Cost-Benefit Value

In this hypothetical example, a community has identified 10 roads needing treatment in a given year. The total estimated cost to treat all 10 roads is a little over $1 million, but the community's pavement management budget is only $600,000. How should community leaders prioritize and decide on this year's projects? An alphabetical listing of the roads including their current condition ratings and appropriate treatment strategies is as follows:

Road Name	Length (feet)	Width (feet)	Appropriate Treatment	Condition (PCI)	Unit Cost ($/s.y.)	Total Job Cost
Cedar Terrace	3,010	24	Reconstruction	40	$27.00	$216,720
Elm Street	4,150	26	Mill & Fill	68	$14.00	$167,844
Hill Street	7,100	28	Crack Seal	91	$0.55	$12,149
Lake Avenue	8,025	26	Fog Seal	94	$1.10	$25,502
Main Street	4,925	40	Rehabilitation	55	$17.50	$383,056
Maple Avenue	4,470	24	Double Surface Treatment	74	$4.50	$53,640
Oak Street	3,520	26	Thin Overlay	70	$7.50	$76,267
Park Street	6,775	30	Single Surface Treatment	81	$2.50	$56,458
Pine Street	3,850	24	Double Surface Treatment	72	$4.50	$46,200
Washington Street	6,080	30	Crack Seal	89	$0.55	$11,147
						$1,048,982

This community could decide to use a "worst-first" pavement management approach which would spend all available funds on the most deteriorated roads. Elected officials and other community leaders are often incentivized toward this approach because the worst roads usually receive the most complaints from taxpayers. To illustrate this approach, we've sorted the 10 road projects by ascending PCI with the worst roads at the top. See that our $600,000 budget is only enough to fix two roads. Maintenance or repair of the other eight roads is deferred at least one more year such that some of those roads will undoubtedly need more extensive (and expensive) treatments when they eventually get attention.

Worst-First Pavement Management Approach

Road Name	Length (feet)	Width (feet)	Condition (PCI)	Appropriate Treatment	Unit Cost ($/s.y.)	Total Job Cost	Cumulative Budget Spent	Miles Repaired
Cedar Terrace	3,010	24	40	Reconstruction	$27.00	$216,720	$216,720	0.57
Main Street	4,925	40	55	Rehabilitation	$17.50	$383,056	$599,776	1.50
Elm Street	4,150	26	68	Mill & Fill	$14.00	$167,844		
Oak Street	3,520	26	70	Thin Overlay	$7.50	$76,267		
Pine Street	3,850	24	72	Double Surface Treatment	$4.50	$46,200		
Maple Avenue	4,470	24	74	Double Surface Treatment	$4.50	$53,640		
Park Street	6,775	30	81	Single Surface Treatment	$2.50	$56,458		
Washington Street	6,080	30	89	Crack Seal	$0.55	$11,147		
Hill Street	7,100	28	91	Crack Seal	$0.55	$12,149		
Lake Avenue	8,025	26	94	Fog Seal	$1.10	$25,502		

An alternative, more optimized and enlightened approach, would be to employ a series of cost-benefit analyses to prioritize this year's projects. Most well-functioning pavement management systems have some sort of cost-benefit prioritization formula built into the software to help users make these network optimization decisions. We often employ the CBV formula below:

$$CBV = \frac{(AADT)/(TCF) \times (SLE)}{(UC) \times (PCI)}$$

Where: CBV = Cost-Benefit Value

AADT = Average Annual Daily Traffic

TCF = Traffic Contraint Factor

SLE = Service Life Extension of appropriate treatment

UC = Unit Cost of appropriate treatment

PCI = Pavement Condition Index

This formula may look a bit complex at first, but is a powerful decision-making tool to quantitatively evaluate and compare projects. It uses basic information to help make the most prudent spending decisions. Traffic Constraint Factors for this formula typically fall in the range of 4 to 10 depending on the specifics of a community's paved road network and traffic distribution, and they are utilized to dampen the effects of traffic counts from influencing CBV outcomes too heavily. For this example, we've used a mid-range TCF value of 7.

Updating our list of 10 roads to include the traffic counts and the service life extensions achieved with the treatments appropriate for each road yields the following chart sorted by declining Cost-Benefit Value (CBV):

Cost-Benefit Value Optimized Management Approach

Road Name	Length (feet)	Width (feet)	Condition (PCI)	AADT	Appropriate Treatment	Service Life Extension (years)	Unit Cost ($/s.y.)	CBV	Total Job Cost
Washington Street	6,080	30	89	5,600	Crack Seal	2	$0.55	32.69	$11,147
Park Street	6,775	30	81	7,800	Single Surface Treatment	5	$2.50	27.51	$56,458
Hill Street	7,100	28	91	4,200	Crack Seal	2	$0.55	23.98	$12,149
Main Street	4,925	40	55	10,200	Rehabilitation	15	$17.50	22.71	$383,056
Pine Street	3,850	24	72	4,400	Double Surface Treatment	8	$4.50	15.52	$46,200
Lake Avenue	8,025	26	94	3,600	Fog Seal	3	$1.10	14.92	$25,502
Maple Avenue	4,470	24	74	3,300	Double Surface Treatment	8	$4.50	11.33	$53,640
Elm Street	4,150	26	68	5,100	Mill & Fill	13	$14.00	9.95	$167,844
Oak Street	3,520	26	70	2,700	Thin Overlay	10	$7.50	7.35	$76,267
Cedar Terrace	3,010	24	40	850	Reconstruction	20	$27.00	2.25	$216,720

Comparing this CBV-optimized work plan with the "worst-first" work plan above, we see a few important things:

* Our $600,000 budget will allow us to work on 7 roads instead of only 2.

* The CBV-optimized approach allows us to repair a total of almost 8 miles of road versus only 1.5 miles using the "worst-first" approach. Some of these repairs are as simple and inexpensive as crack sealing and fog sealing, but this preventive maintenance avoids more costly future repairs.

* Main Street, the most expensive project on our list, still gets fixed as it should given the high volume of traffic it carries and its importance to the community.

* Cedar Terrace with its relatively low traffic count doesn't get reconstructed in the current budget year, and instead that money is allocated to preserving 6 other roads all in need of preventive maintenance type treatments. As the overall network improves, the lesser traveled Cedar Terrace will eventually get reconstructed, but not at the expense of allowing more heavily traveled roads in the community to deteriorate without maintenance.

A worst-first pavement management approach over multiple years has proven to be a losing strategy with more and more roads gradually becoming poor than the community can afford to rebuild without bonding or other major financial commitment. A CBV-optimized approach, on the other hand, is a winning strategy and one that the best pavement managers often employ.