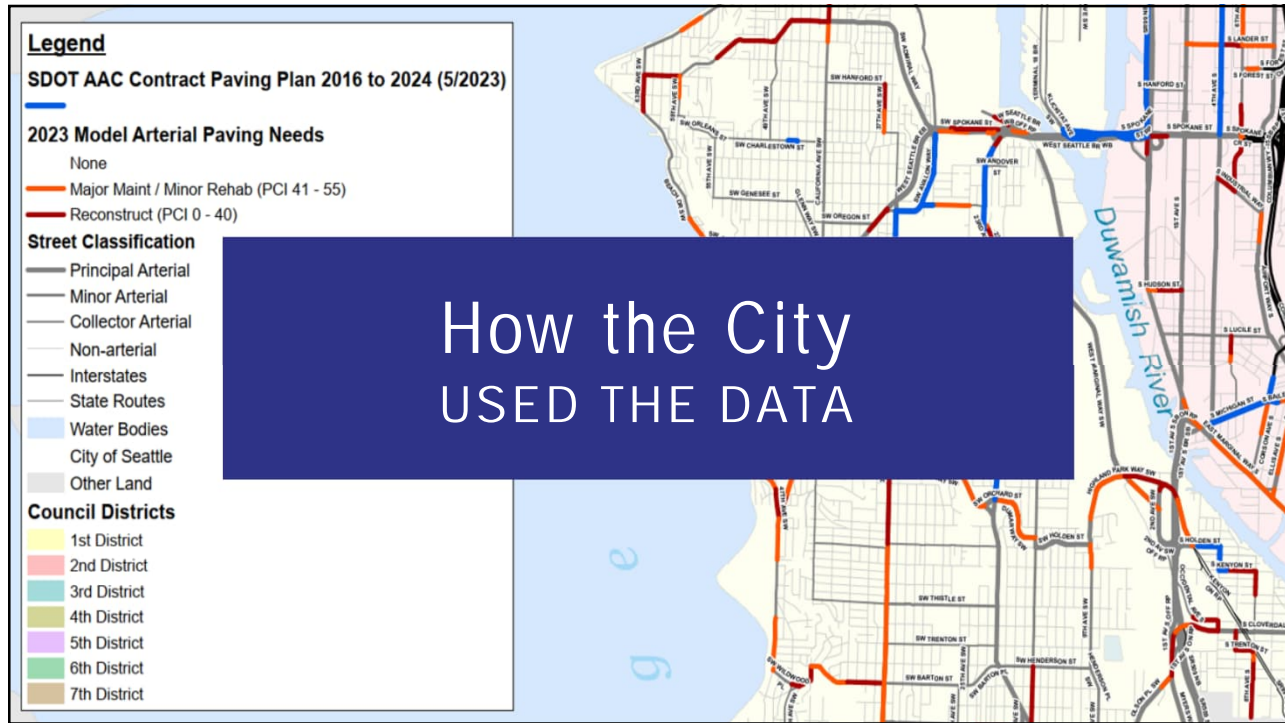
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**THANK YOU**



**Kurt Keifer, PhD, PE**  
Principal Engineer  
President



**Sadaf Khosravifar, PhD, PE**  
Project Manager



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Project Manager (QES)

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