A Study of Varied Prioritization Methods for Road Repair

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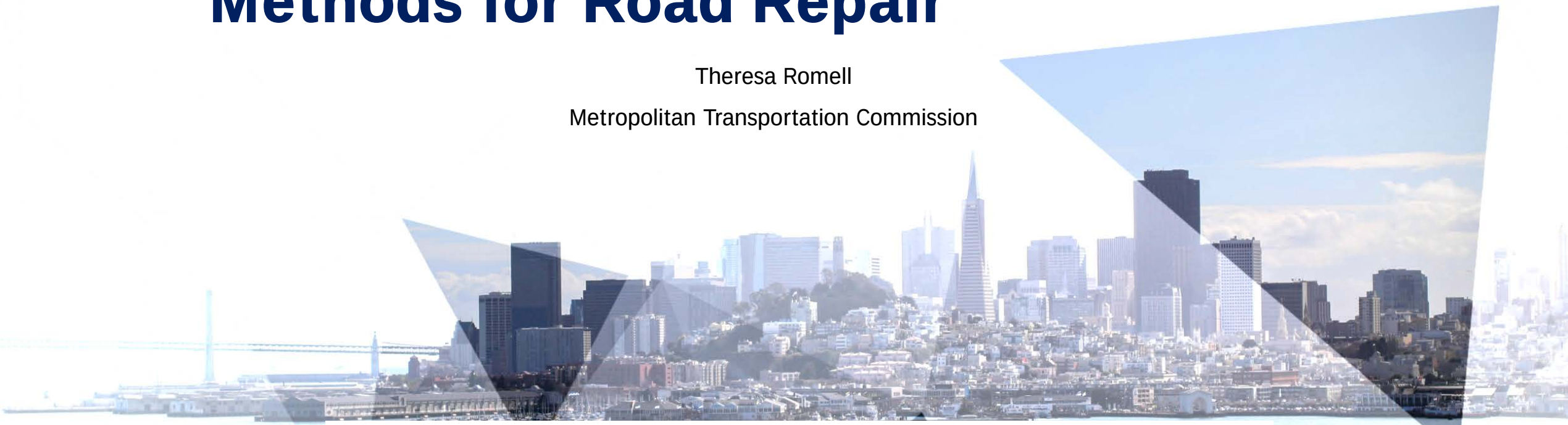
Metropolitan Transportation Commission



11th National Conference on Transportation Asset Management

Minneapolis

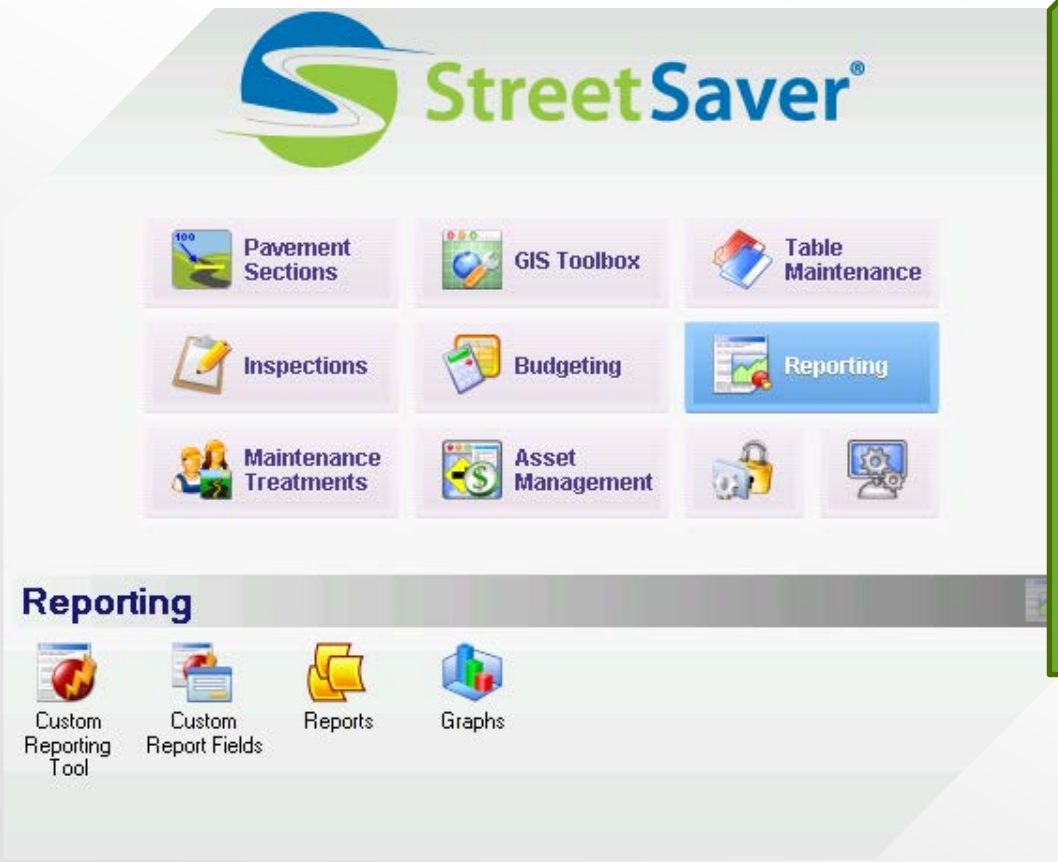
July 10 – 12, 2016

San Francisco Bay Area Region

- 9 Counties
- 100 Local Jurisdictions
- 43,000 lane miles of roads
- Average PCI = 67
- All jurisdictions use StreetSaver

StreetSaver®

Tools / Technology



- Network Level Pavement Management System
- Initially Developed 30 Years Ago
- 400+ Users

- Cloud-Based
- SQL Server Based
- 8 Distresses – ASTM D6433
- Weighted Effectiveness Ratio Prioritization Default

- GIS Mapping
- Budget & Target Driven Scenarios
- **Project Selection**
- Asset Management Solutions

Problem Statement:

With Limited Resources, On What Basis Should Governments Prioritize Funding for Road Repair?

Prioritization Methods

- Cost Effectiveness (WER)
- Worst First
- Maximize “User” Cost Savings
- Benefit/Cost Assessment
- Other Goals – Transit Route Preference, Active Transportation, District, Political/Socioeconomic

Prioritization Case Study

Sample Jurisdiction

- Mid-Size, Urban Jurisdiction
- 1,000 Lane Miles
- Current PCI = 61
- Backlog = $148 M
- 10-Year Maintenance Need = $395 M
- Annual Budget = $20 M

Needs - Projected PCI/Cost Summary

Inflation Rate = **3.00** **%** Printed: 06/23/2016

Year	PCI Treated	PCI Untreated	PM Cost	Rehab Cost	Cost
2016	78	61	$5,471,283	$142,925,269	$148,396,552
2017	78	58	$718,200	$43,820,807	$44,539,007
2018	79	56	$1,191,569	$47,126,202	$48,317,771
2019	80	54	$1,125,566	$47,209,898	$48,335,464
2020	81	51	$1,157,819	$41,327,747	$42,485,566
2021	81	49	$1,434,612	$17,090,959	$18,525,571
2022	80	46	$1,213,210	$10,242,066	$11,455,276
2023	79	44	$944,354	$2,674,727	$3,619,081
2024	78	41	$1,092,189	$6,223,204	$7,315,393
2025	78	39	$11,325,856	$10,789,327	$22,115,183

% PM	PM Total Cost	Rehab Total Cost	Total Cost
6.50%	**$25,674,658**	**$369,430,206**	**$395,104,864**

Prioritization Approach #1 – WER (Default for Streetsaver)

WER = $\frac{\text{(Area/Year)WF}}{\text{EUAC/SY}}$

Where:

WER = Weighted Effectiveness Ratio

AREA = Area of improvement under PCI curve

YR = Years Affected

WF = Functional Class weighting factor

EUAC = Equivalent uniform annual cost

SY = Square yards in pavement section

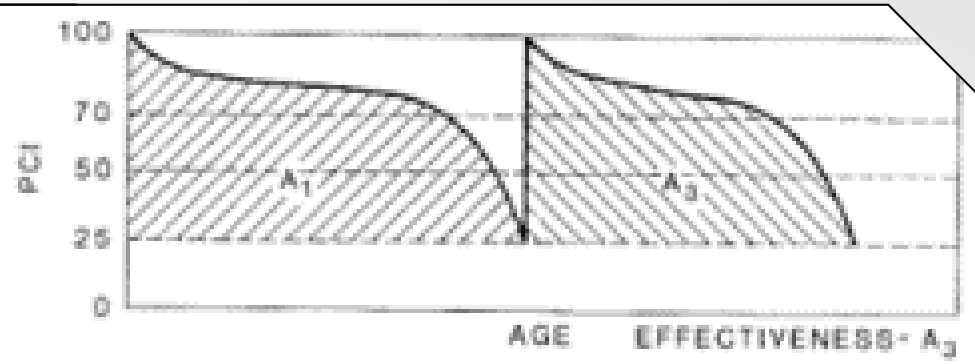


FIGURE 2 Effectiveness of rehabilitation applied at the end of acceptable pavement life shown as A_2.

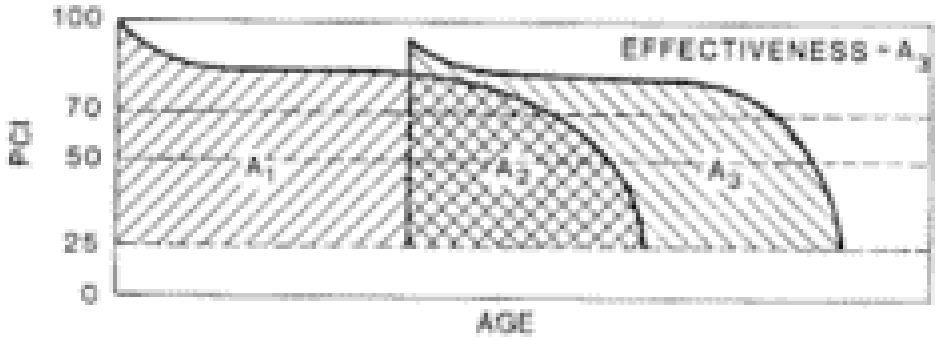
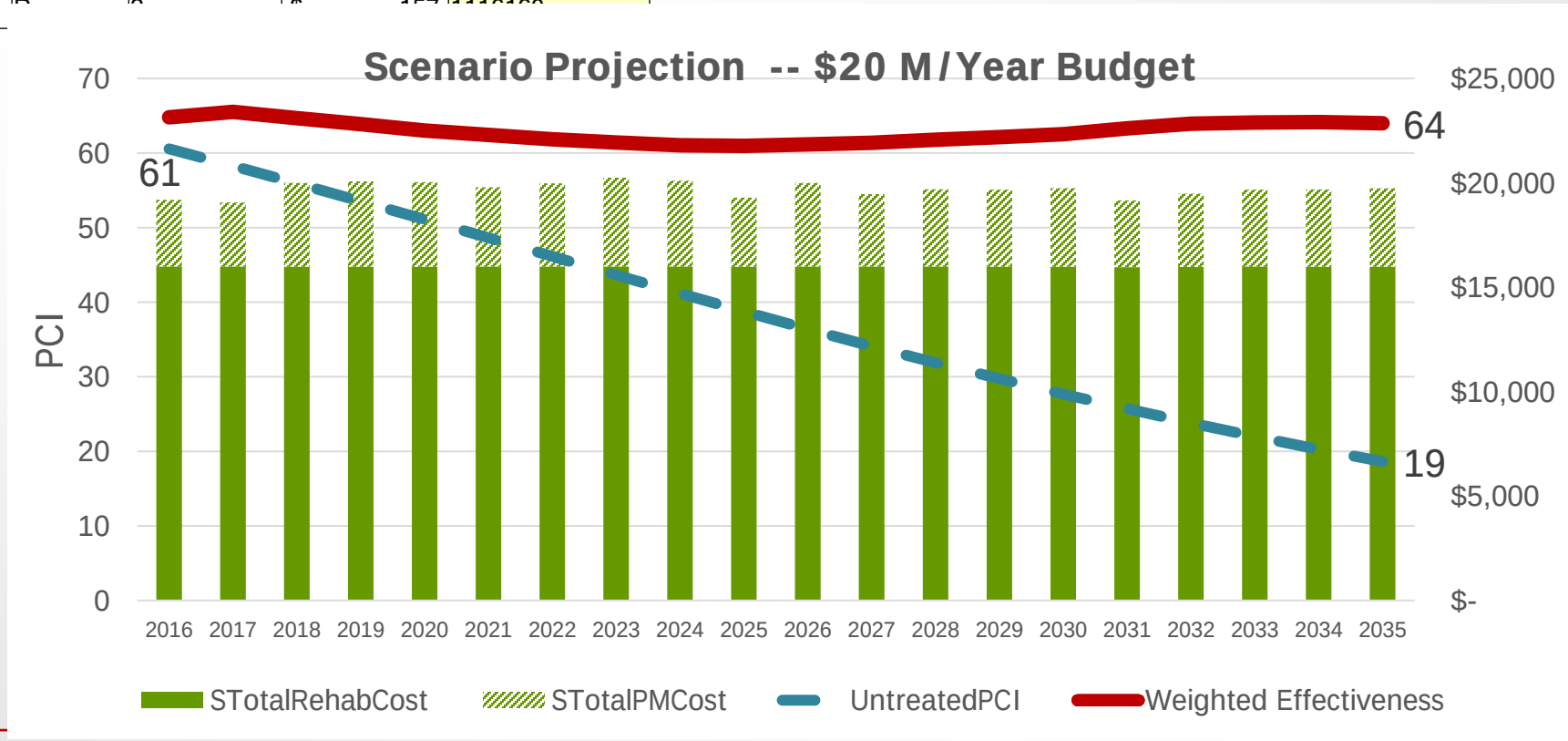


FIGURE 3 Effectiveness of rehabilitation applied ...re end of acceptable pavement life shown as A_2.

Prioritization Approach #1 -- WER

Street ID	Section ID	PCI Prior to Treatment	Treated PCI	Section Area	Functional Class	Life Extension	Total Cost	Weighted Effectiveness
05925	N130	84	85	62880	A	1	$ 236	2279105
03920	N100	84	85	74232	A	1	$ 232	2120820
07530	N090	80	82	7986	R	2	$ 109	1219594
04970	N100	81	83	16874	R	1	$ 261	1138017
07828	W100	75	77	17148				



Project Selection Process

Perform Needs Calculation in PMS

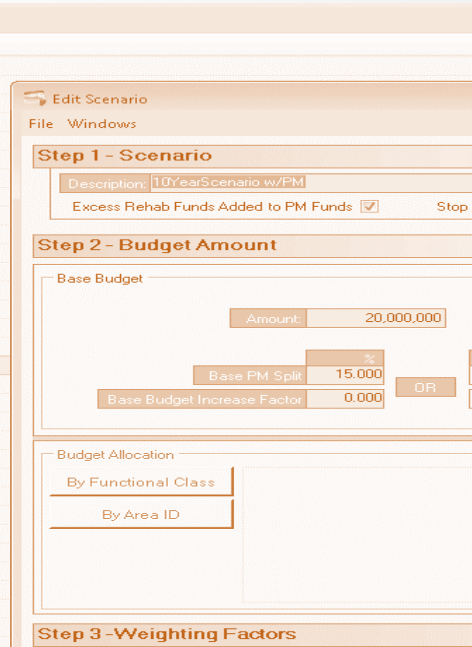
Download Section Information & Perform Analysis in Excel

Import Selected Sections as a "Project"

Add Project to Scenario and Run

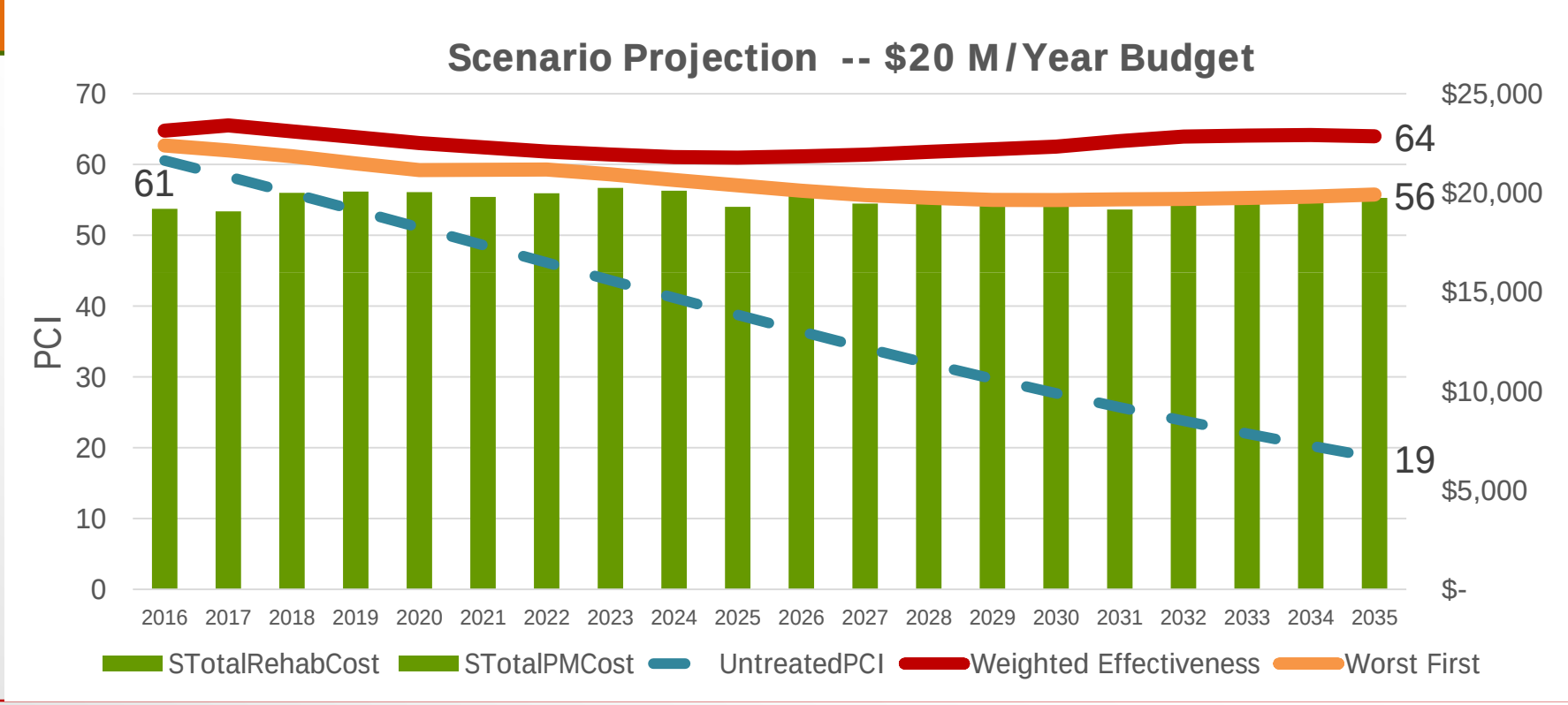
Street ID	Section ID	Life Extension	Weighted Effectiveness	PCI Prior to Treatment	Section Area	Functional Class	Total Cost
00040	W101	34	5847	14	23913	R	$ 201,826
00200	N115	24	3829	15	29973.57	C	$ 458,995
00105	W110	82	7730	20	10224	R	$ 108,556
00045	W110	34	6497	23	7944	R	$ 60,339
00020	W130E	25	3524	23	16160	A	$ 343,023
05660	N100	33	10669	40	13941	R	$ 66,638
04367	N100	33	16958	40	10560	R	$ 31,774
04715	W114	25	12001	40	52860	A	$ 361,680
01460	W100	33	16953	40	8768	R	$ 26,382
02445	W100	33	16952	40	7040	R	$ 21,183
03883	W100	33	16952	40	7127	R	$ 21,444
04371	W270	27	10033		17040.24	C	$ 98,720
07503	W100	33	1		3004	R	$ 129,394
03802	N100				24000	R	$ 72,213
03665	N100					R	$ 45,254
05330						R	$ 63,894
00555	N1				59200	R	$ 178,126
02105	W100				5120	R	$ 159,832
01926					34464	R	$ 103,698
01130	W				2451	R	$ 112,096
03099	N12				12960	R	$ 61,949
04615				40	6120	R	$ 18,414
05174	W100		16921	40	6400	R	$ 19,257
07666	W100	33	10656	40	5040	R	$ 24,091

Customize download info with custom report wizard



Prioritization Approach #2 – Worst First

- Prioritize repair of backlog by PCI: lowest to highest
- No funds for preventive maintenance



Prioritization Approach #3 – User Cost

- Most common proxy for user cost is **“Vehicle Operating Cost (VOC)”** associated with driving on poorly maintained roadways
- Prioritizes high usage streets with poorer conditions for repair
- Requires PCI to IRI conversion
- Can use actual vehicle miles traveled info or proportional, based on functional class

TRIP
a national transportation research group

Prioritization Approach #3 – User Cost

User Cost Savings =

$(AVMT_{PAVESEC} \times VOC\ UnTr) - (AVMT_{PAVESEC} \times VOC\ Tr)$

Where:

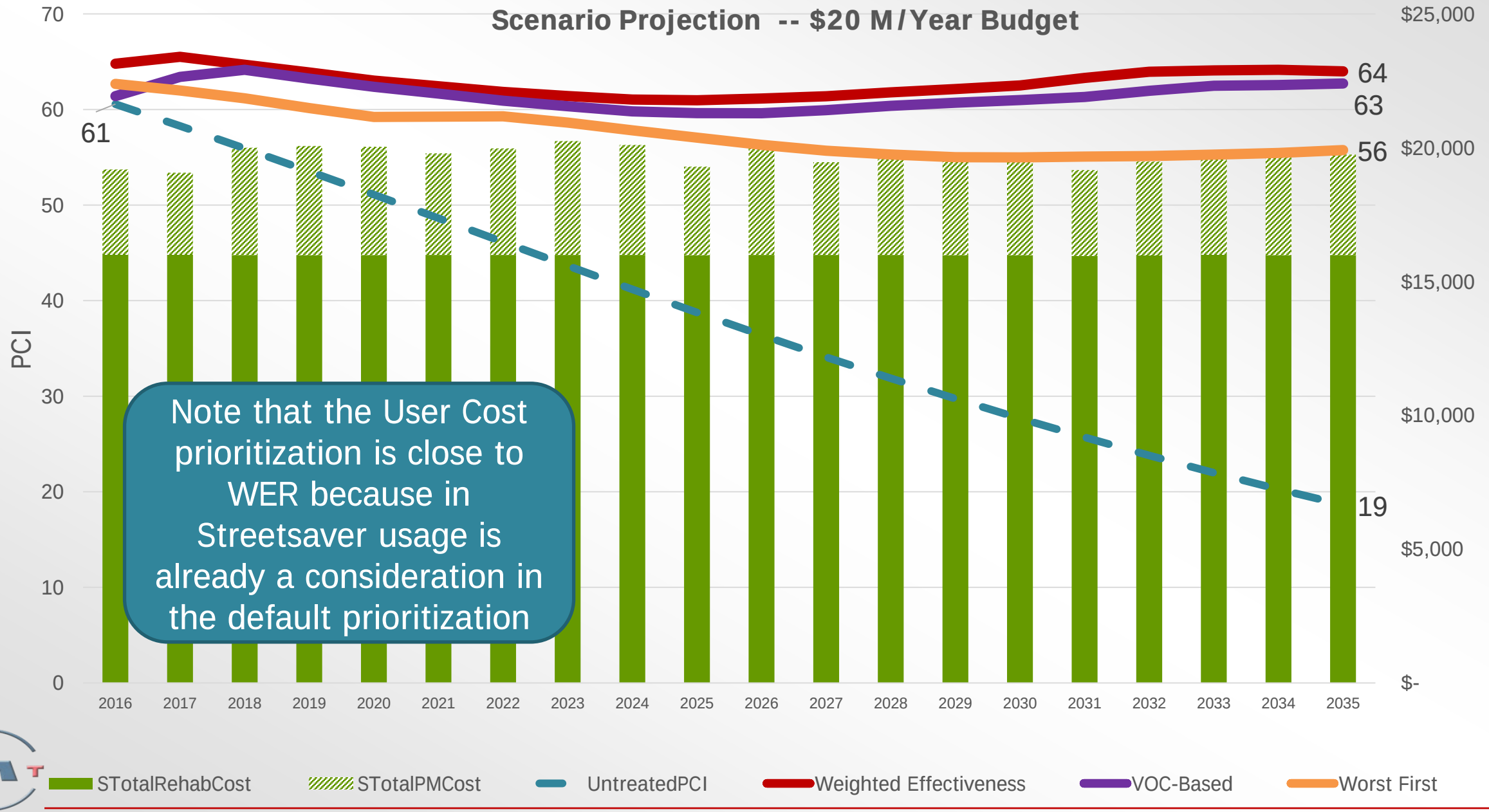
$AVMT_{PAVESEC}$ = Annual vehicle miles traveled on pavement section

VOC UnTr= Total vehicle operating cost before maintenance treatment

VOC Tr = Total vehicle operating cost after recommended treatment is applied

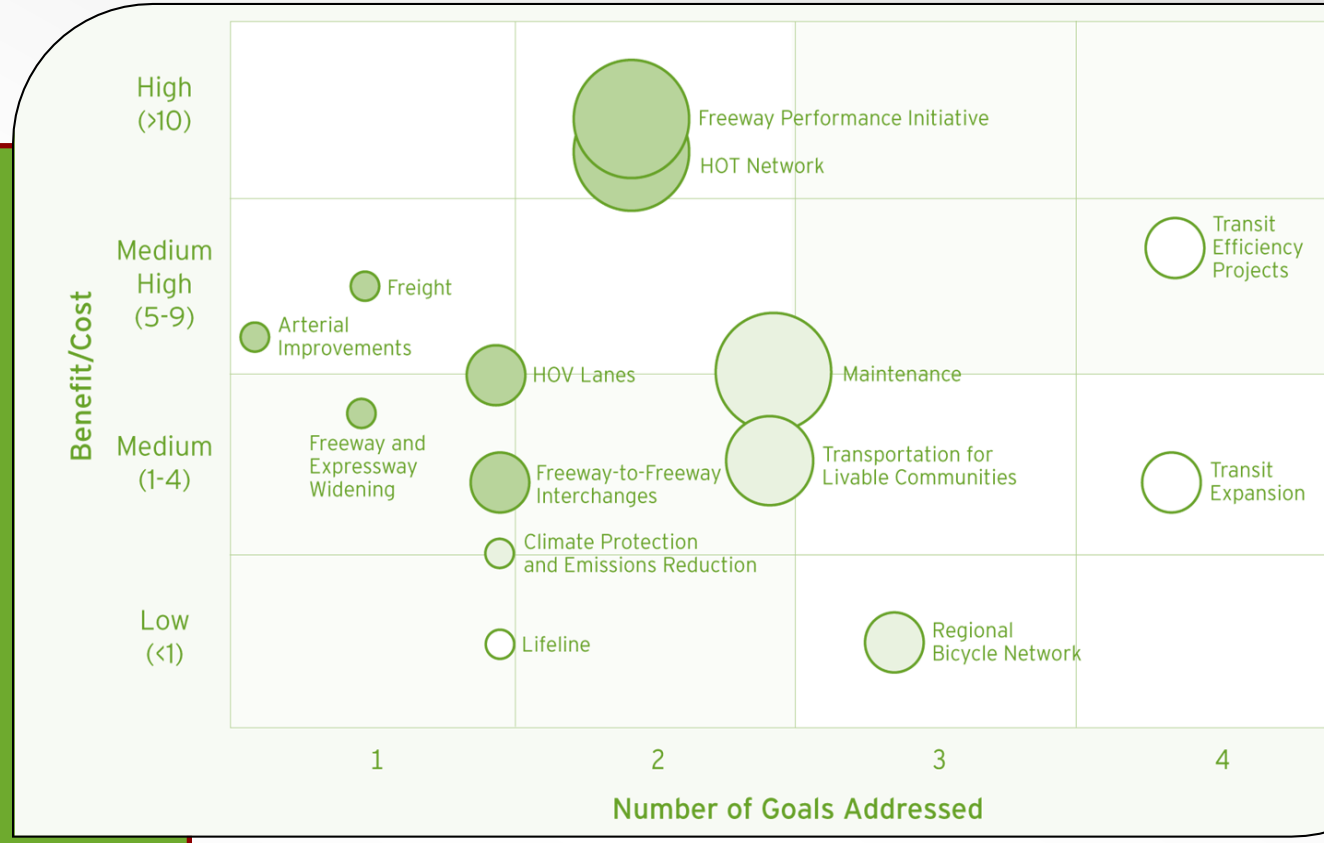
Street ID	Section ID	Lanes	Section Length	Functional Class	VOC Untreated	VOC Treated	% Mileage by FC	AVMT	VOC Benefit
01265	N142	5	2115	A	0.3901	0.3185	0.92%	3450085	$ 246,891
05905	N140	4	3642	A	0.3782	0.3185	1.27%	4752798	$ 283,553
02626	W100	2	5183	A	0.3782	0.3185	0.90%	3381899	$ 201,765
00070	W100	4	2162	A	0.3901	0.3185	0.75%	2821403	$ 201,902
05750	W120	4	4557	A	0.3536	0.3185	1.58%	5946870	$ 208,899
03980	W105	4	2018	A	0.3901	0.3185	0.70%	2633483	$ 188,454
06820	N135	3	2535	A	0.3901	0.3185	0.66%	2481125	$ 177,552

PCI Range	IRI	Total VOC/mi
84-100	1	0.3185
67-83	2	0.3232
58-66	3	0.3279
52-57	4	0.3409
48-51	5	0.3536
44-47	6	0.3660
42-43	7	0.3782
39-41	8	0.3901
37-38	9	0.4018
36-36	10	0.4133
34-35	11	0.4246
33-33	12	0.4357
32-32	13	0.4468
31-31	14	0.4576
30-30	15	0.4684
29-29	16	0.4790
28-28	18	0.5000
27-27	20	0.5205
26-26	22	0.5407
25-25	24	0.5606
0-24	24	0.5606


Scenario Projection -- $20 M/Year Budget
PCI
70
60
50
40
30
20
10
0
$25,000
$20,000
$15,000
$10,000
$5,000
$-
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
61
64
63
56
19
Note that the User Cost prioritization is close to WER because in Streetsaver usage is already a consideration in the default prioritization
STotalRehabCost
STotalPMCost
UntreatedPCI
Weighted Effectiveness
VOC-Based
Worst First

Prioritization Approach #4 – Benefit Cost

- Allows you to prioritize maintenance according to “bang for the buck” towards agency/community goals
  - A. User cost savings
  - B. Asset value preservation
  - C. Hybrid
- B/C values are all relative provided comparison is single-investment focused (i.e., pavement only, not pavement vs. transit or expansion investment)



Prioritization Approach #4 – B/C: User Cost

User Cost B/C=

$$\frac{(\text{VOC UnTr} - \text{VOC Tr}) \times \text{TrLEV}}{\text{Total Cost of Maintenance Treatment}}$$

Where:

VOC UnTr = Vehicle Operating Cost before Treatment

VOC Tr = Vehicle Operating Cost after Treatment

TrLEV=Life extension value of treatment applied

Street ID	Section ID	Life Extension	PCI Prior to Treatment	Treated PCI	Lanes	Functional Class	Total Cost	Lane Mileage	% Mileage by FC	AVMT	VOC Untreated	VOC Treated	VOC Benefit	VOC_BC
05500	W130	25	41	100	3	A	$ 152,075	0.60	0.27%	1027685	0.3901	0.3185	$ 1,834,114	12.06
01325	N160	25	41	100	2	A	$ 77,631	0.25	0.12%	437174	0.3901	0.3185	$ 785,072	10.11
01265	N142	25	41	100	5	A	$ 694,622	2.00	0.92%	3450085	0.3901	0.3185	$ 6,231,536	8.97
00070	W100	24	43	100	4	A	$ 601,209	1.64	0.75%	2821403	0.3901	0.3185	$ 4,919,056	8.18
02240	N132N	23	47	100	4	A	$ 173,861	0.7	0.32%	1205817	0.3660	0.3185	$ 1,322,979	7.61
02185	W120W	24	42	100	1	A	$ 195,004	0.58	0.27%	998322	0.3782	0.3185	$ 1,457,387	7.47
05750	W135	24	44	100	4	A	$ 212,384	0.46	0.21%	797353	0.3901	0.3185	$ 1,386,973	6.53

Prioritization Approach #4 – B/C: Asset Value

Asset Value Preservation B/C =

EAV (Extended Asset Value) - CAV (Current Asset Value)

Total Cost of Maintenance Treatment

Where:

$CAV = RSL_{UnTr} / UL_{FC} \times RC_{FC}$

EAV = Treated PCI x CAV

RC_{FC} = Avg. cost to replace sq. yd. of pavement in functional class x sq. yds. in section

UL_{FC} = Avg. useful life of pavement in functional class

RSL_{UnTr} = Untreated PCI / 100 x UL_{FC}

Street ID	Section ID	PCI Prior to Treatment	Treated PCI	Section Area	Functional Class	Total Cost	Replacement Cost	RSL	Current Value	Extended Value	AV Benefit	AV_BC
07859	N100	75	78	1072	R	$ 30	$ 9,048	23	$ 568,144	$ 584,807	$ 16,663	1600
07859	W100	70	72	3248	R	$ 91	$ 27,413	18	$ 138,367	$ 143,782	$ 5,415	627
07811	N100	81	82	6462	R	$ 57	$ 54,539	30	$ 447,779	$ 457,372	$ 9,592	613
07876	W90	75	77	19764	R	$ 200	$ 166,808	34	$ 128,619	$ 132,596	$ 3,976	546
07814	N090	74	76	2575	R	$ 46	$ 21,733	22	$ 689,485	$ 711,785	$ 22,301	470
07855	N100	83	85	9380	R	$ 122	$ 79,167	34	$ 265,632	$ 270,089	$ 4,457	458
07808	N100	83	84	8008	R	$ 139	$ 67,588	34	$ 604,916	$ 615,289	$ 10,373	409

Prioritization Approach #4 – B/C: Hybrid

Hybrid B/C Prioritization =

User Cost Benefit + Asset Value Benefit

Total Cost of Maintenance Treatment

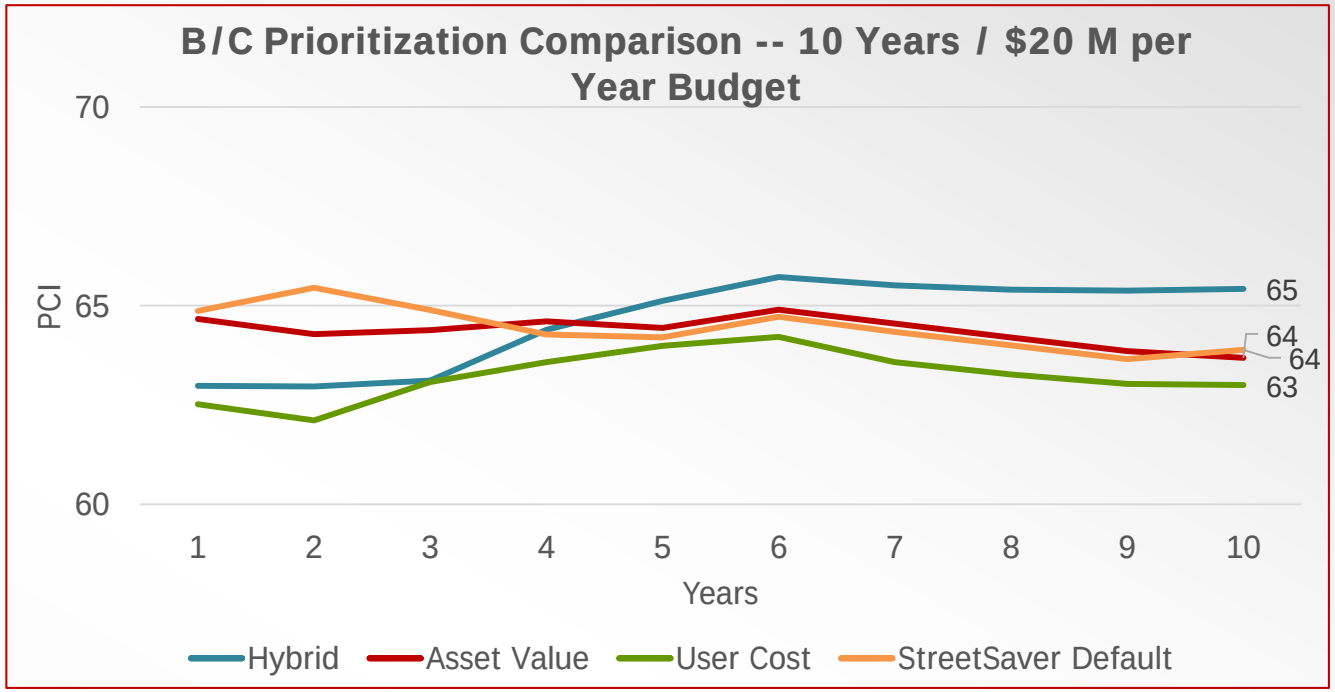
Or…

Prioritize all sections in maintenance backlog with a B/C > 1

Street ID	Section ID	PCI Prior to Treatment	Treated PCI	Functional Class	Total Cost	VOC_BC	AV_BC	Combined Benefit	Combined BC
01075	W100	53	100	R	$ 13,090	0	4	$ 23,780	65
07918	W105	46	100	R	$ 5,281	1	4	$ 366,482	63
05776	N100	51	64	R	$ 3,202	1	30	$ 8,833	63
07876	W110	75	77	R	$ 247	0	34	$ 4,707	62
07290	N110	85	92	R	$ 884	0	149	$ 47,826	61
00640	N100	51	64	R	$ 1,968	1	3	$ 9,476	61
07828	W100	75	77	R	$ 157	0	104	$ 46,503	59
03920	N100	84	85	A	$ 232	23	9	$ 6,883	59
05925	N130	84	85	A	$ 236	26	6	$ 9,392	58

B/C Prioritization Comparison

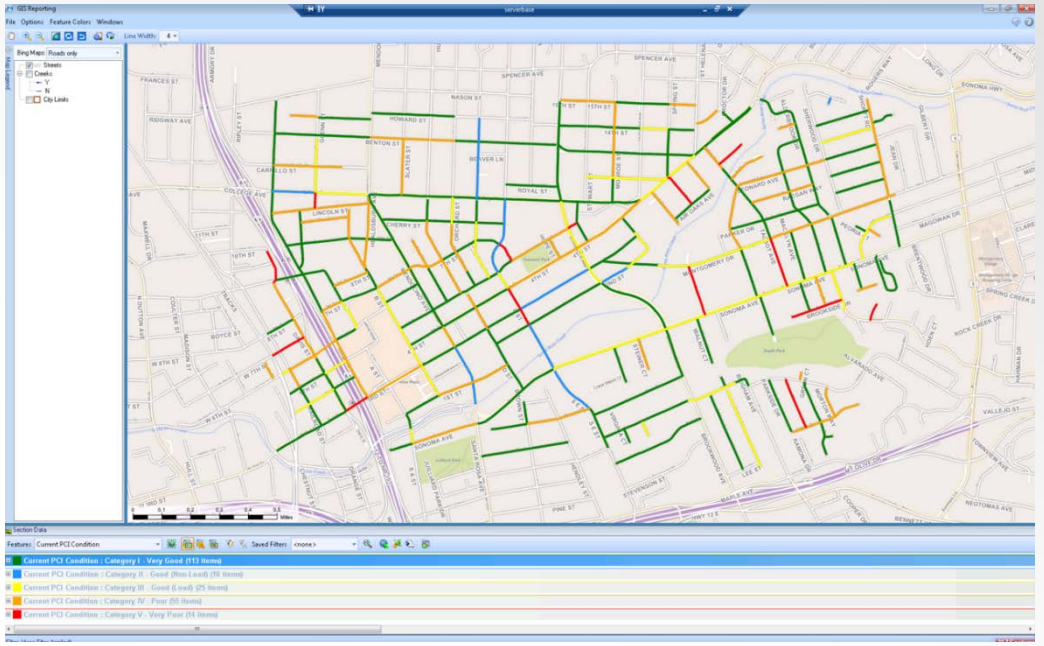
	Hybrid	Asset Value	User Cost	StreetSaver Default
2016	63	65	63	65
2017	63	64	62	65
2018	63	64	63	65
2019	64	65	64	64
2020	65	64	64	64
2021	66	65	64	65
2022	66	65	64	64
2023	65	64	63	64
2024	65	64	63	64
2025	65	64	63	64
2026 Backlog ($1,000)	$ 304,020	$ 296,285	$ 307,077	$ 297,894



- Comparison with default (WER) enables managers to gauge the long-term costs of prioritization methods

Other Common Prioritization Models

Active Transportation



Transit Routes

Location-Based
Political / Socioeconomic

Conclusions

- **Prioritization methods should align with agency and community goals**
- **Most prioritization model impacts can be modeled with a flexible pavement management system that can incorporate user-defined projects**
- **Varied prioritization models should be compared to the baseline (PMS default) to determine the cost and network condition trade-offs involved**
- **Closeness of prioritization model performance to default will vary based on network conditions, budget, and time**

Thank You!

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